Benefit-Cost Analysis Supplementary Documentation

RAISE Program

State Street Premium Corridor Infrastructure Project

Valley Regional Transit, Boise, ID

April 11, 2022

Table of Contents

List of Tables

Benefit-Cost Analysis Supplementary Documentation

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. Benefits have been monetized to the fullest extent possible. Efforts have been made to quantify benefits where monetization is not possible. A qualitative discussion is also provided when a benefit is anticipated but is not easily monetized or quantified.

Valley Regional Transit (VRT) in Boise, Idaho is pursuing the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant Program to build the State Street Premium Corridor Infrastructure Project. The project specifically targets VRT bus Route 9 on State Street from Downtown Boise to N. Bogart Lane, in Boise. The State Street RAISE grant will activate the regions plans to make State Street a multi-modal corridor. The latest draft of the regional long-range transportation plan, *Communities in Motion 2040 2.0*, highlights improvements to this segment of the State Street Corridor, as the ***highest priority*** among all unfunded regional public transportation projects. The grant would fund final design, and construction of active transportation infrastructure at nine locations along the corridor and transit amenities at 27 bus stops. It would also fund planning of transit and active transportation infrastructure at the key intersection of State and Bogart.

The improvements to the bus route involve the following:

- Bus Priority spot treatments and signal priority at intersections.
- New or improved bus platforms that include upgrades to shelters, near level boarding, in-lane stop platforms, fare collection systems, and real-time rider information displays.
- Bus electrification and charging infrastructure.
- Drainage repairs and upgrades, including culverts, aprons, catch basins, etc.
- Spot upgrades of ADA pedestrian facilities, sidewalks, and driveways along the corridor.
- A protected bicycle intersection, infill of bicycle lanes and a curb protected multi-use path.
- New curb and gutter treatments where existing curbs and gutters are currently missing.

These improvements have monetizable effects for the city of Boise. The BCA models the following benefits:

- The improved bus priority treatments and fare collection systems will reduce travel time along the corridor and wait time at bus stops
- The improvements to intersections and pedestrian, cycling, and bus stop infrastructure will reduce the number of accidents and injuries

- The improved bus stop facilities (including weather protection, benches, ADA/level boarding platforms, and real-time displays) will provide a safer and more enjoyable transit experience for passengers

Table ES-1 summarizes the changes expected from the project and the associated benefits. Monetized and non-monetized benefits are provided.

Table ES-1: Merit Criteria and Cost-Effectiveness - Summary of Infrastructure Improvements and Associated Benefits, 2020 Dollars

Current Status or Baseline & Problems to be Addressed	Changes to Baseline/Alternatives	Types of Impacts	Benefits	Summary of Results (Discounted 2020 $)	Page #
Valley Regional Transit (VRT) in Boise, Idaho has identified VRT bus Route 9 along the State Street corridor as one that stands to benefit from major transit improvements.	The project will make significant improvements in advancing the regional version of the State Street multi-modal corridor. This includes reducing travel time and wait time for bus passengers, improving safety for multi-modal users, and building transit facilities for bus passengers, pedestrians, and cyclists.	Improved travel times along the 9th street corridor by reducing on board bus transit time and passenger wait time	Travel Time Savings	$11,000,393	Pg. 16
		Improved safety by building roadway and transit infrastructure improvements that will reduce accidents and injuries	Accident Cost Savings	$5,756,115	Pg. 17
		Install weather protection, benches, ADA/Level boarding platforms, and real time transit displays to improve passenger experience	Facility Amenities Benefits	$809,504	Pg. 19
	The improved bus service will attract travelers that currently use automobile	Reduce use of automobile by switching travelers to bus service	Roadway Congestion Reduction Benefits	$188,899	Pg. 20
		Reduce automobile emissions by switching travelers to bus service	Emissions Reduction Benefits	$51,459	Pg. 22

The project is expected to start generating benefits when the construction and installation of the improvements is complete in 2027.

The period of analysis used in the estimation of the project's benefits and costs includes 4 years of project development and construction (design and engineering, construction, and contingency planning in 2023 – 2026) and 30 years of operations (2027 – 2056). The total project capital costs are $9.7 million in undiscounted 2020 dollars. The breakdown of project costs is presented in Table ES-2.

Table ES-2: Summary of Project Costs, Undiscounted 2020 Dollars

Cost Category	Constant 2020 $
Design & Engineering	$550,000
Construction	$8,170,176
Contingency	$1,000,000
Total	**$9,720,176**

A summary of the relevant data and calculations used to derive the benefits and costs of the project are shown in the BCA model (in 2020 dollars[1]). Based on the analysis presented in the rest of this document, the project is expected to generate $17.8 million in discounted benefits and $6.9 million in discounted costs using a 7 percent real discount rate for all benefit categories (except for CO2 emissions which are discounted at a 3 percent real discount rate). Therefore, the project is expected to generate a Net Present Value of $10.9 million and a Benefit-Cost Ratio of 2.57. In other words, for each dollar spent in project costs, approximately $2.57 worth of benefits will be generated by the improvements. The project will especially benefit the non-driving populations including the elderly, youth, students, lower income individuals and other disadvantaged populations.

In addition to the monetized benefits, the project would generate benefits that are difficult to quantify. These include construction of charging stations for electric buses, that will enable the transition to electric buses along the route, eliminate local emissions and reduce noise. Other non-quantifiable benefits include pedestrian benefits resulting from a wider sidewalk in a section of the State Street and signaled crossings at busy intersections and cycling benefits resulting from building bike share stations in some bus stations to improve transit access. These improvements will also improve intermodal connectivity between active transportation modes and transit.

A summary table of annual monetized benefits and costs is provided in Section 10.

[1] The benefits and costs in this Technical Appendix are expressed in constant dollars of 2020 and have been discounted to the year 2020.

2. Introduction

This document provides detailed technical information on the economic analyses conducted in support of the grant application for the State Street Premium Corridor Infrastructure Project:

- Section 3, Methodological Framework, introduces the conceptual framework used in the Benefit-Cost Analysis.
- Section 4, Project Overview provides an overview of the project, including a brief description of existing conditions and proposed alternatives; a summary of cost estimates and schedule; and a description of the types of effects that the project is expected to generate.
- Section 5, General Assumptions, discusses the general assumptions used in the estimation of project costs and benefits, while estimates of travel demand can be found in Section 6.
- Specific data elements and assumptions pertaining to the long-term outcome selection criteria are presented in Section 7, Estimation of Economic Benefits, along with associated benefit estimates.
- Estimates of the project's Net Present Value (NPV), its Benefit-Cost Ratio (BCR) and other project evaluation metrics are introduced in Section 8, Summary of Findings and BCA Outcomes.
- Next, Section 9, BCA Sensitivity Analysis, provides the outcomes of the sensitivity analysis. Additional data tables are provided within the BCA model including annual estimates of benefits and costs to assist the U.S. Department of Transportation (USDOT) in its review of the application.[2]
- Section 10, Summary of Benefits and Costs, provides results for project costs and benefits for each analysis year.

3. 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 particular project. A project's societal return-on-investment is estimated by comparing the monetized benefits against the project's total costs.

The benefits of the project are based on the expected impacts on both users and non-users of the facility. In addition, a BCA evaluates the benefits and costs over the entire life cycle of the project. Therefore, 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 (U.S. DOT) 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. In other words, a BCR greater than 1.0 indicates that for every dollar spent in project costs, more

[2] The BCA model is provided separately as part of the application.

than one dollar will be generated in benefits. The net present value (NPV), calculated by subtracting the discounted project costs from the project's discounted societal benefits, measures the total benefit that society enjoys as a result of the project improvements.

The specific methodology for the State Street Premium Corridor Infrastructure Project was developed using the BCA guidance published by U.S. DOT in March 2022.[3] In particular, the methodology involves:

- Establishing existing and future conditions under the build and no-build scenarios.
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement.
- Using U.S. DOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects.
- Discounting future benefits and costs with the real discount rate of 7 percent for all categories.
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

4. Project Overview

Valley Regional Transit, the Community Planning Association of Southwest Idaho (COMPASS) and the land use and transportation agencies along the State Street corridor are seeking federal funding through the Rebuilding American Infrastructure through Sustainability and Equity (RAISE) program to improve walking and biking infrastructure and make transit faster, quieter, and easier to use.

The bicycle and pedestrian improvements include a buffered multi-use path, additional street crossings, improved wheelchair ramps and access, improved bicycle crossings and connections with lower stress facilities, and reduced conflicts between bicycle lanes/paths at bus stops.

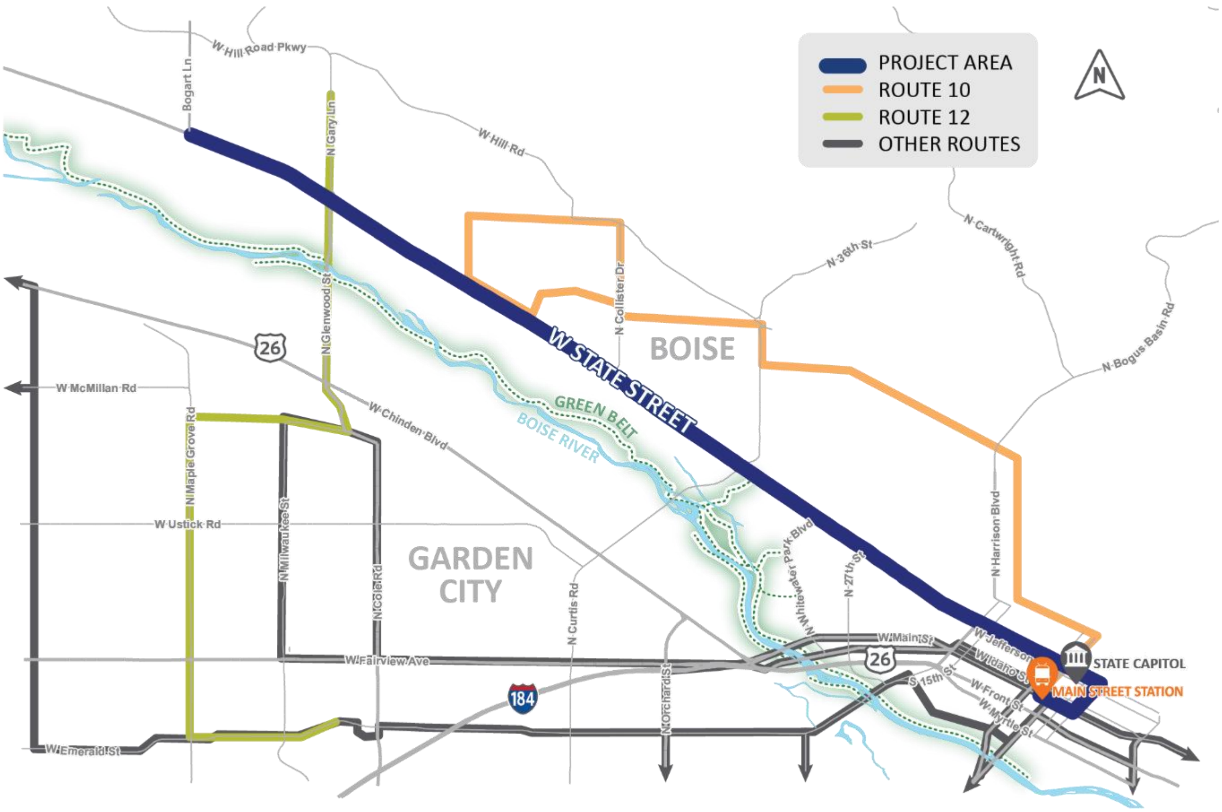
The transit improvements reduce the amount of time spent getting on and off the bus by providing ticket vending machines, bus stop designs that are easier for people using mobility devices. Real-time information about the next bus arrival will make transit easier to use. Improved bus shelters, benches, trash receptacles, and lighting will make transit safer. The complete electrification of transit along the State Street corridor will enabling to eliminate local emissions and reduce noise.

Together the non-motorized and transit improvements along this highly used six and half mile corridor will advance the regional multi-modal vision of the corridor. It will also address transportation equity concerns by connecting low-income residents, refugee populations, and affordable housing developments with employers, grocery stores, healthcare facilities, primary,

[3] U.S. DOT. *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*. March 2022 (Rev). Available at: Benefit-Cost Analysis Guidance for Discretionary Grant Programs | US Department of Transportation

secondary and post-secondary schools, recreational facilities and other life enhancing opportunities.

Figure 1. Project Area - State Street from Downtown Boise to Bogart



4.1 Base Case and Alternatives

Base Case – The No-Build scenario assumes no changes to transit service, bicycle and pedestrian infrastructure or roadway geometries. As a result, transit operations will face additional delay along the corridor due to traffic volumes resulting in up to a minute of additional delay per bus at busy intersections. Without geometric changes to address connectivity and safety, the additional traffic volumes will result in 70 crashes at study intersections along the corridor by 2035.

Build Case – The Build Scenario includes improvements to reduce transit operations delay moving along the State Street corridor and dwell-time reduction measures at transit stops. Combined, these measures result in operational performance improvements of approximately 10% and will attract additional transit riders to the corridor. The project also includes a number of intersection geometry changes and crossing improvements that will result in a 23% reduction in crashes at study intersections along the corridor.

4.2 Types of Impacts

The proposed improvements from the State Street Premium Corridor Infrastructure Project are expected to significantly reduce delays and travel times for passengers, avoid accidents and injuries along the corridor and improve the bus ridership experience. These impacts are described in more detail below:

- **Reduction in delays:** The project elements will reduce bus travel time along the segment and reduce wait time at bus stations.
- **Reduction in accidents and injuries:** The geometry changes to intersections combined with the infrastructure improvements to bus, pedestrian, and bicycle facilities will reduce the number of accidents and injuries along the State Street Corridor.
- **Construction of amenity facilities:** Amenity facilities at bus stops along the corridor will improve the comfort of journeys made by bus riders.

In addition to the monetized benefits listed above, the project would generate benefits that are difficult to quantify. These include construction of charging stations for electric buses, that will enable the transition to electric buses along the route, eliminate local emissions and reduce noise. Other non-quantifiable benefits include pedestrian benefits resulting from a wider sidewalk in a section of the State Street and signaled crossings at busy intersections and cycling benefits resulting from building bike share stations in some bus stations to improve transit access. These improvements will also improve intermodal connectivity between active transportation modes and transit.

4.3 Project Cost and Schedule[4]

The construction of the improvements part of the State Street Premium Corridor Infrastructure Project are expected to occur from year 2023 to 2026 with opening year in 2027. The costs associated with preliminary design and engineering, construction, and contingency planning are expected to be incurred between 2023 and 2026. The breakdown of project costs is presented in Table 1. The capital expenditures of the project will add up to $9.7 million (undiscounted).

Table 1: Project Cost Summary, Undiscounted 2020 Dollars

Calendar Year	Capital Expenditures (2020 $)
2023	$754,493
2024	$2,582,771
2025	$1,741,609
2026	$4,641,302
Total	**$9,720,176**

5. General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the preliminary engineering and the start of construction.

The monetized benefits and costs are estimated in 2020 dollars with future dollars discounted in compliance with U.S. DOT BCA requirements using a 7 percent real rate for all categories (except

[4] All cost estimates in this section are in millions of 2020 dollars, discounted to 2020 using a 7 percent real discount rate.

for CO_2 emissions, which are discounted at 3 percent). The benefits and costs have been discounted to year 2020.

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

- Input prices are expressed in 2020 dollars.
- The period of analysis begins in 2023 and ends in 2056. It includes project development and construction years (2023 – 2026) and 30 years of operations (2027 - 2056).
- A constant 7 percent real discount rate is assumed throughout the period of analysis for most categories (except for CO_2 emissions, which are discounted at 3 percent).

6. Demand Projections

The improvements to the bus service included as part of the State Street Premium Corridor Infrastructure Project will make it more desirable and attract new riders from other transit services and provide an opportunity for commuters using automobiles to switch modes. This section outlines the assumptions, methodology, and results of the analysis that was used to quantify the future demand for bus services.

6.1 Methodology and Assumptions

ASSUMPTIONS

Travel demand is a function of the transit supply and the demand which is linked to population and households. The analysis incorporated data and guidance from several local sources to better understand and the travel demand and benefits associated with supply and demand components of the analysis. National Research and data from the local MPO supported the methodology. The assumptions were developed for a 2019 pre-pandemic scenario and an existing condition of 2022, a horizon year of 2035 without improvements, and finally the build scenario. The two build conditions included the following components.

<u>Build Case for 2022 and 2035</u>[5]

- Stop consolidation for five station that improved travel time
  - Three outbound stations were consolidated
    - State St @ 21st
    - State St @ Collister St
    - State St @ Northgate Shopping
  - Two inbound stations were consolidated
    - State St @ 21st
    - State St @ 29th
- Transit Signal and roadway improvements which resulted in travel time improvements
- Collectively this improvement improved travel time by over three minutes end-to-end, or 1.6 minutes for the average user.

[5] In the BCA spreadsheet model this scenario is identified as Scenario "a".

The transit service data for 2022 and for 2035 consisted of accessing the data described below which was obtained from Valley Transit, COMPASS MPO, and the project team.

- Verifying its alignment
- Matching stop locations with adjacent land use
- Checking location and capacity of park-and-ride lots
- Researching the competing/connecting bus service in the area
- Examining the travel time between stations (including dwell) and in-vehicle travel time into the downtown by time and direction
- Establishing the headways by time-period

The supply side included socio-economic data, demographic forecasts, counts, and surveys.

- Transit Counts
- 2021 COMPASS Onboard Survey
- Demographic data from COMPASS
- COMPASS Travel Model Outputs
- Valley Regional Transit, usage data reported to the FTA National Transit Database

The methodology utilized research on elasticities of demand for travel time and elasticities produced by:

- Victoria Transportation Policy Institute
- American Planning Association Transportation Planning Handbook
- Transit Cooperative Research Program. TCRP_RRD_61, Travelers Response to Transportation System Changes

METHODOLOGY

The analysis examined the changes to existing 2022 and future 2035 service plan and ridership without travel time or headway improvements. The existing condition for the Route 9 was built entirely on existing ridership data and published service schedules. Mode of access to the stations was considered, focusing on walk access markets, on a park-and-ride lot, and connecting/competing bus service for the inner and outer stations. An average weekday was used as the starting point for the analysis for the near-term build alternatives. The 2022 demand is lower that pre-pandemic 2019 ridership that was reported by Valley Regional Transit, but it represented the best data set available for the near-term.

All the stations have a strong walk access market, with the terminal stop which also has a small park-and-ride lot that isn't expected to be expanded in the future. Some of the connecting/ competing bus markets in this corridor include Routes 10 and 12. It was assumed that even though stops were being consolidated, the catchment area around the remaining stops was sufficient and overlapping with the removed stops to minimize any possible reduction in ridership from losing stops.

The future 2035 was developed by examining the land use changes that are expected to occur in this corridor as referenced by CAMPO and the Valley Transit Bus Rapid Transit Alternative

Analysis. This corridor is anticipating significant growth, an increase in households from 1,541 to 3,157 between 2019 and 2035. Employment and jobs are also growing from 3,829 in 2019 to over 12,595 by 2035. To create an estimate of 2035 demand and to account for the eventual return to pre-pandemic transit use, the 2019 ridership for the Route 9 was grown instead of the 2022 ridership data. This increase in households and employment create a need for travel options that the 2035 demand analysis shows exist in the future and the Route 9 helps serve.

Using research data on elasticities of demand nationally and implied from several CAMPO travel demand model tests, the relationships between travel time changes for the peak and off-peak periods were calculated to produce weekday ridership changes by station due to the proposed improvements. The ridership demand for the Route 9 unlinked transit boardings was factored by 269 to get an annual estimate. The 269 was derived from the ratio of the 2019 Valley Regional Transit NTD submission for annual and weekday unlinked transit trips in the region.

The elasticity calculation was used to develop the demand for the Route 9 service with the improvements, but a mode-shift analysis was used to identify how many autos could be diverted to transit based on an appraisal of competing and connecting service. Since there was not a lot of other bus service in this corridor, a conservative estimate of 60% of the new Route 9 ridership was assumed to be auto diversions. A one-way travel distance of 7 miles was assumed for the route which was then used to calculate the one-way vehicle miles traveled. Multiplying the auto diversions by the trip length helped produce the estimated reduction in vehicle miles travelled. The vehicle hours travelled reductions was backed into from travel speed data along this corridor for the peak periods.

6.2 Demand Projections

The analysis examined three years and two build alternatives, 2019, 2022, and one for 2035. These two alternatives are identified with the letters “a” and “b”, where “a” includes improvements that reduce travel time savings and “b” includes the same travel time improvements as “a” plus a reduction in headways. Since the more conservative alternative is “a” the demand projections for this alternative are used in this BCA.

The Route 9 commuter bus is approximately 6 miles in length with travelling from its terminus at Gary & Bunch to downtown Boise. It operates at 15-minute headways in the peaks between 5:15 AM and 9:39 PM on weekdays. The travel times varies slightly depending on direction and time-period, but generally ranges from 20 minutes to 25 minutes. There are 22 outbound stops and 20 inbound stops.

The 2019 pre-pandemic scenario had approximately 810 boardings daily, with a little more than half going outbound when compared to the inbound direction. Many of the bus stops attract between 20 to 30 boardings daily with three attracting more than 40 boardings daily. The pandemic has surpassed ridership due to a variety of reasons which include shifting of trips to telecommuting, changes in workforce, and transit attractiveness has been reduced to being in a confined space with other passengers. The 2021 daily boardings were 530 and the 2022 daily boardings were 470. These numbers are likely to improve with time, but it may take another couple of years to get back to 2019 pre-pandemic levels. The change in demand associated with the pandemic are shown in Table 2 and Table 3. Changes associated with the auto mode are reported in Table 4.

The theoretical Route 9 travel time improvements associated with the near-term 2022 findings resulted in 2.6 minutes of improvement in-vehicle travel time for the entire route depending on direction and time-period. This translates into approximately 1.3 minutes of travel time benefit for the average rider. This travel time improvement resulted in a 6.9% increase in daily boardings on the route. Annually these improvements lead to an increase in Route 9 ridership of 8,800 due to travel time improvements. Of these new transit riders to the Route 9 service, approximately 5,300 were auto diversions which resulted in an annual reduction of 37,000 vehicle miles travelled (VMT).

The estimated Route 9 travel time improvements associated with the near-term 2035 findings resulted in 2.6 minutes of improvement in-vehicle travel time for the entire route depending on direction and time-period. This translates into approximately 1.3 minutes of travel time benefit for the average rider. This travel time improvement resulted in a 6.5% increase in daily boardings on the route. Annually these improvements could lead to an increase in Route 9 ridership of 39,700 for travel time improvements. Of these new transit riders to the Route 9 service, approximately 23,800 were auto diversions which resulted in an annual reduction of 166,800 vehicle miles travelled (VMT).

Table 2. Travel Demand Results: Transit Boardings

Route 9	Boardings							
Alternative	2019_Base	2021_Base	2022_Base	2022_Bld_a	2022_Bld_b	2035_Nbld	2035_Bld_a	2035_Bld_b
Daily								
Westbound Summary	445	307	278	297	318	1,335	1,422	1,514
Eastbound Summary	366	224	195	208	223	934	995	1,060
Total	811	531	473	505	541	2,269	2,417	2,574
Delta				33	69		148	305
Percent Change				6.9%	14.5%		6.5%	13.4%
Annual								
Westbound Summary	119,682	82,511	74,662	79,964	85,641	359,046	382,405	407,292
Eastbound Summary	98,465	60,269	52,465	55,974	59,949	251,333	267,683	285,104
Total	218,147	142,781	127,127	135,938	145,590	610,379	650,088	692,396
Delta				8,811	18,463		39,709	82,017
Percent Change				6.9%	14.5%		6.5%	13.4%

Table 3. Travel Demand Results: Transit Metrics

Route 9	Transit Metrics			
Alternative	2022_Bld_a	2022_Bld_b	2035_Bld_a	2035_Bld_b
Change in Daily				
Linked Transit Trips	20	41	89	183
Unlinked Transit Trips	26	54	117	241
Change in Annual				
Linked Transit Trips	5,286	11,078	23,826	49,210
Unlinked Transit Trips	6,978	14,623	31,450	64,958

Table 4. Travel Demand Results: Auto

Route 9	Automotive Metrics			
Annual Auto Benefits	2022_Bld_a	2022_Bld_b	2035_Bld_a	2035_Bld_b
Auto Diversions	5,286	11,078	23,826	49,210
VMT Reduction	37,005	77,546	166,779	344,473
VHT reduction	1,396	2,915	7,008	14,413

7. Estimation of Economic Benefits

This section describes the measurement approach used for each benefit or impact category identified in the Executive Summary and provides an overview of the associated methodology, assumptions, and estimates.

Table 5 outlines general assumptions used in the BCA.

Table 5: General Assumptions Used in the Benefit-Cost Analysis

Variable Name	Unit	Value	Source
General Discount Rate	percent	7%	U.S.DOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs - March 2022
Construction Period	years	2023 - 2026	VRT; HDR Assumption.
Project Opening Year	year	2027	
Analysis Period	years	30	
Annualization Factor	days/year	260	HDR Assumption

7.1 Travel Time Savings

Travel time savings are estimated using the travel time projections for bus riders and the delay/ wait time projections for passengers waiting at the bus stops combined with the appropriate values of travel time recommended in the U.S. DOT BCA guidance.

7.2.1 METHODOLOGY

Estimation of travel time savings are based on an analysis of bus operations using a Synchro model and the analysis of stop-level improvements combined with Transit Delay Reduction Treatments derived from literature research. The travel time reductions are only estimated for bus users.[6] Furthermore, travel time savings are separated into reduction in trip time and reduction in dwell / wait time.

[6] Travel time savings for bus drivers have not been monetized in this BCA to present a conservative estimation of benefits.

Trip time savings for bus riders are estimated on a daily, per-bus basis. They are converted into passenger-hours of savings using the average bus ridership for a bus round trip. These passenger-hours of savings are then annualized using the number of weekdays in a year.[7] The passenger-hours of savings are monetized using the appropriate value of time.

Dwell / wait time savings are estimated in daily averages per bus stop. They are converted to passenger-hours of savings using the average boardings per stop (for a bus round trip) for those stops where improvements are proposed and annualized using the number of weekdays in a year. Per the USDOT BCA guidance, these benefits are monetized using the value of time corresponding to waiting, standing, and transfer Time.

7.2.2 ASSUMPTIONS

The assumptions used in the estimation of travel time savings are summarized in Table 6.

Table 6: Assumptions Used in the Estimation of Travel Time Savings

Variable Name	Unit	Value	Source
Value of Time, In-Vehicle Travel All Purpose	2020 $/hour	17.8	U.S.DOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs - March 2022
Value of Time, Walking, Cycling, Waiting, Standing, and Transfer Time	2020 $/hour	32.4	

7.2.3 BENEFIT ESTIMATES

The project is expected to reduce almost 270,000 person-hours of travel and almost 1.6 million person-hours of waiting for bus users over the entire 30 years of analysis. Table 7 outlines the benefits of travel time over the project lifecycle. They account for $11.0 million in benefits over the life cycle, discounted at 7 percent.

Table 7: Estimates of Travel Time Savings, Millions of 2020 Dollars

Benefit Type	Constant 2020 $	Discounted 2020 $
Bus Passenger Travel Time Savings	$4.80	$1.12
Passenger Wait Time Reduction	$51.52	$9.88
Total Travel Time Savings	**$56.32**	**$11.00**

7.2 Accident Cost Savings

The project will build infrastructure improvements to the roadway, bus, pedestrian, and bicycle facilities that will reduce the number of accidents and injuries along the State Street Corridor. In addition, the improved bus service will create additional (induced) ridership. This induced

[7] The BCA model assumes an annualization factor of 260 days (instead of the 269 days used in the demand analysis) to be conservative.

ridership is assumed to divert from automobiles, reducing vehicle miles traveled. As a result, additional reductions in crashes are anticipated from this modal diversion.

7.3.1 METHODOLOGY

A crash analysis was conducted to develop crash forecasts for the build and no build scenarios for the years 2025 and 2035. Crash estimates are based on the projected effects of the infrastructure improvements to roadway, pedestrian bicycle and bus passenger facilities. The data is provided in four crash severity categories: crashes resulting in no injury, possible injury, non-incapacitating injury, and incapacitating injury. The reduction in crashes from the no build to build scenarios are applied to U.S. DOT recommended monetization values.

The safety benefits from induced bus ridership are based on the reduction in vehicle-miles traveled that result from improved bus service. The number of vehicle-miles traveled is estimated as part of the demand projections and are combined with crash rates to calculate the reduction in fatal and injury crashes. The crash rates were obtained from the Idaho Transportation Department, Office of Highway Safety (IDAHO TRAFFIC CRASHES) and correspond to urban crash rates. The reduction in fatal and injury crashes is monetized applying U.S. DOT recommended monetization values.

7.3.2 ASSUMPTIONS

Table 8 presents assumptions used in estimating the accident cost savings.

Table 8: Assumptions Used in Estimating the Accident Cost Savings

Variable Name	Unit	Value	Source/Notes
Cost of Incapacitating Injury	2020 $/event	$554,800	USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs - March 2022, Table A-1
Cost of Non-Incapacitating Injury	2020 $/event	$151,100	
Cost of Possible Injury	2020 $/event	$77,200	
Cost of No Injury	2020 $/event	$3,900	
Cost of Injury Crash	2020 $/event	$302,600	
Cost of Fatal Crash	2020 $/event	$12,837,400	

7.2.1 BENEFIT ESTIMATES

The crash forecasts related to infrastructure improvements to roadway, pedestrian bicycle and bus passenger facilities to are presented in the BCA model in the *Safety Data* worksheet. The analysis shows a reduction of 0.38 incapacitating crashes (A), 1.41 non-incapacitating crashes (B), 2.04 crashes with possible injury (C) and 9.27 crashes with no injuries (O) between the build and no build scenarios in year 2035. These reductions have been extrapolated to each year of analysis resulting in a total reduction of 12.5 incapacitating crashes (A), 47.3 non-incapacitating crashes (B), 68.3 crashes with possible injury (C) and 310.8 crashes with no injuries (O) over the 30-year period.

In addition, the reduction in automobile VMT due to induced bus ridership reduces injury crashes by 5.5 and fatal crashes by 0.05 over the 30-year period of analysis. These results are presented in the *Safety Benefits* worksheet in the BCA model.

The aggregated safety benefits for the period of analysis are presented in

Table 9, using a discount rate of 7 percent. The crash cost savings total $5.8 million (discounted at 7 percent) over the life of the project.

Table 9: Accident Cost Savings Estimates, Millions of 2020 Dollars

Benefit Type	Constant 2020 $	Discounted 2020 $
Incapacitating Crash Cost Savings	$6.96	$1.79
Non-incapacitating Crash Cost Savings	$7.15	$1.82
Possible Injury Crash Cost Savings	$5.27	$1.34
No Injury Crash Cost Savings	$1.21	$0.31
Total Accident Cost Savings from Infrastructure Improvements	***$20.60***	***$5.26***
Injury Crash Cost Savings from Induced Bus Ridership	$1.67	$0.37
Fatality Crash Cost Savings from Induced Bus Ridership	$0.59	$0.13
Total Accident Cost Savings from Induced Bus Ridership	***$2.27***	***$0.50***
Total Accident Cost Savings	**$22.86**	**$5.76**

7.3 Amenity Facility Benefits

The BCA estimates the benefits of installing amenity facilities at bus stops, such as weather protection, benches, ADA compliant ramps/level boarding platforms, and real time transit information displays. These benefits are monetized using values outlined in the U.S. DOT's BCA Guidance.

7.4.1 METHODOLOGY

The BCA monetizes amenity facility benefits by combining the list of transit facility improvements with the boarding estimates at each bus stop along the State Street Corridor. The list of transit facility improvements can be found in the *AT Improvements by Stop* worksheet of the BCA Model. Current passenger boardings are presented in the *Hist Ridership Data* worksheet of the BCA Model and this information is used to estimate the number of beneficiaries for each transit facility amenity.

Forecasted boardings are presented in the *Fut Ridership Data* worksheet. The forecasted boardings from the *Hist Ridership Data* worksheet are used to estimate the annual growth rate of boardings and, in order to be conservative, this growth rate was calculated between the 2019 base numbers and the 2035 no build numbers.[8] The annual future beneficiaries of each transit facility amenity are estimated using the current number of beneficiaries plus this growth rate. The resulting number of beneficiaries is then applied to the monetization values for each amenity type, as outlined in the U.S. DOT's BCA Guidance.

7.4.2 ASSUMPTIONS

The assumptions used in the estimation of amenity facility benefits are provided in Table 10.

Table 10: Assumptions Used in Estimating the Accident Cost Savings

Variable Name	Unit	Value	Source/Notes
Value of Weather Protection	2020 $/user	0.24	USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs - March 2022, Table A-10
Value of Bench	2020 $/user	0.18	
Value of Step-Free Access to Vehicle	2020 $/user	0.39	
Value of Real-Time Display	2020 $/user	0.29	

7.4.3 BENEFIT ESTIMATES

The estimated number of bus users that will benefit in year 2035 from the different facility amenities is approximately 60,500 for weather protection; 2,000 for benches; 78,000 for level boarding ramps and 158,000 for real-time information display.

The aggregated facility amenity benefits for the period of analysis are presented in Table 11, using a discount rate of 7 percent. The benefits will total $0.4 million (discounted at 7 percent) over the life of the project.

Table 11: Accident Cost Savings Estimates, Millions of 2020 Dollars

Benefit Type	Constant 2020 $	Discounted 2020 $
Weather Protection Benefit	$0.56	$0.13
Bench Benefit	$0.01	$0.00
ADA/Level Boarding Ramp Benefit	$1.17	$0.27
Real-Time Display Benefit	$1.76	$0.41
Total Amenity Facility Benefits	**$3.50**	**$0.81**

[8] This is, the growth rate does not include induced bus ridership and are starting from a pre-pandemic level (which is higher than the 2021 observations).

7.4 Roadway Congestion Reduction Benefits

Roadway congestion reduction benefits are the result of travelers switching from automobiles to buses due to improved travel times for transit. The BCA estimates these benefits from the amount of vehicle miles traveled reduced as a result of the modal switch. These benefits are monetized using per-mile values outlined in the U.S. DOT's BCA Guidance.

7.4.4 METHODOLOGY

The BCA monetizes roadway congestion reduction benefits by combining the amount of reduced automobile VMT due to induced bus ridership with the per-mile value of congestion as outlined in the U.S. DOT BCA Guidance. The VMT reduction is calculated assuming that a proportion of the new (induced) bus users are diverting from automobile (see Demand Projections section for more details). The forecasted auto VMT reduction is presented in the *Fut Ridership Data* worksheet.

7.4.5 ASSUMPTIONS

The assumptions used in the estimation of roadway congestion reduction benefits are provided in Table 12.

Table 12: Assumptions Used in Estimating the Roadway Congestion Reduction Benefits

Variable Name	Unit	Value	Source/Notes
Congestion Cost	2020 $/VMT	0.124	USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs - March 2022, Table A-13

7.4.6 BENEFIT ESTIMATES

The modal switch from automobile to bus will generate an approximate reduction of 7 million automobile VMT over the 30-year period of analysis.[9]

The aggregated roadway congestion reduction benefits for the period of analysis are presented in Table 13, using a discount rate of 7 percent. The benefits will total $0.4 million (discounted at 7 percent) over the life of the project.

Table 13: Roadway Congestion Reduction Benefits Estimate, Millions of 2020 Dollars

Benefit Type	Constant 2020 $	Discounted 2020 $
Congestion Reduction	$0.86	$0.19

[9] Note the number of bus VMT does not change between the No Build and Build Scenarios, and therefore the automobile VMT reduction is a net reduction.

Total Congestion Reduction Benefits	$0.86	$0.19

7.5 Emission Cost Reduction Benefits

The reduction in automobile VMT from the modal diversion to bus also generates reduction in emissions that pollute the environment. The BCA monetizes the emission reduction benefit by combining the reduction in the amount of CO_2, NO_x, SO_x and $PM_{2.5}$ emissions due to reduced automobile VMT with the cost of emissions for these pollutants as outlined in the U.S. DOT BCA guidance.

7.4.7 METHODOLOGY

The amount of CO_2, NO_x, SO_x and $PM_{2.5}$ emissions reduced due to the modal shift is calculated using the reduction in automobile VMT and the emission factors for this vehicle type.[10] The emission factors are retrieved from EPA's software MOVES and correspond to the project region assuming an automobile average speed of 40 miles per hour.[11] These emission factors can be found in the *Emission Rate Lookup* worksheet. The amount of reduced emissions for each pollutant is then applied to the damage cost of emissions outlined in the U.S. DOT BCA Guidance.

7.4.8 ASSUMPTIONS

The assumptions used in the emission cost reduction benefits are provided in Table 14.

Table 14: Assumptions Used in Estimating the Emissions Cost Reduction Benefit

Variable Name	Unit	Value	Source/Notes
Damage Cost per Metric Ton – NO_x	2020 $/metric ton	Varies by year (see *Emission Cost Lookup* worksheet)	USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs - March 2022, Table A-6
Damage Cost per Metric Ton – SO_x	2020 $/metric ton		
Damage Cost per Metric Ton – $PM_{2.5}$	2020 $/metric ton		
Damage Cost per Metric Ton – CO_2	2020 $/metric ton		

[10] Note the number of bus VMT does not change between the No Build and Build Scenarios, and therefore the automobile emissions reduction is a net reduction.

[11] The comparable region is the city of Sioux Falls in South Dakota.

7.4.9 BENEFIT ESTIMATES

The reduction of approximately 7 million automobile VMT during the 30-year period of analysis results in a reduction of approximately 1,388 short tons of CO_2 emissions, 0.16 short tons of NO_x emissions, 0.01 short tons of $PM_{2.5}$ emissions and 0.01 short tons of SO_x emissions.

The aggregated emission cost reduction benefits for the period of analysis are presented in Table 15, using a discount rate of 7 percent. The benefits will total $0.05 million (discounted at 7 percent, except for CO_2 which is discounted at 3 percent) over the life of the project.

Table 15: Emission Cost Reduction Benefit Estimates, Millions of 2020 Dollars

Benefit Type	Constant 2020 $	Discounted 2020 $
CO_2 Emissions	$0.10	$0.05
NO_X Emissions	$0.00	$0.00
$PM_{2.5}$ Emissions	$0.00	$0.00
SO_x Emissions	$0.00	$0.00
Total	**$0.11**	**$0.05**

8. Summary of Findings and BCA Outcomes

Table 16 and Table 17 summarize the BCA findings. Annual costs and benefits are computer over the lifecycle of the project (30 years of operations).

Table 16: Estimates of Economic Benefits, Millions of 2020 Dollars

Benefits	Constant 2020 $	Discounted 2020 $
Travel Time Savings	$56.32	$11.00
Vehicle Operating Cost Savings	$22.86	$5.76
Accident Cost Savings	$3.50	$0.81
Congestion Reduction Benefit	$0.86	$0.19
Emissions Reduction Benefit	$0.11	$0.05
Total Benefits	**$83.65**	**$17.81**

Table 17: Overall Results of the Benefit-Cost Analysis, Millions of 2020 Dollars

Project Evaluation Metric	Constant 2020 $	Discounted 2020 $
Total Benefits	$83.65	$17.81
Total Costs	$9.72	$6.92
Net Present Value	$73.93	$10.89
Benefit-Cost Ratio	8.61	2.57
Internal Rate of Return	15%	

Payback Period (years)	8 years

With a 7 percent general discount rate the $6.9 million investment would result in $17.9 million in total benefits and a benefit-cost ratio of approximately 2.57.

9. BCA Sensitivity Analysis

The BCA outcomes presented in the previous sections rely on a large number of assumptions and long-term projections, both of which are subject to considerable uncertainty.

The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the BCA outcomes: the "critical variables."

The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables – how much the final results would vary with reasonable departures from the "preferred" or most likely value for the variable
- Assess the robustness of the BCA and evaluate, in particular, whether the conclusions reached under the "preferred" set of input values are significantly altered by reasonable departures from those values.

In the sensitivity analysis, only one assumption from the baseline model is changed to see the effect of that assumption on initial results. The cases presented in the sensitivity analysis are the following:

- Benefits Period: decreasing the operations period to 20 years
- Discount Rate: reducing the general discount rate to 3 percent
- Value of Time: increasing the value of time by 25% for passenger vehicles and trucks
- Project Cost: increasing and decreasing the total project cost by 30%.

The sensitivity results are presented in Table 18.

Table 18: Quantitative Assessment of Sensitivity, Summary

Parameters	Change in Parameter Value	Current NPV	New NPV	Change in NPV	New B/C Ratio
Benefits Period	Decreasing the operations period to 20 years	$10.89	$5.88	-45.96%	1.85
Discount Rate	Reducing the general discount rate to 3 percent		$32.49	198.51%	4.88
Value of Time	25% Increase in Value of Time for Passenger Vehicles and Trucks		$13.64	25.26%	2.97
Project Cost	Increasing the total project cost by 30%		$8.81	-19.07%	1.98
	Decreasing the total project cost by 30%		$12.96	19.07%	3.68

10. Summary of Benefits and Costs

Table 19 presents the benefits and costs of the project in 2020 dollars discounted.

Table 19: Summary of Benefits and Costs, Discounted[12]

CY	Travel Time Savings	Accident Cost Savings	Amenities Benefit	Congestion Reduction Benefits	Emissions Reduction Benefits	Total Benefits	Total Capital Costs	Net Present Value
2022	$0	$0	$0	$0	$0	$0	$0	$0
2023	$0	$0	$0	$0	$0	$0	$615,891	-$615,891
2024	$0	$0	$0	$0	$0	$0	$1,970,384	-$1,970,384
2025	$0	$0	$0	$0	$0	$0	$1,241,743	-$1,241,743
2026	$0	$0	$0	$0	$0	$0	$3,092,696	-$3,092,696
2027	$266,684	$349,167	$37,153	$6,712	$837	$660,553	$0	$660,553
2028	$285,040	$334,411	$37,005	$6,993	$934	$664,383	$0	$664,383
2029	$302,091	$320,091	$36,718	$7,209	$1,014	$667,123	$0	$667,123
2030	$317,784	$306,214	$36,310	$7,367	$1,091	$668,765	$0	$668,765
2031	$332,086	$292,782	$35,798	$7,473	$1,164	$669,304	$0	$669,304
2032	$344,985	$279,797	$35,198	$7,534	$1,235	$668,748	$0	$668,748
2033	$356,482	$267,258	$34,523	$7,554	$1,302	$667,120	$0	$667,120
2034	$366,595	$255,162	$33,786	$7,540	$1,367	$664,450	$0	$664,450
2035	$375,351	$243,505	$32,997	$7,496	$1,429	$660,778	$0	$660,778
2036	$382,786	$232,282	$32,167	$7,425	$1,511	$656,171	$0	$656,171
2037	$388,945	$221,484	$31,305	$7,331	$1,571	$650,636	$0	$650,636
2038	$393,878	$211,105	$30,417	$7,217	$1,628	$644,246	$0	$644,246
2039	$397,639	$201,137	$29,512	$7,087	$1,682	$637,057	$0	$637,057
2040	$400,286	$191,569	$28,595	$6,944	$1,734	$629,127	$0	$629,127
2041	$401,878	$182,392	$27,672	$6,788	$1,784	$620,514	$0	$620,514
2042	$402,479	$173,596	$26,747	$6,624	$1,831	$611,275	$0	$611,275
2043	$402,148	$165,170	$25,825	$6,451	$1,900	$601,494	$0	$601,494
2044	$400,950	$157,104	$24,908	$6,273	$1,943	$591,178	$0	$591,178

[12] Categories were discounted at 7 percent real rate except for CO_2 emissions, which were discounted at a 3 percent real rate.

CY	Travel Time Savings	Accident Cost Savings	Amenities Benefit	Congestion Reduction Benefits	Emissions Reduction Benefits	Total Benefits	Total Capital Costs	Net Present Value
2045	$398,946	$149,386	$24,002	$6,091	$1,983	$580,408	$0	$580,408
2046	$396,197	$142,005	$23,107	$5,906	$2,021	$569,237	$0	$569,237
2047	$392,763	$134,951	$22,227	$5,719	$2,057	$557,716	$0	$557,716
2048	$388,701	$128,212	$21,362	$5,531	$2,091	$545,898	$0	$545,898
2049	$384,069	$121,778	$20,516	$5,343	$2,123	$533,828	$0	$533,828
2050	$378,919	$115,636	$19,689	$5,156	$2,178	$521,578	$0	$521,578
2051	$373,305	$109,777	$18,883	$4,971	$2,180	$509,116	$0	$509,116
2052	$367,276	$104,190	$18,098	$4,787	$2,181	$496,531	$0	$496,531
2053	$360,880	$98,863	$17,334	$4,607	$2,179	$483,863	$0	$483,863
2054	$354,161	$93,788	$16,593	$4,430	$2,176	$471,148	$0	$471,148
2055	$347,162	$88,954	$15,875	$4,256	$2,171	$458,418	$0	$458,418
2056	$339,924	$84,351	$15,180	$4,086	$2,164	$445,704	$0	$445,704
Total	**$11,000,393**	**$5,756,115**	**$809,504**	**$188,899**	**$51,459**	**$17,806,370**	**$6,920,714**	**$10,885,656**

Note: CY = Calendar Year