I-205 Corridor Widening: Stafford Road to OR43
Benefit Cost Analysis Description, Assumptions, and Factors

Project Description

I-205 is a critical link in the spine of America's West Coast freight system, carrying more than 106,000 vehicles per day through the project area. This 7 mile segment of I-205 is the last remaining 2 lane section which creates a bottleneck causing drivers nearly seven hours of traffic backups and congestion each day. This is anticipated to increase to 14 hours a day by 2045. This delay significantly impacts freight and the public. In addition, the existing bridges on the mainline are seismically substandard and would make the corridor impassible after a significant seismic event. This project will add a third lane in each direction, as well as replace 6 bridges on the mainline, seismically retrofit four bridges, and replace two bridge overcrossings of the mainline to obtain required vertical clearances for freight. **The net present value of these benefits is $341.4 million in 2020 dollars, and the benefit cost ratio (BCR) is 2.52.**

The baseline for this project is a no build alternative that would result in no tolling and no lane additions. The main economic benefits of the project also align with INFRA criteria and include the following benefits (net present values (NPV) in $2020):

- Safety: $150.4 million
- State of Good Repair: $6.1 million
- Economic Impacts including Freight Movement benefits: $370.3 million
- Climate Change benefits through emissions and vehicle hours driven reductions: $9.2 million

This BCA quantifies benefits from those categories according to March 2022 US DOT BCA Guidance. The congestion and safety benefits are 65.4% and 26.6% of the project benefits claimed in this analysis, respectively. It is possible there are additional non-quantifiable safety benefits from increased resilience to earthquake damage not claimed here. The project benefits are robust to uncertainty about future benefits, as well. For example, even if only 8% of the claimed VHD reductions occur, this project will still have positive net present value.

Demand management through tolling significantly improves congestion outcomes on an important freight corridor. Traffic volumes along the corridor are expected to adjust accordingly, even seeing reduce traffic volumes during some peak hours relative to the no build alternative. This corridor sees a high volume of freight traffic, averaging 14% of total traffic counts in the pre-pandemic traffic study. While the share of freight traveling on the road is held constant, it is possible this share will increase over time since demand management through tolling will discourage marginally low value trips, which tend to be from passenger vehicles (consistent with their value of time in US DOT Guidance). Because of this, the quantified benefits to freight likely understates the value of travel time savings and congestion benefits for freight.

Safety benefits are quantified based on the Enhanced Interchange Safety Analysis Tool (ISATe). This tool showed a 21% reduction in crashes for the Build over the No Build scenario for this project, which saw multiple fatalities in the study period. It is possible there are additional non-quantifiable safety benefits from increased resilience to earthquake damage not claimed here due to the difficultly of predicting such an event. Costs of the earthquake retrofits are quantified and included, though.

The assumptions and factors used in this analysis in order to comply with US DOT BCA guidance are detailed below, along with references to the where the calculations are made in the attached spreadsheet to reach the final results.

Methodology: Value of Travel Time Savings and Congestion Reduction

Value of Travel Time savings, or Vehicle Hours of Driving (VHD) benefits are calculated from traffic studies on pre-pandemic traffic levels and modeled traffic volumes under the addition of tolling. These traffic figures are provided by WSP USA and their Transportation Engineering team. Volume growth under the baseline is limited by congestion and lack of additional lanes, while volume growth under the Build scenario sees slower growth over time due to the ability of tolling to manage demand. Volumes and travel times are reduced under the Build scenario relative to baseline. See the “Traffic Count Data” worksheet in the attached spreadsheet for a comparison of traffic volumes at each end of the project under Build and No Build scenarios, and how those change from 2027 to 2045. In the No Build scenario, volumes decrease from 2027 to 2045. Volumes under the Build scenario start lower than the baseline in 2027, but do see growth through 2045. This growth is extended through 2046 for this analysis to cover the 20 year expected lifespan of the project.

The VHD benefits analysis covers only peak hours, though there are likely benefits at all hours under demand management. WSD USA modeled travel time savings for the I-205 segments affected by the project and show per vehicle trip savings between 1.41 and 8.14 minutes per vehicle in the year after project completion relative to the baseline, and savings from 3.97 to 14.53 minutes in 2045 relative to baseline. This table is in the Modeled Travel Times worksheet attached.

The analysis assumes the VHD savings of the full length because the modeling of traffic shows this project affects travel times along the entire corridor, but the incremental savings for (1) just the project corridor (first two row below), and (2) the project corridor and its immediate approach segments (middle rows below) are shown as well for robustness analysis purposes. Using travel time savings on only this specific project segment reduces the BCR from 2.52 to 2.00, while using the savings that include the approach segments reduces the BCR from 2.52 to 2.50. These can be calculated in the spreadsheet by copying the Difference values into the VHD Savings Worksheet cells E50:F51. A compound annual growth rate is calculate for the growth in savings between 2027 and 2045, and is extended to 2046 to reach the full 20 year lifespan of the analysis.

Table 1: Peak Period Travel Time Savings by I-205 segment

		2027						2045					
		Build		No Build		Difference		Build		No Build		Difference	
From	To	AM Travel 7-9 AM	PM Travel 4-6 PM	AM Travel 7-9 AM	PM Travel 4-6 PM	AM Travel 7-9 AM	PM Travel 4-6 PM	AM Travel 7-9 AM	PM Travel 4-6 PM	AM Travel 7-9 AM	PM Travel 4-6 PM	AM Travel 7-9 AM	PM Travel 4-6 PM
Stafford Rd	**OR-213**	8.66	8.89	12.86	14.36	-4.20	-5.47	8.44	10.12	12.68	15.24	-4.24	-5.12
OR-213	**Stafford Rd**	7.97	7.97	8.85	8.96	-0.88	-0.99	7.97	8.00	11.68	11.61	-3.71	-3.61
I-15 ramps	**OR-213**	10.51	10.81	14.73	19.19	-4.22	-8.38	10.29	12.35	14.55	26.87	-4.26	-14.52
Gladstone	**Through Stafford Rd**	18.65	16.19	25.41	17.16	-6.76	-0.97	21.67	16.67	26.65	20.67	-4.98	-4.00
I-5 ramps	**Gladstone**	18.52	19.16	22.75	27.30	-4.23	-8.14	18.22	20.34	22.50	34.87	-4.28	-14.53
Gladstone	**I-5 ramps**	23.53	21.77	30.30	23.18	-6.77	-1.41	26.57	21.66	31.57	25.63	-5.00	-3.97

Source: WSD USA traffic model

Assumptions and Factor Descriptions

Factors used or developed to make the benefit-cost calculations are described below; along with their sources. In the worksheets, all factors are converted into 2020 dollars.

Average vehicle occupancy: a) Passenger vehicles – 1.67; b) Heavy trucks – 1.00. This corridor is primarily a freight and passenger corridor, and bus travel is not analyzed. Source: "Benefit Cost Analysis Guidance for Discretionary Grant Programs," U.S. Department of Transportation, March 2022, Table A-4. These values are entered in cell E39 and E42 of the "Modeled Travel Times" sheet.

Business v. personal travel share of travel: Applied the "All Purposes" estimate of 11.8% business and 88.2% personal travel from Table A-3 along with the vehicle occupancy default from the same table to apply to light duty vehicles. Source: "Benefit Cost Analysis Guidance for Discretionary Grant Programs," U.S. Department of Transportation, March 2022, Table A-3. This factor is first entered in "Modeled Travel Times" cell D39.

Construction cost estimates and schedule: For the Full Project, construction cost estimates by broad category and schedule are presented in column K and row 42 of the "Cost_4" worksheet.

Construction delay costs: We do not quantify construction delay costs but note that they are expected to some degree. From the I-205 Improvements Project DCE:

Maintenance of Traffic: The number and speed of I-205 traffic travel lanes will typically be maintained throughout the construction of the project. Rolling slowdowns of NB and SB traffic will be required during rock blasting. The rolling slowdowns will be timed to coincide with lowest traffic volumes during times of day when blasting can be done safely. Traffic on Willamette Falls Drive will be delayed for up to 30 minutes during these times. Bi-directional weekend closures of I-205 will be necessary during the sliding of the NB and SB lanes of the Abernethy Bridge. During the weekend the Abernethy Bridge NB lanes are slid to the final configuration, I-205 NB will be closed from I-5 to OR 99E. During the weekend of the Abernethy Bridge SB lane slide I-205 SB will be closed from OR 213 to OR 43. Traffic will be detoured to I-5 and I-84 or will have the option of utilizing the extensive local street network to navigate to their destinations. Nighttime lane closures of I-205, Borland Road, and Woodbine Road in accordance with ODOT Standard Specifications will be necessary during existing structure demolition and new bridge beam erections. For three weeks during the reconstruction of the OR 43 Interchange, OR 43 will be closed from Willamette Falls Drive to the I-205 NB on-ramp. OR 43 SB traffic will be able to access I-205 NB and SB during construction; however, NB OR 43 traffic will be detoured to OR 99E to access NB and SB I-205.

Capital cost information: The cost estimates in the "Cost_4" worksheet are expressed in year-of-expenditure (YOE) dollars. These are simultaneously converted into 2020 dollars and discounted 2020 dollars in rows 30, 60 and 90 of the "7% Discounting" worksheet. The inflation adjustment factors may be found in cells Q67-Q72 of the Inputs Worksheet." The discount rate is seven percent and is first entered in cell B27 of the "7% Discounting" worksheet.

Cost savings (pavement): The highway owners involved have significant and on-going pavement preservation programs. Construction will displace one round of pavement preservation activity for each component in 2026. The calculations in column J of the "7% Discounting" worksheet are based on the assumption of pavement preservation costs of $300,000 per lane mile in 2020 dollars (see rows 1-5 of the “Cost_4” worksheet). As this will be rebuilt roadway, the new pavement is expected to last 25 years. The project only displaces one cycle, and cost savings only apply to existing lane-miles.

Emissions per gallon: The factors listed below were calculated by solving for tailpipe emissions per gallon using Tables 3-26, 3-27, and 3-28 of The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised), National Highway Traffic Safety Administration, DOT HS 812 013, May 2015 (revised). The tailpipe emissions per gallon were added to the upstream emissions per gallon, then short tons were converted to metric tons to produce the following estimates:

- CO2 – 0.010984958 metric tons per gallon
- NOX – 0.000021648881 metric tons per gallon
- PM2.5 – 0.000001826287 metric tons per gallon
- SOX – 0.000001315191 metric tons per gallon

These are entered in “Inputs Worksheet” cells J43:J48.

Fuel consumption reduction due to reduced VHD: We use a value of 0.542 gallons per VHD and apply that to totals in the “VHD Savings” worksheet Rows 42 and 43. These values are discounted at 7% in the “7% Discounting” spreadsheet. Source: The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised), National Highway Traffic Safety Administration, DOT HS 812 013, May 2015 (revised), page 91. Factor is entered in “Inputs Worksheet” cell I39, and referenced in the VHD savings calculations on the “Modeled Travel Times” worksheet cell C48.

Fuel price: $3.85 per gallon. Source: US Energy Information Administration (EIA) Regular Gasoline Prices for West Coast less Califonrian on 5/4/2022. Figure has been converted to 2020 dollars. This factor is first entered in “Inputs Worksheet” cell R41.

Reduction in GHG (CO2) emissions: Damage costs per metric ton varies over time, starting at $56 in 2026 and increasing to $80 in 2047, the last year we considered for analysis. Source: “Benefit Cost Analysis Guidance for Discretionary Grant Programs,” U.S. Department of Transportation, March 2022, Table A-6. This factor is first entered in “Inputs Worksheet” Row 70, columns AV-BR.

Reduction in NOX emissions: $16,800-18,000 damage costs per short ton for our analysis period 2025-2046. Source“Benefit Cost Analysis Guidance for Discretionary Grant Programs,” U.S. Department of Transportation, March 2022, Table A-6. This factor is first entered in “Inputs Worksheet” Row 73, columns AV-BR.

Reduction in PM2.5 emissions: $796,600-$852,700 damage costs per short ton for our analysis period 2025-2046. Source: “Benefit Cost Analysis Guidance for Discretionary Grant Programs,” U.S. Department of Transportation, March 2022, Table A-6. This factor is first entered in “Inputs Worksheet” Row 71, columns AV-BR.

Reduction in SO2 emissions: $44,900-$48,200 damage costs per short ton for our analysis period 2025-2046. Source“Benefit Cost Analysis Guidance for Discretionary Grant Programs,” U.S. Department of Transportation, March 2022, Table A-6. This factor is first entered in “Inputs Worksheet” Row 72, columns AV-BR.

Hourly value of time savings: For passenger vehicles, used the “All Purposes” estimate of $17.80 per hour from Table A-3. For truck drivers, used the estimate of $32.00 per hour from Table A-3. For bus drivers, the figure is $33.00 per hour from Table A-3. Source “Benefit Cost Analysis Guidance for Discretionary Grant Programs,” U.S. Department of Transportation, March 2022, Table A-3. These factors are first entered in “Inputs Worksheet” cells D42, D44 and D46.

Improved peak hour reliability: Equivalent to the reduction in peak vehicle hours of delay (VHD). Source: Estimates of the value of reliability have a wide range, vary around values of VHD, and are highly correlated with congestion. Note that no benefits are assumed for off-peak reliability or congestion improvements (excepting off-peak crashes). While quantifying the value of the benefit is difficult, travel time reliability studies from WSD USA showed significant reductions in travel time variability relative to the No Build Alternative.

Induced travel: Induced travel is likely to be zero due to the implementation of tolling and demand management pricing. This can be seen in the change in traffic volumes assumed in worksheet “Traffic Count Data.” The source of this data is modeling done by WSD USA transportation engineers.

Inflation adjustment: The discount factors for converting future year costs (including fuel) to 2020 dollars are; 2021 – 1.0679, 2022 – 1.2052, 2023 – 1.2603, 2024 – 1.3056, 2025 – 1.3514, 2026 – 1.3987. These reflect IHS Markit’s April 2022 chained price index for state and local investment in highways and streets. The 2020 factor is applied to fuel in “Inputs Worksheet” cell R41, and the other factors are applied to capital expenditures in the “7% Discounting” worksheet. An inflation factor is included in the YOE cost estimates. However, the adjustment for each year is unclear, so IHS Markit’s index was used to convert YOE dollars to 2018 dollars. The index factors are entered in cells Q67-Q72 of the “Inputs Worksheet.”

Maintenance costs: $7,531 per new lane mile per year. Source: Oregon Department of Transportation’s FYs 2016-2018 non-overhead average annual maintenance costs on a per lane-mile basis, converted to 2018 dollars. This figure is first entered in “Inputs Worksheet” cell N41. This figure is then applied to the New Lane-Miles entries of the “Cost_” worksheets in the “7% Discounting” worksheet.

Noise: Noise costs are not considered in this analysis for two reasons. 1) With declines in traffic volumes expected relative to the baseline in many hours of the day, it is possible there will be net benefits in terms of noise. However, these would be offset if people are diverting onto other streets. We do not have enough information to value this change at a social scale. 2) Noise walls are being built for this project that will limit noise from the added lane to minimal noise changes. These results can be found in the Final Noise Technical Report on the project website: https://i205corridor.org/library

Proportion of vehicle types: The share of light passenger vehicles and share of trucks is from a pre-pandemic traffic study that found 89% passenger vehicle traffic (11% truck) on the Southbound lanes and 83% passenger vehicle traffic (17% truck) on the northbound lanes. These values can be found in the worksheet “Modeled Travel Times” cells H21 and H22.

Source: MS2, daily truck volumes for Wednesday, June 19, 2019. MS2 daily volumes are classified based on vehicles length in up to five categories (0 to 20, 20 to 35, 35 to 61, 61 to 150, and 150+ foot-long vehicles. Truck volumes reported in this section refer to vehicles longer than 20 feet. (20- to 35-foot-long vehicles are classified as Medium trucks, and vehicles longer than 35 feet are classified as Heavy trucks.)

Reduced vehicle operating costs: Other than fuel consumption (addressed above), project is not expected to have a noticeable effect on vehicle operating costs.

Residual value: $20.7 million for the full project. Source: Amount is the present value of the straight-line depreciated amount of the investment. Asset management experience indicates much roadway construction does not depreciate or does not depreciate in a way that would affect the next 20 year planning horizon. Roadway construction is depreciated over 25 years. Structures are depreciated over 75 years. Right-of-way, utility relocation, and engineering do not depreciate. Calculations are made in the "Cost_" worksheets. Conversion to present value occurs in the "7% Discounting" worksheet.

Safety: This project will have significant safety benefits. Expected crashes are based on 2015-2019 collected crash data, the five year averages of which can be found in cells H68-L68 of "Inputs Worksheet." The table on "Modeled Travel Times" starting in Cell 56 is included below, with the I-205 crashes used to project safety benefits.

Table 2: Corridor Crashes by Severity (2015-2019)

Corridor Crashes by Severity (2015 through 2019)

Corridor	Fatal	Injury	Property Damage Only	Total
I-205	2	892	853	**1,747**

We had to make some assumptions about the severity of the injuries in this data. 90% were assigned as Injury C, 6% as Injury B, and 4% as Injury A, which was consistent with other projects on similar corridors available to the economist. This also results in a conservative estimate of values of avoided crashes by assigning the vast majority to the lowest severity level.

Over time, crash growth is expected to change at the same rate as average daily traffic (see "Inputs Worksheet" cells I20-I22, which refer back to cells C5-C14 of the "VHD Savings" worksheet). The expected crash reduction value of 21% is applied is listed in cells B6 of the "Inputs Worksheet." The source is the traffic analysis received from WSD USA. WSD USA modeled higher reductions in crashes for the 2045 Build scenario that, if interpolated across the project, would result in significantly higher safety benefits. Without modeling for each year in between, this analysis chose to project based on the historical averages and estimated reductions to err on the side of reliability.

Calculation of improved reliability due to crash reduction: This calculation follows the same methodology as improved peak hour reliability above. Sources: The values applied are from Tables A-1 and A-2 of "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," U.S. Department of Transportation March 2022, and are found in AB59-AB64 of the "Inputs Worksheet." Reduced hours of delay resulting from reduced crashes are based on the NHTSA, The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised), Table 3-21 applied to comparable functional classes. These are listed in AC59-AC64 of the "Inputs Worksheet." Safety-related data is brought together and calculated in the "7% Discounting" worksheet.

VHD reduction factors: VHD reduction is based on traffic volumes and time savings per trip estimates from WSD USA, and can be found in the tables in the "Modeled Travel Times" and "Traffic Count Data" worksheets of the BCA model. These estimates are developed relative to a No Build Baseline, with No Build volumes reported in the "Traffic Count Data" as well. Travel time savings are calculated relative to the No Build baseline, and total travel times can be seen in the top table in the Modeled Travel Times worksheet. Truck share of traffic for Northbound and Southbound lanes can be found in the table starting in cell C20 of the “Modeled Travel Times” worksheet.

The worksheet “VHD Savings” calculates the benefits from travel time savings.

Peak hour VHD savings under the Build alternative has been calculated for 2027 and 2046. These are first entered in the spreadsheets in “VHD Savings” cells F18-Y26. Following BCA guidance that benefits should only accrue to existing users, we calculate these savings for the modeled Build traffic volumes only. In cases where Build volumes exceed No Build volumes, we only count half of the time savings. The volumes for the Build scenario are in cells F5-Y13 and the volumes for the No Build are in F69-Y77. Dividing the time savings by two at this step is equivalent to dividing the value of the savings by two only for those users later.

These times are then converted into estimates of annual vehicle hours of delay savings in Cells F33-Y36 for Trucks and Cars in each direction using the Table A-3 values and observed share of trucks using the corridor in each direction. We use the standard value of 251 peak hour days for a year. The undiscounted sum of these Travel Time Savings are given in Row 38 of the “VHD Savings” and then discounted appropriately at 7% on the “7% Discounting” worksheet.

The year of opening is assumed to be 2027. Figures for 2028-2044, and 2046 were interpolated since the modeling already estimated figures for 2027 and 2045. We used a compound annual growth rate (CAGR) calculation for this interpolation, as seen in cells C5-C13 of the “VHD Savings” worksheet.

The average annual growth rate of peak hour VHD savings is 1.9%, though the Southbound segment actually sees a reduction in travel time savings under Build conditions between 2027 and 2045. These figures are used to apply growth rates by peak hour period (AM vs PM) and direction (Northbound vs Southbound) to the benefits calculation adding certainty in our benefits analysis. We are able to apply time savings (or the loss of savings in the southbound AM case), to the appropriate modeled traffic volumes.