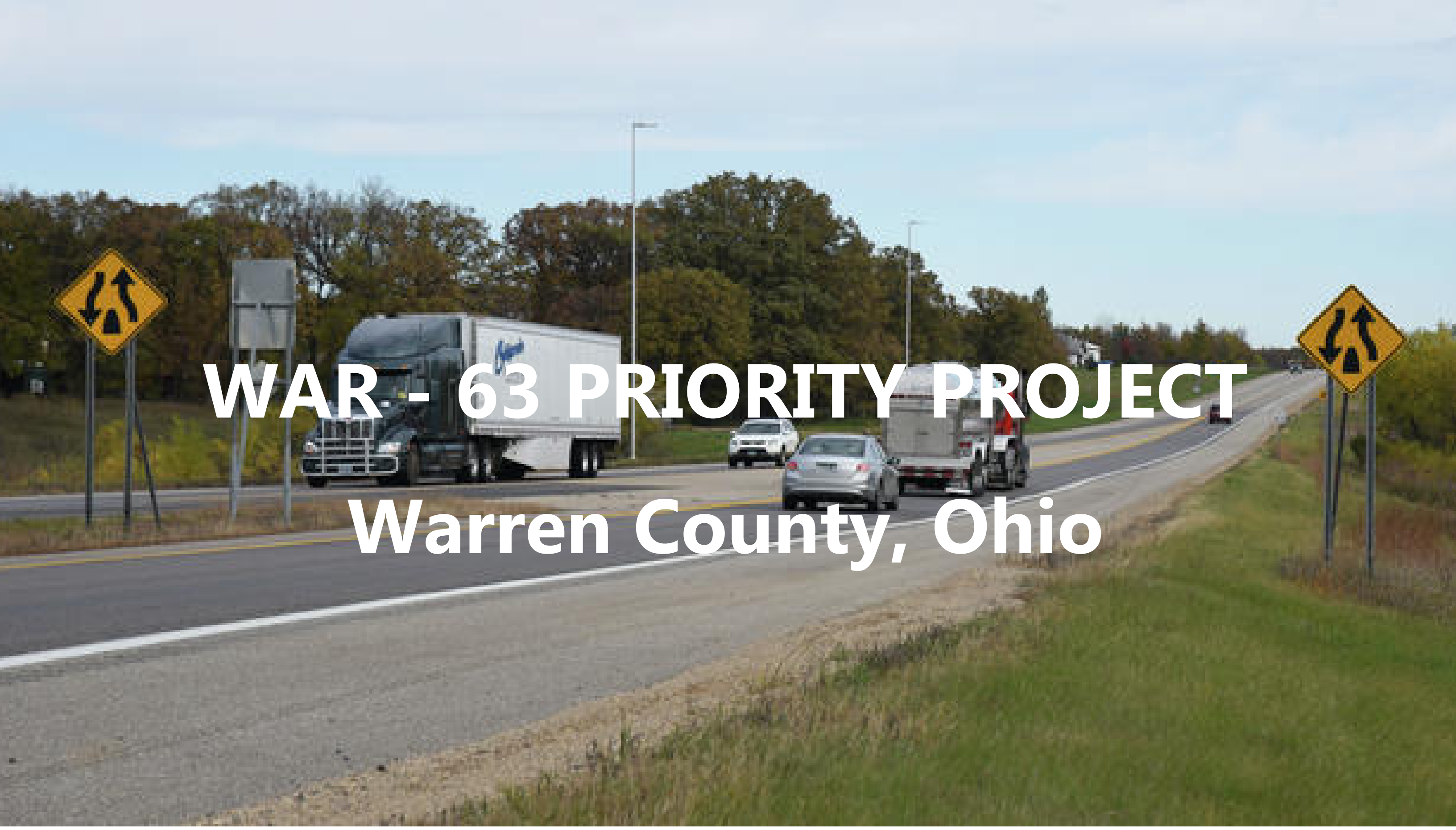
# Benefit-Cost Analysis



# WAR - 63 PRIORITY PROJECT

## Warren County, Ohio

**Warren County Transportation Improvement District**

**June 2019**

# BENEFIT – COST ANALYSIS

## WAR-63 PRIORITY PROJECT
## WARREN COUNTY, OHIO

**WARREN COUNTY TRANSPORTATION IMPROVEMENT DISTRICT**
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**June 2019**

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# 1. Executive Summary

Benefit-Cost Analysis (BCA) compares the benefits of a project to the costs associated with the proposed investment.

A Benefit-Cost Analysis was conducted for the WAR 63 Priority Project using the nationally-recognized *Cal-B/C INFRA* tool developed and supported by the California Department of Transportation. The WAR 63 Priority Project involves widening, geometric improvement and access management of a predominately 2-lane section of SR 63 in Turtle Creek Township in Warren County, Ohio and will extend from west of an at-grade rail crossing in the City of Monroe (SLM = 0.80) to just past a signalized intersection with SR 741 (SLM = 3.5).

The project is located in the Cincinnati Ohio, Kentucky, Indiana (OKI) Urbanized Area. Despite a portion of the project being included in the urbanized area, the project immediately abuts and extends into the rural boundary and currently behaves as a rural primary arterial.

Because the State of Ohio (owner of the facility) is facing a scenario where, despite an increase in the state gas tax, resources for capital expenditures for new or expanded facilities are scarce, and first cost is of primary concern, two build options are being considered. The "best value scenario" will be tested by the market during design-build project procurement.

The No Build scenario maintains the existing 2-lane configuration. Evaluating the No Build scenario helps identify the costs borne by both agency and roadway users in continuing to operate and maintain an inadequate existing facility compared to proposed investment alternatives. Significant resources will be expended to operate and maintain the facility. Regional background traffic growth will continue to put pressure on the facility resulting in a degrading level of service growing more pronounced over time.

Build Case Number 1 – 4-Lane Undivided, identifies the "minimum build" scenario. It is the lowest first-cost build alternative, ODOT's current preferred alternative, and the basis of the BUILD application. It provides four though lanes with center turn-lanes at major intersections, increasing capacity. Regional background growth will be accommodated under this scenario. Additional local development is anticipated and accounted for in the analysis, but absent assurance that it will not impact the level of service of the facility, it is expected to be limited to current committed plans developed in expectation the widening project will occur. These development plans could be abandoned if widening does not in fact occur.

Build Case Number 2 – 4-Lane Divided, provides for a 4-lane divided expansion with grass median and center turn lanes at access locations. Regional background growth will be accommodated under this scenario. Additional local development is anticipated, and because of the differential in motorist experience (reduced visual intrusion and separation of counter-flow traffic) as compared to the 4-lane undivided section, this scenario is expected to produce higher caliber logistic warehousing, advanced manufacturing, and office campus growth.

The benefit-cost analysis found that Build Case Number 2 (4-Lane Divided) returns significantly higher benefit-cost ratios than Build Case Number 1 (4-Lane Undivided), in the range of +20%. This is due primarily to cumulatively significant differences in operational efficiency, net life-cycle cost, and safety performance effects on project benefits over the period of analysis. Both build cases yield significantly positive B/C ratios, in the range of 3.7 to 4.5:1.

Comparative results of the Benefit-Cost Analysis for the two cases evaluated are summarized in **Table ES-1**:

**TABLE ES-1. Comparative results of benefit-cost analysis, WAR-63 Priority Project**

| Measure | Build Case Number 1 4-Lane Undivided | Build Case Number 2 4-Lane Divided |
|---|---|---|
| Life Cycle Costs | $ 22,000,000 | $ 26,200,000 |
| Life Cycle Benefits | $ 81,700,000 | $ 117,200,000 |
| Net Present Value | $ 59,000,000 | $ 91,000,000 |
| Benefit/Cost Ratio | 3.7 | 4.5 |
| Rate of Return on Investment | 17.6% | 22.8% |
| Payback Period | 10 Years | 7 Years |

Benefit-Cost Analysis, while a useful benchmark from which to evaluate and compare potential transportation investments, is not the only decision-making tool involved in project selection. Other considerations include financial capacity, community concerns, and environmental factors.

This analysis will be used during the design-build procurement process, which will use alternative technical concepts to elicit best value outcomes for the funding agencies and roadway users.

## 2. Introduction

A Benefit-Cost Analysis (BCA) provides estimates of the anticipated benefits that are expected to accrue from a project over a specified period (in this case 21 years – a 20-year service life and 1-year construction period) and compares them to the anticipated costs of the project.

Background technical information about how the analysis was conducted is provided in Sections 3 through 7:

> **Section 3, Methodology**, discusses the general approach taken in conducting the BCA.
>
> **Section 4, Project Overview**, includes a brief description of the project, the existing conditions and proposed alternatives; a discussion of the types of impacts expected (both benefits and costs); and a summary of agency costs (capital, operations, and maintenance).
>
> **Section 5, General Approach and Assumptions**, discusses the assumptions about estimating project costs and benefits, and associated rationale, used in conducting the BCA. Use of the Cal-B/C INFRA modeling tool is introduced.
>
> **Section 6, Travel Demand Projections,** discusses the assumptions about travel demand and growth used in conducting the BCA.
>
> **Section 7, Data Inputs and Assumptions**, describes the economic benefits evaluated using the Cal-B/C INFRA modeling tool and provides the inputs (data and assumptions) used in building the project's benefit-cost profile.

Evaluation of model output and associated findings are provided in Sections 8 and 9:

> **Section 8, Summary of Benefit-Cost Outcomes**, discusses the model output and presents the findings of the analysis. It discusses both traditional benefit streams, and those associated with the BUILD merit criteria.
>
> **Section 9, Benefit-Cost Sensitivity Analysis**, discusses the changes in model outputs when changes are made to project input variables.

## 3. Methodology

The U.S. Department of Transportation Benefit-Cost Analysis Guidance for Discretionary Grant Programs[1] was followed in designing the approach to BCA for the WAR-63 Priority Project. Specifically, the methodology involved:

1) Selecting a project with independent utility;
2) Understanding existing and future conditions under the build and no-build scenarios;
3) Evaluating benefits identified in the U.S. Department of Transportation Benefit-Cost Analysis Guidance for Discretionary Grant Programs and in the merit criteria found in the BUILD Notice of Funding Opportunity (NOFO, Federal Register/Vol. 84, No.78/Tuesday, April 23, 2019);
4) Measuring benefits in dollar terms when possible, and expressing benefits and costs in a common unit of measurement;
5) Quantifying benefits or costs that cannot be monetized using physical units in which they naturally occur, and when it is not possible to either monetize or quantify, describing the costs or benefits qualitatively;
6) Using U.S. DOT guidance (Appendix A) for the valuation of travel time savings, safety benefits and air quality;
7) Relying on industry best practice and professional engineering judgement for valuation of other variables;

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[1] U.S. Department of Transportation Benefit-Cost Analysis Guidance for Discretionary Grant Programs, June 2018
[2] https://www2.census.gov/geo/maps/dc10map/UAUC_RefMap/ua/ua16885_cincinnati_oh--ky--in/DC10UA16885_000.pdf
[3] Available at http://www.dot.ca.gov/hq/tpp/offices/eab/LCBC_Analysis_Model.html
[4] The OKI travel demand model output did not correlate well with existing traffic conditions

8) Discounting future benefits and costs at 7% as recommended by the U.S. DOT guidance;

9) Conducting a sensitivity analysis to assess the impacts of changes in key assumptions.

*Cal-B/C INFRA*, a nationally-recognized and applied tool developed and supported by the California Department of Transportation, was used as the primary analysis platform in conducting the B/C work for the WAR-63 Priority Project.  Agency costs developed in the *Life-Cycle Cost Analysis* for the project (using FHWA's *RealCost* analysis tool) were part of the input array to *Cal-B/C INFRA* and the overall B/C analysis.

# 4. Project Overview

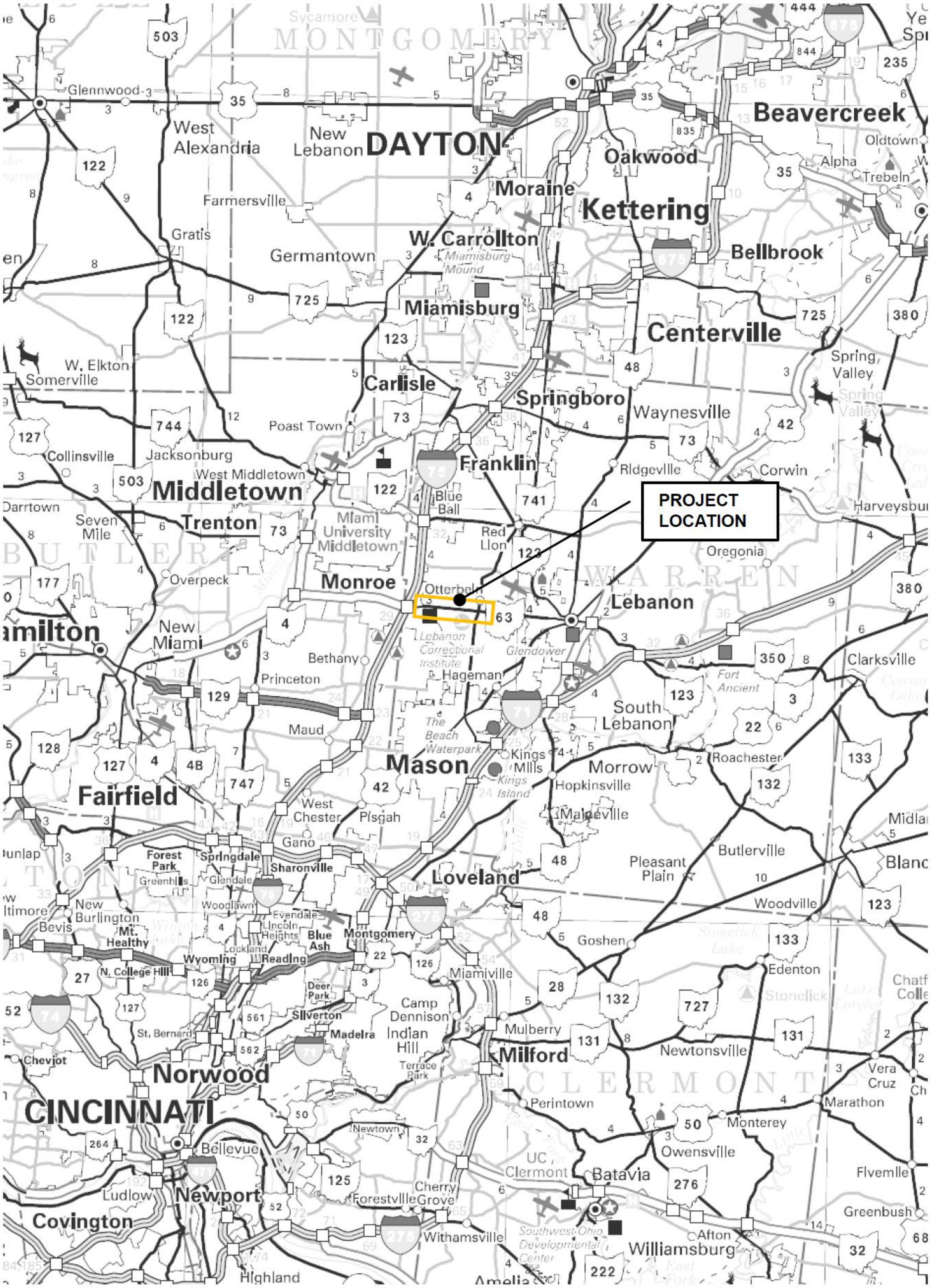
Ohio SR 63 in Warren County has a long history as a transportation corridor. Established in the early 1800s, it functions today with travel and right-of-way conditions that date mostly from the 1950s. The facility is a primary rural arterial and functions as an important regional connector between Interstates 71 and 75, despite having only two travel lanes and significant design deficiencies.

Today, travel demand exceeds capacity and crash rates are more than double the statewide average for similar facilities. Heavy trucks and commercial vehicles have become a significant traffic component, most with regional or national origins and destinations. Current level of service (LOS) often degrades to F during peak periods and, considering only baseline traffic growth, conditions will continue to degrade over the planning horizon. Significant new traffic-generating development due to planned conversion of public and private agricultural lands to commercial use cannot be accommodated on the existing facility.

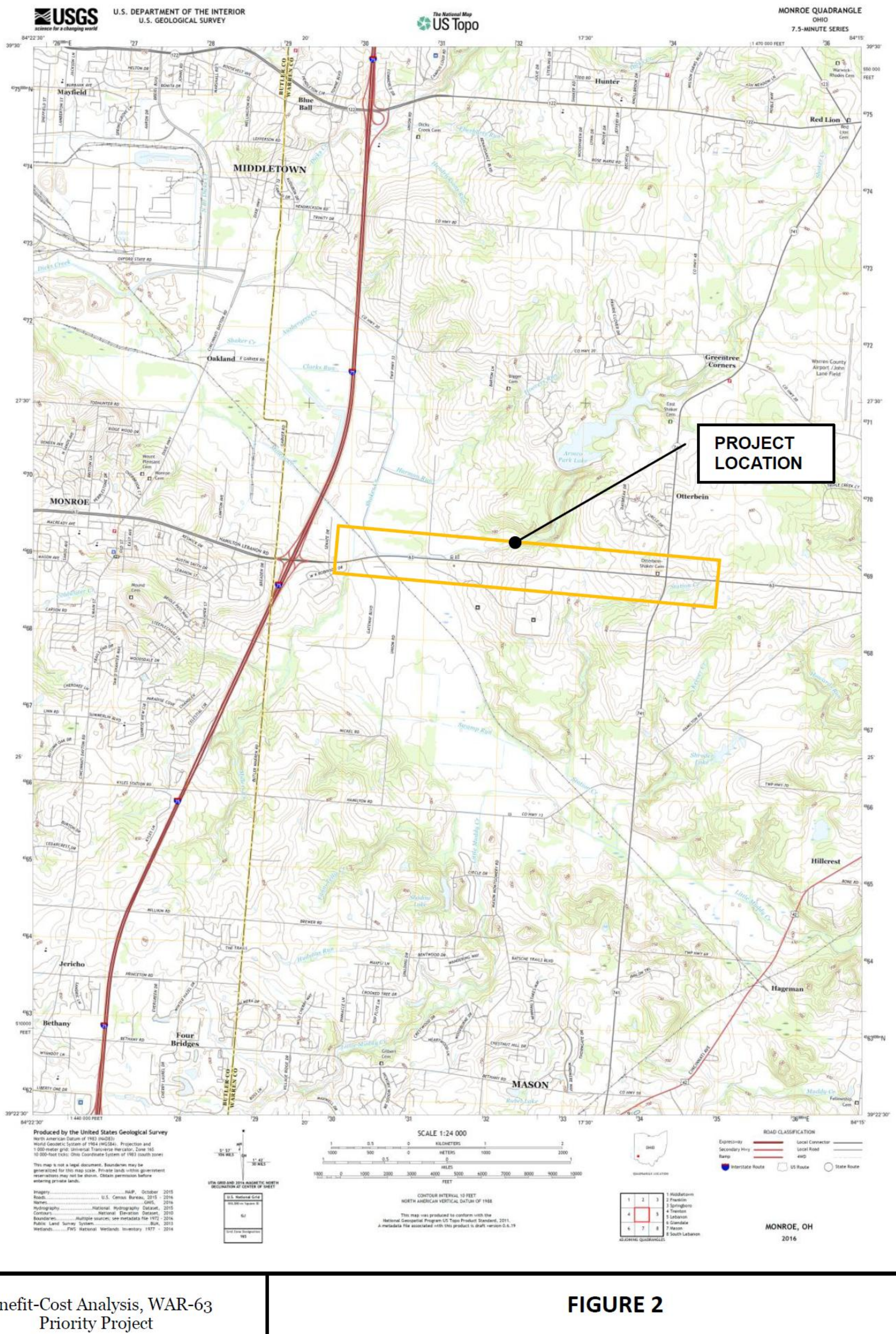
The project is located midway between the Cincinnati and Dayton metropolitan areas (see **Figures 1 and 2**, pages 10 and 11), and receives regional travel demand and traffic influences from both of these major population and commerce centers, as well from established communities and growing rural development areas in Warren and Butler counties.

The purpose of the proposed action for the WAR-63 Priority Project is to improve connectivity, mobility, safety, and access along the most heavily traveled portion of the SR 63 corridor in Warren County to achieve the following outcomes:

- Maintain effective east-west connectivity between Interstates 71 and 75;
- Improve safety and reduce crash risk;
- Provide effective accommodation of different trip types and modes;
- Provide a balanced transportation solution for environmental resources amid a changing land use picture.



| | |
|---|---|
| Benefit-Cost Analysis, WAR-63<br>Priority Project<br>Warren County Transportation Improvement District<br>June 2019<br>**RL RECORD LLC** Consultants | **FIGURE 1**<br>**Project Location - Regional**<br>Basemap Source: Ohio DOT, 2019 |



Benefit-Cost Analysis, WAR-63
Priority Project

Warren County Transportation Improvement District

June 2019

**RL RECORD LLC** Consultants

## FIGURE 2

## Project Location - Local

Basemap Source: USGS, 2016

The WAR-63 Priority Project involves widening, geometric improvement and access management of a predominately 2-lane section of SR 63 in Turtle Creek Township in Warren County, Ohio and will extend from west of an at-grade rail crossing in the City of Monroe (SLM = 0.80) to just past a signalized intersection with SR 741 (SLM = 3.5). General project limits will encompass an estimated 1,000 feet both north and south of the centerline of existing SR 63. The project involves replacement of six (6) culverts.

Design and location alternatives, including centerline location, vertical profile, and cross section within this footprint have been developed and analyzed with specific consideration of environmental impacts, constructability, and maintenance of traffic with specific regard to best practical design principles. Access management, right-of-way preservation and internal circulation are significant concerns in selecting the preferred alternative.

A portion of the WAR-63 Priority Project is located in the Cincinnati Ohio, Kentucky, Indiana (OKI) Urbanized Area[2], but it immediately abuts, and extends into, the rural boundary and behaves currently as a rural primary arterial.

Because the State of Ohio (owner of the facility) is facing a scenario where, despite a recent increase in the state gas tax, resources for capital expenditures for new or expanded facilities are scarce and first cost is a primary concern, two build options are being considered, including a least first cost scenario. The “best value scenario” will be tested by the market during design-build project procurement.

## 4.1 Base Case – No Build

The No Build scenario maintains the existing 2-lane configuration. Significant resources will be expended to operate and maintain the facility. Regional background traffic growth will continue to put pressure on the facility resulting in a degrading level of service growing more pronounced over time. Evaluation of the No Build scenario helps identify the costs borne by both agency and roadway users in continuing to operate and maintain the existing facility.

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[2] https://www2.census.gov/geo/maps/dc10map/UAUC_RefMap/ua/ua16885_cincinnati_oh--ky--in/DC10UA16885_000.pdf

Impacts from the No-Build scenario compared to a highway improvement scenario are expected to include:

- Increased travel times for both car and truck traffic;
- Lower travel speeds;
- Growing congestion;
- Degradation in travel time reliability;
- Increased crash rate;
- Increased facility closures due to crashes;
- Increased vehicle operating costs; and
- Emissions impacts.

## 4.2 Build Case Number 1 – 4-Lane Undivided Section

Build Case Number 1 identifies the "minimum build" scenario. It is the lowest first-cost build alternative, ODOT's current preferred alternative, and the basis of the BUILD application. It provides four though lanes with center turn-lanes at major intersections, increasing capacity. Regional background traffic growth will be accommodated under this scenario. Additional local development is anticipated, but absent assurance that it will not impact the level of service of the facility, it is expected to be limited to induced traffic estimated using the Cal-B/C INFRA modeling tool.

Impacts are expected to include:

- Reduction in travel times for both car and truck traffic;
- Higher travel speeds;
- Reduced travel times;
- Reduced congestion;
- Improvement in travel time reliability;
- Increased crash severity (higher travel speed, no safety median);
- Reduced facility closures due to crashes;
- Reduced vehicle operating costs; and
- Emissions impacts.

## 4.3 Build Case Number 2 – 4-Lane Divided Section

Build Case Number 2 provides for a 4-lane divided expansion with grass safety median and center turn lanes at access locations. Regional background traffic growth will be accommodated under this scenario. Additional local development is anticipated, and because of the differential in motorist experience as compared to the 4-lane undivided section (reduced visual distraction and concern for on-coming vehicles) this scenario is expected to produce higher caliber economic investment in the Priority Project travelshed, including logistic warehousing, advanced manufacturing, and office campus growth. This is discussed in greater detail in the "*Developer Forum Summary Report – Warren County Heritage Area Transportation Plan and WAR-63 Priority Project,* WCTID, June 2019," found in **Attachment 13** at: ftp://ftp.co.warren.oh.us/WAR-63%20Priority%20Project%20BUILD%20application%20ATTACHMENTS/.

Impacts are expected to include:

- Reduction in travel times for both car and truck traffic;
- Higher travel speeds;
- Reduced travel times;
- Reduced congestion;
- Improvement in travel time reliability;
- Reduced crash rate and severity;
- Reduced facility closures due to crashes;
- Reduced vehicle operating costs; and
- Emissions impacts.

## 4.4 Project Costs and Schedule

Agency project costs (construction, maintenance, rehabilitation) were estimated and scheduled for the three scenarios described above. **Tables 1 through 3** show these costs in today's (2019) dollars, beginning on Page 15. These are entered into Cal-B/C INFRA as discounted 2017 incremental costs (summarized in **Table 4** on Page 18).

Table 1: *Project Costs and Schedule – Base Case - No Build*

Table 2: *Project Costs and Schedule – Build Case Number 1 – 4-Lane Undivided Section*

Table 3: *Project Costs and Schedule – Build Case Number 2 – 4-Lane Divided Section*

Table 4: *Incremental Cost Inputs*

If a BUILD grant is awarded, project construction is expected to take place in 2021 with a 1-year construction period, opening to full service during 2022.

Additional information on project costs used in the B/C analysis is found in **Appendix A**.

**TABLE 1. Project costs and schedule, No Build, WAR-63 Priority Project (expressed in 2019 dollars)**

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| **Construction Period** | | | | | | | |
| 1 | 2021 | $ - | $ - | $ - | $ - | $ - | $ - |
| **Service Life** | | | | | | | |
| 1 | 2022 | | | | $ 64,000 | $ 505,000 | $ 569,000 |
| 2 | 2023 | | | | $ 64,000 | $ - | $ 64,000 |
| 3 | 2024 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 4 | 2025 | | | | $ 64,000 | $ - | $ 64,000 |
| 5 | 2026 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 6 | 2027 | | | | $ 64,000 | $ 180,000 | $ 244,000 |
| 7 | 2028 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 8 | 2029 | | | | $ 64,000 | $ - | $ 64,000 |
| 9 | 2030 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 10 | 2031 | | | | $ 64,000 | $ - | $ 64,000 |
| 11 | 2032 | | | | $ 64,000 | $ 132,000 | $ 196,000 |
| 12 | 2033 | | | | $ 64,000 | $ 4,687,000 | $ 4,751,000 |
| 13 | 2034 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 14 | 2035 | | | | $ 64,000 | $ - | $ 64,000 |
| 15 | 2036 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 16 | 2037 | | | | $ 64,000 | $ - | $ 64,000 |
| 17 | 2038 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 18 | 2039 | | | | $ 64,000 | $ - | $ 64,000 |
| 19 | 2040 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 20 | 2041 | | | | $ 64,000 | $ - | $ 64,000 |
| Total Service Life | | | | | $ 1,280,000 | $ 5,944,000 | $ 7,224,000 |

**TABLE 2. Project costs and schedule, Build Case Number 1, 4-lane undivided, WAR-63 Priority Project (expressed in 2019 dollars)**

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| **Construction Period** | | | | | | | |
| 1 | 2021 | $ 750,000 | $ 250,000 | $24,000,000 | $ - | $ - | $ 25,000,000 |
| **Service Life** | | | | | | | |
| 1 | 2022 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 2 | 2023 | | | | $ 80,000 | $ - | $ 80,000 |
| 3 | 2024 | | | | $ 80,000 | $ - | $ 80,000 |
| 4 | 2025 | | | | $ 80,000 | $ - | $ 80,000 |
| 5 | 2026 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 6 | 2027 | | | | $ 80,000 | $ - | $ 80,000 |
| 7 | 2028 | | | | $ 80,000 | $ - | $ 80,000 |
| 8 | 2029 | | | | $ 80,000 | $ - | $ 80,000 |
| 9 | 2030 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 10 | 2031 | | | | $ 80,000 | $ - | $ 80,000 |
| 11 | 2032 | | | | $ 80,000 | $ 123,000 | $ 203,000 |
| 12 | 2033 | | | | $ 80,000 | $ - | $ 80,000 |
| 13 | 2034 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 14 | 2035 | | | | $ 80,000 | $ - | $ 80,000 |
| 15 | 2036 | | | | $ 80,000 | $ - | $ 80,000 |
| 16 | 2037 | | | | $ 80,000 | $ 1,875,000 | $ 1,955,000 |
| 17 | 2038 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 18 | 2039 | | | | $ 80,000 | $ 159,000 | $ 239,000 |
| 19 | 2040 | | | | $ 80,000 | $ - | $ 80,000 |
| 20 | 2041 | | | | $ 80,000 | $ - | $ 80,000 |
| Total Service Life | | | | | $ 1,600,000 | $ 2,432,000 | $ 4,032,000 |

**TABLE 3. Project costs and schedule, Build Case Number 2, 4-lane divided, WAR-63 Priority Project (expressed in 2019 dollars)**

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| **Construction Period** | | | | | | | |
| 1 | 2021 | $ 750,000 | $ 250,000 | $28,000,000 | $ - | $ - | $ 29,000,000 |
| **Service Life** | | | | | | | |
| 1 | 2022 | | | | $ 86,000 | $ 55,000 | $ 141,000 |
| 2 | 2023 | | | | $ 86,000 | $ - | $ 86,000 |
| 3 | 2024 | | | | $ 86,000 | $ - | $ 86,000 |
| 4 | 2025 | | | | $ 86,000 | $ - | $ 86,000 |
| 5 | 2026 | | | | $ 86,000 | $ - | $ 86,000 |
| 6 | 2027 | | | | $ 86,000 | $ 55,000 | $ 141,000 |
| 7 | 2028 | | | | $ 86,000 | $ - | $ 86,000 |
| 8 | 2029 | | | | $ 86,000 | $ - | $ 86,000 |
| 9 | 2030 | | | | $ 86,000 | $ - | $ 86,000 |
| 10 | 2031 | | | | $ 86,000 | $ - | $ 86,000 |
| 11 | 2032 | | | | $ 86,000 | $ 331,000 | $ 417,000 |
| 12 | 2033 | | | | $ 86,000 | $ - | $ 86,000 |
| 13 | 2034 | | | | $ 86,000 | $ - | $ 86,000 |
| 14 | 2035 | | | | $ 86,000 | $ - | $ 86,000 |
| 15 | 2036 | | | | $ 86,000 | $ - | $ 86,000 |
| 16 | 2037 | | | | $ 86,000 | $ 1,930,000 | $ 2,016,000 |
| 17 | 2038 | | | | $ 86,000 | $ - | $ 86,000 |
| 18 | 2039 | | | | $ 86,000 | $ 159,000 | $ 245,000 |
| 19 | 2040 | | | | $ 86,000 | $ - | $ 86,000 |
| 20 | 2041 | | | | $ 86,000 | $ - | $ 86,000 |
| Total Service Life | | | | | $ 1,720,000 | $ 2,530,000 | $ 4,250,000 |

**TABLE 4. Incremental Cost Inputs**

| | | **4-Lane Undivided** | | **4-Lane Divided** | |
|---|---|---|---|---|---|
| **Year** | **No Build Total** | **Total Cost** | **Incremental Cost** | **Total Cost** | **Incremental Cost** |
| | | | Costs Expressed in Constant (2017) Dollars | | |
| **REHABILITATION COSTS (PERIODIC ACTIVITIES)** | | | | | |
| Year 0 - 2021 | $ - | $ - | $ - | $ - | $ - |
| Year 1 - 2022 | $ 482 | $ 52 | $ (430) | $ 52 | $ (430) |
| Year 2 - 2023 | $ - | $ - | $ - | $ - | $ - |
| Year 3 - 2024 | $ 52 | $ - | $ (52) | $ - | $ (52) |
| Year 4 - 2025 | $ - | $ - | $ - | $ - | $ - |
| Year 5 - 2026 | $ 52 | $ 52 | $ - | $ - | $ (52) |
| Year 6 - 2027 | $ 172 | $ - | $ (172) | $ 52 | $ (120) |
| Year 7 - 2028 | $ 52 | $ - | $ (52) | $ - | $ - |
| Year 8 - 2029 | $ - | $ - | $ - | $ - | $ - |
| Year 9 - 2030 | $ 52 | $ 52 | $ - | $ - | $ (52) |
| Year 10- 2031 | $ - | $ - | $ - | $ - | $ - |
| Year 11 - 2032 | $ 126 | $ 117 | $ (9) | $ 316 | $ 190 |
| Year 12 - 2033 | $ 4,470 | $ - | $ (4,470) | $ - | $ (4,470) |
| Year 13 - 2034 | $ 52 | $ 52 | $ - | $ - | $ (52) |
| Year 14 - 2035 | $ - | $ - | $ - | $ - | $ - |
| Year 15 - 2036 | $ 52 | $ - | $ (52) | $ - | $ (52) |
| Year 16 - 2037 | $ - | $ 1,788 | $ 1,788 | $ 1,841 | $ 1,841 |
| Year 17 - 2038 | $ 52 | $ 52 | $ - | $ - | $ (52) |
| Year 18 - 2039 | $ - | $ 152 | $ 152 | $ 152 | $ 152 |
| Year 19 - 2040 | $ 52 | $ - | $ (52) | $ - | $ (52) |
| Year 20 - 2041 | $ - | $ - | $ - | $ - | $ - |
| **MAINTENANCE COSTS (ONGOING ANNUAL)** | | | | | |
| All years as PV 2017 dollars | $ 61,042 | $ 76,302 | $ 15,260 | $ 82,025 | $ 20,983 |

# 5. General Approach and Assumptions

## 5.1 Key Assumptions

This Benefit-Cost Analysis measures benefits against costs throughout a period of analysis beginning at the start of construction (2021) and including a 20-year service life. The monetized benefits and costs are stated in 2017 constant dollars in compliance with U.S. DOT guidance.

Following this methodology:

- Inputs to the Cal-B/C INFRA tool are expressed in 2017 dollars;
- The analysis period begins in 2021, and includes twenty years of operations (2022- 2042);
- A 7 percent discount rate is used throughout the analysis period;
- All inputs are entered as incremental costs (the difference between build and no-build costs) rather than total costs;
- Although some project support costs are "sunk costs", including preparation of this document and associated analysis, these are included in accordance with U.S. DOT BCA guidance.

## 5.2 Cal-B/C INFRA Modeling Tool

The California Department of Transportation's *Cal-B/C INFRA* analysis tool[3] was used as the primary analysis platform in conducting the B/C work for the WAR-63 Priority Project. This model was chosen because it is nationally recognized and easily comparable to other applicants' BCA submittals. Cal-B/C requires the user to specify a relatively modest number of underlying project assumptions, relying on industry standards to calculate outputs.

A full listing of inputs to and outputs from this model for the various scenarios evaluated for the WAR-63 Priority Project are found in **Appendix C** and are available as active and accessible .xls workbook files in Attachment 9 at: ftp://ftp.co.warren.oh.us/WAR-63%20Priority%20Project%20BUILD%20application%20ATTACHMENTS/.

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[3] Available at http://www.dot.ca.gov/hq/tpp/offices/eab/LCBC_Analysis_Model.html

# 6. Travel Demand Projections

The WAR 63 Priority Project exists at the fringe of the Ohio, Kentucky, Indiana (OKI) Urbanized Area (UA). Despite being included in the urbanized area, the project immediately abuts and extend into the rural boundary and behaves currently as a rural primary arterial. Macroscale traffic modeling forecasts from the Ohio-Kentucky-Indiana Regional council of Governments (MPO) were obtained and compared against comparative trend-based forecasts from the Ohio Department of Transportation. Because the Traffic Analysis Zones used in the regional traffic forecast were too large to accurately predict traffic growth along the corridor[4], the Ohio DOT used agency SHIFT[5] traffic forecast software to estimate baseline traffic growth along the WAR 63 corridor, which was used in this analysis.

A baseline[6] of 3 percent compounded regional background traffic growth was used for the no-build scenario[7]. Build scenarios use a 3.2 percent compounded growth rate to incorporate both development and induced demand. Historical traffic growth on the facility has averaged about 3 percent per year since 1980 through current day (**Figure 1**, below).

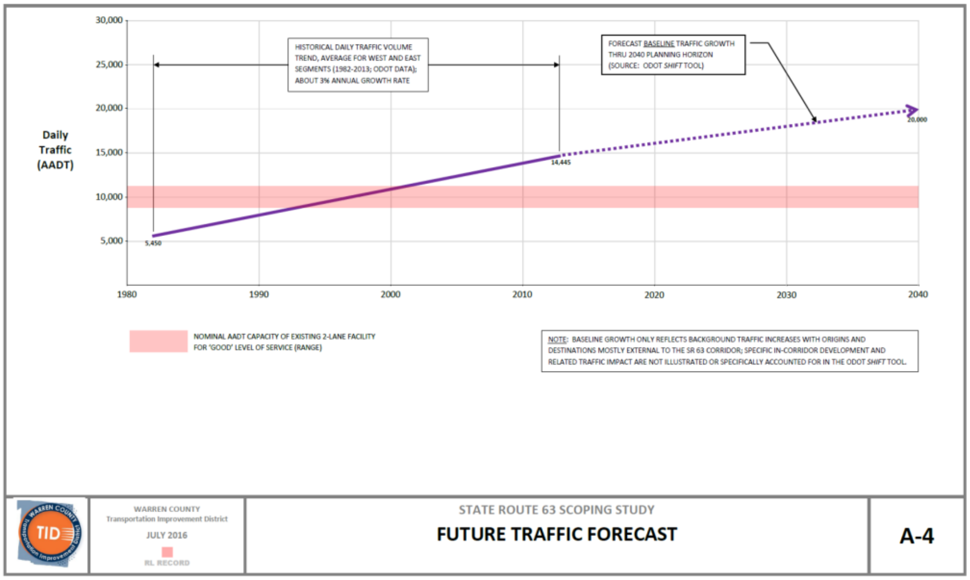

FIGURE 1 – Historical and forecast traffic for WAR-63 Priority Project, baseline traffic only

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[4] The OKI travel demand model output did not correlate well with existing traffic conditions
[5] Simplified Highway Forecasting Tool
[6] Baseline traffic is primarily external traffic that uses the corridor today and does not account for development and travel demand along the corridor.
[7] ODOT forecast was a little less than 3%; a 3% (rounded) growth rate was used, also consistent with historical rate of record.

# 7. Data Inputs and Assumptions

## 7.1 Strategy-Level Inputs

Strategy-level inputs to the B/C analysis for various scenarios evaluated are found in **Appendix B**.

## 7.2 Travel Time Savings

The difference in travel time under the no-build scenario and those under the build scenarios constitute the travel time savings. Travel times are calculated separately for cars and trucks, and during peak and non-peak periods. Cal-B/C distributes traffic to peak and off-peak periods based on typical traffic distributions for urban and rural area and the specified length of the peak period. We used a rural distribution (discussed earlier) and a 13-hour peak period, based on actual hourly data collected for the facility.

## 7.3 Vehicle Operating Costs

Fuel consumption and vehicle maintenance cost vary according to average speed conditions. Non-fuel costs are estimated on a fixed per mile cost that includes oil, tires, maintenance, repairs, and depreciation. Other costs such as insurance and registration are not included because they generally do not vary with mileage. Cal-B/C separates fuel and non-fuel costs to allow users to ascertain the impact of changes in fuel prices.

## 7.4 Vehicle Emissions Costs

Vehicle emissions are affected by changes in average speed. Cal-B/C estimates vehicle emissions based on fuel consumption (discussed above).

## 7.5 Accident Cost Savings

Cal-B/C uses the change in accident rate to estimate the safety benefits of roadway projects. Actual counts are compared to state-wide averages for comparable facilities.

## 7.6 Summary of Inputs

The following tables, in addition to the information in **Appendix B**, identify data input assumptions and sources utilized in the B/C analysis work, beginning on **Page 22:**

Table 5: *Project Data Inputs*

Table 6: *Highway Design and Traffic Data Inputs*

Table 7: *Highway Accident Data Inputs*

**TABLE 5. Project Data Inputs**

| Data Category | Base Values | Data Source | Range of Values for Sensitivity Analysis | |
|---|---|---|---|---|
| | | | Min | Max |
| Project Type | General Highway | | General Highway | General Highway |
| Project Location | Rural | | Rural | Rural |
| Length of Construction Period (Years) | 1 | | 1 | 1 |
| One or Two way Data | | | 2 | 2 |
| Length of Peak Period (Hours) | 13 | ODOT Traffic Database | 13 | 13 |

**TABLE 6. Highway design and traffic data inputs**

| Data Category | No Build | Build Case 1 | Build Case 2 | Data Source | Range of Values for Sensitivity Analysis | |
|---|---|---|---|---|---|---|
| | | | | | Min | Max |
| HIGHWAY DESIGN DATA | | | | | | |
| Roadway Type | Conventional Hwy | Conventional Hwy | Conventional Hwy | Project plans | -- | -- |
| Number of General Traffic Lanes | 2 | 4 | 4 | Project plans | -- | -- |
| Highway Free-Flow Speed | 50 | 55 | 60 | HCM, AASHTO Green Book, field data and ODOT plans | -- | -- |
| AVERAGE DAILY TRAFFIC | | | | | | |
| Current Year (0) | 20,600 | 20,600 | 20,600 | ODOT Traffic Counts | -- | -- |
| Base Year (1) | 21,337 | 24,184 | 24,184 | SHIFT | -- | -- |
| Forecast Year (20) | 35,346 | 40,062 | 40,062 | SHIFT | 36,056 | 44,068 |
| Percent Trucks | 9% | 9% | 9% | ODOT Traffic Database | -- | -- |
| Truck Speed | 50 | 50 | 50 | Observed Speed | -- | -- |
| PAVEMENT CONDITION | | | | | | |
| Base Year (1) | 75 | 100 | 100 | ODOT Transportation Information Mapping System (TIMS) | -- | -- |
| Forecast Year (20) | -- | 100 | 100 | Assumed from Project Asset Management Plan | -- | -- |
| AVERAGE VEHICLE OCCUPANCY | | | | | | |
| General Traffic (Peak) | 1.30 | 1.30 | 1.30 | Default Values | -- | -- |
| General Traffic (Non-Peak) | 1.15 | 1.15 | 1.15 | Default Values | -- | -- |

**TABLE 7. Highway accident data inputs**

| Data Category | No-Build | | Build Case 1 | Build Case 2 | Data Source |
|---|---|---|---|---|---|
| | Count | Rate | | | |
| ACTUAL 3-YEAR ACCIDENT DATA | | | | | |
| Total Accidents | 126 | 1.86 | -- | -- | ODOT Safety Data Base |
| Fatal Accidents | 1 | 0.015 | -- | -- | ODOT Safety Data Base |
| Injury Accidents | 33 | 0.49 | -- | -- | ODOT Safety Data Base |
| Property Damage Only Accidents | 92 | 1.36 | -- | -- | ODOT Safety Data Base |
| STATEWIDE AVERAGE ACCIDENT RATE FOR SAME TYPE FACILITY | | | | | |
| Accident Rate (per million vehicle-miles) | -- | 1.72 | 1.3 | 0.75 | ODOT Safety Data Base |
| Percent Fatal | -- | 0.3 | 0.3 | 0.3 | ODOT Safety Data Base |
| Percent Injury | -- | 23.5 | 23.5 | 23.5 | ODOT Safety Data Base |

# 8. Summary of Benefit-Cost Analysis Outcomes and Findings

## 8.1 Overall Findings for Traditional Benefits

Traditional monetized benefits evaluated during a BCA include travel time savings, vehicle maintenance costs and vehicle emissions. For the WAR-63 Priority Project BCA work, only these traditional benefits have been quantified and included in the benefit side of the analysis. The overall findings for the BCA work, considering only traditional benefits, are summarized in **Table 8** below:

**TABLE 8. Comparative results of benefit-cost analysis for traditional benefits, WAR-63 Priority Project**

| Measure | Build Case Number 1 4-Lane Undivided | Build Case Number 2 4-Lane Divided |
|---|---|---|
| Life Cycle Costs | $ 22,000,000 | $ 26,200,000 |
| Life Cycle Benefits | $ 81,700,000 | $ 117,200,000 |
| Net Present Value | $ 59,000,000 | $ 91,000,000 |
| Benefit/Cost Ratio | 3.7 | 4.5 |
| Rate of Return on Investment | 17.6% | 22.8% |
| Payback Period | 10 Years | 7 Years |

A breakdown of component benefit values for traditional measures of travel time savings, vehicle maintenance costs and vehicle emissions can be found in **Appendix B.**

Build Case Number 2 (4-Lane Divided) consistently returns higher BCA ratios as compared to Build Case Number 1(4-Lane Undivided). This is due primarily to cumulatively significant differences in operational efficiency, net life-cycle cost, and safety performance effects on project benefits over the period of analysis.

Benefit-Cost Analysis, while a useful benchmark from which to evaluate and compare potential transportation investments, is not the only decision-making tool involved in project selection. Other considerations include financial capacity, community concerns, and environmental factors, as well as other benefits or considerations that have not been monetized or included in the quantified BCA findings.

This analysis will be used during the design-build procurement process, which will use alternative technical concepts to elicit best value outcomes for the funding agencies and roadway users.

### 8.2 Other Benefits

Certain benefits are not amenable to monetization. Beyond traditional benefits, this project also addresses a number of other benefits that, at this stage of project development, either cannot be quantified, or have not been quantified to an extent that would conservatively allow direct incorporation into the benefits inputs of the BCA work documented in this report.

The non-traditional benefits of significance in the WAR-63 Priority Project include the following:

- Benefits deriving from an improved State of Good Repair
- Benefits deriving from improved Economic Competiveness
- Benefits deriving from innovative Environmental Sustainability approaches
- Benefits deriving from enhanced Quality of Life measures in the project travelshed community
- Benefits deriving from Innovation
- Benefits deriving from Partnerships in shared interests linked to the project investment

Each of these categories is discussed below. None of these non-traditional categories has any quantified benefits assigned in the benefit-cost results reported herein for the WAR-63 Priority Project. However, in the process of procurement and project delivery, including development of alternative technical concepts under performance-based design-build project sale, it is anticipated that some or all of these will be revisited under a quantified-value benefit-cost analysis update, to aid in assessing and determining best value in market response.

## State of Good Repair Value Contributions to Project Benefits

Pavement Conditions are currently acceptable (75 PCR) through-out most of the length of the project. The PCR will be returned to 100 immediately upon project completion, and the asset management plan will ensure that the pavement is maintained in good condition throughout the life of the project. Pavement condition contributes to a reduction in user maintenance and operating cost. Pavement condition was not used in calculating the B/C ratios reported in this document.

The project, if proposed innovative technology alternative technical concepts are accepted, will also benefit from increased resiliency in terms of system and trip-time reliability in recovery from incidents, allowing for faster detection and response, resulting in a greater number of hours at full capacity with fully functioning roadway appurtenances (signals, guardrail, etc.). This contributes to both safety and state of good repair improvements.

## Economic Competitiveness Value Contributions to Project Benefits

Economic impacts were not included in the BCA to avoid double-counting benefits[8], but they are substantial, including the potential for attracting in excess of $1 Billion in high-value investment.

The project will include modal accommodation for bus transit, school transit, and non-motorized transit. These were identified during stakeholder outreach as desired and necessary for both project success and economic development.

The project preserves one of the last cross-county connections between Interstates 75 and 71, supporting the continued development of a logistics-based hub, increasing the agglomerative benefits of interconnectivity of distribution services.

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[8] B/C addresses the productivity increases attributable to the roadway improvements. Economic Impact measures the attractiveness of the facility to investors.

The proximity of Lebanon Correctional Institute and Warren Correctional Institute provide a source of workforce for logistics and distribution services.

## Environmental Sustainability Value Contributions to Project Benefits

The WAR-63 Priority Project has been developed, and will be delivered, in comprehensive consideration of the project's "Envelope of Influence" on the built and natural environment. The "Envelope of Influence" is part of the *Enhanced Environmental Outcomes and Performance* (EEOP) approach to project delivery, a concept for better, performance based environmental outcomes developed by the project team and presented in various stages of development to DOT for policy consideration[9]. To achieve better environmental outcomes including various elements of Environmental Sustainability beyond the "NEPA minimum" standard, understanding the "Envelope of Influence" is key.

The "Envelope of Influence" (see **Figure 2)** refers to the area outside of the proposed project right of way that will benefit from the transportation investment. Project benefits "outside the right of way" are often associated with land use and development. However, the Envelope of Influence, and potential for benefit capture, includes a much broader array of value measures. The envelope includes disparate natural and man-made value categories that are measurably benefited by the transportation investment and have value to system users and stakeholders. This includes categories such as stormwater quantity and quality, noise, public health, ecosystems, aesthetics, travel time savings, intermodal enhancements, safety and access among others.

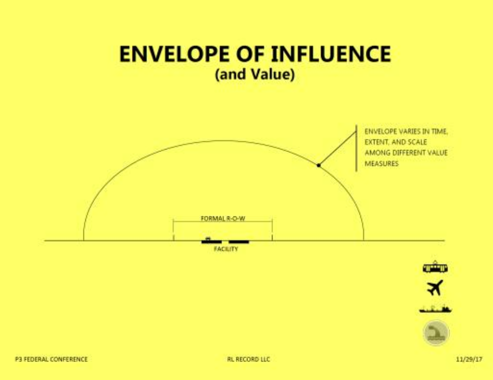

**FIGURE 2 – Understanding and accounting for the Envelope of Influence is important to achieving best project value and best environmental sustainably outcomes**

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[9] Concept development and proprietary supporting information on file with DOT OST (RL RECORD Consultants, 2017-2019).

The WAR-63 Priority Project development process included an evaluation of the "Envelope of Influence" and a robust stakeholder and public outreach effort to identify value areas. Combined with environmental field studies and analysis, an array of "Envelope" value category and measures has been identified that will explored, refined and, depending on market response, incorporated in project delivery.

The project is still in the development phase, and evolutionary discussions with stakeholders are ongoing. Community "willingness to pay" for enhanced outcomes beyond a NEPA minimum will be determined and considered with acceptance or rejection of alternative technical concepts during the design-build procurement process.

In any case, the following enhanced and value-based environmental benefits are expected to accrue from this project compared to the "NEPA minimum":

- Reduced particulates and emissions (pavement treatment and asset management, profile improvement, platoon management) [public health, quality of life, economic competiveness, water quality, and ecosystem benefits]
- Reduced traffic noise (pavement treatment, profile improvement, platoon management) [public heath, quality of life, economic competiveness, and ecosystem benefits]
- Reduced stray light from highway lighting (smart lighting) [public heath, quality of life, economic competiveness, and ecosystem benefits]
- Reduced stormwater runoff intensity, volume and pollutants (pavement treatment, enhanced BMPs and source control) [public health, quality of life, economic competiveness, water quality, and ecosystem benefits]
- Mitigation of risk to Section 7 Wild and Scenic River watershed (pavement treatment, enhanced BMPs and source control) [nationally-designated resource protection, water quality, and ecosystem benefits]
- Mitigation of risk to Great Miami Buried River Valley designated aquifer (pavement treatment, enhanced containment BMPs and source control, construction management) [nationally-designated aquifer protection, public health, source water quality benefits]
- Improved aquatic and terrestrial systems habitat and connectivity (culvert treatments, Shaker Run enhancements, terrestrial corridor enhancements)

> [biotic value and function, public heath, quality of life, economic competiveness, water quality, and ecosystem benefits]

Values and performance measures are being developed in these and other categories for integration in best-value project delivery. “Mini-BCAs” will be conducted for each category during the final stages of project development to establish thresholds for evaluating alternative technical concepts in procurement.

No potential benefits of enhanced environmental performance and Environmental Sustainability have been included, at this point, as quantified benefits in the BCA work to date for the WAR-63 Priority Project. However, as the “mini-BCAs” described above come on line, it is expected that the project will deliver measurable and significant additional benefits to the environment on a value-and-performance basis.

## Quality of Life Value Contributions to Project Benefits

Establishing a modern, safe highway corridor with improved aesthetics will provide a comprehensive jump in quality of life perspectives, experiences and relationships for communities, stakeholders and citizens of the WAR-63 Priority Project travelshed. This translates to beneficial effects on property values, community afflation, and economic influence that, along with enhanced and purposeful environmental benefits, are all key measures of quality of life

Stakeholder outreach has included communication with the cable and potential fiber-optic suppliers in the area. Discussions continue regarding shared resources, such as donations or cost sharing of communications technology that can benefit long-term highway operations as well as travelshed stakeholders and citizens.

Additionally, during stakeholder outreach, Warren County Water and Sewer expressed interest in co-locating a water line in the project Right-of-Way during construction. They are also interested in building a Waste-Water Sewage Treatment Plant on some of the available prison property along the corridor, enhancing the economic competitiveness of the envelope of influence.

The project will, as discussed above, accommodate improved modal choices and improved connectivity for residents to regional destinations and for workers from the region commuting to jobs available along the project corridor.

No potential benefits of enhanced Quality of life have been included, at this point, as quantified benefits in the BCA work to date for the WAR-63 Priority Project. However, "mini-BCAs" may be performed in the final stages of project development leading to procurement to identify and facilitate project elements that measurably and cost-effectively provide Quality of Life benefits.

## Innovation Value Contributions to Project Benefits

There is intrinsic value in innovation. Communities, individuals, stakeholders, leaders, property owners, investors, jobs creators and even the environment all benefit from properly targeted innovation that brings greater value or better performance to infrastructure investments.

The WAR-63 Priority Project is delivering valuable innovation along with needed highway improvements.

The WAR 63 Priority Project brings a specific plan for innovative application of technology, creative environmental approaches, value-and-performance based procurement, and a locally-driven financial strategy to project delivery.

Application of Technology: The WAR-63 Priority Project has been planned and positioned to take best advantage of appropriate technologies that will enhance and protect the value of the transportation investment. The *Technologies Report, War-63 Priority Project, WCTID, April 2019,* **Attachment 15,** and the project *Technology Template,* (May 2019), **Attachment 16,** (both available at: ftp://ftp.co.warren.oh.us/WAR-63%20Priority%20Project%20BUILD%20application%20ATTACHMENTS/ ) describe the recommended implementation of various technologies, including smart intersection and illumination control, variable speed limits, and accommodation of a future automated transit connection, using Alternative Technical Concepts during the design-build procurement process to assess best value. Some of these anticipated benefits are referenced above under State of Good Repair.

Creative Environmental Approach: Comprehensively engaging stakeholders during the project development allows us to investigate the community's "willingness to pay" for enhancements that benefit stakeholders, as well as other pathways for measurable added value in environmental outcomes, within the "Envelope of Influence". Examples are found under the Environmental Sustainability section above, and the Partnerships section below.

Value-and-Performance Based Procurement: The Project will be procured and delivered using a value and performance design-build approach. The creative capacity of the transportation construction industry will be tapped to identify Best Value elements for the project using Alternative Technical Concepts for certain basic highway components and alternatives, as well as technology and environmental value additions. "Mini-BCAs" will be used, among other considerations, to evaluate ATCs. The technology and environmental elements may contain certain performance requirements, as well as requirements to operate and maintain and upgrade them throughout their expected service life. The "mini-BCAs" will help determine worthwhile and value-creating investments that provide net positive additions to project benefits.

Locally-driven Financial Strategy: The Ohio DOT (owner of the facility), does not have the resources, despite a recent gas-tax increase, to contribute to capital expansion costs of the facility, but recognizes the need for and critical timing of the project. It has partnered with the Warren County Ohio Transportation Improvement District, the grant applicant, which will provide up to 50% of the capital costs necessary to match an anticipated BUILD Application award from DOT. This project is a locally driven action grounded in performance and value based expectations for best use of capital dollars, and best long-term outcomes.

## Partnership Value Contributions to Project Benefits

The project has a diverse set of partners pursuing mutual interests on multiple fronts. These are outlined in the table below, and continued discussions during project development will identify partners' commitment to investment and community/stakeholder "willingness to pay", or otherwise have value, or costs, assigned or accrued indirectly. Only net value benefits will be pursued or evaluated as part of the WAR-63-Priority Project delivery.

**TABLE 9. Anticipated Partnership Value Contributions to Project Benefits, WAR-63 Priority Project**

| Partner Entity | Interest | Opportunity | Potential Synergy and Value Transfer Mechanism | Value Potential[10] |
|---|---|---|---|---|
| | | | | |
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TABLE 9 UNDER REVIEW AND REVISION; NOT CENTRAL TO BCA KEY FINDINGS

Each opportunity identified above for partnership and revenue potential will be examined for best value ("mini BCA") contribution to the community and "willingness to pay" by the identified stakeholders in design-build ATC procurement process.

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[10] Preliminary opinion estimates of 20-Year Net Present Value in areas of capital efficiencies, service cost-effectiveness, property values, measured environmental benefits, or other quality of life value measures realized by partners, citizens, communities and stakeholders. None of these order-of-magnitude value estimates are included in the benefit or cost side considerations of the BCA work performed for the WAR-63 Priority Project but are real considerations for value creation important to and understood by the local implementing partners.

# 9. Benefit-Cost Sensitivity Analysis

BCAs are subject to varying levels of uncertainty attributable to the use of preliminary cost estimates, difficulty of modeling future traffic levels, and other incomplete understanding of parameters. Sensitivity analysis is used to illustrate how the results of the BCA changes if alternative values are used for sensitive variables subject to uncertainty.

For the WAR-63 Priority Project, two variable parameters have potential for significant effect on resultant B/C ratios: future traffic volumes and project construction cost. To assess sensitivity to these variables, the following analyses were made to determine effect on B/C ratios, as summarized in **Table 10** below:

- Future Traffic: Forecast Year AADT was assessed subject to a 10% increase or decrease in travel demand.
- Project Cost: Project construction cost was assessed subject to a 10% increase or decrease in dollar cost.

**TABLE 10. Benefit-cost sensitivity analysis summary, WAR-63 Priority Project**

| Sensitive Parameter | Change in Parameter Value | Value | B/C Ratio |
|---|---|---|---|
| Build Case Number 1: 4-Lane Undivided | | | |
| Forecast Year AADT | Initial Forecast | 40,062 | 3.7 |
| | 10% Increase | 44,068 | 3.3 |
| | 10% Decrease | 36,056 | 4.1 |
| Project Construction Cost Estimate | Initial Estimate | $ 23,844,000 | 3.7 |
| | 10% Increase | $ 26,229,000 | 3.3 |
| | 10% Decrease | $ 21,459,916 | 4.2 |
| Build Case Number 1: 4-Lane Divided | | | |
| Forecast Year AADT | Initial Forecast | 40,062 | 4.5 |
| | 10% Increase | 44,068 | 4.2 |
| | 10% Decrease | 36,056 | 4.7 |
| Project Construction Cost Estimate | Initial Estimate | $ 27,659,000 | 4.5 |
| | 10% Increase | $ 30,425,000 | 4.1 |

| | | | |
|---|---|---|---|
| | 10% Decrease | $ 24,894,000 | 5.0 |

From the sensitivity analyses performed, the WAR 63 Priority Project demonstrates robust and dependable BCA performance metrics. The benefit/cost ratio remains strong when capital costs increases, or traffic growth rate slows or quickens at a rate different from that expected.

# APPENDIX A Project Costs Inputs to B/C Analysis

PROJECT COSTS AND SCHEDULE - NO BUILD
Expressed in Today's (2019) Dollars

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| Construction Period | | | | | | | |
| 1 | 2021 | $ - | $ - | $ - | $ - | $ - | |
| Service Life | | | | | | | |
| 1 | 2022 | | | | $ 64,000 | $ 505,000 | $ 569,000 |
| 2 | 2023 | | | | $ 64,000 | $ - | $ 64,000 |
| 3 | 2024 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 4 | 2025 | | | | $ 64,000 | $ - | $ 64,000 |
| 5 | 2026 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 6 | 2027 | | | | $ 64,000 | $ 180,000 | $ 244,000 |
| 7 | 2028 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 8 | 2029 | | | | $ 64,000 | $ - | $ 64,000 |
| 9 | 2030 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 10 | 2031 | | | | $ 64,000 | $ - | $ 64,000 |
| 11 | 2032 | | | | $ 64,000 | $ 132,000 | $ 196,000 |
| 12 | 2033 | | | | $ 64,000 | $ 4,687,000 | $ 4,751,000 |
| 13 | 2034 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 14 | 2035 | | | | $ 64,000 | $ - | $ 64,000 |
| 15 | 2036 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 16 | 2037 | | | | $ 64,000 | $ - | $ 64,000 |
| 17 | 2038 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 18 | 2039 | | | | $ 64,000 | $ - | $ 64,000 |
| 19 | 2040 | | | | $ 64,000 | $ 55,000 | $ 119,000 |
| 20 | 2041 | | | | $ 64,000 | $ - | $ 64,000 |
| Total Service Life | | | | | $ 1,280,000 | $ 5,944,000 | $ 7,224,000 |

PROJECT COSTS AND SCHEDULE - NO BUILD
Expressed in Constant (2017) Dollars

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| Construction Period | | | | | | | |
| 1 | 2021 | $ - | $ - | $ - | $ - | $ - | |
| Service Life | | | | | | | |
| 1 | 2022 | | | | $ 61,042 | $ 481,656 | $ 542,698 |
| 2 | 2023 | | | | $ 61,042 | $ - | $ 61,042 |
| 3 | 2024 | | | | $ 61,042 | $ 52,458 | $ 113,500 |
| 4 | 2025 | | | | $ 61,042 | $ - | $ 61,042 |
| 5 | 2026 | | | | $ 61,042 | $ 52,458 | $ 113,500 |
| 6 | 2027 | | | | $ 61,042 | $ 171,679 | $ 232,721 |
| 7 | 2028 | | | | $ 61,042 | $ 52,458 | $ 113,500 |
| 8 | 2029 | | | | $ 61,042 | $ - | $ 61,042 |
| 9 | 2030 | | | | $ 61,042 | $ 52,458 | $ 113,500 |
| 10 | 2031 | | | | $ 61,042 | $ - | $ 61,042 |
| 11 | 2032 | | | | $ 61,042 | $ 125,898 | $ 186,940 |
| 12 | 2033 | | | | $ 61,042 | $ 4,470,219 | $ 4,531,261 |
| 13 | 2034 | | | | $ 61,042 | $ 52,458 | $ 113,500 |
| 14 | 2035 | | | | $ 61,042 | $ - | $ 61,042 |
| 15 | 2036 | | | | $ 61,042 | $ 52,458 | $ 113,500 |
| 16 | 2037 | | | | $ 61,042 | $ - | $ 61,042 |
| 17 | 2038 | | | | $ 61,042 | $ 52,458 | $ 113,500 |
| 18 | 2039 | | | | $ 61,042 | $ - | $ 61,042 |
| 19 | 2040 | | | | $ 61,042 | $ 52,458 | $ 113,500 |
| 20 | 2041 | | | | $ 61,042 | $ - | $ 61,042 |
| Total Service Life | | | | | $ 1,220,840 | $ 5,669,116 | $ 6,889,956 |

| REHABILITATION ACTIVITIES - NO BUILD | | | |
|---|---|---|---|
| Description | Year | Date | Rehabilitation Costs |
| Service Life | | | |
| Replace Suface Wearing Course | 1 | 2022 | $ 450,000 |
| Incident Caused Lane Closures & Repairs | 1 | 2022 | $ 55,000 |
| | 2 | 2023 | $ - |
| Incident Caused Lane Closures & Repairs | 3 | 2024 | $ 55,000 |
| | 4 | 2025 | $ - |
| Incident Caused Lane Closures & Repairs | 5 | 2026 | $ 55,000 |
| Major Drainage Rehabilitation | 6 | 2027 | $ 180,000 |
| Incident Caused Lane Closures & Repairs | 7 | 2028 | $ 55,000 |
| | 8 | 2029 | $ - |
| Incident Caused Lane Closures & Repairs | 9 | 2030 | $ 55,000 |
| | 10 | 2031 | $ - |
| Incident Caused Lane Closures & Repairs | 11 | 2032 | $ 55,000 |
| Guardrail Replacement | 11 | 2032 | $ 77,000 |
| Full Deapth Pavement Replacement | 12 | 2033 | $ 3,515,000 |
| Culvert Replacement | 12 | 2033 | $ 576,000 |
| Major Shoulder Rehabilitation | 12 | 2033 | $ 123,000 |
| Overhead Sign and Signal Replacement | 12 | 2033 | $ 473,000 |
| Incident Caused Lane Closures & Repairs | 13 | 2034 | $ 55,000 |
| | 14 | 2035 | $ - |
| Incident Caused Lane Closures & Repairs | 15 | 2036 | $ 55,000 |
| | 16 | 2037 | $ - |
| Incident Caused Lane Closures & Repairs | 17 | 2038 | $ 55,000 |
| | 18 | 2039 | $ - |
| Incident Caused Lane Closures & Repairs | 19 | 2040 | $ 55,000 |
| | 20 | 2041 | $ - |
| | | | |
| Total Rehabilitation Costs | | | $ 5,944,000 |

PROJECT COSTS AND SCHEDULE - BUILD CASE NUMBER 1 - 4-LANE UNDIVIDED
Expressed in Today's (2019) Dollars

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| Construction Period | | | | | | | |
| 1 | 2021 | $ 750,000 | $ 250,000 | $ 24,000,000 | $ - | $ - | $ 25,000,000 |
| Service Life | | | | | | | |
| 1 | 2022 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 2 | 2023 | | | | $ 80,000 | $ - | $ 80,000 |
| 3 | 2024 | | | | $ 80,000 | $ - | $ 80,000 |
| 4 | 2025 | | | | $ 80,000 | $ - | $ 80,000 |
| 5 | 2026 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 6 | 2027 | | | | $ 80,000 | $ - | $ 80,000 |
| 7 | 2028 | | | | $ 80,000 | $ - | $ 80,000 |
| 8 | 2029 | | | | $ 80,000 | $ - | $ 80,000 |
| 9 | 2030 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 10 | 2031 | | | | $ 80,000 | $ - | $ 80,000 |
| 11 | 2032 | | | | $ 80,000 | $ 123,000 | $ 203,000 |
| 12 | 2033 | | | | $ 80,000 | $ - | $ 80,000 |
| 13 | 2034 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 14 | 2035 | | | | $ 80,000 | $ - | $ 80,000 |
| 15 | 2036 | | | | $ 80,000 | $ - | $ 80,000 |
| 16 | 2037 | | | | $ 80,000 | $ 1,875,000 | $ 1,955,000 |
| 17 | 2038 | | | | $ 80,000 | $ 55,000 | $ 135,000 |
| 18 | 2039 | | | | $ 80,000 | $ 159,000 | $ 239,000 |
| 19 | 2040 | | | | $ 80,000 | $ - | $ 80,000 |
| 20 | 2041 | | | | $ 80,000 | $ - | $ 80,000 |
| Total Service Life | | | | | $ 1,600,000 | $ 2,432,000 | $ 4,032,000 |

PROJECT COSTS AND SCHEDULE - BUILD CASE NUMBER 1 - 4-LANE UNDIVIDED
Expressed in Constant (2017) Dollars

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| Construction Period | | | | | | | |
| 1 | 2021 | $ 715,331 | $ 238,444 | $ 22,890,576 | $ - | $ - | $ 23,844,351 |
| +10% | 2021 | $ 786,864 | $ 262,288 | $ 25,179,634 | | | $ 26,228,786 |
| -10% | 2021 | $ 643,798 | $ 214,600 | $ 20,601,518 | | | $ 21,459,916 |
| Service Life | | | | | | | |
| 1 | 2022 | | | | $ 76,302 | $ 52,458 | $ 128,760 |
| 2 | 2023 | | | | $ 76,302 | $ - | $ 76,302 |
| 3 | 2024 | | | | $ 76,302 | $ - | $ 76,302 |
| 4 | 2025 | | | | $ 76,302 | $ - | $ 76,302 |
| 5 | 2026 | | | | $ 76,302 | $ 52,458 | $ 128,760 |
| 6 | 2027 | | | | $ 76,302 | $ - | $ 76,302 |
| 7 | 2028 | | | | $ 76,302 | $ - | $ 76,302 |
| 8 | 2029 | | | | $ 76,302 | $ - | $ 76,302 |
| 9 | 2030 | | | | $ 76,302 | $ 52,458 | $ 128,760 |
| 10 | 2031 | | | | $ 76,302 | $ - | $ 76,302 |
| 11 | 2032 | | | | $ 76,302 | $ 117,314 | $ 193,616 |
| 12 | 2033 | | | | $ 76,302 | $ - | $ 76,302 |
| 13 | 2034 | | | | $ 76,302 | $ 52,458 | $ 128,760 |
| 14 | 2035 | | | | $ 76,302 | $ - | $ 76,302 |
| 15 | 2036 | | | | $ 76,302 | $ - | $ 76,302 |
| 16 | 2037 | | | | $ 76,302 | $ 1,788,327 | $ 1,864,629 |
| 17 | 2038 | | | | $ 76,302 | $ 52,458 | $ 128,760 |
| 18 | 2039 | | | | $ 76,302 | $ 151,650 | $ 227,952 |
| 19 | 2040 | | | | $ 76,302 | $ - | $ 76,302 |
| 20 | 2041 | | | | $ 76,302 | $ - | $ 76,302 |
| Total Service Life | | | | | $ 1,526,040 | $ 2,319,581 | $ 3,845,621 |

| REHABILITATION ACTIVITIES - 4-LANE UNDIVIDED | | | |
|---|---|---|---|
| | | | |
| Description | Year | Date | Rehabilitation Costs |
| Service Life | | | |
| Incident Caused Lane Closures & Repairs | 1 | 2022 | $ 55,000 |
| | 2 | 2023 | $ - |
| | 3 | 2024 | $ - |
| | 4 | 2025 | $ - |
| Incident Caused Lane Closures & Repairs | 5 | 2026 | $ 55,000 |
| | 6 | 2027 | $ - |
| | 7 | 2028 | $ - |
| | 8 | 2029 | $ - |
| Incident Caused Lane Closures & Repairs | 9 | 2030 | $ 55,000 |
| | 10 | 2031 | $ - |
| Major Shoulder Rehabilitation | 11 | 2032 | $ 123,000 |
| | 12 | 2033 | $ - |
| Incident Caused Lane Closures & Repairs | 13 | 2034 | $ 55,000 |
| | 14 | 2035 | $ - |
| Incident Caused Lane Closures & Repairs | 15 | 2036 | $ - |
| Replace Surface Wearing Course | 16 | 2037 | $ 750,000 |
| Major Drainage Rehabilitation | 16 | 2037 | $ 180,000 |
| Overhead Sign and Signal Replacement | 16 | 2037 | $ 945,000 |
| Incident Caused Lane Closures & Repairs | 17 | 2038 | $ 55,000 |
| Guardrail Replacement | 18 | 2039 | $ 159,000 |
| Incident Caused Lane Closures & Repairs | 19 | 2040 | $ - |
| | 20 | 2041 | $ - |
| | | | |
| Total Rehabilitation Costs | | | $ 2,432,000 |

PROJECT COSTS AND SCHEDULE - BUILD CASE NUMBER 2 - 4-LANE DIVIDED

Expressed in Today's (2019) Dollars

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| Construction Period | | | | | | | |
| 1 | 2021 | $ 750,000 | $ 250,000 | $ 28,000,000 | $ - | $ - | $ 29,000,000 |
| Service Life | | | | | | | |
| 1 | 2022 | | | | $ 86,000 | $ 55,000 | $ 141,000 |
| 2 | 2023 | | | | $ 86,000 | $ - | $ 86,000 |
| 3 | 2024 | | | | $ 86,000 | $ - | $ 86,000 |
| 4 | 2025 | | | | $ 86,000 | $ - | $ 86,000 |
| 5 | 2026 | | | | $ 86,000 | $ - | $ 86,000 |
| 6 | 2027 | | | | $ 86,000 | $ 55,000 | $ 141,000 |
| 7 | 2028 | | | | $ 86,000 | | $ 86,000 |
| 8 | 2029 | | | | $ 86,000 | | $ 86,000 |
| 9 | 2030 | | | | $ 86,000 | | $ 86,000 |
| 10 | 2031 | | | | $ 86,000 | | $ 86,000 |
| 11 | 2032 | | | | $ 86,000 | $ 331,000 | $ 417,000 |
| 12 | 2033 | | | | $ 86,000 | | $ 86,000 |
| 13 | 2034 | | | | $ 86,000 | | $ 86,000 |
| 14 | 2035 | | | | $ 86,000 | | $ 86,000 |
| 15 | 2036 | | | | $ 86,000 | | $ 86,000 |
| 16 | 2037 | | | | $ 86,000 | $ 1,930,000 | $ 2,016,000 |
| 17 | 2038 | | | | $ 86,000 | | $ 86,000 |
| 18 | 2039 | | | | $ 86,000 | $ 159,000 | $ 245,000 |
| 19 | 2040 | | | | $ 86,000 | | $ 86,000 |
| 20 | 2041 | | | | $ 86,000 | | $ 86,000 |
| Total Service Life | | | | | $ 1,720,000 | $ 2,530,000 | $ 4,250,000 |

PROJECT COSTS AND SCHEDULE - BUILD CASE NUMBER 2 - 4-LANE DIVIDED

Expressed in Constant (2017) Dollars

| Year | Date | Initial Costs | | | Subsequent Costs | | Total Costs |
|---|---|---|---|---|---|---|---|
| | | Project Support | Right of Way | Construction | Maintenance and Operations | Rehabilitation | |
| Construction Period | | | | | | | |
| 1 | 2021 | $ 715,331 | $ 238,444 | $ 26,705,672 | $ - | $ - | $ 27,659,447 |
| +10% | 2021 | 786,864 | 262,288 | 29,376,239 | | | $ 30,425,392 |
| -10% | 2021 | 643,798 | 214,600 | 24,035,105 | | | $ 24,893,502 |
| Service Life | | | | | | | |
| 1 | 2022 | | | | $ 82,025 | $ 52,458 | $ 134,483 |
| 2 | 2023 | | | | $ 82,025 | $ - | $ 82,025 |
| 3 | 2024 | | | | $ 82,025 | $ - | $ 82,025 |
| 4 | 2025 | | | | $ 82,025 | $ - | $ 82,025 |
| 5 | 2026 | | | | $ 82,025 | $ - | $ 82,025 |
| 6 | 2027 | | | | $ 82,025 | $ 52,458 | $ 134,483 |
| 7 | 2028 | | | | $ 82,025 | $ - | $ 82,025 |
| 8 | 2029 | | | | $ 82,025 | $ - | $ 82,025 |
| 9 | 2030 | | | | $ 82,025 | $ - | $ 82,025 |
| 10 | 2031 | | | | $ 82,025 | $ - | $ 82,025 |
| 11 | 2032 | | | | $ 82,025 | $ 315,699 | $ 397,724 |
| 12 | 2033 | | | | $ 82,025 | $ - | $ 82,025 |
| 13 | 2034 | | | | $ 82,025 | $ - | $ 82,025 |
| 14 | 2035 | | | | $ 82,025 | $ - | $ 82,025 |
| 15 | 2036 | | | | $ 82,025 | $ - | $ 82,025 |
| 16 | 2037 | | | | $ 82,025 | $ 1,840,784 | $ 1,922,809 |
| 17 | 2038 | | | | $ 82,025 | $ - | $ 82,025 |
| 18 | 2039 | | | | $ 82,025 | $ 151,650 | $ 233,675 |
| 19 | 2040 | | | | $ 82,025 | $ - | $ 82,025 |
| 20 | 2041 | | | | $ 82,025 | $ - | $ 82,025 |
| Total Service Life | | | | | $ 1,640,500 | $ 2,413,049 | $ 4,053,549 |

## REHABILITATION ACTIVITIES - 4-LANE DIVIDED

| Description | Year | Date | Rehabilitation Costs |
|---|---|---|---|
| Service Life | | | |
| Incident Caused Lane Closures & Repairs | 1 | 2022 | $ 55,000 |
| | 2 | 2023 | $ - |
| | 3 | 2024 | $ - |
| | 4 | 2025 | $ - |
| | 5 | 2026 | $ - |
| Incident Caused Lane Closures & Repairs | 6 | 2027 | $ 55,000 |
| | 7 | 2028 | $ - |
| | 8 | 2029 | $ - |
| | 9 | 2030 | $ - |
| | 10 | 2031 | $ - |
| Major Shoulder Rehabilitation | 11 | 2032 | $ 123,000 |
| Major Median Rehabilitation | 11 | 2032 | $ 153,000 |
| Incident Caused Lane Closures & Repairs | 11 | 2032 | $ 55,000 |
| | 12 | 2033 | $ - |
| | 13 | 2034 | $ - |
| | 14 | 2035 | $ - |
| | 15 | 2036 | $ - |
| Replace Surface Wearing Course | 16 | 2037 | $ 750,000 |
| Major Drainage Rehabilitation | 16 | 2037 | $ 180,000 |
| Overhead Sign and Signal Replacement | 16 | 2037 | $ 945,000 |
| Incident Caused Lane Closures & Repairs | 16 | 2027 | $ 55,000 |
| | 17 | 2038 | $ - |
| Guardrail Replacement | 18 | 2039 | $ 159,000 |
| Incident Caused Lane Closures & Repairs | 19 | 2040 | $ - |
| | 20 | 2041 | $ - |
| | | | |
| Total Rehabilitation Costs | | | $ 2,530,000 |

# WARREN COUNTY TRANSPORTATION IMPROVEMENT DISTRICT
# WAR 63 PRIORITY SEGMENT
# LIFE CYCLE COST ANALYSIS
# MAINTENANCE COSTS - NO MOT

Expressed in Today's (2019) Dollars

| Activity | No Build | 4-Lane Undivided | 4-Lane Divided |
|---|---|---|---|
| Pavement | $ 40,000 | $ 51,000 | $ 51,000 |
| Culverts | $ 5,000 | $ 6,000 | $ 7,000 |
| Open Drainage | $ 2,000 | $ 2,000 | $ 2,000 |
| Shoulders | $ 11,000 | $ 15,000 | $ 15,000 |
| Guardrail | | | |
| Median | | | $ 4,000 |
| Cable Barrier | | | |
| Signs and Signals | $ 6,000 | $ 6,000 | $ 7,000 |
| Outages | | | |
| | $ 64,000 | $ 80,000 | $ 86,000 |

Expressed in Constant (2017) Dollars

| Activity | No Build | 4-Lane Undivided | 4-Lane Divided |
|---|---|---|---|
| Pavement | $ 38,151 | $ 48,642 | $ 48,642 |
| Culverts | $ 4,769 | $ 5,723 | $ 6,676 |
| Open Drainage | $ 1,908 | $ 1,908 | $ 1,908 |
| Shoulders | $ 10,492 | $ 14,307 | $ 14,307 |
| Guardrail | | | |
| Median | | | $ 3,815 |
| Cable Barrier | | | |
| Signs and Signals | $ 5,723 | $ 5,723 | $ 6,676 |
| Outages | | | |
| | $ 61,043 | $ 76,303 | $ 82,024 |
| Incremental Change | | $ 15,260 | $ 20,981 |

Warren County Transportation Improvement District
Life Cycle Cost Analysis
WAR-SR-63
Minor and Regular Maintenance (No MOT Required)

| | No Build | | | | 4-Lane Divided | | | | 4-Lane Undivided | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost per Occurance | Frequency of Occurance (Number per Time Period) | Time Period | Annual Cost | Cost per Occurance | Frequency of Occurance (Number per Time Period) | Time Period | Annual Cost | Cost per Occurance | Frequency of Occurance (Number per Time Period) | Time Period | Annual Cost |
| **Pavement** | | | | | | | | | | | | |
| Snow Removal/Pretreatment | $ 3,000 | 8.00 | Annual | $ 24,000 | $ 5,000 | 8.00 | Annual | $ 40,000 | $ 5,000 | 8.00 | Annual | $ 40,000 |
| Crack Sealing/Pot Hole Repair | $ 5,400 | 3.00 | Annual | $ 16,200 | $ 3,600 | 3.00 | Annual | $ 10,800 | $ 3,600 | 3.00 | Annual | $ 10,800 |
| Subtotal | | | | $ 40,200 | | | | $ 50,800 | | | | $ 50,800 |
| **Culverts** | | | | | | | | | | | | |
| Culvert Inspection (6) | $ 2,100 | 1.00 | Annual | $ 2,100 | $ 2,100 | 1.00 | Annual | $ 2,100 | $ 2,100 | 1.00 | Annual | $ 2,100 |
| Culvert Cleanout (6) | $ 5,000 | 0.50 | Annual | $ 2,500 | $ 7,000 | 0.50 | Annual | $ 3,500 | $ 10,000 | 0.50 | Annual | $ 5,000 |
| Subtotal | | | | $ 4,600 | | | | $ 5,600 | | | | $ 7,100 |
| **Open Drainage** | | | | | | | | | | | | |
| Stormwater BMP Maintenance | $ - | 0.00 | Annual | $ - | $ | 0.00 | Annual | $ - | $ | 0.00 | Annual | $ - |
| Ditch Cleaning | $ 8,500 | 0.25 | Annual | $ 2,125 | $ 8,500 | 0.25 | Annual | $ 2,125 | $ 8,500 | 0.25 | Annual | $ 2,125 |
| Curb Inlet Cleanout | $ 1,000 | 0.25 | Annual | $ 250 | $ 1,000 | 0.25 | Annual | $ 250 | $ 1,000 | 0.25 | Annual | $ 250 |
| Subtotal | | | | $ 2,375 | | | | $ 2,375 | | | | $ 2,375 |
| **Shoulders** | | | | | | | | | | | | |
| Mowing | $ 1,200 | 3.00 | Annual | $ 3,600 | $ 2,400 | 3.00 | Annual | $ 7,200 | $ 2,400 | 3.00 | Annual | $ 7,200 |
| Litter and Debris Cleanup | $ 1,200 | 2.00 | Annual | $ 2,400 | $ 1,200 | 2.00 | Annual | $ 2,400 | $ 1,200 | 2.00 | Annual | $ 2,400 |
| Sweeping and Vacuuming | $ 2,200 | 2.00 | Annual | $ 4,400 | $ 2,200 | 2.00 | Annual | $ 4,400 | $ 2,200 | 2.00 | Annual | $ 4,400 |
| ROW Fence Repair/Replacement | $ 8,500 | 0.10 | Annual | $ 850 | $ 8,500 | 0.10 | Annual | $ 850 | $ 8,500 | 0.10 | Annual | $ 850 |
| Subtotal | | | | $ 11,250 | | | | $ 14,850 | | | | $ 14,850 |
| **Guardrail** | | | | | | | | | | | | |
| **Median** | | | | | | | | | | | | |
| Mowing | | | | | | | | | $ 1,200 | 3.00 | Annual | $ 3,600 |
| **Barrier** | | | | | | | | | | | | |
| **Signs and Signals** | | | | | | | | | | | | |
| Signal Inspection/Timing | $ 2,100 | 1.00 | Annual | $ 2,100 | $ 2,100 | 1.00 | Annual | $ 2,100 | $ 2,100 | 1.00 | Annual | $ 2,100 |
| Bulb/Lamp/Sensor Replacement | $ 600 | 1.00 | Annual | $ 600 | $ 600 | 1.00 | Annual | $ 600 | $ 600 | 1.00 | Annual | $ 600 |
| Signal Repair/Maintenance | $ 3,000 | 0.25 | Annual | $ 750 | $ 3,000 | 0.25 | Annual | $ 750 | $ 3,000 | 0.25 | Annual | $ 750 |
| Sign Replacement (Traffic Control and Ground Mounted) | $ 24,000 | 0.10 | Annual | $ 2,400 | $ 24,000 | 0.10 | Annual | $ 2,400 | $ 36,000 | 0.10 | Annual | $ 3,600 |
| Subtotoal | | | | $ 5,850 | | | | $ 5,850 | | | | $ 7,050 |
| **Outages** | | | | | | | | | | | | |
| Total | | | | $ 64,275 | | | | $ 79,475 | | | | $ 85,775 |

# APPENDIX B Strategy-Level Inputs to B/C Analysis

| **PROJECT DATA INPUTS** | | | | |
|---|---|---|---|---|
| **Data Category** | **Base Values** | **Data Source** | **Range of Values for Sensitivity Analysis** | |
| Project Type | General Highway | | General Highway | General Highway |
| Project Location | Rural | | Rural | Rural |
| Length of Construction Period (Years) | 1 | | 1 | 1 |
| One or Two way Data | | | 2 | 2 |
| Length of Peak Period (Hours) | 13 | ODOT Traffic Database | 13 | 13 |

| HIGHWAY DESIGN AND TRAFFIC DATA INPUTS | | | | | | |
|---|---|---|---|---|---|---|
| **Data Category** | **No Build** | **Build Case 1** | **Build Case 2** | **Data Source** | **Range of Values for Sensitivity Analysis** | |
| | | | | | **Min** | **Max** |
| HIGHWAY DESIGN DATA | | | | | | |
| Roadway Type | Conventional Hwy | Conventional Hwy | Conventional Hwy | Project plans | -- | -- |
| Number of General Traffic Lanes | 2 | 4 | 4 | Project plans | -- | -- |
| Highway Free-Flow Speed | 50 | 55 | 60 | HCM, AASHTO Green Book, field data and ODOT plans | -- | -- |
| AVERAGE DAILY TRAFFIC | | | | | | |
| Current Year (0) | 20,600 | 20,600 | 20,600 | ODOT Traffic Counts | -- | -- |
| Base Year (1) | 21,337 | 24,184 | 24,184 | SHIFT | -- | -- |
| Forecast Year (20) | 35,346 | 40,062 | 40,062 | SHIFT | 36,056 | 44,068 |
| Percent Trucks | 9% | 9% | 9% | ODOT Traffic Database | -- | -- |
| Truck Speed | 50 | 50 | 50 | Observed Speed | -- | -- |
| PAVEMENT CONDITION | | | | | | |
| Base Year (1) | 75 | 100 | 100 | ODOT Transportation Information Mapping System (TIMS) | -- | -- |
| Forecast Year (20) | -- | 100 | 100 | Assumed from Project Asset Management Plan | -- | -- |
| AVERAGE VEHICLE OCCUPANCY | | | | | | |
| General Traffic (Peak) | 1.30 | 1.30 | 1.30 | Default Values | -- | -- |
| General Traffic (Non-Peak) | 1.15 | 1.15 | 1.15 | Default Values | -- | -- |

| HIGHWAY ACCIDENT DATA INPUTS | | | | | |
|---|---|---|---|---|---|
| Data Category | No-Build | | Build Case 1 | Build Case 2 | Data Source |
| | Count | Rate | | | |
| ACTUAL 3-YEAR ACCIDENT DATA | | | | | |
| Total Accidents | 126 | 1.86 | -- | -- | ODOT Safety Data Base |
| Fatal Accidents | 1 | 0.015 | -- | -- | ODOT Safety Data Base |
| Injury Accidents | 33 | 0.49 | -- | -- | ODOT Safety Data Base |
| Property Damage Only Accidents | 92 | 1.36 | -- | -- | ODOT Safety Data Base |
| STATEWIDE AVERAGE ACCIDENT RATE FOR SAME TYPE FACILITY | | | | | |
| Accident Rate (per million vehicle-miles) | -- | 1.72 | 1.3 | 0.75 | ODOT Safety Data Base |
| Percent Fatal | -- | 0.3 | 0.3 | 0.3 | ODOT Safety Data Base |
| Percent Injury | -- | 23.5 | 23.5 | 23.5 | ODOT Safety Data Base |

# APPENDIX C Cal-B/C Version 6.2 Input and Output Sheets – All Build Cases and Scenarios

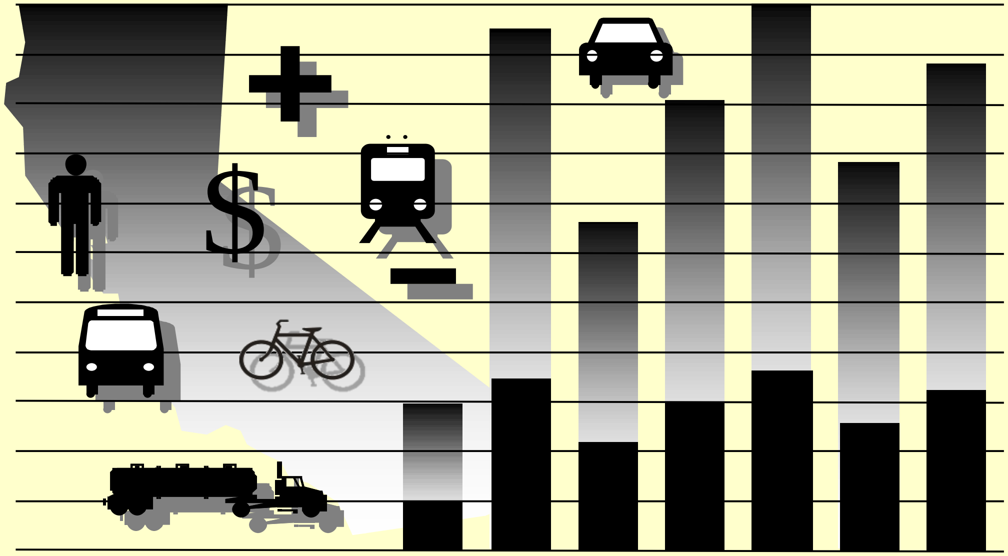
Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Undivided, $25M TPC, 40,062 AADT

WAR-63 Priority Project BCA

Caltrans
California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**

Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

Rose Agacer (916) 651-6014 rose_agacer@dot.ca.gov

# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period.  Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual.  Other adjustments are made for weaving and pavement conditions.  An option is also available to conduct a simple queuing analysis.  Accidents are estimated from statewide averages and recent data for the facility.  If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically.  Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road.  The user clicks a button and the model clears the Project Information worksheet to receive information on  other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed).  The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available.  The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed).  These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### **PROJECT DATA** (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

### *Type of Project*

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

### *Project Location*

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

### *Length of Construction Period*

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

### *One- or Two-Way Data*

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

### *Length of Peak Period(s)*

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

### *Highway Design*

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

### *Average Daily Traffic (ADT)*

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

***Average Hourly HOV/HOT Lane Traffic***

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

***Percent Traffic in Weave***

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

***Percent Trucks***

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

***Truck Speed***

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

***On-Ramp Volume***

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

***Queue Formation***

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

***Pavement Condition (for Pavement Rehab. Projects)***

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

***Average Vehicle Occupancy (AVO)***

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## **HIGHWAY ACCIDENT DATA** (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

***Actual 3-Year Accident Data (from Table B)***

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

***Statewide Basic Average Accident Rate***

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## **RAIL AND TRANSIT DATA** (Box 1D)

*This section is used for rail and transit projects only.*

***Annual Person-Trips***

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

***Percent Trips during Peak Period***

32 Insert % annual person-trips that occur during peak period.

***Percent New Trips from Parallel Highway***

33 Insert % new transit person-trips originating on parallel highway.

***Annual Vehicle-Miles***

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

***Average Vehicles per Train***

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

***Reduction in Transit Accidents***

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

***Average Transit Travel Time***

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

***Highway Grade Crossing***

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

***Transit Agency Costs (for Transit TMS Projects)***

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

| | |
|---|---|
| **District:** | WCTID |
| **PROJECT:** | WAR 63 Priority Segment 4 Lane Undivided |

| | |
|---|---|
| EA: | |
| PPNO: | |

1A

## PROJECT DATA

| | | |
|---|---|---|
| ***Type of Project*** | | |
| Select project type from list | General Highway | |
| ***Project Location*** (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural) | 3 | |
| Length of Construction Period | 1 | years |
| One- or Two-Way Data | 2 | enter 1 or 2 |
| | Current | |
| ***Length of Peak Period(s)*** (up to 24 hrs) | 13 | hours |

1B

## HIGHWAY DESIGN AND TRAFFIC DATA

| ***Highway Design*** | | No Build | Build |
|---|---|---|---|
| Roadway Type (Fwy, Exp, Conv Hwy) | | C | C |
| Number of General Traffic Lanes | | 2 | 4 |
| Number of HOV/HOT Lanes | | 0 | 0 |
| HOV Restriction (2 or 3) | | 0 | |
| Exclusive ROW for Buses (y/n) | | N | |
| Highway Free-Flow Speed | | 50 | 55 |
| Ramp Design Speed (if aux. lane/off-ramp proj.) | | | |
| Length (in miles) | Highway Segment | 3.0 | 3.0 |
| | Impacted Length | 3.0 | 3.0 |

| ***Average Daily Traffic*** | | | |
|---|---|---|---|
| | Current | 20,600 | |
| | | No Build | Build |
| | Base (Year 1) | 21,337 | 24,184 |
| | Forecast (Year 20) | 35,346 | 40,062 |
| ***Average Hourly HOV/HOT Lane Traffic*** | | | 0 |
| Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.) | | | 100% |
| ***Percent Traffic in Weave*** | | | 0.0% |
| ***Percent Trucks*** (include RVs, if applicable) | | 9% | 9% |
| ***Truck Speed*** | | 50 | |

| ***On-Ramp Volume*** | Peak | Non-Peak |
|---|---|---|
| Hourly Ramp Volume (if aux. lane/on-ramp proj.) | 0 | 0 |
| Metering Strategy (1, 2, 3, or D, if on-ramp proj.) | | |

| ***Queue Formation*** (if queuing or grade crossing project) | Year 1 | Year 20 |
|---|---|---|
| Arrival Rate (in vehicles per hour) | 0 | 0 |
| Departure Rate (in vehicles per hour) | 0 | 0 |

| ***Pavement Condition*** (if pavement project) | | No Build | Build |
|---|---|---|---|
| IRI (inches/mile) | Base (Year 1) | | |
| | Forecast (Year 20) | | |

| ***Average Vehicle Occupancy (AVO)*** | | No Build | Build |
|---|---|---|---|
| General Traffic | Non-Peak | 1.30 | 1.30 |
| | Peak | 1.15 | 1.15 |
| High Occupancy Vehicle (if HOV/HOT lanes) | | 2.15 | 2.15 |

1C

## HIGHWAY ACCIDENT DATA

| ***Actual 3-Year Accident Data (from Table B)*** | Count (No.) | Rate |
|---|---|---|
| Total Accidents (Tot) | 126 | 1.86 |
| Fatal Accidents (Fat) | 1 | 0.015 |
| Injury Accidents (Inj) | 33 | 0.49 |
| Property Damage Only (PDO) Accidents | 92 | 1.36 |

| ***Statewide Basic Average Accident Rate*** | No Build | Build |
|---|---|---|
| Rate Group | | |
| Accident Rate (per million vehicle-miles) | 1.72 | 1.30 |
| Percent Fatal Accidents (Pct Fat) | 0.3% | 0.3% |
| Percent Injury Accidents (Pct Inj) | 23.5% | 23.5% |

1D

## RAIL AND TRANSIT DATA

| ***Annual Person-Trips*** | No Build | Build |
|---|---|---|
| Base (Year 1) | | |
| Forecast (Year 20) | | |
| ***Percent Trips during Peak Period*** | 89% | |
| ***Percent New Trips from Parallel Highway*** | | 100% |

| ***Annual Vehicle-Miles*** | No Build | Build |
|---|---|---|
| Base (Year 1) | | |
| Forecast (Year 20) | | |
| ***Average Vehicles/Train*** (if rail project) | | |

| ***Reduction in Transit Accidents*** | |
|---|---|
| Percent Reduction (if safety project) | |

| ***Average Transit Travel Time*** | | No Build | Build |
|---|---|---|---|
| In-Vehicle | Non-Peak (in minutes) | | 0.0 |
| | Peak (in minutes) | | 0.0 |
| Out-of-Vehicle | Non-Peak (in minutes) | 0.0 | 0.0 |
| | Peak (in minutes) | 0.0 | 0.0 |

| ***Highway Grade Crossing*** | Current | Year 1 | Year 20 |
|---|---|---|---|
| Annual Number of Trains | | 0 | |
| Avg. Gate Down Time (in min.) | | 0.0 | |

| ***Transit Agency Costs*** (if TMS project) | No Build | Build |
|---|---|---|
| Annual Capital Expenditure | | $0 |
| Annual Ops. and Maintenance Expenditure | | $0 |

*Model should be run for both roads for intersection or bypass highway projects, and may be run twice for connectors. Press button below to prepare model to enter data for second road. After data are entered, results reflect total project benefits.*

Prepare Model for Second Road

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 32,300 | | 32,300 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 3,195 | | 3,195 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 54.4 | | 54.4 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 4,156 | | 4,156 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 411 | | 411 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |

**Hwy Safety or Weaving Improvement** 0% collision reduction factor (per HSIP Guidelines)

| **Adjustment Factor** (Actual/Statewide Avg. Existing) | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.011 | | 0.011 | |
| Injury Accidents | 0.37 | | 0.37 | |
| PDO Accidents | 1.03 | | 1.03 | |
| Total Accidents | 1.410 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

**Detailed Information Available?** (y/n) N

**Aggregate Segment Length** (estimate as VMT/total volume)

| | | |
|---|---|---|
| All Ramps | | miles |
| Arterials | | miles |

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

## ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 13,558,088 | 1,596,025 |
| Truck Trips | 1,028,749 | 1,166,009 | 137,260 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 1,972,037 | 232,143 |
| Truck Trips | 132,367 | 150,028 | 17,661 |
| Total Trips | 14,863,073 | 16,846,162 | 1,983,089 |

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4 Lane Undivided

EA:
PPNO:

3

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| **Life-Cycle Costs (mil. $)** | $22.0 |
| **Life-Cycle Benefits (mil. $)** | $81.7 |
| **Net Present Value (mil. $)** | $59.7 |
| **Benefit / Cost Ratio:** | 3.7 |
| **Rate of Return on Investment:** | 17.6% |
| **Payback Period:** | 10 years |

| **ITEMIZED BENEFITS (mil. $)** | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| **Travel Time Savings** | $69.7 | $12.0 | $81.6 | $4.1 |
| **Veh. Op. Cost Savings** | -$9.7 | -$1.9 | -$11.6 | -$0.6 |
| **Accident Cost Savings** | $10.5 | $1.0 | $11.6 | $0.6 |
| **Emission Cost Savings** | -$0.0 | $0.1 | $0.1 | $0.0 |
| **TOTAL BENEFITS** | $70.5 | $11.2 | $81.7 | $4.1 |
| **Person-Hours of Time Saved** | | | 13,884,608 | 694,230 |

***Should benefit-cost results include:***

| | |
|---|---|
| **1) Induced Travel? (y/n)** | Y<br>Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y<br>Default = Y |
| **3) Accident Costs? (y/n)** | Y<br>Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for $CO_2e$ | Y<br>Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| **EMISSIONS REDUCTION** | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| **CO Emissions Saved** | 33 | 2 | $0.0 | $0.0 |
| **$CO_2$ Emissions Saved** | 29,334 | 1,467 | $0.0 | $0.0 |
| **$NO_X$ Emissions Saved** | 60 | 3 | $0.1 | $0.0 |
| **$PM_{10}$ Emissions Saved** | 0 | 0 | $0.0 | $0.0 |
| **$PM_{2.5}$ Emissions Saved** | 0 | 0 | | |
| **$SO_X$ Emissions Saved** | 0 | 0 | -$0.0 | -$0.0 |
| **VOC Emissions Saved** | 7 | 0 | $0.0 | $0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $648,782 | $0 | $21,244 | $0 | $0 | $78,532 | $0 | $0 |
| 20 | $0 | $8,381,211 | $0 | $1,592,605 | $0 | $0 | $35,971 | $0 | $0 |
| 2 | $0 | $863,076 | $0 | $67,138 | $0 | $0 | $75,930 | $0 | $0 |
| 3 | $0 | $1,080,908 | $0 | $113,677 | $0 | $0 | $73,333 | $0 | $0 |
| 4 | $0 | $1,302,957 | $0 | $160,980 | $0 | $0 | $70,751 | $0 | $0 |
| 5 | $0 | $1,530,130 | $0 | $209,212 | $0 | $0 | $68,192 | $0 | $0 |
| 6 | $0 | $1,763,601 | $0 | $258,592 | $0 | $0 | $65,666 | $0 | $0 |
| 7 | $0 | $2,004,859 | $0 | $309,403 | $0 | $0 | $63,178 | $0 | $0 |
| 8 | $0 | $2,255,777 | $0 | $362,005 | $0 | $0 | $60,735 | $0 | $0 |
| 9 | $0 | $2,518,709 | $0 | $416,850 | $0 | $0 | $58,341 | $0 | $0 |
| 10 | $0 | $2,796,621 | $0 | $474,513 | $0 | $0 | $56,000 | $0 | $0 |
| 11 | $0 | $3,093,271 | $0 | $535,727 | $0 | $0 | $53,716 | $0 | $0 |
| 12 | $0 | $3,413,480 | $0 | $601,428 | $0 | $0 | $51,491 | $0 | $0 |
| 13 | $0 | $3,763,506 | $0 | $672,837 | $0 | $0 | $49,328 | $0 | $0 |
| 14 | $0 | $4,151,612 | $0 | $751,565 | $0 | $0 | $47,227 | $0 | $0 |
| 15 | $0 | $4,588,931 | $0 | $839,787 | $0 | $0 | $45,190 | $0 | $0 |
| 16 | $0 | $5,090,826 | $0 | $940,499 | $0 | $0 | $43,217 | $0 | $0 |
| 17 | $0 | $5,679,105 | $0 | $1,057,960 | $0 | $0 | $41,309 | $0 | $0 |
| 18 | $0 | $6,385,816 | $0 | $1,198,424 | $0 | $0 | $39,465 | $0 | $0 |
| 19 | $0 | $7,260,075 | $0 | $1,371,478 | $0 | $0 | $37,686 | $0 | $0 |
| **Total** | **$0** | **$68,573,252** | **$0** | **$11,955,923** | **$0** | **$0** | **$1,115,259** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| **Year** | **TRANSIT** | | | | **Present Value of Travel Time Benefits** | **Constant Dollars** | **Total Per-Hrs of Time Saved** |
|---|---|---|---|---|---|---|---|
| | **Peak In-Vehicle** | **Peak Out-of-Veh** | **Non-Peak In-Vehicle** | **Non-Peak Out-of-Veh** | | | |
| 1 | $0 | $0 | $0 | $0 | $748,557 | $800,956 | 53,742 |
| 20 | $0 | $0 | $0 | $0 | $10,009,787 | $38,734,717 | 2,405,888 |
| 2 | $0 | $0 | $0 | $0 | $1,006,143 | $1,151,934 | 75,607 |
| 3 | $0 | $0 | $0 | $0 | $1,267,917 | $1,553,253 | 100,589 |
| 4 | $0 | $0 | $0 | $0 | $1,534,687 | $2,011,661 | 129,107 |
| 5 | $0 | $0 | $0 | $0 | $1,807,534 | $2,535,160 | 161,656 |
| 6 | $0 | $0 | $0 | $0 | $2,087,859 | $3,133,314 | 198,828 |
| 7 | $0 | $0 | $0 | $0 | $2,377,440 | $3,817,650 | 241,339 |
| 8 | $0 | $0 | $0 | $0 | $2,678,517 | $4,602,190 | 290,055 |
| 9 | $0 | $0 | $0 | $0 | $2,993,900 | $5,504,163 | 346,046 |
| 10 | $0 | $0 | $0 | $0 | $3,327,134 | $6,544,977 | 410,636 |
| 11 | $0 | $0 | $0 | $0 | $3,682,714 | $7,751,568 | 485,496 |
| 12 | $0 | $0 | $0 | $0 | $4,066,399 | $9,158,310 | 572,753 |
| 13 | $0 | $0 | $0 | $0 | $4,485,670 | $10,809,769 | 675,171 |
| 14 | $0 | $0 | $0 | $0 | $4,950,404 | $12,764,785 | 796,392 |
| 15 | $0 | $0 | $0 | $0 | $5,473,908 | $15,102,685 | 941,333 |
| 16 | $0 | $0 | $0 | $0 | $6,074,542 | $17,933,043 | 1,116,782 |
| 17 | $0 | $0 | $0 | $0 | $6,778,374 | $21,411,630 | 1,332,389 |
| 18 | $0 | $0 | $0 | $0 | $7,623,706 | $25,767,609 | 1,602,351 |
| 19 | $0 | $0 | $0 | $0 | $8,669,240 | $31,352,546 | 1,948,448 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$81,644,434** | **$222,441,922** | **13,884,608** |

C

# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | | Present Value of |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | Veh Op Cost Benefits |
| 1 | $0 | ($942,318) | $0 | ($140,639) | $0 | ($121,246) | $0 | ($18,190) | - | - | ($1,222,393) |
| 20 | $0 | $393,073 | $0 | $63,534 | $0 | ($55,540) | $0 | ($8,332) | - | - | $392,735 |
| 2 | $0 | ($906,477) | $0 | ($134,213) | $0 | ($117,231) | $0 | ($17,587) | - | - | ($1,175,508) |
| 3 | $0 | ($875,476) | $0 | ($128,258) | $0 | ($113,221) | $0 | ($16,986) | - | - | ($1,133,940) |
| 4 | $0 | ($829,424) | $0 | ($129,013) | $0 | ($109,235) | $0 | ($16,388) | - | - | ($1,084,059) |
| 5 | $0 | ($784,760) | $0 | ($129,428) | $0 | ($105,285) | $0 | ($15,795) | - | - | ($1,035,269) |
| 6 | $0 | ($734,492) | $0 | ($126,468) | $0 | ($101,385) | $0 | ($15,210) | - | - | ($977,555) |
| 7 | $0 | ($679,475) | $0 | ($120,501) | $0 | ($97,545) | $0 | ($14,634) | - | - | ($912,155) |
| 8 | $0 | ($627,059) | $0 | ($114,427) | $0 | ($93,773) | $0 | ($14,068) | - | - | ($849,328) |
| 9 | $0 | ($558,400) | $0 | ($116,708) | $0 | ($90,077) | $0 | ($13,514) | - | - | ($778,699) |
| 10 | $0 | ($496,830) | $0 | ($118,284) | $0 | ($86,463) | $0 | ($12,972) | - | - | ($714,549) |
| 11 | $0 | ($424,546) | $0 | ($112,210) | $0 | ($82,937) | $0 | ($12,443) | - | - | ($632,135) |
| 12 | $0 | ($346,014) | $0 | ($99,650) | $0 | ($79,502) | $0 | ($11,927) | - | - | ($537,094) |
| 13 | $0 | ($275,742) | $0 | ($87,884) | $0 | ($76,162) | $0 | ($11,426) | - | - | ($451,214) |
| 14 | $0 | ($220,803) | $0 | ($73,806) | $0 | ($72,918) | $0 | ($10,939) | - | - | ($378,466) |
| 15 | $0 | ($133,476) | $0 | ($50,634) | $0 | ($69,773) | $0 | ($10,468) | - | - | ($264,351) |
| 16 | $0 | ($53,244) | $0 | ($29,107) | $0 | ($66,727) | $0 | ($10,011) | - | - | ($159,088) |
| 17 | $0 | $55,788 | $0 | ($16,090) | $0 | ($63,781) | $0 | ($9,569) | - | - | ($33,651) |
| 18 | $0 | $153,096 | $0 | ($4,163) | $0 | ($60,935) | $0 | ($9,142) | - | - | $78,856 |
| 19 | $0 | $267,853 | $0 | $23,047 | $0 | ($58,188) | $0 | ($8,730) | - | - | $223,982 |
| **Total** | **$0** | **($8,018,727)** | **$0** | **($1,644,903)** | **$0** | **($1,721,924)** | **$0** | **($258,331)** | **-** | **-** | **($11,643,884)** |

| Constant Dollars |
|---|
| ($1,307,961) |
| $1,519,760 |
| |
| ($1,345,840) |
| ($1,389,126) |
| ($1,420,981) |
| ($1,452,019) |
| ($1,467,047) |
| ($1,464,722) |
| ($1,459,303) |
| ($1,431,607) |
| ($1,405,627) |
| ($1,330,550) |
| ($1,209,638) |
| ($1,087,355) |
| ($975,889) |
| ($729,352) |
| ($469,655) |
| ($106,298) |
| $266,529 |
| $810,037 |
| |
| **($17,456,643)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | All Periods | |
| 1 | $0 | $658,157 | $0 | $65,092 | $0 | $84,684 | $0 | $8,375 | $0 | $816,308 |
| 20 | $0 | $301,451 | $0 | $29,814 | $0 | $38,787 | $0 | $3,836 | $0 | $373,888 |
| 2 | $0 | $636,351 | $0 | $62,936 | $0 | $81,878 | $0 | $8,098 | $0 | $789,263 |
| 3 | $0 | $614,582 | $0 | $60,783 | $0 | $79,077 | $0 | $7,821 | $0 | $762,263 |
| 4 | $0 | $592,938 | $0 | $58,642 | $0 | $76,292 | $0 | $7,545 | $0 | $735,418 |
| 5 | $0 | $571,496 | $0 | $56,522 | $0 | $73,533 | $0 | $7,273 | $0 | $708,823 |
| 6 | $0 | $550,321 | $0 | $54,427 | $0 | $70,809 | $0 | $7,003 | $0 | $682,560 |
| 7 | $0 | $529,471 | $0 | $52,365 | $0 | $68,126 | $0 | $6,738 | $0 | $656,700 |
| 8 | $0 | $508,993 | $0 | $50,340 | $0 | $65,491 | $0 | $6,477 | $0 | $631,302 |
| 9 | $0 | $488,929 | $0 | $48,356 | $0 | $62,910 | $0 | $6,222 | $0 | $606,416 |
| 10 | $0 | $469,312 | $0 | $46,415 | $0 | $60,386 | $0 | $5,972 | $0 | $582,085 |
| 11 | $0 | $450,169 | $0 | $44,522 | $0 | $57,922 | $0 | $5,729 | $0 | $558,342 |
| 12 | $0 | $431,522 | $0 | $42,678 | $0 | $55,523 | $0 | $5,491 | $0 | $535,214 |
| 13 | $0 | $413,388 | $0 | $40,885 | $0 | $53,190 | $0 | $5,261 | $0 | $512,723 |
| 14 | $0 | $395,780 | $0 | $39,143 | $0 | $50,924 | $0 | $5,036 | $0 | $490,884 |
| 15 | $0 | $378,707 | $0 | $37,454 | $0 | $48,727 | $0 | $4,819 | $0 | $469,708 |
| 16 | $0 | $362,173 | $0 | $35,819 | $0 | $46,600 | $0 | $4,609 | $0 | $449,201 |
| 17 | $0 | $346,182 | $0 | $34,238 | $0 | $44,543 | $0 | $4,405 | $0 | $429,368 |
| 18 | $0 | $330,734 | $0 | $32,710 | $0 | $42,555 | $0 | $4,209 | $0 | $410,207 |
| 19 | $0 | $315,824 | $0 | $31,235 | $0 | $40,637 | $0 | $4,019 | $0 | $391,715 |
| **Total** | **$0** | **$9,346,481** | **$0** | **$924,377** | **$0** | **$1,202,595** | **$0** | **$118,938** | **$0** | **$11,592,390** |

| Constant Dollars |
|---|
| $873,450 |
| $1,446,827 |
|  |
| $903,628 |
| $933,805 |
| $963,983 |
| $994,161 |
| $1,024,339 |
| $1,054,516 |
| $1,084,694 |
| $1,114,872 |
| $1,145,050 |
| $1,175,228 |
| $1,205,405 |
| $1,235,583 |
| $1,265,761 |
| $1,295,939 |
| $1,326,116 |
| $1,356,294 |
| $1,386,472 |
| $1,416,650 |
|  |
| **$23,202,773** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,936) | $0 | ($14,529) | $0 | $0 | ($1,519) | $0 | ($2,162) |
| 20 | $0 | $15,358 | $0 | $42,617 | $0 | $0 | ($214) | $0 | ($263) |
| 2 | $0 | ($10,909) | $0 | ($9,710) | $0 | $0 | ($1,471) | $0 | ($2,091) |
| 3 | $0 | ($10,800) | $0 | ($5,182) | $0 | $0 | ($1,423) | $0 | ($2,020) |
| 4 | $0 | ($10,450) | $0 | ($4,380) | $0 | $0 | ($1,376) | $0 | ($1,950) |
| 5 | $0 | ($9,394) | $0 | ($3,685) | $0 | $0 | ($1,329) | $0 | ($1,880) |
| 6 | $0 | ($8,954) | $0 | ($3,230) | $0 | $0 | ($1,282) | $0 | ($1,811) |
| 7 | $0 | ($7,752) | $0 | ($3,005) | $0 | $0 | ($1,236) | $0 | ($1,743) |
| 8 | $0 | ($805) | $0 | $3,229 | $0 | $0 | ($341) | $0 | ($435) |
| 9 | $0 | $83 | $0 | $4,189 | $0 | $0 | ($329) | $0 | ($418) |
| 10 | $0 | $908 | $0 | $5,010 | $0 | $0 | ($317) | $0 | ($402) |
| 11 | $0 | $1,848 | $0 | $6,288 | $0 | $0 | ($306) | $0 | ($386) |
| 12 | $0 | $2,748 | $0 | $7,859 | $0 | $0 | ($294) | $0 | ($371) |
| 13 | $0 | $3,636 | $0 | $9,329 | $0 | $0 | ($283) | $0 | ($356) |
| 14 | $0 | $4,275 | $0 | $11,499 | $0 | $0 | ($272) | $0 | ($341) |
| 15 | $0 | $5,615 | $0 | $16,003 | $0 | $0 | ($262) | $0 | ($327) |
| 16 | $0 | $6,882 | $0 | $20,049 | $0 | $0 | ($252) | $0 | ($313) |
| 17 | $0 | $9,050 | $0 | $23,007 | $0 | $0 | ($242) | $0 | ($300) |
| 18 | $0 | $10,645 | $0 | $25,653 | $0 | $0 | ($232) | $0 | ($287) |
| 19 | $0 | $12,697 | $0 | $32,403 | $0 | $0 | ($223) | $0 | ($275) |
| **Total** | **$0** | **$2,746** | **$0** | **$163,415** | **$0** | **$0** | **($13,202)** | **$0** | **($18,132)** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($30,147) | ($32,257) |
| 20 | $0 | $0 | $0 | $0 | $57,499 | $222,502 |
| 2 | $0 | $0 | $0 | $0 | ($24,181) | ($27,685) |
| 3 | $0 | $0 | $0 | $0 | ($19,426) | ($23,798) |
| 4 | $0 | $0 | $0 | $0 | ($18,156) | ($23,798) |
| 5 | $0 | $0 | $0 | $0 | ($16,287) | ($22,844) |
| 6 | $0 | $0 | $0 | $0 | ($15,277) | ($22,927) |
| 7 | $0 | $0 | $0 | $0 | ($13,736) | ($22,056) |
| 8 | $0 | $0 | $0 | $0 | $1,648 | $2,832 |
| 9 | $0 | $0 | $0 | $0 | $3,525 | $6,480 |
| 10 | $0 | $0 | $0 | $0 | $5,198 | $10,226 |
| 11 | $0 | $0 | $0 | $0 | $7,444 | $15,669 |
| 12 | $0 | $0 | $0 | $0 | $9,942 | $22,391 |
| 13 | $0 | $0 | $0 | $0 | $12,327 | $29,705 |
| 14 | $0 | $0 | $0 | $0 | $15,160 | $39,091 |
| 15 | $0 | $0 | $0 | $0 | $21,028 | $58,018 |
| 16 | $0 | $0 | $0 | $0 | $26,367 | $77,839 |
| 17 | $0 | $0 | $0 | $0 | $31,515 | $99,550 |
| 18 | $0 | $0 | $0 | $0 | $35,780 | $120,932 |
| 19 | $0 | $0 | $0 | $0 | $44,604 | $161,310 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$134,827** | **$691,181** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
| 1 | (8) | (1,646) | (2) | (0) | (0) | (1) | (0) |
| 20 | 18 | 10,734 | 19 | 0 | 0 | 2 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | (8) | (1,498) | (2) | (0) | (0) | (1) | (0) |
| 3 | (8) | (1,392) | (2) | (0) | (0) | (1) | (0) |
| 4 | (7) | (1,317) | (2) | (0) | (0) | (0) | (0) |
| 5 | (7) | (1,235) | (2) | (0) | (0) | (0) | (0) |
| 6 | (6) | (1,082) | (2) | (0) | (0) | (0) | (0) |
| 7 | (6) | (853) | (2) | (0) | (0) | (0) | (0) |
| 8 | 1 | (431) | 0 | 0 | (0) | 0 | (0) |
| 9 | 1 | (261) | 1 | 0 | (0) | 0 | 0 |
| 10 | 2 | (82) | 1 | 0 | (0) | 0 | 0 |
| 11 | 2 | 225 | 1 | 0 | 0 | 0 | 0 |
| 12 | 3 | 670 | 2 | 0 | 0 | 0 | 0 |
| 13 | 4 | 1,136 | 2 | 0 | 0 | 0 | 0 |
| 14 | 5 | 1,602 | 3 | 0 | 0 | 0 | 0 |
| 15 | 6 | 2,538 | 5 | 0 | 0 | 1 | 0 |
| 16 | 7 | 3,515 | 7 | 0 | 0 | 1 | 0 |
| 17 | 9 | 4,731 | 8 | 0 | 0 | 1 | 0 |
| 18 | 11 | 5,996 | 10 | 0 | 0 | 1 | 0 |
| 19 | 14 | 7,983 | 13 | 0 | 0 | 2 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total** | **33** | **29,334** | **60** | **0** | **0** | **7** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| **Year** | **DOLLARS EMISSIONS SAVED** (PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | **CO** | **$CO_2$** | **$NO_X$** | **$PM_{10}$** | **$SO_X$** | **VOC** |
| 1 | $0 | ($1,423) | ($17,029) | ($8,650) | ($2,051) | ($992) |
| 20 | $0 | $3,739 | $40,425 | $10,779 | $1,305 | $1,251 |
| 2 | $0 | ($1,235) | ($14,072) | ($6,043) | ($1,920) | ($912) |
| 3 | $0 | ($1,094) | ($11,414) | ($4,279) | ($1,793) | ($847) |
| 4 | $0 | ($987) | ($10,751) | ($3,932) | ($1,730) | ($756) |
| 5 | $0 | ($882) | ($10,123) | ($3,027) | ($1,585) | ($670) |
| 6 | $0 | ($737) | ($9,237) | ($3,218) | ($1,518) | ($567) |
| 7 | $0 | ($554) | ($8,136) | ($3,207) | ($1,384) | ($455) |
| 8 | $0 | ($267) | $1,888 | $198 | ($208) | $36 |
| 9 | $0 | ($154) | $2,888 | $843 | ($143) | $91 |
| 10 | $0 | ($46) | $3,803 | $1,383 | ($83) | $141 |
| 11 | $0 | $121 | $5,100 | $1,977 | $44 | $202 |
| 12 | $0 | $342 | $6,712 | $2,519 | $98 | $271 |
| 13 | $0 | $553 | $8,176 | $3,056 | $207 | $334 |
| 14 | $0 | $744 | $10,351 | $3,410 | $273 | $383 |
| 15 | $0 | $1,123 | $14,743 | $4,274 | $402 | $487 |
| 16 | $0 | $1,483 | $18,717 | $5,014 | $573 | $580 |
| 17 | $0 | $1,902 | $21,540 | $6,640 | $702 | $730 |
| 18 | $0 | $2,299 | $24,059 | $7,741 | $818 | $863 |
| 19 | $0 | $2,917 | $30,549 | $9,043 | $1,054 | $1,041 |
| **Total** | **$0** | **$7,846** | **$108,188** | **$24,520** | **($6,938)** | **$1,210** |

A

# NET PRESENT VALUE CALCULATION

| Year | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $748,557 | ($1,222,393) | $816,308 | ($30,147) | | | | |
| 2 | $1,006,143 | ($1,175,508) | $789,263 | ($24,181) | | | | |
| 3 | $1,267,917 | ($1,133,940) | $762,263 | ($19,426) | | | | |
| 4 | $1,534,687 | ($1,084,059) | $735,418 | ($18,156) | | | | |
| 5 | $1,807,534 | ($1,035,269) | $708,823 | ($16,287) | | | | |
| 6 | $2,087,859 | ($977,555) | $682,560 | ($15,277) | | | | |
| 7 | $2,377,440 | ($912,155) | $656,700 | ($13,736) | | | | |
| 8 | $2,678,517 | ($849,328) | $631,302 | $1,648 | | | | |
| 9 | $2,993,900 | ($778,699) | $606,416 | $3,525 | | | | |
| 10 | $3,327,134 | ($714,549) | $582,085 | $5,198 | | | | |
| 11 | $3,682,714 | ($632,135) | $558,342 | $7,444 | | | | |
| 12 | $4,066,399 | ($537,094) | $535,214 | $9,942 | | | | |
| 13 | $4,485,670 | ($451,214) | $512,723 | $12,327 | | | | |
| 14 | $4,950,404 | ($378,466) | $490,884 | $15,160 | | | | |
| 15 | $5,473,908 | ($264,351) | $469,708 | $21,028 | | | | |
| 16 | $6,074,542 | ($159,088) | $449,201 | $26,367 | | | | |
| 17 | $6,778,374 | ($33,651) | $429,368 | $31,515 | | | | |
| 18 | $7,623,706 | $78,856 | $410,207 | $35,780 | | | | |
| 19 | $8,669,240 | $223,982 | $391,715 | $44,604 | | | | |
| 20 | $10,009,787 | $392,735 | $373,888 | $57,499 | | | | |
| **Total** | $81,644,434 | ($11,643,884) | $11,592,390 | $134,827 | $0 | $0 | $0 | $0 |

| | | | | |
|---|---|---|---|---|
| 13,884,608 | Person-Hours of Time Saved | | | Person-Hours of Time Saved |

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 33 | $0 | CO Saved | | | CO Saved |
| 29,334 | $7,846 | $CO_2$ Saved | | | $CO_2$ Saved |
| 60 | $108,188 | $NO_X$ Saved | | | $NO_X$ Saved |
| 0 | $24,520 | $PM_{10}$ Saved | | | $PM_{10}$ Saved |
| 0 | | $PM_{2.5}$ Saved | | | $PM_{2.5}$ Saved |
| 0 | ($6,938) | $SO_X$ Saved | | | $SO_X$ Saved |
| 7 | $1,210 | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $11,955,923 | ($1,903,233) | $1,043,315 | $145,283 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | |
| | | | | $0 | $23,844,000 | ($23,844,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $312,326 | ($387,850) | $700,176 |
| | | | | $595,717 | $13,102 | $582,615 |
| | | | | $876,814 | ($30,203) | $907,017 |
| | | | | $1,167,890 | $11,443 | $1,156,446 |
| | | | | $1,464,801 | $10,695 | $1,454,106 |
| | | | | $1,777,587 | ($104,616) | $1,882,203 |
| | | | | $2,108,250 | ($23,042) | $2,131,291 |
| | | | | $2,462,139 | $8,730 | $2,453,409 |
| | | | | $2,825,142 | $8,159 | $2,816,983 |
| | | | | $3,199,869 | $7,625 | $3,192,244 |
| | | | | $3,616,366 | $2,851 | $3,613,515 |
| | | | | $4,074,462 | ($1,978,073) | $6,052,535 |
| | | | | $4,559,506 | $6,224 | $4,553,281 |
| | | | | $5,077,982 | $5,817 | $5,072,164 |
| | | | | $5,700,293 | ($13,411) | $5,713,704 |
| | | | | $6,391,022 | $610,738 | $5,780,284 |
| | | | | $7,205,606 | $4,749 | $7,200,857 |
| | | | | $8,148,549 | $49,409 | $8,099,139 |
| | | | | $9,329,541 | ($10,231) | $9,339,772 |
| | | | | $10,833,908 | $3,876 | $10,830,032 |
| $0 | $0 | $0 | $0 | **$81,727,767** | **$22,039,994** | **$59,687,773** |

| | |
|---|---|
| | Person-Hours of Time Saved |

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $800,956 | ($1,307,961) | $873,450 | ($32,257) | | | | |
| 2 | $1,151,934 | ($1,345,840) | $903,628 | ($27,685) | | | | |
| 3 | $1,553,253 | ($1,389,126) | $933,805 | ($23,798) | | | | |
| 4 | $2,011,661 | ($1,420,981) | $963,983 | ($23,798) | | | | |
| 5 | $2,535,160 | ($1,452,019) | $994,161 | ($22,844) | | | | |
| 6 | $3,133,314 | ($1,467,047) | $1,024,339 | ($22,927) | | | | |
| 7 | $3,817,650 | ($1,464,722) | $1,054,516 | ($22,056) | | | | |
| 8 | $4,602,190 | ($1,459,303) | $1,084,694 | $2,832 | | | | |
| 9 | $5,504,163 | ($1,431,607) | $1,114,872 | $6,480 | | | | |
| 10 | $6,544,977 | ($1,405,627) | $1,145,050 | $10,226 | | | | |
| 11 | $7,751,568 | ($1,330,550) | $1,175,228 | $15,669 | | | | |
| 12 | $9,158,310 | ($1,209,638) | $1,205,405 | $22,391 | | | | |
| 13 | $10,809,769 | ($1,087,355) | $1,235,583 | $29,705 | | | | |
| 14 | $12,764,785 | ($975,889) | $1,265,761 | $39,091 | | | | |
| 15 | $15,102,685 | ($729,352) | $1,295,939 | $58,018 | | | | |
| 16 | $17,933,043 | ($469,655) | $1,326,116 | $77,839 | | | | |
| 17 | $21,411,630 | ($106,298) | $1,356,294 | $99,550 | | | | |
| 18 | $25,767,609 | $266,529 | $1,386,472 | $120,932 | | | | |
| 19 | $31,352,546 | $810,037 | $1,416,650 | $161,310 | | | | |
| 20 | $38,734,717 | $1,519,760 | $1,446,827 | $222,502 | | | | |
| **Total** | $222,441,922 | ($17,456,643) | $23,202,773 | $691,181 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | | |
| | | | | $0 | $23,844,000 | ($23,844,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $334,188 | ($415,000) | $749,188 | $749,188 |
| | | | | $682,036 | $15,000 | $667,036 | $1,416,225 |
| | | | | $1,074,135 | ($37,000) | $1,111,135 | $2,527,359 |
| | | | | $1,530,865 | $15,000 | $1,515,865 | $4,043,225 |
| | | | | $2,054,459 | $15,000 | $2,039,459 | $6,082,683 |
| | | | | $2,667,679 | ($157,000) | $2,824,679 | $8,907,362 |
| | | | | $3,385,388 | ($37,000) | $3,422,388 | $12,329,750 |
| | | | | $4,230,413 | $15,000 | $4,215,413 | $16,545,163 |
| | | | | $5,193,908 | $15,000 | $5,178,908 | $21,724,071 |
| | | | | $6,294,626 | $15,000 | $6,279,626 | $28,003,697 |
| | | | | $7,611,914 | $6,000 | $7,605,914 | $35,609,611 |
| | | | | $9,176,469 | ($4,455,000) | $13,631,469 | $49,241,081 |
| | | | | $10,987,702 | $15,000 | $10,972,702 | $60,213,783 |
| | | | | $13,093,749 | $15,000 | $13,078,749 | $73,292,532 |
| | | | | $15,727,289 | ($37,000) | $15,764,289 | $89,056,821 |
| | | | | $18,867,344 | $1,803,000 | $17,064,344 | $106,121,165 |
| | | | | $22,761,176 | $15,000 | $22,746,176 | $128,867,341 |
| | | | | $27,541,542 | $167,000 | $27,374,542 | $156,241,884 |
| | | | | $33,740,542 | ($37,000) | $33,777,542 | $190,019,426 |
| | | | | $41,923,807 | $15,000 | $41,908,807 | $231,928,233 |
| $0 | $0 | $0 | $0 | **$228,879,233** | **$20,795,000** | **$208,084,233** | |

**Total Construction Costs** **$23,844,000**

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($23,844,000) |
| 2 | $749,188 |
| 3 | $667,036 |
| 4 | $1,111,135 |
| 5 | $1,515,865 |
| 6 | $2,039,459 |
| 7 | $2,824,679 |
| 8 | $3,422,388 |
| 9 | $4,215,413 |
| 10 | $5,178,908 |
| 11 | $6,279,626 |
| 12 | $7,605,914 |
| 13 | $13,631,469 |
| 14 | $10,972,702 |
| 15 | $13,078,749 |
| 16 | $15,764,289 |
| 17 | $17,064,344 |
| 18 | $22,746,176 |
| 19 | $27,374,542 |
| 20 | $33,777,542 |
| 21 | $41,908,807 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **17.65%** |
| **Payback Period** | **10 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |

**OMB GDP Inflator** **1.01719172**

Yellow cells - adjusted

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | *1* |
| Real Discount Rate | 7.0% | *2* |

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | *3* |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | *3* |
| Benefits and Costs | $ 10.69 | $/hr | *4* |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | *5* |
| Truck | $ 31.20 | $/hr/veh | *5* |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | *6* |
| Transit | $ 13.75 | $/hr/per | *5* |
| Out-of-Vehicle Travel | 2 | times | *5* |
| Incident-Related Travel | 3 | times | *7* |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | *8* |
| Truck (diesel) | $ 3.07 | $/gal | *8* |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | *9* |
| State Sales Tax (diesel) | **13.00%** | % | *9* |
| Average Local Sales Tax | 0.50% | % | *9* |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | *9* |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | *9* |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | *9* |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | *9* |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | *10* |
| Truck | $ 0.437 | $/mi | *11* |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | *12* |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | *12* |
| Level B (Moderate) | $ 125,000 | $/event | *12* |
| Level C (Minor) | $ 63,900 | $/event | *12* |
| Cost of Property Damage | $ 4,300 | $/event | *13* |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | *14* |
| Injury Accident | 0.29 | per mil veh-mi | *14* |
| PDO Accident | 0.55 | per mil veh-mi | *14* |
| Non-Freeway | 1.05 | per mil veh-mi | *15* |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | *16* |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | *17* |
| HOV Lanes | 0.55 | 8 | 1,600 | | *18* |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

## *Active Transportation Parameters*

| General Travel Activity Characteristics Parameters | Value | Units | |
|---|---|---|---|
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| | | | |
| Vehicle Statistics | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | *19* |
| | | | |
| Active Transportation User Characteristics | | | |
| Average Cycling Speed | 11.80 | mph | *20* |
| Average Walking Speed | 3.00 | mph | *21* |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | *19* |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | *19* |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| | | | |
| Value of Travel Time | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| | | | |
| Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class | | | |
| Class I | 0.57 | - | *20* |
| Class II | 0.49 | - | *20* |
| Class III | 0.92 | - | *20* |
| Class IV | 0.49 | - | *20* |
| *Note: Class IV assumed to be the same as Class II* | | | |
| | | | |
| Walking Journey Quality Values per Mile by Amentity | | | |
| Street Lighting | $0.110 | $/mi | *22* |
| Curb Level | $0.078 | $/mi | *22* |
| Crowding | $0.055 | $/mi | *22* |
| Pavement Evenness | $0.026 | $/mi | *22* |
| Information Panels | $0.026 | $/mi | *22* |
| Benches | $0.017 | $/mi | *22* |
| Directional Signage | $0.017 | $/mi | *22* |
| | | | |
| Health (Absenteeism Reduction) | | | |
| Average Absence of Employees | 3.60 | days/yr | *23* |
| Percentage Covered by Short-Term Sick Leave | 95% | % | *24* |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | *25* |
| | | | |
| Health (Mortality Reduction) | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | *26* |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | *26* |
| | | | |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | *27* |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | *27* |
| | | | |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | *28* |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | *28* |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

## Travel Demand Tables

### Project Types

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

### DEMAND FOR TRAVEL IN PEAK PERIOD

(percent of total daily travel)

| Number of Hours in Peak Period | Urban | | | | Rural | |
|---|---|---|---|---|---|---|
| | So. California | | No. California | | | |
| | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

### AGE COHORTS FOR MORTALITY RISK REDUCTION

(percent of population)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

### AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP

(miles/trip)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

### TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS

(percent of trips)

| Mode | Trip Purpose | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident | | 0.1176 | 0.6446 |
| Cost per Event | | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

## HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | CO$_2$e | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

CO$_2$e Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

## PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 |  | 583.58 | 62.02 |  | 19.73 |  |
|  | 2022 | 45.67 |  | 250.11 | 31.01 |  | 19.73 |  |

## LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 |  | 1.13 | 0.17 |  | 0.06 |  |
|  | 2022 | 0.14 |  | 1.14 | 0.17 |  | 0.06 |  |

## FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |
|  | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |

|  |  |  |
|---|---|---|
| Freight Rail Fuel Efficiency | 468 | ton-miles/gal |
| Fuel Burned at Idle | 4 | gal/hr |

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## ***Pavement Adjustments*** (used only for pavement projects)

### PAVEMENT DETERIORATION

(IRI in inches/mile)

| | Year 20, By Loading | | |
|---|---|---|---|
| **Year 0** | **Light** | **Medium** | **Heavy** |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

### VEHICLE OPERATING SPEED

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

### FUEL CONSUMPTION

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

### NON-FUEL COSTS

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## Weaving Adjustments (used only for freeway connector, HOV connector, and HOV drop ramp projects)

### VEHICLE OPERATING SPEED

(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## TMS Adjustments (used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

### PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| Strategy | Speed | Volume | Speed | Volume | TT | VOC | Em | Benefit |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

### TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| TMS Strategy | Time | Capital | O&M |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

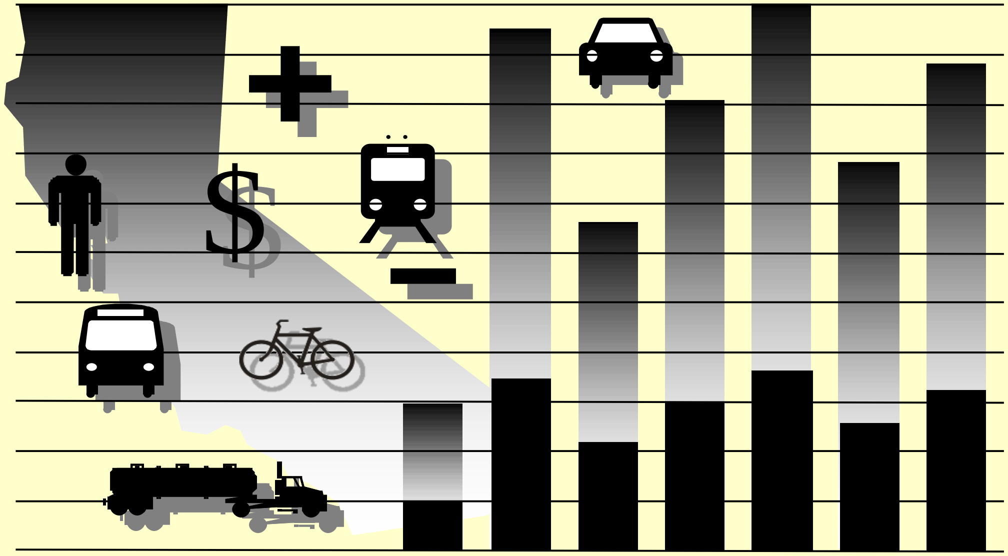
Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Undivided, $25M +10% TPC, 40,062 AADT

WAR-63 Priority Project BCA

California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**
Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

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# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period.  Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual.  Other adjustments are made for weaving and pavement conditions.  An option is also available to conduct a simple queuing analysis.  Accidents are estimated from statewide averages and recent data for the facility.  If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically.  Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road.  The user clicks a button and the model clears the Project Information worksheet to receive information on  other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed).  The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available.  The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed).  These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### PROJECT DATA (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

***Type of Project***

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

***Project Location***

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

***Length of Construction Period***

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

***One- or Two-Way Data***

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

***Length of Peak Period(s)***

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

***Highway Design***

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

***Average Daily Traffic (ADT)***

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

***Average Hourly HOV/HOT Lane Traffic***

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

***Percent Traffic in Weave***

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

***Percent Trucks***

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

***Truck Speed***

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

***On-Ramp Volume***

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

***Queue Formation***

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

***Pavement Condition (for Pavement Rehab. Projects)***

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

***Average Vehicle Occupancy (AVO)***

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## **HIGHWAY ACCIDENT DATA** (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

***Actual 3-Year Accident Data (from Table B)***

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

***Statewide Basic Average Accident Rate***

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## **RAIL AND TRANSIT DATA** (Box 1D)

*This section is used for rail and transit projects only.*

***Annual Person-Trips***

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

***Percent Trips during Peak Period***

32 Insert % annual person-trips that occur during peak period.

***Percent New Trips from Parallel Highway***

33 Insert % new transit person-trips originating on parallel highway.

***Annual Vehicle-Miles***

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

***Average Vehicles per Train***

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

***Reduction in Transit Accidents***

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

***Average Transit Travel Time***

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

***Highway Grade Crossing***

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

***Transit Agency Costs (for Transit TMS Projects)***

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Undivided

EA:
PPNO:

## 1A PROJECT DATA

| | | |
|---|---|---|
| ***Type of Project*** | | |
| Select project type from list | General Highway | |
| ***Project Location*** (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural) | 3 | |
| Length of Construction Period | 1 | years |
| One- or Two-Way Data | 2 | enter 1 or 2 |
| | Current | |
| ***Length of Peak Period(s)*** (up to 24 hrs) | 13 | hours |

## 1B HIGHWAY DESIGN AND TRAFFIC DATA

| ***Highway Design*** | | No Build | Build |
|---|---|---|---|
| Roadway Type (Fwy, Exp, Conv Hwy) | | C | C |
| Number of General Traffic Lanes | | 2 | 4 |
| Number of HOV/HOT Lanes | | 0 | 0 |
| HOV Restriction (2 or 3) | | 0 | |
| Exclusive ROW for Buses (y/n) | | N | |
| Highway Free-Flow Speed | | 50 | 55 |
| Ramp Design Speed (if aux. lane/off-ramp proj.) | | | |
| Length (in miles) | Highway Segment | 3.0 | 3.0 |
| | Impacted Length | 3.0 | 3.0 |

| ***Average Daily Traffic*** | | | |
|---|---|---|---|
| | Current | 20,600 | |
| | | No Build | Build |
| | Base (Year 1) | 21,337 | 24,184 |
| | Forecast (Year 20) | 35,346 | 40,062 |
| ***Average Hourly HOV/HOT Lane Traffic*** | | | 0 |
| Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.) | | | 100% |
| ***Percent Traffic in Weave*** | | | 0.0% |
| ***Percent Trucks*** (include RVs, if applicable) | | 9% | 9% |
| ***Truck Speed*** | | 50 | |

| ***On-Ramp Volume*** | Peak | Non-Peak |
|---|---|---|
| Hourly Ramp Volume (if aux. lane/on-ramp proj.) | 0 | 0 |
| Metering Strategy (1, 2, 3, or D, if on-ramp proj.) | | |

| ***Queue Formation*** (if queuing or grade crossing project) | Year 1 | Year 20 |
|---|---|---|
| Arrival Rate (in vehicles per hour) | 0 | 0 |
| Departure Rate (in vehicles per hour) | 0 | 0 |

| ***Pavement Condition*** (if pavement project) | | No Build | Build |
|---|---|---|---|
| IRI (inches/mile) | Base (Year 1) | | |
| | Forecast (Year 20) | | |

| ***Average Vehicle Occupancy (AVO)*** | | No Build | Build |
|---|---|---|---|
| General Traffic | Non-Peak | 1.30 | 1.30 |
| | Peak | 1.15 | 1.15 |
| High Occupancy Vehicle (if HOV/HOT lanes) | | 2.15 | 2.15 |

## 1C HIGHWAY ACCIDENT DATA

| ***Actual 3-Year Accident Data (from Table B)*** | Count (No.) | Rate |
|---|---|---|
| Total Accidents (Tot) | 126 | 1.86 |
| Fatal Accidents (Fat) | 1 | 0.015 |
| Injury Accidents (Inj) | 33 | 0.49 |
| Property Damage Only (PDO) Accidents | 92 | 1.36 |

| ***Statewide Basic Average Accident Rate*** | No Build | Build |
|---|---|---|
| Rate Group | | |
| Accident Rate (per million vehicle-miles) | 1.72 | 1.30 |
| Percent Fatal Accidents (Pct Fat) | 0.3% | 0.3% |
| Percent Injury Accidents (Pct Inj) | 23.5% | 23.5% |

## 1D RAIL AND TRANSIT DATA

| ***Annual Person-Trips*** | | No Build | Build |
|---|---|---|---|
| | Base (Year 1) | | |
| | Forecast (Year 20) | | |
| ***Percent Trips during Peak Period*** | | 89% | |
| ***Percent New Trips from Parallel Highway*** | | | 100% |

| ***Annual Vehicle-Miles*** | | No Build | Build |
|---|---|---|---|
| | Base (Year 1) | | |
| | Forecast (Year 20) | | |
| ***Average Vehicles/Train*** (if rail project) | | | |

| ***Reduction in Transit Accidents*** | |
|---|---|
| Percent Reduction (if safety project) | |

| ***Average Transit Travel Time*** | | No Build | Build |
|---|---|---|---|
| In-Vehicle | Non-Peak (in minutes) | | 0.0 |
| | Peak (in minutes) | | 0.0 |
| Out-of-Vehicle | Non-Peak (in minutes) | 0.0 | 0.0 |
| | Peak (in minutes) | 0.0 | 0.0 |

| ***Highway Grade Crossing*** | Current | Year 1 | Year 20 |
|---|---|---|---|
| Annual Number of Trains | | 0 | |
| Avg. Gate Down Time (in min.) | | 0.0 | |

| ***Transit Agency Costs*** (if TMS project) | No Build | Build |
|---|---|---|
| Annual Capital Expenditure | | $0 |
| Annual Ops. and Maintenance Expenditure | | $0 |

*Model should be run for both roads for intersection or bypass highway projects, and may be run twice for connectors. Press button below to prepare model to enter data for second road. After data are entered, results reflect total project benefits.*

Prepare Model for Second Road

*Enter all project costs (in today's dollars) in columns 1 to 7. Costs during construction should be entered in the first eight rows.*
*Project costs (including maintenance and operating costs) should be net of costs without project.*

## 1E PROJECT COSTS (enter costs in thousands of dollars)

| Col. no. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | DIRECT PROJECT COSTS | | | | | | Transit Agency Cost Savings | TOTAL COSTS (in dollars) | |
| | INITIAL COSTS | | | SUBSEQUENT COSTS | | Mitigation | | | |
| | Project Support | R / W | Construction | Maint./ Op. | Rehab. | | | Constant Dollars | Present Value |
| **Construction Period** | | | | | | | | | |
| 1 | $787 | $262 | $25,180 | | | | | $26,229,000 | $26,229,000 |
| 2 | | | | | | | | 0 | 0 |
| 3 | | | | | | | | 0 | 0 |
| 4 | | | | | | | | 0 | 0 |
| 5 | | | | | | | | 0 | 0 |
| 6 | | | | | | | | 0 | 0 |
| 7 | | | | | | | | 0 | 0 |
| 8 | | | | | | | | 0 | 0 |
| **Project Open** | | | | | | | | | |
| 1 | | | | $15 | ($430) | | | ($415,000) | ($387,850) |
| 2 | | | | $15 | | | | 15,000 | 13,102 |
| 3 | | | | $15 | ($52) | | | (37,000) | (30,203) |
| 4 | | | | $15 | | | | 15,000 | 11,443 |
| 5 | | | | $15 | | | | 15,000 | 10,695 |
| 6 | | | | $15 | ($172) | | | (157,000) | (104,616) |
| 7 | | | | $15 | ($52) | | | (37,000) | (23,042) |
| 8 | | | | $15 | | | | 15,000 | 8,730 |
| 9 | | | | $15 | | | | 15,000 | 8,159 |
| 10 | | | | $15 | | | | 15,000 | 7,625 |
| 11 | | | | $15 | ($9) | | | 6,000 | 2,851 |
| 12 | | | | $15 | ($4,470) | | | (4,455,000) | (1,978,073) |
| 13 | | | | $15 | | | | 15,000 | 6,224 |
| 14 | | | | $15 | | | | 15,000 | 5,817 |
| 15 | | | | $15 | ($52) | | | (37,000) | (13,411) |
| 16 | | | | $15 | $1,788 | | | 1,803,000 | 610,738 |
| 17 | | | | $15 | | | | 15,000 | 4,749 |
| 18 | | | | $15 | $152 | | | 167,000 | 49,409 |
| 19 | | | | $15 | ($52) | | | (37,000) | (10,231) |
| 20 | | | | $15 | | | | 15,000 | 3,876 |
| **Total** | $787 | $262 | $25,180 | $300 | ($3,349) | $0 | $0 | $23,180,000 | $24,424,994 |

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 32,300 | | 32,300 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 3,195 | | 3,195 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 54.4 | | 54.4 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 4,156 | | 4,156 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 411 | | 411 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |

**Hwy Safety or Weaving Improvement** 0% collision reduction factor (per HSIP Guidelines)

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.011 | | 0.011 | |
| Injury Accidents | 0.37 | | 0.37 | |
| PDO Accidents | 1.03 | | 1.03 | |
| Total Accidents | 1.410 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

**Detailed Information Available?** (y/n) N

**Aggregate Segment Length** (estimate as VMT/total volume)

All Ramps ______ miles

Arterials ______ miles

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

## ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |

| | | | |
|---|---|---|---|
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 13,558,088 | 1,596,025 |
| Truck Trips | 1,028,749 | 1,166,009 | 137,260 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 1,972,037 | 232,143 |
| Truck Trips | 132,367 | 150,028 | 17,661 |
| Total Trips | 14,863,073 | 16,846,162 | 1,983,089 |

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Undivided

EA:
PPNO:

③

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| **Life-Cycle Costs (mil. $)** | $24.4 |
| **Life-Cycle Benefits (mil. $)** | $81.7 |
| **Net Present Value (mil. $)** | $57.3 |
| **Benefit / Cost Ratio:** | 3.3 |
| **Rate of Return on Investment:** | 16.7% |
| **Payback Period:** | 10 years |

| **ITEMIZED BENEFITS (mil. $)** | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| **Travel Time Savings** | $69.7 | $12.0 | $81.6 | $4.1 |
| **Veh. Op. Cost Savings** | -$9.7 | -$1.9 | -$11.6 | -$0.6 |
| **Accident Cost Savings** | $10.5 | $1.0 | $11.6 | $0.6 |
| **Emission Cost Savings** | -$0.0 | $0.1 | $0.1 | $0.0 |
| **TOTAL BENEFITS** | $70.5 | $11.2 | $81.7 | $4.1 |
| **Person-Hours of Time Saved** | | | 13,884,608 | 694,230 |

***Should benefit-cost results include:***

| | |
|---|---|
| **1) Induced Travel? (y/n)** | Y<br>Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y<br>Default = Y |
| **3) Accident Costs? (y/n)** | Y<br>Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for $CO_2e$ | Y<br>Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| **EMISSIONS REDUCTION** | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| **CO Emissions Saved** | 33 | 2 | $0.0 | $0.0 |
| **$CO_2$ Emissions Saved** | 29,334 | 1,467 | $0.0 | $0.0 |
| **$NO_X$ Emissions Saved** | 60 | 3 | $0.1 | $0.0 |
| **$PM_{10}$ Emissions Saved** | 0 | 0 | $0.0 | $0.0 |
| **$PM_{2.5}$ Emissions Saved** | 0 | 0 | | |
| **$SO_X$ Emissions Saved** | 0 | 0 | -$0.0 | -$0.0 |
| **VOC Emissions Saved** | 7 | 0 | $0.0 | $0.0 |

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# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Peak HOV** | **Peak Non-HOV** | **Peak Weaving** | **Peak Truck** | **Peak Ramp** | **Peak Arterial** | **Non-Peak Non-HOV** | **Non-Peak Weaving** | **Non-Peak Truck** |
| 1 | $0 | $648,782 | $0 | $21,244 | $0 | $0 | $78,532 | $0 | $0 |
| 20 | $0 | $8,381,211 | $0 | $1,592,605 | $0 | $0 | $35,971 | $0 | $0 |
| 2 | $0 | $863,076 | $0 | $67,138 | $0 | $0 | $75,930 | $0 | $0 |
| 3 | $0 | $1,080,908 | $0 | $113,677 | $0 | $0 | $73,333 | $0 | $0 |
| 4 | $0 | $1,302,957 | $0 | $160,980 | $0 | $0 | $70,751 | $0 | $0 |
| 5 | $0 | $1,530,130 | $0 | $209,212 | $0 | $0 | $68,192 | $0 | $0 |
| 6 | $0 | $1,763,601 | $0 | $258,592 | $0 | $0 | $65,666 | $0 | $0 |
| 7 | $0 | $2,004,859 | $0 | $309,403 | $0 | $0 | $63,178 | $0 | $0 |
| 8 | $0 | $2,255,777 | $0 | $362,005 | $0 | $0 | $60,735 | $0 | $0 |
| 9 | $0 | $2,518,709 | $0 | $416,850 | $0 | $0 | $58,341 | $0 | $0 |
| 10 | $0 | $2,796,621 | $0 | $474,513 | $0 | $0 | $56,000 | $0 | $0 |
| 11 | $0 | $3,093,271 | $0 | $535,727 | $0 | $0 | $53,716 | $0 | $0 |
| 12 | $0 | $3,413,480 | $0 | $601,428 | $0 | $0 | $51,491 | $0 | $0 |
| 13 | $0 | $3,763,506 | $0 | $672,837 | $0 | $0 | $49,328 | $0 | $0 |
| 14 | $0 | $4,151,612 | $0 | $751,565 | $0 | $0 | $47,227 | $0 | $0 |
| 15 | $0 | $4,588,931 | $0 | $839,787 | $0 | $0 | $45,190 | $0 | $0 |
| 16 | $0 | $5,090,826 | $0 | $940,499 | $0 | $0 | $43,217 | $0 | $0 |
| 17 | $0 | $5,679,105 | $0 | $1,057,960 | $0 | $0 | $41,309 | $0 | $0 |
| 18 | $0 | $6,385,816 | $0 | $1,198,424 | $0 | $0 | $39,465 | $0 | $0 |
| 19 | $0 | $7,260,075 | $0 | $1,371,478 | $0 | $0 | $37,686 | $0 | $0 |
| **Total** | **$0** | **$68,573,252** | **$0** | **$11,955,923** | **$0** | **$0** | **$1,115,259** | **$0** | **$0** |

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# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| | Peak In-Vehicle | Peak Out-of-Veh | Non-Peak In-Vehicle | Non-Peak Out-of-Veh | | | |
| 1 | $0 | $0 | $0 | $0 | $748,557 | $800,956 | 53,742 |
| 20 | $0 | $0 | $0 | $0 | $10,009,787 | $38,734,717 | 2,405,888 |
| 2 | $0 | $0 | $0 | $0 | $1,006,143 | $1,151,934 | 75,607 |
| 3 | $0 | $0 | $0 | $0 | $1,267,917 | $1,553,253 | 100,589 |
| 4 | $0 | $0 | $0 | $0 | $1,534,687 | $2,011,661 | 129,107 |
| 5 | $0 | $0 | $0 | $0 | $1,807,534 | $2,535,160 | 161,656 |
| 6 | $0 | $0 | $0 | $0 | $2,087,859 | $3,133,314 | 198,828 |
| 7 | $0 | $0 | $0 | $0 | $2,377,440 | $3,817,650 | 241,339 |
| 8 | $0 | $0 | $0 | $0 | $2,678,517 | $4,602,190 | 290,055 |
| 9 | $0 | $0 | $0 | $0 | $2,993,900 | $5,504,163 | 346,046 |
| 10 | $0 | $0 | $0 | $0 | $3,327,134 | $6,544,977 | 410,636 |
| 11 | $0 | $0 | $0 | $0 | $3,682,714 | $7,751,568 | 485,496 |
| 12 | $0 | $0 | $0 | $0 | $4,066,399 | $9,158,310 | 572,753 |
| 13 | $0 | $0 | $0 | $0 | $4,485,670 | $10,809,769 | 675,171 |
| 14 | $0 | $0 | $0 | $0 | $4,950,404 | $12,764,785 | 796,392 |
| 15 | $0 | $0 | $0 | $0 | $5,473,908 | $15,102,685 | 941,333 |
| 16 | $0 | $0 | $0 | $0 | $6,074,542 | $17,933,043 | 1,116,782 |
| 17 | $0 | $0 | $0 | $0 | $6,778,374 | $21,411,630 | 1,332,389 |
| 18 | $0 | $0 | $0 | $0 | $7,623,706 | $25,767,609 | 1,602,351 |
| 19 | $0 | $0 | $0 | $0 | $8,669,240 | $31,352,546 | 1,948,448 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$81,644,434** | **$222,441,922** | **13,884,608** |

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# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | | Present Value of Veh Op Cost Benefits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | |
| 1 | $0 | ($942,318) | $0 | ($140,639) | $0 | ($121,246) | $0 | ($18,190) | - | - | ($1,222,393) |
| 20 | $0 | $393,073 | $0 | $63,534 | $0 | ($55,540) | $0 | ($8,332) | - | - | $392,735 |
| 2 | $0 | ($906,477) | $0 | ($134,213) | $0 | ($117,231) | $0 | ($17,587) | - | - | ($1,175,508) |
| 3 | $0 | ($875,476) | $0 | ($128,258) | $0 | ($113,221) | $0 | ($16,986) | - | - | ($1,133,940) |
| 4 | $0 | ($829,424) | $0 | ($129,013) | $0 | ($109,235) | $0 | ($16,388) | - | - | ($1,084,059) |
| 5 | $0 | ($784,760) | $0 | ($129,428) | $0 | ($105,285) | $0 | ($15,795) | - | - | ($1,035,269) |
| 6 | $0 | ($734,492) | $0 | ($126,468) | $0 | ($101,385) | $0 | ($15,210) | - | - | ($977,555) |
| 7 | $0 | ($679,475) | $0 | ($120,501) | $0 | ($97,545) | $0 | ($14,634) | - | - | ($912,155) |
| 8 | $0 | ($627,059) | $0 | ($114,427) | $0 | ($93,773) | $0 | ($14,068) | - | - | ($849,328) |
| 9 | $0 | ($558,400) | $0 | ($116,708) | $0 | ($90,077) | $0 | ($13,514) | - | - | ($778,699) |
| 10 | $0 | ($496,830) | $0 | ($118,284) | $0 | ($86,463) | $0 | ($12,972) | - | - | ($714,549) |
| 11 | $0 | ($424,546) | $0 | ($112,210) | $0 | ($82,937) | $0 | ($12,443) | - | - | ($632,135) |
| 12 | $0 | ($346,014) | $0 | ($99,650) | $0 | ($79,502) | $0 | ($11,927) | - | - | ($537,094) |
| 13 | $0 | ($275,742) | $0 | ($87,884) | $0 | ($76,162) | $0 | ($11,426) | - | - | ($451,214) |
| 14 | $0 | ($220,803) | $0 | ($73,806) | $0 | ($72,918) | $0 | ($10,939) | - | - | ($378,466) |
| 15 | $0 | ($133,476) | $0 | ($50,634) | $0 | ($69,773) | $0 | ($10,468) | - | - | ($264,351) |
| 16 | $0 | ($53,244) | $0 | ($29,107) | $0 | ($66,727) | $0 | ($10,011) | - | - | ($159,088) |
| 17 | $0 | $55,788 | $0 | ($16,090) | $0 | ($63,781) | $0 | ($9,569) | - | - | ($33,651) |
| 18 | $0 | $153,096 | $0 | ($4,163) | $0 | ($60,935) | $0 | ($9,142) | - | - | $78,856 |
| 19 | $0 | $267,853 | $0 | $23,047 | $0 | ($58,188) | $0 | ($8,730) | - | - | $223,982 |
| **Total** | **$0** | **($8,018,727)** | **$0** | **($1,644,903)** | **$0** | **($1,721,924)** | **$0** | **($258,331)** | **-** | **-** | **($11,643,884)** |

| Constant Dollars |
|---:|
| ($1,307,961) |
| $1,519,760 |
|  |
| ($1,345,840) |
| ($1,389,126) |
| ($1,420,981) |
| ($1,452,019) |
| ($1,467,047) |
| ($1,464,722) |
| ($1,459,303) |
| ($1,431,607) |
| ($1,405,627) |
| ($1,330,550) |
| ($1,209,638) |
| ($1,087,355) |
| ($975,889) |
| ($729,352) |
| ($469,655) |
| ($106,298) |
| $266,529 |
| $810,037 |
|  |
| **($17,456,643)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Peak HOV** | **Peak Non-HOV** | **Peak Weaving** | **Peak Truck** | **Peak Arterial** | **Non-Peak Non-HOV** | **Non-Peak Weaving** | **Non-Peak Truck** | **All Periods** | **Present Value of Accident Benefits** |
| 1 | $0 | $658,157 | $0 | $65,092 | $0 | $84,684 | $0 | $8,375 | $0 | $816,308 |
| 20 | $0 | $301,451 | $0 | $29,814 | $0 | $38,787 | $0 | $3,836 | $0 | $373,888 |
| | | | | | | | | | | |
| 2 | $0 | $636,351 | $0 | $62,936 | $0 | $81,878 | $0 | $8,098 | $0 | $789,263 |
| 3 | $0 | $614,582 | $0 | $60,783 | $0 | $79,077 | $0 | $7,821 | $0 | $762,263 |
| 4 | $0 | $592,938 | $0 | $58,642 | $0 | $76,292 | $0 | $7,545 | $0 | $735,418 |
| 5 | $0 | $571,496 | $0 | $56,522 | $0 | $73,533 | $0 | $7,273 | $0 | $708,823 |
| 6 | $0 | $550,321 | $0 | $54,427 | $0 | $70,809 | $0 | $7,003 | $0 | $682,560 |
| 7 | $0 | $529,471 | $0 | $52,365 | $0 | $68,126 | $0 | $6,738 | $0 | $656,700 |
| 8 | $0 | $508,993 | $0 | $50,340 | $0 | $65,491 | $0 | $6,477 | $0 | $631,302 |
| 9 | $0 | $488,929 | $0 | $48,356 | $0 | $62,910 | $0 | $6,222 | $0 | $606,416 |
| 10 | $0 | $469,312 | $0 | $46,415 | $0 | $60,386 | $0 | $5,972 | $0 | $582,085 |
| 11 | $0 | $450,169 | $0 | $44,522 | $0 | $57,922 | $0 | $5,729 | $0 | $558,342 |
| 12 | $0 | $431,522 | $0 | $42,678 | $0 | $55,523 | $0 | $5,491 | $0 | $535,214 |
| 13 | $0 | $413,388 | $0 | $40,885 | $0 | $53,190 | $0 | $5,261 | $0 | $512,723 |
| 14 | $0 | $395,780 | $0 | $39,143 | $0 | $50,924 | $0 | $5,036 | $0 | $490,884 |
| 15 | $0 | $378,707 | $0 | $37,454 | $0 | $48,727 | $0 | $4,819 | $0 | $469,708 |
| 16 | $0 | $362,173 | $0 | $35,819 | $0 | $46,600 | $0 | $4,609 | $0 | $449,201 |
| 17 | $0 | $346,182 | $0 | $34,238 | $0 | $44,543 | $0 | $4,405 | $0 | $429,368 |
| 18 | $0 | $330,734 | $0 | $32,710 | $0 | $42,555 | $0 | $4,209 | $0 | $410,207 |
| 19 | $0 | $315,824 | $0 | $31,235 | $0 | $40,637 | $0 | $4,019 | $0 | $391,715 |
| | | | | | | | | | | |
| **Total** | **$0** | **$9,346,481** | **$0** | **$924,377** | **$0** | **$1,202,595** | **$0** | **$118,938** | **$0** | **$11,592,390** |

| Constant Dollars |
|---|
| $873,450 |
| $1,446,827 |
| |
| $903,628 |
| $933,805 |
| $963,983 |
| $994,161 |
| $1,024,339 |
| $1,054,516 |
| $1,084,694 |
| $1,114,872 |
| $1,145,050 |
| $1,175,228 |
| $1,205,405 |
| $1,235,583 |
| $1,265,761 |
| $1,295,939 |
| $1,326,116 |
| $1,356,294 |
| $1,386,472 |
| $1,416,650 |
| |
| **$23,202,773** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,936) | $0 | ($14,529) | $0 | $0 | ($1,519) | $0 | ($2,162) |
| 20 | $0 | $15,358 | $0 | $42,617 | $0 | $0 | ($214) | $0 | ($263) |
| 2 | $0 | ($10,909) | $0 | ($9,710) | $0 | $0 | ($1,471) | $0 | ($2,091) |
| 3 | $0 | ($10,800) | $0 | ($5,182) | $0 | $0 | ($1,423) | $0 | ($2,020) |
| 4 | $0 | ($10,450) | $0 | ($4,380) | $0 | $0 | ($1,376) | $0 | ($1,950) |
| 5 | $0 | ($9,394) | $0 | ($3,685) | $0 | $0 | ($1,329) | $0 | ($1,880) |
| 6 | $0 | ($8,954) | $0 | ($3,230) | $0 | $0 | ($1,282) | $0 | ($1,811) |
| 7 | $0 | ($7,752) | $0 | ($3,005) | $0 | $0 | ($1,236) | $0 | ($1,743) |
| 8 | $0 | ($805) | $0 | $3,229 | $0 | $0 | ($341) | $0 | ($435) |
| 9 | $0 | $83 | $0 | $4,189 | $0 | $0 | ($329) | $0 | ($418) |
| 10 | $0 | $908 | $0 | $5,010 | $0 | $0 | ($317) | $0 | ($402) |
| 11 | $0 | $1,848 | $0 | $6,288 | $0 | $0 | ($306) | $0 | ($386) |
| 12 | $0 | $2,748 | $0 | $7,859 | $0 | $0 | ($294) | $0 | ($371) |
| 13 | $0 | $3,636 | $0 | $9,329 | $0 | $0 | ($283) | $0 | ($356) |
| 14 | $0 | $4,275 | $0 | $11,499 | $0 | $0 | ($272) | $0 | ($341) |
| 15 | $0 | $5,615 | $0 | $16,003 | $0 | $0 | ($262) | $0 | ($327) |
| 16 | $0 | $6,882 | $0 | $20,049 | $0 | $0 | ($252) | $0 | ($313) |
| 17 | $0 | $9,050 | $0 | $23,007 | $0 | $0 | ($242) | $0 | ($300) |
| 18 | $0 | $10,645 | $0 | $25,653 | $0 | $0 | ($232) | $0 | ($287) |
| 19 | $0 | $12,697 | $0 | $32,403 | $0 | $0 | ($223) | $0 | ($275) |
| **Total** | **$0** | **$2,746** | **$0** | **$163,415** | **$0** | **$0** | **($13,202)** | **$0** | **($18,132)** |

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# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($30,147) | ($32,257) |
| 20 | $0 | $0 | $0 | $0 | $57,499 | $222,502 |
| 2 | $0 | $0 | $0 | $0 | ($24,181) | ($27,685) |
| 3 | $0 | $0 | $0 | $0 | ($19,426) | ($23,798) |
| 4 | $0 | $0 | $0 | $0 | ($18,156) | ($23,798) |
| 5 | $0 | $0 | $0 | $0 | ($16,287) | ($22,844) |
| 6 | $0 | $0 | $0 | $0 | ($15,277) | ($22,927) |
| 7 | $0 | $0 | $0 | $0 | ($13,736) | ($22,056) |
| 8 | $0 | $0 | $0 | $0 | $1,648 | $2,832 |
| 9 | $0 | $0 | $0 | $0 | $3,525 | $6,480 |
| 10 | $0 | $0 | $0 | $0 | $5,198 | $10,226 |
| 11 | $0 | $0 | $0 | $0 | $7,444 | $15,669 |
| 12 | $0 | $0 | $0 | $0 | $9,942 | $22,391 |
| 13 | $0 | $0 | $0 | $0 | $12,327 | $29,705 |
| 14 | $0 | $0 | $0 | $0 | $15,160 | $39,091 |
| 15 | $0 | $0 | $0 | $0 | $21,028 | $58,018 |
| 16 | $0 | $0 | $0 | $0 | $26,367 | $77,839 |
| 17 | $0 | $0 | $0 | $0 | $31,515 | $99,550 |
| 18 | $0 | $0 | $0 | $0 | $35,780 | $120,932 |
| 19 | $0 | $0 | $0 | $0 | $44,604 | $161,310 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$134,827** | **$691,181** |

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# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
| 1 | (8) | (1,646) | (2) | (0) | (0) | (1) | (0) |
| 20 | 18 | 10,734 | 19 | 0 | 0 | 2 | 0 |
| | | | | | | | |
| 2 | (8) | (1,498) | (2) | (0) | (0) | (1) | (0) |
| 3 | (8) | (1,392) | (2) | (0) | (0) | (1) | (0) |
| 4 | (7) | (1,317) | (2) | (0) | (0) | (0) | (0) |
| 5 | (7) | (1,235) | (2) | (0) | (0) | (0) | (0) |
| 6 | (6) | (1,082) | (2) | (0) | (0) | (0) | (0) |
| 7 | (6) | (853) | (2) | (0) | (0) | (0) | (0) |
| 8 | 1 | (431) | 0 | 0 | (0) | 0 | (0) |
| 9 | 1 | (261) | 1 | 0 | (0) | 0 | 0 |
| 10 | 2 | (82) | 1 | 0 | (0) | 0 | 0 |
| 11 | 2 | 225 | 1 | 0 | 0 | 0 | 0 |
| 12 | 3 | 670 | 2 | 0 | 0 | 0 | 0 |
| 13 | 4 | 1,136 | 2 | 0 | 0 | 0 | 0 |
| 14 | 5 | 1,602 | 3 | 0 | 0 | 0 | 0 |
| 15 | 6 | 2,538 | 5 | 0 | 0 | 1 | 0 |
| 16 | 7 | 3,515 | 7 | 0 | 0 | 1 | 0 |
| 17 | 9 | 4,731 | 8 | 0 | 0 | 1 | 0 |
| 18 | 11 | 5,996 | 10 | 0 | 0 | 1 | 0 |
| 19 | 14 | 7,983 | 13 | 0 | 0 | 2 | 0 |
| | | | | | | | |
| **Total** | **33** | **29,334** | **60** | **0** | **0** | **7** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| **Year** | **DOLLARS EMISSIONS SAVED** (PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | **CO** | **CO$_2$** | **NO$_X$** | **PM$_{10}$** | **SO$_X$** | **VOC** |
| 1 | $0 | ($1,423) | ($17,029) | ($8,650) | ($2,051) | ($992) |
| 20 | $0 | $3,739 | $40,425 | $10,779 | $1,305 | $1,251 |
| | | | | | | |
| 2 | $0 | ($1,235) | ($14,072) | ($6,043) | ($1,920) | ($912) |
| 3 | $0 | ($1,094) | ($11,414) | ($4,279) | ($1,793) | ($847) |
| 4 | $0 | ($987) | ($10,751) | ($3,932) | ($1,730) | ($756) |
| 5 | $0 | ($882) | ($10,123) | ($3,027) | ($1,585) | ($670) |
| 6 | $0 | ($737) | ($9,237) | ($3,218) | ($1,518) | ($567) |
| 7 | $0 | ($554) | ($8,136) | ($3,207) | ($1,384) | ($455) |
| 8 | $0 | ($267) | $1,888 | $198 | ($208) | $36 |
| 9 | $0 | ($154) | $2,888 | $843 | ($143) | $91 |
| 10 | $0 | ($46) | $3,803 | $1,383 | ($83) | $141 |
| 11 | $0 | $121 | $5,100 | $1,977 | $44 | $202 |
| 12 | $0 | $342 | $6,712 | $2,519 | $98 | $271 |
| 13 | $0 | $553 | $8,176 | $3,056 | $207 | $334 |
| 14 | $0 | $744 | $10,351 | $3,410 | $273 | $383 |
| 15 | $0 | $1,123 | $14,743 | $4,274 | $402 | $487 |
| 16 | $0 | $1,483 | $18,717 | $5,014 | $573 | $580 |
| 17 | $0 | $1,902 | $21,540 | $6,640 | $702 | $730 |
| 18 | $0 | $2,299 | $24,059 | $7,741 | $818 | $863 |
| 19 | $0 | $2,917 | $30,549 | $9,043 | $1,054 | $1,041 |
| | | | | | | |
| **Total** | **$0** | **$7,846** | **$108,188** | **$24,520** | **($6,938)** | **$1,210** |

A

# NET PRESENT VALUE CALCULATION

| Year | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $748,557 | ($1,222,393) | $816,308 | ($30,147) | | | | |
| 2 | $1,006,143 | ($1,175,508) | $789,263 | ($24,181) | | | | |
| 3 | $1,267,917 | ($1,133,940) | $762,263 | ($19,426) | | | | |
| 4 | $1,534,687 | ($1,084,059) | $735,418 | ($18,156) | | | | |
| 5 | $1,807,534 | ($1,035,269) | $708,823 | ($16,287) | | | | |
| 6 | $2,087,859 | ($977,555) | $682,560 | ($15,277) | | | | |
| 7 | $2,377,440 | ($912,155) | $656,700 | ($13,736) | | | | |
| 8 | $2,678,517 | ($849,328) | $631,302 | $1,648 | | | | |
| 9 | $2,993,900 | ($778,699) | $606,416 | $3,525 | | | | |
| 10 | $3,327,134 | ($714,549) | $582,085 | $5,198 | | | | |
| 11 | $3,682,714 | ($632,135) | $558,342 | $7,444 | | | | |
| 12 | $4,066,399 | ($537,094) | $535,214 | $9,942 | | | | |
| 13 | $4,485,670 | ($451,214) | $512,723 | $12,327 | | | | |
| 14 | $4,950,404 | ($378,466) | $490,884 | $15,160 | | | | |
| 15 | $5,473,908 | ($264,351) | $469,708 | $21,028 | | | | |
| 16 | $6,074,542 | ($159,088) | $449,201 | $26,367 | | | | |
| 17 | $6,778,374 | ($33,651) | $429,368 | $31,515 | | | | |
| 18 | $7,623,706 | $78,856 | $410,207 | $35,780 | | | | |
| 19 | $8,669,240 | $223,982 | $391,715 | $44,604 | | | | |
| 20 | $10,009,787 | $392,735 | $373,888 | $57,499 | | | | |
| **Total** | $81,644,434 | ($11,643,884) | $11,592,390 | $134,827 | $0 | $0 | $0 | $0 |

13,884,608 Person-Hours of Time Saved

Person-Hours of Time Saved

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 33 | $0 | CO Saved | | | CO Saved |
| 29,334 | $7,846 | $CO_2$ Saved | | | $CO_2$ Saved |
| 60 | $108,188 | $NO_X$ Saved | | | $NO_X$ Saved |
| 0 | $24,520 | $PM_{10}$ Saved | | | $PM_{10}$ Saved |
| 0 | | $PM_{2.5}$ Saved | | | $PM_{2.5}$ Saved |
| 0 | ($6,938) | $SO_X$ Saved | | | $SO_X$ Saved |
| 7 | $1,210 | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $11,955,923 | ($1,903,233) | $1,043,315 | $145,283 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | | | |
|---|---|---|---|---|---|---|
| **Travel Time Savings** | **Vehicle Op. Cost Savings** | **Accident Reductions** | **Vehicle Emission Reductions** | **Present Value of Total User Benefits** | **Present Value of Total Project Costs** | **NET PRESENT VALUE** |
| | | | | | | |
| | | | | $0 | $26,229,000 | ($26,229,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | | | |
| | | | | $312,326 | ($387,850) | $700,176 |
| | | | | $595,717 | $13,102 | $582,615 |
| | | | | $876,814 | ($30,203) | $907,017 |
| | | | | $1,167,890 | $11,443 | $1,156,446 |
| | | | | $1,464,801 | $10,695 | $1,454,106 |
| | | | | $1,777,587 | ($104,616) | $1,882,203 |
| | | | | $2,108,250 | ($23,042) | $2,131,291 |
| | | | | $2,462,139 | $8,730 | $2,453,409 |
| | | | | $2,825,142 | $8,159 | $2,816,983 |
| | | | | $3,199,869 | $7,625 | $3,192,244 |
| | | | | $3,616,366 | $2,851 | $3,613,515 |
| | | | | $4,074,462 | ($1,978,073) | $6,052,535 |
| | | | | $4,559,506 | $6,224 | $4,553,281 |
| | | | | $5,077,982 | $5,817 | $5,072,164 |
| | | | | $5,700,293 | ($13,411) | $5,713,704 |
| | | | | $6,391,022 | $610,738 | $5,780,284 |
| | | | | $7,205,606 | $4,749 | $7,200,857 |
| | | | | $8,148,549 | $49,409 | $8,099,139 |
| | | | | $9,329,541 | ($10,231) | $9,339,772 |
| | | | | $10,833,908 | $3,876 | $10,830,032 |
| | | | | | | |
| $0 | $0 | $0 | $0 | **$81,727,767** | **$24,424,994** | **$57,302,773** |

| | |
|---|---|
| | Person-Hours of Time Saved |

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $800,956 | ($1,307,961) | $873,450 | ($32,257) | | | | |
| 2 | $1,151,934 | ($1,345,840) | $903,628 | ($27,685) | | | | |
| 3 | $1,553,253 | ($1,389,126) | $933,805 | ($23,798) | | | | |
| 4 | $2,011,661 | ($1,420,981) | $963,983 | ($23,798) | | | | |
| 5 | $2,535,160 | ($1,452,019) | $994,161 | ($22,844) | | | | |
| 6 | $3,133,314 | ($1,467,047) | $1,024,339 | ($22,927) | | | | |
| 7 | $3,817,650 | ($1,464,722) | $1,054,516 | ($22,056) | | | | |
| 8 | $4,602,190 | ($1,459,303) | $1,084,694 | $2,832 | | | | |
| 9 | $5,504,163 | ($1,431,607) | $1,114,872 | $6,480 | | | | |
| 10 | $6,544,977 | ($1,405,627) | $1,145,050 | $10,226 | | | | |
| 11 | $7,751,568 | ($1,330,550) | $1,175,228 | $15,669 | | | | |
| 12 | $9,158,310 | ($1,209,638) | $1,205,405 | $22,391 | | | | |
| 13 | $10,809,769 | ($1,087,355) | $1,235,583 | $29,705 | | | | |
| 14 | $12,764,785 | ($975,889) | $1,265,761 | $39,091 | | | | |
| 15 | $15,102,685 | ($729,352) | $1,295,939 | $58,018 | | | | |
| 16 | $17,933,043 | ($469,655) | $1,326,116 | $77,839 | | | | |
| 17 | $21,411,630 | ($106,298) | $1,356,294 | $99,550 | | | | |
| 18 | $25,767,609 | $266,529 | $1,386,472 | $120,932 | | | | |
| 19 | $31,352,546 | $810,037 | $1,416,650 | $161,310 | | | | |
| 20 | $38,734,717 | $1,519,760 | $1,446,827 | $222,502 | | | | |
| **Total** | $222,441,922 | ($17,456,643) | $23,202,773 | $691,181 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | | |
| | | | | $0 | $26,229,000 | ($26,229,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $334,188 | ($415,000) | $749,188 | $749,188 |
| | | | | $682,036 | $15,000 | $667,036 | $1,416,225 |
| | | | | $1,074,135 | ($37,000) | $1,111,135 | $2,527,359 |
| | | | | $1,530,865 | $15,000 | $1,515,865 | $4,043,225 |
| | | | | $2,054,459 | $15,000 | $2,039,459 | $6,082,683 |
| | | | | $2,667,679 | ($157,000) | $2,824,679 | $8,907,362 |
| | | | | $3,385,388 | ($37,000) | $3,422,388 | $12,329,750 |
| | | | | $4,230,413 | $15,000 | $4,215,413 | $16,545,163 |
| | | | | $5,193,908 | $15,000 | $5,178,908 | $21,724,071 |
| | | | | $6,294,626 | $15,000 | $6,279,626 | $28,003,697 |
| | | | | $7,611,914 | $6,000 | $7,605,914 | $35,609,611 |
| | | | | $9,176,469 | ($4,455,000) | $13,631,469 | $49,241,081 |
| | | | | $10,987,702 | $15,000 | $10,972,702 | $60,213,783 |
| | | | | $13,093,749 | $15,000 | $13,078,749 | $73,292,532 |
| | | | | $15,727,289 | ($37,000) | $15,764,289 | $89,056,821 |
| | | | | $18,867,344 | $1,803,000 | $17,064,344 | $106,121,165 |
| | | | | $22,761,176 | $15,000 | $22,746,176 | $128,867,341 |
| | | | | $27,541,542 | $167,000 | $27,374,542 | $156,241,884 |
| | | | | $33,740,542 | ($37,000) | $33,777,542 | $190,019,426 |
| | | | | $41,923,807 | $15,000 | $41,908,807 | $231,928,233 |
| $0 | $0 | $0 | $0 | **$228,879,233** | **$23,180,000** | **$205,699,233** | |

| | |
|---|---|
| **Total Construction Costs** | **$26,229,000** |

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($26,229,000) |
| 2 | $749,188 |
| 3 | $667,036 |
| 4 | $1,111,135 |
| 5 | $1,515,865 |
| 6 | $2,039,459 |
| 7 | $2,824,679 |
| 8 | $3,422,388 |
| 9 | $4,215,413 |
| 10 | $5,178,908 |
| 11 | $6,279,626 |
| 12 | $7,605,914 |
| 13 | $13,631,469 |
| 14 | $10,972,702 |
| 15 | $13,078,749 |
| 16 | $15,764,289 |
| 17 | $17,064,344 |
| 18 | $22,746,176 |
| 19 | $27,374,542 |
| 20 | $33,777,542 |
| 21 | $41,908,807 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **16.72%** |
| **Payback Period** | **10 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |

**OMB GDP Inflator** **1.01719172**

Yellow cells - adjusted

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | *1* |
| Real Discount Rate | 7.0% | *2* |

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | *3* |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | *3* |
| Benefits and Costs | $ 10.69 | $/hr | *4* |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | *5* |
| Truck | $ 31.20 | $/hr/veh | *5* |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | *6* |
| Transit | $ 13.75 | $/hr/per | *5* |
| Out-of-Vehicle Travel | 2 | times | *5* |
| Incident-Related Travel | 3 | times | *7* |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | *8* |
| Truck (diesel) | $ 3.07 | $/gal | *8* |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | *9* |
| State Sales Tax (diesel) | **13.00%** | % | *9* |
| Average Local Sales Tax | 0.50% | % | *9* |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | *9* |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | *9* |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | *9* |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | *9* |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | *10* |
| Truck | $ 0.437 | $/mi | *11* |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | *12* |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | *12* |
| Level B (Moderate) | $ 125,000 | $/event | *12* |
| Level C (Minor) | $ 63,900 | $/event | *12* |
| Cost of Property Damage | $ 4,300 | $/event | *13* |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | *14* |
| Injury Accident | 0.29 | per mil veh-mi | *14* |
| PDO Accident | 0.55 | per mil veh-mi | *14* |
| Non-Freeway | 1.05 | per mil veh-mi | *15* |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | *16* |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | *17* |
| HOV Lanes | 0.55 | 8 | 1,600 | | *18* |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

### Active Transportation Parameters

| General Travel Activity Characteristics Parameters | Value | Units | |
|---|---|---|---|
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| **Vehicle Statistics** | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | *19* |
| **Active Transportation User Characteristics** | | | |
| Average Cycling Speed | 11.80 | mph | *20* |
| Average Walking Speed | 3.00 | mph | *21* |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | *19* |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | *19* |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| **Value of Travel Time** | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| **Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class** | | | |
| Class I | 0.57 | - | *20* |
| Class II | 0.49 | - | *20* |
| Class III | 0.92 | - | *20* |
| Class IV | 0.49 | - | *20* |
| *Note: Class IV assumed to be the same as Class II* | | | |
| **Walking Journey Quality Values per Mile by Amentity** | | | |
| Street Lighting | $0.110 | $/mi | *22* |
| Curb Level | $0.078 | $/mi | *22* |
| Crowding | $0.055 | $/mi | *22* |
| Pavement Evenness | $0.026 | $/mi | *22* |
| Information Panels | $0.026 | $/mi | *22* |
| Benches | $0.017 | $/mi | *22* |
| Directional Signage | $0.017 | $/mi | *22* |
| **Health (Absenteeism Reduction)** | | | |
| Average Absence of Employees | 3.60 | days/yr | *23* |
| Percentage Covered by Short-Term Sick Leave | 95% | % | *24* |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | *25* |
| **Health (Mortality Reduction)** | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | *26* |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | *26* |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | *27* |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | *27* |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | *28* |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | *28* |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

### *Project Types*

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| | | | |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| | | | |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| | | | |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| | | | |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

## *Travel Demand Tables*

**DEMAND FOR TRAVEL IN PEAK PERIOD**
(percent of total daily travel)

| Number of | Urban | | | | | |
|---|---|---|---|---|---|---|
| Hours in | So. California | | No. California | | Rural | |
| Peak Period | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

**AGE COHORTS FOR MORTALITY RISK REDUCTION**
(percent of population)

| | | Urban | | |
|---|---|---|---|---|
| Mode | Age Cohort | South | North | Rural |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

**AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP**
(miles/trip)

| | | Urban | | |
|---|---|---|---|---|
| Mode | Age Cohort | South | North | Rural |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

**TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS**
(percent of trips)

| | | Urban | | |
|---|---|---|---|---|
| Mode | Trip Purpose | South | North | Rural |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident | | 0.1176 | 0.6446 |
| Cost per Event | | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary*
*Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

## HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | $CO_2e$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | $0.907 | $8,300 | $377,800 | $48,900 | $2,000 |
| CA Urban Area | 2 | $0 | $0.907 | $8,300 | $377,800 | $48,900 | $2,000 |
| CA Rural Area | 3 | $0 | $0.907 | $8,300 | $377,800 | $48,900 | $2,000 |

$CO_2e$ Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

## PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 |  | 583.58 | 62.02 |  | 19.73 |  |
|  | 2022 | 45.67 |  | 250.11 | 31.01 |  | 19.73 |  |

## LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 |  | 1.13 | 0.17 |  | 0.06 |  |
|  | 2022 | 0.14 |  | 1.14 | 0.17 |  | 0.06 |  |

## FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |
|  | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |

| | | |
|---|---|---|
| Freight Rail Fuel Efficiency | 468 | ton-miles/gal |
| Fuel Burned at Idle | 4 | gal/hr |

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## *Pavement Adjustments* (used only for pavement projects)

### PAVEMENT DETERIORATION

(IRI in inches/mile)

| | Year 20, By Loading | | |
|---|---|---|---|
| Year 0 | Light | Medium | Heavy |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

### VEHICLE OPERATING SPEED

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

### FUEL CONSUMPTION

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

### NON-FUEL COSTS

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## Weaving Adjustments (used only for freeway connector, HOV connector, and HOV drop ramp projects)

### VEHICLE OPERATING SPEED
(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## TMS Adjustments (used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

### PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS
(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| **Strategy** | **Speed** | **Volume** | **Speed** | **Volume** | **TT** | **VOC** | **Em** | **Benefit** |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

### TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS
(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| **TMS Strategy** | **Time** | **Capital** | **O&M** |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Undivided, $25M -10% TPC, 40,062 AADT

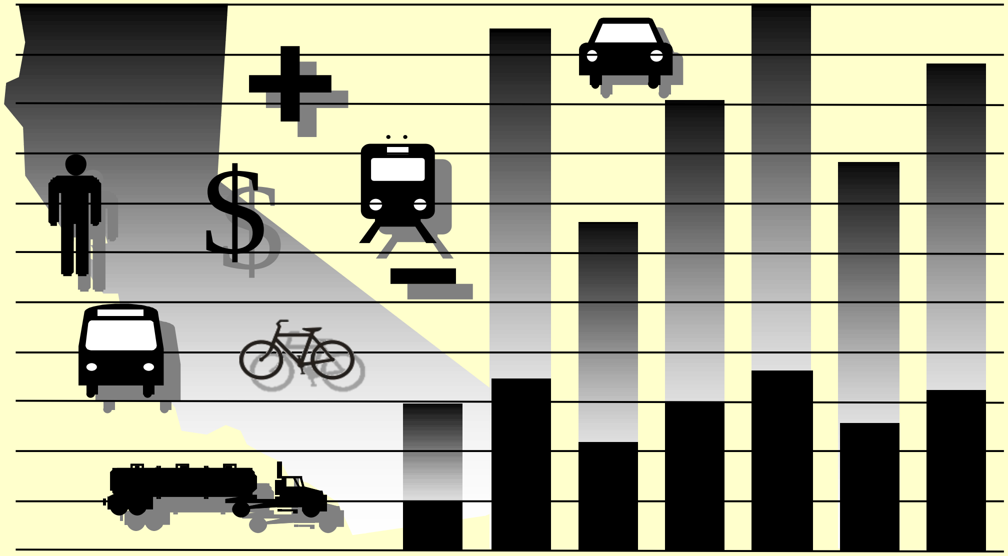
WAR-63 Priority Project BCA

Caltrans

California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**
Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

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# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period. Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual. Other adjustments are made for weaving and pavement conditions. An option is also available to conduct a simple queuing analysis. Accidents are estimated from statewide averages and recent data for the facility. If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically. Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road. The user clicks a button and the model clears the Project Information worksheet to receive information on other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed). The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available. The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed). These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### **PROJECT DATA** (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

***Type of Project***

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

***Project Location***

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

***Length of Construction Period***

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

***One- or Two-Way Data***

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

***Length of Peak Period(s)***

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## **HIGHWAY DESIGN AND TRAFFIC DATA** (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

***Highway Design***

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

***Average Daily Traffic (ADT)***

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

### *Average Hourly HOV/HOT Lane Traffic*

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

### *Percent Traffic in Weave*

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

### *Percent Trucks*

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

### *Truck Speed*

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

### *On-Ramp Volume*

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

### *Queue Formation*

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

### *Pavement Condition (for Pavement Rehab. Projects)*

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

### *Average Vehicle Occupancy (AVO)*

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## HIGHWAY ACCIDENT DATA (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

### *Actual 3-Year Accident Data (from Table B)*

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

### *Statewide Basic Average Accident Rate*

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## RAIL AND TRANSIT DATA (Box 1D)

*This section is used for rail and transit projects only.*

***Annual Person-Trips***

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

***Percent Trips during Peak Period***

32 Insert % annual person-trips that occur during peak period.

***Percent New Trips from Parallel Highway***

33 Insert % new transit person-trips originating on parallel highway.

***Annual Vehicle-Miles***

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

***Average Vehicles per Train***

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

***Reduction in Transit Accidents***

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

***Average Transit Travel Time***

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

***Highway Grade Crossing***

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

***Transit Agency Costs (for Transit TMS Projects)***

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## PROJECT COSTS (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.

47 Model adds agency cost savings due to transit TMS automatically.

48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.

50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.

52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.

53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.

54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.

56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.

57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.

59 Summary results are available immediately in the Results worksheet.

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Undivided

EA:
PPNO:

1A

## PROJECT DATA

| | | |
|---|---|---|
| ***Type of Project*** | | |
| Select project type from list | General Highway | |
| ***Project Location*** (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural) | 3 | |
| Length of Construction Period | 1 | years |
| One- or Two-Way Data | 2 | enter 1 or 2 |
| | Current | |
| ***Length of Peak Period(s)*** (up to 24 hrs) | 13 | hours |

1B

## HIGHWAY DESIGN AND TRAFFIC DATA

| ***Highway Design*** | | No Build | Build |
|---|---|---|---|
| Roadway Type (Fwy, Exp, Conv Hwy) | | C | C |
| Number of General Traffic Lanes | | 2 | 4 |
| Number of HOV/HOT Lanes | | 0 | 0 |
| HOV Restriction (2 or 3) | | 0 | |
| Exclusive ROW for Buses (y/n) | | N | |
| Highway Free-Flow Speed | | 50 | 55 |
| Ramp Design Speed (if aux. lane/off-ramp proj.) | | | |
| Length (in miles) | Highway Segment | 3.0 | 3.0 |
| | Impacted Length | 3.0 | 3.0 |

| ***Average Daily Traffic*** | | | |
|---|---|---|---|
| | Current | 20,600 | |
| | | No Build | Build |
| | Base (Year 1) | 21,337 | 24,184 |
| | Forecast (Year 20) | 35,346 | 40,062 |
| ***Average Hourly HOV/HOT Lane Traffic*** | | | 0 |
| Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.) | | | 100% |
| ***Percent Traffic in Weave*** | | | 0.0% |
| ***Percent Trucks*** (include RVs, if applicable) | | 9% | 9% |
| ***Truck Speed*** | | 50 | |

| ***On-Ramp Volume*** | Peak | Non-Peak |
|---|---|---|
| Hourly Ramp Volume (if aux. lane/on-ramp proj.) | 0 | 0 |
| Metering Strategy (1, 2, 3, or D, if on-ramp proj.) | | |

| ***Queue Formation*** (if queuing or grade crossing project) | Year 1 | Year 20 |
|---|---|---|
| Arrival Rate (in vehicles per hour) | 0 | 0 |
| Departure Rate (in vehicles per hour) | 0 | 0 |

| ***Pavement Condition*** (if pavement project) | | No Build | Build |
|---|---|---|---|
| IRI (inches/mile) | Base (Year 1) | | |
| | Forecast (Year 20) | | |

| ***Average Vehicle Occupancy (AVO)*** | | No Build | Build |
|---|---|---|---|
| General Traffic | Non-Peak | 1.30 | 1.30 |
| | Peak | 1.15 | 1.15 |
| High Occupancy Vehicle (if HOV/HOT lanes) | | 2.15 | 2.15 |

1C

## HIGHWAY ACCIDENT DATA

| ***Actual 3-Year Accident Data (from Table B)*** | Count (No.) | Rate |
|---|---|---|
| Total Accidents (Tot) | 126 | 1.86 |
| Fatal Accidents (Fat) | 1 | 0.015 |
| Injury Accidents (Inj) | 33 | 0.49 |
| Property Damage Only (PDO) Accidents | 92 | 1.36 |

| ***Statewide Basic Average Accident Rate*** | No Build | Build |
|---|---|---|
| Rate Group | | |
| Accident Rate (per million vehicle-miles) | 1.72 | 1.30 |
| Percent Fatal Accidents (Pct Fat) | 0.3% | 0.3% |
| Percent Injury Accidents (Pct Inj) | 23.5% | 23.5% |

1D

## RAIL AND TRANSIT DATA

| ***Annual Person-Trips*** | No Build | Build |
|---|---|---|
| Base (Year 1) | | |
| Forecast (Year 20) | | |
| ***Percent Trips during Peak Period*** | 89% | |
| ***Percent New Trips from Parallel Highway*** | | 100% |

| ***Annual Vehicle-Miles*** | No Build | Build |
|---|---|---|
| Base (Year 1) | | |
| Forecast (Year 20) | | |
| ***Average Vehicles/Train*** (if rail project) | | |

| ***Reduction in Transit Accidents*** | | |
|---|---|---|
| Percent Reduction (if safety project) | | |

| ***Average Transit Travel Time*** | | No Build | Build |
|---|---|---|---|
| In-Vehicle | Non-Peak (in minutes) | | 0.0 |
| | Peak (in minutes) | | 0.0 |
| Out-of-Vehicle | Non-Peak (in minutes) | 0.0 | 0.0 |
| | Peak (in minutes) | 0.0 | 0.0 |

| ***Highway Grade Crossing*** | Current | Year 1 | Year 20 |
|---|---|---|---|
| Annual Number of Trains | | 0 | |
| Avg. Gate Down Time (in min.) | | 0.0 | |

| ***Transit Agency Costs*** (if TMS project) | No Build | Build |
|---|---|---|
| Annual Capital Expenditure | | $0 |
| Annual Ops. and Maintenance Expenditure | | $0 |

*Model should be run for both roads for intersection or bypass highway projects, and may be run twice for connectors. Press button below to prepare model to enter data for second road. After data are entered, results reflect total project benefits.*

Prepare Model for Second Road

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 32,300 | | 32,300 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 3,195 | | 3,195 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 54.4 | | 54.4 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 4,156 | | 4,156 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 411 | | 411 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |
| **Hwy Safety or Weaving Improvement** | | 0% | collision reduction factor (per HSIP Guidelines) | |
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.011 | | 0.011 | |
| Injury Accidents | 0.37 | | 0.37 | |
| PDO Accidents | 1.03 | | 1.03 | |
| Total Accidents | 1.410 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

| | | |
|---|---|---|
| **Detailed Information Available?** (y/n) | N | |
| **Aggregate Segment Length** (estimate as VMT/total volume) | | |
| All Ramps | | miles |
| Arterials | | miles |

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

## ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 13,558,088 | 1,596,025 |
| Truck Trips | 1,028,749 | 1,166,009 | 137,260 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 1,972,037 | 232,143 |
| Truck Trips | 132,367 | 150,028 | 17,661 |
| Total Trips | 14,863,073 | 16,846,162 | 1,983,089 |

**District:** **WCTID**

**PROJECT:** **WAR 63 Priority Segment 4-Lane Undivided**

EA:

PPNO:

3

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| **Life-Cycle Costs (mil. $)** | $19.7 |
| **Life-Cycle Benefits (mil. $)** | $81.7 |
| **Net Present Value (mil. $)** | $62.1 |
| **Benefit / Cost Ratio:** | 4.2 |
| **Rate of Return on Investment:** | 18.7% |
| **Payback Period:** | 9 years |

| **ITEMIZED BENEFITS (mil. $)** | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| **Travel Time Savings** | $69.7 | $12.0 | $81.6 | $4.1 |
| **Veh. Op. Cost Savings** | -$9.7 | -$1.9 | -$11.6 | -$0.6 |
| **Accident Cost Savings** | $10.5 | $1.0 | $11.6 | $0.6 |
| **Emission Cost Savings** | -$0.0 | $0.1 | $0.1 | $0.0 |
| **TOTAL BENEFITS** | $70.5 | $11.2 | $81.7 | $4.1 |
| **Person-Hours of Time Saved** | | | 13,884,608 | 694,230 |

***Should benefit-cost results include:***

| | |
|---|---|
| **1) Induced Travel? (y/n)** | Y<br>Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y<br>Default = Y |
| **3) Accident Costs? (y/n)** | Y<br>Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for $CO_2e$ | Y<br>Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| **EMISSIONS REDUCTION** | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| **CO Emissions Saved** | 33 | 2 | $0.0 | $0.0 |
| **$CO_2$ Emissions Saved** | 29,334 | 1,467 | $0.0 | $0.0 |
| **$NO_X$ Emissions Saved** | 60 | 3 | $0.1 | $0.0 |
| **$PM_{10}$ Emissions Saved** | 0 | 0 | $0.0 | $0.0 |
| **$PM_{2.5}$ Emissions Saved** | 0 | 0 | | |
| **$SO_X$ Emissions Saved** | 0 | 0 | -$0.0 | -$0.0 |
| **VOC Emissions Saved** | 7 | 0 | $0.0 | $0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $648,782 | $0 | $21,244 | $0 | $0 | $78,532 | $0 | $0 |
| 20 | $0 | $8,381,211 | $0 | $1,592,605 | $0 | $0 | $35,971 | $0 | $0 |
| | | | | | | | | | |
| 2 | $0 | $863,076 | $0 | $67,138 | $0 | $0 | $75,930 | $0 | $0 |
| 3 | $0 | $1,080,908 | $0 | $113,677 | $0 | $0 | $73,333 | $0 | $0 |
| 4 | $0 | $1,302,957 | $0 | $160,980 | $0 | $0 | $70,751 | $0 | $0 |
| 5 | $0 | $1,530,130 | $0 | $209,212 | $0 | $0 | $68,192 | $0 | $0 |
| 6 | $0 | $1,763,601 | $0 | $258,592 | $0 | $0 | $65,666 | $0 | $0 |
| 7 | $0 | $2,004,859 | $0 | $309,403 | $0 | $0 | $63,178 | $0 | $0 |
| 8 | $0 | $2,255,777 | $0 | $362,005 | $0 | $0 | $60,735 | $0 | $0 |
| 9 | $0 | $2,518,709 | $0 | $416,850 | $0 | $0 | $58,341 | $0 | $0 |
| 10 | $0 | $2,796,621 | $0 | $474,513 | $0 | $0 | $56,000 | $0 | $0 |
| 11 | $0 | $3,093,271 | $0 | $535,727 | $0 | $0 | $53,716 | $0 | $0 |
| 12 | $0 | $3,413,480 | $0 | $601,428 | $0 | $0 | $51,491 | $0 | $0 |
| 13 | $0 | $3,763,506 | $0 | $672,837 | $0 | $0 | $49,328 | $0 | $0 |
| 14 | $0 | $4,151,612 | $0 | $751,565 | $0 | $0 | $47,227 | $0 | $0 |
| 15 | $0 | $4,588,931 | $0 | $839,787 | $0 | $0 | $45,190 | $0 | $0 |
| 16 | $0 | $5,090,826 | $0 | $940,499 | $0 | $0 | $43,217 | $0 | $0 |
| 17 | $0 | $5,679,105 | $0 | $1,057,960 | $0 | $0 | $41,309 | $0 | $0 |
| 18 | $0 | $6,385,816 | $0 | $1,198,424 | $0 | $0 | $39,465 | $0 | $0 |
| 19 | $0 | $7,260,075 | $0 | $1,371,478 | $0 | $0 | $37,686 | $0 | $0 |
| | | | | | | | | | |
| **Total** | **$0** | **$68,573,252** | **$0** | **$11,955,923** | **$0** | **$0** | **$1,115,259** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

|  | TRANSIT |  |  |  | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| Year | Peak In-Vehicle | Peak Out-of-Veh | Non-Peak In-Vehicle | Non-Peak Out-of-Veh |  |  |  |
| 1 | $0 | $0 | $0 | $0 | $748,557 | $800,956 | 53,742 |
| 20 | $0 | $0 | $0 | $0 | $10,009,787 | $38,734,717 | 2,405,888 |
| 2 | $0 | $0 | $0 | $0 | $1,006,143 | $1,151,934 | 75,607 |
| 3 | $0 | $0 | $0 | $0 | $1,267,917 | $1,553,253 | 100,589 |
| 4 | $0 | $0 | $0 | $0 | $1,534,687 | $2,011,661 | 129,107 |
| 5 | $0 | $0 | $0 | $0 | $1,807,534 | $2,535,160 | 161,656 |
| 6 | $0 | $0 | $0 | $0 | $2,087,859 | $3,133,314 | 198,828 |
| 7 | $0 | $0 | $0 | $0 | $2,377,440 | $3,817,650 | 241,339 |
| 8 | $0 | $0 | $0 | $0 | $2,678,517 | $4,602,190 | 290,055 |
| 9 | $0 | $0 | $0 | $0 | $2,993,900 | $5,504,163 | 346,046 |
| 10 | $0 | $0 | $0 | $0 | $3,327,134 | $6,544,977 | 410,636 |
| 11 | $0 | $0 | $0 | $0 | $3,682,714 | $7,751,568 | 485,496 |
| 12 | $0 | $0 | $0 | $0 | $4,066,399 | $9,158,310 | 572,753 |
| 13 | $0 | $0 | $0 | $0 | $4,485,670 | $10,809,769 | 675,171 |
| 14 | $0 | $0 | $0 | $0 | $4,950,404 | $12,764,785 | 796,392 |
| 15 | $0 | $0 | $0 | $0 | $5,473,908 | $15,102,685 | 941,333 |
| 16 | $0 | $0 | $0 | $0 | $6,074,542 | $17,933,043 | 1,116,782 |
| 17 | $0 | $0 | $0 | $0 | $6,778,374 | $21,411,630 | 1,332,389 |
| 18 | $0 | $0 | $0 | $0 | $7,623,706 | $25,767,609 | 1,602,351 |
| 19 | $0 | $0 | $0 | $0 | $8,669,240 | $31,352,546 | 1,948,448 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$81,644,434** | **$222,441,922** | **13,884,608** |

C

# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | | Present Value of Veh Op Cost Benefits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | |
| 1 | $0 | ($942,318) | $0 | ($140,639) | $0 | ($121,246) | $0 | ($18,190) | - | - | ($1,222,393) |
| 20 | $0 | $393,073 | $0 | $63,534 | $0 | ($55,540) | $0 | ($8,332) | - | - | $392,735 |
| 2 | $0 | ($906,477) | $0 | ($134,213) | $0 | ($117,231) | $0 | ($17,587) | - | - | ($1,175,508) |
| 3 | $0 | ($875,476) | $0 | ($128,258) | $0 | ($113,221) | $0 | ($16,986) | - | - | ($1,133,940) |
| 4 | $0 | ($829,424) | $0 | ($129,013) | $0 | ($109,235) | $0 | ($16,388) | - | - | ($1,084,059) |
| 5 | $0 | ($784,760) | $0 | ($129,428) | $0 | ($105,285) | $0 | ($15,795) | - | - | ($1,035,269) |
| 6 | $0 | ($734,492) | $0 | ($126,468) | $0 | ($101,385) | $0 | ($15,210) | - | - | ($977,555) |
| 7 | $0 | ($679,475) | $0 | ($120,501) | $0 | ($97,545) | $0 | ($14,634) | - | - | ($912,155) |
| 8 | $0 | ($627,059) | $0 | ($114,427) | $0 | ($93,773) | $0 | ($14,068) | - | - | ($849,328) |
| 9 | $0 | ($558,400) | $0 | ($116,708) | $0 | ($90,077) | $0 | ($13,514) | - | - | ($778,699) |
| 10 | $0 | ($496,830) | $0 | ($118,284) | $0 | ($86,463) | $0 | ($12,972) | - | - | ($714,549) |
| 11 | $0 | ($424,546) | $0 | ($112,210) | $0 | ($82,937) | $0 | ($12,443) | - | - | ($632,135) |
| 12 | $0 | ($346,014) | $0 | ($99,650) | $0 | ($79,502) | $0 | ($11,927) | - | - | ($537,094) |
| 13 | $0 | ($275,742) | $0 | ($87,884) | $0 | ($76,162) | $0 | ($11,426) | - | - | ($451,214) |
| 14 | $0 | ($220,803) | $0 | ($73,806) | $0 | ($72,918) | $0 | ($10,939) | - | - | ($378,466) |
| 15 | $0 | ($133,476) | $0 | ($50,634) | $0 | ($69,773) | $0 | ($10,468) | - | - | ($264,351) |
| 16 | $0 | ($53,244) | $0 | ($29,107) | $0 | ($66,727) | $0 | ($10,011) | - | - | ($159,088) |
| 17 | $0 | $55,788 | $0 | ($16,090) | $0 | ($63,781) | $0 | ($9,569) | - | - | ($33,651) |
| 18 | $0 | $153,096 | $0 | ($4,163) | $0 | ($60,935) | $0 | ($9,142) | - | - | $78,856 |
| 19 | $0 | $267,853 | $0 | $23,047 | $0 | ($58,188) | $0 | ($8,730) | - | - | $223,982 |
| **Total** | **$0** | **($8,018,727)** | **$0** | **($1,644,903)** | **$0** | **($1,721,924)** | **$0** | **($258,331)** | **-** | **-** | **($11,643,884)** |

| Constant Dollars |
|---|
| ($1,307,961) |
| $1,519,760 |
|  |
| ($1,345,840) |
| ($1,389,126) |
| ($1,420,981) |
| ($1,452,019) |
| ($1,467,047) |
| ($1,464,722) |
| ($1,459,303) |
| ($1,431,607) |
| ($1,405,627) |
| ($1,330,550) |
| ($1,209,638) |
| ($1,087,355) |
| ($975,889) |
| ($729,352) |
| ($469,655) |
| ($106,298) |
| $266,529 |
| $810,037 |
|  |
| **($17,456,643)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Peak HOV** | **Peak Non-HOV** | **Peak Weaving** | **Peak Truck** | **Peak Arterial** | **Non-Peak Non-HOV** | **Non-Peak Weaving** | **Non-Peak Truck** | **All Periods** | |
| 1 | $0 | $658,157 | $0 | $65,092 | $0 | $84,684 | $0 | $8,375 | $0 | $816,308 |
| 20 | $0 | $301,451 | $0 | $29,814 | $0 | $38,787 | $0 | $3,836 | $0 | $373,888 |
| 2 | $0 | $636,351 | $0 | $62,936 | $0 | $81,878 | $0 | $8,098 | $0 | $789,263 |
| 3 | $0 | $614,582 | $0 | $60,783 | $0 | $79,077 | $0 | $7,821 | $0 | $762,263 |
| 4 | $0 | $592,938 | $0 | $58,642 | $0 | $76,292 | $0 | $7,545 | $0 | $735,418 |
| 5 | $0 | $571,496 | $0 | $56,522 | $0 | $73,533 | $0 | $7,273 | $0 | $708,823 |
| 6 | $0 | $550,321 | $0 | $54,427 | $0 | $70,809 | $0 | $7,003 | $0 | $682,560 |
| 7 | $0 | $529,471 | $0 | $52,365 | $0 | $68,126 | $0 | $6,738 | $0 | $656,700 |
| 8 | $0 | $508,993 | $0 | $50,340 | $0 | $65,491 | $0 | $6,477 | $0 | $631,302 |
| 9 | $0 | $488,929 | $0 | $48,356 | $0 | $62,910 | $0 | $6,222 | $0 | $606,416 |
| 10 | $0 | $469,312 | $0 | $46,415 | $0 | $60,386 | $0 | $5,972 | $0 | $582,085 |
| 11 | $0 | $450,169 | $0 | $44,522 | $0 | $57,922 | $0 | $5,729 | $0 | $558,342 |
| 12 | $0 | $431,522 | $0 | $42,678 | $0 | $55,523 | $0 | $5,491 | $0 | $535,214 |
| 13 | $0 | $413,388 | $0 | $40,885 | $0 | $53,190 | $0 | $5,261 | $0 | $512,723 |
| 14 | $0 | $395,780 | $0 | $39,143 | $0 | $50,924 | $0 | $5,036 | $0 | $490,884 |
| 15 | $0 | $378,707 | $0 | $37,454 | $0 | $48,727 | $0 | $4,819 | $0 | $469,708 |
| 16 | $0 | $362,173 | $0 | $35,819 | $0 | $46,600 | $0 | $4,609 | $0 | $449,201 |
| 17 | $0 | $346,182 | $0 | $34,238 | $0 | $44,543 | $0 | $4,405 | $0 | $429,368 |
| 18 | $0 | $330,734 | $0 | $32,710 | $0 | $42,555 | $0 | $4,209 | $0 | $410,207 |
| 19 | $0 | $315,824 | $0 | $31,235 | $0 | $40,637 | $0 | $4,019 | $0 | $391,715 |
| **Total** | **$0** | **$9,346,481** | **$0** | **$924,377** | **$0** | **$1,202,595** | **$0** | **$118,938** | **$0** | **$11,592,390** |

| Constant Dollars |
|---:|
| $873,450 |
| $1,446,827 |
| |
| $903,628 |
| $933,805 |
| $963,983 |
| $994,161 |
| $1,024,339 |
| $1,054,516 |
| $1,084,694 |
| $1,114,872 |
| $1,145,050 |
| $1,175,228 |
| $1,205,405 |
| $1,235,583 |
| $1,265,761 |
| $1,295,939 |
| $1,326,116 |
| $1,356,294 |
| $1,386,472 |
| $1,416,650 |
| |
| **$23,202,773** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,936) | $0 | ($14,529) | $0 | $0 | ($1,519) | $0 | ($2,162) |
| 20 | $0 | $15,358 | $0 | $42,617 | $0 | $0 | ($214) | $0 | ($263) |
| | | | | | | | | | |
| 2 | $0 | ($10,909) | $0 | ($9,710) | $0 | $0 | ($1,471) | $0 | ($2,091) |
| 3 | $0 | ($10,800) | $0 | ($5,182) | $0 | $0 | ($1,423) | $0 | ($2,020) |
| 4 | $0 | ($10,450) | $0 | ($4,380) | $0 | $0 | ($1,376) | $0 | ($1,950) |
| 5 | $0 | ($9,394) | $0 | ($3,685) | $0 | $0 | ($1,329) | $0 | ($1,880) |
| 6 | $0 | ($8,954) | $0 | ($3,230) | $0 | $0 | ($1,282) | $0 | ($1,811) |
| 7 | $0 | ($7,752) | $0 | ($3,005) | $0 | $0 | ($1,236) | $0 | ($1,743) |
| 8 | $0 | ($805) | $0 | $3,229 | $0 | $0 | ($341) | $0 | ($435) |
| 9 | $0 | $83 | $0 | $4,189 | $0 | $0 | ($329) | $0 | ($418) |
| 10 | $0 | $908 | $0 | $5,010 | $0 | $0 | ($317) | $0 | ($402) |
| 11 | $0 | $1,848 | $0 | $6,288 | $0 | $0 | ($306) | $0 | ($386) |
| 12 | $0 | $2,748 | $0 | $7,859 | $0 | $0 | ($294) | $0 | ($371) |
| 13 | $0 | $3,636 | $0 | $9,329 | $0 | $0 | ($283) | $0 | ($356) |
| 14 | $0 | $4,275 | $0 | $11,499 | $0 | $0 | ($272) | $0 | ($341) |
| 15 | $0 | $5,615 | $0 | $16,003 | $0 | $0 | ($262) | $0 | ($327) |
| 16 | $0 | $6,882 | $0 | $20,049 | $0 | $0 | ($252) | $0 | ($313) |
| 17 | $0 | $9,050 | $0 | $23,007 | $0 | $0 | ($242) | $0 | ($300) |
| 18 | $0 | $10,645 | $0 | $25,653 | $0 | $0 | ($232) | $0 | ($287) |
| 19 | $0 | $12,697 | $0 | $32,403 | $0 | $0 | ($223) | $0 | ($275) |
| | | | | | | | | | |
| **Total** | **$0** | **$2,746** | **$0** | **$163,415** | **$0** | **$0** | **($13,202)** | **$0** | **($18,132)** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($30,147) | ($32,257) |
| 20 | $0 | $0 | $0 | $0 | $57,499 | $222,502 |
| 2 | $0 | $0 | $0 | $0 | ($24,181) | ($27,685) |
| 3 | $0 | $0 | $0 | $0 | ($19,426) | ($23,798) |
| 4 | $0 | $0 | $0 | $0 | ($18,156) | ($23,798) |
| 5 | $0 | $0 | $0 | $0 | ($16,287) | ($22,844) |
| 6 | $0 | $0 | $0 | $0 | ($15,277) | ($22,927) |
| 7 | $0 | $0 | $0 | $0 | ($13,736) | ($22,056) |
| 8 | $0 | $0 | $0 | $0 | $1,648 | $2,832 |
| 9 | $0 | $0 | $0 | $0 | $3,525 | $6,480 |
| 10 | $0 | $0 | $0 | $0 | $5,198 | $10,226 |
| 11 | $0 | $0 | $0 | $0 | $7,444 | $15,669 |
| 12 | $0 | $0 | $0 | $0 | $9,942 | $22,391 |
| 13 | $0 | $0 | $0 | $0 | $12,327 | $29,705 |
| 14 | $0 | $0 | $0 | $0 | $15,160 | $39,091 |
| 15 | $0 | $0 | $0 | $0 | $21,028 | $58,018 |
| 16 | $0 | $0 | $0 | $0 | $26,367 | $77,839 |
| 17 | $0 | $0 | $0 | $0 | $31,515 | $99,550 |
| 18 | $0 | $0 | $0 | $0 | $35,780 | $120,932 |
| 19 | $0 | $0 | $0 | $0 | $44,604 | $161,310 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$134,827** | **$691,181** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
| 1 | (8) | (1,646) | (2) | (0) | (0) | (1) | (0) |
| 20 | 18 | 10,734 | 19 | 0 | 0 | 2 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | (8) | (1,498) | (2) | (0) | (0) | (1) | (0) |
| 3 | (8) | (1,392) | (2) | (0) | (0) | (1) | (0) |
| 4 | (7) | (1,317) | (2) | (0) | (0) | (0) | (0) |
| 5 | (7) | (1,235) | (2) | (0) | (0) | (0) | (0) |
| 6 | (6) | (1,082) | (2) | (0) | (0) | (0) | (0) |
| 7 | (6) | (853) | (2) | (0) | (0) | (0) | (0) |
| 8 | 1 | (431) | 0 | 0 | (0) | 0 | (0) |
| 9 | 1 | (261) | 1 | 0 | (0) | 0 | 0 |
| 10 | 2 | (82) | 1 | 0 | (0) | 0 | 0 |
| 11 | 2 | 225 | 1 | 0 | 0 | 0 | 0 |
| 12 | 3 | 670 | 2 | 0 | 0 | 0 | 0 |
| 13 | 4 | 1,136 | 2 | 0 | 0 | 0 | 0 |
| 14 | 5 | 1,602 | 3 | 0 | 0 | 0 | 0 |
| 15 | 6 | 2,538 | 5 | 0 | 0 | 1 | 0 |
| 16 | 7 | 3,515 | 7 | 0 | 0 | 1 | 0 |
| 17 | 9 | 4,731 | 8 | 0 | 0 | 1 | 0 |
| 18 | 11 | 5,996 | 10 | 0 | 0 | 1 | 0 |
| 19 | 14 | 7,983 | 13 | 0 | 0 | 2 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total** | **33** | **29,334** | **60** | **0** | **0** | **7** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | DOLLARS EMISSIONS SAVED (PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
| 1 | $0 | ($1,423) | ($17,029) | ($8,650) | ($2,051) | ($992) |
| 20 | $0 | $3,739 | $40,425 | $10,779 | $1,305 | $1,251 |
| 2 | $0 | ($1,235) | ($14,072) | ($6,043) | ($1,920) | ($912) |
| 3 | $0 | ($1,094) | ($11,414) | ($4,279) | ($1,793) | ($847) |
| 4 | $0 | ($987) | ($10,751) | ($3,932) | ($1,730) | ($756) |
| 5 | $0 | ($882) | ($10,123) | ($3,027) | ($1,585) | ($670) |
| 6 | $0 | ($737) | ($9,237) | ($3,218) | ($1,518) | ($567) |
| 7 | $0 | ($554) | ($8,136) | ($3,207) | ($1,384) | ($455) |
| 8 | $0 | ($267) | $1,888 | $198 | ($208) | $36 |
| 9 | $0 | ($154) | $2,888 | $843 | ($143) | $91 |
| 10 | $0 | ($46) | $3,803 | $1,383 | ($83) | $141 |
| 11 | $0 | $121 | $5,100 | $1,977 | $44 | $202 |
| 12 | $0 | $342 | $6,712 | $2,519 | $98 | $271 |
| 13 | $0 | $553 | $8,176 | $3,056 | $207 | $334 |
| 14 | $0 | $744 | $10,351 | $3,410 | $273 | $383 |
| 15 | $0 | $1,123 | $14,743 | $4,274 | $402 | $487 |
| 16 | $0 | $1,483 | $18,717 | $5,014 | $573 | $580 |
| 17 | $0 | $1,902 | $21,540 | $6,640 | $702 | $730 |
| 18 | $0 | $2,299 | $24,059 | $7,741 | $818 | $863 |
| 19 | $0 | $2,917 | $30,549 | $9,043 | $1,054 | $1,041 |
| **Total** | **$0** | **$7,846** | **$108,188** | **$24,520** | **($6,938)** | **$1,210** |

A

# NET PRESENT VALUE CALCULATION

| Year | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $748,557 | ($1,222,393) | $816,308 | ($30,147) | | | | |
| 2 | $1,006,143 | ($1,175,508) | $789,263 | ($24,181) | | | | |
| 3 | $1,267,917 | ($1,133,940) | $762,263 | ($19,426) | | | | |
| 4 | $1,534,687 | ($1,084,059) | $735,418 | ($18,156) | | | | |
| 5 | $1,807,534 | ($1,035,269) | $708,823 | ($16,287) | | | | |
| 6 | $2,087,859 | ($977,555) | $682,560 | ($15,277) | | | | |
| 7 | $2,377,440 | ($912,155) | $656,700 | ($13,736) | | | | |
| 8 | $2,678,517 | ($849,328) | $631,302 | $1,648 | | | | |
| 9 | $2,993,900 | ($778,699) | $606,416 | $3,525 | | | | |
| 10 | $3,327,134 | ($714,549) | $582,085 | $5,198 | | | | |
| 11 | $3,682,714 | ($632,135) | $558,342 | $7,444 | | | | |
| 12 | $4,066,399 | ($537,094) | $535,214 | $9,942 | | | | |
| 13 | $4,485,670 | ($451,214) | $512,723 | $12,327 | | | | |
| 14 | $4,950,404 | ($378,466) | $490,884 | $15,160 | | | | |
| 15 | $5,473,908 | ($264,351) | $469,708 | $21,028 | | | | |
| 16 | $6,074,542 | ($159,088) | $449,201 | $26,367 | | | | |
| 17 | $6,778,374 | ($33,651) | $429,368 | $31,515 | | | | |
| 18 | $7,623,706 | $78,856 | $410,207 | $35,780 | | | | |
| 19 | $8,669,240 | $223,982 | $391,715 | $44,604 | | | | |
| 20 | $10,009,787 | $392,735 | $373,888 | $57,499 | | | | |
| **Total** | $81,644,434 | ($11,643,884) | $11,592,390 | $134,827 | $0 | $0 | $0 | $0 |

| | | | |
|---|---|---|---|
| 13,884,608 | Person-Hours of Time Saved | | Person-Hours of Time Saved |

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 33 | $0 | CO Saved | | | CO Saved |
| 29,334 | $7,846 | $CO_2$ Saved | | | $CO_2$ Saved |
| 60 | $108,188 | $NO_X$ Saved | | | $NO_X$ Saved |
| 0 | $24,520 | $PM_{10}$ Saved | | | $PM_{10}$ Saved |
| 0 | | $PM_{2.5}$ Saved | | | $PM_{2.5}$ Saved |
| 0 | ($6,938) | $SO_X$ Saved | | | $SO_X$ Saved |
| 7 | $1,210 | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $11,955,923 | ($1,903,233) | $1,043,315 | $145,283 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | |
| | | | | $0 | $21,461,000 | ($21,461,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $312,326 | ($387,850) | $700,176 |
| | | | | $595,717 | $13,102 | $582,615 |
| | | | | $876,814 | ($30,203) | $907,017 |
| | | | | $1,167,890 | $11,443 | $1,156,446 |
| | | | | $1,464,801 | $10,695 | $1,454,106 |
| | | | | $1,777,587 | ($104,616) | $1,882,203 |
| | | | | $2,108,250 | ($23,042) | $2,131,291 |
| | | | | $2,462,139 | $8,730 | $2,453,409 |
| | | | | $2,825,142 | $8,159 | $2,816,983 |
| | | | | $3,199,869 | $7,625 | $3,192,244 |
| | | | | $3,616,366 | $2,851 | $3,613,515 |
| | | | | $4,074,462 | ($1,978,073) | $6,052,535 |
| | | | | $4,559,506 | $6,224 | $4,553,281 |
| | | | | $5,077,982 | $5,817 | $5,072,164 |
| | | | | $5,700,293 | ($13,411) | $5,713,704 |
| | | | | $6,391,022 | $610,738 | $5,780,284 |
| | | | | $7,205,606 | $4,749 | $7,200,857 |
| | | | | $8,148,549 | $49,409 | $8,099,139 |
| | | | | $9,329,541 | ($10,231) | $9,339,772 |
| | | | | $10,833,908 | $3,876 | $10,830,032 |
| $0 | $0 | $0 | $0 | **$81,727,767** | **$19,656,994** | **$62,070,773** |

| | |
|---|---|
| | Person-Hours of Time Saved |

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| Year | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $800,956 | ($1,307,961) | $873,450 | ($32,257) | | | | |
| 2 | $1,151,934 | ($1,345,840) | $903,628 | ($27,685) | | | | |
| 3 | $1,553,253 | ($1,389,126) | $933,805 | ($23,798) | | | | |
| 4 | $2,011,661 | ($1,420,981) | $963,983 | ($23,798) | | | | |
| 5 | $2,535,160 | ($1,452,019) | $994,161 | ($22,844) | | | | |
| 6 | $3,133,314 | ($1,467,047) | $1,024,339 | ($22,927) | | | | |
| 7 | $3,817,650 | ($1,464,722) | $1,054,516 | ($22,056) | | | | |
| 8 | $4,602,190 | ($1,459,303) | $1,084,694 | $2,832 | | | | |
| 9 | $5,504,163 | ($1,431,607) | $1,114,872 | $6,480 | | | | |
| 10 | $6,544,977 | ($1,405,627) | $1,145,050 | $10,226 | | | | |
| 11 | $7,751,568 | ($1,330,550) | $1,175,228 | $15,669 | | | | |
| 12 | $9,158,310 | ($1,209,638) | $1,205,405 | $22,391 | | | | |
| 13 | $10,809,769 | ($1,087,355) | $1,235,583 | $29,705 | | | | |
| 14 | $12,764,785 | ($975,889) | $1,265,761 | $39,091 | | | | |
| 15 | $15,102,685 | ($729,352) | $1,295,939 | $58,018 | | | | |
| 16 | $17,933,043 | ($469,655) | $1,326,116 | $77,839 | | | | |
| 17 | $21,411,630 | ($106,298) | $1,356,294 | $99,550 | | | | |
| 18 | $25,767,609 | $266,529 | $1,386,472 | $120,932 | | | | |
| 19 | $31,352,546 | $810,037 | $1,416,650 | $161,310 | | | | |
| 20 | $38,734,717 | $1,519,760 | $1,446,827 | $222,502 | | | | |
| **Total** | $222,441,922 | ($17,456,643) | $23,202,773 | $691,181 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | | |
| | | | | $0 | $21,461,000 | ($21,461,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $334,188 | ($415,000) | $749,188 | $749,188 |
| | | | | $682,036 | $15,000 | $667,036 | $1,416,225 |
| | | | | $1,074,135 | ($37,000) | $1,111,135 | $2,527,359 |
| | | | | $1,530,865 | $15,000 | $1,515,865 | $4,043,225 |
| | | | | $2,054,459 | $15,000 | $2,039,459 | $6,082,683 |
| | | | | $2,667,679 | ($157,000) | $2,824,679 | $8,907,362 |
| | | | | $3,385,388 | ($37,000) | $3,422,388 | $12,329,750 |
| | | | | $4,230,413 | $15,000 | $4,215,413 | $16,545,163 |
| | | | | $5,193,908 | $15,000 | $5,178,908 | $21,724,071 |
| | | | | $6,294,626 | $15,000 | $6,279,626 | $28,003,697 |
| | | | | $7,611,914 | $6,000 | $7,605,914 | $35,609,611 |
| | | | | $9,176,469 | ($4,455,000) | $13,631,469 | $49,241,081 |
| | | | | $10,987,702 | $15,000 | $10,972,702 | $60,213,783 |
| | | | | $13,093,749 | $15,000 | $13,078,749 | $73,292,532 |
| | | | | $15,727,289 | ($37,000) | $15,764,289 | $89,056,821 |
| | | | | $18,867,344 | $1,803,000 | $17,064,344 | $106,121,165 |
| | | | | $22,761,176 | $15,000 | $22,746,176 | $128,867,341 |
| | | | | $27,541,542 | $167,000 | $27,374,542 | $156,241,884 |
| | | | | $33,740,542 | ($37,000) | $33,777,542 | $190,019,426 |
| | | | | $41,923,807 | $15,000 | $41,908,807 | $231,928,233 |
| $0 | $0 | $0 | $0 | **$228,879,233** | **$18,412,000** | **$210,467,233** | |

| | |
|---|---|
| **Total Construction Costs** | **$21,461,000** |

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($21,461,000) |
| 2 | $749,188 |
| 3 | $667,036 |
| 4 | $1,111,135 |
| 5 | $1,515,865 |
| 6 | $2,039,459 |
| 7 | $2,824,679 |
| 8 | $3,422,388 |
| 9 | $4,215,413 |
| 10 | $5,178,908 |
| 11 | $6,279,626 |
| 12 | $7,605,914 |
| 13 | $13,631,469 |
| 14 | $10,972,702 |
| 15 | $13,078,749 |
| 16 | $15,764,289 |
| 17 | $17,064,344 |
| 18 | $22,746,176 |
| 19 | $27,374,542 |
| 20 | $33,777,542 |
| 21 | $41,908,807 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

**Internal Rate of Return** **18.70%**

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

**Payback Period** **9 years**

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |
| **OMB GDP Inflator** | **1.01719172** | |

Yellow cells - adjusted

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | 1 |
| Real Discount Rate | 7.0% | 2 |

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | 3 |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | 3 |
| Benefits and Costs | $ 10.69 | $/hr | 4 |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | 5 |
| Truck | $ 31.20 | $/hr/veh | 5 |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | 6 |
| Transit | $ 13.75 | $/hr/per | 5 |
| Out-of-Vehicle Travel | 2 | times | 5 |
| Incident-Related Travel | 3 | times | 7 |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | 8 |
| Truck (diesel) | $ 3.07 | $/gal | 8 |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | 9 |
| State Sales Tax (diesel) | **13.00%** | % | 9 |
| Average Local Sales Tax | 0.50% | % | 9 |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | 9 |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | 9 |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | 9 |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | 9 |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | 10 |
| Truck | $ 0.437 | $/mi | 11 |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | 12 |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | 12 |
| Level B (Moderate) | $ 125,000 | $/event | 12 |
| Level C (Minor) | $ 63,900 | $/event | 12 |
| Cost of Property Damage | $ 4,300 | $/event | 13 |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | 14 |
| Injury Accident | 0.29 | per mil veh-mi | 14 |
| PDO Accident | 0.55 | per mil veh-mi | 14 |
| Non-Freeway | 1.05 | per mil veh-mi | 15 |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | 16 |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | 16, 17 |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | 16, 17 |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | 17 |
| HOV Lanes | 0.55 | 8 | 1,600 | | 18 |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

### *Active Transportation Parameters*

| General Travel Activity Characteristics Parameters | Value | Units | |
|---|---|---|---|
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| **Vehicle Statistics** | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | *19* |
| **Active Transportation User Characteristics** | | | |
| Average Cycling Speed | 11.80 | mph | *20* |
| Average Walking Speed | 3.00 | mph | *21* |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | *19* |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | *19* |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| **Value of Travel Time** | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| **Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class** | | | |
| Class I | 0.57 | - | *20* |
| Class II | 0.49 | - | *20* |
| Class III | 0.92 | - | *20* |
| Class IV | 0.49 | - | *20* |
| *Note: Class IV assumed to be the same as Class II* | | | |
| **Walking Journey Quality Values per Mile by Amentity** | | | |
| Street Lighting | $0.110 | $/mi | *22* |
| Curb Level | $0.078 | $/mi | *22* |
| Crowding | $0.055 | $/mi | *22* |
| Pavement Evenness | $0.026 | $/mi | *22* |
| Information Panels | $0.026 | $/mi | *22* |
| Benches | $0.017 | $/mi | *22* |
| Directional Signage | $0.017 | $/mi | *22* |
| **Health (Absenteeism Reduction)** | | | |
| Average Absence of Employees | 3.60 | days/yr | *23* |
| Percentage Covered by Short-Term Sick Leave | 95% | % | *24* |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | *25* |
| **Health (Mortality Reduction)** | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | *26* |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | *26* |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | *27* |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | *27* |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | *28* |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | *28* |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

## *Travel Demand Tables*

***Project Types***

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| | | | |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| | | | |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| | | | |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| | | | |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

### DEMAND FOR TRAVEL IN PEAK PERIOD
(percent of total daily travel)

| Number of Hours in Peak Period | Urban | | | | | |
|---|---|---|---|---|---|---|
| | So. California | | No. California | | Rural | |
| | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

### AGE COHORTS FOR MORTALITY RISK REDUCTION
(percent of population)

| | | Urban | | |
|---|---|---|---|---|
| **Mode** | **Age Cohort** | **South** | **North** | **Rural** |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

### AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP
(miles/trip)

| | | Urban | | |
|---|---|---|---|---|
| **Mode** | **Age Cohort** | **South** | **North** | **Rural** |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

### TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS
(percent of trips)

| | | Urban | | |
|---|---|---|---|---|
| **Mode** | **Trip Purpose** | **South** | **North** | **Rural** |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## Accident Tables

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident | | 0.1176 | 0.6446 |
| Cost per Event | | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary*
*Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

## HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | $CO_2e$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

| | | |
|---|---|---|
| $CO_2e$ Uprater | 2.0% | increase in value per year |

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

## PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 | | 583.58 | 62.02 | | 19.73 | |
| | 2022 | 45.67 | | 250.11 | 31.01 | | 19.73 | |

## LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 | | 1.13 | 0.17 | | 0.06 | |
| | 2022 | 0.14 | | 1.14 | 0.17 | | 0.06 | |

## FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 | | 10,206 | 28.10 | 0.43 | | | |
| | 2030 | | 10,206 | 28.10 | 0.43 | | | |

| | | |
|---|---|---|
| Freight Rail Fuel Efficiency | 468 | ton-miles/gal |
| Fuel Burned at Idle | 4 | gal/hr |

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## *Pavement Adjustments* (used only for pavement projects)

**PAVEMENT DETERIORATION**

(IRI in inches/mile)

| Year 0 | Year 20, By Loading | | |
|---|---|---|---|
| | **Light** | **Medium** | **Heavy** |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

**VEHICLE OPERATING SPEED**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

**FUEL CONSUMPTION**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

**NON-FUEL COSTS**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## ***Weaving Adjustments*** (used only for freeway connector, HOV connector, and HOV drop ramp projects)

**VEHICLE OPERATING SPEED**

(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## ***TMS Adjustments*** (used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

**PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS**

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| Strategy | Speed | Volume | Speed | Volume | TT | VOC | Em | Benefit |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

**TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS**

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| TMS Strategy | Time | Capital | O&M |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

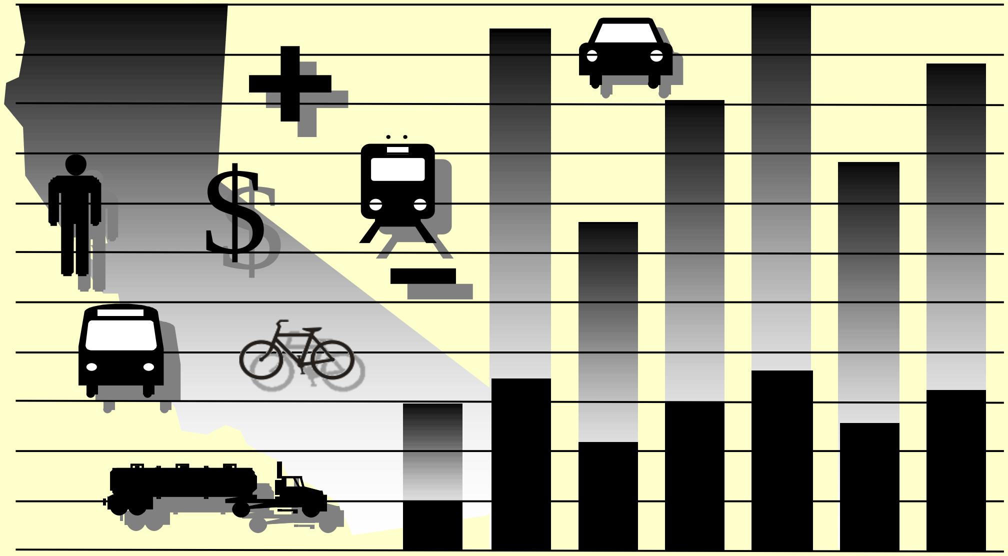
Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Undivided, $25M TPC, 36,056 AADT

WAR-63 Priority Project BCA

California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**
Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

Rose Agacer (916) 651-6014 rose_agacer@dot.ca.gov

# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period. Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual. Other adjustments are made for weaving and pavement conditions. An option is also available to conduct a simple queuing analysis. Accidents are estimated from statewide averages and recent data for the facility. If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically. Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road. The user clicks a button and the model clears the Project Information worksheet to receive information on other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed). The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available. The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed). These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### **PROJECT DATA** (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

***Type of Project***

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

***Project Location***

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

***Length of Construction Period***

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

***One- or Two-Way Data***

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

***Length of Peak Period(s)***

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

***Highway Design***

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

***Average Daily Traffic (ADT)***

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

### *Average Hourly HOV/HOT Lane Traffic*

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

### *Percent Traffic in Weave*

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

### *Percent Trucks*

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

### *Truck Speed*

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

### *On-Ramp Volume*

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

### *Queue Formation*

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

### *Pavement Condition (for Pavement Rehab. Projects)*

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

### *Average Vehicle Occupancy (AVO)*

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## HIGHWAY ACCIDENT DATA (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

### *Actual 3-Year Accident Data (from Table B)*

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

### *Statewide Basic Average Accident Rate*

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## RAIL AND TRANSIT DATA (Box 1D)

*This section is used for rail and transit projects only.*

### *Annual Person-Trips*

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

### *Percent Trips during Peak Period*

32 Insert % annual person-trips that occur during peak period.

### *Percent New Trips from Parallel Highway*

33 Insert % new transit person-trips originating on parallel highway.

### *Annual Vehicle-Miles*

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

### *Average Vehicles per Train*

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

### *Reduction in Transit Accidents*

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

### *Average Transit Travel Time*

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

### *Highway Grade Crossing*

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

### *Transit Agency Costs (for Transit TMS Projects)*

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Undivided

EA:
PPNO:

1A

## PROJECT DATA

| | | |
|---|---|---|
| ***Type of Project*** | | |
| Select project type from list | General Highway | |
| ***Project Location*** (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural) | 3 | |
| Length of Construction Period | 1 | years |
| One- or Two-Way Data | 2 | enter 1 or 2 |
| | Current | |
| ***Length of Peak Period(s)*** (up to 24 hrs) | 13 | hours |

1B

## HIGHWAY DESIGN AND TRAFFIC DATA

| ***Highway Design*** | No Build | Build |
|---|---|---|
| Roadway Type (Fwy, Exp, Conv Hwy) | C | C |
| Number of General Traffic Lanes | 2 | 4 |
| Number of HOV/HOT Lanes | 0 | 0 |
| HOV Restriction (2 or 3) | 0 | |
| Exclusive ROW for Buses (y/n) | N | |
| Highway Free-Flow Speed | 50 | 55 |
| Ramp Design Speed (if aux. lane/off-ramp proj.) | | |
| Length (in miles) Highway Segment | 3.0 | 3.0 |
| Impacted Length | 3.0 | 3.0 |

| ***Average Daily Traffic*** | | |
|---|---|---|
| Current | 20,600 | |
| | No Build | Build |
| Base (Year 1) | 21,337 | 24,184 |
| Forecast (Year 20) | 35,346 | 36,056 |
| ***Average Hourly HOV/HOT Lane Traffic*** | | 0 |
| Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.) | | 100% |
| ***Percent Traffic in Weave*** | | 0.0% |
| ***Percent Trucks*** (include RVs, if applicable) | 9% | 9% |
| ***Truck Speed*** | 50 | |

| ***On-Ramp Volume*** | Peak | Non-Peak |
|---|---|---|
| Hourly Ramp Volume (if aux. lane/on-ramp proj.) | 0 | 0 |
| Metering Strategy (1, 2, 3, or D, if on-ramp proj.) | | |

| ***Queue Formation*** (if queuing or grade crossing project) | Year 1 | Year 20 |
|---|---|---|
| Arrival Rate (in vehicles per hour) | 0 | 0 |
| Departure Rate (in vehicles per hour) | 0 | 0 |

| ***Pavement Condition*** (if pavement project) | No Build | Build |
|---|---|---|
| IRI (inches/mile) Base (Year 1) | | |
| Forecast (Year 20) | | |

| ***Average Vehicle Occupancy (AVO)*** | No Build | Build |
|---|---|---|
| General Traffic Non-Peak | 1.30 | 1.30 |
| Peak | 1.15 | 1.15 |
| High Occupancy Vehicle (if HOV/HOT lanes) | 2.15 | 2.15 |

1C

## HIGHWAY ACCIDENT DATA

| ***Actual 3-Year Accident Data (from Table B)*** | Count (No.) | Rate |
|---|---|---|
| Total Accidents (Tot) | 126 | 1.86 |
| Fatal Accidents (Fat) | 1 | 0.015 |
| Injury Accidents (Inj) | 33 | 0.49 |
| Property Damage Only (PDO) Accidents | 92 | 1.36 |

| ***Statewide Basic Average Accident Rate*** | No Build | Build |
|---|---|---|
| Rate Group | | |
| Accident Rate (per million vehicle-miles) | 1.72 | 1.30 |
| Percent Fatal Accidents (Pct Fat) | 0.3% | 0.3% |
| Percent Injury Accidents (Pct Inj) | 23.5% | 23.5% |

1D

## RAIL AND TRANSIT DATA

| ***Annual Person-Trips*** | No Build | Build |
|---|---|---|
| Base (Year 1) | | |
| Forecast (Year 20) | | |
| ***Percent Trips during Peak Period*** | 89% | |
| ***Percent New Trips from Parallel Highway*** | | 100% |

| ***Annual Vehicle-Miles*** | No Build | Build |
|---|---|---|
| Base (Year 1) | | |
| Forecast (Year 20) | | |
| ***Average Vehicles/Train*** (if rail project) | | |

| ***Reduction in Transit Accidents*** | |
|---|---|
| Percent Reduction (if safety project) | |

| ***Average Transit Travel Time*** | | No Build | Build |
|---|---|---|---|
| In-Vehicle | Non-Peak (in minutes) | | 0.0 |
| | Peak (in minutes) | | 0.0 |
| Out-of-Vehicle | Non-Peak (in minutes) | 0.0 | 0.0 |
| | Peak (in minutes) | 0.0 | 0.0 |

| ***Highway Grade Crossing*** | Current | Year 1 | Year 20 |
|---|---|---|---|
| Annual Number of Trains | | 0 | |
| Avg. Gate Down Time (in min.) | | 0.0 | |

| ***Transit Agency Costs*** (if TMS project) | No Build | Build |
|---|---|---|
| Annual Capital Expenditure | | $0 |
| Annual Ops. and Maintenance Expenditure | | $0 |

*Model should be run for both roads for intersection or bypass highway projects, ar may be run twice for connectors. Press button below to prepare model to enter data for second road. After data are entered, results reflect total project benefits.*

Prepare Model for Second Road

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 29,071 | | 29,071 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,875 | | 2,875 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 54.8 | | 54.8 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,740 | | 3,740 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 370 | | 370 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |

**Hwy Safety or Weaving Improvement** 0% collision reduction factor (per HSIP Guidelines)

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.011 | | 0.011 | |
| Injury Accidents | 0.37 | | 0.37 | |
| PDO Accidents | 1.03 | | 1.03 | |
| Total Accidents | 1.410 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

**Detailed Information Available?** (y/n) N

**Aggregate Segment Length** (estimate as VMT/total volume)

All Ramps miles

Arterials miles

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

## ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 12,202,347 | 240,284 |
| Truck Trips | 1,028,749 | 1,049,413 | 20,665 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 1,774,843 | 34,949 |
| Truck Trips | 132,367 | 135,026 | 2,659 |
| Total Trips | 14,863,073 | 15,161,630 | 298,557 |

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Undivided

EA:

PPNO:

3

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| Life-Cycle Costs (mil. $) | $22.0 |
| Life-Cycle Benefits (mil. $) | $89.5 |
| Net Present Value (mil. $) | $67.5 |
| Benefit / Cost Ratio: | 4.1 |
| Rate of Return on Investment: | 18.9% |
| Payback Period: | 9 years |

| ITEMIZED BENEFITS (mil. $) | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| Travel Time Savings | $67.1 | $11.5 | $78.6 | $3.9 |
| Veh. Op. Cost Savings | -$3.5 | -$0.9 | -$4.4 | -$0.2 |
| Accident Cost Savings | $13.8 | $1.4 | $15.1 | $0.8 |
| Emission Cost Savings | $0.0 | $0.2 | $0.2 | $0.0 |
| **TOTAL BENEFITS** | $77.4 | $12.1 | $89.5 | $4.5 |
| Person-Hours of Time Saved | | | 13,926,555 | 696,328 |

***Should benefit-cost results include:***

| | | |
|---|---|---|
| **1) Induced Travel? (y/n)** | Y | Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y | Default = Y |
| **3) Accident Costs? (y/n)** | Y | Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for $CO_2e$ | Y | Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| EMISSIONS REDUCTION | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| CO Emissions Saved | 76 | 4 | $0.0 | $0.0 |
| $CO_2$ Emissions Saved | 44,325 | 2,216 | $0.0 | $0.0 |
| $NO_X$ Emissions Saved | 72 | 4 | $0.2 | $0.0 |
| $PM_{10}$ Emissions Saved | 0 | 0 | $0.0 | $0.0 |
| $PM_{2.5}$ Emissions Saved | 0 | 0 | | |
| $SO_X$ Emissions Saved | 0 | 0 | -$0.0 | -$0.0 |
| VOC Emissions Saved | 9 | 0 | $0.0 | $0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $648,782 | $0 | $21,244 | $0 | $0 | $78,532 | $0 | $0 |
| 20 | $0 | $7,953,246 | $0 | $1,507,999 | $0 | $0 | $34,060 | $0 | $0 |
| 2 | $0 | $861,202 | $0 | $66,837 | $0 | $0 | $75,590 | $0 | $0 |
| 3 | $0 | $1,075,374 | $0 | $112,692 | $0 | $0 | $72,698 | $0 | $0 |
| 4 | $0 | $1,292,080 | $0 | $158,953 | $0 | $0 | $69,860 | $0 | $0 |
| 5 | $0 | $1,512,307 | $0 | $205,806 | $0 | $0 | $67,082 | $0 | $0 |
| 6 | $0 | $1,737,278 | $0 | $253,486 | $0 | $0 | $64,369 | $0 | $0 |
| 7 | $0 | $1,968,502 | $0 | $302,281 | $0 | $0 | $61,724 | $0 | $0 |
| 8 | $0 | $2,207,840 | $0 | $352,554 | $0 | $0 | $59,149 | $0 | $0 |
| 9 | $0 | $2,457,593 | $0 | $404,749 | $0 | $0 | $56,648 | $0 | $0 |
| 10 | $0 | $2,720,628 | $0 | $459,425 | $0 | $0 | $54,220 | $0 | $0 |
| 11 | $0 | $3,000,548 | $0 | $517,286 | $0 | $0 | $51,867 | $0 | $0 |
| 12 | $0 | $3,301,943 | $0 | $579,225 | $0 | $0 | $49,591 | $0 | $0 |
| 13 | $0 | $3,630,745 | $0 | $646,401 | $0 | $0 | $47,390 | $0 | $0 |
| 14 | $0 | $3,994,760 | $0 | $720,339 | $0 | $0 | $45,265 | $0 | $0 |
| 15 | $0 | $4,404,478 | $0 | $803,086 | $0 | $0 | $43,215 | $0 | $0 |
| 16 | $0 | $4,874,346 | $0 | $897,464 | $0 | $0 | $41,239 | $0 | $0 |
| 17 | $0 | $5,424,851 | $0 | $1,007,471 | $0 | $0 | $39,337 | $0 | $0 |
| 18 | $0 | $6,086,070 | $0 | $1,138,980 | $0 | $0 | $37,508 | $0 | $0 |
| 19 | $0 | $6,904,074 | $0 | $1,300,984 | $0 | $0 | $35,749 | $0 | $0 |
| **Total** | **$0** | **$66,056,648** | **$0** | **$11,457,262** | **$0** | **$0** | **$1,085,092** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| | TRANSIT | | | | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| Year | Peak In-Vehicle | Peak Out-of-Veh | Non-Peak In-Vehicle | Non-Peak Out-of-Veh | | | |
| 1 | $0 | $0 | $0 | $0 | $748,557 | $800,956 | 53,742 |
| 20 | $0 | $0 | $0 | $0 | $9,495,305 | $36,743,834 | 2,410,703 |
| | | | | | | | |
| 2 | $0 | $0 | $0 | $0 | $1,003,630 | $1,149,056 | 75,763 |
| 3 | $0 | $0 | $0 | $0 | $1,260,763 | $1,544,489 | 100,912 |
| 4 | $0 | $0 | $0 | $0 | $1,520,893 | $1,993,581 | 129,607 |
| 5 | $0 | $0 | $0 | $0 | $1,785,196 | $2,503,829 | 162,344 |
| 6 | $0 | $0 | $0 | $0 | $2,055,133 | $3,084,200 | 199,716 |
| 7 | $0 | $0 | $0 | $0 | $2,332,508 | $3,745,497 | 242,436 |
| 8 | $0 | $0 | $0 | $0 | $2,619,543 | $4,500,863 | 291,373 |
| 9 | $0 | $0 | $0 | $0 | $2,918,990 | $5,366,443 | 347,595 |
| 10 | $0 | $0 | $0 | $0 | $3,234,273 | $6,362,304 | 412,427 |
| 11 | $0 | $0 | $0 | $0 | $3,569,701 | $7,513,691 | 487,540 |
| 12 | $0 | $0 | $0 | $0 | $3,930,758 | $8,852,821 | 575,062 |
| 13 | $0 | $0 | $0 | $0 | $4,324,536 | $10,421,461 | 677,754 |
| 14 | $0 | $0 | $0 | $0 | $4,760,364 | $12,274,761 | 799,261 |
| 15 | $0 | $0 | $0 | $0 | $5,250,779 | $14,487,065 | 944,499 |
| 16 | $0 | $0 | $0 | $0 | $5,813,049 | $17,161,074 | 1,120,256 |
| 17 | $0 | $0 | $0 | $0 | $6,471,660 | $20,442,777 | 1,336,181 |
| 18 | $0 | $0 | $0 | $0 | $7,262,558 | $24,546,955 | 1,606,473 |
| 19 | $0 | $0 | $0 | $0 | $8,240,807 | $29,803,106 | 1,952,911 |
| | | | | | | | |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$78,599,002** | **$213,298,764** | **13,926,555** |

C

# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | | Present Value of Veh Op Cost Benefits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | |
| 1 | $0 | ($942,318) | $0 | ($140,639) | $0 | ($121,246) | $0 | ($18,190) | - | - | ($1,222,393) |
| 20 | $0 | $744,727 | $0 | $118,544 | $0 | ($10,265) | $0 | ($1,254) | - | - | $851,750 |
| 2 | $0 | ($843,921) | $0 | ($124,428) | $0 | ($109,177) | $0 | ($16,328) | - | - | ($1,093,854) |
| 3 | $0 | ($758,548) | $0 | ($109,967) | $0 | ($98,167) | $0 | ($14,632) | - | - | ($981,315) |
| 4 | $0 | ($665,508) | $0 | ($103,371) | $0 | ($88,131) | $0 | ($13,089) | - | - | ($870,098) |
| 5 | $0 | ($580,503) | $0 | ($97,476) | $0 | ($78,988) | $0 | ($11,684) | - | - | ($768,651) |
| 6 | $0 | ($495,873) | $0 | ($89,141) | $0 | ($70,663) | $0 | ($10,407) | - | - | ($666,085) |
| 7 | $0 | ($411,866) | $0 | ($78,639) | $0 | ($63,090) | $0 | ($9,248) | - | - | ($562,843) |
| 8 | $0 | ($335,274) | $0 | ($68,783) | $0 | ($56,206) | $0 | ($8,195) | - | - | ($468,458) |
| 9 | $0 | ($246,746) | $0 | ($67,956) | $0 | ($49,952) | $0 | ($7,241) | - | - | ($371,896) |
| 10 | $0 | ($169,157) | $0 | ($67,026) | $0 | ($44,276) | $0 | ($6,376) | - | - | ($286,835) |
| 11 | $0 | ($84,283) | $0 | ($58,982) | $0 | ($39,129) | $0 | ($5,594) | - | - | ($187,987) |
| 12 | $0 | $3,789 | $0 | ($44,931) | $0 | ($34,465) | $0 | ($4,887) | - | - | ($80,493) |
| 13 | $0 | $80,897 | $0 | ($32,095) | $0 | ($30,245) | $0 | ($4,248) | - | - | $14,309 |
| 14 | $0 | $140,280 | $0 | ($17,322) | $0 | ($26,429) | $0 | ($3,672) | - | - | $92,858 |
| 15 | $0 | $229,943 | $0 | $6,216 | $0 | ($22,983) | $0 | ($3,153) | - | - | $210,023 |
| 16 | $0 | $310,660 | $0 | $27,819 | $0 | ($19,875) | $0 | ($2,686) | - | - | $315,918 |
| 17 | $0 | $418,559 | $0 | $40,659 | $0 | ($17,075) | $0 | ($2,267) | - | - | $439,876 |
| 18 | $0 | $513,324 | $0 | $52,188 | $0 | ($14,556) | $0 | ($1,891) | - | - | $549,064 |
| 19 | $0 | $624,318 | $0 | $78,809 | $0 | ($12,294) | $0 | ($1,555) | - | - | $689,278 |
| **Total** | **$0** | **($2,467,500)** | **$0** | **($776,521)** | **$0** | **($1,007,212)** | **$0** | **($146,598)** | **-** | **-** | **($4,397,830)** |

| Constant Dollars |
|---|
| ($1,307,961) |
| $3,296,004 |
| |
| ($1,252,353) |
| ($1,202,153) |
| ($1,140,521) |
| ($1,078,073) |
| ($999,614) |
| ($903,803) |
| ($804,898) |
| ($683,715) |
| ($564,248) |
| ($395,685) |
| ($181,286) |
| $34,483 |
| $239,436 |
| $579,459 |
| $932,643 |
| $1,389,487 |
| $1,855,800 |
| $2,492,794 |
| |
| **$305,799** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | All Periods | |
| 1 | $0 | $658,157 | $0 | $65,092 | $0 | $84,684 | $0 | $8,375 | $0 | $816,308 |
| 20 | $0 | $481,598 | $0 | $47,631 | $0 | $61,966 | $0 | $6,129 | $0 | $597,323 |
| 2 | $0 | $668,398 | $0 | $66,105 | $0 | $86,002 | $0 | $8,506 | $0 | $829,010 |
| 3 | $0 | $674,483 | $0 | $66,707 | $0 | $86,784 | $0 | $8,583 | $0 | $836,557 |
| 4 | $0 | $676,910 | $0 | $66,947 | $0 | $87,097 | $0 | $8,614 | $0 | $839,568 |
| 5 | $0 | $676,134 | $0 | $66,870 | $0 | $86,997 | $0 | $8,604 | $0 | $838,605 |
| 6 | $0 | $672,562 | $0 | $66,517 | $0 | $86,537 | $0 | $8,559 | $0 | $834,175 |
| 7 | $0 | $666,563 | $0 | $65,924 | $0 | $85,765 | $0 | $8,482 | $0 | $826,735 |
| 8 | $0 | $658,471 | $0 | $65,124 | $0 | $84,724 | $0 | $8,379 | $0 | $816,699 |
| 9 | $0 | $648,585 | $0 | $64,146 | $0 | $83,452 | $0 | $8,254 | $0 | $804,437 |
| 10 | $0 | $637,175 | $0 | $63,017 | $0 | $81,984 | $0 | $8,108 | $0 | $790,284 |
| 11 | $0 | $624,481 | $0 | $61,762 | $0 | $80,351 | $0 | $7,947 | $0 | $774,540 |
| 12 | $0 | $610,721 | $0 | $60,401 | $0 | $78,580 | $0 | $7,772 | $0 | $757,474 |
| 13 | $0 | $596,089 | $0 | $58,954 | $0 | $76,698 | $0 | $7,585 | $0 | $739,326 |
| 14 | $0 | $580,758 | $0 | $57,438 | $0 | $74,725 | $0 | $7,390 | $0 | $720,311 |
| 15 | $0 | $564,881 | $0 | $55,867 | $0 | $72,682 | $0 | $7,188 | $0 | $700,619 |
| 16 | $0 | $548,596 | $0 | $54,257 | $0 | $70,587 | $0 | $6,981 | $0 | $680,421 |
| 17 | $0 | $532,025 | $0 | $52,618 | $0 | $68,455 | $0 | $6,770 | $0 | $659,867 |
| 18 | $0 | $515,273 | $0 | $50,961 | $0 | $66,299 | $0 | $6,557 | $0 | $639,091 |
| 19 | $0 | $498,437 | $0 | $49,296 | $0 | $64,133 | $0 | $6,343 | $0 | $618,208 |
| **Total** | **$0** | **$12,190,297** | **$0** | **$1,205,634** | **$0** | **$1,568,503** | **$0** | **$155,127** | **$0** | **$15,119,561** |

| Constant Dollars |
|---|
| $873,450 |
| $2,311,452 |
| |
| $949,134 |
| $1,024,818 |
| $1,100,503 |
| $1,176,187 |
| $1,251,871 |
| $1,327,556 |
| $1,403,240 |
| $1,478,924 |
| $1,554,609 |
| $1,630,293 |
| $1,705,977 |
| $1,781,662 |
| $1,857,346 |
| $1,933,030 |
| $2,008,715 |
| $2,084,399 |
| $2,160,083 |
| $2,235,768 |
| |
| **$31,849,018** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,936) | $0 | ($14,529) | $0 | $0 | ($1,519) | $0 | ($2,162) |
| 20 | $0 | $16,655 | $0 | $44,350 | $0 | $0 | ($46) | $0 | ($40) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | $0 | ($10,209) | $0 | ($8,547) | $0 | $0 | ($1,381) | $0 | ($1,942) |
| 3 | $0 | ($9,491) | $0 | ($3,007) | $0 | $0 | ($1,255) | $0 | ($1,740) |
| 4 | $0 | ($8,611) | $0 | ($1,329) | $0 | $0 | ($1,139) | $0 | ($1,557) |
| 5 | $0 | ($7,098) | $0 | $118 | $0 | $0 | ($1,033) | $0 | ($1,391) |
| 6 | $0 | ($6,268) | $0 | $1,214 | $0 | $0 | ($935) | $0 | ($1,239) |
| 7 | $0 | ($4,734) | $0 | $1,982 | $0 | $0 | ($846) | $0 | ($1,101) |
| 8 | $0 | $221 | $0 | $4,641 | $0 | $0 | ($209) | $0 | ($253) |
| 9 | $0 | $1,183 | $0 | $5,698 | $0 | $0 | ($187) | $0 | ($224) |
| 10 | $0 | $2,069 | $0 | $6,599 | $0 | $0 | ($168) | $0 | ($198) |
| 11 | $0 | $3,058 | $0 | $7,941 | $0 | $0 | ($150) | $0 | ($174) |
| 12 | $0 | $3,997 | $0 | $9,561 | $0 | $0 | ($133) | $0 | ($152) |
| 13 | $0 | $4,914 | $0 | $11,067 | $0 | $0 | ($119) | $0 | ($132) |
| 14 | $0 | $5,574 | $0 | $13,261 | $0 | $0 | ($105) | $0 | ($115) |
| 15 | $0 | $6,927 | $0 | $17,779 | $0 | $0 | ($93) | $0 | ($99) |
| 16 | $0 | $8,202 | $0 | $21,831 | $0 | $0 | ($82) | $0 | ($84) |
| 17 | $0 | $10,371 | $0 | $24,786 | $0 | $0 | ($71) | $0 | ($71) |
| 18 | $0 | $11,963 | $0 | $27,422 | $0 | $0 | ($62) | $0 | ($59) |
| 19 | $0 | $14,007 | $0 | $34,157 | $0 | $0 | ($54) | $0 | ($49) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Total** | **$0** | **$30,793** | **$0** | **$204,995** | **$0** | **$0** | **($9,587)** | **$0** | **($12,782)** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($30,147) | ($32,257) |
| 20 | $0 | $0 | $0 | $0 | $60,920 | $235,739 |
| 2 | $0 | $0 | $0 | $0 | ($22,079) | ($25,278) |
| 3 | $0 | $0 | $0 | $0 | ($15,493) | ($18,979) |
| 4 | $0 | $0 | $0 | $0 | ($12,636) | ($16,564) |
| 5 | $0 | $0 | $0 | $0 | ($9,404) | ($13,189) |
| 6 | $0 | $0 | $0 | $0 | ($7,228) | ($10,848) |
| 7 | $0 | $0 | $0 | $0 | ($4,701) | ($7,548) |
| 8 | $0 | $0 | $0 | $0 | $4,399 | $7,558 |
| 9 | $0 | $0 | $0 | $0 | $6,470 | $11,895 |
| 10 | $0 | $0 | $0 | $0 | $8,302 | $16,332 |
| 11 | $0 | $0 | $0 | $0 | $10,675 | $22,470 |
| 12 | $0 | $0 | $0 | $0 | $13,272 | $29,891 |
| 13 | $0 | $0 | $0 | $0 | $15,730 | $37,908 |
| 14 | $0 | $0 | $0 | $0 | $18,615 | $48,000 |
| 15 | $0 | $0 | $0 | $0 | $24,515 | $67,638 |
| 16 | $0 | $0 | $0 | $0 | $29,867 | $88,174 |
| 17 | $0 | $0 | $0 | $0 | $35,014 | $110,603 |
| 18 | $0 | $0 | $0 | $0 | $39,264 | $132,709 |
| 19 | $0 | $0 | $0 | $0 | $48,061 | $173,815 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$213,419** | **$858,069** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
| 1 | (8) | (1,646) | (2) | (0) | (0) | (1) | (0) |
| 20 | 21 | 12,165 | 20 | 0 | 0 | 3 | 0 |
| 2 | (7) | (1,390) | (2) | (0) | (0) | (0) | (0) |
| 3 | (6) | (1,177) | (1) | (0) | (0) | (0) | (0) |
| 4 | (5) | (994) | (1) | (0) | (0) | (0) | (0) |
| 5 | (4) | (804) | (1) | (0) | (0) | (0) | (0) |
| 6 | (3) | (543) | (1) | (0) | (0) | (0) | (0) |
| 7 | (2) | (207) | (1) | (0) | (0) | (0) | 0 |
| 8 | 2 | 96 | 1 | 0 | (0) | 0 | 0 |
| 9 | 2 | 341 | 1 | 0 | 0 | 0 | 0 |
| 10 | 3 | 596 | 1 | 0 | 0 | 0 | 0 |
| 11 | 4 | 978 | 2 | 0 | 0 | 0 | 0 |
| 12 | 5 | 1,498 | 2 | 0 | 0 | 0 | 0 |
| 13 | 6 | 2,040 | 3 | 0 | 0 | 1 | 0 |
| 14 | 7 | 2,581 | 4 | 0 | 0 | 1 | 0 |
| 15 | 8 | 3,592 | 6 | 0 | 0 | 1 | 0 |
| 16 | 10 | 4,645 | 7 | 0 | 0 | 1 | 0 |
| 17 | 12 | 5,936 | 9 | 0 | 0 | 1 | 0 |
| 18 | 14 | 7,277 | 11 | 0 | 0 | 2 | 0 |
| 19 | 17 | 9,339 | 14 | 0 | 0 | 2 | 0 |
| **Total** | **76** | **44,325** | **72** | **0** | **0** | **9** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | DOLLARS EMISSIONS SAVED (PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
| 1 | $0 | ($1,423) | ($17,029) | ($8,650) | ($2,051) | ($992) |
| 20 | $0 | $4,238 | $42,386 | $11,476 | $1,486 | $1,335 |
| 2 | $0 | ($1,146) | ($12,863) | ($5,441) | ($1,783) | ($845) |
| 3 | $0 | ($925) | ($9,154) | ($3,154) | ($1,538) | ($723) |
| 4 | $0 | ($745) | ($7,582) | ($2,355) | ($1,372) | ($582) |
| 5 | $0 | ($574) | ($6,175) | ($1,062) | ($1,139) | ($453) |
| 6 | $0 | ($370) | ($4,625) | ($923) | ($998) | ($314) |
| 7 | $0 | ($134) | ($2,963) | ($632) | ($800) | ($170) |
| 8 | $0 | $60 | $3,515 | $776 | ($58) | $106 |
| 9 | $0 | $201 | $4,626 | $1,460 | $17 | $165 |
| 10 | $0 | $335 | $5,631 | $2,033 | $85 | $219 |
| 11 | $0 | $524 | $6,997 | $2,651 | $219 | $284 |
| 12 | $0 | $765 | $8,662 | $3,212 | $278 | $355 |
| 13 | $0 | $993 | $10,165 | $3,762 | $390 | $420 |
| 14 | $0 | $1,198 | $12,365 | $4,125 | $458 | $469 |
| 15 | $0 | $1,590 | $16,769 | $4,993 | $589 | $574 |
| 16 | $0 | $1,960 | $20,746 | $5,735 | $759 | $668 |
| 17 | $0 | $2,387 | $23,563 | $7,359 | $888 | $817 |
| 18 | $0 | $2,790 | $26,068 | $8,454 | $1,003 | $949 |
| 19 | $0 | $3,413 | $32,536 | $9,749 | $1,237 | $1,126 |
| **Total** | **$0** | **$15,137** | **$153,638** | **$43,567** | **($2,330)** | **$3,407** |

A

# NET PRESENT VALUE CALCULATION

| Year | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $748,557 | ($1,222,393) | $816,308 | ($30,147) | | | | |
| 2 | $1,003,630 | ($1,093,854) | $829,010 | ($22,079) | | | | |
| 3 | $1,260,763 | ($981,315) | $836,557 | ($15,493) | | | | |
| 4 | $1,520,893 | ($870,098) | $839,568 | ($12,636) | | | | |
| 5 | $1,785,196 | ($768,651) | $838,605 | ($9,404) | | | | |
| 6 | $2,055,133 | ($666,085) | $834,175 | ($7,228) | | | | |
| 7 | $2,332,508 | ($562,843) | $826,735 | ($4,701) | | | | |
| 8 | $2,619,543 | ($468,458) | $816,699 | $4,399 | | | | |
| 9 | $2,918,990 | ($371,896) | $804,437 | $6,470 | | | | |
| 10 | $3,234,273 | ($286,835) | $790,284 | $8,302 | | | | |
| 11 | $3,569,701 | ($187,987) | $774,540 | $10,675 | | | | |
| 12 | $3,930,758 | ($80,493) | $757,474 | $13,272 | | | | |
| 13 | $4,324,536 | $14,309 | $739,326 | $15,730 | | | | |
| 14 | $4,760,364 | $92,858 | $720,311 | $18,615 | | | | |
| 15 | $5,250,779 | $210,023 | $700,619 | $24,515 | | | | |
| 16 | $5,813,049 | $315,918 | $680,421 | $29,867 | | | | |
| 17 | $6,471,660 | $439,876 | $659,867 | $35,014 | | | | |
| 18 | $7,262,558 | $549,064 | $639,091 | $39,264 | | | | |
| 19 | $8,240,807 | $689,278 | $618,208 | $48,061 | | | | |
| 20 | $9,495,305 | $851,750 | $597,323 | $60,920 | | | | |
| **Total** | $78,599,002 | ($4,397,830) | $15,119,561 | $213,419 | $0 | $0 | $0 | $0 |

| | | | |
|---|---|---|---|
| 13,926,555 | Person-Hours of Time Saved | | Person-Hours of Time Saved |

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 76 | $0 | CO Saved | | | CO Saved |
| 44,325 | $15,137 | CO$_2$ Saved | | | CO$_2$ Saved |
| 72 | $153,638 | NO$_X$ Saved | | | NO$_X$ Saved |
| 0 | $43,567 | PM$_{10}$ Saved | | | PM$_{10}$ Saved |
| 0 | | PM$_{2.5}$ Saved | | | PM$_{2.5}$ Saved |
| 0 | ($2,330) | SO$_X$ Saved | | | SO$_X$ Saved |
| 9 | $3,407 | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $11,457,262 | ($923,119) | $1,360,760 | $192,213 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | |
| | | | | $0 | $23,844,000 | ($23,844,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $312,326 | ($387,850) | $700,176 |
| | | | | $716,708 | $13,102 | $703,606 |
| | | | | $1,100,513 | ($30,203) | $1,130,716 |
| | | | | $1,477,727 | $11,443 | $1,466,283 |
| | | | | $1,845,747 | $10,695 | $1,835,052 |
| | | | | $2,215,994 | ($104,616) | $2,320,610 |
| | | | | $2,591,699 | ($23,042) | $2,614,741 |
| | | | | $2,972,183 | $8,730 | $2,963,453 |
| | | | | $3,358,001 | $8,159 | $3,349,842 |
| | | | | $3,746,024 | $7,625 | $3,738,399 |
| | | | | $4,166,929 | $2,851 | $4,164,079 |
| | | | | $4,621,012 | ($1,978,073) | $6,599,085 |
| | | | | $5,093,902 | $6,224 | $5,087,678 |
| | | | | $5,592,148 | $5,817 | $5,586,330 |
| | | | | $6,185,936 | ($13,411) | $6,199,347 |
| | | | | $6,839,257 | $610,738 | $6,228,518 |
| | | | | $7,606,417 | $4,749 | $7,601,669 |
| | | | | $8,489,977 | $49,409 | $8,440,568 |
| | | | | $9,596,355 | ($10,231) | $9,606,586 |
| | | | | $11,005,298 | $3,876 | $11,001,421 |
| $0 | $0 | $0 | $0 | **$89,534,151** | **$22,039,994** | **$67,494,158** |

Person-Hours of Time Saved

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | CO$_2$ Saved |
| | | NO$_X$ Saved |
| | | PM$_{10}$ Saved |
| | | PM$_{2.5}$ Saved |
| | | SO$_X$ Saved |
| | | VOC Saved |

Freight Benefits Only

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $800,956 | ($1,307,961) | $873,450 | ($32,257) | | | | |
| 2 | $1,149,056 | ($1,252,353) | $949,134 | ($25,278) | | | | |
| 3 | $1,544,489 | ($1,202,153) | $1,024,818 | ($18,979) | | | | |
| 4 | $1,993,581 | ($1,140,521) | $1,100,503 | ($16,564) | | | | |
| 5 | $2,503,829 | ($1,078,073) | $1,176,187 | ($13,189) | | | | |
| 6 | $3,084,200 | ($999,614) | $1,251,871 | ($10,848) | | | | |
| 7 | $3,745,497 | ($903,803) | $1,327,556 | ($7,548) | | | | |
| 8 | $4,500,863 | ($804,898) | $1,403,240 | $7,558 | | | | |
| 9 | $5,366,443 | ($683,715) | $1,478,924 | $11,895 | | | | |
| 10 | $6,362,304 | ($564,248) | $1,554,609 | $16,332 | | | | |
| 11 | $7,513,691 | ($395,685) | $1,630,293 | $22,470 | | | | |
| 12 | $8,852,821 | ($181,286) | $1,705,977 | $29,891 | | | | |
| 13 | $10,421,461 | $34,483 | $1,781,662 | $37,908 | | | | |
| 14 | $12,274,761 | $239,436 | $1,857,346 | $48,000 | | | | |
| 15 | $14,487,065 | $579,459 | $1,933,030 | $67,638 | | | | |
| 16 | $17,161,074 | $932,643 | $2,008,715 | $88,174 | | | | |
| 17 | $20,442,777 | $1,389,487 | $2,084,399 | $110,603 | | | | |
| 18 | $24,546,955 | $1,855,800 | $2,160,083 | $132,709 | | | | |
| 19 | $29,803,106 | $2,492,794 | $2,235,768 | $173,815 | | | | |
| 20 | $36,743,834 | $3,296,004 | $2,311,452 | $235,739 | | | | |
| **Total** | $213,298,764 | $305,799 | $31,849,018 | $858,069 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
| | | | | $0 | $23,844,000 | ($23,844,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $334,188 | ($415,000) | $749,188 | $749,188 |
| | | | | $820,559 | $15,000 | $805,559 | $1,554,747 |
| | | | | $1,348,176 | ($37,000) | $1,385,176 | $2,939,923 |
| | | | | $1,936,998 | $15,000 | $1,921,998 | $4,861,922 |
| | | | | $2,588,755 | $15,000 | $2,573,755 | $7,435,677 |
| | | | | $3,325,610 | ($157,000) | $3,482,610 | $10,918,286 |
| | | | | $4,161,702 | ($37,000) | $4,198,702 | $15,116,989 |
| | | | | $5,106,763 | $15,000 | $5,091,763 | $20,208,752 |
| | | | | $6,173,548 | $15,000 | $6,158,548 | $26,367,299 |
| | | | | $7,368,997 | $15,000 | $7,353,997 | $33,721,297 |
| | | | | $8,770,769 | $6,000 | $8,764,769 | $42,486,066 |
| | | | | $10,407,403 | ($4,455,000) | $14,862,403 | $57,348,469 |
| | | | | $12,275,514 | $15,000 | $12,260,514 | $69,608,983 |
| | | | | $14,419,543 | $15,000 | $14,404,543 | $84,013,527 |
| | | | | $17,067,193 | ($37,000) | $17,104,193 | $101,117,719 |
| | | | | $20,190,605 | $1,803,000 | $18,387,605 | $119,505,325 |
| | | | | $24,027,266 | $15,000 | $24,012,266 | $143,517,591 |
| | | | | $28,695,548 | $167,000 | $28,528,548 | $172,046,139 |
| | | | | $34,705,482 | ($37,000) | $34,742,482 | $206,788,621 |
| | | | | $42,587,029 | $15,000 | $42,572,029 | $249,360,650 |
| $0 | $0 | $0 | $0 | **$246,311,650** | **$20,795,000** | **$225,516,650** | |

**Total Construction Costs** **$23,844,000**

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($23,844,000) |
| 2 | $749,188 |
| 3 | $805,559 |
| 4 | $1,385,176 |
| 5 | $1,921,998 |
| 6 | $2,573,755 |
| 7 | $3,482,610 |
| 8 | $4,198,702 |
| 9 | $5,091,763 |
| 10 | $6,158,548 |
| 11 | $7,353,997 |
| 12 | $8,764,769 |
| 13 | $14,862,403 |
| 14 | $12,260,514 |
| 15 | $14,404,543 |
| 16 | $17,104,193 |
| 17 | $18,387,605 |
| 18 | $24,012,266 |
| 19 | $28,528,548 |
| 20 | $34,742,482 |
| 21 | $42,572,029 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **18.86%** |
| **Payback Period** | **9 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | *1* |
| Real Discount Rate | 7.0% | *2* |

Yellow cells - adjusted

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |

**OMB GDP Inflator** **1.01719172**

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | *3* |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | *3* |
| Benefits and Costs | $ 10.69 | $/hr | *4* |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | *5* |
| Truck | $ 31.20 | $/hr/veh | *5* |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | *6* |
| Transit | $ 13.75 | $/hr/per | *5* |
| Out-of-Vehicle Travel | 2 | times | *5* |
| Incident-Related Travel | 3 | times | *7* |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | *8* |
| Truck (diesel) | $ 3.07 | $/gal | *8* |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | *9* |
| State Sales Tax (diesel) | **13.00%** | % | *9* |
| Average Local Sales Tax | 0.50% | % | *9* |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | *9* |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | *9* |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | *9* |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | *9* |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | *10* |
| Truck | $ 0.437 | $/mi | *11* |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | *12* |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | *12* |
| Level B (Moderate) | $ 125,000 | $/event | *12* |
| Level C (Minor) | $ 63,900 | $/event | *12* |
| Cost of Property Damage | $ 4,300 | $/event | *13* |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | *14* |
| Injury Accident | 0.29 | per mil veh-mi | *14* |
| PDO Accident | 0.55 | per mil veh-mi | *14* |
| Non-Freeway | 1.05 | per mil veh-mi | *15* |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | *16* |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | *17* |
| HOV Lanes | 0.55 | 8 | 1,600 | | *18* |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

### Active Transportation Parameters

| General Travel Activity Characteristics Parameters | Value | Units | |
|---|---|---|---|
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| Vehicle Statistics | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | 19 |
| Active Transportation User Characteristics | | | |
| Average Cycling Speed | 11.80 | mph | 20 |
| Average Walking Speed | 3.00 | mph | 21 |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | 19 |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | 19 |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| Value of Travel Time | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class | | | |
| Class I | 0.57 | - | 20 |
| Class II | 0.49 | - | 20 |
| Class III | 0.92 | - | 20 |
| Class IV | 0.49 | - | 20 |
| *Note: Class IV assumed to be the same as Class II* | | | |
| Walking Journey Quality Values per Mile by Amentity | | | |
| Street Lighting | $0.110 | $/mi | 22 |
| Curb Level | $0.078 | $/mi | 22 |
| Crowding | $0.055 | $/mi | 22 |
| Pavement Evenness | $0.026 | $/mi | 22 |
| Information Panels | $0.026 | $/mi | 22 |
| Benches | $0.017 | $/mi | 22 |
| Directional Signage | $0.017 | $/mi | 22 |
| Health (Absenteeism Reduction) | | | |
| Average Absence of Employees | 3.60 | days/yr | 23 |
| Percentage Covered by Short-Term Sick Leave | 95% | % | 24 |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | 25 |
| Health (Mortality Reduction) | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | 26 |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | 26 |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | 27 |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | 27 |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | 28 |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | 28 |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

## Travel Demand Tables

### Project Types

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| | | | |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| | | | |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| | | | |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| | | | |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

**DEMAND FOR TRAVEL IN PEAK PERIOD**
(percent of total daily travel)

| Number of Hours in Peak Period | Urban | | | | Rural | |
|---|---|---|---|---|---|---|
| | So. California | | No. California | | | |
| | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

**AGE COHORTS FOR MORTALITY RISK REDUCTION**
(percent of population)

| | | Urban | | |
|---|---|---|---|---|
| Mode | Age Cohort | South | North | Rural |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

**AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP**
(miles/trip)

| | | Urban | | |
|---|---|---|---|---|
| Mode | Age Cohort | South | North | Rural |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

**TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS**
(percent of trips)

| | | Urban | | |
|---|---|---|---|---|
| Mode | Trip Purpose | South | North | Rural |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

**FUEL CONSUMPTION RATES**

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*

*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY
(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### NUMBER OF FATALITIES
(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES
(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED
(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES
(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF HIGHWAY ACCIDENTS
($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS
(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### COST OF NON-HIGHWAY ACCIDENT EVENTS
($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS
($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS
(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident |  | 0.1176 | 0.6446 |
| Cost per Event |  | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary*
*Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### PASSING LANE ACCIDENT REDUCTION FACTORS
(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

**HIGHWAY EMISSIONS FACTORS (g/mi)**

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

**HIGHWAY EMISSIONS FACTORS (g/mi)**

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

**HIGHWAY EMISSIONS FACTORS (g/mi)**

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

**HIGHWAY EMISSIONS FACTORS (g/mi)**

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

## HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | $CO_2$e | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

$CO_2$e Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

## PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 | | 583.58 | 62.02 | | 19.73 | |
| | 2022 | 45.67 | | 250.11 | 31.01 | | 19.73 | |

## LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 | | 1.13 | 0.17 | | 0.06 | |
| | 2022 | 0.14 | | 1.14 | 0.17 | | 0.06 | |

## FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 | | 10,206 | 28.10 | 0.43 | | | |
| | 2030 | | 10,206 | 28.10 | 0.43 | | | |

Freight Rail Fuel Efficiency 468 ton-miles/gal
Fuel Burned at Idle 4 gal/hr

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## *Pavement Adjustments* (used only for pavement projects)

### PAVEMENT DETERIORATION

(IRI in inches/mile)

|  | Year 20, By Loading |  |  |
|---|---|---|---|
| Year 0 | Light | Medium | Heavy |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

### VEHICLE OPERATING SPEED

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

### FUEL CONSUMPTION

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

### NON-FUEL COSTS

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## Weaving Adjustments (used only for freeway connector, HOV connector, and HOV drop ramp projects)

**VEHICLE OPERATING SPEED**

(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## TMS Adjustments (used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

**PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS**

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| Strategy | Speed | Volume | Speed | Volume | TT | VOC | Em | Benefit |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

**TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS**

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| TMS Strategy | Time | Capital | O&M |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

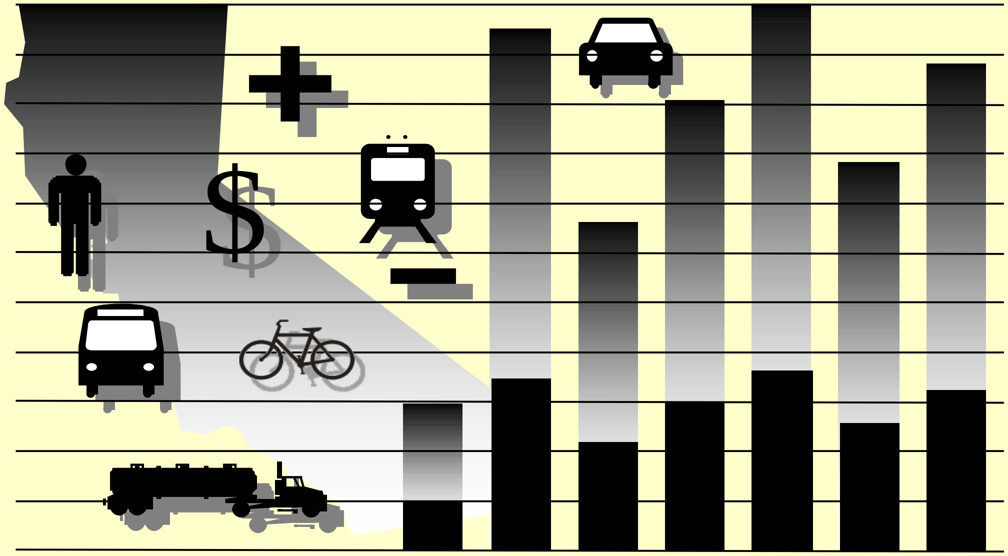
*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Undivided, $25M TPC, 44068 AADT

WAR-63 Priority Project BCA

California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications
## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**
Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

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## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period.  Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual.  Other adjustments are made for weaving and pavement conditions.  An option is also available to conduct a simple queuing analysis.  Accidents are estimated from statewide averages and recent data for the facility.  If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically.  Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road.  The user clicks a button and the model clears the Project Information worksheet to receive information on  other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed).  The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available.  The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed).  These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### **PROJECT DATA** (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

### *Type of Project*

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

### *Project Location*

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

### *Length of Construction Period*

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

### *One- or Two-Way Data*

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

### *Length of Peak Period(s)*

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

### *Highway Design*

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

### *Average Daily Traffic (ADT)*

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

### *Average Hourly HOV/HOT Lane Traffic*

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

### *Percent Traffic in Weave*

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

### *Percent Trucks*

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

### *Truck Speed*

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

### *On-Ramp Volume*

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

### *Queue Formation*

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

### *Pavement Condition (for Pavement Rehab. Projects)*

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

### *Average Vehicle Occupancy (AVO)*

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## HIGHWAY ACCIDENT DATA (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

### *Actual 3-Year Accident Data (from Table B)*

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

### *Statewide Basic Average Accident Rate*

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## RAIL AND TRANSIT DATA (Box 1D)

*This section is used for rail and transit projects only.*

***Annual Person-Trips***

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

***Percent Trips during Peak Period***

32 Insert % annual person-trips that occur during peak period.

***Percent New Trips from Parallel Highway***

33 Insert % new transit person-trips originating on parallel highway.

***Annual Vehicle-Miles***

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

***Average Vehicles per Train***

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

***Reduction in Transit Accidents***

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

***Average Transit Travel Time***

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

***Highway Grade Crossing***

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

***Transit Agency Costs (for Transit TMS Projects)***

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

1E

# PROJECT COSTS (enter costs in thousands of dollars)

| Col. no. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | | |
|---|---|---|---|---|---|---|---|---|---|
| | DIRECT PROJECT COSTS | | | | | | Transit Agency Cost Savings | TOTAL COSTS (in dollars) | |
| | INITIAL COSTS | | | SUBSEQUENT COSTS | | | | | |
| Year | Project Support | R / W | Construction | Maint./ Op. | Rehab. | Mitigation | | Constant Dollars | Present Value |
| **Construction Period** | | | | | | | | | |
| 1 | $715 | $238 | $22,891 | | | | | $23,844,000 | $23,844,000 |
| 2 | | | | | | | | 0 | 0 |
| 3 | | | | | | | | 0 | 0 |
| 4 | | | | | | | | 0 | 0 |
| 5 | | | | | | | | 0 | 0 |
| 6 | | | | | | | | 0 | 0 |
| 7 | | | | | | | | 0 | 0 |
| 8 | | | | | | | | 0 | 0 |
| **Project Open** | | | | | | | | | |
| 1 | | | | $15 | ($430) | | | ($415,000) | ($387,850) |
| 2 | | | | $15 | | | | 15,000 | 13,102 |
| 3 | | | | $15 | ($52) | | | (37,000) | (30,203) |
| 4 | | | | $15 | | | | 15,000 | 11,443 |
| 5 | | | | $15 | | | | 15,000 | 10,695 |
| 6 | | | | $15 | ($172) | | | (157,000) | (104,616) |
| 7 | | | | $15 | ($52) | | | (37,000) | (23,042) |
| 8 | | | | $15 | | | | 15,000 | 8,730 |
| 9 | | | | $15 | | | | 15,000 | 8,159 |
| 10 | | | | $15 | | | | 15,000 | 7,625 |
| 11 | | | | $15 | ($9) | | | 6,000 | 2,851 |
| 12 | | | | $15 | ($4,470) | | | (4,455,000) | (1,978,073) |
| 13 | | | | $15 | | | | 15,000 | 6,224 |
| 14 | | | | $15 | | | | 15,000 | 5,817 |
| 15 | | | | $15 | ($52) | | | (37,000) | (13,411) |
| 16 | | | | $15 | $1,788 | | | 1,803,000 | 610,738 |
| 17 | | | | $15 | | | | 15,000 | 4,749 |
| 18 | | | | $15 | $152 | | | 167,000 | 49,409 |
| 19 | | | | $15 | ($52) | | | (37,000) | (10,231) |
| 20 | | | | $15 | | | | 15,000 | 3,876 |
| **Total** | $715 | $238 | $22,891 | $300 | ($3,349) | $0 | $0 | $20,795,000 | $22,039,994 |

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 35,530 | | 35,530 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 3,514 | | 3,514 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 53.6 | | 53.6 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 4,572 | | 4,572 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 452 | | 452 | |
| Non-HOV Speed | 55.0 | | 55.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |
| **Hwy Safety or Weaving Improvement** | | 0% | collision reduction factor (per HSIP Guidelines) | |
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.011 | | 0.011 | |
| Injury Accidents | 0.37 | | 0.37 | |
| PDO Accidents | 1.03 | | 1.03 | |
| Total Accidents | 1.410 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

| | | |
|---|---|---|
| **Detailed Information Available?** (y/n) | N | |
| **Aggregate Segment Length** (estimate as VMT/total volume) | | |
| All Ramps | | miles |
| Arterials | | miles |

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

## ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| Year 1 | No Build | Build | Induced |
|---|---|---|---|
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |

| Year 20 | No Build | Build | Induced |
|---|---|---|---|
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 14,913,829 | 2,951,766 |
| Truck Trips | 1,028,749 | 1,282,604 | 253,855 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 2,169,231 | 429,337 |
| Truck Trips | 132,367 | 165,030 | 32,663 |
| Total Trips | 14,863,073 | 18,530,694 | 3,667,621 |

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Undivided

EA:
PPNO:

③

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| Life-Cycle Costs (mil. $) | $22.0 |
| Life-Cycle Benefits (mil. $) | $73.7 |
| Net Present Value (mil. $) | $51.6 |
| Benefit / Cost Ratio: | 3.3 |
| Rate of Return on Investment: | 16.4% |
| Payback Period: | 11 years |

| ITEMIZED BENEFITS (mil. $) | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| Travel Time Savings | $72.0 | $12.5 | $84.4 | $4.2 |
| Veh. Op. Cost Savings | -$16.0 | -$2.9 | -$18.9 | -$0.9 |
| Accident Cost Savings | $7.3 | $0.7 | $8.1 | $0.4 |
| Emission Cost Savings | -$0.0 | $0.1 | $0.1 | $0.0 |
| **TOTAL BENEFITS** | $63.3 | $10.4 | $73.7 | $3.7 |
| Person-Hours of Time Saved | | | 13,799,386 | 689,969 |

*Should benefit-cost results include:*

| | |
|---|---|
| 1) Induced Travel? (y/n) | Y<br>Default = Y |
| 2) Vehicle Operating Costs? (y/n) | Y<br>Default = Y |
| 3) Accident Costs? (y/n) | Y<br>Default = Y |
| 4) Vehicle Emissions? (y/n)<br>includes value for $CO_2e$ | Y<br>Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| EMISSIONS REDUCTION | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| CO Emissions Saved | -11 | -1 | $0.0 | $0.0 |
| $CO_2$ Emissions Saved | 14,673 | 734 | $0.0 | $0.0 |
| $NO_X$ Emissions Saved | 48 | 2 | $0.1 | $0.0 |
| $PM_{10}$ Emissions Saved | 0 | 0 | $0.0 | $0.0 |
| $PM_{2.5}$ Emissions Saved | 0 | 0 | | |
| $SO_X$ Emissions Saved | 0 | 0 | -$0.0 | -$0.0 |
| VOC Emissions Saved | 5 | 0 | -$0.0 | -$0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $648,782 | $0 | $21,244 | $0 | $0 | $78,532 | $0 | $0 |
| 20 | $0 | $8,787,156 | $0 | $1,677,211 | $0 | $0 | $37,882 | $0 | $0 |
| | | | | | | | | | |
| 2 | $0 | $862,918 | $0 | $67,438 | $0 | $0 | $76,270 | $0 | $0 |
| 3 | $0 | $1,082,457 | $0 | $114,662 | $0 | $0 | $73,968 | $0 | $0 |
| 4 | $0 | $1,307,984 | $0 | $163,006 | $0 | $0 | $71,641 | $0 | $0 |
| 5 | $0 | $1,540,333 | $0 | $212,617 | $0 | $0 | $69,302 | $0 | $0 |
| 6 | $0 | $1,780,635 | $0 | $263,698 | $0 | $0 | $66,963 | $0 | $0 |
| 7 | $0 | $2,030,359 | $0 | $316,525 | $0 | $0 | $64,633 | $0 | $0 |
| 8 | $0 | $2,291,397 | $0 | $371,455 | $0 | $0 | $62,321 | $0 | $0 |
| 9 | $0 | $2,566,155 | $0 | $428,950 | $0 | $0 | $60,035 | $0 | $0 |
| 10 | $0 | $2,857,696 | $0 | $489,602 | $0 | $0 | $57,781 | $0 | $0 |
| 11 | $0 | $3,169,936 | $0 | $554,168 | $0 | $0 | $55,565 | $0 | $0 |
| 12 | $0 | $3,507,921 | $0 | $623,630 | $0 | $0 | $53,392 | $0 | $0 |
| 13 | $0 | $3,878,234 | $0 | $699,272 | $0 | $0 | $51,266 | $0 | $0 |
| 14 | $0 | $4,289,594 | $0 | $782,792 | $0 | $0 | $49,189 | $0 | $0 |
| 15 | $0 | $4,753,774 | $0 | $876,488 | $0 | $0 | $47,164 | $0 | $0 |
| 16 | $0 | $5,287,045 | $0 | $983,535 | $0 | $0 | $45,194 | $0 | $0 |
| 17 | $0 | $5,912,536 | $0 | $1,108,449 | $0 | $0 | $43,280 | $0 | $0 |
| 18 | $0 | $6,664,262 | $0 | $1,257,868 | $0 | $0 | $41,423 | $0 | $0 |
| 19 | $0 | $7,594,379 | $0 | $1,441,973 | $0 | $0 | $39,623 | $0 | $0 |
| | | | | | | | | | |
| **Total** | **$0** | **$70,813,551** | **$0** | **$12,454,583** | **$0** | **$0** | **$1,145,425** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| | Peak In-Vehicle | Peak Out-of-Veh | Non-Peak In-Vehicle | Non-Peak Out-of-Veh | | | |
| 1 | $0 | $0 | $0 | $0 | $748,557 | $800,956 | 53,742 |
| 20 | $0 | $0 | $0 | $0 | $10,502,249 | $40,640,389 | 2,396,042 |
| 2 | $0 | $0 | $0 | $0 | $1,006,626 | $1,152,486 | 75,294 |
| 3 | $0 | $0 | $0 | $0 | $1,271,087 | $1,557,136 | 99,942 |
| 4 | $0 | $0 | $0 | $0 | $1,542,631 | $2,022,075 | 128,103 |
| 5 | $0 | $0 | $0 | $0 | $1,822,253 | $2,555,804 | 160,272 |
| 6 | $0 | $0 | $0 | $0 | $2,111,296 | $3,168,486 | 197,043 |
| 7 | $0 | $0 | $0 | $0 | $2,411,517 | $3,872,370 | 239,129 |
| 8 | $0 | $0 | $0 | $0 | $2,725,173 | $4,682,355 | 287,398 |
| 9 | $0 | $0 | $0 | $0 | $3,055,140 | $5,616,750 | 342,919 |
| 10 | $0 | $0 | $0 | $0 | $3,405,078 | $6,698,305 | 407,016 |
| 11 | $0 | $0 | $0 | $0 | $3,779,669 | $7,955,643 | 481,359 |
| 12 | $0 | $0 | $0 | $0 | $4,184,944 | $9,425,295 | 568,078 |
| 13 | $0 | $0 | $0 | $0 | $4,628,771 | $11,154,622 | 669,932 |
| 14 | $0 | $0 | $0 | $0 | $5,121,574 | $13,206,154 | 790,567 |
| 15 | $0 | $0 | $0 | $0 | $5,677,425 | $15,664,196 | 934,898 |
| 16 | $0 | $0 | $0 | $0 | $6,315,774 | $18,645,200 | 1,109,713 |
| 17 | $0 | $0 | $0 | $0 | $7,064,265 | $22,314,708 | 1,324,662 |
| 18 | $0 | $0 | $0 | $0 | $7,963,553 | $26,916,270 | 1,593,942 |
| 19 | $0 | $0 | $0 | $0 | $9,075,975 | $32,823,515 | 1,939,333 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$84,413,559** | **$230,872,714** | **13,799,386** |

C

# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | | Present Value of Veh Op Cost Benefits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | |
| 1 | $0 | ($942,318) | $0 | ($140,639) | $0 | ($121,246) | $0 | ($18,190) | - | - | ($1,222,393) |
| 20 | $0 | $46,246 | $0 | $8,525 | $0 | ($100,815) | $0 | ($15,410) | - | - | ($61,454) |
| 2 | $0 | ($969,033) | $0 | ($143,999) | $0 | ($125,285) | $0 | ($18,847) | - | - | ($1,257,163) |
| 3 | $0 | ($992,403) | $0 | ($146,549) | $0 | ($128,275) | $0 | ($19,339) | - | - | ($1,286,566) |
| 4 | $0 | ($993,341) | $0 | ($154,654) | $0 | ($130,339) | $0 | ($19,687) | - | - | ($1,298,021) |
| 5 | $0 | ($989,018) | $0 | ($161,380) | $0 | ($131,583) | $0 | ($19,907) | - | - | ($1,301,888) |
| 6 | $0 | ($973,110) | $0 | ($163,795) | $0 | ($132,107) | $0 | ($20,013) | - | - | ($1,289,025) |
| 7 | $0 | ($947,085) | $0 | ($162,363) | $0 | ($131,999) | $0 | ($20,020) | - | - | ($1,261,467) |
| 8 | $0 | ($918,845) | $0 | ($160,072) | $0 | ($131,340) | $0 | ($19,941) | - | - | ($1,230,198) |
| 9 | $0 | ($870,054) | $0 | ($165,461) | $0 | ($130,202) | $0 | ($19,787) | - | - | ($1,185,503) |
| 10 | $0 | ($824,504) | $0 | ($169,542) | $0 | ($128,651) | $0 | ($19,567) | - | - | ($1,142,264) |
| 11 | $0 | ($764,809) | $0 | ($165,437) | $0 | ($126,745) | $0 | ($19,291) | - | - | ($1,076,283) |
| 12 | $0 | ($695,817) | $0 | ($154,370) | $0 | ($124,539) | $0 | ($18,968) | - | - | ($993,694) |
| 13 | $0 | ($632,381) | $0 | ($143,673) | $0 | ($122,078) | $0 | ($18,604) | - | - | ($916,737) |
| 14 | $0 | ($581,886) | $0 | ($130,291) | $0 | ($119,407) | $0 | ($18,207) | - | - | ($849,790) |
| 15 | $0 | ($490,931) | $0 | ($107,484) | $0 | ($116,562) | $0 | ($17,782) | - | - | ($732,759) |
| 16 | $0 | ($411,423) | $0 | ($86,033) | $0 | ($113,579) | $0 | ($17,335) | - | - | ($628,370) |
| 17 | $0 | ($301,492) | $0 | ($72,838) | $0 | ($110,487) | $0 | ($16,870) | - | - | ($501,688) |
| 18 | $0 | ($201,870) | $0 | ($60,513) | $0 | ($107,314) | $0 | ($16,392) | - | - | ($386,089) |
| 19 | $0 | ($83,571) | $0 | ($32,715) | $0 | ($104,083) | $0 | ($15,904) | - | - | ($236,273) |
| **Total** | **$0** | **($13,537,643)** | **$0** | **($2,513,285)** | **$0** | **($2,436,635)** | **$0** | **($370,064)** | **-** | **-** | **($18,857,627)** |

| Constant Dollars |
|---|
| ($1,307,961) |
| ($237,809) |
| |
| ($1,439,326) |
| ($1,576,099) |
| ($1,701,440) |
| ($1,825,965) |
| ($1,934,479) |
| ($2,025,641) |
| ($2,113,709) |
| ($2,179,499) |
| ($2,247,006) |
| ($2,265,416) |
| ($2,237,990) |
| ($2,209,194) |
| ($2,191,213) |
| ($2,021,706) |
| ($1,855,052) |
| ($1,584,738) |
| ($1,304,955) |
| ($854,490) |
| |
| **($35,113,688)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | All Periods | |
| 1 | $0 | $658,157 | $0 | $65,092 | $0 | $84,684 | $0 | $8,375 | $0 | $816,308 |
| 20 | $0 | $121,304 | $0 | $11,997 | $0 | $15,608 | $0 | $1,544 | $0 | $150,452 |
| 2 | $0 | $604,305 | $0 | $59,766 | $0 | $77,755 | $0 | $7,690 | $0 | $749,516 |
| 3 | $0 | $554,682 | $0 | $54,859 | $0 | $71,370 | $0 | $7,059 | $0 | $687,970 |
| 4 | $0 | $508,966 | $0 | $50,337 | $0 | $65,488 | $0 | $6,477 | $0 | $631,268 |
| 5 | $0 | $466,857 | $0 | $46,173 | $0 | $60,070 | $0 | $5,941 | $0 | $579,041 |
| 6 | $0 | $428,080 | $0 | $42,338 | $0 | $55,080 | $0 | $5,447 | $0 | $530,945 |
| 7 | $0 | $392,378 | $0 | $38,807 | $0 | $50,487 | $0 | $4,993 | $0 | $486,665 |
| 8 | $0 | $359,516 | $0 | $35,556 | $0 | $46,258 | $0 | $4,575 | $0 | $445,905 |
| 9 | $0 | $329,273 | $0 | $32,566 | $0 | $42,367 | $0 | $4,190 | $0 | $408,396 |
| 10 | $0 | $301,449 | $0 | $29,814 | $0 | $38,787 | $0 | $3,836 | $0 | $373,886 |
| 11 | $0 | $275,857 | $0 | $27,283 | $0 | $35,494 | $0 | $3,510 | $0 | $342,144 |
| 12 | $0 | $252,323 | $0 | $24,955 | $0 | $32,466 | $0 | $3,211 | $0 | $312,954 |
| 13 | $0 | $230,687 | $0 | $22,815 | $0 | $29,682 | $0 | $2,936 | $0 | $286,120 |
| 14 | $0 | $210,802 | $0 | $20,849 | $0 | $27,124 | $0 | $2,683 | $0 | $261,457 |
| 15 | $0 | $192,532 | $0 | $19,042 | $0 | $24,773 | $0 | $2,450 | $0 | $238,796 |
| 16 | $0 | $175,750 | $0 | $17,382 | $0 | $22,613 | $0 | $2,236 | $0 | $217,982 |
| 17 | $0 | $160,340 | $0 | $15,858 | $0 | $20,631 | $0 | $2,040 | $0 | $198,869 |
| 18 | $0 | $146,194 | $0 | $14,459 | $0 | $18,810 | $0 | $1,860 | $0 | $181,323 |
| 19 | $0 | $133,212 | $0 | $13,175 | $0 | $17,140 | $0 | $1,695 | $0 | $165,222 |
| **Total** | **$0** | **$6,502,664** | **$0** | **$643,121** | **$0** | **$836,686** | **$0** | **$82,749** | **$0** | **$8,065,220** |

| Constant Dollars |
|---:|
| $873,450 |
| $582,203 |
| |
| $858,121 |
| $842,792 |
| $827,463 |
| $812,135 |
| $796,806 |
| $781,477 |
| $766,148 |
| $750,820 |
| $735,491 |
| $720,162 |
| $704,833 |
| $689,504 |
| $674,176 |
| $658,847 |
| $643,518 |
| $628,189 |
| $612,860 |
| $597,532 |
| |
| **$14,556,527** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,936) | $0 | ($14,529) | $0 | $0 | ($1,519) | $0 | ($2,162) |
| 20 | $0 | $14,083 | $0 | $40,884 | $0 | $0 | ($381) | $0 | ($486) |
| | | | | | | | | | |
| 2 | $0 | ($11,608) | $0 | ($10,874) | $0 | $0 | ($1,561) | $0 | ($2,241) |
| 3 | $0 | ($12,109) | $0 | ($7,358) | $0 | $0 | ($1,592) | $0 | ($2,300) |
| 4 | $0 | ($12,289) | $0 | ($7,431) | $0 | $0 | ($1,613) | $0 | ($2,342) |
| 5 | $0 | ($11,689) | $0 | ($7,488) | $0 | $0 | ($1,625) | $0 | ($2,369) |
| 6 | $0 | ($11,640) | $0 | ($7,675) | $0 | $0 | ($1,628) | $0 | ($2,383) |
| 7 | $0 | ($10,770) | $0 | ($7,991) | $0 | $0 | ($1,625) | $0 | ($2,385) |
| 8 | $0 | ($1,831) | $0 | $1,818 | $0 | $0 | ($473) | $0 | ($616) |
| 9 | $0 | ($1,017) | $0 | $2,680 | $0 | $0 | ($471) | $0 | ($613) |
| 10 | $0 | ($253) | $0 | $3,420 | $0 | $0 | ($467) | $0 | ($607) |
| 11 | $0 | $638 | $0 | $4,635 | $0 | $0 | ($462) | $0 | ($599) |
| 12 | $0 | $1,499 | $0 | $6,158 | $0 | $0 | ($455) | $0 | ($590) |
| 13 | $0 | $2,358 | $0 | $7,592 | $0 | $0 | ($448) | $0 | ($579) |
| 14 | $0 | $2,976 | $0 | $9,737 | $0 | $0 | ($440) | $0 | ($568) |
| 15 | $0 | $4,327 | $0 | $14,227 | $0 | $0 | ($431) | $0 | ($556) |
| 16 | $0 | $5,587 | $0 | $18,268 | $0 | $0 | ($422) | $0 | ($542) |
| 17 | $0 | $7,753 | $0 | $21,228 | $0 | $0 | ($412) | $0 | ($529) |
| 18 | $0 | $9,352 | $0 | $23,884 | $0 | $0 | ($402) | $0 | ($515) |
| 19 | $0 | $11,411 | $0 | $30,650 | $0 | $0 | ($391) | $0 | ($500) |
| | | | | | | | | | |
| **Total** | **$0** | **($25,157)** | **$0** | **$121,835** | **$0** | **$0** | **($16,817)** | **$0** | **($23,482)** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($30,147) | ($32,257) |
| 20 | $0 | $0 | $0 | $0 | $54,101 | $209,352 |
| | | | | | | |
| 2 | $0 | $0 | $0 | $0 | ($26,284) | ($30,093) |
| 3 | $0 | $0 | $0 | $0 | ($23,360) | ($28,617) |
| 4 | $0 | $0 | $0 | $0 | ($23,675) | ($31,033) |
| 5 | $0 | $0 | $0 | $0 | ($23,171) | ($32,498) |
| 6 | $0 | $0 | $0 | $0 | ($23,326) | ($35,006) |
| 7 | $0 | $0 | $0 | $0 | ($22,770) | ($36,564) |
| 8 | $0 | $0 | $0 | $0 | ($1,103) | ($1,895) |
| 9 | $0 | $0 | $0 | $0 | $580 | $1,066 |
| 10 | $0 | $0 | $0 | $0 | $2,094 | $4,120 |
| 11 | $0 | $0 | $0 | $0 | $4,213 | $8,867 |
| 12 | $0 | $0 | $0 | $0 | $6,612 | $14,891 |
| 13 | $0 | $0 | $0 | $0 | $8,923 | $21,503 |
| 14 | $0 | $0 | $0 | $0 | $11,705 | $30,182 |
| 15 | $0 | $0 | $0 | $0 | $17,567 | $48,469 |
| 16 | $0 | $0 | $0 | $0 | $22,891 | $67,578 |
| 17 | $0 | $0 | $0 | $0 | $28,040 | $88,574 |
| 18 | $0 | $0 | $0 | $0 | $32,319 | $109,236 |
| 19 | $0 | $0 | $0 | $0 | $41,169 | $148,889 |
| | | | | | | |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$56,379** | **$524,765** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
| 1 | (8) | (1,646) | (2) | (0) | (0) | (1) | (0) |
| 20 | 15 | 9,362 | 18 | 0 | 0 | 2 | 0 |
| 2 | (8) | (1,606) | (2) | (0) | (0) | (1) | (0) |
| 3 | (9) | (1,608) | (2) | (0) | (0) | (1) | (0) |
| 4 | (9) | (1,640) | (2) | (0) | (0) | (1) | (0) |
| 5 | (9) | (1,666) | (2) | (0) | (0) | (1) | (0) |
| 6 | (9) | (1,621) | (3) | (0) | (0) | (1) | (0) |
| 7 | (9) | (1,500) | (3) | (0) | (0) | (1) | (0) |
| 8 | (1) | (958) | 0 | (0) | (0) | (0) | (0) |
| 9 | (0) | (864) | 0 | 0 | (0) | 0 | (0) |
| 10 | (0) | (760) | 0 | 0 | (0) | 0 | 0 |
| 11 | 0 | (528) | 1 | 0 | (0) | 0 | 0 |
| 12 | 1 | (159) | 1 | 0 | (0) | 0 | 0 |
| 13 | 2 | 233 | 2 | 0 | 0 | 0 | 0 |
| 14 | 2 | 623 | 3 | 0 | 0 | 0 | 0 |
| 15 | 3 | 1,535 | 4 | 0 | 0 | 1 | 0 |
| 16 | 4 | 2,439 | 6 | 0 | 0 | 1 | 0 |
| 17 | 6 | 3,580 | 7 | 0 | 0 | 1 | 0 |
| 18 | 8 | 4,772 | 9 | 0 | 0 | 1 | 0 |
| 19 | 11 | 6,685 | 12 | 0 | 0 | 2 | 0 |
| **Total** | **(11)** | **14,673** | **48** | **0** | **(0)** | **5** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | DOLLARS EMISSIONS SAVED (PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
| 1 | $0 | ($1,423) | ($17,029) | ($8,650) | ($2,051) | ($992) |
| 20 | $0 | $3,261 | $38,464 | $10,082 | $1,125 | $1,169 |
| | | | | | | |
| 2 | $0 | ($1,324) | ($15,281) | ($6,644) | ($2,056) | ($978) |
| 3 | $0 | ($1,263) | ($13,674) | ($5,403) | ($2,048) | ($971) |
| 4 | $0 | ($1,229) | ($13,919) | ($5,509) | ($2,088) | ($931) |
| 5 | $0 | ($1,190) | ($14,071) | ($4,992) | ($2,031) | ($888) |
| 6 | $0 | ($1,103) | ($13,849) | ($5,514) | ($2,039) | ($821) |
| 7 | $0 | ($973) | ($13,308) | ($5,781) | ($1,969) | ($739) |
| 8 | $0 | ($593) | $261 | ($380) | ($357) | ($33) |
| 9 | $0 | ($509) | $1,150 | $225 | ($303) | $16 |
| 10 | $0 | ($427) | $1,976 | $734 | ($251) | $62 |
| 11 | $0 | ($283) | $3,202 | $1,303 | ($131) | $121 |
| 12 | $0 | ($81) | $4,761 | $1,826 | ($81) | $188 |
| 13 | $0 | $113 | $6,187 | $2,349 | $24 | $249 |
| 14 | $0 | $289 | $8,337 | $2,695 | $87 | $296 |
| 15 | $0 | $679 | $12,716 | $3,554 | $216 | $402 |
| 16 | $0 | $1,029 | $16,688 | $4,293 | $386 | $496 |
| 17 | $0 | $1,440 | $19,517 | $5,921 | $516 | $646 |
| 18 | $0 | $1,829 | $22,050 | $7,027 | $634 | $779 |
| 19 | $0 | $2,443 | $28,561 | $8,337 | $871 | $958 |
| | | | | | | |
| **Total** | **$0** | **$685** | **$62,739** | **$5,473** | **($11,545)** | **($972)** |

A

# NET PRESENT VALUE CALCULATION

| Year | PRESENT VALUE OF USER BENEFITS |  |  |  | PRESENT VALUE OF USER BENEFITS (road 2) |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** |  |  |  |  |  |  |  |  |
| 1 |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |  |  |
| **Project Open** |  |  |  |  |  |  |  |  |
| 1 | $748,557 | ($1,222,393) | $816,308 | ($30,147) |  |  |  |  |
| 2 | $1,006,626 | ($1,257,163) | $749,516 | ($26,284) |  |  |  |  |
| 3 | $1,271,087 | ($1,286,566) | $687,970 | ($23,360) |  |  |  |  |
| 4 | $1,542,631 | ($1,298,021) | $631,268 | ($23,675) |  |  |  |  |
| 5 | $1,822,253 | ($1,301,888) | $579,041 | ($23,171) |  |  |  |  |
| 6 | $2,111,296 | ($1,289,025) | $530,945 | ($23,326) |  |  |  |  |
| 7 | $2,411,517 | ($1,261,467) | $486,665 | ($22,770) |  |  |  |  |
| 8 | $2,725,173 | ($1,230,198) | $445,905 | ($1,103) |  |  |  |  |
| 9 | $3,055,140 | ($1,185,503) | $408,396 | $580 |  |  |  |  |
| 10 | $3,405,078 | ($1,142,264) | $373,886 | $2,094 |  |  |  |  |
| 11 | $3,779,669 | ($1,076,283) | $342,144 | $4,213 |  |  |  |  |
| 12 | $4,184,944 | ($993,694) | $312,954 | $6,612 |  |  |  |  |
| 13 | $4,628,771 | ($916,737) | $286,120 | $8,923 |  |  |  |  |
| 14 | $5,121,574 | ($849,790) | $261,457 | $11,705 |  |  |  |  |
| 15 | $5,677,425 | ($732,759) | $238,796 | $17,567 |  |  |  |  |
| 16 | $6,315,774 | ($628,370) | $217,982 | $22,891 |  |  |  |  |
| 17 | $7,064,265 | ($501,688) | $198,869 | $28,040 |  |  |  |  |
| 18 | $7,963,553 | ($386,089) | $181,323 | $32,319 |  |  |  |  |
| 19 | $9,075,975 | ($236,273) | $165,222 | $41,169 |  |  |  |  |
| 20 | $10,502,249 | ($61,454) | $150,452 | $54,101 |  |  |  |  |
| **Total** | $84,413,559 | ($18,857,627) | $8,065,220 | $56,379 | $0 | $0 | $0 | $0 |

|  |  |  |  |
|---|---|---|---|
| 13,799,386 | Person-Hours of Time Saved |  | Person-Hours of Time Saved |

| tons | $ PV |  | tons | $ PV |  |
|---|---|---|---|---|---|
| (11) | $0 | CO Saved |  |  | CO Saved |
| 14,673 | $685 | $CO_2$ Saved |  |  | $CO_2$ Saved |
| 48 | $62,739 | $NO_X$ Saved |  |  | $NO_X$ Saved |
| 0 | $5,473 | $PM_{10}$ Saved |  |  | $PM_{10}$ Saved |
| 0 |  | $PM_{2.5}$ Saved |  |  | $PM_{2.5}$ Saved |
| (0) | ($11,545) | $SO_X$ Saved |  |  | $SO_X$ Saved |
| 5 | ($972) | VOC Saved |  |  | VOC Saved |

|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| $12,454,583 | ($2,883,348) | $725,870 | $98,353 |  |  |  |  |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | |
| | | | | $0 | $23,844,000 | ($23,844,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $312,326 | ($387,850) | $700,176 |
| | | | | $472,695 | $13,102 | $459,593 |
| | | | | $649,131 | ($30,203) | $679,334 |
| | | | | $852,204 | $11,443 | $840,760 |
| | | | | $1,076,235 | $10,695 | $1,065,540 |
| | | | | $1,329,890 | ($104,616) | $1,434,506 |
| | | | | $1,613,944 | ($23,042) | $1,636,986 |
| | | | | $1,939,778 | $8,730 | $1,931,048 |
| | | | | $2,278,612 | $8,159 | $2,270,453 |
| | | | | $2,638,795 | $7,625 | $2,631,170 |
| | | | | $3,049,743 | $2,851 | $3,046,892 |
| | | | | $3,510,816 | ($1,978,073) | $5,488,889 |
| | | | | $4,007,077 | $6,224 | $4,000,853 |
| | | | | $4,544,946 | $5,817 | $4,539,129 |
| | | | | $5,201,030 | ($13,411) | $5,214,440 |
| | | | | $5,928,277 | $610,738 | $5,317,538 |
| | | | | $6,789,486 | $4,749 | $6,784,738 |
| | | | | $7,791,106 | $49,409 | $7,741,697 |
| | | | | $9,046,093 | ($10,231) | $9,056,324 |
| | | | | $10,645,347 | $3,876 | $10,641,471 |
| $0 | $0 | $0 | $0 | **$73,677,531** | **$22,039,994** | **$51,637,537** |

| | |
|---|---|
| | Person-Hours of Time Saved |

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| Construction Period | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| Project Open | | | | | | | | |
| 1 | $800,956 | ($1,307,961) | $873,450 | ($32,257) | | | | |
| 2 | $1,152,486 | ($1,439,326) | $858,121 | ($30,093) | | | | |
| 3 | $1,557,136 | ($1,576,099) | $842,792 | ($28,617) | | | | |
| 4 | $2,022,075 | ($1,701,440) | $827,463 | ($31,033) | | | | |
| 5 | $2,555,804 | ($1,825,965) | $812,135 | ($32,498) | | | | |
| 6 | $3,168,486 | ($1,934,479) | $796,806 | ($35,006) | | | | |
| 7 | $3,872,370 | ($2,025,641) | $781,477 | ($36,564) | | | | |
| 8 | $4,682,355 | ($2,113,709) | $766,148 | ($1,895) | | | | |
| 9 | $5,616,750 | ($2,179,499) | $750,820 | $1,066 | | | | |
| 10 | $6,698,305 | ($2,247,006) | $735,491 | $4,120 | | | | |
| 11 | $7,955,643 | ($2,265,416) | $720,162 | $8,867 | | | | |
| 12 | $9,425,295 | ($2,237,990) | $704,833 | $14,891 | | | | |
| 13 | $11,154,622 | ($2,209,194) | $689,504 | $21,503 | | | | |
| 14 | $13,206,154 | ($2,191,213) | $674,176 | $30,182 | | | | |
| 15 | $15,664,196 | ($2,021,706) | $658,847 | $48,469 | | | | |
| 16 | $18,645,200 | ($1,855,052) | $643,518 | $67,578 | | | | |
| 17 | $22,314,708 | ($1,584,738) | $628,189 | $88,574 | | | | |
| 18 | $26,916,270 | ($1,304,955) | $612,860 | $109,236 | | | | |
| 19 | $32,823,515 | ($854,490) | $597,532 | $148,889 | | | | |
| 20 | $40,640,389 | ($237,809) | $582,203 | $209,352 | | | | |
| **Total** | $230,872,714 | ($35,113,688) | $14,556,527 | $524,765 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | | |
| | | | | $0 | $23,844,000 | ($23,844,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $334,188 | ($415,000) | $749,188 | $749,188 |
| | | | | $541,188 | $15,000 | $526,188 | $1,275,377 |
| | | | | $795,213 | ($37,000) | $832,213 | $2,107,589 |
| | | | | $1,117,065 | $15,000 | $1,102,065 | $3,209,654 |
| | | | | $1,509,475 | $15,000 | $1,494,475 | $4,704,130 |
| | | | | $1,995,806 | ($157,000) | $2,152,806 | $6,856,936 |
| | | | | $2,591,641 | ($37,000) | $2,628,641 | $9,485,578 |
| | | | | $3,332,899 | $15,000 | $3,317,899 | $12,803,477 |
| | | | | $4,189,136 | $15,000 | $4,174,136 | $16,977,613 |
| | | | | $5,190,910 | $15,000 | $5,175,910 | $22,153,523 |
| | | | | $6,419,257 | $6,000 | $6,413,257 | $28,566,780 |
| | | | | $7,907,030 | ($4,455,000) | $12,362,030 | $40,928,810 |
| | | | | $9,656,435 | $15,000 | $9,641,435 | $50,570,245 |
| | | | | $11,719,298 | $15,000 | $11,704,298 | $62,274,543 |
| | | | | $14,349,805 | ($37,000) | $14,386,805 | $76,661,348 |
| | | | | $17,501,244 | $1,803,000 | $15,698,244 | $92,359,592 |
| | | | | $21,446,733 | $15,000 | $21,431,733 | $113,791,325 |
| | | | | $26,333,412 | $167,000 | $26,166,412 | $139,957,737 |
| | | | | $32,715,446 | ($37,000) | $32,752,446 | $172,710,183 |
| | | | | $41,194,135 | $15,000 | $41,179,135 | $213,889,318 |
| $0 | $0 | $0 | $0 | **$210,840,318** | **$20,795,000** | **$190,045,318** | |

| | |
|---|---|
| **Total Construction Costs** | **$23,844,000** |

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($23,844,000) |
| 2 | $749,188 |
| 3 | $526,188 |
| 4 | $832,213 |
| 5 | $1,102,065 |
| 6 | $1,494,475 |
| 7 | $2,152,806 |
| 8 | $2,628,641 |
| 9 | $3,317,899 |
| 10 | $4,174,136 |
| 11 | $5,175,910 |
| 12 | $6,413,257 |
| 13 | $12,362,030 |
| 14 | $9,641,435 |
| 15 | $11,704,298 |
| 16 | $14,386,805 |
| 17 | $15,698,244 |
| 18 | $21,431,733 |
| 19 | $26,166,412 |
| 20 | $32,752,446 |
| 21 | $41,179,135 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **16.36%** |
| **Payback Period** | **11 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |

**OMB GDP Inflator** **1.01719172**

Yellow cells - adjusted

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | *1* |
| Real Discount Rate | 7.0% | *2* |

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | *3* |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | *3* |
| Benefits and Costs | $ 10.69 | $/hr | *4* |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | *5* |
| Truck | $ 31.20 | $/hr/veh | *5* |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | *6* |
| Transit | $ 13.75 | $/hr/per | *5* |
| Out-of-Vehicle Travel | 2 | times | *5* |
| Incident-Related Travel | 3 | times | *7* |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | *8* |
| Truck (diesel) | $ 3.07 | $/gal | *8* |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | *9* |
| State Sales Tax (diesel) | **13.00%** | % | *9* |
| Average Local Sales Tax | 0.50% | % | *9* |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | *9* |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | *9* |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | *9* |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | *9* |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | *10* |
| Truck | $ 0.437 | $/mi | *11* |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | *12* |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | *12* |
| Level B (Moderate) | $ 125,000 | $/event | *12* |
| Level C (Minor) | $ 63,900 | $/event | *12* |
| Cost of Property Damage | $ 4,300 | $/event | *13* |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | *14* |
| Injury Accident | 0.29 | per mil veh-mi | *14* |
| PDO Accident | 0.55 | per mil veh-mi | *14* |
| Non-Freeway | 1.05 | per mil veh-mi | *15* |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | *16* |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | *17* |
| HOV Lanes | 0.55 | 8 | 1,600 | | *18* |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

## *Active Transportation Parameters*

| General Travel Activity Characteristics Parameters | Value | Units | |
|---|---|---|---|
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| **Vehicle Statistics** | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | *19* |
| **Active Transportation User Characteristics** | | | |
| Average Cycling Speed | 11.80 | mph | *20* |
| Average Walking Speed | 3.00 | mph | *21* |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | *19* |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | *19* |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| **Value of Travel Time** | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| **Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class** | | | |
| Class I | 0.57 | - | *20* |
| Class II | 0.49 | - | *20* |
| Class III | 0.92 | - | *20* |
| Class IV | 0.49 | - | *20* |
| *Note: Class IV assumed to be the same as Class II* | | | |
| **Walking Journey Quality Values per Mile by Amentity** | | | |
| Street Lighting | $0.110 | $/mi | *22* |
| Curb Level | $0.078 | $/mi | *22* |
| Crowding | $0.055 | $/mi | *22* |
| Pavement Evenness | $0.026 | $/mi | *22* |
| Information Panels | $0.026 | $/mi | *22* |
| Benches | $0.017 | $/mi | *22* |
| Directional Signage | $0.017 | $/mi | *22* |
| **Health (Absenteeism Reduction)** | | | |
| Average Absence of Employees | 3.60 | days/yr | *23* |
| Percentage Covered by Short-Term Sick Leave | 95% | % | *24* |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | *25* |
| **Health (Mortality Reduction)** | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | *26* |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | *26* |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | *27* |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | *27* |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | *28* |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | *28* |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

## Travel Demand Tables

### Project Types

|  |  |  |  |
|---|---|---|---|
| Highway Capacity Expansion |  |  | Please select a type of highway project |
| General Highway | TRUE | GenHwy |  |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| Rail or Transit Cap Expansion |  |  | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| Hwy Operational Improvement |  |  | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| Transp Mgmt Systems (TMS) |  |  | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| TMS Lookup Code | NoAdj | TMSLookup |  |
| User Modified Inputs | FALSE | UserAdjInputs |  |

### DEMAND FOR TRAVEL IN PEAK PERIOD

(percent of total daily travel)

| Number of Hours in Peak Period | Urban |  |  |  | Rural |  |
|---|---|---|---|---|---|---|
|  | So. California |  | No. California |  |  |  |
|  | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

### AGE COHORTS FOR MORTALITY RISK REDUCTION

(percent of population)

|  |  | Urban |  |  |
|---|---|---|---|---|
| **Mode** | **Age Cohort** | **South** | **North** | **Rural** |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

### AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP

(miles/trip)

|  |  | Urban |  |  |
|---|---|---|---|---|
| **Mode** | **Age Cohort** | **South** | **North** | **Rural** |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
|  | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
|  | Children <16 | 0.46 | 0.58 | 0.42 |

### TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS

(percent of trips)

|  |  | Urban |  |  |
|---|---|---|---|---|
| **Mode** | **Trip Purpose** | **South** | **North** | **Rural** |
| Cycling | Commuting | 8% | 11% | 7% |
|  | Recreation | 15% | 13% | 15% |
|  | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
|  | Recreation | 10% | 10% | 15% |
|  | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident |  | 0.1176 | 0.6446 |
| Cost per Event |  | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary*
*Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## ***Emissions Tables***

**HIGHWAY EMISSIONS FACTORS (g/mi)**

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

**HIGHWAY EMISSIONS FACTORS (g/mi)**

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

### HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | $CO_2e$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

$CO_2e$ Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

### PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 |  | 583.58 | 62.02 |  | 19.73 |  |
|  | 2022 | 45.67 |  | 250.11 | 31.01 |  | 19.73 |  |

### LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 |  | 1.13 | 0.17 |  | 0.06 |  |
|  | 2022 | 0.14 |  | 1.14 | 0.17 |  | 0.06 |  |

### FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |
|  | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |

| | | |
|---|---|---|
| Freight Rail Fuel Efficiency | 468 | ton-miles/gal |
| Fuel Burned at Idle | 4 | gal/hr |

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## *Pavement Adjustments* (used only for pavement projects)

**PAVEMENT DETERIORATION**

(IRI in inches/mile)

| | Year 20, By Loading | | |
|---|---|---|---|
| **Year 0** | **Light** | **Medium** | **Heavy** |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

**VEHICLE OPERATING SPEED**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

**FUEL CONSUMPTION**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

**NON-FUEL COSTS**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## ***Weaving Adjustments*** (used only for freeway connector, HOV connector, and HOV drop ramp projects)

**VEHICLE OPERATING SPEED**

(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## ***TMS Adjustments*** (used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

**PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS**

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| Strategy | Speed | Volume | Speed | Volume | TT | VOC | Em | Benefit |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

**TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS**

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| TMS Strategy | Time | Capital | O&M |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

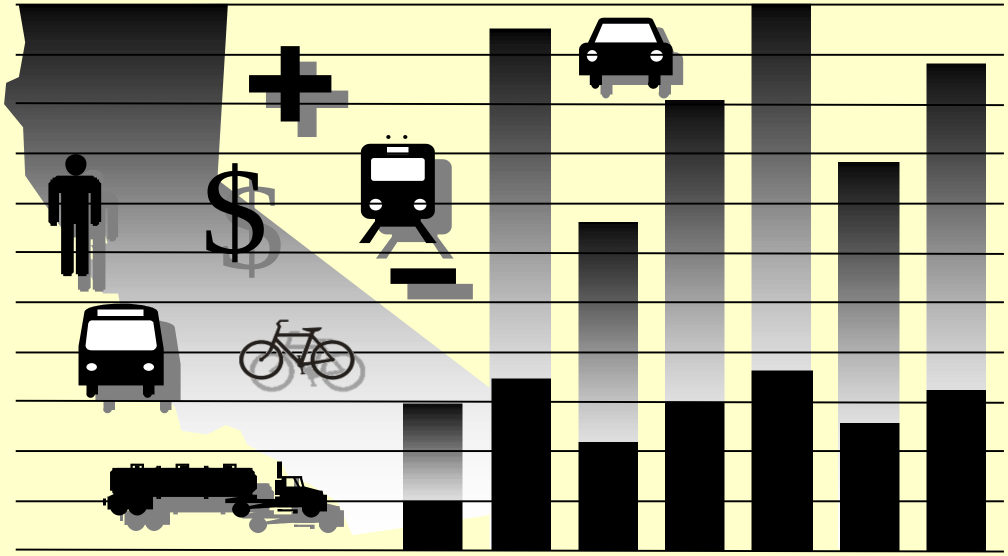
Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Divided 29M (2019) TPC, 40062 ADT

WAR-63 Priority Project BCA

California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**

Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

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# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period. Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual. Other adjustments are made for weaving and pavement conditions. An option is also available to conduct a simple queuing analysis. Accidents are estimated from statewide averages and recent data for the facility. If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically. Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road. The user clicks a button and the model clears the Project Information worksheet to receive information on other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed). The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available. The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed). These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### **PROJECT DATA** (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

### *Type of Project*

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

### *Project Location*

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

### *Length of Construction Period*

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

### *One- or Two-Way Data*

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

### *Length of Peak Period(s)*

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

### *Highway Design*

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

### *Average Daily Traffic (ADT)*

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

***Average Hourly HOV/HOT Lane Traffic***

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

***Percent Traffic in Weave***

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

***Percent Trucks***

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

***Truck Speed***

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

***On-Ramp Volume***

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

***Queue Formation***

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

***Pavement Condition (for Pavement Rehab. Projects)***

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

***Average Vehicle Occupancy (AVO)***

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## **HIGHWAY ACCIDENT DATA** (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

***Actual 3-Year Accident Data (from Table B)***

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

***Statewide Basic Average Accident Rate***

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## **RAIL AND TRANSIT DATA** (Box 1D)

*This section is used for rail and transit projects only.*

***Annual Person-Trips***

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

***Percent Trips during Peak Period***

32 Insert % annual person-trips that occur during peak period.

***Percent New Trips from Parallel Highway***

33 Insert % new transit person-trips originating on parallel highway.

***Annual Vehicle-Miles***

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

***Average Vehicles per Train***

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

***Reduction in Transit Accidents***

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

***Average Transit Travel Time***

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

***Highway Grade Crossing***

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

***Transit Agency Costs (for Transit TMS Projects)***

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Divided

EA:
PPNO:

## 1A PROJECT DATA

| | | |
|---|---|---|
| ***Type of Project*** | | |
| Select project type from list | General Highway | |
| ***Project Location*** (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural) | 3 | |
| Length of Construction Period | 1 | years |
| One- or Two-Way Data | 2 | enter 1 or 2 |
| | Current | |
| ***Length of Peak Period(s)*** (up to 24 hrs) | 13 | hours |

## 1B HIGHWAY DESIGN AND TRAFFIC DATA

| ***Highway Design*** | No Build | Build |
|---|---|---|
| Roadway Type (Fwy, Exp, Conv Hwy) | C | C |
| Number of General Traffic Lanes | 2 | 4 |
| Number of HOV/HOT Lanes | 0 | 0 |
| HOV Restriction (2 or 3) | 0 | |
| Exclusive ROW for Buses (y/n) | N | |
| Highway Free-Flow Speed | 50 | 60 |
| Ramp Design Speed (if aux. lane/off-ramp proj.) | | |
| Length (in miles) Highway Segment | 3.0 | 3.0 |
| Impacted Length | 3.0 | 3.0 |

| ***Average Daily Traffic*** | | |
|---|---|---|
| Current | 20,600 | |
| | No Build | Build |
| Base (Year 1) | 21,337 | 24,184 |
| Forecast (Year 20) | 35,346 | 40,062 |
| ***Average Hourly HOV/HOT Lane Traffic*** | | 0 |
| Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.) | | 100% |
| ***Percent Traffic in Weave*** | | 0.0% |
| ***Percent Trucks*** (include RVs, if applicable) | 9% | 9% |
| ***Truck Speed*** | 50 | |

| ***On-Ramp Volume*** | Peak | Non-Peak |
|---|---|---|
| Hourly Ramp Volume (if aux. lane/on-ramp proj.) | 0 | 0 |
| Metering Strategy (1, 2, 3, or D, if on-ramp proj.) | | |

| ***Queue Formation*** (if queuing or grade crossing project) | Year 1 | Year 20 |
|---|---|---|
| Arrival Rate (in vehicles per hour) | 0 | 0 |
| Departure Rate (in vehicles per hour) | 0 | 0 |

| ***Pavement Condition*** (if pavement project) | No Build | Build |
|---|---|---|
| IRI (inches/mile) Base (Year 1) | | |
| Forecast (Year 20) | | |

| ***Average Vehicle Occupancy (AVO)*** | No Build | Build |
|---|---|---|
| General Traffic Non-Peak | 1.30 | 1.30 |
| Peak | 1.15 | 1.15 |
| High Occupancy Vehicle (if HOV/HOT lanes) | 2.15 | 2.15 |

## 1C HIGHWAY ACCIDENT DATA

| ***Actual 3-Year Accident Data (from Table B)*** | Count (No.) | Rate |
|---|---|---|
| Total Accidents (Tot) | 126 | 1.86 |
| Fatal Accidents (Fat) | 1 | 0.015 |
| Injury Accidents (Inj) | 33 | 0.49 |
| Property Damage Only (PDO) Accidents | 92 | 1.36 |

| ***Statewide Basic Average Accident Rate*** | No Build | Build |
|---|---|---|
| Rate Group | | |
| Accident Rate (per million vehicle-miles) | 1.72 | 0.75 |
| Percent Fatal Accidents (Pct Fat) | 0.3% | 0.3% |
| Percent Injury Accidents (Pct Inj) | 23.5% | 23.5% |

## 1D RAIL AND TRANSIT DATA

| ***Annual Person-Trips*** | No Build | Build |
|---|---|---|
| Base (Year 1) | | |
| Forecast (Year 20) | | |
| ***Percent Trips during Peak Period*** | 89% | |
| ***Percent New Trips from Parallel Highway*** | | 100% |

| ***Annual Vehicle-Miles*** | No Build | Build |
|---|---|---|
| Base (Year 1) | | |
| Forecast (Year 20) | | |
| ***Average Vehicles/Train*** (if rail project) | | |

| ***Reduction in Transit Accidents*** | |
|---|---|
| Percent Reduction (if safety project) | |

| ***Average Transit Travel Time*** | | No Build | Build |
|---|---|---|---|
| In-Vehicle | Non-Peak (in minutes) | | 0.0 |
| | Peak (in minutes) | | 0.0 |
| Out-of-Vehicle | Non-Peak (in minutes) | 0.0 | 0.0 |
| | Peak (in minutes) | 0.0 | 0.0 |

| ***Highway Grade Crossing*** | Current | Year 1 | Year 20 |
|---|---|---|---|
| Annual Number of Trains | | 0 | |
| Avg. Gate Down Time (in min.) | | 0.0 | |

| ***Transit Agency Costs*** (if TMS project) | No Build | Build |
|---|---|---|
| Annual Capital Expenditure | | $0 |
| Annual Ops. and Maintenance Expenditure | | $0 |

*Model should be run for both roads for intersection or bypass highway projects, ar may be run twice for connectors. Press button below to prepare model to enter data for second road. After data are entered, results reflect total project benefits.*

Prepare Model for Second Road

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 32,300 | | 32,300 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 3,195 | | 3,195 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 59.4 | | 59.4 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 4,156 | | 4,156 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 411 | | 411 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |
| **Hwy Safety or Weaving Improvement** | | 0% | collision reduction factor (per HSIP Guidelines) | |
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.007 | | 0.007 | |
| Injury Accidents | 0.21 | | 0.21 | |
| PDO Accidents | 0.59 | | 0.59 | |
| Total Accidents | 0.813 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

| | | |
|---|---|---|
| **Detailed Information Available?** (y/n) | N | |
| **Aggregate Segment Length** (estimate as VMT/total volume) | | |
| All Ramps | | miles |
| Arterials | | miles |

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

# ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 13,558,088 | 1,596,025 |
| Truck Trips | 1,028,749 | 1,166,009 | 137,260 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 1,972,037 | 232,143 |
| Truck Trips | 132,367 | 150,028 | 17,661 |
| Total Trips | 14,863,073 | 16,846,162 | 1,983,089 |

**District:** **WCTID**

**PROJECT:** **WAR 63 Priority Segment 4-Lane Divided**

EA:

PPNO:

(3)

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| **Life-Cycle Costs (mil. $)** | $26.2 |
| **Life-Cycle Benefits (mil. $)** | $117.2 |
| **Net Present Value (mil. $)** | $91.0 |
| **Benefit / Cost Ratio:** | 4.5 |
| **Rate of Return on Investment:** | 22.8% |
| **Payback Period:** | 7 years |

| **ITEMIZED BENEFITS (mil. $)** | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| **Travel Time Savings** | $77.1 | $12.0 | $89.0 | $4.5 |
| **Veh. Op. Cost Savings** | -$11.0 | -$1.9 | -$12.9 | -$0.6 |
| **Accident Cost Savings** | $37.2 | $3.7 | $40.9 | $2.0 |
| **Emission Cost Savings** | -$0.0 | $0.1 | $0.1 | $0.0 |
| **TOTAL BENEFITS** | $103.3 | $13.9 | $117.2 | $5.9 |
| **Person-Hours of Time Saved** | | | 14,893,457 | 744,673 |

***Should benefit-cost results include:***

| | | |
|---|---|---|
| **1) Induced Travel? (y/n)** | Y | Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y | Default = Y |
| **3) Accident Costs? (y/n)** | Y | Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for CO$_2$e | Y | Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| **EMISSIONS REDUCTION** | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| **CO Emissions Saved** | 62 | 3 | $0.0 | $0.0 |
| **CO$_2$ Emissions Saved** | 19,373 | 969 | $0.0 | $0.0 |
| **NO$_X$ Emissions Saved** | 61 | 3 | $0.1 | $0.0 |
| **PM$_{10}$ Emissions Saved** | 0 | 0 | $0.0 | $0.0 |
| **PM$_{2.5}$ Emissions Saved** | 0 | 0 | | |
| **SO$_X$ Emissions Saved** | 0 | 0 | -$0.0 | -$0.0 |
| **VOC Emissions Saved** | 6 | 0 | $0.0 | $0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $1,098,713 | $0 | $21,244 | $0 | $0 | $143,975 | $0 | $0 |
| 20 | $0 | $8,591,679 | $0 | $1,592,605 | $0 | $0 | $65,947 | $0 | $0 |
| | | | | | | | | | |
| 2 | $0 | $1,298,582 | $0 | $67,138 | $0 | $0 | $139,205 | $0 | $0 |
| 3 | $0 | $1,501,981 | $0 | $113,677 | $0 | $0 | $134,444 | $0 | $0 |
| 4 | $0 | $1,709,650 | $0 | $160,980 | $0 | $0 | $129,710 | $0 | $0 |
| 5 | $0 | $1,922,550 | $0 | $209,212 | $0 | $0 | $125,019 | $0 | $0 |
| 6 | $0 | $2,141,900 | $0 | $258,592 | $0 | $0 | $120,388 | $0 | $0 |
| 7 | $0 | $2,369,229 | $0 | $309,403 | $0 | $0 | $115,827 | $0 | $0 |
| 8 | $0 | $2,606,443 | $0 | $362,005 | $0 | $0 | $111,348 | $0 | $0 |
| 9 | $0 | $2,855,926 | $0 | $416,850 | $0 | $0 | $106,959 | $0 | $0 |
| 10 | $0 | $3,120,666 | $0 | $474,513 | $0 | $0 | $102,667 | $0 | $0 |
| 11 | $0 | $3,404,444 | $0 | $535,727 | $0 | $0 | $98,480 | $0 | $0 |
| 12 | $0 | $3,712,094 | $0 | $601,428 | $0 | $0 | $94,401 | $0 | $0 |
| 13 | $0 | $4,049,889 | $0 | $672,837 | $0 | $0 | $90,434 | $0 | $0 |
| 14 | $0 | $4,426,101 | $0 | $751,565 | $0 | $0 | $86,582 | $0 | $0 |
| 15 | $0 | $4,851,872 | $0 | $839,787 | $0 | $0 | $82,847 | $0 | $0 |
| 16 | $0 | $5,342,567 | $0 | $940,499 | $0 | $0 | $79,231 | $0 | $0 |
| 17 | $0 | $5,919,998 | $0 | $1,057,960 | $0 | $0 | $75,733 | $0 | $0 |
| 18 | $0 | $6,616,216 | $0 | $1,198,424 | $0 | $0 | $72,353 | $0 | $0 |
| 19 | $0 | $7,480,334 | $0 | $1,371,478 | $0 | $0 | $69,092 | $0 | $0 |
| | | | | | | | | | |
| **Total** | **$0** | **$75,020,833** | **$0** | **$11,955,923** | **$0** | **$0** | **$2,044,641** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| | TRANSIT | | | | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| **Year** | **Peak In-Vehicle** | **Peak Out-of-Veh** | **Non-Peak In-Vehicle** | **Non-Peak Out-of-Veh** | | | |
| 1 | $0 | $0 | $0 | $0 | $1,263,932 | $1,352,407 | 91,339 |
| 20 | $0 | $0 | $0 | $0 | $10,250,231 | $39,665,160 | 2,469,324 |
| 2 | $0 | $0 | $0 | $0 | $1,504,925 | $1,722,989 | 114,541 |
| 3 | $0 | $0 | $0 | $0 | $1,750,102 | $2,143,950 | 140,862 |
| 4 | $0 | $0 | $0 | $0 | $2,000,339 | $2,622,037 | 170,722 |
| 5 | $0 | $0 | $0 | $0 | $2,256,781 | $3,165,253 | 204,615 |
| 6 | $0 | $0 | $0 | $0 | $2,520,880 | $3,783,161 | 243,134 |
| 7 | $0 | $0 | $0 | $0 | $2,794,459 | $4,487,290 | 286,994 |
| 8 | $0 | $0 | $0 | $0 | $3,079,795 | $5,291,661 | 337,063 |
| 9 | $0 | $0 | $0 | $0 | $3,379,734 | $6,213,503 | 394,408 |
| 10 | $0 | $0 | $0 | $0 | $3,697,847 | $7,274,224 | 460,356 |
| 11 | $0 | $0 | $0 | $0 | $4,038,650 | $8,500,761 | 536,575 |
| 12 | $0 | $0 | $0 | $0 | $4,407,923 | $9,927,487 | 625,195 |
| 13 | $0 | $0 | $0 | $0 | $4,813,159 | $11,598,968 | 728,977 |
| 14 | $0 | $0 | $0 | $0 | $5,264,249 | $13,574,045 | 851,567 |
| 15 | $0 | $0 | $0 | $0 | $5,774,506 | $15,932,044 | 997,878 |
| 16 | $0 | $0 | $0 | $0 | $6,362,297 | $18,782,542 | 1,174,700 |
| 17 | $0 | $0 | $0 | $0 | $7,053,691 | $22,281,306 | 1,391,682 |
| 18 | $0 | $0 | $0 | $0 | $7,886,993 | $26,657,502 | 1,663,023 |
| 19 | $0 | $0 | $0 | $0 | $8,920,904 | $32,262,694 | 2,010,501 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$89,021,397** | **$237,238,984** | **14,893,457** |

C

# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | | Present Value of |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | Veh Op Cost Benefits |
| 1 | $0 | ($1,028,520) | $0 | ($140,639) | $0 | ($132,338) | $0 | ($18,190) | - | - | ($1,319,687) |
| 20 | $0 | $357,976 | $0 | $63,534 | $0 | ($60,621) | $0 | ($8,332) | - | - | $352,557 |
| | | | | | | | | | | | |
| 2 | $0 | ($980,563) | $0 | ($134,213) | $0 | ($127,955) | $0 | ($17,587) | - | - | ($1,260,318) |
| 3 | $0 | ($947,027) | $0 | ($128,258) | $0 | ($123,578) | $0 | ($16,986) | - | - | ($1,215,849) |
| 4 | $0 | ($898,456) | $0 | ($129,013) | $0 | ($119,227) | $0 | ($16,388) | - | - | ($1,163,084) |
| 5 | $0 | ($851,296) | $0 | ($129,428) | $0 | ($114,917) | $0 | ($15,795) | - | - | ($1,111,436) |
| 6 | $0 | ($798,562) | $0 | ($126,468) | $0 | ($110,660) | $0 | ($15,210) | - | - | ($1,050,900) |
| 7 | $0 | ($741,119) | $0 | ($120,501) | $0 | ($106,468) | $0 | ($14,634) | - | - | ($982,722) |
| 8 | $0 | ($686,319) | $0 | ($114,427) | $0 | ($102,351) | $0 | ($14,068) | - | - | ($917,166) |
| 9 | $0 | ($615,324) | $0 | ($116,708) | $0 | ($98,317) | $0 | ($13,514) | - | - | ($843,863) |
| 10 | $0 | ($551,470) | $0 | ($118,284) | $0 | ($94,373) | $0 | ($12,972) | - | - | ($777,099) |
| 11 | $0 | ($476,957) | $0 | ($112,210) | $0 | ($90,524) | $0 | ($12,443) | - | - | ($692,133) |
| 12 | $0 | ($396,255) | $0 | ($99,650) | $0 | ($86,774) | $0 | ($11,927) | - | - | ($594,607) |
| 13 | $0 | ($323,872) | $0 | ($87,884) | $0 | ($83,128) | $0 | ($11,426) | - | - | ($506,310) |
| 14 | $0 | ($266,882) | $0 | ($73,806) | $0 | ($79,588) | $0 | ($10,939) | - | - | ($431,216) |
| 15 | $0 | ($177,568) | $0 | ($50,634) | $0 | ($76,155) | $0 | ($10,468) | - | - | ($314,825) |
| 16 | $0 | ($95,411) | $0 | ($29,107) | $0 | ($72,831) | $0 | ($10,011) | - | - | ($207,359) |
| 17 | $0 | $15,483 | $0 | ($16,090) | $0 | ($69,615) | $0 | ($9,569) | - | - | ($79,791) |
| 18 | $0 | $114,589 | $0 | ($4,163) | $0 | ($66,509) | $0 | ($9,142) | - | - | $34,775 |
| 19 | $0 | $231,082 | $0 | $23,047 | $0 | ($63,511) | $0 | ($8,730) | - | - | $181,888 |
| | | | | | | | | | | | |
| **Total** | **$0** | **($9,116,475)** | **$0** | **($1,644,903)** | **$0** | **($1,879,438)** | **$0** | **($258,331)** | **-** | **-** | **($12,899,146)** |

| Constant Dollars |
|---:|
| ($1,412,065) |
| $1,364,284 |
| |
| ($1,442,938) |
| ($1,489,468) |
| ($1,524,566) |
| ($1,558,847) |
| ($1,577,118) |
| ($1,578,037) |
| ($1,575,861) |
| ($1,551,408) |
| ($1,528,671) |
| ($1,456,838) |
| ($1,339,169) |
| ($1,220,129) |
| ($1,111,906) |
| ($868,613) |
| ($612,158) |
| ($252,045) |
| $117,539 |
| $657,804 |
| |
| **($19,960,210)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | All Periods | |
| 1 | $0 | $2,322,165 | $0 | $229,665 | $0 | $298,789 | $0 | $29,551 | $0 | $2,880,169 |
| 20 | $0 | $1,063,649 | $0 | $105,196 | $0 | $136,858 | $0 | $13,535 | $0 | $1,319,239 |
| 2 | $0 | $2,245,238 | $0 | $222,056 | $0 | $288,891 | $0 | $28,572 | $0 | $2,784,756 |
| 3 | $0 | $2,168,437 | $0 | $214,461 | $0 | $279,009 | $0 | $27,594 | $0 | $2,689,501 |
| 4 | $0 | $2,092,076 | $0 | $206,909 | $0 | $269,184 | $0 | $26,623 | $0 | $2,594,791 |
| 5 | $0 | $2,016,426 | $0 | $199,427 | $0 | $259,450 | $0 | $25,660 | $0 | $2,500,962 |
| 6 | $0 | $1,941,720 | $0 | $192,038 | $0 | $249,838 | $0 | $24,709 | $0 | $2,408,305 |
| 7 | $0 | $1,868,159 | $0 | $184,763 | $0 | $240,373 | $0 | $23,773 | $0 | $2,317,067 |
| 8 | $0 | $1,795,912 | $0 | $177,618 | $0 | $231,077 | $0 | $22,854 | $0 | $2,227,460 |
| 9 | $0 | $1,725,122 | $0 | $170,617 | $0 | $221,968 | $0 | $21,953 | $0 | $2,139,660 |
| 10 | $0 | $1,655,909 | $0 | $163,771 | $0 | $213,063 | $0 | $21,072 | $0 | $2,053,815 |
| 11 | $0 | $1,588,368 | $0 | $157,091 | $0 | $204,372 | $0 | $20,213 | $0 | $1,970,045 |
| 12 | $0 | $1,522,578 | $0 | $150,585 | $0 | $195,907 | $0 | $19,375 | $0 | $1,888,445 |
| 13 | $0 | $1,458,597 | $0 | $144,257 | $0 | $187,675 | $0 | $18,561 | $0 | $1,809,090 |
| 14 | $0 | $1,396,471 | $0 | $138,113 | $0 | $179,681 | $0 | $17,771 | $0 | $1,732,036 |
| 15 | $0 | $1,336,232 | $0 | $132,155 | $0 | $171,930 | $0 | $17,004 | $0 | $1,657,321 |
| 16 | $0 | $1,277,897 | $0 | $126,385 | $0 | $164,425 | $0 | $16,262 | $0 | $1,584,969 |
| 17 | $0 | $1,221,476 | $0 | $120,805 | $0 | $157,165 | $0 | $15,544 | $0 | $1,514,991 |
| 18 | $0 | $1,166,969 | $0 | $115,414 | $0 | $150,152 | $0 | $14,850 | $0 | $1,447,385 |
| 19 | $0 | $1,114,365 | $0 | $110,212 | $0 | $143,383 | $0 | $14,181 | $0 | $1,382,141 |
| **Total** | **$0** | **$32,977,766** | **$0** | **$3,261,537** | **$0** | **$4,243,189** | **$0** | **$419,656** | **$0** | **$40,902,148** |

| Constant Dollars |
|---|
| $3,081,780 |
| $5,105,037 |
| |
| $3,188,268 |
| $3,294,755 |
| $3,401,242 |
| $3,507,729 |
| $3,614,216 |
| $3,720,704 |
| $3,827,191 |
| $3,933,678 |
| $4,040,165 |
| $4,146,652 |
| $4,253,140 |
| $4,359,627 |
| $4,466,114 |
| $4,572,601 |
| $4,679,088 |
| $4,785,576 |
| $4,892,063 |
| $4,998,550 |
| |
| **$81,868,176** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,268) | $0 | ($14,529) | $0 | $0 | ($1,433) | $0 | ($2,162) |
| 20 | $0 | $14,801 | $0 | $42,617 | $0 | $0 | ($287) | $0 | ($263) |
| 2 | $0 | ($10,630) | $0 | ($9,710) | $0 | $0 | ($1,389) | $0 | ($2,091) |
| 3 | $0 | ($10,538) | $0 | ($5,182) | $0 | $0 | ($1,345) | $0 | ($2,020) |
| 4 | $0 | ($10,205) | $0 | ($4,380) | $0 | $0 | ($1,301) | $0 | ($1,950) |
| 5 | $0 | ($9,164) | $0 | ($3,685) | $0 | $0 | ($1,258) | $0 | ($1,880) |
| 6 | $0 | ($8,740) | $0 | ($3,230) | $0 | $0 | ($1,215) | $0 | ($1,811) |
| 7 | $0 | ($7,553) | $0 | ($3,005) | $0 | $0 | ($1,172) | $0 | ($1,743) |
| 8 | $0 | ($1,688) | $0 | $3,229 | $0 | $0 | ($457) | $0 | ($435) |
| 9 | $0 | ($768) | $0 | $4,189 | $0 | $0 | ($441) | $0 | ($418) |
| 10 | $0 | $87 | $0 | $5,010 | $0 | $0 | ($425) | $0 | ($402) |
| 11 | $0 | $1,056 | $0 | $6,288 | $0 | $0 | ($410) | $0 | ($386) |
| 12 | $0 | $1,985 | $0 | $7,859 | $0 | $0 | ($394) | $0 | ($371) |
| 13 | $0 | $2,901 | $0 | $9,329 | $0 | $0 | ($380) | $0 | ($356) |
| 14 | $0 | $3,568 | $0 | $11,499 | $0 | $0 | ($365) | $0 | ($341) |
| 15 | $0 | $4,934 | $0 | $16,003 | $0 | $0 | ($351) | $0 | ($327) |
| 16 | $0 | $6,228 | $0 | $20,049 | $0 | $0 | ($338) | $0 | ($313) |
| 17 | $0 | $8,421 | $0 | $23,007 | $0 | $0 | ($324) | $0 | ($300) |
| 18 | $0 | $10,041 | $0 | $25,653 | $0 | $0 | ($312) | $0 | ($287) |
| 19 | $0 | $12,117 | $0 | $32,403 | $0 | $0 | ($299) | $0 | ($275) |
| **Total** | **$0** | **($4,416)** | **$0** | **$163,415** | **$0** | **$0** | **($13,896)** | **$0** | **($18,132)** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($29,393) | ($31,450) |
| 20 | $0 | $0 | $0 | $0 | $56,868 | $220,063 |
| 2 | $0 | $0 | $0 | $0 | ($23,821) | ($27,273) |
| 3 | $0 | $0 | $0 | $0 | ($19,087) | ($23,382) |
| 4 | $0 | $0 | $0 | $0 | ($17,836) | ($23,379) |
| 5 | $0 | $0 | $0 | $0 | ($15,987) | ($22,422) |
| 6 | $0 | $0 | $0 | $0 | ($14,996) | ($22,504) |
| 7 | $0 | $0 | $0 | $0 | ($13,472) | ($21,634) |
| 8 | $0 | $0 | $0 | $0 | $650 | $1,117 |
| 9 | $0 | $0 | $0 | $0 | $2,561 | $4,709 |
| 10 | $0 | $0 | $0 | $0 | $4,269 | $8,398 |
| 11 | $0 | $0 | $0 | $0 | $6,548 | $13,783 |
| 12 | $0 | $0 | $0 | $0 | $9,079 | $20,447 |
| 13 | $0 | $0 | $0 | $0 | $11,495 | $27,701 |
| 14 | $0 | $0 | $0 | $0 | $14,360 | $37,027 |
| 15 | $0 | $0 | $0 | $0 | $20,258 | $55,894 |
| 16 | $0 | $0 | $0 | $0 | $25,626 | $75,653 |
| 17 | $0 | $0 | $0 | $0 | $30,803 | $97,302 |
| 18 | $0 | $0 | $0 | $0 | $35,096 | $118,621 |
| 19 | $0 | $0 | $0 | $0 | $43,947 | $158,935 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$126,971** | **$667,607** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|
| 1 | (5) | (2,185) | (2) | (0) | (0) | (1) | (0) |
| 20 | 19 | 10,199 | 19 | 0 | 0 | 2 | 0 |
| | | | | | | | |
| 2 | (5) | (2,011) | (2) | (0) | (0) | (1) | (0) |
| 3 | (5) | (1,922) | (2) | (0) | (0) | (1) | (0) |
| 4 | (5) | (1,864) | (2) | (0) | (0) | (1) | (0) |
| 5 | (4) | (1,799) | (2) | (0) | (0) | (0) | (0) |
| 6 | (4) | (1,663) | (2) | (0) | (0) | (0) | (0) |
| 7 | (3) | (1,451) | (1) | (0) | (0) | (0) | (0) |
| 8 | 1 | (832) | 0 | (0) | (0) | 0 | (0) |
| 9 | 2 | (674) | 1 | 0 | (0) | 0 | 0 |
| 10 | 2 | (506) | 1 | 0 | (0) | 0 | 0 |
| 11 | 3 | (210) | 1 | 0 | (0) | 0 | 0 |
| 12 | 4 | 224 | 2 | 0 | 0 | 0 | 0 |
| 13 | 5 | 679 | 2 | 0 | 0 | 0 | 0 |
| 14 | 6 | 1,134 | 3 | 0 | 0 | 0 | 0 |
| 15 | 7 | 2,058 | 5 | 0 | 0 | 1 | 0 |
| 16 | 8 | 3,025 | 7 | 0 | 0 | 1 | 0 |
| 17 | 10 | 4,229 | 8 | 0 | 0 | 1 | 0 |
| 18 | 12 | 5,483 | 10 | 0 | 0 | 1 | 0 |
| 19 | 15 | 7,459 | 13 | 0 | 0 | 2 | 0 |
| | | | | | | | |
| **Total** | **62** | **19,373** | **61** | **0** | **(0)** | **6** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | DOLLARS EMISSIONS SAVED<br>(PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
| 1 | $0 | ($1,890) | ($15,566) | ($8,650) | ($2,294) | ($992) |
| 20 | $0 | $3,553 | $40,482 | $10,349 | $1,250 | $1,234 |
| 2 | $0 | ($1,658) | ($13,046) | ($6,043) | ($2,155) | ($920) |
| 3 | $0 | ($1,510) | ($10,423) | ($4,279) | ($2,020) | ($855) |
| 4 | $0 | ($1,396) | ($9,795) | ($3,932) | ($1,949) | ($764) |
| 5 | $0 | ($1,285) | ($9,201) | ($3,027) | ($1,796) | ($678) |
| 6 | $0 | ($1,132) | ($8,349) | ($3,218) | ($1,721) | ($575) |
| 7 | $0 | ($942) | ($7,282) | ($3,207) | ($1,580) | ($462) |
| 8 | $0 | ($515) | $1,985 | ($527) | ($301) | $9 |
| 9 | $0 | ($397) | $2,982 | $146 | ($233) | $64 |
| 10 | $0 | ($284) | $3,893 | $715 | ($169) | $115 |
| 11 | $0 | ($112) | $5,186 | $1,336 | ($39) | $178 |
| 12 | $0 | $114 | $6,794 | $1,904 | $19 | $248 |
| 13 | $0 | $331 | $8,255 | $2,466 | $131 | $312 |
| 14 | $0 | $526 | $10,427 | $2,846 | $200 | $361 |
| 15 | $0 | $911 | $14,815 | $3,734 | $333 | $466 |
| 16 | $0 | $1,276 | $18,787 | $4,497 | $506 | $561 |
| 17 | $0 | $1,701 | $21,607 | $6,147 | $638 | $711 |
| 18 | $0 | $2,102 | $24,122 | $7,269 | $757 | $845 |
| 19 | $0 | $2,726 | $30,609 | $8,593 | $996 | $1,023 |
| **Total** | **$0** | **$2,118** | **$116,282** | **$17,119** | **($9,428)** | **$880** |

A

# NET PRESENT VALUE CALCULATION

| | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Travel Time Savings** | **Vehicle Op. Cost Savings** | **Accident Reductions** | **Vehicle Emission Reductions** | **Travel Time Savings** | **Vehicle Op. Cost Savings** | **Accident Reductions** | **Vehicle Emission Reductions** |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,263,932 | ($1,319,687) | $2,880,169 | ($29,393) | | | | |
| 2 | $1,504,925 | ($1,260,318) | $2,784,756 | ($23,821) | | | | |
| 3 | $1,750,102 | ($1,215,849) | $2,689,501 | ($19,087) | | | | |
| 4 | $2,000,339 | ($1,163,084) | $2,594,791 | ($17,836) | | | | |
| 5 | $2,256,781 | ($1,111,436) | $2,500,962 | ($15,987) | | | | |
| 6 | $2,520,880 | ($1,050,900) | $2,408,305 | ($14,996) | | | | |
| 7 | $2,794,459 | ($982,722) | $2,317,067 | ($13,472) | | | | |
| 8 | $3,079,795 | ($917,166) | $2,227,460 | $650 | | | | |
| 9 | $3,379,734 | ($843,863) | $2,139,660 | $2,561 | | | | |
| 10 | $3,697,847 | ($777,099) | $2,053,815 | $4,269 | | | | |
| 11 | $4,038,650 | ($692,133) | $1,970,045 | $6,548 | | | | |
| 12 | $4,407,923 | ($594,607) | $1,888,445 | $9,079 | | | | |
| 13 | $4,813,159 | ($506,310) | $1,809,090 | $11,495 | | | | |
| 14 | $5,264,249 | ($431,216) | $1,732,036 | $14,360 | | | | |
| 15 | $5,774,506 | ($314,825) | $1,657,321 | $20,258 | | | | |
| 16 | $6,362,297 | ($207,359) | $1,584,969 | $25,626 | | | | |
| 17 | $7,053,691 | ($79,791) | $1,514,991 | $30,803 | | | | |
| 18 | $7,886,993 | $34,775 | $1,447,385 | $35,096 | | | | |
| 19 | $8,920,904 | $181,888 | $1,382,141 | $43,947 | | | | |
| 20 | $10,250,231 | $352,557 | $1,319,239 | $56,868 | | | | |
| **Total** | $89,021,397 | ($12,899,146) | $40,902,148 | $126,971 | $0 | $0 | $0 | $0 |

14,893,457 Person-Hours of Time Saved

Person-Hours of Time Saved

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 62 | $0 | CO Saved | | | CO Saved |
| 19,373 | $2,118 | $CO_2$ Saved | | | $CO_2$ Saved |
| 61 | $116,282 | $NO_X$ Saved | | | $NO_X$ Saved |
| 0 | $17,119 | $PM_{10}$ Saved | | | $PM_{10}$ Saved |
| 0 | | $PM_{2.5}$ Saved | | | $PM_{2.5}$ Saved |
| (0) | ($9,428) | $SO_X$ Saved | | | $SO_X$ Saved |
| 6 | $880 | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $11,955,923 | ($1,903,233) | $3,681,193 | $145,283 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | |
| | | | | $0 | $27,659,000 | ($27,659,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $2,795,021 | ($382,243) | $3,177,264 |
| | | | | $3,005,542 | $18,342 | $2,987,200 |
| | | | | $3,204,667 | ($25,305) | $3,229,972 |
| | | | | $3,414,211 | $16,021 | $3,398,190 |
| | | | | $3,630,321 | ($22,103) | $3,652,423 |
| | | | | $3,863,289 | $93,954 | $3,769,335 |
| | | | | $4,115,332 | $13,078 | $4,102,254 |
| | | | | $4,390,739 | $12,222 | $4,378,517 |
| | | | | $4,678,092 | ($16,862) | $4,694,954 |
| | | | | $4,978,832 | $10,675 | $4,968,157 |
| | | | | $5,323,110 | $100,245 | $5,222,865 |
| | | | | $5,710,840 | ($1,979,405) | $7,690,245 |
| | | | | $6,127,435 | ($12,864) | $6,140,298 |
| | | | | $6,579,429 | $8,144 | $6,571,284 |
| | | | | $7,137,260 | ($11,236) | $7,148,496 |
| | | | | $7,765,533 | $630,724 | $7,134,809 |
| | | | | $8,519,694 | ($9,814) | $8,529,508 |
| | | | | $9,404,249 | $51,184 | $9,353,065 |
| | | | | $10,528,880 | ($8,572) | $10,537,451 |
| | | | | $11,978,895 | $5,427 | $11,973,468 |
| $0 | $0 | $0 | $0 | **$117,151,370** | **$26,150,613** | **$91,000,757** |

| | |
|---|---|
| | Person-Hours of Time Saved |

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| Year | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,352,407 | ($1,412,065) | $3,081,780 | ($31,450) | | | | |
| 2 | $1,722,989 | ($1,442,938) | $3,188,268 | ($27,273) | | | | |
| 3 | $2,143,950 | ($1,489,468) | $3,294,755 | ($23,382) | | | | |
| 4 | $2,622,037 | ($1,524,566) | $3,401,242 | ($23,379) | | | | |
| 5 | $3,165,253 | ($1,558,847) | $3,507,729 | ($22,422) | | | | |
| 6 | $3,783,161 | ($1,577,118) | $3,614,216 | ($22,504) | | | | |
| 7 | $4,487,290 | ($1,578,037) | $3,720,704 | ($21,634) | | | | |
| 8 | $5,291,661 | ($1,575,861) | $3,827,191 | $1,117 | | | | |
| 9 | $6,213,503 | ($1,551,408) | $3,933,678 | $4,709 | | | | |
| 10 | $7,274,224 | ($1,528,671) | $4,040,165 | $8,398 | | | | |
| 11 | $8,500,761 | ($1,456,838) | $4,146,652 | $13,783 | | | | |
| 12 | $9,927,487 | ($1,339,169) | $4,253,140 | $20,447 | | | | |
| 13 | $11,598,968 | ($1,220,129) | $4,359,627 | $27,701 | | | | |
| 14 | $13,574,045 | ($1,111,906) | $4,466,114 | $37,027 | | | | |
| 15 | $15,932,044 | ($868,613) | $4,572,601 | $55,894 | | | | |
| 16 | $18,782,542 | ($612,158) | $4,679,088 | $75,653 | | | | |
| 17 | $22,281,306 | ($252,045) | $4,785,576 | $97,302 | | | | |
| 18 | $26,657,502 | $117,539 | $4,892,063 | $118,621 | | | | |
| 19 | $32,262,694 | $657,804 | $4,998,550 | $158,935 | | | | |
| 20 | $39,665,160 | $1,364,284 | $5,105,037 | $220,063 | | | | |
| **Total** | $237,238,984 | ($19,960,210) | $81,868,176 | $667,607 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | | |
| | | | | $0 | $27,659,000 | ($27,659,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $2,990,673 | ($409,000) | $3,399,673 | $3,399,673 |
| | | | | $3,441,045 | $21,000 | $3,420,045 | $6,819,718 |
| | | | | $3,925,855 | ($31,000) | $3,956,855 | $10,776,573 |
| | | | | $4,475,334 | $21,000 | $4,454,334 | $15,230,907 |
| | | | | $5,091,712 | ($31,000) | $5,122,712 | $20,353,620 |
| | | | | $5,797,755 | $141,000 | $5,656,755 | $26,010,374 |
| | | | | $6,608,323 | $21,000 | $6,587,323 | $32,597,698 |
| | | | | $7,544,108 | $21,000 | $7,523,108 | $40,120,805 |
| | | | | $8,600,482 | ($31,000) | $8,631,482 | $48,752,287 |
| | | | | $9,794,116 | $21,000 | $9,773,116 | $58,525,404 |
| | | | | $11,204,358 | $211,000 | $10,993,358 | $69,518,761 |
| | | | | $12,861,905 | ($4,458,000) | $17,319,905 | $86,838,666 |
| | | | | $14,766,167 | ($31,000) | $14,797,167 | $101,635,834 |
| | | | | $16,965,281 | $21,000 | $16,944,281 | $118,580,115 |
| | | | | $19,691,927 | ($31,000) | $19,722,927 | $138,303,041 |
| | | | | $22,925,125 | $1,862,000 | $21,063,125 | $159,366,167 |
| | | | | $26,912,139 | ($31,000) | $26,943,139 | $186,309,306 |
| | | | | $31,785,725 | $173,000 | $31,612,725 | $217,922,030 |
| | | | | $38,077,983 | ($31,000) | $38,108,983 | $256,031,013 |
| | | | | $46,354,543 | $21,000 | $46,333,543 | $302,364,556 |
| $0 | $0 | $0 | $0 | **$299,814,556** | **$25,109,000** | **$274,705,556** | |

**Total Construction Costs** **$27,659,000**

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($27,659,000) |
| 2 | $3,399,673 |
| 3 | $3,420,045 |
| 4 | $3,956,855 |
| 5 | $4,454,334 |
| 6 | $5,122,712 |
| 7 | $5,656,755 |
| 8 | $6,587,323 |
| 9 | $7,523,108 |
| 10 | $8,631,482 |
| 11 | $9,773,116 |
| 12 | $10,993,358 |
| 13 | $17,319,905 |
| 14 | $14,797,167 |
| 15 | $16,944,281 |
| 16 | $19,722,927 |
| 17 | $21,063,125 |
| 18 | $26,943,139 |
| 19 | $31,612,725 |
| 20 | $38,108,983 |
| 21 | $46,333,543 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **22.81%** |
| **Payback Period** | **7 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | *1* |
| Real Discount Rate | 7.0% | *2* |

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | *3* |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | *3* |
| Benefits and Costs | $ 10.69 | $/hr | *4* |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | *5* |
| Truck | $ 31.20 | $/hr/veh | *5* |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | *6* |
| Transit | $ 13.75 | $/hr/per | *5* |
| Out-of-Vehicle Travel | 2 | times | *5* |
| Incident-Related Travel | 3 | times | *7* |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | *8* |
| Truck (diesel) | $ 3.07 | $/gal | *8* |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | *9* |
| State Sales Tax (diesel) | **13.00%** | % | *9* |
| Average Local Sales Tax | 0.50% | % | *9* |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | *9* |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | *9* |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | *9* |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | *9* |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | *10* |
| Truck | $ 0.437 | $/mi | *11* |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | *12* |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | *12* |
| Level B (Moderate) | $ 125,000 | $/event | *12* |
| Level C (Minor) | $ 63,900 | $/event | *12* |
| Cost of Property Damage | $ 4,300 | $/event | *13* |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | *14* |
| Injury Accident | 0.29 | per mil veh-mi | *14* |
| PDO Accident | 0.55 | per mil veh-mi | *14* |
| Non-Freeway | 1.05 | per mil veh-mi | *15* |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

OMB GDP Deflator Table 10.1

https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |
| **OMB GDP Inflator** | **1.01719172** | |

Yellow cells - adjusted

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | *16* |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | *17* |
| HOV Lanes | 0.55 | 8 | 1,600 | | *18* |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

## *Active Transportation Parameters*

| | Value | Units | |
|---|---|---|---|
| General Travel Activity Characteristics Parameters | | | |
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| Vehicle Statistics | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | *19* |
| Active Transportation User Characteristics | | | |
| Average Cycling Speed | 11.80 | mph | *20* |
| Average Walking Speed | 3.00 | mph | *21* |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | *19* |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | *19* |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| Value of Travel Time | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class | | | |
| Class I | 0.57 | - | *20* |
| Class II | 0.49 | - | *20* |
| Class III | 0.92 | - | *20* |
| Class IV | 0.49 | - | *20* |
| *Note: Class IV assumed to be the same as Class II* | | | |
| Walking Journey Quality Values per Mile by Amentity | | | |
| Street Lighting | $0.110 | $/mi | *22* |
| Curb Level | $0.078 | $/mi | *22* |
| Crowding | $0.055 | $/mi | *22* |
| Pavement Evenness | $0.026 | $/mi | *22* |
| Information Panels | $0.026 | $/mi | *22* |
| Benches | $0.017 | $/mi | *22* |
| Directional Signage | $0.017 | $/mi | *22* |
| Health (Absenteeism Reduction) | | | |
| Average Absence of Employees | 3.60 | days/yr | *23* |
| Percentage Covered by Short-Term Sick Leave | 95% | % | *24* |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | *25* |
| Health (Mortality Reduction) | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | *26* |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | *26* |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | *27* |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | *27* |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | *28* |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | *28* |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

**Project Types**

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

## *Travel Demand Tables*

### DEMAND FOR TRAVEL IN PEAK PERIOD

(percent of total daily travel)

| Number of Hours in Peak Period | Urban | | | | Rural | |
|---|---|---|---|---|---|---|
| | So. California | | No. California | | | |
| | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

### AGE COHORTS FOR MORTALITY RISK REDUCTION

(percent of population)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

### AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP

(miles/trip)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

### TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS

(percent of trips)

| Mode | Trip Purpose | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident | | 0.1176 | 0.6446 |
| Cost per Event | | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary*
*Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

**HIGHWAY EMISSIONS FACTORS (g/mi)**

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

**HIGHWAY EMISSIONS FACTORS (g/mi)**

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

## HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | $CO_2e$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

$CO_2e$ Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

## PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 | | 583.58 | 62.02 | | 19.73 | |
| | 2022 | 45.67 | | 250.11 | 31.01 | | 19.73 | |

## LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 | | 1.13 | 0.17 | | 0.06 | |
| | 2022 | 0.14 | | 1.14 | 0.17 | | 0.06 | |

## FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 | | 10,206 | 28.10 | 0.43 | | | |
| | 2030 | | 10,206 | 28.10 | 0.43 | | | |

Freight Rail Fuel Efficiency 468 ton-miles/gal
Fuel Burned at Idle 4 gal/hr

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## ***Pavement Adjustments*** (used only for pavement projects)

### PAVEMENT DETERIORATION

(IRI in inches/mile)

| Year 0 | Year 20, By Loading | | |
|---|---|---|---|
| | Light | Medium | Heavy |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

### VEHICLE OPERATING SPEED

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

### FUEL CONSUMPTION

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

### NON-FUEL COSTS

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## *Weaving Adjustments* (used only for freeway connector, HOV connector, and HOV drop ramp projects)

**VEHICLE OPERATING SPEED**

(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## *TMS Adjustments* (used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

**PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS**

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| Strategy | Speed | Volume | Speed | Volume | TT | VOC | Em | Benefit |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

**TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS**

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| TMS Strategy | Time | Capital | O&M |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

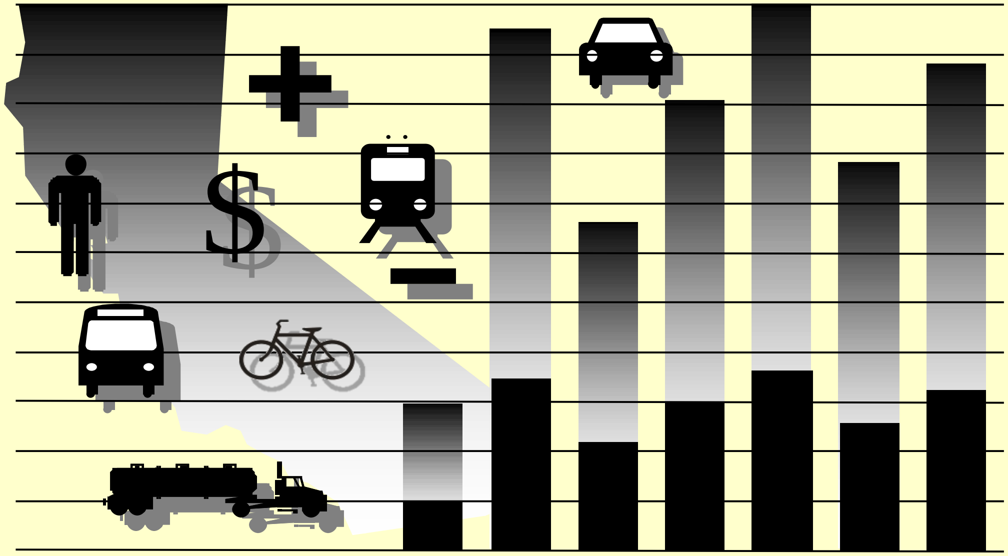
Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Divided 29M (2019) +10% TPC, 40062 ADT

WAR-63 Priority Project BCA

California Department Of Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**

**Division of Transportation Planning**

Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

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# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period. Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual. Other adjustments are made for weaving and pavement conditions. An option is also available to conduct a simple queuing analysis. Accidents are estimated from statewide averages and recent data for the facility. If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically. Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road. The user clicks a button and the model clears the Project Information worksheet to receive information on other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed). The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available. The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed). These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### **PROJECT DATA** (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

### *Type of Project*

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

### *Project Location*

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

### *Length of Construction Period*

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

### *One- or Two-Way Data*

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

### *Length of Peak Period(s)*

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

### *Highway Design*

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

### *Average Daily Traffic (ADT)*

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

***Average Hourly HOV/HOT Lane Traffic***

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

***Percent Traffic in Weave***

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

***Percent Trucks***

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

***Truck Speed***

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

***On-Ramp Volume***

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

***Queue Formation***

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

***Pavement Condition (for Pavement Rehab. Projects)***

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

***Average Vehicle Occupancy (AVO)***

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## **HIGHWAY ACCIDENT DATA** (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

***Actual 3-Year Accident Data (from Table B)***

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

***Statewide Basic Average Accident Rate***

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## **RAIL AND TRANSIT DATA** (Box 1D)

*This section is used for rail and transit projects only.*

***Annual Person-Trips***

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

***Percent Trips during Peak Period***

32 Insert % annual person-trips that occur during peak period.

***Percent New Trips from Parallel Highway***

33 Insert % new transit person-trips originating on parallel highway.

***Annual Vehicle-Miles***

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

***Average Vehicles per Train***

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

***Reduction in Transit Accidents***

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

***Average Transit Travel Time***

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

***Highway Grade Crossing***

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

***Transit Agency Costs (for Transit TMS Projects)***

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

1E

# PROJECT COSTS (enter costs in thousands of dollars)

| Col. no. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | | |
|---|---|---|---|---|---|---|---|---|---|
| | DIRECT PROJECT COSTS | | | | | | Transit Agency Cost Savings | TOTAL COSTS (in dollars) | |
| | INITIAL COSTS | | | SUBSEQUENT COSTS | | | | | |
| Year | Project Support | R / W | Construction | Maint./ Op. | Rehab. | Mitigation | | Constant Dollars | Present Value |
| **Construction Period** | | | | | | | | | |
| 1 | $787 | $262 | $29,376 | | | | | $30,425,000 | $30,425,000 |
| 2 | | | | | | | | 0 | 0 |
| 3 | | | | | | | | 0 | 0 |
| 4 | | | | | | | | 0 | 0 |
| 5 | | | | | | | | 0 | 0 |
| 6 | | | | | | | | 0 | 0 |
| 7 | | | | | | | | 0 | 0 |
| 8 | | | | | | | | 0 | 0 |
| **Project Open** | | | | | | | | | |
| 1 | | | | $21 | ($430) | | | ($409,000) | ($382,243) |
| 2 | | | | $21 | | | | 21,000 | 18,342 |
| 3 | | | | $21 | ($52) | | | (31,000) | (25,305) |
| 4 | | | | $21 | | | | 21,000 | 16,021 |
| 5 | | | | $21 | ($52) | | | (31,000) | (22,103) |
| 6 | | | | $21 | $120 | | | 141,000 | 93,954 |
| 7 | | | | $21 | | | | 21,000 | 13,078 |
| 8 | | | | $21 | | | | 21,000 | 12,222 |
| 9 | | | | $21 | ($52) | | | (31,000) | (16,862) |
| 10 | | | | $21 | | | | 21,000 | 10,675 |
| 11 | | | | $21 | $190 | | | 211,000 | 100,245 |
| 12 | | | | $21 | ($4,479) | | | (4,458,000) | (1,979,405) |
| 13 | | | | $21 | ($52) | | | (31,000) | (12,864) |
| 14 | | | | $21 | | | | 21,000 | 8,144 |
| 15 | | | | $21 | ($52) | | | (31,000) | (11,236) |
| 16 | | | | $21 | $1,841 | | | 1,862,000 | 630,724 |
| 17 | | | | $21 | ($52) | | | (31,000) | (9,814) |
| 18 | | | | $21 | $152 | | | 173,000 | 51,184 |
| 19 | | | | $21 | ($52) | | | (31,000) | (8,572) |
| 20 | | | | $21 | | | | 21,000 | 5,427 |
| **Total** | $787 | $262 | $29,376 | $420 | ($2,970) | $0 | $0 | $27,875,000 | $28,916,613 |

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 32,300 | | 32,300 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 3,195 | | 3,195 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 59.4 | | 59.4 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 4,156 | | 4,156 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 411 | | 411 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |

**Hwy Safety or Weaving Improvement** 0% collision reduction factor (per HSIP Guidelines)

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.007 | | 0.007 | |
| Injury Accidents | 0.21 | | 0.21 | |
| PDO Accidents | 0.59 | | 0.59 | |
| Total Accidents | 0.813 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

**Detailed Information Available?** (y/n) N

**Aggregate Segment Length** (estimate as VMT/total volume)

All Ramps miles

Arterials miles

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

# ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 13,558,088 | 1,596,025 |
| Truck Trips | 1,028,749 | 1,166,009 | 137,260 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 1,972,037 | 232,143 |
| Truck Trips | 132,367 | 150,028 | 17,661 |
| Total Trips | 14,863,073 | 16,846,162 | 1,983,089 |

**District:** **WCTID**

**PROJECT:** **WAR 63 Priority Segment 4-Lane Divided**

EA:

PPNO:

3

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| **Life-Cycle Costs (mil. $)** | $28.9 |
| **Life-Cycle Benefits (mil. $)** | $117.2 |
| **Net Present Value (mil. $)** | $88.2 |
| **Benefit / Cost Ratio:** | 4.1 |
| **Rate of Return on Investment:** | 21.4% |
| **Payback Period:** | 7 years |

| **ITEMIZED BENEFITS (mil. $)** | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| **Travel Time Savings** | $77.1 | $12.0 | $89.0 | $4.5 |
| **Veh. Op. Cost Savings** | -$11.0 | -$1.9 | -$12.9 | -$0.6 |
| **Accident Cost Savings** | $37.2 | $3.7 | $40.9 | $2.0 |
| **Emission Cost Savings** | -$0.0 | $0.1 | $0.1 | $0.0 |
| **TOTAL BENEFITS** | $103.3 | $13.9 | $117.2 | $5.9 |
| **Person-Hours of Time Saved** | | | 14,893,457 | 744,673 |

***Should benefit-cost results include:***

| | |
|---|---|
| **1) Induced Travel? (y/n)** | Y<br>Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y<br>Default = Y |
| **3) Accident Costs? (y/n)** | Y<br>Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for $CO_2e$ | Y<br>Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| **EMISSIONS REDUCTION** | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| **CO Emissions Saved** | 62 | 3 | $0.0 | $0.0 |
| **$CO_2$ Emissions Saved** | 19,373 | 969 | $0.0 | $0.0 |
| **$NO_X$ Emissions Saved** | 61 | 3 | $0.1 | $0.0 |
| **$PM_{10}$ Emissions Saved** | 0 | 0 | $0.0 | $0.0 |
| **$PM_{2.5}$ Emissions Saved** | 0 | 0 | | |
| **$SO_X$ Emissions Saved** | 0 | 0 | -$0.0 | -$0.0 |
| **VOC Emissions Saved** | 6 | 0 | $0.0 | $0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $1,098,713 | $0 | $21,244 | $0 | $0 | $143,975 | $0 | $0 |
| 20 | $0 | $8,591,679 | $0 | $1,592,605 | $0 | $0 | $65,947 | $0 | $0 |
| 2 | $0 | $1,298,582 | $0 | $67,138 | $0 | $0 | $139,205 | $0 | $0 |
| 3 | $0 | $1,501,981 | $0 | $113,677 | $0 | $0 | $134,444 | $0 | $0 |
| 4 | $0 | $1,709,650 | $0 | $160,980 | $0 | $0 | $129,710 | $0 | $0 |
| 5 | $0 | $1,922,550 | $0 | $209,212 | $0 | $0 | $125,019 | $0 | $0 |
| 6 | $0 | $2,141,900 | $0 | $258,592 | $0 | $0 | $120,388 | $0 | $0 |
| 7 | $0 | $2,369,229 | $0 | $309,403 | $0 | $0 | $115,827 | $0 | $0 |
| 8 | $0 | $2,606,443 | $0 | $362,005 | $0 | $0 | $111,348 | $0 | $0 |
| 9 | $0 | $2,855,926 | $0 | $416,850 | $0 | $0 | $106,959 | $0 | $0 |
| 10 | $0 | $3,120,666 | $0 | $474,513 | $0 | $0 | $102,667 | $0 | $0 |
| 11 | $0 | $3,404,444 | $0 | $535,727 | $0 | $0 | $98,480 | $0 | $0 |
| 12 | $0 | $3,712,094 | $0 | $601,428 | $0 | $0 | $94,401 | $0 | $0 |
| 13 | $0 | $4,049,889 | $0 | $672,837 | $0 | $0 | $90,434 | $0 | $0 |
| 14 | $0 | $4,426,101 | $0 | $751,565 | $0 | $0 | $86,582 | $0 | $0 |
| 15 | $0 | $4,851,872 | $0 | $839,787 | $0 | $0 | $82,847 | $0 | $0 |
| 16 | $0 | $5,342,567 | $0 | $940,499 | $0 | $0 | $79,231 | $0 | $0 |
| 17 | $0 | $5,919,998 | $0 | $1,057,960 | $0 | $0 | $75,733 | $0 | $0 |
| 18 | $0 | $6,616,216 | $0 | $1,198,424 | $0 | $0 | $72,353 | $0 | $0 |
| 19 | $0 | $7,480,334 | $0 | $1,371,478 | $0 | $0 | $69,092 | $0 | $0 |
| **Total** | **$0** | **$75,020,833** | **$0** | **$11,955,923** | **$0** | **$0** | **$2,044,641** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| | Peak In-Vehicle | Peak Out-of-Veh | Non-Peak In-Vehicle | Non-Peak Out-of-Veh | | | |
| 1 | $0 | $0 | $0 | $0 | $1,263,932 | $1,352,407 | 91,339 |
| 20 | $0 | $0 | $0 | $0 | $10,250,231 | $39,665,160 | 2,469,324 |
| 2 | $0 | $0 | $0 | $0 | $1,504,925 | $1,722,989 | 114,541 |
| 3 | $0 | $0 | $0 | $0 | $1,750,102 | $2,143,950 | 140,862 |
| 4 | $0 | $0 | $0 | $0 | $2,000,339 | $2,622,037 | 170,722 |
| 5 | $0 | $0 | $0 | $0 | $2,256,781 | $3,165,253 | 204,615 |
| 6 | $0 | $0 | $0 | $0 | $2,520,880 | $3,783,161 | 243,134 |
| 7 | $0 | $0 | $0 | $0 | $2,794,459 | $4,487,290 | 286,994 |
| 8 | $0 | $0 | $0 | $0 | $3,079,795 | $5,291,661 | 337,063 |
| 9 | $0 | $0 | $0 | $0 | $3,379,734 | $6,213,503 | 394,408 |
| 10 | $0 | $0 | $0 | $0 | $3,697,847 | $7,274,224 | 460,356 |
| 11 | $0 | $0 | $0 | $0 | $4,038,650 | $8,500,761 | 536,575 |
| 12 | $0 | $0 | $0 | $0 | $4,407,923 | $9,927,487 | 625,195 |
| 13 | $0 | $0 | $0 | $0 | $4,813,159 | $11,598,968 | 728,977 |
| 14 | $0 | $0 | $0 | $0 | $5,264,249 | $13,574,045 | 851,567 |
| 15 | $0 | $0 | $0 | $0 | $5,774,506 | $15,932,044 | 997,878 |
| 16 | $0 | $0 | $0 | $0 | $6,362,297 | $18,782,542 | 1,174,700 |
| 17 | $0 | $0 | $0 | $0 | $7,053,691 | $22,281,306 | 1,391,682 |
| 18 | $0 | $0 | $0 | $0 | $7,886,993 | $26,657,502 | 1,663,023 |
| 19 | $0 | $0 | $0 | $0 | $8,920,904 | $32,262,694 | 2,010,501 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$89,021,397** | **$237,238,984** | **14,893,457** |

C

# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | | Present Value of |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | Veh Op Cost Benefits |
| 1 | $0 | ($1,028,520) | $0 | ($140,639) | $0 | ($132,338) | $0 | ($18,190) | - | - | ($1,319,687) |
| 20 | $0 | $357,976 | $0 | $63,534 | $0 | ($60,621) | $0 | ($8,332) | - | - | $352,557 |
| | | | | | | | | | | | |
| 2 | $0 | ($980,563) | $0 | ($134,213) | $0 | ($127,955) | $0 | ($17,587) | - | - | ($1,260,318) |
| 3 | $0 | ($947,027) | $0 | ($128,258) | $0 | ($123,578) | $0 | ($16,986) | - | - | ($1,215,849) |
| 4 | $0 | ($898,456) | $0 | ($129,013) | $0 | ($119,227) | $0 | ($16,388) | - | - | ($1,163,084) |
| 5 | $0 | ($851,296) | $0 | ($129,428) | $0 | ($114,917) | $0 | ($15,795) | - | - | ($1,111,436) |
| 6 | $0 | ($798,562) | $0 | ($126,468) | $0 | ($110,660) | $0 | ($15,210) | - | - | ($1,050,900) |
| 7 | $0 | ($741,119) | $0 | ($120,501) | $0 | ($106,468) | $0 | ($14,634) | - | - | ($982,722) |
| 8 | $0 | ($686,319) | $0 | ($114,427) | $0 | ($102,351) | $0 | ($14,068) | - | - | ($917,166) |
| 9 | $0 | ($615,324) | $0 | ($116,708) | $0 | ($98,317) | $0 | ($13,514) | - | - | ($843,863) |
| 10 | $0 | ($551,470) | $0 | ($118,284) | $0 | ($94,373) | $0 | ($12,972) | - | - | ($777,099) |
| 11 | $0 | ($476,957) | $0 | ($112,210) | $0 | ($90,524) | $0 | ($12,443) | - | - | ($692,133) |
| 12 | $0 | ($396,255) | $0 | ($99,650) | $0 | ($86,774) | $0 | ($11,927) | - | - | ($594,607) |
| 13 | $0 | ($323,872) | $0 | ($87,884) | $0 | ($83,128) | $0 | ($11,426) | - | - | ($506,310) |
| 14 | $0 | ($266,882) | $0 | ($73,806) | $0 | ($79,588) | $0 | ($10,939) | - | - | ($431,216) |
| 15 | $0 | ($177,568) | $0 | ($50,634) | $0 | ($76,155) | $0 | ($10,468) | - | - | ($314,825) |
| 16 | $0 | ($95,411) | $0 | ($29,107) | $0 | ($72,831) | $0 | ($10,011) | - | - | ($207,359) |
| 17 | $0 | $15,483 | $0 | ($16,090) | $0 | ($69,615) | $0 | ($9,569) | - | - | ($79,791) |
| 18 | $0 | $114,589 | $0 | ($4,163) | $0 | ($66,509) | $0 | ($9,142) | - | - | $34,775 |
| 19 | $0 | $231,082 | $0 | $23,047 | $0 | ($63,511) | $0 | ($8,730) | - | - | $181,888 |
| | | | | | | | | | | | |
| **Total** | **$0** | **($9,116,475)** | **$0** | **($1,644,903)** | **$0** | **($1,879,438)** | **$0** | **($258,331)** | **-** | **-** | **($12,899,146)** |

| Constant Dollars |
|---|
| ($1,412,065) |
| $1,364,284 |
| |
| ($1,442,938) |
| ($1,489,468) |
| ($1,524,566) |
| ($1,558,847) |
| ($1,577,118) |
| ($1,578,037) |
| ($1,575,861) |
| ($1,551,408) |
| ($1,528,671) |
| ($1,456,838) |
| ($1,339,169) |
| ($1,220,129) |
| ($1,111,906) |
| ($868,613) |
| ($612,158) |
| ($252,045) |
| $117,539 |
| $657,804 |
| |
| **($19,960,210)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | All Periods | |
| 1 | $0 | $2,322,165 | $0 | $229,665 | $0 | $298,789 | $0 | $29,551 | $0 | $2,880,169 |
| 20 | $0 | $1,063,649 | $0 | $105,196 | $0 | $136,858 | $0 | $13,535 | $0 | $1,319,239 |
| | | | | | | | | | | |
| 2 | $0 | $2,245,238 | $0 | $222,056 | $0 | $288,891 | $0 | $28,572 | $0 | $2,784,756 |
| 3 | $0 | $2,168,437 | $0 | $214,461 | $0 | $279,009 | $0 | $27,594 | $0 | $2,689,501 |
| 4 | $0 | $2,092,076 | $0 | $206,909 | $0 | $269,184 | $0 | $26,623 | $0 | $2,594,791 |
| 5 | $0 | $2,016,426 | $0 | $199,427 | $0 | $259,450 | $0 | $25,660 | $0 | $2,500,962 |
| 6 | $0 | $1,941,720 | $0 | $192,038 | $0 | $249,838 | $0 | $24,709 | $0 | $2,408,305 |
| 7 | $0 | $1,868,159 | $0 | $184,763 | $0 | $240,373 | $0 | $23,773 | $0 | $2,317,067 |
| 8 | $0 | $1,795,912 | $0 | $177,618 | $0 | $231,077 | $0 | $22,854 | $0 | $2,227,460 |
| 9 | $0 | $1,725,122 | $0 | $170,617 | $0 | $221,968 | $0 | $21,953 | $0 | $2,139,660 |
| 10 | $0 | $1,655,909 | $0 | $163,771 | $0 | $213,063 | $0 | $21,072 | $0 | $2,053,815 |
| 11 | $0 | $1,588,368 | $0 | $157,091 | $0 | $204,372 | $0 | $20,213 | $0 | $1,970,045 |
| 12 | $0 | $1,522,578 | $0 | $150,585 | $0 | $195,907 | $0 | $19,375 | $0 | $1,888,445 |
| 13 | $0 | $1,458,597 | $0 | $144,257 | $0 | $187,675 | $0 | $18,561 | $0 | $1,809,090 |
| 14 | $0 | $1,396,471 | $0 | $138,113 | $0 | $179,681 | $0 | $17,771 | $0 | $1,732,036 |
| 15 | $0 | $1,336,232 | $0 | $132,155 | $0 | $171,930 | $0 | $17,004 | $0 | $1,657,321 |
| 16 | $0 | $1,277,897 | $0 | $126,385 | $0 | $164,425 | $0 | $16,262 | $0 | $1,584,969 |
| 17 | $0 | $1,221,476 | $0 | $120,805 | $0 | $157,165 | $0 | $15,544 | $0 | $1,514,991 |
| 18 | $0 | $1,166,969 | $0 | $115,414 | $0 | $150,152 | $0 | $14,850 | $0 | $1,447,385 |
| 19 | $0 | $1,114,365 | $0 | $110,212 | $0 | $143,383 | $0 | $14,181 | $0 | $1,382,141 |
| | | | | | | | | | | |
| **Total** | **$0** | **$32,977,766** | **$0** | **$3,261,537** | **$0** | **$4,243,189** | **$0** | **$419,656** | **$0** | **$40,902,148** |

| Constant Dollars |
|---|
| $3,081,780 |
| $5,105,037 |
| |
| $3,188,268 |
| $3,294,755 |
| $3,401,242 |
| $3,507,729 |
| $3,614,216 |
| $3,720,704 |
| $3,827,191 |
| $3,933,678 |
| $4,040,165 |
| $4,146,652 |
| $4,253,140 |
| $4,359,627 |
| $4,466,114 |
| $4,572,601 |
| $4,679,088 |
| $4,785,576 |
| $4,892,063 |
| $4,998,550 |
| |
| **$81,868,176** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,268) | $0 | ($14,529) | $0 | $0 | ($1,433) | $0 | ($2,162) |
| 20 | $0 | $14,801 | $0 | $42,617 | $0 | $0 | ($287) | $0 | ($263) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | $0 | ($10,630) | $0 | ($9,710) | $0 | $0 | ($1,389) | $0 | ($2,091) |
| 3 | $0 | ($10,538) | $0 | ($5,182) | $0 | $0 | ($1,345) | $0 | ($2,020) |
| 4 | $0 | ($10,205) | $0 | ($4,380) | $0 | $0 | ($1,301) | $0 | ($1,950) |
| 5 | $0 | ($9,164) | $0 | ($3,685) | $0 | $0 | ($1,258) | $0 | ($1,880) |
| 6 | $0 | ($8,740) | $0 | ($3,230) | $0 | $0 | ($1,215) | $0 | ($1,811) |
| 7 | $0 | ($7,553) | $0 | ($3,005) | $0 | $0 | ($1,172) | $0 | ($1,743) |
| 8 | $0 | ($1,688) | $0 | $3,229 | $0 | $0 | ($457) | $0 | ($435) |
| 9 | $0 | ($768) | $0 | $4,189 | $0 | $0 | ($441) | $0 | ($418) |
| 10 | $0 | $87 | $0 | $5,010 | $0 | $0 | ($425) | $0 | ($402) |
| 11 | $0 | $1,056 | $0 | $6,288 | $0 | $0 | ($410) | $0 | ($386) |
| 12 | $0 | $1,985 | $0 | $7,859 | $0 | $0 | ($394) | $0 | ($371) |
| 13 | $0 | $2,901 | $0 | $9,329 | $0 | $0 | ($380) | $0 | ($356) |
| 14 | $0 | $3,568 | $0 | $11,499 | $0 | $0 | ($365) | $0 | ($341) |
| 15 | $0 | $4,934 | $0 | $16,003 | $0 | $0 | ($351) | $0 | ($327) |
| 16 | $0 | $6,228 | $0 | $20,049 | $0 | $0 | ($338) | $0 | ($313) |
| 17 | $0 | $8,421 | $0 | $23,007 | $0 | $0 | ($324) | $0 | ($300) |
| 18 | $0 | $10,041 | $0 | $25,653 | $0 | $0 | ($312) | $0 | ($287) |
| 19 | $0 | $12,117 | $0 | $32,403 | $0 | $0 | ($299) | $0 | ($275) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Total** | **$0** | **($4,416)** | **$0** | **$163,415** | **$0** | **$0** | **($13,896)** | **$0** | **($18,132)** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT |  |  |  | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
|  | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail |  |  |
| 1 | $0 | $0 | $0 | $0 | ($29,393) | ($31,450) |
| 20 | $0 | $0 | $0 | $0 | $56,868 | $220,063 |
| 2 | $0 | $0 | $0 | $0 | ($23,821) | ($27,273) |
| 3 | $0 | $0 | $0 | $0 | ($19,087) | ($23,382) |
| 4 | $0 | $0 | $0 | $0 | ($17,836) | ($23,379) |
| 5 | $0 | $0 | $0 | $0 | ($15,987) | ($22,422) |
| 6 | $0 | $0 | $0 | $0 | ($14,996) | ($22,504) |
| 7 | $0 | $0 | $0 | $0 | ($13,472) | ($21,634) |
| 8 | $0 | $0 | $0 | $0 | $650 | $1,117 |
| 9 | $0 | $0 | $0 | $0 | $2,561 | $4,709 |
| 10 | $0 | $0 | $0 | $0 | $4,269 | $8,398 |
| 11 | $0 | $0 | $0 | $0 | $6,548 | $13,783 |
| 12 | $0 | $0 | $0 | $0 | $9,079 | $20,447 |
| 13 | $0 | $0 | $0 | $0 | $11,495 | $27,701 |
| 14 | $0 | $0 | $0 | $0 | $14,360 | $37,027 |
| 15 | $0 | $0 | $0 | $0 | $20,258 | $55,894 |
| 16 | $0 | $0 | $0 | $0 | $25,626 | $75,653 |
| 17 | $0 | $0 | $0 | $0 | $30,803 | $97,302 |
| 18 | $0 | $0 | $0 | $0 | $35,096 | $118,621 |
| 19 | $0 | $0 | $0 | $0 | $43,947 | $158,935 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$126,971** | **$667,607** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
| 1 | (5) | (2,185) | (2) | (0) | (0) | (1) | (0) |
| 20 | 19 | 10,199 | 19 | 0 | 0 | 2 | 0 |
| 2 | (5) | (2,011) | (2) | (0) | (0) | (1) | (0) |
| 3 | (5) | (1,922) | (2) | (0) | (0) | (1) | (0) |
| 4 | (5) | (1,864) | (2) | (0) | (0) | (1) | (0) |
| 5 | (4) | (1,799) | (2) | (0) | (0) | (0) | (0) |
| 6 | (4) | (1,663) | (2) | (0) | (0) | (0) | (0) |
| 7 | (3) | (1,451) | (1) | (0) | (0) | (0) | (0) |
| 8 | 1 | (832) | 0 | (0) | (0) | 0 | (0) |
| 9 | 2 | (674) | 1 | 0 | (0) | 0 | 0 |
| 10 | 2 | (506) | 1 | 0 | (0) | 0 | 0 |
| 11 | 3 | (210) | 1 | 0 | (0) | 0 | 0 |
| 12 | 4 | 224 | 2 | 0 | 0 | 0 | 0 |
| 13 | 5 | 679 | 2 | 0 | 0 | 0 | 0 |
| 14 | 6 | 1,134 | 3 | 0 | 0 | 0 | 0 |
| 15 | 7 | 2,058 | 5 | 0 | 0 | 1 | 0 |
| 16 | 8 | 3,025 | 7 | 0 | 0 | 1 | 0 |
| 17 | 10 | 4,229 | 8 | 0 | 0 | 1 | 0 |
| 18 | 12 | 5,483 | 10 | 0 | 0 | 1 | 0 |
| 19 | 15 | 7,459 | 13 | 0 | 0 | 2 | 0 |
| **Total** | **62** | **19,373** | **61** | **0** | **(0)** | **6** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | DOLLARS EMISSIONS SAVED (PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
| 1 | $0 | ($1,890) | ($15,566) | ($8,650) | ($2,294) | ($992) |
| 20 | $0 | $3,553 | $40,482 | $10,349 | $1,250 | $1,234 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | $0 | ($1,658) | ($13,046) | ($6,043) | ($2,155) | ($920) |
| 3 | $0 | ($1,510) | ($10,423) | ($4,279) | ($2,020) | ($855) |
| 4 | $0 | ($1,396) | ($9,795) | ($3,932) | ($1,949) | ($764) |
| 5 | $0 | ($1,285) | ($9,201) | ($3,027) | ($1,796) | ($678) |
| 6 | $0 | ($1,132) | ($8,349) | ($3,218) | ($1,721) | ($575) |
| 7 | $0 | ($942) | ($7,282) | ($3,207) | ($1,580) | ($462) |
| 8 | $0 | ($515) | $1,985 | ($527) | ($301) | $9 |
| 9 | $0 | ($397) | $2,982 | $146 | ($233) | $64 |
| 10 | $0 | ($284) | $3,893 | $715 | ($169) | $115 |
| 11 | $0 | ($112) | $5,186 | $1,336 | ($39) | $178 |
| 12 | $0 | $114 | $6,794 | $1,904 | $19 | $248 |
| 13 | $0 | $331 | $8,255 | $2,466 | $131 | $312 |
| 14 | $0 | $526 | $10,427 | $2,846 | $200 | $361 |
| 15 | $0 | $911 | $14,815 | $3,734 | $333 | $466 |
| 16 | $0 | $1,276 | $18,787 | $4,497 | $506 | $561 |
| 17 | $0 | $1,701 | $21,607 | $6,147 | $638 | $711 |
| 18 | $0 | $2,102 | $24,122 | $7,269 | $757 | $845 |
| 19 | $0 | $2,726 | $30,609 | $8,593 | $996 | $1,023 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total** | **$0** | **$2,118** | **$116,282** | **$17,119** | **($9,428)** | **$880** |

A

# NET PRESENT VALUE CALCULATION

| | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Travel Time Savings** | **Vehicle Op. Cost Savings** | **Accident Reductions** | **Vehicle Emission Reductions** | **Travel Time Savings** | **Vehicle Op. Cost Savings** | **Accident Reductions** | **Vehicle Emission Reductions** |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,263,932 | ($1,319,687) | $2,880,169 | ($29,393) | | | | |
| 2 | $1,504,925 | ($1,260,318) | $2,784,756 | ($23,821) | | | | |
| 3 | $1,750,102 | ($1,215,849) | $2,689,501 | ($19,087) | | | | |
| 4 | $2,000,339 | ($1,163,084) | $2,594,791 | ($17,836) | | | | |
| 5 | $2,256,781 | ($1,111,436) | $2,500,962 | ($15,987) | | | | |
| 6 | $2,520,880 | ($1,050,900) | $2,408,305 | ($14,996) | | | | |
| 7 | $2,794,459 | ($982,722) | $2,317,067 | ($13,472) | | | | |
| 8 | $3,079,795 | ($917,166) | $2,227,460 | $650 | | | | |
| 9 | $3,379,734 | ($843,863) | $2,139,660 | $2,561 | | | | |
| 10 | $3,697,847 | ($777,099) | $2,053,815 | $4,269 | | | | |
| 11 | $4,038,650 | ($692,133) | $1,970,045 | $6,548 | | | | |
| 12 | $4,407,923 | ($594,607) | $1,888,445 | $9,079 | | | | |
| 13 | $4,813,159 | ($506,310) | $1,809,090 | $11,495 | | | | |
| 14 | $5,264,249 | ($431,216) | $1,732,036 | $14,360 | | | | |
| 15 | $5,774,506 | ($314,825) | $1,657,321 | $20,258 | | | | |
| 16 | $6,362,297 | ($207,359) | $1,584,969 | $25,626 | | | | |
| 17 | $7,053,691 | ($79,791) | $1,514,991 | $30,803 | | | | |
| 18 | $7,886,993 | $34,775 | $1,447,385 | $35,096 | | | | |
| 19 | $8,920,904 | $181,888 | $1,382,141 | $43,947 | | | | |
| 20 | $10,250,231 | $352,557 | $1,319,239 | $56,868 | | | | |
| **Total** | $89,021,397 | ($12,899,146) | $40,902,148 | $126,971 | $0 | $0 | $0 | $0 |

| | | | |
|---|---|---|---|
| 14,893,457 | Person-Hours of Time Saved | | Person-Hours of Time Saved |

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 62 | $0 | CO Saved | | | CO Saved |
| 19,373 | $2,118 | $CO_2$ Saved | | | $CO_2$ Saved |
| 61 | $116,282 | $NO_X$ Saved | | | $NO_X$ Saved |
| 0 | $17,119 | $PM_{10}$ Saved | | | $PM_{10}$ Saved |
| 0 | | $PM_{2.5}$ Saved | | | $PM_{2.5}$ Saved |
| (0) | ($9,428) | $SO_X$ Saved | | | $SO_X$ Saved |
| 6 | $880 | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $11,955,923 | ($1,903,233) | $3,681,193 | $145,283 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | |
| | | | | $0 | $30,425,000 | ($30,425,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $2,795,021 | ($382,243) | $3,177,264 |
| | | | | $3,005,542 | $18,342 | $2,987,200 |
| | | | | $3,204,667 | ($25,305) | $3,229,972 |
| | | | | $3,414,211 | $16,021 | $3,398,190 |
| | | | | $3,630,321 | ($22,103) | $3,652,423 |
| | | | | $3,863,289 | $93,954 | $3,769,335 |
| | | | | $4,115,332 | $13,078 | $4,102,254 |
| | | | | $4,390,739 | $12,222 | $4,378,517 |
| | | | | $4,678,092 | ($16,862) | $4,694,954 |
| | | | | $4,978,832 | $10,675 | $4,968,157 |
| | | | | $5,323,110 | $100,245 | $5,222,865 |
| | | | | $5,710,840 | ($1,979,405) | $7,690,245 |
| | | | | $6,127,435 | ($12,864) | $6,140,298 |
| | | | | $6,579,429 | $8,144 | $6,571,284 |
| | | | | $7,137,260 | ($11,236) | $7,148,496 |
| | | | | $7,765,533 | $630,724 | $7,134,809 |
| | | | | $8,519,694 | ($9,814) | $8,529,508 |
| | | | | $9,404,249 | $51,184 | $9,353,065 |
| | | | | $10,528,880 | ($8,572) | $10,537,451 |
| | | | | $11,978,895 | $5,427 | $11,973,468 |
| $0 | $0 | $0 | $0 | **$117,151,370** | **$28,916,613** | **$88,234,757** |

Person-Hours of Time Saved

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,352,407 | ($1,412,065) | $3,081,780 | ($31,450) | | | | |
| 2 | $1,722,989 | ($1,442,938) | $3,188,268 | ($27,273) | | | | |
| 3 | $2,143,950 | ($1,489,468) | $3,294,755 | ($23,382) | | | | |
| 4 | $2,622,037 | ($1,524,566) | $3,401,242 | ($23,379) | | | | |
| 5 | $3,165,253 | ($1,558,847) | $3,507,729 | ($22,422) | | | | |
| 6 | $3,783,161 | ($1,577,118) | $3,614,216 | ($22,504) | | | | |
| 7 | $4,487,290 | ($1,578,037) | $3,720,704 | ($21,634) | | | | |
| 8 | $5,291,661 | ($1,575,861) | $3,827,191 | $1,117 | | | | |
| 9 | $6,213,503 | ($1,551,408) | $3,933,678 | $4,709 | | | | |
| 10 | $7,274,224 | ($1,528,671) | $4,040,165 | $8,398 | | | | |
| 11 | $8,500,761 | ($1,456,838) | $4,146,652 | $13,783 | | | | |
| 12 | $9,927,487 | ($1,339,169) | $4,253,140 | $20,447 | | | | |
| 13 | $11,598,968 | ($1,220,129) | $4,359,627 | $27,701 | | | | |
| 14 | $13,574,045 | ($1,111,906) | $4,466,114 | $37,027 | | | | |
| 15 | $15,932,044 | ($868,613) | $4,572,601 | $55,894 | | | | |
| 16 | $18,782,542 | ($612,158) | $4,679,088 | $75,653 | | | | |
| 17 | $22,281,306 | ($252,045) | $4,785,576 | $97,302 | | | | |
| 18 | $26,657,502 | $117,539 | $4,892,063 | $118,621 | | | | |
| 19 | $32,262,694 | $657,804 | $4,998,550 | $158,935 | | | | |
| 20 | $39,665,160 | $1,364,284 | $5,105,037 | $220,063 | | | | |
| **Total** | $237,238,984 | ($19,960,210) | $81,868,176 | $667,607 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | | |
| | | | | $0 | $30,425,000 | ($30,425,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $2,990,673 | ($409,000) | $3,399,673 | $3,399,673 |
| | | | | $3,441,045 | $21,000 | $3,420,045 | $6,819,718 |
| | | | | $3,925,855 | ($31,000) | $3,956,855 | $10,776,573 |
| | | | | $4,475,334 | $21,000 | $4,454,334 | $15,230,907 |
| | | | | $5,091,712 | ($31,000) | $5,122,712 | $20,353,620 |
| | | | | $5,797,755 | $141,000 | $5,656,755 | $26,010,374 |
| | | | | $6,608,323 | $21,000 | $6,587,323 | $32,597,698 |
| | | | | $7,544,108 | $21,000 | $7,523,108 | $40,120,805 |
| | | | | $8,600,482 | ($31,000) | $8,631,482 | $48,752,287 |
| | | | | $9,794,116 | $21,000 | $9,773,116 | $58,525,404 |
| | | | | $11,204,358 | $211,000 | $10,993,358 | $69,518,761 |
| | | | | $12,861,905 | ($4,458,000) | $17,319,905 | $86,838,666 |
| | | | | $14,766,167 | ($31,000) | $14,797,167 | $101,635,834 |
| | | | | $16,965,281 | $21,000 | $16,944,281 | $118,580,115 |
| | | | | $19,691,927 | ($31,000) | $19,722,927 | $138,303,041 |
| | | | | $22,925,125 | $1,862,000 | $21,063,125 | $159,366,167 |
| | | | | $26,912,139 | ($31,000) | $26,943,139 | $186,309,306 |
| | | | | $31,785,725 | $173,000 | $31,612,725 | $217,922,030 |
| | | | | $38,077,983 | ($31,000) | $38,108,983 | $256,031,013 |
| | | | | $46,354,543 | $21,000 | $46,333,543 | $302,364,556 |
| $0 | $0 | $0 | $0 | **$299,814,556** | **$27,875,000** | **$271,939,556** | |

| | |
|---|---|
| **Total Construction Costs** | **$30,425,000** |

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($30,425,000) |
| 2 | $3,399,673 |
| 3 | $3,420,045 |
| 4 | $3,956,855 |
| 5 | $4,454,334 |
| 6 | $5,122,712 |
| 7 | $5,656,755 |
| 8 | $6,587,323 |
| 9 | $7,523,108 |
| 10 | $8,631,482 |
| 11 | $9,773,116 |
| 12 | $10,993,358 |
| 13 | $17,319,905 |
| 14 | $14,797,167 |
| 15 | $16,944,281 |
| 16 | $19,722,927 |
| 17 | $21,063,125 |
| 18 | $26,943,139 |
| 19 | $31,612,725 |
| 20 | $38,108,983 |
| 21 | $46,333,543 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **21.43%** |
| **Payback Period** | **7 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |
| **OMB GDP Inflator** | **1.01719172** | |

Yellow cells - adjusted

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | 1 |
| Real Discount Rate | 7.0% | 2 |

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | 3 |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | 3 |
| Benefits and Costs | $ 10.69 | $/hr | 4 |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | 5 |
| Truck | $ 31.20 | $/hr/veh | 5 |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | 6 |
| Transit | $ 13.75 | $/hr/per | 5 |
| Out-of-Vehicle Travel | 2 | times | 5 |
| Incident-Related Travel | 3 | times | 7 |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | 8 |
| Truck (diesel) | $ 3.07 | $/gal | 8 |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | 9 |
| State Sales Tax (diesel) | **13.00%** | % | 9 |
| Average Local Sales Tax | 0.50% | % | 9 |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | 9 |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | 9 |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | 9 |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | 9 |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | 10 |
| Truck | $ 0.437 | $/mi | 11 |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

### *Accident Cost Parameters*

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | 12 |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | 12 |
| Level B (Moderate) | $ 125,000 | $/event | 12 |
| Level C (Minor) | $ 63,900 | $/event | 12 |
| Cost of Property Damage | $ 4,300 | $/event | 13 |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | 14 |
| Injury Accident | 0.29 | per mil veh-mi | 14 |
| PDO Accident | 0.55 | per mil veh-mi | 14 |
| Non-Freeway | 1.05 | per mil veh-mi | 15 |

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | 16 |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | 16, 17 |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | 16, 17 |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | 17 |
| HOV Lanes | 0.55 | 8 | 1,600 | | 18 |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

alue

## *Active Transportation Parameters*

| General Travel Activity Characteristics Parameters | Value | Units | |
|---|---|---|---|
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| **Vehicle Statistics** | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | *19* |
| **Active Transportation User Characteristics** | | | |
| Average Cycling Speed | 11.80 | mph | *20* |
| Average Walking Speed | 3.00 | mph | *21* |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | *19* |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | *19* |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| **Value of Travel Time** | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| **Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class** | | | |
| Class I | 0.57 | - | *20* |
| Class II | 0.49 | - | *20* |
| Class III | 0.92 | - | *20* |
| Class IV | 0.49 | - | *20* |
| *Note: Class IV assumed to be the same as Class II* | | | |
| **Walking Journey Quality Values per Mile by Amentity** | | | |
| Street Lighting | $0.110 | $/mi | *22* |
| Curb Level | $0.078 | $/mi | *22* |
| Crowding | $0.055 | $/mi | *22* |
| Pavement Evenness | $0.026 | $/mi | *22* |
| Information Panels | $0.026 | $/mi | *22* |
| Benches | $0.017 | $/mi | *22* |
| Directional Signage | $0.017 | $/mi | *22* |
| **Health (Absenteeism Reduction)** | | | |
| Average Absence of Employees | 3.60 | days/yr | *23* |
| Percentage Covered by Short-Term Sick Leave | 95% | % | *24* |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | *25* |
| **Health (Mortality Reduction)** | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | *26* |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | *26* |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | *27* |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | *27* |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | *28* |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | *28* |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

## *Travel Demand Tables*

***Project Types***

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| | | | |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| | | | |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| | | | |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| | | | |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

### DEMAND FOR TRAVEL IN PEAK PERIOD

(percent of total daily travel)

| Number of Hours in Peak Period | Urban | | | | Rural | |
|---|---|---|---|---|---|---|
| | So. California | | No. California | | | |
| | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

### AGE COHORTS FOR MORTALITY RISK REDUCTION

(percent of population)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

### AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP

(miles/trip)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

### TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS

(percent of trips)

| Mode | Trip Purpose | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident | | 0.1176 | 0.6446 |
| Cost per Event | | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary*
*Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

## HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | $CO_2$e | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

$CO_2$e Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

## PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 |  | 583.58 | 62.02 |  | 19.73 |  |
|  | 2022 | 45.67 |  | 250.11 | 31.01 |  | 19.73 |  |

## LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 |  | 1.13 | 0.17 |  | 0.06 |  |
|  | 2022 | 0.14 |  | 1.14 | 0.17 |  | 0.06 |  |

## FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |
|  | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |

| | | |
|---|---|---|
| Freight Rail Fuel Efficiency | 468 | ton-miles/gal |
| Fuel Burned at Idle | 4 | gal/hr |

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## ***Pavement Adjustments*** (used only for pavement projects)

### PAVEMENT DETERIORATION

(IRI in inches/mile)

| | Year 20, By Loading | | |
|---|---|---|---|
| **Year 0** | **Light** | **Medium** | **Heavy** |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

### VEHICLE OPERATING SPEED

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

### FUEL CONSUMPTION

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

### NON-FUEL COSTS

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## *Weaving Adjustments*

(used only for freeway connector, HOV connector, and HOV drop ramp projects)

### VEHICLE OPERATING SPEED

(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## *TMS Adjustments*

(used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

### PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| Strategy | Speed | Volume | Speed | Volume | TT | VOC | Em | Benefit |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

### TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| TMS Strategy | Time | Capital | O&M |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

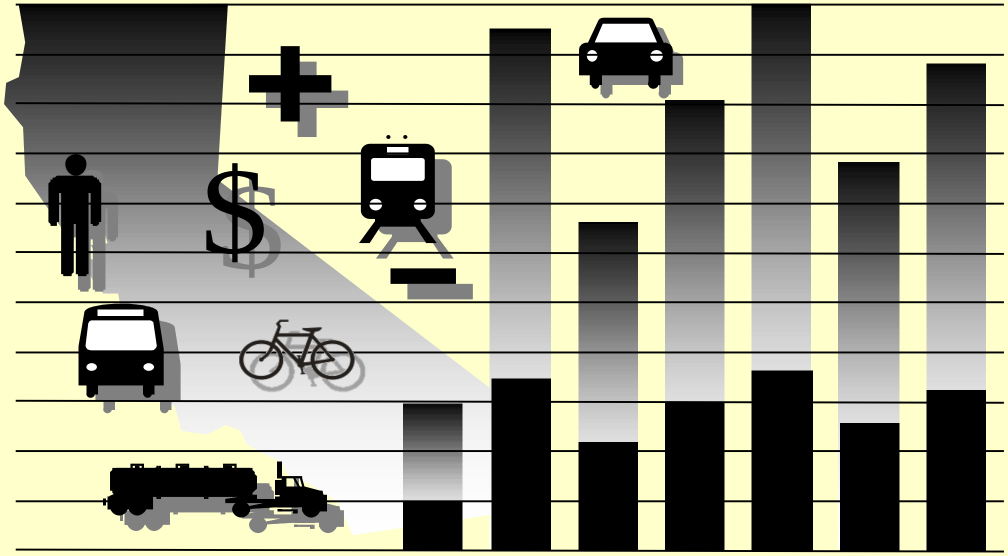
Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Divided 29M (2019) -10% TPC, 40062 ADT

WAR-63 Priority Project BCA

Caltrans
California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**
Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

Rose Agacer (916) 651-6014 rose_agacer@dot.ca.gov

# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period. Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual. Other adjustments are made for weaving and pavement conditions. An option is also available to conduct a simple queuing analysis. Accidents are estimated from statewide averages and recent data for the facility. If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically. Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road. The user clicks a button and the model clears the Project Information worksheet to receive information on other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed). The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available. The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed). These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### **PROJECT DATA** (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

### *Type of Project*

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

### *Project Location*

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

### *Length of Construction Period*

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

### *One- or Two-Way Data*

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

### *Length of Peak Period(s)*

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

### *Highway Design*

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

### *Average Daily Traffic (ADT)*

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

***Average Hourly HOV/HOT Lane Traffic***

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

***Percent Traffic in Weave***

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

***Percent Trucks***

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

***Truck Speed***

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

***On-Ramp Volume***

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

***Queue Formation***

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

***Pavement Condition (for Pavement Rehab. Projects)***

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

***Average Vehicle Occupancy (AVO)***

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## **HIGHWAY ACCIDENT DATA** (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

***Actual 3-Year Accident Data (from Table B)***

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

***Statewide Basic Average Accident Rate***

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## **RAIL AND TRANSIT DATA** (Box 1D)

*This section is used for rail and transit projects only.*

***Annual Person-Trips***

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

***Percent Trips during Peak Period***

32 Insert % annual person-trips that occur during peak period.

***Percent New Trips from Parallel Highway***

33 Insert % new transit person-trips originating on parallel highway.

***Annual Vehicle-Miles***

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

***Average Vehicles per Train***

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

***Reduction in Transit Accidents***

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

***Average Transit Travel Time***

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

***Highway Grade Crossing***

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

***Transit Agency Costs (for Transit TMS Projects)***

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

1E

# PROJECT COSTS (enter costs in thousands of dollars)

| Col. no. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | | |
|---|---|---|---|---|---|---|---|---|---|
| | DIRECT PROJECT COSTS | | | | | | Transit Agency Cost Savings | TOTAL COSTS (in dollars) | |
| | INITIAL COSTS | | | SUBSEQUENT COSTS | | | | | |
| Year | Project Support | R / W | Construction | Maint./ Op. | Rehab. | Mitigation | | Constant Dollars | Present Value |
| **Construction Period** | | | | | | | | | |
| 1 | $644 | $215 | $24,035 | | | | | $24,894,000 | $24,894,000 |
| 2 | | | | | | | | 0 | 0 |
| 3 | | | | | | | | 0 | 0 |
| 4 | | | | | | | | 0 | 0 |
| 5 | | | | | | | | 0 | 0 |
| 6 | | | | | | | | 0 | 0 |
| 7 | | | | | | | | 0 | 0 |
| 8 | | | | | | | | 0 | 0 |
| **Project Open** | | | | | | | | | |
| 1 | | | | $21 | ($430) | | | ($409,000) | ($382,243) |
| 2 | | | | $21 | | | | 21,000 | 18,342 |
| 3 | | | | $21 | ($52) | | | (31,000) | (25,305) |
| 4 | | | | $21 | | | | 21,000 | 16,021 |
| 5 | | | | $21 | ($52) | | | (31,000) | (22,103) |
| 6 | | | | $21 | $120 | | | 141,000 | 93,954 |
| 7 | | | | $21 | | | | 21,000 | 13,078 |
| 8 | | | | $21 | | | | 21,000 | 12,222 |
| 9 | | | | $21 | ($52) | | | (31,000) | (16,862) |
| 10 | | | | $21 | | | | 21,000 | 10,675 |
| 11 | | | | $21 | $190 | | | 211,000 | 100,245 |
| 12 | | | | $21 | ($4,479) | | | (4,458,000) | (1,979,405) |
| 13 | | | | $21 | ($52) | | | (31,000) | (12,864) |
| 14 | | | | $21 | | | | 21,000 | 8,144 |
| 15 | | | | $21 | ($52) | | | (31,000) | (11,236) |
| 16 | | | | $21 | $1,841 | | | 1,862,000 | 630,724 |
| 17 | | | | $21 | ($52) | | | (31,000) | (9,814) |
| 18 | | | | $21 | $152 | | | 173,000 | 51,184 |
| 19 | | | | $21 | ($52) | | | (31,000) | (8,572) |
| 20 | | | | $21 | | | | 21,000 | 5,427 |
| **Total** | $644 | $215 | $24,035 | $420 | ($2,970) | $0 | $0 | $22,344,000 | $23,385,613 |

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 32,300 | | 32,300 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 3,195 | | 3,195 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 59.4 | | 59.4 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 4,156 | | 4,156 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 411 | | 411 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |

**Hwy Safety or Weaving Improvement** 0% collision reduction factor (per HSIP Guidelines)

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.007 | | 0.007 | |
| Injury Accidents | 0.21 | | 0.21 | |
| PDO Accidents | 0.59 | | 0.59 | |
| Total Accidents | 0.813 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

**Detailed Information Available?** (y/n) N

**Aggregate Segment Length** (estimate as VMT/total volume)

All Ramps ____ miles

Arterials ____ miles

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

## ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 13,558,088 | 1,596,025 |
| Truck Trips | 1,028,749 | 1,166,009 | 137,260 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 1,972,037 | 232,143 |
| Truck Trips | 132,367 | 150,028 | 17,661 |
| Total Trips | 14,863,073 | 16,846,162 | 1,983,089 |

| | |
|---|---|
| **District:** | **WCTID** |
| **PROJECT:** | **WAR 63 Priority Segment 4-Lane Divided** |

| | |
|---|---|
| EA: | |
| PPNO: | |

3

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| **Life-Cycle Costs (mil. $)** | $23.4 |
| **Life-Cycle Benefits (mil. $)** | $117.2 |
| **Net Present Value (mil. $)** | $93.8 |
| **Benefit / Cost Ratio:** | 5.0 |
| **Rate of Return on Investment:** | 24.4% |
| **Payback Period:** | 6 years |

| **ITEMIZED BENEFITS (mil. $)** | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| **Travel Time Savings** | $77.1 | $12.0 | $89.0 | $4.5 |
| **Veh. Op. Cost Savings** | -$11.0 | -$1.9 | -$12.9 | -$0.6 |
| **Accident Cost Savings** | $37.2 | $3.7 | $40.9 | $2.0 |
| **Emission Cost Savings** | -$0.0 | $0.1 | $0.1 | $0.0 |
| **TOTAL BENEFITS** | $103.3 | $13.9 | $117.2 | $5.9 |
| **Person-Hours of Time Saved** | | | 14,893,457 | 744,673 |

***Should benefit-cost results include:***

| | |
|---|---|
| **1) Induced Travel? (y/n)** | Y<br>Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y<br>Default = Y |
| **3) Accident Costs? (y/n)** | Y<br>Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for $CO_2e$ | Y<br>Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| **EMISSIONS REDUCTION** | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| **CO Emissions Saved** | 62 | 3 | $0.0 | $0.0 |
| **$CO_2$ Emissions Saved** | 19,373 | 969 | $0.0 | $0.0 |
| **$NO_X$ Emissions Saved** | 61 | 3 | $0.1 | $0.0 |
| **$PM_{10}$ Emissions Saved** | 0 | 0 | $0.0 | $0.0 |
| **$PM_{2.5}$ Emissions Saved** | 0 | 0 | | |
| **$SO_X$ Emissions Saved** | 0 | 0 | -$0.0 | -$0.0 |
| **VOC Emissions Saved** | 6 | 0 | $0.0 | $0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $1,098,713 | $0 | $21,244 | $0 | $0 | $143,975 | $0 | $0 |
| 20 | $0 | $8,591,679 | $0 | $1,592,605 | $0 | $0 | $65,947 | $0 | $0 |
| 2 | $0 | $1,298,582 | $0 | $67,138 | $0 | $0 | $139,205 | $0 | $0 |
| 3 | $0 | $1,501,981 | $0 | $113,677 | $0 | $0 | $134,444 | $0 | $0 |
| 4 | $0 | $1,709,650 | $0 | $160,980 | $0 | $0 | $129,710 | $0 | $0 |
| 5 | $0 | $1,922,550 | $0 | $209,212 | $0 | $0 | $125,019 | $0 | $0 |
| 6 | $0 | $2,141,900 | $0 | $258,592 | $0 | $0 | $120,388 | $0 | $0 |
| 7 | $0 | $2,369,229 | $0 | $309,403 | $0 | $0 | $115,827 | $0 | $0 |
| 8 | $0 | $2,606,443 | $0 | $362,005 | $0 | $0 | $111,348 | $0 | $0 |
| 9 | $0 | $2,855,926 | $0 | $416,850 | $0 | $0 | $106,959 | $0 | $0 |
| 10 | $0 | $3,120,666 | $0 | $474,513 | $0 | $0 | $102,667 | $0 | $0 |
| 11 | $0 | $3,404,444 | $0 | $535,727 | $0 | $0 | $98,480 | $0 | $0 |
| 12 | $0 | $3,712,094 | $0 | $601,428 | $0 | $0 | $94,401 | $0 | $0 |
| 13 | $0 | $4,049,889 | $0 | $672,837 | $0 | $0 | $90,434 | $0 | $0 |
| 14 | $0 | $4,426,101 | $0 | $751,565 | $0 | $0 | $86,582 | $0 | $0 |
| 15 | $0 | $4,851,872 | $0 | $839,787 | $0 | $0 | $82,847 | $0 | $0 |
| 16 | $0 | $5,342,567 | $0 | $940,499 | $0 | $0 | $79,231 | $0 | $0 |
| 17 | $0 | $5,919,998 | $0 | $1,057,960 | $0 | $0 | $75,733 | $0 | $0 |
| 18 | $0 | $6,616,216 | $0 | $1,198,424 | $0 | $0 | $72,353 | $0 | $0 |
| 19 | $0 | $7,480,334 | $0 | $1,371,478 | $0 | $0 | $69,092 | $0 | $0 |
| **Total** | **$0** | **$75,020,833** | **$0** | **$11,955,923** | **$0** | **$0** | **$2,044,641** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| | Peak In-Vehicle | Peak Out-of-Veh | Non-Peak In-Vehicle | Non-Peak Out-of-Veh | | | |
| 1 | $0 | $0 | $0 | $0 | $1,263,932 | $1,352,407 | 91,339 |
| 20 | $0 | $0 | $0 | $0 | $10,250,231 | $39,665,160 | 2,469,324 |
| 2 | $0 | $0 | $0 | $0 | $1,504,925 | $1,722,989 | 114,541 |
| 3 | $0 | $0 | $0 | $0 | $1,750,102 | $2,143,950 | 140,862 |
| 4 | $0 | $0 | $0 | $0 | $2,000,339 | $2,622,037 | 170,722 |
| 5 | $0 | $0 | $0 | $0 | $2,256,781 | $3,165,253 | 204,615 |
| 6 | $0 | $0 | $0 | $0 | $2,520,880 | $3,783,161 | 243,134 |
| 7 | $0 | $0 | $0 | $0 | $2,794,459 | $4,487,290 | 286,994 |
| 8 | $0 | $0 | $0 | $0 | $3,079,795 | $5,291,661 | 337,063 |
| 9 | $0 | $0 | $0 | $0 | $3,379,734 | $6,213,503 | 394,408 |
| 10 | $0 | $0 | $0 | $0 | $3,697,847 | $7,274,224 | 460,356 |
| 11 | $0 | $0 | $0 | $0 | $4,038,650 | $8,500,761 | 536,575 |
| 12 | $0 | $0 | $0 | $0 | $4,407,923 | $9,927,487 | 625,195 |
| 13 | $0 | $0 | $0 | $0 | $4,813,159 | $11,598,968 | 728,977 |
| 14 | $0 | $0 | $0 | $0 | $5,264,249 | $13,574,045 | 851,567 |
| 15 | $0 | $0 | $0 | $0 | $5,774,506 | $15,932,044 | 997,878 |
| 16 | $0 | $0 | $0 | $0 | $6,362,297 | $18,782,542 | 1,174,700 |
| 17 | $0 | $0 | $0 | $0 | $7,053,691 | $22,281,306 | 1,391,682 |
| 18 | $0 | $0 | $0 | $0 | $7,886,993 | $26,657,502 | 1,663,023 |
| 19 | $0 | $0 | $0 | $0 | $8,920,904 | $32,262,694 | 2,010,501 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$89,021,397** | **$237,238,984** | **14,893,457** |

C

# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| | HIGHWAY | | | | | | | | TRANSIT | | Present Value of Veh Op Cost Benefits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | |
| 1 | $0 | ($1,028,520) | $0 | ($140,639) | $0 | ($132,338) | $0 | ($18,190) | - | - | ($1,319,687) |
| 20 | $0 | $357,976 | $0 | $63,534 | $0 | ($60,621) | $0 | ($8,332) | - | - | $352,557 |
| | | | | | | | | | | | |
| 2 | $0 | ($980,563) | $0 | ($134,213) | $0 | ($127,955) | $0 | ($17,587) | - | - | ($1,260,318) |
| 3 | $0 | ($947,027) | $0 | ($128,258) | $0 | ($123,578) | $0 | ($16,986) | - | - | ($1,215,849) |
| 4 | $0 | ($898,456) | $0 | ($129,013) | $0 | ($119,227) | $0 | ($16,388) | - | - | ($1,163,084) |
| 5 | $0 | ($851,296) | $0 | ($129,428) | $0 | ($114,917) | $0 | ($15,795) | - | - | ($1,111,436) |
| 6 | $0 | ($798,562) | $0 | ($126,468) | $0 | ($110,660) | $0 | ($15,210) | - | - | ($1,050,900) |
| 7 | $0 | ($741,119) | $0 | ($120,501) | $0 | ($106,468) | $0 | ($14,634) | - | - | ($982,722) |
| 8 | $0 | ($686,319) | $0 | ($114,427) | $0 | ($102,351) | $0 | ($14,068) | - | - | ($917,166) |
| 9 | $0 | ($615,324) | $0 | ($116,708) | $0 | ($98,317) | $0 | ($13,514) | - | - | ($843,863) |
| 10 | $0 | ($551,470) | $0 | ($118,284) | $0 | ($94,373) | $0 | ($12,972) | - | - | ($777,099) |
| 11 | $0 | ($476,957) | $0 | ($112,210) | $0 | ($90,524) | $0 | ($12,443) | - | - | ($692,133) |
| 12 | $0 | ($396,255) | $0 | ($99,650) | $0 | ($86,774) | $0 | ($11,927) | - | - | ($594,607) |
| 13 | $0 | ($323,872) | $0 | ($87,884) | $0 | ($83,128) | $0 | ($11,426) | - | - | ($506,310) |
| 14 | $0 | ($266,882) | $0 | ($73,806) | $0 | ($79,588) | $0 | ($10,939) | - | - | ($431,216) |
| 15 | $0 | ($177,568) | $0 | ($50,634) | $0 | ($76,155) | $0 | ($10,468) | - | - | ($314,825) |
| 16 | $0 | ($95,411) | $0 | ($29,107) | $0 | ($72,831) | $0 | ($10,011) | - | - | ($207,359) |
| 17 | $0 | $15,483 | $0 | ($16,090) | $0 | ($69,615) | $0 | ($9,569) | - | - | ($79,791) |
| 18 | $0 | $114,589 | $0 | ($4,163) | $0 | ($66,509) | $0 | ($9,142) | - | - | $34,775 |
| 19 | $0 | $231,082 | $0 | $23,047 | $0 | ($63,511) | $0 | ($8,730) | - | - | $181,888 |
| | | | | | | | | | | | |
| **Total** | **$0** | **($9,116,475)** | **$0** | **($1,644,903)** | **$0** | **($1,879,438)** | **$0** | **($258,331)** | **-** | **-** | **($12,899,146)** |

| Constant Dollars |
|---|
| ($1,412,065) |
| $1,364,284 |
| |
| ($1,442,938) |
| ($1,489,468) |
| ($1,524,566) |
| ($1,558,847) |
| ($1,577,118) |
| ($1,578,037) |
| ($1,575,861) |
| ($1,551,408) |
| ($1,528,671) |
| ($1,456,838) |
| ($1,339,169) |
| ($1,220,129) |
| ($1,111,906) |
| ($868,613) |
| ($612,158) |
| ($252,045) |
| $117,539 |
| $657,804 |
| |
| **($19,960,210)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | All Periods | |
| 1 | $0 | $2,322,165 | $0 | $229,665 | $0 | $298,789 | $0 | $29,551 | $0 | $2,880,169 |
| 20 | $0 | $1,063,649 | $0 | $105,196 | $0 | $136,858 | $0 | $13,535 | $0 | $1,319,239 |
| 2 | $0 | $2,245,238 | $0 | $222,056 | $0 | $288,891 | $0 | $28,572 | $0 | $2,784,756 |
| 3 | $0 | $2,168,437 | $0 | $214,461 | $0 | $279,009 | $0 | $27,594 | $0 | $2,689,501 |
| 4 | $0 | $2,092,076 | $0 | $206,909 | $0 | $269,184 | $0 | $26,623 | $0 | $2,594,791 |
| 5 | $0 | $2,016,426 | $0 | $199,427 | $0 | $259,450 | $0 | $25,660 | $0 | $2,500,962 |
| 6 | $0 | $1,941,720 | $0 | $192,038 | $0 | $249,838 | $0 | $24,709 | $0 | $2,408,305 |
| 7 | $0 | $1,868,159 | $0 | $184,763 | $0 | $240,373 | $0 | $23,773 | $0 | $2,317,067 |
| 8 | $0 | $1,795,912 | $0 | $177,618 | $0 | $231,077 | $0 | $22,854 | $0 | $2,227,460 |
| 9 | $0 | $1,725,122 | $0 | $170,617 | $0 | $221,968 | $0 | $21,953 | $0 | $2,139,660 |
| 10 | $0 | $1,655,909 | $0 | $163,771 | $0 | $213,063 | $0 | $21,072 | $0 | $2,053,815 |
| 11 | $0 | $1,588,368 | $0 | $157,091 | $0 | $204,372 | $0 | $20,213 | $0 | $1,970,045 |
| 12 | $0 | $1,522,578 | $0 | $150,585 | $0 | $195,907 | $0 | $19,375 | $0 | $1,888,445 |
| 13 | $0 | $1,458,597 | $0 | $144,257 | $0 | $187,675 | $0 | $18,561 | $0 | $1,809,090 |
| 14 | $0 | $1,396,471 | $0 | $138,113 | $0 | $179,681 | $0 | $17,771 | $0 | $1,732,036 |
| 15 | $0 | $1,336,232 | $0 | $132,155 | $0 | $171,930 | $0 | $17,004 | $0 | $1,657,321 |
| 16 | $0 | $1,277,897 | $0 | $126,385 | $0 | $164,425 | $0 | $16,262 | $0 | $1,584,969 |
| 17 | $0 | $1,221,476 | $0 | $120,805 | $0 | $157,165 | $0 | $15,544 | $0 | $1,514,991 |
| 18 | $0 | $1,166,969 | $0 | $115,414 | $0 | $150,152 | $0 | $14,850 | $0 | $1,447,385 |
| 19 | $0 | $1,114,365 | $0 | $110,212 | $0 | $143,383 | $0 | $14,181 | $0 | $1,382,141 |
| **Total** | **$0** | **$32,977,766** | **$0** | **$3,261,537** | **$0** | **$4,243,189** | **$0** | **$419,656** | **$0** | **$40,902,148** |

| Constant Dollars |
|---:|
| $3,081,780 |
| $5,105,037 |
| |
| $3,188,268 |
| $3,294,755 |
| $3,401,242 |
| $3,507,729 |
| $3,614,216 |
| $3,720,704 |
| $3,827,191 |
| $3,933,678 |
| $4,040,165 |
| $4,146,652 |
| $4,253,140 |
| $4,359,627 |
| $4,466,114 |
| $4,572,601 |
| $4,679,088 |
| $4,785,576 |
| $4,892,063 |
| $4,998,550 |
| |
| **$81,868,176** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,268) | $0 | ($14,529) | $0 | $0 | ($1,433) | $0 | ($2,162) |
| 20 | $0 | $14,801 | $0 | $42,617 | $0 | $0 | ($287) | $0 | ($263) |
| 2 | $0 | ($10,630) | $0 | ($9,710) | $0 | $0 | ($1,389) | $0 | ($2,091) |
| 3 | $0 | ($10,538) | $0 | ($5,182) | $0 | $0 | ($1,345) | $0 | ($2,020) |
| 4 | $0 | ($10,205) | $0 | ($4,380) | $0 | $0 | ($1,301) | $0 | ($1,950) |
| 5 | $0 | ($9,164) | $0 | ($3,685) | $0 | $0 | ($1,258) | $0 | ($1,880) |
| 6 | $0 | ($8,740) | $0 | ($3,230) | $0 | $0 | ($1,215) | $0 | ($1,811) |
| 7 | $0 | ($7,553) | $0 | ($3,005) | $0 | $0 | ($1,172) | $0 | ($1,743) |
| 8 | $0 | ($1,688) | $0 | $3,229 | $0 | $0 | ($457) | $0 | ($435) |
| 9 | $0 | ($768) | $0 | $4,189 | $0 | $0 | ($441) | $0 | ($418) |
| 10 | $0 | $87 | $0 | $5,010 | $0 | $0 | ($425) | $0 | ($402) |
| 11 | $0 | $1,056 | $0 | $6,288 | $0 | $0 | ($410) | $0 | ($386) |
| 12 | $0 | $1,985 | $0 | $7,859 | $0 | $0 | ($394) | $0 | ($371) |
| 13 | $0 | $2,901 | $0 | $9,329 | $0 | $0 | ($380) | $0 | ($356) |
| 14 | $0 | $3,568 | $0 | $11,499 | $0 | $0 | ($365) | $0 | ($341) |
| 15 | $0 | $4,934 | $0 | $16,003 | $0 | $0 | ($351) | $0 | ($327) |
| 16 | $0 | $6,228 | $0 | $20,049 | $0 | $0 | ($338) | $0 | ($313) |
| 17 | $0 | $8,421 | $0 | $23,007 | $0 | $0 | ($324) | $0 | ($300) |
| 18 | $0 | $10,041 | $0 | $25,653 | $0 | $0 | ($312) | $0 | ($287) |
| 19 | $0 | $12,117 | $0 | $32,403 | $0 | $0 | ($299) | $0 | ($275) |
| **Total** | **$0** | **($4,416)** | **$0** | **$163,415** | **$0** | **$0** | **($13,896)** | **$0** | **($18,132)** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($29,393) | ($31,450) |
| 20 | $0 | $0 | $0 | $0 | $56,868 | $220,063 |
| 2 | $0 | $0 | $0 | $0 | ($23,821) | ($27,273) |
| 3 | $0 | $0 | $0 | $0 | ($19,087) | ($23,382) |
| 4 | $0 | $0 | $0 | $0 | ($17,836) | ($23,379) |
| 5 | $0 | $0 | $0 | $0 | ($15,987) | ($22,422) |
| 6 | $0 | $0 | $0 | $0 | ($14,996) | ($22,504) |
| 7 | $0 | $0 | $0 | $0 | ($13,472) | ($21,634) |
| 8 | $0 | $0 | $0 | $0 | $650 | $1,117 |
| 9 | $0 | $0 | $0 | $0 | $2,561 | $4,709 |
| 10 | $0 | $0 | $0 | $0 | $4,269 | $8,398 |
| 11 | $0 | $0 | $0 | $0 | $6,548 | $13,783 |
| 12 | $0 | $0 | $0 | $0 | $9,079 | $20,447 |
| 13 | $0 | $0 | $0 | $0 | $11,495 | $27,701 |
| 14 | $0 | $0 | $0 | $0 | $14,360 | $37,027 |
| 15 | $0 | $0 | $0 | $0 | $20,258 | $55,894 |
| 16 | $0 | $0 | $0 | $0 | $25,626 | $75,653 |
| 17 | $0 | $0 | $0 | $0 | $30,803 | $97,302 |
| 18 | $0 | $0 | $0 | $0 | $35,096 | $118,621 |
| 19 | $0 | $0 | $0 | $0 | $43,947 | $158,935 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$126,971** | **$667,607** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
| 1 | (5) | (2,185) | (2) | (0) | (0) | (1) | (0) |
| 20 | 19 | 10,199 | 19 | 0 | 0 | 2 | 0 |
| 2 | (5) | (2,011) | (2) | (0) | (0) | (1) | (0) |
| 3 | (5) | (1,922) | (2) | (0) | (0) | (1) | (0) |
| 4 | (5) | (1,864) | (2) | (0) | (0) | (1) | (0) |
| 5 | (4) | (1,799) | (2) | (0) | (0) | (0) | (0) |
| 6 | (4) | (1,663) | (2) | (0) | (0) | (0) | (0) |
| 7 | (3) | (1,451) | (1) | (0) | (0) | (0) | (0) |
| 8 | 1 | (832) | 0 | (0) | (0) | 0 | (0) |
| 9 | 2 | (674) | 1 | 0 | (0) | 0 | 0 |
| 10 | 2 | (506) | 1 | 0 | (0) | 0 | 0 |
| 11 | 3 | (210) | 1 | 0 | (0) | 0 | 0 |
| 12 | 4 | 224 | 2 | 0 | 0 | 0 | 0 |
| 13 | 5 | 679 | 2 | 0 | 0 | 0 | 0 |
| 14 | 6 | 1,134 | 3 | 0 | 0 | 0 | 0 |
| 15 | 7 | 2,058 | 5 | 0 | 0 | 1 | 0 |
| 16 | 8 | 3,025 | 7 | 0 | 0 | 1 | 0 |
| 17 | 10 | 4,229 | 8 | 0 | 0 | 1 | 0 |
| 18 | 12 | 5,483 | 10 | 0 | 0 | 1 | 0 |
| 19 | 15 | 7,459 | 13 | 0 | 0 | 2 | 0 |
| **Total** | **62** | **19,373** | **61** | **0** | **(0)** | **6** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | DOLLARS EMISSIONS SAVED<br>(PV $/yr)<br>CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|
| 1 | $0 | ($1,890) | ($15,566) | ($8,650) | ($2,294) | ($992) |
| 20 | $0 | $3,553 | $40,482 | $10,349 | $1,250 | $1,234 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | $0 | ($1,658) | ($13,046) | ($6,043) | ($2,155) | ($920) |
| 3 | $0 | ($1,510) | ($10,423) | ($4,279) | ($2,020) | ($855) |
| 4 | $0 | ($1,396) | ($9,795) | ($3,932) | ($1,949) | ($764) |
| 5 | $0 | ($1,285) | ($9,201) | ($3,027) | ($1,796) | ($678) |
| 6 | $0 | ($1,132) | ($8,349) | ($3,218) | ($1,721) | ($575) |
| 7 | $0 | ($942) | ($7,282) | ($3,207) | ($1,580) | ($462) |
| 8 | $0 | ($515) | $1,985 | ($527) | ($301) | $9 |
| 9 | $0 | ($397) | $2,982 | $146 | ($233) | $64 |
| 10 | $0 | ($284) | $3,893 | $715 | ($169) | $115 |
| 11 | $0 | ($112) | $5,186 | $1,336 | ($39) | $178 |
| 12 | $0 | $114 | $6,794 | $1,904 | $19 | $248 |
| 13 | $0 | $331 | $8,255 | $2,466 | $131 | $312 |
| 14 | $0 | $526 | $10,427 | $2,846 | $200 | $361 |
| 15 | $0 | $911 | $14,815 | $3,734 | $333 | $466 |
| 16 | $0 | $1,276 | $18,787 | $4,497 | $506 | $561 |
| 17 | $0 | $1,701 | $21,607 | $6,147 | $638 | $711 |
| 18 | $0 | $2,102 | $24,122 | $7,269 | $757 | $845 |
| 19 | $0 | $2,726 | $30,609 | $8,593 | $996 | $1,023 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total** | **$0** | **$2,118** | **$116,282** | **$17,119** | **($9,428)** | **$880** |

A

# NET PRESENT VALUE CALCULATION

| Year | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,263,932 | ($1,319,687) | $2,880,169 | ($29,393) | | | | |
| 2 | $1,504,925 | ($1,260,318) | $2,784,756 | ($23,821) | | | | |
| 3 | $1,750,102 | ($1,215,849) | $2,689,501 | ($19,087) | | | | |
| 4 | $2,000,339 | ($1,163,084) | $2,594,791 | ($17,836) | | | | |
| 5 | $2,256,781 | ($1,111,436) | $2,500,962 | ($15,987) | | | | |
| 6 | $2,520,880 | ($1,050,900) | $2,408,305 | ($14,996) | | | | |
| 7 | $2,794,459 | ($982,722) | $2,317,067 | ($13,472) | | | | |
| 8 | $3,079,795 | ($917,166) | $2,227,460 | $650 | | | | |
| 9 | $3,379,734 | ($843,863) | $2,139,660 | $2,561 | | | | |
| 10 | $3,697,847 | ($777,099) | $2,053,815 | $4,269 | | | | |
| 11 | $4,038,650 | ($692,133) | $1,970,045 | $6,548 | | | | |
| 12 | $4,407,923 | ($594,607) | $1,888,445 | $9,079 | | | | |
| 13 | $4,813,159 | ($506,310) | $1,809,090 | $11,495 | | | | |
| 14 | $5,264,249 | ($431,216) | $1,732,036 | $14,360 | | | | |
| 15 | $5,774,506 | ($314,825) | $1,657,321 | $20,258 | | | | |
| 16 | $6,362,297 | ($207,359) | $1,584,969 | $25,626 | | | | |
| 17 | $7,053,691 | ($79,791) | $1,514,991 | $30,803 | | | | |
| 18 | $7,886,993 | $34,775 | $1,447,385 | $35,096 | | | | |
| 19 | $8,920,904 | $181,888 | $1,382,141 | $43,947 | | | | |
| 20 | $10,250,231 | $352,557 | $1,319,239 | $56,868 | | | | |
| **Total** | $89,021,397 | ($12,899,146) | $40,902,148 | $126,971 | $0 | $0 | $0 | $0 |

| | | | | |
|---|---|---|---|---|
| 14,893,457 | Person-Hours of Time Saved | | | Person-Hours of Time Saved |

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 62 | $0 | CO Saved | | | CO Saved |
| 19,373 | $2,118 | CO$_2$ Saved | | | CO$_2$ Saved |
| 61 | $116,282 | NO$_X$ Saved | | | NO$_X$ Saved |
| 0 | $17,119 | PM$_{10}$ Saved | | | PM$_{10}$ Saved |
| 0 | | PM$_{2.5}$ Saved | | | PM$_{2.5}$ Saved |
| (0) | ($9,428) | SO$_X$ Saved | | | SO$_X$ Saved |
| 6 | $880 | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $11,955,923 | ($1,903,233) | $3,681,193 | $145,283 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | |
| | | | | $0 | $24,894,000 | ($24,894,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $2,795,021 | ($382,243) | $3,177,264 |
| | | | | $3,005,542 | $18,342 | $2,987,200 |
| | | | | $3,204,667 | ($25,305) | $3,229,972 |
| | | | | $3,414,211 | $16,021 | $3,398,190 |
| | | | | $3,630,321 | ($22,103) | $3,652,423 |
| | | | | $3,863,289 | $93,954 | $3,769,335 |
| | | | | $4,115,332 | $13,078 | $4,102,254 |
| | | | | $4,390,739 | $12,222 | $4,378,517 |
| | | | | $4,678,092 | ($16,862) | $4,694,954 |
| | | | | $4,978,832 | $10,675 | $4,968,157 |
| | | | | $5,323,110 | $100,245 | $5,222,865 |
| | | | | $5,710,840 | ($1,979,405) | $7,690,245 |
| | | | | $6,127,435 | ($12,864) | $6,140,298 |
| | | | | $6,579,429 | $8,144 | $6,571,284 |
| | | | | $7,137,260 | ($11,236) | $7,148,496 |
| | | | | $7,765,533 | $630,724 | $7,134,809 |
| | | | | $8,519,694 | ($9,814) | $8,529,508 |
| | | | | $9,404,249 | $51,184 | $9,353,065 |
| | | | | $10,528,880 | ($8,572) | $10,537,451 |
| | | | | $11,978,895 | $5,427 | $11,973,468 |
| $0 | $0 | $0 | $0 | **$117,151,370** | **$23,385,613** | **$93,765,757** |

| | |
|---|---|
| | Person-Hours of Time Saved |

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| Year | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,352,407 | ($1,412,065) | $3,081,780 | ($31,450) | | | | |
| 2 | $1,722,989 | ($1,442,938) | $3,188,268 | ($27,273) | | | | |
| 3 | $2,143,950 | ($1,489,468) | $3,294,755 | ($23,382) | | | | |
| 4 | $2,622,037 | ($1,524,566) | $3,401,242 | ($23,379) | | | | |
| 5 | $3,165,253 | ($1,558,847) | $3,507,729 | ($22,422) | | | | |
| 6 | $3,783,161 | ($1,577,118) | $3,614,216 | ($22,504) | | | | |
| 7 | $4,487,290 | ($1,578,037) | $3,720,704 | ($21,634) | | | | |
| 8 | $5,291,661 | ($1,575,861) | $3,827,191 | $1,117 | | | | |
| 9 | $6,213,503 | ($1,551,408) | $3,933,678 | $4,709 | | | | |
| 10 | $7,274,224 | ($1,528,671) | $4,040,165 | $8,398 | | | | |
| 11 | $8,500,761 | ($1,456,838) | $4,146,652 | $13,783 | | | | |
| 12 | $9,927,487 | ($1,339,169) | $4,253,140 | $20,447 | | | | |
| 13 | $11,598,968 | ($1,220,129) | $4,359,627 | $27,701 | | | | |
| 14 | $13,574,045 | ($1,111,906) | $4,466,114 | $37,027 | | | | |
| 15 | $15,932,044 | ($868,613) | $4,572,601 | $55,894 | | | | |
| 16 | $18,782,542 | ($612,158) | $4,679,088 | $75,653 | | | | |
| 17 | $22,281,306 | ($252,045) | $4,785,576 | $97,302 | | | | |
| 18 | $26,657,502 | $117,539 | $4,892,063 | $118,621 | | | | |
| 19 | $32,262,694 | $657,804 | $4,998,550 | $158,935 | | | | |
| 20 | $39,665,160 | $1,364,284 | $5,105,037 | $220,063 | | | | |
| **Total** | $237,238,984 | ($19,960,210) | $81,868,176 | $667,607 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
| | | | | $0 | $24,894,000 | ($24,894,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $2,990,673 | ($409,000) | $3,399,673 | $3,399,673 |
| | | | | $3,441,045 | $21,000 | $3,420,045 | $6,819,718 |
| | | | | $3,925,855 | ($31,000) | $3,956,855 | $10,776,573 |
| | | | | $4,475,334 | $21,000 | $4,454,334 | $15,230,907 |
| | | | | $5,091,712 | ($31,000) | $5,122,712 | $20,353,620 |
| | | | | $5,797,755 | $141,000 | $5,656,755 | $26,010,374 |
| | | | | $6,608,323 | $21,000 | $6,587,323 | $32,597,698 |
| | | | | $7,544,108 | $21,000 | $7,523,108 | $40,120,805 |
| | | | | $8,600,482 | ($31,000) | $8,631,482 | $48,752,287 |
| | | | | $9,794,116 | $21,000 | $9,773,116 | $58,525,404 |
| | | | | $11,204,358 | $211,000 | $10,993,358 | $69,518,761 |
| | | | | $12,861,905 | ($4,458,000) | $17,319,905 | $86,838,666 |
| | | | | $14,766,167 | ($31,000) | $14,797,167 | $101,635,834 |
| | | | | $16,965,281 | $21,000 | $16,944,281 | $118,580,115 |
| | | | | $19,691,927 | ($31,000) | $19,722,927 | $138,303,041 |
| | | | | $22,925,125 | $1,862,000 | $21,063,125 | $159,366,167 |
| | | | | $26,912,139 | ($31,000) | $26,943,139 | $186,309,306 |
| | | | | $31,785,725 | $173,000 | $31,612,725 | $217,922,030 |
| | | | | $38,077,983 | ($31,000) | $38,108,983 | $256,031,013 |
| | | | | $46,354,543 | $21,000 | $46,333,543 | $302,364,556 |
| $0 | $0 | $0 | $0 | **$299,814,556** | **$22,344,000** | **$277,470,556** | |

| | |
|---|---|
| **Total Construction Costs** | **$24,894,000** |

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($24,894,000) |
| 2 | $3,399,673 |
| 3 | $3,420,045 |
| 4 | $3,956,855 |
| 5 | $4,454,334 |
| 6 | $5,122,712 |
| 7 | $5,656,755 |
| 8 | $6,587,323 |
| 9 | $7,523,108 |
| 10 | $8,631,482 |
| 11 | $9,773,116 |
| 12 | $10,993,358 |
| 13 | $17,319,905 |
| 14 | $14,797,167 |
| 15 | $16,944,281 |
| 16 | $19,722,927 |
| 17 | $21,063,125 |
| 18 | $26,943,139 |
| 19 | $31,612,725 |
| 20 | $38,108,983 |
| 21 | $46,333,543 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **24.42%** |
| **Payback Period** | **6 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |

**OMB GDP Inflator** **1.01719172**

Yellow cells - adjusted

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | *1* |
| Real Discount Rate | 7.0% | *2* |

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | *3* |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | *3* |
| Benefits and Costs | $ 10.69 | $/hr | *4* |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | *5* |
| Truck | $ 31.20 | $/hr/veh | *5* |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | *6* |
| Transit | $ 13.75 | $/hr/per | *5* |
| Out-of-Vehicle Travel | 2 | times | *5* |
| Incident-Related Travel | 3 | times | *7* |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | *8* |
| Truck (diesel) | $ 3.07 | $/gal | *8* |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | *9* |
| State Sales Tax (diesel) | **13.00%** | % | *9* |
| Average Local Sales Tax | 0.50% | % | *9* |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | *9* |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | *9* |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | *9* |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | *9* |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | *10* |
| Truck | $ 0.437 | $/mi | *11* |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | *12* |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | *12* |
| Level B (Moderate) | $ 125,000 | $/event | *12* |
| Level C (Minor) | $ 63,900 | $/event | *12* |
| Cost of Property Damage | $ 4,300 | $/event | *13* |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | *14* |
| Injury Accident | 0.29 | per mil veh-mi | *14* |
| PDO Accident | 0.55 | per mil veh-mi | *14* |
| Non-Freeway | 1.05 | per mil veh-mi | *15* |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | *16* |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | *17* |
| HOV Lanes | 0.55 | 8 | 1,600 | | *18* |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

### ***Active Transportation Parameters***

| | Value | Units | |
|---|---|---|---|
| General Travel Activity Characteristics Parameters | | | |
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| Vehicle Statistics | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | *19* |
| Active Transportation User Characteristics | | | |
| Average Cycling Speed | 11.80 | mph | *20* |
| Average Walking Speed | 3.00 | mph | *21* |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | *19* |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | *19* |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| Value of Travel Time | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class | | | |
| Class I | 0.57 | - | *20* |
| Class II | 0.49 | - | *20* |
| Class III | 0.92 | - | *20* |
| Class IV | 0.49 | - | *20* |
| *Note: Class IV assumed to be the same as Class II* | | | |
| Walking Journey Quality Values per Mile by Amentity | | | |
| Street Lighting | $0.110 | $/mi | *22* |
| Curb Level | $0.078 | $/mi | *22* |
| Crowding | $0.055 | $/mi | *22* |
| Pavement Evenness | $0.026 | $/mi | *22* |
| Information Panels | $0.026 | $/mi | *22* |
| Benches | $0.017 | $/mi | *22* |
| Directional Signage | $0.017 | $/mi | *22* |
| Health (Absenteeism Reduction) | | | |
| Average Absence of Employees | 3.60 | days/yr | *23* |
| Percentage Covered by Short-Term Sick Leave | 95% | % | *24* |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | *25* |
| Health (Mortality Reduction) | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | *26* |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | *26* |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | *27* |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | *27* |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | *28* |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | *28* |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

## Travel Demand Tables

### Project Types

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

### DEMAND FOR TRAVEL IN PEAK PERIOD

(percent of total daily travel)

| Number of | Urban | | | | | |
|---|---|---|---|---|---|---|
| Hours in | So. California | | No. California | | Rural | |
| Peak Period | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

### AGE COHORTS FOR MORTALITY RISK REDUCTION

(percent of population)

| | | Urban | | |
|---|---|---|---|---|
| **Mode** | **Age Cohort** | **South** | **North** | **Rural** |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

### AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP

(miles/trip)

| | | Urban | | |
|---|---|---|---|---|
| **Mode** | **Age Cohort** | **South** | **North** | **Rural** |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

### TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS

(percent of trips)

| | | Urban | | |
|---|---|---|---|---|
| **Mode** | **Trip Purpose** | **South** | **North** | **Rural** |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident | | 0.1176 | 0.6446 |
| Cost per Event | | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
|  | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
|  | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
|  | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
|  | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
|  | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
|  | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
|  | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
|  | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
|  | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
|  | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
|  | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
|  | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
|  | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
|  | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
|  | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
|  | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
|  | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
|  | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
|  | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
|  | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
|  | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
|  | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
|  | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
|  | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
|  | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
|  | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
|  | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
|  | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
|  | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
|  | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
|  | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
|  | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
|  | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
|  | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
|  | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
|  | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
|  | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
|  | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
|  | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
|  | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
|  | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
|  | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
|  | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
|  | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
|  | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
|  | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
|  | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
|  | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
|  | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
|  | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
|  | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
|  | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
|  | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
|  | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
|  | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
|  | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
|  | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
|  | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
|  | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
|  | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
|  | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
|  | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
|  | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
|  | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
|  | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
|  | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
|  | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
|  | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
|  | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
|  | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
|  | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
|  | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
|  | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
|  | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
|  | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
|  | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
|  | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
|  | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
|  | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
|  | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
|  | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
|  | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
|  | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
|  | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
|  | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
|  | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
|  | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
|  | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
|  | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
|  | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
|  | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
|  | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
|  | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
|  | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
|  | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
|  | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
|  | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
|  | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
|  | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
|  | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
|  | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
|  | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
|  | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
|  | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
|  | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
|  | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
|  | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
|  | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
|  | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
|  | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
|  | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
|  | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
|  | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
|  | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
|  | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
|  | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
|  | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
|  | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
|  | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
|  | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
|  | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
|  | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
|  | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
|  | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
|  | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
|  | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
|  | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
|  | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
|  | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
|  | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
|  | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
|  | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
|  | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
|  | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
|  | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
|  | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
|  | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
|  | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
|  | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
|  | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

### HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | $CO_2e$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

$CO_2e$ Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

### PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 |  | 583.58 | 62.02 |  | 19.73 |  |
|  | 2022 | 45.67 |  | 250.11 | 31.01 |  | 19.73 |  |

### LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 |  | 1.13 | 0.17 |  | 0.06 |  |
|  | 2022 | 0.14 |  | 1.14 | 0.17 |  | 0.06 |  |

### FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |
|  | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |

| | | |
|---|---|---|
| Freight Rail Fuel Efficiency | 468 | ton-miles/gal |
| Fuel Burned at Idle | 4 | gal/hr |

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## *Pavement Adjustments* (used only for pavement projects)

**PAVEMENT DETERIORATION**

(IRI in inches/mile)

| Year 0 | Year 20, By Loading | | |
|---|---|---|---|
| | Light | Medium | Heavy |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

**VEHICLE OPERATING SPEED**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

**FUEL CONSUMPTION**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

**NON-FUEL COSTS**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## ***Weaving Adjustments*** (used only for freeway connector, HOV connector, and HOV drop ramp projects)

**VEHICLE OPERATING SPEED**

(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## ***TMS Adjustments*** (used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

**PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS**

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| Strategy | Speed | Volume | Speed | Volume | TT | VOC | Em | Benefit |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

**TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS**

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| TMS Strategy | Time | Capital | O&M |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

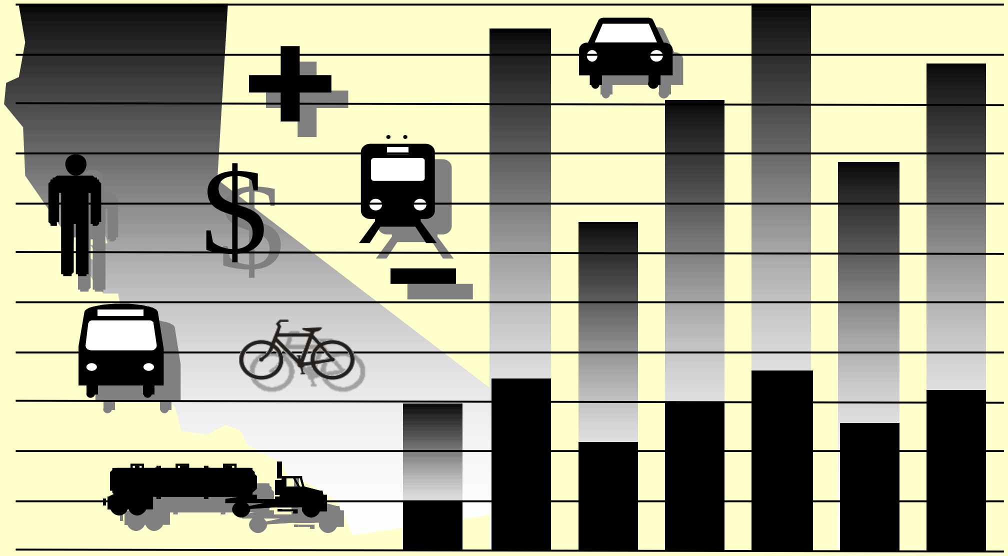
Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Divided 29M (2019) TPC, 36068 ADT

WAR-63 Priority Project BCA

California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**
Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

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# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period.  Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual.  Other adjustments are made for weaving and pavement conditions.  An option is also available to conduct a simple queuing analysis.  Accidents are estimated from statewide averages and recent data for the facility.  If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically.  Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road.  The user clicks a button and the model clears the Project Information worksheet to receive information on  other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed).  The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available.  The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed).  These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### PROJECT DATA (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

### *Type of Project*

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

### *Project Location*

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

### *Length of Construction Period*

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

### *One- or Two-Way Data*

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

### *Length of Peak Period(s)*

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

### *Highway Design*

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

### *Average Daily Traffic (ADT)*

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

***Average Hourly HOV/HOT Lane Traffic***

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

***Percent Traffic in Weave***

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

***Percent Trucks***

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

***Truck Speed***

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

***On-Ramp Volume***

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

***Queue Formation***

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

***Pavement Condition (for Pavement Rehab. Projects)***

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

***Average Vehicle Occupancy (AVO)***

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## **HIGHWAY ACCIDENT DATA** (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

***Actual 3-Year Accident Data (from Table B)***

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

***Statewide Basic Average Accident Rate***

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## **RAIL AND TRANSIT DATA** (Box 1D)

*This section is used for rail and transit projects only.*

### *Annual Person-Trips*

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

### *Percent Trips during Peak Period*

32 Insert % annual person-trips that occur during peak period.

### *Percent New Trips from Parallel Highway*

33 Insert % new transit person-trips originating on parallel highway.

### *Annual Vehicle-Miles*

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

### *Average Vehicles per Train*

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

### *Reduction in Transit Accidents*

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

### *Average Transit Travel Time*

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

### *Highway Grade Crossing*

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

### *Transit Agency Costs (for Transit TMS Projects)*

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

1E

# PROJECT COSTS (enter costs in thousands of dollars)

| Col. no. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | | |
|---|---|---|---|---|---|---|---|---|---|
| | DIRECT PROJECT COSTS | | | | | | Transit Agency Cost Savings | TOTAL COSTS (in dollars) | |
| | INITIAL COSTS | | | SUBSEQUENT COSTS | | | | | |
| Year | Project Support | R / W | Construction | Maint./ Op. | Rehab. | Mitigation | | Constant Dollars | Present Value |
| **Construction Period** | | | | | | | | | |
| 1 | $715 | $238 | $26,706 | | | | | $27,659,000 | $27,659,000 |
| 2 | | | | | | | | 0 | 0 |
| 3 | | | | | | | | 0 | 0 |
| 4 | | | | | | | | 0 | 0 |
| 5 | | | | | | | | 0 | 0 |
| 6 | | | | | | | | 0 | 0 |
| 7 | | | | | | | | 0 | 0 |
| 8 | | | | | | | | 0 | 0 |
| **Project Open** | | | | | | | | | |
| 1 | | | | $21 | ($430) | | | ($409,000) | ($382,243) |
| 2 | | | | $21 | | | | 21,000 | 18,342 |
| 3 | | | | $21 | ($52) | | | (31,000) | (25,305) |
| 4 | | | | $21 | | | | 21,000 | 16,021 |
| 5 | | | | $21 | ($52) | | | (31,000) | (22,103) |
| 6 | | | | $21 | $120 | | | 141,000 | 93,954 |
| 7 | | | | $21 | | | | 21,000 | 13,078 |
| 8 | | | | $21 | | | | 21,000 | 12,222 |
| 9 | | | | $21 | ($52) | | | (31,000) | (16,862) |
| 10 | | | | $21 | | | | 21,000 | 10,675 |
| 11 | | | | $21 | $190 | | | 211,000 | 100,245 |
| 12 | | | | $21 | ($4,479) | | | (4,458,000) | (1,979,405) |
| 13 | | | | $21 | ($52) | | | (31,000) | (12,864) |
| 14 | | | | $21 | | | | 21,000 | 8,144 |
| 15 | | | | $21 | ($52) | | | (31,000) | (11,236) |
| 16 | | | | $21 | $1,841 | | | 1,862,000 | 630,724 |
| 17 | | | | $21 | ($52) | | | (31,000) | (9,814) |
| 18 | | | | $21 | $152 | | | 173,000 | 51,184 |
| 19 | | | | $21 | ($52) | | | (31,000) | (8,572) |
| 20 | | | | $21 | | | | 21,000 | 5,427 |
| **Total** | $715 | $238 | $26,706 | $420 | ($2,970) | $0 | $0 | $25,109,000 | $26,150,613 |

2A

# HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 29,080 | | 29,080 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,876 | | 2,876 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 59.8 | | 59.8 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,742 | | 3,742 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 370 | | 370 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |

**Hwy Safety or Weaving Improvement** 0% collision reduction factor (per HSIP Guidelines)

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.007 | | 0.007 | |
| Injury Accidents | 0.21 | | 0.21 | |
| PDO Accidents | 0.59 | | 0.59 | |
| Total Accidents | 0.813 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

**Detailed Information Available?** (y/n) N

**Aggregate Segment Length** (estimate as VMT/total volume)

All Ramps ______ miles

Arterials ______ miles

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

## ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 12,206,408 | 244,345 |
| Truck Trips | 1,028,749 | 1,049,763 | 21,014 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 1,775,434 | 35,540 |
| Truck Trips | 132,367 | 135,071 | 2,704 |
| Total Trips | 14,863,073 | 15,166,676 | 303,603 |

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Divided

EA:
PPNO:

③

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| **Life-Cycle Costs (mil. $)** | $26.2 |
| **Life-Cycle Benefits (mil. $)** | $123.3 |
| **Net Present Value (mil. $)** | $97.1 |
| **Benefit / Cost Ratio:** | 4.7 |
| **Rate of Return on Investment:** | 23.7% |
| **Payback Period:** | 6 years |

| **ITEMIZED BENEFITS (mil. $)** | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| **Travel Time Savings** | $74.3 | $11.5 | $85.7 | $4.3 |
| **Veh. Op. Cost Savings** | -$4.7 | -$0.9 | -$5.6 | -$0.3 |
| **Accident Cost Savings** | $39.1 | $3.9 | $42.9 | $2.1 |
| **Emission Cost Savings** | $0.0 | $0.2 | $0.2 | $0.0 |
| **TOTAL BENEFITS** | $108.7 | $14.6 | $123.3 | $6.2 |
| **Person-Hours of Time Saved** | | | 14,928,674 | 746,434 |

***Should benefit-cost results include:***

| | |
|---|---|
| **1) Induced Travel? (y/n)** | Y<br>Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y<br>Default = Y |
| **3) Accident Costs? (y/n)** | Y<br>Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for $CO_2e$ | Y<br>Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| **EMISSIONS REDUCTION** | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| **CO Emissions Saved** | 104 | 5 | $0.0 | $0.0 |
| **$CO_2$ Emissions Saved** | 34,884 | 1,744 | $0.0 | $0.0 |
| **$NO_X$ Emissions Saved** | 73 | 4 | $0.2 | $0.0 |
| **$PM_{10}$ Emissions Saved** | 0 | 0 | $0.0 | $0.0 |
| **$PM_{2.5}$ Emissions Saved** | 0 | 0 | | |
| **$SO_X$ Emissions Saved** | 0 | 0 | -$0.0 | -$0.0 |
| **VOC Emissions Saved** | 9 | 0 | $0.0 | $0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $1,098,713 | $0 | $21,244 | $0 | $0 | $143,975 | $0 | $0 |
| 20 | $0 | $8,151,124 | $0 | $1,508,252 | $0 | $0 | $62,454 | $0 | $0 |
| 2 | $0 | $1,294,458 | $0 | $66,838 | $0 | $0 | $138,584 | $0 | $0 |
| 3 | $0 | $1,492,226 | $0 | $112,695 | $0 | $0 | $133,282 | $0 | $0 |
| 4 | $0 | $1,692,835 | $0 | $158,959 | $0 | $0 | $128,081 | $0 | $0 |
| 5 | $0 | $1,897,301 | $0 | $205,816 | $0 | $0 | $122,990 | $0 | $0 |
| 6 | $0 | $2,106,874 | $0 | $253,501 | $0 | $0 | $118,017 | $0 | $0 |
| 7 | $0 | $2,323,082 | $0 | $302,303 | $0 | $0 | $113,169 | $0 | $0 |
| 8 | $0 | $2,547,802 | $0 | $352,582 | $0 | $0 | $108,449 | $0 | $0 |
| 9 | $0 | $2,783,348 | $0 | $404,785 | $0 | $0 | $103,863 | $0 | $0 |
| 10 | $0 | $3,032,596 | $0 | $459,471 | $0 | $0 | $99,413 | $0 | $0 |
| 11 | $0 | $3,299,157 | $0 | $517,341 | $0 | $0 | $95,100 | $0 | $0 |
| 12 | $0 | $3,587,624 | $0 | $579,291 | $0 | $0 | $90,926 | $0 | $0 |
| 13 | $0 | $3,903,932 | $0 | $646,481 | $0 | $0 | $86,892 | $0 | $0 |
| 14 | $0 | $4,255,888 | $0 | $720,433 | $0 | $0 | $82,996 | $0 | $0 |
| 15 | $0 | $4,653,982 | $0 | $803,196 | $0 | $0 | $79,238 | $0 | $0 |
| 16 | $0 | $5,112,658 | $0 | $897,593 | $0 | $0 | $75,616 | $0 | $0 |
| 17 | $0 | $5,652,404 | $0 | $1,007,623 | $0 | $0 | $72,129 | $0 | $0 |
| 18 | $0 | $6,303,296 | $0 | $1,139,158 | $0 | $0 | $68,775 | $0 | $0 |
| 19 | $0 | $7,111,406 | $0 | $1,301,195 | $0 | $0 | $65,551 | $0 | $0 |
| **Total** | **$0** | **$72,300,705** | **$0** | **$11,458,756** | **$0** | **$0** | **$1,989,502** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| | Peak In-Vehicle | Peak Out-of-Veh | Non-Peak In-Vehicle | Non-Peak Out-of-Veh | | | |
| 1 | $0 | $0 | $0 | $0 | $1,263,932 | $1,352,407 | 91,339 |
| 20 | $0 | $0 | $0 | $0 | $9,721,831 | $37,620,419 | 2,473,365 |
| 2 | $0 | $0 | $0 | $0 | $1,499,880 | $1,717,213 | 114,672 |
| 3 | $0 | $0 | $0 | $0 | $1,738,203 | $2,129,373 | 141,134 |
| 4 | $0 | $0 | $0 | $0 | $1,979,875 | $2,595,212 | 171,142 |
| 5 | $0 | $0 | $0 | $0 | $2,226,108 | $3,122,232 | 205,193 |
| 6 | $0 | $0 | $0 | $0 | $2,478,392 | $3,719,398 | 243,880 |
| 7 | $0 | $0 | $0 | $0 | $2,738,553 | $4,397,518 | 287,916 |
| 8 | $0 | $0 | $0 | $0 | $3,008,833 | $5,169,735 | 338,169 |
| 9 | $0 | $0 | $0 | $0 | $3,291,996 | $6,052,201 | 395,709 |
| 10 | $0 | $0 | $0 | $0 | $3,591,479 | $7,064,983 | 461,860 |
| 11 | $0 | $0 | $0 | $0 | $3,911,598 | $8,233,334 | 538,291 |
| 12 | $0 | $0 | $0 | $0 | $4,257,842 | $9,589,475 | 627,133 |
| 13 | $0 | $0 | $0 | $0 | $4,637,305 | $11,175,185 | 731,146 |
| 14 | $0 | $0 | $0 | $0 | $5,059,317 | $13,045,621 | 853,976 |
| 15 | $0 | $0 | $0 | $0 | $5,536,416 | $15,275,145 | 1,000,536 |
| 16 | $0 | $0 | $0 | $0 | $6,085,867 | $17,966,477 | 1,177,616 |
| 17 | $0 | $0 | $0 | $0 | $6,732,156 | $21,265,636 | 1,394,866 |
| 18 | $0 | $0 | $0 | $0 | $7,511,229 | $25,387,446 | 1,666,483 |
| 19 | $0 | $0 | $0 | $0 | $8,478,152 | $30,661,469 | 2,014,247 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$85,748,963** | **$227,540,480** | **14,928,674** |

C

# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | | Present Value of Veh Op Cost Benefits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | |
| 1 | $0 | ($1,028,520) | $0 | ($140,639) | $0 | ($132,338) | $0 | ($18,190) | - | - | ($1,319,687) |
| 20 | $0 | $712,075 | $0 | $118,379 | $0 | ($14,975) | $0 | ($1,276) | - | - | $814,203 |
| 2 | $0 | ($917,572) | $0 | ($124,457) | $0 | ($119,835) | $0 | ($16,332) | - | - | ($1,178,196) |
| 3 | $0 | ($829,287) | $0 | ($110,021) | $0 | ($108,401) | $0 | ($14,640) | - | - | ($1,062,349) |
| 4 | $0 | ($733,400) | $0 | ($103,448) | $0 | ($97,950) | $0 | ($13,099) | - | - | ($947,897) |
| 5 | $0 | ($645,618) | $0 | ($97,572) | $0 | ($88,403) | $0 | ($11,696) | - | - | ($843,290) |
| 6 | $0 | ($558,285) | $0 | ($89,253) | $0 | ($79,686) | $0 | ($10,422) | - | - | ($737,645) |
| 7 | $0 | ($471,649) | $0 | ($78,764) | $0 | ($71,731) | $0 | ($9,264) | - | - | ($631,408) |
| 8 | $0 | ($392,504) | $0 | ($68,920) | $0 | ($64,476) | $0 | ($8,213) | - | - | ($534,113) |
| 9 | $0 | ($301,503) | $0 | ($68,102) | $0 | ($57,863) | $0 | ($7,260) | - | - | ($434,728) |
| 10 | $0 | ($221,518) | $0 | ($67,180) | $0 | ($51,840) | $0 | ($6,396) | - | - | ($346,933) |
| 11 | $0 | ($134,328) | $0 | ($59,141) | $0 | ($46,356) | $0 | ($5,614) | - | - | ($245,440) |
| 12 | $0 | ($44,019) | $0 | ($45,094) | $0 | ($41,369) | $0 | ($4,908) | - | - | ($135,390) |
| 13 | $0 | $35,248 | $0 | ($32,262) | $0 | ($36,836) | $0 | ($4,269) | - | - | ($38,119) |
| 14 | $0 | $96,712 | $0 | ($17,491) | $0 | ($32,718) | $0 | ($3,693) | - | - | $42,809 |
| 15 | $0 | $188,378 | $0 | $6,045 | $0 | ($28,982) | $0 | ($3,175) | - | - | $162,267 |
| 16 | $0 | $271,024 | $0 | $27,648 | $0 | ($25,595) | $0 | ($2,708) | - | - | $270,370 |
| 17 | $0 | $380,776 | $0 | $40,489 | $0 | ($22,526) | $0 | ($2,289) | - | - | $396,450 |
| 18 | $0 | $477,322 | $0 | $52,019 | $0 | ($19,750) | $0 | ($1,913) | - | - | $507,678 |
| 19 | $0 | $590,026 | $0 | $78,642 | $0 | ($17,241) | $0 | ($1,576) | - | - | $649,851 |
| **Total** | **$0** | **($3,526,640)** | **$0** | **($779,122)** | **$0** | **($1,158,872)** | **$0** | **($146,932)** | **-** | **-** | **($5,611,566)** |

| Constant Dollars |
|---|
| ($1,412,065) |
| $3,150,708 |
| |
| ($1,348,916) |
| ($1,301,423) |
| ($1,242,499) |
| ($1,182,758) |
| ($1,107,007) |
| ($1,013,903) |
| ($917,705) |
| ($799,230) |
| ($682,470) |
| ($516,615) |
| ($304,923) |
| ($91,861) |
| $110,384 |
| $447,700 |
| $798,176 |
| $1,252,312 |
| $1,715,918 |
| $2,350,205 |
| |
| **($2,095,973)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | All Periods | |
| 1 | $0 | $2,322,165 | $0 | $229,665 | $0 | $298,789 | $0 | $29,551 | $0 | $2,880,169 |
| 20 | $0 | $1,167,269 | $0 | $115,444 | $0 | $150,190 | $0 | $14,854 | $0 | $1,447,758 |
| 2 | $0 | $2,263,671 | $0 | $223,880 | $0 | $291,262 | $0 | $28,806 | $0 | $2,807,619 |
| 3 | $0 | $2,202,892 | $0 | $217,868 | $0 | $283,442 | $0 | $28,033 | $0 | $2,732,235 |
| 4 | $0 | $2,140,377 | $0 | $211,686 | $0 | $275,398 | $0 | $27,237 | $0 | $2,654,698 |
| 5 | $0 | $2,076,613 | $0 | $205,379 | $0 | $267,194 | $0 | $26,426 | $0 | $2,575,613 |
| 6 | $0 | $2,012,032 | $0 | $198,992 | $0 | $258,885 | $0 | $25,604 | $0 | $2,495,513 |
| 7 | $0 | $1,947,014 | $0 | $192,562 | $0 | $250,519 | $0 | $24,777 | $0 | $2,414,871 |
| 8 | $0 | $1,881,891 | $0 | $186,121 | $0 | $242,139 | $0 | $23,948 | $0 | $2,334,099 |
| 9 | $0 | $1,816,956 | $0 | $179,699 | $0 | $233,784 | $0 | $23,122 | $0 | $2,253,561 |
| 10 | $0 | $1,752,463 | $0 | $173,320 | $0 | $225,486 | $0 | $22,301 | $0 | $2,173,570 |
| 11 | $0 | $1,688,632 | $0 | $167,008 | $0 | $217,273 | $0 | $21,489 | $0 | $2,094,401 |
| 12 | $0 | $1,625,652 | $0 | $160,779 | $0 | $209,170 | $0 | $20,687 | $0 | $2,016,288 |
| 13 | $0 | $1,563,686 | $0 | $154,650 | $0 | $201,197 | $0 | $19,899 | $0 | $1,939,431 |
| 14 | $0 | $1,502,870 | $0 | $148,635 | $0 | $193,371 | $0 | $19,125 | $0 | $1,864,001 |
| 15 | $0 | $1,443,318 | $0 | $142,746 | $0 | $185,709 | $0 | $18,367 | $0 | $1,790,140 |
| 16 | $0 | $1,385,127 | $0 | $136,991 | $0 | $178,222 | $0 | $17,626 | $0 | $1,717,965 |
| 17 | $0 | $1,328,372 | $0 | $131,377 | $0 | $170,919 | $0 | $16,904 | $0 | $1,647,573 |
| 18 | $0 | $1,273,115 | $0 | $125,912 | $0 | $163,809 | $0 | $16,201 | $0 | $1,579,038 |
| 19 | $0 | $1,219,402 | $0 | $120,600 | $0 | $156,898 | $0 | $15,517 | $0 | $1,512,418 |
| **Total** | **$0** | **$34,613,515** | **$0** | **$3,423,315** | **$0** | **$4,453,658** | **$0** | **$440,472** | **$0** | **$42,930,959** |

| Constant Dollars |
|---|
| $3,081,780 |
| $5,602,365 |
| |
| $3,214,443 |
| $3,347,105 |
| $3,479,767 |
| $3,612,430 |
| $3,745,092 |
| $3,877,754 |
| $4,010,417 |
| $4,143,079 |
| $4,275,741 |
| $4,408,404 |
| $4,541,066 |
| $4,673,728 |
| $4,806,391 |
| $4,939,053 |
| $5,071,715 |
| $5,204,378 |
| $5,337,040 |
| $5,469,702 |
| |
| **$86,841,452** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,268) | $0 | ($14,529) | $0 | $0 | ($1,433) | $0 | ($2,162) |
| 20 | $0 | $16,150 | $0 | $44,345 | $0 | $0 | ($113) | $0 | ($40) |
| 2 | $0 | ($9,935) | $0 | ($8,550) | $0 | $0 | ($1,300) | $0 | ($1,942) |
| 3 | $0 | ($9,237) | $0 | ($3,013) | $0 | $0 | ($1,178) | $0 | ($1,741) |
| 4 | $0 | ($8,377) | $0 | ($1,338) | $0 | $0 | ($1,067) | $0 | ($1,559) |
| 5 | $0 | ($6,883) | $0 | $107 | $0 | $0 | ($965) | $0 | ($1,392) |
| 6 | $0 | ($6,070) | $0 | $1,201 | $0 | $0 | ($872) | $0 | ($1,241) |
| 7 | $0 | ($4,552) | $0 | $1,967 | $0 | $0 | ($787) | $0 | ($1,103) |
| 8 | $0 | ($621) | $0 | $4,636 | $0 | $0 | ($319) | $0 | ($254) |
| 9 | $0 | $375 | $0 | $5,694 | $0 | $0 | ($293) | $0 | ($225) |
| 10 | $0 | $1,293 | $0 | $6,594 | $0 | $0 | ($270) | $0 | ($198) |
| 11 | $0 | $2,313 | $0 | $7,936 | $0 | $0 | ($247) | $0 | ($174) |
| 12 | $0 | $3,282 | $0 | $9,556 | $0 | $0 | ($227) | $0 | ($153) |
| 13 | $0 | $4,230 | $0 | $11,062 | $0 | $0 | ($208) | $0 | ($133) |
| 14 | $0 | $4,918 | $0 | $13,255 | $0 | $0 | ($191) | $0 | ($115) |
| 15 | $0 | $6,299 | $0 | $17,774 | $0 | $0 | ($175) | $0 | ($99) |
| 16 | $0 | $7,600 | $0 | $21,825 | $0 | $0 | ($161) | $0 | ($85) |
| 17 | $0 | $9,794 | $0 | $24,780 | $0 | $0 | ($147) | $0 | ($72) |
| 18 | $0 | $11,411 | $0 | $27,417 | $0 | $0 | ($135) | $0 | ($60) |
| 19 | $0 | $13,479 | $0 | $34,152 | $0 | $0 | ($123) | $0 | ($50) |
| **Total** | **$0** | **$24,199** | **$0** | **$204,870** | **$0** | **$0** | **($10,212)** | **$0** | **($12,798)** |

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# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($29,393) | ($31,450) |
| 20 | $0 | $0 | $0 | $0 | $60,342 | $233,503 |
| 2 | $0 | $0 | $0 | $0 | ($21,728) | ($24,876) |
| 3 | $0 | $0 | $0 | $0 | ($15,170) | ($18,584) |
| 4 | $0 | $0 | $0 | $0 | ($12,341) | ($16,176) |
| 5 | $0 | $0 | $0 | $0 | ($9,133) | ($12,809) |
| 6 | $0 | $0 | $0 | $0 | ($6,981) | ($10,477) |
| 7 | $0 | $0 | $0 | $0 | ($4,476) | ($7,187) |
| 8 | $0 | $0 | $0 | $0 | $3,442 | $5,913 |
| 9 | $0 | $0 | $0 | $0 | $5,550 | $10,204 |
| 10 | $0 | $0 | $0 | $0 | $7,419 | $14,595 |
| 11 | $0 | $0 | $0 | $0 | $9,827 | $20,685 |
| 12 | $0 | $0 | $0 | $0 | $12,459 | $28,059 |
| 13 | $0 | $0 | $0 | $0 | $14,950 | $36,027 |
| 14 | $0 | $0 | $0 | $0 | $17,867 | $46,071 |
| 15 | $0 | $0 | $0 | $0 | $23,798 | $65,659 |
| 16 | $0 | $0 | $0 | $0 | $29,180 | $86,145 |
| 17 | $0 | $0 | $0 | $0 | $34,356 | $108,524 |
| 18 | $0 | $0 | $0 | $0 | $38,633 | $130,578 |
| 19 | $0 | $0 | $0 | $0 | $47,457 | $171,631 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$206,059** | **$836,034** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
| 1 | (5) | (2,185) | (2) | (0) | (0) | (1) | (0) |
| 20 | 22 | 11,679 | 20 | 0 | 0 | 3 | 0 |
| | | | | | | | |
| 2 | (5) | (1,899) | (2) | (0) | (0) | (0) | (0) |
| 3 | (4) | (1,698) | (1) | (0) | (0) | (0) | (0) |
| 4 | (3) | (1,529) | (1) | (0) | (0) | (0) | (0) |
| 5 | (2) | (1,352) | (1) | (0) | (0) | (0) | (0) |
| 6 | (1) | (1,104) | (1) | (0) | (0) | (0) | (0) |
| 7 | 1 | (781) | (0) | (0) | (0) | (0) | (0) |
| 8 | 3 | (287) | 1 | 0 | (0) | 0 | 0 |
| 9 | 3 | (51) | 1 | 0 | (0) | 0 | 0 |
| 10 | 4 | 195 | 1 | 0 | 0 | 0 | 0 |
| 11 | 5 | 569 | 2 | 0 | 0 | 0 | 0 |
| 12 | 6 | 1,081 | 2 | 0 | 0 | 0 | 0 |
| 13 | 7 | 1,614 | 3 | 0 | 0 | 0 | 0 |
| 14 | 8 | 2,147 | 4 | 0 | 0 | 1 | 0 |
| 15 | 9 | 3,149 | 6 | 0 | 0 | 1 | 0 |
| 16 | 11 | 4,193 | 7 | 0 | 0 | 1 | 0 |
| 17 | 13 | 5,475 | 9 | 0 | 0 | 1 | 0 |
| 18 | 15 | 6,808 | 11 | 0 | 0 | 2 | 0 |
| 19 | 18 | 8,861 | 14 | 0 | 0 | 2 | 0 |
| | | | | | | | |
| **Total** | **104** | **34,884** | **73** | **0** | **0** | **9** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | DOLLARS EMISSIONS SAVED (PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
| 1 | $0 | ($1,890) | ($15,566) | ($8,650) | ($2,294) | ($992) |
| 20 | $0 | $4,068 | $42,432 | $11,087 | $1,435 | $1,320 |
| 2 | $0 | ($1,566) | ($11,849) | ($5,443) | ($2,017) | ($854) |
| 3 | $0 | ($1,335) | ($8,186) | ($3,157) | ($1,762) | ($731) |
| 4 | $0 | ($1,145) | ($6,658) | ($2,360) | ($1,587) | ($590) |
| 5 | $0 | ($965) | ($5,293) | ($1,068) | ($1,345) | ($461) |
| 6 | $0 | ($752) | ($3,784) | ($930) | ($1,195) | ($321) |
| 7 | $0 | ($507) | ($2,162) | ($640) | ($989) | ($178) |
| 8 | $0 | ($178) | $3,603 | $85 | ($148) | $80 |
| 9 | $0 | ($30) | $4,710 | $799 | ($69) | $140 |
| 10 | $0 | $110 | $5,710 | $1,402 | $3 | $195 |
| 11 | $0 | $305 | $7,072 | $2,049 | $140 | $261 |
| 12 | $0 | $552 | $8,733 | $2,637 | $203 | $333 |
| 13 | $0 | $786 | $10,232 | $3,214 | $319 | $398 |
| 14 | $0 | $996 | $12,428 | $3,603 | $390 | $449 |
| 15 | $0 | $1,393 | $16,830 | $4,496 | $524 | $554 |
| 16 | $0 | $1,769 | $20,804 | $5,261 | $698 | $649 |
| 17 | $0 | $2,202 | $23,618 | $6,907 | $829 | $800 |
| 18 | $0 | $2,610 | $26,119 | $8,025 | $947 | $933 |
| 19 | $0 | $3,238 | $32,585 | $9,340 | $1,184 | $1,110 |
| **Total** | **$0** | **$9,663** | **$161,376** | **$36,656** | **($4,730)** | **$3,093** |

A

# NET PRESENT VALUE CALCULATION

| Year | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,263,932 | ($1,319,687) | $2,880,169 | ($29,393) | | | | |
| 2 | $1,499,880 | ($1,178,196) | $2,807,619 | ($21,728) | | | | |
| 3 | $1,738,203 | ($1,062,349) | $2,732,235 | ($15,170) | | | | |
| 4 | $1,979,875 | ($947,897) | $2,654,698 | ($12,341) | | | | |
| 5 | $2,226,108 | ($843,290) | $2,575,613 | ($9,133) | | | | |
| 6 | $2,478,392 | ($737,645) | $2,495,513 | ($6,981) | | | | |
| 7 | $2,738,553 | ($631,408) | $2,414,871 | ($4,476) | | | | |
| 8 | $3,008,833 | ($534,113) | $2,334,099 | $3,442 | | | | |
| 9 | $3,291,996 | ($434,728) | $2,253,561 | $5,550 | | | | |
| 10 | $3,591,479 | ($346,933) | $2,173,570 | $7,419 | | | | |
| 11 | $3,911,598 | ($245,440) | $2,094,401 | $9,827 | | | | |
| 12 | $4,257,842 | ($135,390) | $2,016,288 | $12,459 | | | | |
| 13 | $4,637,305 | ($38,119) | $1,939,431 | $14,950 | | | | |
| 14 | $5,059,317 | $42,809 | $1,864,001 | $17,867 | | | | |
| 15 | $5,536,416 | $162,267 | $1,790,140 | $23,798 | | | | |
| 16 | $6,085,867 | $270,370 | $1,717,965 | $29,180 | | | | |
| 17 | $6,732,156 | $396,450 | $1,647,573 | $34,356 | | | | |
| 18 | $7,511,229 | $507,678 | $1,579,038 | $38,633 | | | | |
| 19 | $8,478,152 | $649,851 | $1,512,418 | $47,457 | | | | |
| 20 | $9,721,831 | $814,203 | $1,447,758 | $60,342 | | | | |
| **Total** | $85,748,963 | ($5,611,566) | $42,930,959 | $206,059 | $0 | $0 | $0 | $0 |

14,928,674 Person-Hours of Time Saved

Person-Hours of Time Saved

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 104 | $0 | CO Saved | | | CO Saved |
| 34,884 | $9,663 | $CO_2$ Saved | | | $CO_2$ Saved |
| 73 | $161,376 | $NO_X$ Saved | | | $NO_X$ Saved |
| 0 | $36,656 | $PM_{10}$ Saved | | | $PM_{10}$ Saved |
| 0 | | $PM_{2.5}$ Saved | | | $PM_{2.5}$ Saved |
| 0 | ($4,730) | $SO_X$ Saved | | | $SO_X$ Saved |
| 9 | $3,093 | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $11,458,756 | ($926,055) | $3,863,786 | $192,072 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | |
| | | | | $0 | $27,659,000 | ($27,659,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $2,795,021 | ($382,243) | $3,177,264 |
| | | | | $3,107,576 | $18,342 | $3,089,234 |
| | | | | $3,392,918 | ($25,305) | $3,418,224 |
| | | | | $3,674,336 | $16,021 | $3,658,315 |
| | | | | $3,949,298 | ($22,103) | $3,971,400 |
| | | | | $4,229,278 | $93,954 | $4,135,324 |
| | | | | $4,517,540 | $13,078 | $4,504,462 |
| | | | | $4,812,261 | $12,222 | $4,800,039 |
| | | | | $5,116,379 | ($16,862) | $5,133,241 |
| | | | | $5,425,535 | $10,675 | $5,414,860 |
| | | | | $5,770,386 | $100,245 | $5,670,141 |
| | | | | $6,151,198 | ($1,979,405) | $8,130,604 |
| | | | | $6,553,566 | ($12,864) | $6,566,430 |
| | | | | $6,983,994 | $8,144 | $6,975,850 |
| | | | | $7,512,620 | ($11,236) | $7,523,856 |
| | | | | $8,103,383 | $630,724 | $7,472,659 |
| | | | | $8,810,534 | ($9,814) | $8,820,348 |
| | | | | $9,636,578 | $51,184 | $9,585,394 |
| | | | | $10,687,879 | ($8,572) | $10,696,451 |
| | | | | $12,044,133 | $5,427 | $12,038,706 |
| $0 | $0 | $0 | $0 | **$123,274,414** | **$26,150,613** | **$97,123,801** |

| | |
|---|---|
| | Person-Hours of Time Saved |

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,352,407 | ($1,412,065) | $3,081,780 | ($31,450) | | | | |
| 2 | $1,717,213 | ($1,348,916) | $3,214,443 | ($24,876) | | | | |
| 3 | $2,129,373 | ($1,301,423) | $3,347,105 | ($18,584) | | | | |
| 4 | $2,595,212 | ($1,242,499) | $3,479,767 | ($16,176) | | | | |
| 5 | $3,122,232 | ($1,182,758) | $3,612,430 | ($12,809) | | | | |
| 6 | $3,719,398 | ($1,107,007) | $3,745,092 | ($10,477) | | | | |
| 7 | $4,397,518 | ($1,013,903) | $3,877,754 | ($7,187) | | | | |
| 8 | $5,169,735 | ($917,705) | $4,010,417 | $5,913 | | | | |
| 9 | $6,052,201 | ($799,230) | $4,143,079 | $10,204 | | | | |
| 10 | $7,064,983 | ($682,470) | $4,275,741 | $14,595 | | | | |
| 11 | $8,233,334 | ($516,615) | $4,408,404 | $20,685 | | | | |
| 12 | $9,589,475 | ($304,923) | $4,541,066 | $28,059 | | | | |
| 13 | $11,175,185 | ($91,861) | $4,673,728 | $36,027 | | | | |
| 14 | $13,045,621 | $110,384 | $4,806,391 | $46,071 | | | | |
| 15 | $15,275,145 | $447,700 | $4,939,053 | $65,659 | | | | |
| 16 | $17,966,477 | $798,176 | $5,071,715 | $86,145 | | | | |
| 17 | $21,265,636 | $1,252,312 | $5,204,378 | $108,524 | | | | |
| 18 | $25,387,446 | $1,715,918 | $5,337,040 | $130,578 | | | | |
| 19 | $30,661,469 | $2,350,205 | $5,469,702 | $171,631 | | | | |
| 20 | $37,620,419 | $3,150,708 | $5,602,365 | $233,503 | | | | |
| **Total** | $227,540,480 | ($2,095,973) | $86,841,452 | $836,034 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | | | | |
| | | | | $0 | $27,659,000 | ($27,659,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $2,990,673 | ($409,000) | $3,399,673 | $3,399,673 |
| | | | | $3,557,864 | $21,000 | $3,536,864 | $6,936,537 |
| | | | | $4,156,471 | ($31,000) | $4,187,471 | $11,124,008 |
| | | | | $4,816,304 | $21,000 | $4,795,304 | $15,919,312 |
| | | | | $5,539,094 | ($31,000) | $5,570,094 | $21,489,406 |
| | | | | $6,347,006 | $141,000 | $6,206,006 | $27,695,413 |
| | | | | $7,254,182 | $21,000 | $7,233,182 | $34,928,595 |
| | | | | $8,268,360 | $21,000 | $8,247,360 | $43,175,955 |
| | | | | $9,406,254 | ($31,000) | $9,437,254 | $52,613,209 |
| | | | | $10,672,849 | $21,000 | $10,651,849 | $63,265,058 |
| | | | | $12,145,808 | $211,000 | $11,934,808 | $75,199,866 |
| | | | | $13,853,677 | ($4,458,000) | $18,311,677 | $93,511,543 |
| | | | | $15,793,079 | ($31,000) | $15,824,079 | $109,335,622 |
| | | | | $18,008,467 | $21,000 | $17,987,467 | $127,323,089 |
| | | | | $20,727,557 | ($31,000) | $20,758,557 | $148,081,646 |
| | | | | $23,922,513 | $1,862,000 | $22,060,513 | $170,142,159 |
| | | | | $27,830,849 | ($31,000) | $27,861,849 | $198,004,008 |
| | | | | $32,570,981 | $173,000 | $32,397,981 | $230,401,989 |
| | | | | $38,653,008 | ($31,000) | $38,684,008 | $269,085,997 |
| | | | | $46,606,995 | $21,000 | $46,585,995 | $315,671,992 |
| $0 | $0 | $0 | $0 | **$313,121,992** | **$25,109,000** | **$288,012,992** | |

| | |
|---|---|
| **Total Construction Costs** | **$27,659,000** |

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($27,659,000) |
| 2 | $3,399,673 |
| 3 | $3,536,864 |
| 4 | $4,187,471 |
| 5 | $4,795,304 |
| 6 | $5,570,094 |
| 7 | $6,206,006 |
| 8 | $7,233,182 |
| 9 | $8,247,360 |
| 10 | $9,437,254 |
| 11 | $10,651,849 |
| 12 | $11,934,808 |
| 13 | $18,311,677 |
| 14 | $15,824,079 |
| 15 | $17,987,467 |
| 16 | $20,758,557 |
| 17 | $22,060,513 |
| 18 | $27,861,849 |
| 19 | $32,397,981 |
| 20 | $38,684,008 |
| 21 | $46,585,995 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **23.69%** |
| **Payback Period** | **6 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## *Parameters*

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |
| **OMB GDP Inflator** | **1.01719172** | |

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | *1* |
| Real Discount Rate | 7.0% | *2* |

Yellow cells - adjusted

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | *3* |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | *3* |
| Benefits and Costs | $ 10.69 | $/hr | *4* |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | *5* |
| Truck | $ 31.20 | $/hr/veh | *5* |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | *6* |
| Transit | $ 13.75 | $/hr/per | *5* |
| Out-of-Vehicle Travel | 2 | times | *5* |
| Incident-Related Travel | 3 | times | *7* |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | *8* |
| Truck (diesel) | $ 3.07 | $/gal | *8* |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | *9* |
| State Sales Tax (diesel) | **13.00%** | % | *9* |
| Average Local Sales Tax | 0.50% | % | *9* |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | *9* |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | *9* |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | *9* |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | *9* |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | *10* |
| Truck | $ 0.437 | $/mi | *11* |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | *12* |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | *12* |
| Level B (Moderate) | $ 125,000 | $/event | *12* |
| Level C (Minor) | $ 63,900 | $/event | *12* |
| Cost of Property Damage | $ 4,300 | $/event | *13* |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | *14* |
| Injury Accident | 0.29 | per mil veh-mi | *14* |
| PDO Accident | 0.55 | per mil veh-mi | *14* |
| Non-Freeway | 1.05 | per mil veh-mi | *15* |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | *16* |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | *17* |
| HOV Lanes | 0.55 | 8 | 1,600 | | *18* |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

## *Active Transportation Parameters*

| General Travel Activity Characteristics Parameters | Value | Units | |
|---|---|---|---|
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| **Vehicle Statistics** | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | *19* |
| **Active Transportation User Characteristics** | | | |
| Average Cycling Speed | 11.80 | mph | *20* |
| Average Walking Speed | 3.00 | mph | *21* |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | *19* |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | *19* |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| **Value of Travel Time** | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| **Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class** | | | |
| Class I | 0.57 | - | *20* |
| Class II | 0.49 | - | *20* |
| Class III | 0.92 | - | *20* |
| Class IV | 0.49 | - | *20* |
| *Note: Class IV assumed to be the same as Class II* | | | |
| **Walking Journey Quality Values per Mile by Amentity** | | | |
| Street Lighting | $0.110 | $/mi | *22* |
| Curb Level | $0.078 | $/mi | *22* |
| Crowding | $0.055 | $/mi | *22* |
| Pavement Evenness | $0.026 | $/mi | *22* |
| Information Panels | $0.026 | $/mi | *22* |
| Benches | $0.017 | $/mi | *22* |
| Directional Signage | $0.017 | $/mi | *22* |
| **Health (Absenteeism Reduction)** | | | |
| Average Absence of Employees | 3.60 | days/yr | *23* |
| Percentage Covered by Short-Term Sick Leave | 95% | % | *24* |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | *25* |
| **Health (Mortality Reduction)** | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | *26* |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | *26* |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | *27* |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | *27* |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | *28* |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | *28* |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

## Travel Demand Tables

**Project Types**

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

### DEMAND FOR TRAVEL IN PEAK PERIOD
(percent of total daily travel)

| Number of Hours in Peak Period | Urban | | | | Rural | |
|---|---|---|---|---|---|---|
| | So. California | | No. California | | | |
| | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

### AGE COHORTS FOR MORTALITY RISK REDUCTION
(percent of population)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

### AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP
(miles/trip)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

### TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS
(percent of trips)

| Mode | Trip Purpose | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES
(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident | | 0.1176 | 0.6446 |
| Cost per Event | | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary*
*Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

## HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | $CO_2$e | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

$CO_2$e Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

## PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 |  | 583.58 | 62.02 |  | 19.73 |  |
|  | 2022 | 45.67 |  | 250.11 | 31.01 |  | 19.73 |  |

## LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 |  | 1.13 | 0.17 |  | 0.06 |  |
|  | 2022 | 0.14 |  | 1.14 | 0.17 |  | 0.06 |  |

## FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |
|  | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |

| | | |
|---|---|---|
| Freight Rail Fuel Efficiency | 468 | ton-miles/gal |
| Fuel Burned at Idle | 4 | gal/hr |

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## **Pavement Adjustments** (used only for pavement projects)

### PAVEMENT DETERIORATION

(IRI in inches/mile)

| | Year 20, By Loading | | |
|---|---|---|---|
| Year 0 | Light | Medium | Heavy |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

### VEHICLE OPERATING SPEED

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

### FUEL CONSUMPTION

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

### NON-FUEL COSTS

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## *Weaving Adjustments*

(used only for freeway connector, HOV connector, and HOV drop ramp projects)

**VEHICLE OPERATING SPEED**

(percent adjustment)

| Percent<br>Weaving | Freeway<br>Conn | HOV<br>Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## *TMS Adjustments*

(used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

**PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS**

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| **Strategy** | **Speed** | **Volume** | **Speed** | **Volume** | **TT** | **VOC** | **Em** | **Benefit** |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

**TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS**

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| **TMS Strategy** | **Time** | **Capital** | **O&M** |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*

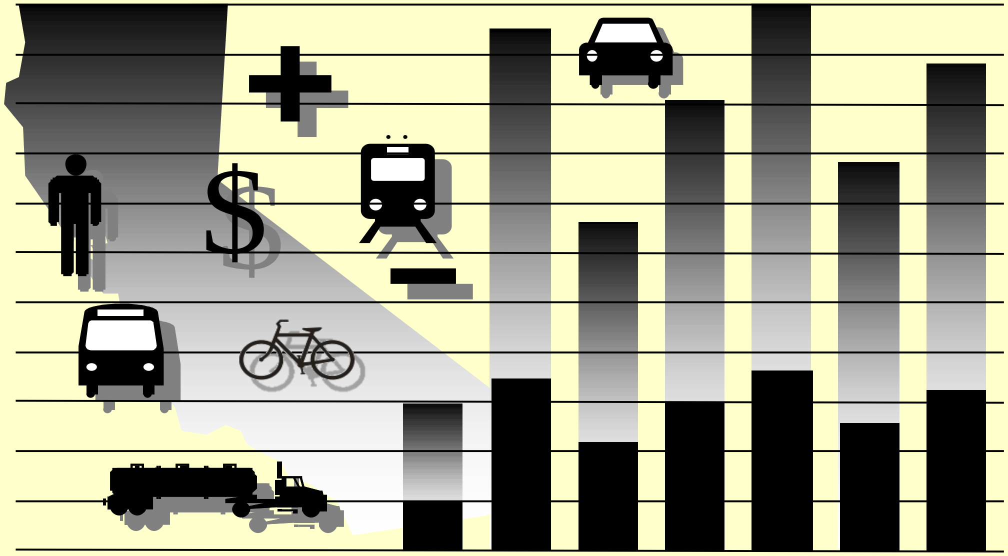
Copy of Cal-BC-V62-INFRA-Model WCTID 4 Lane Divided 29M (2019) TPC, 44068 ADT

WAR-63 Priority Project BCA

California
Department
Of
Transportation

# California Life-Cycle Benefit/Cost Analysis Model for 2019 INFRA Applications

## (Cal-B/C) Version 6.2



**Office of Transportation Economics**
**Division of Transportation Planning**
Based on US DOT's December 2018 Benefit-Cost Analysis Guidance and CA Values

For questions and comments, please contact:

| | | |
|---|---|---|
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# CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL (CAL-B/C)

## INTRODUCTION

This spreadsheet model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle costs, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period. Annual benefits are also calculated.

The model is arranged by worksheets and contains the following information, data, and results:

| **Worksheets** | **Contents** |
|---|---|
| Instructions | General model description and assumptions |
| 1) Project Information | Project input data |
| 2) Model Inputs | Highway speed, volume, accident data, and trips estimated by model |
| 3) Results | Summary results of analysis |
| Travel Time | Calculation of travel time and induced demand impacts |
| Vehicle Operating Costs | Calculation of highway vehicle operating cost impacts |
| Accident Costs | Calculation of accident cost impacts |
| Emissions | Calculation of emission impacts |
| Final Calculations | Calculation of net present value, internal rate of return, and payback period |
| Parameters | Economic assumptions, lookup tables, and other model parameters |

The model is designed so that the user generally needs to enter data only in the green boxes on the Project Information worksheet. The model estimates detailed highway speed, volume, and accident data for the user to review on the Model Inputs worksheet. Highway speeds are estimated from volumes using relationships found in the Highway Capacity Manual. Other adjustments are made for weaving and pavement conditions. An option is also available to conduct a simple queuing analysis. Accidents are estimated from statewide averages and recent data for the facility. If available, inputs from regional planning or traffic simulation models can be entered to override model calculations. Summary results are shown in Results worksheet.

The remaining worksheets are provided for the user to see, but model performs calculations automatically. Some projects (i.e., truck only lanes, bypasses, intersections, and connectors) require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before the user enters information about the second road. The user clicks a button and the model clears the Project Information worksheet to receive information on other road.

In the process of economic analysis, some generally accepted economic assumptions are necessary. These assumptions include: the real and nominal discount rates, unit user costs (e.g., value of time), consumption rates (e.g., fuel consumption and vehicle emissions), and accident rates. These assumptions are given in the Parameters worksheet and should not be changed by the user.

After reading the instructions in this worksheet, the user should proceed to the Project Information worksheet and input data for the specific project in the green boxes (light gray when printed). The model provides default values in the red boxes (medium gray when printed). These values can be changed by the user, if information specific to the project is available. The model calculates some values based on relationships or assumptions, with results shown in the blue boxes (dark gray when printed). These values can be changed by the user.

## INSTRUCTIONS

The user can analyze most projects simply by entering limited data on the Project Information Sheet and getting results on the Results page. The Model Inputs page allows the user to enter more detailed data adjust estimated speeds, volumes, and accidents rates, and check the number of trips estimated for projects that affect vehicle occupancy.

### **PROJECT DATA** (Box 1A)

*This section provides general information about the project and is used for highway, rail, and transit projects. At the top of the sheet, the user can enter information about the project, such as the project name, Caltrans district, and funding information.*

### *Type of Project*

1 Please select the appropriate type of highway, rail, or transit project from the pull-down menu. The menu appears if user clicks on the green box next to the project type.

*For a truck only lane, bypass or intersection project, model reminds user that information must be entered for both roads impacted by project. After entering information for the first road, the user clicks a button at bottom of the worksheet to prepare model for data on the bypass or intersecting road. The user may also enter information for connector projects involving two roads.*

### *Project Location*

2 Insert a 1, 2, or 3 for the appropriate region of California. This information is used to estimate peak traffic and emissions benefits.

### *Length of Construction Period*

3 Insert the number of construction years before benefits begin. This must be a whole number (round to next higher integer).

### *One- or Two-Way Data*

4 Indicate whether Highway Design and Traffic Data to be entered in Box 1B is for a single direction or both directions of highway.

### *Length of Peak Period(s)*

5 Insert the number of peak period hours per typical day. The model provides a default of 5 hours (statewide average). Model estimates total % daily traffic occurring during peak period using a lookup table developed from Traffic Census data. Model does not distinguish between weekdays and weekends.

*To model a 24-hour HOV or HOT lane, enter 24 hours so peak is 100% of ADT. To model a ramp metering project, user should enter the number of hours per day that metering is operational.*

## HIGHWAY DESIGN AND TRAFFIC DATA (Box 1B)

*Highway design and traffic data must be entered for highway projects. Enter data consistent with one- or two-way answer in Box 1A. Statewide default values are provided for some inputs.*

### *Highway Design*

6 **Roadway Type:** Indicate if the road is a freeway, expressway, or conventional highway in build and no build cases.

7 **Number of General Traffic Lanes:** Insert number of general purpose (not HOV or bus) lanes in both directions for build and no build cases. Enter data consistent with Box 1A.

8 **Number of HOV Lanes:** Insert number of HOV lanes in both directions for the build and no build cases. A value must be provided if an HOV restriction is entered on the next row.

9 **HOV Restriction:** If highway facility has/will have HOV lanes, enter the HOV restriction (e.g., 2 means 2 people per vehicle). Must be entered for an HOV project. Enter for a non-HOV project, if facility has HOV lanes. Changes in HOV restrictions are special project types and handled automatically by model.

10 **Exclusive ROW for Buses:** If bus project, indicate (with "Y" or "N") whether buses have exclusive right-of-way. This information is used to estimate emissions.

11 **Highway Free-Flow Speed:** Insert free-flow speed for build and no build cases. Model assumes build is same as no build, if not entered.

12 **Ramp Design Speed:** If auxiliary lane or off-ramp project, enter the design speed of the appropriate on- or off-ramp. This is used to estimate the speed of traffic affected by weaving.

13 **Highway Segment:** Insert segment length for build and no build cases. Model assumes build is same as no build, if not entered.

14 **Impacted Length:** The model estimates an area affected by the project. In most cases, this equals the segment length. For passing lane projects, the default affected area is 3 miles longer than the project area. For auxiliary lane and off-ramp projects, the default affected area is 1500 feet. For connectors and HOV drop ramps, default affected area is 3250 feet. User can change these lengths.

### *Average Daily Traffic (ADT)*

15 **Current:** For most projects, insert current two-way ADT on facility. For operational improvements, enter only the one-way ADT applicable to the project. Enter data consistent with one-way or two-way answer in Box 1A.

16 **Forecast (Year 20):** Insert projected ADT for 20 years after construction completion for build and no build cases. Model assumes build is same as no build, if not entered.

*The model uses the current and forecasted ADT to estimate annual traffic for 20 years after construction, assuming a linear trend. User can change base (Year 1) forecasts.*

***Average Hourly HOV/HOT Lane Traffic***

17 Insert hourly HOV/HOT volumes for build and no build cases in a typical peak hour.

***Percent Traffic in Weave***

18 For operational improvements, insert % traffic affected by weaving. Model suggests a % based on the type of project (2 right lanes for auxiliary lanes, 3 right lanes for off-ramps, 2.5% of all traffic for freeway connectors, and 4% of HOV traffic for HOV connectors and drop ramps). Users can change values for project conditions.

***Percent Trucks***

19 Insert estimated % of ADT comprised of trucks in build and no build cases. Model provides a default value (statewide average).

***Truck Speed***

20 If passing lane project, enter estimated speed (in MPH) for slow vehicles (trucks, recreational vehicles, etc.). Values must be entered for passing lane projects.

***On-Ramp Volume***

21 **Hourly Ramp Volume:** If auxiliary lane or on-ramp widening project, insert average hourly ramp volume to estimate traffic affected by weaving for auxiliary lanes and metering effectiveness for on-ramp widening. No entry needed for ramp metering projects.

22 **Metering Strategy:** If on-ramp widening project, enter 1, 2, or 3 for vehicles allowed per green signal. Enter "D" for dual metering. No entry should be made for ramp metering projects.

***Queue Formation***

23 **Arrival Rate:** For queuing and rail grade crossing projects, enter vehicles per hour contributing to queue. Arrival rate should be estimated only for time queue grows. Model estimates queue dissipation automatically.

24 **Departure Rate:** For queuing and rail crossing projects, enter vehicles per hour leaving queue.

***Pavement Condition (for Pavement Rehab. Projects)***

25 If pavement rehabilitation project, enter base (Year 1) International Roughness Index (IRI) for build and no build. Model will calculate Year 20 values using standard parameters unless entered by user.

***Average Vehicle Occupancy (AVO)***

26 Model provides default values. The figures change automatically, depending on presence of HOV lanes. Adjust if project-specific data are available.

## HIGHWAY ACCIDENT DATA (Box 1C)

*Statewide default values are provided for transit projects. The model uses information provided to calculate accident rates for each accident type in the Model Inputs worksheet.*

***Actual 3-Year Accident Data (from Table B)***

27 Insert the total number of fatal, injury, and property damage only accidents on the segment over the 3 most recent years. For rail grade crossing projects, enter 10-year accident data from FRA WBAPS in fatal and injury rows and collision prediction in total accident row.

***Statewide Basic Average Accident Rate***

28 Insert statewide average accident rates per million vehicle-miles (or million vehicles, as appropriate) for build and no build highway rate groups. Include Base Rate and ADT Factor where applicable.

29 Insert statewide % of accidents that are fatal and injury accidents for road classifications similar to build and no build facilities.

*The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for the new road classification. Additional adjustments (accident savings) are made for highway TMS projects. Results are presented in the Model Inputs worksheet and can be changed by the user.*

## RAIL AND TRANSIT DATA (Box 1D)

*This section is used for rail and transit projects only.*

***Annual Person-Trips***

30 **Base (Year 1):** Insert estimated annual transit person-trips for first year after construction completion in build and no build cases. For a transit TMS project, enter only person-trips on routes affected. If the routes are substantially different, the benefits analysis should be split into pieces.

31 **Forecast (Year 20):** Insert forecasted annual transit person-trips for 20 years after construction completion in build and no build cases.

***Percent Trips during Peak Period***

32 Insert % annual person-trips that occur during peak period.

***Percent New Trips from Parallel Highway***

33 Insert % new transit person-trips originating on parallel highway.

***Annual Vehicle-Miles***

34 **Base (Year 1):** Insert estimated annual vehicle-miles for first year after construction completion in build and no build cases. For passenger rail projects, multiply the number of train-miles by the average number of rail cars per train consist.

35 **Forecast (Year 20):** Insert forecasted annual vehicle-miles for 20 years after construction completion in build and no build cases.

***Average Vehicles per Train***

36 If passenger rail project, insert the average number of rail cars per train consist. This is used to calculate emissions.

***Reduction in Transit Accidents***

37 If project affects transit/rail safety, insert estimated percent accident reduction due to project. Increases should be entered as negative %.

***Average Transit Travel Time***

38 **In-Vehicle:** Insert average in-vehicle transit travel time in minutes during peak and non-peak periods in build and no build cases. For TMS Projects, insert the average for all transit routes impacted. Model assumes build is same as no build for most projects. Signal priority and bus rapid transit projects reduce time. User can adjust build travel times.

39 **Out-of-Vehicle:** Insert average out-of-vehicle transit travel time in minutes during peak and non-peak periods. Model monetizes out-of-vehicle travel time at a higher value.

***Highway Grade Crossing***

40 **Annual Number of Trains:** Insert annual number of passenger and freight trains entering highway-rail crossing.

41 **Average Gate Down Time:** Insert average time per train that crossing gate is down for passenger and freight trains.

***Transit Agency Costs (for Transit TMS Projects)***

42 **Annual Capital Expenditure:** If transit TMS project, insert annual agency capital expenditures for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

43 **Annual Ops. and Maintenance Expenditure:** If transit TMS project, insert the annual average operating and maintenance costs for routes impacted by project. Model calculates cost reductions for expenditures in build case due to transit TMS. Agency cost savings are entered automatically as a negative cost in Box 1E.

## **PROJECT COSTS** (Box 1E)

*Net project costs should be entered in the years they are expected to occur. Costs should be entered for construction period and for twenty years after construction completion. Construction Year 1 is the first year that costs are incurred. All costs should be entered in thousands of dollars.*

44 Insert project's initial costs in constant (Year 2016) dollars for project development, right-of-way, and construction. The number of construction years with costs should equal the length of the construction period (Box 1A, Input 5).

45 Insert estimated future incremental maintenance/operating and rehabilitation costs in constant (Year 2016) dollars. These figures should be entered in the years after the project opens.

46 Insert estimated mitigation costs (e.g., wetlands, community, and sound walls) in constant (Year 2016) dollars during construction and for 20 years after construction completion.
47 Model adds agency cost savings due to transit TMS automatically.
48 Insert any other costs not already included.

## HIGHWAY SPEED AND VOLUME INPUTS (Box 2A)

*This section allows user to review detailed speed and volume data estimated by the model. These values are estimated from the inputs provided in the Project Information sheet.*

49 User may enter new speed and volume data for the highway in the green boxes to override model calculations, if detailed data are available from a travel demand or micro-simulation model. The model estimates speeds and volumes on highway for HOVs, non-HOVs, weaving vehicles, and trucks during the peak and non-peak periods in Year 1 and Year 20 in build and no build cases. Speeds are estimated using a BPR curve (or queuing analysis). Adjustments are made to speed and volumes to account for weaving, transit mode shifts, pavement condition, and TMS.
50 If TMS project and detailed simulation data are available, the highway results should be inputted in the green cells. Model will use the data in place of figures estimated by the model.

## HIGHWAY ACCIDENT RATES (Box 2B)

*User may adjust accident rates calculated by the model. User may also enter TASAS highway accident data for rail grade crossing projects in this box.*

51 **No Build:** Fatality, injury and PDO accident rates for no build facility are estimated using inputs from Box 1C of the Project Information sheet. User may change these rates in green boxes.
52 **Highway Safety or Weaving Improvement:** Model assumes an overall safety improvement for off-ramp and ramp metering projects. User may adjust this percentage. For safety projects, user should enter collision reduction factor from HSIP Guidelines.
53 **Adjustment Factor:** User may change the ratios of facility accident rates to statewide averages used in calculating rates for the build facility. These factors are also adjusted by the collision reduction factor.
54 **Build Facility:** User may modify the fatality, injury, and PDO accident rates for build facility. Model estimates these accident rates using statewide average rates and the adjustment factors.

## RAMP AND ARTERIAL INPUTS (Box 2C)

*This section allows users to enter detailed arterial information for an arterial signal management project or detailed ramp and arterial data for a highway TMS project.*

55 **Detailed Information Available:** Input "Y" if detailed arterial and/or ramp data are available. Model automatically selects "Y" if other data are inputted. User should enter detailed ramp and arterial data for TMS highway project if detailed highway data are entered in Box 2A.
56 **Aggregate Segment Length:** Input the total segment lengths for the ramps and arterials. These can be estimated from travel demand or micro-simulation model data as VMT/total trips.
57 User may enter speeds and volumes on ramps and arterials during peak and non-peak periods in Year 1 and Year 20 in build and no build cases. If arterial signal management project, user must enter arterial data. Benefits are estimated assuming all vehicles are automobiles.

## ANNUAL PERSON-TRIPS (Box 2D)

*This section is for information purposes only. It allows user to examine number trips estimated for projects that affect AVO (e.g., HOT lane and HOV conversions).*

## NEXT STEPS

58 For bypass, intersection, and connector projects, click button on Project Information page after data are verified for the first road. Enter data for the second road in Boxes 1B and 1C. As with the first road, detailed data may be verified on Model Inputs page. Model prompts user to save interim version of analysis before proceeding.
59 Summary results are available immediately in the Results worksheet.

1E

## PROJECT COSTS (enter costs in thousands of dollars)

| Col. no. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | DIRECT PROJECT COSTS | | | | | | Transit Agency Cost Savings | TOTAL COSTS (in dollars) | |
| | INITIAL COSTS | | | SUBSEQUENT COSTS | | | | | |
| | Project Support | R / W | Construction | Maint./ Op. | Rehab. | Mitigation | | Constant Dollars | Present Value |
| **Construction Period** | | | | | | | | | |
| 1 | $715 | $238 | $26,706 | | | | | $27,659,000 | $27,659,000 |
| 2 | | | | | | | | 0 | 0 |
| 3 | | | | | | | | 0 | 0 |
| 4 | | | | | | | | 0 | 0 |
| 5 | | | | | | | | 0 | 0 |
| 6 | | | | | | | | 0 | 0 |
| 7 | | | | | | | | 0 | 0 |
| 8 | | | | | | | | 0 | 0 |
| **Project Open** | | | | | | | | | |
| 1 | | | | $21 | ($430) | | | ($409,000) | ($382,243) |
| 2 | | | | $21 | | | | 21,000 | 18,342 |
| 3 | | | | $21 | ($52) | | | (31,000) | (25,305) |
| 4 | | | | $21 | | | | 21,000 | 16,021 |
| 5 | | | | $21 | ($52) | | | (31,000) | (22,103) |
| 6 | | | | $21 | $120 | | | 141,000 | 93,954 |
| 7 | | | | $21 | | | | 21,000 | 13,078 |
| 8 | | | | $21 | | | | 21,000 | 12,222 |
| 9 | | | | $21 | ($52) | | | (31,000) | (16,862) |
| 10 | | | | $21 | | | | 21,000 | 10,675 |
| 11 | | | | $21 | $190 | | | 211,000 | 100,245 |
| 12 | | | | $21 | ($4,479) | | | (4,458,000) | (1,979,405) |
| 13 | | | | $21 | ($52) | | | (31,000) | (12,864) |
| 14 | | | | $21 | | | | 21,000 | 8,144 |
| 15 | | | | $21 | ($52) | | | (31,000) | (11,236) |
| 16 | | | | $21 | $1,841 | | | 1,862,000 | 630,724 |
| 17 | | | | $21 | ($52) | | | (31,000) | (9,814) |
| 18 | | | | $21 | $152 | | | 173,000 | 51,184 |
| 19 | | | | $21 | ($52) | | | (31,000) | (8,572) |
| 20 | | | | $21 | | | | 21,000 | 5,427 |
| **Total** | $715 | $238 | $26,706 | $420 | ($2,970) | $0 | $0 | $25,109,000 | $26,150,613 |

2A

## HIGHWAY SPEED AND VOLUME INPUTS

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 17,203 | | 17,203 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,701 | | 1,701 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 49.1 | | 49.1 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 49.1 | | 49.1 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,214 | | 2,214 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 219 | | 219 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 28,498 | | 28,498 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 2,818 | | 2,818 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 12.5 | | 12.5 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 12.5 | | 12.5 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 3,667 | | 3,667 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 363 | | 363 | |
| Non-HOV Speed | 50.0 | | 50.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| **Build** | | | | |
| ***Year 1*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 19,499 | | 19,499 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 1,928 | | 1,928 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 2,509 | | 2,509 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 248 | | 248 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| ***Year 20*** | | | | |
| Peak Period | | | | |
| HOV Volume | 0 | | 0 | |
| Non-HOV Volume | 35,530 | | 35,530 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 3,514 | | 3,514 | |
| HOV Speed | 55.0 | | 55.0 | |
| Non-HOV Speed | 58.4 | | 58.4 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |
| Non-Peak Period | | | | |
| Non-HOV Volume | 4,572 | | 4,572 | |
| Weaving Volume | 0 | | 0 | |
| Truck Volume | 452 | | 452 | |
| Non-HOV Speed | 60.0 | | 60.0 | |
| Weaving Speed | 55.0 | | 55.0 | |
| Truck Speed | 50.0 | | 50.0 | |

*Model speed estimates based on Highway Capacity Manual, pavement research, and research on weaving impacts*

2B

## HIGHWAY ACCIDENT RATES

| | Calculated by Model | Changed by User | Used for Proj. Eval. | Reason for Change |
|---|---|---|---|---|
| **No Build** | | | | |
| Fatal Accidents | 0.015 | | 0.015 | |
| Injury Accidents | 0.49 | | 0.49 | |
| PDO Accidents | 1.36 | | 1.36 | |
| Total Accidents | 1.865 | | | |
| **Hwy Safety or Weaving Improvement** | | 0% | collision reduction factor (per HSIP Guidelines) | |
| **Adjustment Factor** (Actual/Statewide Avg. Existing) | | | | |
| Fatal Accidents | 2.9070 | | 2.9070 | |
| Injury Accidents | 1.2123 | | 1.2123 | |
| PDO Accidents | 1.0377 | | 1.0377 | |
| **Build** | | | | |
| Fatal Accidents | 0.007 | | 0.007 | |
| Injury Accidents | 0.21 | | 0.21 | |
| PDO Accidents | 0.59 | | 0.59 | |
| Total Accidents | 0.813 | | | |

2C

## RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

**Detailed Information Available?** (y/n) N

**Aggregate Segment Length** (estimate as VMT/total volume)

| | | |
|---|---|---|
| All Ramps | | miles |
| Arterials | | miles |

| | Entered by User | Used for Proj. Eval. | Source/Notes |
|---|---|---|---|
| **No Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| **Build (Peak Period Only)** | | | |
| ***Year 1*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |
| ***Year 20*** | | | |
| Aggregate Ramp Volume | | 0 | |
| Aggregate Arterial Volume | | 0 | |
| Average Ramp Speed | | 5.0 | |
| Average Arterial Speed | | 5.0 | |

2D

## ANNUAL PERSON-TRIPS

(for HOV and HOT lane projects that affect average vehicle occupancy)

| | No Build | Build | Induced |
|---|---|---|---|
| **Year 1** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 7,221,132 | 8,184,534 | 963,402 |
| Truck Trips | 621,024 | 703,878 | 82,853 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,050,321 | 1,190,448 | 140,128 |
| Truck Trips | 79,906 | 90,567 | 10,661 |
| Total Trips | 8,972,383 | 10,169,427 | 1,197,044 |
| **Year 20** | | | |
| Peak Period | | | |
| HOV Trips | 0 | 0 | |
| Non-HOV Trips | 11,962,063 | 14,913,829 | 2,951,766 |
| Truck Trips | 1,028,749 | 1,282,604 | 253,855 |
| Non-Peak Period | | | |
| Non-HOV Trips | 1,739,894 | 2,169,231 | 429,337 |
| Truck Trips | 132,367 | 165,030 | 32,663 |
| Total Trips | 14,863,073 | 18,530,694 | 3,667,621 |

**District:** WCTID

**PROJECT:** WAR 63 Priority Segment 4-Lane Divided

EA:
PPNO:

③

# INVESTMENT ANALYSIS

## SUMMARY RESULTS

| | |
|---|---|
| **Life-Cycle Costs (mil. $)** | $26.2 |
| **Life-Cycle Benefits (mil. $)** | $110.8 |
| **Net Present Value (mil. $)** | $84.6 |
| **Benefit / Cost Ratio:** | 4.2 |
| **Rate of Return on Investment:** | 21.9% |
| **Payback Period:** | 7 years |

| **ITEMIZED BENEFITS (mil. $)** | Passenger Benefits | Freight Benefits | Total Over 20 Years | Average Annual |
|---|---|---|---|---|
| **Travel Time Savings** | $79.5 | $12.5 | $92.0 | $4.6 |
| **Veh. Op. Cost Savings** | -$17.2 | -$2.9 | -$20.1 | -$1.0 |
| **Accident Cost Savings** | $35.4 | $3.5 | $38.9 | $1.9 |
| **Emission Cost Savings** | -$0.0 | $0.1 | $0.1 | $0.0 |
| **TOTAL BENEFITS** | $97.6 | $13.2 | $110.8 | $5.5 |
| **Person-Hours of Time Saved** | | | 14,803,924 | 740,196 |

### *Should benefit-cost results include:*

| | | |
|---|---|---|
| **1) Induced Travel? (y/n)** | Y | Default = Y |
| **2) Vehicle Operating Costs? (y/n)** | Y | Default = Y |
| **3) Accident Costs? (y/n)** | Y | Default = Y |
| **4) Vehicle Emissions? (y/n)**<br>includes value for $CO_2e$ | Y | Default = Y |

| | Tons | | Value (mil. $) | |
|---|---|---|---|---|
| **EMISSIONS REDUCTION** | Total Over 20 Years | Average Annual | Total Over 20 Years | Average Annual |
| **CO Emissions Saved** | 19 | 1 | $0.0 | $0.0 |
| **$CO_2$ Emissions Saved** | 4,654 | 233 | -$0.0 | -$0.0 |
| **$NO_X$ Emissions Saved** | 50 | 2 | $0.1 | $0.0 |
| **$PM_{10}$ Emissions Saved** | 0 | 0 | $0.0 | $0.0 |
| **$PM_{2.5}$ Emissions Saved** | 0 | 0 | | |
| **$SO_X$ Emissions Saved** | 0 | 0 | -$0.0 | -$0.0 |
| **VOC Emissions Saved** | 4 | 0 | -$0.0 | -$0.0 |

C

# SUMMARY OF TRAVEL TIME BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | $1,098,713 | $0 | $21,244 | $0 | $0 | $143,975 | $0 | $0 |
| 20 | $0 | $9,006,812 | $0 | $1,677,211 | $0 | $0 | $69,451 | $0 | $0 |
| 2 | $0 | $1,300,171 | $0 | $67,438 | $0 | $0 | $139,829 | $0 | $0 |
| 3 | $0 | $1,506,785 | $0 | $114,662 | $0 | $0 | $135,609 | $0 | $0 |
| 4 | $0 | $1,719,224 | $0 | $163,006 | $0 | $0 | $131,343 | $0 | $0 |
| 5 | $0 | $1,938,400 | $0 | $212,617 | $0 | $0 | $127,054 | $0 | $0 |
| 6 | $0 | $2,165,507 | $0 | $263,698 | $0 | $0 | $122,765 | $0 | $0 |
| 7 | $0 | $2,402,075 | $0 | $316,525 | $0 | $0 | $118,493 | $0 | $0 |
| 8 | $0 | $2,650,044 | $0 | $371,455 | $0 | $0 | $114,255 | $0 | $0 |
| 9 | $0 | $2,911,864 | $0 | $428,950 | $0 | $0 | $110,064 | $0 | $0 |
| 10 | $0 | $3,190,638 | $0 | $489,602 | $0 | $0 | $105,932 | $0 | $0 |
| 11 | $0 | $3,490,313 | $0 | $554,168 | $0 | $0 | $101,870 | $0 | $0 |
| 12 | $0 | $3,815,963 | $0 | $623,630 | $0 | $0 | $97,886 | $0 | $0 |
| 13 | $0 | $4,174,193 | $0 | $699,272 | $0 | $0 | $93,987 | $0 | $0 |
| 14 | $0 | $4,573,742 | $0 | $782,792 | $0 | $0 | $90,180 | $0 | $0 |
| 15 | $0 | $5,026,398 | $0 | $876,488 | $0 | $0 | $86,468 | $0 | $0 |
| 16 | $0 | $5,548,446 | $0 | $983,535 | $0 | $0 | $82,856 | $0 | $0 |
| 17 | $0 | $6,163,022 | $0 | $1,108,449 | $0 | $0 | $79,347 | $0 | $0 |
| 18 | $0 | $6,904,150 | $0 | $1,257,868 | $0 | $0 | $75,942 | $0 | $0 |
| 19 | $0 | $7,823,989 | $0 | $1,441,973 | $0 | $0 | $72,643 | $0 | $0 |
| **Total** | **$0** | **$77,410,451** | **$0** | **$12,454,583** | **$0** | **$0** | **$2,099,946** | **$0** | **$0** |

C

# SUMMARY OF TRAVEL TIME BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Travel Time Benefits | Constant Dollars | Total Per-Hrs of Time Saved |
|---|---|---|---|---|---|---|---|
| | Peak In-Vehicle | Peak Out-of-Veh | Non-Peak In-Vehicle | Non-Peak Out-of-Veh | | | |
| 1 | $0 | $0 | $0 | $0 | $1,263,932 | $1,352,407 | 91,339 |
| 20 | $0 | $0 | $0 | $0 | $10,753,474 | $41,612,552 | 2,458,979 |
| 2 | $0 | $0 | $0 | $0 | $1,507,438 | $1,725,866 | 114,213 |
| 3 | $0 | $0 | $0 | $0 | $1,757,056 | $2,152,469 | 140,183 |
| 4 | $0 | $0 | $0 | $0 | $2,013,573 | $2,639,383 | 169,667 |
| 5 | $0 | $0 | $0 | $0 | $2,278,071 | $3,195,113 | 203,162 |
| 6 | $0 | $0 | $0 | $0 | $2,551,970 | $3,829,819 | 241,259 |
| 7 | $0 | $0 | $0 | $0 | $2,837,093 | $4,555,751 | 284,673 |
| 8 | $0 | $0 | $0 | $0 | $3,135,753 | $5,387,808 | 334,272 |
| 9 | $0 | $0 | $0 | $0 | $3,450,878 | $6,344,299 | 391,123 |
| 10 | $0 | $0 | $0 | $0 | $3,786,172 | $7,447,973 | 456,553 |
| 11 | $0 | $0 | $0 | $0 | $4,146,351 | $8,727,454 | 532,230 |
| 12 | $0 | $0 | $0 | $0 | $4,537,480 | $10,219,273 | 620,283 |
| 13 | $0 | $0 | $0 | $0 | $4,967,452 | $11,970,790 | 723,474 |
| 14 | $0 | $0 | $0 | $0 | $5,446,714 | $14,044,537 | 845,447 |
| 15 | $0 | $0 | $0 | $0 | $5,989,354 | $16,524,817 | 991,118 |
| 16 | $0 | $0 | $0 | $0 | $6,614,837 | $19,528,082 | 1,167,273 |
| 17 | $0 | $0 | $0 | $0 | $7,350,818 | $23,219,875 | 1,383,564 |
| 18 | $0 | $0 | $0 | $0 | $8,237,960 | $27,843,746 | 1,654,188 |
| 19 | $0 | $0 | $0 | $0 | $9,338,605 | $33,773,322 | 2,000,924 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$91,964,980** | **$246,095,336** | **14,803,924** |

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# SUMMARY OF VEHICLE OPERATING COST BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | | Present Value of Veh Op Cost Benefits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | Peak Period | Non-Peak Period | |
| 1 | $0 | ($1,028,520) | $0 | ($140,639) | $0 | ($132,338) | $0 | ($18,190) | - | - | ($1,319,687) |
| 20 | $0 | $12,465 | $0 | $8,525 | $0 | ($106,403) | $0 | ($15,410) | - | - | ($100,824) |
| 2 | $0 | ($1,043,743) | $0 | ($143,999) | $0 | ($136,099) | $0 | ($18,847) | - | - | ($1,342,688) |
| 3 | $0 | ($1,065,121) | $0 | ($146,549) | $0 | ($138,802) | $0 | ($19,339) | - | - | ($1,369,811) |
| 4 | $0 | ($1,064,009) | $0 | ($154,654) | $0 | ($140,568) | $0 | ($19,687) | - | - | ($1,378,918) |
| 5 | $0 | ($1,057,592) | $0 | ($161,380) | $0 | ($141,509) | $0 | ($19,907) | - | - | ($1,380,388) |
| 6 | $0 | ($1,039,562) | $0 | ($163,795) | $0 | ($141,726) | $0 | ($20,013) | - | - | ($1,365,097) |
| 7 | $0 | ($1,011,399) | $0 | ($162,363) | $0 | ($141,309) | $0 | ($20,020) | - | - | ($1,335,092) |
| 8 | $0 | ($981,017) | $0 | ($160,072) | $0 | ($140,339) | $0 | ($19,941) | - | - | ($1,301,369) |
| 9 | $0 | ($930,089) | $0 | ($165,461) | $0 | ($138,892) | $0 | ($19,787) | - | - | ($1,254,228) |
| 10 | $0 | ($882,414) | $0 | ($169,542) | $0 | ($137,033) | $0 | ($19,567) | - | - | ($1,208,557) |
| 11 | $0 | ($820,616) | $0 | ($165,437) | $0 | ($134,824) | $0 | ($19,291) | - | - | ($1,140,168) |
| 12 | $0 | ($749,549) | $0 | ($154,370) | $0 | ($132,316) | $0 | ($18,968) | - | - | ($1,055,204) |
| 13 | $0 | ($671,147) | $0 | ($143,673) | $0 | ($129,560) | $0 | ($18,604) | - | - | ($962,986) |
| 14 | $0 | ($619,148) | $0 | ($130,291) | $0 | ($126,598) | $0 | ($18,207) | - | - | ($894,245) |
| 15 | $0 | ($532,685) | $0 | ($107,484) | $0 | ($123,470) | $0 | ($17,782) | - | - | ($781,421) |
| 16 | $0 | ($451,498) | $0 | ($86,033) | $0 | ($120,208) | $0 | ($17,335) | - | - | ($675,074) |
| 17 | $0 | ($339,927) | $0 | ($72,838) | $0 | ($116,845) | $0 | ($16,870) | - | - | ($546,481) |
| 18 | $0 | ($238,709) | $0 | ($60,513) | $0 | ($113,408) | $0 | ($16,392) | - | - | ($429,023) |
| 19 | $0 | ($118,859) | $0 | ($32,715) | $0 | ($109,920) | $0 | ($15,904) | - | - | ($277,399) |
| **Total** | **$0** | **($14,633,140)** | **$0** | **($2,513,285)** | **$0** | **($2,602,169)** | **$0** | **($370,064)** | **-** | **-** | **($20,118,658)** |

| Constant Dollars |
|---:|
| ($1,412,065) |
| ($390,158) |
| |
| ($1,537,243) |
| ($1,678,077) |
| ($1,807,480) |
| ($1,936,066) |
| ($2,048,642) |
| ($2,143,865) |
| ($2,235,995) |
| ($2,305,847) |
| ($2,377,414) |
| ($2,399,886) |
| ($2,376,521) |
| ($2,320,646) |
| ($2,305,840) |
| ($2,155,965) |
| ($1,992,929) |
| ($1,726,233) |
| ($1,450,067) |
| ($1,003,220) |
| |
| **($37,604,160)** |

C

# SUMMARY OF ACCIDENT REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | TRANSIT | Present Value of Accident Benefits |
|---|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck | All Periods | |
| 1 | $0 | $2,322,165 | $0 | $229,665 | $0 | $298,789 | $0 | $29,551 | $0 | $2,880,169 |
| 20 | $0 | $959,718 | $0 | $94,917 | $0 | $123,485 | $0 | $12,213 | $0 | $1,190,334 |
| 2 | $0 | $2,226,749 | $0 | $220,228 | $0 | $286,512 | $0 | $28,336 | $0 | $2,761,825 |
| 3 | $0 | $2,133,880 | $0 | $211,043 | $0 | $274,562 | $0 | $27,155 | $0 | $2,646,640 |
| 4 | $0 | $2,043,631 | $0 | $202,117 | $0 | $262,950 | $0 | $26,006 | $0 | $2,534,705 |
| 5 | $0 | $1,956,058 | $0 | $193,456 | $0 | $251,682 | $0 | $24,892 | $0 | $2,426,088 |
| 6 | $0 | $1,871,196 | $0 | $185,063 | $0 | $240,763 | $0 | $23,812 | $0 | $2,320,835 |
| 7 | $0 | $1,789,067 | $0 | $176,941 | $0 | $230,196 | $0 | $22,767 | $0 | $2,218,970 |
| 8 | $0 | $1,709,675 | $0 | $169,089 | $0 | $219,981 | $0 | $21,756 | $0 | $2,120,500 |
| 9 | $0 | $1,633,013 | $0 | $161,507 | $0 | $210,117 | $0 | $20,781 | $0 | $2,025,418 |
| 10 | $0 | $1,559,065 | $0 | $154,193 | $0 | $200,602 | $0 | $19,840 | $0 | $1,933,700 |
| 11 | $0 | $1,487,804 | $0 | $147,145 | $0 | $191,433 | $0 | $18,933 | $0 | $1,845,315 |
| 12 | $0 | $1,419,193 | $0 | $140,360 | $0 | $182,605 | $0 | $18,060 | $0 | $1,760,218 |
| 13 | $0 | $1,353,193 | $0 | $133,832 | $0 | $174,113 | $0 | $17,220 | $0 | $1,678,357 |
| 14 | $0 | $1,289,753 | $0 | $127,558 | $0 | $165,950 | $0 | $16,413 | $0 | $1,599,674 |
| 15 | $0 | $1,228,823 | $0 | $121,532 | $0 | $158,110 | $0 | $15,637 | $0 | $1,524,103 |
| 16 | $0 | $1,170,345 | $0 | $115,748 | $0 | $150,586 | $0 | $14,893 | $0 | $1,451,573 |
| 17 | $0 | $1,114,260 | $0 | $110,201 | $0 | $143,370 | $0 | $14,179 | $0 | $1,382,010 |
| 18 | $0 | $1,060,503 | $0 | $104,885 | $0 | $136,453 | $0 | $13,495 | $0 | $1,315,337 |
| 19 | $0 | $1,009,012 | $0 | $99,792 | $0 | $129,828 | $0 | $12,840 | $0 | $1,251,472 |
| **Total** | **$0** | **$31,337,103** | **$0** | **$3,099,274** | **$0** | **$4,032,088** | **$0** | **$398,778** | **$0** | **$38,867,242** |

| Constant Dollars |
|---|
| $3,081,780 |
| $4,606,215 |
| |
| $3,162,014 |
| $3,242,247 |
| $3,322,481 |
| $3,402,714 |
| $3,482,947 |
| $3,563,181 |
| $3,643,414 |
| $3,723,648 |
| $3,803,881 |
| $3,884,115 |
| $3,964,348 |
| $4,044,581 |
| $4,124,815 |
| $4,205,048 |
| $4,285,282 |
| $4,365,515 |
| $4,445,748 |
| $4,525,982 |
| |
| **$76,879,957** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS

| Year | HIGHWAY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Peak HOV | Peak Non-HOV | Peak Weaving | Peak Truck | Peak Ramp | Peak Arterial | Non-Peak Non-HOV | Non-Peak Weaving | Non-Peak Truck |
| 1 | $0 | ($11,268) | $0 | ($14,529) | $0 | $0 | ($1,433) | $0 | ($2,162) |
| 20 | $0 | $13,899 | $0 | $40,884 | $0 | $0 | ($461) | $0 | ($486) |
| | | | | | | | | | |
| 2 | $0 | ($11,327) | $0 | ($10,874) | $0 | $0 | ($1,479) | $0 | ($2,241) |
| 3 | $0 | ($11,843) | $0 | ($7,358) | $0 | $0 | ($1,513) | $0 | ($2,300) |
| 4 | $0 | ($12,037) | $0 | ($7,431) | $0 | $0 | ($1,537) | $0 | ($2,342) |
| 5 | $0 | ($11,452) | $0 | ($7,488) | $0 | $0 | ($1,552) | $0 | ($2,369) |
| 6 | $0 | ($11,418) | $0 | ($7,675) | $0 | $0 | ($1,559) | $0 | ($2,383) |
| 7 | $0 | ($10,562) | $0 | ($7,991) | $0 | $0 | ($1,558) | $0 | ($2,385) |
| 8 | $0 | ($2,757) | $0 | $1,818 | $0 | $0 | ($595) | $0 | ($616) |
| 9 | $0 | ($1,915) | $0 | $2,680 | $0 | $0 | ($589) | $0 | ($613) |
| 10 | $0 | ($1,123) | $0 | $3,420 | $0 | $0 | ($581) | $0 | ($607) |
| 11 | $0 | ($205) | $0 | $4,635 | $0 | $0 | ($572) | $0 | ($599) |
| 12 | $0 | $683 | $0 | $6,158 | $0 | $0 | ($562) | $0 | ($590) |
| 13 | $0 | $2,167 | $0 | $7,592 | $0 | $0 | ($552) | $0 | ($579) |
| 14 | $0 | $2,789 | $0 | $9,737 | $0 | $0 | ($540) | $0 | ($568) |
| 15 | $0 | $4,119 | $0 | $14,227 | $0 | $0 | ($528) | $0 | ($556) |
| 16 | $0 | $5,384 | $0 | $18,268 | $0 | $0 | ($515) | $0 | ($542) |
| 17 | $0 | $7,554 | $0 | $21,228 | $0 | $0 | ($502) | $0 | ($529) |
| 18 | $0 | $9,158 | $0 | $23,884 | $0 | $0 | ($489) | $0 | ($515) |
| 19 | $0 | $11,222 | $0 | $30,650 | $0 | $0 | ($475) | $0 | ($500) |
| | | | | | | | | | |
| **Total** | **$0** | **($28,934)** | **$0** | **$121,835** | **$0** | **$0** | **($17,590)** | **$0** | **($23,482)** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TRANSIT | | | | Present Value of Emission Benefits | Constant Dollars |
|---|---|---|---|---|---|---|
| | Peak Bus | Non-Peak Bus | Passenger Rail | Light Rail | | |
| 1 | $0 | $0 | $0 | $0 | ($29,393) | ($31,450) |
| 20 | $0 | $0 | $0 | $0 | $53,836 | $208,329 |
| 2 | $0 | $0 | $0 | $0 | ($25,921) | ($29,677) |
| 3 | $0 | $0 | $0 | $0 | ($23,015) | ($28,194) |
| 4 | $0 | $0 | $0 | $0 | ($23,347) | ($30,604) |
| 5 | $0 | $0 | $0 | $0 | ($22,861) | ($32,064) |
| 6 | $0 | $0 | $0 | $0 | ($23,034) | ($34,568) |
| 7 | $0 | $0 | $0 | $0 | ($22,496) | ($36,123) |
| 8 | $0 | $0 | $0 | $0 | ($2,150) | ($3,694) |
| 9 | $0 | $0 | $0 | $0 | ($436) | ($802) |
| 10 | $0 | $0 | $0 | $0 | $1,109 | $2,182 |
| 11 | $0 | $0 | $0 | $0 | $3,259 | $6,859 |
| 12 | $0 | $0 | $0 | $0 | $5,689 | $12,812 |
| 13 | $0 | $0 | $0 | $0 | $8,627 | $20,791 |
| 14 | $0 | $0 | $0 | $0 | $11,418 | $29,440 |
| 15 | $0 | $0 | $0 | $0 | $17,262 | $47,626 |
| 16 | $0 | $0 | $0 | $0 | $22,594 | $66,701 |
| 17 | $0 | $0 | $0 | $0 | $27,751 | $87,661 |
| 18 | $0 | $0 | $0 | $0 | $32,038 | $108,287 |
| 19 | $0 | $0 | $0 | $0 | $40,897 | $147,903 |
| **Total** | **$0** | **$0** | **$0** | **$0** | **$51,828** | **$511,418** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| Year | TONS EMISSIONS SAVED (tons/yr) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
| 1 | (5) | (2,185) | (2) | (0) | (0) | (1) | (0) |
| 20 | 16 | 8,828 | 18 | 0 | 0 | 2 | 0 |
| 2 | (6) | (2,123) | (2) | (0) | (0) | (1) | (0) |
| 3 | (7) | (2,146) | (2) | (0) | (0) | (1) | (0) |
| 4 | (7) | (2,200) | (2) | (0) | (0) | (1) | (0) |
| 5 | (7) | (2,247) | (2) | (0) | (0) | (1) | (0) |
| 6 | (7) | (2,223) | (2) | (0) | (0) | (1) | (0) |
| 7 | (7) | (2,124) | (2) | (0) | (0) | (1) | (0) |
| 8 | 0 | (1,379) | 0 | (0) | (0) | (0) | (0) |
| 9 | 1 | (1,299) | 0 | (0) | (0) | (0) | (0) |
| 10 | 1 | (1,209) | 0 | 0 | (0) | 0 | 0 |
| 11 | 1 | (991) | 1 | 0 | (0) | 0 | 0 |
| 12 | 2 | (636) | 1 | 0 | (0) | 0 | 0 |
| 13 | 3 | (163) | 2 | 0 | (0) | 0 | 0 |
| 14 | 3 | 216 | 3 | 0 | 0 | 0 | 0 |
| 15 | 4 | 1,065 | 4 | 0 | 0 | 1 | 0 |
| 16 | 5 | 1,956 | 6 | 0 | 0 | 1 | 0 |
| 17 | 7 | 3,085 | 7 | 0 | 0 | 1 | 0 |
| 18 | 9 | 4,264 | 9 | 0 | 0 | 1 | 0 |
| 19 | 12 | 6,164 | 12 | 0 | 0 | 2 | 0 |
| **Total** | **19** | **4,654** | **50** | **0** | **(0)** | **4** | **0** |

C

# SUMMARY OF EMISSION REDUCTION BENEFITS (continued)

| **Year** | **DOLLARS EMISSIONS SAVED**<br>(PV $/yr) | | | | | |
|---|---|---|---|---|---|---|
| | **CO** | **$CO_2$** | **$NO_X$** | **$PM_{10}$** | **$SO_X$** | **VOC** |
| 1 | $0 | ($1,890) | ($15,566) | ($8,650) | ($2,294) | ($992) |
| 20 | $0 | $3,075 | $38,518 | $10,028 | $1,064 | $1,151 |
| 2 | $0 | ($1,750) | ($14,246) | ($6,644) | ($2,293) | ($987) |
| 3 | $0 | ($1,686) | ($12,667) | ($5,403) | ($2,279) | ($980) |
| 4 | $0 | ($1,648) | ($12,940) | ($5,509) | ($2,311) | ($939) |
| 5 | $0 | ($1,605) | ($13,121) | ($4,992) | ($2,248) | ($896) |
| 6 | $0 | ($1,514) | ($12,929) | ($5,514) | ($2,250) | ($829) |
| 7 | $0 | ($1,378) | ($12,418) | ($5,781) | ($2,172) | ($747) |
| 8 | $0 | ($853) | $363 | ($1,141) | ($456) | ($63) |
| 9 | $0 | ($766) | $1,249 | ($510) | ($398) | ($12) |
| 10 | $0 | ($680) | $2,071 | $25 | ($343) | $35 |
| 11 | $0 | ($531) | $3,294 | $620 | ($219) | $95 |
| 12 | $0 | ($325) | $4,849 | $1,168 | ($166) | $163 |
| 13 | $0 | ($79) | $6,260 | $2,277 | ($57) | $228 |
| 14 | $0 | $100 | $8,407 | $2,625 | $9 | $276 |
| 15 | $0 | $471 | $12,783 | $3,487 | $140 | $380 |
| 16 | $0 | $825 | $16,752 | $4,229 | $313 | $475 |
| 17 | $0 | $1,241 | $19,579 | $5,860 | $446 | $625 |
| 18 | $0 | $1,635 | $22,109 | $6,968 | $567 | $759 |
| 19 | $0 | $2,253 | $28,617 | $8,280 | $807 | $939 |
| **Total** | **$0** | **($5,105)** | **$70,966** | **$1,425** | **($14,140)** | **($1,319)** |

A

# NET PRESENT VALUE CALCULATION

| Year | PRESENT VALUE OF USER BENEFITS | | | | PRESENT VALUE OF USER BENEFITS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,263,932 | ($1,319,687) | $2,880,169 | ($29,393) | | | | |
| 2 | $1,507,438 | ($1,342,688) | $2,761,825 | ($25,921) | | | | |
| 3 | $1,757,056 | ($1,369,811) | $2,646,640 | ($23,015) | | | | |
| 4 | $2,013,573 | ($1,378,918) | $2,534,705 | ($23,347) | | | | |
| 5 | $2,278,071 | ($1,380,388) | $2,426,088 | ($22,861) | | | | |
| 6 | $2,551,970 | ($1,365,097) | $2,320,835 | ($23,034) | | | | |
| 7 | $2,837,093 | ($1,335,092) | $2,218,970 | ($22,496) | | | | |
| 8 | $3,135,753 | ($1,301,369) | $2,120,500 | ($2,150) | | | | |
| 9 | $3,450,878 | ($1,254,228) | $2,025,418 | ($436) | | | | |
| 10 | $3,786,172 | ($1,208,557) | $1,933,700 | $1,109 | | | | |
| 11 | $4,146,351 | ($1,140,168) | $1,845,315 | $3,259 | | | | |
| 12 | $4,537,480 | ($1,055,204) | $1,760,218 | $5,689 | | | | |
| 13 | $4,967,452 | ($962,986) | $1,678,357 | $8,627 | | | | |
| 14 | $5,446,714 | ($894,245) | $1,599,674 | $11,418 | | | | |
| 15 | $5,989,354 | ($781,421) | $1,524,103 | $17,262 | | | | |
| 16 | $6,614,837 | ($675,074) | $1,451,573 | $22,594 | | | | |
| 17 | $7,350,818 | ($546,481) | $1,382,010 | $27,751 | | | | |
| 18 | $8,237,960 | ($429,023) | $1,315,337 | $32,038 | | | | |
| 19 | $9,338,605 | ($277,399) | $1,251,472 | $40,897 | | | | |
| 20 | $10,753,474 | ($100,824) | $1,190,334 | $53,836 | | | | |
| **Total** | $91,964,980 | ($20,118,658) | $38,867,242 | $51,828 | $0 | $0 | $0 | $0 |

| | | | |
|---|---|---|---|
| 14,803,924 | Person-Hours of Time Saved | | Person-Hours of Time Saved |

| tons | $ PV | | tons | $ PV | |
|---|---|---|---|---|---|
| 19 | $0 | CO Saved | | | CO Saved |
| 4,654 | ($5,105) | $CO_2$ Saved | | | $CO_2$ Saved |
| 50 | $70,966 | $NO_X$ Saved | | | $NO_X$ Saved |
| 0 | $1,425 | $PM_{10}$ Saved | | | $PM_{10}$ Saved |
| 0 | | $PM_{2.5}$ Saved | | | $PM_{2.5}$ Saved |
| (0) | ($14,140) | $SO_X$ Saved | | | $SO_X$ Saved |
| 4 | ($1,319) | VOC Saved | | | VOC Saved |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $12,454,583 | ($2,883,348) | $3,498,052 | $98,353 | | | | |

| PRESENT VALUE OF USER BENEFITS (road 3) | | | | Present Value of Total User Benefits | Present Value of Total Project Costs | NET PRESENT VALUE |
|---|---|---|---|---|---|---|
| **Travel Time Savings** | **Vehicle Op. Cost Savings** | **Accident Reductions** | **Vehicle Emission Reductions** | | | |
| | | | | $0 | $27,659,000 | ($27,659,000) |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $0 | $0 | $0 |
| | | | | $2,795,021 | ($382,243) | $3,177,264 |
| | | | | $2,900,655 | $18,342 | $2,882,313 |
| | | | | $3,010,870 | ($25,305) | $3,036,175 |
| | | | | $3,146,012 | $16,021 | $3,129,991 |
| | | | | $3,300,910 | ($22,103) | $3,323,012 |
| | | | | $3,484,674 | $93,954 | $3,390,720 |
| | | | | $3,698,475 | $13,078 | $3,685,398 |
| | | | | $3,952,735 | $12,222 | $3,940,512 |
| | | | | $4,221,632 | ($16,862) | $4,238,494 |
| | | | | $4,512,424 | $10,675 | $4,501,749 |
| | | | | $4,854,756 | $100,245 | $4,754,511 |
| | | | | $5,248,182 | ($1,979,405) | $7,227,587 |
| | | | | $5,691,452 | ($12,864) | $5,704,316 |
| | | | | $6,163,561 | $8,144 | $6,155,417 |
| | | | | $6,749,298 | ($11,236) | $6,760,534 |
| | | | | $7,413,930 | $630,724 | $6,783,206 |
| | | | | $8,214,098 | ($9,814) | $8,223,912 |
| | | | | $9,156,312 | $51,184 | $9,105,127 |
| | | | | $10,353,575 | ($8,572) | $10,362,146 |
| | | | | $11,896,820 | $5,427 | $11,891,393 |
| $0 | $0 | $0 | $0 | **$110,765,392** | **$26,150,613** | **$84,614,779** |

| | |
|---|---|
| | Person-Hours of Time Saved |

| tons | $ PV | |
|---|---|---|
| | | CO Saved |
| | | $CO_2$ Saved |
| | | $NO_X$ Saved |
| | | $PM_{10}$ Saved |
| | | $PM_{2.5}$ Saved |
| | | $SO_X$ Saved |
| | | VOC Saved |

| | | | | |
|---|---|---|---|---|
| | | | | Freight Benefits Only |

B

# INTERNAL RATE OF RETURN ON INVESTMENT AND PAYBACK PERIOD

| | USER BENEFITS IN CONSTANT DOLLARS | | | | USER BENEFITS IN CONSTANT DOLLARS (road 2) | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions |
| **Construction Period** | | | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| **Project Open** | | | | | | | | |
| 1 | $1,352,407 | ($1,412,065) | $3,081,780 | ($31,450) | | | | |
| 2 | $1,725,866 | ($1,537,243) | $3,162,014 | ($29,677) | | | | |
| 3 | $2,152,469 | ($1,678,077) | $3,242,247 | ($28,194) | | | | |
| 4 | $2,639,383 | ($1,807,480) | $3,322,481 | ($30,604) | | | | |
| 5 | $3,195,113 | ($1,936,066) | $3,402,714 | ($32,064) | | | | |
| 6 | $3,829,819 | ($2,048,642) | $3,482,947 | ($34,568) | | | | |
| 7 | $4,555,751 | ($2,143,865) | $3,563,181 | ($36,123) | | | | |
| 8 | $5,387,808 | ($2,235,995) | $3,643,414 | ($3,694) | | | | |
| 9 | $6,344,299 | ($2,305,847) | $3,723,648 | ($802) | | | | |
| 10 | $7,447,973 | ($2,377,414) | $3,803,881 | $2,182 | | | | |
| 11 | $8,727,454 | ($2,399,886) | $3,884,115 | $6,859 | | | | |
| 12 | $10,219,273 | ($2,376,521) | $3,964,348 | $12,812 | | | | |
| 13 | $11,970,790 | ($2,320,646) | $4,044,581 | $20,791 | | | | |
| 14 | $14,044,537 | ($2,305,840) | $4,124,815 | $29,440 | | | | |
| 15 | $16,524,817 | ($2,155,965) | $4,205,048 | $47,626 | | | | |
| 16 | $19,528,082 | ($1,992,929) | $4,285,282 | $66,701 | | | | |
| 17 | $23,219,875 | ($1,726,233) | $4,365,515 | $87,661 | | | | |
| 18 | $27,843,746 | ($1,450,067) | $4,445,748 | $108,287 | | | | |
| 19 | $33,773,322 | ($1,003,220) | $4,525,982 | $147,903 | | | | |
| 20 | $41,612,552 | ($390,158) | $4,606,215 | $208,329 | | | | |
| **Total** | $246,095,336 | ($37,604,160) | $76,879,957 | $511,418 | $0 | $0 | $0 | $0 |

| USER BENEFITS IN CONSTANT DOLLARS (road 3) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Travel Time Savings | Vehicle Op. Cost Savings | Accident Reductions | Vehicle Emission Reductions | Total User Benefits in Constant Dollars | Total Project Costs in Constant Dollars | ANNUAL RETURNS ON INVESTMENT | CUMULATIVE RETURNS AFTER PROJ OPENS |
| | | | | $0 | $27,659,000 | ($27,659,000) | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $0 | $0 | $0 | |
| | | | | $2,990,673 | ($409,000) | $3,399,673 | $3,399,673 |
| | | | | $3,320,960 | $21,000 | $3,299,960 | $6,699,633 |
| | | | | $3,688,445 | ($31,000) | $3,719,445 | $10,419,077 |
| | | | | $4,123,780 | $21,000 | $4,102,780 | $14,521,858 |
| | | | | $4,629,697 | ($31,000) | $4,660,697 | $19,182,554 |
| | | | | $5,229,556 | $141,000 | $5,088,556 | $24,271,111 |
| | | | | $5,938,943 | $21,000 | $5,917,943 | $30,189,054 |
| | | | | $6,791,534 | $21,000 | $6,770,534 | $36,959,588 |
| | | | | $7,761,298 | ($31,000) | $7,792,298 | $44,751,886 |
| | | | | $8,876,622 | $21,000 | $8,855,622 | $53,607,508 |
| | | | | $10,218,542 | $211,000 | $10,007,542 | $63,615,050 |
| | | | | $11,819,912 | ($4,458,000) | $16,277,912 | $79,892,962 |
| | | | | $13,715,517 | ($31,000) | $13,746,517 | $93,639,479 |
| | | | | $15,892,952 | $21,000 | $15,871,952 | $109,511,431 |
| | | | | $18,621,526 | ($31,000) | $18,652,526 | $128,163,957 |
| | | | | $21,887,136 | $1,862,000 | $20,025,136 | $148,189,093 |
| | | | | $25,946,819 | ($31,000) | $25,977,819 | $174,166,912 |
| | | | | $30,947,714 | $173,000 | $30,774,714 | $204,941,626 |
| | | | | $37,443,988 | ($31,000) | $37,474,988 | $242,416,614 |
| | | | | $46,036,938 | $21,000 | $46,015,938 | $288,432,552 |
| $0 | $0 | $0 | $0 | **$285,882,552** | **$25,109,000** | **$260,773,552** | |

| | |
|---|---|
| **Total Construction Costs** | **$27,659,000** |

| Years After Construction Begins | ANNUAL RETURNS ON INVESTMENT |
|---|---|
| 1 | ($27,659,000) |
| 2 | $3,399,673 |
| 3 | $3,299,960 |
| 4 | $3,719,445 |
| 5 | $4,102,780 |
| 6 | $4,660,697 |
| 7 | $5,088,556 |
| 8 | $5,917,943 |
| 9 | $6,770,534 |
| 10 | $7,792,298 |
| 11 | $8,855,622 |
| 12 | $10,007,542 |
| 13 | $16,277,912 |
| 14 | $13,746,517 |
| 15 | $15,871,952 |
| 16 | $18,652,526 |
| 17 | $20,025,136 |
| 18 | $25,977,819 |
| 19 | $30,774,714 |
| 20 | $37,474,988 |
| 21 | $46,015,938 |
| 22 | $0 |
| 23 | $0 |
| 24 | $0 |
| 25 | $0 |
| 26 | $0 |
| 27 | $0 |
| 28 | $0 |

| | |
|---|---|
| **Internal Rate of Return** | **21.87%** |
| **Payback Period** | **7 years** |

The INTERNAL RATE OF RETURN (IRR) is the discount rate at which benefits and costs break even (are equal). For a project with an IRR greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The IRR allows projects with different costs, different benefit flows, and different time periods to be compared.

The PAYBACK PERIOD is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback Period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

## Parameters

*This page contains all economic values and rate tables.*
*To update economic values automatically, change "Economic Update Factor."*

OMB GDP Deflator Table 10.1
https://www.whitehouse.gov/omb/budget/Historicals

| | | |
|---|---|---|
| 2007 | 0.9684 | Dec. 18 Table A-8 2016 v |
| 2011 | 1.0293 | 1.018 |
| 2012 | 1.0481 | |
| 2013 | 1.0658 | |
| 2014 | 1.0852 | |
| 2015 | 1.0983 | |
| 2016 | 1.111 | |
| 2017 | 1.1301 | |
| **OMB GDP Inflator** | **1.01719172** | |

Yellow cells - adjusted

### *General Economic Parameters*

| | | |
|---|---|---|
| Year of Current Dollars for Model | 2017 | |
| Economic Update Factor (Using GDP Deflator) | 1.02 | *1* |
| Real Discount Rate | 7.0% | *2* |

### *Travel Time Parameters*

| | Value | Units | |
|---|---|---|---|
| Statewide Average Hourly Wage | $ 27.50 | $/hr | *3* |
| Heavy and Light Truck Drivers | | | |
| Average Hourly Wage | $ 20.50 | $/hr | *3* |
| Benefits and Costs | $ 10.69 | $/hr | *4* |
| Value of Time | | | |
| Automobile | $ 13.75 | $/hr/per | *5* |
| Truck | $ 31.20 | $/hr/veh | *5* |
| Auto & Truck Composite | $ 19.05 | $/hr/veh | *6* |
| Transit | $ 13.75 | $/hr/per | *5* |
| Out-of-Vehicle Travel | 2 | times | *5* |
| Incident-Related Travel | 3 | times | *7* |
| Travel Time Uprater | 0.0% | annual incr | |

### *Vehicle Operating Cost Parameters*

| | | | |
|---|---|---|---|
| Average Fuel Price | | | |
| Automobile (regular unleaded) | $ 3.08 | $/gal | *8* |
| Truck (diesel) | $ 3.07 | $/gal | *8* |
| Sales and Fuel Taxes | | | |
| State Sales Tax (gasoline) | 2.25% | % | *9* |
| State Sales Tax (diesel) | **13.00%** | % | *9* |
| Average Local Sales Tax | 0.50% | % | *9* |
| Federal Fuel Excise Tax (gasoline) | $ 0.184 | $/gal | *9* |
| Federal Fuel Excise Tax (diesel) | $ 0.244 | $/gal | *9* |
| State Fuel Excise Tax (gasoline) | $ 0.417 | $/gal | *9* |
| State Fuel Excise Tax (diesel) | $ 0.360 | $/gal | *9* |
| Fuel Cost Per Gallon (Exclude Taxes) | | | |
| Automobile | $ 2.40 | $/gal | |
| Truck | $ 2.10 | $/gal | |
| Non-Fuel Cost Per Mile | | | |
| Automobile | $ 0.319 | $/mi | *10* |
| Truck | $ 0.437 | $/mi | *11* |
| Idling Speed for Op. Costs and Emissions | 5 | mph | |

### *Accident Cost Parameters*

| | | | |
|---|---|---|---|
| Cost of a Fatality | $ 9,600,000 | $/event | *12* |
| Cost of an Injury | | | |
| Level A (Severe) | $ 459,100 | $/event | *12* |
| Level B (Moderate) | $ 125,000 | $/event | *12* |
| Level C (Minor) | $ 63,900 | $/event | *12* |
| Cost of Property Damage | $ 4,300 | $/event | *13* |
| Cost of Highway Accident | | | |
| Fatal Accident | $ 11,100,000 | $/accident | |
| Injury Accident | $ 154,400 | $/accident | |
| PDO Accident | $ 13,700 | $/accident | |
| Average Cost | $ 280,400 | $/accident | |
| Statewide Highway Accident Rates | | | |
| Fatal Accident | 0.006 | per mil veh-mi | *14* |
| Injury Accident | 0.29 | per mil veh-mi | *14* |
| PDO Accident | 0.55 | per mil veh-mi | *14* |
| Non-Freeway | 1.05 | per mil veh-mi | *15* |

*Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009*

### *Highway Operations Parameters*

| | Value | Units | |
|---|---|---|---|
| Maximum V/C Ratio | 1.56 | - | *16* |
| Percent ADT in Peak Period | 88.6% | % | |
| Percent ADT in Average Peak Hour | 6.8% | % | |
| Annualization Factor | 365 | days/yr | |

| | Alpha | Beta | Capacity (vphpl) | Dep. Rate (vphpl) | |
|---|---|---|---|---|---|
| Freeway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Expressway | 0.20 | 10 | 2,000 | 1,800 | *16, 17* |
| Conventional Highway | 0.05 | 10 | 800 | 1,400 | *17* |
| HOV Lanes | 0.55 | 8 | 1,600 | | *18* |

| Non-HOV Lanes | Alpha | Beta | Capacity (vphpl) |
|---|---|---|---|
| No Build | 0.05 | 10 | 800 |
| Build | 0.05 | 10 | 800 |

*Sources: 16) Highway Capacity Manual, 17) NCHRP 387, 18) PeMS data*

Fuel prices - data provided by the US Energy Information Administration's Petroleum and Other Liquids annual report.
Yellow cells - adjusted for SB 1 rate changes that became effective on 11/17.

Diesel sales tax is the combination of the sales tax rate and the excise diesel sales tax.

Note: non-fuel costs are based on 2016 Cal-B/C estimate and esclated to 2017 using OMB Table 10.1 GDP
Cannot use US DOT Guidance because their value factors in gasoline or diesel fuel prices.
Cal-B/C auto value assessed at 3.13 cents (2016) and base value for truck is ATRI 2014 value.

Note: accident costs are based on Dec. 2018 guidance, which estimated the values in 2017 as the base year.

| | | | |
|---|---|---|---|
| US DOT 2016 Guide KABCO Level Values | K | 9600000 | *Note: 2017 fed values |
| | A | 459100 | |
| | B | 125000 | |
| | C | 63900 | |
| FHWA INFRA Benefit Cost Guidance Dec-2018 PDO Value | | 4300 | |

alue

### Active Transportation Parameters

| | Value | Units | |
|---|---|---|---|
| General Travel Activity Characteristics Parameters | | | |
| Cycling Days per Year | 365 | days | |
| Walking Days per Year | 365 | days | |
| School Days per Year | 180 | days | |
| Vehicle Statistics | | | |
| Average Vehicle Speed | 25 | mph | |
| Average Vehicle Occupancy | 1.25 | persons / veh | 19 |
| Active Transportation User Characteristics | | | |
| Average Cycling Speed | 11.80 | mph | 20 |
| Average Walking Speed | 3.00 | mph | 21 |
| Number of Unlinked Cycling Trips per Day | 1.93 | trips | 19 |
| Number of Unlinked Pedestrian Trips per Day | 2.38 | trips | 19 |
| Diversion of Cyclists from Personal Vehicles | 50% | assumption | |
| Diversion of Pedestrians from Personal Vehicles | 50% | assumption | |
| Value of Travel Time | | | |
| Adults | $ 13.75 | $/hr/per | |
| Children | $ 13.75 | $/hr/per | |
| Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class | | | |
| Class I | 0.57 | - | 20 |
| Class II | 0.49 | - | 20 |
| Class III | 0.92 | - | 20 |
| Class IV | 0.49 | - | 20 |
| *Note: Class IV assumed to be the same as Class II* | | | |
| Walking Journey Quality Values per Mile by Amentity | | | |
| Street Lighting | $0.110 | $/mi | 22 |
| Curb Level | $0.078 | $/mi | 22 |
| Crowding | $0.055 | $/mi | 22 |
| Pavement Evenness | $0.026 | $/mi | 22 |
| Information Panels | $0.026 | $/mi | 22 |
| Benches | $0.017 | $/mi | 22 |
| Directional Signage | $0.017 | $/mi | 22 |
| Health (Absenteeism Reduction) | | | |
| Average Absence of Employees | 3.60 | days/yr | 23 |
| Percentage Covered by Short-Term Sick Leave | 95% | % | 24 |
| Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day | 6% | % | 25 |
| Health (Mortality Reduction) | | | |
| Percentage of Cyclists Aged 16-64 | 66.0% | % | 26 |
| Percentage of Pedestrians Aged 16-74 | 70.0% | % | 26 |
| Percentage Reduction in Mortality per 365 Annual Cycling Miles | 4.5% | % | 27 |
| Percentage Reduction in Mortality per 365 Annual Walking Miles | 9.0% | % | 27 |
| Morality Rate - All Causes (Aged 20-64) | 266 | #/100,000 people | 28 |
| Morality Rate - All Causes (Aged 20-74) | 395 | #/100,000 people | 28 |

*Sources: 19) 2000-2001 California Statewide Travel Survey, 20) Hood et al., 2011, 21) WHO HEAT Model, 2012, 22) Heuman et al., 2005, 23) CDC, 2007, 24) UK TAG, 2014, 25) WHO, 2003, 26) 2010-2012 California Household Transporation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2*

## Project Types

| | | | |
|---|---|---|---|
| Highway Capacity Expansion | | | Please select a type of highway project |
| General Highway | TRUE | GenHwy | |
| HOV Lane Addition | FALSE | HOV | Enter HOV restriction in section 1B |
| HOT Lane Addition | FALSE | HOT | Include toll payers as HOVs & check AVOs |
| Passing Lane | FALSE | Passing | Enter a truck speed in section 1B |
| Intersection | FALSE | Intersect | Remember to run model for both roads |
| Truck Only Lane | FALSE | TruckLane | Remember to run macro for truck lane |
| Bypass | FALSE | Bypass | Remember to run model for both roads |
| Queuing | FALSE | Queuing | Add arrival rate & check departure rate in 1B |
| Pavement | FALSE | Pavement | Enter pavement condition in section 1B |
| Rail or Transit Cap Expansion | | | Please select a type of rail or transit project |
| Passenger Rail | FALSE | PassRail | Enter data in both sections 1B & 1E |
| Light-Rail (LRT) | FALSE | LRT | Enter data in both sections 1B & 1E |
| Bus | FALSE | Bus | Enter data in both sections 1B & 1E |
| Hwy-Rail Grade Crossing | FALSE | HwyRail | Put hwy design in 1B, safety in 1C & crossing in 1D |
| Hwy Operational Improvement | | | Please select a type of op. improvement |
| Auxiliary Lane | FALSE | AuxLane | Enter ramp design speed & on-ramp volume |
| Freeway Connector | FALSE | FreeConn | Check percent traffic in weave in section 1B |
| HOV Connector | FALSE | HOVConn | Check percent traffic in weave in section 1B |
| HOV Drop Ramp | FALSE | HOVDrop | Check percent traffic in weave in section 1B |
| Off-Ramp Widening | FALSE | OffRamp | Check percent traffic in weave in section 1B |
| On-Ramp Widening | FALSE | OnRamp | Enter on-ramp volume & metering strategy |
| HOV-2 to HOV-3 Conv | FALSE | HOV2to3 | Check AVOs & trips in sections 1B & 2D |
| HOT Lane Conversion | FALSE | HOTConv | Check AVOs & trips in sections 1B & 2D |
| Transp Mgmt Systems (TMS) | | | Please select a type of TMS project |
| Ramp Metering | FALSE | RM | Enter model data, if avail, in sections 2A & 2C |
| Ramp Metering Signal Coord | FALSE | AM | Enter model data, if avail, in sections 2A & 2C |
| Incident Management | FALSE | IM | Enter model data, if avail, in sections 2A & 2C |
| Traveler Information | FALSE | TI | Enter model data, if avail, in sections 2A & 2C |
| Arterial Signal Management | FALSE | ASM | Complete only sections 1A, 1E & 2C |
| Transit Vehicle Location (AVL) | FALSE | AVL | Enter transit agency costs in section 1D |
| Transit Vehicle Signal Priority | FALSE | SigPriority | Check travel time in section 1D |
| Bus Rapid Transit (BRT) | FALSE | BRT | Enter free-flow bus lane speed in section 1B |
| TMS Lookup Code | NoAdj | TMSLookup | |
| User Modified Inputs | FALSE | UserAdjInputs | |

## *Travel Demand Tables*

### DEMAND FOR TRAVEL IN PEAK PERIOD

(percent of total daily travel)

| Number of Hours in Peak Period | Urban | | | | Rural | |
|---|---|---|---|---|---|---|
| | So. California | | No. California | | | |
| | Fwy/Exp | Other | Fwy/Exp | Other | Fwy/Exp | Other |
| 1 | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% | 8.5% |
| 2 | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% | 16.8% |
| 3 | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% |
| 4 | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% | 32.8% |
| 5 | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% | 40.3% |
| 6 | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% | 47.4% |
| 7 | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% | 54.2% |
| 8 | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% | 60.8% |
| 9 | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% | 67.1% |
| 10 | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% | 73.4% |
| 11 | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% | 79.0% |
| 12 | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% | 84.3% |
| 13 | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% | 88.6% |
| 14 | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% | 91.6% |
| 15 | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% | 94.3% |
| 16 | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% | 96.4% |
| 17 | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |
| 18 | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% | 98.5% |
| 19 | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% | 99.1% |
| 20 | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% | 99.4% |
| 21 | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% | 99.7% |
| 22 | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% | 99.8% |
| 23 | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% | 99.9% |
| 24 | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey, Final Report Appendix, June 2013*

### AGE COHORTS FOR MORTALITY RISK REDUCTION

(percent of population)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Age 16-64 | 70.5% | 73.4% | 66.0% |
| Walking | Age 16-74 | 76.2% | 80.7% | 70.0% |

### AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP

(miles/trip)

| Mode | Age Cohort | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Adults | 1.83 | 1.85 | 2.91 |
| | Children <16 | 0.88 | 1.03 | 1.66 |
| Walking | Adults | 0.52 | 0.66 | 0.29 |
| | Children <16 | 0.46 | 0.58 | 0.42 |

### TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS

(percent of trips)

| Mode | Trip Purpose | Urban | | Rural |
|---|---|---|---|---|
| | | South | North | |
| Cycling | Commuting | 8% | 11% | 7% |
| | Recreation | 15% | 13% | 15% |
| | Other Destination | 77% | 76% | 78% |
| Walking | Commuting | 5% | 9% | 4% |
| | Recreation | 10% | 10% | 15% |
| | Other Destination | 85% | 81% | 81% |

*Source: California Department of Transportation, 2010-2012 California Household Travel Survey database, 2012*

## *Operating Cost Tables*

### FUEL CONSUMPTION RATES

(gal/veh-mi)

| Speed | Auto* | Truck |
|---|---|---|
| 5 | 0.1024 | 0.2112 |
| 6 | 0.0971 | 0.2056 |
| 7 | 0.0919 | 0.2000 |
| 8 | 0.0867 | 0.1944 |
| 9 | 0.0815 | 0.1888 |
| 10 | 0.0763 | 0.1832 |
| 11 | 0.0727 | 0.1707 |
| 12 | 0.0691 | 0.1583 |
| 13 | 0.0656 | 0.1459 |
| 14 | 0.0620 | 0.1335 |
| 15 | 0.0584 | 0.1211 |
| 16 | 0.0560 | 0.1181 |
| 17 | 0.0536 | 0.1150 |
| 18 | 0.0513 | 0.1120 |
| 19 | 0.0489 | 0.1089 |
| 20 | 0.0465 | 0.1059 |
| 21 | 0.0449 | 0.1011 |
| 22 | 0.0433 | 0.0963 |
| 23 | 0.0417 | 0.0916 |
| 24 | 0.0401 | 0.0868 |
| 25 | 0.0384 | 0.0821 |
| 26 | 0.0374 | 0.0804 |
| 27 | 0.0363 | 0.0788 |
| 28 | 0.0352 | 0.0771 |
| 29 | 0.0341 | 0.0755 |
| 30 | 0.0330 | 0.0738 |
| 31 | 0.0323 | 0.0750 |
| 32 | 0.0316 | 0.0763 |
| 33 | 0.0310 | 0.0774 |
| 34 | 0.0303 | 0.0786 |
| 35 | 0.0296 | 0.0799 |
| 36 | 0.0292 | 0.0796 |
| 37 | 0.0288 | 0.0794 |
| 38 | 0.0284 | 0.0792 |
| 39 | 0.0280 | 0.0790 |
| 40 | 0.0276 | 0.0788 |
| 41 | 0.0274 | 0.0796 |
| 42 | 0.0272 | 0.0804 |
| 43 | 0.0270 | 0.0812 |
| 44 | 0.0268 | 0.0820 |
| 45 | 0.0266 | 0.0828 |
| 46 | 0.0266 | 0.0826 |
| 47 | 0.0266 | 0.0824 |
| 48 | 0.0266 | 0.0821 |
| 49 | 0.0266 | 0.0819 |
| 50 | 0.0266 | 0.0817 |
| 51 | 0.0268 | 0.0826 |
| 52 | 0.0270 | 0.0834 |
| 53 | 0.0272 | 0.0842 |
| 54 | 0.0274 | 0.0850 |
| 55 | 0.0275 | 0.0858 |
| 56 | 0.0279 | 0.0839 |
| 57 | 0.0283 | 0.0820 |
| 58 | 0.0286 | 0.0802 |
| 59 | 0.0290 | 0.0783 |
| 60 | 0.0293 | 0.0764 |
| 61 | 0.0300 | 0.0756 |
| 62 | 0.0306 | 0.0749 |
| 63 | 0.0312 | 0.0741 |
| 64 | 0.0319 | 0.0734 |
| 65 | 0.0325 | 0.0726 |
| 66 | 0.0331 | 0.0765 |
| 67 | 0.0337 | 0.0804 |
| 68 | 0.0343 | 0.0842 |
| 69 | 0.0350 | 0.0881 |
| 70 | 0.0356 | 0.0920 |

** Includes motorcycles & motorhomes*
*Note: Five mph is best estimate for idling*

*Source: California Air Resources Board,*
*EMFAC2014, 2016 & 2036 average*

## *Accident Tables*

### HIGHWAY INJURY SEVERITY FREQUENCY

(percent of injuries)

| Event | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Severe Injury (A) | 4.78% | 4.78% | 4.78% | 4.78% |
| Other Visible Injury (B) | 25.54% | 25.54% | 25.54% | 25.54% |
| Complaint of Pain (C) | 69.68% | 69.68% | 69.68% | 69.68% |

*Source: 2013 SWITRS Annual Report, Table 8C*

### NUMBER OF FATALITIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.09 | 1.08 | 1.14 | 1.11 |

### NUMBER OF INJURIES

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 0.81 | 0.82 | 1.12 | 0.95 |
| Injury Accident | 1.44 | 1.43 | 1.50 | 1.44 |

### NUMBER OF VEHICLES INVOLVED

(events/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.51 | 1.69 | 1.58 | 1.63 |
| Injury Accident | 1.82 | 2.10 | 1.59 | 1.99 |
| PDO Accident | 1.80 | 2.03 | 1.59 | 1.96 |

### DISTRIBUTION OF ACCIDENT TYPES

(percent of accidents)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | 1.18% | 0.45% | 1.92% | 0.71% |
| Injury Accident | 34.93% | 33.09% | 38.25% | 33.98% |
| PDO Accident | 63.89% | 66.45% | 59.83% | 65.31% |

*Source: California Department of Transportation,TASAS Unit, 2010 to 2013 average*

### COST OF HIGHWAY ACCIDENTS

($/accident)

| Accident Type | Urban | Suburban | Rural | Average |
|---|---|---|---|---|
| Fatal Accident | $10,600,000 | $10,500,000 | $11,100,000 | $10,800,000 |
| Injury Accident | $149,500 | $149,700 | $154,400 | $150,200 |
| PDO Accident | $15,500 | $17,500 | $13,700 | $16,900 |
| All Types | $187,200 | $108,400 | $280,400 | $138,800 |

*Source: Combination of above four tables*

### RATES FOR NON-HIGHWAY ACCIDENT EVENTS

(events/million veh-mi)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | 0.0555 | 0.2480 | 0.0349 | 0.9917 |
| Injury | 0.2519 | 3.9469 | 3.6535 | 7.7862 |
| All Accidents | 0.2775 | 5.3817 | 2.6733 | 13.5424 |

*Sources: USDOT,Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average*
*FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.*

### COST OF NON-HIGHWAY ACCIDENT EVENTS

($/event)

| Event | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Fatality | $9,600,000 | $9,600,000 | $9,600,000 | $9,600,000 |
| Injury | $177,700 | $177,700 | $177,700 | $177,700 |
| Prop Damage | $78,800 | $12,400 | $3,800 | $147,600 |

*Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average*
*FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.*

### COSTS OF NON-HIGHWAY ACCIDENTS

($/million veh-mi)

| Value | Pass Train | Light Rail | Bus | Freight Rail |
|---|---|---|---|---|
| Cost | $599,400 | $3,148,900 | $994,400 | $12,902,800 |

*Source: Combination of above two tables*

### HIGHWAY-RAIL GRADE CROSSING INCIDENTS

(units in table)

| Value | Incident | Fatality | Injury |
|---|---|---|---|
| Total Events | 799 | 94 | 515 |
| Avg per Incident |  | 0.1176 | 0.6446 |
| Cost per Event |  | $9,600,000 | $177,700 |

*Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary*
*Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016*

### PASSING LANE ACCIDENT REDUCTION FACTORS

(rate with passing lane/rate without passing lane)

| Minimum ADT | Fatality | Injury | PDO |
|---|---|---|---|
| 0 | 25.0% | 69.4% | 92.6% |
| 5,000 | 19.2% | 80.3% | 96.5% |
| 10,000 | 84.0% | 57.7% | 97.8% |

*Source: Taylor and Jain, 1991*

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| | 9 | 2.9749 | 954.81 | 0.2734 | 0.0093 | 0.0096 | 0.2262 | 0.0086 |
| | 10 | 2.7982 | 890.22 | 0.2552 | 0.0083 | 0.0089 | 0.1982 | 0.0077 |
| | 11 | 2.7335 | 850.65 | 0.2497 | 0.0078 | 0.0085 | 0.1864 | 0.0072 |
| | 12 | 2.6688 | 811.08 | 0.2443 | 0.0072 | 0.0081 | 0.1747 | 0.0067 |
| | 13 | 2.6041 | 771.51 | 0.2389 | 0.0067 | 0.0077 | 0.1630 | 0.0062 |
| | 14 | 2.5395 | 731.95 | 0.2335 | 0.0062 | 0.0073 | 0.1512 | 0.0057 |
| | 15 | 2.4748 | 692.38 | 0.2281 | 0.0056 | 0.0070 | 0.1395 | 0.0052 |
| | 16 | 2.4099 | 664.13 | 0.2225 | 0.0053 | 0.0067 | 0.1314 | 0.0049 |
| | 17 | 2.3450 | 635.88 | 0.2168 | 0.0050 | 0.0064 | 0.1232 | 0.0046 |
| | 18 | 2.2801 | 607.62 | 0.2112 | 0.0047 | 0.0061 | 0.1150 | 0.0043 |
| | 19 | 2.2153 | 579.37 | 0.2056 | 0.0044 | 0.0058 | 0.1069 | 0.0040 |
| | 20 | 2.1504 | 551.12 | 0.1999 | 0.0040 | 0.0055 | 0.0987 | 0.0037 |
| | 21 | 2.0928 | 532.04 | 0.1948 | 0.0038 | 0.0053 | 0.0934 | 0.0035 |
| | 22 | 2.0353 | 512.95 | 0.1897 | 0.0036 | 0.0052 | 0.0881 | 0.0033 |
| | 23 | 1.9777 | 493.87 | 0.1846 | 0.0034 | 0.0050 | 0.0828 | 0.0031 |
| | 24 | 1.9202 | 474.78 | 0.1795 | 0.0032 | 0.0048 | 0.0775 | 0.0029 |
| | 25 | 1.8626 | 455.70 | 0.1744 | 0.0030 | 0.0046 | 0.0722 | 0.0027 |
| | 26 | 1.8252 | 442.81 | 0.1719 | 0.0028 | 0.0045 | 0.0693 | 0.0026 |
| | 27 | 1.7878 | 429.93 | 0.1693 | 0.0027 | 0.0043 | 0.0663 | 0.0025 |
| | 28 | 1.7504 | 417.04 | 0.1668 | 0.0026 | 0.0042 | 0.0633 | 0.0024 |
| | 29 | 1.7130 | 404.16 | 0.1643 | 0.0024 | 0.0041 | 0.0603 | 0.0023 |
| | 30 | 1.6756 | 391.27 | 0.1617 | 0.0023 | 0.0039 | 0.0573 | 0.0021 |
| | 31 | 1.6579 | 383.46 | 0.1613 | 0.0022 | 0.0039 | 0.0559 | 0.0021 |
| | 32 | 1.6402 | 375.65 | 0.1608 | 0.0022 | 0.0038 | 0.0544 | 0.0020 |
| | 33 | 1.6225 | 367.83 | 0.1603 | 0.0021 | 0.0037 | 0.0529 | 0.0019 |
| | 34 | 1.6048 | 360.02 | 0.1598 | 0.0020 | 0.0036 | 0.0515 | 0.0019 |
| | 35 | 1.5870 | 352.21 | 0.1593 | 0.0019 | 0.0035 | 0.0500 | 0.0018 |
| | 36 | 1.5734 | 347.40 | 0.1594 | 0.0019 | 0.0035 | 0.0491 | 0.0017 |
| | 37 | 1.5598 | 342.60 | 0.1594 | 0.0018 | 0.0034 | 0.0482 | 0.0017 |
| | 38 | 1.5462 | 337.79 | 0.1594 | 0.0018 | 0.0034 | 0.0474 | 0.0017 |
| | 39 | 1.5326 | 332.99 | 0.1594 | 0.0017 | 0.0033 | 0.0465 | 0.0016 |
| | 40 | 1.5190 | 328.18 | 0.1594 | 0.0017 | 0.0033 | 0.0456 | 0.0016 |
| | 41 | 1.5076 | 325.84 | 0.1598 | 0.0017 | 0.0033 | 0.0452 | 0.0015 |
| | 42 | 1.4963 | 323.50 | 0.1602 | 0.0016 | 0.0033 | 0.0449 | 0.0015 |
| | 43 | 1.4849 | 321.16 | 0.1607 | 0.0016 | 0.0032 | 0.0445 | 0.0015 |
| | 44 | 1.4736 | 318.82 | 0.1611 | 0.0016 | 0.0032 | 0.0441 | 0.0015 |
| | 45 | 1.4622 | 316.48 | 0.1615 | 0.0016 | 0.0032 | 0.0438 | 0.0015 |
| | 46 | 1.4550 | 316.61 | 0.1623 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 47 | 1.4478 | 316.74 | 0.1631 | 0.0016 | 0.0032 | 0.0438 | 0.0014 |
| | 48 | 1.4405 | 316.87 | 0.1639 | 0.0016 | 0.0032 | 0.0437 | 0.0014 |
| | 49 | 1.4333 | 317.01 | 0.1647 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 50 | 1.4261 | 317.14 | 0.1655 | 0.0015 | 0.0032 | 0.0437 | 0.0014 |
| | 51 | 1.4181 | 319.34 | 0.1663 | 0.0015 | 0.0032 | 0.0439 | 0.0014 |
| | 52 | 1.4101 | 321.54 | 0.1671 | 0.0015 | 0.0032 | 0.0442 | 0.0014 |
| | 53 | 1.4022 | 323.75 | 0.1678 | 0.0016 | 0.0033 | 0.0444 | 0.0014 |
| | 54 | 1.3942 | 325.95 | 0.1686 | 0.0016 | 0.0033 | 0.0446 | 0.0014 |
| | 55 | 1.3862 | 328.15 | 0.1694 | 0.0016 | 0.0033 | 0.0448 | 0.0014 |
| | 56 | 1.3680 | 332.21 | 0.1680 | 0.0016 | 0.0033 | 0.0448 | 0.0015 |
| | 57 | 1.3497 | 336.27 | 0.1666 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 58 | 1.3315 | 340.33 | 0.1651 | 0.0016 | 0.0034 | 0.0448 | 0.0015 |
| | 59 | 1.3132 | 344.39 | 0.1637 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 60 | 1.2950 | 348.45 | 0.1623 | 0.0016 | 0.0035 | 0.0448 | 0.0015 |
| | 61 | 1.3020 | 356.51 | 0.1640 | 0.0017 | 0.0036 | 0.0462 | 0.0015 |
| | 62 | 1.3089 | 364.56 | 0.1658 | 0.0017 | 0.0037 | 0.0477 | 0.0016 |
| | 63 | 1.3159 | 372.62 | 0.1675 | 0.0017 | 0.0037 | 0.0491 | 0.0016 |
| | 64 | 1.3229 | 380.68 | 0.1693 | 0.0018 | 0.0038 | 0.0505 | 0.0016 |
| | 65 | 1.3299 | 388.74 | 0.1710 | 0.0018 | 0.0039 | 0.0519 | 0.0017 |
| | 66 | 1.3750 | 397.41 | 0.1757 | 0.0018 | 0.0040 | 0.0544 | 0.0017 |
| | 67 | 1.4201 | 406.07 | 0.1804 | 0.0019 | 0.0041 | 0.0568 | 0.0017 |
| | 68 | 1.4653 | 414.74 | 0.1850 | 0.0019 | 0.0042 | 0.0592 | 0.0018 |
| | 69 | 1.5104 | 423.41 | 0.1897 | 0.0019 | 0.0043 | 0.0616 | 0.0018 |
| | 70 | 1.5555 | 432.08 | 0.1944 | 0.0020 | 0.0043 | 0.0640 | 0.0018 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| | 9 | 0.9130 | 582.66 | 0.0601 | 0.0046 | 0.0058 | 0.0837 | 0.0043 |
| | 10 | 0.8827 | 544.56 | 0.0577 | 0.0041 | 0.0054 | 0.0753 | 0.0038 |
| | 11 | 0.8622 | 519.72 | 0.0564 | 0.0039 | 0.0052 | 0.0706 | 0.0036 |
| | 12 | 0.8416 | 494.88 | 0.0550 | 0.0036 | 0.0050 | 0.0659 | 0.0033 |
| | 13 | 0.8211 | 470.04 | 0.0537 | 0.0033 | 0.0047 | 0.0612 | 0.0030 |
| | 14 | 0.8006 | 445.20 | 0.0524 | 0.0030 | 0.0045 | 0.0565 | 0.0028 |
| | 15 | 0.7800 | 420.36 | 0.0510 | 0.0028 | 0.0042 | 0.0517 | 0.0025 |
| | 16 | 0.7621 | 403.50 | 0.0499 | 0.0026 | 0.0040 | 0.0486 | 0.0024 |
| | 17 | 0.7441 | 386.63 | 0.0489 | 0.0024 | 0.0039 | 0.0456 | 0.0022 |
| | 18 | 0.7261 | 369.76 | 0.0478 | 0.0023 | 0.0037 | 0.0425 | 0.0021 |
| | 19 | 0.7082 | 352.89 | 0.0467 | 0.0021 | 0.0035 | 0.0394 | 0.0019 |
| | 20 | 0.6902 | 336.02 | 0.0456 | 0.0019 | 0.0034 | 0.0363 | 0.0018 |
| | 21 | 0.6767 | 324.45 | 0.0448 | 0.0018 | 0.0032 | 0.0345 | 0.0017 |
| | 22 | 0.6632 | 312.87 | 0.0440 | 0.0017 | 0.0031 | 0.0327 | 0.0016 |
| | 23 | 0.6497 | 301.30 | 0.0431 | 0.0016 | 0.0030 | 0.0309 | 0.0015 |
| | 24 | 0.6362 | 289.73 | 0.0423 | 0.0015 | 0.0029 | 0.0291 | 0.0014 |
| | 25 | 0.6227 | 278.16 | 0.0415 | 0.0014 | 0.0028 | 0.0273 | 0.0013 |
| | 26 | 0.6110 | 270.26 | 0.0409 | 0.0014 | 0.0027 | 0.0261 | 0.0013 |
| | 27 | 0.5993 | 262.35 | 0.0402 | 0.0013 | 0.0026 | 0.0250 | 0.0012 |
| | 28 | 0.5877 | 254.45 | 0.0395 | 0.0012 | 0.0025 | 0.0238 | 0.0011 |
| | 29 | 0.5760 | 246.55 | 0.0389 | 0.0012 | 0.0025 | 0.0227 | 0.0011 |
| | 30 | 0.5643 | 238.64 | 0.0382 | 0.0011 | 0.0024 | 0.0215 | 0.0010 |
| | 31 | 0.5571 | 233.62 | 0.0380 | 0.0011 | 0.0023 | 0.0208 | 0.0010 |
| | 32 | 0.5500 | 228.61 | 0.0378 | 0.0010 | 0.0023 | 0.0201 | 0.0009 |
| | 33 | 0.5428 | 223.59 | 0.0376 | 0.0010 | 0.0022 | 0.0194 | 0.0009 |
| | 34 | 0.5356 | 218.57 | 0.0374 | 0.0010 | 0.0022 | 0.0187 | 0.0009 |
| | 35 | 0.5284 | 213.55 | 0.0372 | 0.0009 | 0.0021 | 0.0180 | 0.0008 |
| | 36 | 0.5216 | 210.51 | 0.0370 | 0.0009 | 0.0021 | 0.0176 | 0.0008 |
| | 37 | 0.5148 | 207.47 | 0.0368 | 0.0009 | 0.0021 | 0.0171 | 0.0008 |
| | 38 | 0.5079 | 204.43 | 0.0366 | 0.0008 | 0.0020 | 0.0167 | 0.0008 |
| | 39 | 0.5011 | 201.39 | 0.0364 | 0.0008 | 0.0020 | 0.0162 | 0.0008 |
| | 40 | 0.4943 | 198.35 | 0.0362 | 0.0008 | 0.0020 | 0.0158 | 0.0007 |
| | 41 | 0.4899 | 196.95 | 0.0362 | 0.0008 | 0.0020 | 0.0156 | 0.0007 |
| | 42 | 0.4855 | 195.54 | 0.0362 | 0.0008 | 0.0020 | 0.0155 | 0.0007 |
| | 43 | 0.4811 | 194.14 | 0.0363 | 0.0008 | 0.0019 | 0.0154 | 0.0007 |
| | 44 | 0.4768 | 192.74 | 0.0363 | 0.0007 | 0.0019 | 0.0152 | 0.0007 |
| | 45 | 0.4724 | 191.33 | 0.0363 | 0.0007 | 0.0019 | 0.0151 | 0.0007 |
| | 46 | 0.4679 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0150 | 0.0007 |
| | 47 | 0.4634 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 48 | 0.4589 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0149 | 0.0007 |
| | 49 | 0.4544 | 191.33 | 0.0364 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 50 | 0.4500 | 191.32 | 0.0365 | 0.0007 | 0.0019 | 0.0147 | 0.0006 |
| | 51 | 0.4455 | 192.68 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 52 | 0.4410 | 194.05 | 0.0365 | 0.0007 | 0.0019 | 0.0148 | 0.0007 |
| | 53 | 0.4365 | 195.41 | 0.0365 | 0.0007 | 0.0020 | 0.0149 | 0.0007 |
| | 54 | 0.4320 | 196.77 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 55 | 0.4275 | 198.13 | 0.0365 | 0.0007 | 0.0020 | 0.0150 | 0.0007 |
| | 56 | 0.4226 | 200.79 | 0.0363 | 0.0007 | 0.0020 | 0.0152 | 0.0007 |
| | 57 | 0.4178 | 203.46 | 0.0362 | 0.0007 | 0.0020 | 0.0154 | 0.0007 |
| | 58 | 0.4130 | 206.12 | 0.0360 | 0.0007 | 0.0021 | 0.0156 | 0.0007 |
| | 59 | 0.4082 | 208.79 | 0.0359 | 0.0008 | 0.0021 | 0.0157 | 0.0007 |
| | 60 | 0.4034 | 211.45 | 0.0358 | 0.0008 | 0.0021 | 0.0159 | 0.0007 |
| | 61 | 0.4063 | 215.99 | 0.0367 | 0.0008 | 0.0022 | 0.0166 | 0.0007 |
| | 62 | 0.4093 | 220.54 | 0.0377 | 0.0008 | 0.0022 | 0.0173 | 0.0007 |
| | 63 | 0.4123 | 225.08 | 0.0387 | 0.0008 | 0.0023 | 0.0180 | 0.0008 |
| | 64 | 0.4152 | 229.62 | 0.0396 | 0.0008 | 0.0023 | 0.0188 | 0.0008 |
| | 65 | 0.4182 | 234.17 | 0.0406 | 0.0009 | 0.0023 | 0.0195 | 0.0008 |
| | 66 | 0.4203 | 238.62 | 0.0401 | 0.0009 | 0.0024 | 0.0197 | 0.0008 |
| | 67 | 0.4224 | 243.08 | 0.0396 | 0.0009 | 0.0024 | 0.0200 | 0.0008 |
| | 68 | 0.4246 | 247.54 | 0.0391 | 0.0009 | 0.0025 | 0.0203 | 0.0008 |
| | 69 | 0.4267 | 252.00 | 0.0386 | 0.0009 | 0.0025 | 0.0206 | 0.0008 |
| | 70 | 0.4288 | 256.46 | 0.0382 | 0.0009 | 0.0026 | 0.0209 | 0.0009 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Truck | 0 | 4.8572 | 39.19 | 1.7997 | 0.0015 | 0.2774 | 0.4175 | 0.0013 |
| | 5 | 5.1803 | 2187.60 | 7.9756 | 0.1137 | 0.0202 | 1.0547 | 0.1087 |
| | 6 | 4.9501 | 2147.78 | 7.8499 | 0.1140 | 0.0199 | 1.0224 | 0.1089 |
| | 7 | 4.7200 | 2107.96 | 7.7242 | 0.1143 | 0.0195 | 0.9901 | 0.1092 |
| | 8 | 4.4898 | 2068.13 | 7.5986 | 0.1146 | 0.0192 | 0.9579 | 0.1095 |
| | 9 | 4.2597 | 2028.31 | 7.4729 | 0.1148 | 0.0189 | 0.9256 | 0.1098 |
| | 10 | 4.0295 | 1988.49 | 7.3473 | 0.1151 | 0.0185 | 0.8934 | 0.1101 |
| | 11 | 3.7759 | 1843.50 | 6.7599 | 0.1061 | 0.0173 | 0.8082 | 0.1015 |
| | 12 | 3.5223 | 1698.51 | 6.1725 | 0.0972 | 0.0160 | 0.7230 | 0.0929 |
| | 13 | 3.2687 | 1553.51 | 5.5851 | 0.0882 | 0.0147 | 0.6378 | 0.0843 |
| | 14 | 3.0151 | 1408.52 | 4.9977 | 0.0792 | 0.0134 | 0.5525 | 0.0757 |
| | 15 | 2.7615 | 1263.53 | 4.4103 | 0.0703 | 0.0121 | 0.4673 | 0.0671 |
| | 16 | 2.6560 | 1263.49 | 4.4801 | 0.0705 | 0.0121 | 0.4442 | 0.0674 |
| | 17 | 2.5504 | 1263.44 | 4.5499 | 0.0708 | 0.0121 | 0.4210 | 0.0677 |
| | 18 | 2.4449 | 1263.40 | 4.6197 | 0.0711 | 0.0121 | 0.3979 | 0.0679 |
| | 19 | 2.3394 | 1263.35 | 4.6895 | 0.0713 | 0.0121 | 0.3747 | 0.0682 |
| | 20 | 2.2339 | 1263.31 | 4.7593 | 0.0716 | 0.0121 | 0.3516 | 0.0685 |
| | 21 | 2.1458 | 1237.01 | 4.6190 | 0.0677 | 0.0119 | 0.3310 | 0.0647 |
| | 22 | 2.0577 | 1210.72 | 4.4786 | 0.0637 | 0.0116 | 0.3105 | 0.0610 |
| | 23 | 1.9697 | 1184.43 | 4.3383 | 0.0598 | 0.0114 | 0.2900 | 0.0572 |
| | 24 | 1.8816 | 1158.13 | 4.1979 | 0.0559 | 0.0111 | 0.2695 | 0.0534 |
| | 25 | 1.7935 | 1131.84 | 4.0576 | 0.0520 | 0.0108 | 0.2489 | 0.0497 |
| | 26 | 1.7441 | 1138.52 | 4.0783 | 0.0519 | 0.0109 | 0.2424 | 0.0496 |
| | 27 | 1.6947 | 1145.20 | 4.0990 | 0.0518 | 0.0110 | 0.2358 | 0.0495 |
| | 28 | 1.6453 | 1151.87 | 4.1197 | 0.0517 | 0.0110 | 0.2293 | 0.0495 |
| | 29 | 1.5959 | 1158.55 | 4.1404 | 0.0517 | 0.0111 | 0.2227 | 0.0494 |
| | 30 | 1.5465 | 1165.23 | 4.1611 | 0.0516 | 0.0111 | 0.2162 | 0.0493 |
| | 31 | 1.5050 | 1199.22 | 4.2631 | 0.0526 | 0.0114 | 0.2128 | 0.0503 |
| | 32 | 1.4634 | 1233.21 | 4.3651 | 0.0537 | 0.0117 | 0.2095 | 0.0513 |
| | 33 | 1.4219 | 1267.20 | 4.4671 | 0.0547 | 0.0120 | 0.2061 | 0.0524 |
| | 34 | 1.3803 | 1301.19 | 4.5691 | 0.0558 | 0.0123 | 0.2028 | 0.0534 |
| | 35 | 1.3387 | 1335.18 | 4.6711 | 0.0568 | 0.0126 | 0.1994 | 0.0544 |
| | 36 | 1.3027 | 1331.17 | 4.6418 | 0.0575 | 0.0126 | 0.1934 | 0.0550 |
| | 37 | 1.2667 | 1327.17 | 4.6126 | 0.0581 | 0.0125 | 0.1873 | 0.0556 |
| | 38 | 1.2306 | 1323.16 | 4.5833 | 0.0587 | 0.0125 | 0.1812 | 0.0562 |
| | 39 | 1.1946 | 1319.16 | 4.5540 | 0.0593 | 0.0125 | 0.1751 | 0.0567 |
| | 40 | 1.1586 | 1315.15 | 4.5247 | 0.0599 | 0.0125 | 0.1690 | 0.0573 |
| | 41 | 1.1260 | 1312.39 | 4.5116 | 0.0598 | 0.0124 | 0.1638 | 0.0572 |
| | 42 | 1.0934 | 1309.62 | 4.4984 | 0.0597 | 0.0124 | 0.1585 | 0.0571 |
| | 43 | 1.0609 | 1306.85 | 4.4852 | 0.0596 | 0.0124 | 0.1533 | 0.0570 |
| | 44 | 1.0283 | 1304.08 | 4.4720 | 0.0594 | 0.0124 | 0.1480 | 0.0569 |
| | 45 | 0.9958 | 1301.32 | 4.4589 | 0.0593 | 0.0124 | 0.1428 | 0.0567 |
| | 46 | 0.9927 | 1264.42 | 4.3777 | 0.0582 | 0.0120 | 0.1381 | 0.0556 |
| | 47 | 0.9897 | 1227.52 | 4.2964 | 0.0570 | 0.0117 | 0.1334 | 0.0545 |
| | 48 | 0.9866 | 1190.62 | 4.2152 | 0.0559 | 0.0114 | 0.1287 | 0.0534 |
| | 49 | 0.9836 | 1153.73 | 4.1340 | 0.0547 | 0.0110 | 0.1240 | 0.0523 |
| | 50 | 0.9805 | 1116.83 | 4.0528 | 0.0535 | 0.0107 | 0.1193 | 0.0512 |
| | 51 | 0.9565 | 1133.04 | 4.1049 | 0.0565 | 0.0109 | 0.1190 | 0.0541 |
| | 52 | 0.9324 | 1149.25 | 4.1569 | 0.0595 | 0.0110 | 0.1188 | 0.0569 |
| | 53 | 0.9083 | 1165.46 | 4.2090 | 0.0625 | 0.0112 | 0.1185 | 0.0597 |
| | 54 | 0.8842 | 1181.67 | 4.2610 | 0.0654 | 0.0113 | 0.1182 | 0.0626 |
| | 55 | 0.8601 | 1197.87 | 4.3131 | 0.0684 | 0.0115 | 0.1179 | 0.0654 |
| | 56 | 0.8633 | 1184.58 | 4.2356 | 0.0702 | 0.0114 | 0.1175 | 0.0672 |
| | 57 | 0.8665 | 1171.29 | 4.1582 | 0.0721 | 0.0112 | 0.1170 | 0.0689 |
| | 58 | 0.8696 | 1158.00 | 4.0807 | 0.0739 | 0.0111 | 0.1166 | 0.0707 |
| | 59 | 0.8728 | 1144.71 | 4.0032 | 0.0757 | 0.0110 | 0.1162 | 0.0725 |
| | 60 | 0.8760 | 1131.42 | 3.9257 | 0.0776 | 0.0109 | 0.1157 | 0.0742 |
| | 61 | 0.8894 | 1131.74 | 3.9251 | 0.0750 | 0.0109 | 0.1151 | 0.0718 |
| | 62 | 0.9028 | 1132.07 | 3.9244 | 0.0725 | 0.0109 | 0.1145 | 0.0694 |
| | 63 | 0.9163 | 1132.39 | 3.9237 | 0.0700 | 0.0109 | 0.1139 | 0.0669 |
| | 64 | 0.9297 | 1132.72 | 3.9230 | 0.0674 | 0.0109 | 0.1133 | 0.0645 |
| | 65 | 0.9431 | 1133.04 | 3.9224 | 0.0649 | 0.0109 | 0.1127 | 0.0621 |
| | 66 | 0.9190 | 1151.08 | 3.9095 | 0.0614 | 0.0110 | 0.1098 | 0.0587 |
| | 67 | 0.8949 | 1169.12 | 3.8966 | 0.0579 | 0.0112 | 0.1070 | 0.0554 |
| | 68 | 0.8707 | 1187.17 | 3.8837 | 0.0544 | 0.0114 | 0.1042 | 0.0521 |
| | 69 | 0.8466 | 1205.21 | 3.8708 | 0.0509 | 0.0115 | 0.1014 | 0.0487 |
| | 70 | 0.8225 | 1223.25 | 3.8579 | 0.0475 | 0.0117 | 0.0986 | 0.0454 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Truck | 0 | 1.8187 | 31.73 | 3.5930 | 0.0006 | 0.0003 | 0.1107 | 0.0005 |
| | 5 | 4.6433 | 2312.07 | 10.1441 | 0.0129 | 0.0198 | 0.4427 | 0.0123 |
| | 6 | 4.3680 | 2256.43 | 9.6372 | 0.0124 | 0.0194 | 0.4211 | 0.0119 |
| | 7 | 4.0927 | 2200.78 | 9.1303 | 0.0120 | 0.0190 | 0.3996 | 0.0114 |
| | 8 | 3.8174 | 2145.13 | 8.6234 | 0.0115 | 0.0186 | 0.3780 | 0.0109 |
| | 9 | 3.5421 | 2089.48 | 8.1165 | 0.0110 | 0.0183 | 0.3564 | 0.0105 |
| | 10 | 3.2668 | 2033.84 | 7.6096 | 0.0105 | 0.0179 | 0.3349 | 0.0100 |
| | 11 | 2.9097 | 1905.69 | 6.8507 | 0.0103 | 0.0169 | 0.3092 | 0.0098 |
| | 12 | 2.5527 | 1777.54 | 6.0919 | 0.0100 | 0.0159 | 0.2835 | 0.0096 |
| | 13 | 2.1957 | 1649.39 | 5.3330 | 0.0098 | 0.0150 | 0.2578 | 0.0093 |
| | 14 | 1.8386 | 1521.24 | 4.5742 | 0.0096 | 0.0140 | 0.2322 | 0.0091 |
| | 15 | 1.4816 | 1393.10 | 3.8153 | 0.0093 | 0.0130 | 0.2065 | 0.0089 |
| | 16 | 1.3940 | 1385.68 | 3.6087 | 0.0089 | 0.0130 | 0.1945 | 0.0085 |
| | 17 | 1.3064 | 1378.26 | 3.4020 | 0.0085 | 0.0129 | 0.1824 | 0.0081 |
| | 18 | 1.2188 | 1370.84 | 3.1953 | 0.0081 | 0.0129 | 0.1704 | 0.0078 |
| | 19 | 1.1312 | 1363.42 | 2.9887 | 0.0077 | 0.0129 | 0.1583 | 0.0074 |
| | 20 | 1.0436 | 1356.00 | 2.7820 | 0.0073 | 0.0128 | 0.1463 | 0.0070 |
| | 21 | 0.9988 | 1325.74 | 2.5267 | 0.0072 | 0.0125 | 0.1372 | 0.0068 |
| | 22 | 0.9541 | 1295.48 | 2.2714 | 0.0070 | 0.0122 | 0.1282 | 0.0067 |
| | 23 | 0.9093 | 1265.22 | 2.0161 | 0.0068 | 0.0119 | 0.1192 | 0.0065 |
| | 24 | 0.8646 | 1234.96 | 1.7608 | 0.0066 | 0.0116 | 0.1101 | 0.0063 |
| | 25 | 0.8198 | 1204.71 | 1.5055 | 0.0065 | 0.0113 | 0.1011 | 0.0062 |
| | 26 | 0.7917 | 1207.23 | 1.4248 | 0.0063 | 0.0114 | 0.0973 | 0.0060 |
| | 27 | 0.7637 | 1209.75 | 1.3441 | 0.0061 | 0.0114 | 0.0936 | 0.0059 |
| | 28 | 0.7356 | 1212.27 | 1.2634 | 0.0060 | 0.0114 | 0.0898 | 0.0057 |
| | 29 | 0.7075 | 1214.80 | 1.1827 | 0.0058 | 0.0115 | 0.0861 | 0.0056 |
| | 30 | 0.6794 | 1217.32 | 1.1020 | 0.0056 | 0.0115 | 0.0823 | 0.0054 |
| | 31 | 0.6715 | 1233.43 | 1.0586 | 0.0055 | 0.0116 | 0.0796 | 0.0053 |
| | 32 | 0.6636 | 1249.54 | 1.0152 | 0.0054 | 0.0117 | 0.0769 | 0.0052 |
| | 33 | 0.6556 | 1265.65 | 0.9719 | 0.0054 | 0.0118 | 0.0742 | 0.0051 |
| | 34 | 0.6477 | 1281.76 | 0.9285 | 0.0053 | 0.0119 | 0.0715 | 0.0050 |
| | 35 | 0.6398 | 1297.87 | 0.8851 | 0.0052 | 0.0120 | 0.0688 | 0.0049 |
| | 36 | 0.6063 | 1289.71 | 0.8393 | 0.0051 | 0.0120 | 0.0653 | 0.0048 |
| | 37 | 0.5729 | 1281.55 | 0.7935 | 0.0050 | 0.0119 | 0.0619 | 0.0047 |
| | 38 | 0.5394 | 1273.38 | 0.7477 | 0.0049 | 0.0119 | 0.0584 | 0.0047 |
| | 39 | 0.5060 | 1265.22 | 0.7020 | 0.0048 | 0.0118 | 0.0549 | 0.0046 |
| | 40 | 0.4725 | 1257.05 | 0.6562 | 0.0047 | 0.0118 | 0.0515 | 0.0045 |
| | 41 | 0.4512 | 1253.52 | 0.6306 | 0.0047 | 0.0117 | 0.0493 | 0.0045 |
| | 42 | 0.4299 | 1249.98 | 0.6050 | 0.0046 | 0.0117 | 0.0471 | 0.0044 |
| | 43 | 0.4086 | 1246.45 | 0.5795 | 0.0046 | 0.0117 | 0.0450 | 0.0044 |
| | 44 | 0.3873 | 1242.91 | 0.5539 | 0.0046 | 0.0117 | 0.0428 | 0.0044 |
| | 45 | 0.3660 | 1239.37 | 0.5283 | 0.0045 | 0.0117 | 0.0406 | 0.0043 |
| | 46 | 0.3462 | 1218.01 | 0.5072 | 0.0045 | 0.0115 | 0.0385 | 0.0043 |
| | 47 | 0.3263 | 1196.64 | 0.4861 | 0.0045 | 0.0113 | 0.0364 | 0.0043 |
| | 48 | 0.3065 | 1175.28 | 0.4649 | 0.0045 | 0.0111 | 0.0343 | 0.0043 |
| | 49 | 0.2866 | 1153.91 | 0.4438 | 0.0044 | 0.0110 | 0.0322 | 0.0042 |
| | 50 | 0.2668 | 1132.54 | 0.4226 | 0.0044 | 0.0108 | 0.0301 | 0.0042 |
| | 51 | 0.2573 | 1134.57 | 0.4082 | 0.0044 | 0.0108 | 0.0288 | 0.0042 |
| | 52 | 0.2478 | 1136.59 | 0.3937 | 0.0043 | 0.0108 | 0.0275 | 0.0041 |
| | 53 | 0.2383 | 1138.62 | 0.3792 | 0.0043 | 0.0109 | 0.0262 | 0.0041 |
| | 54 | 0.2288 | 1140.64 | 0.3648 | 0.0042 | 0.0109 | 0.0250 | 0.0040 |
| | 55 | 0.2193 | 1142.66 | 0.3503 | 0.0042 | 0.0109 | 0.0237 | 0.0040 |
| | 56 | 0.2078 | 1127.35 | 0.3362 | 0.0041 | 0.0108 | 0.0227 | 0.0039 |
| | 57 | 0.1963 | 1112.03 | 0.3221 | 0.0040 | 0.0106 | 0.0217 | 0.0039 |
| | 58 | 0.1848 | 1096.71 | 0.3080 | 0.0040 | 0.0105 | 0.0207 | 0.0038 |
| | 59 | 0.1733 | 1081.40 | 0.2939 | 0.0039 | 0.0103 | 0.0197 | 0.0037 |
| | 60 | 0.1618 | 1066.08 | 0.2798 | 0.0038 | 0.0102 | 0.0188 | 0.0037 |
| | 61 | 0.1650 | 1070.20 | 0.2846 | 0.0039 | 0.0102 | 0.0192 | 0.0037 |
| | 62 | 0.1682 | 1074.31 | 0.2895 | 0.0040 | 0.0103 | 0.0196 | 0.0038 |
| | 63 | 0.1715 | 1078.43 | 0.2943 | 0.0040 | 0.0103 | 0.0200 | 0.0039 |
| | 64 | 0.1747 | 1082.54 | 0.2992 | 0.0041 | 0.0104 | 0.0204 | 0.0039 |
| | 65 | 0.1779 | 1086.66 | 0.3040 | 0.0041 | 0.0104 | 0.0208 | 0.0040 |
| | 66 | 0.1760 | 1103.78 | 0.3088 | 0.0042 | 0.0106 | 0.0212 | 0.0040 |
| | 67 | 0.1741 | 1120.90 | 0.3135 | 0.0042 | 0.0107 | 0.0216 | 0.0041 |
| | 68 | 0.1721 | 1138.02 | 0.3183 | 0.0043 | 0.0109 | 0.0220 | 0.0041 |
| | 69 | 0.1702 | 1155.14 | 0.3231 | 0.0043 | 0.0110 | 0.0224 | 0.0041 |
| | 70 | 0.1683 | 1172.25 | 0.3278 | 0.0044 | 0.0112 | 0.0228 | 0.0042 |

## *Emissions Tables*

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2016

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 3.4104 | 81.98 | 0.2740 | 0.0028 | 0.0009 | 0.2826 | 0.0026 |
| | 5 | 3.6818 | 1213.16 | 0.3465 | 0.0133 | 0.0122 | 0.3386 | 0.0123 |
| | 6 | 3.5051 | 1148.57 | 0.3282 | 0.0123 | 0.0115 | 0.3105 | 0.0114 |
| | 7 | 3.3284 | 1083.98 | 0.3099 | 0.0113 | 0.0109 | 0.2824 | 0.0104 |
| | 8 | 3.1516 | 1019.40 | 0.2917 | 0.0103 | 0.0102 | 0.2543 | 0.0095 |
| Bus | 0 | 10.6824 | 82.09 | 2.0123 | 0.0012 | 0.0010 | 0.6855 | 0.0011 |
| | 5 | 19.5713 | 3427.66 | 22.0894 | 0.4156 | 0.0272 | 3.1109 | 0.3975 |
| | 6 | 18.6137 | 3345.92 | 21.1559 | 0.3970 | 0.0267 | 2.9232 | 0.3798 |
| | 7 | 17.6561 | 3264.17 | 20.2224 | 0.3785 | 0.0261 | 2.7356 | 0.3621 |
| | 8 | 16.6985 | 3182.43 | 19.2889 | 0.3600 | 0.0255 | 2.5480 | 0.3444 |
| | 9 | 15.7409 | 3100.68 | 18.3553 | 0.3415 | 0.0250 | 2.3604 | 0.3266 |
| | 10 | 14.7833 | 3018.94 | 17.4218 | 0.3230 | 0.0244 | 2.1728 | 0.3089 |
| | 11 | 13.9614 | 2881.27 | 16.5060 | 0.3034 | 0.0232 | 1.9877 | 0.2902 |
| | 12 | 13.1394 | 2743.60 | 15.5903 | 0.2838 | 0.0220 | 1.8026 | 0.2714 |
| | 13 | 12.3175 | 2605.93 | 14.6745 | 0.2642 | 0.0208 | 1.6175 | 0.2527 |
| | 14 | 11.4955 | 2468.25 | 13.7588 | 0.2446 | 0.0196 | 1.4324 | 0.2339 |
| | 15 | 10.6736 | 2330.58 | 12.8430 | 0.2250 | 0.0184 | 1.2473 | 0.2152 |
| | 16 | 10.6229 | 2266.47 | 12.7712 | 0.2193 | 0.0175 | 1.1680 | 0.2097 |
| | 17 | 10.5723 | 2202.36 | 12.6993 | 0.2136 | 0.0167 | 1.0886 | 0.2043 |
| | 18 | 10.5216 | 2138.25 | 12.6275 | 0.2079 | 0.0158 | 1.0093 | 0.1988 |
| | 19 | 10.4710 | 2074.14 | 12.5556 | 0.2022 | 0.0150 | 0.9300 | 0.1934 |
| | 20 | 10.4204 | 2010.03 | 12.4838 | 0.1965 | 0.0141 | 0.8506 | 0.1879 |
| | 21 | 8.8913 | 1886.19 | 11.1329 | 0.1690 | 0.0139 | 0.7311 | 0.1617 |
| | 22 | 7.3623 | 1762.35 | 9.7821 | 0.1416 | 0.0137 | 0.6115 | 0.1355 |
| | 23 | 5.8333 | 1638.51 | 8.4313 | 0.1142 | 0.0134 | 0.4920 | 0.1092 |
| | 24 | 4.3043 | 1514.66 | 7.0804 | 0.0868 | 0.0132 | 0.3724 | 0.0830 |
| | 25 | 2.7753 | 1390.82 | 5.7296 | 0.0594 | 0.0130 | 0.2529 | 0.0568 |
| | 26 | 2.7002 | 1372.44 | 5.6622 | 0.0576 | 0.0128 | 0.2422 | 0.0550 |
| | 27 | 2.6250 | 1354.06 | 5.5948 | 0.0558 | 0.0126 | 0.2315 | 0.0533 |
| | 28 | 2.5498 | 1335.67 | 5.5273 | 0.0539 | 0.0124 | 0.2208 | 0.0516 |
| | 29 | 2.4746 | 1317.29 | 5.4599 | 0.0521 | 0.0123 | 0.2102 | 0.0499 |
| | 30 | 2.3995 | 1298.91 | 5.3925 | 0.0503 | 0.0121 | 0.1995 | 0.0482 |
| | 31 | 2.3420 | 1282.69 | 5.3486 | 0.0492 | 0.0120 | 0.1915 | 0.0470 |
| | 32 | 2.2845 | 1266.48 | 5.3046 | 0.0480 | 0.0118 | 0.1836 | 0.0459 |
| | 33 | 2.2270 | 1250.27 | 5.2607 | 0.0469 | 0.0117 | 0.1757 | 0.0448 |
| | 34 | 2.1695 | 1234.05 | 5.2168 | 0.0457 | 0.0116 | 0.1678 | 0.0437 |
| | 35 | 2.1120 | 1217.84 | 5.1728 | 0.0445 | 0.0114 | 0.1598 | 0.0426 |
| | 36 | 2.0857 | 1213.36 | 5.0993 | 0.0437 | 0.0114 | 0.1557 | 0.0418 |
| | 37 | 2.0594 | 1208.88 | 5.0258 | 0.0429 | 0.0113 | 0.1516 | 0.0410 |
| | 38 | 2.0332 | 1204.40 | 4.9523 | 0.0421 | 0.0113 | 0.1475 | 0.0402 |
| | 39 | 2.0069 | 1199.92 | 4.8788 | 0.0413 | 0.0112 | 0.1434 | 0.0395 |
| | 40 | 1.9806 | 1195.43 | 4.8052 | 0.0405 | 0.0112 | 0.1393 | 0.0387 |
| | 41 | 1.9688 | 1187.57 | 4.7070 | 0.0397 | 0.0111 | 0.1362 | 0.0380 |
| | 42 | 1.9571 | 1179.70 | 4.6088 | 0.0389 | 0.0110 | 0.1330 | 0.0372 |
| | 43 | 1.9453 | 1171.83 | 4.5106 | 0.0382 | 0.0109 | 0.1298 | 0.0365 |
| | 44 | 1.9336 | 1163.96 | 4.4123 | 0.0374 | 0.0108 | 0.1267 | 0.0358 |
| | 45 | 1.9218 | 1156.09 | 4.3141 | 0.0367 | 0.0108 | 0.1235 | 0.0351 |
| | 46 | 1.8909 | 1152.61 | 4.2857 | 0.0369 | 0.0107 | 0.1221 | 0.0353 |
| | 47 | 1.8600 | 1149.13 | 4.2572 | 0.0371 | 0.0107 | 0.1208 | 0.0355 |
| | 48 | 1.8291 | 1145.65 | 4.2288 | 0.0373 | 0.0107 | 0.1194 | 0.0356 |
| | 49 | 1.7982 | 1142.17 | 4.2004 | 0.0375 | 0.0106 | 0.1180 | 0.0358 |
| | 50 | 1.7673 | 1138.69 | 4.1719 | 0.0377 | 0.0106 | 0.1166 | 0.0360 |
| | 51 | 1.7408 | 1137.05 | 4.2359 | 0.0389 | 0.0106 | 0.1169 | 0.0372 |
| | 52 | 1.7143 | 1135.42 | 4.2998 | 0.0402 | 0.0106 | 0.1172 | 0.0384 |
| | 53 | 1.6878 | 1133.78 | 4.3638 | 0.0414 | 0.0105 | 0.1175 | 0.0396 |
| | 54 | 1.6613 | 1132.15 | 4.4277 | 0.0427 | 0.0105 | 0.1178 | 0.0408 |
| | 55 | 1.6348 | 1130.51 | 4.4916 | 0.0440 | 0.0105 | 0.1181 | 0.0420 |
| | 56 | 1.6585 | 1135.25 | 4.5276 | 0.0451 | 0.0105 | 0.1215 | 0.0431 |
| | 57 | 1.6822 | 1139.98 | 4.5635 | 0.0463 | 0.0105 | 0.1249 | 0.0442 |
| | 58 | 1.7059 | 1144.71 | 4.5994 | 0.0474 | 0.0106 | 0.1283 | 0.0454 |
| | 59 | 1.7296 | 1149.45 | 4.6354 | 0.0486 | 0.0106 | 0.1317 | 0.0465 |
| | 60 | 1.7533 | 1154.18 | 4.6713 | 0.0497 | 0.0106 | 0.1351 | 0.0476 |
| | 61 | 1.7947 | 1155.82 | 4.5966 | 0.0489 | 0.0105 | 0.1380 | 0.0468 |
| | 62 | 1.8361 | 1157.45 | 4.5218 | 0.0481 | 0.0105 | 0.1409 | 0.0460 |
| | 63 | 1.8775 | 1159.09 | 4.4471 | 0.0473 | 0.0105 | 0.1439 | 0.0452 |
| | 64 | 1.9189 | 1160.73 | 4.3724 | 0.0465 | 0.0105 | 0.1468 | 0.0445 |
| | 65 | 1.9602 | 1162.37 | 4.2976 | 0.0457 | 0.0104 | 0.1497 | 0.0437 |
| | 66 | 2.1296 | 1155.48 | 4.0816 | 0.0427 | 0.0103 | 0.1552 | 0.0408 |
| | 67 | 2.2989 | 1148.59 | 3.8657 | 0.0396 | 0.0102 | 0.1606 | 0.0379 |
| | 68 | 2.4683 | 1141.70 | 3.6497 | 0.0366 | 0.0101 | 0.1660 | 0.0350 |
| | 69 | 2.6376 | 1134.81 | 3.4337 | 0.0336 | 0.0100 | 0.1715 | 0.0321 |
| | 70 | 2.8070 | 1127.92 | 3.2177 | 0.0306 | 0.0099 | 0.1769 | 0.0292 |

### HIGHWAY EMISSIONS FACTORS (g/mi)

Model Year 2036

| Mode | Speed | CO | $CO_2$ | $NO_X$ | $PM_{10}$ | $SO_X$ | VOC | $PM_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Auto | 0 | 0.6940 | 45.66 | 0.0331 | 0.0014 | 0.0005 | 0.0462 | 0.0013 |
| | 5 | 1.0344 | 735.07 | 0.0699 | 0.0066 | 0.0074 | 0.1171 | 0.0061 |
| | 6 | 1.0041 | 696.96 | 0.0674 | 0.0061 | 0.0070 | 0.1088 | 0.0056 |
| | 7 | 0.9737 | 658.86 | 0.0650 | 0.0056 | 0.0066 | 0.1004 | 0.0052 |
| | 8 | 0.9434 | 620.76 | 0.0626 | 0.0051 | 0.0062 | 0.0920 | 0.0047 |
| Bus | 0 | 5.1788 | 80.98 | 2.5880 | 0.0012 | 0.0009 | 0.3524 | 0.0011 |
| | 5 | 9.8072 | 2999.55 | 5.2920 | 0.0368 | 0.0239 | 0.3870 | 0.0351 |
| | 6 | 9.1891 | 2922.57 | 5.0911 | 0.0348 | 0.0234 | 0.3644 | 0.0332 |
| | 7 | 8.5709 | 2845.60 | 4.8902 | 0.0329 | 0.0228 | 0.3417 | 0.0313 |
| | 8 | 7.9528 | 2768.62 | 4.6894 | 0.0309 | 0.0223 | 0.3191 | 0.0295 |
| | 9 | 7.3346 | 2691.64 | 4.4885 | 0.0289 | 0.0218 | 0.2964 | 0.0276 |
| | 10 | 6.7165 | 2614.67 | 4.2876 | 0.0270 | 0.0212 | 0.2738 | 0.0257 |
| | 11 | 6.1348 | 2484.67 | 3.9696 | 0.0252 | 0.0201 | 0.2512 | 0.0240 |
| | 12 | 5.5532 | 2354.67 | 3.6516 | 0.0234 | 0.0189 | 0.2286 | 0.0224 |
| | 13 | 4.9715 | 2224.67 | 3.3336 | 0.0217 | 0.0178 | 0.2060 | 0.0207 |
| | 14 | 4.3899 | 2094.67 | 3.0156 | 0.0199 | 0.0166 | 0.1833 | 0.0190 |
| | 15 | 3.8082 | 1964.68 | 2.6976 | 0.0182 | 0.0154 | 0.1607 | 0.0173 |
| | 16 | 3.6563 | 1904.74 | 2.5064 | 0.0180 | 0.0145 | 0.1489 | 0.0172 |
| | 17 | 3.5044 | 1844.81 | 2.3152 | 0.0179 | 0.0135 | 0.1370 | 0.0171 |
| | 18 | 3.3525 | 1784.88 | 2.1240 | 0.0178 | 0.0126 | 0.1251 | 0.0170 |
| | 19 | 3.2006 | 1724.95 | 1.9328 | 0.0176 | 0.0116 | 0.1133 | 0.0168 |
| | 20 | 3.0487 | 1665.02 | 1.7416 | 0.0175 | 0.0107 | 0.1014 | 0.0167 |
| | 21 | 2.5385 | 1582.49 | 1.6010 | 0.0148 | 0.0109 | 0.0929 | 0.0142 |
| | 22 | 2.0284 | 1499.96 | 1.4603 | 0.0122 | 0.0111 | 0.0843 | 0.0116 |
| | 23 | 1.5183 | 1417.43 | 1.3197 | 0.0095 | 0.0114 | 0.0758 | 0.0091 |
| | 24 | 1.0082 | 1334.89 | 1.1791 | 0.0068 | 0.0116 | 0.0673 | 0.0065 |
| | 25 | 0.4981 | 1252.36 | 1.0384 | 0.0041 | 0.0118 | 0.0587 | 0.0039 |
| | 26 | 0.4776 | 1237.58 | 0.9754 | 0.0040 | 0.0117 | 0.0559 | 0.0038 |
| | 27 | 0.4571 | 1222.81 | 0.9124 | 0.0039 | 0.0115 | 0.0531 | 0.0037 |
| | 28 | 0.4366 | 1208.03 | 0.8493 | 0.0038 | 0.0114 | 0.0503 | 0.0036 |
| | 29 | 0.4162 | 1193.25 | 0.7863 | 0.0037 | 0.0113 | 0.0474 | 0.0035 |
| | 30 | 0.3957 | 1178.47 | 0.7233 | 0.0036 | 0.0111 | 0.0446 | 0.0034 |
| | 31 | 0.3799 | 1165.30 | 0.6873 | 0.0035 | 0.0110 | 0.0424 | 0.0034 |
| | 32 | 0.3642 | 1152.13 | 0.6513 | 0.0035 | 0.0109 | 0.0401 | 0.0033 |
| | 33 | 0.3485 | 1138.97 | 0.6154 | 0.0034 | 0.0108 | 0.0379 | 0.0032 |
| | 34 | 0.3327 | 1125.80 | 0.5794 | 0.0033 | 0.0106 | 0.0356 | 0.0032 |
| | 35 | 0.3170 | 1112.63 | 0.5435 | 0.0033 | 0.0105 | 0.0334 | 0.0031 |
| | 36 | 0.3098 | 1109.21 | 0.5225 | 0.0032 | 0.0105 | 0.0319 | 0.0031 |
| | 37 | 0.3026 | 1105.78 | 0.5015 | 0.0032 | 0.0104 | 0.0305 | 0.0030 |
| | 38 | 0.2955 | 1102.35 | 0.4805 | 0.0031 | 0.0104 | 0.0290 | 0.0030 |
| | 39 | 0.2883 | 1098.92 | 0.4595 | 0.0031 | 0.0104 | 0.0276 | 0.0029 |
| | 40 | 0.2811 | 1095.50 | 0.4385 | 0.0030 | 0.0103 | 0.0262 | 0.0029 |
| | 41 | 0.2757 | 1088.64 | 0.4217 | 0.0030 | 0.0103 | 0.0249 | 0.0028 |
| | 42 | 0.2702 | 1081.79 | 0.4050 | 0.0029 | 0.0102 | 0.0237 | 0.0028 |
| | 43 | 0.2648 | 1074.94 | 0.3882 | 0.0029 | 0.0101 | 0.0224 | 0.0027 |
| | 44 | 0.2593 | 1068.09 | 0.3715 | 0.0028 | 0.0100 | 0.0212 | 0.0027 |
| | 45 | 0.2539 | 1061.24 | 0.3548 | 0.0027 | 0.0100 | 0.0199 | 0.0026 |
| | 46 | 0.2474 | 1059.07 | 0.3451 | 0.0027 | 0.0100 | 0.0193 | 0.0026 |
| | 47 | 0.2410 | 1056.90 | 0.3354 | 0.0027 | 0.0099 | 0.0187 | 0.0026 |
| | 48 | 0.2346 | 1054.73 | 0.3257 | 0.0027 | 0.0099 | 0.0181 | 0.0026 |
| | 49 | 0.2281 | 1052.56 | 0.3160 | 0.0027 | 0.0099 | 0.0175 | 0.0025 |
| | 50 | 0.2217 | 1050.39 | 0.3063 | 0.0027 | 0.0099 | 0.0169 | 0.0025 |
| | 51 | 0.2164 | 1048.76 | 0.3035 | 0.0027 | 0.0098 | 0.0165 | 0.0026 |
| | 52 | 0.2111 | 1047.14 | 0.3006 | 0.0027 | 0.0098 | 0.0161 | 0.0026 |
| | 53 | 0.2059 | 1045.51 | 0.2977 | 0.0028 | 0.0098 | 0.0157 | 0.0026 |
| | 54 | 0.2006 | 1043.88 | 0.2948 | 0.0028 | 0.0098 | 0.0152 | 0.0027 |
| | 55 | 0.1954 | 1042.25 | 0.2919 | 0.0028 | 0.0098 | 0.0148 | 0.0027 |
| | 56 | 0.1959 | 1045.09 | 0.2934 | 0.0029 | 0.0098 | 0.0148 | 0.0028 |
| | 57 | 0.1963 | 1047.93 | 0.2949 | 0.0029 | 0.0098 | 0.0149 | 0.0028 |
| | 58 | 0.1968 | 1050.76 | 0.2965 | 0.0030 | 0.0098 | 0.0149 | 0.0029 |
| | 59 | 0.1973 | 1053.60 | 0.2980 | 0.0031 | 0.0098 | 0.0149 | 0.0029 |
| | 60 | 0.1978 | 1056.44 | 0.2995 | 0.0031 | 0.0098 | 0.0149 | 0.0030 |
| | 61 | 0.2010 | 1057.33 | 0.2952 | 0.0031 | 0.0098 | 0.0151 | 0.0029 |
| | 62 | 0.2041 | 1058.23 | 0.2909 | 0.0030 | 0.0098 | 0.0153 | 0.0029 |
| | 63 | 0.2073 | 1059.13 | 0.2867 | 0.0030 | 0.0098 | 0.0154 | 0.0029 |
| | 64 | 0.2105 | 1060.03 | 0.2824 | 0.0030 | 0.0098 | 0.0156 | 0.0028 |
| | 65 | 0.2137 | 1060.93 | 0.2781 | 0.0029 | 0.0098 | 0.0158 | 0.0028 |
| | 66 | 0.2299 | 1055.18 | 0.2781 | 0.0029 | 0.0096 | 0.0162 | 0.0027 |
| | 67 | 0.2461 | 1049.43 | 0.2780 | 0.0028 | 0.0095 | 0.0166 | 0.0027 |
| | 68 | 0.2623 | 1043.68 | 0.2780 | 0.0028 | 0.0094 | 0.0170 | 0.0026 |
| | 69 | 0.2785 | 1037.93 | 0.2780 | 0.0027 | 0.0093 | 0.0174 | 0.0026 |
| | 70 | 0.2947 | 1032.18 | 0.2779 | 0.0027 | 0.0092 | 0.0178 | 0.0025 |

*Source: California Air Resources Board, EMFAC 2014*

*Notes: 1) Zero mph corresponds to starts, 2) Other emissions factors include idling emissions and exclude diurnal and evaporative emissions, 3) Five mph is best estimate for idling*

## HEALTH COST OF TRANSPORTATION EMISSIONS

($/ton)

| Area | Proj Loc | CO | CO$_2$e | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC |
|---|---|---|---|---|---|---|---|
| LA/South Coast | 1 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Urban Area | 2 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |
| CA Rural Area | 3 | $0 | **$0.907** | **$8,300** | **$377,800** | **$48,900** | **$2,000** |

CO$_2$e Uprater 2.0% increase in value per year

*Note: According to FHWA INFRA B/C Guidance Dec, 2018, Table A-7 Cost of SCC is $1.00 per metric ton.*
*Cal-B/C is in short ton units--converted metric value to short ton value, equating to $0.9207/ton for a base year*

## PASSENGER TRAIN EMISSIONS FACTORS

(g/train-mile)

| Mode | Year | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Passenger Train | 2002 | 45.67 |  | 583.58 | 62.02 |  | 19.73 |  |
|  | 2022 | 45.67 |  | 250.11 | 31.01 |  | 19.73 |  |

## LIGHT RAIL EMISSIONS FACTORS

(g/veh-mile)

| Mode | Year | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Light Rail | 2002 | 0.14 |  | 1.13 | 0.17 |  | 0.06 |  |
|  | 2022 | 0.14 |  | 1.14 | 0.17 |  | 0.06 |  |

## FREIGHT LOCOMOTIVE EMISSIONS FACTORS

(g/gal)

| Mode | Year | CO | CO$_2$ | NO$_X$ | PM$_{10}$ | SO$_X$ | VOC | PM$_{2.5}$ |
|---|---|---|---|---|---|---|---|---|
| Freight Rail | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |
|  | 2030 |  | 10,206 | 28.10 | 0.43 |  |  |  |

| | | |
|---|---|---|
| Freight Rail Fuel Efficiency | 468 | ton-miles/gal |
| Fuel Burned at Idle | 4 | gal/hr |

*Sources: California Air Resources Board*
*Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, June 2017*
*California Environmental Protection Agency / Air Resources Board, Technology Assessment:*
*Freight Locomotives, November 2016*

## ***Pavement Adjustments*** (used only for pavement projects)

**PAVEMENT DETERIORATION**

(IRI in inches/mile)

| | Year 20, By Loading | | |
|---|---|---|---|
| **Year 0** | **Light** | **Medium** | **Heavy** |
| 0 | 125 | 150 | 350 |
| 25 | 150 | 200 | 500 |
| 50 | 175 | 250 | 675 |
| 75 | 200 | 300 | 750 |
| 100 | 275 | 400 | 750 |
| 125 | 325 | 475 | 750 |
| 150 | 400 | 575 | 750 |
| 175 | 500 | 700 | 750 |
| 200 | 575 | 750 | 750 |
| 225 | 650 | 750 | 750 |
| 250 | 750 | 750 | 750 |
| 275 | 750 | 750 | 750 |
| 300 | 750 | 750 | 750 |
| 325 | 750 | 750 | 750 |
| 350 | 750 | 750 | 750 |
| 375 | 750 | 750 | 750 |
| 400 | 750 | 750 | 750 |
| 425 | 750 | 750 | 750 |
| 450 | 750 | 750 | 750 |

*Source: Paterson, 1987*

**VEHICLE OPERATING SPEED**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.025 |
| 25 | 1.000 | 1.025 |
| 50 | 1.000 | 1.025 |
| 75 | 1.000 | 1.025 |
| 100 | 1.000 | 1.025 |
| 125 | 1.000 | 1.025 |
| 150 | 1.000 | 1.013 |
| 175 | 1.000 | 1.000 |
| 200 | 1.000 | 0.980 |
| 225 | 1.000 | 0.949 |
| 250 | 1.000 | 0.919 |
| 275 | 0.991 | 0.890 |
| 300 | 0.981 | 0.862 |
| 325 | 0.971 | 0.834 |
| 350 | 0.961 | 0.808 |
| 375 | 0.952 | 0.782 |
| 400 | 0.942 | 0.758 |
| 425 | 0.932 | 0.734 |
| 450 | 0.923 | 0.709 |

*Source: Botterill, 1996 and 1997*

**FUEL CONSUMPTION**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 0.971 | 0.961 |
| 25 | 0.977 | 0.965 |
| 50 | 0.980 | 0.970 |
| 75 | 0.982 | 0.975 |
| 100 | 0.985 | 0.980 |
| 125 | 0.990 | 0.986 |
| 150 | 0.995 | 0.993 |
| 175 | 1.000 | 1.000 |
| 200 | 1.005 | 1.007 |
| 225 | 1.012 | 1.017 |
| 250 | 1.019 | 1.026 |
| 275 | 1.027 | 1.036 |
| 300 | 1.034 | 1.047 |
| 325 | 1.041 | 1.058 |
| 350 | 1.050 | 1.070 |
| 375 | 1.061 | 1.085 |
| 400 | 1.072 | 1.100 |
| 425 | 1.082 | 1.114 |
| 450 | 1.093 | 1.129 |

*Source: Texas Transportation Institute, 1994*

**NON-FUEL COSTS**

(percent adjustment)

| IRI | Auto | Truck |
|---|---|---|
| 0 | 1.000 | 1.000 |
| 25 | 1.000 | 1.000 |
| 50 | 1.000 | 1.000 |
| 75 | 1.000 | 1.000 |
| 100 | 1.000 | 1.000 |
| 125 | 1.000 | 1.000 |
| 150 | 1.017 | 1.018 |
| 175 | 1.034 | 1.038 |
| 200 | 1.052 | 1.058 |
| 225 | 1.070 | 1.078 |
| 250 | 1.088 | 1.097 |
| 275 | 1.105 | 1.117 |
| 300 | 1.123 | 1.137 |
| 325 | 1.141 | 1.156 |
| 350 | 1.159 | 1.176 |
| 375 | 1.176 | 1.196 |
| 400 | 1.194 | 1.216 |
| 425 | 1.212 | 1.235 |
| 450 | 1.230 | 1.255 |

*Source: ARRB Research Board TR VOC Model*

## Weaving Adjustments (used only for freeway connector, HOV connector, and HOV drop ramp projects)

### VEHICLE OPERATING SPEED

(percent adjustment)

| Percent Weaving | Freeway Conn | HOV Project |
|---|---|---|
| 0.000 | 1.000 | 1.000 |
| 0.002 | 0.982 | 0.988 |
| 0.004 | 0.964 | 0.976 |
| 0.006 | 0.945 | 0.964 |
| 0.008 | 0.927 | 0.952 |
| 0.010 | 0.909 | 0.939 |
| 0.012 | 0.891 | 0.927 |
| 0.014 | 0.873 | 0.915 |
| 0.016 | 0.855 | 0.903 |
| 0.018 | 0.836 | 0.891 |
| 0.020 | 0.789 | 0.879 |
| 0.022 | 0.747 | 0.867 |
| 0.024 | 0.706 | 0.855 |
| 0.026 | 0.664 | 0.842 |
| 0.028 | 0.623 | 0.817 |
| 0.030 | 0.581 | 0.789 |
| 0.032 | 0.540 | 0.761 |
| 0.034 | 0.498 | 0.734 |
| 0.036 | 0.476 | 0.706 |
| 0.038 | 0.473 | 0.678 |
| 0.040 | 0.471 | 0.650 |
| 0.042 | 0.468 | 0.623 |
| 0.044 | 0.466 | 0.595 |
| 0.046 | 0.463 | 0.567 |
| 0.048 | 0.460 | 0.540 |
| 0.050 | 0.458 | 0.512 |
| 0.052 | 0.455 | 0.484 |
| 0.054 | 0.453 | 0.476 |
| 0.056 | 0.453 | 0.474 |
| 0.058 | 0.453 | 0.473 |
| 0.060 | 0.453 | 0.471 |
| 0.062 | 0.453 | 0.469 |
| 0.064 | 0.453 | 0.467 |
| 0.066 | 0.453 | 0.466 |
| 0.068 | 0.453 | 0.464 |
| 0.070 | 0.453 | 0.462 |
| 0.072 | 0.453 | 0.460 |
| 0.074 | 0.453 | 0.459 |
| 0.076 | 0.453 | 0.457 |
| 0.078 | 0.453 | 0.455 |
| 0.080 | 0.453 | 0.453 |

*Source: Fitzpatrick, Brewer, and Venglar, 2003*

## TMS Adjustments (used only for ramp metering, ramp metering signal coordination, incident management, traveler information projects, AVL, transit priority, and BRT projects)

### PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS

(percent adjustment)

| TMS | Without | | With | | Non-Highway Benefits | | | Total |
|---|---|---|---|---|---|---|---|---|
| Strategy | Speed | Volume | Speed | Volume | TT | VOC | Em | Benefit |
| AMoth | 1.02 | 0.95 | 1.02 | 0.95 | -5.05 | 12.81 | 1.37 | 0.74 |
| AMsev | 1.53 | 0.94 | 1.53 | 0.94 | 1.21 | 1.38 | -0.37 | 1.00 |
| IMoth | 0.88 | 1.18 | 0.98 | 0.96 | 0.51 | 0.15 | 0.06 | 0.74 |
| IMsev | 1.01 | 0.97 | 1.01 | 0.95 | 0.30 | 0.31 | 0.30 | 1.00 |
| NoAdj | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| ORoth | 0.98 | 1.03 | 1.00 | 1.00 | -0.07 | -0.03 | -0.07 | 0.00 |
| ORsev | 0.95 | 1.03 | 1.00 | 1.00 | 0.00 | 0.00 | 5.67 | 0.00 |
| RMoth | 1.00 | 1.00 | 1.03 | 0.97 | -0.07 | -0.03 | -0.07 | 1.00 |
| RMsev | 1.00 | 1.00 | 1.05 | 0.97 | 0.00 | 0.00 | 5.67 | 1.00 |
| TIoth | 1.00 | 1.00 | 1.02 | 0.97 | -0.11 | -0.12 | -0.35 | 1.00 |
| TIsev | 1.00 | 1.00 | 1.01 | 0.97 | -0.39 | -0.39 | -0.35 | 1.00 |

*Source: California Department of Transportation TMS Master Plan, 2003*
*29) Chaudhary and Messer, 2000*

### TRANSIT TRAVEL TIME AND AGENCY COST SAVINGS

(percent savings)

| | Travel | Agency Costs | |
|---|---|---|---|
| TMS Strategy | Time | Capital | O&M |
| Transit Vehicle Location (AVL) | 15% | 2% | 8% |
| Transit Vehicle Signal Priority | 10% | - | - |
| Bus Rapid Transit (BRT) | 29% | - | - |

*Sources: FHWA ITS Deployment Analysis System (IDAS), California PATH*