Appendix F

Technical Memorandum #7

Evaluation of Alternatives

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Evaluation of Alternatives

Countywide Transit Plan

FINAL Technical Memorandum #7

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Alameda County Transportation Commission

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With

Cambridge Systematics
Community Design & Architecture
Strategic Economics

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Acronyms

Acronym/Abbreviation	Definition
ACE	Altamont Commuter Express
AC Transit	Alameda-Contra Costa Transit District
Alameda CTC	Alameda County Transportation Commission
BART	Bay Area Rapid Transit
GHG	Greenhouse Gases
HH	Households
MTC	Metropolitan Transportation Commission
SF	San Francisco
TOD	Transit-Oriented Development

1.0. Introduction

1.1. Study Process

This Technical Memorandum discusses the evaluation of transit alternatives and the development of short- and long-range investment strategies for Alameda County.

The purposes of this memorandum are as follows:

- Apply the updated countywide transportation model and elasticity based-model assessment tools as an initial assessment of the effectiveness of the transit investment strategies.
- Estimate ridership, vehicle miles and hours traveled, travel times, and mode shares for investments using the Alameda County Transportation Commission (CTC) updated travel demand model and/or other methodology developed in cooperation with Alameda CTC to effectively evaluate the proposed investments.
- Assess cost and financial feasibility based on qualitative measures identified in Task 6.

This evaluation builds on the transit vision and goals adopted by Alameda CTC in March 20151, which were applied to the draft recommendations and proposed network modifications.

Transit Vision and Goals

The performance measures for the Alameda Countywide Transit Plan are derived from the transit vision and goals documented in Technical Memorandum #3, which describes the linkage between the vision and goals for the Transit Plan and Alameda CTC's vision and goals from the 2012 Countywide Transportation Plan.

Transit Vision

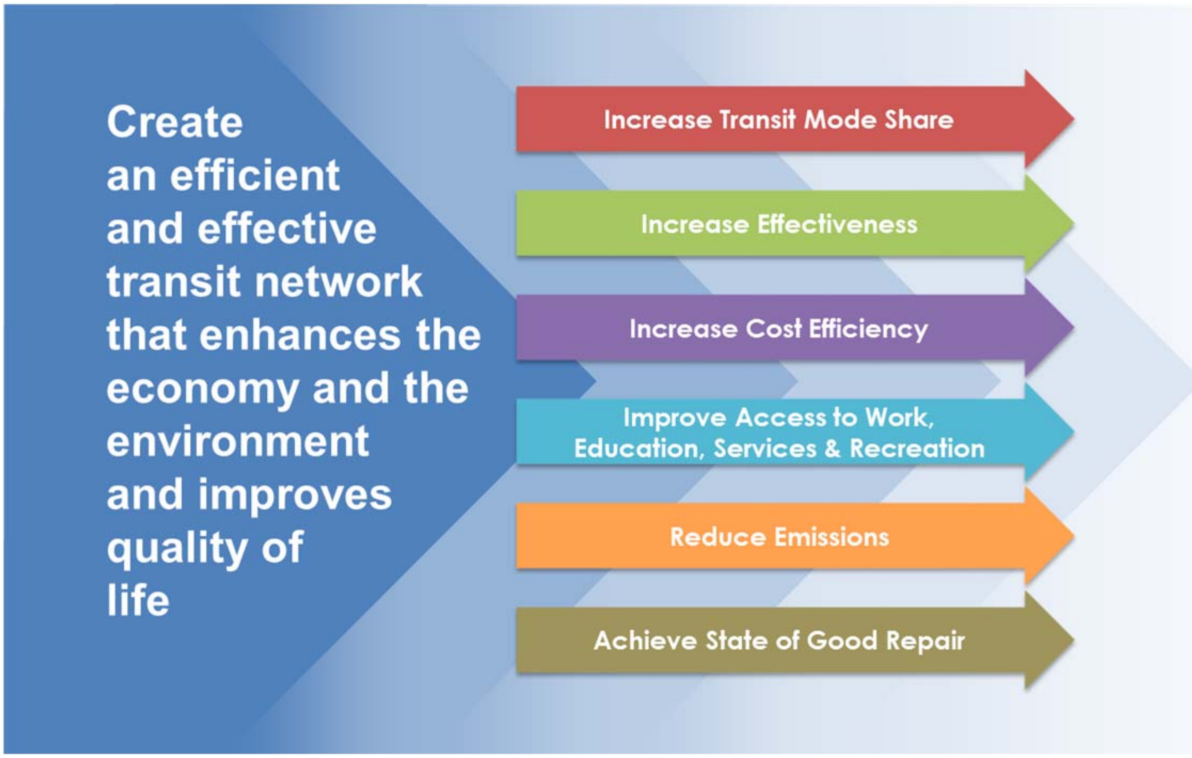
The adopted vision focuses on the challenge to improve transit network efficiency and effectiveness while providing environmental and economic benefits. The vision is as follows:

> *"Create an efficient and effective transit network that enhances the economy and the environment and improves the quality of life."*

A simple, focused vision sets the stage for an effective performance framework. The strategic goals define what the vision needs to accomplish through a set of separate, yet integrated, elements that support the vision.

Transit Goals

Based on the vision, and an understanding of the current conditions in the county, a set of six transit goals were identified:



1.2. Projects Included in Transit Network

For this planning effort, the Draft Transit Network Recommendations defined during creation of the network vision were developed through a strategic technical analysis based on a thorough review of existing conditions, existing plans and studies, a market and transit operational analysis, and an understanding of Alameda CTC's transit vision and goals. As a result, the evaluation of the transit vision network begins with a relatively limited set of Draft Transit Network Recommendations described in Technical Memorandum #5.[1]

The qualitative and quantitative performance measure evaluation, described in the remainder of this memorandum, represents a refined set of measures that were used to provide a more robust picture of the performance of the transit vision network as a whole and for individual draft recommendations. The focus of the evaluation was to provide information regarding the characteristics of each draft recommendation rather

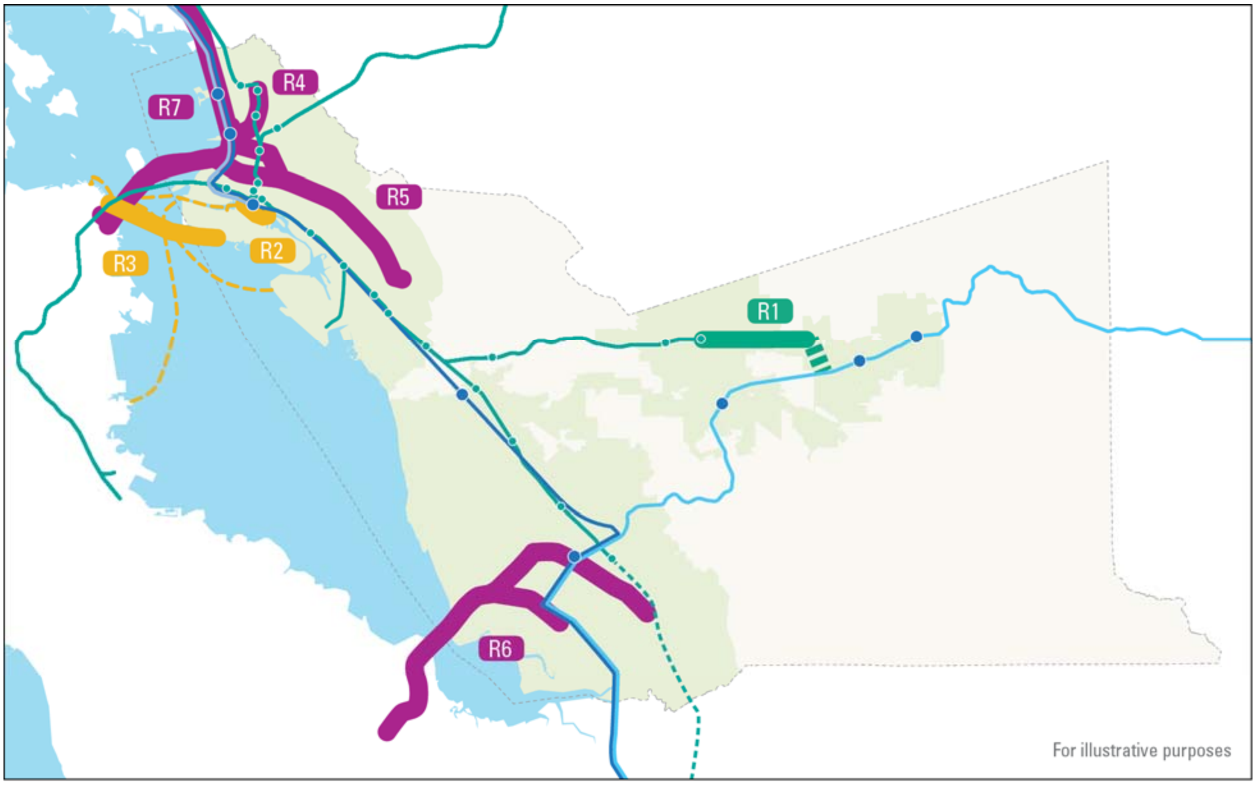
[1] See *Revised Draft Technical Memorandum #5: Transit Network Methodology*, Alameda Countywide Transit Plan, August 2015

than the development of a rank-ordered list of recommendations, as well as to evaluate how all the recommendations performed on a network level.

The following projects have been evaluated as part of Task 7 and are illustrated in Figures 1 and 2:

- Regional Express Tier
    - R1 Bay Area Rapid Transit (BART) Extension to Livermore/ Altamont Commuter Express (ACE)
    - R2 Brooklyn Basin – San Francisco (SF) Ferry Terminal
    - R3 Alameda – SF Ferry Terminal
    - R4 Berkeley – Emeryville – SF Transbay Transit Center
    - R5 Eastmont Transit Center – Downtown Oakland –SF Transbay Transit Center
    - R6 Tri-Cities – Palo Alto (with Southeast and Irvington extensions)
    - R7 – Emeryville – Berkeley – San Rafael
- Urban Rapid Tier
    - U1 Emeryville – Bay Fair BART Station
    - U2 Richmond – Jack London Square
    - U3 Berkeley – Alameda
    - U4 Berkeley – Fruitvale BART
    - U5 Bay Fair BART – Union City BART
    - U6 Bay Fair BART – Warm Springs BART (with Warm Springs extension)
    - U7 W. Dublin/Pleasanton BART – Livermore/ACE

Figure 1: Proposed Projects – Regional Express Tier



BART
- R1 BART Extension to Livermore/ACE

Ferry
- R2 Brooklyn Basin—SF Ferry Terminal
- R3 Alameda—SF Ferry Terminal

Express Bus
- R4 Berkeley—Emeryville—SF Transbay Transit Center
- R5 Eastmont Transit Center—Downtown Oakland—SF Transbay Transit Center
- R6 Tri-Cities—Palo Alto
- R7 Emeryville—Berkeley—San Rafael

Figure 2: Proposed Projects - Urban Rapid Tier

U1 Emeryville—Bay Fair BART Station
U2 Richmond—Jack London Square
U3 Berkeley—Alameda
U4 Berkeley—Fruitvale BART
U5 Bay Fair BART—Union City BART
U6 Bay Fair BART—Warm Springs BART
U7 W. Dublin/Pleasanton BART—Livermore/ACE

1.3. Network Alternatives

Task 5 generated a set of draft recommendations to help the county make progress toward achieving the transit vision and goals. These draft recommendations are collectively referred to as the transit vision network. The vision network was compared against existing conditions and a future baseline network that is consistent with the projects contained in the Metropolitan Transportation Commission's (MTC's) 2035 Regional Transportation Plan (Table 1).

Table 1: Network Alternatives

#	Network Alternatives	Year	Description
1	Existing Conditions	2010	2010 land use and transportation conditions per the updated Countywide Travel Demand Model
2	Baseline Conditions	2040	Consistent with MTC's Regional Transportation Plan
3	Vision	2040	Set of all improvements identified in the Countywide Transit Plan

Source: Parsons Brinckerhoff, 2015

2.0. Performance Evaluation

2.1. Performance Measures

The performance measures were developed in Task 6 to assess how the transit vision network and draft recommendations support implementation of the adopted transit vision and goals. These measures are described in more detail in *Technical Memorandum #6 Evaluation Methodology and Performance Measures*.

Performance measures apply to two types of evaluations:

- **Network:** This evaluation quantifies the anticipated benefits cumulatively resulting from the draft recommendations with respect to each identified goal. Performance measures were applied to the 2010 baseline as well as the 2040 vision network in order to gauge the relative effect of each network alternative.
- **Project:** This assessment considers the costs and benefits of both capital and operating activities associated with each draft recommendation or proposed project. General assumptions were made regarding capital and operating costs for each proposed network recommendation. (Projects that are already in the project development or environmental phase were not evaluated.) These cost assumptions were used only for comparative purposes and are intended to provide information that can be used in prioritizing and/or phasing of project implementation.
    - **Capital:** This evaluation will allow Alameda CTC to conduct a comparative assessment of capital projects with respect to each identified goal.
    - **Operations**: A significant portion of the county's funds will continue to support operations and maintenance of transit services. The operating performance varies significantly across transit operators. This evaluation

will allow Alameda CTC to evaluate operations practices of transit operators.

Both quantitative and qualitative performance measures have been identified for network and project evaluation. These are described below.

Quantitative Performance Measures

Quantitative performance measures for each goal are summarized in Table 2 and are described in the following section.

Table 2: Quantitative Performance Measures

<table>
<tr><th rowspan="2">#</th><th rowspan="2">Goals</th><th colspan="3">Performance Measures</th></tr>
<tr><th>Network-Level</th><th>Project-Level Capital</th><th>Project-Level Operating</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Increase transit mode share</td><td>Per capita daily transit ridership</td><td colspan="2">Net new riders</td></tr>
<tr><td>Percentage of intra-county passenger trips on transit</td><td></td><td></td></tr>
<tr><td rowspan="5">2</td><td rowspan="5">Increase effectiveness (including inter-regional travel)</td><td>Passenger trips per revenue vehicle mile</td><td></td><td>Passenger trips per revenue vehicle mile</td></tr>
<tr><td>Miles of dedicated right-of-way</td><td>Miles of dedicated right-of-way</td><td></td></tr>
<tr><td>Daily passenger trips (unlinked)</td><td colspan="2">Daily passenger trips (unlinked)</td></tr>
<tr><td></td><td>Reduction in transit travel time (peak/off-peak)</td><td></td></tr>
<tr><td></td><td>Number of transit hubs served, including inter-regional hubs</td><td></td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Increase cost efficiency</td><td></td><td>Capital cost per net new rider</td><td></td></tr>
<tr><td></td><td></td><td>Operating cost per passenger trip</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Improve access</td><td colspan="2">Number of households/jobs within one-half mile of transit stops</td><td></td></tr>
<tr><td colspan="2">Number of Communities of Concern affected</td><td></td></tr>
<tr><td>5</td><td>Reduce emissions</td><td>Greenhouse gas emissions</td><td></td><td></td></tr>
<tr><td>6</td><td>State of good repair</td><td></td><td>Asset lifecycle is considered in annualized capital cost estimates</td><td></td></tr>
</table>

Note: Performance measures shaded in gray are not applicable for this type of evaluation.
Source: Parsons Brinckerhoff, 2015

The definitions for the quantitative performance measures are as follows:

- **Per capita daily transit ridership**: This measure was used to compare transit usage normalized with population over time (2010 vs. 2040). For evaluation of networks, ridership and population data were taken from the travel demand estimation process. A combination of the Alameda County Travel Demand Model (ACTDM) and existing ridership data was used to estimate 2040 baseline ridership. Specifically, the model was used to forecast the growth in ridership on each network corridor and the growth factor was then applied to actual measured existing ridership. This method was applied to forecasts for all transit providers, and reported on the project level only.
- **Percentage of intra-county passenger trips on transit**: This measure was used to track progress toward increasing transit mode share for intra- county trips. For evaluation of networks, intra-county ridership data were taken from the travel demand estimation process.
- **Net new riders**: This measure was used to compare the ability of a project to attract new riders to transit. This measure was used for evaluation of projects only and uses estimates of net new riders from the travel demand estimate process.
- **Passenger trips per revenue vehicle mile**: This measure was used to assess the utilization and cost effectiveness of service for the vision network and between proposed projects. For both network and project evaluations, the passenger trips were derived from the ACTDM estimation process, while the revenue vehicle mile data were derived from proposed service levels.
- **Miles of dedicated right-of-way**: This measure is a proxy for the reliability of transit service under the assumption that exclusivity reduces schedule variability associated with intermittent general purpose traffic congestion. This metric is applied only for the project level and focused on ROW width assumptions to support transit. Implementation of any of the network recommendations will require close coordination with local jurisdictions to address ROW and traffic operational needs. . . . . .
- **Daily passenger trips**: This measure shows the passenger trips associated with each proposed transit project and is also aggregated to the network level.
- **Reduction in transit travel time**: Transit travel time improvements were estimated based on the type of physical changes proposed (e.g., bus lanes, queue jumps, Transit Signal Priority, off-board fare collection, raised platforms, etc.) for the corridor. This measure was applied at the project level.
- **Number of transit hubs served, including inter-regional hubs:** This measure shows the "interconnectivity" of a particular transit line. The transit hubs within approximately 300 feet of the project alignments in Alameda and Contra Costa counties were counted. Transit hubs include commuter rail stations, rapid rail stations, ferry terminals, municipal airports, transit centers, and park-and-ride lots.

- **Capital cost per net new rider**: This measure was applied at the network and project level. Capital costs were estimated from databases that have compiled costs for comparable types of improvements in Alameda County and in other regions. Costs were then annualized based on the life cycle for major elements within the cost estimate (e.g., roadway improvements, systems, vehicles). These costs are expressed in 2015 dollars.
- For the recommended projects, ridership forecasts were prepared for a future year baseline network and future year with the project with the difference between the two forecasts being the net new riders. These daily ridership forecasts were also annualized. Annualized capital cost estimates were then divided by annualized forecasts of ridership to yield cost per net new rider expressed in 2015 dollars.
- **Operating cost per passenger trip**: This measure was applied at the network and project level. Operating costs were estimated from current operating costs (2016) for comparable types of service in Alameda County and other regions. In order to calculate operating costs per rider, an annualization factor of 300 was used to convert daily ridership into annual which was then applied to annual operating costs. The ridership annualization factor takes into account variations ridership over time (e.g. weekday vs. weekend) for the types of transit services being proposed in the plan.
- **Total cost per passenger trip:** For this evaluation, total cost is defined as the annualized capital cost plus the annual operating cost based on service assumptions used in the ridership forecasting process.
- **Number of households and jobs within one-half mile of transit stops**: This measure provides useful information related to the potential market with proposed service changes. It was applied at the network and project levels. For the network level evaluation, households and jobs in Alameda and Contra Costa counties were calculated for 2010 and 2040. For the project level, the number of households and jobs in Alameda and Contra Costa counties were calculated based on the 2040 population and employment forecast. Transit stop locations are subject to change; therefore, the number of households and jobs were calculated within one-half mile of the transit alignments rather than one-half mile of transit stops.
- **Number of Communities of Concern affected:** This measure helps to establish whether the proposed modification could have a positive impact on Communities of Concern (i.e., those communities that face particular transportation challenges, either because of affordability, disability, or age-related or other mobility limitations) as defined by MTC. Data from MTC[2] was used to identify census tracts containing Communities of Concern in Alameda and Contra Costa counties.

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[2] Metropolitan Transportation Commission. 2014. Communities of Concern website and 2012 data table. *http://gis.mtc.ca.gov/samples/Interactive_Maps/cocs.html* Accessed Feb. 9, 2016

- **Greenhouse gas (GHG) emissions:** This measure was applied on the network level only and is generated based on output from the travel forecasting process. This measure is reported in metric tons of CO_2 per year.
- **Cost of mid-life overhaul and/or replacements before 2045:** In order to reflect the goal of state of good repair, asset lifecycle is considered in annualized capital cost estimates.

Qualitative Performance Measures

In addition to the quantitative measures listed above, the projects were also evaluated using a set of qualitative performance measures to capture those benefits that cannot be readily modeled or forecasted so as to provide a quantitative metric. Qualitative measures include the following:

- **Support transit-oriented development (TOD) strategy:** Linking transit investment with supportive land use patterns is critical to the success of transit. This performance measure assesses the characteristics of land uses adjacent to the proposed transit project to determine the potential for transit success. Key elements of this measure include density, mix of uses, pedestrian and bicycle access, and parking management policies.
- **Number of existing or planned major activity nodes served:** Major activity nodes with high levels of transit demand serve as anchors for transit routes. Proposed projects were evaluated in terms of how well they serve multiple existing or planned major activity nodes (including active Priority Development Areas and locally identified infill development areas near transit).
- **Intermodal connectivity**: Projects were evaluated in terms of how effectively they connect different types of transit services within the transit network. This was evaluated by assessing the number of transit service tiers served and the ease of access between different transit modes, including first- and last-mile connecting services.
- **Customer experience:** A qualitative assessment was made of each project's impact to the rider's experience based on factors such as service reliability, ease of transfers based on distance between stations, ease of access to transit information, and whether the proposed project has the potential to improve customer satisfaction.
- **Compatibility with Arterials Plan recommendations**: Coordination with Alameda CTC's Arterials Plan typologies will ensure consistency between both plans. The Arterials Plan is anticipated to be updated to reflect consistency with the Countywide Transit Plan.

3.0. Evaluation Results

Results from the evaluation of draft recommendations using quantitative and qualitative performance measures are presented in a matrix format. For each performance measure, results are presented on a three-point scale (low ○ medium ◑ and high ●).

3.1. Interpreting Evaluation Results

Evaluation results are presented at both the network and project levels. The intent of the evaluation is to provide a robust picture of the attributes and effects of each proposed project and the network as a whole on a consistent set of key measures that would assist Alameda CTC decision-making during future phases of program implementation.

Several factors should be considered when interpreting the evaluation results for both the network and project-specific summaries:

- Corridor length should be taken into account especially when considering demographic evaluation measures such as households and employment within one-half mile of transit stops.
- While the ACTDM includes all nine Bay Area counties, the geographic extent of the analysis is focused on Alameda and Contra Costa counties as this fostered a more efficient modeling effort. Results for households, jobs, communities of concern, and number of transit hubs highlight only these two counties.
- In the evaluation of proposed transit improvements, the focus can often fall onto a subset of the measures (e.g., net new riders or mode shift). However, it is important to also consider the positive impact of these projects to existing riders who will receive the benefits of travel time savings, reliability, and increased access to other transit facilities or job centers.

Notes on Project-Specific Ratings

Results for each evaluation measure were prepared for each of the proposed projects. The low, medium, and high ratings shown below in Table 3 are intended to facilitate the comparison between proposed projects. These ranges were developed using a relative scale which reflected the range of results witnessed for each measure, using a natural breaks method. The following table summarizes the ranges used to convert the results by measure into the low, medium, or high rating scale shown in the tables for each proposed project.

Table 3: Rating ranges used in project evaluation

Measure	Low	Medium	High
Net New Riders	0 - 5,000	5,000 - 10,000	>10,000
Passenger Trips per Revenue Vehicle Mile	0 - 5	6 - 20	> 20
Daily Passenger Trips	0 - 5,000	5,000 - 25,000	>25,000
Capital Cost per Net New Rider	>$30	$30 - $10	<$10
Operating Cost	>$10	$10 - $5	<$5
Total Cost per Passenger Trip	>$30	$30 - $10	<$10
Miles of Dedicated Right-of-Way (% of Total Length)	0 - 40%	40% - 70%	>70%
Reduction in Transit Travel Time	<10%	10% - 20%	>20%
Number of Transit Hubs Served	0 - 2	3 - 4	>4
Intermodal Connectivity	0 - 2	3	>3
Number of Households within One-Half Mile of Transit Stops	0 - 10,000	10,000 - 80,000	>80,000
Number of Jobs within One-Half Mile of Transit Stops	0 - 25,000	25,000 - 100,000	>100,000
Support TOD Strategy	Not Applicable		
Number of Communities of Concern Affected	0 - 4	5 - 30	>30
Number of Existing or Planned Major Activity Nodes Served	0 - 2	3	> 3
Customer Experience	Not Applicable		
Compatible with Arterials Plan	All Are Compatible		

Note: ranges apply to results presented in Figure 4 through Figure 19

3.2. Network Evaluation

The intent of presenting an evaluation of the proposed plan at the network level using the measures described above is to provide insight into the combined effect of implementing all the proposed projects on the entire transit network in Alameda County. For the network evaluation, a comparison was made among the Existing Conditions Network (2010) and the Vision Network (2040). Comparing these networks provides insight into the underlying growth in transit demand expected to occur over the next 25 years.

The Alameda CTC model's 2040 baseline condition represents planned land development, major service improvements planned as part of AC Transit's Service Expansion Plan, and transit and highway improvements reflected in the 2040 base scenario of the Alameda CTC model, consistent with Plan Bay Area. The Alameda CTC model includes all local transit improvements in Plan Bay Area in Alameda County as well as all major improvements on all region-serving transit operators. The Vision Network includes all elements of the Baseline Network plus the modifications for the individual projects discussed in Section 1.2.

A comparison of the key metrics for Existing Conditions (2010) and Vision Conditions (2040) shows a strong increase in transit demand with over 100% increase in daily passenger trips driven by increases in population, employment, and congestion, as discussed in detail in Technical Memorandum #2. The Vision Network responds to this increased demand for transit by providing key improvements to routes serving some of the most promising markets. The result is a network that provides travel time savings and service quality improvements to over 600,000 riders and also generates an additional 383,000 daily passenger trips when compared to the 2010 Existing Conditions. A summary of the network evaluation is shown in Figure 3.

Figure 3: Network evaluation results

		EXISTING CONDITIONS (2010)	VISION (2040)
	PER CAPITA DAILY TRANSIT RIDERSHIP	0.20	0.35
	PERCENTAGE OF INTRA-COUNTY TRIPS ON TRANSIT	4.8%	8.0%
	PASSENGER TRIPS PER REVENUE VEHICLE MILE	3.1	4.6
	DAILY PASSENGER TRIPS	305,000	688,000
	MILES OF NEW RIGHT-OF-WAY DEDICATED TO TRANSIT FOR VISION NETWORK	-	73.6* MILES
	NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS	648,000 HH / 813,000 JOBS	855,000 HH / 1,140,000 JOBS
	NUMBER OF COMMUNITIES OF CONCERN AFFECTED**	150	161
	GHG EMISSIONS (IN METRIC TONS PER YEAR)	5,572,000	4,232,000

* Depending on implementation, overlap in routes could potentially reduce total miles of dedicated right-of-way
** Assumes the same locations in the future

NOTE: All recommendations presented in this memo are intended to be a conceptual framework, and all routing and stop alignments will require further technical evaluation and public input.

3.3. Project Evaluation

Projects were not ranked for level of importance or for implementation priority in the evaluation process. Future actions will require consideration of project inter-relationships and funding opportunities and constraints that will also play a part in the selection of which projects are implemented and when. Instead, projects were evaluated based on the set of performance measures described in Section 2 to inform the plan development process.

Earlier technical memoranda have established a set of transit service tiers as an organizing structure that has been used to describe and categorize different types of existing and proposed changes to the transit system in Alameda County. The projects included in this evaluation come from two specific transit tiers due to the strong market analysis results that identified these tiers as those where Alameda County has the greatest potential to capture more transit market share: the Regional Express tier and the Urban Rapid tier. To inform future decisions regarding which of the proposed projects will be implemented and in what order, evaluation measures are presented for each project with ratings developed based on a comparison with all other proposed projects. A separate set of ratings is provided in Figures 20 and 21 at the end of this section with ratings based on a comparison of projects only within its respective tier. This second set of tier-specific ratings is provided to allow comparison of similar types of transit service. In particular, the nature of Regional Express type service with more point-to-point longer-distance trips tends to result in lower ridership than the Urban Rapid service tier.

Regional Express Tier

Project-specific evaluation summaries for the Regional Express tier are presented in Figures 4 through 10.

Figure 4: R1 evaluation results

REGIONAL EXPRESS TIER

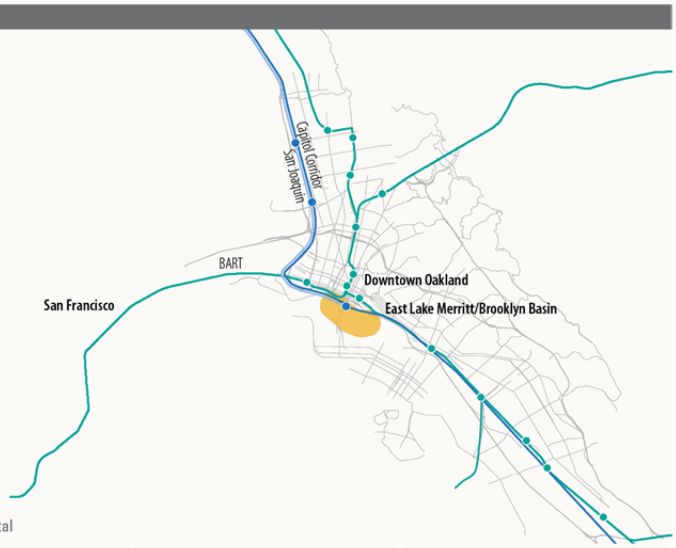
R1
BART Extension to Livermore/ACE

Measure	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS		
PASSENGER TRIPS PER REVENUE VEHICLE MILE		
DAILY PASSENGER TRIPS		
CAPITAL COST ($ MILLION)		
ANNUALIZED CAPITAL COST PER NET NEW RIDER		
OPERATING COST PER PASSENGER TRIP		
TOTAL COST PER PASSENGER TRIP		
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)		
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	NOT REPORTED. CURRENTLY UNDERGOING ENVIRONMENTAL REVIEW.	
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS		
INTERMODAL CONNECTIVITY		
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS		
SUPPORT TOD STRATEGY		
NUMBER OF COMMUNITIES OF CONCERN AFFECTED		
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED		
CUSTOMER EXPERIENCE		
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS		

Figure 5: R2 evaluation results

REGIONAL EXPRESS TIER

R2
Brooklyn Basin—SF Ferry Terminal



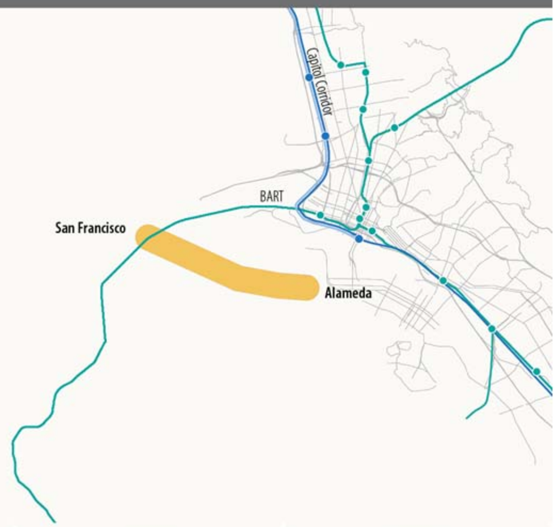
* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	1,800	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE	30	●
DAILY PASSENGER TRIPS	1,800	○
CAPITAL COST ($ MILLION)	$66	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$8	●
OPERATING COST PER PASSENGER TRIP	$7	◑
TOTAL COST PER PASSENGER TRIP**	$16	◑
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	100%	●
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	NO REDUCTION (NEW ROUTE)	UNRATED (NEW ROUTE)
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	1 HUB	○
INTERMODAL CONNECTIVITY***	3 MODES	◑
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	8,000 HH / 21,000 JOBS	○ / ○
SUPPORT TOD STRATEGY***	HIGH	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	7	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	1	○
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 6: R3 evaluation results

REGIONAL EXPRESS TIER

R3
Alameda—
SF Ferry Terminal



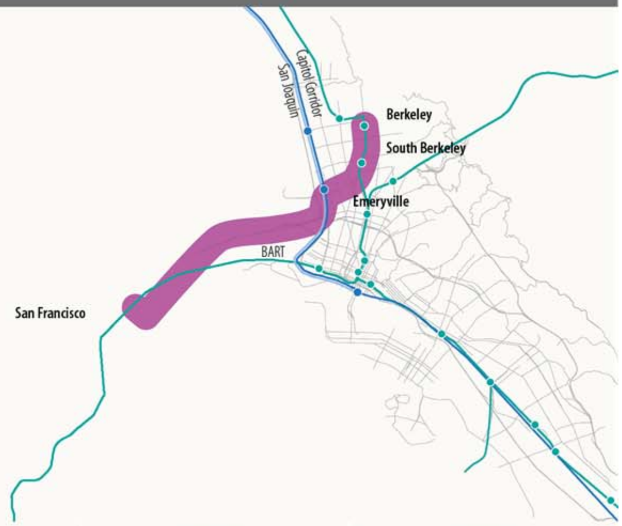
* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◐, HIGH ●)
DAILY NET NEW RIDERS	2,100	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE	47	●
DAILY PASSENGER TRIPS	6,000	◐
CAPITAL COST ($ MILLION)	$66	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$7	●
OPERATING COST PER PASSENGER TRIP	$2	●
TOTAL COST PER PASSENGER TRIP**	$5	●
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	100%	●
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	NO REDUCTION (NEW ROUTE)	UNRATED (NEW ROUTE)
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	0 HUBS	○
INTERMODAL CONNECTIVITY***	1 MODE	○
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	200 HH / 400 JOBS	○ / ○
SUPPORT TOD STRATEGY***	HIGH	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	0	○
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	1	○
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 7: R4 evaluation results

REGIONAL EXPRESS TIER

R4 Berkeley— Emeryville— SF Transbay Transit Center



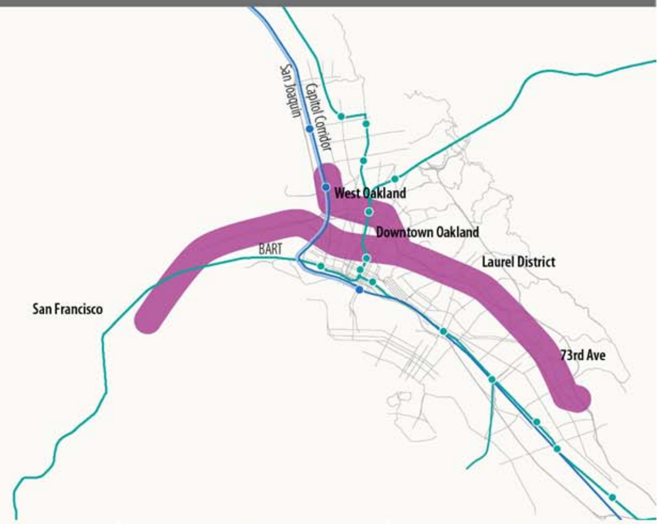
* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	2,200	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE	3	○
DAILY PASSENGER TRIPS	6,400	◑
CAPITAL COST ($ MILLION)	$151	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$11	●
OPERATING COST PER PASSENGER TRIP	$8	◑
TOTAL COST PER PASSENGER TRIP**	$12	◑
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	4 MILES (63% OF ROUTE NOT INCL. BAY BRIDGE)	◑
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-18% / -7%	◑
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	3 HUBS	◑
INTERMODAL CONNECTIVITY***	3 MODES	◑
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	41,000 HH / 73,000 JOBS	◑ / ◑
SUPPORT TOD STRATEGY***	HIGH	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	11	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	1	○
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 8: R5 evaluation results

REGIONAL EXPRESS TIER

R5 Eastmont Transit Center— Downtown Oakland— SF Transbay Transit Center



* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	9,800	◑
PASSENGER TRIPS PER REVENUE VEHICLE MILE	17	◑
DAILY PASSENGER TRIPS	34,300	●
CAPITAL COST ($ MILLION)	$319	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$5	●
OPERATING COST PER PASSENGER TRIP	$1	●
TOTAL COST PER PASSENGER TRIP**	$3	●
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	8.4 MILES (61%)	◑
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-32% / -21%	●
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	3 HUBS	◑
INTERMODAL CONNECTIVITY***	4 MODES	●
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	105,000 HH / 163,000 JOBS	● / ●
SUPPORT TOD STRATEGY***	HIGH	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	49	●
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	7	●
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 9: R6 evaluation results

REGIONAL EXPRESS TIER

R6 Tri-Cities— Palo Alto

* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

Measure	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	1,400	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE	1	○
DAILY PASSENGER TRIPS	4,600	◑
CAPITAL COST ($ MILLION)	$337	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$28	◑
OPERATING COST PER PASSENGER TRIP	$9	◑
TOTAL COST PER PASSENGER TRIP**	$17	◑
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	13.1 MILES (47%)	◑
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-10% PEAK	◑
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	0 HUBS	○
INTERMODAL CONNECTIVITY***	3 MODES	◑
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	37,000 HH / 44,000 JOBS	◑ / ◑
SUPPORT TOD STRATEGY***	MEDIUM	◑
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	5	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	0	○
CUSTOMER EXPERIENCE	MODERATE IMPROVEMENT	◑
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 10: R7 evaluation results

REGIONAL EXPRESS TIER

R7 Emeryville—Berkeley—San Rafael

* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

Measure	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	230	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE	1	○
DAILY PASSENGER TRIPS	460	○
CAPITAL COST ($ MILLION)	$70	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$44	○
OPERATING COST PER PASSENGER TRIP	$25	○
TOTAL COST PER PASSENGER TRIP**	$47	○
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	2.5 MILES (13%)	○
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-1% PEAK	○
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	3 HUBS	◑
INTERMODAL CONNECTIVITY***	3 MODES	◑
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	51,000 HH / 70,000 JOBS	◑ / ◑
SUPPORT TOD STRATEGY***	HIGH	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	15	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	1	○
CUSTOMER EXPERIENCE	MODERATE IMPROVEMENT	◑
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

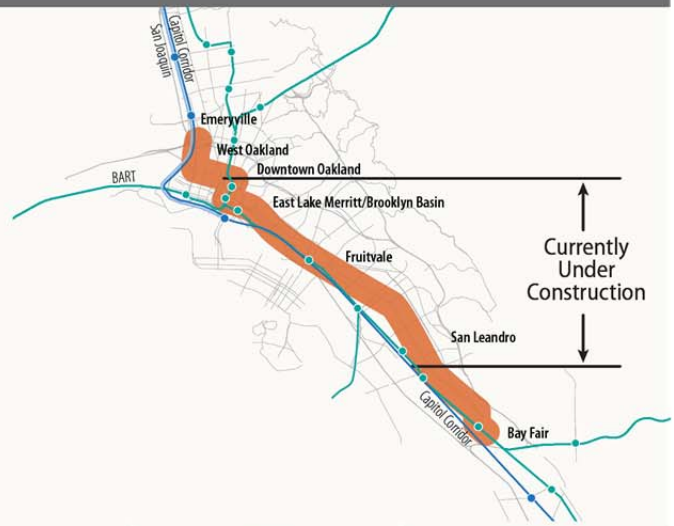
Urban Rapid Tier

Project-specific evaluation summaries for the Urban Rapid tier are presented in Figures 11 through 17.

Figure 11: U1 evaluation results

URBAN RAPID TIER

U1 Emeryville— Bay Fair BART Station



* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

Measure	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	18,700	●
PASSENGER TRIPS PER REVENUE VEHICLE MILE	13	◑
DAILY PASSENGER TRIPS	44,400	●
CAPITAL COST ($ MILLION)	$89	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$1	●
OPERATING COST PER PASSENGER TRIP	$1	●
TOTAL COST PER PASSENGER TRIP**	$2	●
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	2.8 MILES (60% OF ROUTE NOT CURRENTLY UNDER CONSTRUCTION)	◑
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-14% / -5%	◑
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	5 HUBS	●
INTERMODAL CONNECTIVITY***	2 MODES	○
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	108,000 HH / 195,000 JOBS	● / ●
SUPPORT TOD STRATEGY***	HIGH	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	60	●
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	7	●
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 12: U2 evaluation results

URBAN RAPID TIER

U2 Richmond—Jack London Square

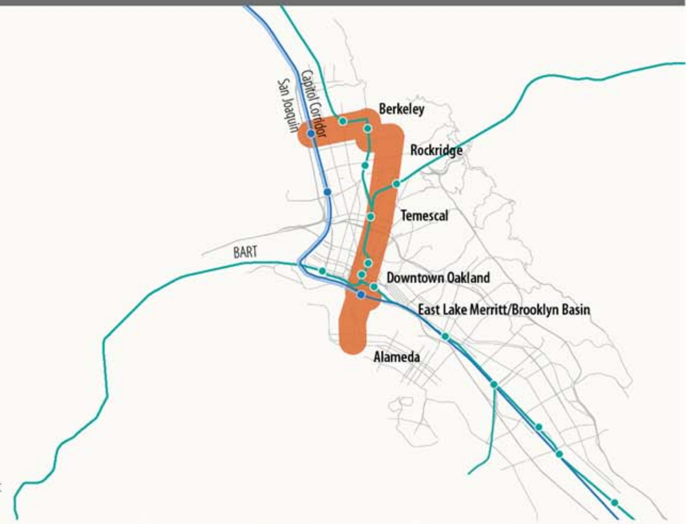
* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	16,100	●
PASSENGER TRIPS PER REVENUE VEHICLE MILE	12	◑
DAILY PASSENGER TRIPS	43,600	●
CAPITAL COST ($ MILLION)	$357	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$4	●
OPERATING COST PER PASSENGER TRIP	$1	●
TOTAL COST PER PASSENGER TRIP**	$3	●
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	10.6 MILES (66%)	◑
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-47% / -25%	●
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	7 HUBS	●
INTERMODAL CONNECTIVITY***	5 MODES	●
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	110,000 HH / 218,000 JOBS	● / ●
SUPPORT TOD STRATEGY***	LOW	○
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	45	●
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	5	●
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 13: U3 evaluation results

URBAN RAPID TIER

U3 Berkeley—Alameda



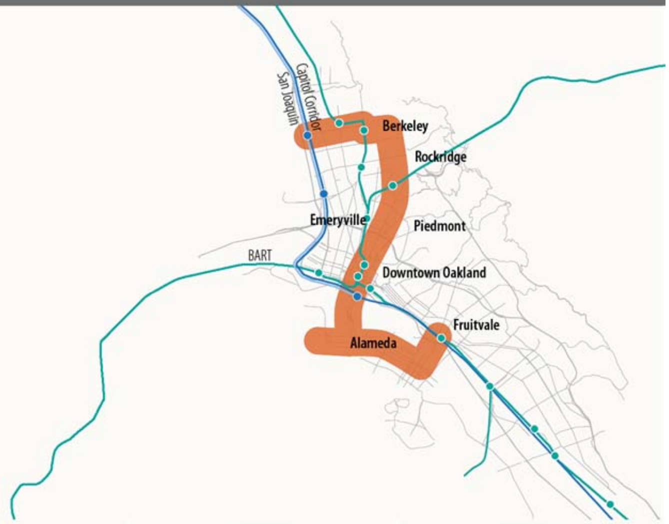
* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	21,900	●
PASSENGER TRIPS PER REVENUE VEHICLE MILE	22	●
DAILY PASSENGER TRIPS	35,600	●
CAPITAL COST ($ MILLION)	$170	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$1	●
OPERATING COST PER PASSENGER TRIP	$1	●
TOTAL COST PER PASSENGER TRIP**	$2	●
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	4.9 MILES (70%)	◑
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-38% / -28%	●
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	3 HUBS	◑
INTERMODAL CONNECTIVITY***	4 MODES	●
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	86,000 HH / 218,000 JOBS	● / ●
SUPPORT TOD STRATEGY***	MEDIUM	◑
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	24	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	4	●
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 14: U4 evaluation results

URBAN RAPID TIER

U4 Berkeley— Fruitvale BART



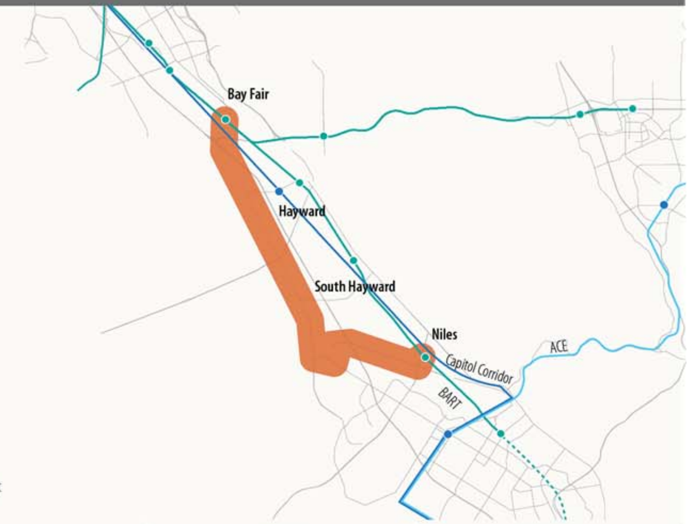
* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	8,900	◑
PASSENGER TRIPS PER REVENUE VEHICLE MILE	13	◑
DAILY PASSENGER TRIPS	38,300	●
CAPITAL COST ($ MILLION)	$141	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$3	●
OPERATING COST PER PASSENGER TRIP	$1	●
TOTAL COST PER PASSENGER TRIP**	$2	●
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	0 MILES (0%)	○
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-17% / -18%	◑
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	6 HUBS	●
INTERMODAL CONNECTIVITY***	4 MODES	●
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	112,000 HH / 245,000 JOBS	● / ●
SUPPORT TOD STRATEGY***	HIGH	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	27	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	4	●
CUSTOMER EXPERIENCE	MODERATE IMPROVEMENT	◑
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 15: U5 evaluation results

URBAN RAPID TIER

U5
Bay Fair BART—Union City BART



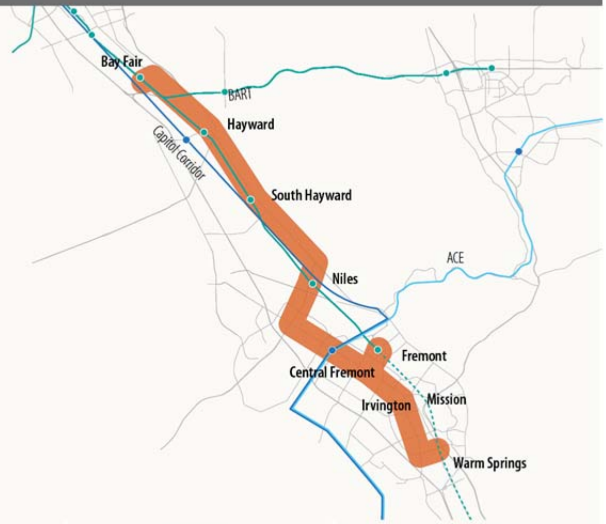
* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	2,600	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE	7	◑
DAILY PASSENGER TRIPS	9,300	◑
CAPITAL COST ($ MILLION)	$89	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$6	●
OPERATING COST PER PASSENGER TRIP	$5	●
TOTAL COST PER PASSENGER TRIP**	$6	●
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	0 MILES (0%)	○
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-22% / -28%	●
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	2 HUBS	○
INTERMODAL CONNECTIVITY***	5 MODES	●
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	37,000 HH / 43,000 JOBS	◑ / ◑
SUPPORT TOD STRATEGY***	HIGH	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	12	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	1	○
CUSTOMER EXPERIENCE	MODERATE IMPROVEMENT	◑
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

Figure 16: U6 evaluation results

URBAN RAPID TIER

U6
Bay Fair BART—Warm Springs BART



	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	14,300	●
PASSENGER TRIPS PER REVENUE VEHICLE MILE	6	◑
DAILY PASSENGER TRIPS	20,700	◑
CAPITAL COST ($ MILLION)	$393	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$4	●
OPERATING COST PER PASSENGER TRIP	$3	●
TOTAL COST PER PASSENGER TRIP**	$6	●
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	16 MILES (100%)	●
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-48% / -34%	●
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	6 HUBS	●
INTERMODAL CONNECTIVITY***	3 MODES	◑
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	84,000 HH / 83,000 JOBS	● / ◑
SUPPORT TOD STRATEGY***	MEDIUM	◑
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	19	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	3	◑
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

Figure 17: U7 evaluation results

URBAN RAPID TIER

U7 W. Dublin/ Pleasanton BART— Livermore/ACE

* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

	RESULT (2040 VISION)	RATING (LOW ○, MEDIUM ◑, HIGH ●)
DAILY NET NEW RIDERS	900	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE	4	○
DAILY PASSENGER TRIPS	4,000	◑
CAPITAL COST ($ MILLION)	$372	UNRATED
ANNUALIZED* CAPITAL COST PER NET NEW RIDER	$71	○
OPERATING COST PER PASSENGER TRIP	$5	●
TOTAL COST PER PASSENGER TRIP**	$20	◑
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	11.3 MILES (86%)	●
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	-13% PEAK	◑
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***	2 HUBS	○
INTERMODAL CONNECTIVITY***	4 MODES	●
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***	27,000 HH / 69,000 JOBS	◑ / ◑
SUPPORT TOD STRATEGY***	LOW	○
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***	0	○
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	3	◑
CUSTOMER EXPERIENCE	SUBSTANTIAL IMPROVEMENT	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	COMPATIBLE	●

3.4. Summary evaluation and comparison of projects

Figures 18 and 19 provide a comparison of the results of the project performance measures and the ratings of projects by measure when compared against all other proposed projects. Figure 18 in particular provides a wealth of information that facilitates comparison of individual projects against others and provides insight into characteristics of groups of projects. The following are some general findings based on a review of the summary evaluation:

- Capital costs range from a low of $66 million for the ferry projects to a high of $392 million for U6 Bay Fair BART – Warm Springs BART, a 16-mile-long dedicated busway.
- Operating costs per passenger trip are generally below $10/passenger trip, with the exception of R7 (Emeryville-Berkeley-San Rafael), which is estimated at $25/passenger trip primarily due to low estimated ridership.
- The net new riders measure varies dramatically from a low of 230 daily new riders for R7 (Emeryville-Berkeley-San Rafael) to a high of 21,900 daily new riders for U3 (Berkeley-Alameda).
- Although they are generally correlated, the ability to generate net new riders does not always correspond to total daily ridership. For example, U3 (Berkeley-Alameda) generates 21,900 net new daily riders and 35,600 daily passenger trips. U4 (Berkeley-Fruitvale BART) generates far fewer new riders (8,900 net new riders) but has higher overall ridership at 38,300 daily passenger trips.
- All projects, with the exception of R7, provide significant efficiency improvements with travel time reductions ranging from 10% to 48%. These travel time savings represent significant benefits to both existing and new riders that should be considered when evaluating projects.
- Generally, projects with more dedicated right-of-way for transit tend to provide greater reduction in travel time. However, even projects without dedicated transit lanes (U4 and U5, for example) generate significant travel time savings (17% and 22%, respectively) through the implementation of other transit operational improvements.
- Capital cost per net new rider varies from a low of $1 for U1 (Emeryville-Bay Fair BART) to a high of $71 for U7 (W. Dublin/Pleasanton BART-Livermore).
- The three projects with the lowest estimated net new riders (R6, R7, and U7) also have the highest costs per net new rider at $28, $44, and $71 respectively.

Figure 18: Summary of evaluation results, all projects

	R1 BART EXTENSION TO LIVERMORE/ACE	R2 BROOKLYN BASIN—SF FERRY TERMINAL	R3 ALAMEDA—SF FERRY TERMINAL	R4 BERKELEY—EMERYVILLE—SF TRANSBAY TRANSIT CENTER	R5 EASTMONT TRANSIT CENTER—DOWNTOWN OAKLAND—SF TRANSBAY TRANSIT CENTER	R6 TRI-CITIES—PALO ALTO	R7 EMERYVILLE—BERKELEY—SAN RAFAEL	U1 EMERYVILLE—BAY FAIR BART STATION	U2 RICHMOND—JACK LONDON SQUARE	U3 BERKELEY—ALAMEDA	U4 BERKELEY—FRUITVALE BART	U5 BAY FAIR BART—UNION CITY BART	U6 BAY FAIR BART—WARM SPRINGS BART	U7 W. DUBLIN/PLEASANTON BART—LIVERMORE/ACE
DAILY NET NEW RIDERS	NOT REPORTED. CURRENTLY UNDERGOING ENVIRONMENTAL REVIEW.	1,800	2,100	2,200	9,800	1,400	230	18,700	16,100	21,900	8,900	2,600	14,300	900
PASSENGER TRIPS PER REVENUE VEHICLE MILE		30	47	3	17	1	1	13	12	22	13	7	6	4
DAILY PASSENGER TRIPS		1,800	6,000	6,400	34,300	4,600	460	44,400	43,600	35,600	38,300	9,300	20,700	4,000
CAPITAL COST ($ MILLION)		$66	$66	$151	$319	$337	$70	$89	$357	$170	$141	$89	$393	$372
ANNUALIZED* CAPITAL COST PER NET NEW RIDER		$8	$7	$11	$5	$28	$44	$1	$4	$1	$3	$6	$4	$71
OPERATING COST PER PASSENGER TRIP		$7	$2	$8	$1	$9	$25	$1	$1	$1	$1	$5	$3	$5
TOTAL COST PER PASSENGER TRIP**		$16	$5	$12	$3	$17	$47	$2	$3	$2	$2	$6	$6	$20
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)		100%	100%	4 MILES (63% OF ROUTE NOT INCL. BAY BRIDGE)	8.4 MILES (61%)	13.1 MILES (47%)	2.5 MILES (13%)	2.8 MILES (60% OF ROUTE NOT CURRENTLY UNDER CONSTRUCTION)	10.6 MILES (66%)	4.9 MILES (70%)	0 MILES (0%)	0 MILES (0%)	16 MILES (100%)	11.3 MILES (86%)
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)		NO REDUCTION (NEW ROUTE)	NO REDUCTION (NEW ROUTE)	-18% / -7%	-32% / -21%	-10% PEAK	-1% PEAK	-14% / -5%	-47% / -25%	-38% / -28%	-17% / -18%	-22% / -28%	-48% / -34%	-13% PEAK
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS***		1 HUB	0 HUBS	3 HUBS	3 HUBS	0 HUBS	3 HUBS	5 HUBS	7 HUBS	3 HUBS	6 HUBS	2 HUBS	6 HUBS	2 HUBS
INTERMODAL CONNECTIVITY***		3 MODES	1 MODE	3 MODES	4 MODES	3 MODES	3 MODES	2 MODES	5 MODES	4 MODES	4 MODES	5 MODES	3 MODES	4 MODES
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS***		8,000 HH / 21,000 JOBS	200 HH / 400 JOBS	41,000 HH / 73,000 JOBS	105,000 HH / 163,000 JOBS	37,000 HH / 44,000 JOBS	51,000 HH / 70,000 JOBS	108,000 HH / 195,000 JOBS	110,000 HH / 218,000 JOBS	86,000 HH / 218,000 JOBS	112,000 HH / 245,000 JOBS	37,000 HH / 43,000 JOBS	84,000 HH / 83,000 JOBS	27,000 HH / 69,000 JOBS
SUPPORT TOD STRATEGY***		HIGH	HIGH	HIGH	HIGH	MEDIUM	HIGH	HIGH	LOW	MEDIUM	HIGH	HIGH	MEDIUM	LOW
NUMBER OF COMMUNITIES OF CONCERN AFFECTED***		7	0	11	49	5	15	60	45	24	27	12	19	0
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED		1	1	1	7	0	1	7	5	4	4	1	3	3
CUSTOMER EXPERIENCE		SUBSTANTIAL IMPROVEMENT	SUBSTANTIAL IMPROVEMENT	SUBSTANTIAL IMPROVEMENT	SUBSTANTIAL IMPROVEMENT	MODERATE IMPROVEMENT	MODERATE IMPROVEMENT	SUBSTANTIAL IMPROVEMENT	SUBSTANTIAL IMPROVEMENT	SUBSTANTIAL IMPROVEMENT	MODERATE IMPROVEMENT	MODERATE IMPROVEMENT	SUBSTANTIAL IMPROVEMENT	SUBSTANTIAL IMPROVEMENT
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS		COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE	COMPATIBLE

* Annualized capital cost based on life cycle of asset
** Based on annual operating cost plus annualized capital cost per annual riders
*** Evaluation includes Alameda and Contra Costa counties only

Figure 19: Summary of evaluation ratings, comparing all projects

	R1 BART EXTENSION TO LIVERMORE/ACE	R2 BROOKLYN BASIN—SF FERRY TERMINAL	R3 ALAMEDA—SF FERRY TERMINAL	R4 BERKELEY—EMERYVILLE—SF TRANSBAY TRANSIT CENTER	R5 EASTMONT TRANSIT CENTER—DOWNTOWN OAKLAND—SF TRANSBAY TRANSIT CENTER	R6 TRI-CITIES—PALO ALTO	R7 EMERYVILLE—BERKELEY—SAN RAFAEL	U1 EMERYVILLE—BAY FAIR BART STATION	U2 RICHMOND—JACK LONDON SQUARE	U3 BERKELEY—ALAMEDA	U4 BERKELEY—FRUITVALE BART	U5 BAY FAIR BART—UNION CITY BART	U6 BAY FAIR BART—WARM SPRINGS BART	U7 W. DUBLIN/PLEASANTON BART—LIVERMORE/ACE
DAILY NET NEW RIDERS	NOT REPORTED. CURRENTLY UNDERGOING ENVIRONMENTAL REVIEW.	○	○	○	◑	○	○	●	●	●	◑	○	●	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE		●	●	○	◑	○	○	◑	◑	●	◑	◑	◑	○
DAILY PASSENGER TRIPS		○	◑	◑	●	◑	○	●	●	●	●	◑	◑	◑
CAPITAL COST		UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED
ANNUALIZED CAPITAL COST PER NET NEW RIDER		●	●	●	●	◑	○	●	●	●	●	●	●	○
OPERATING COST PER PASSENGER TRIP		◑	●	◑	●	◑	○	●	●	●	●	●	●	●
TOTAL COST PER PASSENGER TRIP		◑	●	◑	●	◑	○	●	●	●	●	●	●	◑
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)		●	●	◑	◑	◑	○	◑	◑	◑	○	○	●	●
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)		UNRATED (NEW ROUTE)	UNRATED (NEW ROUTE)	◑	●	◑	○	◑	●	●	◑	●	●	◑
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS		○	○	◑	◑	○	◑	●	●	◑	●	○	●	○
INTERMODAL CONNECTIVITY		◑	○	◑	●	◑	◑	○	●	●	●	●	◑	●
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS		○ / ○	○ / ○	◑ / ◑	● / ●	◑ / ◑	◑ / ◑	● / ●	● / ●	● / ●	● / ●	◑ / ◑	● / ◑	◑ / ◑
SUPPORT TOD STRATEGY		●	●	●	●	◑	●	●	○	◑	●	●	◑	○
NUMBER OF COMMUNITIES OF CONCERN AFFECTED		◑	○	◑	●	◑	◑	●	●	◑	◑	◑	◑	○
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED		○	○	○	●	○	○	●	●	●	●	○	◑	◑
CUSTOMER EXPERIENCE		●	●	●	●	◑	◑	●	●	●	◑	◑	●	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS		●	●	●	●	●	●	●	●	●	●	●	●	●

PERFORMANCE RATING
LOW ○ MEDIUM ◑ HIGH ●

Secondary comparison of projects relative to respective tiers

In this section project ratings of low, medium, and high values were assigned based on a rating scale developed specifically for each tier, using a similar natural breaks method that was used when comparing all projects. Note, the Regional Express tier and the Urban Rapid tier present some challenges for interpretation of the comparisons between the projects, which related to large differences in scale for the types of projects recommended. The Regional Express Tier contains two ferry projects that are very unique in their operating characteristics, and R5, which contains characteristics of both the Urban Rapid tier and the Regional Express tier. The differences between the tiers and projects present challenges to comparisons, but the analysis still determined it is relevant to compare projects within (in addition to across) tiers.

In general, the tier-specific ratings shifted some of the ratings, but the relative patterns did not vary dramatically. Examples of specific changes are the improvement of R5 from a medium score for Daily Net New Riders to a high score, and R2, R3, R4, and R6 from a low rating to a medium. Another example of a ratings change resulting from the tier-specific comparison are projects U4, U5, and U6, which change from all high ratings when compared to all projects for the operating cost per passenger trip but were only rated as low, medium, and low, respectively, when compared only against Urban Rapid tier projects.

Figure 20: Summary of Regional Express ratings relative to project tier

	R1 BART EXTENSION TO LIVERMORE/ACE	R2 BROOKLYN BASIN—SF FERRY TERMINAL	R3 ALAMEDA—SF FERRY TERMINAL	R4 BERKELEY—EMERYVILLE—SF TRANSBAY TRANSIT CENTER	R5 EASTMONT TRANSIT CENTER—DOWNTOWN OAKLAND—SF TRANSBAY TRANSIT CENTER	R6 TRI-CITIES—PALO ALTO	R7 EMERYVILLE—BERKELEY—SAN RAFAEL
DAILY NET NEW RIDERS	NOT REPORTED. CURRENTLY UNDERGOING ENVIRONMENTAL REVIEW.	◑	◑	◑	●	◑	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE		●	◑	○	◑	○	○
DAILY PASSENGER TRIPS		○	◑	◑	●	◑	○
CAPITAL COST		UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED
ANNUALIZED CAPITAL COST PER NET NEW RIDER		●	●	◑	●	○	○
OPERATING COST PER PASSENGER TRIP		◑	●	◑	●	◑	○
TOTAL COST PER PASSENGER TRIP		◑	●	◑	●	◑	○
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)		●	●	◑	◑	◑	○
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)		UNRATED (NEW ROUTE)	UNRATED (NEW ROUTE)	◑	●	◑	○
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS		◑	○	●	●	○	●
INTERMODAL CONNECTIVITY		◑	○	◑	●	◑	◑
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS		○ / ◑	○ / ○	◑ / ◑	● / ●	◑ / ◑	◑ / ◑
SUPPORT TOD STRATEGY		●	●	●	●	◑	●
NUMBER OF COMMUNITIES OF CONCERN AFFECTED		◑	○	◑	●	◑	◑
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED		○	○	○	●	○	○
CUSTOMER EXPERIENCE		●	●	●	●	◑	◑
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS		●	●	●	●	●	●

PERFORMANCE RATING
LOW ○ MEDIUM ◑ HIGH ●

Figure 21: Summary of Urban Rapid ratings relative to project tier

	U1 EMERYVILLE—BAY FAIR BART STATION	U2 RICHMOND—JACK LONDON SQUARE	U3 BERKELEY—ALAMEDA	U4 BERKELEY—FRUITVALE BART	U5 BAY FAIR BART—UNION CITY BART	U6 BAY FAIR BART—WARM SPRINGS BART	U7 W. DUBLIN/ PLEASANTON BART—LIVERMORE/ ACE
DAILY NET NEW RIDERS	●	●	●	◑	○	●	○
PASSENGER TRIPS PER REVENUE VEHICLE MILE	◑	◑	●	◑	○	○	○
DAILY PASSENGER TRIPS	●	●	●	●	○	◑	○
CAPITAL COST	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED	UNRATED
ANNUALIZED CAPITAL COST PER NET NEW RIDER	●	●	●	●	●	●	○
OPERATING COST PER PASSENGER TRIP	●	●	●	●	○	◑	○
TOTAL COST PER PASSENGER TRIP	●	●	●	●	◑	◑	○
MILES OF RIGHT-OF-WAY DEDICATED TO TRANSIT (% OF TOTAL CORRIDOR LENGTH)	◑	◑	◑	○	○	●	●
REDUCTION IN TRANSIT TRAVEL TIME (PEAK/OFF-PEAK)	○	●	●	◑	◑	●	○
NUMBER OF TRANSIT HUBS SERVED, INCLUDING INTER-REGIONAL HUBS	◑	●	◑	●	○	◑	○
INTERMODAL CONNECTIVITY	○	●	●	●	●	◑	●
NUMBER OF HH/JOBS WITHIN HALF-MILE OF TRANSIT STOPS	● / ◑	● / ●	◑ / ●	● / ●	○ / ○	◑ / ○	○ / ○
SUPPORT TOD STRATEGY	●	○	◑	●	●	◑	○
NUMBER OF COMMUNITIES OF CONCERN AFFECTED	●	●	◑	◑	◑	◑	○
NUMBER OF EXISTING OR PLANNED MAJOR ACTIVITY NODES SERVED	●	●	●	●	○	◑	◑
CUSTOMER EXPERIENCE	●	●	●	◑	◑	●	●
COMPATIBILITY WITH ARTERIALS PLAN RECOMMENDATIONS	●	●	●	●	●	●	●

PERFORMANCE RATING
LOW ○ MEDIUM ◑ HIGH ●

Attachment A – Technical Notes

Notes on Analysis for Selected Measures

Attachment A provides additional detail regarding the methods used to calculate and summarize the selected performance measures for the proposed projects.

Measures:

- Number of households and jobs within one-half mile of transit stops
- Number of Communities of Concern affected
- Number of transit hubs served

Analysis Notes:

GIS software was used to compute statistics for each potential project to assess the number of households, jobs, Communities of Concern, and transit hubs. A one-half-mile buffer (radius) was applied around the alignment centerline for each proposed project. For any census tracts or traffic analysis zones that were partially within a buffer, a relative percentage was applied. For example, if 43% of a traffic analysis zone was within the buffer for a given project, 43% of the zone's jobs were assumed to be within the buffer area.

Measure:

- Capital costs

Analysis Notes:

Unit costs, design, and contingency assumptions for the capital cost analysis are shown in the following table in 2015 dollars.

Category	Element	Assumptions	Unit	Quantity	Cost per Unit	Cost
Roadway/Track	Light rail track		Mile	0	$ 125,900,000	$ -
	Exclusive Bus Lanes	Concrete lanes	Mile	0	$ 7,460,000	$ -
	Semi-Exclusive Bus Lanes	Concrete lanes	Mile	0	$ 3,030,000	$ -
	Mixed Flow		Mile	0	$ -	$ -
	Transit Priority Zone	Bus mall (allows autos)	Mile	0	$ 470,000	
	Bus turntable		Each	0	$ 1,000,000	$ -
	Queue jumps		Each	0	$ 320,000	$ -
	Curb Extensions		Each	0	$ 37,500	$ -
Stations	Light rail	2-sided station	Each	0	$ 600,000	$ -
	BRT Median	2-sided station	Each	0	$ 400,000	$ -
	BRT Curbside		Each	0	$ 300,000	$ -
	Rapid Bus Stop		Each	0	$ 200,000	$ -
	Enhanced Bus Stop-High	1/2 stops with shelter	Each	0	$ 150,000	$ -
	Enhanced Bus Stop-Low	1/2 stops w/o shelter	Each	0	$ 50,000	$ -
	Relocated Local Bus stops	Per Corridor	Lump sum	0	$ 20,000	$ -
Support Facilities	Operator restrooms	2 per corridor	Each	0	$ 225,000	$ -
	New Maintenance Facility	LRT Only	Lump Sum	0	$ 100,000,000	$ -
Systems	Transit Signal Priority	Includes controller upgrade	Per Intersection	0	$ 45,000	$ -
	Transit Signal Priority	Without controller upgrade	Per Intersection	0	$ 20,000	$ -
	Adaptive signal control	From other projects	Per Intersection	0	$ 50,000	$ -
	Real-Time Information	Rapid/BRT/LRT only	Per Station/Stop	0	$ 17,500	$ -
	Off-Board Fare Collection	BRT/LRT only	Per Station/Stop	0	$ 25,000	$ -
Construction Subtotal						**$ -**
Property Acquisition		BRT/LRT only	Lump Sum	0		$ -
Vehicles		BRT: 60'; zero-emission; 2-sided	Each	0	$ 1,500,000	$ -
		For Rapid Bus: 40' hybrid	Each	0	$ 777,000	$ -
		For Enhanced Bus: 40' hybrid	Each	0	$ 771,000	$ -
Branding/Marketing			Percentage	2.0%		$ -
Project Development	Design/Engineering		Percentage	15.0%		$ -
	Agency Costs		Percentage	7.0%		$ -
	Construction Management		Percentage	10.0%		$ -
	Environmental/Inspections/Legal		Percentage	6.0%		$ -
Subtotal						$ -
Contingency		**Assume 35% of total**	**Percentage**	35.0%		$ -
Total Cost (Current Year Dollars)						$ -

Measure:

- Operating cost per passenger trip.

Analysis Notes:

Cost information provided by transit operators.

Measure:

- Total cost per passenger trip

Analysis Notes:

Both operating costs and capital costs were annualized and then divided by forecasts of annual passenger trips. Capital cost annualization factors were based on the following assumed lifespans for the major categories of the unit cost elements.

Major Cost Category	Assumed Life Span (in years)
Roadway	30
Stations	30
Support Facilities	30
Systems	10
Property	30
Vehicles	12
Marketing/Project Development	30
Contingency	30

Notes on Project-Specific Ratings

Results for each evaluation measure were prepared for each of the proposed projects. Ratings are intended to facilitate the comparison between proposed projects and were therefore developed using a relative scale developed after reviewing the results for all projects and using a natural breaks method to group results into appropriate rating categories. The following table summarizes the ranges used to convert the results by measure into the low, medium, or high rating scale shown in the tables for each proposed project. The concept of natural breaks or cluster analysis was used to assign project ratings. The analysis includes the task of grouping a set of objects (or in this case scores) in such a way that objects in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). Analysis of clusters itself is not one specific algorithm, but the general task to be solved. It can be achieved by various algorithms that differ significantly in their notion of what constitutes a cluster and how to efficiently find them. This type of analysis is not an automatic task, but an iterative process of knowledge discovery or interactive multi-objective optimization that involves trial and failure.

Measure	Low	Medium	High
Net New Riders	0 - 5,000	5,000 - 10,000	>10,000
Passenger Trips per Revenue Vehicle Mile	0 - 5	6 - 20	> 20
Daily Passenger Trips	0 - 5,000	5,000 - 25,000	>25,000
Capital Cost per Net New Rider	>$30	$30 - $10	<$10
Operating Cost	>$10	$10 - $5	<$5
Total Cost per Passenger Trip	>$30	$30 - $10	<$10
Miles of Dedicated Right-of-Way (% of Total Length)	0 - 40%	40% - 70%	>70%
Reduction in Transit Travel Time	<10%	10% - 20%	>20%
Number of Transit Hubs Served	0 - 2	3 - 4	>4
Number of Households within One-Half Mile of Transit Stops	0 - 10,000	10,000 - 80,000	>80,000
Number of Jobs within One-Half Mile of Transit Stops	0 - 25,000	25,000 - 100,000	>100,000
Number of Communities of Concern Affected	0 - 4	5 - 30	>30
Number of Existing or Planned Major Activity Nodes Served	0-2	3	>3
Customer Experience	Not Applicable		
Compatible with Arterials Plan	All Are Compatible		

Attachment B – Modeling and Evaluation Methodology

General Modeling Methodology

There are two general approaches to transit forecasting. **Synthetic** methods forecast ridership based on information on land uses, travel behavior, and the modes and routes available to travelers. These are usually combined into a four-step model such as the Alameda CTC Travel Demand Model**.**

Incremental approaches, in contrast, are based on observed transit usage and forecast changes using elasticities for whatever type of change is being made (fares, frequency, etc.). The forecast change in ridership is then applied to the base ridership to get the forecast of ridership after the change in fares, frequency, etc.

Both methods are considered valid by FTA but there are situations where one is preferred over the other. Generally speaking, synthetic methods function best when forecasting the effects of large- scale changes such as the growth in regional population and employment over a multi-decade period. Synthetic methods are preferred when forecasting the effects of small-scale projects that are not represented in regional models, such as queue jumps and bulb-outs.

For the current study, a combination of synthetic and incremental approaches was used to capture the advantages of each and overcome the limitations that either approach would have if used alone. The synthetic approach was used to estimate 2040 baseline ridership as well as analyze proposed changes to route alignment or line extensions. Incremental methods were then used to estimate the likely percentage changes to travel time and ridership from improvements such as frequency of service, stop reduction, transit lanes, bulb-outs, and queue jumps. These percentage changes were then applied to the 2040 baseline ridership and travel times.

The Alameda CTC model was created in 2007 based on MTC's BAYCAST model. The model covers the entire MTC region, but has added detail within Alameda County. The model was subsequently updated in 2009 with new land use forecasts, a new truck model, and a post-processor to estimate travel-related greenhouse gas emissions. The mode split component of the ACTC model was copied from the VTA model, which has more detail than the BAYCAST model. Specifically, within the transit portion of the mode split model, the ACTC model has five modes with walk access (local bus, express bus, light rail, commuter rail, and BART) and two modes with drive access (park and ride, kiss and ride). The current version was released in 2015 and includes the land use and transportation assumptions in the current Regional Transportation Plan/Sustainable Communities Strategy[3].

Generally, the travel model was used to forecast 2040 Baseline conditions, and incremental methods were used for 2040 Plus Project conditions. Travel times were estimated first, so changes in travel time could inform the ridership forecasting through the incremental method.

Transit Travel Time Methodology

Existing peak and uncongested travel times for each corridor were used as the starting point for calculating the change in travel time for each alternative and to form the baseline travel time comparison for the alternatives. AC Transit staff provided existing peak and uncongested travel times for most of their corridors. For Adeline and all corridors with other operators actual performance data was not available, so existing travel times were based on transit schedules.

Travel times for the 2040 Baseline scenario were estimated by applying the percentage change in travel time between the 2010 model and 2040 model to the existing peak travel times. This represents the change in travel delay due to the increase road congestion anticipated in 2040. Uncongested average speeds were assumed to stay the same as existing, with the only changes in uncongested travel time being those that result from changes in route length or alignment.

The incremental method was used to examine most changes that are planned for each corridor and develop estimates for changes in travel time resulting from those changes. The travel time savings computed for each corridor were calculated based on the aggregate accumulated travel time savings of the individual improvements. The travel time savings generated by each element were based on an analysis of the time savings for that improvement using observations from various transit systems found in literature. Given the preliminary nature of the work at this point, the exact number and specific location of the various elements was not known for some corridors. In those instances, an estimate, based on the type of corridor improvement, was developed. For example, it was assumed that there will typically be three stops per mile along a Rapid Bus corridor. Parsons Brinckerhoff worked with AC Transit to develop these assumptions used in situations where more specific information is not available at this planning stage of project development.

The elements which were analyzed for travel time savings are as follows:

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[3] *Plan Bay Area, Strategy for a Sustainable Region*, Metropolitan Transportation Commission, Adopted July 18, 2013

- Curb extensions
  - o Computed as eight seconds saved per curb extension[4] multiplied by the number of curb extensions on the corridor
- Queue-jump lanes
  - o Computed as 8.5 seconds saved per queue-jump lane[5] multiplied by the number of queue-jump lanes on the corridor
- Tranist lanes and Transit Priority Zones
  - o First the delay due to congestion (minutes/mile) was computed as the difference between peak and uncongested travel time divided by distance.
  - o Transit lanes were assigned a transit lanes factor to reduce congestion delay. The factors were 0.8 for exclusive transit lanes and light rail track and 0.5 for semi- exclusive (curb-running) lanes and Transit Priority Zones. The 0.8 factor for exclusive lanes means that buses operating in those lanes would escape congestion delay 80% of the time but would still be affected by congestion 20% of the time, such as at signalized intersections.
  - o Time savings was computed as congestion delay per mile multiplied by the miles of transit lanes multiplied by the transit lanes factor.
  - o This resulted time savings per mile consistent with values from other studies[6].
  - o Transit travel in mixed traffic was assumed to have no travel time savings compared to the Baseline condition (*i.e.* transit lanes factor = 0).
  - o The LRT scenario for the Telegraph corridor was assumed to be entirely exclusive lanes.
- Transit Signal Priority (TSP) and Adaptive Signal Control (ASC)
  - o Calculated per signalized intersection
  - o Assumed an average of six seconds savings per signalized intersection[7]
  - o Benefits of TSP and ASC have been shown to not be additive[8]
- Dwell time at stops/stations

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4 TCRP Synthesis 83 - Bus and Rail Transit Preferential Treatments in Mixed Traffic, TRB 2010 - Table 24

5 TCRP Synthesis 83 - Bus and Rail Transit Preferential Treatments in Mixed Traffic, TRB 2010 - Chapter 6, Page 67

6 TCRP Synthesis 83 - Bus and Rail Transit Preferential Treatments in Mixed Traffic, TRB 2010 – Chapter 6, Page 69

7 TCRP Synthesis 83 - Bus and Rail Transit Preferential Treatments in Mixed Traffic, TRB 2010 - Figures 49 through 52

8 Integrating Transit Signal Priority within Adaptive Traffic Signal Control Systems, Research Paper by Dion & Rakha, 2005

  - o Enhanced and Rapid bus assume current average dwell times of 25 and 20 seconds respectively.
  - o BRT assumes a 15-second dwell time per stop as a result of off-board fare collection allowing multi-door boarding, raised passenger platforms providing level boarding, faster access for people using wheelchairs, and faster access for those bringing bicycles on board. The 15 second dwell time was based on experience from Lane Transit District and Community Transit BRT lines which have similar BRT features at their stations. BRT vehicles were assumed to have the same benefit as curb extensions in regard to stopping and re-entering the traffic stream as curb extensions for a savings of 8 seconds per stop. This yields a total of 18-seconds travel time savings per BRT stop. These assumptions apply to projects: R4, R5, U1, U2, U3 and U6.

- Stop spacing
  - o Stop spacing for Urban Rapid and Regional Express tiers was assumed to be one-third-mile with exceptions for special conditions (e.g. cross-bay bridges) and the Hesperian corridor.
- Changes in route alignment
  - o For changes in route alignment and route extensions, travel time was assumed to change proportionally with change in route length (*i.e.* travel speed would be similar).

Travel time savings for items such as transit lanes and transit signal priority vary from corridor to corridor depending on traffic congestion, the number of signalized intersections, speed limits, and other specific corridor attributes. Uncongested travel time is less subject to other vehicles on the roadway or intersection delays and so the benefits of congestion-avoidance measures, such as exclusive lanes, are smaller during uncongested hours. Benefits of transit lanes were therefore not credited to uncongested travel time. Curb extensions, TSP/ASC intersections, and queue jump lanes were assumed to have half the travel time savings at uncongested travel times as during peak times.

Travel time comparisons between existing service, Year 2040 Baseline, and the Year 2040 with corridor improvements are complicated by changes in routing, including several corridors that are to be extended. For this reason, travel time was analyzed in two ways. In order to provide an assessment of the impact of the proposed corridor improvements, travel time was considered using common sections of the corridor, allowing for an “apples to apples” comparison. In addition, full corridor travel time, including any extensions, was also calculated to provide the basis for determining corridor operating cost and vehicle requirements.

Ridership Estimating Methodology

AC Transit's bus routes are represented in the model as a series of points along the road system, some of which are designated as stops. Ridership is estimated based on comparison of the overall cost of using transit versus using some other mode, for each origin-destination pair. The costs of taking the bus include:

- If walk access, then walk time from home to bus stop. If kiss-and-ride access, then drive time. If park-and-ride access, then drive time and parking costs. Access costs occur at both the origin end and the destination end of the trip.
- Wait time at the bus stop, which is a function of service frequency. The model allows for different headways for peak- and off-peak hours.
- Bus travel time, which is computed based on auto travel time, for example 30% more than auto travel time along the same roadway segment. This formulation allows the model to reflect the effect of congested conditions on both auto and bus travel times.
- Fares

Each model run generates two ridership figures. One is based on AM weekday peak period conditions (traffic levels, headways, etc.) and is used to represent the six peak hours of the day (three hours in the AM and three hours in the PM). The other figure is based on weekday mid-day conditions (speeds, headways, etc.) and represents all off-peak hours. Weekends, holidays, and special events are not represented in the Alameda CTC model.

As is the case with virtually all four-step models, the Alameda CTC model is much more accurate for auto travel than for transit, especially bus transit. The model is validated (tested for accuracy) at the level of daily ridership by transit operator. In other words, the model is expected to provide a good estimate of total daily ridership for each transit operator, but is not validated for more detailed levels of analysis, such as ridership on individual lines at different times of the day.

Knowing this, forecasters use models of this type mainly for comparative purposes. For example, the model may be 40% off on its base forecast for ridership on a route, but can still give a reasonable forecast of the percentage increase in ridership from shortening the headways, which can then be applied to the actual ridership. It can also provide a reasonable indication of which of three alternative routes, A, B, or C, is likely to attract the most riders. But this model cannot provide accurate forecasts of the effects of microscale changes such as queue jumps or curb extensions, whose effects are small in relation to the model's margin of error.

A combination of the Alameda CTC model and existing ridership data was used to estimate 2040 baseline ridership. Specifically, the model was used to forecast the growth in ridership on each route, and the growth factor was then applied to actual measured existing ridership.

The Alameda CTC model's 2040 baseline condition represents planned land development, major service improvements planned as part of AC Transit's Service Expansion Plan (SEP), and transit and highway improvements reflected in the 2040 base scenario of the Alameda CTC model, consistent with Plan Bay Area. The Alameda CTC model includes all local transit improvements in Plan Bay Area in Alameda County as well as all major improvements on all region-serving transit operators (such as BART and AC Transit).

Growth in ridership between the base year (2010) and future year (2040) was applied to the known existing ridership on a line-by-line basis consistent with the ratio method or the difference method.[9] The ratio method and the difference method eliminate certain types of imperfections in the forecast of background traffic and therefore improve the accuracy of traffic forecasts. Because existing ridership data is from 2014, growth between 2010 and 2040 was factored down to reflect 26 years of growth rather than the 30 years represented in the model. Where there is no existing service, the modeled 2040 value was directly used.

Changes in ridership and travel time due to new/extended routes were synthetically modeled with a modified Project 2040 version of the Alameda CTC model that includes all project changes. Service frequency and transit lanes were also represented in the Plus Project model run in order to quantify system-wide performance.

The incremental method was used to examine the change in ridership resulting from changes in travel time, frequency, and other qualitative enhancements. Using established ridership elasticities, estimates were made for the ridership impact of the specific improvements, which were then aggregated to determine the ridership impact

[9] The ratio method and the difference method are two ways to correct for some of the error inherent in a model, which is by definition a simplification of reality. Essentially, the methods compute either the ratio or arithmetic difference between the modeled version of existing conditions and actual measured existing values. Then the ratio or difference is applied to the future modeled conditions. Another way to think about the application of the two methods is that we want to isolate the changes in travel patterns that occur between two modeled scenarios (one of which represents existing conditions) and apply those changes to actual existing conditions to produce forecasts of the scenario condition. In most cases the ratio method was used, except when doing so produced unrealistic forecasts (i.e., when the base condition model values are very small). (Both methods are described in more detail NCHRP Report 255, *Highway Traffic Data for Urbanized Area Project Planning and Design*, Transportation Research Board, 1982.)

Ratio: Forecast = Existing value X (Scenario model value / Base model value)
Difference: Forecast = Existing value + (Scenario model value – Base model value)

for the corridor. The ridership elasticity with respect to travel time was set as -0.6[10], which means that a 10% reduction in travel time would yield a 6% increase in ridership. The ridership elasticity for headways was set as -0.5[11], or in other words, a 10% decrease in headways would result in a 5% increase in ridership.

In addition, elements such as real-time passenger information and branding, which do not result in direct travel time savings, have been shown to have positive ridership impact. The FTA has established equivalent travel time credits for these elements that were used to determine the ridership impact of those improvements. Consistent with FTA, we assumed that real time traveler information (dynamic scheduling) would have a travel time credit of one-minute. The travel time elasticity was then applied to this additional one-minute savings to find the expected increase in ridership. This benefit was assumed for corridors that would add this enhancement and not already have it in the 2040 Baseline condition. Note that this equivalent one-minute time savings was only used for estimating ridership, and not counted toward the travel time forecast.

Route extensions, such as the Warm Springs extension on U6 Bay Fair BART to Warm Springs BART, were forecast separately, using the model to obtain a forecast volume for the last segment of the existing route and for the proposed extension. The existing ridership for the last segment of the existing route was compared with the forecast ridership to obtain a factor for how much the model is over- or underestimating ridership at the end of the line. The factor was then applied to the forecast ridership for the extension.

VMT and RVH Methodology

Vehicle-miles-traveled (VMT) is a key input in evaluating greenhouse gas (GHG) emissions. VMT was estimated for buses, autos, and ferries for existing, 2040 Baseline, and 2040 Plus Project conditions. The unit of analysis was Alameda County. For autos this means all VMT on roads within Alameda County. All VMT for transit vehicles that travel to/from or within Alameda County for AC Transit, LAVTA, Union City, and WETA are included.

In parallel to estimating VMT for transit, revenue-vehicle-hours (RVH) was also estimated.

Existing Conditions

[10] John F. Kain and Zvi Liu (1999), "Secrets of Success," *Transportation Research A*, Vol. 33, No. 7/8, Sept./Nov. 1999, pp. 601-624.

[11] Todd A. Litman (2013), "Understanding Transport Demands and Elasticities: How Prices and Other Factors Affect Travel Behavior." Victoria Transport Policy Institute, 2013. page 52; at www.vpti.org/elasticities.pdf

Existing VMT for Alameda County was found from existing sources for each mode.

Bus

Total annual bus revenue-vehicle-miles (RVM) for AC Transit, LAVTA, and Union City was 18,880,734. The following ratios of deadhead miles relative to revenue-miles were used to calculate total vehicle miles from revenue miles.

- AC Transit: 0.155 (2013 Annual Performance Report Data)
- LAVTA: 0.140 (2014 Operating Statistics)
- Union City: 0.155 (data unavailable, assumed to be the same as AC Transit)

Accounting for the deadhead miles, the existing total annual bus travel was computed as 21.8M vehicle-miles.

Similarly, existing RVH was obtained from operator statistics, with a total annual RVH of 1.68M.

Auto

Alameda County daily auto VMT was 40,243,280 in 2013 according to Caltrans[12]. This VMT number was annualized by a factor of 365 days/year. A distribution of Alameda County VMT by 5-mph-speed strata was taken from the ACTC model.

Ferry

Alameda County serving ferries traveled 155,000 vehicle-miles annually according to WETA who report 122,697 revenue-miles and a 0.261 deadhead to revenue ratio for fiscal year 2015. Existing annual RVH for WETA service servicing Alameda County is 8,430.

2040 Baseline

Bus

Ideally, vehicle-miles for buses would be added up from each line based on the number of trips and length of route. Because this information is not readily available for the 2040 baseline scenario, we used the transit coding in the travel model to estimate the change in service between the base and future years. The model does represent peak and off-peak headways and distances for each line, but does not represent hours of service, or headways for other time periods such as late night or weekends. The service-miles modeled for 2010 and 2040 baseline scenarios were summarized and a

[12] Caltrans, California Public Road Data 2013: Statistical Information Derived from the Highway Performance Monitoring System. November 2014. Page 16. Available at: http://www.dot.ca.gov/hq/tsip/hpms/hpmslibrary/prd/2013prd/2013PRD-revised.pdf

21% increase in service was found. This increase was applied to the existing bus vehicle miles traveled to compute an estimate of 2040 Baseline bus-miles.

Similarly, the amount of RVH was extracted from the base and future ACTC models to find a percentage increase from existing. The resulting 27% increase in bus service was applied to the existing RVH to calculate 2040 Baseline RVH.

Auto

The ACTC model summarizes daily VMT by county. The amount of VMT growth was calculated from the 2010 and 2040 Baseline models, and used to estimate the auto VMT in Alameda County for 2040. This number was also annualized by a factor of 365 days/year. A distribution of auto VMT by speed was also extracted from the ACTC model for 2040 as it was for 2010. These distributions were applied to 2040 auto VMT as part of the GHG analysis.

Ferry

Revenue vehicle hours for the planned San Francisco—Berkeley ferry were added to the existing ferry RVH to find total ferry RVH for 2040 Baseline.

2040 Plus Project

Bus

The VMT and RVH for project corridors was estimated for both the 2040 Baseline and 2040 Plus Project conditions, and the net new bus VMT and RVH were added to the 2040 bus VMT and RVH. For AC Transit corridors (including the Dumbarton Express), AC Transit provided calculations of annual revenue-miles for the Plus Project condition based on the number of buses per weekday and weekend-day and route lengths. AC Transit also provided calculations for annual RVH based on run times and number of buses. WSP | PB performed similar calculations for the LAVTA and GGT corridors as well as the 2040 Baseline condition for the AC Transit corridors. Revenue-miles were converted to bus VMT using the deadhead to revenue mile ratio, and the bus VMT and RHV were annualized based assuming 255 weekdays and 110 weekend days/holiday. Then the net new bus VMT, or difference between Baseline and Plus Project VMT, was added to the 2040 Baseline bus VMT to yield 2040 Plus Project bus VMT. The same procedure was then used to determine 2040 Plus Project bus RVH.

Auto

The Alameda CTC model covers too large a region to accurately measure the VMT effects of corridor-specific transit improvements.[13] The change in auto VMT was therefore estimated based on the number of trips switching to transit from driving.

The travel model results show that the total number of person trips will be the same with and without the transit projects, indicating that trips shift mode from auto to transit. This means that person-trips by auto would be reduced by the same amount as the net new transit trips taken as the total from the corridors-level (off-model) ridership forecasts.

A vehicle occupancy rate of 1.2 persons per vehicle was applied to estimate the number of vehicle trips replaced by transit trips. An average vehicle trip length was determined based on the average trip length for Alameda County transit trips (9.1 miles) in the travel model, because these trips would be the same length as auto trips which are eligible for a mode-shift to transit. The reduction in auto VMT was computed as the number of eliminated auto trips X the average trip length. Applying the reduction to the 2040 Baseline auto VMT yields 2040 Plus Project auto VMT.

Ferry

The project modifies ferry service between San Francisco and Oakland/ Alameda and extends service to Brooklyn Basin. Based on the planned frequencies, distances, and service hours, the project generates a net increase in ferry VMT by 53,500 annually. This net increase was added to the 2040 Baseline ferry VMT to find the 2040 Plus Project ferry VMT. The same process was used to determine 2040 Plus Project RVH.

[13] Specifically, the model's estimate of a 0.07% reduction from 2040 Baseline conditions to 2040 Plus Project conditions is too small in relation to the model's margin of error to be considered a reliable estimate. The problem is that the model covers an area with millions of auto trips and the random calculation errors in model runs (rounding, etc.) for such high volumes swamps the effect of local transit improvements.

Attachment C – GHG Emissions Evaluation Methodology

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MEMORANDUM

To:	Sudhish Verma
From:	Ivy Edmonds-Hess
Date:	March 17, 2016
Project Name:	Alameda CTC Countywide Transit Plan
Project Number:	13347A
Subject:	Greenhouse Gas Emissions Evaluation

As part of the evaluation process for the Alameda Countrywide Transit Plan, performance measures are being used to compare the plan to existing conditions (2010) and future baseline conditions (2040). One of the performance measures is reduction of greenhouse gas (GHG) emissions.

This memo summarizes the evaluation methodology followed and the results of the analysis.

Evaluation Methodology

The Plan has the potential to affect GHG emissions from changes in roadway traffic and passenger ferry service. The Plan's impact on roadway traffic is reflected in changes in the region's vehicle miles traveled (VMT) and associated vehicle speeds. Changes to passenger ferry service can also affect the miles traveled by the ferries and the associated consumption of fuel.

Gases that trap heat in the atmosphere are often referred to as GHGs. As concentrations of GHGs increase, the Earth's temperature also increases. While some GHGs occur naturally, many are generated by human activities such as the burning of fossil fuels. Since more than 80 percent of the total amount of greenhouse gases is carbon dioxide (CO_2)[1], changes to CO_2 emissions from the proposed Plan were used as an indicator of impacts from all greenhouse gases.

CO_2 emissions were calculated and are presented in Attachment 2 to this memo. The calculations for on-road motor vehicles are based on VMT in the study area, travel speed distributions, and emission factors determined by the EPA-approved emission factor model EMFAC2014, developed by the California Air Resources Board (CARB). It is assumed that all buses will be zero emissions by 2040.

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[1] U.S. Energy Information Administration, Emissions of Greenhouse Gases in the U.S., March 31, 2011.

Since the EMFAC2014 model only addresses emissions from on-road motor vehicles, a different methodology was used to address emissions from passenger ferries. In January 2016, CARB released Draft Greenhouse Gas Quantification Methodology for the California State Transportation Agency Transit and Intercity Rail Capital Program[2]. In Appendix E of this document ferry emission factors are provided by fuel type. Since the amount of fuel to be consumed by current and future ferry service was not readily available, information in an article in Issue 2001-4 of Energies magazine entitled "Comparison of Ferry Boat and Highway Bridge Energy Use"[3] was used. Table 1 of this article presented 2008 diesel fuel consumption rates for selected U.S. ferry boat operators. This survey included the fuel consumption rate of 0.12 mile per gallon of diesel fuel for the Golden Gate Ferry Service. This was used as estimate for the ferries specified in the Plan.

Evaluation Results

CO_2 emissions estimated based on the 2010 Existing, 2040 Baseline, and 2040 Plus Project VMT are presented in the table below. The emissions are summarized by autos, trucks, buses, and ferries.

It was estimated that the 2010 Existing condition generates 5.57 million metric tons of CO_2. The 2040 Baseline condition, with an estimate of 4.27 million metric tons of CO_2, shows an improvement compared to the 2010 Existing condition. The EMFAC2014 model assumes that future emission factors will be reduced as more GHG regulations and programs are implemented and newer, cleaner vehicle technologies come to market. These improvements in emissions are more than enough to offset the increase in VMT between 2010 and 2040 due to growth.

The Project would generate approximately 4.23 million metric tons of CO_2, a slight decrease of about 40,000 metric tons or 0.9 percent compared to the 2040 Baseline condition.

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[2] California Air Resources Board, Draft Greenhouse Gas Quantification Methodology for the California State Transportation Agency Transit and Intercity Rail Capital Program, Greenhouse Gas Reduction Fund FY 2016-17, Appendix E - Ferry Emission Factor Lookup Table, January 12, 2016.

[3] Cottrell, Wayne D., Comparison of Ferry Boat and Highway Bridge Energy Use, Table 1 - Year 2008 Diesel Fuel Consumption by Selected U.S. Ferry Boat Operators, Energies, Issue 2011-4, Published January, 27, 2011.

Total GHG Emissions (metric tons/year)

	2010 Existing	2040 Baseline	2040 Plus Project
Total Light-Duty Autos	3,181,591	2,162,828	2,126,097
Total Trucks (including light, medium, and heavy-duty)	2,331,852	2,080,563	2,070,971
Total Bus	40,686	0	0
Total Ferry	17,670	29,184	35,340
Overall Total	**5,571,799**	**4,272,574**	**4,232407**

ATTACHMENT 1

2010 AND 2040

EMFAC2014

MODEL OUTPUT

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2010
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2010	LDA	5	GAS	1082.135
Alameda	2010	LDA	5	DSL	862.646
Alameda	2010	LDA	10	GAS	799.478
Alameda	2010	LDA	10	DSL	718.666
Alameda	2010	LDA	15	GAS	615.593
Alameda	2010	LDA	15	DSL	591.100
Alameda	2010	LDA	20	GAS	493.371
Alameda	2010	LDA	20	DSL	484.894
Alameda	2010	LDA	25	GAS	408.779
Alameda	2010	LDA	25	DSL	406.459
Alameda	2010	LDA	30	GAS	352.356
Alameda	2010	LDA	30	DSL	352.068
Alameda	2010	LDA	35	GAS	314.656
Alameda	2010	LDA	35	DSL	318.262
Alameda	2010	LDA	40	GAS	291.493
Alameda	2010	LDA	40	DSL	297.822
Alameda	2010	LDA	45	GAS	280.710
Alameda	2010	LDA	45	DSL	287.673
Alameda	2010	LDA	50	GAS	280.053
Alameda	2010	LDA	50	DSL	288.406
Alameda	2010	LDA	55	GAS	290.763
Alameda	2010	LDA	55	DSL	301.794
Alameda	2010	LDA	60	GAS	312.915
Alameda	2010	LDA	60	DSL	327.181
Alameda	2010	LDA	65	GAS	349.503
Alameda	2010	LDA	65	DSL	367.817
Alameda	2010	LDT1	5	GAS	1245.686
Alameda	2010	LDT1	5	DSL	1021.619
Alameda	2010	LDT1	10	GAS	920.634
Alameda	2010	LDT1	10	DSL	859.965
Alameda	2010	LDT1	15	GAS	708.870
Alameda	2010	LDT1	15	DSL	713.053
Alameda	2010	LDT1	20	GAS	567.974
Alameda	2010	LDT1	20	DSL	585.827
Alameda	2010	LDT1	25	GAS	470.630
Alameda	2010	LDT1	25	DSL	491.195
Alameda	2010	LDT1	30	GAS	405.618
Alameda	2010	LDT1	30	DSL	424.745

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2010
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2010	LDT1	35	GAS	362.231
Alameda	2010	LDT1	35	DSL	383.348
Alameda	2010	LDT1	40	GAS	335.593
Alameda	2010	LDT1	40	DSL	357.787
Alameda	2010	LDT1	45	GAS	323.159
Alameda	2010	LDT1	45	DSL	344.967
Alameda	2010	LDT1	50	GAS	322.436
Alameda	2010	LDT1	50	DSL	345.540
Alameda	2010	LDT1	55	GAS	334.723
Alameda	2010	LDT1	55	DSL	361.291
Alameda	2010	LDT1	60	GAS	360.218
Alameda	2010	LDT1	60	DSL	391.352
Alameda	2010	LDT1	65	GAS	402.331
Alameda	2010	LDT1	65	DSL	439.576
Alameda	2010	LDT2	5	GAS	1483.692
Alameda	2010	LDT2	5	DSL	1152.531
Alameda	2010	LDT2	10	GAS	1096.267
Alameda	2010	LDT2	10	DSL	970.162
Alameda	2010	LDT2	15	GAS	844.114
Alameda	2010	LDT2	15	DSL	804.424
Alameda	2010	LDT2	20	GAS	676.464
Alameda	2010	LDT2	20	DSL	660.896
Alameda	2010	LDT2	25	GAS	560.494
Alameda	2010	LDT2	25	DSL	554.138
Alameda	2010	LDT2	30	GAS	483.111
Alameda	2010	LDT2	30	DSL	479.172
Alameda	2010	LDT2	35	GAS	431.425
Alameda	2010	LDT2	35	DSL	432.471
Alameda	2010	LDT2	40	GAS	399.677
Alameda	2010	LDT2	40	DSL	403.634
Alameda	2010	LDT2	45	GAS	384.884
Alameda	2010	LDT2	45	DSL	389.172
Alameda	2010	LDT2	50	GAS	383.996
Alameda	2010	LDT2	50	DSL	389.818
Alameda	2010	LDT2	55	GAS	398.665
Alameda	2010	LDT2	55	DSL	407.587
Alameda	2010	LDT2	60	GAS	429.035
Alameda	2010	LDT2	60	DSL	441.500

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2010
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2010	LDT2	65	GAS	479.198
Alameda	2010	LDT2	65	DSL	495.904
Alameda	2010	LHD1	5	GAS	1407.491
Alameda	2010	LHD1	5	DSL	1304.151
Alameda	2010	LHD1	10	GAS	1384.385
Alameda	2010	LHD1	10	DSL	1096.342
Alameda	2010	LHD1	15	GAS	961.714
Alameda	2010	LHD1	15	DSL	716.003
Alameda	2010	LHD1	20	GAS	834.980
Alameda	2010	LHD1	20	DSL	610.285
Alameda	2010	LHD1	25	GAS	765.398
Alameda	2010	LHD1	25	DSL	541.264
Alameda	2010	LHD1	30	GAS	694.647
Alameda	2010	LHD1	30	DSL	491.527
Alameda	2010	LHD1	35	GAS	694.647
Alameda	2010	LHD1	35	DSL	491.527
Alameda	2010	LHD1	40	GAS	692.036
Alameda	2010	LHD1	40	DSL	478.070
Alameda	2010	LHD1	45	GAS	688.858
Alameda	2010	LHD1	45	DSL	466.320
Alameda	2010	LHD1	50	GAS	726.452
Alameda	2010	LHD1	50	DSL	488.874
Alameda	2010	LHD1	55	GAS	765.398
Alameda	2010	LHD1	55	DSL	510.856
Alameda	2010	LHD2	5	GAS	1500.695
Alameda	2010	LHD2	5	DSL	1375.554
Alameda	2010	LHD2	10	GAS	1557.657
Alameda	2010	LHD2	10	DSL	1222.498
Alameda	2010	LHD2	15	GAS	1095.748
Alameda	2010	LHD2	15	DSL	813.780
Alameda	2010	LHD2	20	GAS	958.966
Alameda	2010	LHD2	20	DSL	694.095
Alameda	2010	LHD2	25	GAS	867.150
Alameda	2010	LHD2	25	DSL	618.547
Alameda	2010	LHD2	30	GAS	783.770
Alameda	2010	LHD2	30	DSL	557.831
Alameda	2010	LHD2	35	GAS	783.770
Alameda	2010	LHD2	35	DSL	557.831

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2010
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2010	LHD2	40	GAS	765.867
Alameda	2010	LHD2	40	DSL	537.456
Alameda	2010	LHD2	45	GAS	747.817
Alameda	2010	LHD2	45	DSL	516.627
Alameda	2010	LHD2	50	GAS	779.625
Alameda	2010	LHD2	50	DSL	535.655
Alameda	2010	LHD2	55	GAS	815.121
Alameda	2010	LHD2	55	DSL	554.429
Alameda	2010	MCY	5	GAS	515.789
Alameda	2010	MCY	10	GAS	382.576
Alameda	2010	MCY	15	GAS	294.523
Alameda	2010	MCY	20	GAS	235.329
Alameda	2010	MCY	25	GAS	195.158
Alameda	2010	MCY	30	GAS	167.980
Alameda	2010	MCY	35	GAS	150.066
Alameda	2010	MCY	40	GAS	139.143
Alameda	2010	MCY	45	GAS	133.905
Alameda	2010	MCY	50	GAS	133.748
Alameda	2010	MCY	55	GAS	138.655
Alameda	2010	MCY	60	GAS	149.190
Alameda	2010	MCY	65	GAS	166.609
Alameda	2010	MDV	5	GAS	1874.325
Alameda	2010	MDV	5	DSL	1404.295
Alameda	2010	MDV	10	GAS	1384.917
Alameda	2010	MDV	10	DSL	1192.588
Alameda	2010	MDV	15	GAS	1066.370
Alameda	2010	MDV	15	DSL	1011.395
Alameda	2010	MDV	20	GAS	854.568
Alameda	2010	MDV	20	DSL	839.959
Alameda	2010	MDV	25	GAS	708.067
Alameda	2010	MDV	25	DSL	710.272
Alameda	2010	MDV	30	GAS	610.307
Alameda	2010	MDV	30	DSL	613.454
Alameda	2010	MDV	35	GAS	545.013
Alameda	2010	MDV	35	DSL	556.625
Alameda	2010	MDV	40	GAS	504.908
Alameda	2010	MDV	40	DSL	520.646
Alameda	2010	MDV	45	GAS	486.219

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2010
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2010	MDV	45	DSL	501.046
Alameda	2010	MDV	50	GAS	485.099
Alameda	2010	MDV	50	DSL	503.557
Alameda	2010	MDV	55	GAS	503.628
Alameda	2010	MDV	55	DSL	531.429
Alameda	2010	MDV	60	GAS	541.994
Alameda	2010	MDV	60	DSL	575.430
Alameda	2010	MDV	65	GAS	605.363
Alameda	2010	MDV	65	DSL	646.127
Alameda	2010	MH	5	GAS	3960.345
Alameda	2010	MH	5	DSL	2120.590
Alameda	2010	MH	10	GAS	3380.801
Alameda	2010	MH	10	DSL	1925.505
Alameda	2010	MH	15	GAS	2330.393
Alameda	2010	MH	15	DSL	1581.007
Alameda	2010	MH	20	GAS	1638.461
Alameda	2010	MH	20	DSL	1297.404
Alameda	2010	MH	25	GAS	1430.724
Alameda	2010	MH	25	DSL	1163.719
Alameda	2010	MH	30	GAS	1314.777
Alameda	2010	MH	30	DSL	1092.326
Alameda	2010	MH	35	GAS	1213.858
Alameda	2010	MH	35	DSL	1033.079
Alameda	2010	MH	40	GAS	1129.316
Alameda	2010	MH	40	DSL	985.977
Alameda	2010	MH	45	GAS	1049.305
Alameda	2010	MH	45	DSL	951.021
Alameda	2010	MH	50	GAS	981.576
Alameda	2010	MH	50	DSL	928.211
Alameda	2010	MH	55	GAS	954.521
Alameda	2010	MH	55	DSL	917.547
Alameda	2010	MH	60	GAS	960.451
Alameda	2010	MH	60	DSL	919.027
Alameda	2010	MH	65	GAS	978.256
Alameda	2010	MH	65	DSL	932.654
Alameda	2010	Motor Coach	5	DSL	3654.716
Alameda	2010	Motor Coach	10	DSL	3297.238
Alameda	2010	Motor Coach	15	DSL	2720.663

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2010
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2010	Motor Coach	20	DSL	2266.173
Alameda	2010	Motor Coach	25	DSL	2037.151
Alameda	2010	Motor Coach	30	DSL	1906.380
Alameda	2010	Motor Coach	35	DSL	1800.489
Alameda	2010	Motor Coach	40	DSL	1716.767
Alameda	2010	Motor Coach	45	DSL	1653.622
Alameda	2010	Motor Coach	50	DSL	1610.078
Alameda	2010	Motor Coach	55	DSL	1585.535
Alameda	2010	Motor Coach	60	DSL	1578.428
Alameda	2010	Motor Coach	65	DSL	1578.428
Alameda	2010	Motor Coach	70	DSL	0.000
Alameda	2010	Motor Coach	75	DSL	0.000
Alameda	2010	Motor Coach	80	DSL	0.000
Alameda	2010	Motor Coach	85	DSL	0.000
Alameda	2010	Motor Coach	90	DSL	0.000
Alameda	2010	OBUS	5	GAS	3960.345
Alameda	2010	OBUS	10	GAS	3380.801
Alameda	2010	OBUS	15	GAS	2330.393
Alameda	2010	OBUS	20	GAS	1638.461
Alameda	2010	OBUS	25	GAS	1430.724
Alameda	2010	OBUS	30	GAS	1314.777
Alameda	2010	OBUS	35	GAS	1213.858
Alameda	2010	OBUS	40	GAS	1129.316
Alameda	2010	OBUS	45	GAS	1049.305
Alameda	2010	OBUS	50	GAS	981.576
Alameda	2010	OBUS	55	GAS	954.521
Alameda	2010	OBUS	60	GAS	960.451
Alameda	2010	OBUS	65	GAS	978.256
Alameda	2010	PTO	20	DSL	2271.689
Alameda	2010	SBUS	5	GAS	1872.864
Alameda	2010	SBUS	5	DSL	2397.778
Alameda	2010	SBUS	10	GAS	1598.795
Alameda	2010	SBUS	10	DSL	2172.004
Alameda	2010	SBUS	15	GAS	1102.052
Alameda	2010	SBUS	15	DSL	1787.735
Alameda	2010	SBUS	20	GAS	774.835
Alameda	2010	SBUS	20	DSL	1476.887
Alameda	2010	SBUS	25	GAS	676.596

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2010
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2010	SBUS	25	DSL	1326.144
Alameda	2010	SBUS	30	GAS	621.764
Alameda	2010	SBUS	30	DSL	1243.204
Alameda	2010	SBUS	35	GAS	574.039
Alameda	2010	SBUS	35	DSL	1175.042
Alameda	2010	SBUS	40	GAS	534.058
Alameda	2010	SBUS	40	DSL	1120.901
Alameda	2010	SBUS	45	GAS	496.221
Alameda	2010	SBUS	45	DSL	1080.339
Alameda	2010	SBUS	50	GAS	464.191
Alameda	2010	SBUS	50	DSL	1053.080
Alameda	2010	SBUS	55	GAS	451.397
Alameda	2010	SBUS	55	DSL	1038.952
Alameda	2010	SBUS	60	GAS	454.201
Alameda	2010	SBUS	60	DSL	1036.436
Alameda	2010	SBUS	65	DSL	0.000
Alameda	2010	SBUS	70	DSL	0.000
Alameda	2010	SBUS	75	DSL	0.000
Alameda	2010	SBUS	80	DSL	0.000
Alameda	2010	SBUS	85	DSL	0.000
Alameda	2010	SBUS	90	DSL	0.000
Alameda	2010	UBUS	5	GAS	3960.345
Alameda	2010	UBUS	5	DSL	4056.679
Alameda	2010	UBUS	10	GAS	3380.801
Alameda	2010	UBUS	10	DSL	3683.482
Alameda	2010	UBUS	15	GAS	2330.393
Alameda	2010	UBUS	15	DSL	3024.458
Alameda	2010	UBUS	20	GAS	1638.461
Alameda	2010	UBUS	20	DSL	2481.928
Alameda	2010	UBUS	25	GAS	1430.724
Alameda	2010	UBUS	25	DSL	2226.188
Alameda	2010	UBUS	30	GAS	1314.777
Alameda	2010	UBUS	30	DSL	2089.614
Alameda	2010	UBUS	35	GAS	1213.858
Alameda	2010	UBUS	35	DSL	1976.275
Alameda	2010	UBUS	40	GAS	1129.316
Alameda	2010	UBUS	40	DSL	1886.170
Alameda	2010	UBUS	45	GAS	1049.305

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2010
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2010	UBUS	45	DSL	1819.299
Alameda	2010	UBUS	50	GAS	981.576
Alameda	2010	UBUS	50	DSL	1775.664
Alameda	2010	UBUS	55	GAS	954.521
Alameda	2010	UBUS	55	DSL	1755.262
Alameda	2010	UBUS	60	GAS	960.451
Alameda	2010	UBUS	60	DSL	1758.095
Alameda	2010	UBUS	65	GAS	978.256
Alameda	2010	UBUS	65	DSL	1784.163

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2040
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2040	LDA	5	GAS	616.515
Alameda	2040	LDA	5	DSL	476.178
Alameda	2040	LDA	10	GAS	455.444
Alameda	2040	LDA	10	DSL	396.701
Alameda	2040	LDA	15	GAS	350.690
Alameda	2040	LDA	15	DSL	326.286
Alameda	2040	LDA	20	GAS	281.080
Alameda	2040	LDA	20	DSL	267.660
Alameda	2040	LDA	25	GAS	232.883
Alameda	2040	LDA	25	DSL	224.364
Alameda	2040	LDA	30	GAS	200.744
Alameda	2040	LDA	30	DSL	194.340
Alameda	2040	LDA	35	GAS	179.264
Alameda	2040	LDA	35	DSL	175.680
Alameda	2040	LDA	40	GAS	166.065
Alameda	2040	LDA	40	DSL	164.397
Alameda	2040	LDA	45	GAS	159.924
Alameda	2040	LDA	45	DSL	158.795
Alameda	2040	LDA	50	GAS	159.546
Alameda	2040	LDA	50	DSL	159.199
Alameda	2040	LDA	55	GAS	165.652
Alameda	2040	LDA	55	DSL	166.589
Alameda	2040	LDA	60	GAS	178.274
Alameda	2040	LDA	60	DSL	180.603
Alameda	2040	LDA	65	GAS	199.119
Alameda	2040	LDA	65	DSL	203.034
Alameda	2040	LDT1	5	GAS	663.072
Alameda	2040	LDT1	5	DSL	504.212
Alameda	2040	LDT1	10	GAS	489.899
Alameda	2040	LDT1	10	DSL	424.428
Alameda	2040	LDT1	15	GAS	377.218
Alameda	2040	LDT1	15	DSL	351.921
Alameda	2040	LDT1	20	GAS	302.313
Alameda	2040	LDT1	20	DSL	289.130
Alameda	2040	LDT1	25	GAS	250.482
Alameda	2040	LDT1	25	DSL	242.425
Alameda	2040	LDT1	30	GAS	215.905
Alameda	2040	LDT1	30	DSL	209.629

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2040
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2040	LDT1	35	GAS	192.805
Alameda	2040	LDT1	35	DSL	189.198
Alameda	2040	LDT1	40	GAS	178.614
Alameda	2040	LDT1	40	DSL	176.583
Alameda	2040	LDT1	45	GAS	172.005
Alameda	2040	LDT1	45	DSL	170.256
Alameda	2040	LDT1	50	GAS	171.605
Alameda	2040	LDT1	50	DSL	170.539
Alameda	2040	LDT1	55	GAS	178.165
Alameda	2040	LDT1	55	DSL	178.312
Alameda	2040	LDT1	60	GAS	191.738
Alameda	2040	LDT1	60	DSL	193.148
Alameda	2040	LDT1	65	GAS	214.156
Alameda	2040	LDT1	65	DSL	216.949
Alameda	2040	LDT2	5	GAS	764.194
Alameda	2040	LDT2	5	DSL	579.102
Alameda	2040	LDT2	10	GAS	564.608
Alameda	2040	LDT2	10	DSL	487.468
Alameda	2040	LDT2	15	GAS	434.743
Alameda	2040	LDT2	15	DSL	404.192
Alameda	2040	LDT2	20	GAS	348.417
Alameda	2040	LDT2	20	DSL	332.074
Alameda	2040	LDT2	25	GAS	288.681
Alameda	2040	LDT2	25	DSL	278.432
Alameda	2040	LDT2	30	GAS	248.831
Alameda	2040	LDT2	30	DSL	240.765
Alameda	2040	LDT2	35	GAS	222.208
Alameda	2040	LDT2	35	DSL	217.300
Alameda	2040	LDT2	40	GAS	205.853
Alameda	2040	LDT2	40	DSL	202.810
Alameda	2040	LDT2	45	GAS	198.237
Alameda	2040	LDT2	45	DSL	195.544
Alameda	2040	LDT2	50	GAS	197.775
Alameda	2040	LDT2	50	DSL	195.868
Alameda	2040	LDT2	55	GAS	205.336
Alameda	2040	LDT2	55	DSL	204.796
Alameda	2040	LDT2	60	GAS	220.979
Alameda	2040	LDT2	60	DSL	221.836

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2040
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2040	LDT2	65	GAS	246.816
Alameda	2040	LDT2	65	DSL	249.172
Alameda	2040	LHD1	5	GAS	1299.672
Alameda	2040	LHD1	5	DSL	1134.517
Alameda	2040	LHD1	10	GAS	1278.336
Alameda	2040	LHD1	10	DSL	953.738
Alameda	2040	LHD1	15	GAS	888.043
Alameda	2040	LHD1	15	DSL	622.871
Alameda	2040	LHD1	20	GAS	771.017
Alameda	2040	LHD1	20	DSL	530.903
Alameda	2040	LHD1	25	GAS	706.766
Alameda	2040	LHD1	25	DSL	470.861
Alameda	2040	LHD1	30	GAS	641.435
Alameda	2040	LHD1	30	DSL	427.593
Alameda	2040	LHD1	35	GAS	641.435
Alameda	2040	LHD1	35	DSL	427.593
Alameda	2040	LHD1	40	GAS	639.024
Alameda	2040	LHD1	40	DSL	415.887
Alameda	2040	LHD1	45	GAS	636.089
Alameda	2040	LHD1	45	DSL	405.665
Alameda	2040	LHD1	50	GAS	670.803
Alameda	2040	LHD1	50	DSL	425.285
Alameda	2040	LHD1	55	GAS	706.766
Alameda	2040	LHD1	55	DSL	444.408
Alameda	2040	LHD2	5	GAS	1370.064
Alameda	2040	LHD2	5	DSL	1186.967
Alameda	2040	LHD2	10	GAS	1422.068
Alameda	2040	LHD2	10	DSL	1054.895
Alameda	2040	LHD2	15	GAS	1000.366
Alameda	2040	LHD2	15	DSL	702.212
Alameda	2040	LHD2	20	GAS	875.490
Alameda	2040	LHD2	20	DSL	598.935
Alameda	2040	LHD2	25	GAS	791.667
Alameda	2040	LHD2	25	DSL	533.745
Alameda	2040	LHD2	30	GAS	715.545
Alameda	2040	LHD2	30	DSL	481.353
Alameda	2040	LHD2	35	GAS	715.545
Alameda	2040	LHD2	35	DSL	481.353

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2040
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2040	LHD2	40	GAS	699.200
Alameda	2040	LHD2	40	DSL	463.771
Alameda	2040	LHD2	45	GAS	682.722
Alameda	2040	LHD2	45	DSL	445.798
Alameda	2040	LHD2	50	GAS	711.761
Alameda	2040	LHD2	50	DSL	462.218
Alameda	2040	LHD2	55	GAS	744.167
Alameda	2040	LHD2	55	DSL	478.417
Alameda	2040	MCY	5	GAS	567.566
Alameda	2040	MCY	10	GAS	420.981
Alameda	2040	MCY	15	GAS	324.088
Alameda	2040	MCY	20	GAS	258.952
Alameda	2040	MCY	25	GAS	214.749
Alameda	2040	MCY	30	GAS	184.842
Alameda	2040	MCY	35	GAS	165.130
Alameda	2040	MCY	40	GAS	153.111
Alameda	2040	MCY	45	GAS	147.347
Alameda	2040	MCY	50	GAS	147.174
Alameda	2040	MCY	55	GAS	152.574
Alameda	2040	MCY	60	GAS	164.166
Alameda	2040	MCY	65	GAS	183.333
Alameda	2040	MDV	5	GAS	1021.751
Alameda	2040	MDV	5	DSL	721.649
Alameda	2040	MDV	10	GAS	754.921
Alameda	2040	MDV	10	DSL	612.856
Alameda	2040	MDV	15	GAS	581.282
Alameda	2040	MDV	15	DSL	519.743
Alameda	2040	MDV	20	GAS	465.847
Alameda	2040	MDV	20	DSL	431.644
Alameda	2040	MDV	25	GAS	385.981
Alameda	2040	MDV	25	DSL	365.000
Alameda	2040	MDV	30	GAS	332.696
Alameda	2040	MDV	30	DSL	315.246
Alameda	2040	MDV	35	GAS	297.101
Alameda	2040	MDV	35	DSL	286.042
Alameda	2040	MDV	40	GAS	275.235
Alameda	2040	MDV	40	DSL	267.553
Alameda	2040	MDV	45	GAS	265.050

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2040
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2040	MDV	45	DSL	257.481
Alameda	2040	MDV	50	GAS	264.436
Alameda	2040	MDV	50	DSL	258.771
Alameda	2040	MDV	55	GAS	274.541
Alameda	2040	MDV	55	DSL	273.094
Alameda	2040	MDV	60	GAS	295.456
Alameda	2040	MDV	60	DSL	295.706
Alameda	2040	MDV	65	GAS	330.001
Alameda	2040	MDV	65	DSL	332.037
Alameda	2040	MH	5	GAS	3670.431
Alameda	2040	MH	5	DSL	1996.538
Alameda	2040	MH	10	GAS	3133.313
Alameda	2040	MH	10	DSL	1812.865
Alameda	2040	MH	15	GAS	2159.798
Alameda	2040	MH	15	DSL	1488.519
Alameda	2040	MH	20	GAS	1518.519
Alameda	2040	MH	20	DSL	1221.507
Alameda	2040	MH	25	GAS	1325.989
Alameda	2040	MH	25	DSL	1095.642
Alameda	2040	MH	30	GAS	1218.530
Alameda	2040	MH	30	DSL	1028.426
Alameda	2040	MH	35	GAS	1124.999
Alameda	2040	MH	35	DSL	972.645
Alameda	2040	MH	40	GAS	1046.646
Alameda	2040	MH	40	DSL	928.299
Alameda	2040	MH	45	GAS	972.492
Alameda	2040	MH	45	DSL	895.388
Alameda	2040	MH	50	GAS	909.720
Alameda	2040	MH	50	DSL	873.912
Alameda	2040	MH	55	GAS	884.646
Alameda	2040	MH	55	DSL	863.871
Alameda	2040	MH	60	GAS	890.142
Alameda	2040	MH	60	DSL	865.265
Alameda	2040	MH	65	GAS	906.643
Alameda	2040	MH	65	DSL	878.095
Alameda	2040	Motor Coach	5	DSL	3013.944
Alameda	2040	Motor Coach	10	DSL	2672.412
Alameda	2040	Motor Coach	15	DSL	2242.133

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2040
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2040	Motor Coach	20	DSL	1958.715
Alameda	2040	Motor Coach	25	DSL	1807.767
Alameda	2040	Motor Coach	30	DSL	1711.683
Alameda	2040	Motor Coach	35	DSL	1635.601
Alameda	2040	Motor Coach	40	DSL	1573.124
Alameda	2040	Motor Coach	45	DSL	1520.438
Alameda	2040	Motor Coach	50	DSL	1475.101
Alameda	2040	Motor Coach	55	DSL	1435.463
Alameda	2040	Motor Coach	60	DSL	1417.403
Alameda	2040	Motor Coach	65	DSL	1417.403
Alameda	2040	Motor Coach	70	DSL	0.000
Alameda	2040	Motor Coach	75	DSL	0.000
Alameda	2040	Motor Coach	80	DSL	0.000
Alameda	2040	Motor Coach	85	DSL	0.000
Alameda	2040	Motor Coach	90	DSL	0.000
Alameda	2040	OBUS	5	GAS	3659.920
Alameda	2040	OBUS	10	GAS	3124.339
Alameda	2040	OBUS	15	GAS	2153.613
Alameda	2040	OBUS	20	GAS	1514.170
Alameda	2040	OBUS	25	GAS	1322.192
Alameda	2040	OBUS	30	GAS	1215.041
Alameda	2040	OBUS	35	GAS	1121.777
Alameda	2040	OBUS	40	GAS	1043.648
Alameda	2040	OBUS	45	GAS	969.706
Alameda	2040	OBUS	50	GAS	907.115
Alameda	2040	OBUS	55	GAS	882.113
Alameda	2040	OBUS	60	GAS	887.593
Alameda	2040	OBUS	65	GAS	904.047
Alameda	2040	PTO	20	DSL	1833.224
Alameda	2040	SBUS	5	GAS	1735.151
Alameda	2040	SBUS	5	DSL	2118.914
Alameda	2040	SBUS	10	GAS	1481.235
Alameda	2040	SBUS	10	DSL	1878.855
Alameda	2040	SBUS	15	GAS	1021.018
Alameda	2040	SBUS	15	DSL	1576.409
Alameda	2040	SBUS	20	GAS	717.861
Alameda	2040	SBUS	20	DSL	1377.189
Alameda	2040	SBUS	25	GAS	626.845

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2040
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2040	SBUS	25	DSL	1270.969
Alameda	2040	SBUS	30	GAS	576.045
Alameda	2040	SBUS	30	DSL	1203.314
Alameda	2040	SBUS	35	GAS	531.829
Alameda	2040	SBUS	35	DSL	1149.750
Alameda	2040	SBUS	40	GAS	494.789
Alameda	2040	SBUS	40	DSL	1105.767
Alameda	2040	SBUS	45	GAS	459.733
Alameda	2040	SBUS	45	DSL	1068.680
Alameda	2040	SBUS	50	GAS	430.059
Alameda	2040	SBUS	50	DSL	1036.769
Alameda	2040	SBUS	55	GAS	418.205
Alameda	2040	SBUS	55	DSL	1008.871
Alameda	2040	SBUS	60	GAS	420.804
Alameda	2040	SBUS	60	DSL	996.160
Alameda	2040	SBUS	65	DSL	0.000
Alameda	2040	SBUS	70	DSL	0.000
Alameda	2040	SBUS	75	DSL	0.000
Alameda	2040	SBUS	80	DSL	0.000
Alameda	2040	SBUS	85	DSL	0.000
Alameda	2040	SBUS	90	DSL	0.000
Alameda	2040	UBUS	5	GAS	3669.484
Alameda	2040	UBUS	5	DSL	3344.665
Alameda	2040	UBUS	10	GAS	3132.504
Alameda	2040	UBUS	10	DSL	3036.970
Alameda	2040	UBUS	15	GAS	2159.241
Alameda	2040	UBUS	15	DSL	2493.616
Alameda	2040	UBUS	20	GAS	1518.127
Alameda	2040	UBUS	20	DSL	2046.308
Alameda	2040	UBUS	25	GAS	1325.647
Alameda	2040	UBUS	25	DSL	1835.455
Alameda	2040	UBUS	30	GAS	1218.216
Alameda	2040	UBUS	30	DSL	1722.852
Alameda	2040	UBUS	35	GAS	1124.709
Alameda	2040	UBUS	35	DSL	1629.406
Alameda	2040	UBUS	40	GAS	1046.375
Alameda	2040	UBUS	40	DSL	1555.116
Alameda	2040	UBUS	45	GAS	972.241

EMFAC2014 (v1.0.7) Emission Rates
Region Type: County
Region: Alameda
Calendar Year: 2040
Season: Annual
Vehicle Classification: EMFAC2011 Categories
Units: miles/day for VMT, g/mile for RUNEX, PMBW and PMTW

Region	CalYr	VehClass	Speed	Fuel	CO2_RUNEX
Alameda	2040	UBUS	45	DSL	1499.982
Alameda	2040	UBUS	50	GAS	909.486
Alameda	2040	UBUS	50	DSL	1464.005
Alameda	2040	UBUS	55	GAS	884.418
Alameda	2040	UBUS	55	DSL	1447.185
Alameda	2040	UBUS	60	GAS	889.912
Alameda	2040	UBUS	60	DSL	1449.520
Alameda	2040	UBUS	65	GAS	906.409
Alameda	2040	UBUS	65	DSL	1471.013

ATTACHMENT 2

CALCULATIONS:

VMT ADJUSTMENTS

ON-ROAD GHG EMISSIONS

AND

FERRY GHG EMISSIONS

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	VMT Summary and Adjustments	**Date:**	3/17/2016

Annual VMT

	2010 Existing	2040 Baseline	2040 Plus Project
Alameda County Non-Bus VMT	14,688,695,000	17,685,710,000	17,436,415,000
Bus VMT	21,807,000	26,431,000	35,080,000
Ferry VMT	155,000.00	256,000	310,000

17% of Non-Bus VMT are heavy-duty trucks

Speed Distribution

Speed	2010 Percent	2040 Percent
5 mph	0.3	0.4
10 mph	0.1	0.1
15 mph	0.3	0.5
20 mph	2.3	3.5
25 mph	5.4	6.1
30 mph	10.2	11.5
35 mph	9.6	11.4
40 mph	7.4	13.3
45 mph	5.0	14.0
50 mph	10.3	10.6
55 mph	11.5	13.2
60 mph	25.5	11.8
65 mph	12.1	3.6
Total	100.0	100.0

Source: Daniel Block, WSP|Parsons Brinckerhoff, March 2, 2016 and March 17, 2016

To calculate GHG emissions, the on-road VMT needs to be convert to additional vehicle classes and by speed using the speed distribution information.

The California Department of Transportation provided guidance on how to adjust VMT by vehicle class in their Air Quality Technical Analysis Notes, published in June 1988.

Light-duty auto VMT = 81% of Non-heavy truck VMT
Light-duty truck VMT = 14% of Non-heavy truck VMT
Medium-duty truck VMT = 5% of Non-heavy truck VMT
Heavy-duty truck VMT should be divided into 70% diesel and 30% gasoline based on 2014 Alameda County Truck Survey Data

Adjusted On-Road VMT

2010 Existing

Speed	Light-duty Auto	Light-duty Truck	Medium-duty Truck	Heavy-duty Gas Truck	Heavy-duty Diesel Truck	Bus
5 mph	29,625,629	5,120,479	1,828,743	2,247,370	5,243,864	65,421
10 mph	9,875,210	1,706,826	609,581	749,123	1,747,955	21,807
15 mph	29,625,629	5,120,479	1,828,743	2,247,370	5,243,864	65,421
20 mph	227,129,822	39,257,006	14,020,359	17,229,839	40,202,958	501,561
25 mph	533,261,321	92,168,623	32,917,365	40,452,666	94,389,554	1,177,578
30 mph	1,007,271,384	174,096,289	62,177,246	76,410,591	178,291,380	2,224,314
35 mph	948,020,126	163,855,330	58,519,761	71,915,851	167,803,652	2,093,472
40 mph	730,765,514	126,305,151	45,108,982	55,435,135	129,348,648	1,613,718
45 mph	493,760,482	85,341,318	30,479,042	37,456,172	87,397,735	1,090,350
50 mph	1,017,146,594	175,803,115	62,786,827	77,159,715	180,039,335	2,246,121
55 mph	1,135,649,110	196,285,031	70,101,797	86,149,196	201,014,791	2,507,805
60 mph	2,518,178,460	435,240,722	155,443,115	191,026,478	445,728,450	5,560,785
65 mph	1,194,900,367	206,525,989	73,759,282	90,643,937	211,502,519	2,638,647
Total	9,875,209,649	1,706,826,359	609,580,843	749,123,445	1,747,954,705	21,807,000

2040 Baseline

Speed	Light-duty Auto	Light-duty Truck	Medium-duty Truck	Heavy-duty Gas Truck	Heavy-duty Diesel Truck	Bus
5 mph	47,560,411	8,220,318	2,935,828	3,607,885	8,418,398	105,724
10 mph	11,890,103	2,055,080	733,957	901,971	2,104,599	26,431
15 mph	59,450,514	10,275,398	3,669,785	4,509,856	10,522,997	132,155
20 mph	416,153,599	71,927,783	25,688,494	31,568,992	73,660,982	925,085
25 mph	725,296,273	125,359,850	44,771,375	55,020,244	128,380,569	1,612,291
30 mph	1,367,361,826	236,334,143	84,405,051	103,726,689	242,028,941	3,039,565
35 mph	1,355,471,723	234,279,063	83,671,094	102,824,718	239,924,342	3,013,134
40 mph	1,581,383,677	273,325,574	97,616,276	119,962,171	279,911,732	3,515,323
45 mph	1,664,614,397	287,711,130	102,753,975	126,275,969	294,643,929	3,700,340
50 mph	1,260,350,900	217,838,427	77,799,438	95,608,948	223,087,546	2,801,686
55 mph	1,569,493,574	271,270,494	96,882,319	119,060,200	277,807,133	3,488,892
60 mph	1,403,032,134	242,499,381	86,606,922	106,432,603	248,342,740	3,118,858
65 mph	428,043,702	73,982,862	26,422,451	32,470,964	75,765,582	951,516
Total	11,890,102,833	2,055,079,502	733,956,965	901,971,210	2,104,599,490	26,431,000

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	VMT Summary and Adjustments	**Date:**	3/17/2016

2040 Plus Project

Speed	Light-duty Auto	Light-duty Truck	Medium-duty Truck	Heavy-duty Gas Truck	Heavy-duty Diesel Truck	Bus
5 mph	46,752,696	8,080,713	2,885,969	3,607,885	8,418,398	140,320
10 mph	11,688,174	2,020,178	721,492	901,971	2,104,599	35,080
15 mph	58,440,869	10,100,891	3,607,461	4,509,856	10,522,997	175,400
20 mph	409,086,086	70,706,237	25,252,228	31,568,992	73,660,982	1,227,800
25 mph	712,978,607	123,230,870	44,011,025	55,020,244	128,380,569	2,139,880
30 mph	1,344,139,997	232,320,493	82,971,605	103,726,689	242,028,941	4,034,200
35 mph	1,332,451,823	230,300,315	82,250,113	102,824,718	239,924,342	3,999,120
40 mph	1,554,527,126	268,683,701	95,958,465	119,962,171	279,911,732	4,665,640
45 mph	1,636,344,344	282,824,948	101,008,910	126,275,969	294,643,929	4,911,200
50 mph	1,238,946,432	214,138,889	76,478,175	95,608,948	223,087,546	3,718,480
55 mph	1,542,838,953	266,663,523	95,236,972	119,060,200	277,807,133	4,630,560
60 mph	1,379,204,518	238,381,028	85,136,081	106,432,603	248,342,740	4,139,440
65 mph	420,774,260	72,726,415	25,973,720	32,470,964	75,765,582	1,262,880
Total	11,688,173,883	2,020,178,202	721,492,215	901,971,210	2,104,599,490	35,080,000

* Since the speed limit for heavy-duty trucks is 55 mph, VMT for 60 and 65 mph will be added to the 55 mph VMT
An assumption is that the project will not reduce heavy-duty vehicles, so their VMT is being held the same as the baseline

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	Calculation of 2010 Existing Motor Vehicle GHG Emissions	**Date:**	3/17/2016

Table 1
GHG Emission Factors (grams/mile)

	2010						
	5 mph	**10 mph**	**15 mph**	**20 mph**	**25 mph**	**30 mph**	**35 mph**
Light-duty Auto	1082.135	799.478	615.593	493.371	408.779	352.356	314.656
Light-duty Truck	1245.686	920.634	708.87	567.974	470.63	405.618	362.231
Medium-duty Truck	1483.692	1096.267	844.114	676.464	560.494	483.111	431.425
Heavy-duty Gas Truck	1407.491	1384.385	961.714	834.98	765.398	694.647	694.647
Heavy-duty Diesel Truck	1304.151	1096.342	716.003	610.285	541.264	491.527	491.527
Bus	4056.679	3683.482	3024.458	2481.928	2226.188	2089.614	1976.275

	2010					
	40 mph	**45 mph**	**50 mph**	**55 mph**	**60 mph**	**65 mph**
Light-duty Auto	291.493	280.71	280.053	290.763	312.915	349.503
Light-duty Truck	335.593	323.159	322.436	334.723	360.218	402.331
Medium-duty Truck	399.677	384.884	383.996	398.665	429.035	479.198
Heavy-duty Gas Truck	692.036	688.858	726.452	765.856	NA	NA
Heavy-duty Diesel Truck	478.07	466.32	488.874	510.856	NA	NA
Bus	1886.17	1819.299	1775.664	1755.262	1758.095	1784.163

Source: EMFAC2014

Table 2
Vehicle Miles Traveled

	5 mph	**10 mph**	**15 mph**	**20 mph**	**25 mph**	**30 mph**	**35 mph**
Light-duty Auto	29,625,629	9,875,210	29,625,629	227,129,822	533,261,321	1,007,271,384	948,020,126
Light-duty Truck	5,120,479	1,706,826	5,120,479	39,257,006	92,168,623	174,096,289	163,855,330
Medium-duty Truck	1,828,743	609,581	1,828,743	14,020,359	32,917,365	62,177,246	58,519,761
Heavy-duty Gas Truck	2,247,370	749,123	2,247,370	17,229,839	40,452,666	76,410,591	71,915,851
Heavy-duty Diesel Truck	5,243,864	1,747,955	5,243,864	40,202,958	94,389,554	178,291,380	167,803,652
Bus	65,421	21,807	65,421	501,561	1,177,578	2,224,314	2,093,472

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	Calculation of 2010 Existing Motor Vehicle GHG Emissions	**Date:**	3/17/2016

Table 2 (Continued)
Vehicle Miles Traveled

	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph
Light-duty Auto	730,765,514	493,760,482	1,017,146,594	1,135,649,110	2,518,178,460	1,194,900,367
Light-duty Truck	126,305,151	85,341,318	175,803,115	196,285,031	435,240,722	206,525,989
Medium-duty Truck	45,108,982	30,479,042	62,786,827	70,101,797	155,443,115	73,759,282
Heavy-duty Gas Truck	55,435,135	37,456,172	77,159,715	367,819,611		
Heavy-duty Diesel Truck	129,348,648	87,397,735	180,039,335	858,245,760		
Bus	1,613,718	1,090,350	2,246,121	2,507,805	5,560,785	2,638,647
	1,132,708,654	750,235,602	1,559,313,212	2,968,950,660	3,908,790,190	2,978,295,490

Table 3
Emissions (metric tons/year)

	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph
Light-duty Auto	31,738	7,816	18,055	110,939	215,806	351,369	295,317
Light-duty Truck	6,315	1,556	3,593	22,074	42,944	69,910	58,760
Medium-duty Truck	2,686	662	1,528	9,389	18,265	29,738	24,994
Heavy-duty Gas Truck	3,132	1,027	2,140	14,243	30,653	52,548	49,457
Heavy-duty Diesel Truck	6,770	1,897	3,717	24,290	50,579	86,759	81,655
Bus	263	80	196	1,232	2,595	4,601	4,096

	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph
Light-duty Auto	210,883	137,217	282,006	326,903	780,096	413,445
Light-duty Truck	41,963	27,303	56,118	65,044	155,214	82,261
Medium-duty Truck	17,849	11,614	23,869	27,668	66,024	34,992
Heavy-duty Gas Truck	37,979	25,544	55,492	278,880		
Heavy-duty Diesel Truck	61,219	40,348	87,136	434,056		
Bus	3,013	1,964	3,948	4,358	9,679	4,661

Total Light-Duty Autos	3,181,591
Total Trucks	2,331,852
Total Bus	40,686

Overall Total 5,554,129

Emissions (pounds/year) = VMT x Emission Factor (grams/mile) x 0.0022 pounds/gram
1 pound = 0.00045 metric ton

Project: Alameda CTC Transit Plan **Prepared by:** Ivy Edmonds-Hess
Subject: Calculation of 2040 Baseline Motor Vehicle GHG Emissions **Date:** 3/17/2016

Table 1
GHG Emission Factors (grams/mile)

	2040						
	5 mph	**10 mph**	**15 mph**	**20 mph**	**25 mph**	**30 mph**	**35 mph**
Light-duty Auto	616.515	455.444	350.69	281.08	232.883	200.744	179.264
Light-duty Truck	663.072	489.899	377.218	302.313	250.482	215.905	192.805
Medium-duty Truck	764.194	564.608	434.743	348.417	288.681	248.831	222.208
Heavy-duty Gas Truck	1299.672	1278.336	888.043	771.017	706.766	641.435	641.435
Heavy-duty Diesel Truck	1134.517	953.738	622.871	530.903	470.861	427.593	427.593
Bus (assumed to be zero emission vehicles)	0	0	0	0	0	0	0

	2040					
	40 mph	**45 mph**	**50 mph**	**55 mph**	**60 mph**	**65 mph**
Light-duty Auto	166.065	159.924	159.924	165.652	178.274	199.119
Light-duty Truck	178.614	172.005	171.605	178.165	191.738	214.156
Medium-duty Truck	205.853	198.237	197.775	205.336	220.979	146.816
Heavy-duty Gas Truck	639.024	636.089	670.803	706.766	NA	NA
Heavy-duty Diesel Truck	415.887	405.665	425.285	444.408	NA	NA
Bus (assumed to be zero emission vehicles)	0	0	0	0	0	0

Source: EMFAC2014

Table 2
Vehicle Miles Traveled

	5 mph	**10 mph**	**15 mph**	**20 mph**	**25 mph**	**30 mph**	**35 mph**
Light-duty Auto	47,560,411	11,890,103	59,450,514	416,153,599	725,296,273	1,367,361,826	1,355,471,723
Light-duty Truck	8,220,318	2,055,080	10,275,398	71,927,783	125,359,850	236,334,143	234,279,063
Medium-duty Truck	2,935,828	733,957	3,669,785	25,688,494	44,771,375	84,405,051	83,671,094
Heavy-duty Gas Truck	3,607,885	901,971	4,509,856	31,568,992	55,020,244	103,726,689	102,824,718
Heavy-duty Diesel Truck	8,418,398	2,104,599	10,522,997	73,660,982	128,380,569	242,028,941	239,924,342
Bus	105,724	26,431	132,155	925,085	1,612,291	3,039,565	3,013,134

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	Calculation of 2040 Baseline Motor Vehicle GHG Emissions	**Date:**	3/17/2016

Table 2 (Continued)
Vehicle Miles Traveled

	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph
Light-duty Auto	1,581,383,677	1,664,614,397	1,260,350,900	1,569,493,574	1,403,032,134	428,043,702
Light-duty Truck	273,325,574	287,711,130	217,838,427	271,270,494	242,499,381	73,982,862
Medium-duty Truck	97,616,276	102,753,975	77,799,438	96,882,319	86,606,922	26,422,451
Heavy-duty Gas Truck	119,962,171	126,275,969	95,608,948	257,963,766	NA	NA
Heavy-duty Diesel Truck	279,911,732	294,643,929	223,087,546	601,915,454	NA	NA
Bus	3,515,323	3,700,340	2,801,686	3,488,892	3,118,858	951,516

Table 3
Emissions (metric tons/year)

	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph
Light-duty Auto	29,028	5,361	20,640	115,803	167,220	271,745	240,557
Light-duty Truck	5,396	997	3,837	21,527	31,086	50,515	44,718
Medium-duty Truck	2,221	410	1,579	8,861	12,795	20,793	18,406
Heavy-duty Gas Truck	4,642	1,141	3,965	24,097	38,498	65,869	65,296
Heavy-duty Diesel Truck	9,455	1,987	6,489	38,716	59,845	102,455	101,564
Bus	0	0	0	0	0	0	0

	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph
Light-duty Auto	259,986	263,550	199,545	257,390	247,623	84,379
Light-duty Truck	48,332	48,993	37,008	47,848	46,031	15,685
Medium-duty Truck	19,894	20,166	15,233	19,694	18,947	3,840
Heavy-duty Gas Truck	75,892	79,520	63,493	180,497		
Heavy-duty Diesel Truck	115,248	118,331	93,927	264,821		
Bus	0	0	0	0	0	0

Total Light-Duty Autos	2,162,828
Total Trucks	2,080,563
Total Bus	0

Overall Total 4,243,391

Emissions (pounds/year) = VMT x Emission Factor (grams/mile) x 0.0022 pounds/gram
1 pound = 0.00045 metric ton

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	Calculation of 2040 Plus Project Motor Vehicle GHG Emissions	**Date:**	3/17/2016

Table 1
GHG Emission Factors (grams/mile)

	2040						
	5 mph	**10 mph**	**15 mph**	**20 mph**	**25 mph**	**30 mph**	**35 mph**
Light-duty Auto	616.515	455.444	350.69	281.08	232.883	200.744	179.264
Light-duty Truck	663.072	489.899	377.218	302.313	250.482	215.905	192.805
Medium-duty Truck	764.194	564.608	434.743	348.417	288.681	248.831	222.208
Heavy-duty Gas Truck	1299.672	1278.336	888.043	771.017	706.766	641.435	641.435
Heavy-duty Diesel Truck	1134.517	953.738	622.871	530.903	470.861	427.593	427.593
Bus (assumed to be zero emission vehicles)	0	0	0	0	0	0	0

	2040					
	40 mph	**45 mph**	**50 mph**	**55 mph**	**60 mph**	**65 mph**
Light-duty Auto	166.065	159.924	159.924	165.652	178.274	199.119
Light-duty Truck	178.614	172.005	171.605	178.165	191.738	214.156
Medium-duty Truck	205.853	198.237	197.775	205.336	220.979	146.816
Heavy-duty Gas Truck	639.024	636.089	670.803	706.766	NA	NA
Heavy-duty Diesel Truck	415.887	405.665	425.285	444.408	NA	NA
Bus (assumed to be zero emission vehicles)	0	0	0	0	0	0

Source: EMFAC2014

Table 2
Vehicle Miles Traveled

	5 mph	**10 mph**	**15 mph**	**20 mph**	**25 mph**	**30 mph**	**35 mph**
Light-duty Auto	46,752,696	11,688,174	58,440,869	409,086,086	712,978,607	1,344,139,997	1,332,451,823
Light-duty Truck	8,080,713	2,020,178	10,100,891	70,706,237	123,230,870	232,320,493	230,300,315
Medium-duty Truck	2,885,969	721,492	3,607,461	25,252,228	44,011,025	82,971,605	82,250,113
Heavy-duty Gas Truck	3,607,885	901,971	4,509,856	31,568,992	55,020,244	103,726,689	102,824,718
Heavy-duty Diesel Truck	8,418,398	2,104,599	10,522,997	73,660,982	128,380,569	242,028,941	239,924,342
Bus	140,320	35,080	175,400	1,227,800	2,139,880	4,034,200	3,999,120

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	Calculation of 2040 Plus Project Motor Vehicle GHG Emissions	**Date:**	3/17/2016

Table 2 (Continued)
Vehicle Miles Traveled

	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph
Light-duty Auto	1,554,527,126	1,636,344,344	1,238,946,432	1,542,838,953	1,379,204,518	420,774,260
Light-duty Truck	268,683,701	282,824,948	214,138,889	266,663,523	238,381,028	72,726,415
Medium-duty Truck	95,958,465	101,008,910	76,478,175	95,236,972	85,136,081	25,973,720
Heavy-duty Gas Truck	119,962,171	126,275,969	95,608,948	257,963,766	NA	NA
Heavy-duty Diesel Truck	279,911,732	294,643,929	223,087,546	601,915,454	NA	NA
Bus	4,665,640	4,911,200	3,718,480	4,630,560	4,139,440	1,262,880

Table 3
Emissions (metric tons/year)

	5 mph	10 mph	15 mph	20 mph	25 mph	30 mph	35 mph
Light-duty Auto	28,536	5,270	20,290	113,836	164,380	267,130	236,472
Light-duty Truck	5,305	980	3,772	21,162	30,558	49,658	43,959
Medium-duty Truck	2,183	403	1,553	8,710	12,578	20,439	18,094
Heavy-duty Gas Truck	4,642	1,141	3,965	24,097	38,498	65,869	65,296
Heavy-duty Diesel Truck	9,455	1,987	6,489	38,716	59,845	102,455	101,564
Bus	0	0	0	0	0	0	0

	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph
Light-duty Auto	255,571	259,074	196,156	253,019	243,418	82,946
Light-duty Truck	47,511	48,161	36,380	47,035	45,250	15,419
Medium-duty Truck	19,556	19,823	14,974	19,360	18,625	3,775
Heavy-duty Gas Truck	75,892	79,520	63,493	180,497		
Heavy-duty Diesel Truck	115,248	118,331	93,927	264,821		
Bus	0	0	0	0	0	0

Total Light-Duty Autos	2,126,097
Total Trucks	2,070,971
Total Bus	0

Overall Total 4,197,067

Emissions (pounds/year) = VMT x Emission Factor (grams/mile) x 0.0022 pounds/gram
1 pound = 0.00045 metric ton

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	Calculation of 2010 Existing Ferry GHG Emissions	**Date:**	3/17/2016

Table 1
GHG Emission Factor (grams/gallon of diesel fuel)

Carbon Dioxide
13,818.00

Source: California Air Resources Board, Draft Greenhouse Gas Quantification Methodology for the California State Transportation Agency Transit and Intercity Rail Capital Program, Greenhouse Gas Reduction Fund FY 2016-17, Appendix E - Ferry Emission Factor Lookup Table, January 12, 2016

Table 2
2040 Annual Ferry Miles Traveled

VMT
155,000

Source: Daniel Block, WSP|Parsons Brinckerhoff, March 17, 2016

Table 3
Emissions

Carbon Dioxide (Pounds/Year)	Carbon Dioxide (Metric Tons/Year)
39,266,150	17,670

Emissions (pounds/yr) = (VMT/Fuel Consumption Rate (miles/gallon of diesel fuel)) x Emission Factor (grams/gallon of diesel fuel) x 0.0022 pounds/gram

Assumptions:

Fuel Consumption Rate is 0.12 mile/gallon of diesel fuel.

Source: Cottrell, Wayne D., Comparison of Ferry Boat and Highway Bridge Energy Use, Table 1 - Year 2008 Diesel Fuel Consumption by Selected U.S. Ferry Boat Operators, Energies, Issue 2011-4, Published January, 27, 2011

Information for Golden Gate Ferries was used.

1 pound = 0.00045 metric ton

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	Calculation of 2040 Baseline Ferry GHG Emissions	**Date:**	3/17/2016

Table 1
GHG Emission Factor (grams/gallon of diesel fuel)

Carbon Dioxide
13,818.00

Source: California Air Resources Board, Draft Greenhouse Gas Quantification Methodology for the California State Transportation Agency Transit and Intercity Rail Capital Program, Greenhouse Gas Reduction Fund FY 2016-17, Appendix E - Ferry Emission Factor Lookup Table, January 12, 2016

Table 2
2040 Annual Ferry Miles Traveled

VMT
256,000

Source: Daniel Block, WSP|Parsons Brinckerhoff, March 17, 2016

Table 3
Emissions

Carbon Dioxide (Pounds/Year)	Carbon Dioxide (Metric Tons/Year)
64,852,480	29,184

Emissions (pounds/yr) = (VMT/Fuel Consumption Rate (miles/gallon of diesel fuel)) x Emission Factor (grams/gallon of diesel fuel) x 0.0022 pounds/gram

Assumptions:

Fuel Consumption Rate is 0.12 mile/gallon of diesel fuel.

Source: Cottrell, Wayne D., Comparison of Ferry Boat and Highway Bridge Energy Use, Table 1 - Year 2008 Diesel Fuel Consumption by Selected U.S. Ferry Boat Operators, Energies, Issue 2011-4, Published January, 27, 2011

Information for Golden Gate Ferries was used.

1 pound = 0.00045 metric ton

Project:	Alameda CTC Transit Plan	**Prepared by:**	Ivy Edmonds-Hess
Subject:	Calculation of 2040 Plus Project Ferry GHG Emissions	**Date:**	3/17/2016

Table 1
GHG Emission Factor (grams/gallon of diesel fuel)

Carbon Dioxide
13,818.00

Source: California Air Resources Board, Draft Greenhouse Gas Quantification Methodology for the California State Transportation Agency Transit and Intercity Rail Capital Program, Greenhouse Gas Reduction Fund FY 2016-17, Appendix E - Ferry Emission Factor Lookup Table, January 12, 2016

Table 2
2040 Annual Ferry Miles Traveled

VMT
310,000

Source: Daniel Block, WSP|Parsons Brinckerhoff, March 17, 2016

Table 3
Emissions

Carbon Dioxide (Pounds/Year)	Carbon Dioxide (Metric Tons/Year)
78,532,300	35,340

Emissions (pounds/yr) = (VMT/Fuel Consumption Rate (miles/gallon of diesel fuel)) x Emission Factor (grams/gallon of diesel fuel) x 0.0022 pounds/gram

Assumptions:

Fuel Consumption Rate is 0.12 mile/gallon of diesel fuel.

Source: Cottrell, Wayne D., Comparison of Ferry Boat and Highway Bridge Energy Use, Table 1 - Year 2008 Diesel Fuel Consumption by Selected U.S. Ferry Boat Operators, Energies, Issue 2011-4, Published January, 27, 2011

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