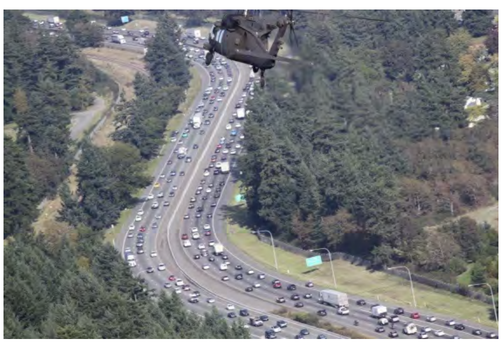
I-5, Steilacoom-DuPont Road to Thorne Lane - Corridor Improvement Project Benefit-Cost Analysis

Washington State Department of Transportation



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CONSULTING SERVICES

I-5, Steilacoom-DuPont Road to Thorne Lane - Corridor Improvement Project, Benefit-Cost Analysis

Project Information

Project:	**I-5, Steilacoom-DuPont Road to Thorne Lane – Corridor Improvements**
Prepared for:	**Washington State Department of Transportation** Olympic Region

Reviewing Agency

Jurisdiction:	Washington State Department of Transportation

Project Representative

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EXECUTIVE SUMMARY

This report documents the Benefit Cost Analysis (BCA) conducted for the I-5, Steilacoom-DuPont Road to Thorne Lane – Corridor Improvement Project. The BCA was prepared to satisfy requirements of the Puget Sound Regional Council to support the use of public funding for this project. This Executive Summary provides a brief overview of BCA evaluation process, highlighting key findings related to total costs and benefits for both a Base Case (No Build Alternative) and a Build Case (Build Alternative), and providing a summary of Net Present Value for the project and a Benefit Cost Ratio.

PROJECT OVERVIEW

In July of 2015, the Washington State Legislature included $495 million in the Connecting Washington revenue package to fund I-5 corridor improvements between the Mounts Road and Thorne Lane interchanges. These improvements will address existing and expected near-term (2020) congestion on the highway mainline, as well as providing reconfigured interchanges that are designed to enhance regional mobility and to meet safety needs through 2040. The project is funded through a 10-year period from 2015 to 2025.

The Project is being constructed in stages. The I-5, Steilacoom-DuPont Road to Thorne Lane stage is the subject of this BCA. Improvements in this stage include:

- A fourth through lane on I-5 from south of Gravelly Lake Drive southbound to Center Drive and from DuPont-Steilacoom Road northbound to Thorne Lane.
- A northbound auxiliary lane from the Berkeley Street interchange to the Thorne Lane interchange, and also from the Thorne Lane interchange to the Gravelly Lake Drive interchange.
- Reconstruction of the Thorne Lane interchange.
- Reconstruction of the Berkeley Street interchange.

COST

Project expenditure are grouped into two primary categories: Capital costs and Operations/ Maintenance and Repair/Rehabilitation costs. All original project costs were estimated by Parametrix in July and early August of 2017, with input from WSDOT staff.

In benefit cost analysis, the costs of an improvement project are often “front loaded” at the beginning of a project’s useful life while benefits accrue over the project’s entire life cycle. In order to account for these different periods of time, the temporal value of money must be explicitly treated. This is done with the use of a social discount rate that reduces all future values to their present value equivalents which are expressed in constant 2017 dollars. The comparison of benefits and costs is then made on the basis of these present value equivalents. The real discount rates used for this analysis were 3 and 7 percent, consistent with 2016 U.S. Department of Transportation guidance for TIGER and FASTLANE Grant applications, and Office of Management and Budget Circulars A-4 and A-94.

The cost analysis is described in greater detail in Chapter 3 of this report, and includes identifying when costs are expected to be incurred and how adjustments to these costs were performed to reflect net present value in 2017 dollars.

The overall project cost is estimated to be $284 .7 million and is expressed in 2017 dollars assuming a 7 percent discount rate. Total project cost at a 3 percent discount rate is estimated to be $309.4 million. A summary of the total project costs for each of the discount rates is provided in Table ES-1.

Table ES-1. Summary of Project Costs, Discounted 2017 Dollars

		Discounted Values	
Cost Elements	**Undiscounted Values**	**3%**	**7%**
Total Capital Costs	$335,575,667	$313,772,323	$288,183,910
Net O&M and R&R Costs	($5,251,000)	($4,346,758)	($3,527,476)
Total Net Construction Cost	**$330,324,667**	**$309,425,565**	**$284,656,433**

BENEFITS

The Project is intended to relieve traffic congestion and improve freight mobility along I-5 through the JBLM vicinity. This improvement would result in travel time savings for auto and truck users, as well as safety enhancements. These benefits were identified as the primary evaluation measures for use in this BCA.

Table ES-2 presents a summary of the net travel time savings and safety benefits associated with the Build Case over the Base Case. Overall project benefits are estimated to be $448,521,000 in 2017 dollars with a 7 percent discount rate. The total estimated travel time savings and safety benefits at a 3 percent discount rate is estimated to be $606,018,000.

Table ES-2. Summary of Project Benefits, Discounted 2017 Dollars

		Discounted Values	
Metric	**Undiscounted Values**	**3%**	**7%**
Travel Time Savings – I-5 Mainline	$706,756,000	$557,770,000	$416,693,000
Travel Time Savings - Interchanges	$60,907,000	$42,077,000	$27,363,000
Safety Benefits	$8,111,000	$6,171,000	$4,465,000
Total Net Benefits	**$775,774,000**	**$606,018,000**	**$448,521,000**

RESULTS

The benefit cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them to each other. The following evaluation measures were used in this assessment:

- **Net Present Value (NPV)**: NPV compares the net benefits (benefits less costs) after being discounted to present values using the assumed real discount rates. The NPV provides a perspective on the overall dollar magnitude of cash flow over time as expressed in 2017 dollars.
- **Benefit Cost Ratio (BCR)**: With the BCR total discounted benefits are divided by the total discounted costs. Projects with a benefit-cost ratio greater than 1 have greater benefits than costs; hence they have positive net benefits. The higher the ratio, the greater the benefits relative to the costs.

Table ES-3 presents the analysis results for the project using three assumed discount rates: Undiscounted (or zero discount), 3 percent discount, and 7 percent discount as prescribed by the USDOT. All benefits and costs were estimated based on constant 2017 dollars over an evaluation period extending 20 years from completion of the project in 2020.

At a discount rate of 7 percent, the project yields a BCR of 1.58; at 3 percent, the project yields a BCR of 1.96. In both cases, the benefits that are likely to result from the I-5 JBLM Stage 2 Design-Build project clearly exceed its costs.

Table ES-3. Benefit Cost Analysis Results, 2017 Dollars

	Project Evaluation Period (2020-2040)		
BCA Metric	**Undiscounted Values**	**Discounted 3%**	**Discounted 7%**
Total Benefits	$775,774,000	$606,018,000	$448,521,000
Total Costs	$330,325,000	$309,426,000	$284,656,000
Net Present Value (NPV)	$445,449,000	$296,592,000	$163,865,000
Benefit Cost Ratio (BCR)	2.35	1.96	1.58

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1. INTRODUCTION

This report documents the Benefit Cost Analysis (BCA) conducted for the I-5, Steilacoom-DuPont Road to Thorne Lane – Corridor Improvement Project. The BCA was prepared to satisfy requirements of the Puget Sound Regional Council to support the use of public funding for this project. The following section describes the BCA framework and highlights the content and organization of this report. The remainder of the report addresses anticipated project benefits, costs and a benefit cost comparison.

1.1 BCA Framework

The purpose of a BCA is to provide an evaluation framework for comparing the benefits associated with a specific action or investment alternative with the costs of implementing that action. In transportation system planning and development, a BCA is prepared to determine if the sum of the benefits of an improvement project (expressed in monetized terms) exceeds the costs of this improvement. When this occurs, a project may then be considered to be justified from an economic perspective, as it would have a greater benefit to the wellbeing of society than its cost.

While it can have broad applicability to measuring the costs and benefits associated with transportation improvements, the scope of a BCA is usually limited by the available information and the methods for estimation and monetization of all the consequences of a specific project. The analysis in this report relies on the results of an in-depth transportation planning study conducted for the I-5 JBLM Vicinity Congestion Relief Project between 2013 and early 2017. Useful data established during that process includes vehicle trips, passenger trips, travel time, hours of congestion, average delay and safety (measured in terms of crashes by total and severity).

The earlier transportation analysis also provides a framework for the BCA by establishing both a Base Case (or No Build Alternative) and a Build Case (or Build Alternative) that can be compared to determine the net benefits (or disbenefits) associated with the Build Case. The BCA assesses the incremental difference between these two cases and identifies any net changes in benefits to society. BCAs are forward-looking in that they compare not only costs and benefits associated with the initial year or years of construction, but also incremental changes over the life cycle of the project. The importance of future societal welfare changes is determined through discounting which reflects both the opportunity cost of the capital[1] and societal preference for the present.

The BCA was conducted in conformance with the benefit-cost methodology established by the U.S. Department of Transportation (USDOT) in the 2016 *TIGER Benefit-Cost Analysis Analyses Guidance for TIGER Applicants* and the 2016 *TIGER and FASTLANE BCA Resource Guide*. The methodologies outlined in these reports include the following analytical assumptions:

[1] Opportunity cost - A benefit, profit, or value of something that must be given up to acquire or achieve something else. In a world of limited resources, an opportunity cost represents the consequence of choosing one course of action which may result in losing the ability to pursue a different choice.

- Defining existing and future conditions under a No Build Base Case as well as under a Build Case.
- Estimating benefits and costs during project development, construction and operation, including at least 20 years of operations beyond the Project completion when benefits accrue.
- Using USDOT recommended monetized values for reduced fatalities, injuries, property damage, and travel time savings.
- Presenting dollar values for outcomes over time (already expressed in 2017 dollars) in present value, discounting back to 2017 using a real discounted rate. In instances where cost estimates are expressed in historical values, using the appropriate Consumer Price Index (CPI) to adjust the values.

1.2 Report Content and Organization

This report is organized into five chapters and an Executive Summary.

Chapter 1 presents an introduction to Benefit Cost Analysis and describes the structure of this report.

Chapter 2 includes an overview of the BCA and its development process including a description of the project and its development history, along with project goals, objectives and key project features. This chapter also presents a discussion of the general assumptions that underlie the BCA including analysis base year, discount rates, evaluation period and key elements of the Base and Build Cases. The costs and benefits of these two alternatives were compared to determine the overall benefit of implementing the Stage 2 Design-Build Project.

Chapter 3 highlights the cost estimates for the Base and Build Cases, illustrating both undiscounted values and total discounted costs by type.

Chapter 4 discusses project benefits focusing on key metrics such as travel time savings for the freeway mainline and modified interchanges, safety and other factors. Key inputs and analysis methodologies are described.

Chapter 5 reports the results of the benefit cost analysis.

2. PROJECT OVERVIEW

2.1 Description of the Project

The Washington State Department of Transportation (WSDOT) is implementing improvements along Interstate 5 (I-5) in the vicinity of Joint Base Lewis-McChord (JBLM) in southern Pierce County to reduce traffic congestion and improve person and freight mobility. The improvements, collectively known as the I-5, Mounts Road to Thorne Lane – Corridor Improvement Project, are being constructed in stages including:

- **Mounts Road to Center Drive** – **Northbound Auxiliary Lane Extension** - extends a northbound auxiliary lane 1.5 miles to provide near term benefit while also be compatible with long term intentions within this area.
- **Steilacoom-DuPont Road to Thorne Lane – Corridor Improvements** – includes adding one through lane to the I-5 mainline between the Thorne Lane interchange (Exit 123) to the north and the Steilacoom – DuPont Road interchange (Exit 119) to the south. The interchanges at Thorne Lane (Exit 123) and Berkeley Street (Exit 122) will be rebuilt.
- **Mounts Road to Steilacoom-DuPont Road** – includes potential improvements to the I-5/Steilacoom Road-DuPont Road interchange (Exit 119) and surrounding area.

Figure 2-1 shows the scope items in the Steilacoom-DuPont Rd. to Thorne Lane stage which is the topic of this Benefit Cost Analysis.

2.2 General Assumptions

This section describes the general assumptions that underlie the BCA including identification of the base year for analysis, the approach to discounting project costs and monetized benefits to determine present values and the evaluation period covered by the analysis.

2.2.1 Discount Rate and Base Year

In benefit cost analysis, the costs of an improvement project are often “front loaded” at the beginning of a project’s useful life while benefits accrue over the project’s entire life cycle. In order to account for these different periods of time, the temporal value of money must be explicitly treated. This is done with the use of a social discount rate that reduces all future values to their present value equivalents. The comparison of benefits and costs is then made on the basis of these present value equivalents.

Costs for this BCA are expressed in constant 2017 dollars. In cases where benefits are expressed in dollars representing another year, they have been adjusted as appropriate to reflect 2017 dollars using the CPI-U[2].

[2] U.S Bureau of Labor Statistics, Consumer Price Index Inflation Calculator, June 2017, http://www.bls.gov/data/inflation_calculator.htm

Figure 2-1. Scope of I-5, Steilacoom-DuPont Road to Thorne Lane Corridor Improvement Project

The real discount rates used for this analysis were 3 and 7 percent, consistent with 2016 U.S. Department of Transportation guidance for TIGER and FASTLANE Grant applications, and Office of Management and Budget Circulars A-4 and A-94.[3]

2.2.2 Consumer Price Index (CPI)

The costs associated with a project typically occur over a period of years. For any money spent in years previous to the completion of a benefit cost analysis, the value of that money needs to be adjusted up to current year value. This is done by utilizing the Bureau of Labor Statistics Consumer Price Index (CPI) online inflation calculator. This calculator allows for adjusting values from a specific month and year in the past to a different month and year at a future date.

[3] U.S. Department of Transportation, Benefit Cost Analysis Analyses Guidance for TIGER Applicants, 2016 and Office of Management and Budget Circulars A-4 and A-94.

Costs in this BCA are expressed in constant 2017 dollars. The most recent month built into the CPI inflation calculator is June, 2017. All previous project costs were inflated to June, 2017 dollars. For each previous year in which project costs were incurred, the month of June was used in the CPI inflation calculator.

In addition to project costs, the CPI inflation calculator was used to adjust the value of unit costs in the benefit calculations. Previous BCA work and USDOT guidance provided values for travel time and safety benefits. These values were all expressed in 2015 dollars. The travel time data was specifically referenced as May, 2015 values. The safety values were more generally labeled as 2015 values. As with the previous project costs, the month of June was used in the CPI inflation calculator to adjust the monetized values for the reduction in fatalities, injuries and property damage. The month of May was used to adjust the monetized values for hours of travel time saved.

2.2.3 Evaluation Period

For the I-5 JBLM Stage 2 Design-Build improvements, the BCA evaluation period includes 21 years extending from the time of estimated completion of Stage 2 construction in 2020 to 2040.

2.3 BASE CASE AND BUILD CASE

2.3.1 Base Case

The Base Case for this BCA analysis assumes that none of the proposed I-5, Steilacoom-DuPont Rd. to Thorne Lane – Corridor Improvements would be constructed. The Base Case assumes that the existing highway system would remain in place but would be augmented by several recent improvements as described below.

Currently, through the Project Area, I-5 has three general purpose (GP) lanes in each direction south of the Thorne Lane interchange and four lanes in each direction north of this interchange. Auxiliary lanes are located in three areas: 1) southbound between the Thorne Lane and Berkeley Street interchanges; 2) both directions between Steilacoom-DuPont Road and Center Drive interchanges; and 3) southbound between Center Drive and Mounts Road interchanges.

As described in the I-5 JBLM Vicinity Congestion Relief Project EA, the Base Case (No Build Alternative) includes the existing transportation network plus funded projects in the Transportation Improvement Programs (TIPs) of local agencies and WSDOT's State Transportation Improvement Plan (STIP). Recent improvements to transportation facilities on JBLM are also included in the Base Case such as the recently constructed Integrity Gate, Mounts Road Gate, and on-base local street improvements. All projects analyzed as part of the Base Case were completed after the 2013 existing model year and/or will be completed before the 2020 modeling year in accordance with the TIPs for DuPont or Lakewood. The Base Case also includes:

- The I-5 Corridor SR 510 to SR 512, TIGER III Grant funded projects completed between 2014 and 2015.

- The Madigan Access Improvement Project to the I-Berkeley Street interchange completed in 2016.
- The Point Defiance Bypass Rail Project expected to be open for service in 2017.

2.3.2 Build Case

As described in Section 2.1, the Build Case is illustrated in Figure 2-1 and includes:

- Mainline widening adds a fourth lane northbound on I-5 from the DuPont-Steilacoom Road interchange on-ramp to the Thorne Lane interchange, and southbound from Thorne Lane to Center Drive.
- Auxiliary lanes would be added northbound between the Berkeley Street and Thorne Lane interchanges and between the Thorne Lane and Gravelly Lake Drive interchanges. The existing southbound auxiliary lanes would be maintained.
- Revised interchange layouts to accommodate added I-5 lanes at Thorne Lane and Berkeley Street.

3. PROJECT COSTS

This section describes the results of the project cost estimating process and indicates total dollar amounts by category of expenditure, identifies when the costs are expected to be incurred, and describes how adjustments to these costs were performed to reflect net present value. Expenditure are grouped into two primary categories: Capital costs and Operations/Maintenance and Repair/Rehabilitation costs. All original project costs were estimated by Parametrix in July and early August of 2017, with input from WSDOT staff.

3.1 CAPITAL COSTS

The Capital cost of this project has been broken down into three types of expense: Project Planning and Preliminary Engineering, Right-of-Way acquisition, and Construction. A breakdown of each of these costs, from 2013 through expected completion of the project in 2021, is provided in Table 3-1. Costs incurred in years prior to 2017 are shown as uninflated costs, specific to the year they were incurred.

Table 3-1. Schedule of Capital Costs, Undiscounted Dollars

Year	Project Planning & Preliminary Engineering	Right-of-Way	Construction	Total
2013	$1,000,000			$1,000,000
2014	$2,000,000			$2,000,000
2015	$4,000,000			$4,000,000
2016	$6,000,000	$2,000,000		$8,000,000
2017	$4,000,000	$4,000,000		$8,000,000
2018	$1,000,000		$45,000,000	$46,000,000
2019	$500,000		$120,000,000	$120,500,000
2020	$500,000		$100,000,000	$100,500,000
2021			$45,000,000	$45,000,000

With a portion of the total project cost already spent and much planned to occur in 2018 and beyond, calculations to inflate and discount the costs to bring them all into constant 2017 dollars were performed. As described is section 2.2.1 and consistent with USDOT guidelines, discount rates of 3 percent and 7 percent were used for this benefit cost analysis. Both of these discount rates were applied to all project costs expected to occur beyond 2017. For project costs incurred between 2013 and 2016, the CPI inflation calculator was used to inflate costs to 2017 dollars. This process is described in section 2.2.2.

Table 3-2 presents a summary of total estimated Capital costs for the Steilacoom-DuPont Road to Thorne Lane project. These totals include the previously spent project costs for planning and engineering that were adjusted to 2017 dollars, as well as the discounted costs for right-of-way and construction. The table further notes the year when construction is expected to start, when it is expected to finish, when the project will open, and construction duration.

Table 3-2. Project Schedule and Costs, Millions of 2017 Dollars

Variable	Unit	Undiscounted Values	Discounted Values* 3%	Discounted Values* 7%
Construction Start	Year	2018	2018	2018
Construction End	Year	2021	2021	2021
Construction Duration	Year	3	3	3
Project Opening	Year	2020	2020	2020
Capital Cost – Professional Services	$ Million	$19.4	$19.3	19.2
Capital Cost – Right-of-Way Acquisition	$ Million	$6.2	$6.2	6.2
Capital Cost - Construction	$ Million	$310.0	$288.3	262.8

* All costs reflect the application of 3 and 7 percent discount rates as noted

3.2 OPERATIONS AND MAINTENANCE (O&M)/REPAIR AND REHABILITATION (R&R) COSTS

In addition to the capital costs associated with the project, an estimate was produced of on-going operating and maintenance costs, as well as repair and rehabilitation costs associated with the improvement over its lifetime. A similar estimate was prepared for the Base Case. These costs were estimated for each year within the benefit cost analysis. These costs for the Base and Build Cases are presented in Table 3-3.

Table 3-3. Schedule of Operations/Maintenance and Repair/Rehabilitation Costs, Undiscounted 2017 Dollars

	Base Case (No Build)		Build Case	
Year	Operations/ Maintenance	Repair/ Rehabilitation	Operations/ Maintenance	Repair/ Rehabilitation
2021	$101,000		$75,000	
2022	$103,000		$77,000	
2023	$106,000	$5,800,000*	$79,000	
2024	$109,000		$81,000	
2025	$111,000		$83,000	
2026	$114,000		$85,000	
2027	$117,000	$100,000**	$87,000	
2028	$120,000		$90,000	
2029	$123,000		$92,000	
2030	$126,000		$94,000	
2031	$129,000		$97,000	
2032	$132,000		$99,000	
2033	$136,000		$101,000	
2034	$139,000		$104,000	
2035	$143,000		$107,000	
2036	$146,000		$109,000	$9,800,000*
2037	$150,000	$100,000**	$112,000	

Table 3-3 Continued. Schedule of Operations/Maintenance and Repair/Rehabilitation Costs, Undiscounted 2017 Dollars

	Base Case (No Build)		Build Case	
Year	Operations/ Maintenance	Repair/ Rehabilitation	Operations/ Maintenance	Repair/ Rehabilitation
2038	$154,000	$8,400,000*	$115,000	
2039	$157,000		$118,000	
2040	$161,000		$121,000	

*HMA Overlay of project area (15 year cycle)
**Pump station rehabilitation (10 year cycle)

As with the capital costs, these O&M and R&R costs need to be discounted to 2017 dollars. This calculation was done for both the Base and Build Cases. It is estimated that the Base Case would experience more total O&M and R&R costs over the duration of the analysis period since it would retain the older interchanges and existing pavement. Major repair and rehabilitation costs expected between 2020 and 2040 for the Base Case include the additional HMA overlay that would be required and costs associated with a pump station rehabilitation. A summary of the total O&M and R&R costs for the Base and Build Cases is provided in Table 3-4. The table illustrates the 3 percent and 7 percent discounted 2017 costs associated with this activity, and shows that there would be a net benefit with the Build Case in comparison with the Base Case of approximately $3.5 million when costs are discounted at 7 percent. This benefit can be applied to the total discounted costs associated with the Build Case to effectively reduce its overall impact in comparison with project benefits.

Table 3-4. Project O&M and R&R Costs, 2017 Dollars

Values	Operations & Maintenance	Repair & Rehabilitation	Total
Base Case (No Build)			
Undiscounted Values	$2,577,000	$14,400,000	$16,977,000
Discounted Values at 3%	$1,712,267	$9,502,600	$11,214,866
Discounted Values at 7%	$1,054,978	$5,970,172	$7,025,149
Build Case			
Undiscounted Values	$1,926,000	$9,800,000	$11,726,000
Discounted Values at 3%	$1,279,306	$5,588,803	$6,868,109
Discounted Values at 7%	$787,891	$2,709,782	$3,497,673
Net Difference No Build over Build Case			
Undiscounted Values	($651,000)	($4,600,000)	($5,251,000)
Discounted Values at 3%	($432,961)	($3,913,797)	($4,346,758)
Discounted Values at 7%	($267,086)	($3,260,390)	($3,527,476)

3.3 CONCLUSIONS ON COSTS

By combining the capital cost of the Build Case with the estimated net O&M and R&R costs through the duration of the analysis period, the total cost of the project over the 21-year analysis cycle can be established. As noted in Table 3-4, the net O&M and R&R costs of the Build Case in comparison to the Base Case were negative, as the Base Case was estimated to incur higher costs than the project. This net negative cost would reduce the overall cost of the project.

The overall project cost, in 2017 dollars assuming a 7 percent discount rate, is estimated to be $284.7 million. The total cost at a 3 percent discount rate is estimated to be $309.4 million. A summary of the total project costs for each of the discount rates is provided in Table 3-5.

Table 3-5. Summary of Project Costs, Discounted 2017 Dollars

		Discounted Values	
Cost Elements	**Undiscounted Values**	**3%**	**7%**
Total Capital Costs	$335,575,667	$313,772,323	$288,183,910
Net O&M and R&R Costs	($5,251,000)	($4,346,758)	($3,527,476)
Total Net Construction Cost	**$330,324,667**	**$309,425,565**	**$284,656,433**

4. PROJECT BENEFITS

The I-5, Steilacoom-DuPont Road to Thorne Lane – Corridor Improvement Project is intended to relieve traffic congestion and improve freight mobility along I-5 through the JBLM vicinity. This improvement would result in travel time savings for auto and truck users, as well as safety enhancements. The identification of expected project benefits and calculation of their monetary value is discussed in this chapter.

4.1 TRAVEL TIME SAVINGS

The analysis of travel time savings benefits was based on output from the travel demand models developed and used as part of the I-5 JBLM Vicinity Congestion Relief Study. The development and use of these models is more fully described in the supportive documents for that study including the Project's NEPA EA and IJR. A brief summary is provided below.

4.1.1 Travel Demand Projections

PSRC and I-5 JBLM Study Area DTA Demand Models

2020 and 2040 travel forecasts were developed using a series of interrelated and complimentary modeling tools developed specifically for this project that were built on the PSRC regional travel demand model. These modeling tools included a Macroscopic Model, a Transit Sketch Planning Model, and a Mesoscopic Model. The following is a general description of each model and how they were integrated to conduct traffic forecasting analysis.

- *Macroscopic (Macro) Model* - The Macro Model is consistent with local land use plans, and the Puget Sound Regional Council (PSRC) and Thurston Regional Planning Council (TRPC) regional models and modeling assumptions. Building on network and growth assumptions in both regional models, this study-specific subarea model was used to develop travel forecasts for I-5 and the local public and military-only street systems. The Macro Model has a base year of 2013, and two forecast horizon years of 2020 and 2040. The model includes mode splits and trip assignments for both high-occupancy vehicles (HOV) and single-occupancy vehicles (SOV) for two time periods: an AM peak period (6 AM to 9 AM), and a PM peak period (3 PM to 6 PM).
- *Transit Sketch Planning (Transit) Model* - The Transit Model captures the effects that commuter-oriented transportation demand management programs (subsidized transit passes, vanpools, shuttles, etc.), investments in high-occupancy vehicle facilities, and improvements to commuter transit service can have on congestion in the corridor. Using the Transit Model in the planning process also allowed the project team to better understand the commuter transit market in this corridor.
- *Mesoscopic (Meso) Model* – The I-5 JBLM Meso Model was developed to evaluate and compare the various alternative improvement packages with a series of detailed transportation performance measures. The Meso Model was built using Dynameq software and is based upon

the Macro Model. As a result, it is consistent with local and regional land use plans and the regional transportation models. The general analysis area of the Meso Model is the I-5 corridor between SR 512 and SR 510, including the adjoining local on-JBLM and off-JBLM arterials. The Meso Model incorporates specific roadway and intersection operational details such as signal timing, roadway channelization, ramp metering, and merging/weaving conflicts along the I-5 mainline. It also includes operational impacts from at-grade railroad crossings and military gate operations. These features enable the Meso Model to dynamically balance traffic volumes as the various alternative routes become congested.

Outputs from the Macro model were adjusted based on transit/TDM trip-making as determined by the Transit Model and the remaining vehicular trip demand was assigned to the roadway network using the Meso Model. This model provided various performance metrics such as travel volumes, speeds, travel times, hours of congestion and mode share (HOV and SOV).

Travel Demand Modeling Results

Table 4-1 presents a summary of key data for the Base and Build Cases that was output from the travel demand modeling process for the I-5 JBLM Vicinity Congestion Relief Study's EA and IJR. This data formed the foundation of the travel time benefit analysis and is reflected in the estimate of safety benefits. Data includes I-5 vehicle trips by autos and trucks, as well as estimated travel times along the I-5 mainline in both the northbound and southbound directions.

Table 4-1. Key Model Output

	2020		2040	
	Base Case	Build Case	Base Case	Build Case
Vehicle Trips (sum of AM and PM peak periods, 6-hours each)				
Auto	101,206	104,735	111,329	118,534
Truck	8,833	9,136	9,685	10,338
Travel Time (minutes)				
Northbound	15.2	10.8	18.6	16.0
Southbound	17.9	14.1	23.5	26.3

Evaluation of Interim Years

As required by USDOT and PSRC guidelines for preparing a BCA, the analysis of project benefits includes not only the two years for which travel forecasts were prepared (2020 and 2040), but also each interim year between these two points in time. In this way, the full benefits of the project over its life cycle can be captured and compared to project costs. The approach used to convert the static travel time savings benefits estimated in 2020 and 2040 involved interpolation of values between these years to produce the necessary stream of benefits.

4.1.2 Calculation of Travel Time Benefits

The calculation of travel time benefits through the project area includes both travel time savings along the I-5 mainline and at the ramp termini intersections of the two interchanges that would be reconstructed as part of this project. The process used to calculate benefits at both types of locations are described in the following pages.

Mainline Travel Time Calculations

To estimate travel time savings with the Build Case along the I-5 mainline, a multi-step analysis process was undertaken using model data for the 6 hour AM peak period and 6 hour PM peak period. The travel demand model indicated that within these two six-hour periods, over 95 percent of demand could be processed. For this reason, it is expected that travel time savings benefits associated with the project would be largely confined to the 12 peak hours of a typical day. The remaining 12 hours (non-peak periods) were assumed to be negligibly different between the Base and Build Cases and were not included in the estimation of mainline travel time savings benefits.

Step One: The first step in the analysis process involved obtaining travel time and link vehicular volume data for the Base and Build Cases from the travel demand model for each of the 12 hours in the AM and PM peak periods. This data was provided for each link in the analysis corridor between SR 512 on the north and Center Drive on the south. Data was also stratified by travel direction. The volume data from each link was averaged to produce a representative volume for the entire corridor for each travel direction.

Step Two: The second step involved segregating projected passenger vehicles from trucks. To accomplish this, the existing 2013 PM peak hour truck percentage were applied to each of the 12 peak period analysis hours. This data was available from the project’s IJR and was provided for each travel direction. Using these truck percentages, the truck volume was removed from the total link volume and the truck travel time and its associated benefits was calculated separately.

Step Three: In the third step, travel time data through the corridor by direction was obtained for each analysis hour from the model. This data was then multiplied by the average vehicle trips during that hour for passenger cars and trucks to determine total travel time. This calculation was performed for the 2020 and 2040 volume horizons for both the Base and Build Cases. Using these two data points, a compound growth percentage was calculated to generate total hours of travel time for each year between 2020 and 2040. A compound growth rate was calculated for each direction of traffic during each analysis hour.

Step Four: The fourth step involved converting total vehicle hours of travel for autos and trucks to person hours of travel for both vehicle types. To make this conversion, average occupancy rates for passenger vehicles and trucks were developed and applied. For this analysis it was conservatively assumed that trucks had an occupancy rate of 1.00. To calculate an occupancy rate for passenger vehicles, data from the project’s travel demand model was used to determine the average occupancy rate for all vehicle types. This data included total daily vehicle volumes and total daily person throughput on I-5 for the 2020 and 2040 AM and PM peak hours for the Base and Build Cases. Using the existing 2013 daily truck percentage data from the IJR, the volume of trucks was estimated and then subtracted from the total link volumes and from the person throughput totals. The remaining values were averaged together to calculate a representative occupancy rate for passenger vehicles. Based on this method, an average passenger vehicle occupancy rate of 1.31 was obtained and used to estimate total auto person trips.

Step Five: In the final step, hourly travel time savings data was summed to obtain daily travel time savings. To convert daily travel time savings to an annual representation, an annualization rate of 352 was used. This rate was calculated using daily link volume data from WSDOT permanent traffic recorder (PTR) R120, located between Main Gate and SR 512. The volume of an average weekday was compared to the volume of an average weekend day. This relationship was such that 352 weekdays was equal to the 365 day total for the location. Thus, travel time savings data is representative of both typical weekday conditions and conditions on the typical weekend.

Intersection Travel Time Calculations

In addition to considering travel time savings benefits on the I-5 mainline, the Build Case also includes reconstruction of the existing ramp termini at the Berkeley Avenue and Thorne Lane interchanges from traffic signals to roundabouts. Because of the improved operational efficiency associated with roundabouts, this conversion is expected to result in 24 hours of benefit for each day of the year.

Similar to the I-5 mainline, the analysis of travel time savings associated with interchange improvements was conducted using a multi-step process. The first step involved obtaining projected 2020 and 2040 AM and PM peak hour intersection turning movement volumes from the IJR. These peak hourly volumes were then converted into hourly volumes across an entire day using guidance from a 1997 national study that illustrated the empiric relationship between time of day and traffic magnitude. These hourly volumes were grouped into five “similar hour” categories and intersection operations analysis was conducted for each category for both the Base and Build Cases. Review of the differences in average intersection delay for the Base and Build Cases allowed an estimate of intersection-related travel time savings with the project to be calculated for each category.

To estimate travel time savings, the average delay of each intersection was multiplied against the total entering volume of vehicles. Data was stratified for passenger cars and trucks (using existing AM and PM peak hour truck percentages) yielding an estimate of 2020 and 2040 total delay for each vehicle type.

Using these two data points, a compound growth percentage was calculated to generate total delay for each year between 2020 and 2040. A compound growth rate was calculated for passenger cars and trucks for each intersection.

After the total vehicle hours of delay were calculated, the occupancy and annualization rates used in the mainline travel time calculation were applied to calculate annual person hours of delay for each intersection.

Monetization of Travel Time Benefits

Once annual hours of travel time for the Base and Build Cases were determined for auto passengers and truck drivers on both the I-5 mainline and at the interchanges, these hours were monetized to reflect the value of travel time for both. Hourly values for auto passengers and truck drivers were obtained from the most currently available USDOT guidance materials. As these materials reflect 2015 dollars, the value of an hour of travel time was inflated to 2017 using the CPI inflation calculator as described in section 2.2.2. The specific values used and the reference sources for these values are shown in Table 4-2.

Hourly travel time values were then multiplied by the estimated total person hours of travel time for the Base and Build Cases. The monetized value of person hours of travel for both Cases was then discounted back to 2017. As described in section 2.2.1, discount rates of 3 percent and 7 percent were used for this benefit cost analysis.

Table 4-2. Travel Time Savings Assumptions and Sources

Variable	Unit	Value	Source
Auto Users: Value of Time (Average of All Purposes, local and intercity)	2017$/hour	$22.04	U.S. DOT "Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis" September 2016
Truck Users: Value of Time	2017$/hour	$33.68	U.S. DOT "Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis" September 2016
Real Wage Growth[4]	Per year	0.0%	U.S. DOT Guidance, 2016
Annualization Factor	Days	352	Existing Weekday/Weekend Ratio and Travel Demand Modeling

As a result of the foregoing analysis process, total travel time savings benefits on the mainline and at intersections over the duration of the project analysis period were estimated to be $444,055,000, discounted to 2017 at a 7 percent discount rate.

4.2 Safety Benefits

Calculation of Safety Benefits

To calculate crash safety benefits, total predicted crashes for the Base and Build Cases were determined based on data prepared for the NEPA EA and IJR using the ISATe predictive tool. This tool is commonly used by WSDOT to identify the likely safety implications of transportation improvement options and is consistent with the analysis protocols of FHWA's *Highway Safety Manual*.

The analysis of safety benefits relied on the crash data and crash rate analysis published in the project's IJR. It should be noted that the ISATe tool predicted that total crashes would increase with the project over the Base Case. However, this result does not accurately represent the safety impact of the project because the project would also cause an increase in the volume of traffic along the corridor. Thus, while

[4] Recently revised guidance from U.S. DOT indicates that no real growth in wages should be assumed over the analysis period.

the total crashes are expected increase, the IJR documents that the crash rate[5] would be reduced in the short term and remain the same in the 2040 planning horizon year. To capture the safety benefit of the project, the total crashes for the Base and Build Cases were calculated by applying the specific crash rate of each to the build condition volumes. This resulted in a higher total number of crashes under the Base Case, which allowed a safety benefit to be calculated.

The analysis of safety benefits involves a multi-step process that includes developing crash rates for each analysis time period and multiplying these by millions of vehicle miles traveled to obtain the expected number of crashes for each analysis year. Crash rates for 2020 and 2040 with the Base and Build Cases were used to calculate a compound growth percentage that allowed interpolation of crash rates for each interim year over the analysis period.

To calculate million vehicle miles, the average mainline volume was multiplied by the total study corridor length of 6.07 miles. This calculation was performed for the 2020 and 2040 volume horizons for both the Base and Build Cases. Using these two data points, a compound growth percentage was calculated to generate total million vehicle miles for each year between 2020 and 2040. The factored crash rates and million vehicle miles for each analysis year were multiplied to estimate total crashes for the Base and Build Cases.

Total crashes then needed to be disaggregated based on severity. The average distribution of crashes across the spectrum of severity[6] (known as the KABCO spectrum) was obtained from an average of the 2020 and 2040 ISATe analysis results published in the Project's IJR. This estimated distribution pattern was used to assign severity to the estimate of total crashes in each of the interim years between 2020 and 2040.

The distribution of crashes by severity using the KABCO spectrum was then converted to MAIS crash severities using a conversion table provided by the TIGER Benefit-Cost Resource Guide. MAIS crash severities have specific monetary values that can be used to calculate the dollar benefit associated with project-related safety improvements. For this analysis the MAIS monetary values were obtained from "Guidance on Treatment of the Economic Value of a Statistical Life in US Department of Transportation Analysis", USDOT, 2016. A summary of the source documents used for the safety benefits calculations is provided in Table 4-3.

[5] A crash rate measures the relationship between crash experience and traffic volumes. When volumes increase but the crash rate drops, then it could be said that a proposed improvement would actually reduce the number of crashes that might be experienced with the same level of traffic in comparison to the non-project condition.

[6] The KABCO spectrum reflects the crash data collection structure commonly used by law enforcement including the Washington State Patrol.

Table 4-3. Safety Benefits Assumptions and Sources

Variable	Unit	Value	Source
Fatality and Injury Rates		Varies	WSDOT Annual Collision Summary, 2013
Crash-to-MAIS Conversion	Rates	Varies	TIGER Benefit-Cost Resource Guide, 2016
MAIS-to-VSL Conversion	Rates	Varies	"Guidance on Treatment of the Economic Value of a Statistical Life in US Department of Transportation Analysis" (USDOT), 2016

4.3 Quantifying and Monetizing Benefits

The benefit values used for the different MAIS crash severities are provided in Table 4-4. These values have been adjusted from 2015 dollars to 2017 dollars using the CPI inflation calculator, as described in section 2.2.2.

Table 4-4. Injury Types as a Fraction of the Value of a Statistical Life (VSL)

MAIS Level	Injury Severity	Percentage of Fatality	Value in 2017$	Source
6	Fatality	100.0%	$9,854,122	USDOT, 2016 (inflated to 2017)
5	Critical	59.3%	$5,843,494	USDOT, 2016 (inflated to 2017)
4	Severe	26.6%	$2,621,196	USDOT, 2016 (inflated to 2017)
3	Serious	10.5%	$1,034,683	USDOT, 2016 (inflated to 2017)
2	Moderate	4.7%	$463,144	USDOT, 2016 (inflated to 2017)
1	Minor	0.3%	$29,562	USDOT, 2016 (inflated to 2017)
0	Property Damage Only	n/a	$4,309	USDOT, 2016 (inflated to 2017)

These monetized values were applied to the spectrum of crashes by severity for each year in the BCA evaluation period. Expected safety benefits for the Base and Build Cases over the duration of the project analysis period were estimated to be $4,465,000 discounted to 2017 at a 7 percent discount rate.

4.4 Conclusions on Benefits

Table 4-5 presents a summary of the net travel time savings and safety benefits associated with the Build Case over the Base Case. Overall project benefits, in 2017 dollars assuming a 7 percent discount rate, are estimated to be $448,521,000. The total estimated travel time savings and safety benefits at a 3 percent discount rate is estimated to be $606,018,000.

Table 4-5. Summary of Project Benefits, Discounted 2017 Dollars

		Discounted Values	
Metric	**Undiscounted Values**	**3%**	**7%**
Travel Time Savings – I-5 Mainline	$706,756,000	$557,770,000	$416,693,000
Travel Time Savings - Interchanges	$60,907,000	$42,077,000	$27,363,000
Safety Benefits	$8,111,000	$6,171,000	$4,465,000
Total Net Benefits	**$775,774,000**	**$606,018,000**	**$448,521,000**

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5. SUMMARY OF RESULTS

This chapter brings together the results of the cost and benefit estimation process and summarizes key findings and conclusions for each evaluation measure assessed in this BCA. Total BCA results are also presented.

5.1 EVALUATION MEASURES

The benefit cost analysis converts potential gains (benefits) and losses (costs) from the I-5, Steilacoom-DuPont Road to Thorne Lane – Corridor Improvement project into monetary units and compares them to each other. The following evaluation measures were used in this assessment:

- **Net Present Value (NPV)**: NPV compares the net benefits (benefits less costs) after being discounted to present values using the assumed real discount rates. The NPV provides a perspective on the overall dollar magnitude of cash flow over time as expressed in 2017 dollars.
- **Benefit Cost Ratio (BCR)**: With the BCR total discounted benefits are divided by the total discounted costs. Projects with a benefit-cost ratio greater than 1 have greater benefits than costs; hence they have positive net benefits. The higher the ratio, the greater the benefits relative to the costs.

5.2 BCA RESULTS

Table 5-1 presents the analysis results for the project using three assumed discount rates: Undiscounted (or zero discount), 3 percent discount, and 7 percent discount as prescribed by the USDOT. All benefits and costs were estimated based on constant 2017 dollars over an evaluation period extending 20 years from completion of the project in 2020.

At a discount rate of 7 percent, the project yields a BCR of 1.58; at 3 percent, the project yields a BCR of 1.96. In both cases, the benefits that are likely to result from the I-5, Steilacoom-DuPont Road to Thorne Lane – Corridor Improvement project clearly exceed its costs.

Table 5-1. Benefit Cost Analysis Results, 2017 Dollars

	Project Evaluation Period (2020-2040)		
BCA Metric	**Undiscounted Values**	**Discounted 3%**	**Discounted 7%**
Total Benefits	$775,774,000	$606,018,000	$448,521,000
Total Costs	$330,325,000	$309,426,000	$284,656,000
Net Present Value (NPV)	$445,449,000	$296,592,000	$163,865,000
Benefit Cost Ratio (BCR)	2.35	1.96	1.58

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