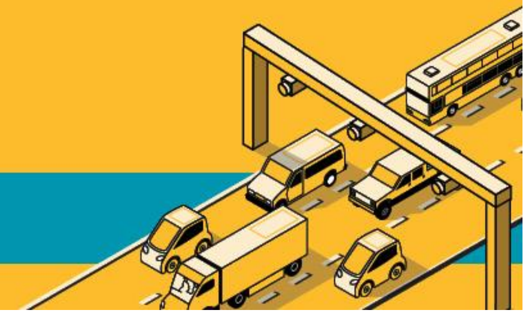
I-205 Toll Project



MEMORANDUM

Date	February 11, 2021
To	Lucinda Broussard, Mandy Putney, Jeff Buckland, Ben White, and Michael Holthoff (ODOT)
From	Tim Thornton, WSP
Subject	Economics Methodology Memorandum – Draft #4
CC	

INTRODUCTION

This memorandum describes the methods that will be used in the I-205 Toll Project (Project) Environmental Assessment (EA) analysis to evaluate economic impacts of the Project alternatives. The analysis and results will be documented in a technical report and summarized in the EA that will be developed to comply with federal guidelines and regulations, including the National Environmental Policy Act (NEPA) and local and state policies, standards, and regulations.

The economic analysis will evaluate impacts from the construction, operations, and maintenance of the Project and will identify mitigation measures as needed.

LEGAL REGULATIONS AND STANDARDS

Laws, Plans, Policies, Regulations, and Guidance

The following is a list of federal, state, and local laws, regulations, plans, policies, and guidance documents that guide or inform the assessment of economics:

- National Environmental Policy Act (1969)
- U.S. Department of Transportation Federal Highway Administration, Community Impact Assessment. A Quick Reference for Transportation, 2018 Update
- U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, 2020 Update
- Local land use planning documents, regulations or ordinances as listed in the Land Use Methodology Memorandum

AREA OF POTENTIAL IMPACT

An area of potential impact (API) is a geographic boundary within which impacts to the human and natural environment could occur as a result of implementing Project alternatives. The appropriate API for economics can vary depending on the direct and indirect impacts being analyzed. For the purposes of this analysis, a primary focus of the economic analysis will be on the potential direct and indirect impacts on businesses stemming from changes to traffic volume on local streets resulting from the Project, as well as the population that would use the Project at the highest frequency. This determination was made from the initial screening results from the Metro regional travel demand model where observed changes in volume exceeded plus or minus five percent as a result of the Project. The economics API encompasses those roadways forecast to experience changes in traffic volumes of plus or minus five percent and with an annual average daily traffic (AADT) increase or decrease of at least 100 or more vehicles that could impact business demand and those residing within a certain proximity of the Project, as shown in Additional impacts, such as those from tolling revenue and expenditure, as well as freight impacts, would extend to a much larger geographic area given that the origin and destination of end-users of the Project corridor are likely to be at a more regional scale. As such, certain economic impacts will be evaluated at larger regional levels as well as at the state level, while estimates of other various benefits of the Project (such as those used in a benefit-cost analysis) will be calculated based on all users of the Project, regardless of geography.

Figure 1.

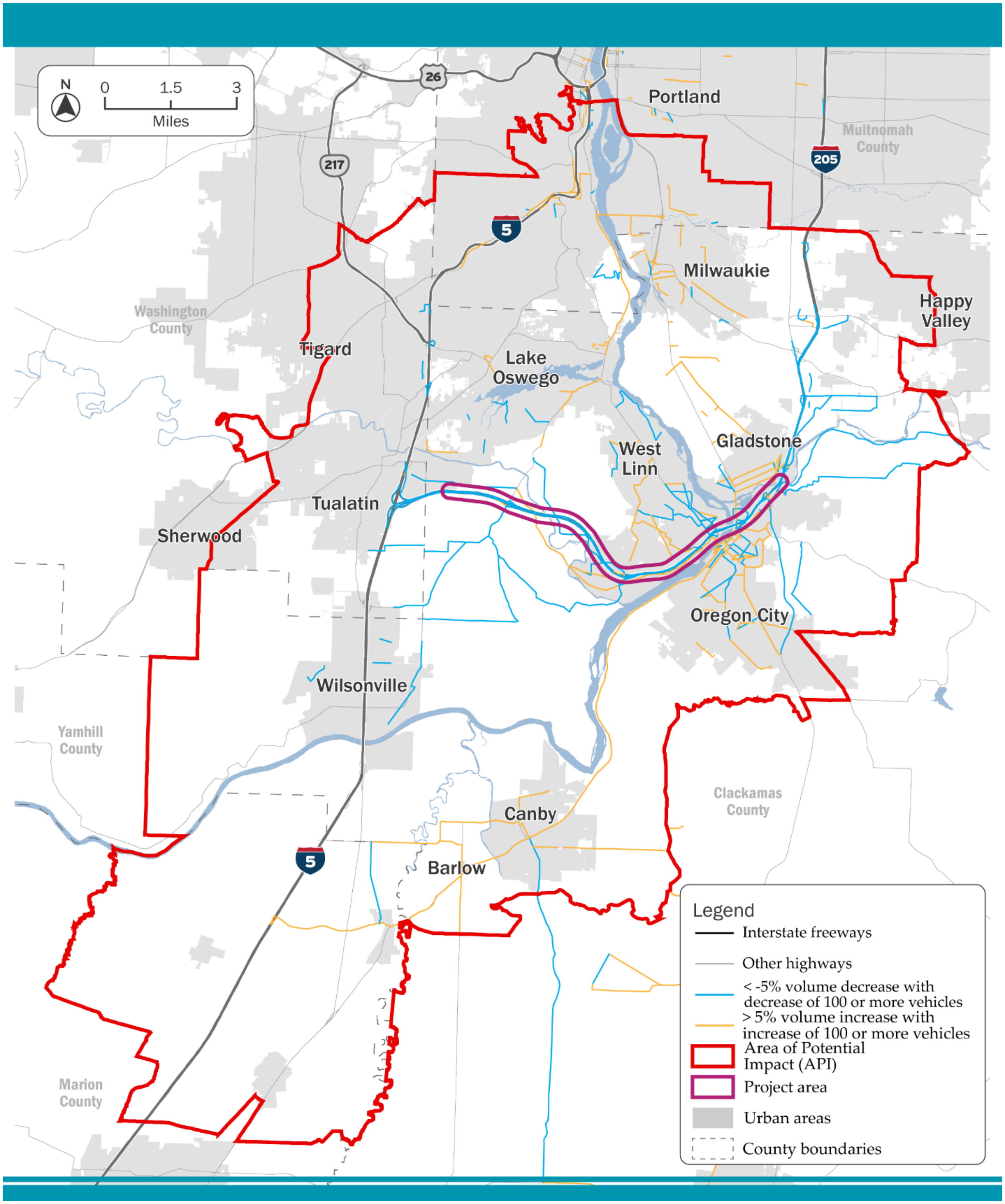
These roadways will be overlaid with additional geospatial information to identify commercial corridors, business districts, and employment concentrations in the API that the Project may impact, with a focus on those identified that may be the most sensitive to changes in traffic patterns such as convenience retail and other industry categories reliant on vehicular traffic volume. Prior to preparation of the Economics Technical Report, this API may be modified once the alternatives to be studied in the EA have been identified and projected traffic volumes have been refined.[1]

Additional impacts, such as those from tolling revenue and expenditure, as well as freight impacts, would extend to a much larger geographic area given that the origin and destination of end-users of the Project corridor are likely to be at a more regional scale. As such, certain economic impacts will be evaluated at larger regional levels[2] as well as at the state level, while estimates of other various benefits of the Project (such as those used in a benefit-cost analysis) will be calculated based on all users of the Project, regardless of geography.

[1] The toll rates will vary by time of day on a schedule, which will be determined based on congestion. The Oregon Transportation Commission will set the toll rate schedule after the NEPA process, but not until close to the time the toll facility opens.

[2] Such as the Portland-Vancouver-Hillsboro Metropolitan Statistical Area (MSA) or the greater Portland urban growth boundary as defined by Metro

Figure 1. Preliminary Economics Direct Impacts API



DESCRIBING THE AFFECTED ENVIRONMENT

Published Sources and Databases

Data used in the 2018 Documented Categorical Exclusion (DCE) prepared for the I-205 Improvements Project will be reviewed to confirm its relevancy and applicability to this study. The following is a list of the data that would be used to determine and describe economic resources/existing conditions:

- Current and forecast socioeconomic data, such as households, household income, population, and employment from several sources, including the Oregon Office of Economic Analysis, U.S. Census American Community Survey (ACS), municipal planning documents from jurisdictions within the API, and/or the Metro's Regional Travel Demand Model
- Business community profile (businesses by industrial categories) based on Google maps, local business directories, municipal planning documents, purchased business data, and other relevant documents
- Inventory of businesses and business districts based on an initial desktop analysis using Google Earth, Google Street View, and other online resources on selected corridors in the API with the largest forecast changes in traffic volume and concentrations of businesses
- Economic structure, such as industry sector multipliers, based on Impact Analysis for Planning (IMPLAN) data files and ODOT job impacts multipliers to estimate economic impacts of Project expenditure
- In coordination with the land use impact analysis, property value information from Metro's Regional Land Information System (RLIS)
- Various available freight data sources such as INRIX-fused National Performance Management Research Data Set (NPMRDS), HERE, American Transportation Research Institute (ATRI), and any other federal, state (ODOT), or third-party data/sources to measure freight impacts (with the goal of supplementing/updating findings from prior freight studies)

Contacts and Coordination

Local governments and business organizations may be contacted to gather information on: (1) the availability of data on businesses in the Project vicinity (number of businesses by category, average revenue, employment, etc.); (2) experience with past construction projects and their impacts on local businesses; and (3) anticipated impacts of the Project.

Field Surveys or Testing

No field surveys or testing will be conducted for the economics analysis.

IMPACT ASSESSMENT METHODS

The impacts analysis will address the Project alternatives' long-term, short-term, and indirect economic impacts on local businesses, residents, and freight transport. Several impacts will be analyzed, including: (1) business impacts resulting from changes in traffic patterns; (2) population impacts resulting from changes in travel times, travel costs, and job accessibility; (3) impacts on freight economics resulting from changes in travel costs, congestion and reliability; (4) broader impacts resulting from toll collection and expenditure of net toll collections; and (5) short-term economic impacts from construction spending. Existing conditions will also be described, including economic trends such as at-place employment and employment by industry sector, and socioeconomic data such as households by income.

Long-Term Impact Assessment Methods

The analysis of direct long-term economic impacts resulting from the Project will consider:

- The adverse and/or beneficial impacts on businesses due to traffic changes, changes in access, and changes in business clustering
- The overall change in household vehicle operating costs in the region
- The resulting change in travel costs as a percentage of household income
- The resulting overall share of regional jobs accessible within a 30-minute drive
- The monetary value of travel time savings to users
- The adverse and/or beneficial impacts to freight transportation resulting from changes in reliability, travel times, and travel costs
- Monetary valuation of all other Project impacts, including changes in safety, emissions (in coordination with the Energy and Greenhouse Gas Emissions Technical Report), pavement maintenance costs, nonmotorized travel benefits, and other identified impacts

Transportation modelling combined with an examination of local maps will be combined to develop an inventory of businesses and business concentrations with the most potential to be impacted by changes in traffic volume. These businesses will be classified by industry category to evaluate overall sensitivity to changes in traffic volumes, based on analyses conducted on other U.S. projects, previously gathered data on business and customer intercept surveys conducted within business corridors, and literature reviews.

Net benefits to users of the Project, including the freight industry, will be analyzed using a benefit-cost analysis framework. The analysis will be based on industry accepted practices and federal guidance regarding benefit-cost analysis including the valuation of benefits such as travel time savings and reliability. Where applicable, Metro's Multi-Criteria Evaluation (MCE)

Toolkit will be used with travel demand model data to generate several of the Project benefits described above.[3]

Short-Term Impact Assessment Methods

Short-term economic impacts resulting from construction spending will be estimated using ODOT's Long Range Planning Unit regional job impacts multipliers and construction dollar conversion table.

Indirect Impacts Assessment Methods

Indirect impacts are those that would take place later in time or are further removed in distance but are still reasonably foreseeable to occur. The analysis of indirect economic impacts that would result from the Project will consider the potential regional economic impacts from toll collections and use of toll revenue.

Regional economic impacts will include an economic input-output approach using IMPLAN, a widely recognized economic impact modeling tool used for forecasting the effect of a given economic change in the economy's activity on a regional economy.

Cumulative Impacts Assessment Methods

The analysis of cumulative impacts to economics is described in the I-205 Toll Project Cumulative Impacts Methodology Memorandum.

MITIGATION APPROACH

The analysis will identify potential mitigation measures for economic impacts, if any, as a result of the Project. The analysis may reference mitigation measures from other environmental topics, including strategies identified by the Project's Equity and Mobility Advisory Committee, and develop additional mitigation measures, as necessary. In accordance with standard practice, the analysis will prioritize mitigation to first avoid, then minimize, and mitigate for impacts.

PERFORMANCE MEASURES

1 presents a preliminary list of performance measures identified to evaluate how the alternatives compare in terms of impacts and benefits to the economy.

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[3] Metro's MCE Toolkit is designed to estimate the monetary project benefits based on changes in travel demand. WSP also maintains its own benefit-cost analysis (BCA) model designed to generate similar outputs. Both the WSP BCA model and the MCE Toolkit will be used to ensure accurate benefit calculations.

Table 1. Economic Performance Measures

Performance Measure	Tool and/or Data Source used for Assessment of Measure
Change in vehicle operating costs in the Portland metro area	WSP Benefit Cost Analysis (BCA) Model[4] and MCE Toolkit (indexed scenario comparison of vehicle operating costs)
Change in travel costs as a percentage of household income	Metro Regional Travel Demand Model and,MCE Toolkit (provides change in total travel time cost)
Monetary value of vehicle travel time savings to users	WSP Benefit Cost Analysis (BCA) Model and MCE Toolkit (indexed scenario comparison)
Change in access to jobs: share of regional jobs accessible within 30-minute drive	Metro travel demand model to identify percent of jobs (# jobs/all regional jobs) one can access from a transportation analysis zone (TAZ) during AM peak hour within a 30-minute drive.
Impacts from (current or new) traffic diversion on identified business concentrations in the study area	Primary research and analysis of identified commercial corridors or concentrations, Metro Regional Travel Demand Model for diversion patterns
Changes in economic conditions (employment, labor income, economic activity) from project construction	IMPLAN economic modeling software
Changes in economic conditions (employment, labor income, economic activity) from collection and use of toll revenue	IMPLAN economic modeling software
Change in reliability, travel times, and travel costs for freight users	Dynamic Traffic Assignment Model, MCE Toolkit (indexed truck segmentation of benefits, where applicable)
Monetary value of changes in safety, emissions, noise. pavement maintenance costs, and other identified impacts	WSP BCA Model

Additional performance measures may be identified during the course of analysis.

[4] An overview of the WSP Benefit-Cost Analysis (BCA) model is attached to this memo

WSP BENEFIT-COST ANALYSIS OVERVIEW

WSP's benefit-cost analysis (BCA) framework is a method to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to objectively and quantitatively measure the expected benefits of a project relative to its costs from a social perspective. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., construction closure impact), and welfare reductions where some groups are expected to be made worse off as a result of the proposed investments.

The analysis is structured to generate two primary outputs or metrics:

- **Benefit Cost Ratio (BCR)**: the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relationship of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs. A BCR above 1 indicates that the project's benefits exceed its costs.
- **Net Present Value (NPV)**: NPV compares the net benefits (benefits minus costs) after being discounted to present values using a real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms. An NPV above 0 indicates that the project's benefits exceed its costs.

While the BCR is a straightforward metric to facilitate comparison, for evaluation of several alternatives with a potentially wide range of relative costs, the BCR may not entirely account for the magnitude or scale of benefits. For example, a very minor/small improvement with a low cost could result in a very high BCR, but the magnitude of total benefits may be far less than that of a larger investment that may generate a lower BCR.

The BCA framework was developed in compliance with federal U.S. Department of Transportation guidance[1] and can consider several benefits as highlighted below:

[1] https://www.transportation.gov/sites/dot.gov/files/2020-01/benefit-cost-analysis-guidance-2020_0.pdf

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Overview of Benefit Types

Economic Competitiveness	Safety	Sustainability / Resiliency	State of Good Repair	Quality of Life
Travel time savings	Reduced incidents	Reduced emissions	Reduced pavement damage	Reduced noise pollution
Truck reliability		Seismic upgrades	Reduced agency O&M / R&R costs	Health benefits
Reduced vehicle O&M costs				Commuter mobility
Fuel savings				Recreational benefits
				Accessibility
				ADA access

ECONOMIC COMPETITIVENESS

Improvements in the mobility of people and goods can be measured and monetized through conventional four-step travel demand modeling. The quantitative variables typically included in a BCA are largely established through the evaluation of travel time savings, transportation mode shift, and vehicle miles traveled (VMT), quantified through travel demand modeling leveraging existing regional evaluation tools.

Reduced Vehicle operating and maintenance costs and fuel costs

Vehicle operating cost savings includes the cost of fuel, as well as maintenance and repair, replacement of tires, and the depreciation of the vehicle over time. Consumption rates per VMT are used to calculate the vehicle operating cost savings. Estimates of VMT and unit costs for each component of vehicle operating cost are applied to the consumption rates to calculate the total vehicle operating cost. The assumptions used in the estimation of vehicle operating costs are presented below. Values will also include additional out-of-pocket operating costs such as user fees and parking fees once improvements have been defined.

Fuel efficiency values are derived from the U.S. Energy Information Administration (EIA), which provides estimates for fuel efficiency through 2050. The values used to calculate fuel efficiency can be found in the table published by EIA titled “Transportation Sector Key Indicators and Delivered Energy Consumption.” (U.S. EIA, 2018). The following fuel efficiency values were used for the different vehicle classes:

- “Light Duty Stock” energy efficiency (mpg) for passenger vehicles.
- “Freight truck” energy efficiency (mpg) for trucks.

Operating Cost Savings Assumptions and Sources

Variable	Unit	Value	Source
Auto Maintenance, Repair & Tires	2018$ / VMT	$0.086	AAA "Your Driving Costs" 2018
Auto Depreciation	2018$ / VMT	$0.239	AAA "Your Driving Costs" 2018
Truck Maintenance & Repair	2018$ / VMT	$0.17	ATRI 2018 Update
Truck Tires	2018$ / VMT	$0.04	ATRI 2018 Update
Truck Depreciation	2018$ / VMT	$0.23	AAA "Your Driving Costs" 2018
Gasoline Costs	2017$ / gal, incl. taxes	range from $2.53 (2019) to $3.67 (2050)	US EIA, "Annual Energy Outlook 2018," Table 12
Diesel Costs	2017$ / gal, incl. taxes	range from $2.78 (2019) to $4.09 (2050)	US EIA, "Annual Energy Outlook 2019," Table 12
Fuel Growth post-2050	% Growth	1.2% for gasoline; 1.3% for diesel	Calculated based on CAGR from EIA forecast
Federal Fuel Taxes	2019$	$0.184 for gasoline; $0.244 for diesel	API, "State Motor Fuel Taxes by State", January 2019
State of Washington Fuel Taxes	2019$	$0.494 for gasoline; $0.494 for diesel	API, "State Motor Fuel Taxes by State", January 2019
Auto Fuel Efficiency	Miles per Gallon	range from 23.67 (2019) to 38.18 (2050)	US EIA, "Annual Energy Outlook 2019," Table 7
Truck Fuel Efficiency	Miles per Gallon	range from 7.34 (2019) to 10.45 (2050)	US EIA, "Annual Energy Outlook 2019," Table 7
Fuel Efficiency Growth post-2050	% Growth	1.6% for gasoline; 1.2% for diesel	Calculated based on CAGR from EIA forecast
Auto Fuel Efficiency Adjustment Factor	Factor	range from 1.00 (55 MPH) to 3.70 (5 MPH)	US EIA 2013
Truck Fuel Efficiency Adjustment Factor	Factor	range from 1.00 (55 MPH) to 2.57 (5 MPH)	US EIA 2013

Connectivity and travel time savings

Travel time savings includes in-vehicle travel time savings for auto drivers and passengers, transit riders, as well as truck drivers. Travel time is considered a cost to users, and its value depends on the disutility that travelers attribute to time spent traveling. A reduction in travel time translates into more time available for work, leisure, or other activities.

Assumptions similar to what will be used in the estimation of travel time savings benefits are presented below:

Travel Time Savings Assumptions and Sources

Variable	Unit	Value	Source
Value of Travel Time Savings - Personal, Local	2018$ per person hour	$15.20	US DOT Guidance, January 2020
Value of Travel Time Savings - Business, Local	2018$ per person hour	$27.10	US DOT Guidance, January 2020
Value of Travel Time Savings - All Purposes, Local	2018$ per person hour	$16.60	US DOT Guidance, January 2020
Value of Travel Time Savings - Personal, Intercity	2018$ per person hour	$21.30	US DOT Guidance, January 2020
Value of Travel Time Savings – Truck Drivers	2018$ per person hour	$29.50	US DOT Guidance, January 2020
Value of Travel Time Savings – Bus Drivers	2018$ per person hour	$31.00	US DOT Guidance, January 2020
Average Vehicle Occupancy Rate, Passenger Vehicle	Persons per vehicle	1.67	US DOT Guidance, January 2020
Average Vehicle Occupancy Rate, Truck	Persons per vehicle	1	US DOT Guidance, January 2020

SAFETY BENEFITS

Reduced Incidents

The cost savings that arise from a reduction in the number of incidents include direct savings (e.g., reduced personal medical expenses, lost wages, and lower individual insurance premiums), as well as significant avoided costs to society (e.g., second party medical and litigation fees, emergency response costs, incident congestion costs, and litigation costs). The value of all such benefits – both direct and societal – could also be approximated by the cost of service disruptions to other travelers, emergency response costs to the region, medical costs, litigation costs, vehicle damages, and economic productivity loss due to workers' inactivity.

Monetized values for fatalities, and incidents categorized on the AIS scale are reported in the U.S. DOT's guidance for "Treatment of the Economic value of a Statistical Life" (U.S. DOT, 2020) – this includes low and high ranges of 20 percent lower and higher respectively used in sensitivity analysis. Values pertaining to property damage only incidents were reported by the National Highway Traffic and Safety Administration, and provided in 2018 dollars (U.S. DOT, 2020). One year of escalation was applied to derive 2018 dollars. The following table lists the range of values used in the sensitivity analysis for each incident type:

Monetized Incident Values

Incident Type	Unit Value (2018 $)
Fatality	$9,600,000
AIS 5	$5,692,800
AIS 4	$2,553,600
AIS 3	$1,008,000
AIS 2	$451,200
AIS 1	$28,800
Property Damage Only	$4,400

Source: U.S. DOT, 2020 update; WSP, 2020

SUSTAINABILITY AND RESILIENCY

Reduced Emissions

The benefits of reducing air pollution include decreases in health complications, disturbances to the natural environment and avoided property damages. Five forms of emissions would be identified, measured and monetized, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide.

Primarily related to reduced direct exposure to residents and workers in buildings within a certain radius of a given project, but also associated with decreases in VMT, the reduction of emissions represents a benefit often enjoyed by persons who do not directly use the facility. The reduction in gasoline and diesel consumption due to less miles traveled results in fewer emissions, including sulfur dioxide and fine particulate matter, being released into the local environment.

The unit value assumptions below provide an example of the current values that would be applied to monetize the reduction in emissions.

Environmental Sustainability Benefits Assumptions and Sources

Variable	Unit	Value	Source
Cost of CO_2 emissions	2018$ per metric ton	$1 through 2035, $2 thereafter	US DOT Guidance, January 2020 (converted from short tons)
Cost of NOx emissions	2018$ per metric ton	$8,600	US DOT Guidance, January 2020 (converted from short tons)
Cost of $PM_{2.5}$ emissions	2018$ per metric ton	$387,300	US DOT Guidance, January 2020 (converted from short tons)
Cost of SO_2 emissions	2018$ per metric ton	$50,100	US DOT Guidance, January 2020 (converted from short tons)
Cost of VOC emissions	2018$ per metric ton	$2,100	US DOT Guidance, January 2020 (converted from short tons)
Emissions per VMT	Metric tons of emissions per VMT	Varies by year, fuel type, and emission type	California Air Resources Board EMFAC Database, 2017; Cal B/C, 2010; EPA MOVES, 2014
Emissions Speed Adjustment Factors	Factor	Varies by year, fuel type, emission type, and speed	California Air Resources Board EMFAC Database, 2014

Drainage

Benefits from drainage improvements will range from the reduction in potential untreated water contaminants as a result of improvements in water collection and downstream treatment; reduced future costs due to potential reduction in flood related interruptions and road closures; and reduction in injuries and incidents on roadways evaluated as part of a study. The risk of future flooding- or drainage-related delays on roadways can also be evaluated using historical data if available.

Seismic Upgrades

Complete asset failure can be evaluated through the substantial disbenefits related to travel time, VMT, emissions, and safety. The BCA methodology would consider an evaluation procedure (Baker, 2000) that was developed to consider a major earthquake with defined probability and compares the travel-related and damage-avoidance benefits that would be generated by retrofit improvements with their associated implementation costs. Emphasis is placed on travel impacts because other, non-transportation economic impacts are impossible to quantify without being able to predict all of the impacts to the built environment associated with a major seismic event. (Parsons Brinckerhoff, 1999)

These avoided disbenefits, along with the cost of full asset replacement in the event of a major earthquake, could be incorporated into the benefit-cost model using a probability factor based on historic seismic data and an additional factor for more common lower magnitude seismic events. Depending on the confidence level of the predictive accuracy on seismic events and the types of capital investments being considered, seismic benefits may also be evaluated as a qualitative measure.

STATE OF GOOD REPAIR

An eventual state of good repair condition benefits analysis would include maintenance and repair savings, deferral of replacement cost savings, reduced VMT, which leads to less road and facility damage, and use of designs and technologies to increase resilience performance during natural hazard events and long-term use. The following table contains the unit values proposed for evaluating the reduced cost of maintenance from reduced vehicle use.

State of Good Repair Values, Auto and Truck, 94-6 Urban-Rural Split, 2018 $

	Pavement Damage Cost per VMT Likely
Auto	$0.0017
Truck	$0.1477

Source: FHWA, WSP, 2020

QUALITY OF LIFE

Key quality of life benefits are derived from mode shift to more active transportation methods as a result of safe and direct access to improved facilities, direct access to outdoor recreational and park spaces, and reduction in noise levels.

Health Benefits

Health benefits apply to new bicyclists who would otherwise not be able to use a facility under existing conditions. These bicyclists realize benefits by increased daily physical activity, which has been shown to improve the health of users and reduce future medical costs. The NCHRP Guidelines for Analysis of Investment in Bicycle Facilities (NCHRP, 2006) identified ten studies which estimated the overall health benefit of increased physical activity. These benefits ranged from $19 to $1,175 per new bicyclist per year, with a median value of $128 (all values in 2006 $), with detailed review available in appendix E of that document. These values were adjusted to 2018 dollars with resulting values of $23.65, $159.30, and $1,462.35 for low, likely, and high values of health benefits respectively. The NCHRP Guidelines state that this benefit is ascribed per daily new user; since bicyclist volumes represent one-way trips, the volume is divided by two in order to estimate the number of total users. This is slightly conservative since not all bicyclists use the same route for the return trip. The benefit is thus defined:

$$Health\ Benefit = \frac{b_n}{2} \cdot H$$

Where:

b_n *= volume of daily new bicyclists, divided by two to convert to trips*
H *= distribution of value of per-capita health benefit, 2018$*

Similar levels of health benefits have also been studied for pedestrians and can be considered with any forecast increase in pedestrian movements.

Commuter Mobility Benefits

Commuters experience a benefit because research has shown that bicyclists and pedestrians prefer using certain facilities over others, with dedicated bicycle infrastructure showing the greatest monetized value of benefit. Similar to the health benefits evaluated in section 3.5.3, any improved bicycle or pedestrian facilities could be evaluated for their potential quantifiable benefits to increased commuter trips by walking or bicycling.

Mobility Benefits - Bicyclists

The NCHRP Guidelines for Analysis of Investment in Bicycle Facilities reviewed available research and found that bicycle commuters are willing to spend 20.38 extra minutes per trip (NCHRP, 2006) to travel on an off-street bicycle trail for reasons including higher level of safety, more pleasant and lower stress experience, and lack of auto impacts such as road spray and exhaust fumes. These benefits can be directly applied to new commute trip bicyclists according to the following formula (modified from NCHRP Report 552):

$$Commute\ Mobility_{bicylcists} = \frac{20.38}{60} \cdot b_{n,c} \cdot \overline{W} \cdot 5 \cdot VOT$$

Where:

- $20.38/60$ *= additional value of off-road bike facility in minutes, converted to hours*
- $b_{n,c}$ *= volume of daily new commute bicyclists*
- $\overline{W}$ *= weighted average of workweeks per year*
- 5 *= number of work days per week*
- VOT *= distribution of value of time, 2016$ / hr*

NCHRP Report 552 Guidelines assumed 50 commute weeks per year. The value of time applied for this benefit is the same as that previously documented and used for travel time savings for local travel across all trip purposes.

Mobility Benefits - Pedestrians

Although previous applications of mobility benefits in the U.S. has typically only applied to bicyclists, research in Europe has valued commuter benefits for improved facilities for pedestrians as well. The UK Department for Transport Guidance on the Appraisal of Walking and Cycling Schemes (U.K. DfT, 2012) has monetized benefits for pedestrians. Accordingly, improvements in the commute experience for pedestrians can also be monetized. The Department for Transport study identified valuation for several aspects of the commuter experience. Only those aspects which are improved in a project are included. These aspects are provided in the following table, using an average 2010 exchange rate of 1 GBP = 1.545 USD (Oanda, 2019).

Monetized Value of Aspects of the Pedestrian Environment

Category	Value, 2010 pence/km	Value, 2018 $/mi
Street Lighting	3.8	0.12
Reduced Crowding	1.9	0.06
Pavement Evenness	0.9	0.02
Total	6.6	0.20

Source: UK DfT Guidance on the Appraisal of Walking and Cycling Schemes, 2012, WSP, 2020

The table below documents values used, and assumptions made for computation of the commuter mobility benefit for pedestrians.

Values Used for Pedestrian Commuter Mobility Computations

Category	Value	Source
Average Pedestrian Trip Length, mi	0.50	2012 Travel Survey, FMPO
Average Walking Speed, mph	3.0	2012 Travel Survey, FMPO
Percent of Pedestrian Users, commuters	16 percent	2012 Travel Survey, FMPO

Source: FMPO, 2012, WSP, 2018

The resulting commuter mobility benefit for pedestrians is computed as follows:

$$Commute\ Mobility_{pedestrians} = p_c \cdot \bar{L} \cdot \bar{W} \cdot 5 \cdot V$$

Where:

p_c = *volume of daily commute pedestrians*
$\bar{L}$ = *weighted average of trip length on trail, miles*
$\bar{W}$ = *weighted average of workweeks per year*
5 = *number of work days per week*
V = *distribution of value of benefit, 2014\$ / mile*

It should be noted that the pedestrian commuter mobility benefit applies to all commute pedestrians who use a facility. The facility will bring the benefits of connectivity, noise and emissions mitigation (monetized separately), reduced crowding, and even pavement and access to all pedestrians.

Recreation Bicycle Benefits

The NCHRP Guidelines for Analysis of Investment in Bicycle Facilities also identified benefits for recreational users of bicycle facilities. These benefits result from the time spent performing recreational activity, since this represents a revealed preference in how recreational bicyclists choose to spend their time. As opposed to recreational pedestrian trips, recreational bicycle trips, may be more apparent and quantifiable with the inclusion of new bicycle facilities, specifically protected or separated facilities.

Use time is assumed to be one hour per bicyclist including preparation and clean-up time (NCHRP, 2006). The value of time for this benefit is assumed to be lower than the value of time used for commuters or the population at large. The NCHRP Guidelines indicate a value of $10 per hour in 2006 dollars, which becomes $12.46 per hour in 2018 dollars. The benefit is computed as follows:

$$Recreation\ Benefit = \frac{b_{n,r}}{2} \cdot 365 \cdot VOT_r$$

Where:

$b_{n,r}$ = *volume of daily new recreational bicyclists, divided by two to convert to trips*
365 = *number of recreation days per year, per NCHRP Report 552*
VOT_r = *distribution of recreational value of time, 2016\$ / hr*

The recreational benefit will likely only be calculated and quantified for bicycle trips as the recreational value of these improvements for pedestrians may be difficult to quantify. In addition, depending on the type of improvement, it may result in a shift of recreational trips from other routes, rather than the creation of specific benefits from increased recreational trips associated with the investment.

Reduced Noise

Reducing VMT or creating noise barriers, creates environmental benefits to society in the form of noise reduction. On a per-VMT basis, these unit values can be estimated based on a Federal Highway Administration (FHWA) cost allocation study report (FHWA, 2000). Strategies that may involve (1) a traditional evaluation of reduction in VMT multiplied by the noise factors based on the projected type of vehicles, and (2) analysis of direct reduction in noise through potential project investments.

When calculating the impact of truck noise, a 60 kip 4-axle single unit trucks is assumed as a proxy for the average type of heavy vehicle. Further refinement will be considered with any additional traffic analysis by vehicle class.

An urban and rural split of 94 percent and 6 percent respectively is typically applied to create a weighted average of the FHWA values for those environments. All values are adjusted from the study's 2000 values to 2018 dollars using a CPI adjustment. (BLS, 2019) See table below for the standard values that will be applied in 2018 dollars.

Noise Costs Auto, 94-6 Urban-Rural Split, 2018 $

	Noise Costs per VMT Likely
Auto	$0.0012
Truck	$0.0317

Source: FHWA, WSP, 2020