



# Cal-B/C Training Module 5

## Understanding Cal-B/C Assumptions and Parameters

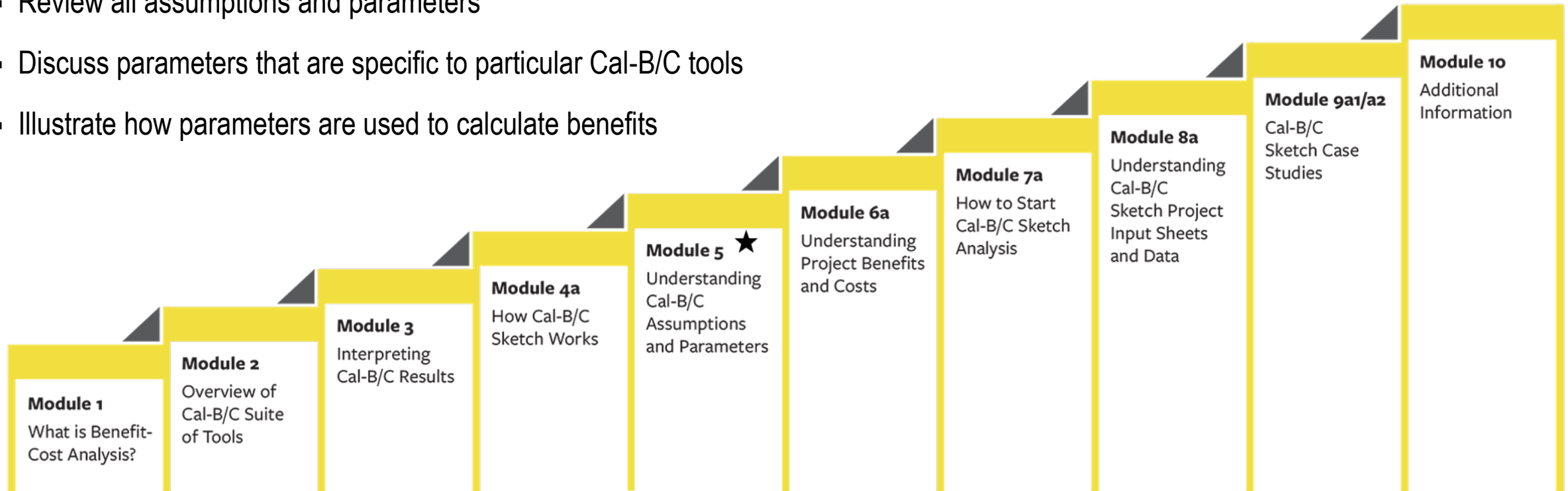


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## **About This Module**

## This module will...

- Provide an overview of the Cal-B/C Parameters worksheet
- Present the Cal-B/C Parameters worksheet design and layout
- Review all assumptions and parameters
- Discuss parameters that are specific to particular Cal-B/C tools
- Illustrate how parameters are used to calculate benefits



★ *This module is covered in this presentation*

## Previous Modules...

- **Module 1** provided a basic introduction on benefit-cost analysis (BCA) and a general overview of how to conduct a BCA
- **Module 2** described the Cal-B/C suite of tools, discussed the types of projects that can be evaluated, and provided guidance on which tools to use for various project types
- **Module 3** presented the Cal-B/C results page, detailed what each output measure means, and explained how they are calculated
- **Module 4** explained how the Cal-B/C tools work and walked through how to use each tool

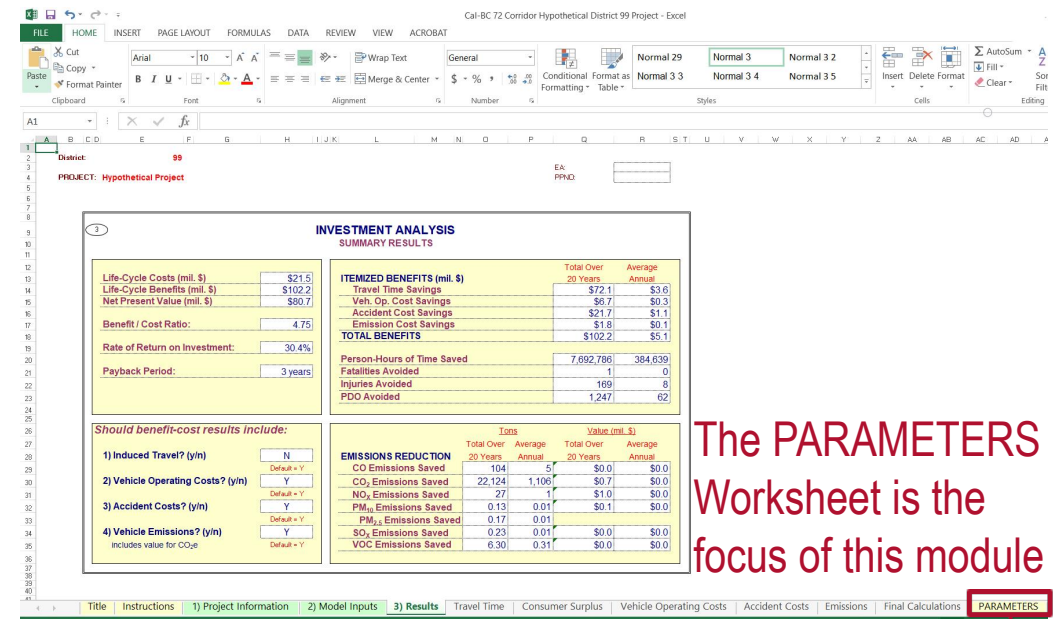
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## **Cal-B/C Parameters Overview**

## Module 5: Cal-B/C Parameters Overview

# Typical Worksheet Layout in Cal-B/C

- Worksheets vary by Cal-B/C tool, but this example from Cal-B/C Sketch is representative of the general structure of the tools in the Cal-B/C suite



The **PARAMETERS** Worksheet is the focus of this module

Worksheets where data will be entered

Worksheets where Cal-B/C performs calculations and tabulates Parameters

Title	Instructions	1) Project Information	2) Model Inputs	3) Results	Travel Time	Vehicle Operating Costs	Accident Costs	Emissions	Final Calculations	PARAMETERS
	Summary instructions on how to fill out each data item in Cal-B/C	<ul style="list-style-type: none"> <li>Project Description/ Type of Project</li> <li>Highway Geometric and Traffic Data</li> <li>Highway Collision Data</li> <li>Rail and Transit Data</li> <li>Project Costs</li> </ul>	<ul style="list-style-type: none"> <li>Default calculations for:                             <ul style="list-style-type: none"> <li>Speeds</li> <li>Volumes</li> <li>Collisions</li> </ul> </li> <li>Additional ramp and arterial inputs</li> <li>Person-trip verification for HOV/HOT projects</li> </ul>	<ul style="list-style-type: none"> <li>BCA Parameters</li> <li>Itemized Benefits (\$)</li> <li>Emission Savings (Tons)</li> </ul>	Calculates No Build and Build Person-Hours and Costs by: <ul style="list-style-type: none"> <li>Year</li> <li>Facility</li> <li>Mode</li> </ul>	Calculates Highway No Build and Build Fuel and Non-Fuel Costs by: <ul style="list-style-type: none"> <li>Year</li> <li>Facility</li> </ul>	Calculates No Build and Build Collision Costs by: <ul style="list-style-type: none"> <li>Year</li> <li>Facility</li> <li>Mode</li> </ul>	Calculates No Build and Build Running and Starting Emissions and Costs: <ul style="list-style-type: none"> <li>Year</li> <li>Facility</li> <li>Mode</li> </ul>	Tabulates final Parameters, including: <ul style="list-style-type: none"> <li>Net present value</li> <li>Internal rate of return</li> </ul>	Key default analysis parameters and assumptions for all Cal-B/C tools

# Cal-B/C Parameters Worksheet

- Where all the Cal-B/C economic assumptions and analysis parameters are located
- Used for all Cal-B/C tools to ensure consistency
- Cal-B/C users can adjust parameters as necessary to best fit their analyses
  - Wage rates are common factors to change
  - Monetary current year can be adjusted to present year by adjusting the economic update factor
  - Changing some factors (e.g., locomotive emissions) may require advanced technical knowledge

## Parameters Used in Cal-B/C Suite of Tools

### General Economic Values

- Year of current dollars for model
- Economic update factor
- Real discount rate

### Highway Operations Measures

- Maximum volume-capacity (v/c) ratio
- Percent ADT in peak period
- Capacity per lane by road type
- Parameters for speed estimation
- Queue departure rates
- Annualization factor

### Travel Time Values

- Automobile, truck, and transit
- Out-of-vehicle and incident-related travel

### User Operating Costs

- Fuel cost per gallon
- Non-fuel cost per mile (automobile and truck)

### Highway Accident Costs

- Cost of a fatality
- Cost of an injury (Level A Severe, Level B Moderate, Level C Minor)
- Cost of a highway accident (fatal, injury, and PDO)
- Statewide highway accident rates (fatal, injury, PDO)

### Transit Accident Rates and Costs

- Highway injury severity frequency
- Highway accident type distribution
- Light-rail and bus accident rates and costs
- Passenger train accident rates and costs
- Highway-rail grade crossing incidents
- Passing lane accident reduction factors

### Highway Emissions Rates

- CO, CO<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub>, SO<sub>x</sub>, and VOC
- Automobile, truck, and bus

### Rail Emissions Rates

- CO, NO<sub>x</sub>, PM<sub>10</sub>, and VOC
- Passenger train, light-rail, freight rail (locomotive)

### Emissions Health Costs

- Urban Southern California, urban Northern California, and rural California
- CO, CO<sub>2</sub>e, NO<sub>x</sub>, PM<sub>10</sub>, SO<sub>x</sub>, and VOC
- Automobile, truck, freight rail (locomotive), and bus

### Active Transportation

- General Travel Activity Characteristics
- User Characteristics
- Cycling Journey Quality (bike class)
- Walking Journey Quality – values per mile by amenity (e.g., street lighting, curb level, information panels, etc.)
- Health Absenteeism Reduction (average absence of employees, percentage covered by short-term sick leave, percentage of sick days reduced when active at least 30 minutes per day)
- Health Mortality Reduction (percentage reduction in mortality, mortality rates)

### Other Values

- Demand for travel in peak period
- Fuel consumption rates for autos and trucks
- Transportation Management System (TMS) adjustment factors

## Cell Color-Coding

- **Green** cells indicate required data
- **Blue** cells contain values calculated in the Parameters worksheet
- **Gray** cells contain calculations and should not be changed
- **Red** cells provide default values that can be changed if needed
  - Parameters worksheet does not have any red cells, but other worksheets in Cal-B/C do have them



# Layout of Parameters Worksheet (Columns A through BL)

The screenshot displays a comprehensive spreadsheet of parameters for Cal-B/C. Key sections include:

- General Economic Parameters:** Includes Year of General Dollars for Model, Economic Update Factor, and Real Discount Rate.
- Highway Operations Parameters:** Covers Minimum V/C Ratio, Average Heavy Vehicle Factor, and various vehicle speed and acceleration parameters.
- Vehicle Operating Cost Parameters:** Details Average Fuel Price, Mileage, and various cost components like tire wear and maintenance.
- Accident Tables:** Multiple tables showing accident rates for different vehicle types and conditions.
- Fuel Consumption Parameters:** Tables for different vehicle classes and trip purposes.

Highway operations (Used by Cal-B/C Sketch to calculate speeds and travel times)

Project Types (Used by Cal-B/C Sketch to identify project types)

Active Transportation (Used by Cal-B/C AT to calculate active transportation benefits)

Travel Demand Tables (Used by Cal-B/C Sketch to calculate peak period demand; Used by Cal-B/C AT to identify age cohorts, trip distance, and trip purpose)

Fuel Consumption (Used by Cal-B/C Sketch, Corridor, and PnR to calculate vehicle operating cost benefits)

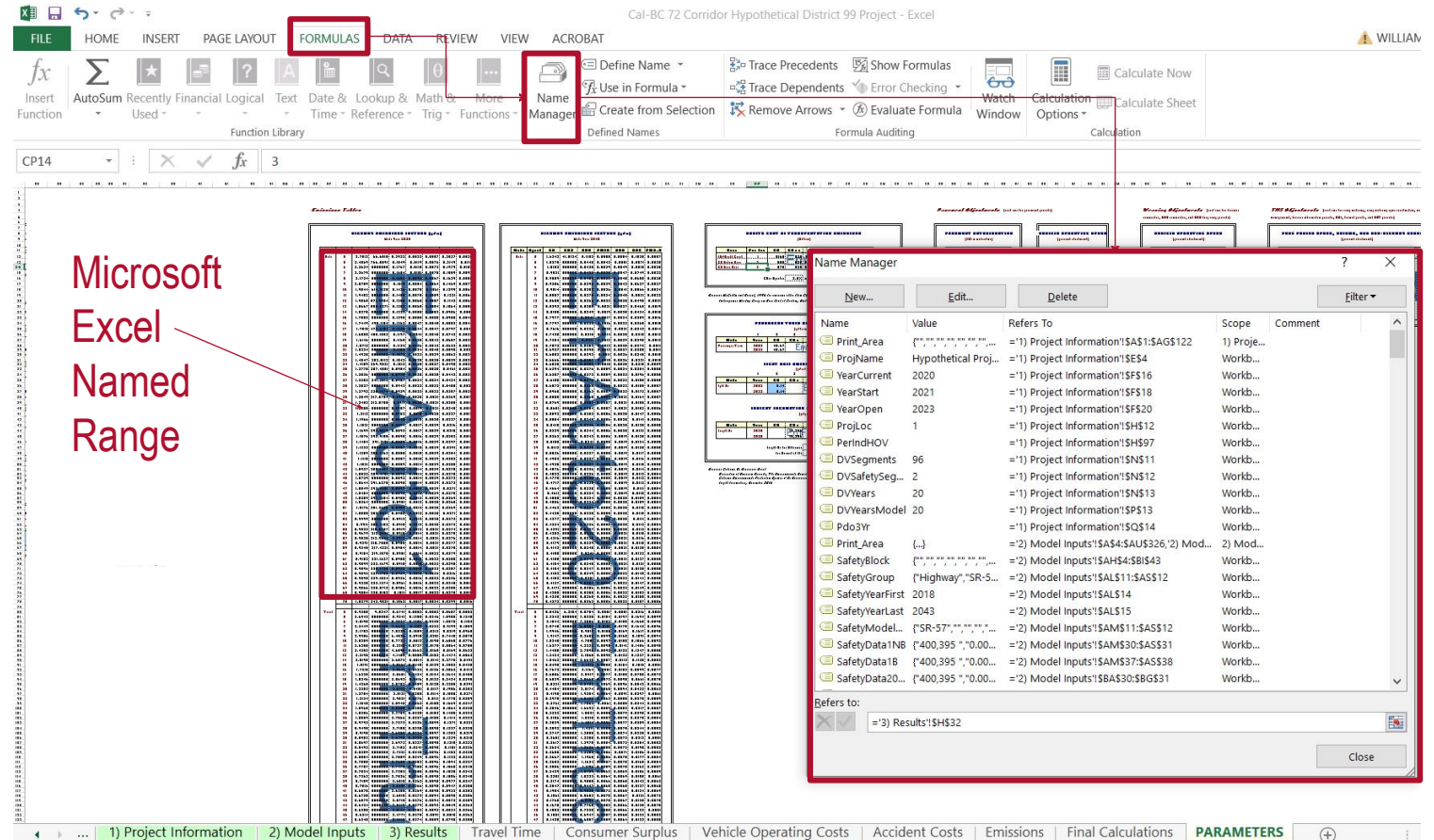
Accident Tables (Used by all Cal-B/C tools to calculate safety benefits)

General economic and unit costs (Used by all Cal-B/C Tools)



# A Note About Named Cell Ranges in Microsoft Excel

- Cal-B/C uses a Microsoft Excel feature called “Named Ranges”
- These are used in formulas to reference an identifiable name rather than a range of cells
- To see what cell ranges are used for a particular named range
  - Click to the **Formulas > Name Manager** icon on your Microsoft Excel ribbon to see a window that lists all the named ranges used in Cal-B/C
  - Window presents a sortable table that lists all named ranges in Cal-B/C along with the location of that named range



## Parameter Description, Excel Location, and Used by Cal-B/C Tool (Slide 1 of 3)

Description of Parameter		Starts in Excel Cell	Parameter Summary Information	Sketch	Corridor	Park and Ride	Active Transportation	Intermodal Freight
General Economic Parameters	General Economic Parameters	B7	Year of current dollars, GDP deflator, and real discount rate to calculate benefits	◆	◆	◆	◆	◆
	Travel Time Parameters	B17	Provides average values of travel time to calculate travel time benefits	◆	◆	◆	◆	◆
	Vehicle Operating Cost Parameters	B34	Provides average fuel prices and taxes to calculate vehicle operating cost benefits	◆	◆	◆		◆
	Accident Cost Parameters	B59	Provides average costs per fatality, injury, property damage only; provides average highway collision rates to be used in collision rates not provided by user	◆	◆	◆	◆	◆
Highway Operational Parameters	Highway Operations Parameters	I17	Used to calculate speeds by using BPR curves when only average daily traffic is input by user	◆				
Active Transportation Parameters	Active Transportation Parameters	R17	Provides various parameters for active transportation projects				◆	
Project Types	Project Types	Y7	Helps Cal-B/C identify appropriate formulas and parameters in benefit calculations	◆				
Travel Demand Tables	Travel Demand Tables (Highways)	AF4	Estimate demand during peak periods from average daily traffic	◆				
	Demand Profiles (Active Transportation)	AF45	Estimate mortality risk by age, trip distances, trip purposes for active transportation				◆	

## Parameter Description, Excel Location, and Used by Cal-B/C Tool (Slide 2 of 3)

Description of Parameter		Starts in Excel Cell	Parameter Summary Information	Sketch	Corridor	Park and Ride	Active Transportation	Intermodal Freight
Operating Cost Tables	Fuel Consumption Rates	AQ4	Calculate fuel consumption by average speed for automobiles and trucks	◆	◆	◆		
Accident Tables	Highway Injury Severity Frequency	AX7	Used to calculate cost of highway accidents by severity by urban/suburban/rural (See Cost of Highway Accidents below)	◆	◆	◆		
	# Of Fatalities, Injuries, Vehicles Involved, and Distributions	AX21	Used to calculate cost of highway accidents by severity by urban/suburban/rural (See Cost of Highway Accidents below)	◆	◆	◆		
	Cost Of Highway Accidents	AX59	Used to calculate highway safety benefits	◆	◆	◆		
	Rates For Non-Highway Accident Events	BF7	Collision rates used to calculate cost per non-highway collisions	◆	◆	◆		
	Cost Of Non-Highway Accident Events	BF21	Unit cost per non-highway collision	◆	◆	◆		
	Cost Of Non-Highway Accidents	BF34	Collision costs per million vehicle-miles (combination of two above tables)	◆	◆	◆		
	Highway-Rail Grade Crossing Incidents	BF45	Collision rate and cost information	◆				

## Parameter Description, Excel Location, and Used by Cal-B/C Tool (Slide 3 of 3)

Description of Parameter		Starts in Excel Cell	Parameter Summary Information	Sketch	Corridor	Park and Ride	Active Transportation	Intermodal Freight
Emission Tables	Emission Tables	BO7	Emission rate by speed bin lookup tables (auto, truck, and bus for Year 1 and Year 20) used to calculate emission reduction benefits	◆	◆	◆	◆	◆
	Health Cost Of Transportation Emissions	CN7	Used to calculate emissions impacts on health by region and by pollutant	◆	◆	◆	◆	◆
	Rail Transit And Freight Emission Factors	CN23	Used to calculate rail transit and freight emissions	◆	◆			◆
Pavement Adjustment Factors	Pavement Deterioration	DA7	Used to calculate International Roughness Index (IRI) degradation by vehicle loading	◆				
	Fuel Consumption	DA37	Used to calculate the improvement in average speed due to pavement IRI improvements	◆				
	Vehicle Operating Speed	DH7	Used to calculate the improvement in average speed due to pavement IRI improvements	◆				
	Non-Fuel Costs	DH37	Used to calculate the improvement in vehicle maintenance costs due to pavement IRI improvements	◆				
Weaving Adjustments	Vehicle Operating Speed Adjustments	DO7	Used to calculate speed adjustments for freeway-to-freeway connector, HOV connector, and HOV drop ramp projects	◆				
TMS Adjustments	Peak Period Speed, Volume, And Non-Highway Benefits	DV7	Used to calculate speed and volume adjustments for highway TMS projects	◆				
	Transit Travel Time And Agency Cost Savings	DV31	Used to calculate speed and volume adjustments for transit automatic vehicle location (AVL), transit signal prioritization, and Bus Rapid Transit (BRT) projects	◆				

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## **General Economic Parameters**

# General Economic Parameters

## Year of Current Dollars for Model

- Allows for a common year to evaluate all costs and benefits
- Current year can be changed (e.g., from 2016 to 2020)

## Economic Update Factor (Using GDP Deflator)

- Can update all dollar values in the Cal-B/C Parameters sheets automatically to another “current” year
- Recommend using Gross Domestic Product (GDP) deflator from the U.S. Office of Management and Budget (OMB)

## Real Discount Rate

- Used by Cal-B/C to calculate the Net Present Value (NPV)
- NPV is current year value of future project benefits
- Cal-B/C default in California is 4%. Some grant programs require a 7%
- Evaluating project using a range of discount rates (e.g., 3% to 10%) is useful for sensitivity analysis

	A	B	C	D	E	F	G	H	
1		<b>Parameters</b>							
2		<i>This page contains all economic values and rate tables.</i>							
3		<i>To update economic values automatically, change "Economic Update Factor."</i>							
4									
5									
6									
7		<b>General Economic Parameters</b>							
8									
9		Year of Current Dollars for Model		2016					
10		Economic Update Factor (Using GDP Deflator)		1.00				1	
11									
12		Real Discount Rate		4.0%				2	
13									

Sources for parameter values  
referenced to the right of parameter  
Source document(s) are listed at  
bottom of section

81 Sources: 1) Office of Management and Budget (OMB), 2) Review of OMB and State  
82 Treasurer's Office data, 3) Bureau of Labor Statistics (BLS) CES, 4) BLS Employment  
83 Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation  
84 TSI and Traffic Operations, 7) IDAS model, 8) AAA Daily Fuel Gauge Report, 9) California  
85 Board of Equalization, 10) AAA Your Driving Costs, 11) American Transportation Research  
86 Institute, 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009  
87  
88



## Travel Time Parameters

- Used by all Cal-B/C Tools

### Statewide Average Hourly Wage

- Follows USDOT guidelines for Value of Time (VOT)

Used to calculate VOT in the following section

### Heavy and Light Truck Drivers

- Trucking costs include average driver wages as inputs
- Also include fringe benefits and other operational costs

### Value of Time (VOT)

- Calculated for auto, truck, and transit modes
- Transit users value time accessing/waiting for transit higher than time spent in transit
- Drivers and passengers value the time spent in incident related travel higher
- VOT can change faster than rate of inflation due to changes in labor productivity

	B	C	D	E	F	G
17	<i>Travel Time Parameters</i>					
18				Value	Units	
19			Statewide Average Hourly Wage	\$ 27.34	\$/hr	3
20						
21			Heavy and Light Truck Drivers			
22			Average Hourly Wage	\$ 20.44	\$/hr	3
23			Benefits and Costs	\$ 10.97	\$/hr	4
24						
25			Value of Time			
26			Automobile	\$ 13.65	\$/hr/per	5
27			Truck	\$ 31.40	\$/hr/veh	5
28			Auto & Truck Composite	\$ 18.95	\$/hr/veh	6
29			Transit	\$ 13.65	\$/hr/per	5
30			Out-of-Vehicle Travel	2	times	5
31			Incident-Related Travel	3	times	7
32			Travel Time Uprater	0.0%	annual incr	

See formulas in blue cells to see how VOT assumptions are applied to wages

Note: Blue shaded cells contain calculated values that can be overridden by user

## Vehicle Operating Cost Parameters

- Used by Cal-B/C Sketch, Corridor, Park and Ride, and Intermodal Freight

### Average Fuel Price

- Average price for a gallon of regular unleaded gasoline and diesel

### Sales and Fuel Taxes

- Federal, state, and local fuel and sale taxes

### Fuel Cost Per Gallon (Exclude Taxes)

- Fuel price without taxes

### Non-Fuel Cost Per Mile

- Cost of tires and maintenance

### Idling Speed for Op. Costs and Emissions

- Vehicle operating costs and emissions for time spent in queues
- 5 mph speed bin approximates vehicles idling

	B	C	D	E	F	G
33						
34			<b>Vehicle Operating Cost Parameters</b>			
35						
36			<b>Average Fuel Price</b>			
37			Automobile (regular unleaded)	\$ 3.18	\$/gal	8
38			Truck (diesel)	\$ 3.00	\$/gal	8
39						
40			<b>Sales and Fuel Taxes</b>			
41			State Sales Tax (gasoline)	2.25%	%	9
42			State Sales Tax (diesel)	7.50%	%	9
43			Average Local Sales Tax	0.50%	%	9
44			Federal Fuel Excise Tax (gasoline)	\$ 0.184	\$/gal	9
45			Federal Fuel Excise Tax (diesel)	\$ 0.244	\$/gal	9
46			State Fuel Excise Tax (gasoline)	\$ 0.278	\$/gal	9
47			State Fuel Excise Tax (diesel)	\$ 0.160	\$/gal	9
48						
49			<b>Fuel Cost Per Gallon (Exclude Taxes)</b>			
50			Automobile	\$ 2.65	\$/gal	
51			Truck	\$ 2.40	\$/gal	
52						
53			<b>Non-Fuel Cost Per Mile</b>			
54			Automobile	\$ 0.313	\$/mi	10
55			Truck	\$ 0.429	\$/mi	11
56						
57			Idling Speed for Op. Costs and Emissions	5	mph	
58						

Note: Blue shaded cells contain calculated values that can be overridden by user

## Accident Cost Parameters

- Used by all Cal-B/C Tools

### Cost of a Fatality

- Economic costs of a fatal event

### Cost of an Injury

- Economic cost due to different levels of injury

### Cost of Property Damage

- Economic cost when property is damaged

### Cost of Highway Accident

- Economic cost of a highway accident
- Values based on event per accident and distribution of accident parameters found in the Parameters worksheet

### Statewide Highway Accident Rates

- Accident rate per million vehicle-miles traveled.

	B	C	D	E	F	G
59	<b>Accident Cost Parameters</b>					
60						
61		Cost of a Fatality		\$ 9,800,000	\$/event	12
62						
63		Cost of an Injury				
64		Level A (Severe)		\$ 466,400	\$/event	12
65		Level B (Moderate)		\$ 127,000	\$/event	12
66		Level C (Minor)		\$ 64,900	\$/event	12
67						
68		Cost of Property Damage		\$ 2,700	\$/event	13
69						
70		Cost of Highway Accident				
71		Fatal Accident		\$ 10,800,000	\$/accident	
72		Injury Accident		\$ 148,800	\$/accident	
73		PDO Accident		\$ 9,700	\$/accident	
74		Average Cost		\$ 185,600	\$/accident	
75						
76		Statewide Highway Accident Rates				
77		Fatal Accident		0.006	per mil veh-mi	14
78		Injury Accident		0.29	per mil veh-mi	14
79		PDO Accident		0.55	per mil veh-mi	14
80		Non-Freeway		1.05	per mil veh-mi	15
81						

Note: **Blue** shaded cells contain calculated values that can be overridden by user

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## **Highway Operational Parameters**

# Highway Operations Parameters

- Used by Cal-B/C Sketch (all tools use the annualization factor)

## Maximum V/C Ratio

- Constrains the Volume to Capacity (V/C) Ratio to ensure inputs are reasonable and pragmatic
- Regional planning models predict demand, but do not constrain demand to roadway capacity

## Percent ADT in Peak Period

- Traffic volume during peak period divided by average daily traffic

## Percent ADT in Average Peak Hour

- Traffic volume during peak hour divided by average daily traffic

## Annualization Factor

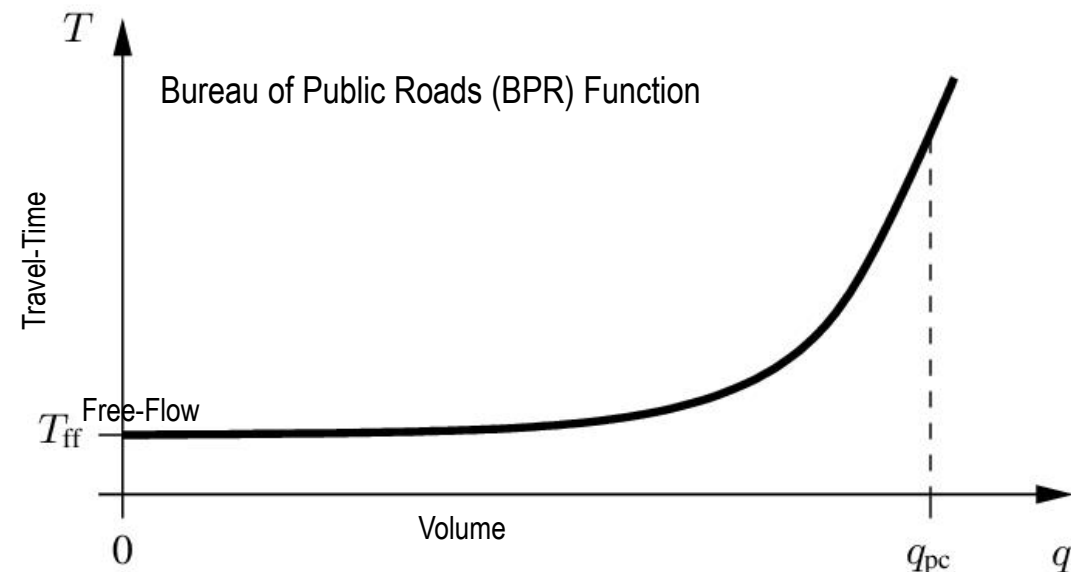
- Equals 365 days with a standardized definition of a “daily” trip, but can be changed by user if only weekday traffic is entered (e.g., 260 days)

## Bureau of Public Roads (BPR) Parameters and Highway Capacities

- Parameters are used to calculate speeds and travel-times

Highway Operations Parameters				
	Value	Units		
Maximum V/C Ratio	1.56	-		
Percent ADT in Peak Period		%		
Percent ADT in Average Peak Hour		%		
Annualization Factor	365	days/yr		
	Alpha	Beta	Capacity (vphpl)	Dep. Rate (vphpl)
Freeway	0.20	10	2,000	1,800
Expressway	0.20	10	2,000	1,800
Conventional Highway	0.05	10	800	1,400
HOV Lanes	0.55	8	1,600	
	Alpha	Beta	Capacity	
Non-HOV Lanes				
No Build				
Build				

Sources: 16) Highway Capacity Manual, 17) NCHRP 367, 18) PeMS data



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## **Active Transportation Parameters**

# Active Transportation Parameters

## General Travel Activity Characteristics Parameters

- Equals 365 days with a standardized definition of a “daily” trip

## Vehicle Statistics

- Average speed and AVO used to calculate emission reductions

## Active Transportation User Characteristics

- Cyclist and pedestrian transportation traits

## Value of Travel Time

- Travel time for valued at 50% of the hourly median household income

## Journey Quality (Cycling and Walking)

- Journey quality is a function of cycling and pedestrian facilities

## Health (Absenteeism Reduction and Mortality Reduction)

- Based on research in absenteeism and mortality (e.g., % sick days reduced, % mortality by age cohort)

	R	S	T	U	V	W
17	<b>Active Transportation Parameters</b>					
18						
19	General Travel Activity Characteristics Parameters			Value	Units	
20	Cycling Days per Year		365	days		
21	Walking Days per Year		365	days		
22	School Days per Year		180	days		
23						
24	Vehicle Statistics					
25	Average Vehicle Speed		25	mph		
26	Average Vehicle Occupancy		1.25	persons / veh		19
27						
28	Active Transportation User Characteristics					
29	Average Cycling Speed		11.80	mph		20
30	Average Walking Speed		3.00	mph		21
31	Number of Unlinked Cycling Trips per Day		1.93	trips		19
32	Number of Unlinked Pedestrian Trips per Day		2.38	trips		19
33	Diversion of Cyclists from Personal Vehicles		50%	assumption		
34	Diversion of Pedestrians from Personal Vehicles		50%	assumption		
35						
36	Value of Travel Time					
37	Adults	\$	13.65	\$/hr/per		
38	Children	\$	13.65	\$/hr/per		
39						
40	Cycling Journey Quality - Facility Preference Factors as Function of Distance by Facility Class					
41	Class I		0.57	-		20
42	Class II		0.49	-		20
43	Class III		0.92	-		20
44	Class IV		0.49	-		20
45	<i>Note: Class IV assumed to be the same as Class II</i>					
46						
47	Walking Journey Quality Values per Mile by Amenity					
48	Street Lighting		\$0.110	\$/mi		22
49	Curb Level		\$0.078	\$/mi		22
50	Crowding		\$0.055	\$/mi		22
51	Pavement Evenness		\$0.026	\$/mi		22
52	Information Panels		\$0.026	\$/mi		22
53	Benches		\$0.017	\$/mi		22
54	Directional Signage		\$0.017	\$/mi		22
55						
56	Health (Absenteeism Reduction)					
57	Average Absence of Employees		3.60	days/yr		23
58	Percentage Covered by Short-Term Sick Leave		95%	%		24
59	Percentage of Sick Days Reduced When Active at Least 30 Minutes per Day		6%	%		25
60						
61	Health (Mortality Reduction)					
62	Percentage of Cyclists Aged 16-64		70.5%	%		26
63	Percentage of Pedestrians Aged 16-74		76.2%	%		26
64						
65	Percentage Reduction in Mortality per 365 Annual Cycling Miles		4.5%	%		27
66	Percentage Reduction in Mortality per 365 Annual Walking Miles		9.0%	%		27
67						
68	Mortality Rate - All Causes (Aged 20-64)		266	#/100,000 people		28
69	Mortality Rate - All Causes (Aged 20-74)		395	#/100,000 people		28
70						
71						

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 Transportation Survey, 27) WHO HEAT Model, 2016, 28) California Department of Health, 2010-2014 Death Rates, Table 5.2

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## **Project Types**



# Project Types

- Used in Cal-B/C Sketch

## Highway Capacity Expansion

- Includes general highway as well as other expansion projects

## Rail or Transit Capacity Expansion

- Includes passenger rail, light rail, bus, and grade crossing projects

## Highway Operational Improvement

- Includes auxiliary lanes, ramps, and various connector projects

## Transportation Management Systems (TMS)

- Includes ramp metering and other TMS elements

	Y	Z	AA	AB	AC	AD
7	<b>Project Types</b>					
8						
9	<b>Highway Capacity Expansion</b>				Please select a type of highway project	
10	General Highway			GenHwy		
11	HOV Lane Addition			HOV	Enter HOV restriction in section 1B	
12	HOT Lane Addition			HOT	Include toll payers as HOVs & check AVOs	
13	Passing Lane			Passing	Enter a truck speed in section 1B	
14	Intersection			Intersect	Remember to run model for both roads	
15	Truck Only Lane			TruckLane	Remember to run macro for truck lane	
16	Bypass			Bypass	Remember to run model for both roads	
17	Queuing			Queuing	Add arrival rate & check departure rate in 1B	
18	Pavement			Pavement	Enter pavement condition in section 1B	
19						
20	<b>Rail or Transit Cap Expansion</b>				Please select a type of rail or transit project	
21	Passenger Rail			PassRail	Enter data in both sections 1B & 1E	
22	Light-Rail (LRT)			LRT	Enter data in both sections 1B & 1E	
23	Bus			Bus	Enter data in both sections 1B & 1E	
24	Hwy-Rail Grade Crossing			HwyRail	Put hwy design in 1B, safety in 1C & crossing in 1D	
25						
26	<b>Hwy Operational Improvement</b>				Please select a type of op. improvement	
27	Auxiliary Lane			AuxLane	Enter ramp design speed & on-ramp volume	
28	Freeway Connector			FreeConn	Check percent traffic in weave in section 1B	
29	HOV Connector			HOVConn	Check percent traffic in weave in section 1B	
30	HOV Drop Ramp			HOVDrop	Check percent traffic in weave in section 1B	
31	Off-Ramp Widening			OffRamp	Check percent traffic in weave in section 1B	
32	On-Ramp Widening			OnRamp	Enter on-ramp volume & metering strategy	
33	HOV-2 to HOV-3 Conv			HOV2to3	Check AVOs & trips in sections 1B & 2D	
34	HOT Lane Conversion			HOTConv	Check AVOs & trips in sections 1B & 2D	
35						
36	<b>Transp Mgmt Systems (TMS)</b>				Please select a type of TMS project	
37	Ramp Metering			RM	Enter model data, if avail, in sections 2A & 2C	
38	Ramp Metering Signal Coord			AM	Enter model data, if avail, in sections 2A & 2C	
39	Incident Management			IM	Enter model data, if avail, in sections 2A & 2C	
40	Traveler Information			TI	Enter model data, if avail, in sections 2A & 2C	
41	Arterial Signal Management			ASM	Complete only sections 1A, 1E & 2C	
42	Transit Vehicle Location (AVL)			AVL	Enter transit agency costs in section 1D	
43	Transit Vehicle Signal Priority			SigPriority	Check travel time in section 1D	
44	Bus Rapid Transit (BRT)			BRT	Enter free-flow bus lane speed in section 1B	
45						
46	TMS Lookup Code			TMSLookup		
47	User Modified Inputs			UserAdjInputs		
48						

07

## **Travel Demand Tables**



## Travel Demand Tables (cont.)

- Used in Cal-B/C Active Transportation
- Estimate mortality risk by age, trip distances, and trip purpose
- Based on Caltrans 2010-2012 California Household Travel Survey

### Age Cohorts For Mortality Risk Reduction

### Average Distance Per Active Transportation Trip

### Trip Purpose For Active Transportation Trips

	AG	AH	AI	AJ	AK	AL
46	<b>AGE COHORTS FOR MORTALITY RISK REDUCTION</b>					
47	(percent of population)					
48						
49			<b>Urban</b>			
50	<b>Mode</b>	<b>Age Cohort</b>	<b>South</b>	<b>North</b>	<b>Rural</b>	
51	Cycling	Age 16-64	70.5%	73.4%	66.0%	
52	Walking	Age 16-74	76.2%	80.7%	70.0%	
53						
54						
55	<b>AVERAGE DISTANCE PER ACTIVE TRANSPORTATION TRIP</b>					
56	(miles/trip)					
57						
58			<b>Urban</b>			
59	<b>Mode</b>	<b>Age Cohort</b>	<b>South</b>	<b>North</b>	<b>Rural</b>	
60	Cycling	Adults	1.83	1.85	2.91	
61		Children <16	0.88	1.03	1.66	
62	Walking	Adults	0.52	0.66	0.29	
63		Children <16	0.46	0.58	0.42	
64						
65						
66	<b>TRIP PURPOSE FOR ACTIVE TRANSPORTATION TRIPS</b>					
67	(percent of trips)					
68						
69			<b>Urban</b>			
70	<b>Mode</b>	<b>Trip Purpose</b>	<b>South</b>	<b>North</b>	<b>Rural</b>	
71	Cycling	Commuting	8%	11%	7%	
72		Recreation	15%	13%	15%	
73		Other Destination	77%	76%	78%	
74	Walking	Commuting	5%	9%	4%	
75		Recreation	10%	10%	15%	
76		Other Destination	85%	81%	81%	

08

## **Fuel Consumption Tables**

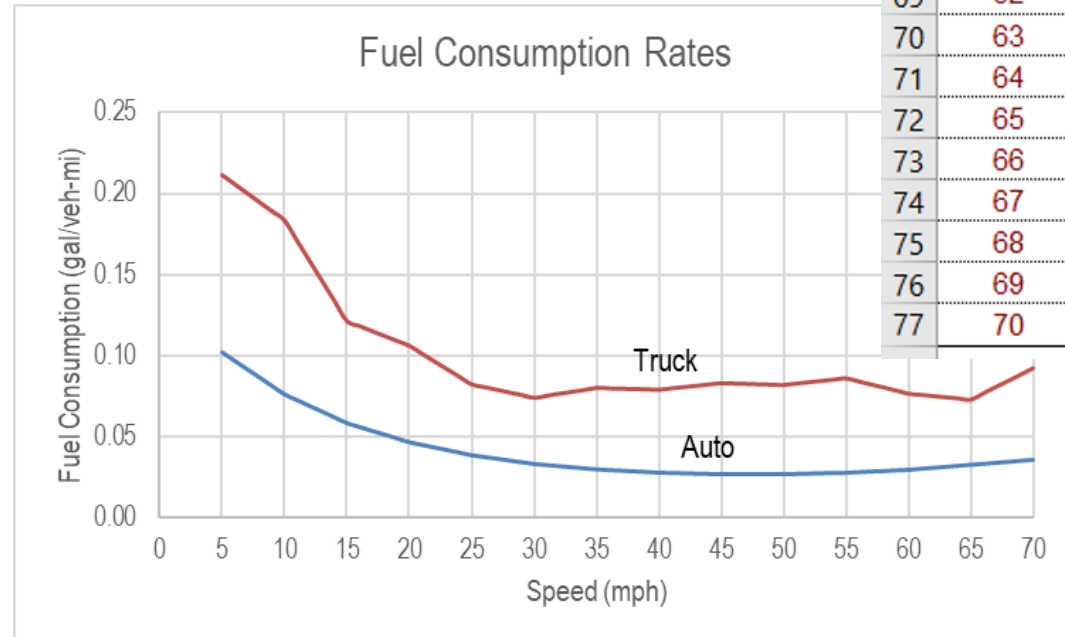
# Fuel Consumption Tables

- Used in Cal-B/C Sketch, Corridor, and Park and Ride

## Fuel Consumption Rates

- Fuel consumption is calculated by average speed for automobiles and trucks
- Note that fuel consumption is “U” shaped
  - As speed increases, fuel consumption decreases until the inflection speed (approximately 45 mph for automobiles)
  - Beyond that speed fuel consumption increases

	AR	AS	AT
8	<b>FUEL CONSUMPTION RATES</b>		
9	(gal/veh-mi)		
10			
11	<b>Speed</b>	<b>Auto*</b>	<b>Truck</b>
12	5	0.1024	0.2112
13	6	0.0971	0.2056
14	7	0.0919	0.2000
15	8	0.0867	0.1944
16	9	0.0815	0.1888
17	10	0.0763	0.1832
18	11	0.0727	0.1707
19	12	0.0691	0.1583
20	13	0.0656	0.1459
68	61	0.0306	0.0750
69	62	0.0306	0.0749
70	63	0.0312	0.0741
71	64	0.0319	0.0734
72	65	0.0325	0.0726
73	66	0.0331	0.0765
74	67	0.0337	0.0804
75	68	0.0343	0.0842
76	69	0.0350	0.0881
77	70	0.0356	0.0920



09

## **Accident Tables**

## Module 5: Accident Tables

# Accident Tables

- Used in Cal-B/C Sketch and Corridor

## Highway Injury Severity Frequency

- Used to calculate frequency of highway accidents by severity
- Referenced by “Cost of Highway Accidents” cells (in blue)

## Number of Fatalities, Injuries, Vehicles Involved, and Distribution

- Used to calculate highway accidents by severity by urban/suburban/rural
- Referenced by “Cost of Highway Accidents” cells (in blue)

## Cost of Highway Accidents

- Used to calculate highway safety benefits
- Calculated based on data described above

	AW	AX	AY	AZ	BA	BB	BC	BD
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**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	\$10,800,000	\$10,700,000	\$11,300,000	\$11,000,000
Injury Accident	\$148,800	\$148,600	\$154,200	\$149,300
PDO Accident	\$9,700	\$11,000	\$8,600	\$10,600
All Types	\$185,600	\$104,600	\$281,100	\$135,800

Source: Combination of above four tables

Used to calculate  
COST OF HIGHWAY  
ACCIDENTS



# Accident Tables (cont.)

## Rates for Non-Highway Accident Events

- Collision rates used to calculate frequency of events (i.e., fatalities, injuries, and crashes) during non-highway collisions

## Cost of Non-Highway Accident Events

- Cost of events used to calculate safety benefits for non-highway collisions

## Cost of Non-Highway Accidents

- Unit cost for non-highway collisions, which aggregates the rates and costs in the prior tables

## Highway-Rail Grade Crossing Incidents

- Collision rate and cost for grade crossing collisions

## Passing Lane Accident Reduction Factors

- Accident reduction factor based on ADT

	BE	BF	BG	BH	BI	BJ	BK	BL
6								
7								
8								
9	<b>RATES FOR NON-HIGHWAY ACCIDENT EVENTS</b>							
10	(events/million veh-mi)							
11	<b>Event</b>	<b>Pass Train</b>	<b>Light Rail</b>	<b>Bus</b>	<b>Freight Rail</b>			
12	Fatality	0.0555	0.2480	0.0349	0.9917			
13	Injury	0.2519	3.9469	3.6535	7.7862			
14	All Accidents	0.2775	5.3817	2.6733	13.5424			
15								
16								
17	Sources: USDOT, Transportation Statistics Annual Report, Table 2-33, 2003 to 2012 average							
18	FRA, Office of Safety Analysis, Table 1.13, 2008 to 2017 YTD average.							
19								
20								
21								
22								
23								
24	<b>COST OF NON-HIGHWAY ACCIDENT EVENTS</b>							
25	(\$/event)							
26	<b>Event</b>	<b>Pass Train</b>	<b>Light Rail</b>	<b>Bus</b>	<b>Freight Rail</b>			
27	Fatality	\$9,800,000	\$9,800,000	\$9,800,000	\$9,800,000			
28	Injury	\$180,500	\$180,500	\$180,500	\$180,500			
29	Prop Damage	\$78,800	\$12,400	\$3,800	\$147,600			
30								
31	Sources: FTA, Transit Safety & Security Statistics, 2002 to 2011 average							
32	FRA, Office of Safety Analysis, Table 3.16, 2014 to 2016 average.							
33								
34								
35								
36	<b>COSTS OF NON-HIGHWAY ACCIDENTS</b>							
37	(\$/million veh-mi)							
38	<b>Value</b>	<b>Pass Train</b>	<b>Light Rail</b>	<b>Bus</b>	<b>Freight Rail</b>			
39	Cost	\$611,200	\$3,209,500	\$1,011,600	\$13,122,900			
40								
41	Source: Combination of above two tables							
42								
43								
44								
45								
46	<b>HIGHWAY-RAIL GRADE CROSSING INCIDENTS</b>							
47	(units in table)							
48	<b>Value</b>	<b>Incident</b>	<b>Fatality</b>	<b>Injury</b>				
49	Total Events	799	94	515				
50	Avg per Incident		0.1176	0.6448				
51	Cost per Event		\$9,800,000	\$180,500				
52								
53								
54								
55	Source: FRA, Office of Safety Analysis, 5.10 - Hwy/Rail Incidents Summary							
56	Table, California, Motor Vehicles, Public Crossings, Jan 2007 to Dec 2016							
57								
58								
59								
60	<b>PASSING LANE ACCIDENT REDUCTION FACTORS</b>							
61	(rate with passing lane/rate without passing lane)							
62	<b>Minimum ADT</b>	<b>Fatality</b>	<b>Injury</b>	<b>PDO</b>				
63	0	25.0%	69.4%	92.6%				
64	5,000	19.2%	80.3%	96.5%				
65	10,000	84.0%	57.7%	97.8%				
66								
67								
68								
69								
70	Source: Taylor and Jain, 1991							

Used to calculate  
COST OF NON-  
HIGHWAY  
ACCIDENTS

10

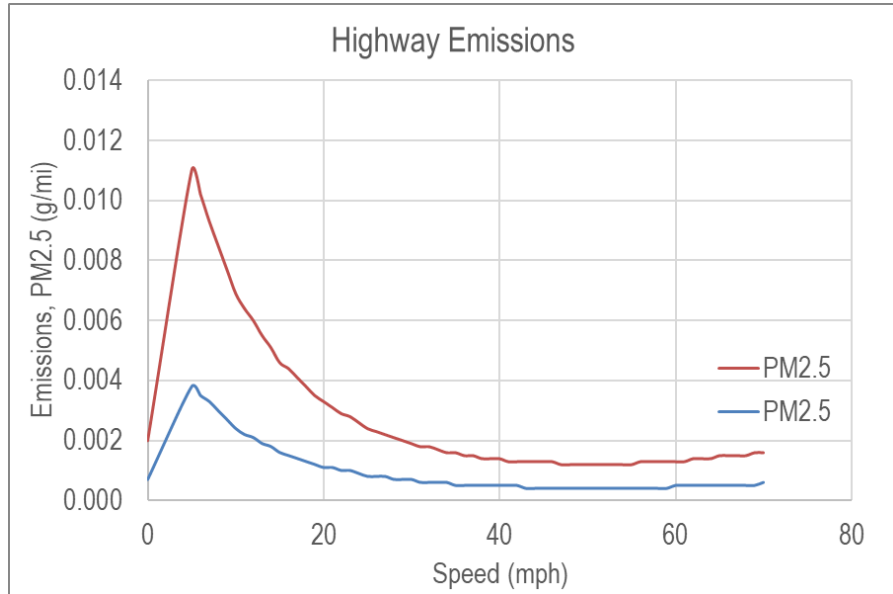
## **Emission Tables**

# Emission Tables

- Used by all Cal-B/C Tools

## Highway Emissions Factors

- Emission rate by speed bin (up to 70 mph)
- Mode: Auto, Truck, and Bus
- Year 1 and Year 20
- Used to calculate emission reduction benefits



	BP	BQ	BR	BS	BT	BU	BV	BW	BX
8	<b>HIGHWAY EMISSIONS FACTORS (g/mi)</b>								
9	Model Year 2020 ← Year 1								
10									
11	Mode	Speed	CO	CO2	NOX	PM10	SOX	VOC	PM2.5
12	Auto	0	2.7812	66.6818	0.2922	0.0022	0.0007	0.3837	0.0020
13		5	2.4569	766.8891	0.1849	0.0119	0.0076	0.2149	0.0110
14		6	2.3624	736.4937	0.1767	0.0110	0.0073	0.1979	0.0102
15		7	2.2679	706.0983	0.1684	0.0101	0.0070	0.1809	0.0093
16		8	2.1734	675.7029	0.1602	0.0092	0.0067	0.1639	0.0085
17	CB	CC	CD	CE	CF	CG	CH	CI	CJ
18	<b>HIGHWAY EMISSIONS FACTORS (g/mi)</b>								
19	Model Year 2040 ← Year 20								
20									
21	Mode	Speed	CO	CO2	NOX	PM10	SOX	VOC	PM2.5
22	Auto	0	1.6243	41.5134	0.1182	0.0008	0.0004	0.1038	0.0007
23		5	1.0375	512.1914	0.0448	0.0042	0.0051	0.0871	0.0038
		6	1.0103	492.7973	0.0435	0.0039	0.0049	0.0810	0.0035
		7	0.9831	473.4032	0.0422	0.0035	0.0047	0.0749	0.0033
		8	0.9559	454.0092	0.0409	0.0032	0.0045	0.0688	0.0030
		9	0.9286	434.6151	0.0396	0.0029	0.0043	0.0627	0.0027
		10	0.9014	415.2211	0.0383	0.0026	0.0041	0.0566	0.0024
		11	0.8807	400.2645	0.0375	0.0024	0.0040	0.0531	0.0022
		12	0.8600	385.3079	0.0366	0.0023	0.0038	0.0495	0.0021
		13	0.8392	370.3513	0.0358	0.0021	0.0037	0.0460	0.0019
		14	0.8185	355.3947	0.0349	0.0019	0.0035	0.0424	0.0018
		15	0.7977	340.4381	0.0341	0.0017	0.0034	0.0389	0.0016



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# **Pavement Adjustment Factors**

## Module 5: Pavement Adjustment Factors

# Pavement Adjustment Factors

- Used in Cal-B/C Sketch

## Pavement Deterioration

- Used to calculate International Roughness Index (IRI) degradation by vehicle loading

## Fuel Consumption

- Used to calculate the reduction in fuel consumption due to pavement IRI improvements

## Vehicle Operating Speed

- Used to calculate the improvement in average speed due to pavement IRI improvements

## Non-Fuel Costs

- Used to calculate the reduction in maintenance costs due to pavement IRI improvements

CZ DA DB DC DD DE DF DG DH DI DJ DK DL

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**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

12

## **Weaving Adjustments**

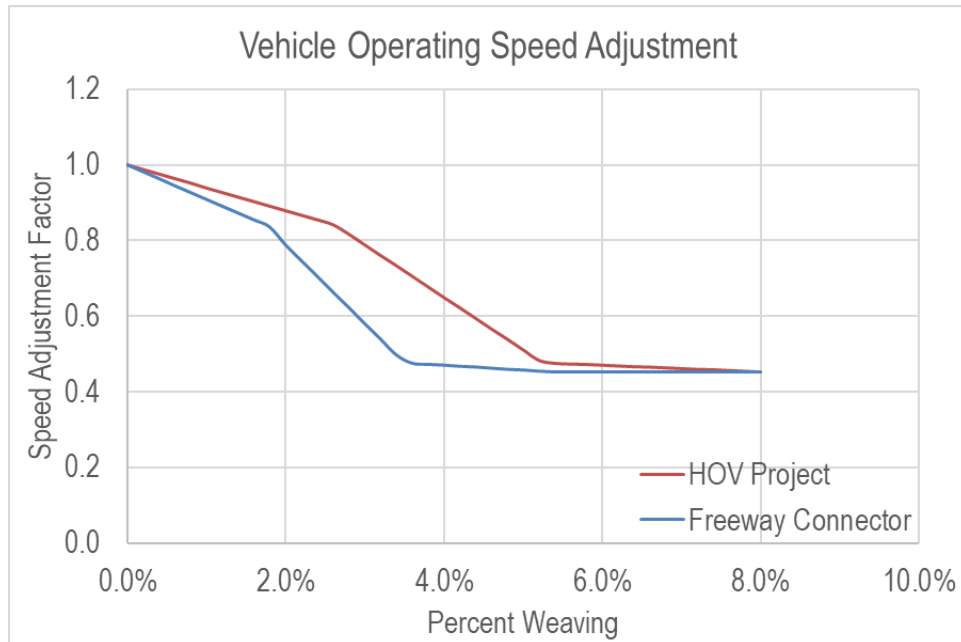
## Module 5: Weaving Adjustments

# Weaving Adjustments

- Used in Cal-B/C Sketch
- Used only for freeway connector, HOV connector, and HOV drop ramp projects

## Vehicle Operating Speed

- Used to calculate speed adjustments for freeway-to-freeway connector, HOV connector, and HOV drop ramp projects



	DP	DQ	DR
8	VEHICLE OPERATING SPEED		
9	(percent adjustment)		
10			
11	Percent	Freeway	HOV
12	Weaving	Conn	Project
13	0.000	1.000	1.000
14	0.002	0.982	0.988
15	0.004	0.964	0.976
16	0.006	0.945	0.964
17	0.008	0.927	0.952
18	0.010	0.909	0.939
19	0.012	0.891	0.927
20	0.014	0.873	0.915
21	0.016	0.855	0.903
22	0.018	0.836	0.891
23	0.020	0.789	0.879
24	0.022	0.747	0.867
25	0.024	0.706	0.855
26	0.026	0.664	0.842
27	0.028	0.623	0.817
28	0.030	0.581	0.789
29	0.032	0.540	0.761
30	0.034	0.498	0.734
31	0.036	0.476	0.706
32	0.038	0.473	0.678
33	0.040	0.471	0.650
34	0.042	0.468	0.623
35	0.044	0.466	0.595
36	0.046	0.463	0.567
37	0.048	0.460	0.540
38	0.050	0.458	0.512
39	0.052	0.455	0.484
40	0.054	0.453	0.476
41	0.056	0.453	0.474
42	0.058	0.453	0.473
43	0.060	0.453	0.471
44	0.062	0.453	0.469
45	0.064	0.453	0.467
46	0.066	0.453	0.466
47	0.068	0.453	0.464
48	0.070	0.453	0.462
49	0.072	0.453	0.460
50	0.074	0.453	0.459
51	0.076	0.453	0.457
52	0.078	0.453	0.455
53	0.080	0.453	0.453



13

## **TMS Adjustments**

## TMS Adjustments

- Used in Cal-B/C Sketch

### Peak Period Speed, Volume, and Non-Highway Benefits

- Used to calculate speed and volume adjustments for highway TMS projects

### Transit Travel Time and Agency Cost Savings

- Used to calculate speed and volume adjustments for:
  - Transit automated vehicle location (AVL) and scheduling
  - Transit signal prioritization
  - Bus rapid transit (BRT)

	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED	EE	EF
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**PEAK PERIOD SPEED, VOLUME, AND NON-HIGHWAY BENEFITS**  
(percent adjustment)

TMS Strategy	Without		With		Non-Highway Benefits			Total Benefit
	Speed	Volume	Speed	Volume	TT	VOC	Em	
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	
ORsev	0.95	1.03	1.00	1.00	0.00	0.00	5.67	
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
Tloth	1.00	1.00	1.02	0.97	-0.11	-0.12	-0.35	1.00
Tlsev	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)

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

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**Conclusion**

## **In this module, you learned...**

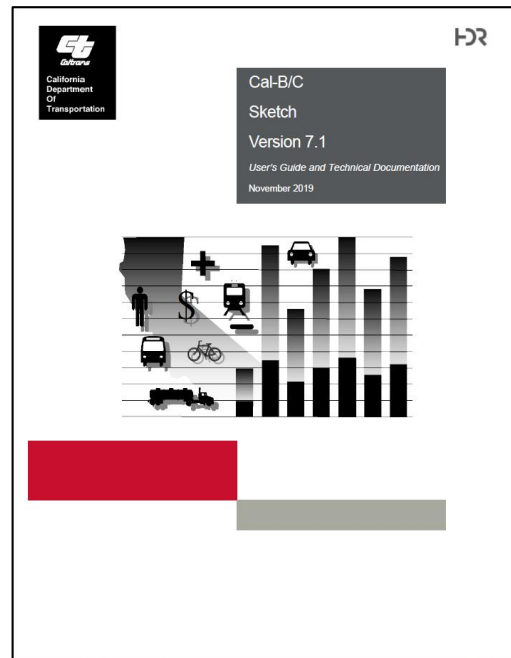
- Details about the Parameters worksheet, including how to locate various parameters
- How these parameters are used to calculate BCA benefits

## Cal-B/C Parameters Documentation

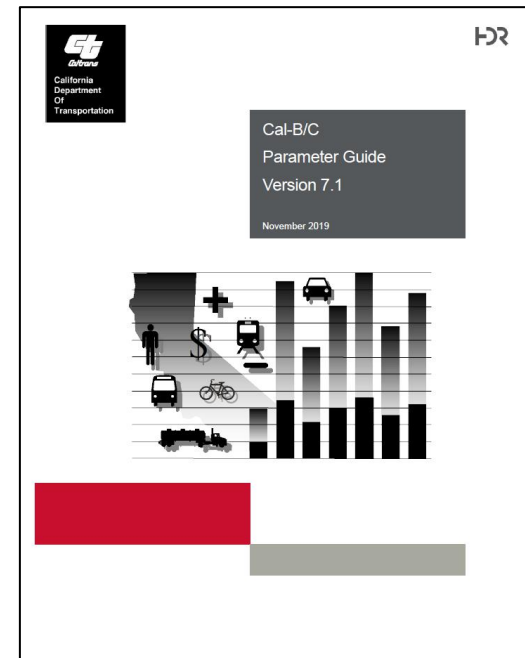
- Users Guide for each tool provides documentation for the parameters
- Parameter Guide for all tools describes economic values and parameters
- User's Guide for all Cal-B/C tools is available on the Caltrans Transportation Economics Branch website:

<https://dot.ca.gov/programs/transportation-planning/economics-data-management/transportation-economics>

User's Guide



Parameter Guide



## What's Next?

- **Module 6a-f** build on this module to show you how benefits are calculated in Cal-B/C
- **Module 7a-f** are “Quick Start” guides to get started immediately on project evaluations
- **Module 8a-f** show how to enter data into Cal-B/C
- **Modules 9a-f** walk through example projects showing how to perform a BCA for the various tools
- **Module 10** closes out the training and will summarize other resources to learn more about BCA