



California  
Department  
Of  
Transportation



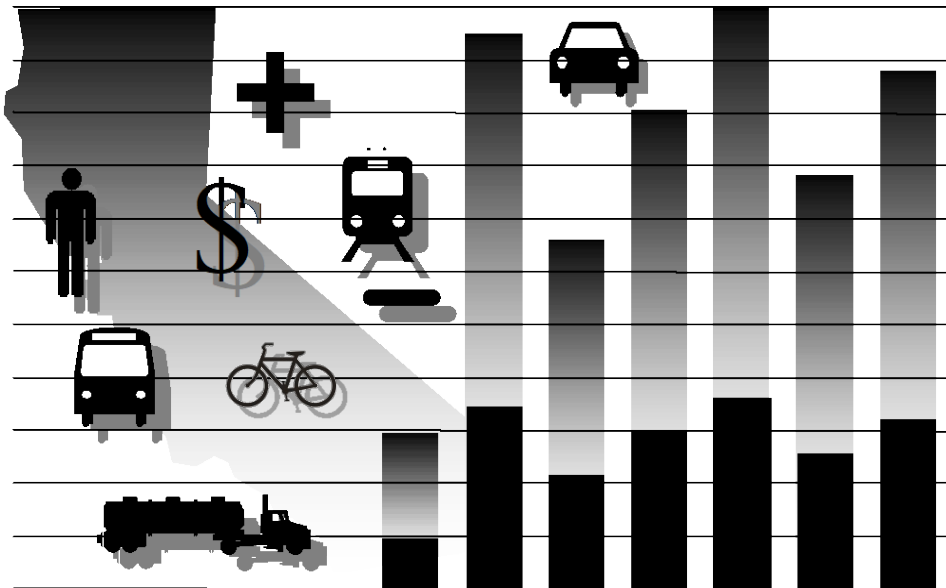
# Cal-B/C

## Intermodal Freight

### Version 7.1

*User's Guide and Technical Documentation*

November 2019





## Table of Contents

<b>1. Overview of Cal-B/C</b>	<b>3</b>
<b>2. Introduction to User Guide</b>	<b>4</b>
<b>3. User Requirements</b>	<b>5</b>
<b>4. Operating System and Software Requirements</b>	<b>5</b>
<b>5. Model Overview</b>	<b>5</b>
<b>6. Worksheet Details and Project Analysis</b>	<b>9</b>
Project Information Worksheet	9
Project Data	10
Freight Capacity and Freight Shipping Costs	11
Freight Volumes by Mode	13
Freight Shipments by Mode	15
Highway Accident Data	16
Transload Operation Data	17
Change in Terminal Efficiency	19
Project Costs	20
Model Inputs Worksheet	22
Results Worksheet	25
<b>Appendix A: Project Example</b>	<b>27</b>
<b>Appendix B: Technical Documentation</b>	<b>38</b>
Background and Scope of Analysis	38
Benefit Estimation	41
Shipper Cost Savings	41
Accident Cost Savings	45
Emission Cost Savings	47
Limitations of Cal-B/C IF	50
Interpolation Methodology	50
Volume Interpolation	50
Other Interpolation Variables	53



## List of Exhibits

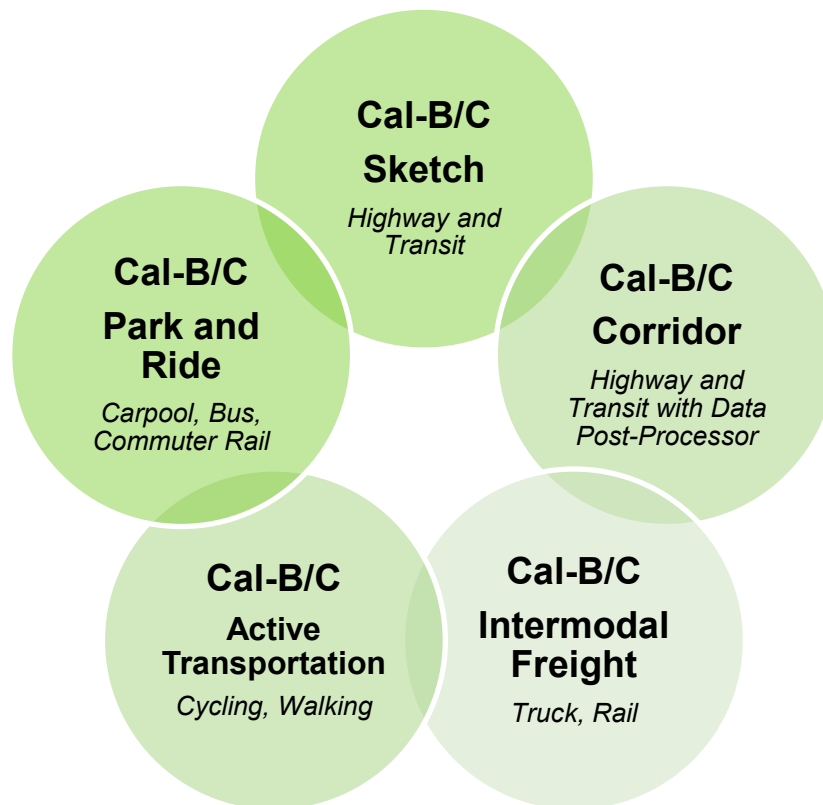
Exhibit 1: Suite of Tools in Cal-B/C Framework.....	3
Exhibit 2: Cal-B/C Graphical User Interface .....	6
Exhibit 3: Project Information Worksheet.....	10
Exhibit 4: Project Information Worksheet – 1a, Project Data .....	10
Exhibit 5: Project Information Worksheet – 1B, Freight Capacity; 1F, Freight Shipping Costs ...	12
Exhibit 6: Project Information Worksheet – 1C, Freight Volumes by Mode .....	13
Exhibit 7: Project Information Worksheet – 1D, Freight Shipments by Mode .....	15
Exhibit 8: Project Information Worksheet – 1E, Highway Accident Data.....	16
Exhibit 9: Project Information Worksheet – 1G, Transload Operations Data.....	18
Exhibit 10: Project Information Worksheet – 1H, Changes in Terminal Efficiency.....	20
Exhibit 11: Project Information Worksheet – 1I, Project Costs.....	21
Exhibit 12: Model Inputs Worksheet.....	23
Exhibit 13: Results Worksheet .....	25
Exhibit 14: Project Data.....	27
Exhibit 15: Freight Capacity .....	28
Exhibit 16: Freight Volumes by Mode.....	29
Exhibit 17: Freight Shipments by Mode.....	30
Exhibit 18: Highway Accident Data.....	31
Exhibit 19: Freight Shipping Costs .....	31
Exhibit 20: Transload Operations Data.....	33
Exhibit 21: Changes in Terminal Efficiency .....	34
Exhibit 22: Project Costs .....	35
Exhibit 23: Model Inputs Layout .....	36
Exhibit 24: Results .....	37
Exhibit 25: Glossary .....	40
Exhibit 26: Standard Current Year / Forecast Year Inputs.....	51
Exhibit 27: Current Year / Forecast Year Inputs with Growth Rates Override by User.....	52

# 1. Overview of Cal-B/C

Welcome to California Department of Transportation (Caltrans) California Life-Cycle Benefit/Cost Analysis suite of tools. Caltrans uses this set of spreadsheet-based tools to conduct investment analyses of projects proposed for the interregional portion of the State Transportation Improvement Program (STIP), the State Highway Operations and Protection Program (SHOPP), applications to the Active Transportation Program (ATP), Senate Bill (SB) 1 programs, and other ad hoc analyses requiring benefit-cost analysis.

The original Cal-B/C model focused on highway and transit modes. This model has been updated several times and ultimately renamed as the **Cal-B/C Sketch** model. This model now covers a wide variety of highway and transit physical and operational improvements. Closely related to the Cal-B/C Sketch model is **Cal-B/C Corridor**, which is based on the same platform, but allows the user to post-process travel demand and micro-simulation model data. In addition, several relatively new sketch planning models have been tailored to evaluate active transportation (**Cal-B/C AT**) projects (e.g., biking and walking facilities), park-and-ride (**Cal-B/C PnR**) programs (e.g., commuter parking and ride-sharing facilities), and intermodal freight (**Cal-B/C IF**) improvements (e.g., freight network expansion and terminal efficiency). Exhibit 1 shows all five tools in the Cal-B/C framework, which allows users to consider many different types of projects.

**Exhibit 1: Suite of Tools in Cal-B/C Framework**



All of the tools in the Cal-B/C framework use consistent methods, rely on the same parameters, and produce comparable results. Together, these tools cover multi-modal analyses of highway, transit, bicycle, pedestrian, Intelligent Transportation System (ITS), operational improvement, and passenger rail projects. In addition, there are other versions of the Cal-B/C model available for more experienced analysts. One version incorporates the additional benefits of improved reliability, beyond those of predictable time savings alone, and could be used if the proposed project warrants it. A separate version of Cal-B/C has been developed to enable users to assess the degree to which uncertainty influences project outcomes. Risk analysis is performed on the same model, but with an Excel add-in module called Risk Analyzer that is used to perform Monte Carlo simulation on user-specified parameters.

## 2. Introduction to User Guide

Welcome to the User's Guide for the *California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C)* Intermodal Freight (IF), Version 7.1. Cal-B/C IF is part of a suite of similarly designed Cal-B/C Microsoft Excel spreadsheet-based tools that can evaluate multi-modal analyses of highway, transit, bicycle, pedestrian, Intelligent Transportation System (ITS), operational improvement, and passenger rail projects. The California Department of Transportation (Caltrans) uses Cal-B/C to conduct benefit-cost analyses (BCAs) of projects proposed for the interregional portion of the State Transportation Improvement Program (STIP), the State Highway Operations and Protection Program (SHOPP) and other ad hoc analyses requiring benefit-cost analysis.

Cal-B/C IF is designed to provide economic benefit-cost analysis for a range of intermodal freight, drayage, transloading, and terminal efficiency projects. The model provides constant dollar economic impacts for three benefit categories:

- Shipper cost savings (reduce costs for shippers)
- Accident cost savings (safety benefits)
- Emission cost savings (air quality and greenhouse gas benefits).

With the exception of terminal efficiency projects, the listed benefits are estimated for both bulk/break bulk and container shipments by mode of transportation. The distinction is intended to capture any difference based on the type of commodity being transported and the corresponding mode. The Cal-B/C IF model also captures changes in the loading/unloading of commodities in relation to the three benefit categories.

This quick-start manual introduces the user to important features of Cal-B/C IF and leads the user through the analysis of a hypothetical project in Appendix A. The technical discussion in Appendix B provides details of the methodologies and the analytical framework used in the model.

## 3. User Requirements

At a minimum, the user of Cal-B/C IF should have a working knowledge of spreadsheets, particularly Microsoft Excel. To use Cal-B/C IF, the reader of this User's Guide must be able to navigate through a multiple-sheet workbook and understand basic principles, functions, and terminology used when discussing spreadsheets

The user should also understand lifecycle benefit-cost analysis and be able to interpret the results in an intermodal freight planning context. The reader can also refer to the Cal-B/C Resource Guide for additional information.

## 4. Operating System and Software Requirements

Cal-B/C IF is a Microsoft Excel macro-enabled workbook (.xlsm) called *Cal-B/C 71 IF*. The file is approximately 600 kilobytes (KB) in size. Although designed for a Windows environment, Cal-B/C IF should work on all computer platforms running Excel.

## 5. Model Overview

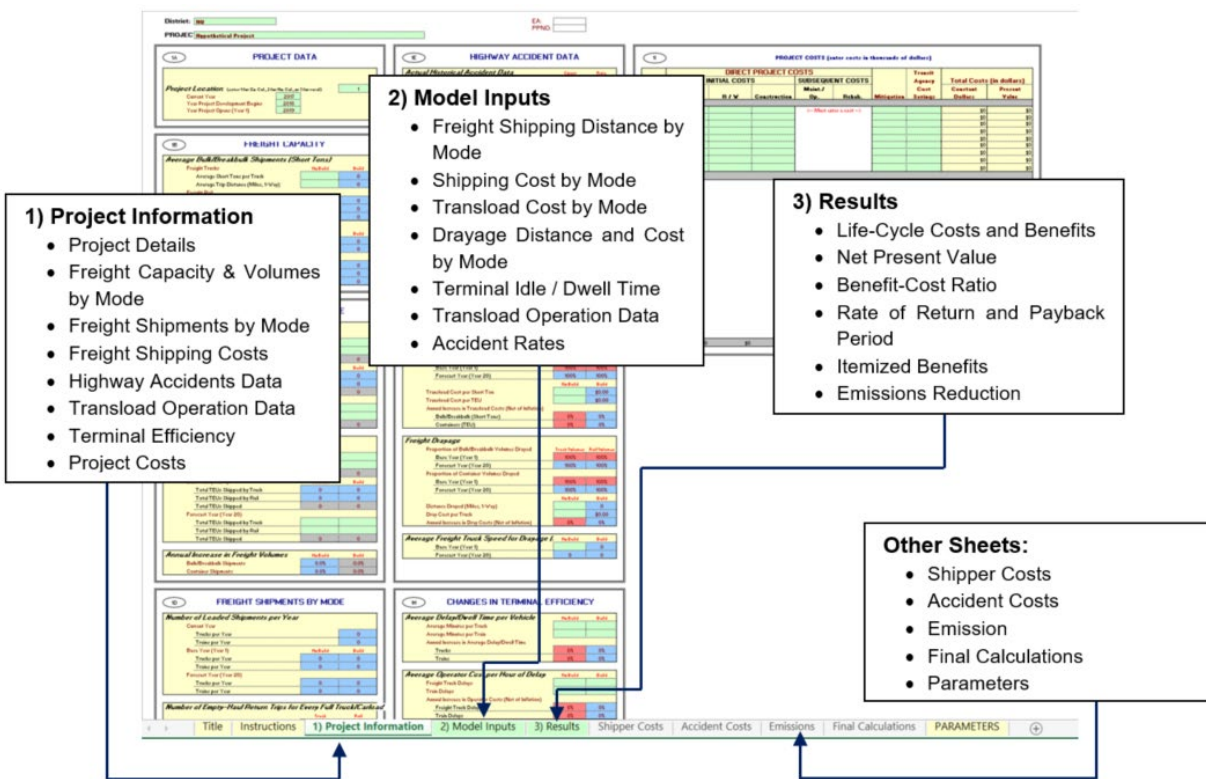
Cal-B/C IF is a Microsoft Excel spreadsheet that provides economic benefit-cost analysis for a range of intermodal freight, drayage, transloading, and terminal efficiency projects. The model provides constant dollar economic impacts for three benefit categories:

- **Shipper cost savings** due to lower overall costs for shippers associated with modal diversion and freight network improvements and transload and operational efficiency
- **Accident cost savings** due to reduced risk of accidents from changes in vehicle use
- **Emission cost savings** due to reduced air pollutant and greenhouse gas emissions associated with vehicle use.

With the exception of terminal efficiency projects, the listed benefits are estimated for both bulk/break bulk and container shipments by mode of transportation. The distinction is intended to capture any difference based on the type of commodity being transported and the corresponding mode. The Cal-B/C IF model also captures benefits from loading/unloading of commodities.

Cal-B/C IF consists of a cover page and nine worksheets in an Excel workbook. The user generally needs to refer to only the first four worksheets after the cover page (including one that provides instructions and reference materials) to conduct analyses and produce results. Other worksheets perform calculations and contain parameters. Exhibit 2 shows locations of these worksheets in the model.

## Exhibit 2: Cal-B/C Graphical User Interface



Cal-B/C IF requires few user inputs, but allows the user to enter many more inputs when available. Cells in the worksheet are color-coded. **Green** cells highlight required data (i.e., the user must input values for the model to work or for the specific aspect mode to be incorporated). **Red** cells provide default values, which the user may change if needed. **Blue** cells contain values calculated by the model, which may be changed if detailed data is available.

Following the cover page, the first worksheet, *Instructions*, provides a short description of the steps required in using the Cal-B/C IF model to perform a basic analysis and hints on how to avoid potential errors.

The *Project Information* worksheet is the main data-entry worksheet. The user enters descriptive information about the project such as:

- Location and project timeline
- Expected shipment volumes, freight capacity, shipping distances, and shipping costs by mode
- Number of empty-haul return trips by mode
- Accident rates and highway speeds for freight trucks
- Transload volumes and costs
- Drayage volumes, distances, and costs
- Terminal delay/dwell times and the cost of delays
- Expected project construction and operating costs.

The *Model Inputs* worksheet in Cal-B/C IF contains distances traveled by mode for shipping commodities and empty hauls, shipping costs by mode, and accident data for trucks. It also contains data on transloading costs, drayed distances and costs, as well as terminal delay times and costs. All the factors mentioned are calculated from the values inputted in the *Project Information* worksheet, which are ultimately used in calculating the project benefits. If project-specific information is available, the factor values may be overridden by the user. It should be noted that freight rail accident data are found in the *Parameters* worksheet and should be adjusted if project-specific data are available.

The *Results* worksheet presents the final investment expenditure as well as annualized and lifecycle benefits. This sheet allows the user to decide which of the three calculated benefits to include. Cal-B/C IF summarizes analysis results on a per-project basis using several measures:

- Lifecycle costs (in millions of dollars)
- Lifecycle benefits (in millions of dollars)
- Net present value (in millions of dollars)
- Benefit/cost ratio (benefits divided by costs)
- Rate of return on investment (in percent return over the project)
- Project payback period (in years).

The model itemizes expected benefits (in millions of dollars) over the full 20-year lifecycle and provides the average annual value.

Although the model generally requires only inputs in the *Project Information* worksheet, along with some potential adjustments in both the *Model Inputs* and *Results* worksheets with potential project-specific data, additional changes may be made by a more experienced user. In particular, the default parameter values may be adjusted in the *Parameters* worksheet to produce tailored results if detailed information is available for specific projects.

This worksheet contains several parameters relevant to intermodal freight projects:

- Freight Rail Accident Rates (fatal, injury, and all accidents)
- Highway Fuel and Emissions Factors for Trucks (CO, CO<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, VOC, fuel consumption by speed)
- Freight Rail Fuel and Emissions Factors (CO, CO<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, and VOC, fuel burned at idle, freight rail fuel efficiency).

The *Parameters* worksheet contains all the economic values and rate tables used in the model. Adjusting the economic update factor using the Gross Domestic Product (GDP) deflator changes the economic values in the model.



The worksheet includes the following parameters:

#### General Economic Values

- Year of current dollars for model<sup>1</sup>
- 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

#### Active Transportation Parameters

- Travel activity characteristics
- User characteristics
- Trip characteristics
- Journey quality
- Health impacts

#### Travel Time Values

- Automobile, truck, and transit
- Out-of-vehicle; 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, PDO)
- Statewide highway accident rates (fatal, injury, PDO)

- 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, and freight locomotive

#### Emissions Health Costs

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

#### Other Values

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

#### Accident Rates and Transit Costs

---

<sup>1</sup> Measured in real (constant) dollars, which are a measure of monetary value adjusted for inflation.

## 6. Worksheet Details and Project Analysis

The following sections describe the three primary Cal-B/C IF worksheets and walks the user through a hypothetical project. The main text in each section introduces the user to an element of the model, and the project examples provide details on the data entry process.

### PROJECT INFORMATION WORKSHEET

The *Project Information* worksheet is the main data input sheet and, for many projects, it would be the only sheet in which the user must enter input values. Moreover, the user should modify other worksheets only if project specific information is available for the variables calculated or presented on those worksheets. The project information worksheet contains nine sections, as seen in Exhibit 3.

Section Number	Name of Section	Location of Section in Worksheet (Top Left Cell: Bottom Right Cell)
1A	Project Data	B6 : I16
1B	Freight Capacity	B18 : I37
1C	Freight Volumes by Mode	B39 : I73
1D	Freight Shipments by Mode	B75 : I98
1E	Highway Accident Data	K6 : S16
1F	Freight Shipping Costs	K18 : S37
1G	Transload Operations Data	K39 : S73
1H	Changes in Terminal Efficiency	K75 : S98
1I	Project Costs (in thousands of dollars)	U6 : AF45

### Exhibit 3: Project Information Worksheet

### Project Data

In this section, the user enters data regarding the project location, the current year, the year the project begins its development, and the first year of project operations (see Exhibit 4).

### Exhibit 4: Project Information Worksheet – 1a, Project Data

1A PROJECT DATA	
<b>Project Location</b> (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	1
Current Year	2017
Year Project Development Begins	2018
Year Project Opens (Year 1)	2019

### Project Location

The Cal-B/C IF model considers three unique areas within California (i.e., Northern California Urban, Southern California Urban, or Rural California). The model uses the location information to determine the appropriate accident costs and health costs of transportation emissions parameters to use in calculating the benefits. The user identifies the project location by selecting “1” for Urban Southern California, “2” for Urban Northern California, and “3” for Rural California.

## ***Project Timeline***

The model requires the user to input the current year, the first year of project development, and the project opening year. This information is used to adjust the respective costs of transportation services, the expected changes in shipment volumes, the number of years of construction, and the final year of the lifecycle benefit-cost study.

## **Freight Capacity and Freight Shipping Costs**

In Section 1B the user enters information regarding the average capacity and average distance one-way trip distance by truck and rail. In Section 1F the user enters the shipper costs by truck and rail. These are broken down between bulk/break bulk shipments (denoted in short tons), and container shipments (denoted in TEUs<sup>2</sup>). Examples of these tables are shown in Exhibit 5.

As in most sections in the *Project Information* worksheet, data are entered for the Build and No Build cases, where the No Build considers the project not moving forward as planned and the Build scenario considers the project moving forward. While the user may enter freight capacity by mode and commodity in both the Build and No Build cases, the default considers the capacities to be the same.

---

<sup>2</sup> Twenty-Foot Equivalent Unit (TEU) is a unit of cargo capacity defined as the length of a 20-foot-long intermodal container.



### Exhibit 5: Project Information Worksheet – 1B, Freight Capacity; 1F, Freight Shipping Costs

The screenshot displays a complex spreadsheet interface for project information. Key sections include:

- PROJECT DATA (1A):** Fields for Project Location, Current Year, and Project Development Budget.
- HIGHWAY ACCIDENT DATA (1C):** Summary of actual historical accidents during the reporting period.
- PROJECT COSTS (1D):** A detailed table of costs categorized by project type, construction phase, and cost type (Initial vs. Subsequent).
- FREIGHT CAPACITY (1B):** A central section for inputting average bulk/breakbulk and container shipments for both trucks and railcars, including trip distances and TEUs.
- FREIGHT SHIPPING COSTS (1F):** A section for inputting shipper costs, including rates per truckload, per TEU, and annual increase percentages.
- Other sections (1E, 1G, 1H):** Cover freight capacity, changes in terminal efficiency, and shipment volumes.

The interface includes a navigation bar at the bottom with tabs for Title, Instructions, 1) Project Information, 2) Model Inputs, 3) Results, Shipper Costs, Accident Costs, Emissions, Final Calculations, and PARAMETERS.

### Average Shipments

This subsection contains information on the capacity and distance shipped by both truck and rail. In the model it is split between bulk/break bulk and container shipments, the structural breakdown of variables under each are similar. In particular, for both, the user must input the average capacity by mode and the average one-way trip distance in miles, as seen in Exhibit 5. The only difference stems from truck and rail capacity. Rail requires the average capacity per railcar and the average number of railcars per train, while trucks only requires the average capacity per truck.

### Shipper Costs

The shipping costs are split between bulk/break bulk and containers by mode. Bulk/break bulk shipping costs require data on the shipping costs per truckload and per carload. Containers, however, require the shipping rates per TEU moved by truck and rail. Shipping costs used by the model also consider the annual increase in shipper costs (net of inflation), denoted in percent, where by default it is assumed to be zero percent. If the annual changes is positive, it implies the



annual shipper costs are increasing, while a negative percentage implies decreasing annual shipper costs.

## Freight Volumes by Mode

In Section 1C, the user provides data on current freight volumes for the current year and the forecasted freight volume for the last year of the lifecycle analysis. Similar to the freight capacity section, freight volume is divided between bulk/break bulk shipments and container shipments for both truck and rail.

As shown in Exhibit 6, there are separate growth rates for freight volumes in the No Build and Build cases, which are calculated from the total volumes. **It is highly recommended that the user ensures the growth rates are the same in the No Build and Build scenarios.**

**Exhibit 6: Project Information Worksheet – 1C, Freight Volumes by Mode**

**1C FREIGHT VOLUMES BY MODE**

**Annual Bulk/Breakbulk Shipments (Short Tons)**

	No Build	Build
<b>Current Year</b>		
Total Tons Shipped by Truck		
Total Tons Shipped by Rail		
<b>Total Tons Shipped</b>	0	
<b>Base Year (Year 1)</b>		
Total Tons Shipped by Truck	0	0
Total Tons Shipped by Rail	0	0
<b>Total Tons Shipped</b>	0	0
<b>Forecast Year (Year 20)</b>		
Total Tons Shipped by Truck		
Total Tons Shipped by Rail		
<b>Total Tons Shipped</b>	0	0

**Annual Container Shipments (TEUs)**

	No Build	Build
<b>Current Year</b>		
Total TEUs Shipped by Truck		
Total TEUs Shipped by Rail		
<b>Total TEUs Shipped</b>	0	
<b>Base Year (Year 1)</b>		
Total TEUs Shipped by Truck	0	0
Total TEUs Shipped by Rail	0	0
<b>Total TEUs Shipped</b>	0	0
<b>Forecast Year (Year 20)</b>		
Total TEUs Shipped by Truck		
Total TEUs Shipped by Rail		
<b>Total TEUs Shipped</b>	0	0

**Annual Increase in Freight Volumes**

	No Build	Build
Bulk/Breakbulk Shipments	0.0%	0.0%
Container Shipments	0.0%	0.0%



### ***Current Year***

The user inputs the current annual volumes of freight shipped for both bulk/break bulk and container shipments by mode (i.e., freight truck or rail), following the definition of current year in the *Project Data* section. The model uses the user inputs to calculate the total volume shipped. These values are used in the calculations for the annual increase in freight volumes, and all three benefit categories.

### ***Forecast Year (Year 20)***

The user provides forecasted volumes of freight shipped for both bulk/break bulk and container shipments by mode (i.e., freight truck or rail), where the forecast year is defined as the last year of the project life cycle. The model uses the inputs to calculate the total volume shipped.

Similar to the current year volumes, these values are used in the calculation for the annual increase in freight volumes and all three benefit categories considered in Cal-B/C IF.

### ***Base Year (Year 1)***

The base year volumes correspond to the volumes in the project opening year (i.e., first year after construction). The values are calculated using the forecasted volumes and the current volumes along with the annual increases in freight volumes. More specifically, for each mode of transportation, the base year volumes are interpolated from the current year to the forecasted final year. The interpolation takes into account the change in the number of trucks/trains and their respective average capacities. While the model does calculate the base year volumes, if the user has project-specific data, the default values may be overridden.

### ***Annual Increase in Freight Volumes***

The default annual increase in freight volumes, presented as a percentage, is automatically calculated by the model using the current and forecasted year volumes. While the user may adjust these values, it is advised that changes to the annual increase in freight volumes be done with utmost discretion.

As mentioned earlier, it is highly recommended that the user ensures the growth rates in both Build and No Build scenarios are the same. This may be accomplished through ensuring equal total volumes in the forecasted year or manually inputting equal growth rates for both scenarios. If the growth rates are not equal, Cal-B/C IF will overestimate benefits from induced impacts. In particular, the induced impacts will be counted at full value, when it should only be counted at half value. Thus, leaving unequal growth rates or unequal forecasted volumes across scenarios would result in overstated benefits and an inaccurate analysis of the project.



## Freight Shipments by Mode

In this section, the user inputs highway speeds for freight trucks and adjustments to the number of empty-haul return trips for every full truck load. The highway speeds for freight trucks are assumed to be the same regardless of haul, but they may vary between the current year and the final year of the lifecycle (forecasted year). The number of empty-haul return trips are assumed to be constant throughout time and scenarios. This is reflected in Exhibit 7.

**Exhibit 7: Project Information Worksheet – 1D, Freight Shipments by Mode**

**1D FREIGHT SHIPMENTS BY MODE**

Number of Loaded Shipments per Year		
Current Year		
Trucks per Year		0
Trains per Year		0
Base Year (Year 1)	No Build	Build
Trucks per Year	0	0
Trains per Year	0	0
Forecast Year (Year 20)		
Trucks per Year	0	0
Trains per Year	0	0

Number of Empty-Haul Return Trips for Every Full Truck/Carload		
	Truck	Rail
Bulk/Breakbulk Shipments	1.0	1.0
Container Shipments	1.0	1.0

Average Truck Speed (mph)		
	No Build	Build
Freight Truck Shipments		
Base Year (Year 1)		0
Forecast Year (Year 20)	0	0

### Number of Loaded Shipments per Year

This section presents the number of trucks and trains per year calculated by Cal-B/C IF. The values are calculated using the respective volumes of freight (current year, base year, and forecast year) from the previous section and the freight capacity. The annual number of trucks/trains is used in determining the shipper cost savings. In addition, combined with the average distance traveled, it provides vehicle-miles necessary for calculating accident costs and emissions.



### Number of Empty-Haul Return Trips for Every Full Truck/Carload

The user may adjust the number of empty-haul return trips per full truck/carload, which has a default value of 1.0. This value is defined as for every full truck/train shipped, the number of empty-haul trucks/trains returning. The value is an adjustment factor in the calculation of accident costs and emissions.

### Average Truck Speed

While this section is divided by the current year and forecast, the user need provide only the average truck speeds for freight trucks in the current year. This follows the conservative default assumption that freight truck speeds neither change over time nor do they vary between the Build and No Build scenarios. However, this may be adjusted by the user if project-specific information regarding average freight-truck speeds is available for the different scenarios.

### Highway Accident Data

This section calculates accident rates for trucks using highway accident data. Accident rates are estimated for fatal, injury, property damage only (PDO), and total accidents from using actual historical accident data. The default accident rates used in Cal-B/C IF are displayed under the “Rate” column in Exhibit 8 and corresponds to data retrieved from the Traffic Accident Surveillance and Analysis System (TASAS). In particular, the default values provided in Cal-B/C IF are statewide average rates for California, which was obtained from the “2013 Statewide Collision Total Check” reported by the TASAS. If the user has project specific data relating to accident counts, they should be inputted under the “Count” column, which allows the model to calculate accident rates tailored to the project. As mentioned, these accident rates are for **freight trucks only**, freight rail accident rates are calculated in the *Parameters* worksheet.

**Exhibit 8: Project Information Worksheet – 1E, Highway Accident Data**

1E HIGHWAY ACCIDENT DATA		
Actual Historical Accident Data	Count	Rate
Total Accidents During Reporting Period		0.846
Fatal Accidents		0.006
Injury Accidents		0.29
Property Damage Only Accidents		0.55
Vehicle Miles Traveled During Reporting Period		

To calculate project-specific accident rates, the user must input vehicle-miles traveled (VMT) since accident rates in the model are derived from the following formula:

$$\text{Accident Rates} = \frac{\text{Accident count}_t}{\text{Vehicle distance traveled}_t}$$

For accident counts, the user must provide a historical count of fatal and injury accidents, as well as either property damage only (PDO) or total accidents during a set horizon. As indicated, the user has the option of either presenting the number of historical PDO accidents or total accidents

as Cal-B/C IF does have the functionality to calculate the count of PDO accidents if fatal, injury, and total accidents are inputted, following the assumption that total accidents are only composed of fatal, injury, and PDO accidents. It is important that for all inputted accident counts and VMT data correspond to the same reporting period since inconsistent reporting periods would infer inaccurate accident rates. For example, if accident counts are from 2015 to 2016, the reported VMT should also be for 2015 to 2016.

Cal-B/C IF does not require all accident count data be entered to create project-specific accident rates. For instance, if the user only has count data for fatal accidents, then the model will calculate project-specific fatal accidents rates, which will be used in the benefit-cost analysis. However, as mentioned above, the key component required by the model to calculate project-specific accident rates is the VMT during the reporting period.

Cal-B/C IF uses the accident rates in the calculation of safety benefits of a project. This section creates the base accident rates for freight trucks that will be used in default in both the Build and No Build scenarios. Adjustments may be made by the user in the *Model Inputs* worksheet if there are differences in accident rates between the two scenarios.

## Transload Operation Data

In Section 1G, the user adjusts for any transload operations or freight drayage that may be relevant for the project. Both inputs include an operation cost for the services. For transload operations, the cost should be in terms of per unit of bulk/break bulk (short tons) and containers (TEUs) that is transloaded. For freight drayage, costs are inputted on a per truck basis. Though the structure of the costs are different between the two, the volume structure are quite similar as seen in Exhibit 9. In particular, the volumes for both are presented as the percentage of total volumes shipped. In addition to the operations costs and volumes, the user must provide data on the average distance drayed, as well as average truck speed for drayage, similar to the format seen in *Freight Shipment*.



Exhibit 9: Project Information Worksheet – 1G, Transload Operations Data

The screenshot displays a complex spreadsheet interface for project information. A callout window titled '1G TRANSLOAD OPERATIONS DATA' is highlighted, showing the following sections:

- Transload Operations**
  - Proportion of Bulk/Breakbulk Volumes Transloaded:
    - Base Year (Year 1): 100% (Truck), 100% (Rail)
    - Forecast Year (Year 20): 100% (Truck), 100% (Rail)
  - Proportion of Container Volumes Transloaded per Year:
    - Base Year (Year 1): 100% (Truck), 100% (Rail)
    - Forecast Year (Year 20): 100% (Truck), 100% (Rail)
  - Transload Cost per Short Ton: No Build, \$0.00
  - Transload Cost per TEU: No Build, \$0.00
  - Annual Increase in Transload Costs (Net of Inflation):
    - Bulk/Breakbulk (Short Tons): 0%
    - Containers (TEU): 0%
- Freight Drayage**
  - Proportion of Bulk/Breakbulk Volumes Drayed:
    - Base Year (Year 1): 100% (Truck), 100% (Rail)
    - Forecast Year (Year 20): 100% (Truck), 100% (Rail)
  - Proportion of Container Volumes Drayed:
    - Base Year (Year 1): 100% (Truck), 100% (Rail)
    - Forecast Year (Year 20): 100% (Truck), 100% (Rail)
  - Distance Drayed (Miles, 1-Way): No Build, 0
  - Dray Cost per Truck: No Build, \$0.00
  - Annual Increase in Dray Costs (Net of Inflation): No Build, 0%
- Average Freight Truck Speed for Drayage (mph)**
  - Base Year (Year 1): No Build, 0
  - Forecast Year (Year 20): No Build, 0

**Transload Operations**

If transload operations are relevant to the project, the user must provide data on the cost per unit. As well, the user should adjust the proportion of the overall volume that is transloaded and the expected annual increase in costs, net of inflation, for both bulk/break bulk and containers.

The default assumption for volume is set at 100 percent of both bulk/break bulk and containers for the base year and is expected to be the same in the forecast year (Year 20) for both modes. The model assumes also that cost per unit will not change depending on the scenario (i.e., Build or No Build), nor does the annual increase in costs, which, by default, is set to zero percent. The user should adjust these percentages and costs if project-specific information regarding transload operations is available. It should be noted that a positive annual change in costs implies increasing costs, while a negative value implies decreasing annual costs.

Due to the equal proportion of volume transloaded across modes, there will be no generated benefits. This is generally true if the proportion of truck and rail volumes are equal. Thus, if the project-specific information presents different proportion of trucks and rail volumes, there will be benefits occurring. This would directly reflect the difference between the No Build and Build

scenarios, due to modal diversion generated by the project. Alternatively, if the cost per unit were to be different across scenarios, it would also result in benefits that can be captured.

### ***Freight Drayage***

If the project includes freight drayage, the user must provide data regarding the one-way distance drayed, the cost per truck, and the average truck speed for drayage. As well, the user should adjust the proportion of the overall volume drayed and the annual increase in costs, net of inflation, for both bulk/break bulk and containers.

The default assumption for the volume drayed is set at 100 percent of both bulk/break bulk and containers for the base year and is expected to be the same in the forecast year (Year 20) for both modes. The model assumes that the cost per truck and the one-way distance drayed will not depend on the scenario (i.e., Build or No Build). In addition, the model also assumes that the annual increase in costs is independent of the scenario. The user should adjust these values with project-specific information regarding drayage if available. It should be noted a positive annual change in costs implies increasing costs, while a negative value implies decreasing annual costs.

Due to a similar structure between the freight drayage and transload operation sub-sections, benefits will be generated in two ways only. One way that benefits are generated is if there is a different proportion of volume drayed across modes, as it would directly reflect the expected modal diversion generated by the project and the difference between the Build and No Build scenarios. The second way benefits are generated is if the dray costs are different across scenarios.

One key difference is that freight drayage impacts both accident cost savings and emission cost savings. Specifically, the average truck speed for drayage is used in the emission cost savings calculations, while the one-way distance drayed is used in the both the emission cost savings and accident cost savings calculations.

### **Change in Terminal Efficiency**

In this section, the user enters data on impacts the project may have on terminal efficiency (see Exhibit 10). The user provides data on the average delay/dwell time in minutes and the cost of the delays for both modes. The user can change the annual increase in delay/dwell time and cost of delays, which are both by default assumed to constant throughout the life cycle (0 percent). These values are used in the shipper cost savings calculations to see the impact project has on operating costs for both freight truck and rail. For freight rail, the inputted terminal efficiency variables are used to calculate any changes to emission costs as a result of the fuel burned while idling at the terminal.

If there are no expected changes to terminal efficiency, it is advised to leave this section blank, which guarantees that no benefits generated for terminal efficiency. If there are expected efficiency changes the user should adjust accordingly. For instance, if the project is expect to decrease delay/dwell time, the user should input a negative percentage for the annual increase





in average delay/dwell time. Similarly, if operating costs are projected to decrease, it should be reflected in the annual change in operator costs.

### Exhibit 10: Project Information Worksheet – 1H, Changes in Terminal Efficiency

The screenshot displays the 'Project Information Worksheet' with several key sections:

- PROJECT DATA (1A):** Fields for Project Location, Current Year, Year Project Development Began, and Year Project Open.
- HIGHWAY ACCIDENT DATA (1E):** Summary of actual historical accidents including Total Accidents, Fatal Accidents, Injury Accidents, Property Damage Only Accidents, and Vehicle Miles Traveled/Distance Reported.
- PROJECT COSTS (1B):** A detailed table for entering costs in thousands of dollars, categorized by Year, Project Support, R/W, Construction, Major Op., Rehab., Mitigation, Transit Agency Cost, and Total Costs (Present Value).
- 1H CHANGES IN TERMINAL EFFICIENCY:** A central summary table showing:
  - Average Delay/Dwell Time per Vehicle:** Average Minutes per Truck, Average Minutes per Train, and Annual Increase in Average Delay/Dwell Time (0% for Trucks and Trains).
  - Average Operator Cost per Hour of Delay:** Freight Truck Delays, Train Delays, and Annual Increase in Operator Costs (Net of Inflation) (0% for Freight Truck Delays and Train Delays).
- Other sections:** Freight Capacity (1C), Freight Shipping Costs (1F), Freight Volumes by Mode (1D), and Freight Shipments by Mode (1G).

## Project Costs

The user enters project construction, operating, right-of-way, and other costs in this section of the *Project Information* worksheet. All costs should be entered as incremental rather than total costs. Costs already incurred are sunk costs and should not be included in the benefit-cost analysis. Incremental costs are estimated as the difference between the Build costs and the No Build costs.

The project costs table contains seven columns for the user to enter cost information in thousands of dollars, as shown in Exhibit 11. All cost values should consider the Year of Current Dollars for Model in the *Parameters* worksheet to ensure consistency. For instance, if the Year of Current Dollars for Model is 2016, all cost values should be in 2016 dollars to ensure consistency with the benefit calculations. The model automatically calculates the sum and present value of all costs inputted by the user.



The leftmost column of the project costs table indicates the years throughout the lifecycle separating the construction period and 20-year project lifecycle. Cal-B/C IF can handle up to nine years of construction, where the number of construction years is determined in the *Project Data* section. For each year of construction where costs data is missing, the message “Must enter a cost” appears in red under the subsequent cost section.

**Exhibit 11: Project Information Worksheet – 11, Project Costs**

**Direct Project Costs (In Thousands of Dollars)**

The direct project costs are broken down into *Initial Costs* and *Subsequent Costs*. Their respective composition is as follows:

- **Initial Costs** include:
  - Project support (e.g., engineering design and management costs)
  - Right-of-way acquisition costs
  - Construction costs.
- **Subsequent Costs** include:
  - Maintenance and operating costs
  - Rehabilitation costs (e.g., pavement overlay, truck, track, or station refurbishment).

The *Initial Costs* should reflect the net capital costs required to complete the project, while the *Subsequent Costs* indicate the estimate future incremental maintenance, operating and



rehabilitation costs in constant dollars. These costs should be entered in the years they are expected to occur. As previously indicated, these costs should be entered in thousands of dollars.

**Mitigation (In Thousands of Dollars)**

Mitigation costs include costs to protect communities and the environment from negative impacts. These costs include wetland and community preservation, as well as sound walls to reduce highway or rail noise. The user enters these costs in constant dollars during construction and for 20 years after construction has been completed.

**Total Costs (In Dollars)**

The model calculates the total costs automatically, and presents the total cost in constant dollars and present value for each year. It should be noted that since total costs are denoted in dollars, the model multiplies the previous columns by 1,000 to convert the values from thousands of dollars to actual values. The project cost table also summarizes the total constant dollar of cost element at the bottom in dollars. Using the *Real Discount Rate* defined in the *Parameters* worksheet and the *Current Year* defined in the *Project Data* section, the following formula is used to calculate the present value:

$$\text{Present Value} = \frac{\text{Future Value (in constant dollars)}}{(1 + \text{Real Discount Rate})^{\text{Future Year} - \text{Current Year}}}$$

**MODEL INPUTS WORKSHEET**

The *Model Inputs* worksheet allows the user to review and replace several values that are used in the model for the benefit-cost analysis. Cal-B/C IF divides these values into four separate sections in the *Model Inputs* worksheet, as seen in Exhibit 12 and the table below. If the user has more project-specific data readily available, then the user should override the Cal-B/C IF calculations. Specifically, for a given variable where the user has project-specific data, the user should input the values in the green cell denoted by the “Changed by User” column and provide the reasoning in the “Reason for Change” column. By doing so, the model recognizes that there are user inputs, which will be used in the benefit calculations and benefit-cost analysis.

Section Number	Name of Section	Location of Section in Worksheet (Top Left Cell: Bottom Right Cell)
2A	Freight Volume Inputs	B2 : N108
2B	Transload Operations Inputs	P2 : AB65
2C	Terminal Efficiency Inputs	P67 : AB108
2D	Accident Rate Inputs	AD2 : AP 24

### Exhibit 12: Model Inputs Worksheet

The screenshot displays three sections of the Model Input worksheet:

- Section 2A: Freight Volume Inputs:** Contains tables for Freight Truck and Freight Train inputs, categorized by mode (Truck/Rail) and shipment type (Laden/Empty). It includes metrics like 'Laden Miles Traveled', 'Empty Miles Traveled', and 'Shipping Cost per Truck/Railcar'.
- Section 2B: Transload Operation Inputs:** Contains tables for Transload Operation inputs, categorized by mode (Truck/Rail) and shipment type (Laden/Empty). It includes metrics like 'Transload Cost per Short Ton' and 'Transload Cost per TEU'.
- Section 2C: Terminal Efficiency Inputs:** Contains tables for Terminal Efficiency inputs, categorized by mode (Truck/Rail) and shipment type (Laden/Empty). It includes metrics like 'Freight Truck Operating Cost per Hour' and 'Freight Train Operating Cost per Hour'.

Navigation tabs at the bottom include: Title, Instructions, 1) Project Information, 2) Model Inputs, 3) Results, Shipper Costs, Accident Costs, Emissions, Final Calculations, and PARAMETERS.

For each section in the *Model Input* worksheet, the model presents the calculated values for both the Build and No Build case. For the Sections 2A to 2C, each scenario is also divided into the first year the project opens (Year 1) and the final year of the project lifecycle (Year 20).

For Freight Volume Inputs, the section further disaggregates into bulk/break bulk and containers. For both types of shipments and for freight trucks and rail, the model presents calculated values for:

- Laden and empty miles traveled
- Laden ton-miles
- Shipping cost per truck and per railcar.

While the laden miles traveled are calculated using the expect number of trucks/trains and their respective average one-way trip distance, the laden ton-miles is derived using the average one-trip distance and the project volumes. For the empty miles traveled, it is calculated using the laden miles traveled and the empty-haul return trips for every full truck/carload, defined in *Freight Shipment* Section. These variables are used in the calculation of both the accident cost savings and emission cost savings. In particular, for accident cost savings, it uses the vehicle-miles traveled by both modes, while for emission costs, truck emissions are calculated using the total distance traveled and the train emissions are derived using the ton-mileage.



The respective shipping costs by mode and by shipment type is aggregated by considering the per unit cost and the average unit shipped by the respective mode, which then aggregated to Year 1 and Year 20 values using the annual increases in shipping costs by mode. The presented shipping costs are used to determine the shipping cost savings benefits for both modes.

For Transload Operations Inputs, the section presents model calculated values for:

- Transload cost per short ton and per TEU
- Truck miles drayed for bulk/break bulk and containers
- Trucks per day
- Dray cost per truck.

The total truck miles drayed for both types of shipments are calculated using the portion of volume drayed by mode, the average one-way distance drayed, and the assumption that the trucks used for drayage have equal capacity to those of freight trucks. The calculated drayed distance is used in the calculation of accident costs saving and emission cost saving benefits.

For both scenarios, the costs for transload and drayage are extracted from the *Transload Operation Data* section. Specifically, the Year 1 costs is extracted directly, while the Year 20 costs are calculated using the combination of Year 1 costs and respective annual changes in costs. The costs values and the calculated trucks per day are used in the calculation of the shipper cost saving benefits.

In Section 2C, Terminal Efficiency Inputs, it presents model calculated values, by mode, for:

- Freight operating cost per hour
- Idle/dwell hours per year.

For both costs and idle/dwell time, the Year 1 values are obtained directly from the *Change in Terminal Efficiency* section. The respective Year 20 values are calculated using the Year 1 values and the respective annual changes. While these values, for both modes, are considered in the calculation of shipper cost saving benefits, expected dwell time for freight rail is also considered in the emissions cost saving benefits.

The Accident Rates Inputs Section presents the model calculated accident rates for freight trucks and the Accident Reduction Factor for each type of accident (i.e., fatal, injury, and PDO accident). The separate accident rates are presented for the No Build and Build scenarios, where No Build scenario uses the historical accident rates inputted by the user in the *Highway Accident Data* section. The Build scenario considers the potential for accident reduction from the No Build, defined by the Accident Reduction Factors. The default value for all accident reduction factors are is 1.00, implying there is no difference between the accident rates across scenarios. The user can adjust this by inputting values greater than 0 if the project is expected to have an impact on accident rates. If the project is expected to lower accident rates, then an accident reduction factors between 0 and 1 should be entered. However, if the project is expected to cause an increase in accidents, then accident reduction factors greater than 1 should be entered. The user can also control the calculations for fatal, injury, and PDO accidents separately. The values presented in

this section is used to calculate the change in the expected accident costs for freight trucks for accident cost savings.

## RESULTS WORKSHEET

The final worksheet covered by this User's Guide is the *Results* worksheet, which provides the benefit-cost assessment results from the Cal-B/C IF model. Exhibit 13 shows the layout of the output table.

**Exhibit 13: Results Worksheet**

Life-Cycle Costs (mil. \$)		\$0.0	<b>ITEMIZED BENEFITS (mil. \$)</b>			
Life-Cycle Benefits (mil. \$)		\$0.0	<b>Shipper Cost Savings</b>		Total Over 20 Years	Average Annual
Net Present Value (mil. \$)		\$0.0	Modal Diversion and Freight Network Improvements		\$0.0	\$0.0
Benefit / Cost Ratio:		N/A	Transload and Operational Efficiency Improvements		\$0.0	\$0.0
Rate of Return on Investment:		N/A	Accident Cost Savings		\$0.0	\$0.0
Payback Period:		N/A	Emission Cost Savings		\$0.0	\$0.0
			<b>TOTAL BENEFITS</b>		<b>\$0.0</b>	<b>\$0.0</b>

Should benefit-cost results include:		<b>EMISSIONS REDUCTION</b>				
		Tons		Value (mil. \$)		
		Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual	
1) Shipper Costs? (y/n)	<input type="text" value="Y"/>	CO Emissions Saved	0	0	\$0.0	\$0.0
	<small>Default = Y</small>	CO <sub>2</sub> Emissions Saved	0	0	\$0.0	\$0.0
2) Accident Costs? (y/n)	<input type="text" value="Y"/>	NO <sub>x</sub> Emissions Saved	0	0	\$0.0	\$0.0
	<small>Default = Y</small>	PM <sub>10</sub> Emissions Saved	0	0	\$0.0	\$0.0
3) Vehicle Emissions? (y/n)	<input type="text" value="Y"/>	PM <sub>2.5</sub> Emissions Saved	0	0		
	<small>Default = Y</small>	SO <sub>x</sub> Emissions Saved	0	0	\$0.0	\$0.0
<small>includes value for CO<sub>2</sub>e</small>		VOC Emissions Saved	0	0	\$0.0	\$0.0

As seen in the figure, the bottom left section of the *Results* worksheet allows the user to determine which of the three benefits to include. For the user to determine which benefits to include, it is a binary choice between “Y” and “N”, which represents yes and no respectively. The default setting for all benefits is “Y”, implying that all benefits are included in the default benefit-cost analysis.

Cal-B/C IF provides various summary results and different calculated project feasibility measures, using a 20-year project lifecycle, which highlight various aspects of a project:

- **Life-Cycle Costs** (in millions of dollars) are the present values for all net project costs, including the initial costs and any subsequent costs in real constant dollars.
- **Life-Cycle Benefits** (in millions of dollars) are the sum of the present value of the considered benefits of the project.
- **Net Present Value** (in millions of dollars), provides a measurement of project feasibility and is calculated as the difference between the lifecycle benefits and costs. In particular, if the net present value is positive (i.e., the lifecycle benefits are greater than the lifecycle costs), the project is feasible.

- **Benefit Cost Ratio** highlights the lifecycle benefits relative to the lifecycle costs of a project. A ratio greater than 1 implies the project has positive economic value.
- **Rate of Return on Investment** is defined as the discount rate which would equalize the lifecycle benefits and costs, and provides another measure of project feasibility. If the rate of return on investment is greater than the discount rate used in the model, it implies the project is expected to provide positive economic value. This measurement also allows the user to compare a variety of projects that have different lifecycle benefits or costs, as well as across different time periods.
- **Payback Period** is the number of years it would take the project to recover the initial construction costs, net of any ongoing costs. If the payback period is expected to be longer than the lifecycle of the project, it implies the initial construction costs are not recovered. It should be noted that the payback period has an inverse relationship with the benefit-cost ratio, in that a shorter payback period results in a higher benefit-cost ratio.

Cal-B/C IF also disaggregates the shipper cost savings into two separate components: Modal Diversion and Freight Network Improvements, and Transload and Operational Efficiency Improvements. The breakdown between the two allows the user to identify magnitude of impact the project has on the changes to the transportation/delivery mode of goods compared to intermediary improvements.

Cal-B/C IF also displays the emissions reduction that a project is expected to generate by pollutant type. The pollutants considered are: CO, CO<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>x</sub>, and VOC. The emissions reduction are presented in both the volume (tons) and value (millions of dollars). Results for volume and value are shown as a grand total over the project lifecycle, as well as an average annual value.

You are now ready to use Cal-B/C IF to model intermodal freight, drayage, transload, and freight terminal improvement projects. For more information about how Cal-B/C estimates particular impacts, please see Appendix B.

# Appendix A: Project Example

In this example, a port in Southern California currently transports 1 million tons of imported mixed freight to markets approximately 400 miles away, with anticipation of volumes growing to 3 million tons by 2040. While the current volumes are transported by rail through a transload facility, the facility is currently at capacity, so any additional volume is expected to be transported by truck. The port is looking to construct a new transload facility with an industrial spur and a capacity of four million tons. This new facility is expected to provide sufficient capacity to continue transporting all the commodities by rail. The project development is expected to start in 2018 and is slated to open in 2021.

## STEP 1: Input Project Data into Infrastructure Project Information Worksheet

All data entry for project analysis begins in the *Project Information* worksheet. This worksheet allows the user to input all the background information relevant to the project.

### (1) Project Data (Box 1A).

This is the space in which the user should enter the basic project information including the general region of project, the current year, the year project development begins, and the year the project is slated to open (see Exhibit 14).

Since the project is located in Southern California, the user should enter “1” in the green-colored box for *Project Location*.

The project starts in 2018 and is slated to open in 2021, the user should input “2018” and “2021” in the *Year Project Development Begins* and *Year Project Open (Year 1)* respectively. The current year box should also be completed, so benefits are discounted to today.

**Exhibit 14: Project Data**

<b>PROJECT DATA</b>	
<b>Project Location</b> (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	1
Current Year	2017
Year Project Development Begins	2018
Year Project Opens (Year 1)	2021

### (2) Freight Capacity (Box 1B).

As this project compares transportation of goods between two different modes, the user should enter freight capacity information, which also includes the average trip distance by mode (see

Exhibit 15). Cal-B/C IF has the capability to assess the transport of both containerized and non-containerized commodities. The user should fill out only the information relevant to the project. In this example, the project focuses on the transportation of break bulk commodities, so the *Average Bulk/Breakbulk Shipments (Short Tons)* section was completed while the *Average Container Shipments (TEUs)* section was left blank.

Let's assume that each truck transports an average of 25 tons and market designations are on average 400 miles away by highway. Let's also assume that each railcar carries approximately 100 tons, with 90 railcars per train. In addition, trains need to transport commodities an average of 450 miles to reach the markets as the route is less direct than trucking. It is assumed that capacity and distances do not change between the No Build and Build scenarios.

The user should input these values in the green boxes under the *No Build* column of the *Average Bulk/Breakbulk Shipments (Short Tons)* section, as seen in Exhibit 15. Since these variables are expected to remain constant, the user does not need to change the corresponding blue boxes under the *Build* column.

**Exhibit 15: Freight Capacity**

1B <b>FREIGHT CAPACITY</b>		
<b>Average Bulk/Breakbulk Shipments (Short Tons)</b>		
<b>Freight Trucks</b>	<b>No Build</b>	<b>Build</b>
Average Short Tons per Truck	25	25
Average Trip Distance (Miles, 1-Way)	400	400
<b>Freight Rail</b>		
Average Short Tons per Railcar	100	100
Average Number of Railcars per Train	90	90
Average Trip Distance (Miles, 1-Way)	450	450
<b>Average Container Shipments (TEUs)</b>		
<b>Freight Trucks</b>	<b>No Build</b>	<b>Build</b>
Average Number of TEUs per Truck		0
Average Trip Distance (Miles, 1-Way)		0
<b>Freight Rail</b>		
Average Number of TEUs per Railcar		0
Average Number of Railcars per Train		0
Average Trip Distance (Miles, 1-Way)		0
Average Short Tons per TEU	10	10

**(3) Freight Volumes by Mode (Box 1C)**

This section highlights the volume forecast used in the project in both the Build and No Build scenario. The user is expected to populate the information related to the project. In this example, *Annual Bulk/Breakbulk Shipments (Short Tons)* was populated with data, as seen in Exhibit 16.



For current volumes, the user should input “1,000,000” in the *Total Tons Shipped by Rail* under the *Current Year* grouping. For the forecasted volumes presented in the *Forecast Year (2040)* grouping, the user is expected to enter the projected volumes in both the Build and No Build scenarios.

Under the No Build scenario, the user should enter “2,000,000” for the *Total Tons Shipped by Truck* and “1,000,000” for the *Total Tons Shipped by Rail*, reflecting the need to transport commodities by truck due to capacity constraints.

Under the Build scenario, the user should enter “3,000,000” for the *Total Tons Shipped by Rail*, reflecting the completion of the new facility and opportunity to improve capacity.

**Exhibit 16: Freight Volumes by Mode**

1C <b>FREIGHT VOLUMES BY MODE</b>			
<b>Annual Bulk/Breakbulk Shipments (Short Tons)</b>			
<i>Current Year</i>			
Total Tons Shipped by Truck			0
Total Tons Shipped by Rail			1,000,000
Total Tons Shipped			1,000,000
<i>Base Year (2021)</i>			
	<i>No Build</i>	<i>Build</i>	
Total Tons Shipped by Truck	347,826	0	
Total Tons Shipped by Rail	1,000,000	1,347,826	
Total Tons Shipped	1,347,826	1,347,826	
<i>Forecast Year (2040)</i>			
Total Tons Shipped by Truck	2,000,000	0	
Total Tons Shipped by Rail	1,000,000	3,000,000	
Total Tons Shipped	3,000,000	3,000,000	
<b>Annual Container Shipments (TEUs)</b>			
<i>Current Year</i>			
Total TEUs Shipped by Truck			
Total TEUs Shipped by Rail			
Total TEUs Shipped			0
<i>Base Year (2021)</i>			
	<i>No Build</i>	<i>Build</i>	
Total TEUs Shipped by Truck	0	0	
Total TEUs Shipped by Rail	0	0	
Total TEUs Shipped	0	0	
<i>Forecast Year (2040)</i>			
Total TEUs Shipped by Truck			
Total TEUs Shipped by Rail			
Total TEUs Shipped	0	0	
<b>Annual Increase in Freight Volumes</b>			
	<i>No Build</i>	<i>Build</i>	
Bulk/Breakbulk Shipments	4.9%	4.9%	
Container Shipments	0.0%	0.0%	

#### (4) Freight Shipments by Mode (Box 1D)

Once the volumes and the capacity information have been entered, the model calculates the number of trains and trucks per year in the current and forecast years based on entered parameters in the *Number of Loaded Shipments per Year* section shown in Exhibit 17. The user should note that these values are calculated and can be overwritten by the user if more accurate values are available. Alternatively, the user may adjust these values from either the capacity or volume assumptions.

In addition, the number of shipments estimated in the model assumes that all trucks and trains will return empty without carrying any return freight. If this assumption is expected to change the user should adjust the red boxes found in *Number of Empty-Haul Return Trips for Every Full Truck/Carload* section.

Finally, the user should input in the average speeds in which freight trucks travel under the *Average Truck Speed (mph)* section. For any projects that include truck transportation, this information is necessary to determine the emissions generated by the truck traffic. As seen in Exhibit 17, the user is required to enter only the current truck speeds in the No Build scenario, while future truck speeds and truck speeds under the Build scenario are assumed to be the same. If this assumption is inaccurate, the user can override the assumed truck speeds presented in the blue cells.

**Exhibit 17: Freight Shipments by Mode**

1D FREIGHT SHIPMENTS BY MODE			
<b>Number of Loaded Shipments per Year</b>			
<b>Current Year</b>			
Trucks per Year			0
Trains per Year			111
<b>Base Year (2021)</b>			
	<b>No Build</b>	<b>Build</b>	
Trucks per Year	13,913		0
Trains per Year	111		150
<b>Forecast Year (2040)</b>			
Trucks per Year	80,000		0
Trains per Year	111		333
<b>Number of Empty-Haul Return Trips for Every Full Truck/Carload</b>			
	<b>Truck</b>	<b>Rail</b>	
Bulk/Breakbulk Shipments	1.0		1.0
Container Shipments	1.0		1.0
<b>Average Truck Speed (mph)</b>			
<b>Freight Truck Shipments</b>			
	<b>No Build</b>	<b>Build</b>	
Base Year (2021)	50		50
Forecast Year (2040)	50		50



### (5) Highway Accident Data (Box 1E)

This section (shown in Exhibit 18) allows the user to input in historical highway accident data if available. Since no recent highway accident data are available for this example, the green cells are left blank and the state average rates will be used in estimating safety benefits.

**Exhibit 18: Highway Accident Data**

1E HIGHWAY ACCIDENT DATA		
<b>Actual Historical Accident Data</b>		
	Count	Rate
Total Accidents During Reporting Period		0.846
Fatal Accidents		0.006
Injury Accidents		0.29
Property Damage Only Accidents		0.55
Vehicle-Miles Traveled During Reporting Period		

### (6) Freight Shipping Costs (Box 1F)

Under the *Freight Shipping Costs* section shown in Exhibit 19, the user is expected to input the average cost of transporting commodities for both containerized and non-containerized freight by mode and by scenario.

As this example focuses on breakbulk shipments, only the shipping costs pertaining to bulk/breakbulk commodities are entered. Specifically, as seen in Exhibit 18, it costs \$2,200 per truckload and \$2,700 per carload to transport the freight from the port. These prices are constant and not expected to change between scenarios.

**Exhibit 19: Freight Shipping Costs**

1F FREIGHT SHIPPING COSTS		
<b>Shipper Costs</b>		
Bulk/Breakbulk Shipping Costs (Current Year Total Rates)	No Build	Build
Per Truckload	\$2,200	\$2,200
Per Carload	\$2,700	\$2,700
Container Shipping Costs (Current Year Total Rates)		
Per TEU Moved by Truck		\$0
Per TEU Moved by Rail		\$0
Annual Increase in Shipper Costs (Net of Inflation)		
Long-Haul Truck Shipments	0.0%	0.0%
Rail Shipments	0.0%	0.0%



## (7) Transload Operations Data (Box 1G)

As seen in Exhibit 20, the next section presents all input in relation to transload operations and freight drayage.

### Transload Operations

Under the *Transload Operations* section, the user will enter the data relevant to the transload operations, such as volumes and costs.

Since this project focuses on developing transload facilities for rail, all freight moving by rail will be transloaded, while all truck volumes are not expected to require transload services. In addition to the share of the volumes, the user should input the relevant cost, indicated by \$6.00 per short ton in the No Build scenario. While the model assumes by default that the cost remains the same in the Build scenario, the cost of trainload at the new facility is expected to decrease to \$5.00 due to improved efficiencies. To reflect this, the user types \$5.00 on top of the calculated value in the blue cell for the Build scenario.

### Freight Drayage

Under the *Freight Drayage* section, the user is expected to enter the information relevant to the drayage service, such as volume, drayage distance, and costs. In addition, truck speeds for drayage are inputted under the *Average Freight Truck Speed for Drayage (mph)*, which is used to determine the emissions from drayage.

In this example, all volumes transported by rail are expected to be drayed to the transload facility, while the volumes transported by trucks are not. Under the No Build scenario, the drayage distance is approximately 10 miles from the port which translates to \$55.00 per truck, based on \$2.75 per truck-mile. By default, the model, assumes the distance and cost are the same in the Build scenario. However, in this example, the new facility is assumed to be 2 miles from the port, the user should override the *Distance Drayed (Miles, 1-Way)* under the Build scenario. In addition, as the underlying drayage cost assumption for this project is based on truck-miles, the reduced truck distance is expected to translate into cheaper drayage costs. This is entered in Cal-B/C IF by overriding \$11.00 per truck presented for *Drayage Cost per Truck* under the Build scenario.

**Exhibit 20: Transload Operations Data**

1G <b>TRANSLOAD OPERATIONS DATA</b>		
<b>Transload Operations</b>		
Proportion of Bulk/Breakbulk Volumes Transloaded	Truck Volumes	Rail Volumes
Base Year (2021)	0%	100%
Forecast Year (2040)	0%	100%
Proportion of Container Volumes Transloaded per Year		
Base Year (2021)	0%	100%
Forecast Year (2040)	0%	100%
Transload Cost per Short Ton	No Build	Build
	\$6.00	\$5.00
Transload Cost per TEU		\$0.00
Annual Increase in Transload Costs (Net of Inflation)		
Bulk/Breakbulk (Short Tons)	0.0%	0.0%
Containers (TEU)	0.0%	0.0%
<b>Freight Drayage</b>		
Proportion of Bulk/Breakbulk Volumes Drayed	Truck Volumes	Rail Volumes
Base Year (2021)	0%	100%
Forecast Year (2040)	0%	100%
Proportion of Container Volumes Drayed		
Base Year (2021)	0%	100%
Forecast Year (2040)	0%	100%
Distance Drayed (Miles, 1-Way)	No Build	Build
	10	2
Drayage Cost per Truck	\$55.00	\$11.00
Annual Increase in Drayage Costs (Net of Inflation)	0.0%	0.0%
<b>Average Freight Truck Speed for Drayage (mph)</b>		
	No Build	Build
Base Year (2021)	30	30
Forecast Year (2040)	30	30

**(8) Changes in Terminal Efficiency (Box 1H)**

For the *Changes in Terminal Efficiency* section shown in Exhibit 21, the user should provide information the delay or dwell times for both truck and trains under both scenarios, as well as the operator costs for the respective modes. As this project is not expected to realize any terminal efficiency improvements, no data was entered.

**Exhibit 21: Changes in Terminal Efficiency**

1H		
<b>CHANGES IN TERMINAL EFFICIENCY</b>		
<b>Average Delay/Dwell Time per Vehicle</b>		
	No Build	Build
Average Minutes per Truck	[Green Box]	[Green Box]
Average Minutes per Train	[Green Box]	[Green Box]
Annual Increase in Average Delay/Dwell Time		
Trucks	0.0%	0.0%
Trains	0.0%	0.0%
<b>Average Operator Cost per Hour of Delay</b>		
	No Build	Build
Freight Truck Delays	[Green Box]	[Green Box]
Train Delays	[Green Box]	[Green Box]
Annual Increase in Operator Costs (Net of Inflation)		
Freight Truck Delays	0.0%	0.0%
Train Delays	0.0%	0.0%

**(9) Project Costs (Box 1I)**

Initial project costs and subsequent on-going costs are entered in this *Project Costs* section. The initial project costs are divided into three categories: project support, right-of-way acquisition, and construction. Subsequent on-going costs reflect future costs such as rehabilitation costs as well as on-going maintenance and operating costs. The costs are entered in thousands of dollars and should be in constant dollars. Using all the relevant cost information, the model will calculate the total project costs by year in both constant dollars and present value.

For this example, assume that the construction of the new facility costs \$220 million over 3 years. A clear breakdown of the initial capital cost can be seen in Exhibit 22. In addition, the project assumes once the new facility is opened, there will be an operating and maintenance cost of \$8 million, which is expected to grow by \$250 thousand annually due to the increase freight volumes.



**Exhibit 22: Project Costs**

PROJECT COSTS (enter costs in thousands of dollars)							
Year	DIRECT PROJECT COSTS					Mitigation	Other Agency Cost Savings
	INITIAL COSTS			SUBSEQUENT COSTS			
	Project Support	R / W	Construction	Maint./ Op.	Rehab.		
<b>Construction Period</b>							
2018	\$10,000						
2019	\$5,000		\$100,000				
2020	\$5,000		\$100,000				
2021							
2022							
2023							
2024							
2025							
2026							
<b>Project Open</b>							
2021				\$8,000			
2022				\$8,250			
2023				\$8,500			
2024				\$8,750			
2025				\$9,000			
2026				\$9,250			
2027				\$9,500			
2028				\$9,750			
2029				\$10,000			
2030				\$10,250			
2031				\$10,500			
2032				\$10,750			
2033				\$11,000			
2034				\$11,250			
2035				\$11,500			
2036				\$11,750			
2037				\$12,000			
2038				\$12,250			
2039				\$12,500			
2040				\$12,750			
<b>Total</b>	\$20,000	\$0	\$200,000	\$207,500	\$0	\$0	\$0

**STEP 2: Confirm Model Inputs Tab**

Once all the necessary information has been entered in the *Project Information* worksheet, the user should review all the relevant calculated inputs in the *Model Inputs* worksheet. These values are calculated by the model using the parameters entered by the user. In this section, while the calculated values are presented in blue, the user SHOULD NOT adjust the blue-cells directly if alternative values are to be used. Instead, the user should identify which inputs needing adjustment and use the green cells located next to the calculated blue cells for making any changes. In addition, there is a space for the user to indicate why the change was implemented. A layout of this tab can be seen in Exhibit 23.

For this example, it is assumed that the calculations from the model do not require additional adjustments, so no changes are made.

### Exhibit 23: Model Inputs Layout

The screenshot displays three worksheets from a spreadsheet model, each with a table of inputs. The tables are organized into three sections:

- Section 2A: Freight Volume Inputs:** Contains multiple tables for 'No Build', 'Fear F', 'Enlighten', 'Fear JP', and 'Build'. Each table lists various freight volume metrics (e.g., 'Lobbs Truck Miles Traveled', 'Empty Truck Miles Traveled', 'Shipping Cost per Truck') and their values across different scenarios.
- Section 2B: Transload Operation Inputs:** Contains tables for 'No Build', 'Fear F', 'Enlighten', 'Fear JP', and 'Build'. It lists transload operation metrics such as 'Transload Cost per Short Ton' and 'Transload Cost per YD'.
- Section 2C: Terminal Efficiency Inputs:** Contains tables for 'No Build', 'Fear F', 'Enlighten', and 'Build'. It lists terminal efficiency metrics like 'Freight Truck Operating Cost per Hour' and 'Freight Truck Miles per Year'.

Each table has columns for 'Controlled', 'Changed', and 'Used For' (By Model, by User, Proj. Ext., Reason for Change). The 'Used For' column is highlighted in yellow. A blue arrow points from the 'Used For' column in Section 2A to the 'Used For' column in Section 2C.

### STEP 3: Review Final Results

Following completion of the first two steps, the user can review the benefit-cost analysis results for the project in the *Results* worksheet. This tab allows the user to see a summary of the final results,<sup>3</sup> with the key metrics such as the net present value and the benefit-cost ratio (BCR) presented in the top left box. The *Results* worksheet also allows the user to include or exclude specific benefits such as shipper cost savings, accident cost savings and vehicle emissions.

The results of the example project can be seen in Exhibit 24, which indicates the project is expected to generate \$462 million in discounted net public benefits and have a BCR of 2.5. The majority of the benefits are generated by the shipper cost savings from truck to rail diversion. Meanwhile the *Transload and Operational Efficiency Improvements* are expected to generate a disbenefit as the volume that requires transload services increases in the Build scenario.

<sup>3</sup> More detail results can be seen in the Final Calculations tab.



**Exhibit 24: Results**

3

**INVESTMENT ANALYSIS**

**SUMMARY RESULTS**

Life-Cycle Costs (mil. \$)	\$316.3
Life-Cycle Benefits (mil. \$)	\$778.1
Net Present Value (mil. \$)	\$461.8
Benefit / Cost Ratio:	2.5
Rate of Return on Investment:	16.7%
Payback Period:	6 years

ITEMIZED BENEFITS (mil. \$)	Total Over 20 Years	Average Annual
Shipper Cost Savings	\$746.0	\$37.3
Modal Diversion and Freight Network Improvements	\$782.4	\$39.1
Transload and Operational Efficiency Improvements	-\$36.4	-\$1.8
Accident Cost Savings	\$30.3	\$1.5
Emission Cost Savings	\$1.8	\$0.1
<b>TOTAL BENEFITS</b>	<b>\$778.1</b>	<b>\$38.9</b>

**Should benefit-cost results include:**

1) Shipper Costs? (y/n)   
Default = Y

2) Accident Costs? (y/n)   
Default = Y

3) Vehicle Emissions? (y/n)   
includes value for CO<sub>2</sub>e  
Default = Y

EMISSIONS REDUCTION	Tons		Value (mil. \$)	
	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual
CO Emissions Saved	339	17	\$0.0	\$0.0
CO <sub>2</sub> Emissions Saved	439,543	21,977	\$12.3	\$0.6
NO <sub>x</sub> Emissions Saved	-479	-24	-\$9.6	-\$0.5
PM <sub>10</sub> Emissions Saved	-10	-1	-\$2.1	-\$0.1
PM <sub>2.5</sub> Emissions Saved	11	1		
SO <sub>x</sub> Emissions Saved	9	0	\$1.0	\$0.0
VOC Emissions Saved	40	2	\$0.1	\$0.0

# Appendix B: Technical Documentation

## BACKGROUND AND SCOPE OF ANALYSIS

Benefits are analyzed in Cal-B/C IF from both a shipper perspective (in cost savings) and wider social benefit (accident and emissions reduction). That said, it is assumed that shipper cost savings are also social benefits since they represent greater levels of economic efficiency, some of which may be passed on to customers.

For each user, several types of benefits are computed including:

- **Shipper cost savings** due to greater shipping efficiency or lower transportation costs.
- **Accident cost savings** due to fewer vehicles on the road. These benefits reflect goods movement shifting from trucks to rail.
- **Emission cost savings** from fewer vehicles on the road and fewer miles driven.

The model estimates the benefits for bulk/break bulk and containerized shipments. It undertakes a holistic approach in estimating project benefits by considering full freight movements, drayage, and transloading operations. See glossary in Exhibit 25 for definitions of technical terms.

Project types that can be assessed by Cal-B/C IF include:

- **Modal Diversion and Freight Network Improvements:** In general, modal diversion projects involve a shift in how commodities are transported. The construction of a new intermodal facility or logistics hub, as an example, allows shippers the option to divert volumes to rail that may currently be shipped by truck. Moving freight long distances by rail is typically cheaper than moving it by truck (all else constant) and freight shipments by rail are associated with fewer accidents and lower emission rates than similar shipments by truck, resulting in net benefits to society. Fewer trucks on the road also mean reduced highway congestion, and ultimately, increased travel speeds for other highway vehicles.

Freight transportation network improvements, such as the additions of new intermodal facilities, railway infrastructure improvements, or the addition of new railway or highway connections between markets can generate similar benefits in terms of cheaper costs, and shorter travel distances. Vehicle capacity improvements, which include economies of scale from larger truck or railcar capacities, as well as longer trains with more railcars, can reduce the overall vehicle-miles traveled. This can have a direct bearing on shipper costs and net benefits to society.

Examples of modal diversion and freight network improvement projects include:

- **Rail Corridor Capacity Improvements:** Increasing the amount of freight that can be shipped through a rail corridor can reduce travel times and costs for existing rail traffic, and accommodate increased train traffic for goods that are otherwise moved by less efficient modes like trucks.



- **Truck Corridor Capacity Improvements:** Increasing capacity along freight highway corridors can improve travel speeds for trucks, reduce travel distance, and reduce shipper costs for trucks that otherwise circumvent heavily congested areas.
- **Projects Enabling Dedicated Freight Movements in Unit Trains:** Infrastructure that allows shifting traffic from manifest trains to dedicated unit trains can reduce shipping costs, move more railcars per train, and require fewer train trips.
- **Loop Track Construction:** Construction of a loop track to handle longer trains that allows for fewer trips along the rail corridor. Loop tracks also allow for the handling of unit trains which results in further efficiencies and reduced shipping costs.
- **Wye Construction / Extension:** Extension or construction of a new wye connection (a triangular rail junction where trains can pass each other) that improves the efficiency of rail movements by offering shorter travel distances and haul times.
- **Rail Infrastructure Upgrades and Enhancements:** Enhancing or upgrading existing infrastructure, such as track, bridges, or train control systems to accommodate railcars with a maximum gross weight of 286,000 pounds, allowing for more freight per railcar and fewer train trips for the same volume of freight.
- **Other Projects That Divert Freight Movements from Trucks to Rail:** Infrastructure that allows shippers to divert traffic from truck to rail reduces truck trips and shipping costs, improves safety, reduces emissions, and increases local highway speeds.
- **Transload Operations and Terminal Efficiency Improvements:** Terminals are under increased strain due to the rapid growth of domestic and trade-related freight movements. Projects that seek to improve terminal efficiency may include expanding terminal facilities to allow for a greater volume of trucks and trains or railcars to be served, installing new equipment, or implementing technology that reduces truck and train delays at terminals through queue detection and monitoring technologies. New equipment that facilitates the transloading process results in improved terminal efficiency by reducing associated costs. Similarly, improvements that reduce the distance or the proportion of freight that must be drayed between facilities can have substantial societal impacts in terms of shipper costs, safety, and emissions. Finally, reducing delay and idle time at terminals reduces operator costs and reduces emissions from idling.

Examples of transload operations and terminal efficiency improvement projects include:

- **New Port/Terminal Technology Implementation:** Implementation of intelligent transportation system (ITS) solutions that improve port/terminal efficiency, reduce operations costs, or reduce congestion and terminal wait times.
- **New Terminal Construction:** Construction of a new freight handling terminal that allows intermodal traffic to access closer market gateways or reduce drayage distances. The reduction in travel distance can be complemented by a potential reduction in drayage costs as well as transload costs due to improved efficiency of a new facility.
- **Port/Terminal Capacity Improvements:** Expansion of a port/terminal's ability to handle an increased volume of freight shipments can reduce travel costs and distance



for freight that otherwise would have traveled to a distant facility due to handling constraints.

Overall, Cal-B/C IF is set up to assess freight volumes based on tonnage (in short tons of freight), or containers (in TEUs). In the case of automobile cargo, automobile volumes must first be converted into tonnage that includes the gross weight of the autos, as well as any intermodal auto racks; the tonnage can then be input under bulk/break bulk sections of the model.

Exhibit 25 provides a glossary of terms used in Cal-B/C IF.

### Exhibit 25: Glossary

Term	Definition
<b>Bulk</b>	Bulk cargo is loose cargo such as grain, coal, and iron ore. Bulk freight is not unitized or packaged and typically transported in cargo holds via bulk carriers. Bulk volumes are measured in short tons in Cal-B/C IF.
<b>Break bulk</b>	Break bulk cargo is cargo that is unitized and loaded individually. Break bulk cargo is generally packaged (e.g., bags, boxes, barrels, etc.) and not containerized. Break bulk volumes are measured in short tons in Cal-B/C IF.
<b>Short tons</b>	Short tons/US ton is measurement of weight equal to 2,000 pounds. Used as the unit of measure for bulk/break bulk volumes in Cal-B/C IF.
<b>TEU</b>	Twenty-foot equivalent unit (TEU) refers to container freight equivalent to a 20-foot-long intermodal container. For instance, a 40-foot container would be equivalent to 2 TEU's.
<b>Intermodal</b>	Freight transportation that requires multiple modes of transportation without any handling of the freight itself when changing modes.
<b>Intermodal Train</b>	A freight train that carries goods or commodities loaded into domestic or international shipping containers or highway semi-trailers on their own wheels.
<b>Transload</b>	The process of transferring a shipment from one mode of transportation to another.
<b>Drayage</b>	The transportation of goods over a short distance and usually part of a longer overall move – for instance from a port to a nearby rail yard.
<b>Empty-haul trip</b>	The movement of empty freight trucks and railcars.
<b>No Build</b>	The scenario where the project does not proceed as planned.
<b>Build</b>	The scenario where the project proceeds as planned.
<b>Current Year</b>	The year the analysis is done. Model results are discounted to current year values.
<b>Base Year</b>	The first year the project is operational is defined as Year 1.
<b>Forecast Year</b>	The final year of the project lifecycle is defined in the model as 20 years after opening.
<b>MPH</b>	Miles per hour (mph) is a measurement of vehicle speed.
<b>VMT</b>	Vehicle-miles traveled (VMT) is a measurement of miles traveled by vehicles for a specific time period including truck-miles and train-miles.
<b>Ton-mile</b>	Unit equivalent to one ton of freight moved one mile.
<b>Modal Diversion</b>	The process of diverting freight volumes from one transportation mode to another. For instance, diverting freight shipments from trucks to rail.



Term	Definition
<b>Manifest Train</b>	A type of freight train that carries goods or commodities for multiple shippers between multiple origins and multiple destinations.
<b>Unit Train</b>	A type of freight train carrying a single bulk commodity typically from a single origin to a single destination for a single shipper.
<b>Railcar</b>	An individual non-powered component of a train used to haul goods or commodities. Railcars are coupled together to comprise a train.
<b>Carload</b>	Used to define a railcar that is loaded with a good or commodity.

## BENEFIT ESTIMATION

Benefits are computed as a difference between No Build (*NB*) and Build (*B*) scenarios. Specifically, the total impact generated by each benefit category is defined as the total difference between the No Build and Build cases over the project lifecycle, which is assumed to be 20 years from the year the project opens. These values are denoted in present value terms and reported as a total over the project lifecycle, as well as an average annual value over the project lifecycle. If the reported net present value is positive, it implies the project generates an economic benefit, while a negative value implies the project generates an economic burden or cost.

A number of user inputs are essential for computing benefits over time. The data, discussed in Cal-B/C Parameters Guide, are used to interpolate freight shipment volumes throughout the project lifecycle and determine the annual number of truck and train trips and shipments. Some inputs may be entered in both short tons and twenty-foot-equivalent units (TEUs) for bulk/break bulk and containerized shipment types, respectively. While annual freight volumes within the project lifecycle are interpolated, unit costs and prices are escalated based on a user-defined real growth rates.

## Shipper Cost Savings

An important potential benefit of intermodal freight projects is cost savings for shippers. These benefits can arise from shipping via a mode that is less costly, or using the same mode but with increased efficiencies, and thus, lower costs. For example, shipping freight by rail can be more cost effective per-mile than by trucks, especially over long haul distances. However, since trucks can provide more direct shipping between origins and destinations, it can be more cost-competitive and logistically advantageous over shorter distances (under 300-500 miles). In either case, any cost savings generated from a project directly benefit shipper. But, it is also reasonable to assume that these savings contribute to more competitive pricing and savings for local businesses and consumers, thereby justifying a broad social benefit of shipping cost savings.

Shipper cost saving benefits are computed in Cal-B/C IF due to changes in modes or processes, transportation costs, facility operational efficiency, or reduced congestion. The computation methods are estimated separately for two broad benefit categories:

- Modal diversion and freight network improvements

- Transload operations and terminal efficiency improvements.

The annual shipper cost saving benefits are defined as the sum of these two benefits, if relevant. Details on computing these benefits are discussed below. In all cases, the methods describe a computation and process for estimating benefits in both the No Build and Build scenarios (i.e., without or with the project). The total net benefits of a project, which would be compared against costs, is computed as the difference between No Build and Build scenarios.

### ***Modal Diversion and Freight Network Improvements Benefit***

Modal diversion and freight network improvements are meant to capture the benefits to shippers associated with diverting volumes between freight trucks and rail. Benefits from modal diversion and freight network improvements are driven by differences in transportation costs with the project. In addition, benefits may accrue from a reduction in the overall number of trucks and trains used to transport freight, simply because trains can carry greater volumes, as well as the average distance traveled. For instance, rail has the ability to transport a far greater volume of goods relative to trucks, but has logistical constraints for short-haul trips. Similarly, capacity improvements for a given mode can be substantial drivers of benefits. For instance, moving goods by unit trains carrying 120 railcars per train will reduce the overall rail trips compared to shipping by manifest trains with an average of 80 railcars per train.

The computation of benefits is conducted separately by mode over time. The descriptions of the benefit calculation equations are described below in terms of factors influencing the scale of impact, impact per unit and value per unit. As shown below, most of the computations of benefits include determining the total costs of shipping by both truck (T) and rail (R), with initial uses as superscripts. The sum of costs of moving freight by both modes in both the No Build and Build scenarios provides the basis for determining the net cost savings with a project. The benefits of shipping cost savings are computed as the difference in benefits between scenarios. See the Cal-B/C Resource Guide for more information on methods and the Cal-B/C Parameters Guide for a discussion on data and sources.

Scale of Impact	Impact Factors	Impact Value per Unit
Volumes of goods transported by mode	<ul style="list-style-type: none"> <li>• Average capacities by mode</li> <li>• Average number of railcars per train</li> </ul>	<ul style="list-style-type: none"> <li>• Shipping costs by mode</li> <li>• Annual growth in shipping costs by mode</li> </ul>

**Scale of Impact:**  $FV^m$

Where:

- $FV^T, FV^R$  = Annual volume (short tons or TEUs) transported by truck (T) or rail (R)

**Impact Factors:**  $AC^m, ART$

Where:

- $AC^T, AC^R$  = Average capacity (# short tons or TEUs) per truck (T) or railcar (R)
- $ART$  = Average number of railcars per train.

**Value of Impact per Unit:  $SC^m$**

Where:

- $SC^T, SC^R$  = Shipping costs (\$/TEU) for truck (T) and railcar (R), potentially estimated with user-defined real growth rates over time. Shipping costs for trains are inputted into the model as (\$/Train); the model converts to (\$/railcar) using the ART factor.

**Total Value of Shipping Cost Savings - Diversion, Network Improvements:**

$$VDN = FV^T \cdot \frac{1}{AC^T} \cdot SC^T + FV^R \cdot \frac{1}{[AC^R \cdot ART]} \cdot [SC^R \cdot ART]$$

***Transload Operations and Terminal Efficiency Improvements***

Shippers can also realize cost savings from improved intermodal operational efficiency. These savings would arise from improved transloading efficiency, streamlined operations, or reduced need for transloading altogether. Concurrently, changes in requirements for draying freight between facilities and the effects on local terminal and traffic congestion can have a direct impact on shipper costs. Cal-B/C IF calculates these benefits as the sum of changes to:

1. **Transload costs:** based on the total volume of rail and truck that would be transloaded and the cost of hauling by truck
2. **Drayage costs:** based on the total volume of rail and truck that would be drayed by truck and the cost of hauling by truck
3. **Terminal efficiency costs:** based on the total volume of rail and truck and transportation delays and then combined with the cost of facility operations per unit of time.

The discussion of each benefit dimension is presented in three parts: scale of impact, impact factors, and impact value per unit. Total benefits equals the difference in value between No Build and Build scenarios. See Cal-B/C Resource Guide for more information on methods and the Cal-B/C Parameters Guide for a discussion on data and sources.

Scale of Impact	Impact Factors	Impact Value per Unit
Volumes of goods transported by mode	<ul style="list-style-type: none"> <li>• Average capacities by mode</li> <li>• Average # of railcars per train</li> <li>• Forecast of delays by mode</li> </ul>	<ul style="list-style-type: none"> <li>• Transload, drayage, and operational costs by mode</li> <li>• Annual growth in costs by mode</li> </ul>

**Scale of Impact:  $FV^m$**

Where:

- $FV^T, FV^R$  = Annual volume (short tons or TEUs) hauled by truck (T) or rail (R)

**Impact Factors:** Transload ( $FT^m$ ), Drayage ( $FD^m, AC^T$ ) and Efficiency ( $FT^m, AC^T, ART, Del^m$ )

Where:

- $AC^T, AC^R$  = Average capacity (short tons or TEUs) per truck (T) or railcar (R)
- ART = Average number of railcars per train
- $FT^T, FT^R$  = Portions (% of volume shipped) of truck (T) and rail (R) volume transloaded
- $FD^T, FD^R$  = Portions (% of volume shipped) of truck (T) and rail (R) volume drayed
- $Del^T, Del^R$  = Forecast of terminal delays for truck (T) and rail (R) hauling, potentially estimated with user-defined annual growth rates over time.

**Impact Value per Unit:** Transload ( $TC^T$ ), Drayage ( $DC^T$ ) and Efficiency ( $OC^T, OC^R$ )

Where:

- $TC^T$  = Forecast of the transload cost per unit for truck (T) movement, potentially estimated with user-defined annual growth rates over time
- $DC^T$  = Forecast of the drayage cost per unit for truck (T) movement, potentially estimated with user-defined annual growth rates over time
- $OC^T, OC^R$  = Forecast of the operations cost per unit for truck (T) and rail (R) movement, potentially estimated with user-defined annual growth rates over time.

Value of shipping cost savings for transload, drayage, and operations are computed separately and summed together as relevant for the No Build and Build scenarios.

<b>Total Value of Shipping Cost Savings – Transload, Drayage, Efficiency:</b>	
<b>Transload:</b>	$VTC = [FV^T \cdot FT^T + FV^R \cdot FT^R] \cdot TC^T$
<b>Drayage:</b>	$VDC = \left[ FV^T \cdot \left[ \frac{FD^T}{AC^T} \right] + FV^R \cdot \left[ \frac{FD^R}{AC^T} \right] \right] \cdot DC^T$
<b>Efficiency:</b>	$VEC = FV^T \cdot \left[ \frac{FT^T}{AC^T} \cdot Del^T \right] \cdot OC^T + FV^R \cdot \left[ \frac{FT^R}{[AC^R \cdot ART]} \cdot Del^R \right] \cdot [OC^R \cdot ART]$
<b>Total Value of All Potential Shipping Cost Savings:</b>	
$VSC = VDN + VTC + VDC + VEC$	



## Accident Cost Savings

Safe transportation plays a key role in assessing the long-term viability of freight supply chains and generates increased public confidence in the overall freight transportation network. Compared to trucks, freight rail is one of the safest modes of transporting freight in North America, with accidents generally resulting from external factors such as collisions with vehicles driving through an active crossing or with trespassers.

Changes in accident costs between No Build and Build scenarios are a direct function of vehicle-miles traveled (VMT) by mode. VMT is derived from the number of trains and trucks and their respective average distances traveled. In Cal-B/C IF, estimated benefits also account for the number of empty-haul trips returning to the point of origin, in order to capture the full distance traveled. In particular, this adjustment allows the model user to capture the distance traveled by empty trucks and trains returning without freight.

Developing reasonable estimates of accident cost savings depends on local accident rates for freight trucks. Cal-B/C IF includes statewide average truck accident rates that are extracted the Traffic Accident Surveillance and Analysis System (TASAS) data. These data are applied to both long distance trucking and drayage movements. Thus, while the model provides default accident rates, project-specific accident rates may be used instead.<sup>4</sup> Project-specific rates should be used only if the total number of incidents by level of severity and the total VMT for a given time period is available to the model user.

Freight rail accident costs are derived using accident data from the Federal Railway Administration (FRA). A weighted average was constructed using data from a ten-year period to determine national rates of fatalities, injuries, and PDOs for every million rail-miles traveled.

Total accident cost is computed from data on VMT and accident rates and costs per accident. In addition, adjustments for the number of empty-haul return trips for trucks and trains are included in the total accident costs. Three types of crash are considered: (a) Fatality collisions; (b) Injury collisions; and (c) PDO collisions. This allows the number of empty trucks and trains returning to their respective point of origin to be considered along with the additional safety costs involved. The estimation of safety benefits is presented below in three parts: scale of impact, impact factors, and value of impact per unit. Total benefits equals the difference in value between No Build and Build scenarios. See Cal-B/C Resource Guide for more information on methods and the Cal-B/C Parameters Guide for a discussion on data and sources.

Scale of Impact	Impact Factors	Impact Value per Unit
Volumes of goods transported by mode	<ul style="list-style-type: none"> <li>Average distance per trip, by mode</li> <li>Average volume capacity, by mode</li> <li>Proportion of empty return trips, by mode</li> </ul>	<ul style="list-style-type: none"> <li>Accident rates, by severity</li> <li>Accident costs, by severity</li> </ul>

<sup>4</sup> Ideally, at least five years of historical accident data should be collected, aggregated and averaged across all such intersections along the existing facility.

### Scale of Impact: $FV^m$

Where:

- $FV^T, FV^R$  = Annual volume (short tons or TEUs) hauled by truck (T) or rail (R)

### Impact Factors: $Dist^m, AC^m, EHTrip^m$

Where:

- $AC^T, AC^R$  = Average capacity (short tons or TEUs) per truck (T) or railcar (R)
- $Dist^T, Dist^R$  = Distance an average vehicle travels by truck (T) or rail (R)
- $FT^T, FT^R$  = Portions (% of volume shipped) of truck (T) and railcar (R) volume transloaded
- $FD^T, FD^R$  = Portions (% of volume shipped) of truck (T) and railcar (R) volume drayed
- $EHTrip^T, EHTrip^R$  = proportion of empty return trips by truck (T) or rail (R).

Combining  $Dist^m, AC^m$  with  $FV^m$  results in estimates of annual long-haul vehicle-miles traveled ( $VMT^m$ )<sup>5</sup> by mode (m) using the equation below:

$$VMT^m = FV^m \cdot \frac{Dist^m}{AC^m}$$

VMT for drayage ( $VMT^D$ ) are similarly computed for drayage:

$$VMT^D = Dist^D \cdot \left[ FV^T \cdot \frac{FD^T}{AC^T} + FV^R \cdot \frac{FD^R}{AC^T} \right]$$

Also, note that this derivation of VMT does not account for return trips. Accordingly,  $EHTrip^m$  is used to adjust total VMT. The resulting equation for total VMT by mode is:

$$TotVMT^m = VMT^m \cdot (1 + EHTrip^m)$$

### Impact Value per Unit: $ACC^m$

Where:

- $ACC^m$  = Sum product of accident frequencies per mile and costs per accident by severity  
 $ACC^m = (FatalAcc^m \cdot CostFatal^m + InjAcc^m \cdot CostInj^m + PDAcc^m \cdot CostPD^m)$

$ACC^m$ , accident costs per-mile by mode, is derived using incident rates by accident severity (e.g.,  $FatalAcc^m$ ) and the respective cost by severity ( $CostFatal^m$ ). The general formulation for accident costs is similar for trucks and rail, but a subtle difference exists for truck costs and train costs.<sup>6</sup> In each case, costs are multiplied by the accident rate per million VMT.

### Total Value of Accident Risk Reduction:

<sup>5</sup> VMT is highlighted because it is a more direct measure of scale of impact for accident risk than  $FV^m$ .

<sup>6</sup> Truck accident costs, such as the cost of a fatal accident ( $CostFatal^T$ ), combines fatalities, injuries and property damage events whereas the cost of a fatal accident by rail ( $CostFatal^R$ ) is just the cost of a fatality.



$$\text{VAR}^T = [\text{TotVMT}^T + \text{TotVMT}^D] \cdot \text{ACC}^T + [\text{TotVMT}^R] \cdot \text{ACC}^R$$

## Emission Cost Savings

Environmental sustainability and health costs are increasingly considered an important component in the evaluation of transportation projects. The impacts of exhaust emissions impose wide-ranging social costs on people, materials, and vegetation. For instance, railroads and automotive companies have invested heavily in fuel-efficient technologies to improve operational efficiency and reduce greenhouse gas emissions. In particular, thousands of new energy efficient locomotives have been acquired, while older locomotives have been retrofitted or retired. Moreover, the implementation of idling-reducing technology has allowed main engines to be shut down in various conditions. Changes in overall vehicle movements through shorter travel distance, improved capacity, and streamlined operations can all impact the overall emissions of greenhouse gas and criteria air contaminants.

Changes in fuel use for any purpose is translated into a change in emissions using emissions factors for specific pollutants. The pollutants that are analyzed in this model include: carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), nitrates oxides (NO<sub>x</sub>), particulate matter (PM<sub>10</sub>), sulfur oxides (SO<sub>x</sub>), and volatile organic compounds (VOC). In each case, pollutant emissions per unit of fuel use, and monetary impact of per unit of emission level are included in the model. Data on emissions factors are obtained from the California Air Resources Board (CARB).

Cal-B/C IF computes freight rail emissions with data on total ton-miles traveled, annual terminal dwell time, and the annual number of trains. Trucks emissions include, for both freight and drayage activity, the annual number of trucks, average speeds and distance, as well as the truck emissions factors are required. Similar to accident costs, emissions cost estimates account for the adjustment for the number of empty-haul trips returning to the point of origin. The estimation of benefits is presented below in three parts: scale of impact, impact factors, and value of impact per unit. Total benefits equals the difference in value between No Build and Build scenarios. See Cal-B/C Resource Guide for more information on methods and the Cal-B/C Parameters Guide for a discussion on data and sources.

Scale of Impact	Impact Factors	Impact Value per Unit
Volumes of goods transported by mode	<ul style="list-style-type: none"> <li>Average distance per trip, by mode</li> <li>Average volume capacity, by mode</li> <li>Proportion of empty return trips, by mode</li> </ul>	<ul style="list-style-type: none"> <li>Valuation per unit of emissions, by pollutant</li> <li>Emissions rates per vehicle, by pollutant</li> </ul>

**Scale of Impact:**  $FV^m$

Where:

- $FV^T, FV^R$  = Annual volume (short tons or TEUs) hauled by truck (T) or rail (R)

**Impact Factors:** Truck ( $Dist^T$ ,  $AC^T$ ,  $EHTrip^T$ ) Rail ( $Dist^R$ ,  $AC^R$ ,  $ART$ ,  $EHTrip^R$ ,  $Del^R$ ,  $RFE$ ,  $RFI$ )

Where:

- $AC^T$ ,  $AC^R$  = Average capacity (# short tons or TEUs) per truck (T) and railcar (R); note that *train* capacity is defined as  $AC^R \cdot ART$ , as discussed above
- $ART$  = Average number of railcars per train<sup>7</sup>
- $Dist^T$ ,  $Dist^R$  = Distance average vehicles travel by truck (T) and rail (R)
- $FT^T$ ,  $FT^R$  = Portions (% of volume shipped) of truck (T) and railcar (R) volume transloaded
- $FD^T$ ,  $FD^R$  = Portions (% of volume shipped) of truck (T) and railcar (R) volume drayed
- $Del^R$  = Forecast of terminal delays for rail (R) movement, potentially estimated with annual growth rates<sup>8</sup>
- $RFE$  = Freight rail fuel efficiency
- $RFI$  = Fuel burned at idle for trains
- $EHTrip^T$ ,  $EHTrip^R$  = proportion of empty return trips by truck (T) or rail (R).

Similar to accident rate analysis,  $Dist^T$ ,  $AC^T$  are combined with  $FV^T$  to estimate annual long-haul vehicle-miles traveled ( $VMT^T$ ) by mode, m:

$$VMT^T = FV^T \cdot \frac{Dist^T}{AC^T}$$

$VMT$  for drayage ( $VMT^D$ ) are also similarly computed for drayage:

$$VMT^D = Dist^D \cdot \left[ FV^T \cdot \frac{FD^T}{AC^T} + FV^R \cdot \frac{FD^R}{AC^R} \right]$$

For rail emissions, similar factors contribute to an estimate of rail total ton-miles. Additional factors include rail fuel efficiency ( $RFE$ ) that computes emissions while moving and idling fuel use ( $RFI$ ) at terminals.<sup>9</sup> The resulting equation:

$$VMT^T = FV^R \cdot \frac{Dist^R \cdot (1 + EHTrip^R)}{RFE} + FV^R \cdot \frac{FT^R \cdot Del^R \cdot RFI}{AC^R \cdot ART}$$

Also, note that this derivation of  $VMT$  does not account for return trips. Accordingly,  $EHTrip^m$  is used to adjust total  $VMT$ . The resulting equation for total  $VMT$  by mode is:

$$TotVMT^m = VMT^m \cdot (1 + EHTrip^m)$$

<sup>7</sup> Note that Cal-B/C IF quantifies total shipping costs with data on the average number of railcars per train, it is possible to compute the volume and shipping costs by train, not just railcars.

<sup>8</sup> It is assumed that trucks delayed in terminals do not idle. Rather, trucks are assumed to turn off their engines resulting in no idling emissions by trucks in terminals.

<sup>9</sup> Idling of course does not increase  $VMT$ . However, combining rail idling and moving emissions in the equation above would not change the result since it simply considers any spent idling time to be normally part of an entire trip.

### Impact Value per Unit: $EC^m$

Where:

- $EC^T, EC^R$  = Emissions cost by mode ( $m$ ) per truck (T) and railcar (R) is equal to the sum product of each pollutant's emissions ( $pollutant^m$ ) rate per mile by mode ( $m$ ), and costs per pollutant ( $VPP_{pollutant}$ ).<sup>10</sup> Total emissions costs for each mode is:

$$EC^m = (CO^m \cdot VPP_{CO} + CO_2^m \cdot VPP_{CO_2} + NO_X^m \cdot VPP_{NO} + PM_{10}^m \cdot VPP_{PM_{10}} + SO_X^m \cdot VPP_{SO} + VOC^m \cdot VPP_{VOC})$$

### Total Value of Emissions Reduction:

$$VER^T = TotVMT^T \cdot EC^T + TotVMT^D \cdot EC^D + TotVMT^R \cdot EC^R$$

<sup>10</sup> Emissions rates are a function of vehicle speed and accordingly, costs per mile differ for long-distance and drayage truck hauling.

## LIMITATIONS OF CAL-B/C IF

One limitation of Cal-B/C IF is that the model is not designed to assess induced freight movements. The importance of identifying and excluding induced volumes in benefit calculations follows the idea that induced shipper impacts were not originally captured in the No Build case, and thus follow a baseline different from the defined No Build case. With a different baseline, induced shipments cannot receive the same value of benefits as the existing shipments. Typically, adjustments, such as “the rule of half”, are applied to account for potential impacts of induced volumes. However, the model makes no such adjustments and captures all impacts for induced shipments at full value. In the case where total volumes differ between the No Build and Build case, and in particular, if the Build case volumes exceed those of the No Build case, the model calculations can create misleading results.

For example, if the No Build is defined as 1 million tons of freight moving 10 miles, at a cost of \$0.10 per ton-mile, the No Build cost per year is \$1 million. If the build case is then defined as the same 1 million tons moving 10 miles by different mode, at a cost of \$0.05 per ton-mile, the Build cost per year would be \$500 thousand and the net benefit would be correctly calculated as \$500 thousand per year (\$1 million minus \$500 thousand). If, however, the user defines the Build case as 2 million tons because the project would induce shippers from other modes, the model would calculate the Build costs to be 2 million times 10 miles, time \$0.05 per ton-mile, equals \$1 million. The net benefit to the project would then be incorrectly displayed as zero. In reality, there should be a \$500 thousand net benefit to existing users, and an unknown impact to the induced volumes (since these may have been moving by different mode, or potentially did not exist at all).

Similarly, the Cal-B/C IF model assumes that project impacts do not result in complete cessation of freight movements (that total freight volumes do not drop to zero). In other words, the model is set up to assess net societal impacts from changes in the freight supply chain rather than pure changes in freight volumes.

## INTERPOLATION METHODOLOGY

### Volume Interpolation

Cal-B/C IF derives annual shipment volumes through linear interpolation between the current and forecasted (Year 20) shipment volumes. Calculations take into account freight capacity by mode and shipment types, and adjusts volumes for either increasing or decreasing volume growth rates.

The model calculates an average growth rate for shipment volumes using the current year and Year 20 volumes provided by the user, and provides it as a calculated variable (as  $g_{vol}^m$ ) that can be replaced or overridden by the user.

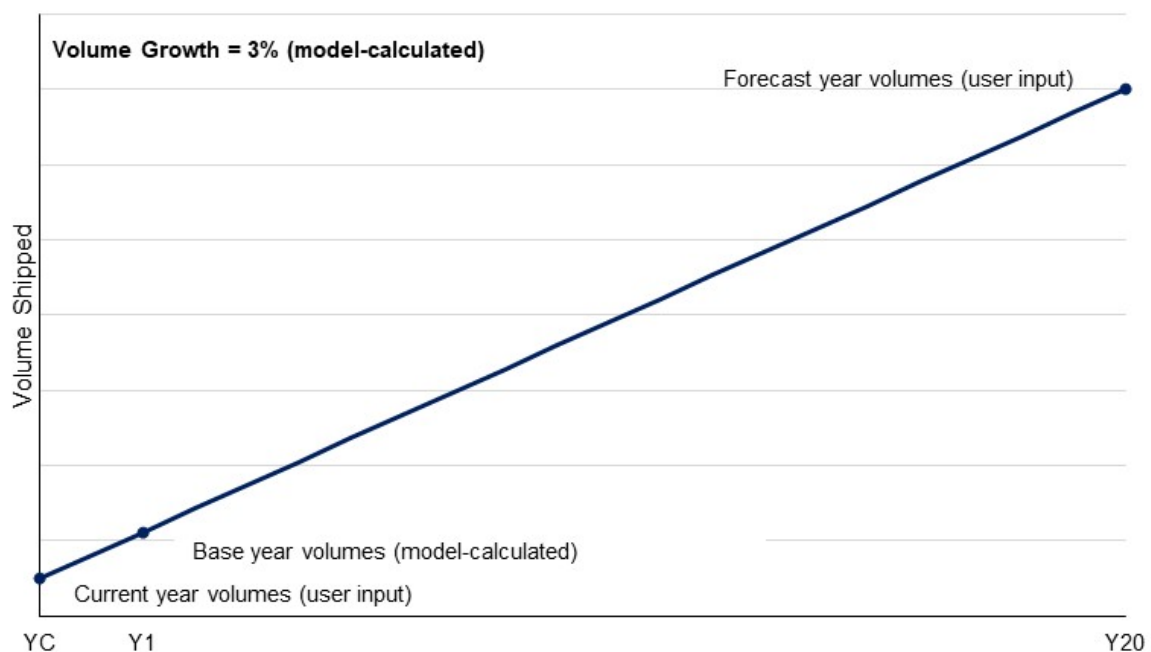
The functionality to replace the model-calculated growth rate allows the user to impose a more aggressive (higher magnitude) freight growth trajectory up to the limit defined by the forecast year volumes. Specifically, when the user enters a different growth rate, the model estimates an ‘unconstrained’ forecast year volume and uses linear interpolation to estimate the increase in

each year of the study period to that 'unconstrained' value. That said, overall volume is capped at the user-input forecast value, so once it reaches the forecasted value, freight volumes remain constant for the remainder of the study period.

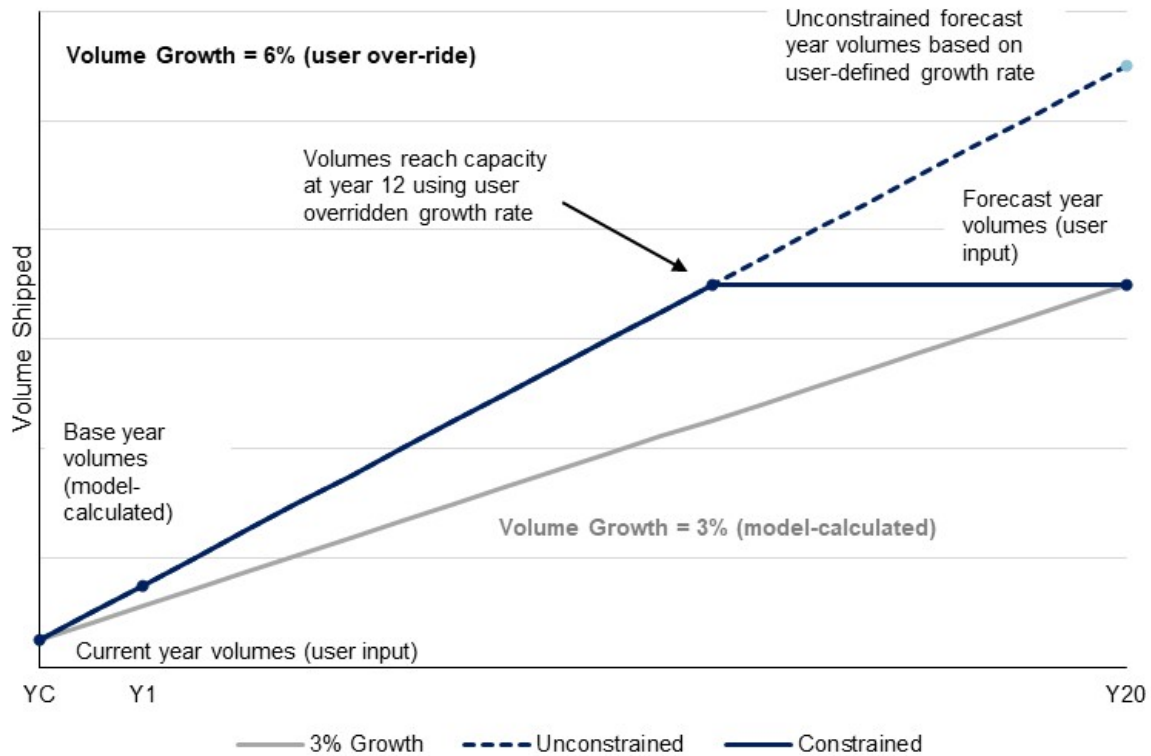
In other words, the forecast year volumes entered by the user can represent the actual volumes expected 20 years after the project opens, or they can be emulated to represent the maximum capacity of freight that would be influenced by the project. For instance, if the current year freight volumes are 1 million tons, and the forecast volume is 2 million tons due to general commodity flow growth, the model will interpolate this growth and display a model-calculated growth rate of 2%. If, on the other hand, the user were evaluating a facility that would increase freight throughput from 1 million tons to 2 million tons and volumes are expected to ramp up within the first few years at an approximate rate of 10%, the user could enter 2 million tons in the forecast year, and override the 2% growth rate with a rate of 10%. The model would then estimate an "unconstrained" forecast value (e.g., an unrealistic 6.7 million tons after 20 years) and begin to interpolate growth of 300 thousand tons of freight per year. At that rate, the user-input forecast value of 2 million tons would be reached in Year 4, at which point it would be capped and remain constant for the remainder of the study period.

At its core, overriding the growth rate allows the user to manipulate the rate at which project freight volumes ramp up to the future total. Exhibit 26 presents an example of the interpolated volumes using the model-calculated growth rates for shipment volumes. Exhibit 27 highlights the case where the growth rates are overridden by the user, with the grey line highlighting the original shipment volumes (as presented in Exhibit 26) prior to user adjustments of the growth rate.

**Exhibit 26: Standard Current Year / Forecast Year Inputs**



**Exhibit 27: Current Year / Forecast Year Inputs with Growth Rates Override by User**



### Volume Interpolation Calculation

The model interpolation calculations use an unconstrained projected freight volume based on the active growth rate, defined as:

$$ucFV_{20} = FV_C \cdot (1 + g_{vol})^{Y_{20} - Y_C}$$

Where:

- $ucFV_{20}$  is the total 'unconstrained' Year 20 volume
- $Y_{20}$  is the final year of the project lifecycle (i.e., year 20)
- $Y_C$  is the current year
- $FV_C$  is the total volume shipped in the current year (i.e.,  $FV_C = FV_C^T + FV_C^R$ )
- $g_{vol}$  is the growth rate for shipment volumes that follows a CAGR formula, defined as:

$$g_{vol} = \left( \frac{FV_{20}}{FV_C} \right)^{\frac{1}{Y_{20} - Y_C}} - 1$$

- $FV_{20}$  is the total forecasted final year volume (i.e.,  $FV_{20} = FV_{20}^T + FV_{20}^R$ ).

Then for a given mode, the annual increase in volume is calculated using the unconstrained final year volumes, project lifecycle duration, the fraction of final year volume transported by mode, and the Year 1 volume transported by mode. This can be expressed by the following formula:



$$AV_i^m = \left( ucFV_{20_i} \cdot \left( \frac{FV_{20_i}^m}{FV_{20_i}} \right) - FV_{1_i}^m \right) \cdot \frac{1}{Y_{20} - Y_1}$$

Where:

- $i$  denotes the shipment type (i.e., bulk/break bulk or container)
- $m$  is the transportation mode (i.e., freight truck or rail)
- $AV_i^m$  is the annual change in volume shipped by mode and shipment type
- $Y_1$  is the project opening year
- $FV_{1_i}^m$  is the volume shipped during the project opening year by mode and shipment type, which is calculated using:

$$FV_{1_i}^m = FV_C^m + \frac{\left( ucFV_{20_i} \cdot \frac{FV_{20_i}^m}{V_{20_i}} - FV_C^m \right)}{Y_{20} - Y_C} \cdot (Y_1 - Y_C)$$

- $FV_{20_i}^m$  is the forecasted final year volume transported by mode and shipment type

For each year between the project opening and the final year of the project lifecycle, the interpolated volume for each shipment type is determined by:

$$FV_t^m = \begin{cases} \text{if } g_{vol}^m > 0 & \text{Min}(FV_1^m + AV^m \cdot (t - Y_1), FV_{20}^m) \\ \text{if } g_{vol}^m < 0 & \text{Max}(FV_1^m + AV^m \cdot (t - Y_1), FV_{20}^m) \end{cases}$$

Where:

- $FV_t^m$  is the future volume in the  $t$  for mode  $m$
- $t$  is a year within the project lifecycle.

The calculated volumes, by mode, are then used to derive the number of trucks, trains, vehicle-miles, and ton-miles. The latter values required average distances traveled while the number of trucks and trains are calculated based capacity variables inputted by the model user.

While Cal-B/C IF allows the model to reach the volume restrictions prior to the final year of the project through growth rate manipulation, there is a special case where that does not hold true. In particular, the model cannot reach zero units prior to the final year.

## Other Interpolation Variables

Other variables interpolated within the model include annual average truck speeds as well as the annual proportion of volumes transloaded and drayed. The methodology used is simpler than the calculation performed for volume interpolation. In particular, the general concept is to derive a constant linear change using the values inputted by the user for the project opening year and the final year of the project lifecycle.

### ***Truck Speed Interpolation Calculation***

Average annual truck speeds are calculated as follows:

$$S_t = S_1 + \frac{S_{20} - S_1}{Y_{20} - Y_1} \cdot (t - Y_1)$$

Where:

- $S_t$  is the average truck speed in year  $t$
- $S_1$  is the average truck speed in the project opening year;  $S_{20}$  is the average truck speed in the final year of the project lifecycle

### ***Transload Volume Interpolation Calculation***

For each shipment type, the general method in calculating the annual proportion of volumes transloaded is as follows:

$$FT_t^m = FT_1^m + \frac{FT_{20}^m - FT_1^m}{Y_{20} - Y_1} \cdot (t - Y_1)$$

Where:

- $m$  is the transportation mode (i.e., truck or rail)
- $FT_t^m$  is the portion of volume that is transloaded in year  $t$
- $FT_1^m$  is the percentage of volumes transloaded in the project opening year;  $FT_{20}^m$  is the percentage of volumes transloaded in the final year of the project lifecycle.

### ***Drayage Volume Interpolation Calculation***

For each shipment type, an identical formula is used for the annual portion of volume drayed. Specially, the annual portion volume drayed follows:

$$FD_t^m = FD_1^m + \frac{FD_{20}^m - FD_1^m}{Y_{20} - Y_1} \cdot (t - Y_1)$$

Where:

- $m$  is the transportation mode (i.e., truck or rail)
- $FD_t^m$  is the portion of volume that is drayed in year  $t$
- $FD_1^m$  is the portion of volume drayed in the project opening year;  $FD_{20}^m$  is the portion of volume drayed in the final year of the project lifecycle.