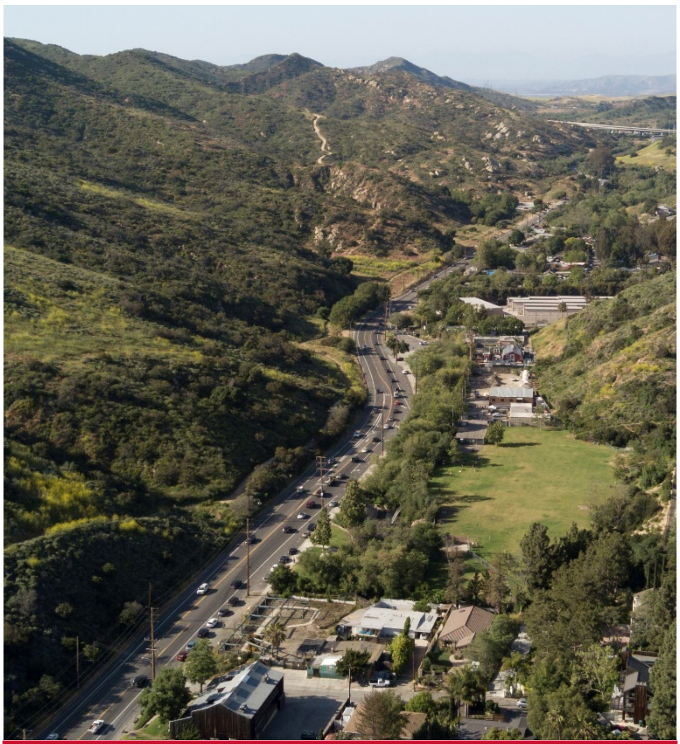

Task 3: Cost/Benefit Framework and Synthesis

Cost-Benefit Analysis and Feasibility Study for the Acquisition of SR 133 from Coast Highway to El Toro Road

Laguna Beach, CA

October 29, 2020

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1 Introduction

The purpose of Task 3: Cost/Benefit Framework and Synthesis is to estimate the potential benefits that may accrue to the City of Laguna Beach ("Laguna Beach" or "the City") as a result of various roadway improvement projects for State Route 133 / Laguna Canyon Road, and to weigh these benefits against the costs of the respective roadway improvements. These improvement projects are unlikely to be implemented unless the City of Laguna Beach acquires the roadway. An overview of benefit-cost analysis (BCA) is provided in the technical memorandum for Task 2: Benefit Identification and Quantification.

This document details the benefit-cost analyses undertaken for four potential roadway improvement projects:

- Alternative 1: Utility Undergrounding
- Alternative 2: Corridor Beautification
- Alternative 3: Bicycle and Pedestrian Infrastructure
- Alternative 4: Roadway Widening

The results of these benefit cost-analyses are summarized in Section 2 below, while Section 3 provides detailed definitions of the four project alternatives. Section 4 describes the methodological framework of the benefit-cost analyses, including descriptions of general assumptions, benefit categories, and project costs. Traffic projections used in the calculation of benefits are discussed in Section 5. Section 6 details the methodologies employed for the calculation and monetization of each benefit category, including the underlying data and assumptions. Detailed results of each benefit-cost analysis are presented in Section 7.

2 Executive Summary

A summary of benefit-cost analysis results for each of the four evaluated project alternatives is presented below in **Table 1** in both undiscounted and discounted terms (using a 7 percent real discount rate). Ranges of possible benefit and cost estimates were generated for each of the four project alternatives. **Table 1** presents the central results only, while the complete results (including "low" and "high" results) are presented in more detail in Section 7.

Table 1: Summary of Benefit-Cost Analysis Results

Project Alternative	30-Year Benefits	30-Year Project Costs	Benefit-Cost Ratio
Undiscounted			
Alternative 1: Utility Undergrounding	$95 Million	$71 Million	1.41
Alternative 2: Beautification	-$2.4 Million	$500 Thousand	-4.85
Alternative 3: Bicycle and Pedestrian Infrastructure	$84 Million	$44 Million	1.92
Alternative 4: Roadway Widening	$178 Million	$109 Million	1.64
Discounted at 7 Percent Discount Rate			
Alternative 1: Utility Undergrounding	$30 Million	$46 Million	0.63
Alternative 2: Beautification	-$735 Thousand	$357 Thousand	-2.06
Alternative 3: Bicycle and Pedestrian Infrastructure	$25 Million	$31 Million	0.81
Alternative 4: Roadway Widening	$45 Million	$78 Million	0.57

3 Alternative Definitions

3.1 Utility Undergrounding

The Utility Undergrounding alternative includes the undergrounding of approximately 2.5 miles of electrical transmission and distribution poles and wires along Laguna Canyon Road between El Toro Road and the Southern California Edison (SCE) substation 1,200 feet south of Canyon Acres Drive. This Utility Undergrounding alternative is consistent with that considered in the Draft Project Study Report (Draft PSR).[1] The project calls for transmission lines along the Laguna Canyon Road corridor to be placed in an underground utility trench along the southbound side of the roadway. Distribution lines (as well as communications, telephone, and cable TV lines) will be placed in an underground utility trench along the northbound side of the roadway, abutting the majority of corridor homes and businesses.

Monetized benefits generated by the Utility Undergrounding alternative include:

- Improved safety conditions from the removal of utility poles that currently pose a roadside hazard;
- Improved aesthetic conditions along the roadway;
- Increased reliability of utility service; and
- Decreased wildfire risk.

[1] Utility Undergrounding alternative details are sourced from the Draft PSR, pp. 30-32.

3.2 Corridor Beautification

The Corridor Beautification alternative maintains and enhances the current rural canyon aesthetic of Laguna Canyon Road. In this alternative, the majority of Laguna Canyon Road is maintained in its current arrangement and aesthetic conditions. Future improvements will include elements that are rustic and rural in nature and small in scale. These include soft surface pathways of decomposed granite or gravel, wood fencing, seating for bus shelters, lighting, and landscaped plantings in the median and adjoining properties. As an example, some large street trees (e.g., sycamores) will be planted in the median of Laguna Canyon Road in the area of Canyon Acres Drive.

Monetized benefits generated by the Corridor Beautification alternative include:

- Improved aesthetic conditions along the Laguna Canyon Road corridor, reflected in increased property values; and
- Carbon sequestration benefits resulting from new plants removing carbon dioxide from the air.

A potential “disbenefit” (or negative benefit) of the Corridor Beautification alternative is:

- Increased safety risk resulting from large trees close to the path of moving vehicles.

Additional non-monetized qualitative benefits of this alternative include:

- Improved stormwater runoff mitigation resulting from the maintained rural, natural landscape.
    - This benefit is not monetized as stormwater runoff conditions are not expected to be improved in this alternative relative to the current "status quo" conditions of Laguna Canyon Road.

3.3 Bicycle and Pedestrian Infrastructure

The Bicycle and Pedestrian Infrastructure alternative features a redesign of Laguna Canyon Road to include one motor vehicle travel lane in each direction, a center turning lane, wider shoulders, a sidewalk on the northbound side of the roadway, a two-way separated bikeway (with emergency vehicle access) on the southbound side of the roadway, and reconfigured intersections. This roadway redesign is consistent with "Alternative 2" as described in the Draft PSR. Project details are sourced from the Draft PSR[2] and its corresponding Traffic Engineering Performance Assessment (TEPA).

Monetized benefits generated by the Bicycle and Pedestrian Infrastructure alternative include:

- Crash reduction safety benefits for cyclists and pedestrians achieved by separating these modes from motor vehicle traffic;
- Crash reduction safety benefits for automobiles achieved by reconfiguring intersections to introduce regular breaks in traffic, facilitating left-turn movements;

[2] Draft PSR, p. 22.

- Improved journey quality for cyclists and pedestrians resulting from the installation of bicycle and pedestrian infrastructure;
- Recreation and health benefits for individuals who begin to walk or cycle as a result of the project improvements; and
- Emissions reduction benefits as some automobile users shift to walking or biking, leading to reduced driving and motor vehicle emissions.

Additional non-monetized qualitative benefits of this alternative include:

- Improved ease and comfort of travel for automobile drivers resulting from redesigned intersections that reduce driver stress;
    - This benefit is considered qualitatively as not enough information is available to accurately monetize it.
- Improved emergency response time as the designated bikeways will be designed to grant access to emergency vehicles and facilitate evacuation from the City of Laguna Beach in emergency events; and
    - This benefit is not monetized due to the high degree of uncertainty regarding the magnitude of benefits.
- Increased property values along the Laguna Canyon Road corridor.
    - This benefit is not monetized as the underlying causes of increased property values are already captured across this alternative’s monetized benefit categories.

3.4 Roadway Widening

The Roadway Widening alternative considers a widening of Laguna Canyon Road between Canyon Acres Drive and El Toro Road to include two travel lanes in each direction, a center turning lane, a sidewalk on the northbound side, and reconfigured intersections. Laguna Canyon Road currently features two travel lanes in each direction and a center turning lane immediately south of Canyon Acres Drive and immediately north of El Toro Road. This project alternative will continue that roadway configuration between the Canyon Acres Drive and El Toro Road intersections, expanding the traffic capacity of the corridor.

Monetized benefits generated by the Roadway Widening alternative include:

- Travel time savings as the roadway widening expands the traffic capacity of Laguna Canyon Road;
- Crash reduction safety benefits for automobiles achieved by reconfiguring intersections to introduce regular breaks in traffic, facilitating left-turn movements;
- Crash reduction safety benefits for pedestrians as the new sidewalk separates pedestrians from automobile traffic;
- Improved journey quality for existing pedestrians through the new sidewalk; and
- Emissions reduction benefits as reduced automotive congestion allows for more consistent vehicle speeds and fuel-efficient driving behaviors.

Additional non-monetized qualitative benefits of this alternative include:

- Improved ease and comfort of travel for automobile drivers resulting from redesigned intersections that reduce driver stress;
  - This benefit is considered qualitatively as not enough information is available to accurately monetize this benefit.
- Improved emergency response time as the designated bikeways will be designed to grant access to emergency vehicles and facilitate evacuation from the City of Laguna Beach in emergency events; and
  - This benefit is not monetized due to the high degree of uncertainty regarding the magnitude of benefits.

4 Methodological Framework

4.1 Principles of Benefit-Cost Analysis

Benefit-Cost Analysis (BCA) is a conceptual framework that quantifies in monetary terms as many of the costs and benefits of a project as possible. Benefits are broadly defined. They represent the extent to which people impacted by the project are made better-off, as measured by their own willingness-to-pay. In other words, central to BCA is the idea that people are best able to judge what is “good” for them, what improves their well-being or welfare.

BCA also adopts the view that a net increase in welfare (as measured by the summation of individual welfare changes) is a good thing, even if some groups within society are made worse-off. A project would be rated positively if the benefits to some were large enough to compensate the losses of others.

Finally, BCA is typically a forward-looking exercise, seeking to anticipate the welfare impacts of a project over its entire life-cycle. Future welfare changes are weighted against today’s changes through discounting. The discount rate represents the (social) opportunity cost of resources and is meant to reflect society’s preference for the present, as well as intergenerational concerns.

4.2 General Assumptions

The benefit-cost analyses conducted in this task quantify and monetize project benefits and weigh them against costs throughout a period of analysis beginning at the start of construction and including 30 years of project operations.

The employed BCA methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Additionally, the BCA approach is consistent with USDOT guidance.[3] Specifically:

- All input prices and monetized values are expressed in 2018 dollars;

[3] USDOT. (2020). *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*.

- The period of analysis begins in 2018 (the base year, per USDOT BCA Guidance) and ends in 2054; it includes project development and construction years (2022-2024) and 30 years of operations (2025-2054);
- The analysis complies with USDOT guidance for the valuation of travel time savings, safety benefits, and emissions reductions benefits, while relying on industry best practice for the valuation of other effects;
- A constant 7 percent real (i.e., adjusted for inflation) discount rate[4] is applied throughout the period of analysis;
- Opening year demand is assumed to be fully realized in 2025; and
- The results shown in this document correspond with the effects of the four “Build” alternatives, relative to the status-quo “No-Build” alternative in which no proposed roadway improvement projects are undertaken.

4.3 Benefit Categories

The benefit categories assessed for each of the four alternatives are consistent with the “potential quantifiable benefits of roadway improvements” described in the technical memorandum for Task 2: Benefit Identification and Quantification. These benefit categories include:

- **Safety Benefits – Crash Reduction**: Roadway infrastructure improvements that are expected to reduce the likelihood or seriousness of vehicular collisions generate crash reduction safety benefits. These improvements include utility undergrounding, intersection reconfigurations as well as the installation of dedicated bicycle and pedestrian infrastructure. In some situations, such as in the case of planting large street trees in close proximity to travel lanes, changes to the roadway conditions may *increase* crash likelihood, resulting in safety “disbenefits.” Crash reduction benefits (or disbenefits) are realized by users of motor vehicles, cyclists, and pedestrians. This benefit category is evaluated for the following project alternatives:
    - Alternative 1: Utility Undergrounding
    - Alternative 2: Corridor Beautification
    - Alternative 3: Bicycle and Pedestrian Infrastructure
    - Alternative 4: Roadway Widening
- **Ease and Comfort of Travel – Aesthetic Benefits**: Two forms of aesthetic benefit are considered: aesthetic improvements resulting from the undergrounding of utility poles and aesthetic improvements resulting from the planting of large street trees. This benefit category is evaluated for the following project alternatives:
    - Alternative 1: Utility Undergrounding

[4] This is consistent with USDOT guidance, which follows the Office of Management and Budget revised Circular A-94 (1992). Note, however, that there is no definitive answer to the question of the appropriate discount rate. Treasury Board of Canada recommends 10 percent; Caltrans’ Cal-B/C model uses 4 percent.

  - Alternative 2: Corridor Beautification
- **Ease and Comfort of Travel – Pedestrian and Cyclist Journey Quality**: Improved or expanded sidewalk conditions and dedicated bicycle facilities are expected to generate "journey quality" benefits for pedestrians and cyclists. This benefit category is evaluated for the following project alternatives:
  - Alternative 3: Bicycle and Pedestrian Infrastructure
  - Alternative 4: Roadway Widening
- **Continuity of Utility Services**: The risk of utility outages, including power outages, is reduced when utility infrastructure is moved underground and better protected from severe weather and surface collisions. This benefit category is evaluated for the following project alternative:
  - Alternative 1: Utility Undergrounding
- **Wildfire Mitigation**: Wildfire risk is minimized when above-ground electricity infrastructure is relocated below ground. This benefit category is evaluated for the following project alternative:
  - Alternative 1: Utility Undergrounding
- **Carbon Sequestration**: Plants and vegetation naturally "sequester" carbon dioxide (CO_2) by converting it from gaseous into solid form. Carbon sequestration benefits accrue as this sequestered carbon no longer contributes to global climate change. This benefit category is evaluated for the following project alternative:
  - Alternative 2: Corridor Beautification
- **Recreation and Health Benefits**: Increased physical activity generates societal benefits in the form of improved health and reduced worker absenteeism. Roadway improvements that spur increased physical activity are expected to generate these health benefits, accordingly. This benefit category is evaluated for the following project alternative:
  - Alternative 3: Bicycle and Pedestrian Infrastructure
- **Emissions Reduction Benefits**: Motor vehicle emissions are largely a function of vehicle miles travelled (VMT) and average fuel consumption per mile, with average fuel consumption determined in part by vehicle speed. Roadway improvements that decrease total VMT or improve fuel economy are expected to yield environmental benefits by decreasing total vehicle emissions. This benefit category is evaluated for the following project alternatives:
  - Alternative 3: Bicycle and Pedestrian Infrastructure
  - Alternative 4: Roadway Widening
- **Travel Time Savings**: Roadway expansion is expected to decrease travel times by reducing congestion and allowing for faster average travel speeds. This benefit category is evaluated for the following project alternative:
  - Alternative 4: Roadway Widening

A matrix of benefit categories and the corresponding project alternatives for which they are evaluated is provided below in **Table 2**.

Table 2: Matrix of Project Benefit Categories

Benefit	Alternative 1 Undergrounding	Alternative 2 Beautification	Alternative 3 Bike / Ped	Alternative 4 Widening
Safety Benefits - Automobiles	+	–	+	+
Safety Benefits - Pedestrians			+	+
Safety Benefits - Cyclists			+	
Aesthetic Benefits	+	+		
Pedestrian Journey Quality			+	+
Bicycle Journey Quality			+	
Continuity of Utility Services	+			
Wildfire Mitigation	+			
Carbon Sequestration		+		
Pedestrian Health Benefits			+	
Cyclist Health Benefits			+	
Emissions Reduction Benefits			+	+
Travel Time Savings				+

4.4 Project Costs

Total project costs for each evaluated alternative include capital costs and operations & maintenance (O&M) costs. Capital costs include the upfront cost of implementing each respective roadway improvement project, incurred in the development/construction phase before the start of the benefits period. Operations and maintenance costs include annually recurring expenses throughout the lifespan of the project, following the completion of construction. O&M costs are evaluated on a “marginal” basis, including only the *additional* costs of operations and maintenance above and beyond the cost of operating the existing infrastructure in its current conditions. Accordingly, an expectation of zero O&M cost does not imply that a given project alternative will be free to maintain, but rather that the cost of maintaining that project alternative will not substantively differ from the cost of maintaining the “No-Build” alternative in its status-quo condition. Alternative cost estimates have been sourced from the Draft PSR and from HDR Engineering. Where detailed cost estimates are not available, cost ranges have been employed to account for uncertainty.

4.4.1 Utility Undergrounding

Capital costs for the Utility Undergrounding alternative are sourced from "Table 12: Project Cost Summary" of the Draft PSR.[5] Total Utility Undergrounding capital costs include "right-of-way acquisition," "electrical undergrounding," and "other utilities" costs, as well as pro-rated allocations of "soft costs" including "PA/ED, PS&E, ROW Support" and "Const. Management." As project costs in the Draft PSR are denominated in 2024 dollars, the 3 percent annual inflation rate assumed in the Draft PSR was applied to deflate capital costs to the 2018 base year for use in the benefit-cost analysis.

A range of potential operations and maintenance costs for the Utility Undergrounding alternative were calculated for use in the benefit-cost analysis. The "low" O&M cost estimate assumes that regular maintenance of the underground utility infrastructure does not substantively differ in cost from that of the existing above-ground infrastructure, yielding no additional O&M costs. The "central" and "high" O&M cost estimates reference a 2016 paper that analyzes costs and benefits of underground electricity transmission and distribution lines.[6] In this paper, annual O&M costs are represented as a percentage of infrastructure replacement cost. The central O&M cost estimate in the Utility Undergrounding BCA references annual O&M costs of 1% and 0.1% of replacement cost for transmission and distribution lines, respectively. The high estimate references O&M costs of 5% and 0.5% for the two respective types of power lines.[7] For both the central and high estimates, replacement costs are assumed to match the capital costs of "electrical undergrounding" and "other utilities," as discussed in the previous paragraph.

Project costs for the Utility Undergrounding alternative are presented below in **Table 3**.

Table 3: Utility Undergrounding Project Costs

	30-Year Total Costs		
	Low	**Central**	**High**
Undiscounted			
Capital Costs	$59.7 Million		
Operations & Maintenance Costs	$0	$11.3 Million	$56.7 Million
TOTAL COST	**$59.7 Million**	**$71.0 Million**	**$116.4 Million**
Discounted at 7 Percent Discount Rate			
Capital Costs	$42.6 Million		
Operations & Maintenance Costs	$0	$3.4 Million	$17.2 Million
TOTAL COST	**$42.6 Million**	**$46.0 Million**	**$59.8 Million**

[5] Draft PSR, p. 28.

[6] Larsen, Peter H. (2016). *A Method to Estimate the Costs and Benefits of Undergrounding Electricity Transmission and Distribution Lines*. Lawrence Berkeley National Laboratory and Stanford University. Available at: https://emp.lbl.gov/sites/all/files/lbnl-1006394_pre-publication.pdf.

[7] Larsen, *op. cit.*, Table 2: Sensitivity analysis and impact categories.

4.4.2 Corridor Beautification

Capital costs for the Corridor Beautification alternative are sourced from HDR Engineering. Capital costs include planting 50 sycamore trees at a cost of $9 thousand per tree, plus an irrigation allowance of $50 thousand. The cost of other elements of the Corridor Beautification alternative, including wood fencing and soft surface pathways of decomposed granite or gravel, are not expected to differ substantively from costs in the No-Build alternative. Similarly, annual O&M expenses of the Corridor Beautification alternative are not expected to differ from those of the No-Build alternative.

Project costs for the Corridor Beautification alternative are presented below in **Table 4**.

Table 4: Corridor Beautification Project Costs

	30-Year Total Costs
Undiscounted	
Capital Costs	$500 Thousand
Operations & Maintenance Costs	$0
TOTAL COST	**$500 Thousand**
Discounted at 7 Percent Discount Rate	
Capital Costs	$357 Thousand
Operations & Maintenance Costs	$0
TOTAL COST	**$357 Thousand**

4.4.3 Bicycle and Pedestrian Infrastructure

Capital costs for the Bicycle and Pedestrian Infrastructure alternative are also sourced from the Draft PSR.[8] Infrastructure capital costs include “roadway items” and “structure items” construction costs that correspond with “Alternative 2” in the Draft PSR, pro-rated “right-of-way acquisition” costs, and pro-rated allocations of soft costs consistent with those discussed in the reference to the Utility Undergrounding alternative. Bicycle and Pedestrian Infrastructure capital costs are also deflated to 2018 dollars from the 2024 dollar values shown in the Draft PSR using a 3 percent annual inflation rate.

The Bicycle and Pedestrian Infrastructure alternative does feature additional pavement and concrete area that will require annual maintenance in the future, but it also refurbishes the existing conditions of Laguna Canyon Road. In light of this roadway expansion and condition improvement, it is assumed that annual operations and maintenance expenses in this alternative will not substantively differ from those in the No-Build alternative.

Project costs for the Bicycle and Pedestrian Infrastructure alternative are presented below in **Table 5**.

[8] Draft PSR, p. 28.

Table 5: Bicycle and Pedestrian Infrastructure Project Costs

	30-Year Total Costs
Undiscounted	
Capital Costs	$43.5 Million
Operations & Maintenance Costs	$0
TOTAL COST	**$43.5 Million**
Discounted at 7 Percent Discount Rate	
Capital Costs	$31.1 Million
Operations & Maintenance Costs	$0
TOTAL COST	**$31.1 Million**

4.4.4 Roadway Widening

Capital Costs for the Roadway Widening alternative are assumed to be two to three times those of the Bicycle and Pedestrian Infrastructure alternative. As the Roadway Widening alternative was not analyzed to the level of detail considered in the Draft PSR, this two- to three-time multiple represents a high-level HDR Engineering estimate.

As is the case for the Bicycle and Pedestrian Infrastructure alternative, the Roadway Widening alternative does feature additional pavement and concrete area that will require annual maintenance in the future, but it also refurbishes the existing conditions of Laguna Canyon Road. Accordingly, operations and maintenance expenses of the Roadway Widening alternative are not expected to substantively differ from those in the No-Build alternative.

Project costs for the Roadway Widening alternative are presented below in **Table 6**.

Table 6: Roadway Widening Project Costs

	30-Year Total Costs		
	Low	Central	High
Undiscounted			
Capital Costs	$87.0 Million	$109 Million	$131 Million
Operations & Maintenance Costs	$0		
TOTAL COST	**$87.0 Million**	**$109 Million**	**$131 Million**
Discounted at 7 Percent Discount Rate			
Capital Costs	$62.1 Million	$77.7 Million	$93.2 Million
Operations & Maintenance Costs	$0		
TOTAL COST	**$62.1 Million**	**$77.7 Million**	**$93.2 Million**

5 Traffic Projections

Projections of automotive, bicycle, and pedestrian miles travelled, as well as automotive speed and vehicle hours travelled were gathered from the Traffic Engineering Performance Assessment (TEPA) conducted for Laguna Canyon Road and from HDR Engineering. These traffic projections underlie the calculations of travel time savings, emissions reduction, bicycle and pedestrian ease and comfort of travel, and bicycle and pedestrian recreation and health benefits.

The results of these traffic projections for both the No-Build and various Build alternatives are presented in **Table 7** on the next page.

Table 7: Summary of Traffic Projection Results

	Unit	2025 Value	2045 Value	Source
No-Build Conditions				
Daily Automobile Vehicle-Miles Travelled	Miles	14,690	21,463	HDR Traffic Engineering Performance Assessment (TEPA)
Daily Automobile Vehicle-Hours Travelled	Hours	670	2,425	
Daily Automobile Average Speed	MPH	21.9	10.8	
Daily Cyclist Miles Travelled	Miles	177	242	HDR Engineering Analysis
Daily Pedestrian Miles Walked	Miles	142	194	
Alternative 3: Bicycle and Pedestrian Infrastructure Build Conditions				
Daily Automobile Vehicle-Miles Averted	Miles	36	49	HDR Engineering Analysis
Daily Cyclist Miles Travelled	Miles	310	423	
Daily Pedestrian Miles Walked	Miles	248	389	
Alternative 4: Corridor Widening Build Conditions				
Daily Automobile Vehicle-Miles Travelled	Miles	17,042	24,675	HDR Engineering Analysis
Daily Automobile Vehicle-Hours Travelled	Hours	799	1,452	
Daily Automobile Average Speed	MPH	21.3	17.0	
Daily Pedestrian Miles Walked	Miles	248	389	

6 Benefits Measurement, Data, and Assumptions

This section describes the measurement approach used for each benefit category evaluated for the four roadway project alternatives, as identified in Section 4.2, and presents the associated assumptions, monetization methodologies, and benefit estimates.

6.1 Safety Benefits – Crash Reduction

Crash reduction safety benefits are monetized by calculating the change in crash likelihood expected to result from roadway changes and reconfigurations included in the project alternatives. This change in expected crash likelihood is then monetized according to USDOT-recommended valuation parameters.

Historical Caltrans safety data for Laguna Canyon Road were referenced to calculate baseline "No-Build" crash frequencies for a variety of collision types. Total utility pole, tree, pedestrian, cyclist, and left-turning vehicle crashes, crash fatalities, and crash injuries for the period from 2009 to 2018 were aggregated from the Caltrans data. Annual crash rates were then calculated from these 10-year aggregations, which are represented below in **Table 8**. These average crash rates can be thought of as the expected likelihood of each crash type in the "No-Build" alternative in which no roadway changes are implemented.

Table 8: Laguna Canyon Road Historical Crash Data (2009 – 2018)

Variable Name	Unit	Value	Source
Average Annual Utility Pole Crashes			HDR Analysis of Caltrans Crash Data
Utility Pole Crashes	Crashes per Year	4.4	
Utility Pole Crash Fatalities	Fatalities per Year	0.0	
Utility Pole Crash Injuries	Injuries per Year	2.7	
Average Annual Tree Crashes			
Tree Crashes	Crashes per Year	1.4	
Tree Crash Fatalities	Fatalities per Year	0.0	
Tree Crash Injuries	Injuries per Year	0.9	
Average Annual Bicycle Crashes			
Bicycle Crashes	Crashes per Year	2.6	
Bicycle Crash Fatalities	Fatalities per Year	0.0	
Bicycle Crash Injuries	Injuries per Year	2.2	
Average Annual Pedestrian Crashes			
Pedestrian Crashes	Crashes per Year	2.1	
Pedestrian Crash Fatalities	Fatalities per Year	0.3	
Pedestrian Crash Injuries	Injuries per Year	1.6	
Average Annual Left-Turning Vehicle Crashes			
Vehicles Involved in Left-Turning Crashes	Crashed Vehicles per Year	22.7	
Left-Turning Vehicle Crash Fatalities	Fatalities per Year	0.0	
Left-Turning Vehicle Crash Injuries	Injuries per Year	2.7	

Crash modification factors (CMFs) were employed in combination with these historical crash frequencies to calculate the future crash likelihoods that are expected to result from the roadway improvements included in each project alternative. A CMF is a multiplier that indicates the proportion of crashes that would be expected to occur after the implementation of a given "countermeasure."[9] CMFs are calculated through applied

[9] http://www.cmfclearinghouse.org/userguide_CMF.cfm

research that analyzes the safety effects of prior implementations of given countermeasures. For example, if an intersection historically has 10 crashes per year, and after the implementation of a specific type of traffic signal that collision rate drops to 6 crashes per year, the CMF for that specific type of traffic signal in the context of that intersection would be 60% (*i.e.*, 6 crashes per year / 10 crashes per year). Multiplying a CMF by a "No-Build" crash rate provides an estimation of expected "Build" crash rate for the "Build" countermeasure; the difference between the "No-Build" and "Build" crash rates approximates the crash aversion safety benefit (or disbenefit).

Crash modification factors employed for the respective roadway changes implemented in the four project alternatives are shown below in **Table 9**. Note that the CMF for the "Relocate Tree Closer to Roadway" countermeasure is greater than 1, implying that crashes are *more* likely when trees are relatively closer to a roadway. CMFs were chosen to apply as appropriately as possible to the safety countermeasures included in the project alternatives. Where CMF ranges are shown, the relatively larger CMFs were applied to estimate "low" safety benefits while the relatively smaller CMFs were applied to estimate "high" safety benefits.

Table 9: Crash Modification Factors Used in the Calculation of Safety Benefits

CMF Countermeasure	Unit	Value	Source
Remove or Relocate Fixed Objects, Including Trees	CMF	0.62	*Data Needs for Tree Removal Crash Modification Factors on Arizona State Highways.* Hovey and Chowdhury 2005.
Relocate Tree Closer to Roadway	Implied Inverse CMF	1.61	
Install Separated Bikeway	CMF	0.55	*Crash Modification Factor Clearinghouse* CMF ID: 4034 "Installation of a cycle track 2-5m from the side of the main road" *Road Factors and Bicycle-Motor Vehicle Crashes at Unsignalized Priority Intersections*
Install Sidewalk	CMF	0.11 – 0.35	*FHWA Desktop Reference for Crash Reduction Factors* "Install sidewalk (to avoid walking along roadway)"
Introduce Regular Breaks in Traffic for Left Turns	CMF	0.61 – 0.72	*Crash Modification Factor Clearinghouse* CMF IDs: 7981 - 7983 "Install a traffic signal" *Safety Evaluation of Signal Installation With and Without Left Turn Lanes on Two Lane Roads in Rural and Suburban Areas*

The calculated reduction in crash likelihoods were monetized according to the USDOT-recommended crash reduction valuations shown in **Table 10** on the next page.

Table 10: Crash Reduction Valuations Used in the Estimation of Safety Benefits ($2018)

Variable Name	Unit	Value	Source
Value of Averted Injury (Severity Unknown)	$ per injury	$174,000	USDOT, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, January 2020. ("USDOT BCA Guidance") Appendix A, Table A-1
Value of Averted Fatality	$ per fatality	$9,600,000	
Value of Averted Property Damage Only Crash	$ per vehicle	$4,400	USDOT BCA Guidance. Appendix A, Table A-2

A summary of crash reduction safety benefits, or disbenefits, is provided below in **Table 11**.

Table 11: Summary of Crash Reduction Safety Benefits

Project Alternative	30-Year Benefit Total		
	Low	Central	High
Undiscounted			
Alternative 1: Utility Undergrounding	$12.5 Million		
Alternative 2: Beautification	-$2.6 Million		
Alternative 3: Bicycle and Pedestrian Infrastructure	$62.3 Million	$73.0 Million	$83.7 Million
Alternative 4: Roadway Widening	$57.7 Million	$68.4 Million	$79.1 Million
Discounted at 7 Percent Discount Rate			
Alternative 1: Utility Undergrounding	$3.8 Million		
Alternative 2: Beautification	-$786 Thousand		
Alternative 3: Bicycle and Pedestrian Infrastructure	$18.9 Million	$22.1 Million	$25.4 Million
Alternative 4: Roadway Widening	$17.5 Million	$20.7 Million	$24.0 Million

6.2 Ease and Comfort of Travel – Aesthetic Benefits

Aesthetic benefits are expected to be generated by project alternatives that improve the look, feel, and character of the Laguna Canyon Road corridor. Specifically, these benefits accrue as a result of the removal of unsightly above-ground utility infrastructure and the planting of new aesthetically pleasing street trees.

Aesthetic benefits associated with utility pole undergrounding are calculated by multiplying the total value of property within sight of Laguna Canyon Road power infrastructure by estimates of averted "overhead utility aesthetic-related property loss."

Estimates of nearby property values are sourced from HDR GIS analysis of the Laguna Canyon Road corridor and from Zillow property value estimates. Total area property values are calculated by multiplying total area property count by the median value of non-zero property values from the Zillow database. This aggregation is generated for all properties within ¼ mile and ½ mile of the Laguna Canyon Road corridor; the ¼ mile radius is utilized as the "base case" in benefit calculation, while the ½ mile radius is available as a sensitivity value. Overhead utility aesthetic-related property loss factor parameters are sourced from economic literature and range from 2.5% to 22.5%.[10]

The assumptions used in the estimation of utility pole undergrounding aesthetic benefits are represented below in **Table 12**. Total aesthetic benefits are calculated as the difference between current property values and those values divided by one minus the respective property loss factors for low, central, and high aesthetic loss estimates. For example, if current properties in sight of overhead utility lines are worth $9 million and those utility lines impose a 10% property loss value, then the same property without those utility lines would be expected to be valued at $10 million [$9 million / (1 – 10%)]. Thus, the aesthetic benefits of removing power lines in this example would be $1 million ($10 million - $9 million).

Table 12: Assumptions Used in the Estimation of Utility Pole Undergrounding Aesthetic Benefits

Variable Name	Unit	Value	Source
Laguna Beach Property Values			
within ¼ mile of Laguna Canyon Road	$	$31.87 Million	HDR GIS Analysis; Zillow Property Database. Product of non-zero median property value and property count. Deflated to $2018 using a 3% annual inflation rate.
within ½ mile of Laguna Canyon Road	$	$106.88 Million	
Overhead Utility Aesthetic-Related Property Loss Factor			
Low	% of property value	2.5%	*A Method to Estimate the Costs and Benefits of Undergrounding Electricity Transmission and Distribution Lines.* Table 2: Sensitivity Analyses and Impact Categories.
Central		12.5%	
High		22.5%	

Street tree planting aesthetic benefits are calculated as the product of total roadway area in sight of new trees and estimates of the aesthetic value of road buffer trees on a dollar per acre basis, as sourced from published literature.[11]

Assumptions used in the estimation of aesthetic benefits are represented in **Table 13** on the next page.

[10] Larsen, *op. cit.*, Table 2: Sensitivity analysis and impact categories.

[11] Moore, Rebecca, *et al.* (2011). *Quantifying the Value of Non-Timber Ecosystem Services from Georgia's Private Forests.* Available at: https://gatrees.org/wp-content/uploads/2020/02/Quantifying-the-Value-of-Non-Timber-Ecosystem-Services-from-Georgias-Private-Forests.pdf. Table 25: Aesthetic and non-use value estimates.

Table 13: Assumptions Used in the Estimation of Street Tree Planting Aesthetic Benefits

Variable Name	Unit	Value	Source
Trees Planted	Trees	50	HDR Assumption
Roadway Area in Sight of New Trees	Acres	9	
Aesthetic Value of Road Buffer Trees			*Quantifying the Value of Non-Timber Ecosystem Services from Georgia's Private Forests.* Table 25: Aesthetic and non-use value estimates. Adjusted to $2018 from $2009 per USDOT BCA Guidance.
Low	$ per Acre per Year	$431	
Central		$717	
High		$1,970	

A summary of monetized aesthetic benefits, both from utility pole undergrounding and street tree planting, is provided below in **Table 14**.

Table 14: Summary of Street Tree Planting Aesthetic Benefits

Project Alternative	30-Year Benefit Total		
	Low	Central	High
Undiscounted			
Alternative 1: Utility Undergrounding	$817 Thousand	$4.6 Million	$9.3 Million
Alternative 2: Beautification	$101 Thousand	$168 Thousand	$461 Thousand
Alternative 3: Bicycle and Pedestrian Infrastructure	--	--	--
Alternative 4: Roadway Widening	--	--	--
Discounted at 7 Percent Discount Rate			
Alternative 1: Utility Undergrounding	$509 Thousand	$2.8 Million	$5.8 Million
Alternative 2: Beautification	$31 Thousand	$51 Thousand	$140 Thousand
Alternative 3: Bicycle and Pedestrian Infrastructure	--	--	--
Alternative 4: Roadway Widening	--	--	--

6.3 Ease and Comfort of Travel – Bicycle and Pedestrian Journey Quality

Project alternatives that expand or improve dedicated infrastructure for cyclists or pedestrians are expected to deliver "journey quality" benefits to the users of those new facilities. Monetized journey quality benefits are calculated for pre-existing cyclists and pedestrians who use sub-standard facilities in the "No-Build" alternative and who will benefit from improved facilities in the project alternatives. Additional journey quality benefits that accrue to new cyclists and pedestrians who do not use facilities in the No-Build alternative are conservatively omitted from benefit monetization in this BCA.

This analysis uses the methodology of the California Department of Transportation's Cal-B/C Active Transportation model (Cal-B/C AT), version 7.2, to assess the value of improved journey quality for pedestrians and cyclists.

For pedestrians, journey quality benefits "are based on the results of stated preference surveys" and are monetized on a per-mile basis.[12] Cal-B/C AT parameters include per-mile pedestrian benefits for seven distinct types of pedestrian amenities: "Street Lighting," "Curb Level," "Crowding," "Pavement Evenness," "Information Panels," "Benches," and "Directional Signage." This BCA utilizes the combined per-mile benefits of Street Lighting, Curb Level, and Pavement Evenness, consistent with the pedestrian infrastructure improvements provided by this project. This monetized per-mile benefit is multiplied by total pre-existing pedestrian mileage, as specified in the "No-Build" alternative and detailed in Section 5, to aggregate walking journey quality benefits realized by pre-existing pedestrians.

Journey quality benefits for cyclists "are driven primarily by revealed preference research on cyclist route [choice]," leveraging "values [that] capture the preference for a designated bike route in comparison with a basic roadway."[13] Cal-BC A/T parameters include cycling "Facility Preference Factors as function of distance by facility class." For example, the Facility Preference Factor for Class I trails is 0.57, indicating that one mile travelled on a Class I trail is equivalent to 0.57 miles traveled on a standard roadway without bicycle facilities. Expressed another way, one mile of cyclist travel on a Class I trail is equivalent to a cyclist averting 0.43 miles of travel on a standard roadway. The Facility Preference Factor for Class IV trails is 0.49. Since the Bicycle and Pedestrian Infrastructure alternative includes a mix of Class I and Class IV bikeway infrastructure, this analysis considers a combined average Facility Preference Factor of 0.53. The mile-equivalent savings of improved cycling facilities is monetized according to average cyclist speed, per Cal-B/C AT parameters, and the per-hour valuation of cyclist time, per USDOT BCA Guidance. As is the case for pedestrian journey quality, cyclist journey quality in this BCA is only monetized for distance travelled by pre-existing cyclists, conservatively excluding additional consumer surplus gained by individuals that begin cycling as a result of project improvements.

The assumptions used in the estimation of bicycle and pedestrian journey quality benefits are summarized in **Table 15** on the next page.

[12] California Department of Transportation. (2019). *Cal-B/C Active Transportation Version 7.1 User's Guide and Technical Documentation*. p. 46.

[13] California Department of Transportation, *op. cit.*, p. 44.

Table 15: Assumptions Used in the Estimation of Journey Quality Benefits

Variable Name	Unit	Value	Source
Value of Averted Fatality	$ per event	$9,600,000	USDOT, *BCA Guidance for Discretionary Grant Programs*, January 2020.
Value of Time: Walking or Cycling	$ per hour	$30.40	
Class I Bikeway Facility Preference Factor	Marginal rate of substitution	0.57	Caltrans *Cal-B/C Active Transportation Model* Version 7.2, February 2020 Monetary values adjusted to $2018 per USDOT BCA Guidance
Class IV Bikeway Facility Preference Factor	Marginal rate of substitution	0.49	
Average Bikeway Facility Preference Factor	Marginal rate of substitution	0.53	
Average Cycling Speed	Miles per hour	11.8	
Pedestrian Value of Amenities: Total of Street Lighting, Curb Level, and Pavement Evenness	$ per mile	$0.223	

A summary of monetized bicycle and pedestrian journey quality benefits is provided below in **Table 16**.

Table 16: Summary of Journey Quality Benefits

Project Alternative	30-Year Benefit Total
Undiscounted	
Alternative 1: Utility Undergrounding	--
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	$1.9 Million
Alternative 4: Roadway Widening	$251 Thousand
Discounted at 7 Percent Discount Rate	
Alternative 1: Utility Undergrounding	--
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	$561 Thousand
Alternative 4: Roadway Widening	$72 Thousand

6.4 Continuity of Utility Services

Above ground utility infrastructure, including electricity transmission and distribution lines, are exposed to the natural elements and to human-caused damage (*e.g.*, vehicle crashes). Relocating utility infrastructure underground or better protecting it at ground level can generate societal benefits by decreasing the risk of utility service interruption.

Continuity of utility services benefits are monetized according to economic literature, Southern California Edison (SCE) statistics on circuit reliability for Laguna Beach, and

HDR analysis of Southern California Association of Governments (SCAG) land use datasets.

An approximation of the number of utility customers served by the electrical infrastructure along Laguna Canyon Road was estimated with the SCAG land use datasets by counting the total number of residential, other, and commercial / industrial parcels within ½-mile, 1-mile, and 2-mile radii of the roadway. This BCA uses the 2-mile radius as the "base case" assumption of the number of customers served by Laguna Canyon Road electrical infrastructure, with the smaller radius values provided for sensitivity analysis purposes.

The economic values of a utility "lost load" for each of these customers were sourced from economic literature analyzing the costs and benefits of utility undergrounding[14] and inflated to 2018 dollars. Lost load valuations are categorized by property type, with residential lost load values ranging from $0.52 to $5.11 per outage, commercial and industrial values ranging from $1,924 to $17,316 per outage, and all other property type values ranging from $90.80 to $817.22.

Estimates of the expectations of averted power outages were sourced from SCE statistics of the frequency of power outages in Laguna Beach and the underlying causes of these outages. The results of HDR's analysis of these SCE statistics show that undergrounding the electrical infrastructure along Laguna Canyon Road would be expected to avert 0.505 electrical outage per year.

The assumptions used in the estimation of continuity of utility services benefits are summarized below in **Table 17**.

Table 17: Assumptions Used in the Estimation of Continuity of Utility Services Benefits

Variable Name	Unit	Value	Source
Utility Customer Count			
Parcels within ½ mile: Residential	Parcels	510	HDR Analysis; SCAG 2016 land use datasets
Parcels within ½ mile: Other	Parcels	4	
Parcels within ½ mile: Commercial and Industrial	Parcels	134	
Parcels within 1 mile: Residential	Parcels	2,684	
Parcels within 1 mile: Other	Parcels	11	
Parcels within 1 mile: Commercial and Industrial	Parcels	340	
Parcels within 2 miles: Residential	Parcels	11,643	
Parcels within 2 miles: Other	Parcels	103	
Parcels within 2 miles: Commercial and Industrial	Parcels	613	
Laguna Beach Power Outage Statistics			

[14] Larsen, *op. cit.*, Table 2: Sensitivity analysis and impact categories.

Variable Name	Unit	Value	Source
Laguna Beach System Average Interruption Frequency Index (SAIFI), 2019	Outages per Year	1.5	Southern California Edison: Circuit Reliability Review, Laguna Beach, 2020.
Laguna Beach Contributions to SAIFI by Outage Cause			
Public Safety Power Shutoff	% of Outages	0.0%	
Equipment Failure		42.3%	
Operation		24.0%	
Vegetation/Animal		13.4%	
Weather/Fire/Earthquake		20.3%	
% Decrease in Outage Cause Resulting from Underground Infrastructure			HDR Analysis
Public Safety Power Shutoff	% Decrease in Outages	0%	
Equipment Failure		5%	
Operation		5%	
Vegetation/Animal		90%	
Weather/Fire/Earthquake		90%	
TOTAL		34%	
Lost Load Values by Customer Class			
Low			*A Method to Estimate the Costs and Benefits of Undergrounding Electricity Transmission and Distribution Lines.* Inflated to $2018 per USDOT BCA Guidance.
Residential	$ per Lost Load	$0.52	
Other		$90.80	
Commercial and Industrial		$1,924	
Central			
Residential	$ per Lost Load	$2.82	
Other		$454.01	
Commercial and Industrial		$9,620	
High			
Residential	$ per Lost Load	$5.11	
Other		$817.22	
Commercial and Industrial		$17,316	

Continuity of utility services benefits are calculated as the product of averted electrical outages per year, customers affected per outage, and value of outage per customer. A summary of monetized continuity of utility services benefits is provided below in **Table 18**.

Table 18: Summary of Continuity of Utility Services Benefits

Project Alternative	30-Year Benefit Total		
	Low	Central	High
Undiscounted			
Alternative 1: Utility Undergrounding	$15.7 Million	$78.4 Million	$141 Million
Alternative 2: Beautification	--	--	--
Alternative 3: Bicycle and Pedestrian Infrastructure	--	--	--
Alternative 4: Roadway Widening	--	--	--
Discounted at 7 Percent Discount Rate			
Alternative 1: Utility Undergrounding	$4.8 Million	$23.8 Million	$42.8 Million
Alternative 2: Beautification	--	--	--
Alternative 3: Bicycle and Pedestrian Infrastructure	--	--	--
Alternative 4: Roadway Widening	--	--	--

6.5 Wildfire Mitigation

Wildfires, which are often sparked by above-ground electricity infrastructure, can be devastating events. In recent Laguna Beach history, a 1993 fire that started north of El Toro Road burned 16,000 acres and destroyed 400 homes (although the cause of this fire was unrelated to electrical infrastructure).

Wildfire mitigation benefits that may accrue from utility undergrounding are calculated based on observed average annual wildfire damage resulting from power line-associated wildfires, as sourced from the California Department of Forestry and Fire Protection (CAL FIRE). As CAL FIRE data for Orange County was not available, CAL FIRE data for Riverside, San Bernardino, and San Diego counties from 2008 to 2018 was used in this analysis. Wildfire mitigation benefits are calculated as the product of annual power line-associated wildfire damage for these three counties and the ratio of project area transmission line mileage to total transmission line mileages in the same three counties.

Assumptions used in the monetization of wildfire mitigation benefits are shown in **Table 19** on the next page.

Table 19: Assumptions Used in the Estimation of Wildfire Mitigation Benefits

<table>
<tr><th>Variable Name</th><th>Unit</th><th>Value</th><th>Source</th></tr>
<tr><td colspan="3">Average Annual Southern California Annual Wildfire Damage, 2008-2018 (Riverside, San Bernardino, and San Diego Counties)</td><td rowspan="3">HDR Analysis of CAL FIRE data</td></tr>
<tr><td>All Wildfires</td><td rowspan="2">Average $ Damage per Year</td><td>$12.18 Million</td></tr>
<tr><td>Power Line-Associated Wildfires</td><td>$167.7 Thousand</td></tr>
<tr><td colspan="3">Electric Transmission Line Mileage</td><td rowspan="4">HDR Analysis of CAL FIRE data</td></tr>
<tr><td>Riverside, San Bernardino, and San Diego Co.</td><td rowspan="2">Miles of Transmission Lines</td><td>7,590</td></tr>
<tr><td>Project Area</td><td>2.5</td></tr>
<tr><td>Mileage Ratio: (Project Area) / (Sample Counties)</td><td>%</td><td>0.03%</td></tr>
</table>

A summary of monetized wildfire mitigation benefits is provided below in **Table 20**. The unpredictable nature and high volatility of wildfire damage imply that the distribution of potential wildfire mitigation benefits has a very “long tail” in statistical terms. In other words, while the average expectation of wildfire mitigation benefits based on eleven years of historic damage may be very low, there is a possibility that wildfire mitigation benefits may be extremely high—measured in the hundreds of millions of dollars—under certain circumstances.

Table 20: Summary of Wildfire Mitigation Benefits

Project Alternative	30-Year Benefit Total
Undiscounted	
Alternative 1: Utility Undergrounding	$1,085
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	--
Alternative 4: Roadway Widening	--
Discounted at 7 Percent Discount Rate	
Alternative 1: Utility Undergrounding	$329
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	--
Alternative 4: Roadway Widening	--

6.6 Carbon Sequestration

Plants and vegetation naturally absorb atmospheric carbon dioxide (CO_2) from the air and “sequester” the carbon in solid form through the process of photosynthesis. Sequestered carbon that is removed from the air no longer contributes to global climate change, generating environmental benefits.

Each new tree planted as part of a roadway improvement project sequesters a given amount of carbon dioxide each year, removing carbon from the atmosphere. Total carbon sequestration benefits are monetized as the product of i) the number of new trees planted in a roadway improvement project; ii) the average canopy area of each tree; iii) the annual rate of carbon sequestration per square meter of new tree canopy; and iv) the monetized Social Cost of Carbon, which represents the value of removing one metric ton of carbon from the atmosphere.

Assumptions used in the estimation of carbon sequestration benefits are summarized below in **Table 21**. Estimates of the Social Cost of Carbon increase from $1 to $2 per metric ton over time, consistent with USDOT BCA Guidance.

Table 21: Assumptions Used in the Estimation of Carbon Sequestration Benefits

Variable Name	Unit	Value	Source
Trees Planted	Trees	50	HDR Assumptions and Calculations for California Sycamore
Tree Canopy Radius	Meters	5	
Total New Tree Canopy Area	Square Meters	3,927	
Urban Tree Carbon Sequestration			*Carbon Storage and Sequestration by Trees in Urban and Community Areas of the United States*
U.S. National Average	Kilograms of Carbon Sequestered per Square Meter of Tree Canopy per Year	0.280	
Los Angeles, CA		0.176	
Social Cost of Carbon (CO_2)	$ per Metric Ton	$1 - $2	USDOT BCA Guidance Appendix A, Table A-7.

Low carbon sequestration benefits are calculated in this BCA using the urban tree carbon sequestration rate of Los Angeles, California, as calculated in published literature relating to carbon storage and sequestration.[15] High carbon sequestration benefits are calculated using the U.S. national average carbon sequestration rate. Central benefits are calculated as the midpoint of the low and high benefits.

A summary of monetized carbon sequestration benefits is provided in **Table 22** on the next page.

[15] Nowak, David J., *et al.* (2013). *Carbon storage and sequestration by trees in urban and community areas of the United States.* Table 2. Available at: https://www.fs.fed.us/nrs/pubs/jrnl/2013/nrs_2013_nowak_001.pdf.

Table 22: Summary of Carbon Sequestration Benefits

Project Alternative	30-Year Benefit Total		
	Low	Central	High
Undiscounted			
Alternative 1: Utility Undergrounding	--	--	--
Alternative 2: Beautification	$30	$39	$48
Alternative 3: Bicycle and Pedestrian Infrastructure	--	--	--
Alternative 4: Roadway Widening	--	--	--
Discounted at 7 Percent Discount Rate			
Alternative 1: Utility Undergrounding	--	--	--
Alternative 2: Beautification	$8	$11	$13
Alternative 3: Bicycle and Pedestrian Infrastructure	--	--	--
Alternative 4: Roadway Widening	--	--	--

6.7 Recreation and Health Benefits

Cyclist and pedestrian journey quality benefits, as discussed in Section 6.3, were calculated for pre-existing users of improved bicyclist and pedestrian infrastructure. Recreation and health benefits, alternatively, are calculated for new “induced” users of that same infrastructure that take up active transportation activity as a result of the project improvements.

Increased physical activity—including increased cycling and walking activity—is generally considered to provide health benefits that accrue to individuals and to society. Societal benefits of increased physical activity come in many forms, including increased worker/student productivity, decreased absenteeism, and decreased health care costs. While various methodologies for monetizing these health benefits are published, this BCA adopts the methods of the Cal-B/C AT model, which monetizes increased active transportation activity (*i.e.*, walking and cycling) in the forms of decreased mortality risk and reduced worker absenteeism.

Improved health benefits monetized in the form of decreased mortality risk are described in the Cal-B/C Active Transportation User Guide:

> *Cal-B/C AT adapts the method and data applied in the WHO HEAT model to estimate benefits of reduced mortality. The HEAT approach determines benefits as a reduction in the relative risk of death for bike facility users due to improved health conditions. The estimated reduction in risk for cycling and walking activity has been parameterized in a simplified form that is based on the distance traveled by mode. For cycling, there is a 4.5% reduction in risk for every 365 miles traveled per year (equal also to a 1 mile travel distance per day, every day). For walking, the annual risk reduction per 365 miles*

traveled is 9%. In addition, risk reduction is maximized at 30% for cycling and 45% for walking.[16]

Consistent with the Cal-B/C AT methodology, this BCA references an individual annual mortality risk and decreases that risk proportionally as a result of increased cycling or walking activity. This decreased mortality risk applies to new cyclists and pedestrians who take up active transportation as a result of project improvements, according to the new cyclist and pedestrian count projections described in Section 5, and is scaled according to projected per-person annual cycling and walking mileage. Decreased mortality risk results in an expected reduction in annual fatalities, and this is monetized according to the Economic Value of a Statistical Life per USDOT BCA Guidance.

This BCA also employs the methods of the Cal-B/C AT model to monetize the health benefits of increased physical activity in the form of reduced absenteeism. This methodology is also based on the WHO HEAT model, with benefits calculated by multiplying induced physical activity trips (as described in Section 5) by the expected annual number of sick days averted as a result of increased physical activity (as sourced from the Cal-B/C AT model) and the average daily salary of a California worker (as sourced from Cal-B/C).

Assumptions used in the estimation of recreation and health benefits are summarized below in **Table 23**.

Table 23: Assumptions Used in the Estimation of Recreation and Health Benefits

Variable Name	Unit	Value	Source
Value of Averted Fatality	$ per Fatality	$9,600,000	USDOT BCA Guidance
Value of Time: Walking or Cycling	$ per hour	$30.40	
Mortality Rate - All Causes (Aged 20-64)	%	0.266%	Caltrans *Cal-B/C Active Transportation Model* Version 7.2; February 2020 Monetary values adjusted to $2018 per USDOT BCA Guidance
Percentage Reduction in Mortality per 365 Annual Cycling Miles	%	4.5%	
Percentage Reduction in Mortality per 365 Annual Walking Miles	%	9.0%	
Average Absence of Employees	Days per Year	3.6	
Percentage Covered by Short-Term Sick Leave	%	95%	
Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day	%	6%	
California Statewide Average Hourly Wage	$ per hour	$28.53	

A summary of monetized recreation and health benefits is provided in **Table 24** on the next page.

Table 24: Summary of Recreation and Health Benefits

Project Alternative	30-Year Benefit Total
Undiscounted	

[16] California Department of Transportation, *op. cit.*, p. 50.

Project Alternative	30-Year Benefit Total
Alternative 1: Utility Undergrounding	--
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	$8.7 Million
Alternative 4: Roadway Widening	--
Discounted at 7 Percent Discount Rate	
Alternative 1: Utility Undergrounding	--
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	$2.5 Million
Alternative 4: Roadway Widening	--

6.8 Emissions Reduction Benefits

Total vehicle emissions are generated as the product of vehicle miles travelled and average pollutant emissions per vehicle mile. Project improvements that reduce vehicle miles travelled—such as through inducing “mode shifting” away from motor vehicles to lower-emission modes of travel—or increase vehicle fuel efficiency—such as through allowing for more constant or efficient travel speeds—are expected to reduce total vehicle emissions.

Emissions reduction benefits are calculated as the difference between total vehicle emissions in the “No-Build” alternative and total emissions in the “Build” project alternative scenarios. Monetized vehicle emissions are calculated by multiplying vehicle miles travelled, as represented in Section 5, by Caltrans-recommended grams-per-mile emissions factors and USDOT-recommended dollars-per-ton emissions valuation factors.

The assumptions and parameters used in the monetization of emissions reduction benefits are shown in **Table 25** on the next page. Note that gram-per-mile emissions factors are time series data dependent on vehicle speed. The values represented in the table below correspond with emissions rates as of 2040 for travel speeds of 20 mph and 10 mph, respectively, which are generally representative for summary purposes of the more detailed time series emissions rates employed in this BCA.

Table 25: Assumptions Used in the Estimation of Emissions Reductions Benefits

Variable Name	Unit	Value	Source
Highway Emissions Factors, 20 mph, Model Year 2040			
Carbon Dioxide (CO_2)	Grams per Mile	282.9	Caltrans *Cal-B/C Active Transportation Model* Version 7.2; February 2020
Volatile Organic Compounds (VOCs)		0.0272	
Nitrogen Oxides (NO_x)		0.0303	
Particulate Matter ($PM_{2.5}$)		0.0011	
Sulfur Dioxide (SO_2)		0.0028	
Highway Emissions Factors, 10 mph, Model Year 2040			
Carbon Dioxide (CO_2)	Grams per Mile	415.2	Caltrans *Cal-B/C Active Transportation Model* Version 7.2; February 2020
Volatile Organic Compounds (VOCs)		0.0566	
Nitrogen Oxides (NO_x)		0.0383	
Particulate Matter ($PM_{2.5}$)		0.0024	
Sulfur Dioxide (SO_2)		0.0041	
Damage Costs for Pollutant Emissions			
Social Cost of Carbon (CO_2)	$ per Metric Ton	$1 - $2	USDOT BCA Guidance Appendix A, Table A-7.
Volatile Organic Compounds (VOCs)		$2,313	USDOT BCA Guidance Appendix A, Table A-6.
Nitrogen Oxides (NO_x)		$9,473	
Particulate Matter ($PM_{2.5}$)		$426,611	
Sulfur Dioxide (SO_2)		$55,185	

A summary of monetized emissions reduction benefits is provided in **Table 26** on the next page.

Table 26: Summary of Emissions Reduction Benefits

Project Alternative	30-Year Benefit Total
Undiscounted	
Alternative 1: Utility Undergrounding	--
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	$809
Alternative 4: Roadway Widening	$61.8 Thousand
Discounted at 7 Percent Discount Rate	
Alternative 1: Utility Undergrounding	--
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	$235
Alternative 4: Roadway Widening	$12.6 Thousand

6.9 Travel Time Savings

Travel time savings are aggregated as motor vehicle drivers and passengers are able to increase their average vehicle travel speed and spend less time waiting in traffic on congested roadways as a result of project improvements. Travel time savings are conservatively aggregated in this BCA only for pre-existing vehicles travelling along Laguna Canyon Road. Time savings that accrue to new drivers who are “induced” to travel along Laguna Canyon Road as a result of roadway improvements are not included in the analysis.

“Build” condition vehicle hours travelled for pre-existing vehicles are computed by multiplying “No-Build” vehicle miles travelled by the inverse of “Build” average vehicle speed. The difference between this imputed “Build” vehicle hours travelled for pre-existing drivers and the projected “No-Build” vehicle hours travelled represents vehicle travel time savings for pre-existing vehicles resulting from the project improvements.

Vehicle hours travelled are converted to person-hours and monetized according to the parameters shown below in **Table 27**.

Table 27: Assumptions Used in the Estimation of Travel Time Savings

Variable Name	Unit	Value	Source
Value of Travel Time: All Purposes	$ per Person-Hour	$15.20	USDOT BCA Guidance Appendix A, Table A-3
Average Vehicle Occupancy: Weekday Peak	Persons per Vehicle	1.48	USDOT BCA Guidance Appendix A, Table A-4

A summary of monetized travel time savings is provided below in **Table 28**.

Table 28: Summary of Travel Time Savings

Project Alternative	30-Year Benefit Total
Undiscounted	
Alternative 1: Utility Undergrounding	--
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	--
Alternative 4: Roadway Widening	$109.5 Million
Discounted at 7 Percent Discount Rate	
Alternative 1: Utility Undergrounding	--
Alternative 2: Beautification	--
Alternative 3: Bicycle and Pedestrian Infrastructure	--
Alternative 4: Roadway Widening	$23.8 Million

7 Benefit-Cost Analysis Results

7.1 Utility Undergrounding

Detailed benefit-cost analysis results for the Utility Undergrounding alternative are presented in **Table 29** on the next page. As a central estimate, this alternative is expected to generate approximately $30.4 million in benefits and $46.0 million in costs over thirty years (using a 7 percent discount rate) resulting in a benefit-cost ratio of 0.63.[17] Low estimates of project benefits and costs are $9.0 million and $42.6 million, respectively, while high estimates are $52.3 million and $59.8 million.

[17] Rather than undergrounding all overhead utilities within the roadway, it is feasible to place electrical transmission lines underground within the Orange County park property adjacent to Laguna Canyon Road. Roadway acquisition would only be required to underground the distribution system within the roadway, resulting in a substantial (50 percent) reduction in the cost of electric undergrounding. As a central estimate, this version of the Utility Undergrounding alternative would generate approximately $30.4 million in benefits and $27.7 million in costs over thirty years (using a 7 percent discount rate) resulting in a benefit-cost ratio of 1.11.

Table 29: Utility Undergrounding Benefit-Cost Analysis Results

	Estimates ($ Thousands) 30 years, Undiscounted			Estimates ($ Thousands) 30 years, Discounted at 7%		
	Low	Central	High	Low	Central	High
Benefit Categories						
Safety Benefits: Crash Reduction	$12,486			$3,784		
Ease and Comfort of Travel: Aesthetic Benefits	$817	$4,553	$9,253	$509	$2,835	$5,762
Continuity of Utility Services Benefits	$15,678	$78,421	$141,164	$4,752	$23,768	$42,784
Wildfire Mitigation Benefits	$1.1			<$1		
TOTAL Gross Benefits	**$28,982**	**$95,461**	**$162,904**	**$9,045**	**$30,388**	**$52,330**
Cost Categories						
Capital Costs	$59,674			$42,612		
Operations and Maintenance Costs[1]	$0	$11,336	$56,678	$0	$3,436	$17,178
TOTAL Costs	**$59,674**	**$71,010**	**$116,352**	**$42,612**	**$46,048**	**$59,790**
Benefit-Cost Ratios						
Low Costs	0.49	1.60	2.73	0.21	0.71	1.23
Central Costs	0.30	**1.41**	2.54	0.13	**0.63**	1.15
High Costs	-0.46	0.65	1.78	-3.82	-3.32	-2.80

1. Operations and Maintenance (O&M) Costs represent additional costs above and beyond the expected cost of operating the existing infrastructure in its current conditions. O&M costs are subtracted from benefits in the numerator of the benefit-cost ratio calculation.

7.2 Corridor Beautification

Detailed benefit-cost analysis results for the Corridor Beautification alternative are presented in **Table 30** on the next page. As a central estimate, this alternative is expected to generate approximately -$735 thousand in benefits (driven by crash safety disbenefits) and $357 thousand in costs over thirty years (using a 7 percent discount rate) resulting in a benefit-cost ratio of -2.06. Low estimates of project benefits are -$755 thousand while high estimates are -$646 thousand, resulting in negative benefit-cost ratios in both situations.

Table 30: Corridor Beautification Benefit-Cost Analysis Results

	Estimates ($ Thousands) 30 years, Undiscounted			Estimates ($ Thousands) 30 years, Discounted at 7%		
	Low	Central	High	Low	Central	High
Benefit Categories						
Ease and Comfort of Travel: Aesthetic Benefits	$101	$168	$461	$31	$51	$140
Carbon Sequestration Benefits	<$1	<$1	<$1	<$1	<$1	<$1
Safety Disbenefit: Increased Crash Risk	-$2,594			-$786		
Total Gross Benefits	**-$2,493**	**-$2,426**	**-$2,133**	**-$755**	**-$735**	**-$646**
Cost Categories						
Capital Costs	$500			$357		
Operations and Maintenance Costs[1]	$0			$0		
TOTAL Costs	**$500**			**$357**		
Benefit-Cost Ratios						
Benefit-Cost Ratio	-4.99	-4.85	-4.27	-2.11	-2.06	-1.81

1. Operations and Maintenance (O&M) Costs represent additional costs above and beyond the expected cost of operating the existing infrastructure in its current conditions.

7.3 Bicycle and Pedestrian Infrastructure

Detailed benefit-cost analysis results for the Bicycle and Pedestrian Infrastructure alternative are presented in **Table 31** on the next page. As a central estimate, this alternative is expected to generate approximately $25.2 million in benefits and $31.1 million in costs over thirty years (using a 7 percent discount rate) resulting in a benefit-cost ratio of 0.81. Low estimates of project benefits are $22.0 million while high estimates are $28.4 million, resulting in benefit-cost ratios of 0.71 and 0.92, respectively.

Table 31: Bicycle and Pedestrian Infrastructure Benefit-Cost Analysis Results

	Estimates ($ thousands) 30 years, Undiscounted			Estimates ($ thousands) 30 years, Discounted at 7%		
	Low	Central	High	Low	Central	High
Benefit Categories						
Safety Benefits: Cyclists and Pedestrians	$58,146	$68,029	$77,912	$17,623	$20,618	$23,613
Safety Benefits: Automobiles	$4,147	$4,962	$5,777	$1,257	$1,504	$1,751
Ease and Comfort of Travel: Cyclists and Pedestrians	$1,947			$561		
Recreation and Health: Cyclists and Pedestrians	$8,746			$2,521		
Emissions Reduction Benefits	<$1			<$21		
TOTAL Gross Benefits	**$72,986**	**$83,684**	**$94,382**	**$21,961**	**$25,204**	**$28,446**
Cost Categories						
Capital Costs	$43,508			$31,068		
Operations and Maintenance Costs[1]	$0			$0		
TOTAL Costs	**$43,508**			**$31,068**		
Benefit-Cost Ratios						
Benefit-Cost Ratio	1.68	**1.92**	2.17	0.71	**0.81**	0.92

1. Operations and Maintenance (O&M) Costs represent additional costs above and beyond the expected cost of operating the existing infrastructure in its current conditions.

7.4 Roadway Widening

Detailed benefit-cost analysis results for the Roadway Widening alternative are presented in **Table 32** on the next page. As a central estimate, this alternative is expected to generate approximately $44.6 million in benefits and $77.7 million in costs over thirty years (using a 7 percent discount rate) resulting in a benefit-cost ratio of 0.57. Low estimates of project benefits and costs are $41.3 million and $62.1 million, respectively, while high estimates are $47.8 million and $93.2 million.

Table 32: Roadway Widening Benefit-Cost Analysis Results

	Estimates ($ thousands) 30 years, Undiscounted			Estimates ($ thousands) 30 years, Discounted at 7%		
	Low	Central	High	Low	Central	High
Benefit Categories						
Travel Time Savings: Automobiles	$109,457			$23,781		
Safety Benefits: Automobiles	$4,147	$4,962	$5,777	$1,257	$1,504	$1,751
Safety Benefits: Pedestrians	$53,533	$63,416	$73,299	$16,225	$19,220	$22,215
Ease and Comfort of Travel Benefits: Pedestrians	$251			$72		
Emissions Reduction Benefits	$62			$13		
TOTAL Gross Benefits	**$167,450**	**$178,147**	**$188,845**	**$41,347**	**$44,589**	**$47,832**
Cost Categories						
Capital Costs	$87,016	$108,770	$130,523	$62,136	$77,670	$93,203
Operations and Maintenance Costs[1]	$0			$0		
TOTAL Costs	**$87,016**	**$108,770**	**$130,523**	**$62,136**	**$77,670**	**$93,203**
Benefit-Cost Ratios						
Low Costs	1.92	2.05	2.17	0.67	0.72	0.77
Central Costs	1.54	**1.64**	1.74	0.53	**0.57**	0.62
High Costs	1.28	1.36	1.45	0.44	0.48	0.51

1. Operations and Maintenance (O&M) Costs represent additional costs above and beyond the expected cost of operating the existing infrastructure in its current conditions.