Commuter Corridors Study

Appendix D
BCA Methodology

1.0 Benefit-Cost Analysis (BCA) Methodology

This section presents the methodology embedded in the Benefit-Cost Analysis (BCA) tool that was utilized in the Commuter Corridors Study to prepare a series of performance metrics. The goal of applying the BCA tool was to better understand the benefits and social equity dimensions of the land use and transportation investment decisions with an economic analysis tool. This BCA tool utilized several performance measures including safety, travel time savings, travel time reliability, vehicle operating costs, vehicle emissions, surface water, noise, physical activity, and accessibility (i.e., travel options and choices).

The BCA methodology presented here reflect best practices based on our knowledge and review of travel benefit estimation techniques applied by peer agencies including San Diego Association of Governments (SANDAG) in California, Metropolitan Transportation Commission (MTC) in California, Puget Sound Regional Council (PSRC) in Washington, and Portland Metro in Oregon, as well as the recent research conducted by RSG for the Federal Highway Administration (FHWA).

The BCA Tool considers nine benefit performance measures in five categories: safety, mobility, environment, livability, and accessibility. These nine benefit performance measures are summarized in Table 1-1 in terms of how they are aggregated in the model, which variables are considered in the computation, and the degree of confidence in the performance measure based on their maturity level.

Link-level measures are calculated for each roadway link in the model and aggregated across the region, OD-level measures are calculated for each zone-to-zone OD pair in the model and aggregated to the origin zone, and zone-level measures are calculated at the zonal level.

The underlying methodology is documented next for the benefit performance measures in terms of how they are computed and how they are monetized.

Table 1-1 Summary of Benefit Performance Measures

Benefit Performance Measure	Benefit Category	Type of Aggregation	Quantities Utilized in the BCA	Maturity of the Measure	Degree of Confidence
Safety	Safety	Link	Fatal, Injury, Property-Damage Only Crashes	Proven	●●●●○
Travel Time	Mobility	OD	Minutes of travel time saved by mode	Proven	●●●●●
Travel Time Reliability	Mobility	OD	Decrease in travel time variability (standard deviation of travel time)	Emerging	●●○○○
Vehicle Operating Costs	Mobility	Link	Gallons of fuel consumed, VMT-based non-fuel costs	Proven	●●●●○
Emissions	Environment	Link	Tons of CO2e, PM2.5, PM10, NOx, VOC	Proven	●●●●●
Surface Water	Environment	Link	VMT-based cost of impacts	Emerging	●●○○○
Noise	Livability	Link	VMT-based cost of impacts	Emerging	●●○○○
Physical Activity	Livability	OD	Avoided mortality	Emerging	●●●○○
Travel Options / Choices	Accessibility	Zone	Monetary value of additional mode / destination options	Emerging	●●●○○

1.1. Safety

The valuation of safety benefits has been a part of transportation benefit-cost analysis for decades; it was one of the original benefits in AASHTO's early Red Books in the 1960's and 70's. Crash prediction methods used in benefit-cost analysis have varied, but AASHTO's HSM is authoritative and is seeing increasing use. Federal guidance has clarified the practice of monetizing transportation safety benefits by providing recommended monetary valuations for crashes by severity.

In the BCA tool, Safety benefits are implemented on the link level. First, the Highway Safety Manual (HSM) crash prediction model, as described in the Interactive Highway Safety Design Manual, is used to estimate yearly crashes for each link and intersection in the TRM for the base case and each scenario. First, the number of yearly crashes is estimated using Safety Performance Functions (SPFs) for roadway segments (links) and intersections (nodes) together with Crash Modification Factors (CMFs). The total annual number of crashes (N) are the sum of crashes along road segments (N_{rs}) and crashes at intersections (N_{int}):

$$N = N_{rs} + N_{int}$$

Both N_{rs} and N_{int} are predicted as the product of the number of crashes predicted by a SPF (N_{SPF}), any relevant CMFs, and a calibration factor (C_r):

$$N_{rs} = C_r \times N_{SPF_{rs}} \times CMF_1 \times \cdots \times CMF_n$$
$$N_{int} = C_r \times N_{SPF_{int}} \times CMF_1 \times \cdots \times CMF_n$$

C_r varies by setting and was calibrated for the CAMPO region by first estimating the number of crashes for the base year run of the TRM, comparing to observed crashes for the base year, and adjusting accordingly.

For roadway segments, SPFs predict the number of crashes per year as follows:

$$N_{SPF_{rs}} = \alpha(\beta ADT)^{\gamma} \times Length(mi)$$

where α, β, and γ are parameters for a given facility type and sometimes other specifics such as number of lanes.

For intersections, SPFs take the form:

$$N_{SPF_{int}} = \alpha + \beta ADT_{HighestVolumeApproach} + \gamma ADT_{LowestVolumeApproach}$$

where α, β, and γ are parameters for a given facility and area type. $ADT_{HighestVolumeApproach}$ and $ADT_{LowestVolumeApproach}$ were calculated by joining node and link data for each TRM scenario run.

The generic SPF illustrated above was implemented separately for each functional class – freeways, rural two-lane highways, rural multi-lane highways, and urban/suburban arterials. To do so, TRM functional classifications were first mapped to HSM classifications as shown in Table 1-2.

Table 1-2 Summary of Benefit Performance Measures

Model Functional Class	Urban or Rural	Highway Safety Manual (HSM) Functional Class
Freeway	Either	Freeway
Arterial	Urban	Arterial urban
Arterial	Rural	Highway rural
Collector	Urban	Arterial urban
Collector	Rural	Highway rural
Ramps	Either	Freeway

The CMFs corresponding to each functional class SPF are estimated using various network attributes such as lane width, shoulder width, grade, presence of median/barrier, lighting, etc. Default or average values of certain network attributes are used when not available. Specifically, average lane widths and shoulder widths assumptions are based on FHWA's Highway Functional Classification Concepts, Criteria and Procedures (Table 3-5)[1]. In cases where the appropriate network attributes are not available, the CMF value is set to 1.

Since the benefits calculator operates at the link level, node level attributes for intersection SPFs are computed via link level calculations. This involves identification of intersections (non-centroids and nodes connected to more than two links) by their control type and computation of the max and min volume at the intersection. Since all the calculations in the benefits calculator are implemented at the link level, each intersection will appear in the processor as many times as the number of links connected to it. Therefore, to avoid double counting, the SPF for each intersection is divided by the number of links it is connected to. Because operational details for intersections details (lighting, angle, etc.) are not available on the network, CMFs for all intersections were set to a value of 1.

Finally, crashes predicted as described above were factored to divide total crashes into three severity categories (fatal, injury, and property-damage-only or PDO).

The United States Department of Transportation (USDOT) recommended Value of a Statistical Life (VSL) was used to translate estimated traffic fatalities to US dollars. USDOT's valuation is based on extensive recent empirical studies and is defined as the additional cost that individuals would be willing to bear for improvements in safety (that is, reductions in risks) that, in the aggregate, reduce the expected number of fatalities by one. This value was then discounted to 2019 dollars.

For non-fatal injury crashes, USDOT recommends applying a factor of 0.047 to the VSL. Property Damage Only (PDO) crashes are assumed to have cost equal to the average property damage claim.

1.2. Travel Time

Travel time savings are generally the most significant component of user benefits for most transportation projects, plans and policies. For existing trips, travel time savings is simply the decrease in travel time for that trip. However, when trips are induced or suppressed, the benefit is calculated based on consumer surplus theory (Figure 1.1). The basic idea is that for induced demand, although the traveler was unwilling to make the trip given the original travel time (cost), as the cost decreases, at some point the traveler would choose to make the trip; the travel time savings for their trip should be measured as any further decrease in travel time beyond the point at which the trip is induced. In the absence of other information, the "Rule of Half" (ROH) assumes that trips induced between a baseline cost and an alternative scenario costs would, on average, be induced at the average of these costs and hence should accrue half of the travel time savings as existing trip-makers. In economic terms, this is the benefit for induced demand is the change in consumer surplus and the ROH amounts to linearization of the travel

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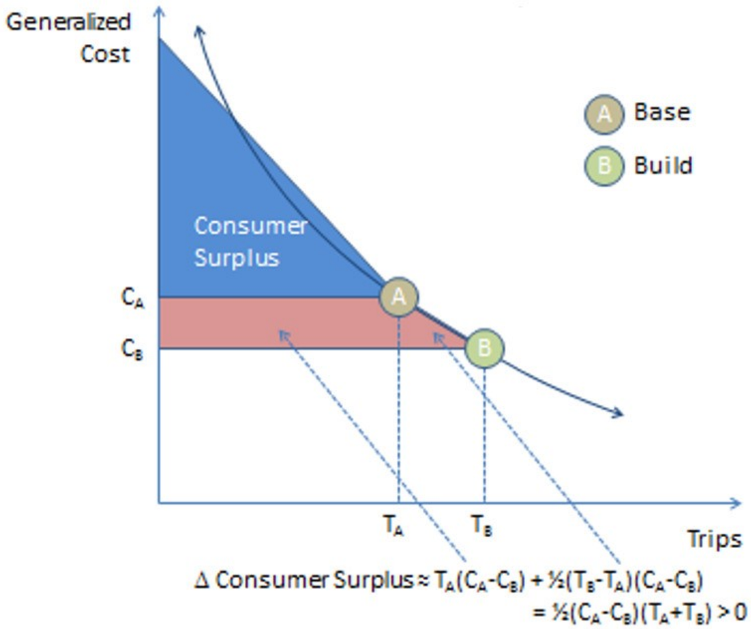
[1] https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/fcauab.pdf

demand function. This method has been applied to user costs and travel time savings in the context of transportation benefit cost analysis for many years and is established good practice.[2]

Figure 1.1 Consumer Surplus



Travel time savings are calculated using the TRMs production-attraction (PA) matrices by trip mode and purpose and appropriate skims. Using the ROH approach as described above, these calculations take the following form:

$$TT_{i,j,k} = -0.5\left(T_{base,i,j,k} + T_{build,i,j,k}\right) \times \left(C_{build,i,j,k} - C_{base,i,j,k}\right) \times \frac{VOT}{60}$$

where $TT_{i,j,k}$ is the travel time savings for origin-destination pair i, mode j, and purpose k; $T_{base,i,j,k}$ is the trip count for OD pair i in the base case; $T_{build,i,j,k}$ the trip count for OD pair i in the build scenario; $C_{build,i,j,k}$ is the travel time for OD pair i in the build scenario; $C_{base,i,j,k}$ is the travel time for OD pair i in the base case; and VOT is the value-of-time.

Travel time savings were calculated separately for off-peak and peak travel. Travel time savings are calculated for all motorized modes, but not for non-motorized modes since walking and biking trip durations are minimally impacted by changes in network congestion. Finally, travel time savings are

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[2] See Abelson, P. and D. Hensher. "Induced Travel and User Benefits: Clarifying Definitions and Measurement for Urban Road Infrastructure." In Handbook of Transport Systems and Traffic Control edited by Kenneth J. Button and David A. Hensher. Pergamon, 2001.

multiplied by VOT, annualized, and discounted to present day values to estimate annual travel time savings:

$$B = TT \times AF \times \frac{1}{1 + r^t}$$

where B is the yearly benefit in 2019 dollars, TT is the aggregate travel time benefit, AF is an annualization factor equal to 365, r is the discount rate (7%), and t is the time difference in years between when the benefit is calculated (2045) and the present (2019).

The valuation of travel time is a challenging topic, much debated in literature. Many different studies and methodologies have produced a range of estimates of the value of travel (VOT) time savings. These studies help establish a reasonable range of values, but also make selection of a particular value difficult. For these reasons, a sensitivity analysis was performed in the initial stages of the project and results were presented to the Technical Steering Committee (see Table 1-3 for a summary). CAMPO staff agreed that the VOT recommended by USDOT, $15.26 in 2019 USD, was appropriate for this study as it provides reasonable, middle of the spectrum scenario analysis results.

Table 1-3 Value of Time (VOT) Sensitivity Analysis Results

Source	Value of Time (VOT) in 2019 US Dollar	Net Present Value for the Highway Expansion Scenario
TRMv6	$13.03 per hour	$119,000
USDOT Guidance	$15.26 per hour	$162,000
TTI/TxDOT	$18.83 per hour	$230,500

1.3. Travel Time Reliability

Travel time reliability is the consistency or dependability in travel times, as measured from day-to-day and/or across different times of the day.[3] Considerable federal research has been done on travel time reliability in recent years and several methods for estimating travel time reliability and its value have now been demonstrated. Numerous methods have been developed to estimate travel time reliably as a function of congestion, most notably the SHRP2 C04 method recently demonstrated by SANDAG[4] and the SHRP2 L11 method recently demonstrated by PSRC[5].

Rather than using a specific method for application in the CAMPO Commuter Corridors Study, a meta-analysis of existing approaches was conducted, and a composite function was developed (dotted red line in Figure 1.2):

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[3] Travel Time Reliability: Making It There On Time, All The Time. 2006. FHWA, http://ops.fhwa.dot.gov/publications/tt_reliability/TTR_Report.htm

[4] Pricing and Travel Time Reliability Enhancements in the SANDAG Activity-Based Travel Model: Final Report

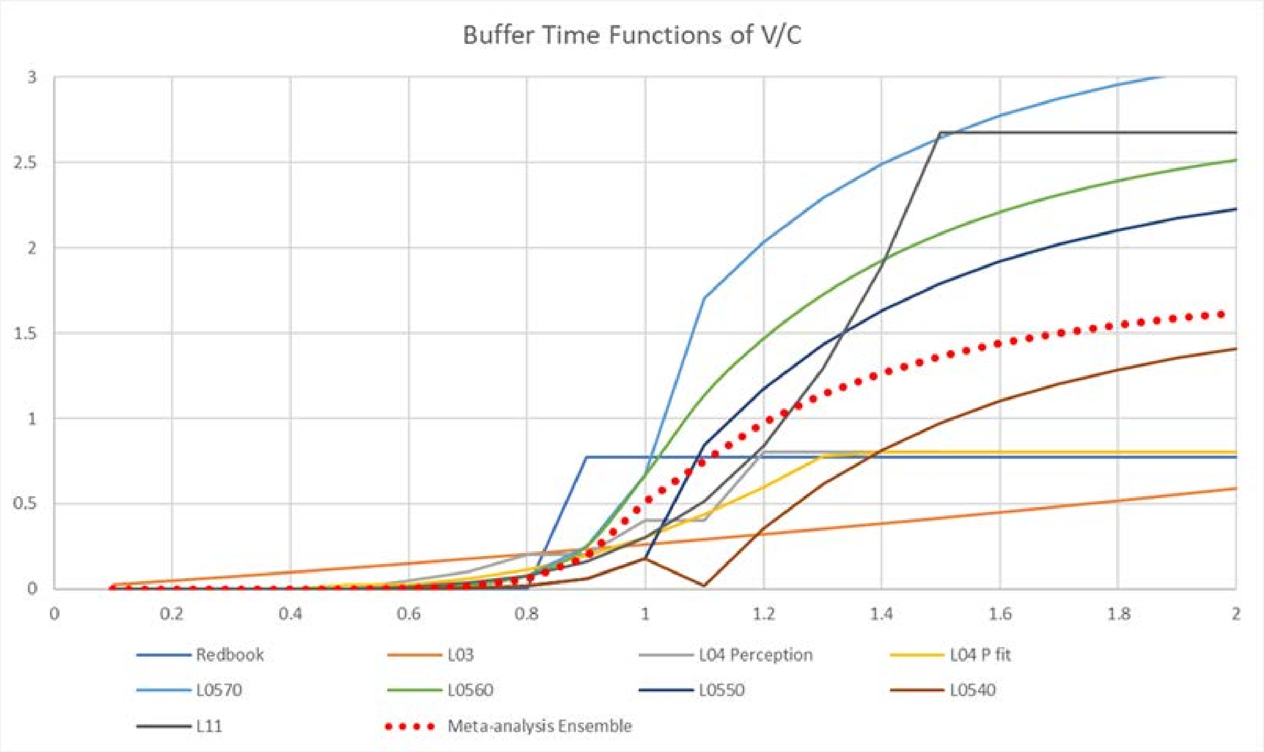
[5] http://www.psrc.org/assets/2127/BCA_Methods_Report_Mar2010update.pdf

$$BTT_i = \begin{cases} TT_i \times 3.67 \times \ln \dfrac{55}{55/1 + 0.15 \times v/c_i{}^{10}}, & v/c_i < 1 \\ TT_i \times 3.67 \times \ln \dfrac{55}{33.5 + 15 \times v/c_i{}^{-3}}, & v/c_i \geq 1 \end{cases}$$

Where BTT_i is the buffer time for link i, TT_i is the congested travel time for link i, and v/c_i is the volume-to-capacity ratio for link i.

For each scenario, BTT_i was calculated for each link and the network was skimmed using congested travel times and buffer times were summed for zone-to-zone path. The skim represents the 95th percentile time it would take to travel between any two zones in the model.

Figure 1.2 Travel Time Reliability as a Function of Volume to Capacity Ratio



Source: SHRP2 C04

The skimmed buffer times estimated as described above were used in a rule-of-half calculation as for travel time savings. Changes in the 95th percentile travel time were then monetized using the USDOT recommended VOT, annualized, and discounted to 2019 dollars.

1.4. Vehicle Operating Costs

Vehicle operating costs represent the variable cost associated with operating a vehicle, such as fuel costs and maintenance. This benefit was calculated on the link level using assigned traffic volumes from the TRM. Maintenance costs were estimated as a function of vehicle-miles travelled while fuel costs were estimates using the United States Environmental Protection Agency (EPA)'s air quality model, or the MOVES model[6]. Vehicle maintenance costs are well-established, and the MOVES model is routinely used to estimate fuel consumption.

However, it is worth noting that there are uncertainties inherent in applying the MOVES model to estimate fuel consumption in the future, such as the potential widespread adoption of electric vehicles in the next several decades[7]. Nonetheless, application of the MOVES model offers the most reasonable current approach to quantify the difference in fuel consumption between different future scenarios.

Vehicle operating costs were calculated differently for fuel and non-fuel cost. These two approaches are described in turn below.

Fuel Costs

The MOVES model is routinely applied for air quality conformity analysis in the region. As part of this process, fuel consumption rates are estimated (pollutant ID 92), which vary by facility type, speed bin, and year, and are output by MOVES in a standard table together with emissions rates. For each link in the TRM, the MOVES fuel consumption rates were multiplied by assigned VMT. The MOVES table expresses fuel consumption in BTUs, which were then converted to gallons of gasoline[8]. Finally, gallons were multiplied by average per-gallon gasoline cost to obtain a monetary value.

Non-Fuel Costs

Automobile operating costs do not include fixed costs that are separately accounted for as vehicle ownership costs, such as purchase, financing, and insurance costs. Automobile operating costs are therefore composed only of maintenance and tire costs. However, truck ownership costs are not separately accounted for and therefore include the costs of truck/trailer lease/purchase, insurance premiums, and permits and licenses in addition to maintenance and tire costs.

Monetization of Fuel Costs

Gasoline costs have been relatively volatile over the past century, although a gradual downward trend can be seen. Prices have varied more substantially over the past decade, spiking in 2010 and returning to pre-spike prices in 2014 (see Figure 1.4). The current national average price for a gallon of gasoline is $2.65. In Raleigh, the average price is slightly lower ($2.47). Given the instability in gasoline prices and the long-term nature of this study, the 10-year average cost per gallon in Raleigh was used to monetize fuel costs savings for the Commuter Corridors Study.

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[6] MOtor Vehicle Emission Simulator (MOVES) is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics.

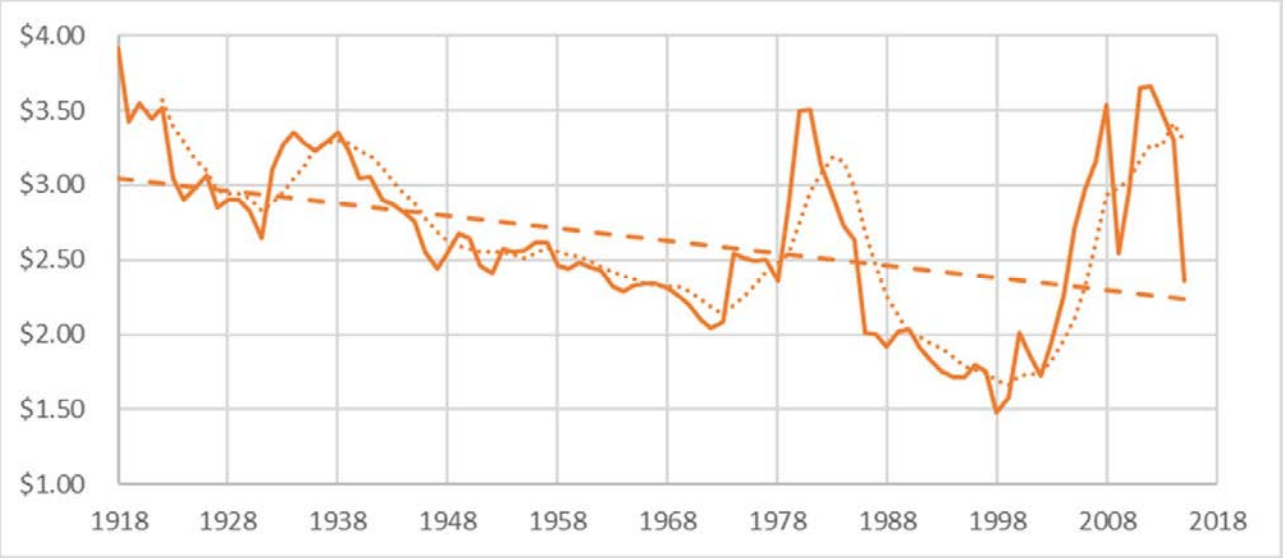
[7] Modeling changes in future fleet fuel efficiency will require revising MOVES's input fleet profiles and then re-running MOVES to produce updated outputs for input to the MCE toolkit. What MOVES assumes for future fleet fuel efficiency is a topic of considerable debate.

[8] http://www.eia.gov/Energyexplained/?page=about_btu

Monetization of Non-Fuel Costs

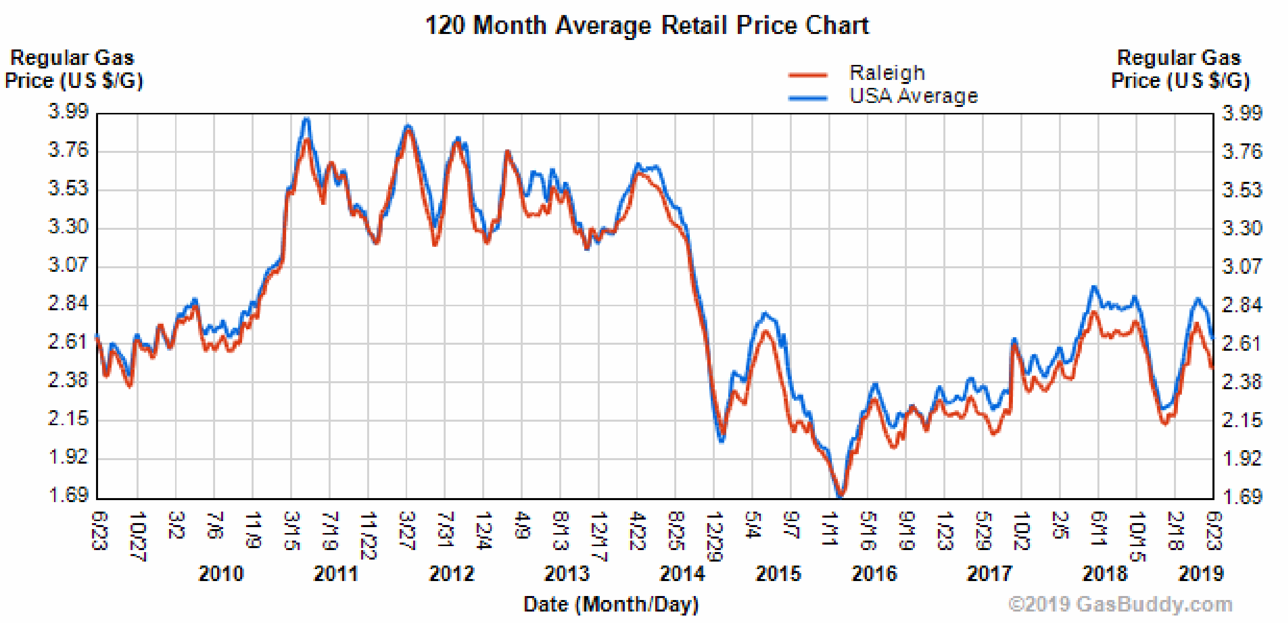
In 2018, AAA estimated a per-mile non-fuel operating cost in the United States of $0.0821/mi. This value accounts for the composition of the vehicle fleet by category (small sedan, SUV, etc.) and can therefore be applied to estimate aggregate costs for the Commuter Corridors Study. This value was multiplied by total VMT for each scenario, annualized, and discounted to 2019 dollars.

Figure 1.3 Inflation Adjusted Gas Prices in the United States, 1918-2018



Note: In the chart above, the solid line represents observed data, the small dash line represents moving average data, and the large dash line represents the trend.

Figure 1.4 Comparison of Raleigh Gas Prices with USA Average, 2009-2019



Source: GASBUDDY.com

1.5. Vehicle Emissions

The valuation of emissions is intended to capture the benefits and costs associated, respectively, with reductions or increases in emissions by pollutant type. EPA's MOVES model is based on considerable academic research and generally accepted as producing good estimates of emissions. The use of MOVES with local data on the vehicle fleet and its fuel efficiency, etc., consistent with air quality analyses provides the best possible method for estimating emissions and these estimates can be regarded as reasonable with some confidence, at least for the near future. However, forecasts of emissions further in the future becomes importantly a function of assumed future fleet fuel efficiency, which is clearly a source of uncertainty.

As for fuel costs, the emissions rates from the MOVES model for pollutants of interest were obtained—greenhouse gases (carbon dioxide equivalents or CO_2e), fine particulate matter ($PM_{2.5}$), particulate matter (PM_{10}), oxides of nitrogen (NO_x), and volatile organic compounds (VOCs). For each link in the TRM, the MOVES emissions rates for the appropriate facility type, speed bin, and year were multiplied by assigned VMT.

A large body of research and practice exists monetizing the impact of transportation emissions, largely based on their public health impacts. USDOT offers guidance on appropriate values for these emissions per metric ton (see Table 1-4). All USDOT values are adopted aside from greenhouse gases, for which the most recent USDOT recommended value is well below scientific consensus. For greenhouse gases, a unit cost recently applied in the Bay Area Air Quality Management District (BAAQMD) Clean Air Plan 2010's Multi-Pollutant Evaluation Method.

Total emissions were multiplied by the costs in Table 1-4, annualized, and discounted to 2019 dollars to monetize vehicle emissions.

Table 1-4 Pollutant Unit Costs

Pollutant	Unit Cost per Metric Ton	Source
CO_2e	$51.81	Bay Area Air Quality Management District
$PM_{2.5}$	$459,000	USDOT
PM_{10}	$139,000	USDOT
NO_x	$7,300	USDOT
VOCs	$37,900	USDOT

1.6. Surface Water

Transportation can significantly impact water quality through, for instance, the deposit of rubber particles, oil, and other pollutants on roads which are washed into storm water when it rains. While quantifying these impacts is challenging, it is generally accepted that water quality impacts are a function of link-level automobile Vehicle Miles of Travel (VMT).

A simple VMT-based approach is used to monetize transportation impacts on surface water quality for the Commuter Corridors Study, implemented as a link-level calculation:

$$W_i = \left(T_{build,i} - T_{base,i}\right) \times \beta$$

where W_i is the monetized impact for link i, $T_{build,i}$ is the modeled link VMT from the TRM in the build scenario, $T_{base,i}$ the modeled link VMT in the base scenario, and β is the estimated unit cost per VMT developed by the Victoria Transport Policy Institute based on research by the Washington State Department of Transportation and the Volpe Institute.

Finally, costs are discounted to 2019 US dollars as before. It is important to note that monetizing surface water impacts in this way does not account for mitigation of these impacts which may be a part of some scenarios or projects. These benefits should be regarded with an understanding of their limitations but are still recommended as the best available method for valuing surface water impacts as a best practice in regional, system or scenario analyses.

1.7. Noise

Increases or decreases in noise caused by transportation have economic value. Transportation is largest source of noise in urban areas, and transportation noise has been linked to several negative health outcomes, including incidence of ischemic heart disease, cognitive impairment of children, sleep disturbance, and tinnitus. Further, studies have shown a general willingness to pay to reduce noise. Thus, changes in transportation noise can be assigned an economic valuation.

Transportation noise is largely a function of vehicle speed and volume, though other factors (physical setting, barriers, etc.) can influence the level and perception of transportation noise. To estimate changes in transportation noise for the Commuter Corridors Study, transportation noise was estimated based on VMT, facility type, and vehicle type[9]:

$$N_i = \left(T_{build,i,v} - T_{base,i,v}\right) \times \beta_{f,v}$$

where N_i is the monetized impact for link i, $T_{build,i,v}$ is the modeled link VMT by vehicle class v from the TRM in the build scenario, $T_{base,i,v}$ the modeled link VMT in the base scenario, and β is a monetization factor than varies based on facility type f and vehicle class v (Table 1-5).

Delucchi and Hsu, cited in both AASHTO's User and Non-User Benefit Analysis for Highways and the Victoria Transportation Policy Institute's Transportation Cost and Benefit Analysis Techniques, Estimates and Implications, recommend the noise impact costs in Table 1-5 as a function of VMT by facility functional class and vehicle type.

Table 1-5 Marginal Noise Costs per 1,000 Miles in Urban Areas

Source	Interstate	Other Freeway	Principal Arterials	Minro Arterials	Collectors
Cars	$ 5.23	$ 7.51	$ 2.08	$ 1.01	$ 0.12
Medium Trucks	$ 15.02	$ 23.32	$ 12.40	$ 9.49	$ 1.86
Heavy Trucks	$ 29.49	$ 54.42	$ 35.46	$ 52.88	$ 8.71

1.8. Physical Activity

Active transportation, including walking and biking trips as well as walking or biking to and from public transit, has well-established public health benefits via increased physical activity. Transportation physical activity is associated with reduced incidence of chronic diseases including diabetes and cardiovascular disease and reduces all-cause mortality. The quantification of these benefits has received significant interest over the several years and several tools and methods to do so have emerged. A growing number of transportation agencies across the country, including SANDAG, MTC, PSRC, Nashville MPO, and

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[9] M. Delucchi and S. Hsu. External Damage Cost of Noise Emitted from Motor Vehicles, Journal of Transportation and Statistics, Vol. 1, No. 3, 1998, pp. 135-168

Metro, have integrated health impacts into their transportation decision-making framework in some manner.

For each scenario, per capita transportation physical activity from non-motorized and transit trips (i.e., walking to transit) was estimated by transportation analysis zone (TAZ), trip purpose, and TRM sub-population. For non-motorized trips, the TRM's non-motorized origin-destination matrix was aggregated by origin zone for each trip purpose to obtain per capita trip rates by sub-population. Trip rates were then multiplied by average duration by purpose from a recent regional household travel survey to obtain per capita physical activity duration. Next, transit trips were aggregated by origin TAZ for each purpose and sub-population. Per capita walking time was obtained by multiplying trip rates by walk time from walking time to and from transit taken from the TRM's transit skims. Non-motorized and transit per capita physical activity durations were summed and converted to metabolic equivalents (MET-hrs). Health impacts were calculated using the population attributable fraction (PAF) approach:

$$PAF_i = \frac{RR_i P_{i,b} - RR_i P_{i,s}}{RR_i P_{i,b}}$$

where PAF_i is the population attributable fraction for sub-population i, RR_i is the relative risk of all-cause mortality for i, $P_{i,b}$ is baseline population exposure and $P_{i,b}$ is population exposure in the modeled scenario. RR_i was estimated using a log-linear dose-response function:

$$RR_i = 0.90^{\frac{MET_i}{11.25}}$$

where MET_i is transportation physical activity for i. Finally, attributable mortality for each sub-population (AM_i) was estimated:

$$AM_i = DR_i \times PAF_i$$

Finally, estimated yearly avoided mortality (AM_i) was multiplied by the Value of a Statistical Life (VSL) and discounted to 2019 dollars.

1.9. Accessibility

While it is widely recognized that the availability of alternative modes or destinations (accessibility) itself constitutes a key benefit of transportation infrastructure and services, systematic approaches to valuing changes in accessibility are limited. Recent research conducted by RSG and ECONorthwest developed an approach to quantify accessibility benefits using changes in destination choice logsums within a travel demand model[10].

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[10] For details, see Advancing Transportation Planning through Innovation and Research: Benefit Cost Analysis using Activity-Based Models, Draft Final Report.

Accessibility benefits were calculated based on the change in destination choice logsums in the TRM. The TRM's destination choice model is based on all available motorized modes, and thus captures changes in accessibility for both auto and transit modes. Benefits were calculated at the zone level. First, trip productions in each zone were multiplied by WHAT:

$$A_{i,j,k} = {}^{-0.5\left(P_{base,i,j,k} + P_{build,i,j,k}\right) \times \left(ls_{base,i,j,k} - ls_{build,i,j,k}\right)}\Big/_{UPM} \times \frac{VOT}{60}$$

where $A_{i,j,k}$ is the travel time savings for zone i, mode j, and purpose k; $P_{base,i,j,k}$ is trip productions for zone i in the base case; $P_{build,i,j,k}$ is trip productions for zone i in the build scenario; $ls_{build,i,j,k}$ is the sum of logsums for zone i in the build scneario; $ls_{base,i,j,k}$ the sum of logsums for zone i base case; and UPM is the utilities per minute specific to each travel mode.

Finally, the rule-of-half was applied as for travel time and reliability calculations to estimate the value of changes in accessibility between the base case and each scenario. Benefits were then annualized and discounted to 2019 dollars.