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Dumbarton Transportation Corridor Study

San Mateo County Transit District

Final Report | November 2017

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samTrans

ACKNOWLEDGEMENTS

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Table of Acronyms

ATCMTD	Advanced Transportation and Congestion Management Technologies Deployment
ARB	Air Resources Board
Alameda CTC	Alameda County Transportation Commission
AC Transit	Alameda-Contra Costa Transit District
ACE	Altamont Commuter Express
BART	Bay Area Rapid Transit
BRT	bus rapid transit
HSR	California High Speed Rail
IBank	California Infrastructure and Economic Development Bank
CTC	California Transportation Commission
CIG	Capital Investment Grant
C/CAG	City/County Association of Governments
CMAQ	Congestion Mitigation and Air Quality
DMU	diesel multiple unit
DB	Dumbarton Express
DB1	Dumbarton Express 1
DTCS	Dumbarton Transportation Corridor Study
EMU	Electric Multiple Unit
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FY	fiscal year
FAST Act	Fixing America's Surface Transportation Act
FASTLANE	Fostering Advancements in Shipping and Transportation for the Long-term Achievement of National Efficiencies
GUP	General Use Permit
GAN	Grant Anticipation Notes
GARVEE	Grant Anticipation Revenue Vehicles
GGRF	Greenhouse Gas Reduction Fund
GHG	greenhouse gas

HOV	high-occupancy vehicles
HCM	Highway Capacity Manual
INFRA	Infrastructure for Rebuilding America
ICM	Integrated Corridor Management
ITS	Intelligent Transportation Systems
ITIP	Interregional Transportation Improvement Program
LOS	level of service
LRT	light rail transit
LEHD	Longitudinal Employer Household Dynamics
MOE	measure of effectiveness
MTC	Metropolitan Transportation Commission
NCHRP	National Highway Cooperative Research Program
PRT	personal rapid transit
PTC	positive train control
PAB	Private Activity Bond
P’13	Projections’13
PTA	Public Transportation Account
P3	public-private partnership
RRIF	Railroad Rehabilitation and Improvement Financing
RM3	Regional Measure 3
RTD	Regional Transportation District
RTIP	Regional Transportation Improvement Program
RTP	Regional Transportation Plan
ROW	right-of-way
SamTrans	San Mateo County Transit District
VTA	Santa Clara Valley Transportation Authority
SB	Senate Bill
SHOPP	State Highway Operation and Protection Program
SR	State Route
STIP	State Transportation Improvement Program
STBG	Surface Transportation Block Grant
STB	Surface Transportation Board
STSFA	Surface Transportation System Funding Alternatives
TIF	Tax Increment Financing
TAZ	traffic analysis zone
TSP	transit signal priority

TCA	Transportation Corridor Agencies
TFCA	Transportation Fund for Clean Air
TIFIA	Transportation Infrastructure Finance and Innovation Act
TIGER	Transportation Investment Generating Economic Recovery
TOD	transit-oriented development
TSM	transportation system management
USDOT	U.S. Department of Transportation
UP	Union Pacific Railroad
V/C	volume-to-capacity
WETA	Water Emergency Transportation Authority

1 Executive Summary

The Dumbarton Transportation Corridor Study (DTCS) is a feasibility study that evaluates potential multimodal transportation improvements within the Dumbarton Corridor in the South San Francisco Bay Area. Improvements are designed to improve mobility between southern Alameda County (East Bay) and San Mateo County / northern Santa Clara County (the Peninsula). The DTCS was led by the San Mateo County Transit District (SamTrans), which purchased the Dumbarton Rail Bridge and right-of-way (ROW) between Redwood Junction and Newark Junction in 1994, anticipating eventual reinstatement of rail service in the Corridor. In addition to studying potential transit services on the Rail Bridge, the DTCS examines improvements to the Dumbarton Highway Bridge and its approaches. SamTrans worked collaboratively with project partners including Facebook, the San Mateo County Transportation Authority (TA), Alameda County Transportation Commission (Alameda CTC), and the Alameda-Contra Costa Transit District (AC Transit) over the course of the study. SamTrans also conducted stakeholder and public outreach at three major study milestones.

The DTCS study area includes cities in San Mateo, Santa Clara and Alameda counties that immediately surround and include the Dumbarton Highway and Rail Bridges. Tier 1 cities are directly affected by transportation facilities on this Corridor while Tier 2 cities are indirectly affected by congestion along the Dumbarton Corridor. **Table 1-1** lists the study area cities and **Figure 1-1** shows the DTCS study area.

Table 1-1: Dumbarton Transportation Corridor Study Area Cities

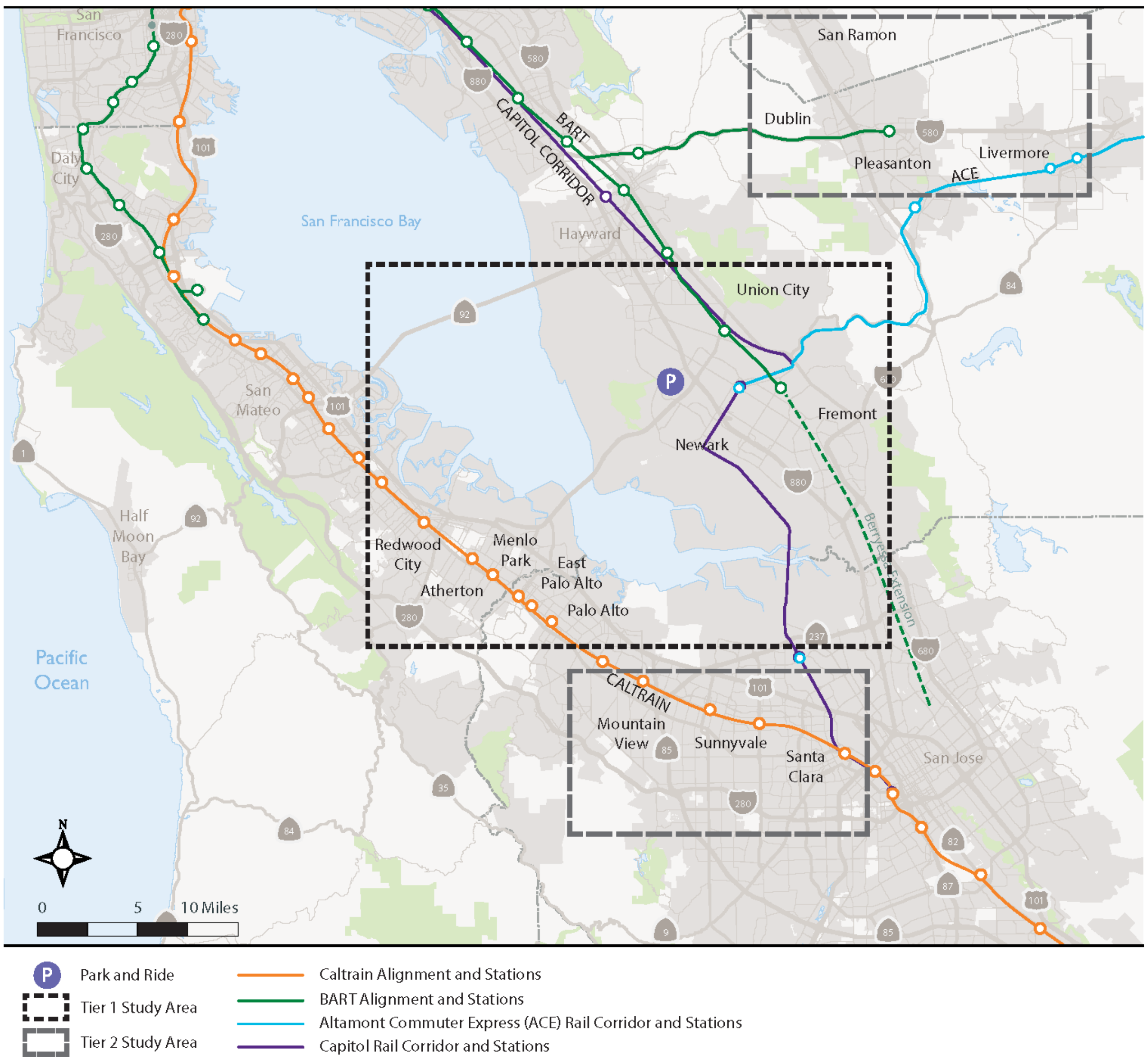
Peninsula Tier 1 Cities	East Bay Tier 1 Cities
• Redwood City • Menlo Park • East Palo Alto • Palo Alto • Stanford (Census-Designated Place) • Atherton	• Union City • Newark • Fremont
Peninsula Tier 2 Cities	**East Bay Tier 2 Cities**
• Mountain View • Sunnyvale • Santa Clara	• San Ramon • Dublin • Pleasanton • Livermore

Source: CDM Smith, 2016

The Corridor has been the subject of feasibility studies since the early 1990s, all part of an attempt to address the growing demand for travel between the East Bay and Peninsula and lack of a high-capacity transit option across the southern portion of the Bay. Traffic congestion and the jobs-housing imbalance between the two sides of the Bay has grown and are projected to worsen if the Corridor isn't improved to move more people, especially during the peak commute travel periods.

Since the last Corridor study conducted in 2012, the transportation landscape has continued to change. Regional rail ridership reached all-time highs and several regional projects have advanced, such as the Caltrain Peninsula Corridor Electrification Project and Bay Area Rapid Transit (BART) extension to San Jose, though they have not been fully realized. Meanwhile, major employers have developed their own commuter shuttle and ferry programs in response to the lack of attractive and reliable cross-county commute options for their employees and the need to manage the travel demand destined for their worksites. In addition, the rise of ridesharing and transportation network companies provides people with other travel options. It is yet to be seen whether this new mode replaces transit trips or fills a void in first and last mile connections to transit stations, particularly rail.

Figure 1-1: Dumbarton Transportation Corridor Study Area



Source: CDM Smith, 2016

The fact remains: projected regional growth will deteriorate the reliability of the existing Dumbarton services and facilities. An increasing desire for innovative solutions among the community has culminated in an effort to develop a multimodal strategy that could be implemented through a partnership with private sector stakeholders.

1.1 Need and Purpose

There are a number of indicators that highlight the need for transportation improvements in the Dumbarton Corridor:

Worsening Roadway Congestion. The existing highway capacity in the Dumbarton Corridor is not sufficient to accommodate current and forecasted peak-hour demands at high levels of service (free-flowing travel). Nearly all major arterials within the DTCS area currently operate at low levels of service (LOS) (E or F) during the morning and evening peak periods. This has produced increasing unpredictability in travel patterns and times that threaten the region's quality of life.

Worsening Jobs Housing Imbalance. A major driver behind the congestion increase in the Dumbarton Corridor is accelerated job growth in Silicon Valley combined with limited housing supply on the Peninsula. Between 2010 and 2014, San Mateo County added 54,600 jobs compared to 2,100 new housing units.[1] This jobs/housing imbalance has resulted in significant commuting into San Mateo County from surrounding areas. Regional forecasts show employment growth will outpace population growth through 2020 and beyond.

Lack of Regional Transit Connectivity. Another driver of congestion is that existing transit systems do not support east-west connectivity in the South Bay. The Dumbarton Highway Bridge is the primary choice for travelers between southern Alameda County and San Mateo and Santa Clara counties but lacks substantial transit options, forcing a higher mode share for the automobile.

Increasing Threats to Economic Growth. Significant congestion makes it difficult for employers to attract and retain talent; exceptionally long travel times result in a less efficient economy that has ripple effects on the region's overall quality of life. In addition to the traditional means of looking at costs, there are social costs to be borne by the commuters, businesses, and overall environmental health if traffic congestion is not addressed.

Increasing Safety Concerns. The Dumbarton Rail Bridge is a potentially significant asset for the San Francisco Bay Area but is non-functional because of historic incidents and inadequate maintenance. Failure to repurpose the Rail Bridge would represent a wasted opportunity to provide needed transportation infrastructure. It also represents a safety hazard in its current condition and could require substantial funding to remove if not repaired.

As a result of this need, the following are the DTCS goals and purpose:

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[1] "The Challenge." *Home for All*. Web. July 20, 2017.

- Identify capital improvements and operational programs in the Dumbarton Corridor that enhance multimodal mobility for local and regional travelers, with an emphasis on improving person throughput by expanding transit service.
- Pursue cost-effective capital, operational and maintenance improvements with a return on investment, if feasible, including the effective repurposing of the Dumbarton Rail Bridge.
- Manage and minimize environmental impacts and financial risk, and maximize safety.
- Ensure local communities in the East Bay and Peninsula are protected from adverse impacts related to the development and operation of regional mobility solutions.

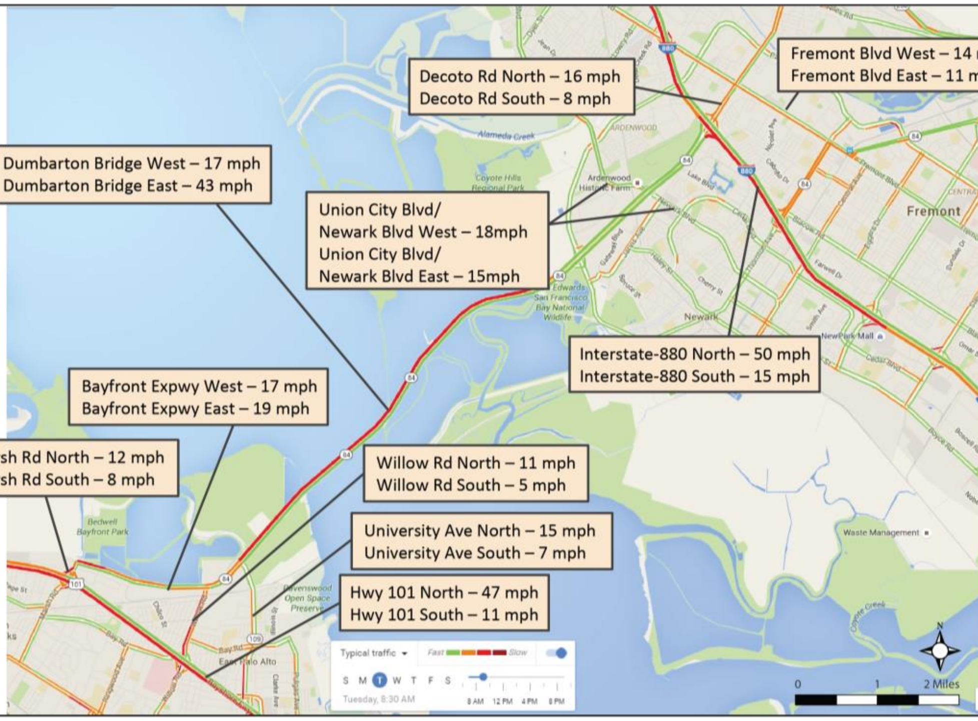
Additional detail about the purpose and need of the study are included in **Chapter 3**.

1.2 Existing and Future Conditions

Traffic congestion in the study area is the primary reason for studying and implementing transportation solutions in the Corridor. As shown in **Figure 1-2** and **Figure 1-3**, average speeds on major arterials in the morning and evening peak periods are low, resulting in significant vehicle and person delay. Regional Plan Bay Area forecasts by the Association of Bay Area Governments, as projected by the San Mateo City/County Association of Governments (C/CAG) – Santa Clara Valley Transportation Authority (VTA) travel demand model, predict that both population and employment of the DTCS cities will grow by 27 percent between 2013 and 2040, or 290,000 residents and 190,000 jobs. The continued pattern of relatively affordable housing in the East Bay and employment growth on the Peninsula will exacerbate the congested conditions on the region's roadways if attractive alternatives are not implemented.

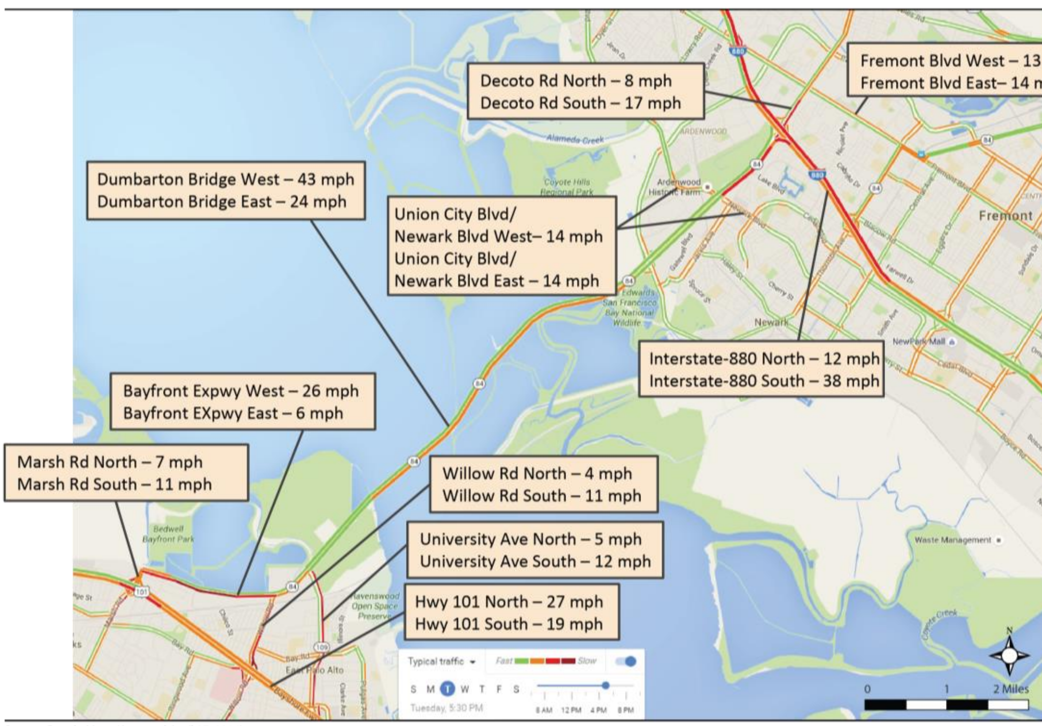
Due to constrained ROW and potential environmental and community impacts, increasing the roadway and highway capacity through widening is very limited and undesirable. Alameda and Santa Clara County have both constructed express lanes to increase the person throughput of high-occupancy vehicle (HOV) lanes, by allowing single-occupant vehicles (SOVs) to pay a toll to use lanes otherwise only available to HOVs. More express lane solutions are being considered throughout the region, including in San Mateo County, to address the congestion on highways by encouraging HOV travel and providing access for transit vehicles where they currently compete with SOVs.

Figure 1-2: Morning Peak Period (8:30 AM) Average Speeds on Major Arterials (2016)



Source: Google Maps (Accessed April 27, 2016)

Figure 1-3: Evening Peak Period (5:30 PM) Average Speeds on Major Arterials (2016)



Source: Google Maps (Accessed April 27, 2016)

The Dumbarton Corridor includes approximately 18 miles of existing rail infrastructure in the Peninsula and East Bay, including the Dumbarton Rail Bridge across the southern part of the San Francisco Bay. The Dumbarton Rail Bridge carries a single railroad track over approximately 1,400 feet of steel truss structure, including a large swing bridge designed to allow watercraft to clear the crossing. Adjacent to the Rail Bridge is the Dumbarton Highway Bridge, which carries State Route (SR) 84 over the San Francisco Bay, and is the shortest such crossing at approximately two miles long. The Highway Bridge connects Menlo Park on the Peninsula to Fremont on the East Bay. The tolled Highway Bridge provides three lanes in each direction except a segment with seven lanes at the toll plaza. There is also a separate two-way bicycle and pedestrian lane along the south side of the Highway Bridge.

There are currently three transbay express bus routes that operate on the Dumbarton Highway Bridge: the Dumbarton Express (DB), Dumbarton Express 1 (DB1), and Stanford University's Line U. While these routes serve Stanford University and major employment destinations in Palo Alto, they do not directly serve several other major activity and employment centers on the Peninsula such as Menlo Park, Redwood City and portions of Santa Clara County. Due to limited operating funds, transit service is often infrequent and not well-integrated or timed with other existing transit networks. Multiple transfers with potentially long wait times are required to reach some key destinations and buses experience the same congestion-related delays as auto drivers.

Private employer-sponsored shuttle services around the region, which provide limited stop bus travel to large employers have mushroomed within the last five years. The Bay Area Council and the Metropolitan Transportation Commission (MTC) performed a study, which summarized private shuttle data from 35 shuttle sponsors from 2012–2014. The data show that shuttles carried over 9.6 million passengers in 2014, and if private shuttles were treated as one transit system they would represent the seventh-largest transit system in the Bay Area. The data also show that up to 50 shuttles per day traveled between San Mateo and Alameda Counties during the survey period. Several employers have also contracted with private ferry operators to provide commuter service for employees where bus travel is too lengthy and impractical. City-mandated limits on automobile trips to the campuses of large employers have spurred the need for these employer-sponsored services.

As shown in **Figure 1-1** multiple passenger rail services exist in and around the study area. Passenger rail service in the East Bay that crosses county lines includes the Bay Area Rapid Transit (BART) District, which serves employment destinations in Alameda/Contra Costa/San Francisco Counties; Altamont Commuter Express (ACE), which connects the Central Valley / Tri-Valley with employment destinations in Santa Clara County (San Jose); and Capital Corridor, which originates in the Sacramento area and serves destinations in Alameda/West Contra Costa/Santa Clara Counties (San Jose). BART is an urban transit system and while service is relatively frequent throughout the day, it makes many stops and trains to San Francisco are especially crowded during the peak periods. ACE and Capitol Corridor provide intercity rail service but have very limited service in the off-peak periods.

Caltrain serves destinations along the Peninsula in San Francisco, San Mateo, and Santa Clara Counties. Past and currently proposed Dumbarton rail alternatives have included use of the

Caltrain mainline to provide service to these destinations. Caltrain mainline capacity is limited, however. While the modernization of Caltrain will certainly improve this situation with a modern signal system and electrified fleet of high-performance vehicles, the track and terminal capacity are constrained and would not change without further investment in infrastructure in the Corridor that would be difficult to accommodate within the narrow ROW. In addition, plans are being developed for high-speed trains to share the Caltrain corridor as part of the statewide high-speed rail network, which increases the demand for rail capacity in the Corridor.

The issue of rail line capacity, or ability of a rail line to handle daily train volume with minimum delay, is a fundamental consideration regarding the potential implementation any rail service. In the East Bay, potential Dumbarton Corridor trains going to and from a terminus adjacent to the Union City BART station would touch on three Union Pacific Railroad (UP) lines: the Coast Subdivision (between Oakland and San Jose via North Elmhurst and Newark), the Niles Subdivision (between Oakland and Newark via Niles Junction), and the Oakland Subdivision (between Oakland, Union City Niles Junction, and Stockton). The 2016 *Alameda County Goods Movement Plan* looked at anticipated 2020 average daily trains (freight and passenger) and the capacity of the lines above measured in terms of trains per day. The area of potential capacity concern for Dumbarton Corridor trains is with regard to crossing the UP Coast Subdivision at Newark to reach the Niles Subdivision running east to Niles (see **Figure 1-4**). This crossing is already at or near capacity and Dumbarton Corridor trains would need a new connection between the Niles Subdivision east of the Fremont Centerville Station and the Oakland Subdivision running north to Union City.

Additional detail about existing and future conditions can be found in **Chapter 4**.

Figure 1-4: Freight Rail Subdivisions in the DTCS Study Area

Source: CDM Smith, 2017

1.3 Alternatives Development

The alternatives were developed in a multi-step process, starting with consideration of a wide range of initial improvement options applicable to the Highway Bridge and its approaches, the Rail Bridge, and other transbay crossing options that would not require either bridge. The initial screening determined which initial improvement options would be carried forward for further analysis. Initial improvement options carried forward for further analysis were then packaged as alternatives, developed in greater detail, and evaluated again in a comparative analysis.

Short-term and long-term initial improvement options for the Highway and Rail Bridge (screened in the initial screening process) are summarized below.

While there are no short-term improvements on the Highway Bridge itself, there are approach improvements that could enhance mobility in the Dumbarton Corridor with an emphasis on bus transit and other HOVs. These options include improvements to the Dumbarton Bridge toll plaza, park-and-ride facilities, roadway infrastructure, traffic and transit operations, transit service, bicycle and pedestrian access, as well as other strategies to improve mobility and access. Long-term options for the Highway Bridge and its approaches build upon the short-term improvements. This includes major infrastructure and operational improvements to enhance transit and traffic operations in the study area such as bus-only, HOV, or express lanes, grade separations, direct connect flyovers, etc.

The initial short-term Rail Bridge improvements include several bicycle and pedestrian multiuse path options, which use the Dumbarton Corridor ROW on the Peninsula. Long-term Rail Bridge improvements include a variety of modes that make up the universe of possible long-term transit options including commuter rail, bus rapid transit, light rail transit, BART, personal rapid transit, group rapid transit, people mover, hyperloop, ferry, and gondola.

Additional detail about initial improvement options can be found in **Chapter 5**.

All initial improvement options were qualitatively evaluated based on the project goals. (More detail about this initial screening can be found in **Chapter 6**.) Based on these criteria, the best performing initial improvement options were packaged into a final set of ten project alternatives:

- Alternative 1: No Build (2020)
- Alternative 2: Short-Term Enhanced Bus on Highway Bridge (2020)
- Alternative 3: No Build (2040)
- Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes (2030)
- Alternative 5: Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction (2030)
- Alternative 6: Busway on Rail Bridge (2030)
- Alternative 7: Rail Shuttle on Rail Bridge (2030)
- Alternative 8: Rail Commuter Single-Track on Rail Bridge (2030)
- Alternative 9: Rail Commuter Double-Track on Rail Bridge (2030)
- Alternative 10: Combination Bus and Rail (2030)

Alternatives 1 and 2 present short-term conditions. Alternative 1 is the No Build Alternative (2020), to be used as a baseline for analysis. Alternative 2 includes enhanced (15-minute peak frequency) Dumbarton Express (DB) and Dumbarton Express 1 (DB1) bus service in addition to two new routes from Union City to Menlo Park/Redwood City and Sunnyvale/Mountain View on the Highway Bridge and corresponding approach improvements. Approach improvements are primarily operational in nature and envisioned to reduce bus travel times and improve reliability.

Alternatives 3-10 represent long-term conditions. Alternative 3 presents the long-term No Build Alternative (2030), to be used as a baseline for analysis. The No Build Alternatives assume no improvements to the Dumbarton Highway Bridge and the removal of the Dumbarton Rail Bridge along with any necessary environmental mitigation.

Alternatives 4 and 5 provide further enhanced (primarily 10-minute peak frequency) bus service (including DB, DB1 and the routes to Menlo Park/Redwood City and Sunnyvale/Mountain View) with different express lane options on the Highway Bridge as well as additional, more capitally intensive approach improvements. Express lanes would allow buses, HOVs and toll-paying vehicles to utilize specified lanes under specified conditions. Tolls, based on levels of congestion or time of day, could help manage demand and speed up bus service while generating revenue for transit services and other improvements. Given these potential benefits, there was a desire to propose a continuous express lanes network from the East Bay, across the Highway Bridge with connectivity to US 101.

More specifically, Alternative 4 proposes reversible express lanes on the Highway Bridge, providing one lane of additional capacity in the peak direction during the peak periods. Alternative 5 includes one express lane in each direction.

Alternatives 6–10 include development of the Rail Bridge and associated ROW.

Alternative 6 assumes bus service similar to the enhanced bus service on the Highway Bridge included in Alternatives 4 and 5, except that the service would primarily operate on the Rail Bridge and associated ROW.

Alternative 7 proposes frequent (15-minute frequency) commuter rail "shuttle" service between Union City BART and Redwood City Caltrain. Complimentary shuttle bus service would be provided from the Redwood City Caltrain Station to employment destinations provided by the DB, DB1, and Mountain View/Sunnyvale routes.

Alternatives 8 and 9 propose less frequent (60-minute frequency) commuter rail service from Union City BART to San Francisco and San Jose, interlining with the Caltrain mainline (operating on the Caltrain mainline tracks). The primary difference between the two alternatives is that one is single-tracked and the other is double-tracked across the Rail Bridge, providing additional capacity. Complimentary shuttle bus service would be provided from the Palo Alto Caltrain Station to the Stanford Research Park.

Alternative 10 is an optimized combination of Highway and Rail Bridge improvements including Enhanced Bus on the Highway Bridge with One Express Lane in Each Direction (Alternative 5) and Rail Commuter Double-Track on Rail Bridge (Alternative 9).

Most arterial improvements were only included in the alternatives that propose enhanced bus service on the Highway Bridge (Alternatives 2, 4 and 5). However, several approach improvements were considered to be essential in reducing congestion in the Menlo Park area and are therefore included in the Rail Bridge alternatives as well. These approach improvements include Willow Road express lanes and grade separations at Willow Road/Bayfront Expressway and University Avenue/Bayfront Expressway.

To the extent possible, rail alternatives were defined as they were previously studied in the *Dumbarton Rail Corridor Environmental Impact Report*, including alignments, station locations, and operations. Key changes to the alternatives for the DTCS include the addition of intermediate stops at Palo Alto, Mountain View, and Sunnyvale in the Rail Commuter Alternatives (Alternatives 8 and 9) to better serve major employment destinations in the South Bay. Another change from the previous analysis was the investigation of a double-track alternative on the Rail Bridge (Alternative 9). This option was applied to the "highest capacity" rail option—the Rail

Commuter (Alternative 8)—but could potentially be applied to the Rail Shuttle Alternative (Alternative 7) as well.

Additionally, there is a bicycle and pedestrian multiuse path option on the Dumbarton Rail ROW from Redwood City to East Palo Alto. This option could be paired with any of the alternatives described above. The bicycle and pedestrian multiuse path is not evaluated with the other alternatives as it is difficult to estimate ridership for the facility (see **Appendix K**) and many of the metrics used to analyze various high-capacity transit modes are not applicable to a bicycle and pedestrian multiuse path. As detailed in **Appendix D**, there are some constraints within the typical 100-foot Dumbarton ROW due to the required widths associated with the various modes that could be implemented. The next phase of study after the DTCS will investigate creative ways to potentially accommodate the bicycle and pedestrian multiuse path on the ROW.

An eleventh alternative (Alternative 11), which assumed a higher employment land use scenario, was also analyzed and included the same rail service in Alternative 9. The purpose of this alternative and associated travel demand model run was to assess what the relative difference might be for each alternative should higher employment projections be realized in the study area. This alternative is primarily included for exploratory purposes and is not included in the scoring and ranking of alternatives in the comparative analysis.

See **Chapter 7** and **Chapter 10** for further details about the various components included in each alternative. These alternatives were further defined from an operations and design standpoint, costed, and analyzed using a travel demand model. Using this information, the alternatives were evaluated in a more rigorous comparative analysis.

1.4 Conceptual Design and Cost Estimates

Five to ten percent design was completed for the alternatives that were advanced beyond the initial screening. Conceptual designs include bus options across either the Dumbarton Highway Bridge or Dumbarton Rail Bridge and ROW; highway and approach options that include express lanes along the Dumbarton Highway Bridge and Bayfront Expressway (SR 84), a tunnel for Willow Road express lanes, bus-only lanes along Willow Road, grade separations at Bayfront Expressway/Willow Road and Bayfront Expressway/University Avenue, and express lane connectivity to US 101; and rail options to introduce Dumbarton rail service across the San Francisco Bay using the Rail Bridge and ROW. Designs developed for connectivity to US 101 assume that the existing HOV lanes on US 101 would be converted to express lanes in the future.

Conceptual designs were not developed for Alternatives 1 through 3, because capital improvements are not proposed as part of the No Build Alternatives (Alternatives 1 and 3) and Alternative 2 primarily contains transit and operational improvements. Conceptual designs for Alternatives 4 through 10 were developed for the specific components that comprise each alternative. Each alternative is subdivided into multiple variations — a base alternative and permutations of that base. To the extent feasible, design elements may be eliminated or added to the alternatives, and as a result several variations of one or more different options that could be considered to improve mobility in the study area have been identified. One example is a bus routing variation applicable to Alternatives 4 through 6. The variation includes bus operations on the Dumbarton Peninsula ROW with a direct connection to planned express lanes on US 101. **Chapter 8** contains additional details about the conceptual designs.

Operations and maintenance (O&M) and capital cost estimates were developed for each alternative except for Alternatives 1 and 3 (No Build Alternatives) because they do not include capital improvements. (Though it should be noted that the cost of Rail Bridge demolition is approximately $150 million.) Annual O&M costs for transit alternatives were based on proposed service frequencies, operating hours, and travel times**.**

The development of probable capital expenditure costs utilized two approaches: reliance on previous cost estimates developed as part of the unpublished 2012 *Dumbarton Rail Corridor (DRC) Project Draft Environmental Impact Statement/Environmental Impact Report* for rail components of the alternatives; and development of new cost estimates for roadway and transit components not studied previously or substantially modified by this study. The opinion of probable capital costs is intended to allow comparisons between alternatives only and are not indented for budgetary or funding purposes.

Table 1-2 summarizes the O&M and capital costs for Alternatives 2 and 4 through 10. Although costs were also developed for variations of several of the alternatives, costs for the base alternatives only are presented below for simplicity. Additional details about cost estimation methodology and results are included in **Chapter 9**.

Table 1-2: Summary of O&M and Capital Costs

Alternative	O&M Costs[1] (million $)	Capital Costs (million $)
Alternative 2: Short-Term Enhanced Bus on Highway Bridge (2020)	$11.5	$15.3
Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes (2030)	$19.6	$1,098.1
Alternative 5: Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction (2030)	$19.8	$1,060.8
Alternative 6: Busway on Rail Bridge (2030)	$16.1	$1,221.2
Alternative 7: Rail Shuttle on Rail Bridge (2030)	$41.1	$1,756.1
Alternative 8: Rail Commuter Single-Track on Rail Bridge (2030)	$37.2	$1,829.9
Alternative 9: Rail Commuter Double-Track on Rail Bridge (2030)	$43.4	$1,957.2
Alternative 10: Combination Bus and Rail (2030) Alternatives 5 and 9	$61.5	$2,403.9

Source: CDM Smith and HDR, 2017

[1] Baseline transit service costs

1.5 Travel Forecasting

To estimate the transportation benefits of the DTCS's alternatives, the C/CAG-VTA travel demand model was used to project how each alternative would perform in terms of transbay travel, vehicle throughput, total transit ridership, congestion, and other characteristics. Land use, population, and employment assumptions in the model are consistent with the MTC Plan Bay Area Regional Transportation Plan (RTP), known as Transportation 2035. However, some assumptions were modified to match observed growth trends that were not anticipated in the

RTP. The model is designed to produce macro-level forecasts for 2020 and 2040, which varies slightly from the established long-term horizon year of 2030.

All of the transportation alternatives show substantial increases in transit ridership over 2013 conditions. This includes both public transit and private shuttle buses operated by major employers. Total transit ridership as shown in **Table 1-3** includes trips that use those services to cross the Bay (transbay trips) and trips that remain on one side of the Bay, such as those between the Redwood City Caltrain Station and the planned Willow Road station in Menlo Park. Transbay ridership is shown in **Table 1-4**.

Increasing congestion on the Dumbarton Highway Bridge will continue to erode the effectiveness of (public and private) transbay bus services that use it. The forecasts predict lower transit ridership in the 2040 No Build scenario than the 2020 No Build scenario. This demonstrates that without the enhancements provided in the bus alternatives, transbay Dumbarton transit service is predicted to degrade significantly between 2020 and 2040 as buses are increasingly delayed in congested conditions.

In total, the bus alternatives generate about 25 percent more ridership than the rail alternatives. This is due in part by more frequent bus service: 10-minute peak headways for four different transbay bus routes versus 15-minute headways for the Rail Shuttle (Alternative 7) and 60-minute headways for the Rail Commuter alternatives (Alternatives 8 and 9). In addition, the bus alternatives provide direct service to multiple destinations and in the case of the One Express Lane in Each Direction (Alternative 5), diminish the corridor capacity for autos. This reduction induces a modal shift from auto to transit. One Express Lane in Each Direction reduces the peak direction single-occupant car carrying capacity of the Dumbarton Highway Bridge the most, providing a single express lane in each direction in place of existing mixed-flow lanes. As a result, Alternative 5 induces about five percent greater transit use than Reversible Express Lanes (Alternative 4), which provides one peak-direction express lane in addition to three general-purpose lanes in the peak direction, providing more capacity.

Table 1-3: Daily Transit Ridership for All Alternatives

Alternative	Rail	Bus	Private Shuttles	Transfers*	Total
Base Year 2013	0	2,700	1,700		4,400
Short-Term (2020) Alternatives					
Alternative 1: No Build 2020	0	4,800	5,900	0	10,700
Alternative 2: Enhanced Bus on Highway Bridge	0	10,200	6,200	500	15,900
Long-Term (2040) Alternatives					
Alternative 3: No Build 2040	0	3,500	5,200	0	8,700
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	0	22,300	5,400	2,600	25,100
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	0	23,800	5,500	2,900	26,400
Alternative 6: Busway on Rail Bridge	0	23,700	4,600	3,000	25,300
Alternative 7: Rail Shuttle on Rail Bridge	13,900	3,300	6,300	1,100	22,400
Alternative 8: Rail Commuter Single-Track on Rail Bridge	12,500	1,000	6,900	0	20,400

Alternative	Rail	Bus	Private Shuttles	Transfers*	Total
Alternative 9: Rail Commuter Double-Track on Rail Bridge	15,300	1,100	6,800	0	23,200
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	11,400	18,600	5,000	2,100	32,900
Alternative 11: High-Employment (with Alternative 9)	27,100	1,100	6,600	100	34,700

Source: Fehr & Peers, 2017
* Transfers represent passengers transferring from one proposed Dumbarton service to another proposed Dumbarton service

Table 1-4 Daily Transbay Ridership for all Alternatives

Alternative	Rail	Bus	Private Shuttles	Total
Base Year 2013	0	2,600	1,700	4,300
Alternative 1: No Build 2020	0	4,300	5,900	10,200
Alternative 2: Enhanced Bus on Highway Bridge	0	7,500	6,200	13,700
Alternative 3: No Build 2040	0	3,400	5,200	8,600
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	0	14,900	5,400	20,300
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	0	15,800	5,500	21,300
Alternative 6: Busway on Rail Bridge	0	14,000	4,600	18,600
Alternative 7: Rail Shuttle on Rail Bridge	9,100	200	6,300	15,600
Alternative 8: Rail Commuter Single-Track on Rail Bridge	8,400	200	6,900	15,500
Alternative 9: Rail Commuter Double-Track on Rail Bridge	8,800	200	6,800	15,800
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	5,600	12,700	5,000	23,300
Alternative 11: High-Employment (with Alternative 9)	20,300	100	6,600	27,000

Source: Fehr and Peers, 2017

When comparing the bus and rail alternatives, it is important to note how each one affects overall Dumbarton Corridor capacity and consequent traffic congestion. As previously mentioned, One Express Lane in Each Direction (Alternative 5) reduces the capacity of the Dumbarton Highway Bridge and approaches for automobile travel by converting general-purpose lanes to express lanes. As a result, for all traffic combined, congestion in terms of total vehicle-hours delay and per-person minutes delay is substantially worse for this express lane alternative. Vehicle-hours of delay are also almost twice as high in the One Express Lane in each Direction Alternative compared to the Reversible Express Lanes Alternative (Alternative 4), and higher than the busway and rail alternatives, which use the Dumbarton Rail Bridge and preserve existing capacity on the Dumbarton Highway Bridge. Trends observed related to total vehicle-hours of delay are generally similar when examining per person minutes delay.

In terms of transit ridership, the Busway Alternative (Alternative 6) offers the combined benefit of increasing corridor throughput through use of the Dumbarton Rail Bridge, avoiding exacerbation of traffic congestion by preserving existing Highway Bridge lanes, and providing direct single-seat service connections for major origin-destination pairs including Union City and

Fremont BART, ACE, Redwood City Caltrain, and the major Corridor employers such as Stanford, Facebook, and Google.

In the rail alternatives, train services attract about two-thirds of the demand that public express buses would carry in the express lanes alternatives. Among the rail alternatives, Rail Commuter Double-Track (Alternative 9) carries the most ridership by collecting transbay trips, local trips within the Dumbarton Corridor (e.g., Redwood City Caltrain Station to Facebook), and trips along the Peninsula to San Francisco and San Jose. Strictly focusing on transbay ridership, the Rail Shuttle (Alternative 7) carries the highest rail ridership due to its higher frequencies compared with the Rail Commuter alternatives. The range of rail forecasts, 12,500 to 15,300 daily riders, is within the range found on comparable segments of existing Bay Area rail services, such as BART through Union City to Fremont and Caltrain through Redwood City, Menlo Park, and Palo Alto.

The rail alternatives also offer the corridor throughput and traffic congestion control advantages as well as the ability to establish a fixed and visible public transit investment in the Corridor suited to stimulating compact transit-oriented development in one of the region's primary jobs-growth markets. While a high-employment scenario would boost the projected ridership of all alternatives, Alternative 11 confirms the incremental benefits of pairing robust transit infrastructure and high-density development in the East Palo Alto, Menlo Park, and Redwood City employment centers. If the projections of the Corridor's major employers bear out and densities reach the high levels accommodated in the cities' general plans, the rail alternatives could see transit ridership exceed that of the other alternatives.

The Combined Bus and Rail Alternative (Alternative 10) consists of the highway improvements and express bus service from One Express Lane in Each Direction (Alternative 5) and the rail service from the Rail Commuter Double-Track (Alternative 9)—the highest-ridership individual bus and rail alternatives. As such, it can be viewed as a best-case scenario for transit crossing the Dumbarton Corridor. Within the Combined Bus and Rail Alternative, while the bus and rail elements trade-off against one another and do not perform as well individually as they do in the One Express Lane in Each Direction and Rail Commuter Double-Track scenarios, the combined benefits of the two modes increase total transit ridership by 21 to 52 percent. In other words, the Bus and Rail Alternative is forecast to have slightly lower bus ridership than One Express Lane in Each Direction and lower rail ridership than Rail Commuter Double-Track, but the Combined Bus and Rail Alternative exhibits the highest aggregate and transbay ridership for any alternative based on *Plan Bay Area* employment projections.

The high-employment scenario (Alternative 11) differs from the Rail Commuter Double-Track only in its land use assumptions, and not in the transportation networks. Nevertheless, the high-employment scenario is forecast to generate approximately 50 percent more total transit riders as compared to the Rail Commuter Double-Track (Alternative 9). This increase is commensurate with the 150 percent increase in employment within the Corridor cities of Menlo Park, Palo Alto, Redwood City, and Mountain View in the high-employment forecast. Transbay transit ridership for the high-employment scenario is approximately 170 percent of Rail Commuter Double-Track transbay transit ridership. The forecasts also assume businesses in this area will be subject to trip caps requiring them to achieve higher transit shares. The substantial increase in transfers to

Dumbarton Rail from ACE in the high-employment scenario highlights a need for the Altamont Corridor to absorb the housing growth required to support such a large increase in employment.

Forecasting suggests that ACE will be a significant source of ridership for any Dumbarton transit service, particularly for the rail alternatives. These forecasts also predict a significant increase in total ACE ridership from the current 5,000 daily riders to 8,000 - 10,000 daily riders (and 20,000 in the high growth alternative). These forecasts are consistent with ACE planning, which suggests a doubling of ridership by 2020. They also suggest that a high-quality transit connection from the Central Valley and Tri-Valley region to the high-employment areas in Silicon Valley would serve a currently un-met need. Thus, ensuring that the connection is as easy as possible with high-frequency express buses (as in Alternatives 4, 5, and 6) or a timed transfer to rail (as in Alternatives 7, 8, 9, and 10) is an important component of these large transfer volumes.

More detail about the travel demand model and results can be found in **Chapter 10**.

1.6 Comparative Analysis

The mobility benefits of the alternatives were evaluated quantitatively and qualitatively based on the four project goals and a set of accompanying metrics as described below:

- **Goal: Enhance mobility** – Mobility of the alternatives was measured by examining estimated daily transbay transit ridership, peak hour load factor, transbay passengers per seat mile in the peak period, minutes of delay per person in the peak period, and operational benefit;
- **Goal: Pursue cost-effective improvements with a return on investment** – Cost-effectiveness and return on investment was measured by considering annualized capital cost per new user, annual operating and maintenance cost per new user, and fundability;
- **Goal: Minimize environmental and financial risk, and maximize safety** – The measures of success for this goal included an assessment of environmental impacts, financial risk, and safety;
- **Goal: Avoid disproportionate burden and disparate impacts** – SamTrans has policies that specify thresholds for determining whether a given action, or project, has a disproportionate burden on low-income populations versus non-low-income populations or a disparate impact on minority populations. Because the alternatives are still conceptual, the assessment of how the alternatives meet this goal are high-level and would require more analysis as projects are developed further.

The comparative analysis was conducted for the long-term alternatives only. Generally, it is assumed that short-term improvements (Alternative 2) would be pursued as there are limited enhancements that can provide increased mobility and congestion relief in the short-term. Each alternative was scored based on the metrics stated above using available information on ridership, capacity, costs, etc.

Alternatives 4 through 10 would meet the DTCS goals to varying degrees. Overall, the Combined Bus and Rail (Alternative 10) and the Busway on the Rail Bridge (Alternative 6) scored the highest with 60 and 57 total points, respectively. These alternatives were followed by the Enhanced Bus on the Highway Bridge with One Express Lane in Each Direction (Alternative 5) at 55 points. Alternative 10 ranked highest or equally best under three of the four DTCS study goals. As a result, Alternative 10, which presents a combination of roadway, bus, and rail improvements, is considered the alternative with the greatest potential to enhance Corridor mobility, while also factoring in cost-effectiveness and financial feasibility, managing risk, maximizing safety, and minimizing environmental and community impacts to the extent possible. Based on the findings of the comparative analysis, DTCS recommends moving forward with Alternative 10 using a phased approach.

Additional information about the comparative analysis can be found in **Chapter 11**.

1.7 Key Findings

The Dumbarton Corridor is a complex network of existing transportation infrastructure paired with unutilized potential that offers a variety of options, each with distinct advantages and disadvantages that cater to different travel markets. By improving Corridor efficiency and travel time reliability, short-distance commuters coming from the Union City / Fremont / Newark (Tri-Cities) area to Peninsula employment destinations would be attracted by a one-seat ride via enhanced bus service on the Highway Bridge. Roadway improvements that allow HOVs to bypass SOVs encourage carpooling and also improve speed and reliability for buses. Long-distance travelers from the Central Valley / Tri-Valley and Capitol Corridor (beyond the BART service area) could drive demand for rail service if there were timed connections with ACE.

The following are some key findings:

- The Highway Bridge approaches in the morning and evening peak periods are severely congested and could benefit from improvements that encourage transit use and HOVs, by providing these vehicles a bypass through congested areas (i.e., the toll plaza, and at Bayfront Expressway intersections at University Avenue and Willow Road). Improvements at the approaches are likely to do more for alleviating congestion than converting general-purpose lanes on the Highway Bridge to express lanes. Addressing capacity on the Highway Bridge alone will not alleviate traffic congestion in the Dumbarton Corridor, as this study confirms that the chokepoints where congestion occurs are at the approaches to the Dumbarton Highway Bridge. With proposed approach improvements, the express lanes alternatives perform well but one configuration of express lanes – the One Express Lane in Each Direction (Alternative 5) – would increase congestion in the study area for general traffic and SOVs. This alternative is preferred, however, because it encourages transit and HOV travel over SOV travel in the general-purpose lanes and is a more sustainable long-term option for mitigating the impacts of growth on the transportation network.

- The bus alternatives produce 25 percent more ridership than rail due to the former's higher frequencies, greater coverage, and direct connections to employment centers; enhanced bus on the Highway Bridge (Alternatives 4 and 5) provides a one-seat ride from the Tri-Cities to the Peninsula. When outside of a dedicated right-of-way, bus service is subject to delays because of traffic congestion. Providing a dedicated busway on the Rail Bridge and ROW (Alternative 6) with a connector to the planned US 101 express lanes would improve reliability for buses, especially the Mountain View/Sunnyvale route that travels on US 101 over 12 miles. However, the Busway Alternative routes still would operate in mixed flow traffic in the East Bay, where they would be subject to congestion-related delay, but Highway Bridge express lanes could be connected with future express lanes on I 880 for a continuous managed lane in the corridor.

- Rail alternatives as defined in this study do not perform as well as the bus alternatives from a ridership standpoint because they are less frequent. Even so, ridership estimates are on par with existing services in similar areas such as BART in Fremont and Union City and Caltrain between Redwood City and Palo Alto. Improvements, such as double-tracking across the Rail Bridge, would provide added operational flexibility that would contribute to the reliability of rail travel. ACE transfers are an important source of rail ridership in the travel behavior forecast, signifying that the Tri-Valley/Central Valley to Peninsula market is likely underserved. Thus, the rail alternatives may provide substantially more ridership potential in the future given the nature of fixed-guideway investments that are independent of highway and arterial conditions and the alternatives' ability to broaden travel markets by attracting longer-distance commuters. The potential for Dumbarton rail services to connect to a larger regional rail network is compelling as the region's employment and housing supply continue to grow in different areas of the Bay Area.

- The most cost-effective alternatives are those that can attract enough riders and or users to cover O&M costs. The DTCS showed that the bus alternatives performed the best in terms of cost-effectiveness. However, the bus alternatives do not perform as well from a fundability perspective. The rail alternatives, while most costly, have the greatest potential for private investment and long-term ridership gains. While the bus alternatives serve the Union City / Fremont / Newark market very well and do not require as many connecting complementary bus services for the last mile of travel, the rail alternatives, particularly the Rail Commuter Double-Track Alternative (Alternative 9), bring the most value by connecting the Peninsula with travelers from farther away. By connecting to the ACE and Capitol Corridor routes, the rail alternatives can safely and reliably connect travelers from cities such as Stockton and Sacramento, to destinations as far north or south on the Peninsula as possible. Using the Rail Bridge for rail service allows the Highway Bridge to continue accommodating enhanced bus service. Further, converting the Rail Bridge to a bus-only facility would preclude the possibility of serving the long-distance market that the rail alternatives can.

- In addition to causing substantial environmental impacts, demolition and removal of the Rail Bridge would eliminate a much-needed Bay crossing in the region. Therefore, the DTCS concludes that rebuilding the Rail Bridge is necessary to improve mobility in the Dumbarton Corridor and in the region. The DTCS also considered increasing the share of transit and HOV trips in the future and found that a combined approach (bus, highway improvements, and rail) fared the best in terms of reducing automobile passengers.

- After the initial screening, all alternatives were considered to have the same low level of disproportionate burden and disparate impacts. The improvement projects identified in this study will be evaluated further in the environmental clearance phase to closely analyze the potential impacts of each project on the communities in which they are located.

- Analysis suggests that there is demand for multimodal improvements that provide better transbay throughput and a combination of highway, Rail Bridge, and approach improvements yielded the best results. Importantly, these modes could complement, rather than compete, with each other - especially if the volumes of transbay commuters continues to increase.

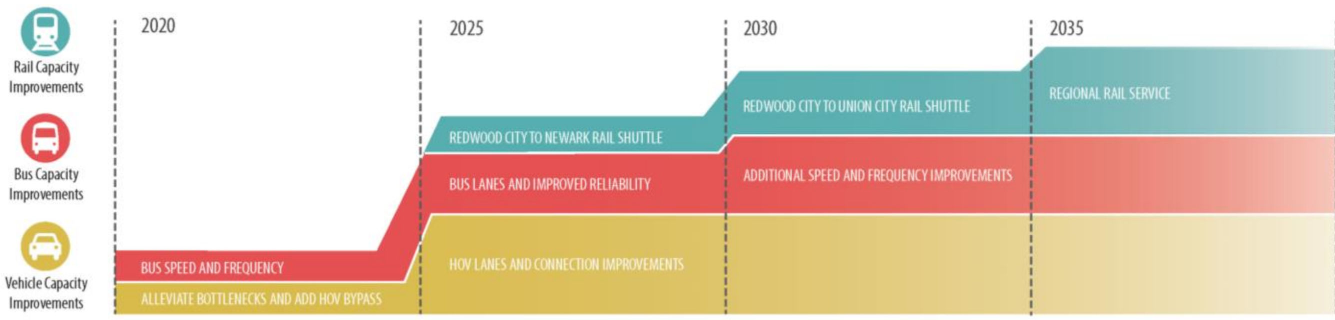
1.8 Recommendations

Based on a comprehensive assessment of mobility, cost-effectiveness, environmental, financial and safety considerations, in addition to equity, the recommended long-term solution focuses on improvements to both the Dumbarton Highway and Rail Bridges as well as local roadways. This is a departure from the "either/or" approach of typical alternatives analyses, including previous studies of the Dumbarton Corridor where "the Project" was defined as a rail project and the alternative was a form of bus service. This is the first time that a combination of rail, enhanced bus service, express lanes, and other roadway improvements comprise a Dumbarton project alternative, although these elements were also analyzed separately for their individual benefits. While the required capital investment in the Corridor will be significant, the opportunity to involve partners from the private sector is unprecedented, and the urgency to address congestion is critical to the health of the Bay Area economy.

This multimodal, multifacility approach can serve different travel markets that use the Corridor and represents a more sustainable solution to long-term travel challenges through its focus on fixed-guideway investments that are independent of the arterial and highway network. In addition, roadway and highway improvements designated for transit and HOVs can increase the person throughput in the area. It should be noted that the No Build Alternative is not considered a viable option, as it would ultimately involve dismantling the Dumbarton Rail Bridge and mitigating the potential environmental impacts associated with this action – requirements by the U.S. Coast Guard if the Rail Bridge is not rehabilitated.

Due to the complexity and multitude of improvements needed to make a significant impact on mobility in the Corridor, a phased approach is proposed. **Figure 1-5** illustrates how the improvements could be phased over time. Certainly, other phasing strategies may also be viable based on available funding.

Figure 1-5: Timeline of Phased Improvements in the Dumbarton Corridor



Source: CDM Smith, 2017

Short-term improvements that could be implemented by 2020 include a handful of enhanced bus service and corresponding Highway Bridge approach improvements. These improvements include the following:

- Adding two new transbay bus routes from Union City BART to Menlo Park/Redwood City and Mountain View/Sunnyvale while increasing the frequency of Route DB and Route DB1 bus service to every 15 minutes and extending the peak period of service to 4 hours in the morning, and 4 hours in the evening
- Adding transit signal priority and queue jump lanes to Decoto Road from I 880 east to Union City BART or where possible given ROW constraints
- Constructing an HOV bypass lane on the westbound approach to the Highway Bridge at Newark Boulevard
- Highway Bridge toll booth removal at the FasTrak lanes and a FasTrak extension to Paseo Padre Parkway
- Adding transit signal priority and queue jump lanes to Bayfront Expressway and Willow Road where possible
- Implementing bus-only lanes on Bayfront Expressway

If pursued aggressively in the short-term, mid-term projects targeted for the 2025 timeframe could include the following:

- Implementing one express lane in each direction on the Highway Bridge with supporting arterial express lanes and other improvements:
  - Implementing eastbound express lanes from the Highway Bridge toll plaza to I 880/Decoto Road
  - Converting the FasTrak lane to an express lane
  - Constructing flyover connections between the I 880 and SR 84 express lanes

  - Instituting all-electronic tolling to cross the Highway Bridge
  - Constructing express lanes on Bayfront Expressway from the Highway Bridge to Marsh Road, in lieu of Willow Road express lanes due to the potential for property acquisitions
  - Implementing peak bus-only lanes on Willow Road, in lieu of Willow Road express lanes due to the potential for property acquisitions
  - Constructing a Willow Road / Bayfront Expressway grade separation
  - Constructing a University Avenue / Bayfront Expressway grade separation
  - Pursing a US 101 / Marsh Road express lanes direct connector, in lieu of Willow Road express lanes due to the potential for property acquisitions with an express lanes connection to US 101 at Willow Road
  - Expanding the Ardenwood park-and-ride facility (including an express lanes direct connector at Newark Boulevard)
- Operating enhanced bus service from University Avenue to the Dumbarton Rail ROW to planned US 101 express lanes via a direct connector, which could speed bus service and enhance reliability.
- Implementing Rail Shuttle service between Redwood City and Newark until unknowns related to regional freight rail and connections to the Union City BART station are resolved. The Rail Shuttle is proposed to be double-tracked to allow for additional capacity into the future. With coordination, this interim rail terminus at Newark could begin to forge connections with ACE and Capitol Corridor. This phase would include a new Newark Park-and-Ride facility.

In the mid-to-long-term with a target year of 2030, improvements would include the following:

- Increasing the frequency of enhanced bus service to 10 minutes in the peak period and 15 minutes in the off-peak period
- Extending the Rail Shuttle from Newark to Union City to connect with BART

In the long-term (i.e., 2035 or beyond), the following is proposed:

- Facilitating commuter rail service that interlines with the Caltrain mainline is desirable to offer a one-seat ride to commuters traveling between the Tri-Valley / Central Valley to the Peninsula and up to San Francisco or down to San Jose. This option would require further investment in the Dumbarton Corridor to electrify the line in addition to new electric rolling stock that will be compatible with the Caltrain mainline. Additionally, the Caltrain mainline will also require upgrades at Redwood Junction and other locations to minimize the potential impacts to mainline operations.

Another option considered in DTCS includes converting a portion of the Dumbarton ROW on the Peninsula to a bicycle and pedestrian multiuse path that could operate next to either bus and/or rail service. While there are width constraints on the Peninsula ROW as detailed in Appendix D, this option will continue to be examined in the next phase of study. Additionally, alternative and more localized pedestrian and bicycle improvements will also be examined further. These are described in Chapter 5 as well as below:

- Pursuing an alternative to the bicycle and pedestrian multiuse path on the Dumbarton ROW. The Bay Trail option described in **Chapter 5** proposes to use sections of the current and proposed Bay Trail between Seaport Boulevard and University Avenue with on-street connections as required. Starting at the Redwood City Caltrain Station, a new Class II bikeway would be constructed on Broadway, connected to a similar path heading north on Chestnut Street. A Class I bikeway would then follow the Rail Corridor under US 101 to Blomquist Street, tying into the planned section of the Bay Trail on Cargill Levee between Seaport Boulevard and Bayfront Park and the existing section of the Bay Trail between Bayfront Park and University Avenue, ultimately leading to the Highway Bridge. This option would have a total length of 5.9 miles to University Avenue.

- Upgrading the existing bicycle and pedestrian lane on the Highway Bridge (including extending the Class I facility on Marshlands Road and implementing pavement and striping improvements along the entire facility)

- Pursuing improvements identified in county and city bicycle and pedestrian plans with the potential to fill gaps in bicycle and pedestrian networks and enhance local and regional access to the Dumbarton Highway Bridge from key origins within the study area.

Appendix M contains additional information about the capital and O&M costs of these proposed improvements phased over time.

1.9 Financing Options

Approximately $2.58 billion in capital and $90 million in annual operating funding will need to be identified for full build-out. Given the size of the project cost, multiple existing and new sources and strategies will need to be pursued to deliver this phased set of complex operational and infrastructure recommendations. SamTrans evaluated nine such strategies, summarized in **Table** 1-5.

Table 1-5: Funding and Financing Strategies for the Dumbarton Transportation Corridor Study Recommendations

	Strategy	Anticipated Revenue
1	Dedicate funding currently available for Dumbarton-related improvements	$30 million
2	Seek additional state and regional funding	$200–$300 million
3	Seek additional local funding	Unknown at this time
4	Acquire private contributions	Unknown at this time
5	Pursue federal grant funding	Unknown at this time
6	Pursue federal and state financing	Unknown at this time
7	Explore Value Capture	$250–$930 million
8	Identify elements that would be attractive for a Public Private Partnership (P3)	Unknown at this time
9	Use fares to cover transit operating costs	$62–$76 million/year
TARGETED TOTAL		**$2.58 billion**

Source: CDM Smith, 2016

- **Strategy #1** - The Measure A sales tax provides funding for transportation improvements in San Mateo County. Approximately $30 million is currently available under Measure A for Dumbarton-related station facilities and Rail Corridor improvements in the communities of Redwood City, Menlo Park, and East Palo Alto in conjunction with the Dumbarton Corridor.
- **Strategy #2** - State and regional funding options include SB 1 (the Transportation Infrastructure and Economic Investment Act), AB 32 as part of the "cap-and-trade" program, programs through MTC, and Regional Measure 3.
- **Strategy #3** - In California, county sales taxes are commonly used to raise new funds for transportation and are increasingly standing in for federal funding. San Mateo County could impose a new sales tax for countywide infrastructure improvements subject to 50 percent plus one vote approval from County cities on the 2018 general election ballot.
- **Strategy #4** - SamTrans may have access to contributions from private partners, including Facebook, which has the ability to build momentum with other companies with an interest in providing enhanced mobility and access for its employees. This effort could replicate the current example of Amazon buying transit assets (rail sets) for the City of Seattle and Sound Transit, in exchange for service improvements and advertising space (train cars).
- **Strategy #5** - SamTrans could pursue federal grant funding under the Federal Transit Administration (FTA) Section 5307 Urbanized Area Formula funds, FTA Section 5339 Bus and Bus Facilities Program funds, Federal Highway Administration's Congestion Mitigation and Air Quality funds through MTC for bus retrofit projects to install clean air emission devices on urban coaches, and United States Department of Transportation's Infrastructure for Rebuilding America competitive grant program. There is also the possibility of applying for FTA Section 5309 funds (Core Capacity, New Starts, Small Starts), depending on the project element and funding amount sought.

- **Strategy #6 -** Federal credit assistance can take one of two forms: loans, where project sponsors borrow federal highway funds directly from a state DOTs or the federal government; and credit enhancements, where a state DOT or the federal government makes federal funds available on a contingent (or standby) basis. These would include the federal Transportation Infrastructure Finance and Innovation Act of 1998, the Federal Railroad Administration's Railroad Rehabilitation & Improvement Financing program, the federal Grant Anticipation Revenue Vehicles program, federal Transit Revenue Bonds, and the State of California Infrastructure and Economic Development Bank (IBank).

- **Strategy #7 -** Value capture includes many types of revenue generating mechanisms, including special assessment district financing, tax increment financing, and development impact fees. As opposed to real estate developments, regional transportation improvements like the DTCS recommendations are more difficult to associate value generated by it directly to individuals and businesses. However, value capture tools can still play a very important part in project funding.

- **Strategy #8 -** Two general forms of (P3) structures are common: availability payment- and concession-based P3s. In availability payment-based P3s, the public authority contracts with a private sector entity to provide a public good, service or product at a constant capacity for a given payment (capacity fee) and a separate charge for usage of the public good, product or service (usage fee). In concession-based P3s, the government grants the private sector the right to build, operate, and charge public users of the public good, infrastructure, or service, a fee or tariff, which is regulated by public regulators and the concession contract.

- **Strategy #9 -** User fees such as transit fares are a logical funding source for transportation projects and should play a larger role. The costs to run efficient electric rail systems are low enough that it's common for fares to cover operating costs—and even throw off additional funds that can be reinvested in capital programs.

1.10 Next Steps

In regard to these recommendations, SamTrans will continue to seek feedback and consensus from communities and public stakeholders around the Dumbarton Corridor in future phases of work.

Additionally, the Metropolitan Transportation Commission is undertaking a study of short-term HOV/transit priority treatments and potentially express lanes in the Dumbarton Corridor. This effort will delve into the operational details of these potential improvements to a greater extent than this broad planning study.

Additional phases of work are needed to progress the program proposed in DTCS. These phases could include the following:

- A technical refinement including additional conceptual design of the Peninsula Dumbarton ROW to determine if there are creative ways to accommodate a bicycle and pedestrian multiuse path while also complying with required modal widths to ensure safe transit services into the future. The technical refinement will also include additional study of bicycle/pedestrian connections outside of the Dumbarton ROW that would further mobility objectives for the communities along the Corridor, like increasing connectivity to the Bay Trail. Additional rail operations analysis and a deeper look at high-capacity, standard gauge rail technologies will also occur.

- Coordination with CalSTA, ACTC, ACE, Capitol Corridor, Union Pacific Railroad (UP), etc. regarding East Bay rail operations
- Additional regional travel behavior forecasting in an attempt to better quantify the potential benefit of the rail alternatives, especially with more streamlined connections with other regional rail services such as ACE and Capitol Corridor
- In addition to the funding strategy and public-private partnership opportunities discussed in Chapters 13 and 14, an in-depth public-private partnership analysis to investigate the viability of the rail alternatives (in addition to other alternatives) given more regional-based rail connections and operating plans
- Design and environmental documentation

Additional analysis of a busway or enhanced bus on the Rail Bridge as a phasing option (regulatory requirements and processes and coordination with UP) or a secondary option to commuter rail service (in the environmental clearance context)

2 Introduction and Background

2.1 Dumbarton Transportation Corridor Study

The Dumbarton Transportation Corridor Study (DTCS) is a feasibility study of transportation improvement options on the Dumbarton Highway Bridge and its approaches as well as improvements to the Dumbarton Rail Bridge to the south.

The study recommends operational and infrastructure improvements on the Highway and Rail Bridges that would be phased over time. Improvements are grouped into short- and long-term transportation alternatives that contribute to an ultimate vision for a multimodal corridor. For the purposes of this study, short-term improvements are considered to be those that can be implemented by or around 2020 and long-term improvements are those that can be implemented by or around 2030.

This feasibility study was led by the San Mateo County Transit District (SamTrans) because SamTrans owns the Dumbarton Rail Bridge and Rail right-of-way (ROW). However, SamTrans worked collaboratively with project partners including Facebook, the San Mateo County Transportation Authority, Alameda County Transportation Commission (Alameda CTC), and the Alameda-Contra Costa Transit District (AC Transit). Facebook also contributed $1.2 million for the DTCS.

It should be noted that Caltrans manages and owns the Highway Bridge and many of the approaches examined in the study. While Caltrans was engaged in the study as a stakeholder, any recommended improvements on the Highway Bridge and approaches will need to proceed through official Caltrans planning processes.

While the Dumbarton Corridor has been studied many times before (see Section 2.3), SamTrans and Facebook forged a partnership in 2015 to conduct a comprehensive study of improvements to alleviate congestion in this vital east-west corridor, given recent job growth and a current jobs-housing imbalance.

2.2 Study Area

The study area includes cities in San Mateo and Alameda counties that immediately surround and include the Dumbarton Highway and Rail Bridges, as well as some cities in Santa Clara County. **Figure 2-1** shows the DTCS study area. The study area includes two Tiers:

- Tier 1: These are cities where a majority of users of the Dumbarton Corridor live or work and where infrastructure and operational improvements to the Corridor will likely be located. The city of Palo Alto, located in Santa Clara County, is included because Stanford University and Stanford Healthcare attracts a large number of trips from the East Bay and provides some transit services using the Dumbarton Corridor. The Tier 1 cities include the following:
    - Peninsula: Redwood City, Atherton, Menlo Park, East Palo Alto, Palo Alto, Stanford Census-Designated Place

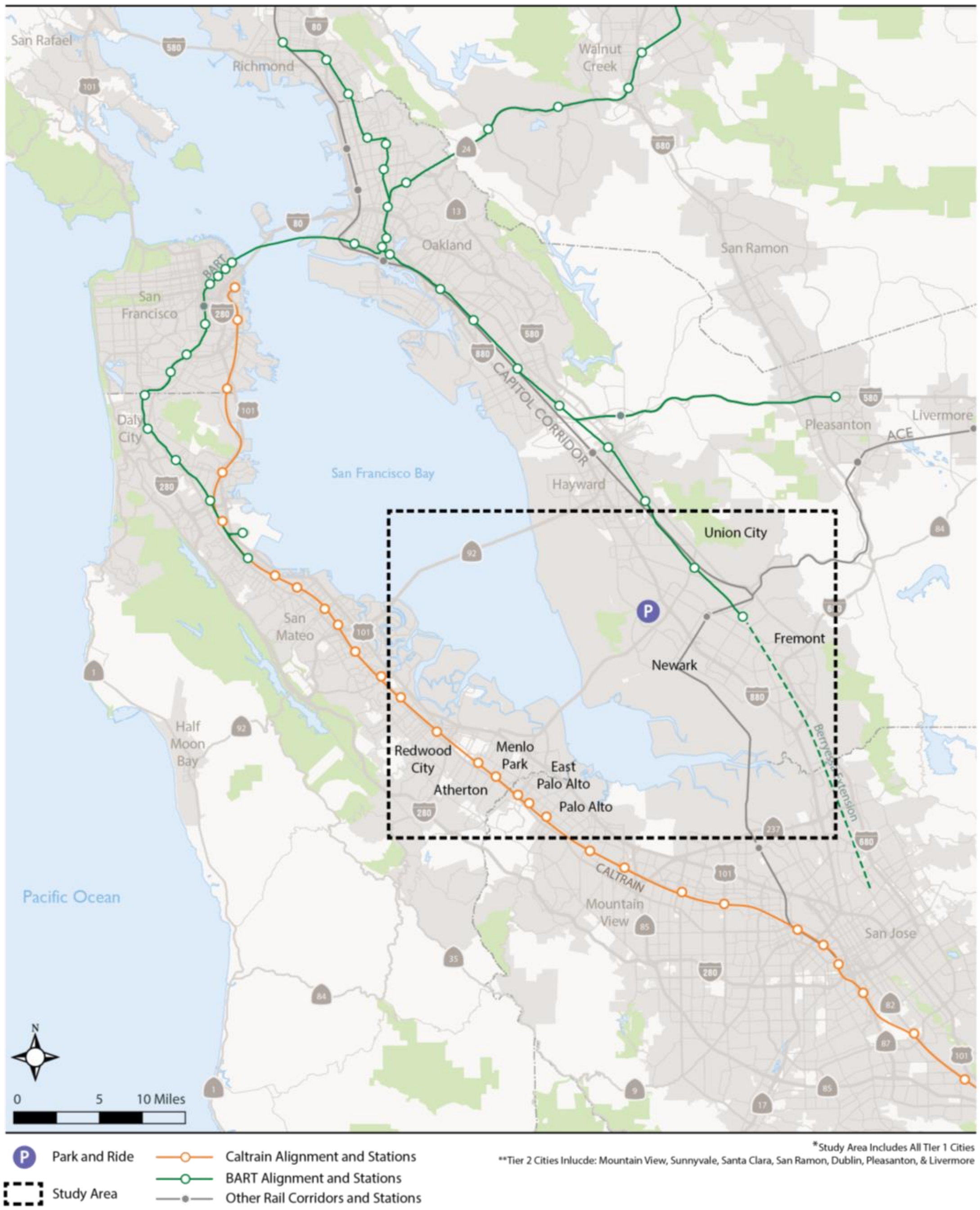
   - East Bay: Newark, Fremont, Union City

- Tier 2: These cities are outside of the immediate Dumbarton Corridor area, but include a large number of residents or employment centers that already or could potentially use the Dumbarton Corridor. The level of analysis related to the Tier 2 cities will be at a higher level to provide a sense for the potential commute market with a qualitative discussion of where employees and major employers are located and the travel options they have in baseline year 2016. The Tier 2 cities include the following:

   - Peninsula (Santa Clara County): Mountain View, Sunnyvale, Santa Clara

   - East Bay: Dublin, Pleasanton, Livermore, Hayward, San Ramon

Figure 2-1: Dumbarton Transportation Corridor Study Area



Source: CDM Smith, 2016

2.3 Previous Dumbarton Corridor Studies

2.3.1 Previous Rail Studies

Previous Dumbarton Corridor studies date back to the 1990s, and primarily focused on defining a rail project that would originate in the Tri-Valley Area (Livermore, Dublin, Pleasanton) in the morning, then travel through the cities of Union City, Fremont, and Newark before crossing the

San Francisco Bay via the Rail Bridge and merging onto the Caltrain mainline, heading to the north toward San Francisco or south toward San Jose. The original cities/stations targeted for service included the following: Menlo Park, East Palo Alto, Newark, Fremont/Centerville, Union City, Redwood City, San Carlos, Belmont, Hillsdale, Hayward Park, San Mateo, Burlingame, Broadway, Millbrae, San Francisco, Atherton, Palo Alto, Mountain View, Sunnyvale, Santa Clara, and San Jose.

Over the last 10 years, two planning and engineering efforts examined a number of different alternatives focused on the Rail Corridor. The first of these was the *Dumbarton Rail Corridor Environmental Phase 1 Alternatives Analysis and Project Purpose and Need*, completed in 2006. During this time, this project was included in Regional Measure 2 and had funds of approximately $300 million programmed to it. This effort considered rail alternatives as well as a Transportation System Management (TSM) bus alternative, including Bus Rapid Transit (BRT) across the Rail Bridge.

The second effort was the *Dumbarton Rail Corridor Alternatives Study*, which was completed in 2011. This study was prepared at the request of the Policy Advisory Committee to take a fresh look at the alternatives for the Dumbarton Corridor given changes that had occurred since the 2006 alternatives analysis.[1] The alternatives included both rail alternatives and TSM bus alternatives. A comprehensive set of alternatives were identified and evaluated. Rail alternatives included increased rail service, rail shuttles across the bay, and extended service to different locations in the East Bay. Bus alternatives identified would use the Dumbarton Rail Bridge and included TSM and BRT options. In total, nine rail alternatives and four bus alternatives were considered for the study. The alternatives would connect to existing Caltrain service in the Peninsula, Bay Area Rapid Transit (BART), Capitol Corridor service and Altamont Commuter Express (ACE) service in the East Bay, and future California High Speed Rail (HSR) service to Los Angeles.

The rail and bus alternatives that were considered in the 2011 study included the following:

Rail

- Original Project: Peak period, peak direction only; 60-minute headways on two routes; eleven stations. Origin-destination pairs include the following: Union City to San Francisco and Union City to San Jose.

- Increased Service - Bi-directional: Peak period, peak direction; bi-directional off-peak shuttle to Redwood City; 30-minute headways; eleven stations. Origin-destination pairs include the following: Union City to San Francisco (peak), Union City to San Jose (peak), and Union City to Redwood City.

- Increased Service - South Only: Peak period, peak direction, bi-directional off-peak shuttle to Menlo Park; 30-minute headways; five stations in the peak and five stations off-peak. Origin-destination pairs include the following: Union City to Mountain View (peak) and Union City to Menlo Park (off- peak).

[1] Policy Advisory Committee was comprised of local representatives.

- Rail Shuttle - Union City (15-minute): Bi-directional all-day service; 15-minute headways; five stations. Origin-destination pairs include the following: Union City to Redwood City.

- Rail Shuttle - Union City (30-minute): Bi-directional all-day service, less frequent service; 30-minute headways; five stations. Origin-destination pairs include the following: Union City to Redwood City.

- Rail Shuttle - Shinn: Bi-directional all-day service; four stations. New BART station at Shinn acting as transfer hub for BART, ACE, Amtrak, Dumbarton Corridor, HSR; 15-minute headways. Origin-destination pairs include the following: Shinn to Redwood City.

- Extended Service - Livermore (Super ACE/HSR) to Redwood City: Connects to ACE/HSR at Livermore (Downtown and Vasco Road), bi-directional service; 30-minute peak headways and 60-minute off-peak headways; seven stations. Origin-destination pairs include the following: Livermore to Redwood City.

- Extended Service - Warm Springs (Super ACE/HSR) to Redwood City: Connects to ACE/HSR at Warm Springs BART, bi-directional service; 30-minute peak headways and 60-minute off-peak headways; five stations. Origin-destination pairs include the following: Warm Springs to Redwood City.

Bus

- Original Bus TSM: Four routes based on original Draft Environmental Impact Statement /Draft Environmental Impact Report approved TSM alternative (August 2008). Routes include the following: Union City BART to Stanford Research Park (bi-directional, peak, midday and weekend service); Fremont BART to Stanford University (bi-directional, peak, and midday service); Mission San Jose (Park-and-Ride South Line) to the Bayshore/NASA Santa Clara Valley Transportation Authority (VTA) Light Rail Transit (LRT) Station (peak direction only); South Hayward BART to the Oracle campus in Redwood City (peak direction only). The Original Bus TSM is based on existing AC Transit Dumbarton Express bus service.

- Enhanced Bus TSM: Routes from Original TSM modified. Bus preferential treatments include transit-only lanes and allowing shoulder operations. Routes include the following: Union City to Stanford Research Park (Yellow); Fremont to Stanford University (Red); Mission San Jose to Redwood City Caltrain (Blue to Green); South Hayward to NASA (Green to Blue).

- BRT – Bayfront Express Busway: Same routes and stops from Enhanced Bus TSM. Expanded bus preferential treatments include elevated HOV lanes on the Bayfront Expressway, transit-only on/off ramps, transit-only lanes and allowing shoulder operations. Grade separations for the elevated HOV lanes are described as Alternative 3: Grade Separations at Bayfront/Willow and Bayfront/University in the 2020 Peninsula Gateway Corridor Study.

- BRT Shuttle – Union City to Redwood City: Bi-directional bus service between Union City BART and Redwood City Caltrain. This alternative includes the same improvements as the enhanced TSM alternative: bus preferential treatment including exclusive bus lanes on the Bayfront Expressway – eastbound direction.

The Original Project, Rail Shuttle – Union City and a combination of these two alternatives were identified as some of the best performing rail alternatives. The combination of Enhanced Bus TSM and the BRT Shuttle were identified as the best performing bus alternatives. More information about the evaluation of these alternatives can be found in **Appendix A**.

2.3.2 Facebook-Led Studies

Arup, in association with Facebook and Fehr & Peers, conducted the Facebook Dumbarton Corridor Study in 2015. The goal of this study was to explore opportunities to connect Facebook's Menlo Park campus with Redwood City and Menlo Park downtowns via dedicated transportation facilities, while maintaining a vehicle trip cap of 10,000 trips for the campus during the morning and evening peak periods under 2025 conditions. Six alternatives were considered as part of this study: a Caltrain Spur, LRT, BRT, personal rapid transit (PRT)[2], group rapid transit [3], and aerial ropeway. Of these six alternatives, two preferred alternatives (BRT and PRT) were evaluated under 2025 conditions. Both preferred alternatives would provide service along the Caltrain and Dumbarton Corridors connecting the Facebook campus with the Redwood City Caltrain Station. Both alternatives are summarized below.

BRT Alternative

- A 1.3-mile service would be provided with ten stations (five community stations and five stations within the Facebook campus).
- At two buses per minute, the BRT alternative could serve about 4,000 to 5,000 passengers per hour.
- The travel time between the Redwood City Caltrain Station and Building 21/22 of the Facebook campus (located at the junction of Bayfront Expressway and Chilco Street) would be about 17 minutes.
- The BRT service would operate at an average speed of 15–30 miles per hour.
- Compared to Facebook employee shuttles, the BRT service would have travel time savings of five minutes.

PRT Alternative

- A PRT service slightly longer than 1.3 miles would be provided. This alternative would provide 13 stations (five at-grade community stations and eight elevated stations within the Facebook campus).
- Using 115–145 vehicles at a short headway of four seconds, this alternative could serve about 5,000 passengers per hour.

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[2] Fixed guideway transit with 2- or 4-person cars.

[3] Fixed guideway transit with 8 + persons per car and operate at faster travel speeds than PRT or LRT.

- The travel time between the Redwood City Caltrain Station and Building 21/22 of the Facebook campus would be about eight minutes.

Both alternatives would serve projected employment at Facebook through 2025. Both alternatives would require dividing the existing 100-foot wide Dumbarton Rail ROW to provide approximately 20 feet of shared-use path to the north, 50–60 feet for conventional rail service in the middle, and 20–30 feet for BRT/PRT service to the south.

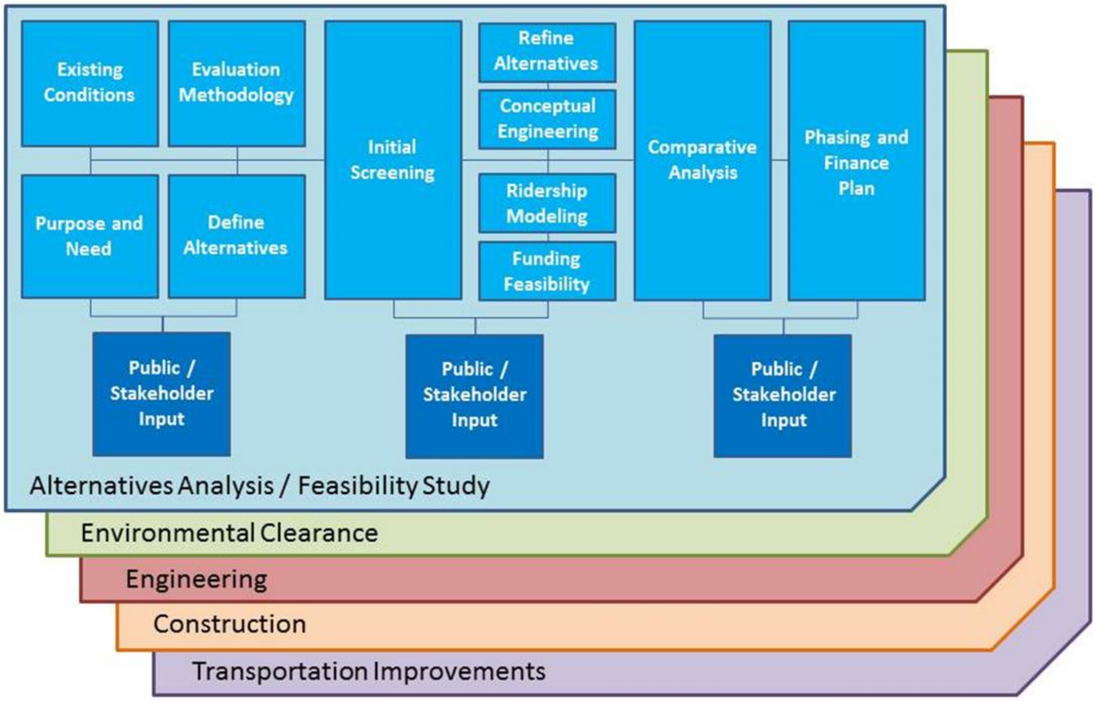
2.4 Feasibility Study Process

A transportation feasibility study is the first phase in the project development process. A feasibility study includes a multi-step planning process to identify a preferred alternative or set of alternatives in a response to an established transportation problem. This process is depicted in **Figure 2-2**.

At the beginning of a feasibility study, existing conditions are examined while the need and purpose of a potential project are defined. An important aspect of the process is to establish goals and objectives by which project alternatives will be evaluated. Initial alternatives are then identified and evaluated in a relatively qualitative manner and an initial screening process is used to narrow down the number of alternatives that will advance to a more detailed phase of analysis. Alternatives that best meet project goals and evaluation metrics are then carried forward and defined and developed at a greater level of detail via operating plans, conceptual design, capital and operating and maintenance cost estimates as well as ridership and operations modeling. These alternatives are then evaluated in a second round of analysis, which is more quantitative in nature. Phasing and financing plans are developed for alternatives that best meet project goals and evaluation metrics. Stakeholder and public outreach is often targeted for specific study milestones as described in Section 2.4.1.

Environmental clearance typically follows a feasibility study. State and federally mandated environmental analysis develops recommended alternatives to a greater level of design and examines environmental impacts and potential mitigation measures prior to additional engineering and construction.

Figure 2-2: Five Stages of Project Development



Source: SamTrans, 2016

2.4.1 Stakeholder and Public Outreach

Project partners and community stakeholders were identified early in the study process. As previously mentioned, project partners included Facebook, Alameda CTC, and AC Transit. Stakeholders were more numerous and include other transit agencies (such as Caltrans, the Metropolitan Transportation Commission, VTA, ACE, etc.) as well as cities and local elected officials. While project partners participated in all aspects of the study, stakeholders were briefed at the beginning of the project as well as at three study milestones. The general public was also briefed at the same study milestones. The outreach process is described in more detail below.

Stakeholder Pre-meeting

A stakeholder pre-meeting was held in January 2016 before the study officially began. At this meeting, project stakeholders were invited to comment on the proposed scope and schedule of the DTCS. At this time, SamTrans also shared the study outreach process moving forward.

Stakeholder and Public Meetings

SamTrans scheduled stakeholder and public outreach meetings to coincide with three major project milestones. For each round of outreach, four meetings were generally held—two in the East Bay (one for stakeholders and one for the general public) and two on the Peninsula (one for stakeholders and one for the general public). Additional public meetings were held in the last round of outreach.

The first round of outreach was conducted in May 2016. The goal of these meetings was to provide background information about the DTCS and Dumbarton Corridor as well as solicit feedback on project goals and objectives and initial alternatives. Meeting details are provided below and a summary of comments received is provided in **Appendix B**.

- East Bay Stakeholder Meeting: May 5, 2016, 11:30 AM – 1:00 PM, Alameda CTC, 1111 Broadway, Suite 800, Oakland, California 94607 – 10 attendees
- East Bay Public Meeting, May 10, 2016, 7:00 – 8:00 PM, Fukaya B Room, Fremont Library, 2400 Stevenson Boulevard, Fremont, California 94538 – 26 attendees
- Peninsula Stakeholder Meeting, May 11, 2016, 10:00 – 11:30 AM, City Council Chamber, 701 Laurel Street, Menlo Park, California 94025 – 9 attendees
- Peninsula Public Meeting, May 12, 2016, 7:00 – 8:00 PM, Ballroom, Menlo Park Senior Center, 110 Terminal Avenue, Menlo Park, California 94025 – 38 attendees

The next milestone was in September 2016. At these meetings, SamTrans provided results of the initial screening analysis and described the alternatives being carried forward for further analysis. Meeting details are provided below and a summary of comments received is provided in **Appendix B**.

- East Bay Stakeholder Meeting, September 8, 2016, 11:30 AM – 1:00 PM, Alameda CTC, 1111 Broadway, Suite. 800, Oakland, California 94607 – 13 attendees
- East Bay Public Meeting, September 12, 2016, 7:00 – 8:00 PM, Newark Public Library, 6300 Civic Terrace Avenue, Newark, California 94560 – 23 attendees
- Peninsula Stakeholder Meeting, September 14, 2016, 10:30 – 12:00 AM, Arrillaga Family Recreation Center, Cypress Room, 700 Alma Street, Menlo Park, California 94025 – 9 attendees
- Peninsula Public Meeting, September 14, 2016, 7:30 – 8:30 PM, Ballroom, Menlo Park Senior Center, 110 Terminal Avenue, Menlo Park, California 94025 – 30 attendees

Finally, in August and September 2017 SamTrans presented preliminary results of the detailed evaluation of alternatives carried forward and recommend a phasing plan. Meeting details are provided below and a summary of comments received throughout the outreach process is provided in **Appendix B**. Frequently Asked Questions are also provided in **Appendix B** in an effort to respond to questions and comments.

- East Bay Stakeholder Meeting, August 15, 2017, 2:30 – 4:00 PM, Alameda CTC, 1111 Broadway, Suite 800, Oakland, California 94607
- East Bay Public Meeting, August 15, 2017, 6:30 – 7:30 PM, Union City Public Library, 34007 Alvarado-Niles Road, California 94587
- Peninsula Stakeholder Meeting, August 16, 2017, 2:30 – 4:00 PM, City Council Chamber, 701 Laurel Street, Menlo Park, California 94025

- Peninsula Public Meeting, August 16, 2017, 6:30 – 7:30 PM, East Palo Alto Library Community Room, 2415 University Avenue, East Palo Alto, California 94303
- East Bay Public Meeting, September 13, 2017, 6:30 – 8:00 PM, Mark Green Sports Center, 31224 Union City Boulevard, Union City, California 94587
- Peninsula Public Meeting, September 25, 2017, 6:30 – 8:00 PM, Menlo Park Senior Center, 100 Terminal Avenue, Menlo Park, California 94025

2.5 Report Structure

The report structure of the DTCS generally follows the steps of a feasibility study. The subsequent chapters are described below:

- Chapter 3 documents the need and purpose of the feasibility study.
- Chapter 4 describes existing and future conditions in the Dumbarton Corridor.
- Chapter 5 identifies initial project alternatives.
- Chapter 6 describes the screening of the initial project alternatives and identifies the alternatives carried forward for further analysis.
- Chapter 7 further refines the alternatives carried forward for additional analysis.
- Chapter 8 discusses the evolution of conceptual design for the alternatives carried forward.
- Chapter 9 covers the methodologies and capital and operating and maintenance costs of each alternative carried forward.
- Chapter 10 discusses travel behavior forecasting methodology and results for the alternatives carried forward.
- Chapter 11 discusses the comparative analysis of alternatives carried forward.
- Chapter 12 identifies recommended alternatives and the phasing of these alternatives over time.
- Chapter 13 identifies a potential funding and financial strategy for the phased recommendations.
- Chapter 14 provides a preliminary screening for public-private-partnership opportunities.

3 Need and Purpose

3.1 Introduction

The southern San Francisco Bay Area is a highly desirable place for both jobs and homes, with significant current and projected growth for San Mateo, Santa Clara, and Alameda counties. Much of this growth is driven by the major employment centers in Silicon Valley, which spans San Mateo and Santa Clara counties. A large number of tech firms and other major employers are headquartered in the region, including Facebook, Google, Stanford University and Hospital, Visa, Oracle, LinkedIn, Apple, and Intel. Since 2010, Silicon Valley has seen accelerated job growth increasing 19.6 percent and far exceeding prerecession levels.[1] As a result, this surge in employment has generated increasing traffic flow throughout the Peninsula.

Silicon Valley employees reside all across northern California, including the residential neighborhoods of the East Bay. While employment has and will continue to grow in Silicon Valley, the East Bay has experienced significant population growth when compared to the Peninsula. The population in Alameda County increased by about 5 percent from 2000 to 2010 and is projected to grow approximately 32 percent between 2010 and 2040. In comparison, San Mateo County grew almost 2 percent from 2000 to 2010, and is projected to grow 26 percent between 2010 and 2040.[2] As a result of this growth, the morning peak hour flow of traffic from residential areas in the East Bay to employment centers on the Peninsula is heavily weighted in the westbound direction, and congestion along the region's roads and bridges, including the Dumbarton Highway Bridge or State Route 84 (SR 84), is a common experience. This pattern is reversed during the evening peak. This jobs-housing imbalance is exacerbated by the lack of regional transit connectivity and limited travel options between the East Bay and the Peninsula.

In response to these issues, SamTrans prepared the Dumbarton Transportation Corridor Study (DTCS), which investigates short- and long-term operational and infrastructure improvements in the Dumbarton Corridor. The study area encompasses both the Dumbarton Highway Bridge (SR 84) as well as the Dumbarton Rail Bridge. For the purposes of the DTCS, jurisdictions directly affected by SR 84 traffic are considered Tier 1 cities: Redwood City, Menlo Park, East Palo Alto, Stanford, Atherton, and Palo Alto on the Peninsula and Newark, Fremont, and Union City in the East Bay. The DTCS also includes cities indirectly affected by Dumbarton Corridor congestion, referred to as Tier 2 cities. These Tier 2 cities are in both Santa Clara County (Mountain View, Sunnyvale, and Santa Clara) and the Tri-Valley (San Ramon, Dublin, Pleasanton, and Livermore) and are included to better understand regional travel markets.

3.2 Need for Transportation Improvements

Within this increasingly congested travel corridor, there is an existing and future need for transportation improvements. This need is driven by a variety of land use challenges and transportation deficiencies including a jobs-housing imbalance spurred by employment opportunities on the Peninsula and residential population growth in the East Bay, a lack of

[1] Joint Venture Silicon Valley, "2016 Silicon Valley Index," 2016, page 17.

[2] US Census Bureau and ABAG Plan Bay Area Projections 2013.

regional connectivity in the South Bay, and limited travel options between the East Bay and the Peninsula. These issues have resulted in significant roadway congestion and lengthy, unpredictable travel times for transbay and local commuters in and around the Dumbarton Corridor.

The following sections discuss the issues noted above, highlighting the need for a comprehensive blend of land use strategies, capital investments, and operational solutions to minimize travel impacts within the Dumbarton Corridor.

3.2.1 Jobs-Housing Imbalance

A major driver behind the travel and congestion increase in the Dumbarton Corridor is accelerated job growth in Silicon Valley combined with limited housing supply on the Peninsula. Between 2010 and 2014, San Mateo County added 54,600 jobs compared to 2,100 new housing units.[3] This jobs-housing imbalance has resulted in a significant amount of people commuting into San Mateo County for work from surrounding areas. According to the Longitudinal Employer Household Dynamics (LEHD, 2014) dataset[4], the majority of the 339,169 persons working in San Mateo County in 2014 lived elsewhere. An estimated 37 percent of San Mateo County workers lived within the County while the remainder of workers commuted mostly from Santa Clara (15 percent), Alameda (14 percent), and San Francisco (12 percent) counties. Commuters from Contra Costa, Solano, and San Joaquin counties comprised 5 percent, 2 percent, and 1 percent of the total, respectively. Combined, more than 20 percent of San Mateo County workers live east of the San Francisco Bay.[5]

Travel estimates from 2013 for the study area (taken from the City/County Association of Governments of San Mateo County-Santa Clara Valley Transportation Authority regional travel demand model) further reiterate a jobs-housing imbalance driven by residential origins in the East Bay and employment destinations on the Peninsula.[6] According to travel estimates, Tier 1 and Tier 2 DTCS cities are responsible for 63 percent of the residential originations and 78 percent of the employment destinations using the Dumbarton Highway Bridge. Of the 63 percent of the Highway Bridge origins contributed by Corridor cities, almost two-thirds are generated in the Tier 1 East Bay cities of Newark, Fremont, and Union City. Of the 78 percent of employment destinations, nearly two-thirds are generated by Tier 1 Peninsula Corridor cities including Menlo Park, Stanford, Palo Alto, and Redwood City.

Regional growth forecasts suggest that both population and employment of the DTCS cities will continue an upward trend, increasing by approximately 27 percent between 2013 and 2040, with passenger traffic increasing by 19 percent on the Dumbarton Highway Bridge. While both East Bay and Peninsula DTCS cities can expect substantial overall growth by 2040, regional forecasts indicate employment growth will outpace population growth between 2013 and 2020. This accelerated employment growth will add an estimated 57,000 jobs to Peninsula DTCS cities

[3] "The Challenge." *Home for All*. Web. July 20, 2017.

[4] The LEHD uses a combination of federal, state, and Census data on employers and their employees to estimate commute flows between geographic areas.

[5] U.S. Census Bureau, OnTheMap Application and LEHD Origin-Destination Employment Statistics (Beginning of Quarter Employment, 2nd Quarter of 2002-2014).

[6] "Dumbarton Transportation Corridor Study Travel Modeling and Forecasts Memo" Fehr & Peers, May 16, 2017.

by 2020, compared to a population growth of 38,000.[7] In contrast, population and employment growth in the East Bay DTCS cities will be roughly equivalent adding 30,000 residents and 33,000 jobs. This estimated growth pattern suggests that the jobs-housing imbalance in Peninsula DTCS cities will not only intensify by 2020, but transbay commutes will likely spread further east as the East Bay DTCS cities will be unable to absorb the Peninsula's growing imbalance.

It should be noted that additional housing construction on the Peninsula could also address the jobs-housing imbalance, though it remains to be seen if enough construction could take place to accommodate demand.

3.2.2 Lack of Regional Transportation Connectivity and Limited Transbay Travel Options

Regional connectivity, frequency, and reliability of transbay transit services are limited, especially in the southern portion of the Bay Area. Existing regional transportation connectivity in the South Bay consists of transit and roadway networks generally oriented in a north-south and east-west direction.

North-south regional connectivity in the South Bay is provided by high-capacity rail transit on the Peninsula and in the East Bay in addition to bus and roadway networks. Caltrain provides commuter rail service along a 77-mile-long alignment that serves 29 stations in San Francisco, San Mateo, and Santa Clara counties. In the East Bay, Bay Area Rapid Transit (BART) provides heavy rail service as far south as Warm Springs in southern Fremont. Altamont Corridor Express provides regional commuter rail service between the Central Valley and San Jose through the Altamont Pass. Additionally, Capitol Corridor operates intercity rail service for 172 miles between Sacramento and San Jose. There is no direct east-west connection between these north-south rail networks, while the travel demand in the region is increasingly growing in the east-west direction.

East-west regional connectivity in the southern portion of the San Francisco Bay is limited to one roadway connection along the Dumbarton Highway Bridge. Although there are three bridges that accommodate automobile and bus transit from the East Bay to the Peninsula, the two northernmost bridges (the San Mateo-Hayward and San Francisco-Oakland Bay bridges) are situated too far north to be conducive to transbay travel in the southern Bay Area. Similarly, SR 237, which runs south of the San Francisco Bay could be used as an alternative to the Dumbarton Highway Bridge, but this route is significantly longer for trips destined for northern Santa Clara County. The Dumbarton Highway Bridge, therefore, is the primary choice for travelers between southern Alameda County and San Mateo or Santa Clara counties; transbay trips in this part of the Bay must drive or utilize limited transbay bus services.

As shown in **Table 3-1**, there are currently three transbay express bus routes that offer transit connections via the Highway Bridge: the Dumbarton Express (DB), Dumbarton Express 1 (DB1), and Stanford University's Line U/AE-F. The two Dumbarton Express services travel between the Union City BART station and Stanford University and Research Park, with an intermediary stop at the Ardenwood Park-and-Ride. Line U originates at Fremont BART and serves Stanford University with stops at the Fremont Centerville Station and Ardenwood Park-and-Ride.

While these routes serve Palo Alto, they do not directly serve several other major activity and employment centers on the Peninsula such as some portions of Menlo Park, Redwood City, and Santa Clara County. Also, as noted in **Table 3-1**, transit service is often infrequent and not well-integrated or timed with other existing transit networks in the East Bay and on the Peninsula. As a result, multiple transfers with potentially long wait times are required to reach some key destinations.

Table 3-1: Transit in the Dumbarton Corridor

Route	Dumbarton Express (DB)	Dumbarton Express 1 (DB1)	U – Stanford/ Stanford (AE-F)	TOTAL
Span of Service	5:20 AM – 9:00 PM	6:00 AM – 9:00 AM 2:30 PM – 9:00 PM	5:30 AM – 9:00 PM 2:30 PM – 7:00 PM	6:00 AM – 9:00 AM 2:30 PM – 7:00 PM
Service Frequency	~30 peak ~60 off-peak	~30	~20	~15
Weekday Trips Per Direction	23 23 WB EB	22 23 WB EB	17 17 WB EB	62 63 WB EB
Peak Period westbound Travel Time (Average Min)	52 mins Scheduled: 37 mins	41 mins Scheduled: 34 mins	41 mins Scheduled: 34 mins	
Peak Period Speed (Miles per Hour)	Actual: 13 mph Free Flow: 29 mph	Actual: 19 mph Free Flow: 36 mph	Actual: 19 mph Free Flow: 36 mph	
Midday Bidirectional Travel Time (Average Min)	29 mins Scheduled: 31 mins			
Midday Speed (Miles per Hour)	Actual: 22 mph Free Flow: 29 mph			
Weekday Patronage	550	570	1,000	2,120
Passengers Per Trip	12 24%	13 26%	29 58%	17 34%

Source: AC Transit, Web-posted Schedules, 2016

Notes: DB Ardenwood-PATC Length 12 miles 7-8am peak hour, 2-3pm midday hour
DB1 Ardenwood-Page Mill/El Camino Length 13 miles 7-8am peak hour
U Ardenwood-El Camino Length 13 miles data unavailable anticipated to be similar to DB1

Existing transit service in the Dumbarton Corridor has no dedicated right-of-way and only one transit preferential facility (a high-occupancy vehicle queue jump at the Dumbarton Highway Bridge Toll Plaza), making it subject to delay from incidents and traffic congestion, leading to long in-vehicle and unreliable travel times.

As previously mentioned, the lack of regional transportation connectivity in the east-west direction contrasts with the dominant transbay travel patterns where many people are commuting from residential areas in the East Bay to employment centers along the Peninsula and in Santa Clara County. As a result, the existing Dumbarton Highway Bridge and transbay bus routes do not effectively meet demand. With significant overall growth expected in the Dumbarton Corridor and the Bay Area as a whole, the need for improved regional connectivity and transit services will likely increase.

3.2.3 Roadway Congestion and Lengthy Travel Times for Local and Transbay Commuters

The existing highway capacity in the Dumbarton Corridor is not sufficient to accommodate current and forecasted peak-hour demands at high levels of service (LOS). There is substantial congestion during morning and evening peak periods, which will increase over time due to growth on both sides of the Bay, making automobile travel times longer and increasingly unpredictable.

The Dumbarton Highway Bridge is a six-lane span (three lanes in each direction) that carries over 70,000 vehicles a day. As previously described, traffic on the Highway Bridge is heavily oriented toward commutes to and from jobs in Silicon Valley with substantial congestion during morning and evening peak periods. Traffic volumes on the bridge are highly peaked, with peak-period peak-direction (westbound morning and eastbound evening) traffic three to four times as high as reverse commute traffic and midday traffic.

Congestion conditions are reflected in a roadway's LOS. LOS is a measure used to characterize the operating conditions of a roadway considering speed, travel time, freedom to maneuver, traffic interruptions, and convenience. The Transportation Research Board's Highway Capacity Manual defines levels of service ranging from LOS A (uncongested) to LOS F (very congested). **Table 3-2** outlines operating conditions for each LOS category.

Table 3-2: General Definitions of Levels of Service

Travel Speed as a Percentage of Base Free-Flow Speed (%)	LOS by Critical Volume-to-Capacity Ratio
	≤ 1.0
> 85	A
> 67 – 85	B
> 50 – 67	C
> 40 – 50	D
> 30 – 40	E
≤ 30	F

Source: Highway Capacity Manual, 2010

As shown in **Table 3-3**, all major arterials within the study area currently operate at LOS E or F during the morning and evening peak periods, except Union City Boulevard and Fremont Boulevard located between Paseo Padre Parkway and Thornton Avenue; these two arterials operate at LOS D or better during the peak periods.

Table 3-3: Existing (2016) Arterial Performance

Arterial	Segment	Distance (miles)	Direction	Average Travel Speed (mph)								
				Free Flow Condition	6:30 AM	7:30 AM	8:30 AM	9:30 AM	4:30 PM	5:30 PM	6:30 PM	7:30 PM
Marsh Road	Bayfront Expressway - Middlefield Road	1.4	Southbound	21	21	11	8	12	14	11	14	17
			Northbound	28	21	14	12	14	8	7	12	17
Willow Road	Bayfront Expressway - US 101	1.1	Southbound	22	13	6	5	8	13	11	9	13
			Northbound	17	13	13	11	11	6	4	5	9
University Avenue	Bayfront Expressway - US 101	2.0	Southbound	24	15	9	7	10	15	12	13	15
			Northbound	20	17	15	15	15	7	5	6	10
Bayfront Expressway	University Avenue - Marsh Road	2.2	Westbound	44	33	22	17	22	26	26	26	26
			Eastbound	33	22	22	19	19	9	6	7	15
Union City Boulevard	Paseo Padre Parkway - Thornton Avenue	2.7	Eastbound	23	20	15	15	18	15	14	15	18
			Westbound	23	20	18	18	18	14	14	14	18
Decoto Road	Paseo Padre Parkway - I 880	1.4	Southbound	28	14	17	8	14	21	17	21	17
			Northbound	26	20	16	16	16	9	8	8	9
Fremont Boulevard	Paseo Padre Parkway - Thornton Avenue	1.9	Eastbound	23	19	13	11	16	16	14	16	19
			Westbound	23	23	19	14	19	16	13	11	19

Source: Google Maps (typical weekday morning and evening peak period speeds from Tuesday through Thursday), 2016; methodology is further described in Chapter 4, Section 4.2.3.

Notes: Orange-colored cells represent LOS E and red-colored cells represent LOS F.

Forecasts based on expected regional population and employment growth indicate 19 percent growth in Dumbarton Highway Bridge traffic between 2013 and 2040, with truck traffic specifically increasing 47 percent (see **Chapter 10** for a complete summary of model forecast results). This increased growth will further intensify congestion within the study area and further degrade LOS for major arterials. In addition, forecasts indicate the increased traffic will lengthen morning and evening peak travel periods resulting in higher percentages of off-peak traffic.

3.3 Purpose of Transportation Improvements

Infrastructure and operational improvements along the Corridor are needed to address mobility issues and deficiencies resulting from population and employment growth, such as increasing congestion on capacity-constrained transit and roadway networks. The purpose of the DTCS is to examine the existing transportation deficiencies within the Corridor and identify cost-effective capital improvements and operational programs that enhance multimodal mobility for local and regional travelers while minimizing impacts to the environment and surrounding communities.

The following goals are the driving force behind the DTCS:

1. Identify capital improvements and operational programs in the Dumbarton Corridor that enhance multimodal mobility for local and regional travelers, with an emphasis on improving person throughput by expanding transit service.

2. Pursue cost-effective capital, operational and maintenance improvements with a return on investment, if feasible, including the effective repurposing of the Dumbarton Rail Bridge.

3. Manage and minimize environmental impacts and financial risk, and maximize safety.

4. Ensure local communities in the East Bay and Peninsula are protected from adverse impacts related to the development and operation of regional mobility solutions.

It should be noted that the Rail Bridge is an underutilized asset and one of just a handful of San Francisco Bay crossings. If the Bridge is not repurposed for transportation purposes, the dismantling of the Bridge will carry a significant capital cost without the addition of capacity or mobility benefits.

For each goal, a set of performance metrics has been established by which the proposed project alternatives can be evaluated. Alternatives will proceed through an initial screening process followed by a comparative analysis. The following sections further describe goals and performance metrics.

3.3.1 Enhance Mobility for Local and Regional Travelers

Proposed capital improvements and operational programs in the Dumbarton Corridor should enhance travel options for local and regional transbay travelers by increasing mode choice and shifting travel from automobiles to transit (i.e., new transit riders), increasing the direct connections between and within modes, reducing total travel time, and bringing transit closer to major origins and destinations. The following metrics were used to measure enhanced mobility for local and regional travelers:

Initial Screening Metrics

- Capacity and throughput, with an emphasis on transit capacity/benefit
- Ability to serve regional travel markets
- Ability to provide frequent transit service

Comparative Analysis Metrics

- Daily transbay transit ridership
- Load factor
- Peak period transbay passengers per seat mile
- Peak period per person minutes delay
- Operational benefit (e.g., reliability, accommodating future demand)

3.3.2 Cost-Effective Improvements with a Return on Investment

Proposed capital and operational improvements in the Dumbarton Corridor should be cost-effective with a return on investment, if feasible. The following metrics will be used to measure the costs and benefits of each alternative:

Initial Screening Metrics

- Average capital cost per mile
- Average operating and maintenance cost per mile
- Capital cost
- Operating and maintenance cost

Comparative Analysis Metrics

- Annualized capital cost per new user
- Annualized operating and maintenance cost per user
- Fundability

3.3.3 Manage and Minimize Environmental Impacts and Financial Risk, and Maximize Safety

Proposed capital improvements and operational programs in the Dumbarton Corridor should adequately balance financial risks and benefits. In addition, the proposed improvements should seek to minimize impacts to environmentally sensitive receptors and maximize safety for all users within the Corridor. The following metrics will be used to measure the environmental impact, financial risk, and safety of each alternative:

Initial Screening Metrics

- Environmental impacts (e.g., disturbance to environmentally sensitive areas)
- Financial risk (e.g., risk of new modes, unproven technologies, etc.)
- Safety (e.g., potential for incidents and accidents, security considerations, etc.)

Comparative Analysis Metrics

- Environmental impacts (e.g., disturbance to environmentally sensitive areas)
- Financial risk (e.g., consideration of project delivery methods)
- Safety (e.g., potential for incidents and accidents, liability issues, etc.)

3.3.4 Ensure Local Communities are Protected from Adverse Impacts

Proposed improvements within the Dumbarton Corridor should be designed to mitigate adverse health and environmental impacts on surrounding communities in the East Bay and Peninsula. In addition, Corridor improvements should ensure equitable access to facilities and services with an emphasis on low-income and minority populations. The following metrics will be used to measure the impact of each alternative on East Bay and Peninsula communities within the study area:

Initial Screening Metrics

- Disproportionate burden on low-income populations (e.g., impacts due to station access, grade crossings, facilities built in community)
- Disparate impacts on minority populations (e.g., impacts due to station access, grade crossings, facilities built in community)

Comparative Analysis Metrics

- Disproportionate burden on low-income populations (e.g., access to new services/facilities, who benefits from the new service (demographics), what happens to existing bus/transit services?)
- Disparate impacts on minority populations (e.g., access to new services/facilities, who benefits from the new service (demographics), what happens to existing bus/transit services?)

4 Existing and Future Conditions

This chapter provides an overview of existing transportation infrastructure and performance as well as existing and projected demographic conditions in the study area. This is followed by a travel market analysis. The information contained in this chapter draws upon many resources, many of which are referenced in the Literature Review, which can be found in **Appendix C**.

4.1 Transportation Infrastructure

The Dumbarton Corridor includes approximately 18 miles of existing rail infrastructure in the Peninsula and East Bay, including the Rail Bridge across the southern part of the San Francisco Bay (**Figure 4-1**). The existing components of the Dumbarton Rail Right-of-Way (ROW) (moving from west to east) are summarized below:

- Redwood City Station to Redwood Junction
  - 0.9 miles along the Peninsula Corridor Joint Powers Board (Caltrain) ROW
  - Existing rail infrastructure owned by Caltrain
  - Limited freight operations
  - Significant passenger rail operations (Caltrain)
- Redwood Junction to Newark Junction/Carter
  - 10.5 miles along Dumbarton Rail ROW, which also spans the Rail Bridge, Don Edwards National Wildlife Refuge, and Newark Slough Bridge.
  - Existing rail infrastructure owned by the San Mateo County Transit District (SamTrans)
  - Limited freight operations between Redwood Junction and Chilco Street in Menlo Park (located 3,100 feet east of the crossing of US 101)
  - No current freight or passenger operations between Chilco Street and Newark Junction (including across the Dumbarton Rail Bridge)
- Newark Junction/Carter
  - 0.4 miles through Newark Junction along the Coast Subdivision
  - Existing rail infrastructure owned by the Union Pacific Railroad (UP)
  - Significant freight operations along this segment
- Newark Junction/Carter to Oakland Subdivision
  - 3.9 miles along Centerville Line

- Existing rail infrastructure owned by UP
- Significant freight and passenger rail service along this segment
- No rail connection between Centerville Line and Oakland Subdivision at this location

▪ Oakland Subdivision to Niles Subdivision at Industrial Parkway in Hayward

- 2.3 miles along Oakland Subdivision
- Existing rail infrastructure owned by UP
- Limited freight operations

Figure 4-1: Dumbarton Corridor Rail Infrastructure

Source: http://www.tillier.net/caltrain_maps/26-TCCM-200-B.pdf, 2016

Before construction of the Dumbarton Rail Bridge, there was no direct access for transcontinental freight to San Francisco; shipments were instead delivered to Oakland and ferried to their destinations on the Peninsula. In 1908, the former Southern Pacific Railroad began construction of the Dumbarton Rail Bridge, which was completed in 1910. The Rail Bridge was used primarily for freight service, but it had limited passenger service in the early years; from approximately 1912 to1918. Freight and passenger cars from Newark connected with regular San Francisco to San Jose service (which would later become the modern-day Caltrain) in Redwood City.

The Dumbarton Rail Bridge carries a single railroad track over approximately 1,400 feet of steel truss structure. To accommodate marine traffic, the Rail Bridge has a central 310-foot long swing segment, now permanently left open. In this state, the Rail Bridge affords 125-foot navigable channel on either side of the swing segment.

Adjacent to the Rail Bridge is the Dumbarton Highway Bridge which carries SR 84 over the San Francisco Bay between Menlo Park and Fremont. Approximately two miles long, it is the shortest bay crossing. There are three lanes in each direction except a westbound segment with seven lanes at the toll plaza. The highway lanes are approximately 11 to 12 feet wide. There is also a separate two-way bicycle and pedestrian lane along the south side of the Bridge, which measures five to six feet wide. The toll plaza is located on the eastern end approximately one-half mile west of Paseo Padre Parkway/Thornton Avenue and only collects tolls from westbound traffic. Drivers can either pay by cash or use a FasTrak electronic toll collection device. The current toll rate is $5 per passenger car and $5 per axle for vehicles with more than two axles. A commute bus or vanpool vehicle may cross toll-free at any time. During weekday peak hours, the leftmost FasTrak-only lane is converted to a High Occupancy Vehicle (HOV) lane allowing HOV 2+ carpool vehicles, clean air vehicles with Department of Motor Vehicles-issued decals, and motorcycles paying a discounted toll of $2.50. The next two leftmost lanes at the toll plaza are FasTrak-only lanes, and all other lanes accept both cash and FasTrak.

The eastern end of the Highway Bridge in Fremont is connected to I 880 by the SR 84 freeway segment. The Highway Bridge's westerly end in Menlo Park is connected to US 101 by the Bayfront Expressway. The Bayfront Expressway is a limited-access road controlled by three major at-grade signalized intersections located at Marsh Road (interchange to US 101), Willow Road (SR 114), and University Avenue (SR 109). In between Marsh Road and Willow Road, there are two additional signalized intersections at Chilco Road and Chrysler Drive.

4.2 Transportation System Performance

4.2.1 Rail System and Service

Freight

The Dumbarton Rail Bridge was last used for freight service in 1982. The removal of the Rail Bridge from service was tied to declining freight volumes to and from San Francisco. Southern Pacific Railroad sold the Dumbarton Corridor line segment from Redwood Junction to Newark to SamTrans in 1994 for about $7 million. In January 1998, the wooden western portion of the Rail Bridge was completely destroyed by fire. The portion of the Dumbarton Line between Redwood Junction and Chilco Street in Menlo Park is still used for limited freight service by UP. No passenger or freight trains use the remaining portion of the Dumbarton Line in the East Bay.

Other rail lines in the study area include the UP Coast, Niles, and Oakland Subdivisions, along with the North Milpitas Industrial Lead (located between Niles Junction and Warm Springs). These lines are described in Section 4.1. All lines have freight rail traffic. The busiest lines are the Coast and Niles Subdivisions.

Union Pacific Trackage Rights Agreement

UP has the right to operate freight service on the Dumbarton Rail ROW, pursuant to the terms laid out in the Dumbarton Branch Trackage Rights Agreement between SamTrans and UP. Under the agreement, the Dumbarton Rail ROW is composed of three segments: Eastside, Westside, and Bridge. Even though a portion of the Bridge was destroyed, all are considered active by the Surface Transportation Board (STB), which has regulatory jurisdiction.

Under the Agreement, if SamTrans operates commuter rail service over the Bridge segment, UP would have the right to limit freight traffic to a window from 12 AM to 5 AM with a secondary window from 10 AM to 3 PM (if freight trains can run at satisfactory speeds).[1]

In general, if a single track is preserved, UP would likely not have any right to veto other uses in the Corridor. Additionally, UP does not have the right to dictate clearances under the agreement and cannot require SamTrans to maintain a larger clearance than what is required by the California Public Utilities Commission and other applicable rules.

If SamTrans proposes a different use for the Corridor, which is incompatible with the operation of freight, SamTrans would have to petition for the STB to change the status of the line to either "discontinued" or "abandoned."

Additionally, there is a buy-out clause included in the agreement that would allow SamTrans to buy out UP on the Rail Bridge itself. A payment of $250,000 from SamTrans to UP would require UP to cease service over the Bridge segment.[2] This would also require the filing of a petition to abandon the service with the STB.

Caltrain

Caltrain provides commuter rail service to three counties: San Francisco, San Mateo, and Santa Clara. Trains operate along the Peninsula, through the South Bay to San Jose and Gilroy. It offers local, limited-stop, and "Baby Bullet" express services during peak periods. Weekday services have a typical frequency of 15–20 minutes, with peak frequency (six minutes) occurring at 5:00 AM on the northbound service. Weekend service is limited to one train per hour with two "Baby Bullet" routes running once in the morning (10:00 AM) and once in the afternoon (5:00 PM). An average trip from San Francisco Station to the Diridon Station in San Jose can take 1 hour 27 minutes on the local service or 1 hour 4 minutes on the "Baby Bullet" express service.[3] Travel within study area cities, such as Redwood City to Palo Alto, can be as little as eight minutes.[4]

Average trip length during the weekday is 22.7 miles. Three of the top ten ridership-producing stations (Palo Alto #2, Redwood City #6, and Menlo Park #10) are within the DTCS area.[5] Average weekday ridership increased to 58,245 in 2015, up 71 percent since 2010.[6]

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[1] Ibid. § 4.3

[2] Ibid. § 4.4

[3] http://www.caltrain.com/schedules/weekdaytimetable.html

[4] http://www.caltrain.com/schedules/weekdaytimetable.html

[5] http://www.caltrain.com/Assets/_Marketing/pdf/2015+Annual+Passenger+Counts.pdf

[6] http://www.caltrain.com/Assets/_Marketing/pdf/2015+Annual+Passenger+Counts.pdf

Caltrain, through private sponsorship and funding from the San Mateo County Transportation Authority (TA) and other public sources, also provides many different shuttles from nearby stations to large centers of employment.[7] Employment centers within the study area boundaries include the following:

- Mid-Point Business Park Area (Redwood City)
- Seaport Centre Business Park Area (Redwood City)
- Redwood Shore-Bayshore Technology Park (Redwood City)
- Embarcadero Shuttle (Palo Alto)
- Marguerite Shuttle system onto Stanford University/Medical Center

Caltrain stations provide a variety of amenities by location. **Table 4-1** provides details on amenities offered at Caltrain stations within the study area, including number of available parking spaces, bike racks, and bicycle lockers.

Table 4-1: Caltrain Station Amenities

Station	Location	Amenities
Redwood City	1 James Avenue, Redwood City, CA	557 Parking Spaces ($55 monthly, $5 daily) 18 Bike Racks 50 Bicycle Lockers
Atherton	1 Dinkelspiel Station Lane, Atherton, CA	96 Parking Spaces ($55 monthly, $5 daily) 26 Bicycle Lockers
Menlo Park	1120 Merrill Street, Menlo Park, CA	155 Parking Spaces ($55 monthly, $5 daily) 8 Bike Racks 50 Shared Access Bike Storage
Palo Alto	95 University Avenue, Palo Alto, CA	389 Parking Spaces ($55 monthly, $5 daily) 178 Bike Racks 94 Bicycle Lockers
Stanford	100 Embarcadero Road, Palo Alto, CA	Not Applicable

Source: http://www.caltrain.com/stations.html (accessed March 30, 2016)

[7] http://www.commute.org/shuttles

Fares

Similar to many other commuter rail fare structures around the nation, the Caltrain fare structure is distance-based. There is a base fare (currently $2.25 for adults) with a fee for each additional zone (currently $1.75 for adults). Users in Zone 1 are charged an additional $0.95 on top of the base fare. San Francisco is in Zone 1, Redwood City is in Zone 2, and Atherton, Menlo Park, and Palo Alto are in Zone 3. The base one-way Clipper Card fares to travel between Zones 1, 2, and 3 are summarized in **Table 4-2**.

Table 4-2: Caltrain Fares

Caltrain Fares			
	Zone 1	Zone 2	Zone 3
Zone 1	$3.20	$5.20	$5.75
Zone 2	$4.00	$2.25	$4.00
Zone 3	$5.75	$4.00	$2.25

Source: http://www.caltrain.com/Fares/farechart.html (accessed March 31, 2016)

Overall System Performance

Caltrain has reached record ridership levels and usage continues to grow. Between 2014 and 2015 weekday ridership grew by 10.7 percent, or 5,634 passengers.[8] The patronage has grown 143 percent since 2004 when the "Baby Bullet" express service was implemented. Caltrain peak period trains are often at 113 percent of seated capacity.[9] For stations with high levels of service, parking is often hard to find and therefore access to Caltrain becomes limited to alternative modes, including bicycling, walking, and shuttle drop-off/pick-up. Caltrain carries more bicycles on-board than any other rail system west of the Mississippi, and Caltrain is studying how to accommodate more bicycles wayside so that people can conveniently use bicycles to access Caltrain. The Caltrain 2015 Annual Passenger Count Study showed 6,207 average weekday bicycle boardings, an increase of 5.7 percent from 2014.[10] Bicyclists being denied boarding because of crowded conditions is not uncommon. Caltrain's 2015 Annual Passenger Count found 209 bicyclists were denied boarding over a seven-day study period.[11] Caltrain has recently retrofitted more cars to store bicycles to help alleviate this issue (adding a third bicycle car in April 2016).[12]

Altamont Commuter Express (ACE)

The San Joaquin Regional Rail Commission operates ACE weekday peak-period commuter rail service between Stockton and San Jose. ACE trains primarily run on tracks owned by UP between Stockton and the Santa Clara Station and on the Caltrain mainline between Santa Clara and the San Jose Diridon Station.

[8] http://www.caltrain.com/Assets/_Marketing/pdf/2015+Annual+Passenger+Counts.pdf

[9] http://www.caltrain.com/Assets/_Marketing/pdf/2015+Annual+Passenger+Counts.pdf

[10] http://www.caltrain.com/Assets/_Marketing/pdf/2015+Annual+Passenger+Counts.pdf

[11] http://www.caltrain.com/Assets/_Marketing/pdf/2015+Annual+Passenger+Counts.pdf

[12] http://www.caltrain.com/about/MediaRelations/news/Caltrain_to_Adjust_Schedule_and_Add_Third_Bicycle_Car_Bicycle_Advisory_Committee_to_Help_Host_Celebratory_Event.html

Within the DTCS area, ACE provides service at the Fremont/Centerville Station. The Fremont/Centerville Station provides approximately 150 commuter park-and-ride spaces[13] and connections to regional transit with parking capacity usually reached by 8:40 AM.[14] The station is served by four AC Transit bus routes (99/210/211/801) as well as Route U.[15]

ACE operates four eastbound and four westbound daily trains through Fremont/Centerville Station during weekday morning and afternoon commute hours. Daily ACE service is summarized in **Table 4-3**.

Table 4-3: ACE Weekday Schedule

ACE Weekday Schedule				
	ACE 1	ACE 3	ACE 5	ACE 7
Westbound Stockton to San Jose (via Fremont)	5:55 AM	7:10 AM	8:15 AM	8:40 AM
	ACE 4	ACE 6	ACE 8	ACE 10
Eastbound Fremont to Stockton	4:05 PM	5:05 PM	6:05 PM	7:08 PM

Source: https://www.acerail.com/Getting-You-There/Maps-Stations (accessed March 31, 2016)

Fares

ACE has a point-to-point fare structure. There are five fare mechanisms: one-way, round trip, 20-trip, monthly, and weekly. Illustrative fares for an adult rider between Stockton and Fremont (terminus to study area) are shown in **Table 4-4** below. The trip between Stockton and Fremont is approximately 65 miles long.

Table 4-4: ACE Fares

ACE Fares			
Stockton to Fremont	Adult	Per Trip Cost Equivalent	Cost per Mile Equivalent
One-way	$10.75	$11.75	$0.17
Round- trip	$19.50	$9.75	$0.15
20-Trip	$152.50	$7.63	$0.12
Monthly	$280.25	$7.01	$0.11

Source: http://www.acerail.com/Files/Fare/PriceTable (accessed March 31, 2016)

Overall System Performance

ACE has reached record ridership and usage continues to grow since its inception in 1998. ACE ridership grew by 20 percent between 2014 and 2015, up to 1.33 million annually, or approximately 5,000 passenger-trips per day.[16] The system has recently added an additional round-trip, increasing its daily number of round-trips between Stockton and San Jose to four. ACE has recently launched its ACEforward campaign aimed at providing six daily round-trips by 2018

[13] Supply is comprised of 126 off-street stalls and 24 on-street parking spaces adjacent to the station.

[14] According to qualitative observations by ACE staff.

[15] http://www.actransit.org/lines-serving-transit-centers/ (accessed March 31, 2016)

[16] SCVTA Transit Operations Performance Report (2014)

and ten daily round-trips by 2022.[17] ACE operates on tracks owned by UP, which affects on-time performance and travel time reliability. Freight has priority over passenger rail and can cause significant delays without any mandatory delay warnings. The ACEforward campaign has identified improvements within the Stockton to San Jose corridor to improve service. However, future improvements will still be subject to freight-first policies. Continued job growth in the Bay Area will likely increase demand for ACE and service to transit hubs like the Fremont/Centerville Station.

Capitol Corridor

The Capitol Corridor trains, operated by Amtrak, run between San Jose and Sacramento, with limited service east to Auburn. Peninsula and East Bay riders can connect to the Capitol Corridor at the Fremont/Centerville Station or in San Jose. The Capitol Corridor operates seven eastbound trains and seven westbound trains daily through the study area via the Fremont/Centerville Station.[18] Weekday and weekend train times vary. Amtrak also runs the long-distance Coast Starlight (Seattle–Los Angeles) through the study area, but this train does not stop at the Fremont/Centerville Station. One round-trip per day traverses the study area. Connections to the Coast Starlight can be made at Oakland and San Jose.

Fares

The Capitol Corridor maintains a point-to-point fare structure. There are four fare mechanisms: one-way, round-trip, 10-trip, and unlimited monthly. Illustrative fares for an adult rider between Sacramento and Fremont (terminus to study area) are shown in **Table 4-5**. The trip is approximately 115 miles long.

Table 4-5: Capitol Corridor Fares

Capitol Corridor Fares			
Sacramento to Fremont	Adult	Per Trip Cost Equivalent	Cost per Mile Equivalent
One-way	$35.00	$35.00	$0.30
Round-trip	$70.00	$35.00	$0.30
10-Trip	$214.00	$21.40	$0.19
Monthly	$560.00	$14.00	$0.12

Source: http://www.capitolcorridor.org/included/docs/fares_and_tickets/all_fares_6.12.13.pdf (accessed April 18, 2016)

Overall System Performance

The Capital Corridor is once again experiencing growth. Year-to-date (through January 2016) ridership is 3.7 percent above 2015 and 4.1 percent above business plan projections due to an improving economy in the San Francisco Bay Area.[19] The route is expected to have an annual ridership of 1.5 million for fiscal year (FY) 2016, an increase of about 50,000 passengers from the previous year. On-time performance is at 95 percent, above the 90 percent standard, and maintains the Capital Corridor services as the most reliable train route in the Amtrak system.

[17] https://www.acerail.com/About/Public-Projects/ACEforward

[18] http://www.capitolcorridor.org/included/docs/schedules/train_schedules.pdf (accessed October 12, 2011)

[19] http://www.capitolcorridor.org/downloads/board_meetings/ccjpaboardfeb2016_supplemental.pdf

From 2008–2012 the number of users who bike to their Amtrak Station increased from seven to 11 percent. The Capitol Corridor's Bicycle Access Plan (adopted February 2013) found a lack of available bicycle facilities at stations and capacity on trains. Similar to other transit agencies in the Bay Area, bicyclists were sometimes denied passage on trains due to a lack of bicycle space. The system is installing secure bicycle storage facilities at select Capitol Corridor stations during the first quarter of FY 2016 and hopes to implement a bicycle lease program by the end of the second quarter of FY 2016.[20]

Capacity of Rail System

The frequency and span of service for passenger rail would be affected by the overall capacity of the railroad it operates on. In the East Bay, potential Dumbarton Corridor trains going to and from a terminus adjacent to Bay Area Rapid Transit (BART) in Union City would touch on three UP lines: the Coast Subdivision (between Oakland and San Jose via North Elmhurst and Newark), the Niles Subdivision (between Oakland and Newark via Niles Junction), and the Oakland Subdivision (between Oakland, Union City Niles Junction, and Stockton). The rail lines are shown in **Figure 4-1**.

The 2016 Alameda County Goods Movement Plan considered the anticipated average daily trains (freight and passenger) for 2020 and the capacity rail lines mentioned above in terms of trains per day. Based on this, a volume-to-capacity (V/C) ratio was calculated. **Table 4-6** shows the V/C ratios for the individual line segments in the Newark-Niles area. Train volumes on the North Milpitas Industrial Lead were not cited in the plan, and are assumed here to be minimal.

Table 4-6: Volume to Capacity Analysis of Rail Lines in the Newark-Niles Area

Volume-to-Capacity Analysis of Rail Lines in the Newark-Niles Area						
Assuming 2020 Train Volumes						
Subdivision	From	To	Number of Main Tracks	Total Trains per Day	Average Capacity	V/C Ratio
UP Coast	San Jose	Newark	1, 2, and 3	42	30	140.0%
	Newark	Oakland	1	10	18	55.5%
UP Niles	Newark	Niles	2	44	75	58.7%
	Niles	Oakland	1	26	30	86.7%
UP Oakland	Oakland	Niles	1	N/A	30	N/A
	Niles	Stockton	1	23	30	76.7%

Source: Alameda County Goods Movement Plan, 2016

Except for the UP Coast Subdivision between San Jose and Newark, all lines will have daily average train volumes below their average capacity limits in 2020. Both the Niles Subdivision and the Oakland Subdivision between Niles and Stockton are approaching their capacity limits. The daily train volume on the Oakland Subdivision between Oakland and Niles was not cited in the plan, but it is assumed here to be minimal. The existence of double-track and triple-track segments on the Coast Subdivision south of Newark helps mitigate congested conditions there;

[20] http://www.capitolcorridor.org/downloads/board_meetings/ccjpaboardfeb2016_supplemental.pdf

the 30 trains per day capacity limit for that line segment in the table above reflects the capacity of a single-track route segment only.

The area of potential capacity concern for Dumbarton Corridor trains is with regard to crossing the UP Coast Subdivision at Newark to reach the Niles Subdivision running east to Niles. Here capacity is already tight, as noted in **Table 4-6**. To reach a Union City terminus, Dumbarton Corridor trains would need a new connection between the Niles Subdivision east of the Fremont/Centerville Station and the Oakland Subdivision running north to Union City.

The train counts include UP and Burlington Northern Santa Fe freight trains (the latter operating on the UP route network via trackage rights) as well as intercity and commuter passenger trains. The passenger trains per segment are noted in **Table 4-7**. The busiest line is the Santa Clara and San Jose Caltrain segment, which operates 92 trains, but Dumbarton Corridor trains would not operate there. The second line is the Coast Subdivision between Newark and Santa Clara. The third is the Niles Subdivision between Niles and Newark.

Table 4-7: Weekday Passenger Train Round-Trips on Rail Lines in the Newark-Niles Area

Weekday Passenger Trains on Rail Lines in the Newark-Niles Area Today			
Subdivision	**From**	**To**	**Passenger Services**
UP Coast	San Jose	Newark	Amtrak Coast Starlight (2); ACE (8); Capitol Corridor (14); not counting Caltrain (92) between Santa Clara and San Jose
	Newark	Oakland	Amtrak Coast Starlight (2)
UP Niles	Newark	Niles	ACE (8); Capitol Corridor (14)
	Niles	Oakland	Capitol Corridor (14)
UP Oakland	Oakland	Niles	None
	Niles	Stockton	ACE (8)

Source: Service timetables, 2016
Notes: Altamont Commuter Express (ACE)

The other area of concern regarding line capacity to handle Dumbarton Rail Corridor trains is on the Caltrain Peninsula mainline itself. In the 2010 *Dumbarton Rail Corridor Project*,[21] various rail alternatives were assumed. One included a separate ROW from the Dumbarton Line north from near Control Point Dumbarton to the Redwood City Caltrain station. Another assumed Dumbarton Corridor trains would access the Caltrain mainline at Redwood Junction to head north to San Francisco and south to San Jose.

The Caltrain mainline is mostly double-track with some sections of triple-track and quadruple-track. The capacity of such a track configuration would be about 200 trains per day.[22] As noted,

[21] Performed by CDM Smith for the San Mateo County Transportation Authority.

[22] Roughly calculated as trains with 10-minute headways operating on double-track for 18-hour days (6 hours assumed for track maintenance and freight operations).

Caltrain today is running 92 trains during the weekday, and UP is running a few trains on the line during a night-time window. Accordingly, there appears to be sufficient capacity on the mainline today to host Dumbarton Corridor trains. Rail capacity studies[23] performed as part of the CalMod program have indicated that even with the introduction of HSR trains there would be adequate capacity to accommodate Dumbarton Corridor trains in the configuration proposed as the Original Project (see Chapter 2). However, the capacity picture likely will change significantly with increased service planned through the Caltrain Modernization Program/Peninsula Corridor Electrification Project (electrification and higher performing vehicles) and the introduction of blended service with California High-Speed Rail (HSR) in the future. Additional operational analysis is required once the details of blended service have been further defined.

4.2.2 Other Transit Systems and Services

AC Transit/Dumbarton Express

AC Transit was created in 1956 in response to the financial collapse of the Key System. In 1974, Fremont and Newark joined the AC Transit District as Special District 2. In 2014 and 2015, AC Transit carried approximately 55,000,000 passenger trips, or an average of 180,000 passenger trips per weekday. The agency operates 140 routes, including 29 transbay routes.

AC Transit provides service principally within and to/from its legislatively defined district. Within the study area, this includes the cities of Fremont, Union City, and, Newark. All three cities have multiple local, transbay, and supplementary service. Three AC Transit lines operate over the Dumbarton Highway Bridge: Dumbarton Express (DB), Dumbarton Express 1 (DB1), and the Stanford U Line, which offers transbay service from Fremont BART Station to Stanford University. Routes DB and DB1 primarily cater to East Bay and Tri-Valley residents commuting to the major employment centers located in the South Bay. The services, administered and governed by AC Transit, are overseen by the Dumbarton Bridge Regional Operations Consortium, a partnership between BART, Caltrain, SamTrans, Union City Transit, and the Santa Clara Valley Transportation Authority (VTA).

- Route DB travels from the Union City BART Station and Ardenwood Park-and-Ride to the Stanford Oval, with stops at Menlo Park, the Palo Alto Caltrain Station, and the Stanford Medical Center (Roth Way at Campus Drive). It operates from 5:15 AM to 8:45 PM and has peak headways of 25 minutes (9:30 AM). The average scheduled runtime is over 55 to 65 minutes to cover the 16.8-mile route.

- Route DB1 travels from the Union City BART station to Deer Creek Road, serving Stanford Research Park and the Palo Alto Veterans Administration Hospital. It operates between 5:30 AM to 8:45 PM and has peak headways of 17 minutes (5:30 AM). The average runtime is over 1.5 hours to cover the 16.8-mile route.

Route DB and DB1 riders are primarily youth and minority; sixty-five percent of residents within a ¼ mile of route DB bus stops identify as a minority; and 22 percent are under the age of 18.[24] Similarly, 70 percent of residents with a ¼ mile of route DB1 bus stops identify as a minority, and

[23] Caltrain/High Speed Rail Blended Service Plan Operations Analysis, June 2013

[24] US Census, American Community Survey 2013

25 percent are under the age of 18. Both routes capture an equal number of people in poverty, 10 percent (9.6 percent for route DB). As of FY 2014, the combined numbers of the two express services was 319,642, or an average of 1,258 passengers per day.[25] Route DB has 12.2 passengers per revenue hour and route DB1 has 12.3 passengers per revenue hour. All express buses are equipped with Wi-Fi and bike racks.

Fares

The Dumbarton Express fare structure is separated into local and transbay trips. There is an additional fee to upgrade from a local fare to a transbay fare. Monthly passes for the Dumbarton Express are available with use of the Clipper Card, which permits riders to access route DB Express using a pre-paid multiservice payment medium. Discounted fares are provided for youth and seniors/disabled passengers.

In addition to the route DB Express monthly pass and cash fares indicated in **Table 4-8**, Dumbarton Express accepts fare media from other transit agencies for transbay and local trips, as summarized below.

Transbay trip fare options include the following:

- VTA – ECO Pass (Express option only)
- Palo Alto Transit Center – Caltrain Monthly Pass with two or more zones

Local trip fare options include the following:

- AC Transit – 31-Day Pass and transfers
- Union City – Transit Pass and transfers
- BART – BART Plus Pass
- Caltrain – Monthly Caltrain Ticket with two or more zones
- SamTrans – Monthly Pass
- VTA – Day Pass, Monthly Pass

[25] http://www.vta.org/sfc/servlet.shepherd/document/download/069A0000001ePEjIAM

Table 4-8: Dumbarton Express Fares

Dumbarton Express Fares	
	Base Passenger Fare (one-way)
Local (one-way)	
Adult	$2.10
Youth/Senior/Disabled	$1.05
Transbay (one-way)	
Adult	$4.20
Youth/Senior/Disabled	$2.10
Transbay Upgrade (one-way)	
Adult	$2.10
Youth/Senior/Disabled	$1.05
DB Monthly Pass (one-way)	
Adult	$151.20
Youth/Senior/Disabled	N/A

Source: http://www.vta.org/getting-around/Fares/Dumbarton-Express (accessed March 29, 2016)

Overall System Performance

AC Transit's transbay ridership has grown by 20 percent since 2013, up to nearly 13,500 average daily riders.[26] While most transbay routes provide service between the East Bay and Downtown San Francisco, routes DB and DB1 passengers account for 10 percent, or 1,300, of the total number of daily transbay commuters.[27] A reduced fleet size amid ridership growth and increased congestion on roadways has caused overall transbay services to become more impacted. Users are more likely to be denied access to a full train, especially bicyclists, since buses have even more limited capacity for bicycles. In spring 2015 the percentage of peak transbay trips with standees was 20 percent.[28] On-time performance is affected in highly impacted and congested areas as transit services come to a slow-down without any transit-only lanes. Buses experience highest maximum loads during the summer months and early in the morning.

AC Transit plans to purchase ten double-decker buses as part of their 2018 replacement plan and increase capacity by more than one thousand seats to address existing capacity issues. This includes Line U, which runs between Union City BART and Stanford University. With BART already over capacity, AC Transit transbay services will become more impacted if the economy continues to improve and more people make the commute from their homes in the East Bay to the jobs-rich areas of San Francisco and the Peninsula.

Stanford University

Stanford University provides two different transbay bus routes in the study area, Line U and Line AE-F. Line U is a partnership with AC Transit, which provides limited, free transportation services to Stanford University affiliates including staff, faculty, and students, as well as regular-cost transbay services for anyone else ($4.20 one-way). Line U travels from the Fremont BART Station

[26] http://www.actransit.org/wp-content/uploads/board_memos/15-191%20Transbay%20Ridership.pdf

[27] http://www.smcta.com/Assets/Dumbarton+Rail+Corridor/PAC/Agendas/PAC+Agenda+Packet+4-25-14.pdf

[28] http://www.actransit.org/wp-content/uploads/board_memos/15-191%20Transbay%20Ridership.pdf

to Stanford, with stops at the Fremont/Centerville Station, the Ardenwood Park-and-Ride, Stanford Shopping Center, and the Stanford Medical Center. It provides morning and afternoon/evening service from 6:00 AM to 9:30 AM and 2:30 PM to 7:00 PM, every 30 minutes. It averages a runtime of 60 to 68 minutes to cover 21.2 miles. Line U sees 29.8 passengers per revenue hour.

Like other transit services connecting both sides of the Dumbarton Highway Bridge, Line U captures high numbers of minority and young populations. Seventy-three percent of residents within a ¼ mile of Line U identify as a minority; 21 percent are under the age of 18.

Line AE-F is the free public shuttle service run by Stanford's Parking and Transportation Services and operates on the same route configuration as Line U, connecting Stanford University to Fremont BART Station with limited stops, including park-and-ride locations at Wells Fargo, Fremont/Centerville Station, Kaiser Permanente, and Ardenwood. Line AE-F runs between 5:25 AM and 7:25 AM and 3:25 PM to 6:25 PM, every 30 minutes. As of February 2016, average daily ridership was 664 passengers. The Ardenwood Park-and-Ride is the most popular stop location, averaging 125 daily boardings.

Overall System Performance

As previously mentioned, Stanford Shuttles operate during peak hours at 30-minute headways. The schedule of Line AE-F is synchronized with AC Transit's Line U to jointly provide 15-minute headways. With increased employment opportunities at a growing research university, further pressure will be put on existing shuttle services to move more employees, students, and staff from the East Bay to the South Bay campus.[29] Line AE-F ridership data from February 2016 shows maximum capacity (81 seats) is consistently reached on morning peak services. The route maintains an average coach capacity of 50 passengers throughout the day, an average load factor of 78 percent, and experiences delay because of congestion along the Corridor.[30]

BART

BART is a rapid transit, heavy-rail system that covers 104 miles and serves 44 stations throughout the San Francisco Bay Area. There are two BART stations within the DTCS area in Union City and Fremont. Both stations have 15-minute headways on Fremont-Richmond and Fremont-Daly City lines during peak-time travel and operate six-minute peak-time travel to non-final destination locations. During FY 2015, average weekday exits at the Fremont BART Station averaged 8,905 (up 28 percent from 2010) and the Union City BART station averaged 4,954 (up 31percent from 2010).[31]

BART stations provide a variety of different amenities by location. **Table 4-9** provides further details on amenities offered at the Union City and Fremont BART stations, including inventory of bicycling parking spaces and the different types of parking permits available for purchase.[32]

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[29] Stanford University recently announced its expansion into Redwood City for a majority of its administrative offices.

[30] Line AE-F February 29 – March 4 Ridership Report.

[31] http://www.bart.gov/about/reports/ridership

[32] http://www.bart.gov/stations

Table 4-9: BART Station Amenities

Station	Amenities	Notes
Union City	Bike Racks 68 Bicycle Lockers 1,155 Parking Spaces Monthly, Long-Term, Extended Weekend, and Daily Fee ($3) Parking	Estimated Parking Full Time: 7:30 AM
Fremont	Bike Racks 76 Bicycle Lockers 2,142 Parking Spaces Monthly, Long-Term, Extended Weekend, and Daily Fee ($3) Parking	Estimated Parking Full Time: 6:30 AM

Source: http://www.bart.gov/stations, 2016

Fares

BART uses a distance-based fare structure with a surcharge for trips through the Transbay Tube and to the San Francisco International Airport. **Table 4-10** identifies representative station-to-station fares departing or arriving at the existing Union City Station under 2016 conditions.

Discounted travel is available to seniors age 65 and older, persons with disabilities, Medicare cardholders, students, and children 5 to 12 years of age via BART's discounted ticket purchase program. BART uses an electronic fare collection system with two primary fare instruments, electronically coded paper tickets and the Clipper Card.

Table 4-10: Fares Connecting Union City to Selected Stations

BART Fares Connecting Union City to Selected Stations	
Station	**Base Passenger Fare (one-way)**
12th Street/Oakland City Center	$4.10
Embarcadero	$5.80
Pittsburg/Bay Point	$6.70
Richmond	$5.00
Dublin/Pleasanton	$4.50
Millbrae	$7.00
Coliseum/Oakland Airport	$3.65
San Francisco Airport	$11.30

Source: http://www.bart.gov/tickets/calculator (accessed March 29, 2016)

Overall System Performance

BART carries 423,000 passengers per day or 125 million passengers per year.[33] Its annual passenger count is now more than what the entire system carried in its first five years of service when it opened in 1972. Peak period trains are very crowded, especially the trains heading to Downtown San Francisco in the morning (peak direction). Many station parking lots in suburban

[33] http://www.bart.gov/about/reports/ridership

areas fill up early in the morning. The Union City parking lot is estimated to be full by 7:30 AM[34] and the Fremont BART Station parking lot is estimated to be full by 6:30 AM.[35]

Union City and Fremont BART are bus transit hubs for the area. However, access to BART via bus is challenging in part because of the low residential densities in most of southern Alameda County (AC Transit will be testing a Flex service model in Newark to see if it is more appropriate for conditions there).

A new Fremont South to Warm Springs Extension opened in 2017, adding 5.4 miles of new track, and new cars are expected to go online this year to assist with widespread overcrowding.

Union City Transit

Union City Transit is the City of Union City's municipal bus system. Routes are coordinated with the arrival and departure of BART trains at the Union City BART Station. Union City Transit operates nine lines and provides connections with AC Transit and the Dumbarton Express for additional regional transportation options. Main transfer points for Union City Transit are located at the Union City BART Station and the Union Landing Transit Center. The service operates between 4:30 AM and 10:20 PM weekdays, 6:45 AM to 7:30 PM Saturday, and 7:45 AM to 6:30 PM Sunday. Frequency varies by route, but fluctuates between 30 minutes and 1 hour.

Fares

Union City Transit serves mostly local routes with a couple of connecting services at discounted rates. There are discounted fares for youth, seniors, and the disabled, as well as available monthly passes. Unlike most agencies in the region, Union City Transit does not yet accept Clipper Cards. **Table 4-11** provides a summary of existing fare prices for both daily and monthly passes.

[34] http://www.bart.gov/stations/ucty

[35] http://www.bart.gov/stations/frmt

Table 4-11: Union City Transit Fares

Union City Transit	
	Base Passenger Fare (one-way, cash)
Cash Fares (one-way)	
Adult	$2.00
Youth/Senior/Disabled	$1.25
Senior (65+)	$1.00
Certified Disability	$1.00
BART-to-Bus	$0.50
AC Transit & DB Express Transfers	$0.25
Monthly Pass (one-way)	
Adult	$55.00
Youth (6–17)	$35.00
Senior (65+)	$26.00
Certified Disability	$26.00

Source: http://www.unioncity.org/departments/transit/fares/fares-information (accessed March 31, 2016)

Overall System Performance

Union City Transit has 1,400 weekday boardings with relatively little change since operations began in 1995.[36] It services local trips to Union City BART, Union Landing, and nearby residential areas and public schools. Union City's FY 2013 short-range transit plan determined adequate capacity during most times of the day, except during morning and afternoon peak hours (7 AM and 3 to 5 PM). The system provides tripper services during these specific times for routes serving the Cesar Chavez Middle School and Logan High School. (Tripper service is regularly scheduled service which is open to the public, but which is designed or modified to accommodate the needs of school students and personnel.) Routes operating on Whipple Road, Alvarado-Niles Road, and through the Decoto District regularly encounter roadway congestion or vehicles blocking the roadway.[37] Route DB, DB1, and the Stanford Shuttles all operate in the Decoto District where the Union City BART Station is located. Timed transfers between Union City Transit and BART are sometimes missed because of traffic congestion. The Union City Engineering and Traffic Study (focused on arterial and collector streets south of Whipple Road and Alvarado-Niles Road and west of the Decoto District) determined 85th percentile speeds to be above recommended speeds (47 miles per hour (mph) to recommended 45 mph).[38] However, transit is still highly susceptible to delay and reduction in on-time performance when traveling near Union City BART and the Decoto District.

SamTrans

SamTrans operates 76 bus routes throughout San Mateo County and into parts of San Francisco and Palo Alto. It began operating bus service in 1976 after consolidating 11 municipal transit services in the county into a coordinated network. In mid-1977, SamTrans inaugurated its

[36] http://www.vitalsigns.mtc.ca.gov/transit-ridership

[37] Union City Transit Short-Range Transit Plan FY 2013–2022, page 6-1

[38] Union City Engineering and Traffic Study, December 2012

mainline service from Palo Alto to San Francisco, previously operated by Greyhound. In 2014, its fixed-route services reported 12,784,391 total passengers, followed by an increase in 2015 to 13,158,700 total passengers.[39] Though SamTrans offers no transbay service, SamTrans routes 280, 281, ECR, 297, and 397 all have connections with route DB at the Palo Alto Caltrain/Transit Center.

Fares

The SamTrans fare structure is separated into two categories: routes outside the City of San Francisco and those running into parts of San Francisco. The DTCS area is focused outside of San Francisco so fares for these trips are included in **Table 4-12**. SamTrans also provides discounted rates for youth, seniors, and the disabled, as well as monthly passes. SamTrans accepts Clipper Card for fare payment.

Table 4-12: SamTrans Fares within Study Area

SamTrans Fares (Outside of San Francisco)	
	Base Passenger Fare (one-way, cash)
Out of San Francisco (one-way)	
Adult	$4.00
Youth /Senior/Disabled	$1.10
Monthly Pass (one-way)	
Adult	$96.00
Youth/Senior/Disabled	$27.00

Source: http://www.samtrans.com/fares/farechart.htm (accessed March 30, 2016)

Overall System Performance

SamTrans ridership has fluctuated, peaking in 2015. During FY 2015 SamTrans carried nearly 13.2 million passengers on its fixed-route bus service, a three percent increase from the previous year.[40] Since then, ridership has dropped for fixed route services across most routes. The agency is currently implementing multiple operational improvements as part of the SamTrans Service Plan to improve connectivity and performance to boost ridership. According to SamTrans' 2012 Triennial Customer Survey, its on-time performance rating has dropped to 3.78 out of 5, a decrease of 0.09 from its 2009 survey.

VTA

VTA provides bus, light rail, and paratransit services, as well as participates as a funding partner in regional rail service including Caltrain, Capital Corridor, BART, and ACE. As Santa Clara County's congestion management agency, VTA is responsible for countywide transportation planning, including congestion management, design and construction of specific highway, pedestrian, and bicycle improvement projects, as well as promotion of Transit-Oriented

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[39] http://www.samtrans.com/about/Bus_Operations_Information/Ridership.html

[40] http://www.samtrans.com/about/MediaRelations/news/SamTrans_Showing_Steady_Growth_in_Ridership.html?PageMode=Print

Development (TOD).[41] Three VTA bus routes serve Stanford at the Palo Alto Transit Center: Routes 22, 25, and the Rapid 522. VTA recently expanded BART services into the South Bay with the opening of the BART Warm Springs extension south of the City of Fremont. The new BART station will impact ridership for the entire system, including additional ridership to Union City and Fremont BART stations and transit services over the Dumbarton Bridge.

Overall System Performance

VTA ridership has fluctuated over time. In 2015, weekly bus ridership was 627,000.[42] Its light rail system remains under capacity (10.9 million passengers in FY 2014), with growth of two percent and weekend ridership growth of 17 percent.[43] VTA operates with high performance reliability (99.67 percent), maintains a good bus on-time performance level (86 percent), as well as a good light rail on-time performance level (85 percent).[44] VTA is currently conducting an analysis of how it can redesign its transit network to maximize ridership and understand growth improvement areas.[45]

Water Emergency Transportation Authority (WETA)

WETA is a regional agency with responsibility to develop and operate a comprehensive Bay Area regional public water transportation system. **Table 4-13** provides a list of the different terminals currently in operation, terminal expansion areas funded and in construction, proposed terminal with partial funding approved, and existing proposed locations without secured funding.[46] Redwood City (shown in **Table 4-13**) is located within the study area and has received partial funding for a Redwood City WETA terminal. Proposed terminals include: Seaplane Lagoon, Berkeley, Redwood City, Hercules, Mission Bay, Carquinez Strait, and others yet to be identified in South Bay cities. No terminals are proposed for the East Bay within the Dumbarton study area. Proposed routes would provide service to San Francisco and the East Bay with one-way trip times estimated to be 45 and 47 minutes.[47][48] WETA's ridership studies forecast 1,420 daily passenger trips between Redwood City and San Francisco and confirm that nearly 800 Oracle employees commute from shoreline communities including Newark/Fremont and Berkeley. WETA is preparing to initiate feasibility studies for all four partially funded expansion terminal locations and is seeking to have them all in operation by 2030.[49] No fare prices have been officially announced, but as with all other existing WETA fare prices, they are expected to vary by individual route and provide discounted rates for children and seniors.

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[41] http://www.vta.org/about-us/inside-vta/about-vta

[42] http://www.vta.org/sfc/servlet.shepherd/document/download/069A0000001OZbXIAW

[43] http://www.vta.org/sfc/servlet.shepherd/document/download/06912000001g79yAAA

[44] SCVTA Transit Operations Performance Report (2014)

[45] http://www.vta.org/projects-and-programs/transit/next-network

[46] http://sanfranciscobayferry.com/sites/default/files/weta/strategicplan/DraftStrategicPlan011416.pdf

[47] http://www.redwoodcityport.com/p7iq/html/FerryStatus.html

[48] http://www.redwoodcityport.com/p7iq/html/FerryStatus.html

[49] http://sanfranciscobayferry.com/sites/default/files/weta/strategicplan/DraftStrategicPlan011416.pdf

Table 4-13: Existing and Planned WETA Terminals

Existing Terminals	Funded Expansion	Partially Funded Expansion	Unfunded
Alameda Harbor Bay	Richmond (2018)	Seaplane Lagoon (Alameda)	Mission Bay
Alameda Main Street	Treasure Island (2022)	Berkeley	Other South Bay
AT&T Park*		Redwood City	Carquinez Strait
Oakland Jack London Square		Hercules	
San Francisco Ferry Building			
San Francisco Pier 41			
South San Francisco			
Vallejo			

Source: WETA, 2016
*During baseball season, limited service

Overall System Performance

The WETA system in 2016 is a small but meaningful component of the Bay Area's transportation system, carrying more than 8,000 daily passengers from terminals in Oakland, Alameda Main Street, Alameda Harbor Bay, South San Francisco, Vallejo, and San Francisco.[50] Ridership on the WETA system has increased 56 percent between 2012 and 2015 and individual routes have grown at double-digit annualized rates over the last three years.[51] The rapid growth has caused crowding and strained capacity on the most popular trips, causing leave-behinds and disrupting travel for passengers. Projections for continued economic growth in the Bay Area—and for job growth in San Francisco in particular—are robust, while capacity on both BART and the Bay Bridge will continue to be limited, suggesting that barring significant changes in the local economy, recent positive trends in ferry ridership will continue.[52] Access at ferry terminals can be a challenge at many locations where parking fills up early in the morning and transit/bicycle access is limited.

Private Shuttles

Private shuttle services are increasingly playing a larger role in Bay Area transportation. Shuttle services are sponsored by employers, institutions, nonprofits, and local jurisdictions. These shuttles are generally regularly scheduled services in buses operating as either "last mile" connections or serving longer routes across the Bay Area. The Bay Area Council and the Metropolitan Transportation Commission (MTC) performed a Bay Area Shuttle Census,[53] which summarized private shuttle data from 35 shuttle sponsors from 2012–2014. The data show that shuttles carried over 9.6 million passengers in 2014, and if private shuttles were treated as one transit system they would represent the seventh-largest transit system in the Bay Area. The data

[50] http://sanfranciscobayferry.com/weta/strategic-plan#demand
[51] http://sanfranciscobayferry.com/weta/strategic-plan#demand
[52] http://sanfranciscobayferry.com/weta/strategic-plan#demand
[53] http://mtc.ca.gov/sites/default/files/2016%20Bay%20Area%20Shuttle%20Census.pdf

also show that up to 50 shuttles per day traveled between San Mateo and Alameda counties during the survey period.

4.2.3 Roadways

The existing and projected performance of the following seven major arterials within the study area, which are therefore more likely to affect access to the Dumbarton Highway Bridge, are discussed in this section. These arterials include Union City Boulevard, Decoto Road, Fremont Boulevard, Bayfront Expressway, Marsh Road, Willow Road, and University Avenue. Additionally, projected performance of two other arterials—Paseo Padre Parkway and the proposed East-West Connector—is discussed under future conditions.

Existing Performance

The existing performance of the seven DTCS arterials was identified as follows:

- The distribution of average travel times during the morning (from 6:30 AM to 9:30 AM) and evening (from 4:30 PM to 7:30 PM) peak periods of a typical weekday (Tuesday, Wednesday, or Thursday) were obtained from Google Maps.
- Using the travel times, average travel speeds along the DTCS arterials were calculated during the morning and evening peak periods.
- Based on the Highway Capacity Manual guidelines[54] (shown in **Table 4-14**) and the average travel speeds, the performance of a corridor during the morning and evening peak periods was estimated.

Table 4-14: Urban Street Level of Service (LOS) Criteria

Travel Speed as a Percentage of Base Free-Flow Speed (%)	LOS by Critical Volume-to-Capacity Ratio
	≤ 1.0
> 85	A
> 67–85	B
> 50–67	C
> 40–50	D
> 30–40	E
≤ 30	F

Source: Highway Capacity Manual 2010

Table 4-15 summarizes the existing performance of the DTCS arterials. Typical peak directions of travel are westbound during the morning peak period and eastbound during the evening peak period. All the DTCS arterials operate at Level of Service (LOS) E or F during the morning and evening peak periods, except Union City Boulevard and Fremont Boulevard between Paseo Padre Parkway and Thornton Avenue; these two arterials operate at LOS D or better during the peak

54 Transportation Research Board Highway Capacity Manual 2010

periods. Existing conditions LOS was determined using Google Maps average travel time information.

The study arterials are expected to operate at LOS E or F during peak periods as follows:

- Southbound Marsh Road (Bayfront Expressway to Middlefield Road) – LOS E (8:30 AM)
- Northbound Marsh Road (Bayfront Expressway to Middlefield Road) – LOS E (4:30 PM), LOS F (5:30 PM)
- Southbound Willow Road (Bayfront Expressway to US 101) – LOS E (9:30 AM), LOS F (7:30 AM through 8:30 AM)
- Northbound Willow Road (Bayfront Expressway to US 101) – LOS E (4:30 PM), LOS F (5:30 PM through 6:30 PM)
- Southbound University Avenue (Bayfront Expressway to US-101) – LOS E (7:30 AM), LOS F (8:30 AM)
- Northbound University Avenue (Bayfront Expressway to US-101) – LOS E (4:30 PM and 6:30 PM), LOS F (5:30 PM)
- Westbound Bayfront Expressway (University Avenue to Marsh Road) – LOS E (8:30 AM)
- Eastbound Bayfront Expressway (University Avenue to Marsh Road) – LOS F (4:30 PM through 6:30 PM)
- Southbound Decoto Road (Paseo Padre Parkway to I 880) – LOS E (8:30 AM)
- Northbound Decoto Road (Paseo Padre Parkway to I 880) – LOS E (4:30 PM through 7:30 PM)

Figure 4-2 and **Figure 4-3** show morning and evening peak period average speeds on the major arterials in the study area.[55]

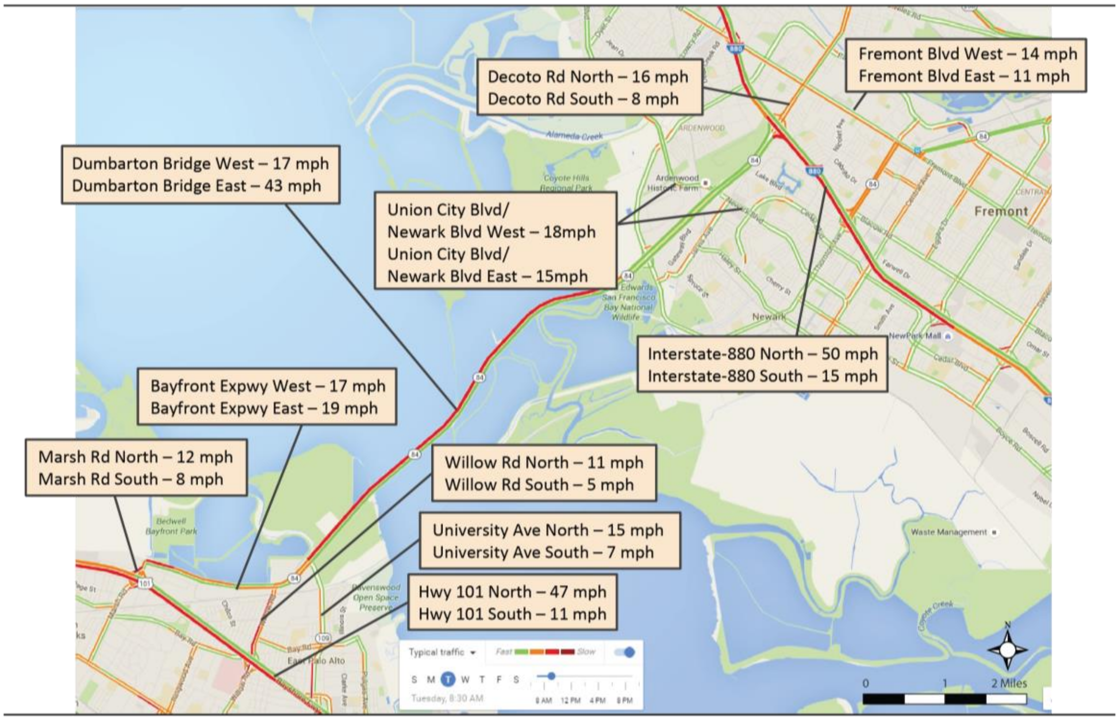
[55] Google Maps (accessed April 27, 2016)

Table 4-15: Existing (2016) Arterial Performance

Arterial	Segment	Distance (miles)	Direction	Average Travel Speed (mph)								
				Free Flow Conditions	6:30 AM	7:30 AM	8:30 AM	9:30 AM	4:30 PM	5:30 PM	6:30 PM	7:30 PM
Marsh Road	Bayfront Expressway - Middlefield Road	1.4	Southbound	21	21	11	8	12	14	11	14	17
			Northbound	28	21	14	12	14	8	7	12	17
Willow Road	Bayfront Expressway - US 101	1.1	Southbound	22	13	6	5	8	13	11	9	13
			Northbound	17	13	13	11	11	6	4	5	9
University Avenue	Bayfront Expressway - US 101	2.0	Southbound	24	15	9	7	10	15	12	13	15
			Northbound	20	17	15	15	15	7	5	6	10
Bayfront Expressway	University Avenue - Marsh Road	2.2	Westbound	44	33	22	17	22	26	26	26	26
			Eastbound	33	22	22	19	19	9	6	7	15
Union City Boulevard	Paseo Padre Parkway - Thornton Avenue	2.7	Eastbound	23	20	15	15	18	15	14	15	18
			Westbound	23	20	18	18	18	14	14	14	18
Decoto Road	Paseo Padre Parkway - I 880	1.4	Southbound	28	14	17	8	14	21	17	21	17
			Northbound	26	20	16	16	16	9	8	8	9
Fremont Boulevard	Paseo Padre Parkway - Thornton Avenue	1.9	Eastbound	23	19	13	11	16	16	14	16	19
			Westbound	23	23	19	14	19	16	13	11	19

Source: Google Maps (typical weekday morning and evening peak period speeds from Tuesday through Thursday), 2016
Notes: Orange-colored cells represent LOS E and red-colored cells represent LOS F.

Figure 4-2: Morning Peak Period Average Speeds on Major Arterials (2016)

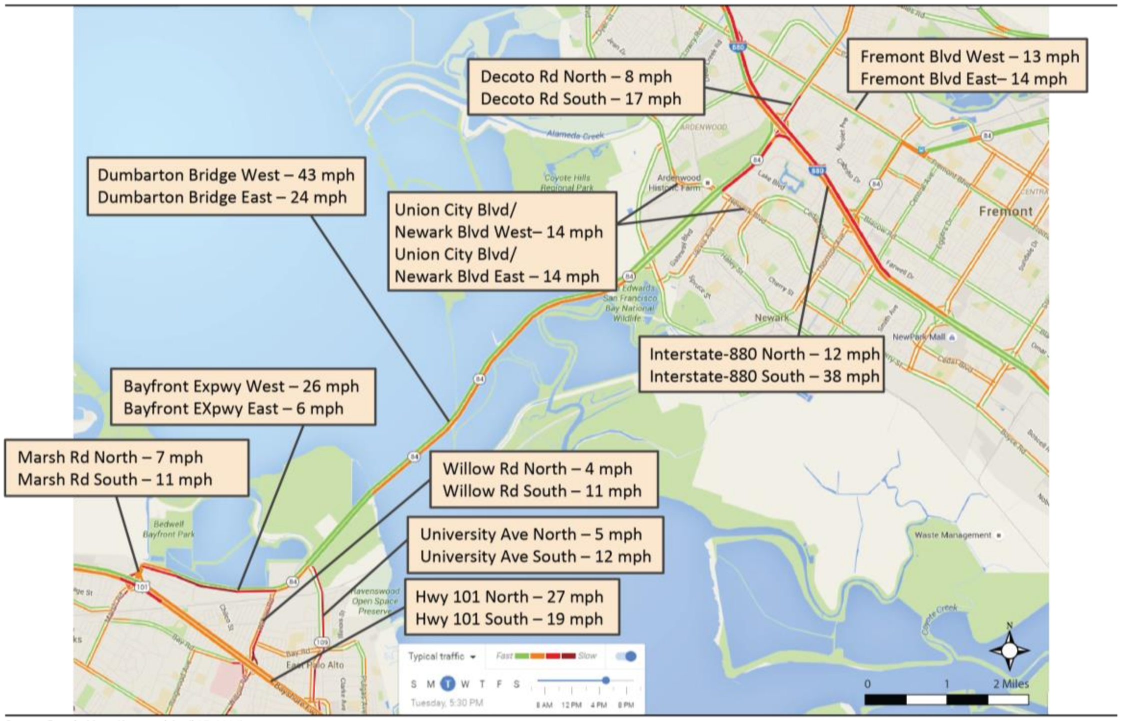


Source: Google Maps (Accessed April 27, 2016)

Dumbarton Transportation Corridor Study

Typical 8:30AM Weekday Arterial and Highway Speeds

Figure 4-3: Evening Peak Period Average Speeds on Major Arterials (2016)



Source: Google Maps (Accessed April 27, 2016)

Dumbarton Transportation Corridor Study

Typical 5:30PM Weekday Arterial and Highway Speeds

4.2.4 Highways

This section summarizes the baseline highway conditions in the study area, including descriptions and planned improvements for the SR 84, I 880, and US 101 freeways in San Mateo, Santa Clara, and Alameda counties.

SR 84

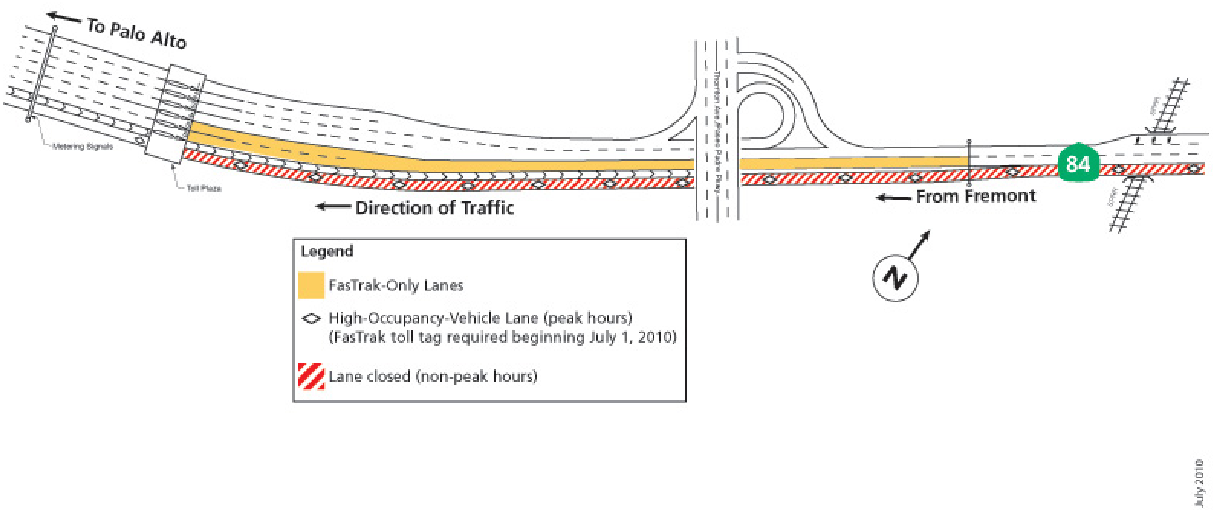
The following sections describe existing conditions and planned improvements for the SR 84 corridor.

Existing Conditions

The SR 84 highway is an east-west-oriented facility that begins at SR 1 near San Gregorio and ends at I 580 in Livermore. The highway travels through the cities of Woodside, Redwood City, and Menlo Park in San Mateo County and through Newark, Fremont, and Livermore in Alameda County. The segment of SR 84 through Menlo Park is known as the Bayfront Expressway, which provides access to Facebook Headquarters at the intersection with Willow Road. The route is designated as a freeway with three lanes in each direction from University Avenue in Menlo Park to I 880 in Fremont. There is an HOV 2+ lane on the westbound approach to the Dumbarton Highway Bridge from the I 880 interchange to the Dumbarton Bridge Toll Plaza. Vehicles exiting from southbound I 880 are directed into the HOV lane as they approach the intersection with

SR 84. The HOV lane operates Monday through Friday between the hours of 5:00 AM and 10:00 AM and between 3:00 PM and 7:00 PM, and allows vehicles with two or more passengers. The lane feeds into a designated HOV lane at the toll plaza that charges a reduced bridge toll ($2.50 instead of $5.00). **Figure 4-4** depicts the existing lane configuration at the toll plaza.

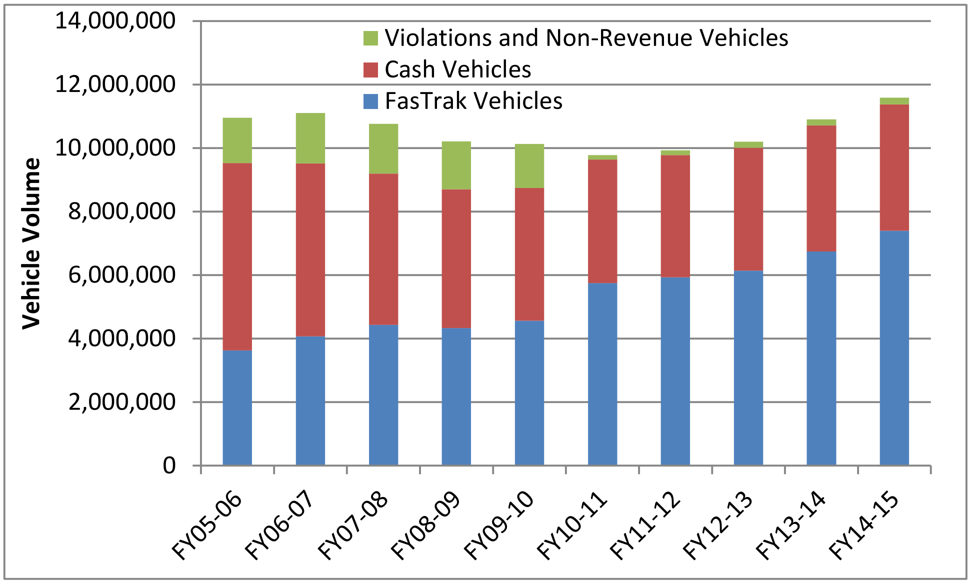
Figure 4-4: Existing SR 84 Toll Plaza Lane Configuration



Source: https://www.bayareafastrak.org/en/howitworks/whereToUse.shtml#dumbarton, 2016

Annual traffic volumes through the Dumbarton Highway Bridge toll plaza are shown by FY in **Figure 4-5**. Volumes are classified by vehicles paying cash and those that use FasTrak. Vehicle volumes for which no toll was collected are also shown. Before 2010, these vehicles included violators, buses and other vehicles with non-revenue transponders, and carpools. On July 1, 2010, a new policy was implemented to charge carpools a reduced toll using FasTrak. Therefore, the volume of vehicles for which no toll was charged decreased significantly between FY 2010 and 2011 and the volume of FasTrak vehicles increased.

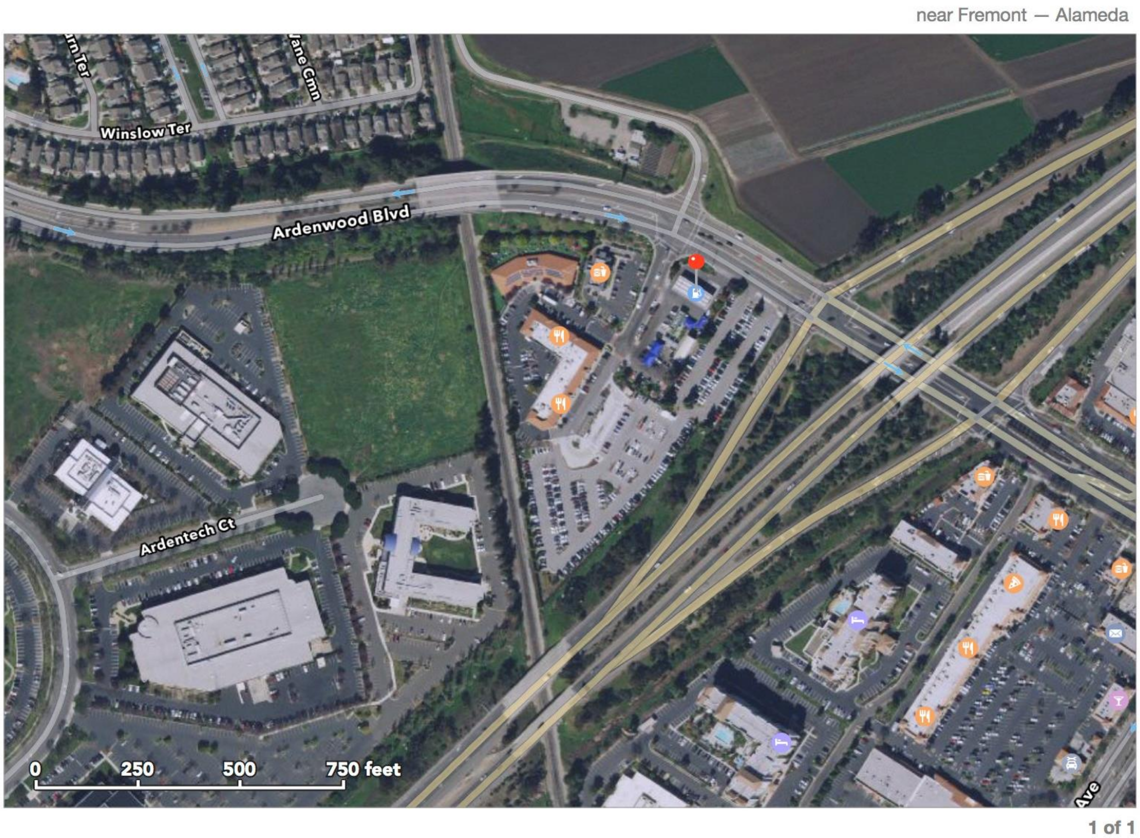
Figure 4-5: Dumbarton Toll Plaza Vehicle Volumes



Source: Bay Area Toll Authority (BATA), 2005 through 2015 historical toll transactions for SR-84 Dumbarton Toll Plaza, 2016

There is one park-and-ride, referred to as the Ardenwood Park-and-Ride, located along the SR 84 Dumbarton Highway Bridge approach at 34867 Ardenwood Boulevard in Fremont. The lot is operated by AC Transit to encourage transit use. It is located near the junction of SR 84 and Ardenwood Boulevard on the border of Fremont and Newark. It currently has 300 free parking spaces, plus 50 reserved spaces priced at $50 per month. In addition, there are four bicycle lockers and 20 bicycle parking spaces. It is also served by a number of AC Transit transbay lines including the M, the SB, and the U, as well as DB Express lines. In 2009, the lot was expanded to 350 spaces, and new landscaping and amenities were added, including bus shelters, lighting, and security measures, real-time bus arrival information and covered bicycle parking and lockers. Still, the lot is regularly full before 7:00 AM. **Figure 4-6** shows an aerial view of the Ardenwood Park-and-Ride near the junction of SR 84 and Ardenwood Boulevard.

Figure 4-6: Ardenwood Park-and-Ride

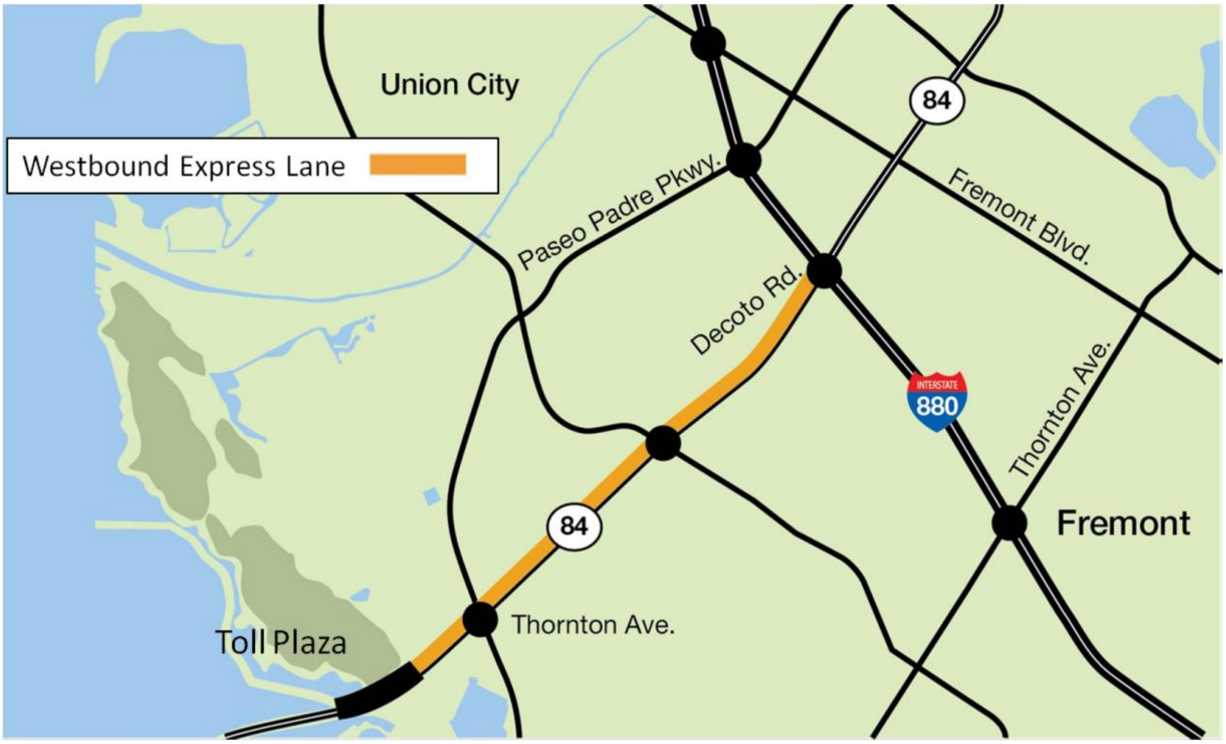


Source: Google Earth, 2016

Planned Projects

SR 84 Westbound Approach Express Lane: The westbound HOV lane at the approach to the Dumbarton Highway Bridge is proposed for conversion to an express lane as part of MTC's Express Lanes Network. The HOV lane is approximately 2.8 miles long from the I 880 interchange to the Dumbarton Highway Bridge Toll Plaza (see **Figure 4-7**). The express lane would allow single-occupant vehicles to use the lane and bypass the queues that often extend upstream of the toll plaza. An opening date for the SR 84 express lane has not been announced by MTC; however, Plan Bay Area, a long-range integrated transportation and land-use/housing strategy for the San Francisco Bay Area, lists the completion date as 2029.

Figure 4-7: Limits of Proposed Express Lane on SR 84 Approach to Dumbarton Bridge



Source: MTC Bay Area Express Lanes Concept of Operations, July 1, 2015

Willow Road Expressway: There is a project listed in Plan Bay Area to improve access to and from the west side of the Dumbarton Highway Bridge on SR 84 connecting to US 101, including flyovers and the conversion of Willow Road between SR 84 and US 101 from an arterial to an expressway. The project cost is listed as $64 million with a completion date of 2030.

US 101

The following sections describe existing conditions and planned improvements for the US 101 corridor.

Existing Conditions

The US 101 freeway is a north-south oriented facility that runs through San Francisco, San Mateo, and Santa Clara Counties. The freeway runs along the west shore of the San Francisco Bay connecting San Jose with San Francisco and is referred to as the Bayshore Freeway. The facility generally consists of four lanes in each direction with auxiliary lanes provided intermittently for on and off ramps. There is an HOV 2+ lane in each direction on the segment of US 101 that starts at Whipple Avenue in Redwood City and extends through Santa Clara County. The segment from Embarcadero Road to SR 85 includes two HOV lanes in each direction. The HOV lanes operate Monday through Friday between the hours of 5:00 AM and 9:00 AM and between 3:00 PM and 7:00 PM, and allow vehicles with two or more passengers.

Planned Projects

US 101 Express Lanes (VTA): As part of VTA's Silicon Valley Express Lanes Program, the HOV lanes on US 101 in Santa Clara County are proposed to be converted to express lanes. Assembly Bill 1105, which was approved by the Governor in 2011, authorizes the extension of the planned express lanes into San Mateo County as far as the limits of the existing HOV lanes (see **Figure 4-8**). However, this extension into San Mateo County is not currently in VTA's short-term phasing plan, which is defined as follows:

- Phase 1: Includes the express lane currently in operation at the I 880/SR 237 direct connectors.
- Phase 2: Includes the extension of the SR 237 express lane westward.
- Phase 3: Includes express lanes on US 101 from the San Mateo/Santa Clara county line through the SR 237 interchange. This also includes the segment of SR 85 from US 101 to I 280 (construction to begin in late 2018).
- Phase 4: Includes direct connections at the US 101/SR 85 interchange.

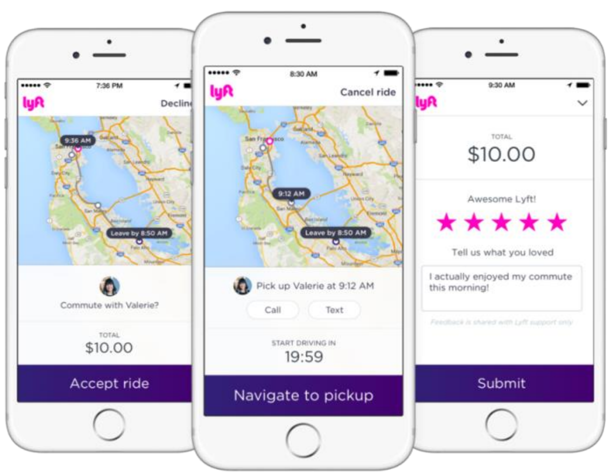
Figure 4-8: VTA Proposed Express Lanes

Source: http://www.vta.org/projects-and-programs/highway/silicon-valley-express-lanes, 2016

US 101 Managed Lanes (San Mateo County): The San Mateo County Transportation Authority (TA) and San Mateo County Association of Governments (C/CAG) are exploring the possibility of extending the HOV lanes in each direction on US 101 through San Mateo County from Whipple Avenue in the south to I 380 in the north. A Project Study Report-Project Development Support for the project was approved by Caltrans in May 2015. One option for extending the HOV lane includes freeway widening and the use of existing auxiliary lanes to add a new lane in each direction. Another option, referred to as "Optimized High Occupancy Toll," is to convert one of the existing general-purpose lanes in each direction to a tolled express lane.

Lyft Carpool: In partnership with MTC, Lyft launched a new carpool option in 2016 to arrange commute trips between San Francisco and Silicon Valley on US 101 (see **Figure 4-9**). Lyft is a transportation network company headquartered in San Francisco. The Lyft Carpool option allows users to sign up to become passengers or drivers. Drivers will be notified of potential passengers along their commute route before making their trip. The goal of the program is to encourage those that would normally drive alone to carpool. Drivers can earn up to $10 for a trip and will have the benefit of being able to use the existing HOV lanes on US 101.

Figure 4-9: Lyft Carpool App Interface



Source: MTC/Lyft, 2016

Freeway Performance Initiative

MTC's Freeway Performance Initiative seeks to maintain optimal speeds, reduce congestion, and improve travel time reliability using smart technology. The Freeway Performance Initiative program includes Freeway Service Patrol coverage, call boxes, arterial system synchronization, ramp metering, and other active management strategies. The Freeway Performance Initiative program has activated ramp metering along the US 101 corridor, which is included as one of three corridors in the Bay Area slated for a full range of smart roadway improvements.

US 101 Interchange Projects

There are planned improvements for several interchanges on US 101 within the vicinity of the Dumbarton Corridor, including the following:

- SR 92 in San Mateo: Includes reconfiguration of the interchanges into a partial cloverleaf with realignment of the on- and off-ramps. Construction is anticipated to begin in 2022.
- Woodside Road in Redwood City: Includes modification of the on- and off-ramps to improve traffic flow and highway operations. Construction is anticipated to begin in 2020 and be complete by 2023.
- Willow Road in Menlo Park: Includes improvement of on- and off-ramps to address the operational deficiencies of the interchange and to provide adequate storage on the off-ramps to reduce queueing on US-101. Construction is anticipated to begin in 2016 and be complete by 2018.
- Oregon Expressway/Embarcadero Road in Palo Alto: Includes the general reconfiguration of the interchange. This project is not funded and therefore does not have a defined construction date.

I 880

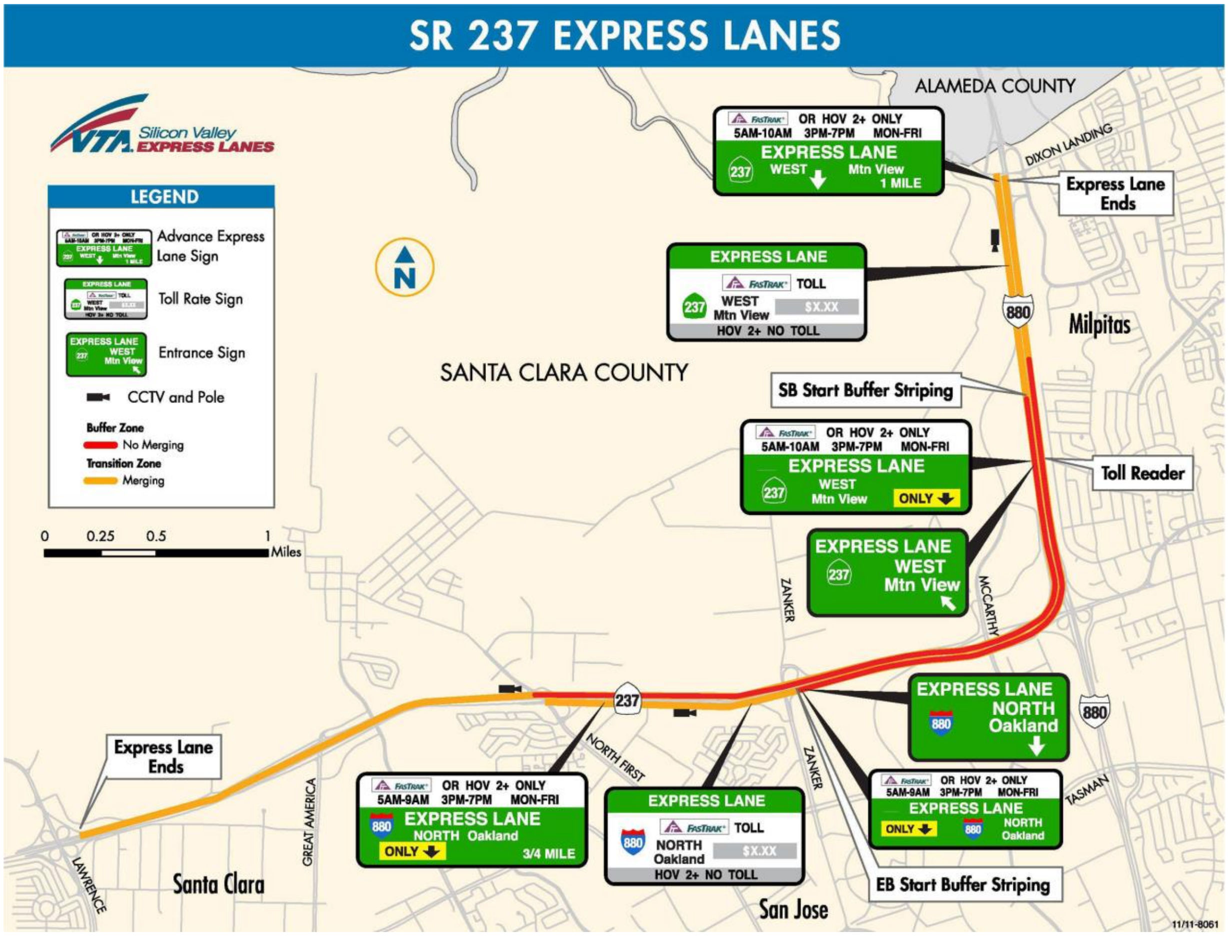
The following sections describe existing conditions and planned improvements for the I 880 corridor.

Existing Conditions

The I 880 corridor is a north-south freeway that runs through Alameda and Santa Clara counties in the East Bay. The facility serves transbay traffic from the San Francisco-Oakland Bay Bridge, the San Mateo Bridge, and the Dumbarton Highway Bridge and serves as a key commuter link between Silicon Valley and the East Bay. The I 880 cross-section varies between four and five lanes in each direction. There is an HOV 2+ lane in each direction; in the southbound direction, the HOV lane runs between Hegenberger Road in Oakland to US 101 in San Jose and in the northbound direction the HOV lane runs between Lewelling Road in San Lorenzo to US 101. The HOV lanes operate Monday through Friday between the hours of 5:00 AM and 9:00 AM and between 3:00 PM and 7:00 PM, and allow vehicles with two or more passengers.

VTA operates an express lane at the I 880/SR 237 direct connectors. The express lane is accessible from southbound I 880 at Dixon Landing Road in Milpitas and allows users to access the direct connector ramp to westbound SR 237 (see **Figure 4-10**). In the opposite direction, the express lane allows users traveling eastbound on SR 237 to use the direct connector ramp to northbound I 880. The express lanes operate from 5:00 AM to 10:00 AM and 3:00 PM to 7:00 PM, Monday through Friday. Payment through the corridor is taken only through FasTrak transmitters.

Figure 4-10: I 880/SR 237 Express Lanes



Source: https://bayareafastrak.org/en/mobile/whereToUse.shtml, 2016

Planned Projects

I 880 Express Lanes: The northbound and southbound HOV lanes on I 880 north of Dixon Landing Road in Milpitas are planned to be converted to express lanes as part of MTC's Express Lanes Network (see **Figure 4-11**). As part of the express lanes conversion, several segments of the lanes will be restriped with a painted buffer to restrict access to the lane for safety and operational reasons. Construction for the I 880 express lanes is expected to start in 2016 and be complete by spring 2019.

Figure 4-11: I 880 Express Lanes

Source: MTC Bay Area Express Lanes Concept of Operations, July 1, 2015

I 880 Integrated Corridor Management: The I 880 Integrated Corridor Management (ICM) project is a planned project to install Intelligent Transportation Systems equipment on arterial streets along the I 880 corridor in Oakland and Fremont (see **Figure 4-12**). Equipment to be installed includes trailblazer signs, closed circuit television cameras, traffic detection stations, traffic signal controller cabinets, and various communication improvements intended to minimize the impacts to the cities when a major incident occurs on I 880. Construction for the I 880 ICM project is scheduled to begin in 2016 and be completed by 2017.[56]

[56] http://mtc.ca.gov/sites/default/files/I880_ICM_FACT_SHEET_FEB20-2015.pdf

Figure 4-12: I 880 ICM Trailblazer Sign Mock-Up (MTC)

Source: http://mtc.ca.gov/sites/default/files/I880_ICM_FACT_SHEET_FEB20-2015.pdf, 2016

I 880 Interchange Projects: There are planned improvements for three interchanges on I 880 within the vicinity of the Dumbarton Corridor, including the following:

- Industrial Parkway: Includes the reconfiguration of the interchange to provide a northbound off-ramp at Industrial Parkway and to provide an HOV bypass lane at the southbound off-ramp. The construction schedule for this project is not defined.
- Whipple Road: Includes full interchange improvements and is currently in the scoping phase.
- Winton Avenue: Includes the reconstruction of ramps to create partial cloverleaf interchange with signaled foot of ramp intersections. The project is currently in its scoping phase.

Bay Area Infrastructure Financing Authority Managed Lanes Implementation Plan

The Bay Area Infrastructure Financing Authority, in cooperation with Caltrans and the California Highway Patrol, is currently developing a regional Managed Lanes Implementation Plan. Managed Lanes Implementation Plan is a strategic planning effort that will lead to the development and implementation of a comprehensive managed lanes system for the nine-county Bay Area. The Plan will define priority strategies for full network development and operational policies that will guide the current and future operations of the regional managed lanes system. The Plan will coordinate and build on the existing body of work of managed lanes in the Bay Area. Priority managed lanes improvement projects identified in this Plan may be reflected in Caltrans statewide Managed Lanes System Plan.

4.3 Current Demographic Analysis

4.3.1 Ethnicity

The Dumbarton Highway Bridge connects regions with very different ethnic makeup. As observed in **Figure 4-13**, the East Bay region is more diverse. A high number of census tracts in the East Bay region have greater than 60 percent minority populations. The Peninsula cities in the study area are less ethnically diverse. According to 2013 American Community Survey information, most census tracts in this region have a minority population between 0 and 45 percent, with a high number having between 0 percent and 30 percent.[57] East Palo Alto has a higher population of minority people than surrounding Menlo Park, Redwood City, and Atherton.

The study area landscape has some variation between the high industrial and commercial zones surrounding cities in the East Bay and the office parks and low-residential housing tracts surrounding cities in the Peninsula. The DRC along the Peninsula travels through various neighborhoods and central business districts. East Bay rail tracks along the Niles and Oakland subdivisions travel through a variety of different land uses. Along its Union City corridor, adjacent land uses include single-family residential, station mixed-use commercial, and community commercial. Along the Fremont corridor, adjacent land uses are mostly residential (low to medium) with pockets of commercial (general, town center, mixed-use) and some park space.

4.3.2 Low-Income

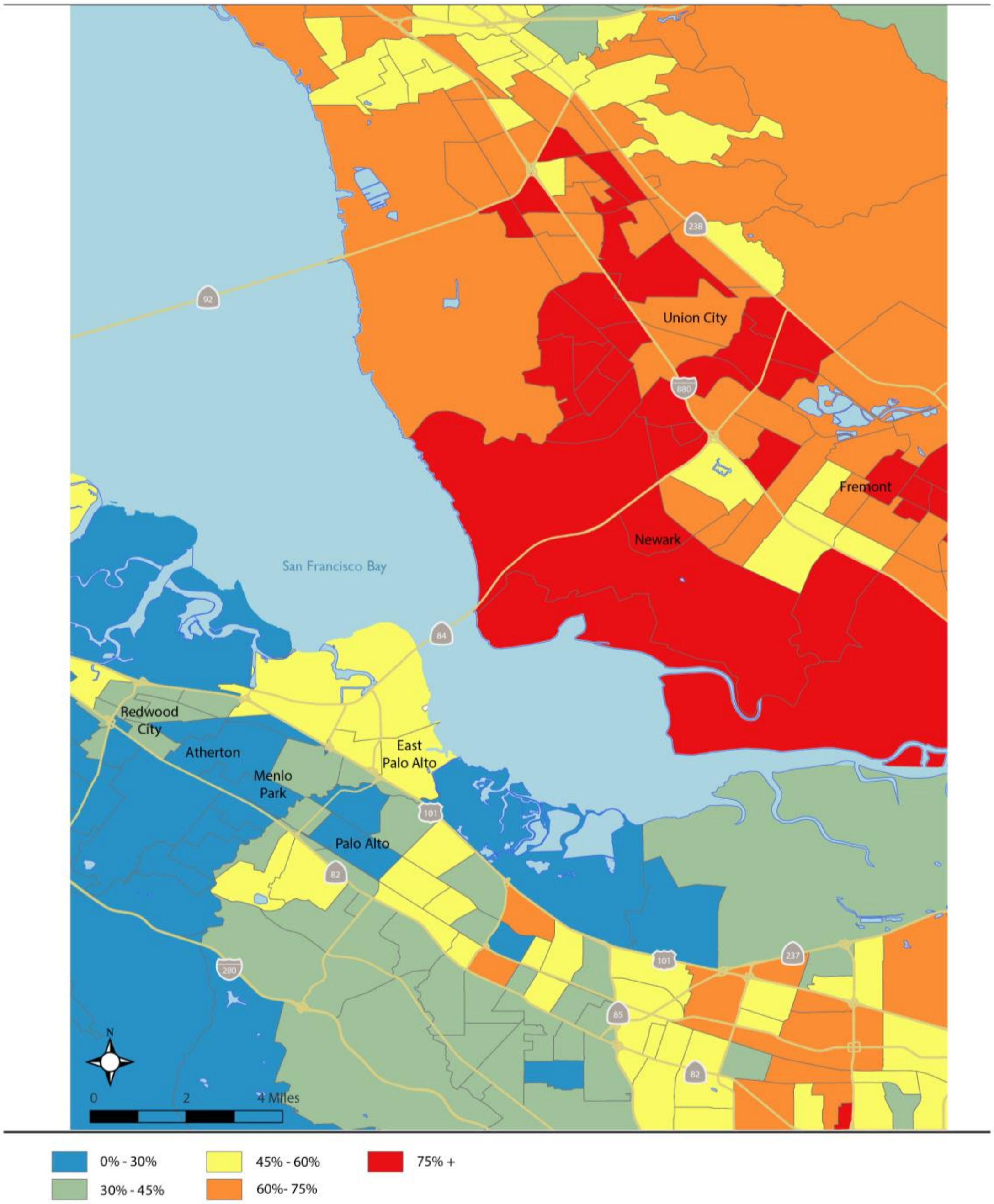
An analysis of income distribution in the study area determined high levels of income. **Figure 4-14** shows distribution of low-income (household income under $60,000—the median household income in California during 2013[58]) in the region by U.S. census tract.[59] Most Peninsula residents are earning well above $60,000, but there are small pockets in East Palo Alto, Redwood City, and Menlo Park with disproportionately high numbers of low-income residents. Residents earning less than $60,000 are more evenly dispersed in the East Bay and have a few highly concentrated pockets north of the East Bay study area.

[57] Minority encapsulates any race category besides Non-Hispanic White.

[58] US Census, American Community Survey, Annual Social and Economic Supplement, 2013

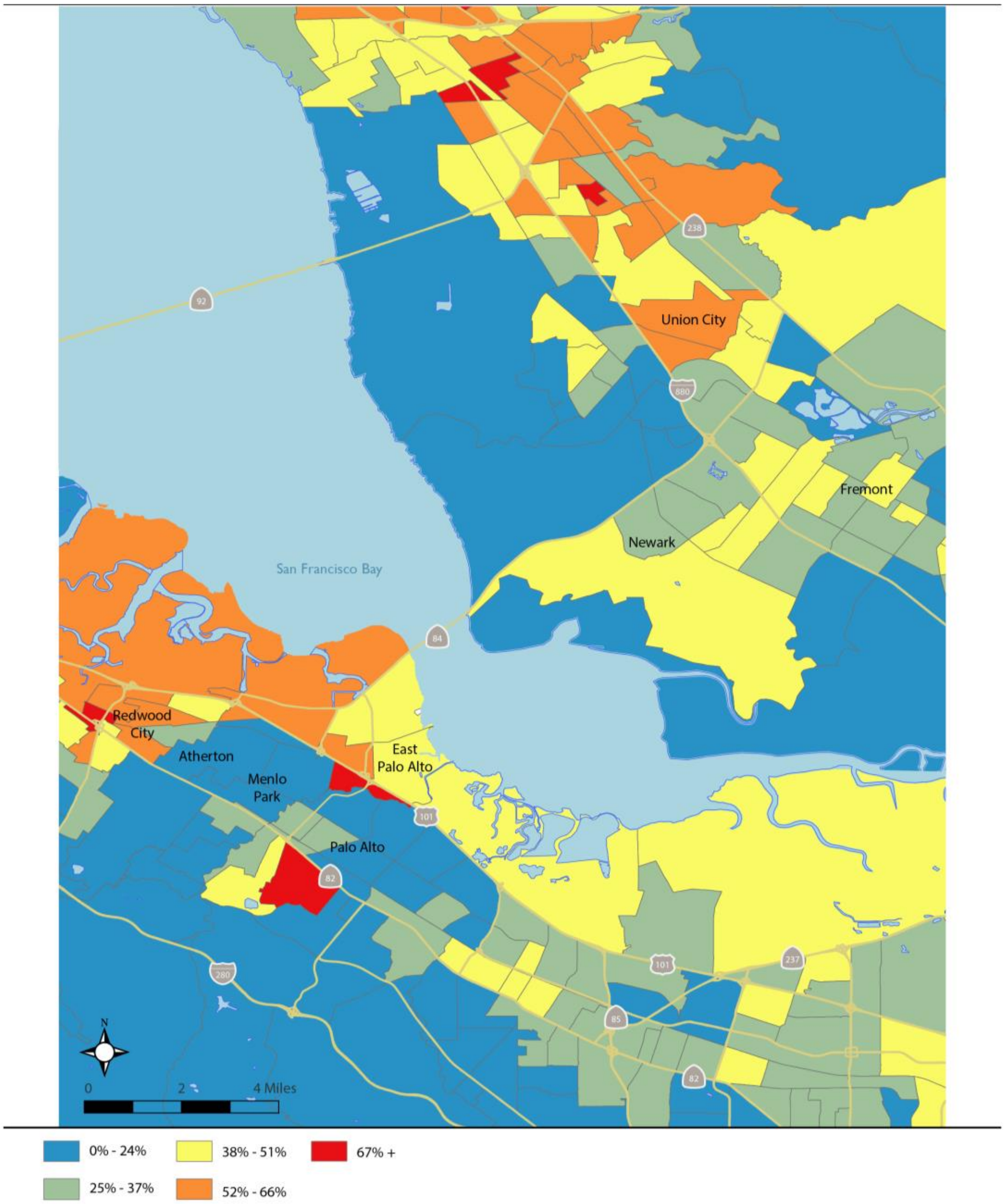
[59] US Census, American Community Survey 2013

Figure 4-13: Minority Population by Census Tract



Source: US Census, American Community Survey, 2013

Figure 4-14: Income under $60,000 by Census Tract



Source: US Census, American Community Survey, 2013

4.3.3 Population Density

The Dumbarton Highway Bridge connects two regions with varying levels of population density. **Table 4-16** provides a breakdown of existing population densities for Tier 1 cities within the study area. All but one of the cities in the region have average densities common for suburban regions. As **Figure 4-15** illustrates, there are substantial variations in population density within cities—especially Fremont and Hayward—as well as between them. East Palo Alto has greater than 11,000 people per square mile. Nine percent of households are zero-car households, with clusters of block groups in the northwest with rates at 10 percent or more, and its high density and proportion of low-income residents make it a key priority area for increased access to transit.[60]

Figure 4-15 also shows 2013 US Census population by census tract for the Peninsula and East Bay cities. A qualitative observation points out that highly populated census tracts in the East Bay are typically low to medium density residential areas, while highly populated census tracts in the Peninsula tend to be in highly dense areas, such as near universities or urban environments. The downtowns that have formed around longtime Caltrain stations are also foci of somewhat higher density housing, particularly in Redwood City and Mountain View.

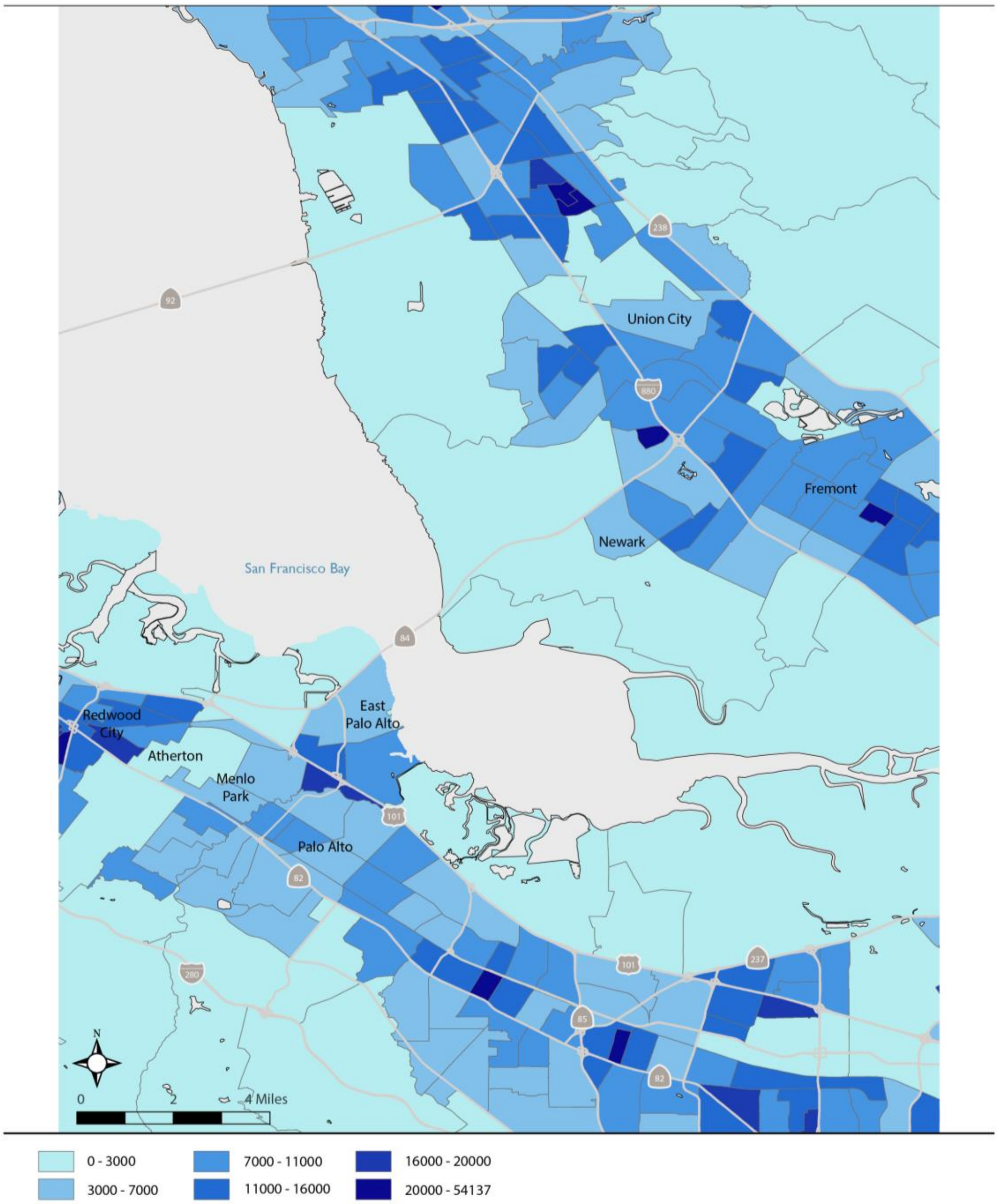
Table 4-16: Existing Population Density

City	Population Per Square Mile
Redwood City	4,152
Atherton	1,460
Menlo Park	3,266
Palo Alto	2,815
East Palo Alto	11,443
Fremont	2,933
Union City	3,776
Newark	3,156

Source: http://www.city-data.com/, 2016

[60] http://resilience.abag.ca.gov/wp-content/documents/housing/East%20Palo%20Alto%20Community%20Profile_final.pdf

Figure 4-15: Population Density by Census Tract



Source: US Census, American Community Survey, 2013

4.3.4 Employment Density

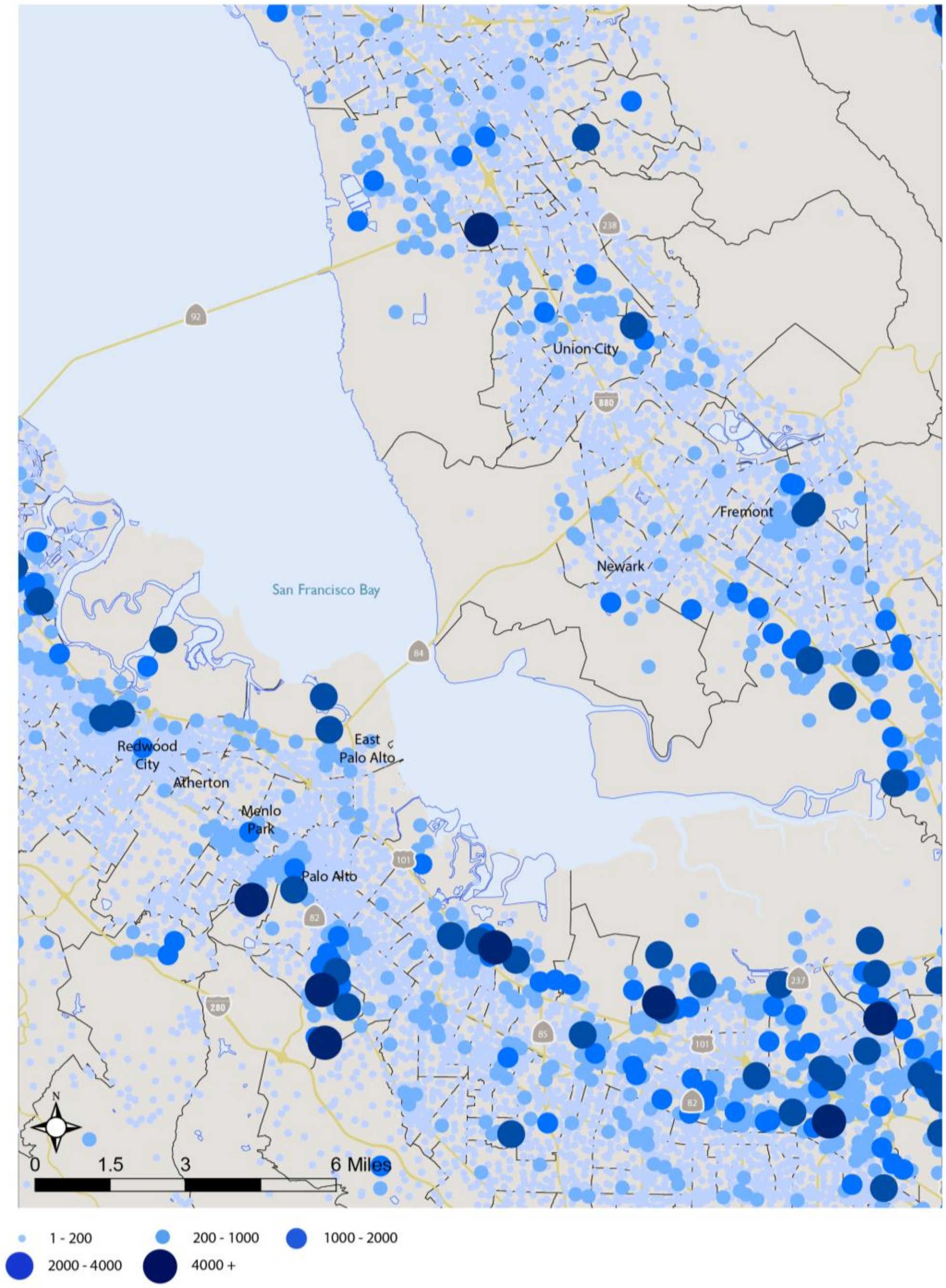
An analysis of job distribution in Tier 1 cities determined the highest centers of employment to be Fremont (90,010 jobs), Palo Alto (89,690), and Redwood City (58,080).[61]

Figure 4-16 shows distribution of jobs throughout the study area and surrounding communities. Peninsula cities tend to have more "hot-spots," or centers of high employment density, than East Bay cites. Both regions maintain strong "small business" areas, or employment centers with less than 200 employees, that parallel existing transit and transportation infrastructure.

Many of the world's largest high-tech corporations are on the Peninsula and help make it a major jobs attractor for the Bay Area region. Within the study area many of these companies account for a significant number of total jobs. Stanford University, Facebook, Oracle, and Tesla are a sample of the high-tech companies whose presence makes a large impact on the existing and future transportation system. Other major employers in the area include local city governments, local school districts, and regional healthcare providers.

[61] http://planbayarea.org/pdf/final_supplemental_reports/FINAL_PBA_Forecast_of_Jobs_Population_and_Housing.pdf

Figure 4-16: Employment Density

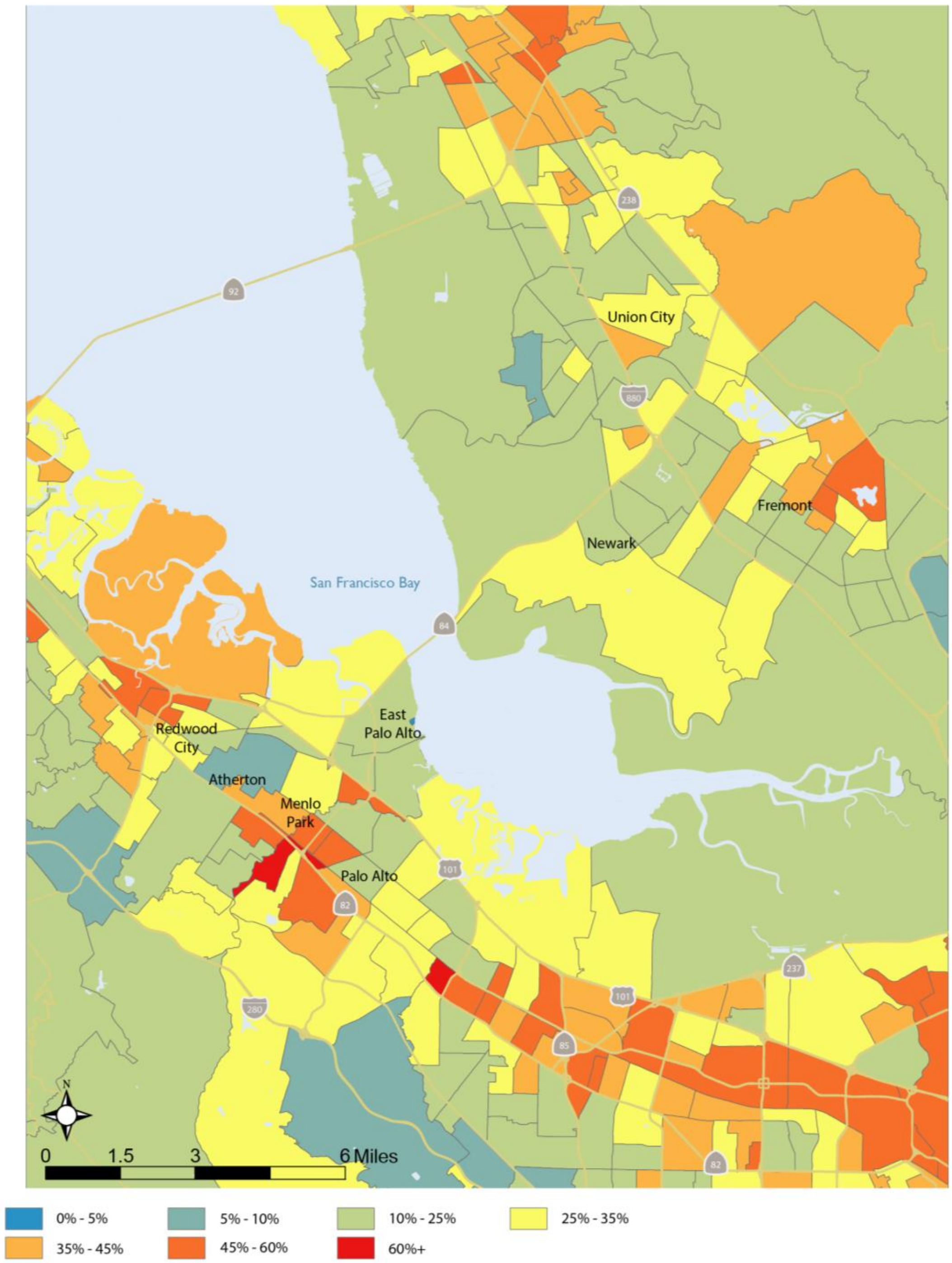


Source:
http://planbayarea.org/pdf/final_supplemental_reports/FINAL_PBA_Forecast_of_Jobs_Population_and_Housing.pdf, 2016

4.3.5 Single-Car Household

An analysis of single-car ownership is shown in **Figure 4-17**. Single-car ownership rates are highly clustered around heavy rail and commuter rail stations, particularly Caltrain stations on the Peninsula and the Fremont BART Station area. Most households in the study area are not single-car households and own more than one vehicle. A greater number of single-car households are located within the Peninsula and South Bay than the East Bay. The low rates of single-car ownership on both sides of the Dumbarton Corridor provide great opportunity to shift modes, particularly with transit.

Figure 4-17: Single-Car Household



Source: US Census, American Community Survey 2013

4.4 Travel Market Analysis

Regional Plan Bay Area forecasts by the Association of Bay Area Governments (ABAG), as contained in the San Mateo City/County Association of Governments (C/CAG)-VTA regional travel model, estimate that both population and employment of the DTCS cities will grow by 27 percent between 2013 and 2040, or 290,000 residents and 190,000 jobs, as indicated in **Table 4-17**. The forecasts represent the region's official Plan Bay Area development scenario used for long range policy and funding decisions at the federal, state and local levels, as included in the Regional Transportation Plan and Sustainable Communities Strategy by MTC. The highest-growth study area cities are expected to be Santa Clara, Fremont, Mountain View, Palo Alto and Stanford, and Sunnyvale with almost 23,000 to 27,000 new jobs each by 2040.

Table 4-17: Regional Market Growth Forecasts

	Plan Bay Area Regional Market Growth Forecasts													
	Employment							Population						
	2013	2020	2040	2013-2020		2013-2040		2013	2020	2040	2013-2020		2013-2040	
Menlo Park	30,208	33,995	36,378	3,787	13%	6,170	20%	39,025	41,192	48,233	2,167	6%	9,208	24%
Palo Alto	98,532	109,667	122,037	11,135	11%	23,505	24%	79,126	83,768	98,691	4,642	6%	19,565	25%
Redwood City	59,226	68,031	74,103	8,805	15%	14,877	25%	78,869	85,094	102,384	6,225	8%	23,515	30%
East Palo Alto	2,110	2,668	3,615	558	26%	1,505	71%	21,217	21,843	23,726	626	3%	2,509	12%
Atherton	2,683	2,864	3,131	181	7%	448	17%	6,961	7,176	7,729	215	3%	768	11%
Fremont	94,633	106,534	120,125	11,901	13%	25,492	27%	218,715	231,945	274,291	13,230	6%	55,576	25%
Newark	18,710	20,789	23,111	2,079	11%	4,401	24%	44,074	47,162	57,576	3,088	7%	13,502	31%
Union City	21,196	23,181	25,366	1,985	9%	4,170	20%	69,519	72,207	81,205	2,688	4%	11,686	17%
Tier 1 Total	327,298	367,729	407,866	40,431	12%	80,568	25%	557,506	590,387	693,835	32,881	6%	136,329	24%
Mt View	57,783	66,471	81,541	8,688	15%	23,758	41%	77,934	83,636	102,104	5,702	7%	24,170	31%
Sunnyvale	81,237	90,601	104,334	9,364	12%	23,097	28%	147,270	158,096	190,710	10,826	7%	43,440	29%
Santa Clara	110,006	124,378	136,855	14,372	13%	26,849	24%	114,883	122,542	153,840	7,659	7%	38,957	34%
Dublin	15,519	19,815	25,669	4,296	28%	10,150	65%	24,114	27,553	38,438	3,439	14%	14,324	59%
Pleasanton	48,289	53,824	59,500	5,535	11%	11,211	23%	48,616	52,392	64,635	3,776	8%	16,019	33%
Livermore	26,601	29,416	31,724	2,815	11%	5,123	19%	68,564	70,918	78,728	2,354	3%	10,164	15%
San Ramon	37,685	41,683	46,492	3,998	11%	8,807	23%	30,258	31,452	37,521	1,194	4%	7,263	24%
Tier 2 Total	377,120	426,188	486,115	49,068	13%	108,995	29%	511,639	546,589	665,976	34,950	7%	154,337	30%
Peninsula Totals	441,785	498,675	561,994	56,890	13%	120,209	27%	565,285	603,347	727,417	38,062	7%	162,132	29%
East Bay Totals	262,633	295,242	331,987	32,609	12%	69,354	26%	503,860	533,629	632,394	29,769	6%	128,534	26%
Study Area Totals	**704,418**	**793,917**	**893,981**	**89,499**	**13%**	**189,563**	**27%**	**1,069,145**	**1,136,976**	**1,359,811**	**67,831**	**6%**	**290,666**	**27%**

Source: C/CAG-VTA Regional Travel Demand Model, 2016

In the study area, and in San Mateo, Santa Clara, and Alameda counties, and in the Bay Area as a whole, employment growth rates are projected to be higher per year between 2013 and 2020 than between 2020 and 2040, while the pace of population growth until 2020 will be similar to the average annual rate from 2013 to 2040. Employment growth has been and will continue to accelerate during the 2013 to 2020 period, with growth rates almost double the average annual growth rate for the 2013 to 2040 period. Peninsula DTCS cities will add about 57,000 jobs by 2020, compared with about population growth of 38,000. As the jobs-housing imbalance in the

Peninsula DTCS cities worsens, growth in transbay commutes by 2020 are likely to increase at a greater rate than the average growth in population and employment.

Population and employment growth in the East Bay DTCS cities will be roughly equivalent, about 30,000 and 33,000 respectively, indicating that they will not be able to absorb the growing Peninsula imbalance, and suggesting that a higher percentage of commutes from the East Bay will come from cities beyond the Tier 1 and Tier 2 East Bay cities.

Table 4-18 through **Table 4-20** present the 2013 estimate and 2040 growth forecast of DTCS transbay city-to-city daily person trips. The pronounced reductions in residents of smaller cities like Atherton and East Palo Alto commuting to jobs in the East Bay are evidence of the increase in jobs per capita forecast for the Peninsula providing greater number of opportunities not requiring transbay travel and, possibly, normal micro-scale imprecision within macro-scale models such as the C/CAG model. Future residents of Redwood City, for example, are projected to be less likely to commute to Union City and Newark than to jobs in Mountain View, Menlo Park and Redwood City itself.

The trips shown in the tables do not all cross the Dumbarton Highway Bridge. For example, SR 237 and the San Mateo Bridge are also routes of choice for trips between Fremont and Sunnyvale and Santa Clara and Palo Alto, and between East Bay Tier 2 cities and Redwood City. The person trip demand also does not represent the number of vehicles crossing the Bay, as it includes carpool and transit passengers. The composition of vehicle traffic demand is presented in the next section.

Table 4-18: Transbay City-to-City Person Trips 2013

		Transbay DTCS Corridor City-to-City Person Trips 2013															
		Tier 1, Peninsula						Tier 2, Peninsula			Tier 1, East Bay			Tier 2, East Bay			
	City	Atherton	East Palo Alto	Menlo Park	Palo Alto	Redwood City	Stanford CDP	Mountain View	Santa Clara	Sunnyvale	Fremont	Newark	Union City	Dublin	Livermore	Pleasanton	San Ramon
Tier 1, Peninsula	Atherton										20,680	9,740	6,062	224	250	778	746
	East Palo Alto										108,284	77,357	49,729	1,625	563	5,950	1,992
	Menlo Park										159,660	84,578	49,082	2,022	1,938	6,824	5,091
	Palo Alto										178,791	64,590	42,081	3,613	4,806	13,396	8,367
	Redwood City										246,617	122,409	78,580	6,493	4,274	15,207	12,490
	Stanford CDP										32,538	11,369	7,820	737	1,086	2,572	1,751
Tier 2, Peninsula	Mountain View										190,141	37,449	23,096	4,007	5,160	16,214	9,797
	Santa Clara										353,509	46,090	25,714	7,601	9,942	30,352	19,341
	Sunnyvale										378,623	53,392	28,332	7,806	10,144	31,646	19,854
Tier 1, East Bay	Fremont	42,493	71,453	514,150	1,009,259	709,447	294,626	737,176	1,496,487	1,238,449							
	Newark	13,509	26,257	171,276	261,377	221,362	95,120	127,399	224,885	179,015							
	Union City	18,609	28,959	217,719	382,327	305,947	113,712	165,974	245,036	213,456							
Tier 2, East Bay	Dublin	853	1,119	8,659	25,792	15,724	16,184	22,391	57,031	42,756							
	Livermore	1,769	2,292	17,900	55,950	31,525	22,279	53,032	123,083	100,587							
	Pleasanton	2,161	2,735	21,464	65,907	38,417	29,572	61,062	142,724	115,480							
	San Ramon	1,155	1,418	11,531	40,814	21,492	13,821	32,468	65,831	55,931							

Source: C/CAG-VTA Regional Travel Demand Model, 2016

Table 4-19: Transbay City-to-City Person Trips 2040

		Transbay DTCS Corridor City-to-City Person Trips 2040															
		Tier 1, Peninsula						Tier 2, Peninsula			Tier 1, East Bay			Tier 2, East Bay			
	City	Atherton	East Palo Alto	Menlo Park	Palo Alto	Redwood City	Stanford CDP	Mountain View	Santa Clara	Sunnyvale	Fremont	Newark	Union City	Dublin	Livermore	Pleasanton	San Ramon
Tier 1, Peninsula	Atherton										19,057	7,985	4,549	305	255	854	864
	East Palo Alto										77,377	43,427	24,728	802	619	2,095	2,168
	Menlo Park										181,525	94,850	52,231	2,593	2,145	6,886	6,048
	Palo Alto										216,488	78,647	49,623	5,488	5,455	16,151	10,407
	Redwood City										254,323	111,356	66,035	6,474	5,094	14,659	15,232
	Stanford CDP										39,909	14,207	9,511	1,135	1,209	3,177	2,151
Tier 2, Peninsula	Mountain View										247,223	50,678	30,573	6,502	6,174	20,720	13,008
	Santa Clara										494,388	62,340	34,674	13,216	12,425	42,044	27,097
	Sunnyvale										482,706	67,756	35,675	12,565	11,633	40,328	25,892
Tier 1, East Bay	Fremont	43,064	98,257	594,828	1,119,227	808,418	325,583	850,508	1,752,743	1,375,947							
	Newark	15,330	42,022	224,599	330,322	280,549	118,711	161,837	268,458	209,759							
	Union City	17,283	36,682	234,382	391,270	318,933	115,501	174,528	266,784	219,574							
Tier 2, East Bay	Dublin	1,104	2,000	12,382	36,123	23,081	24,763	33,441	80,665	60,174							
	Livermore	1,864	3,280	20,605	62,972	37,575	25,092	63,109	138,364	112,219							
	Pleasanton	2,417	4,217	26,678	79,811	49,109	36,315	79,309	179,588	142,576							
	San Ramon	1,106	1,876	12,314	43,378	23,807	14,186	35,636	75,739	60,929							

Source: C/CAG-VTA Regional Travel Demand Model, 2016

Table 4-20: Transbay City-to-City Person Trips Growth from 2013 to 2040

		Transbay DTCS Corridor City-to-City Person Trips Growth from 2013 to 2040															
		Tier 1, Peninsula						Tier 2, Peninsula			Tier 1, East Bay			Tier 2, East Bay			
	City	Atherton	East Palo Alto	Menlo Park	Palo Alto	Redwood City	Stanford CDP	Mountain View	Santa Clara	Sunnyvale	Fremont	Newark	Union City	Dublin	Livermore	Pleasanton	San Ramon
Tier 1, Peninsula	Atherton										-8%	-18%	-25%	36%	2%	10%	16%
	East Palo Alto										-29%	-44%	-50%	-51%	10%	-65%	9%
	Menlo Park										14%	12%	6%	28%	11%	1%	19%
	Palo Alto										21%	22%	18%	52%	14%	21%	24%
	Redwood City										3%	-9%	-16%	0%	19%	-4%	22%
	Stanford CDP										23%	25%	22%	54%	11%	24%	23%
Tier 2, Peninsula	Mountain View										30%	35%	32%	62%	20%	28%	33%
	Santa Clara										40%	35%	35%	74%	25%	39%	40%
	Sunnyvale										27%	27%	26%	61%	15%	27%	30%
Tier 1, East Bay	Fremont	1%	38%	16%	11%	14%	11%	15%	17%	11%							
	Newark	13%	60%	31%	26%	27%	25%	27%	19%	17%							
	Union City	-7%	27%	8%	2%	4%	2%	5%	9%	3%							
Tier 2, East Bay	Dublin	29%	79%	43%	40%	47%	53%	49%	41%	41%							
	Livermore	5%	43%	15%	13%	19%	13%	19%	12%	12%							
	Pleasanton	12%	54%	24%	21%	28%	23%	30%	26%	23%							
	San Ramon	-4%	32%	7%	6%	11%	3%	10%	15%	9%							

Source: C/CAG-VTA Regional Travel Demand Model, 2016

4.4.1 Sources of Dumbarton Traffic

Of the travel origins and destinations served by the Dumbarton Highway Bridge, those responsible for the highest percentages of Highway Bridge use are Palo Alto, Menlo Park, Redwood City, Fremont, Union City and Newark. Each represents more than five percent of 2013 Highway Bridge use and is projected to continue to do so through 2040. The sixteen DTCS Tier 1 and Tier 2 cities are responsible for 63 percent of the residential originations and 78 percent of the employment destinations using the Dumbarton. Of the 63 percent of the Highway Bridge origins contributed by Corridor cities, almost two-thirds are generated in Fremont (21 percent), Union City (10 percent), and Newark (nine percent). Of the 78 percent of destinations, over two-thirds are generated in Palo Alto (22 percent), Menlo Park (nine percent), Fremont (nine percent), Stanford (eight percent) and Redwood City (eight percent).

Table 4-21 and **Source:** C/CAG-VTA Regional Travel Demand Model, 2016

Table 4-22 indicate the share of commute period Highway Bridge travel attributable to intra-Corridor travel for 2013 and 2040. The tables represent the three-hour morning peak period for each DTCS origin-city to destination-city pair respectively with trip orientation generally from residential origins to employment destinations. While 63 percent of the residentially produced trip origins and 78 percent of the employment-attracted trip destinations are generated by Tier 1 and Tier 2 cities, less than 50 percent of the travel is intra-Corridor, travelling from one DTCS city to another. Trips among pairs of the sixteen DTCS cities represent about 45 percent of the total Bridge traffic count. **Table 4-21** and **Source:** C/CAG-VTA Regional Travel Demand Model, 2016

Table 4-22 also highlight those origin-destination pairs that are individually responsible for more than one percent of Highway Bridge use and show the share for which each city is responsible. The remaining use is generated at a wide variety of origin and destination cities, none responsible for more than two percent of overall use.

Even though the precise percentages may vary over the 27-year forecast period, the city pairs indicated in **Table 4-21** and **Source:** C/CAG-VTA Regional Travel Demand Model, 2016

Table 4-22 represent the most dominant sources of Highway Bridge demand both today and in the future on which to focus targeted system and services planning: Fremont, Union City and Newark to Menlo Park, Palo Alto and Stanford, Mountain View and Redwood City. Also important will be system integration in the form of connectivity to Caltrain, BART, ACE and Capital Corridor and park-and-ride hubs to facilitate connections with commuters from beyond the Tier 1 and Tier 2 DTCS cities. Other cities with more than one percent of the morning peak period origins crossing the Bridge include Hayward, San Leandro, Oakland and Castro Valley. Destination cities responsible for more than one percent of the morning peak period Bridge traffic include Cupertino, San Carlos, Los Altos, Oakland, and Hayward.

Table 4-21: Percent of Dumbarton 2013 Morning Peak Traffic by Origin and Destination

Percent of Dumbarton 2013 AM Peak Traffic by Origin and Destination

City Destination > Origin v	Atherton	Dublin	East Palo Alto	Fremont	Livermore	Menlo Park	Mountain View	Newark	Palo Alto	Pleasanton	Redwood City	San Ramon	Santa Clara	Stanford CDP	Sunnyvale	Union City	Total
Atherton																	0.4%
Dublin																	0.3%
East Palo Alto																	2.3%
Fremont						2.7%	1.3%		5.6%		3.7%			1.8%			16.5%
Livermore																	0.5%
Menlo Park				1.4%													2.7%
Mountain View																	1.0%
Newark									1.6%		1.3%						5.8%
Palo Alto				1.2%													2.4%
Pleasanton																	0.6%
Redwood City				2.2%				1.0%									3.9%
San Ramon																	0.3%
Santa Clara																	0.0%
Stanford CDP																	0.5%
Sunnyvale																	0.4%
Union City						1.1%			2.4%		1.5%						7.6%
Total	0.4%	0.0%	1.3%	6.8%	0.0%	4.9%	2.8%	3.6%	10.6%	0.3%	6.5%	0.1%	0.0%	3.6%	1.5%	2.8%	**45.2%**

Blank cells have percentages less than 1%

Source: C/CAG-VTA Regional Travel Demand Model, 2016

Table 4-22: Percent of Dumbarton 2040 Morning Peak Traffic by Origin and Destination

Percent of Dumbarton 2040 AM Peak Traffic by Origin and Destination

City Destination > Origin v	Atherton	Dublin	East Palo Alto	Fremont	Livermore	Menlo Park	Mountain View	Newark	Palo Alto	Pleasanton	Redwood City	San Ramon	Santa Clara	Stanford CDP	Sunnyvale	Union City	**Total**
Atherton																	0.2%
Dublin																	0.4%
East Palo Alto																	1.1%
Fremont						2.5%	1.6%		4.9%		3.3%			1.6%			15.4%
Livermore																	0.6%
Menlo Park				1.3%													2.3%
Mountain View																	1.2%
Newark									1.6%		1.1%						5.8%
Palo Alto				1.3%													2.6%
Pleasanton																	0.9%
Redwood City				1.8%													3.0%
San Ramon																	0.4%
Santa Clara																	0.0%
Stanford CDP																	0.5%
Sunnyvale																	0.7%
Union City									1.9%		1.1%						6.7%
Total	0.4%	0.0%	0.8%	6.1%	0.0%	4.6%	3.8%	3.1%	9.5%	0.1%	5.5%	0.1%	0.2%	3.3%	2.1%	2.2%	**41.8%**

Blank cells have percentages less than 1%

Source: C/CAG-VTA Regional Travel Demand Model, 2016

Table 4-23 shows the approach and departure directions in the morning and evening peak on the Dumbarton Highway Bridge. On the Peninsula, 15 to 20 percent of peak Bridge traffic approaches or departs via US 101 north and 40 percent via US 101 south, with 20 to 25 percent travelling to/from the Highway Bridge via Willow Road and 20 percent to/from University Avenue west of US 101. In the East Bay, 10 percent of peak bridge traffic approaches or departs via I 880 north and 20-25 percent via I 880 south, with 20-25 percent travelling to/from the Highway Bridge via Decoto Road and 40-45 percent to/from surface streets such as Ardenwood Boulevard between I 880 and the Highway Bridge toll plaza. Expansion of park-and-ride capacity and Dumbarton bus or rail service should consider opportunities to intercept traffic approaching from the most dominant source directions north and south on I 880, SR 84 east and Decoto Road.

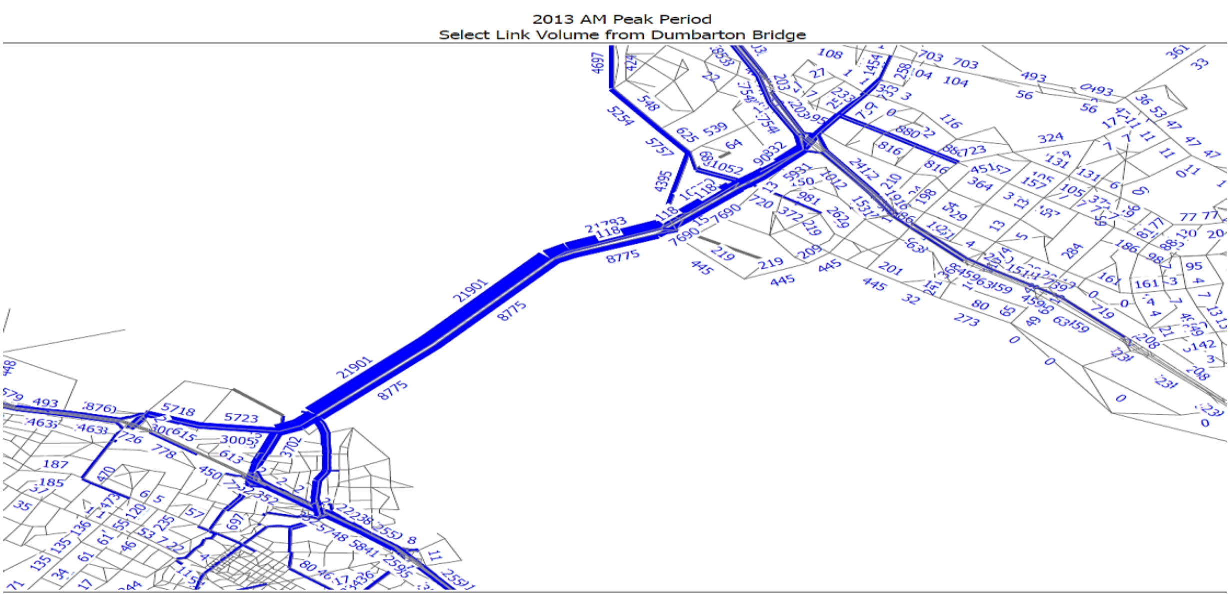
Table 4-23: Dumbarton Traffic Approach and Departure Directions

	Morning Peak Westbound		Evening Peak Eastbound	
	Approach %	Departure %	Approach %	Departure %
US 101 North		23%	16%	
Willow Road		19%	26%	
University Avenue west of US 101		22%	19%	
US 101 South		37%	39%	
I 880 North	11%			10%
I 880 South	22%			24%
Decoto Road	20%			27%
Ardenwood, Newark Boulevard, Paseo Padre Parkway	47%			39%
Total	100%	100%	100%	100%

Source: C/CAG-VTA Regional Travel Demand Model, 2016

At the more detailed level, the approach and departure volumes are shown for each network link on maps such as **Figure 4-18**.

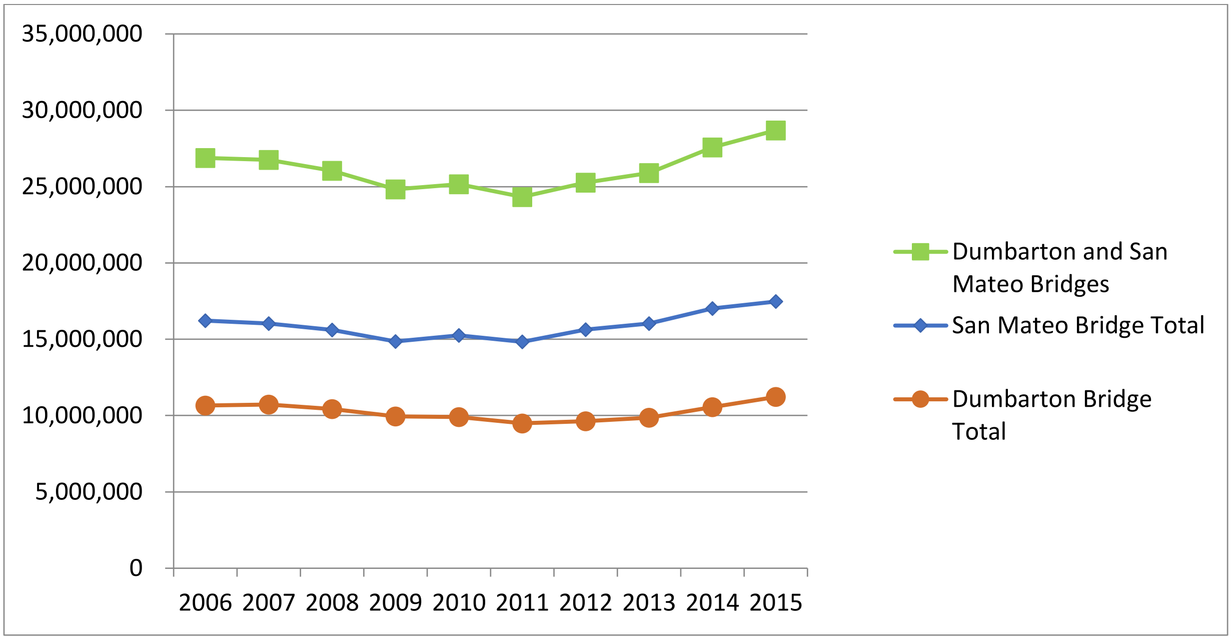
Figure 4-18: Approach and Departure Volumes



Source: C/CAG-VTA Regional Travel Demand Model, 2016

Dumbarton Highway Bridge traffic has grown by 13 percent over the past five years, but the gain has been mostly attributable to the recession recovery. As shown in **Figure 4-19**, until 2014, annual traffic on the both the Dumbarton and San Mateo bridges were below 2006 levels, and Dumbarton Highway Bridge traffic now exceeds 2006 levels by only about five percent.

Figure 4-19: Annual Westbound Bridge Volumes 2006-2005



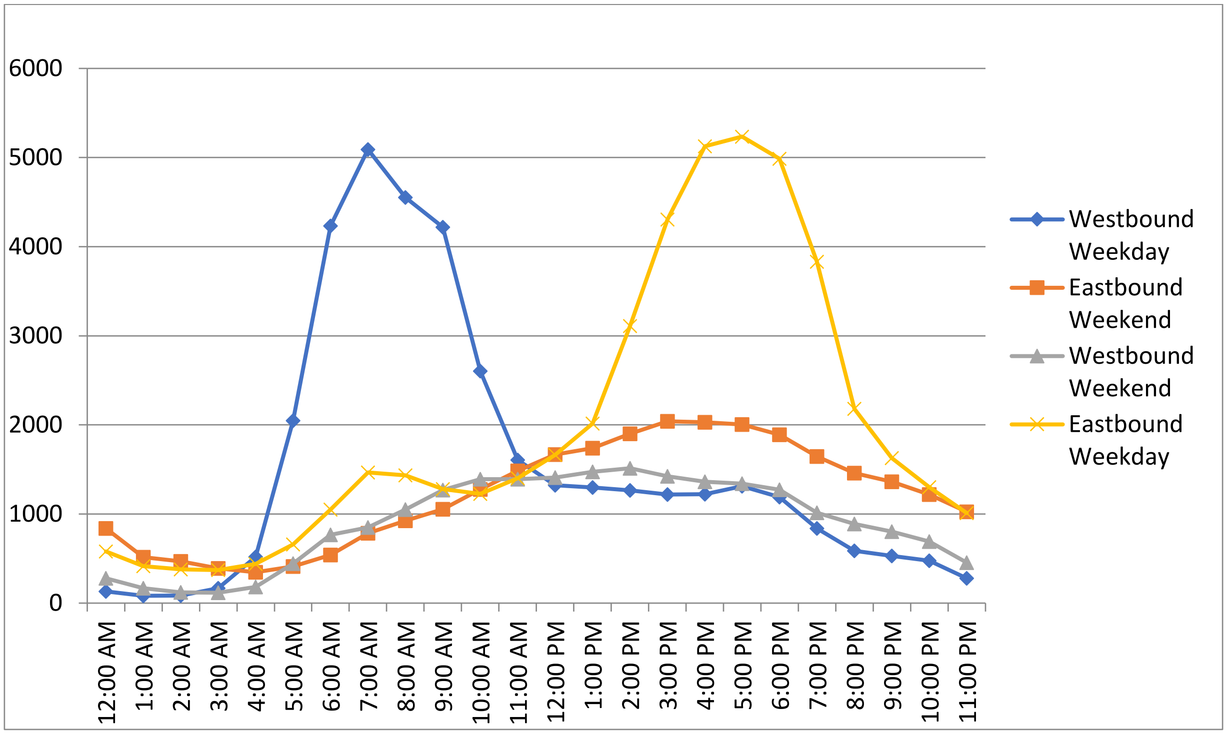
Source: C/CAG-VTA Regional Travel Demand Model, 2016

Forecasts produced by VTA and the C/CAG travel model project a 19 percent growth in Highway Bridge traffic between 2013 and 2040, or about 0.7 percent a year. This is slightly higher than 0.6 percent combined effects of the recessed and accelerated growth rates of the past ten years and with the Plan Bay Area annual 0.65 percent regional employment growth projection for 2020 to 2040. However, it's well below the rapid two percent annual growth rate of the past five years.

4.4.2 Composition of Dumbarton Traffic

Dumbarton traffic is heavily oriented toward commutes to jobs in Silicon Valley. Traffic volumes on the Highway Bridge are highly peaked, with peak-period peak-direction (westbound morning and eastbound evening) traffic three to four times as high as reverse commute traffic and midday traffic. Peak weekday traffic also exceeds peak weekend traffic by more than 150 percent as shown in **Figure 4-20**.

Figure 4-20: Hourly Dumbarton Bridge Traffic 2015



Source: C/CAG-VTA Regional Travel Demand Model, 2016

C/CAG model forecasts, based on Plan Bay Area population and employment growth, project Dumbarton Highway Bridge passenger traffic to grow 19 percent between 2013 and 2040, and truck traffic to grow 47 percent. The forecasts anticipate spreading of the peak period, with off-peak traffic growing by greater percentages than peak period traffic. They also anticipate a shift toward higher occupancy vehicles, with vehicles with three occupants or more (HOV 3+) increasing at greater rates than both single-occupant vehicles and two-occupant HOV. This trend is shown in **Table 4-24**.

Table 4-24: Projected 2013-2040 Change in Dumbarton Bridge Demand by Vehicle Class

Mode Class	Peak Period	Off-Peak Period	Daily
Single-Occupant	17%	21%	19%
HOV 2	10%	6%	8%
HOV 3+	17%	36%	29%
Truck	44%	50%	47%

Source: C/CAG-VTA Regional Travel Demand Model, 2016

Public and private transit play an important but relatively small role in serving travel demand across the Bay. AC Transit Dumbarton Express lines DB and DB1 carry 1,100 to 1,200 riders daily, and private shuttles operated or contracted by major Silicon Valley employers carry about 1,400 passengers a day across the Highway Bridge. Of the current Dumbarton travel, public and private bus riders combined represent about two to three percent of the daily person trip demand and about six percent of peak-period demand.

4.4.3 Potential for Increased Transit Share

The Alameda County Transportation Commission Countywide Transit Plan identifies 2040 transit travel markets within, to and from Alameda County based, in part, on a Transit Competitiveness Index between Travel Analysis Zones based on the following factors:

- Trip intensities at origins, destinations, and between origin-destination pairs;
- Land use density/diversity and central business district characteristics at origins and destinations;
- Parking costs and availability and tolls;
- Roadway congestion;
- Household characteristics (income, size, and vehicle ownership); and
- Trip type (commute vs. other)

The 2040 TCI analysis found that there is a potentially highly competitive transit market between central Fremont and Palo Alto (including the Stanford campus) and the Ardenwood Park-and-Ride and Palo Alto. The central Fremont area is centered around the Fremont BART station and Washington Hospital as demand generators and park-and-ride opportunities. The TCI also accounted for the effects of existing park-and-ride locations, including the lot at SR 84 and Ardenwood Boulevard.

A focused examination of the market within the AC Transit/MTC Tri-City Transit Study concluded that, while there is a need for all-day service for intra-East Bay travel by youth, college-age, senior, and transit-dependent demographic groups, work trips dominate the transbay travel demand between the East Bay and the Peninsula.

The TCI analysis does not address the unique set of travel options and traveler characteristics of employees of Silicon Valley tech firms. The relative demand for and performance of public versus employer-provided commuter bus services to major San Mateo or Santa Clara County employers will require more focused analysis. Nor does TCI include the potential future market for park-and-ride, commute-oriented transit services more generally. Because the market analysis approach focused on identifying origin-destination pairs with concentrated trip making between them, it did not identify potential future markets for new park-and-ride facilities and commute transit services from dispersed origins in the East Bay to concentrated destinations (such as major employers) in San Mateo and Santa Clara County.

5 Initial Improvement Options

5.1 Introduction

This chapter describes the universe of initial short- and long-term improvement options for the Dumbarton Highway and Rail Bridge. Short-term refers to project delivery by around 2020, while long-term refers to delivery by 2030. Many improvements under consideration are from previous Dumbarton Corridor studies. All improvements described below are subjected to an initial screening in Chapter 6. Improvements carried forward from that process will constitute the final study alternatives described in Chapter 7.

5.2 No Build Alternative

The No Build Alternative assumes that no improvements will be made to the Highway Bridge. It also includes removal of the existing Dumbarton Rail Bridge with any related environmental mitigations. Under this alternative, the capacity of the Dumbarton Corridor would be limited to that of the Highway Bridge as it exists today. The No Build Alternative does not address existing transportation deficiencies in the study area and serves as a baseline condition from which the Build Alternatives will be assessed.

5.3 Short-Term Highway Bridge and Approach Improvements

Short-term Highway Bridge improvements can enhance mobility in the Corridor with an emphasis on bus transit by 2020. These include, but are not limited to, improvements to the Highway Bridge toll plaza, park-and-ride facilities, roadway infrastructure, traffic operations, transit service, and bicycle and pedestrian access. There are no short-term options for the Highway Bridge specifically. The complete list of short-term improvements are described below.

5.3.1 Short-Term East Bay Bridge Approach Improvements

Bridge Toll Improvements

This initial short-term toll plaza improvement is designed to improve peak period travel time reliability at the toll plaza:

- **State Route 84 (SR 84) Toll Booth Removal at FasTrak Lanes**: This would remove toll booths at the FasTrak lanes so as to ameliorate typical peak-period delays at this location. Metering lights may need to be activated to manage downstream traffic.

Park-and-Ride Improvements

This initial short-term improvement will supplement already constrained park-and-ride capacity:

- **Shared Parking**: Negotiated shared-parking arrangements at church parking lots for use as park-and-rides during the week could serve as access points for transbay transit services and as a revenue source for the religious institution.

Infrastructure Improvements

Initial short-term infrastructure improvements include enhancements that improve travel time reliability for transit and high occupancy vehicles (HOV):

- **Decoto Road Transit Signal Priority and Queue Jump Lanes**: This would provide signal synchronization, transit priority, and queue jump lanes on Decoto Road between the Union City BART station and the Highway Bridge to enhance through movements for buses in the peak period. Queue jump lanes would require either conversion of both westbound and eastbound right turn lanes or the area adjacent to the right turn lanes to queue jump lanes.

- **SR 84/Newark Boulevard HOV Bypass Lane**: This option proposes an HOV bypass lane on the on-ramp to SR 84 from Newark Boulevard.

- **SR 84 FasTrak Lane Extension**: This would extend the current start of the FasTrak lane east of the Paseo Padre Parkway interchange, potentially increasing efficiency for buses.

5.3.2 Short-Term Peninsula Bridge Approach Improvements

Operations and Infrastructure Improvements

The following initial short-term improvements will improve travel time and reliability for transit passengers and HOVs in the western study area:

- **Bayfront Expressway and Willow Road Transit Signal Priority and Queue Jump Lanes**: This option would provide signal synchronization, transit priority, and queue jump lanes on Bayfront Expressway (between University Avenue and Willow Road) and Willow Road (between Bayfront Expressway and Newbridge Street) to improve peak period bus travel time. Queue jump lanes would require conversion of westbound right turn lanes or the area adjacent to the right turn lanes to queue jump lanes.

- **Bayfront Expressway Bus-Only Lanes**: This option would convert the curb lane or shoulder along Bayfront Expressway between the Highway Bridge and Willow Road to a peak period bus-only lane.

5.3.3 Short-Term Transit Service Improvements

In conjunction with the Highway Bridge and approach improvements, the DTCS proposes a number of short-term transit service improvements that are designed to address existing gaps in service between the East Bay and Palo Alto, Menlo Park, Redwood City, Mountain View, Sunnyvale, and other parts of the Peninsula and South Bay. Additionally, these improvements are also intended to integrate with existing regional transit service in the East Bay.

Enhanced Dumbarton Express and Dumbarton Express 1 Bus Service

This option proposes short-term service improvements for existing public bus routes that run between Fremont, Newark, and Union City (also known as the Tri-Cities), and Palo Alto/Stanford. This includes the Dumbarton Express (DB), Dumbarton Express 1 (DB1), and Stanford University's Line U. Under this option, service frequencies for the DB and DB1 routes would increase between 2020 and 2040 to achieve a target transit mode share across the Dumbarton Corridor of 30 percent by 2040 (20 percent by 2025).

It is assumed that increased frequencies on the DB and DB1 routes would render Line U unnecessary as long as one of the remaining routes (DB1) originated at Fremont BART (which Line U serves). In addition, these service improvements would be supported by the short-term approach improvements previously described making bus service faster and more reliable.

Menlo Park/Redwood City Express Bus Route

The Menlo Park/Redwood City Express Bus Route would create a new service between the Tri-Cities, Menlo Park, and the Redwood City Caltrain Station via the Highway Bridge and Bayfront Expressway. This service would effectively link Menlo Park and Redwood City employment centers with BART and Caltrain as well as provide additional transit access for communities adjacent to Bayfront Expressway. Similar to the enhanced DB and DB1 bus service routes described above, this route would adopt a mode share target of 30 percent by 2040 (20 percent by 2025), supported by high frequency service and the approach improvements noted in the previous sections.

Mountain View/Sunnyvale Express Bus Route

The Mountain View/Sunnyvale Bus Route would create a new bus service between the Tri-Cities, Mountain View, and Sunnyvale via the Highway Bridge and US 101. This service would provide a link between the Tri-City area and the Mountain View and Sunnyvale employment centers east of US 101. This route would adopt a 10 percent mode share target supported by frequent service and supporting approach improvements.

5.3.4 Short-Term Bicycle and Pedestrian Improvements

Improved Highway Bridge Access via Bicycle and Pedestrian Path

The existing bicycle and pedestrian path on the Highway Bridge is not a complete Class I facility across the entirety of the Bridge as it becomes a bike path (Class II) on Marshlands Road. Short-term improvements include the upgrade of the facility to Class I in this area with pavement and striping improvements throughout.

In addition to the upgrades on the existing Highway Bridge path, the initial short-term bicycle and pedestrian improvements are composed of proposed improvements identified in county and city bicycle and pedestrian plans.

Many jurisdictions surrounding the Dumbarton Corridor have adopted or are in the process of developing bicycle and pedestrian plans. These plans identify a number of bicycle improvements with the potential to close gaps in the existing bicycle network and enhance local and regional access to the Highway Bridge from key origins within the study area. These improvements are listed in **Table 5-1** and could be considered as potential alternatives to a multiuse path on the Dumbarton Corridor ROW described further in Section 5.5.

Table 5-1: Proposed Local Bicycle Improvement Projects

City	Proposed Project	Planning Document	Year Adopted	Page
Peninsula				
Atherton	Class 3 bikeway on Marsh Road between Middlefield Road and Bay Road	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-6
East Palo Alto	Class 2 bikeway at US 101 overcrossing – 300' north of Donohoe Street to Woodland Avenue	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-2
East Palo Alto	Improvements to existing University Avenue overcrossing at US 101	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-6, A-15
East Palo Alto	Widen and restripe class 2 bikeway on University Avenue	East Palo Alto Bicycle Transportation Plan	March 2011	10
Menlo Park	Ringwood Avenue Class 3 bike route between Bay Road and the Ringwood Bicycle and Pedestrian Bridge crossing at US 101	Menlo Park Comprehensive Bicycle Development Plan	January 2005	5-32
Menlo Park	Hamilton Ave Class 3 bike route from Ringwood Bicycle and Pedestrian Bridge crossing to Willow Road	Menlo Park Comprehensive Bicycle Development Plan	January 2005	5-28
Menlo Park/East Palo Alto	Newbridge Street Class 2 bike route from Ringwood Bicycle and Pedestrian Bridge crossing to Bay Road	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-7
Menlo Park	Marsh Road Class 2 Bikeway from Bay Road to Bayfront Expressway*	Menlo Park Comprehensive Bicycle Development Plan	January 2005	5-63
Redwood City	Complete Marshall Street on-street bikeway from Arguello Avenue to Chestnut Street (Arguello Ave to Walnut Street is complete)	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-3
Redwood City	Chestnut Street on-street bikeway from Marshall Street to Veterans Boulevard	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-3
Redwood City	Chestnut Street path from Veterans Boulevard to Stein Am Rhein Ct.**	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-3
Redwood City	Seaport Boulevard on-street bikeway from Stein Am Rhein Ct to Seaport Boulevard**	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-7
East Bay				
Newark	Class 3 bicycle boulevard on Lake Boulevard between SR 84 and Cedar Boulevard	City of Newark Pedestrian and Bicycle Plan	February 2017	138
Newark	Improve access to Ardenwood Historic Park on Lake Boulevard	City of Newark Pedestrian and Bicycle Plan	February 2017	138

City	Proposed Project	Planning Document	Year Adopted	Page
Newark	Pavement improvements on Marshlands Road between Thornton Avenue and the Newark city limits	City of Newark Pedestrian and Bicycle Plan	February 2017	139
Newark	Class 2 buffered bicycle lanes on Thornton Avenue between Willow Street and Peachtree Avenue; Class 4 separated bikeway on Thornton between Peachtree Avenue and Gateway Boulevard; and Class 2 bike lanes on Thornton between Gateway Boulevard and SR 84	City of Newark Pedestrian and Bicycle Plan	February 2017	106
Newark	Class 2 bicycle lane on Willow Street between Thornton Ave and Central Avenue	City of Newark Pedestrian and Bicycle Plan	February 2017	41
Newark	Class 2 bicycle lanes on Central Avenue between Willow Street and Filbert Street. Interim Class 3 bicycle lanes on Central Avenue between Filbert Street and Newark Boulevard with Class 2 bicycle lanes proposed in the long-term	City of Newark Pedestrian and Bicycle Plan	February 2017	41, 136
Newark	Class 4 separated bikeway on Newark Boulevard between SR 84 and Central	City of Newark Pedestrian and Bicycle Plan	February 2017	40, 139
Union City	Bicycle improvements on Decoto Road between Mission Boulevard and the Fremont border	City of Union City Pedestrian and Bicycle Master Plan	January 2012	5-13
Union City	Bicycle improvements on Union City Boulevard between Smith Street and Fremont border	City of Union City Pedestrian and Bicycle Master Plan	January 2012	5-29

Note: These projects were identified based on their potential to improve network connectivity and access to the Dumbarton Bridge. Further study and local coordination would be necessary prior to the development and implementation of any proposed facility.

* The San Mateo County Comprehensive Bicycle and Pedestrian plan identifies a similar project broken out by jurisdictions.

** Project included in US 101/SR 84 Interchange Project.

5.3.5 Other Short-Term Enhancements

In addition to the infrastructure and operational improvements described above, the following strategies were identified as having the potential to improve mobility in the Corridor but are difficult to evaluate. Therefore, these strategies are considered in conjunction with the overall initial short-term improvement package.

- **Enhanced Incident Management**: This would enhance traffic incident management through the addition of closed-circuit television cameras and dedicated Freeway Service Patrol vehicles within the study area.
- **Employer Incentive Programs**: This would provide funding for employers in the region to incentivize carpooling, vanpooling, and transit.

- **Provide Comparative Travel Time Information**: Dynamic message signs would be installed at strategic locations within the study area to provide travel time information for alternate routes and modes.

- **Active Traffic Management Strategies**: These would include queue warning, speed harmonization, and lane control signals to improve traffic flow.

- **Partnerships with Transportation Network Companies**: Partner with Transportation Network Companies to provide services that match passengers with drivers, or to provide last-mile solutions.

- **Autonomous Vehicles**: Consider dedicating lanes for use by high-capacity autonomous vehicles or using autonomous vehicles as last-mile solutions.

5.4 Long-Term Highway Bridge and Approach Improvements

The following sections describe long-term Highway Bridge and approach improvements that can be implemented by 2030. These options build upon the short-term improvements described in Section 5.3 and include major infrastructure and operational improvements to enhance traffic and transit operations in the study area. The long-term improvement options described below are organized by geographic location within the study area and by improvement type.

5.4.1 Long-Term Highway Bridge Improvements

Operations and Infrastructure Improvements

These initial long-term improvement options aim to enhance peak-hour traffic and transit operations on the Highway Bridge. Because they are more complex than the short-term options, they require a more intensive planning, design, construction and/or implementation process. Except when noted, most options assume that the lane configuration of the Highway Bridge remains the same.

- **Highway 1: Reversible Bus-Only, HOV, or Express Lane**: This option would convert a general-purpose lane to a reversible lane for buses, HOVs or toll-paying vehicles using a moveable median barrier. The reversible lane would increase peak direction roadway capacity for such vehicles by one lane during the peak hour. This option includes activation of metering lights at the toll plaza to manage peak period traffic flow.

- **Highway 2: Reversible General-Purpose Lane**: This option would convert a general-purpose lane to a reversible lane for all vehicles using a moveable median barrier. The reversible lane would increase peak direction roadway capacity for all vehicles by one lane during the peak hour. This option also includes activation of metering lights at the toll plaza to manage peak period traffic flow.

- **Highway 3: 2 Reversible Bus-Only, HOV, or Express Lanes in Median:** This option would convert the left general-purpose lane in each direction to two reversible lanes for buses, HOVs, or toll-paying vehicles. This option would require two permanent barriers. The reversible lanes would increase roadway capacity by two lanes during the peak hour in the peak direction. This option includes activation of metering lights at the toll plaza to manage peak period traffic flow.

- **Highway 4: 2 Reversible General-Purpose Lanes in Median**: This option would convert the inner-most general-purpose lane from each direction into two reversible lanes for all vehicles. Like the previous option, this improvement would require two permanent barriers. The reversible lanes would increase peak direction roadway capacity by one lane during the peak hour. This option also includes activation of metering lights at the toll plaza to manage peak period traffic flow.

- **Highway 5: One Bus-Only, HOV, or Express Lane in Each Direction**: This option proposes the conversion of one general-purpose lane in each direction to one lane for buses, HOVs, or toll-paying vehicles in each direction. This option does not require barriers nor does it increase roadway capacity. This option includes activation of metering lights at the toll plaza to manage peak period traffic flow.

Other options assume the conversion of the bike/pedestrian path, which is currently separate from the six traffic lanes, to a vehicle lane. These options assume that the bike/pedestrian lane would be replaced on the Dumbarton Rail Bridge:

- **Highway 6: Reversible Bus-Only, HOV, or Express Lane on Outside**: This option proposes the conversion of the bike/pedestrian lane to a reversible lane for buses, HOVs or toll-paying vehicles. The reversible lane would increase peak period roadway capacity by one lane during the peak hour. This option also includes activation of metering lights at the toll plaza to manage peak period traffic flow.

- **Highway 7: Reversible Bus-Only, HOV, or Express Lane in Median**: This option proposes the conversion of the bike/pedestrian lane to a general-purpose lane and the construction of a reversible lane for buses, HOVs or toll-paying vehicles in the median. This option would require a movable barrier. The reversible lane would increase peak direction roadway capacity by one lane during the peak hour. This option also includes activation of metering lights at the toll plaza to manage peak period traffic flow.

- **Highway 8: Reversible General-Purpose Lane in Median**: This option proposes the conversion of the bike/pedestrian lane to a general-purpose lane and the construction of a reversible lane for all vehicles in the median. This option would require a movable barrier. The reversible lane would increase peak direction roadway capacity in the peak direction by one lane during the peak hour. This option also includes activation of metering lights at the toll plaza to manage peak period traffic flow.

Another subset of options assumes the conversion of the bike/pedestrian lane to a vehicle lane with a new bike/pedestrian lane on a cantilever structure:

- **Highway 9: Reversible Bus-Only, HOV, or Express Lane in Median**: This option proposes the conversion of the bike/pedestrian lane to a general-purpose lane, the replacement of the bike/pedestrian lane on a cantilever structure and the construction of a reversible lane for buses, HOVs or toll-paying vehicles in the median. This option would require a movable barrier. The reversible lane would increase peak direction roadway capacity by one lane during the peak hour. This option also includes activation of metering lights at the toll plaza to manage peak period traffic flow.

- **Highway 10: Reversible General-Purpose Lane in Median**: This option proposes the conversion of the bike/pedestrian lane to a general-purpose lane, the replacement of the bike/pedestrian lane on a cantilever structure and the construction of a reversible lane for all vehicles in the median. This option would require a movable barrier. The reversible lane would increase peak direction roadway capacity by one lane during the peak hour. This option also includes activation of metering lights at the toll plaza to manage peak period traffic flow.

5.4.2 Long-Term East Bay Bridge Approach Improvements

Bridge Toll Improvements

Initial long-term improvements to the toll plaza are described below:

- **SR 84 All Electronic Tolling**: This improvement would completely remove cash payment at the toll plaza in favor of all-electronic tolling. There would be no stopping or slowing down at the toll booth. As part of this option, metering lights at the toll plaza would be activated to manage peak period traffic.

Park-and-Ride Improvements

Initial long-term improvements include the following park-and-ride options in the eastern study area. These options consider the construction of a new park-and-ride facility as well as the expansion of an existing park-and-ride lot to improve driving access to transit service.

- **Newark Park-and-Ride**: This option proposes construction of a new public park-and-ride lot in Newark as identified in the Newark Transit-Oriented Development Specific Plan.

- **Ardenwood Park-and-Ride Expansion**: Under this option, the existing Ardenwood Park-and-Ride lot would be expanded and integrated with the enhanced transit service options.

Operations and Infrastructure Improvements

The initial long-term operations and infrastructure improvements in the East Bay, which could particularly benefit HOVs and transit include the following:

- **SR 84 Eastbound Bus-Only, HOV, or Express Lanes**: This improvement would add a bus-only, HOV, or Express Lane from the Highway Bridge toll plaza to I 880/Decoto Road.

- **SR 84/I 880 Bus-Only, HOV, or Express Lane Direct Connectors**: This option proposes to construct peak period HOV to HOV direct connectors from I 880 southbound to SR 84 westbound and I 880 northbound to SR 84 westbound.

- **SR 84/Newark Boulevard Bus-Only, HOV, or Express Lane Direct Connectors**: This option proposes the construction of SR 84 westbound and eastbound HOV or Express Lane on-ramps from Newark Boulevard.

- **FasTrak Lane Conversion to Bus-Only, HOV, or Express Lanes**: This option would convert the extended FasTrak lane (identified in the short-term) to a peak-period bus-only, HOV, or express lane.

5.4.3 Long-Term Peninsula Bridge Approach Improvements

Operations and Infrastructure Improvements

The following long-term improvement options are designed to enhance travel time and reliability for travelers, particularly on transit, on the western side of the study area:

- **Bayfront Expressway Bus-Only, HOV, or Express Lanes**[1]: This option proposes to convert the curb- or shoulder-running peak-period bus-only lanes proposed in the short-term to peak-period median-running bus-only, HOV, or express lanes from the Dumbarton Bridge to Willow Road.

- **Bayfront Expressway Extension**: To improve the connection between the Highway Bridge landing and northbound US 101, this option proposes construction of a direct flyover connection between Bayfront Expressway/Marsh Road and US 101 north of Marsh Road.

- **US 101/Marsh Road Bus-Only, HOV, or Express Lane Direct Connector**: This option proposes adding a direct connector from southbound Marsh Road to the planned US 101 northbound and southbound express lanes.

- **Marsh Road/Bayfront Expressway Grade Separation**: This option would construct a grade separation at the Bayfront Expressway and Marsh Road intersection to eliminate traffic lights.

- **Willow Road/Bayfront Expressway Grade Separation**[2]: This option would construct a grade separation at the Bayfront Expressway and Willow Road intersection (including grade separations at the Dumbarton Rail ROW and Hamilton Avenue) to eliminate the existing signalized intersections and allow uninterrupted traffic flow. A tight diamond interchange with connections between the Willow Road Expressway (described below) and the local streets would be made with a combination of underground ramps.

- **University Avenue/Bayfront Expressway Grade Separation**[3]: This improvement would construct a grade separation at the Bayfront Expressway and University Avenue intersection. A flyover ramp connecting westbound Bayfront Expressway to southbound University Avenue would be constructed.

- **University Avenue Interchange Reconfiguration**: This option proposes to reconfigure the northbound US 101/University Avenue ramp and eliminate the University Avenue off-ramp/Donohoe Street intersection.

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[1] 2020 Peninsula Gateway Corridor Study.

[2] 2020 Peninsula Gateway Corridor Study.

[3] 2020 Peninsula Gateway Corridor Study.

- **Willow Road Bus-Only, HOV, or Express Lanes**[4]: This option includes a variety of improvements that would enhance access to and from the west side of the Highway Bridge along Bayfront Expressway to US 101, including flyovers, interchange improvements, and the conversion of Willow Road between Bayfront Expressway and US 101 to bus-only, HOV, or express lanes. Further, this option includes six potential configurations including:
  - Two northbound and two southbound depressed express lanes
  - One northbound and one southbound depressed express lane
  - Two reversible depressed express lanes
  - Three depressed express lanes with a reversible middle lane
  - Tunnel express lanes under the existing surface street
  - Modified depressed express lanes (one lane in each direction) with the surface street cantilevered inboard to minimize frontage impacts
- **University Avenue Bus-Only, HOV, or Express Lanes**[5]: Similar to the Willow Road improvements described above, this option proposes to convert University Avenue to a peak-period expressway. This option includes six different configurations for the proposed University Avenue express lanes including:
  - Two northbound and two southbound depressed express lanes
  - One northbound and one southbound depressed express lane
  - Two reversible depressed express lanes
  - Three depressed express lanes with a reversible middle lane
  - Tunnel express lanes under the existing surface street
  - Modified depressed express lanes (one lane in each direction) with the surface street cantilevered inboard to minimize frontage impacts

5.4.4 Long-Term Transit Service Improvements

The DTCS also proposes transit service improvements in conjunction with the initial long-term Highway Bridge and approach options. The transit service improvements build on the enhancements to short-term route DB, DB1, Menlo Park/Redwood City and Mountain View/Sunnyvale express bus services as discussed in Section 5.3.4.

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[4] 2020 Peninsula Gateway Corridor Study.

[5] 2020 Peninsula Gateway Corridor Study.

5.5 Short-Term Rail Bridge and ROW Improvements

The initial short-term bicycle and pedestrian improvements include several multiuse path options, which utilize the Dumbarton Corridor ROW.

5.5.1 Multiuse Path Options

Facebook has proposed a multiuse path along the Dumbarton Rail ROW between the Redwood City Caltrain Station to University Avenue. The multiuse path is intended to provide a dedicated and safe facility for non-motorized travel. The path would have periodic connections into neighboring residential areas and office sites.

Four options for the multiuse path are described below. Each option is designed to integrate with existing county bike improvement plans.

- **Bay Trail**: The Bay Trail option uses sections of the current and proposed Bay Trail between Seaport Boulevard and University Avenue with on-street connections as required. Starting at the Redwood City Caltrain Station, a new Class II bikeway is provided on Broadway, connected to a similar path heading north on Chestnut Street. A Class I bikeway then follows the Rail Corridor under US 101 to Blomquist Street, tying into the planned section of the Bay Trail on Cargill Levee between Seaport Boulevard and Bayfront Park[6] and the existing section of the Bay Trail between Bayfront Park and University Avenue, ultimately leading to the Highway Bridge. This option would have a total length of 5.9 miles to University Avenue.

- **Dumbarton Corridor**: The Dumbarton Corridor option uses the existing Dumbarton Rail ROW between Middlefield Road and University Avenue. The option begins on a Class II bikeway at the Redwood City Caltrain Station and connects to the Dumbarton Rail ROW at a trailhead at Middlefield Road. The proposed trail would continue eastwardly on the Dumbarton Rail ROW and terminate east of University Avenue. This option would have a total length of 4.6 miles, including about 3.3 miles on the Dumbarton Rail ROW.

- **Dumbarton Corridor/Bay Trail**: The Dumbarton Corridor and Bay Trail option uses sections of the Dumbarton Rail ROW, the existing Bay Trail, and on-street options to provide a multiuse connection between downtown Redwood City and University Avenue. Total trail length is 5.8 miles, with 2.4 miles within the Dumbarton Corridor, 1.8 miles on the existing Bay Trail, and the rest on city streets.

- **Class II Bikeway along Bay Street and Florence Road**: The Bay Street and Florence Road option uses sections of the Dumbarton Rail ROW and on-street options. The path begins on-street at Redwood City Caltrain Station; the bikeway then runs along Bay Road and Florence Street past Marsh Road and ties into the Dumbarton Rail ROW immediately east of Marsh Road. The separated bicycle and pedestrian multiuse path would continue along the Dumbarton Rail ROW to University Avenue. The total length of this alternative would be 4.6 miles, with 1.9 miles on the Dumbarton Corridor.

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[6] Bay Trail proposed segment No. 2089.0.

5.6 Long-Term Rail Bridge and ROW Improvements

In addition to the Highway Bridge and approach improvements, the DTCS explores a variety of long-term transit and bicycle/pedestrian options that would operate on or in place of the Dumbarton Rail Bridge. The modes that make up the universe of long-term transit options include commuter rail, Bus Rapid Transit (BRT), Light Rail Transit (LRT), Bay Area Rapid Transit (BART), Personal Rapid Transit (PRT), Group Rapid Transit (GRT), People Mover, Hyperloop, ferry, and gondola.

The following sections describe the long-term transit and bicycle and pedestrian options that would utilize the Dumbarton Rail Bridge.

5.6.1 Transit Service Improvements

Bus Rapid Transit (BRT)

BRT is bus-based transit designed to improve capacity, speed and reliability relative to conventional bus service through the use of dedicated bus lanes, transit priority measures at intersections, off-board fare payment systems, etc. The BRT option would provide routes DB, DB1, Menlo Park/Redwood City and Mountain View/Sunnyvale express bus service between Union City BART and the Redwood City Caltrain Station (described Section 5.3.4) via the Dumbarton Rail Bridge. On the Peninsula, BRT would travel on Middlefield Road near Redwood Junction to the Redwood City Caltrain Station. In the East Bay, BRT would travel via Thornton Road, Paseo Padre Parkway, and Decoto Road to the Union City BART station.

Commuter Rail

Commuter rail is standard gauge passenger rail service similar to existing Caltrain service, but clean Diesel Multiple Units or Electric Multiple Units are assumed rather than diesel locomotives and train cars. There are two types of commuter rail services that are being carried forward from previous Dumbarton Corridor studies.

The first is the Rail Shuttle, which would provide commuter rail shuttle service between Union City BART and the Redwood City Caltrain Station via the Dumbarton Rail Bridge. This option would require more frequent (15-minute) headways so passengers could more easily transfer to Caltrain service.

The second is the Rail Commuter option, which would provide commuter rail service between Union City BART and San Francisco and San Jose via the Dumbarton Rail Bridge and Caltrain mainline. This option would operate at less frequent headways due to challenges related to interlining with the Caltrain mainline.

Light Rail Transit (LRT)

LRT is tram-like electrified passenger rail service that can operate in dedicated guideway or on street, similar to existing Santa Clara Valley Transportation Authority (VTA) LRT service. The LRT option would provide service between Union City BART and VTA in Mountain View via the Dumbarton Rail Bridge. This option would require additional ROW and travel on surface streets.

Bay Area Rapid Transit (BART)

This option proposes a conventional heavy rail or third rail BART extension from Union City BART to the Redwood City Caltrain Station via the Dumbarton Rail Bridge. To accommodate BART in the East Bay and on the Peninsula, this option would require dedicated ROW, likely an aerial structure.

Personal Rapid Transit (PRT)

PRT is a mode of public transit that features small automated vehicles operating on a network of specially built guideways. This option proposes a PRT system from Union City BART to the Redwood City Caltrain Station via the Dumbarton Rail Bridge. To accommodate PRT in the East Bay and on the Peninsula, this option would require dedicated ROW, likely an aerial structure.

Group Rapid Transit (GRT)

GRT is a mode of public transit similar to PRT except that it features larger vehicles with large passenger capacity. This option proposes a GRT system from Union City BART to the Redwood City Caltrain Station via the Dumbarton Rail Bridge. To accommodate GRT in the East Bay and on the Peninsula, this option would require dedicated ROW, likely an aerial structure.

People Mover

A people mover or automated people mover is a grade-separated passenger transit system, which typically serves relatively small areas such as airports. This option proposes a People Mover system from Union City BART to the Redwood City Caltrain Station via the Dumbarton Rail Bridge. To accommodate a People Mover in the East Bay and on the Peninsula, this option would require dedicated ROW, likely an aerial structure.

Hyperloop

Hyperloop is a proposed mode of passenger transportation which consists of a sealed tube or system of tubes through which a pod may travel free of air resistance or friction. This option proposes “Hyperloop” service connecting the East Bay and the Peninsula via an aerial structure. This alternative would require the removal of the existing Dumbarton Rail Bridge.

Tunnel Under Bay

This option proposes to construct a tunnel under the Bay that would serve as an exclusive ROW for bus, rail, or other high-capacity transit modes. Similar to Hyperloop, this option would require the removal of the existing Dumbarton Rail Bridge.

Ferry

This option proposes ferry services between the East Bay and a new terminal (such as the Port of Redwood City) on the Peninsula. Depending on the location of terminals and vessel type, this option could require dredging of the Bay. In addition, this alternative would require parking facilities at the East Bay terminal as well as bus/shuttle connections to the Redwood City Caltrain Station on the Peninsula and Union City BART in the East Bay.

Gondola

A gondola is an aerial tramway. This option proposes gondola service connecting the East Bay and the Peninsula via an aerial tram structure. This option would require the removal of the existing Dumbarton Rail Bridge. In addition, the gondola option would require parking facilities at the East Bay terminal as well as bus/shuttle connections to the Redwood City Caltrain Station on the Peninsula and Union City BART in the East Bay.

5.6.2 Bicycle and Pedestrian Improvements

In addition to the various transit options described above, the DTCS includes a long-term bicycle and pedestrian multiuse path option that would stretch from East Palo Alto across the Dumbarton Rail Bridge ending at Union City BART. It is assumed that this option would extend the short-term bicycle and pedestrian multiuse path options described in Section 5.3.4.

6 Initial Screening

6.1 Introduction

As noted in Chapter 5, the Dumbarton Transportation Corridor Study (DTCS) considered a wide variety of initial short- and long–term improvement options on the Dumbarton Highway Bridge and approaches as well as the Dumbarton Rail Bridge. Using a qualitative screening process, the short- and long-term initial improvements were grouped by facility type and evaluated against a set of performance criteria established for each of the four project goals. The project goals and related initial screening criteria are listed below. See Chapter 3 for further discussion of the goals and criteria.

- **Goal 1: Enhance Mobility for Local and Regional Travelers**
    - Criteria 1.1: Capacity and throughput, with an emphasis on transit capacity benefit
- **Goal 2: Cost-Effective Improvements with Return on Investment**
    - Criteria 2.1: Average capital cost per mile
    - Criteria 2.2: Average operating and maintenance cost per mile
- **Goal 3: Manage and Minimize Environmental Impacts and Financial Risk, and Maximize Safety**
    - Criteria 3.1: Environmental impacts
    - Criteria 3.2: Financial risk
    - Criteria 3.3: Safety
- **Goal 4: Ensure Local Communities are Protected from Adverse Impacts**
    - Criteria 4.1: Disproportionate burden on low-income populations
    - Criteria 4.2: Disparate impacts on minority communities

Based on these high-level criteria, the best performing initial improvement options were assembled into a final set of project alternatives to be carried forward for design, cost estimation, modeling and further analysis. The following sections describe the initial screening methodology used for each facility and summarize the initial improvements selected to be carried forward.

6.2 Highway Bridge and Approach Improvements

The following sections describe the methodology, initial screening criteria, and scoring used to evaluate the Highway Bridge and approach improvement options.

It should be noted that some Highway Bridge and approach improvements discussed in Chapter 5 are not included in the initial screening process. These improvements include short- and long-term transit service improvements (Sections 5.3.3 and 5.4.4), locally proposed short-term bicycle and pedestrian improvements (Section 5.3.4), and other enhancements (Section 5.3.5). Many of these improvements were identified through previous studies and/or deemed as crucial mobility enhancements not requiring screening. Therefore, these options were carried forward without going through the initial screening process.

6.2.1 Highway Bridge Improvements

As discussed previously in Chapter 5, the DTCS identified ten highway-based options to enhance peak-hour transit and traffic operations on the Dumbarton Highway Bridge. For the initial screening, lane configuration options were grouped into three categories as they were described in Chapter 5:

- Configurations that retain the Highway Bridge's current lane configuration (maintaining six lanes),
- Configurations that convert the existing bicycle and pedestrian facility to a vehicle lane and relocate the bicycle and pedestrian facility to the Rail Bridge and
- Configurations that convert the existing bicycle and pedestrian facility to a vehicle lane and relocate the bicycle and pedestrian facility to a cantilevered deck.

The Highway Bridge lane configuration options were then evaluated independently against the initial screening criteria with a weighted scoring system. Each of the four project goals were weighed equally regardless of the number of related metrics. The initial screening criteria, weighting, and scores for the lane configuration options are shown in **Table 6-1**.

In general, the lane configuration options that would operate within the existing cross section of the Highway Bridge scored best, providing capacity for transit with a lower financial risk when compared to configurations that would relocate the bicycle and pedestrian facility. Specifically, Highway 5, which proposes two managed lanes, one in each direction, scored the highest followed by Highway 3 (two reversible lanes in each direction) and Highway 1 (one reversible managed lane). These top three configurations scored within 1.5 points of each other and were carried forward for further analysis.

Table 6-1: Highway Bridge Initial Improvements Evaluation and Scoring

Highway Bridge Configuration Alternatives		Evaluation Metrics and Scoring								
		1. Enhance Mobility	2. Cost-Effectiveness		3. Minimize Environmental and Financial Risk, Maximize Safety			4. Avoid Disproportionate Burden and Disparate Impacts		Cumulative Score
		1.1 Capacity Benefiting Transit (25%)	2.1 Average Capital Cost per Mile (16.6%)	2.2 Average Operating and Maint-enance Cost per Mile (8.3%)	3.1 Environ-mental Impacts (8.3%)	3.2 Financial Risk (8.3%)	3.3 Safety (8.3%)	4.1 Dispropor-tionate Burden (12.5%)	4.2 Disparate Impacts (12.5%)	
		6 = high capacity	4 = low cost	2 = low cost	2 = low risk	2 = low risk	2 = low risk	3 = low burden	3 = low impact	24 = max score
Utilize existing pavement cross section	Hwy 1: Reversible Bus-Only, (High Occupancy Vehicle) HOV, or Express Lane	5	2	1	1.5	2	1	3	3	18.5
	Hwy 2: Reversible General-Purpose Lane	3	2	1.5	1.5	2	1	2	2	15
	Hwy 3: 2 Reversible Bus-Only, HOV, or Express Lanes in Median	6	2	1	1.5	2	1	3	3	19.5
	Hwy 4: 2 Reversible General-Purpose Lanes in Median	3	2	1.5	1.5	2	1	2	2	15
	Hwy 5: One Bus-Only, HOV, or Express Lane in Each Direction	5	3	2	2	2	2	2	2	20
Convert bike/ped to vehicle lane	Hwy 6: Reversible Bus-Only, HOV, or Express Lane on Outside	5	1	0.5	1	1	0.5	3	3	15
	Hwy 7: Reversible Bus-Only, HOV, or Express Lane in Median	5	1	0.5	1	1	1	3	3	15.5
	Hwy 8: Reversible General-Purpose Lane in Median	2	1	1	1	1	1	2	2	11
Convert bike/ped to vehicle lane and add new bike lane	Hwy 9: Reversible Bus-Only, HOV, or Express Lane in Median	5	0.5	0	0.5	0.5	1	3	3	13.5
	Hwy 10: Reversible General-Purpose Lane in Median	2	0.5	0	0.5	0.5	1	2	2	8.5

Source: SamTrans, 2016

6.2.2 East Bay Highway Bridge Approach Improvements

In addition to the Highway Bridge improvements, the DTCS identified a total of 12 short- and long-term East Bay Highway Bridge approach improvements. As described in Chapter 5, Sections 5.3.2 and 5.4.2, these improvements include operational and infrastructure enhancements to encourage transit use and improve travel time reliability on the westbound approach to the Dumbarton Highway Bridge.

Different from the methodology used to screen the Highway Bridge improvements, the East Bay Highway Bridge approach improvements were evaluated using a pass/fail scoring system. Because each of these approach options will only be developed at a high level of detail and requires additional examination beyond the DTCS, the approach options were only evaluated for a general ability to improve transit service and capacity, and were not assessed with the remaining project goals and performance criteria.

As noted in **Table 6-2**, it was determined that all East Bay Highway Bridge approach improvements would directly benefit transit service and capacity and therefore received a "pass" score. All 12 improvement options were carried forward for further analysis.

6.2.3 Peninsula Highway Bridge Approach Improvements

In conjunction with the East Bay Highway Bridge approach improvements, the DTCS identified a total of ten short- and long-term Peninsula Highway Bridge approach improvements (see Sections 5.3.3 and 5.4.3 for further details) with the potential to encourage transit use and enhance travel time and reliability.

Using the same methodology as the East Bay Highway Bridge approach screening, the Peninsula Highway Bridge approach improvements were evaluated at a high-level for their ability to improve transit service and capacity. Again, the screening process used a qualitative pass/fail approach to score each improvement option.

As shown in **Table 6-3,** only some approach improvements were determined to directly benefit transit, receiving a "pass" score. Other approach improvements, including the Marsh Road grade separation, Bayfront Expressway extension, University Avenue express lanes, and University Avenue and Willow Road interchange reconfigurations received a "fail" score. While these improvements would improve traffic generally, it was determined that they do not provide a direct benefit to major transit routes in the Corridor. However, despite receiving a "fail," these improvements can still be considered in future studies for their general congestion relief benefits.

Table 6-2: East Bay Approach Improvements Initial Evaluation and Scoring

East Bay Approach Alternatives	Evaluation Metrics and Scoring							
	1. Enhance Mobility	2. Cost-Effectiveness		3. Minimize Environmental and Financial Risk, Maximize Safety			4. Avoid Disproportionate Burden and Disparate Impacts	
	1.1 Capacity Benefiting Transit (Pass/Fail)	2.1 Average Capital Cost per Mile	2.2 Average Operating and Maint-enance Cost per Mile	3.1 Environ-mental Impacts	3.2 Financial Risk	3.3 Safety	4.1 Dispro-portionate Burden	4.2 Disparate Impacts
State Route 84 (SR 84) Toll Booth Removal at FasTrak Lanes	Pass							
Shared Parking	Pass							
Decoto Road Transit Signal Priority and Queue Jump Lanes	Pass							
SR 84/Newark Boulevard HOV Bypass Lane	Pass							
SR 84 FasTrak Lane Extension	Pass							
SR 84 All Electronic Tolling	Pass							
Newark Park-and-Ride	Pass							
Ardenwood Park-and-Ride Expansion	Pass							
SR 84 Eastbound Bus-Only, HOV, or Express Lanes	Pass							
SR 84/Interstate-880 Bus-Only, HOV, or Express Lane Direct Connectors	Pass							
SR 84/Newark Boulevard Bus-Only, HOV, or Express Lane Direct Connectors	Pass							
FasTrak Lane Conversion to Bus-Only, HOV, or Express Lanes	Pass							

Source: SamTrans, 2016

Table 6-3: Peninsula Approach Improvements Initial Evaluation and Scoring

Peninsula Approach Alternatives	Evaluation Metrics and Scoring							
	1. Enhance Mobility	2. Cost-Effectiveness		3. Minimize Environmental and Financial Risk, Maximize Safety			4. Avoid Disproportionate Burden and Disparate Impacts	
	1.1 Capacity Benefiting Transit (Pass/Fail)	2.1 Average Capital Cost per Mile	2.2 Average Operating and Maintenance Cost per Mile	3.1 Environ-mental Impacts	3.2 Financial Risk	3.3 Safety	4.1 Dispro-portionate Burden	4.2 Disparate Impacts
Bayfront Expressway/Willow Road Transit Signal Priority and Queue Jump Lanes	Pass							
Bayfront Expressway Bus-Only, HOV, or Express Lanes	Pass							
Bayfront Expressway Extension	Fail							
US 101/Marsh Road Bus-Only, HOV, or Express Lane Direct Connector	Pass							
Marsh Road/Bayfront Expressway Grade Separation	Fail							
Willow Road/Bayfront Expressway Grade Separation	Pass							
University Avenue/Bayfront Expressway Grade Separation	Pass							
University Avenue Interchange Reconfiguration	Fail							
Willow Road Bus-Only, HOV, or Express Lanes	Pass							
University Avenue Bus-Only, HOV, or Express Lanes	Fail							

Source: SamTrans, 2016

6.2.4 Rail Bridge and Right-of-Way (ROW) Improvements

As described in Sections 5.5 and 5.6, the DTCS also considers a variety of transit and bicycle and pedestrian improvements that would operate on or near the Dumbarton Rail Bridge and Dumbarton Rail ROW. In contrast to the Highway Bridge and approach improvements screening, a two-step process was used to screen the Rail Bridge and ROW improvement options. To refine the list of potential transit options, step one of the initial screening process evaluated each option against the same performance criteria used to assess the Highway Bridge and approach improvement options. Following this, high-level transit operations plans were identified for the highest scoring transit modes. The transit operations plans were then evaluated against a second set of initial screening criteria that considered regional travel markets and transit frequency.

The two-step screening process, initial screening criteria, and results are discussed in more detail below.

Step 1: Rail Bridge and ROW Transit Modes

Table 6-4 shows the 12 transit options identified for the Rail Bridge, Dumbarton Rail ROW, and vicinity as well as the initial screening criteria for which they were evaluated. Similar to the Highway Bridge improvements, the Rail Bridge and ROW improvements were first analyzed at a high-level using a weighted scoring system with each project goal weighed equally.

As shown in **Table 6-4**, the Bus Rapid Transit (BRT), commuter rail, and bike/pedestrian options scored the highest (all within one point) and were carried forward to Step 2 of the initial screening process. In general, these options scored best because they offer a cost-effective, low risk transit solution that would operate in the existing ROW (without requiring grade separated structures) thereby minimizing environmental and disparate impacts.

It should be noted that the ferry mode scored fourth highest behind the bike/pedestrian option (approximately two points lower). Despite a high score, this service was dropped from further analysis because it would operate beyond the Corridor limits. However, ferry service can potentially be studied in more depth by a third party.

Table 6-4: Rail Bridge, ROW, and Vicinity Transit Modal Options Evaluation and Scoring

Rail Bridge, ROW and Vicinity Transit Modal Alternatives	Evaluation Metrics and Scoring								
	1. Enhance Mobility	2. Cost-Effectiveness		3. Minimize Environmental and Financial Risk, Maximize Safety			4. Avoid Disproportionate Burden and Disparate Impacts		Cumulative Score
	1.1: Capacity Benefiting Transit (25%)	2.1: Average Capital Cost per Mile (16.6%)	2.2: Average Operating and Maintenance Cost per Mile (8.3%)	3.1: Environ-mental Impacts (8.3%)	3.2: Financial Risk (8.3%)	3.3: Safety (8.3%)	4.1: Disproportionate Burden (12.5%)	4.2: Disparate Impacts (12.5%)	
	6 = High Cap	4 = Low Cost	2 = Low Cost	2 = Low Risk	2 = Low Risk	2 = Low Risk	3 = Low Burden	3 = Low Impact	24 = Max Score
Bus Rapid Transit (BRT)	4	3	1	1.5	2	1.5	2.5	2.5	18
Commuter Rail	5	2	1	1.5	2	1.5	2.5	2.5	18
Light Rail Transit (LRT)	4	2	1	1	1	1.5	1	1	12.5
Bay Area Rapid Transit (BART)	6	0	0	1	0.5	2	0.5	0.5	10.5
Personal Rapid Transit	2	1	0.5	1.5	0.5	2	0.5	0.5	8.5
Group Rapid Transit	3	1	0.5	1.5	0.5	2	0.5	0.5	9.5
People mover	2	1	0.5	1.5	0.5	2	0.5	0.5	8.5
Hyperloop	4	0	0.5	0.5	0	0	0.5	0.5	6
Tunnel (BRT, LRT, Commuter Rail)	5	0	1	0	0	1	0.5	0.5	8
Ferry	2	3	1	1	1.5	2	2	2.5	15
Gondola	2	2	1	0.5	0.5	1	0.5	0.5	8
Bicycle/Pedestrian	1	4	2	2	2	1.5	2.5	2	17

Source: SamTrans, 2016

Step 2: Potential Transit Operations

To investigate potential operations scenarios and further define the transit improvement options on the Rail Bridge and ROW, high-level transit operations plans were identified for the two highest scoring improvements from Step 1 (BRT and commuter rail) and evaluated against the Step 2 initial screening criteria shown in **Table 6-5**. (The idea of an operating plan does not apply to the bike and pedestrian multiuse path.) The screening criteria in Step 2 differed from that of Step 1 in that it also considered regional travel markets and transit frequency under the enhance mobility goal. Furthermore, Step 2 assumed that all modal and transit operations improvements perform the same under financial risk and safety. Again, these improvements were evaluated using a screening-level qualitative approach.

As shown in **Table 6-5**, Step 2 identified and evaluated six potential BRT and commuter rail operating scenarios on the Rail Bridge. Based on the initial screening criteria, the highest-scoring scenarios include single-track commuter rail on the Rail Bridge that interlines with Caltrain (operates on Caltrain's ROW), single-lane BRT on the Rail Bridge, single-track commuter rail shuttle on the Rail Bridge, and two-track commuter rail on the Rail Bridge that interlines with Caltrain. Single track or lane options on the Rail Bridge generally assume that there would be multiple tracks or lanes elsewhere or passing tracks where necessary.

It is worth mentioning that although most Rail Bridge options are single-lane or single-track, the East Bay and Peninsula ROWs have the capacity to accommodate multiple lanes, tracks, or modes. The Peninsula ROW width in particular is considered to be wide enough to accommodate multiple modes and because it is SamTrans-owned, multiple modes can be considered. The potential accommodation of multiple lanes, tracks, and modes in this area is discussed further in **Appendix D**. While the East Bay ROW is also wide enough to accommodate two modes, it is owned by Union Pacific Railroad and so only one mode is considered for the purposes of the DTCS.

In general, the improvements that would require expansion of the Rail Bridge to accommodate two lanes or modes, such as the BRT/commuter rail combination or two-lane BRT, didn't perform as well due to increased capital costs and potential for greater environmental impacts. Although the two-track commuter rail scenario would also require a Rail Bridge expansion, it was carried forward due to its potential for high capacity/throughput and ability to serve more regional travel markets.

Since the three highway configurations carried forward for additional analysis (Hwy 5, 3, and 1) all maintain the bicycle and pedestrian facility on the Highway Bridge, a bicycle and pedestrian facility or multiuse path is not proposed for the Rail Bridge and was omitted from the Step 2 screening. However, a multiuse path (for which options were discussed in Chapter 5, Section 5.5) could still be implemented on the Peninsula ROW and is therefore carried forward for further analysis.

Additionally, it should be noted that of the multiuse path options described in Section 5.5, the Dumbarton Corridor option was selected as the preferred option because it has the most dedicated ROW. However, the other options described remain viable.

Table 6-5: Rail Bridge and ROW Transit Operations Plan Evaluation and Scoring

Rail Bridge Transit Modal Alternatives and Transit Operations Plan	Evaluation Metrics and Scoring										
	1. Enhance Mobility			2. Cost-Effectiveness		3. Minimize Environmental and Financial Risk, Maximize Safety			4. Avoid Disproportionate Burden and Disparate Impacts		Cumulative Score
	1.1 Capacity/ Throughput (8.3%)	1.2 Regional Travel Markets (8.3%)	1.3 Transit Frequency (8.3%)	2.1 Capital Cost (16.6%)	2.2 Operating and Maintenance Cost (8.3%)	3.1 Environ-mental Impacts (8.3%)	3.2 Financial Risk (8.3%)	3.3 Safety (8.3%)	4.1 Disproportionate Burden (12.5%)	4.2 Disparate Impacts (12.5%)	
	2=High Capacity	2 = High Regional Access	2 = High Frequency	4 = Low Cost	2 = Low Cost	2 = Low Risk	2 = Low Risk	2 = Low Risk	3 = Low Burden	3 = Low Impact	24 = Max Score
BRT single lane - 10–15-minute frequencies	0.5	0.5	1.5	4	1.5	1.5	2	2	2.5	2	18
BRT x 2 lanes - 10–15-minute frequencies + more routes	1	1	2	2	1	0.5	2	2	1.5	1.5	14.5
Commuter rail single-track - Shuttle	1.5	0.5	1.5	3	1.5	1.5	2	2	2	2	17.5
Commuter rail single-track - Commuter	1	1	1	3.5	2	2	2	2	2	2	18.5
Commuter rail double-track - Commuter	2	2	1.5	2	1	0.5	2	2	1.5	2.5	17
BRT and commuter rail (various track/lane configurations)	1.5	1.5	1.5	1	0.5	0.5	2	2	1.5	2.5	14.5

Source: SamTrans, 2016

6.3 Alternatives Carried Forward

Using the initial screening process described above, initial improvements were evaluated at a high-level for their potential to achieve the DTCS project goals. The results of the initial screening are shown in **Table 6-6** and are organized by facility location. Using this list of suggested improvements, the DTCS team formed a final set of ten project alternatives to be carried forward for further analysis. The final combined set of project alternatives are described in more detail in Chapter 7, Alternatives Carried Forward.

Table 6-6: Initial Improvements Carried Forward

Highway Bridge and Approach Options		
Highway Bridge	**East Bay Highway Bridge Approach**	**Peninsula Highway Bridge Approach**
▪ Hwy 1: Reversible Bus-Only, HOV, or Express Lane ▪ Hwy 3: 2 Reversible Bus-Only, HOV, or Express Lanes in Median ▪ Hwy 5: One Bus-Only, HOV, or Express Lane in Each Direction ▪ Transit Service Improvements including enhanced Dumbarton Express and Dumbarton Express 1 service as well as two new routes to Menlo Park/Redwood City and Mountain View/Sunnyvale ▪ Locally proposed bicycle and pedestrian improvements ▪ "Other" enhancements (see section 5.3.5)	▪ State Route 84 (SR 84) Toll Booth Removal at FasTrak Lanes ▪ Shared Parking ▪ Decoto Road Transit Signal Priority and Queue Jump Lanes ▪ SR 84/Newark Boulevard HOV Bypass Lane ▪ SR 84 FasTrak Lane Extension ▪ SR 84 All Electronic Tolling ▪ Newark Park-and-Ride ▪ Ardenwood Park-and-Ride Expansion ▪ SR 84 Eastbound Bus-Only, HOV, or Express Lanes ▪ SR 84/Interstate 880 Bus-Only, HOV, or Express Lane Direct Connectors ▪ SR 84/Newark Boulevard Bus-Only, HOV, or Express Lane Direct Connectors ▪ FasTrak Lane Conversion to Bus-Only, HOV, or Express Lanes	▪ US 101/Marsh Road Bus-Only, HOV, or Express Lane Direct Connector ▪ Bayfront Expressway/Willow Road Transit Signal Priority and Queue Jump Lanes ▪ Bayfront Expressway Bus-Only, HOV, or Express Lanes ▪ Willow Road/ Bayfront Expressway Grade Separation ▪ University Avenue/ Bayfront Expressway Grade Separation ▪ Willow Road Bus-Only, HOV, or Express Lanes
Rail Bridge and ROW Options		
Rail Bridge	**East Bay Rail ROW**	**Peninsula Rail ROW**
BRT single-lane - 10-15 min headways	BRT operating in street – 10-15 min headways	BRT double-lane with bicycle and pedestrian multiuse path or rail adjacent
Commuter rail single-track - Shuttle	Commuter rail double-track - Shuttle	Commuter rail double-track with bicycle and pedestrian multiuse path or BRT adjacent
Commuter rail single-track - Commuter	Commuter rail double-track - Commuter	Commuter rail double-track with bicycle and pedestrian multiuse path or BRT adjacent
Commuter rail double-track - Commuter	Commuter rail double-track - Commuter	Commuter rail double-track with bicycle and pedestrian multiuse path or BRT adjacent

Source: SamTrans, 2016

7 Alternatives Carried Forward

Based on the outcomes of the initial alternatives screening (as described in Section 6.4), ten alternatives were assembled for modeling purposes and subsequent analysis. The alternatives are summarized briefly here, and in more detail in the following sections:

- Alternative 1: No Build (2020)
- Alternative 2: Short-Term Enhanced Bus on Highway Bridge (2020)
- Alternative 3: No Build (2030)
- Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes 4/2 (2030)
- Alternative 5: Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction 3/3 (2030)
- Alternative 6: Busway on Rail Bridge (2030)
- Alternative 7: Rail Shuttle on Rail Bridge (2030)
- Alternative 8: Rail Commuter Single-Track on Rail Bridge (2030)
- Alternative 9: Rail Commuter Double-Track on Rail Bridge (2030)
- Alternative 10: Combination Bus and Rail (2030)

Alternatives 1 and 2 present short-term conditions, including the No Build Alternative (2020) as well as enhanced bus service on the Highway Bridge and corresponding approach improvements. Alternatives 3-10 represent long-term conditions. Alternative 3 presents the long-term No Build condition (2030), to be used as a baseline for analysis. Alternatives 4 and 5 provide further enhanced bus service with different express lane options on the Highway Bridge as well as additional approach improvements. Alternatives 6–10 include development of the Rail Bridge and associated right-of-way (ROW). Specifically, Alternative 6 provides enhanced bus service on the Rail Bridge. Alterative 7 provides a commuter rail "shuttle" service on the Rail Bridge. Alternatives 8 and 9 provide commuter rail "commuter" service, with Alternative 8 being single-tracked across the Rail Bridge and Alternative 9 being double-tracked across the Rail Bridge. Alternative 10 provides an optimized combination of alternatives on the Highway Bridge and Rail Bridge.

The express lanes alternatives (Alternatives 4 and 5) were further defined with express lanes over bus-only or high-occupancy vehicle (HOV) lanes as they are targeted for the long-term. Express lanes would allow buses, HOVs and toll-paying vehicles to utilize specified lanes under specified conditions. Tolls, based on levels of congestion or time of day, could help manage demand while generating revenue for transit services and other improvements. Given these potential benefits, there was a desire to propose a continuous express lanes network across the

Highway Bridge with connectivity to US 101. It should be noted that existing legislation does not currently allow the conversion of a general-purpose lane to an express lane without intermediate HOV lanes. It is assumed that this legislation has been modified by the time the express lanes would be implemented.

Most arterial improvements were only included in the alternatives that propose enhanced bus service on the Highway Bridge (Alternatives 2, 4, and 5). However, several approach improvements were considered to be essential in reducing congestion in the Menlo Park area and are therefore included in the Rail Bridge alternatives as well. These approach improvements include Willow Road Express Lanes and grade separations at Willow Road/Bayfront Expressway and University Avenue/Bayfront Expressway. Approach improvements included in each alternative are described in more detail in the following sections.

To the extent possible, rail alternatives were defined as they were previously studied in the *Dumbarton Rail Corridor Environmental Impact Report*, including alignments, station locations, and operations. Key changes to the alternatives for the DTCS include the addition of intermediate stops at Palo Alto, Mountain View, and Sunnyvale in the Rail Commuter Alternatives (Alternatives 8 and 9) to better serve major employment destinations in the South Bay. Another change from the previous analysis was the investigation of a double-track alternative on the Rail Bridge (Alternative 9). This option was applied to the "highest capacity" rail option—the Rail Commuter Single-Track on Rail Bridge (Alternative 8)—but could potentially be applied to the Rail Shuttle on Rail Bridge (Alternative 7) as well.

Additionally, there is a bicycle and pedestrian multiuse path option on the Dumbarton Rail ROW from Redwood City to East Palo Alto. This option could potentially be paired with any of the alternatives described above. As detailed in **Appendix D**, there are some constraints within the typical 100-foot Dumbarton ROW due to the required widths associated with the various modes that could be implemented. The next phase of study after the DTCS will investigate creative ways to potentially accommodate a bicycle and pedestrian multiuse path on the ROW.

Lastly, some improvements brought forward for further analysis in the initial screening process (described in Chapter 6) were found to have fatal flaws. These alternatives include the two reversible HOV, bus-only or express lanes in the median on the Highway Bridge as well as shared parking. The two reversible express lanes on the Highway Bridge were found to not fit within the existing cross section of the Highway Bridge given the width associated with two permanent barriers. Shared parking opportunities were examined, but no viable locations were found in the immediate study area.

7.1 Highway Bridge and Approach Improvements

The short- and long-term No Build Alternatives (Alternatives 1 and 3) do not include improvements to the Highway Bridge or approaches.

Short-Term Enhanced Bus on the Highway Bridge (Alternative 2) assumes no improvements to the Highway Bridge, but recommends a number of short-term approach improvements. The express lanes alternatives (Alternatives 4 and 5) are the same except that they differentiate between two possible configurations of express lanes on the Highway Bridge. As previously mentioned, these alternatives were further defined with express lanes over bus-only or HOV lanes as they are targeted for the long-term. Each of these alternatives assumes additional, long-term approach improvements.

As described above, more approach improvements are included in the alternatives that propose enhanced bus on the Highway Bridge (Alternatives 2, 4, and 5) in an effort to make bus services more efficient and reliable. These alternatives also assume the deconstruction of the Rail Bridge, and so the Highway Bridge would need to provide greater transbay capacity to accommodate demand.

The alternatives that propose transit services on the Rail Bridge (Alternatives 6, 7, 8, and 9) do not include improvements on the Highway Bridge and have similar, minimal approach improvements because proposed transit service would use dedicated Rail ROW and the Rail Bridge, which would increase transbay capacity.

The Combination Bus and Rail (Alternative 10) provides an optimized combination of Highway and Rail Bridge improvements including Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction (Alternative 5). Therefore, Highway Bridge and approach improvements in Alternative 10 are the same as Alternative 5.

Table 7-1 summarizes the Highway Bridge and approach improvements included in each alternative.

Table 7-1: Highway Bridge and Approach Improvements

Alternative	Decoto Road from Union City BART to I 880	SR 84	FasTrak	Highway Bridge	Bayfront Expressway	Willow Road	US 101
1. No Build (2020)	--	--	--	--	--	--	--
2. Short-Term Enhanced Bus on Highway Bridge (2020)	▪ Transit Signal Priority (TSP) and queue jump lanes	▪ High-Occupancy Vehicle (HOV) bypass lane at Newark Boulevard	▪ Remove toll booths ▪ FasTrak lane extension to east of Paseo Parkway	--	▪ TSP and queue jump lanes ▪ Bus-only lanes	▪ TSP and queue jump lanes	--
3 No Build (2040)	--	--	--	--	--	--	--
4. Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes 4/2 (2030)	--	▪ New eastbound express lanes from toll plaza to I 880/ Decoto Road ▪ Express lanes direct connectors at I 880 ▪ Express lanes direct connectors at Newark Boulevard	▪ FasTrak lane conversion to express lane ▪ Convert to all-electronic tolling	▪ Reversible express lanes	▪ Express lanes from the Highway Bridge to Willow Road ▪ Grade separation at Willow Road ▪ Grade separation at University Avenue	▪ Grade separation at Bayfront Expressway (same as previous column) ▪ Express lanes direct connection from SR 84 ▪ Express lanes ▪ Express lanes flyover connection to US 101	▪ Express lanes direct connector at Marsh Road

Alternative	Decoto Road from Union City BART to I 880	SR 84	FasTrak	Highway Bridge	Bayfront Expressway	Willow Road	US 101
5. Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction 3/3 (2030)	--	▪ New eastbound express lanes from toll plaza to I 880/Decoto Road ▪ Express lanes direct connectors at I 880 ▪ Express lanes direct connectors at Newark Boulevard	▪ FasTrak lane conversion to express lane ▪ Convert to all-electronic tolling	▪ One express lane in each direction	▪ Express lanes from the Highway Bridge to Willow Road ▪ Grade separation at Willow Road ▪ Grade separation at University Avenue	▪ Grade separation at Bayfront Expressway (same as previous column) ▪ Express lanes direct connection from SR 84 ▪ Express lanes ▪ Express lanes flyover connection to US 101	▪ Express lanes direct connector at Marsh Road
6. Busway on Rail Bridge (2030)	--	--	--	--	▪ Grade separation at Willow Road ▪ Grade separation at University Avenue	▪ Grade separation at Bayfront Expressway (same as previous column) ▪ Express lanes ▪ Express lanes flyover connection to US 101	--
7. Rail Shuttle on Rail Bridge (2030)	--	--	--	--	▪ Grade separation at Willow Road ▪ Grade separation at University Avenue	▪ Grade separation at Bayfront Expressway (same as previous column) ▪ Express lanes ▪ Express lanes flyover connection to US 101	--

Alternative	Decoto Road from Union City BART to I 880	SR 84	FasTrak	Highway Bridge	Bayfront Expressway	Willow Road	US 101
8. Rail Commuter Single-Track on Rail Bridge (2030)	--	--	--	--	▪ Grade separation at Willow Road ▪ Grade separation at University Avenue	▪ Grade separation at Bayfront Expressway (same as previous column) ▪ Express lanes ▪ Express lanes flyover connection to US 101	--
9. Rail Commuter Double-Track on Rail Bridge (2030)	--	--	--	--	▪ Grade separation at Willow Road ▪ Grade separation at University Avenue	▪ Grade separation at Bayfront Expressway (same as previous column) ▪ Express lanes ▪ Express lanes flyover connection to US 101	--
10. Combination Bus and Rail (2030)	--	▪ New eastbound express lanes from toll plaza to I 880/Decoto Road ▪ Express lanes direct connectors at I 880 ▪ Express lanes direct connectors at Newark Boulevard	▪ FasTrak lane conversion to express lane ▪ Convert to all-electronic tolling	▪ One express lane in each direction	▪ Express lanes from the Highway Bridge to Willow Road ▪ Grade separation at Willow Road ▪ Grade separation at University Avenue	▪ Grade separation at Bayfront Expressway (same as previous column) ▪ Express lanes direct connection from SR 84 ▪ Express lanes ▪ Express lanes flyover connection to US 101	▪ Express lanes direct connector at Marsh Road

Source: CDM Smith, 2017

Transit service dependent upon the Highway Bridge and approach improvements is included in Alternatives 2, 4, 5, and 10. Such bus service includes enhanced service on Dumbarton Express (DB) and Dumbarton Express 1 (DB1) as well as two new routes from Union City BART to Menlo Park/Redwood City and Union City BART to Mountain View/Sunnyvale. Each of these routes would utilize the Highway Bridge and approach improvements. As noted in Chapter 5, route DB1 service is modified to originate at Fremont BART.

7.2 Rail Bridge and ROW Improvements

The Rail Bridge would be deconstructed as part of the No Build Alternatives (Alternatives 1 and 3) as well as the alternatives that propose enhanced bus on the Highway Bridge (Alternatives 2, 4, and 5). Rail Bridge reconstruction is assumed for all alternatives that propose service on the Rail Bridge and associated ROW (Alternatives 6-10).

Busway on Rail Bridge (Alternative 6) assumes bus service similar to the enhanced bus service on the Highway Bridge included in Alternatives 2, 4, and 5, except that the service would primarily operate on the Rail Bridge and associated ROW. Such bus service includes enhanced DB and DB1 service as well as two new routes from Union City BART to Menlo Park/Redwood City and Union City BART to Mountain View/Sunnyvale.

The Rail Shuttle on Rail Bridge (Alternative 7) proposes frequent commuter rail shuttle service between Union City BART and Redwood City Caltrain. Complimentary shuttle bus service is provided from the Redwood City Caltrain Station to employment destinations provided by the DB, DB1, and Mountain View/Sunnyvale routes.

The Rail Commuter alternatives on the Rail Bridge (Alternatives 8 and 9) propose less frequent commuter rail service from Union City BART to San Francisco and San Jose, interlining with the Caltrain mainline (operating on the Caltrain mainline tracks). The primary difference between the two alternatives is that one is single-tracked and the other is double-tracked across the Rail Bridge, providing additional capacity. Complimentary shuttle bus service is provided from the Palo Alto Caltrain Station to the Stanford Research Park.

While previous operational analysis showed that one northbound and one southbound Rail Commuter train per hour could use the Caltrain mainline under the blended system operations plan, (blending future Caltrain and HSR services) such operations would need to be reexamined after HSR more clearly identifies operational needs in the Corridor.

Additionally, an electrified system is assumed for the alternatives that would interline with the Caltrain mainline (Alternatives 8 and 9). Clean Diesel Multiple Units (DMUs) are assumed for the Rail Shuttle on Rail Bridge (Alternative 7).

Combination Bus and Rail (Alternative 10) would provide an optimized combination of Highway and Rail Bridge improvements including Rail Commuter Double-Track on Rail Bridge (Alternative 9). Therefore, Rail Bridge improvements in Alternative 10 are the same as Alternative 9.

It should be noted that proposed rail operations in the East Bay (applicable to Alternatives 7–10) are based on assumptions from the previous study. Proposed rail operations need to be reviewed and potentially modified in the next phase of study based on coordination with Union Pacific Railroad (UP), the owner of freight lines extending to Union City, beyond the Dumbarton Rail ROW owned by SamTrans.

Table 7-2 summarizes proposed Rail Bridge improvements.

Table 7-2: Rail Bridge and ROW Improvements

Alternative	Improvement
1. No Build (2020)	Deconstruction
2. Short-Term Enhanced Bus on Highway Bridge (2020)	Deconstruction
3 No Build (2030)	Deconstruction
4. Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes 4/2 (2030)	Deconstruction
5. Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction 3/3 (2030)	Deconstruction
6. Busway on Rail Bridge (2030)	Enhanced bus service from Union City BART to Stanford University, Fremont BART to Stanford Research Park and Union City BART to Menlo Park/Redwood City and Mountain View/Sunnyvale using Rail Bridge and associated ROW
7. Rail Shuttle on Rail Bridge (2030)	Bi-directional commuter Rail Shuttle service from Union City BART to Redwood City Caltrain
8. Rail Commuter Single-Track on Rail Bridge (2030)	Single-track Rail Commuter service from Union City BART to San Francisco and San Jose in the morning peak; all trains reverse in evening peak
9. Rail Commuter Double-Track on Rail Bridge (2030)	Double-track and bidirectional Rail Commuter service from Union City BART to San Francisco and San Jose
10. Combination Bus and Rail (2030)	Double-track and bidirectional Rail Commuter service from Union City BART to San Francisco and San Jose

Source: CDM Smith, 2017

7.3 Bicycle and Pedestrian Improvements

In addition to Alternatives 1-10, there is the option to include a bicycle and pedestrian multiuse path on the Peninsula ROW from Redwood City to East Palo Alto in conjunction with any of the bus or rail alternatives. The Peninsula ROW is approximately 100-feet wide and therefore has some constraints due to the width needed for various modes. Additional information about modal ROW requirements and best practices is included in **Appendix D**. The next phase of study after the DTCS will investigate creative ways to most efficiently utilize the 100-foot ROW.

The following sections summarize the proposed Highway Bridge and approach improvements and Rail Bridge and ROW improvements for each alternative. Additional details about each alternative, including transit stop locations, can be found in the operating plan factsheets, included as **Appendix E**.

7.4 Alternative 1: No Build (2020)

Alternative 1, the short-term No Build Alternative, is included for comparison purposes to assess the relative benefits and impacts of implementing short-term alternatives under consideration.

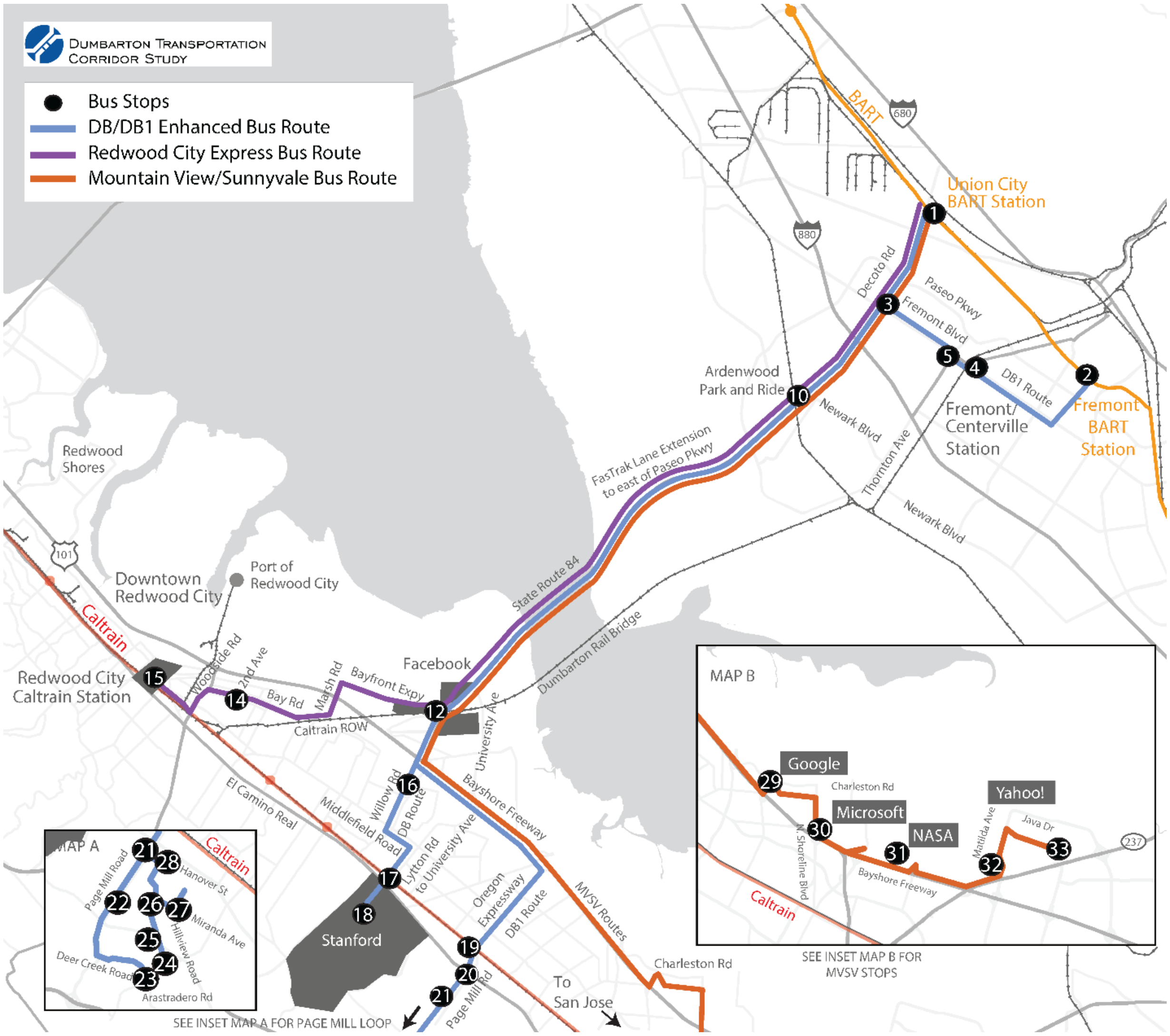
- **Highway Bridge and Approach Improvements**: No improvements would be made to the Highway Bridge or the approaches.
- **Rail Bridge and ROW Improvements**: The Rail Bridge would be deconstructed. The Peninsula ROW could be used for another purpose.

7.5 Alternative 2: Short-Term Enhanced Bus on Highway Bridge (2020)

Alternative 2 is a short-term alternative that includes enhanced express bus service on the Dumbarton Highway Bridge and select approach improvements to increase flow and access to and from the Dumbarton Highway Bridge. **Figure 7-1** shows the improvements that would occur as part of Alternative 2. **Appendix E** contains operating plan factsheets.

- **Highway Bridge and Approach Improvements**: No improvements would be made to the Highway Bridge.
  - Approach improvements in the East Bay include the following:
    - Decoto Road transit signal priority and queue jump lanes I 880 east to Union City BART
    - SR 84/Newark Boulevard HOV bypass lane
    - SR 84 Toll booth removal at FasTrak lanes, FasTrak lane extension to east of Paseo Padre Parkway
  - Approach improvements on the Peninsula include the following:
    - Bayfront Expressway and Willow Road transit signal priority and queue jump lanes
    - Bayfront Expressway bus-only lanes

Figure 7-1: Alternative 2



Source: CDM Smith, 2017

Alternative 2 would increase existing bi-directional route DB and DB1 bus service and add two new routes between Union City and Menlo Park/Redwood City and Union City and Mountain View/Sunnyvale. Alternative 2 assumes 38 standard buses would be used (17 of which are existing). **Table 7-3** summarizes the bus route service hours and frequency.

Table 7-3: Alternative 2 Bus Route Service Hours and Headways

Route Name	Route	Headways (minutes)			
		AM Peak 6AM – 9AM	Mid-Day 9AM – 3PM	PM Peak 3PM – 7PM	Evening 7PM – 10PM
DB	Union City BART to Stanford University	15	20	15	20
DB1	Fremont BART to Stanford Research Park	15	20	15	20
MP/RWC	Union City BART to Menlo Park and Redwood City Caltrain	15	20	15	20
MV/S	Union City BART to Mountain View/ Sunnyvale	15	30	15	30

Source: CDM Smith, 2017

- **Rail Bridge and ROW Improvements**: The Rail Bridge is assumed to be deconstructed. The ROW could be used for another purpose.

7.6 Alternative 3: No Build (2030)

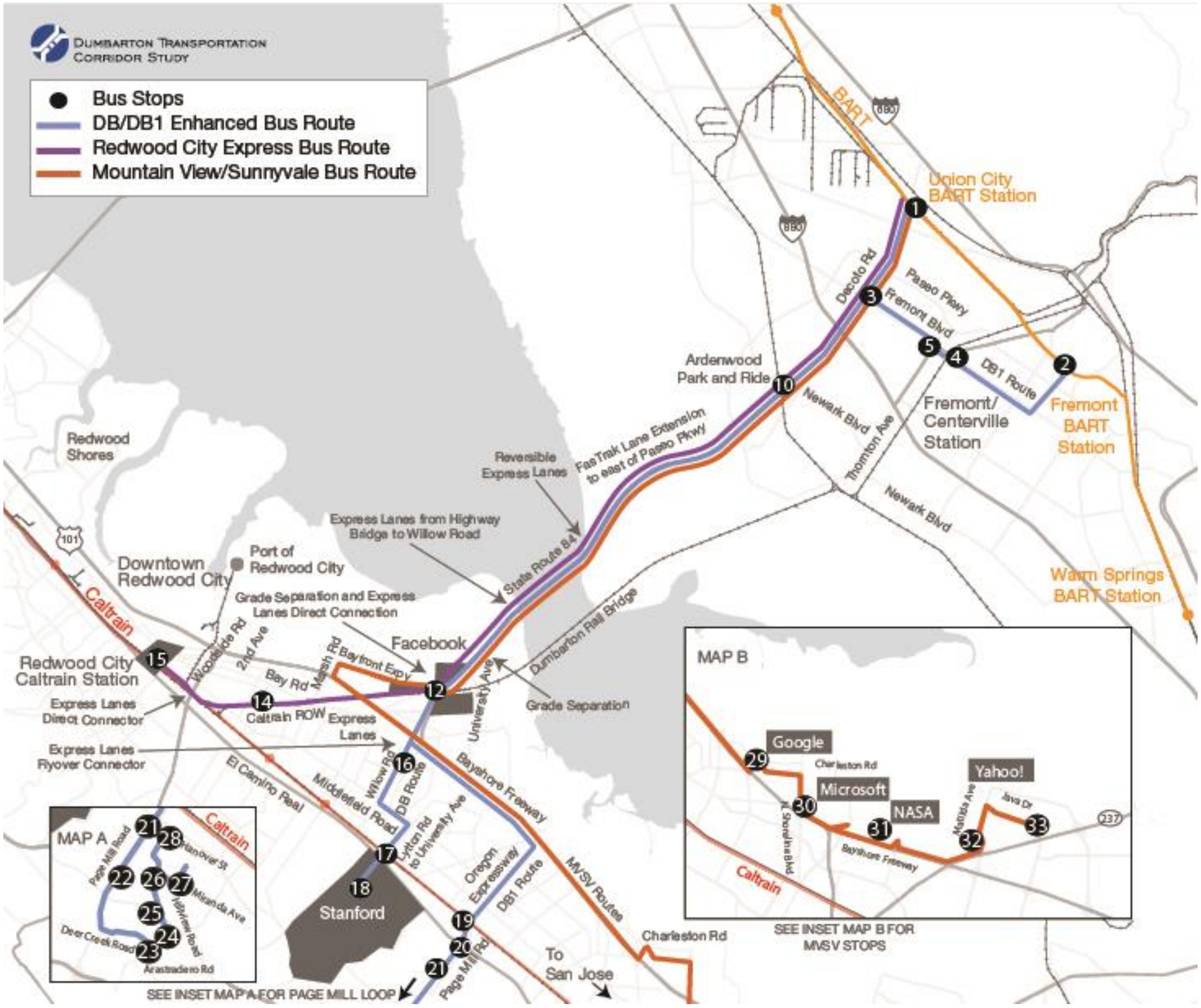
Alternative 3 is the long-term No Build Alternative. Similar to Alternative 1, it is included for comparison purposes to assess the relative benefits and impacts of implementing the long-term alternatives under consideration.

- **Highway Bridge and Approach Improvements**: No improvements would be made to the Highway Bridge or the approaches.
- **Rail Bridge and ROW Improvements**: The Rail Bridge would be deconstructed. The ROW could be used for another purpose.

7.7 Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes 4/2 (2030)

Alternative 4 is a long-term alternative that includes enhanced express bus service operating in reversible express lanes on the Highway Bridge with additional approach improvements beyond those suggested for 2020. These additional approach improvements include ways to create a continuous express lanes network connecting I 880 to US 101. Approach improvements would further increase flow and access to and from the Dumbarton Highway Bridge. **Figure 7-2** shows the improvements that would occur as part of Alternative 4. **Appendix E** contains operating plan factsheets.

Figure 7-2: Alternative 4



Source: CDM Smith, 2017

- **Highway Bridge and Approach Improvements**: Alternative 4 includes reversible express lanes on the Highway Bridge, which would provide an additional lane of capacity for buses, HOVs and toll-paying vehicles in the peak direction in the morning and evening. Reversible express lanes require a movable barrier that would be adjusted with a “Zipper” vehicle based on time of day.
  - Approach improvements in the East Bay include the following:
    - SR 84 eastbound express lanes from toll plaza to I 880/Decoto Road
    - SR 84/I 880 express lanes direct connectors
    - SR 84 FasTrak lane conversion to express lane
    - SR 84 all-electronic tolling

    - Ardenwood Park-and-Ride expansion (includes SR 84/Newark Boulevard express lanes direct connectors)

- Approach improvements on the Peninsula include the following:
    - Bayfront Expressway express lanes from the Highway Bridge to Willow Road
    - Willow Road/Bayfront Expressway grade separation (includes SR 84 to Willow Road express lanes direct connection)
    - University Avenue/Bayfront Expressway grade separation
    - Willow Road express lanes in addition to supporting facilities such as Willow Road to US 101 express lanes flyover connection
    - US 101/Marsh Road express lanes direct connector

Alternative 4 would further increase bi-directional routes DB and DB1 service along the Highway Bridge. Routes between Union City and Menlo Park/Redwood City and Union City and Mountain View/Sunnyvale would also operate at greater frequencies. The bus route that serves Menlo Park/Redwood City would use the Dumbarton Rail ROW on the Peninsula, which would include a dedicated busway in the ROW and replacement of the Rail Bridge over US 101. Routes DB and DB1 would use express lanes along Willow Road. The route that serves Mountain View/Sunnyvale would use express lanes along Bayfront Expressway. A transit center would be constructed at Willow Road. This alternative assumes the use of 52 double-decker buses. **Table 7-4** summarizes the bus route service hours and frequency.

Table 7-4: Alternative 4 Bus Route Service Hours and Headways

Route Name	Route	Headways (minutes)			
		AM Peak 6AM – 9AM	Mid-Day 9AM – 3PM	PM Peak 3PM – 7PM	Evening 7PM – 10PM
DB	Union City BART to Stanford University	10	15	10	15
DB1	Fremont BART to Stanford Research Park	10	15	10	15
MP/RWC	Union City BART to Menlo Park and Redwood City Caltrain	10	15	10	15
MV/S	Union City BART to Mountain View/Sunnyvale	10	20	10	20

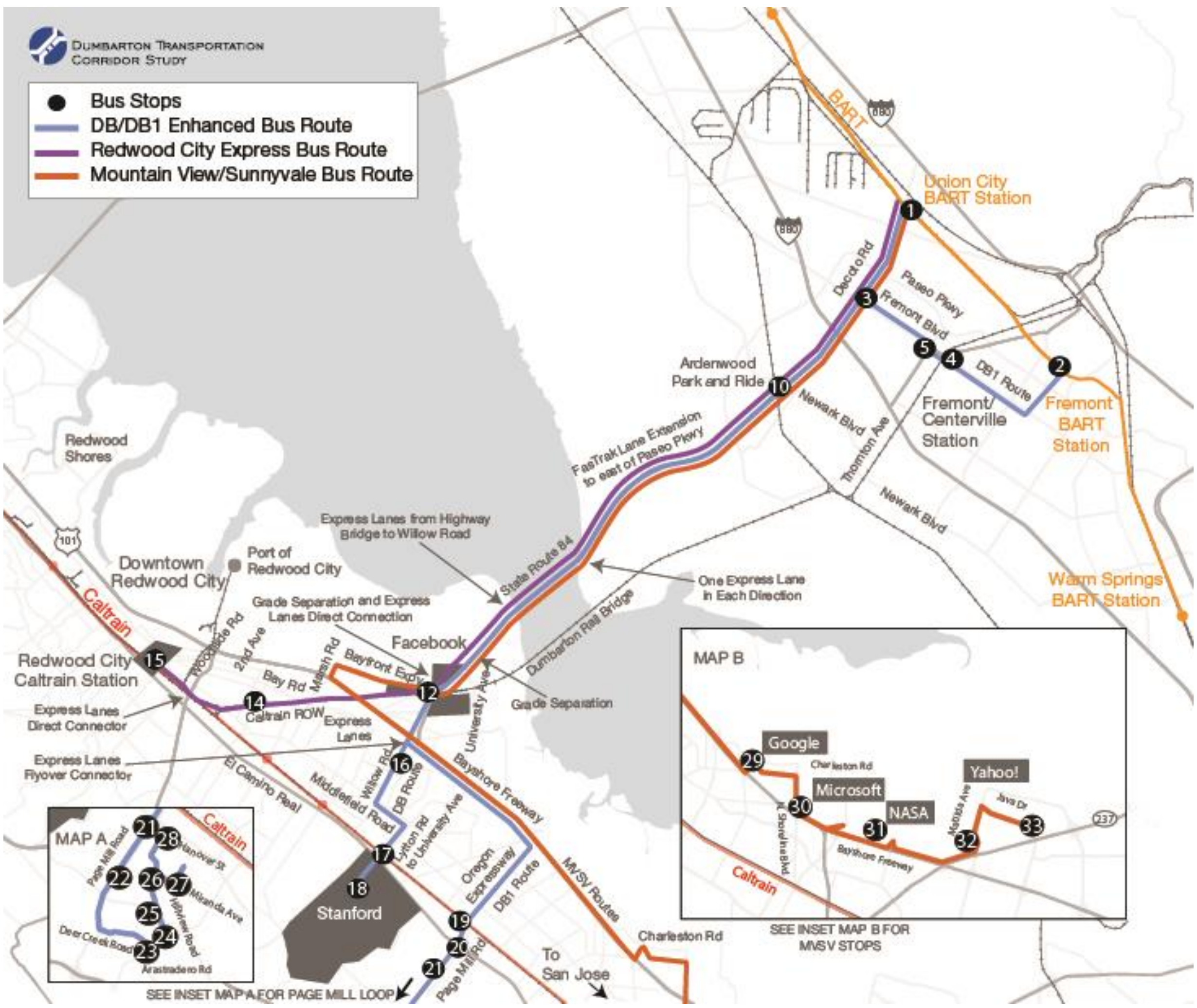
Source: CDM Smith, 2017

- **Rail Bridge and ROW Improvements:** The Rail Bridge would be deconstructed. The ROW could be used for another purpose.

7.8 Alternative 5: Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction (2030)

Alternative 5 is a long-term alternative that includes enhanced express bus service operating in one express lane in each direction on the Highway Bridge with additional approach improvements beyond those suggested for 2020. These additional approach improvements include ways to create a continuous express lanes network connecting I 880 to US 101. Approach improvements are identical to what is included in Alternative 4 and would increase flow and access to and from the existing Dumbarton Highway Bridge. **Figure 7-3** shows the improvements that would occur as part of Alternative 5. **Appendix E** contains operating plan factsheets.

Figure 7-3: Alternative 5



Source: CDM Smith, 2017

- **Highway Bridge and Approach Improvements**: Alternative 5 includes one express lane in each direction on the Highway Bridge, which would be available for buses, HOVs and toll-paying vehicles.

- Approach improvements in the East Bay include the following:
  - SR 84 eastbound express lanes from toll plaza to I 880/Decoto Road
  - SR 84/I 880 express lanes direct connectors
  - SR 84 FasTrak lane conversion to express lane
  - SR 84 all-electronic tolling
  - Ardenwood Park-and-Ride expansion (includes SR 84/Newark Boulevard express lanes direct connectors)
- Approach improvements on the Peninsula include the following:
  - Bayfront Expressway express lanes from the Highway Bridge to Willow Road
  - Willow Road/Bayfront Expressway grade separation (includes SR 84 to Willow Road express lanes direct connection)
  - University Avenue/Bayfront Expressway grade separation
  - Willow Road express lanes in addition to supporting facilities such as Willow Road to US 101 express lanes flyover connection
  - US 101/Marsh Road express lanes direct connector

Bus service included as part of Alternative 5 is identical to Alternative 4. Alternative 5 would increase existing bi-directional routes DB and DB1 service along the Highway Bridge. Routes between Union City and Menlo Park/Redwood City and Union City and Mountain View/Sunnyvale would also operate at greater frequencies. Bus routes that serve Menlo Park/Redwood City would use the Dumbarton Rail ROW on the Peninsula, which would include a dedicated busway in the ROW and replacement of the US 101 bridge. Routes DB and DB1 would use express lanes along Willow Road. Routes that serve Mountain View/Sunnyvale would use express lanes along Bayfront Expressway. A transit center would be constructed at Willow Road. This alternative assumes the use of 52 double-decker buses. **Table 7-5** summarizes the bus route service hours and frequency.

Table 7-5: Alternative 5 Bus Route Service Hours and Headways

Route Name	Route	Headways (minutes)			
		AM Peak 6AM – 9AM	Mid-Day 9AM – 3PM	PM Peak 3PM – 7PM	Evening 7PM – 10PM
DB	Union City BART to Stanford University	10	15	10	15
DB1	Fremont BART to Stanford Research Park	10	15	10	15
MP/RWC	Union City BART to Menlo Park and Redwood City Caltrain	10	15	10	15
MV/S	Union City BART to Mountain View/Sunnyvale	10	20	10	20

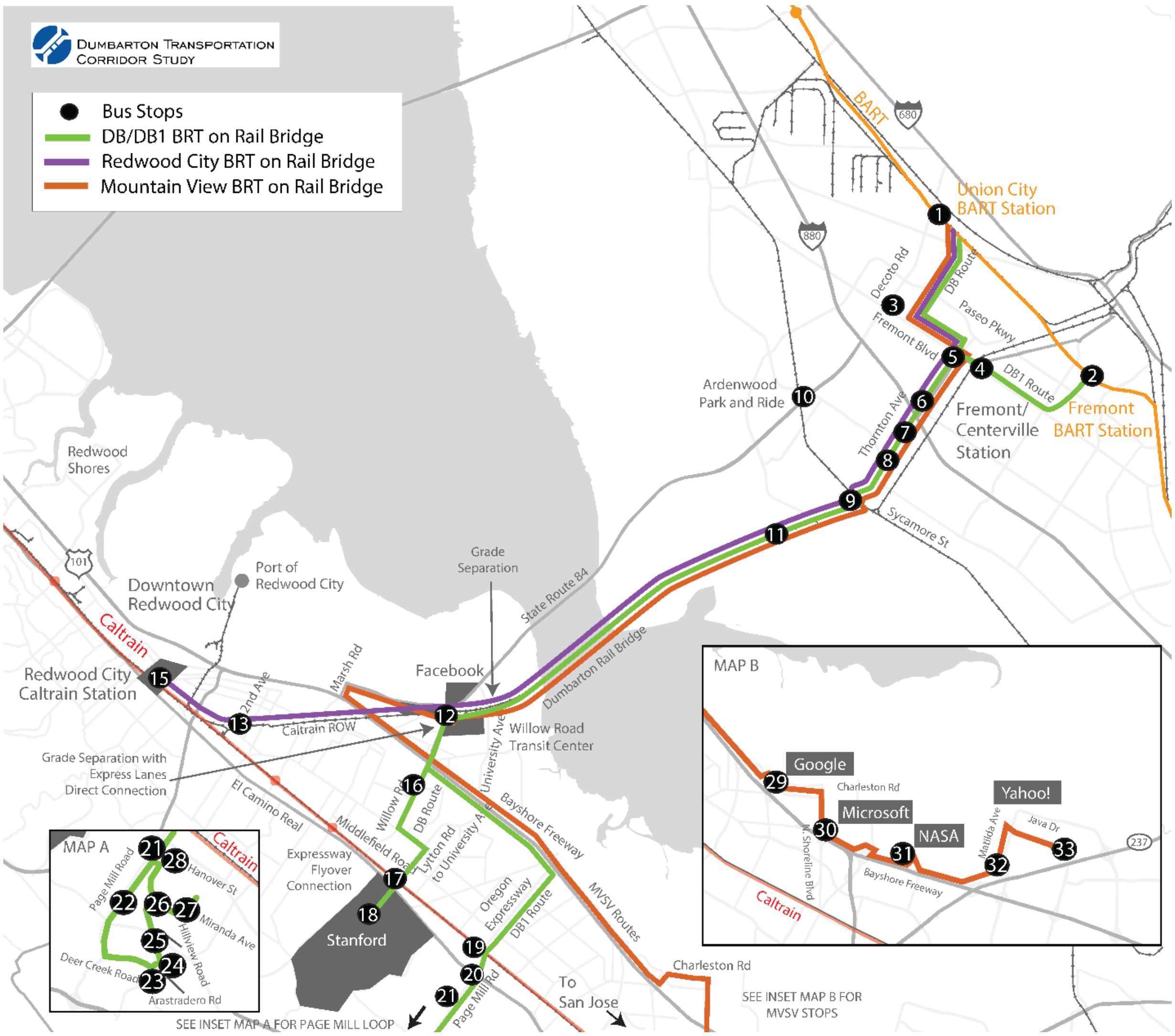
Source: CDM Smith, 2017

- **Rail Bridge Improvements**: The Rail Bridge would be deconstructed. The ROW could be used for another purpose.

7.9 Alternative 6: Busway on Rail Bridge (2030)

Alternative 6 is a long-term alternative that includes bus service on the Dumbarton Rail Bridge and associated ROW. The alternative assumes complete restoration of the Dumbarton Rail Bridge. The alternative would also provide a few approach improvements to improve travel speed and reliability in the particularly congested area around Bayfront Expressway/Willow Road and Bayfront Expressway/University Avenue on the Peninsula. **Figure 7-4** shows the improvements that would occur as part of Alternative 6. **Appendix E** contains operating plan factsheets.

Figure 7-4: Alternative 6



Source: CDM Smith, 2017

- **Highway Bridge and Approach Improvements**: No improvements would be made to the Highway Bridge as part of Alternative 6.
  - Approach improvements in the East Bay include the following:
    - New Newark Park-and-Ride
  - Approach improvements on the Peninsula include the following:
    - Willow Road/Bayfront Expressway grade separation
    - University Avenue/Bayfront Expressway grade separation
    - Willow Road express lanes and supporting facilities such as Willow Road to US 101 expressway flyover connection
- **Rail Bridge and ROW Improvements**: The Busway on Rail Bridge (Alternative 6) includes similar enhanced bus service as Alternatives 4 and 5 except that it would operate on the Rail Bridge instead of the Highway Bridge after starting on East Bay roadways. The Rail Bridge and Peninsula ROW would be improved to become a dedicated busway, and all transbay bus routes (DB, DB1, Menlo Park/Redwood City and Mountain View/Sunnyvale) would run along the Rail Bridge traveling east to west. Bus service would reverse using the Highway Bridge (with fewer stops in the non-peak direction) since there would just be a single lane on the Rail Bridge. Buses that serve Menlo Park/Redwood City would use the Dumbarton Rail ROW on the Peninsula, which would include a dedicated busway in the ROW and replacement of the US 101 bridge. Routes DB and DB1 would use express lanes along Willow Road. A transit center would be constructed at Willow Road. This alternative assumes the use of 51 double-decker buses. **Table 7-6** summarizes the bus route service hours and frequency.

Table 7-6: Alternative 6 Bus Route Service Hours and Headways

Route Name	Route	Headways (minutes)			
		AM Peak 6AM – 9AM	Mid-Day 9AM – 3PM	PM Peak 3PM – 7PM	Evening 7PM – 10PM
DB	Union City BART to Stanford University	10	15	10	15
DB1	Fremont BART to Stanford Research Park	10	15	10	15
MP/RWC	Union City BART to Menlo Park and Redwood City Caltrain	10	15	10	15
MV/S	Union City BART to Mountain View/Sunnyvale	10	20	10	20

Source: CDM Smith, 2017

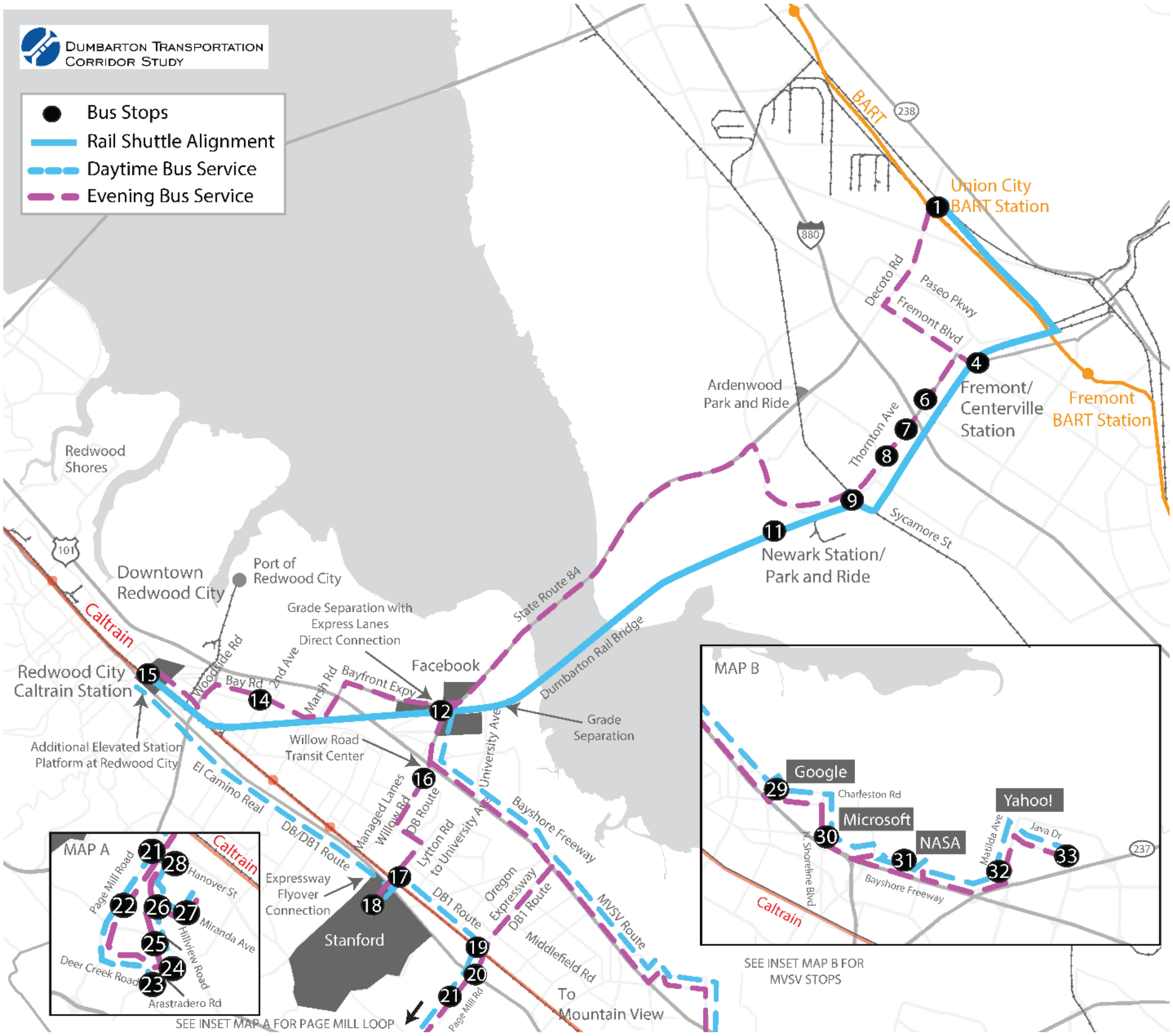
7.10 Alternative 7: Rail Shuttle on Rail Bridge (2030)

Alternative 7 is a long-term rail alternative that includes commuter rail service acting as a "Shuttle" between Union City and Redwood City. Therefore, this alternative assumes complete restoration of the Rail Bridge. Complimentary bus service would operate during the day from the Redwood City Caltrain Station and new Willow Road Station to destinations served by routes DB, DB1 as well as the route to Mountain View/Sunnyvale. Complimentary bus service similar to routes DB, DB1 and the routes to Menlo Park/Redwood City and Mountain View/Sunnyvale would operate after the conclusion of Rail Shuttle service in the evening.

The alternative would also provide a few approach improvements to improve travel speed and reliability in the particularly congested area around Bayfront Expressway/Willow Road and Bayfront Expressway/University Avenue on the Peninsula.

Figure 7-5 shows the improvements that would occur as part of Alternative 7. **Appendix E** contains operating plan factsheets.

Figure 7-5: Alternative 7



Source: CDM Smith, 2017

- **Highway Bridge and Approach Improvements**: No improvements would be made to the Highway Bridge as part of Alternative 7.
  - Approach improvements in the East Bay include the following:
    - New Newark Park-and-Ride
  - Approach improvements on the Peninsula include the following:
    - Willow Road/Bayfront Expressway grade separation
    - University Avenue/Bayfront Expressway grade separation
    - Willow Road express lanes and supporting facilities such as Willow Road to US 101 expressway flyover connection

To help forge first and last mile connections to major employment centers, Alternative 7 would provide complimentary daytime bus service from Redwood City to Stanford University and Stanford Research Park, as well as service from the Willow Road Transit Center to Mountain View/Sunnyvale. Complimentary evening bus service would be provided from Union City BART to Stanford University (DB), Fremont BART to Stanford Research Park (DB1), Union City BART to Menlo Park/Redwood City and Union City BART to Mountain View/Sunnyvale after the Shuttle stops operating. Bus routes DB, DB1, and Mountain View/Sunnyvale would use express lanes along Willow Road. This alternative assumes the use of 28 standard buses. **Table 7-7** summarizes the bus route service hours and frequency.

Table 7-7: Alternative 7 Bus Route Service Hours and Headways

Route Name	Route	Headways (minutes)			
		AM Peak 6AM – 9AM	Mid-Day 9AM – 3PM	PM Peak 3PM – 7PM	Evening 7PM – 10PM
DB	Union City BART (evening)/Redwood City Caltrain (daytime) to Stanford University	15	30	15	20
DB1	Fremont BART (evening)/Redwood City Caltrain (daytime) to Stanford Research Park	15	30	15	20
MP/RWC	Union City BART to Redwood City Caltrain	N/A	N/A	N/A	20
MV/S	Union City BART (evening)/Redwood City Caltrain (daytime) to Mountain View/Sunnyvale	15	30	15	20

Source: CDM Smith, 2017

- **Rail Bridge and ROW Improvements**: The UP mainline and Dumbarton Rail Bridge and ROW would provide an exclusive bi-directional Rail Shuttle service from Union City BART to the Redwood City Caltrain Station with intermediate stops at the Fremont Centerville Station, new Newark Station (with park-and-ride) and new Willow Road Transit Station. The Rail Bridge would be single-tracked with double tracks on the peninsula ROW. An additional station platform would be needed in Redwood City where passengers would need to make a cross-platform transfer if they want to continue onto Caltrain mainline service. The Rail Shuttle would operate at 15-minute headways during the morning and evening peak periods and 30-minute headways during the daytime. The Rail Shuttle would run from 6 AM to 7 PM. The Rail Shuttle would run DMU cabs and cars; 23 DMUs are assumed.

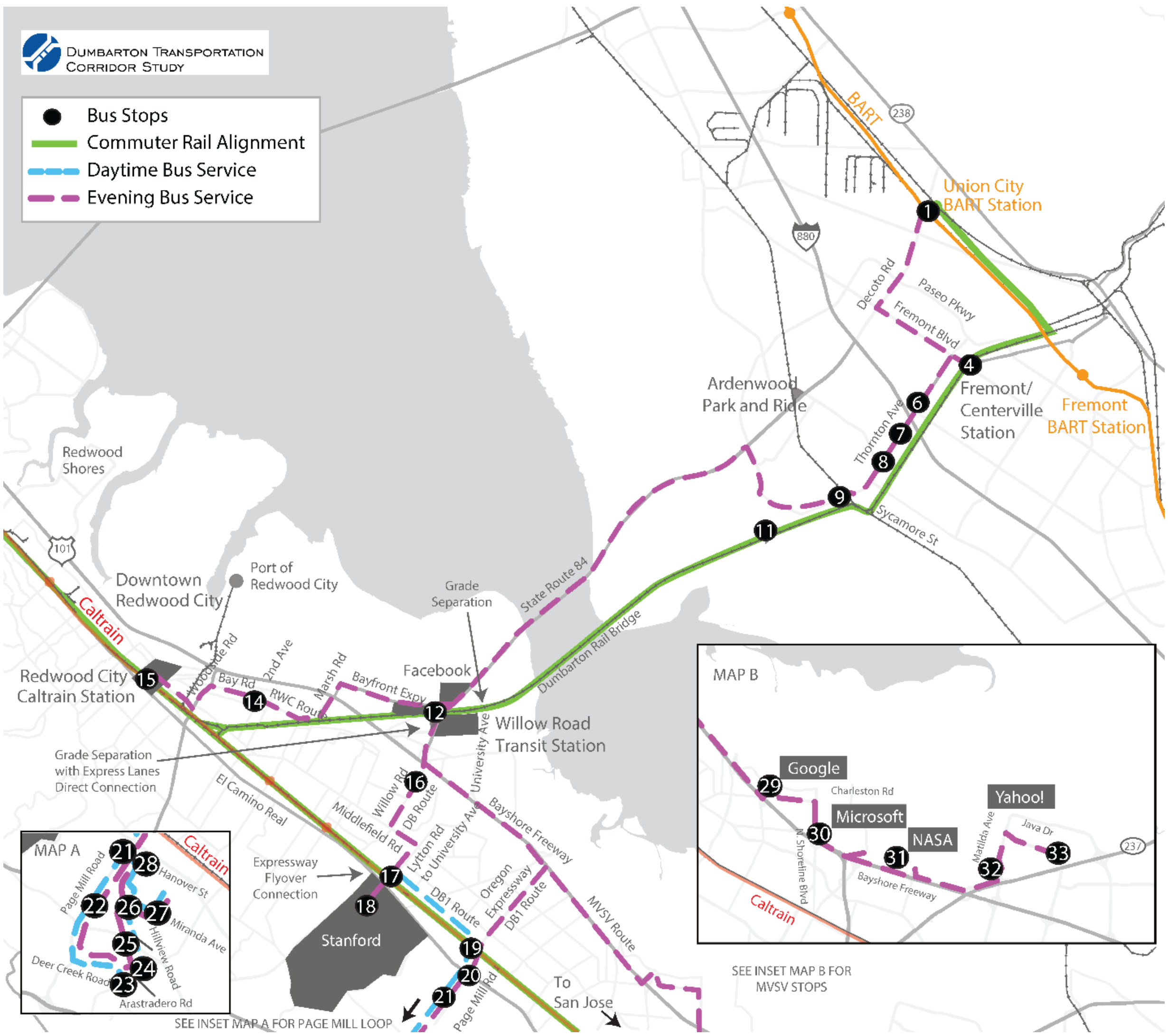
7.11 Alternative 8: Rail Commuter Single-Track on Rail Bridge (2030)

Alternative 8 is a long-term rail alternative that includes commuter rail “Commuter” service between Union City and San Francisco and San Jose. Therefore, this alternative assumes complete restoration of the Rail Bridge, which would be single-tracked. Complimentary bus service would operate during the day from Palo Alto Caltrain to destinations served by route DB1. Complimentary bus service similar to routes DB, DB1, and the routes to Menlo Park/Redwood City and Mountain View/Sunnyvale would operate after the conclusion of Rail Commuter service in the evening.

The alternative would also provide a few approach improvements to improve travel speed and reliability in the particularly congested area around Bayfront Expressway/Willow Road and Bayfront Expressway/University Avenue on the Peninsula.

Figure 7-6 shows the improvements that would occur as part of Alternative 8. **Appendix E** contains operating plan factsheets.

Figure 7-6: Alternative 8



Source: CDM Smith, 2017

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- **Highway Bridge and Approach Improvements**: No improvements would be made to the Highway Bridge as part of Alternative 8.
  - Approach improvements in the East Bay include the following:
    - New Newark Park-and-Ride
  - Approach improvements on the Peninsula include the following:
    - Willow Road/Bayfront Expressway grade separation
    - University Avenue/Bayfront Expressway grade separation
    - Willow Road express lanes and supporting facilities such as Willow Road to US 101 expressway flyover connection

To help forge first and last mile connections to major employment centers, Alternative 8 would provide complimentary daytime bus service from the Palo Alto Caltrain Station to the Stanford Research Park. Complimentary evening bus service would be provided from Union City BART to Stanford University (DB), Fremont BART to Stanford Research Park (DB1), Union City BART to Menlo Park/Redwood City and Union City BART to Mountain View/Sunnyvale after the Rail Commuter stops operating. Bus routes DB, DB1, and Mountain View/Sunnyvale would use express lanes along Willow Road. This alternative assumes the use of 28 standard buses. **Table 7-8** summarizes the bus route service hours and frequency.

Table 7-8: Alternative 8 Bus Route Service Hours and Headways

Route Name	Route	Headways (minutes)			
		AM Peak 6AM – 9AM	Mid-Day 9AM – 3PM	PM Peak 3PM – 7PM	Evening 7PM – 10PM
DB	Union City BART to Stanford University	N/A	N/A	N/A	20
DB1	Fremont BART (evening)/Palo Alto Caltrain (daytime) to Stanford Research Park	15	30	15	20
MP/RWC	Union City BART to Menlo Park and Redwood City Caltrain	N/A	N/A	N/A	20
MV/S	Union City BART to Mountain View/Sunnyvale	N/A	N/A	N/A	20

Source: CDM Smith, 2017

- **Rail Bridge and ROW Improvements**: The UP mainline, Dumbarton Rail Bridge and ROW as well as the Caltrain mainline would provide an exclusive single-directional commuter rail service from Union City BART to San Francisco and San Jose. Between Union City BART and San Francisco, trains would make intermediate stops at the Fremont Centerville Station, new Newark Station (with park-and-ride), new Willow Road Transit Station, and the Redwood City Caltrain Station before expressing to San Francisco. Between Union City BART and San Jose, trains would make intermediate stops at the Fremont Centerville Station, new Newark Station (with park-and-ride), new Willow Road Transit Station, Palo

Alto Caltrain, Mountain View Caltrain, and Sunnyvale Caltrain before expressing to San Jose. The Rail Bridge would be single-tracked with double tracks on the peninsula ROW. Northbound and southbound trains would run at 60-minute headways from 6 AM to 7 PM; trains would run reverse during the evening peak. The route would run electric multiple units (EMUs) cars and trailers; 30 EMUs are assumed.

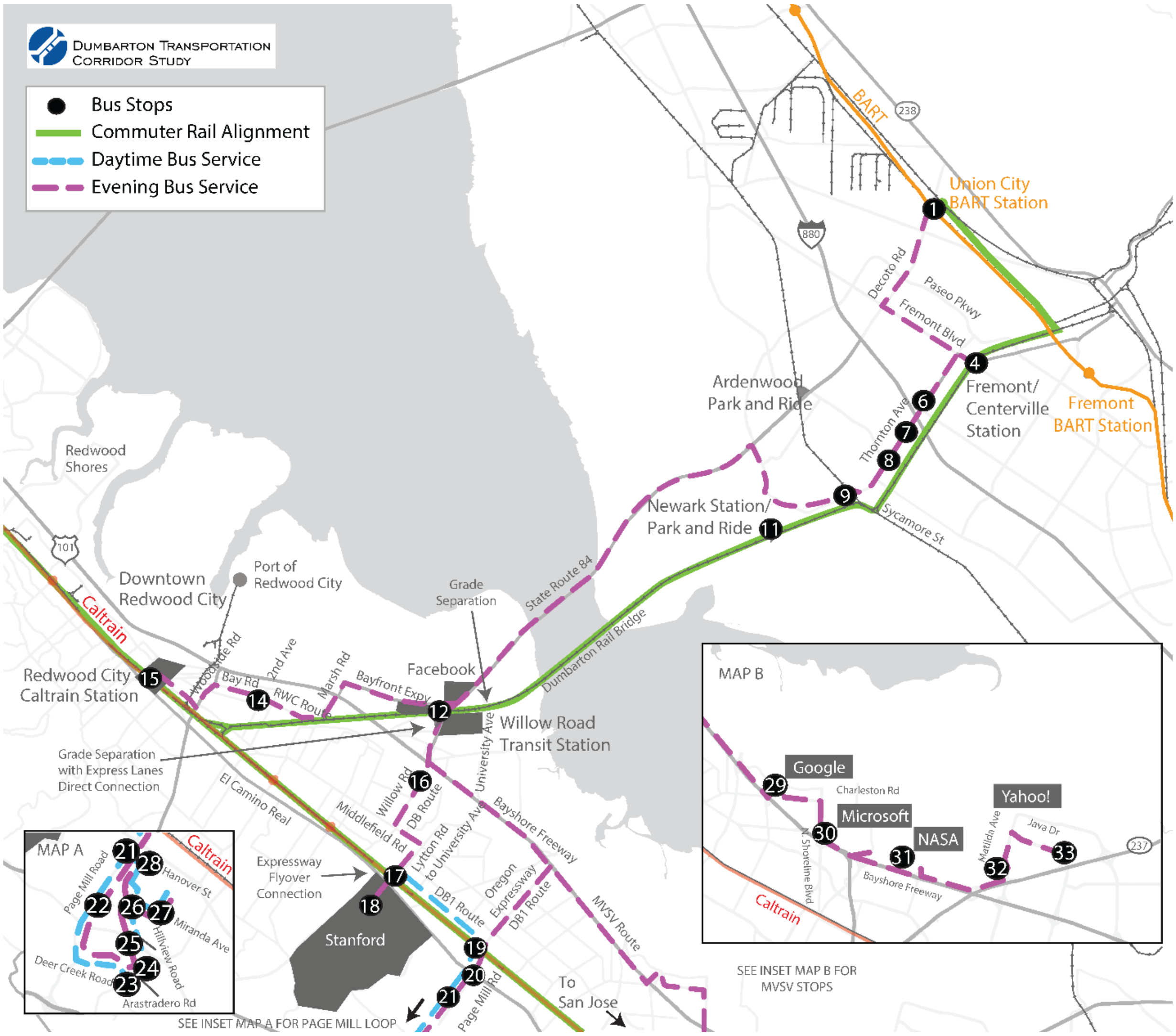
7.12 Alternative 9: Rail Commuter Double-Track on Rail Bridge (2030)

Alternative 9 is a long-term rail alternative that includes commuter rail "Commuter" service between Union City and San Francisco and San Jose. Like Alternative 8, this alternative assumes complete restoration of the Rail Bridge but it would be double-tracked and serves as a higher capacity rail alternative. Also like Alternative 8, complimentary bus service would operate during the day from Palo Alto Caltrain to destinations served by route DB1. Complimentary bus service similar to routes DB, DB1, and the routes to Menlo Park/Redwood City and Mountain View/Sunnyvale would operate after the end of rail service in the evening.

Also similar to Alternative 8, Alternative 9 would provide a few approach improvements to improve travel speed and reliability in the particularly congested area around Bayfront Expressway/Willow Road and Bayfront Expressway/University Avenue on the Peninsula.

Figure 7-7 shows the improvements that would occur as part of Alternative 9. **Appendix E** contains operating plan factsheets.

Figure 7-7: Alternative 9



Source: CDM Smith, 2017

- **Highway Bridge and Approach Improvements**: No improvements would be made to the Highway Bridge as part of Alternative 9.
  - Approach improvements in the East Bay include the following:
    - New Newark Park-and-Ride
  - Approach improvements on the Peninsula include the following:
    - Willow Road/Bayfront Expressway grade separation
    - University Avenue/Bayfront Expressway grade separation
    - Willow Road express lanes and supporting facilities such as Willow Road to US 101 expressway flyover connection

To help forge first and last mile connections to major employment centers, Alternative 9 would provide complimentary daytime bus service from the Palo Alto Caltrain Station to the Stanford Research Park. Complimentary evening bus service would be provided from Union City BART to Stanford University (DB), Fremont BART to Stanford Research Park (DB1), Union City BART to Menlo Park/Redwood City and Union City BART to Mountain View/Sunnyvale after the Rail Commuter stops operating. Bus routes DB, DB1, and Mountain View/Sunnyvale would use express lanes along Willow Road. This alternative assumes the use of 28 standard buses. **Table 7-9** summarizes the bus route service hours and frequency.

Table 7-9: Alternative 9 Bus Route Service Hours and Headways

Route Name	Route	Headways (minutes)			
		AM Peak 6AM – 9AM	Mid-Day 9AM – 3PM	PM Peak 3PM – 7PM	Evening 7PM – 10PM
DB	Union City BART to Stanford University	N/A	N/A	N/A	20
DB1	Fremont BART (evening)/Palo Alto Caltrain (daytime) to Stanford Research Park	15	30	15	20
MP/RWC	Union City BART to Menlo Park and Redwood City Caltrain	N/A	N/A	N/A	20
MV/S	Union City BART to Mountain View/Sunnyvale	N/A	N/A	N/A	20

Source: CDM Smith, 2017

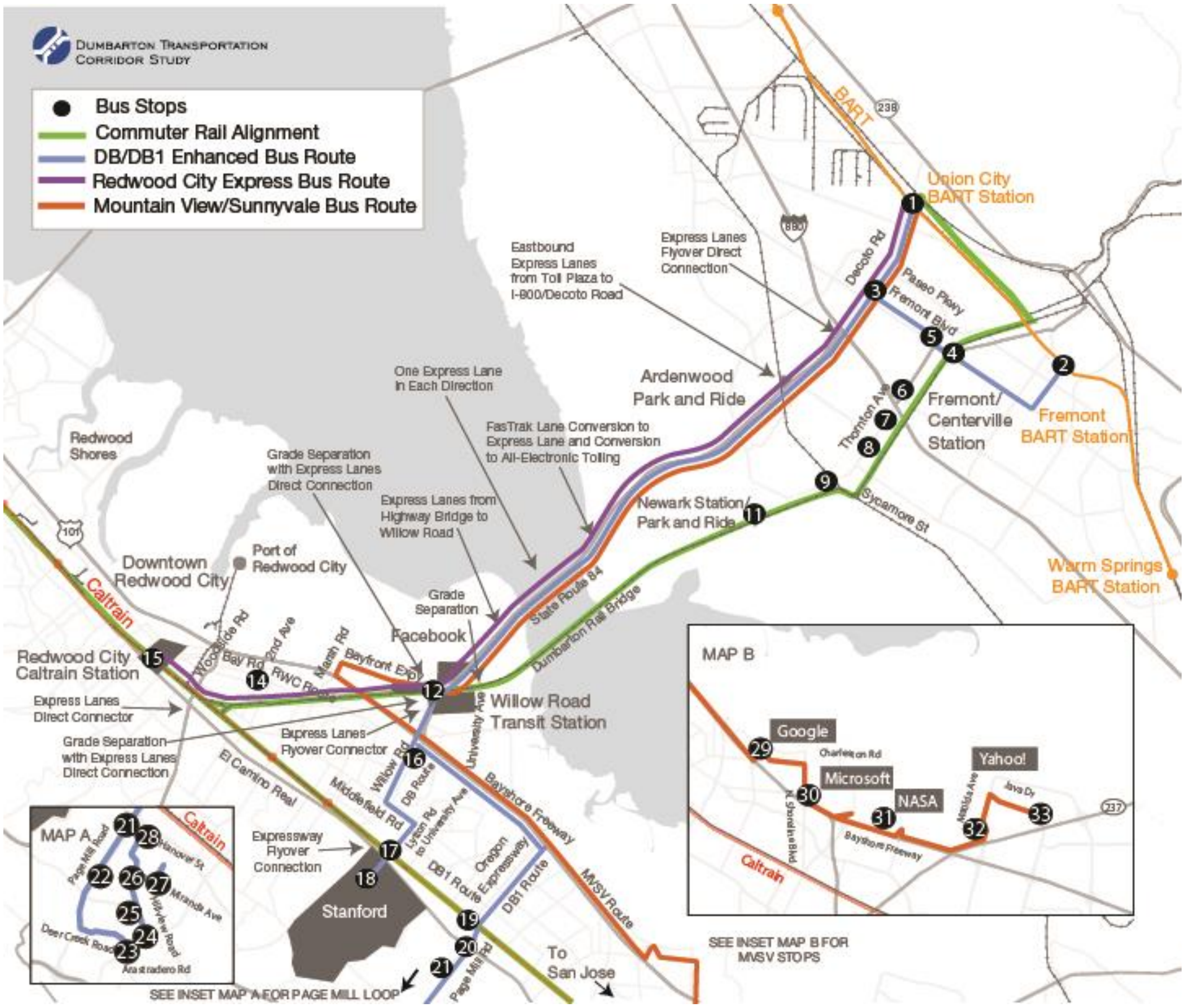
- **Rail Bridge and ROW Improvements**: The UP mainline, Dumbarton Rail Bridge and Dumbarton Rail ROW as well as the Caltrain mainline would provide an exclusive bi-directional Rail Commuter service from Union City BART to San Francisco and San Jose. Between Union City BART and San Francisco, trains would make intermediate stops at the Fremont Centerville Station, new Newark Station (with park-and-ride), new Willow Road Transit Station, and Redwood City Caltrain before expressing to San Francisco. Between Union City BART and San Jose, trains would make intermediate stops at the Fremont Centerville Station, new Newark Station (with park-and-ride), new Willow Road Transit Station, Palo Alto Caltrain, Mountain View Caltrain, and Sunnyvale Caltrain before expressing to San Jose. The Rail Bridge would be double-tracked on the Rail Bridge and Dumbarton Rail ROW. Northbound and southbound trains would run at 60-minute headways from 6 AM to 7 PM. The route would run EMU cars and trailers; 30 EMUs are assumed.

7.13 Alternative 10: Combination Bus and Rail (2030)

Alternative 10 combines the best-performing bus and rail alternatives per ridership projections, as described further in Chapter 10. Therefore, Highway Bridge and approach improvements are the same as those of Alternative 5, and Rail Bridge and ROW improvements are the same as Alternative 9. Therefore, this combined alternative assumes that rail service would operate next to bus service in the Peninsula Dumbarton Rail ROW. It should be noted that Alternative 6 was not considered for inclusion in this combined alternative as it provides bus service that is duplicative to that proposed on the Highway Bridge.

Figure 7-8 shows the improvements that would occur as part of Alternative 10. **Appendix E** contains the operating plan factsheets.

Figure 7-8: Alternative 10



Source: CDM Smith, 2017

8 Conceptual Design

This chapter provides a description of the design elements of the long-term alternatives carried forward for detailed evaluation. Because this is a planning-level feasibility study, it should be noted that conceptual designs were not produced for every component of the proposed alternatives due to scope limitations. For instance, designs related to proposed approach improvements were focused on the particularly congested area around Willow Road/Bayfront Expressway and University/Bayfront Expressway in Menlo Park.

Designs can be found in **Appendix F** as referenced throughout the Chapter. Operating analysis that tests the viability of such designs in the vicinity of Bayfront Expressway/Willow Road in Menlo Park are included in **Appendix G**.

8.1 Conceptual Design Approach

Conceptual design was developed for the various components that comprise the long-term alternatives. Generally, between 5 percent and 10 percent design was completed for the alternative elements defined in the following sections. Aerial photography was used to approximate available right-of-way (ROW), roadway, and rail corridor widths, and existing adjacent land uses.

Alternatives described below for which conceptual designs were prepared include bus options across either the Dumbarton Highway Bridge or Rail Bridge along with highway and roadway mobility options that include express lanes along the Highway Bridge and Bayfront Expressway (SR 84), Willow Road express lanes, bus-only lanes along Willow Road, grade separations at Bayfront Expressway/Willow Road and Bayfront Expressway/University Avenue, and express lane connectivity to US 101; and rail options to introduce Dumbarton Rail service across the San Francisco Bay using the Dumbarton Rail Bridge and ROW. Designs developed for connectivity to US 101 assume that the existing high-occupancy vehicle (HOV) lanes on US 101 would be converted to express lanes in the future.

8.2 Evolution of Design

The design process revealed that some proposed alternative components were not feasible or desirable. As mentioned in Chapter 7, the option that proposed two reversible bus-only, HOV, or express lanes on the Highway Bridge was found to not fit within the existing cross section of the Bridge and was eliminated from further consideration. Additionally, while it was initially believed that Willow Road could provide the best express lane access to US 101, express lanes on Willow Road were found to require tunneling (instead of being depressed) and the connection to US 101 proved to be difficult to construct and would require property acquisitions. It is for these reasons that bus-only lanes on Willow Road and extended express lanes on Bayfront Expressway were further examined, with a potential connection to planned express lanes on US 101 at Marsh Road. Similarly, while it was believed that express buses exiting off the Highway Bridge would be able to easily access Willow Road Transit Center while keeping within proposed express lanes to Willow Road, this option was found to require property acquisitions in a sensitive marshland area. Thus, a sub-option to operate buses down University Avenue to the Dumbarton Rail ROW with a potential bus-only connection at US 101 evolved. Such design options are discussed in further detail in the following sections.

8.3 Locations of Design Options

The alternatives include elements from multiple areas along the Corridor; therefore, designs were developed by location and options within these areas are incorporated into the alternatives in various combinations.

The locations considered in the development of design options include the following:

- Highway Bridge and Approach Options
  - Dumbarton Highway Bridge – Express Lanes
  - Bayfront Expressway at University Avenue – Grade Separation
  - Bayfront Expressway at Willow Road and Willow Road Transit Center – Grade Separation and Connectivity to Transit Center
  - Willow Road between Bayfront Expressway and US 101 – Willow Road Express Lanes and Willow Road Bus-Only Lanes
  - Bayfront Expressway/Marsh Road at US 101 – Express Lanes
  - Ardenwood Park-and-Ride – Park-and-Ride Expansion
  - Newark – New Park-and-Ride
- Rail Bridge and ROW Options
  - Rail ROW at US 101 – ROW to US 101 Connector
  - Redwood Junction Wye – Modal Options
  - East Bay Corridor and Dumbarton Rail Bridge – Rail Service Options
  - Rail ROW on Bridge and At-grade – Rail Service Options
  - Redwood City Caltrain Station Area – Rail Service Options

8.4 Highway Bridge and Approach Options

Design options for improvements to the Dumbarton Highway Bridge, Bayfront Expressway, University Avenue, Willow Road, and Marsh Road were developed to provide greater mobility and reduced travel times for transit vehicles, HOVs and the general commuting public through the Corridor. The design options discussed by location are provided below.

8.4.1 Dumbarton Highway Bridge – Express Lanes Options

The DTCS has proposed alternatives that would provide a continuous express lanes network for transit, HOV, and potential toll-paying single-occupancy vehicles (SOVs) from the East Bay, across the Highway Bridge, along Bayfront Expressway, and connecting to planned express lanes on US 101. Two express lane options have been developed for the Highway Bridge that use the existing available ROW without widening the Bridge. Option 1 converts the two innermost current general-purpose lanes to one express lane in each direction. With this option, the highway capacity of the general-purpose lanes would decrease by one-third; however, the benefits include improved mobility for transit vehicles, HOV vehicles, and SOV willing to pay a toll. Moreover, Option 1 minimizes the required modifications to the Highway Bridge and its approaches, requiring new lane striping, tolling equipment (e.g., gantries) near the entry and exit points, and other Intelligent Transportation Systems (ITS) equipment for toll warnings and notifications. **Figure F-1** in **Appendix E** provides typical sections of the segments along Bayfront Expressway west of the Highway Bridge, on the Highway Bridge itself, and between the Highway Bridge and the toll plaza with Option 1.

Option 2 provides an express lane that accommodates peak travel flow in the peak direction by enforcing a reversible express lane with movable barrier. In the morning peak period, four lanes are available for vehicles traveling westward—three general-purpose lanes and one express lane—while two general-purpose lanes are provided for East Bay-bound vehicles. In the evening peak period, the configuration is reversed with four eastbound lanes and two westbound lanes. A movable barrier would safely segregate the express lanes from oncoming traffic flow. The inclusion of a movable barrier means that roadway striping is a point of emphasis, transition zones may need special signing for clarity, and that no left shoulder exists for the length of this alternative.

Figure F-2 shows the lane configurations, moveable barrier transition zones, and typical sections for four segments with Option 2: from Bayfront Expressway west of the Highway Bridge (sheets 1a for morning condition and 1b for evening condition); at the Highway Bridge (sheets 2a for morning condition and 2b for evening condition), east of the Highway Bridge (sheets 3a for morning condition and 3b for evening condition), and approaching the toll plaza (sheets 4a for morning condition and 4b for evening condition).

8.4.2 Bayfront Expressway at University Avenue – Grade Separation Options

At the intersection of Bayfront Expressway and University Avenue, two options for grade separations are proposed. Option 1, shown in **Figure F-3,** includes westbound-to-southbound direct-connect flyover ramps to allow vehicles from the express lane and general-purpose lanes coming off the Highway Bridge to turn left without interruption using one ramp from the median (express lane access) and one ramp from the outermost lane (general-purpose access). Both lanes would merge into southbound University Avenue at grade approximately 600 feet south of Bayfront Expressway. If an alternative that includes buses on the rail ROW is selected, buses coming from the Dumbarton Highway Bridge would use the flyover ramp and turn right off of University Avenue into the rail ROW for access to a proposed Willow Road Transit Center and points beyond. The flyover ramp from the express lane also accommodates direct access from the express lane to the frontage road along Bayfront Expressway for local access to Facebook campuses and other locations along Willow Road. With this alternative, express lane through traffic would remain at-grade through the University Avenue intersection.

Option 2 shown in **Figure F-4** includes an additional direct express lane connection from northbound University Avenue to eastbound Bayfront Expressway (towards the Highway Bridge). If an alternative that includes buses on the rail ROW is selected, East Bay-bound transit vehicles would link to northbound University Avenue prior to utilizing the flyover that joins this path with the express lane on Bayfront Expressway. With this option, the existing rail intersection at University Avenue would remain at-grade and a bus-only traffic signal would be added to allow left turns for buses from the ROW.

With Option 2, the eastbound flyover ramp would be constructed as an extended part of the retaining wall and Bridge structure that would support the westbound traffic lanes as proposed in Option 1. The eastbound lane would tie into the eastbound express lane at approximately the same location where the westbound lane starts to elevate. The inside eastbound lane would require a tighter design curve, which will consequently dictate slower travel speeds for vehicles. The original radius of curvature and location were designed with constructability in mind; using a larger turning radius would result in longer sweeping curves over the Bayfront Expressway lanes at-grade below, and column placement, in addition to span lengths, may become quite challenging as a result of this layout.

With both options, there would be a traffic signal at the University Avenue intersection, allowing for vehicles from eastbound University Avenue to turn left into either the northbound express lane or northbound local access lane on Bayfront Expressway. For this movement, the at-grade express lane traffic in both directions would stop at the signal. Westbound Bayfront Expressway from either the express lane or the general-purpose lanes would use the direct-connect ramps to turn left onto southbound University Avenue. Eastbound Bayfront Expressway traffic would have a free-flow right turn on southbound University Avenue, and northbound University Avenue would have a free-flow right turn onto eastbound Bayfront Expressway.

8.4.3 Bayfront Expressway at Willow Road and Willow Road Transit Center – Grade Separation and Connectivity to Transit Center Options

Bayfront Expressway at Willow Road is a critical link in any express lane network between the Highway Bridge and US 101. As mentioned in Section 8.2, the connection to US 101 can occur at either Willow Road or Marsh Road. With either option for the express lanes connection to US 101, one express lane in each direction would be maintained along Bayfront Expressway across University Avenue and Willow Road. The proposed design of the Bayfront Expressway/Willow Road intersection includes a grade separation to divide traffic between vehicles wishing to continue on Bayfront Expressway (elevated) and those needing access to the main Facebook campus or southbound on Willow Road (at-grade). However, several options have been considered for connectivity to Willow Road from the express lanes.

With Options 1 and 2, an express lane connection to US 101 would occur at the US 101/Willow Road Interchange. To maintain continuous flow along Willow Road, a tunnel would be constructed under Willow Road so that transit, HOV, and toll-paying SOV could travel in free-flow traffic. Refer to Section 8.4.4 for more information on the express lanes/tunnel option. With both of these Willow Road express lanes options, a two-way ramp taking express lane vehicles over eastbound Bayfront Expressway would shift express lanes to the south side of Bayfront Expressway before entering a tunnel entrenched underneath the length of Willow Road that would ultimately connect to US 101. Vehicles traveling east on Bayfront Expressway, or automobiles exiting Facebook's campus, are able to access the express lane tunnel to US 101 by a slip ramp whose entrance is just south of the intersection.

Both Options 1 and 2 include a Willow Road Transit Center located east of Willow Road adjacent to the Dumbarton Rail ROW. The options differ in the bus connectivity to and from the transit center. With Option 1, buses would be provided a direct at-grade connection from the express lanes to the transit center just before the express lanes descend into the tunnel. To accommodate this connection, substantial acquisition of property in the southeast quadrant of the Willow Road/Bayfront Expressway intersection would be required. **Figure F-5** illustrates the proposed grade separation at the Willow Road/Bayfront Expressway intersection, the express lanes and tunnel under Willow Road, the Willow Road connection to Bayfront Expressway, and the transit connection to the proposed Willow Road Transit Center. The express lane direct connection includes a signalized intersection at street level to allow for buses to enter and exit the transit center access route; however, westbound vehicles are offered a continuous travel lane.

With Option 2, as shown in **Figure F-6**, the direct connection between the express lanes and the transit center is not included to eliminate the need to acquire property at this location; however, bus access to the transit center would be available using the Dumbarton Rail ROW. With Option 2, buses would exit the express lanes at University Avenue using the proposed flyover and travel one block south to enter the bus lanes on the Dumbarton Rail ROW. Buses would be provided free-flow access to the Willow Road Transit Center and would continue west along the Dumbarton Rail ROW (refer to Section 8.5.1 for more information).

Several factors and considerations guided the design of Options 1 and 2. An effort to avoid or minimize the encroachment on environmentally sensitive areas (i.e., the southeast quadrant of the Willow Road/Bayfront Expressway intersection) and Facebook's property results in fewer lanes for the ramps and frontage road and slower travel speeds for express lanes to permit for a tighter curve upon entering the tunnel below Willow Road. In addition, even with express lanes along Willow Road (via tunnel), there is a desire to include a grade separation at the Bayfront/Willow intersection to increase capacity and facilitate critical vehicle movements.

Options 3 and 4 do not provide the direct express lane connection at the US 101/Willow Road interchange, and thereby eliminate the tunnel under Willow Road. With both of these options without Willow Road express lanes, the direct connection to US 101 would occur at the Marsh Road interchange (refer to Section 8.4.5 for details). With these options, bus access to the Willow Road Transit Center would be from University Avenue. Option 3, as shown in **Figure F-7**, includes the addition of a full intersection just north of the Dumbarton Rail ROW on Willow Road for alternative bus access, shuttle access, and kiss-and-ride access to the transit center. Left turns in and out would be allowed. Option 4, in contrast, would not include a full intersection near the Dumbarton Rail ROW, and instead would include right-in/right-out access only into the transit center (see **Figure F-8**).

With Option 3, the west side of Willow Road at the proposed signalized intersection location is already used as Facebook's South Campus auxiliary entrance for Service and Delivery Vehicles (which may possibly be converted to a main entry point) and the east side contains the roadway entrance for ExtraSpace Storage. The proposed intersection for transit center access would be positioned approximately 400 feet south of the major Bayfront Expressway/Willow Road intersection, which would require coordinated signal timing, especially during peak periods. Buses traveling south on Willow Road and turning left into the transit center would take precedence with regards to signal priority. However, it is anticipated that many general-purpose vehicles would also be turning left into the transit center to drop off passengers, which may result in a potential issue with vehicular stacking in this left turn lane that may interfere with operations at the Bayfront Expressway/Willow Road intersection.

The Dumbarton Rail ROW would be grade-separated over Willow Road, and could accommodate buses destined for Redwood City and other points north or potentially US 101 if a connection is constructed from the Dumbarton Rail ROW. The Dumbarton Rail ROW could also accommodate Dumbarton rail service if it is selected as part of a preferred alternative. Above-grade bus and rail platforms would allow buses and trains (if included) to stop at the Willow Road Transit Center and connect to other modes as well as local destinations such as Facebook. With Option 3, as the rail ROW elevates west of University Avenue, just over a quarter mile east of Willow Road, a westbound bus-only slip ramp will be provided to allow buses destined for Willow Road or points south to exit the elevated structure and access the at-grade bus station. The reverse movement, allowing eastbound buses from Willow Road or points south to enter the rail ROW from the at-grade transit center would be accommodated with an eastbound bus-only slip ramp. Buses would exit or enter the at-grade station via the signalized intersection described above.

With Option 4, the signalized intersection at the at-grade entrance to and exit from the Willow Road Transit Center would be eliminated and only right-in/right-out access from northbound Willow Road would be accommodated. Under the rail/bus overpass (Willow Road grade separation), space would be available on both sides of Willow Road for additional bus and vehicular drop-offs/pick-ups in both directions. There is no turning movement allowed for the southbound bus traffic into the transit center.

As with all options, the Dumbarton Rail ROW would be grade-separated over Willow Road and would accommodate buses destined for Redwood City and other points north or potentially US 101 if a connection is constructed from the Rail Corridor. With only right-in/right-out access to/from the transit center, the full range of movements available with Option 3 would not available with Option 4. Eastbound buses would be able to enter the Dumbarton Rail ROW through the transit center using a bus-only slip ramp; however, westbound buses would need to exit the express lanes prior to University Avenue via a flyover ramp that allows local access along Bayfront Expressway to Facebook and Willow Road. Buses would turn left onto Willow Road for access to the drop-off area under the rail/bus overpass.

8.4.4 Willow Road between Bayfront Expressway and US 101 – Willow Road Express Lanes and Willow Road Peak-Period Bus-Only Lanes Options

Two scenarios were developed for Willow Road between Bayfront Expressway and US 101: one that provides an express lanes connection to US 101 at the US 101/Willow Road Interchange and one that includes improvements to allow for enhanced bus service between Bayfront Expressway and US 101.

In the first scenario, Willow Road Options 1 and 2 as described above, the Willow Road Express Lanes via a tunnel would continue south along Willow Road to just north of US 101. The tunnel was determined to be more constructible than depressed express lanes and would terminate at Newbridge Street and a trench section would continue for an additional 600 feet. There are several options for an express lane connection to US 101, including high-cost direct-connect flyover ramps that would require reconfiguration of the interchange and low-cost at-grade connectivity that would require lane weaving and merging into the US 101 express lanes.

The tunnel under Willow Road would be 50 feet wide, allowing a 12-foot travel lane, 4-foot inner shoulder, and 8-foot outer shoulder in each direction. **Figure F-6**, sheets 2b, 3b, and 4b, illustrate the proposed tunnel configuration to accommodate Willow Road Express Lanes and connectivity to US 101. Willow Road Express Lanes would be difficult to construct, as it would occur beneath a crucial link in the study area's transportation network and likely street closures would have adverse impacts on mobility and access. Moreover, the connection to US 101 HOV lanes (and future express lanes) would be challenging given the upcoming reconstruction of the Willow Road/US 101 freeway interchange. It is likely that this connection would require the acquisition of homes and a business.

In the second scenario that avoids the construction challenges noted above for Options 1 and 2, Willow Road Options 3 and 4 would provide an express-lanes connection to US 101 at the US 101/ Marsh Road Interchange and Willow Road would be improved to accommodate enhanced transit during the peak period (see **Figure F-9**). The approximate 80-foot-wide roadway section of Willow Road would be reconfigured to include two 11-foot general-purpose travel lanes and one 12-foot peak period shoulder bus-only lane in each direction. There would be a 12-foot median/left-turn lane and variable sidewalk and landscaping on either side depending on available ROW. While bus lanes would be peak-period only, buses could have transit signal priority along Willow Road throughout the day. There is also the possibility that the bus lanes could be shared with bicycles during the peak periods. Additional analysis would be required to determine the preferred off-peak usage, which may allow on-street parking or bike-only usage.

8.4.5 Bayfront Expressway/Marsh Road at US 101 – Express Lanes and US 101 Connector Options

As mentioned previously, there is a desire to provide an express lanes network from the East Bay, across the Highway Bridge, to planned express lanes on US 101, Since the Dumbarton Highway Bridge does not connect to US 101 directly, express lanes would be constructed within Bayfront Expressway and connect to US 101 at either Willow Road, as described above, or Marsh Road. With both of these connection options, Bayfront Expressway would be reconfigured to include one center express lane in each direction from the Highway Bridge, across University Avenue, and over Willow Road. Unlike the US 101/Willow Road tunnel, with the US 101/Marsh Road Interchange connection, express lanes would continue along the length of Bayfront Expressway and connect to the US 101 express lanes in one of two options described below.

With both options, express lanes would be grade-separated over Willow Road and return to grade within the center median of Bayfront Expressway approximately 600 feet west of Willow Road. Between the Willow Road grade separation and Chrysler Drive where the express lanes elevate, the express lanes would be barrier-separated from the general-purpose lanes, restricting left turns from westbound Bayfront Expressway into Facebook's South Campus or from Facebook's South Campus to westbound Bayfront Expressway. Bayfront Expressway's intersection with Chrysler Drive would also become right-in/right-out only. The express lanes would be grade separated over Chilco Street to allow left turns into and out of Chilco Street. Dedicated Texas U-turns, i.e., local access U-turns beneath the intersection overpasses that bypass the traffic signal, would be available at Chilco Street and Willow Road to accommodate traffic to and from Facebook's South Campus. With both options, express lane flyover ramps would merge into the US 101 center HOV lane. The number of general-purpose and express lanes on US 101 would not change; however, the roadway profile would be widened as lanes would be moved farther from the median to accommodate the ramps and acceleration/deceleration lanes.

With Option 1, as seen in **Figure F-10**, both the eastbound and westbound express lanes within the center median of Bayfront Expressway would elevate starting approximately 200 feet east of Chrysler Drive and use a flyover ramp that will remain elevated north of eastbound Bayfront Expressway and over the Bayfront Expressway/Marsh Road intersection and existing US 101 northbound on-ramp. The flyover ramp would follow an alignment on the north side of Bayfront Expressway and west side of Marsh Road, and would require the acquisition of property on the west side of Marsh Road. There is a potential for a flyover alignment on the east side of Marsh Road, but this option also results in ROW impacts, and tighter curve radius than with the west side alignment that will reduce the design speed to below minimum speed for reasonable traffic flow.

With Option 1, the westbound express lane would split into one lane that merges into the US 101 northbound express lane and one that will merge into the US 101 southbound express lane. In both directions on US 101, the ramps return to grade approximately 800 feet from Marsh Road, and there is an additional 1,800 to 2,000 feet of acceleration lanes to accommodate the merge with the US 101 express lane. Accordingly, in the opposite direction, an 1,800- to 2,000-foot-long deceleration lane would split from the express lane in each direction on US 101, elevate to an exit ramp 800 feet from Marsh Road, and the two ramps from each direction would merge and continue to the Bayfront Expressway median elevated over the west side of Marsh Lane.

The direct-connect ramps to and from the HOV lanes on US 101 in Option 1 may also be considered independent of express lanes along Bayfront Expressway. Implementation of the ramps alone would provide a faster connection to US 101 for those wanting to use the HOV lanes.

Option 2 does not provide full bi-directional express lane connectivity with US 101; instead, it provides peak-period /peak-direction connectivity. Option 2 includes a flyover ramp with one reversible lane connecting Bayfront Expressway with the express lanes on US 101. Approximately 800 feet east of Chrysler Drive, a moveable barrier (operated by a Zipper vehicle) would function to allow one-way traffic on the flyover ramp to US 101. In the morning peak period, westbound Bayfront Expressway express lane traffic would continue onto the ramp, past Chrysler Drive, over the Bayfront Expressway/Marsh Road intersection, and over the existing US 101 northbound on-ramp, at which point it would separate into a US 101 northbound ramp and a US 101 southbound ramp (see **Figure F-11**). In each direction, the single-direction ramps would return to grade in the median of US 101 approximately 800 feet from Marsh Road. In the southbound direction, a moveable barrier would direct morning traffic to merge into the southbound US 101 HOV lane; in the northbound direction, a moveable barrier would direct morning traffic to merge into the northbound lane.

Option 2 in the evening peak period would operate in reverse (see **Figure F-12**). The moveable barrier on each side of Marsh Road would direct northbound and southbound US 101 HOV users to the single-direction flyover off-ramp that provide direct connectivity to the Bayfront Expressway express lane. Once at-grade along Bayfront Expressway, the moveable barrier would direct traffic to the eastbound Bayfront Expressway express lane.

8.4.6 Ardenwood Park-and-Ride – Park-and-Ride Expansion

An expansion to the existing Ardenwood Park-and-Ride lot is considered to increase capacity for enhanced bus service in the Dumbarton Corridor. The Ardenwood location has advantages of existing bus services and ridership, and a potential direct in-line connection from the highway to the Dumbarton Highway Bridge allowing for faster and more direct service.

The Ardenwood park-and-ride lot is located west of SR 84, south of Ardenwood Boulevard and east of the UP ROW, on the border of the cities of Fremont and Newark. The DTCS proposes to expand the existing Ardenwood park-and-ride lot so that it acts as a transit center. Potential proposed Ardenwood Transit Center amenities include a new rail station (for a potential Capitol Corridor connection), “kiss-and-ride” drop-off area, an enhanced bus station, and a shared parking structure. As part of the concept for the Ardenwood Transit Center, three design options were considered. Option 1 is an enhanced bus station at Ardenwood Boulevard, Option 2 is an in-line enhanced bus station and Option 3 is an in-line enhanced bus station with an Ardenwood Terrace Extension.

Option 1 includes a rail station platform located along the UP ROW, a 1,200-space parking structure with retail on the ground floor along Ardenwood Terrace, and an inline enhanced bus facility at Ardenwood Boulevard and SR 84. Option 1 would require a new signal between the enhanced bus station and the on-/off- ramps on Ardenwood Boulevard, which would be difficult due to close spacing of adjacent signals. This option would also require splitting the enhanced bus platforms, constructing two long ramps and retaining structures. **Figures F-13 through F-15** illustrate the conceptual site plans and cross sections for Option 1.

Similar to Option 1, Option 2 includes a rail station platform located east of the UP ROW as well as a 1,200-space parking structure with retail on the ground floor along Ardenwood Terrace. Option 2 also includes an inline enhanced bus station, however, contrary to Option 1 the station would be located further south on SR 84. This option also includes a direct connection between the parking structure and enhanced bus platforms. **Figures F-16 through F-18** illustrate the conceptual site plans and cross sections for Option 2.

Option 3 includes a rail station platform located east of the UP ROW as well as a 1,200-space parking structure, and inline enhanced bus platform in the same location as Option 2. Contrary to

Option 1 and 2, Option 3 includes retail on the third level of the structure along the Ardenwood Terrace Extension adjacent to the "kiss and ride" drop-off area. **Figures F-19 through F-21** illustrate the conceptual site plans and cross sections for Option 3.

All three options for the Ardenwood Transit Center include improved sidewalks, bike lanes, and a shared multiuse path to improve access for cyclists and pedestrians. The shared multiuse path provides a new connection to the Transit Center with development on the east side of the freeway, which currently has no access. In addition, all three alternatives will provide access for several express bus routes.

While all three options improve access, the circulation varies slightly. As shown in **Figure F-22**, station access for Option 1 is limited for pedestrians, and lacks a direct connection between the transit center and the enhanced bus platforms. A grade-separated pedestrian crossing over the rail tracks would be necessary for access to the west rail platform. Station access for Option 2 is direct and convenient (see **Figure F-23**). A pedestrian ramp from the station to the bus platforms provides access. A pedestrian ramp from the westbound bus platform level provides access to the west rail platform. Option 3 (see **Figure F-24**) includes a road extension ramp, which provides an opportunity to connect bicycle facilities to the Bay Trail. Station access for Option 3 is direct and convenient. Pedestrian access to the west rail platform is provided by two ramps.

8.4.7 Newark – New Park-and-Ride Facility

The Newark location does not connect to any existing transit on the Dumbarton Corridor, but would be ideally located to support rail or bus alternatives that would utilize the existing Rail Bridge. This station is located in a single-family residential neighborhood, parallel to an extension of Enterprise Drive, south of the UP ROW at Willow Street. The primary entrance would be located near Willow Street on Enterprise Drive, with a secondary entrance also on Enterprise Drive to the west. **Figure F-25** and **Figure F-26** illustrate the plans from the City of Newark.

The proposed station includes 550 parking space surface lot including electrical vehicle charging stations, a train station and a bus drop-off area. The plans indicate a potential connection to the Bay Trail from the Newark Transit Station via Hickory Street.

8.5 Rail Bridge and ROW

As noted earlier in Chapters 6 and 7, a bicycle/pedestrian multiuse path is being considered with bus and rail modes on the Peninsula Dumbarton ROW. Adhering to strict ROW width requirements for each mode, it was initially found that only two of three modes could fit within the Dumbarton ROW. Under this logic, modes could be implemented in any combination including rail/bus, rail/multiuse path, and bus/multiuse path, all of which are described in more detail below and in **Appendix F**. However, creative ways to potentially accommodate all three modes will be investigated in the next phase of study after the DTCS. Additional information about available ROW width is included in **Appendix D**.

8.5.1 Rail ROW at US 101 – ROW to US 101 Connector

If buses are operated within the Peninsula Dumbarton Rail ROW, alone or in conjunction with either rail or a multiuse path, direct connectivity to US 101 would be necessary. Not all bus routes that travel through the study area would use the Rail ROW/US 101 connection, as some bus routes may use Willow Road or those headed to Redwood City would continue to use the Dumbarton Rail ROW (see Section 8.5.2). However, with the Rail ROW/US 101 connection, buses could travel from the Dumbarton Highway Bridge and use University Avenue to turn onto the Rail ROW. These buses would stop at the Willow Road Transit Center and continue about 1.25 miles to US 101 to serve Stanford (via Willow Road) the Research Park (via Oregon Expressway) and Santa Clara County.

The junction of US 101 and the Rail ROW would be reconfigured into a bus-only interchange, allowing buses destined for locations accessible from US 101 to connect directly to the US 101 HOV lanes. From a reconstructed rail bridge over US 101, buses would turn left or right from a signalized intersection to access ramps to the US 101 median that would merge with the HOV lanes in each direction (see **Figure F-27**). The ramps would be approximately 400 feet before they meet US 101 at grade, and an additional 1,200 feet would be necessary before a complete merge with the HOV lanes. The geometric profile of US 101 would be widened for a length of 1,600 to 2,000 feet in each direction from the new rail bridge to accommodate the existing four general-purpose lanes, one HOV lanes, required shoulders, and the new ramp/merge lane in each direction. Retaining walls would be required on each side of the 200-foot-wide ROW.

8.5.2 Redwood Junction Wye – Modal Options

At Redwood Junction, the Dumbarton Rail ROW terminates and elements of two study alternatives occur: (1) with the rail alternatives, westbound trains merge into the Caltrain mainline, and (2) with alternatives that include bus and/or multiuse path on the Rail ROW, these modes must exit the ROW before the rail merge with the Caltrain mainline. Study alternatives up to this point include options for the Dumbarton Rail ROW to accommodate rail and bus (Option 1), rail and multiuse path (Option 2), and bus and multiuse path (Option 3), as shown in **Figure F-28** (sheets 1, 2, and 3, respectively). Option 1 may be used if bus only were to operate within the Rail ROW. With these options, all buses, pedestrians, and bicyclists must exit the Rail ROW at Redwood Junction onto Middlefield Road. Alternatively, the Rail ROW may be used for rail operations only.

In the rail and bus scenario, Option 1, the rail tracks would be located in the middle of the Rail ROW, the westbound bus lane would be located north of the tracks, and the eastbound bus lane would be located south of the tracks. In this scenario, there would not be a bicycle and pedestrian multiuse path within the Dumbarton Rail ROW. The complexity of rail, bus, and other vehicular traffic at Middlefield Road, local roads such as Northside Avenue and Pacific Avenue, and driveway access to a heath care facility and other businesses at this location may warrant a grade separation or reconfiguration of the intersection.

In both the rail/multiuse path (Option 2) and bus/multiuse path (Option 3) scenarios, the multiuse path would be located north of the rail or bus alignment, respectively. The bicycle and pedestrian multiuse path would terminate at Middlefield Road. In the bus/multiuse path scenario, or Option 1 with bus only, the need for bus traffic to merge onto Middlefield Road may require signal timing modifications or the reconfiguration of the intersection. With the rail/multiuse path scenario, the rail operations across Middlefield Road may warrant a grade separation.

As previously noted, creative ways to potentially accommodate a bicycle/pedestrian multiuse path in the Peninsula Dumbarton ROW will be investigated in the next phase of study after the DTCS.

8.5.3 East Bay Corridor and Dumbarton Rail Bridge – Rail Service Options

There are three options for rail along the Dumbarton Rail ROW: Rail Commuter Single Track (Option 1); Rail Commuter Double Track (Option 2); and Rail Shuttle (Option 3). The alignments for the three options, including conceptual design of new track and grade separations/bridges, are shown in **Figures F-29 through F-31**. The rail operations in the East Bay for all options are assumed to be the same, with service provided to and from the Union City BART Intermodal Station. In all three options, service continues across the San Francisco Bay, and along the Dumbarton Rail ROW on the Peninsula, for a total of 17 miles to Redwood Junction (Middlefield Road). With Options 1 and 2, the rail service would split at the junction, with half of the trains entering the southbound Caltrain mainline heading to San Jose Diridon Station with intermediate stops at Palo Alto, Mountain View and Sunnyvale and half of the trains continuing onto the northbound Caltrain mainline to San Francisco, stopping at Redwood City. With Option 3, all trains would continue onto the northbound Caltrain mainline at Redwood Junction for an additional 1.3 miles and stop and terminate at Redwood City.

In all options, starting from the east, the Dumbarton rail service would operate on the existing Union Pacific Railroad (UP) Oakland Subdivision, with a new layover yard and wye for turnaround movements located approximately 1.5 miles north of the Union City Intermodal Station in the City of Hayward. The proposed layover yard would be located just north of Whipple Road, on the west side of UP's main track. With Option 1 (Rail Commuter Single Track), approximately 1.5 miles of new track would be installed at the northern terminus at the layover facility and an additional 1.6 miles of new track would be installed between one-quarter mile north of the Union City Intermodal Station and 700 feet south of the Whipple Road overpass. With Options 2 (Rail Commuter Double Track) and 3 (Rail Shuttle), new track would be installed along the entire alignment. With all options, improvements would be made to the Union City Intermodal Station to provide for Dumbarton rail service on a new platform parallel to and northeast of the existing BART platform and station. Improvements to the grade separation at Decoto Road would be required to accommodate the additional track by the station.

The rail service would continue southeast on the Oakland Subdivision into the City of Fremont and use a new rail bridge over Alameda Creek and a new wye connecting track at Shinn to allow southbound trains on the Oakland Subdivision to head westbound on the UP's Niles Subdivision (also referred to as the "Centerville Line"). Modifications to the existing Niles Subdivision (Centerville Line)/BART grade separation are required to provide space for the new wye connection. The rail alignment would continue to the existing Fremont Centerville Station for connections with Capitol Corridor and ACE. Improvements would be made to the Fremont Centerville Station to extend the platform and add parking. Rail service would continue along the existing Centerville Line into the City of Newark and pass through Newark Junction on a short segment of the UP's Coast Line to connect to the Dumbarton Line. Option 2 (Rail Commuter Double Track) would include a new second track starting at Newark Junction, along the Dumbarton Line in Newark, and across the Bay. With Options 1 (Rail Commuter Single Track) and 3 (Rail Shuttle), approximately 9,000 feet of a new second track would be installed starting just east of Chestnut Street in Newark. Option 3 also includes one-quarter mile of new track through Newark Junction. With all options, a new rail station, including a park-and-ride facility, would be constructed just west of Willow Street.

Across the San Francisco Bay, the alignment would follow the existing Dumbarton Rail ROW. The existing Newark Slough swing span bridge would be replaced with a new through-plate girder swing span supported on retrofitted caisson. The approach structures and both the existing (burned) Dumbarton timber approach trestle and the original concrete bridge spans would be replaced with new concrete box girder spans on concrete piles. The through truss girder spans on either side of the swing span will be replaced with fixed concrete tee bulb spans on new large-diameter Cast-in-Steel-Shell piles. The Dumbarton Rail Bridge swing span will be replaced with a new Bascule movable span and the remaining concrete spans constructed in the 1960s will be seismically retrofitted. New track will be installed across the entire Rail Bridge and the old Bridge removed. **Figure F-32** illustrates typical sections for single- and double-track options for rail on bridge truss and on existing bents, each accommodating a future overhead catenary system.

8.5.4 Dumbarton Rail ROW between the Rail Bridge and Redwood Junction – Rail Service Options

On the Peninsula, rail service would continue on the Dumbarton Rail ROW westward across University Avenue (at-grade) to an elevated section over Willow Road where a rail station would be constructed. With all options, two tracks would be installed from the shoreline to approximately 1,500 feet east of Chilco Street, and one new track would continue to just east of Marsh Road. Service would follow the Dumbarton Rail ROW using existing track to Redwood Junction. Grade separations at Marsh Road and 5th Avenue are proposed. At Redwood Junction, trains in Options 1 (Rail Commuter Single Track) and 2 (Rail Commuter Double Track) would enter the Caltrain mainline (half heading north to Redwood City and San Francisco and half heading south to San Jose). A series of track cross-overs would be installed between Redwood Junction and Redwood City Station to allow Dumbarton trains to access either main track 1 or 2. In addition, the lead track to the Port of Redwood City would be realigned. For the Rail Shuttle Option 3, at Redwood Junction, all westbound trains exit the Dumbarton Rail ROW and merge with the northbound Caltrain mainline to Redwood City. Northwest of Redwood City Junction, one new track would be installed for the shuttle trains entering and exiting the Redwood City Station terminus. **Figure F-32** illustrates the typical sections for single- and double-track options along the at-grade portions of the rail alignment.

With a rail/bus combination along this stretch of the Dumbarton Rail ROW, the at-grade cross-section includes 65 feet for two rail tracks plus 17.5 feet on either side for buses (12-foot lanes and 5.5-foot shoulders). **Figure F-33** shows the typical sections for the at-grade rail/bus scenario on the Peninsula.

8.5.5 Redwood City Station Area – Rail Service Options

All rail options would include a stop at the Redwood City Station. Design options in the Redwood City Station area consider operation of passenger rail service along the Dumbarton Rail ROW to Redwood City, as described below.

With the Rail Commuter Options 1 and 2, the transbay trains would follow the Dumbarton Rail ROW to Redwood Junction, at which point half of the trains would head northbound on the Caltrain mainline to San Francisco with a stop at Redwood City, and the other half would travel through the wye at Redwood Junction to the southbound Caltrain mainline headed to San Jose. No modifications to the Redwood City Station would be necessary with the Options 1 and 2. However, with the Rail Shuttle or Option 3, all trains would pass the Redwood City Junction and head north to Redwood City, terminating at the Redwood City Station. Option 3 would require substantial modifications to the station for the station platform and the approach tracks to allow the Shuttle trains to use designated track that terminates and turns around at the station.

With Option 3, Redwood City Station would include a stub-end terminus for Dumbarton trains to accommodate two inbound/outbound tracks necessary to provide the transbay rail service and to accommodate ease of transfer for rail passengers between services. The existing station location is constrained by built-up commercial land uses on both sides, and southwest of the tracks is a brand new high-density residential development (one newly constructed building and one building currently under construction). Therefore, it is infeasible to add two new tracks for the stub-end terminus at-grade adjacent to the existing tracks and station without impacting the adjacent land uses. As a result, three station design options (sub-options of Rail Shuttle Option 3) were considered and reviewed by the City of Redwood City: elevated Dumbarton terminus at existing station (station Option 1); new at-grade Redwood City Station north of Broadway/Marshall Street (station Option 2); and new at-grade Redwood City Station south of existing station (station Option 3). Station Option 3 would result in significant ROW acquisition, including the displacement of the Sequoia Station commercial area and newly constructed apartments south of Jefferson Avenue; therefore, it was eliminated from further study. Station Options 1 and 2 were advanced and conceptual designs are shown in **Figure F-34** (sheets 1 and 2) and **Figure F-35** (sheets 1 and 2), respectively.

Station Option 1 elevates the Dumbarton rail terminus above the existing Redwood City Caltrain Station, including an aerial center platform. Bi-directional transfers can be made between mainline Caltrain service and Dumbarton service, as well as transfers to the bus station and access to Downtown Redwood City. South of the station, one main Dumbarton track would operate adjacent to and northeast of the two existing mainline tracks. The Dumbarton track would initiate its elevation at Main Street and split into two main elevated tracks near Jefferson Avenue. The elevated structure would be located between existing high-rise residential buildings and those currently under construction southwest of the tracks and the newly constructed BOX development northeast of the tracks.

With Station Option 2, the Redwood City Caltrain Station would relocate north of Broadway/Marshall Street to accommodate two Dumbarton tracks adjacent to the two Caltrain mainline tracks with cross-platform and aerial platform transfers available. As with Option 1, approaching the station, one main Dumbarton track would operate adjacent to and northeast of the two existing mainline tracks and split into two tracks near Jefferson Street; however, with Option 2, the tracks would remain at-grade. To accommodate the additional two at-grade tracks, the existing Caltrain mainline tracks would shift south outside of existing ROW into the existing bus station and potentially into a building in the northwestern part of the Sequoia Station development that includes Caltrain parking and retail businesses.

8.6 Summary of Design Options

Table 8-1 below summarizes the design options developed as part of the DTCS and considered for the project alternatives described in Section 8.7.

Table 8-1: Summary of DTCS Design Options by Location

Location	Options			
	1	2	3	4
Highway Bridge and Approach Options				
Dumbarton Highway Bridge	Express Lanes in Each Direction	Reversible Express Lanes with Movable Barrier	N/A	N/A
Bayfront Expressway at University Avenue	Westbound Direct-Connect Flyover	Bi-directional Direct-Connect Flyover	N/A	N/A
Bayfront Expressway at Willow Road and Willow Road Transit Center	Willow Express Lanes/ Tunnel; Transit Direct Connection	Willow Express Lanes/ Tunnel; No Transit Direct Connection	No Willow Express Lanes/ Tunnel; Signalized Transit Center Access	No Willow Express Lanes/ Tunnel; Right-in/Right-out Transit Center Access
Willow Road between Bayfront Expressway and US 101	Willow Express Lanes/ Tunnel with Connection to US 101	Willow Express Lanes/ Tunnel with Connection to US 101	Willow Road Peak-Period Bus-Only Lanes	Willow Road Peak-Period Bus-Only Lanes
Bayfront Expressway/Marsh Road at US 101	Bi-directional Express Lanes Direct Connection at Marsh Interchange	Reversible Express Lane Direct Connection at Marsh Interchange	N/A	N/A
Ardenwood Park-and-Ride	Rail platform, 1,200 space structure, bus station	Rail platform, 1,200 space structure, bus station, connection between structure and bus station	Rail platform, 1,200 space structure, bus station, connection between structure and bus station and retail	N/A
Newark Park-and-Ride	Train station, bus drop-off, 550 space surface lot	N/A	N/A	N/A
Rail Bridge and ROW Options				
Rail ROW at US 101	Direct Bus Connection to US 101	N/A	N/A	N/A
Redwood Junction Wye	Rail and Bus in ROW	Rail and Multiuse Path in ROW	Bus and Multiuse Path in ROW	N/A
East Bay Corridor and Dumbarton Rail Bridge	Rail Commuter – Single-Track	Rail Commuter – Double-Track	Rail Shuttle	N/A
Rail ROW on Bridge and At-grade	Rail Commuter – Single-Track	Rail Commuter – Double-Track	Rail Shuttle	N/A
Redwood City Station Area	Elevated Rail Shuttle Station	Relocated Rail Shuttle Station	N/A	N/A

Source: HDR, 2017

8.7 Project Alternatives

Alternatives below carried forward are discussed in detail in Chapter 7:

- Alternative 1: No Build (2020)
- Alternative 2: Short-Term Enhanced Bus on Highway Bridge (2020)
- Alternative 3: No Build (2030)
- Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes 4/2 (2030)

- Alternative 5: Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction 3/3 (2030)
- Alternative 6: Busway on Rail Bridge (2030)
- Alternative 7: Rail Shuttle on Rail Bridge (2030)
- Alternative 8: Rail Commuter Single-Track on Rail Bridge (2030)
- Alternative 9: Rail Commuter Double-Track on Rail Bridge (2030)
- Alternative 10: Combination Bus and Rail (2030)

Conceptual designs were not developed for Alternatives 1 through 3, as capital improvements are not proposed as part of those alternatives. Alternatives 4 through 10 are described below in regards to the specific components that have been conceptually designed, as described above. Each alternative is subdivided into a base alternative and variations on that base. To the extent feasible, design elements may be eliminated or added to the alternatives, and as a result several variations of one or more different options exist for each alternative.

8.7.1 Alternative 4 (Base): Enhanced Bus on Highway Bridge with Reversible Express Lanes

Alternative 4 includes improvements to provide reversible express lanes across the Dumbarton Highway Bridge and an express-lane direct connection to US 101 via Bayfront Expressway and Willow Road. The Willow Road express lanes would be grade-separated from existing Willow Road and operate in a tunnel. University Avenue and Bayfront Expressway would be grade separated.

Highway Bridge and Approach Options:

- Dumbarton Highway Bridge Option 2
- Bayfront Expressway at University Avenue Option 1/2
- Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1
- Willow Road between Bayfront Expressway and US 101 Option 1/2
- Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only)
- Ardenwood Park-and-Ride (Best for Bus Service)

Rail Bridge and ROW Options:

- Redwood Junction Wye Option 1 (bus only)

Alternative 4 Sub-options

Highway Bridge and Approach Options:

- Replace Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1 with Option 2
- Replace Willow Road between Bayfront Expressway and US 101 Option1/2 with Option 3/4
- Replace Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only) with Bayfront Expressway/Marsh Road at US 101 Option 1 (full) / 2
- Replace Ardenwood Park-and-Ride (Best for Bus Service) with Ardenwood Park-and-Ride with Best for Bus and Rail Service

Rail Bridge and ROW Options:

- Add Rail Dumbarton Rail ROW at US 101 Option 1

These sub-options equate to a number of alternative combinations as listed below:

- **Alternative 4A: Base with Dumbarton ROW to US 101 Connector** – Alternative 4A includes the same elements as Alternative 4 (Base) and adds a direct connection from the Dumbarton Rail ROW to US 101 for buses.
- **Alternative 4A.1: Base with Bi-directional University Avenue Flyover** – Alternative 4A.1 includes all improvements in Alternative 4A and includes a bi-direction flyover at Bayfront Expressway and University Avenue instead of a single westbound flyover.
- **Alternative 4B: Base without Willow Road Express Lanes** – With Alternative 4B, the Dumbarton Highway Bridge express lanes would continue along Bayfront Expressway just past Willow Road, with grade separations at University Avenue and Willow Road; however, the Willow Road express lanes would not be implemented, thereby not providing a direct express-lanes connection to US 101.
- **Alternative 4B.1: Base without Willow Road Express Lanes and with Willow Road Bus Lanes** – Alternative 4B.1 includes the same design features as Alternative 4B, and adds dedicated bus lanes along Willow Road between Bayfront Expressway and US 101.
- **Alternative 4B.2: Base without Willow Express Lanes, with Willow Road Bus Lanes, and with Dumbarton ROW to US 101 Connector** – Alternative 4B.2 expands upon Alternative 4B.1 by adding a direct connection from the Dumbarton Rail ROW to US 101 for buses.
- **Alternative 4B.3: Base without Willow Express Lanes, and with Willow Road Bus Lanes and Express Lanes to US 101/Marsh Road Interchange** –Alternative 4B.3 is a variation that includes all components of Alternative 4B.1 as well as a direct express-lane connection to US 101 at the Marsh Road interchange.

- **Alternative 4C: Base with Ardenwood Park-and-Ride for Bus and Potential Rail Service** – Alternative 4C is identical to the base scenario except the Ardenwood Park-and-Ride would be expanded to not only accommodate bus service but also potential rail service. The design components are identical to Alternative 4 (Base).
- **Alternative 4C.1: Base without Willow Express Lanes, with Willow Road Bus Lanes, with Dumbarton ROW to US 101 Connector, and with Ardenwood Park-and-Ride for Bus and Potential Rail Service** – Alternative 4C1 is identical to the base scenario except the Ardenwood Park-and-Ride would be expanded to not only accommodate bus service but also potential rail service while Willow Road Express Lanes would be replaced with Willow Road Bus Lanes.
- **Alternative 4D: Base with Ardenwood Park-and-Ride for Bus and Rail Service** – Alternative 4D is identical to the base scenario except the Ardenwood Park-and-Ride would be expanded to accommodate both bus and rail service. The design components are identical to Alternative 4 (Base).

8.7.2 Alternative 5 (Base): Enhanced Bus on Highway Bridge with One Express Lane in Each Direction

Alternative 5 is similar to Alternative 4, except that there would be one express lane in each direction across the Dumbarton Highway Bridge (as opposed to reversible express lanes with Alternative 4).

Highway Bridge and Approach Options:

- Dumbarton Highway Bridge Option 1
- Bayfront Expressway at University Avenue Option 1/2
- Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1
- Willow Road between Bayfront Expressway and US 101 Option 1/2
- Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only)
- Ardenwood Park-and-Ride (Best for Bus Service)

Rail Bridge and ROW Options:

- Redwood Junction Wye Option 1 (bus only)

Alternative 5 Sub-options

Highway Bridge and Approach Options:

- Replace Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1 with Option 2
- Replace Willow Road between Bayfront Expressway and US 101 Option1/2 with Option 3/4

- Replace Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only) with Bayfront Expressway/Marsh Road at US 101 Option 1 (full) / 2
- Replace Ardenwood Park-and-Ride (Best for Bus Service) with Ardenwood Park-and-Ride with Best for Bus and Rail Service

Rail Bridge and ROW Options:

- Add Rail Dumbarton Rail ROW at US 101 Option 1

These sub-options equate to a number of alternative combinations as listed below:

- **Alternative 5A: Base with Dumbarton ROW to US 101 Connector** – Alternative 5A includes the same elements as Alternative 5 (Base) and adds a direct connection from the Dumbarton Rail ROW to US 101 for buses.
- **Alternative 5A.1: Base with Bi-directional University Avenue Flyover** – Alternative 5A.1 includes all improvements in Alternative 5A and includes a bi-direction flyover at Bayfront Expressway and University Avenue instead of a single westbound flyover.
- **Alternative 5B: Base without Willow Road Express Lanes** – With Alternative 5B, the Dumbarton Highway Bridge express lanes would continue along Bayfront Expressway just past Willow Road, with grade separations at University Avenue and Willow Road; however, the Willow Road express lanes would not be implemented, thereby not providing a direct express-lanes connection to US 101.
- **Alternative 5B.1: Base without Willow Road Express Lanes and with Willow Road Bus Lanes** – Alternative 5B.1 includes the same design features as Alternative 5B, and adds dedicated bus lanes along Willow Road between Bayfront Expressway and US 101.
- **Alternative 5B.2: Base without Willow Express Lanes, with Willow Road Bus Lanes, and with Dumbarton ROW to US 101 Connector** – Alternative 5B.2 expands upon Alternative 5B.1 by adding a direct connection from the Dumbarton Rail ROW to Alternative 5B.3: Base without Willow Express Lanes, and with Willow Road Bus Lanes and Express Lanes to US 101/Marsh Road Interchange.
- **Alternative 5B.3: Base without Willow Road Express Lanes, and with Willow Road Bus Lanes and Express Lanes to US 101/Marsh Road Interchange** – Alternative 5B.3 is a variation that includes all components of Alternative 5B.1 as well as a direct express-lane connection to US 101 at the Marsh Road interchange.
- **Alternative 5C: Base with Ardenwood Park-and-Ride for Bus and Potential Rail Service** – Alternative 5C is identical to the base scenario except the Ardenwood Park-and-Ride would be expanded to not only accommodate bus service but also potential rail service. The design components are identical to Alternative 5 (Base).

- **Alternative 5C.1: Base without Willow Express Lanes, with Willow Road Bus Lanes, with Dumbarton ROW to US 101 Connector, and with Ardenwood Park-and-Ride for Bus and Potential Rail Service** – Alternative 5C1 is identical to Alternative 5A except the Ardenwood Park-and-Ride would be expanded to not only accommodate bus service but also potential rail service while Willow Road Express Lanes would be replaced with Willow Road Bus Lanes.

- **Alternative 5D: Base with Ardenwood Park-and-Ride for Bus and Rail Service** – Alternative 5D is identical to the base scenario except the Ardenwood Park-and-Ride would be expanded to accommodate both bus and rail service. The design components are identical to Alternative 5 (Base).

8.7.3 Alternative 6 (Base): Busway on Rail Bridge

Alternative 6 considers operation of enhanced bus service from Union City BART in the East Bay, across the Dumbarton Rail Bridge, and within the Dumbarton Rail ROW on the Peninsula. It includes select approach improvements on the Peninsula including Willow Road Express Lanes as well as grade separations at Willow Road and University Avenue at Bayfront Expressway.

Highway Bridge and Approach Options:

- Bayfront Expressway at University Avenue Option 1/2
- Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1
- Willow Road between Bayfront Expressway and US 101 Option 1/2

Rail Bridge and ROW Options:

- Redwood Junction Wye Option 1 (bus only)

Alternative 6 Sub-options

Highway Bridge and Approach Options:

- Replace Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1 with Option 2
- Replace Willow Road between Bayfront Expressway and US 101 Option1/2 with Option 3/4
- Replace Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only) with Bayfront Expressway/Marsh Road at US 101 Option 1 (full) / 2

Rail Bridge and ROW Options:

- Add Rail Dumbarton Rail ROW at US 101 Option 1

These sub-options equate to a number of alternative combinations as listed below:

- **Alternative 6A: Base with Dumbarton Right-of-Way to US 101 Connector** – Alternative 6A includes all improvements in the base scenario and adds a direct connection between the Dumbarton Rail ROW and US 101 for buses.
- **Alternative 6B: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes** – Alternative 6B is a variation of Alternative 6 that does not include the roadway improvements in the base scenario.
- **Alternative 6B.1: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes, and with Dumbarton Right-of-Way to US 101 Connector** – Alternative 6B.1 is similar to Alternative 6B except it adds a direct connection between the Dumbarton Rail ROW and US 101 for buses.
- **Alternative 6C: Base with Bi-directional University Avenue Flyover** – Alternative 6C includes all improvements in Alternative 6 (Base) as well as a bi-direction flyover at Bayfront Expressway and University Avenue instead of a single westbound flyover.

8.7.4 Alternative 7 (Base): Rail Shuttle on Rail Bridge

Alternative 7 considers Rail Shuttle operations between Union City BART and Redwood City Caltrain, using the Dumbarton Rail Bridge and ROW. It includes select approach improvements on the Peninsula including Willow Road Express Lanes as well as grade separations at Willow Road and University Avenue at Bayfront Expressway.

Highway Bridge and Approach Options:

- Bayfront Expressway at University Avenue Option 1/2
- Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1
- Willow Road between Bayfront Expressway and US 101 Option 1/2

Rail Bridge and ROW Options:

- Redwood Junction Wye Option 1/2
- East Bay Corridor and Dumbarton Rail Bridge Option 3
- Rail ROW on Bridge and At-grade Option 3
- Redwood City Station Area Option 1/2

Alternative 7 Sub-options

Highway Bridge and Approach Options:

- Replace Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1 with Option 2
- Replace Willow Road between Bayfront Expressway and US 101 Option1/2 with Option 3/4
- Replace Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only) with Bayfront Expressway/Marsh Road at US 101 Option 1 (full) / 2

These sub-options equate to a number of alternative combinations as listed below:

- **Alternative 7A: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes** – Alternative 7A eliminates the roadway and intersection improvements on Bayfront Expressway.
- **Alternative 7B: Base with Redwood City Station Option 2** – Alternative 7B includes all improvements in the base scenario; however, a new at-grade rail terminus station in Redwood City north of Broadway Street is considered instead of an elevated station.
- **Alternative 7C: Base with Bi-directional University Avenue Flyover** – Alternative 7C includes all improvements in Alternative 7 (Base) with a bi-direction flyover at Bayfront Expressway and University Avenue instead of a single westbound flyover.

8.7.5 Alternative 8 (Base): Rail Commuter Single-Track on Rail Bridge

Alternative 8 provides single-track commuter rail operations between the Union City BART and San Francisco and San Jose, using the Dumbarton Rail Bridge, ROW and Caltrain mainline. It includes select approach improvements on the Peninsula including Willow Road Express Lanes as well as grade separations at Willow Road and University Avenue at Bayfront Expressway.

Highway Bridge and Approach Options:

- Bayfront Expressway at University Avenue Option 1/2
- Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1
- Willow Road between Bayfront Expressway and US 101 Option 1/2

Rail Bridge and ROW Options:

- Redwood Junction Wye Option 1/2
- East Bay Corridor and Dumbarton Rail Bridge Option 1
- Rail ROW on Bridge and At-grade Option 1

Alternative 8 Sub-options

Highway Bridge and Approach Options:

- Replace Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1 with Option 2
- Replace Willow Road between Bayfront Expressway and US 101 Option1/2 with Option 3/4
- Replace Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only) with Bayfront Expressway/Marsh Road at US 101 Option 1 (full) / 2

These sub-options equate to a number of alternative combinations as listed below:

- **Alternative 8A: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes** – Alternative 8A eliminates the roadway and intersection improvements on Bayfront Expressway.
- **Alternative 8B: Base with Bi-directional University Avenue Flyover** – Alternative 8B includes all improvements in Alternative 8 (Base) and includes a bi-direction flyover at Bayfront Expressway and University Avenue instead of a single westbound flyover.

8.7.6 Alternative 9 (Base): Rail Commuter Double-Track on Rail Bridge

Alternative 9 is similar to Alternative 8, except that Alternative 9 would utilize two tracks on the Dumbarton Bridge (as opposed to one track in Alternative 8).

Highway Bridge and Approach Options:

- Bayfront Expressway at University Avenue Option 1/2
- Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1
- Willow Road between Bayfront Expressway and US 101 Option 1/2

Rail Bridge and ROW Options:

- Redwood Junction Wye Option 1/2
- East Bay Corridor and Dumbarton Rail Bridge Option 2
- Rail ROW on Bridge and At-grade Option 2

Alternative 9 Sub-options

Highway Bridge and Approach Options:

- Replace Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1 with Option 2

- Replace Willow Road between Bayfront Expressway and US 101 Option1/2 with Option 3/4
- Replace Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only) with Bayfront Expressway/Marsh Road at US 101 Option 1 (full) / 2

These sub-options equate to a number of alternative combinations as listed below:

- **Alternative 9A: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes** – Alternative 9A eliminates the roadway and intersection improvements on Bayfront Expressway.
- **Alternative 9B: Base with Bi-directional University Avenue Flyover** – Alternative 9B includes all improvements in Alternative 9 (Base) and includes a bi-direction flyover at Bayfront Expressway and University Avenue instead of a single westbound flyover.

8.7.7 Alternative 10 (Base): Combination Bus and Rail

Alternative 10 combines Alternative 5 (Enhanced Bus on Highway Bridge with One Express Lane in Each Direction) with Alternative 9 (Commuter Rail Double-Track on Rail Bridge). With Alternative 10, both rail and bus would operate within the Dumbarton Rail ROW on the Peninsula.

Highway Bridge and Approach Options:

- Dumbarton Highway Bridge Option 1
- Bayfront Expressway at University Avenue Option 1/2
- Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1
- Willow Road between Bayfront Expressway and US 101 Option 1/2
- Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only)
- Ardenwood Park-and-Ride (Best for Bus Service)

Rail Bridge and ROW Options:

- Redwood Junction Wye Option 1
- East Bay Corridor and Dumbarton Rail Bridge Option 2
- Rail ROW on Bridge and At-grade Option 2

Alternative 10 Sub-options

Highway Bridge and Approach Options:

- Replace Bayfront Expressway at Willow Road and Willow Road Transit Center Option 1 with Option 2

- Replace Willow Road between Bayfront Expressway and US 101 Option1/2 with Option 3/4
- Replace Bayfront Expressway/Marsh Road at US 101 Option 1 (ramps only) with Bayfront Expressway/Marsh Road at US 101 Option 1 (full) / 2
- Replace Ardenwood Park-and-Ride (Best for Bus Service) with Ardenwood Park-and-Ride with Best for Bus and Rail Service

Rail Bridge and ROW Options:

- Add Rail Dumbarton Rail ROW at US 101 Option 1

9 Cost Estimates

9.1 Operating and Maintenance (O&M) Cost Estimates

9.1.1 Transit Methodology and Assumptions

The annual O&M costs for each alternative are rough order-of-magnitude estimates that were based on the service frequencies, operating hours, and travel time assumptions in the transit operating plans developed for the various alternatives. Different cost estimating methodologies were used for bus and rail modes, described below.

Bus Alternatives

Annual O&M costs for transit service are based on several assumptions about the operating cost per hour, which are as follows:

- Operating cost is $110 per hour (2016 dollars).
- Operating hours include revenue and non-revenue hours.
- Cost includes costs for administration and vehicle maintenance, which is consistent with the existing cost of the Dumbarton Express bus services.
- Layover time is assumed to be 20 percent of revenue hours. This time also includes deadheading and other non-revenue service activities.[1]
- Four hour AM and PM peak periods were also assumed.

The O&M costs are based on the alternatives as described in Chapter 7 and **Appendix E**. However, there are a couple alternative options or variations as noted below.

Option of Dumbarton ROW to US 101 Connection for Alternatives 4 through 6

As detailed in Chapter 8, Alternatives 4a, 5a, and 6a envision the Dumbarton Express (DB), Dumbarton Express 1(DB1), and Mountain View/Sunnyvale routes operating on University Avenue and/or a new direct connector to planned US 101 express lanes from the Dumbarton ROW. (The Menlo Park/Redwood City route is already assumed to operate on the Peninsula ROW until Middlefield Avenue.)

These options were developed because express lanes connections from the Highway Bridge to the proposed Willow Road express lanes (applicable to Alternatives 4 and 5) require sensitive marshlands property that may be unavailable for development. It was determined that there would also be value applying this option to Alternative 6, which does not assume express lanes operations, but could benefit from streamlined bus operations.

It should be noted that Route DB and DB1 are projected to experience a slight increase in travel time with this option because staying on the Peninsula ROW to US 101 (instead of using Willow Road) would result in a longer trip distance. However, reliability would improve since the

[1] Operating cost per hour and layover assumptions were provided by AC Transit.

Peninsula Rail ROW would not be subject to the traffic congestion found on the local roadways. The Mountain View/Sunnyvale route would benefit from travel time savings from having a direct connector to US 101 (instead of getting on US 101 at Marsh Road) because the route includes over 12 miles of travel on US 101.

Rail Alternatives

Because the Rail Shuttle alternative (Alternative 7) assumes Diesel Multiple Unit (DMU) trains and the Rail Commuter alternatives (Alternatives 8 and 9) assume Electric Multiple Unit (EMU) trains, unique cost estimating methodologies were designed for each.

The Rail Shuttle DMU operating costs were derived from the Sprinter service in North San Diego County, which also operates DMUs. The average annual operating cost per vehicle revenue mile for Sprinter was $27.78 in 2013 dollars according to the National Transit Database. This figure was multiplied by three (vehicles) to arrive at a unit cost per train mile and then escalated at three percent per year to arrive at $91.07 per train mile in 2016 dollars.

The Rail Commuter EMU methodology used a cost model developed for Caltrain to estimate operating and maintenance costs for the Caltrain mainline once it is electrified.[2] A three-variable formula that included route miles, train miles, and train hours as inputs was used to estimate the operating and maintenance cost of the two Rail Commuter alternatives. The unit costs in the formula are: $76,085 per route mile, $1,372 per train mile, and $8.42 per train hour in 2016 dollars. It is assumed that such service would operate with four-car consists.

Additionally, each of the rail alternatives includes some level of complimentary bus service, whether it be in the daytime or evening. O&M costs for the complimentary bus service were estimated using the same methodology as for the bus alternatives (Alternatives 2 and 4 through 6).

9.1.2 Express Lanes Methodology and Assumptions

The annual O&M costs for various express lanes alternatives were prepared using unit costs from other local express lanes systems including I 680 southbound express lanes operated by the Sunol Joint Powers Authority and State Route (SR) 237 express lanes operated by the Santa Clara Valley Transit Authority. I 680 southbound express lanes have an annual operating cost per toll zone of $580,000[3] while the SR 237 express lanes have an annual operating cost per toll zone of $550,000[4]. Averaging these estimated costs and using a 150 percent cost multiplier for video enforcement[5] provides an estimated annual O&M cost of $847,500.

These costs include the following: agency and contracted labor, revenue collection fees (provided by the Bay Area Toll Authority), express lanes maintenance (provided by Caltrans), toll system maintenance, California Highway Patrol enforcement, IT support, insurance, marketing/public

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[2] Peninsula Corridor Electrification Program Financial Plan, December 2016.

[3] Sunol JPA Annual Financial Report June 30, 2016

[4] Murali Ramanujam at VTA, 3/27/17 (assumes equipment replacement cost spread over ten years)

[5] To estimate additional cost associated with license plate enforcement (not included in I 680SB and SR 237 costs)

outreach, utilities, and video/imaging enforcement. Costs do not include roadway and structural maintenance costs.

Additional annual O&M costs are required for reversible express lanes options, which require moveable barriers and associated labor and equipment. The Golden Gate Transit District provided a fully loaded rate of $666,440 annually to operate the reversible lanes on the Golden Gate Bridge.[6] This cost includes operators, lane workers, mechanics, tow truck service and fuel, lube, and fluid. Additional detail about which express lanes options are applicable to each alternative is provided in **Table 9-1** and in Chapter 7. **Appendix H** contains additional O&M cost information.

9.1.3 Cost Estimates for Alternative 2, and 4 through 10

Table 9-1: summarizes the O&M costs in 2016 dollars.

Table 9-1: Annual O&M Costs for Alternatives 2, 4-10

Alternative	Annual O&M Cost (Millions in 2016 dollars)				
	Baseline Transit Service	Option of Right-of-Way to US 101 Connection	Complimentary Bus Service	Express Lanes	Total Cost with Baseline
Alternative 2: Short-Term Enhanced Bus on Highway Bridge (2020)	$11.5	N/A	N/A	N/A	$11.5
Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes (2030)	$13.6	$16.3	N/A	$6.0	$19.6
Alternative 5: Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction (2030)	$13.6	$16.3	N/A	$6.2	$19.8
Alternative 6: Busway on Rail Bridge (2030)	$14.4	$17.4	N/A	$1.7	$16.1
Alternative 7: Rail Shuttle on Rail Bridge (2030)	$32.2	N/A	$7.2	$1.7	$41.1
Alternative 8: Rail Commuter Single-Track on Rail Bridge (2030)	$32.0	N/A	$3.5	$1.7	$37.2
Alternative 9: Rail Commuter Double-Track on Rail Bridge (2030)	$38.2	N/A	$3.5	$1.7	$43.4
Alternative 10: Combination Bus and Rail (2030) Alternatives 5 and 9	$51.8	$16.3	$3.5	$6.2	$61.5

Source: Arup (short-term), CDM Smith (long-term), SamTrans (Combination Bus and Rail), 2017

Full O&M cost details can be found in **Appendix H**.

[6] Developed using information from Kary Witt at Golden Gate Bridge provided 3/9/17

9.1.4 Cost Estimate for Bicycle and Pedestrian Multiuse Path

An O&M cost estimate for a potential five-mile multiuse path in the Dumbarton ROW was derived from an average of other trail O&M costs that have been made available from other Bay Area cities, with an emphasis on the Peninsula (**Table 9-2**). From this sample, the average operating and maintenance cost per mile is $11,511 for typical maintenance activities such as vegetation management and removal, drainable system upkeep, lighting system upkeep, pavement upkeep and repair, striping/signage upkeep, and maintenance of any trailhead facilities or signs, etc.

Table 9-2: Planned Bicycle and Pedestrian Multiuse Path Operating and Maintenance Costs

Location	Cost/Mile
Lafayette Bike Plan	$8,500
Mill Valley to Corte Madera Trail Project	$10,578
City of Albany Active Transportation Plan	$25,000
San Mateo County Comprehensive Bicycle Route Plan (2000)	$8,500
City of San Mateo Bike Plan	$8,500
Menlo Park Comprehensive Bicycle Development Plan	$8,500
Palo Alto Comprehensive Bike Ped Plan	$11,000
Average	$11,511

Thus, the projected O&M cost for a 4.6-mile facility is approximately $53,000 annually.

9.2 Capital Cost Estimates

9.2.1 Methodology and Assumptions

The development of probable capital expenditure (Capex) costs used two different approaches: (1) reliance on previous cost estimates developed as part of the unpublished 2012 *Dumbarton Rail Corridor (DRC) Project Draft Environmental Impact Statement/Environmental Impact Report* for rail components of the project; and development of new cost estimates for roadway and transit components not studied in the DRC project or substantially modified by the Dumbarton Transportation Corridor Study (DTCS).

The opinion of probable Capex costs is an order-of-magnitude estimate in 2017 dollars and has not been escalated to mid-point of construction based on the proposed implementation timeframes. Given the level of design (i.e., generally five to 10 percent), the accuracy of the estimates could vary significantly from -30 percent on the low end to +50 percent on the high end and could also vary by project component. The opinions of probable Capex costs are intended to allow comparisons between projects only and is not indented for budgetary or funding purposes.

The opinion of probable Capex costs developed as part of the DTCS can also vary significantly as more detailed design information becomes available and quantities are more accurately defined. Labor, material, and equipment rates may also vary significantly based on regional and national economic conditions at the time of construction. Therefore, costs may vary significantly in later phases of project development.

9.2.2 Estimates of DRC-Identified Project Components

The DTCS utilized previously prepared Capex cost for the implementation of rail service between the East Bay and Peninsula and for the rehabilitation of the Dumbarton Rail Bridge from the DRC project developed in 2012. The DRC project costs were escalated based on a three percent annual inflation factor to 2017 dollars except for ROW costs. ROW costs were escalated based on a factor of six percent annually to reflect the strong recovery of real estate values from the 2008/2009 economic recession.

9.2.3 Estimates of Study-Identified Project Components

New project components identified by the DTCS included primarily roadway transit improvements, which were not considered by the DRC study. Examples include, but are not limited to, improvements like Willow Road express lanes, grade separations at University Avenue/Bayfront Expressway and Willow Road/Bayfront Expressway, etc. However, the DTCS significantly modified the Peninsula Rail concepts from the DRC study requiring new estimates to be prepared for rail projects in San Mateo County.

Project Quantities

The quantities developed for the estimate of Capex costs are based on conceptual-level engineering and experience from similar projects. Quantities are limited to the major construction elements and are approximated based on available aerial imagery.

Unit Costs and Resources

Standard unit costs were developed for the major project construction elements. Unit costs were developed based on the following resources:

- Recent Caltrain project cost data including the 25th Street Grade Separation project in the City of San Mateo and the Los Gatos Creek Bridge project in the City of San Jose
- Caltrans cost database
- Historical data from similar projects completed by team members
- Engineers experience and judgment based on similar projects

Project Development Costs and Contractor Markups

The base construction costs developed for each of the projects includes contractor overhead and profit in the unit costs and a mobilization/demobilization factor of 12 percent. A construction contingency of 30 percent was then added to the base cost to reflect five to 10 percent level of design to determine the estimated 2017 construction cost of the projects. Project development costs were added to the construction cost to determine the total estimated opinion of probable Capex costs as follows:

- Project administration: five percent of construction costs
- Environmental analysis and review estimated as lump sum based on potential project impacts

- Preliminary and final engineering: ten percent of construction costs
- Construction management: six percent of construction costs
- Environmental mitigation: six percent of construction costs
- Project Reserve: five percent of construction, project development, and ROW costs

ROW costs were estimated based on the type of existing land use ranging from undeveloped to dense urban development categories. Building acquisition costs were based on a unit cost per square foot. All unit costs include acquisition-related costs such as appraisals, title research, and negotiations.

Vehicle Costs

Bus Alternatives

Vehicle costs were calculated by estimating the fleet size via operating characteristics and applying a unit cost per bus in 2016 dollars. The project assumed that all new buses would be purchased for the Dumbarton services except for the Short-Term Enhanced Bus on the Highway Bridge (Alternative 2), which would be able to utilize existing vehicles. **Table 9-3** shows bus vehicle costs provided by AC Transit.

Table 9-3: Unit Vehicle Costs for Bus Alternatives

Vehicle Type	Alternative	Cost per Vehicle (2016$)	Capacity (seats)
40-foot standard bus	Short-Term Enhanced Bus on Highway Bridge (Alternative 2) Complimentary bus service for Rail Shuttle on Rail Bridge (Alternative 7) and Rail Commuter on Rail Bridge (Alternatives 8 and 9) (DB / DB1 / MV/S destinations)	$500,000	40
Double-decker bus	Long-Term Enhanced Bus on Highway Bridge (Alternatives 4 and 5) Busway on Rail Bridge (Alternative 6)	$1,000,000	80

Source: AC Transit, 2017

The fleet size for each bus alternative was determined by the frequency of service, length of the route, travel and layover time (12 percent of run time), and spares needed (15 percent spare ratio) (**Table 9-4**).

Table 9-4: Fleet Sizes for Bus Alternatives

Alternative	Vehicles	Spares (25%)	Total
Alternative 2: Short-Term Enhanced Bus on Highway	33	5	38
Alternatives 4 & 5: Long-Term Enhanced Bus on Highway	45	7	52
Alternative 6: Busway on Rail Bridge	44	7	51
Alternative 7: Rail Shuttle on Rail Bridge	24	4	28
Alternative 8: Rail Commuter Single-Track on Rail Bridge	24	4	28
Alternative 9: Rail Commuter Double-Track on Rail Bridge	24	4	28

Source: Arup and CDM Smith, 2017

Because 21 vehicles are already available for the Short-Term Enhanced Bus on the Highway Bridge, it is assumed that the procurement of only 17 vehicles is required.

Rail Alternatives

Rail vehicle costs were obtained from two Bay Area projects: the Bay Area Rapid Transit District (BART) eBART extension to Antioch, which will be operating DMUs, and the Caltrain Peninsula Corridor Electrification Program, which will operate bi-level EMUs. Since the two Rail Commuter alternatives would operate on the Caltrain mainline and share some platforms, those alternatives would have to operate vehicles similar to Caltrain's and therefore would need to be bi-level. As previously mentioned, the Rail Shuttle would operate three-car consists, while the Rail Commuter alternatives would operate four-car consists. **Table 9-5** provides unit costs for rail vehicles.

Table 9-5: Unit Vehicle Costs for Rail Alternatives

Vehicle Type	Alternative	Cost per Vehicle (2016$)	Capacity (seats)
DMU Single-Level, 3-car consist	Rail Shuttle on Rail Bridge (Alternative 7)	$6,000,000	104
EMU Bi-Level, 4-car consist	Rail Commuter on Rail Bridge (Alternatives 8 and 9)	$5,800,000	113

Source: BART and Caltrain, 2017

The fleet size was determined by the frequency of service, length of the route, travel and layover time, and spares needed (25 percent spare ratio). It was estimated that the two Rail Commuter alternatives would have the same size fleet because the Rail Commuter Double-Track (Alternative 9) would use the train consists that would otherwise be laid over in a yard for Rail Commuter Single-Track (Alternative 8). Fleet size for the rail alternatives is shown in **Table 9-6** below.

Table 9-6: Fleet Size for Rail Alternatives

Alternative 7: Rail Shuttle DMU 3-car consist	Vehicles	Spares (25%)	Total
DMU cab	12	3	15
DMU car	6	2	8
Total Fleet			23

Alternatives 8 & 9: Rail Commuter EMU 4-car consist	Vehicles	Spares (25%)	Total
EMU power car	12	3	15
EMU trailer	12	3	15
Total Fleet			30

Source: CDM Smith, 2017

Cost Estimates

Table 9-7 shows the bus and rail vehicle costs for each alternative, assuming a 4-hour peak period. In the rail alternatives, the cost of connecting complimentary bus service is also shown.

Table 9-7: Vehicle Costs for Bus and Rail Alternatives

Alternative	Vehicle Costs (Millions 2016$)	
	Bus	Rail
Alternative 2: Short-Term Enhanced Bus on Highway Bridge (2020)	17 buses $17	N/A
Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes (2030)	52 buses $52	N/A
Alternative 5: Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction (2030)	52 buses $52	N/A
Alternative 6: Busway on Rail Bridge (2030)	51 buses $51	N/A
Alternative 7: Rail Shuttle on Rail Bridge (2030)	28 buses $14	6 consists + 5 spares $138
Alternative 8: Rail Commuter Single-Track on Rail Bridge (2030)	28 buses $14	6 consists + 6 spares $174
Alternative 9: Rail Commuter Double-Track on Rail Bridge (2030)	28 buses $14	6 consists + 6 spares $174
Alternative 10: Combination Bus and Rail (2030) Alternatives 5 and 9	80 buses $76	6 consists + 6 spares $174

Source: Arup (short-term), CDM Smith (long-term), SamTrans (Combination Bus and Rail), 2017

Further information about vehicle estimates and costs are included in **Appendix H**.

9.2.4 Cost Estimates for Alternatives 1 through 10

As discussed in Chapter 8, there are many design possibilities and combinations associated with each alternative. Capital cost estimates are discussed for the base alternatives and sub-options introduced in Chapter 8. Additional detail regarding capital cost breakdowns are included in **Appendix I**.

Alternatives 1 and 3: No Build Alternatives

The No Build Alternatives (Alternatives 1 and 3) assume no capital improvements but have a capital cost of approximately $150 million for deconstruction of the existing Rail Bridge.

Alternative 2: Short-Term Enhanced Bus on Highway Bridge

Alternative 2 includes enhanced bus service on the Highway Bridge as well as approach improvements.

Alternative 2 requires the acquisition of 17 new 40-foot buses, totaling $8.5 million.

In addition, Highway Bridge and approach improvements totaling $42.8 million would include the following:

- SR 84 Toll Booth Removal at FasTrak Lanes and FasTrak Lane Extension to East of Paseo Padre Parkway
- Decoto Road Transit Signal Priority and Queue Jump Lanes from I 880 east to Union City BART Station
- SR 84/Newark Boulevard HOV Bypass Lane
- Bayfront Expressway and Willow Road Transit Signal Priority and Queue Jump Lanes
- Bayfront Expressway Bus-only Lanes

The estimated capital cost for Alternative 2 is $51.3 million.

Alternative 4 (Base): Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes

Alternative 4 (Base) assumes reversible express lanes on the Highway Bridge with an express lane connection to US 101 via Willow Road, as well as other transit and Highway Bridge/approach improvements along the SR 84 corridor from I 880 to US 101.

Alternative 4 (Base) includes the following transit improvements, totaling $160.1 million:

- Busway within existing ROW from Middlefield Road to University Avenue with US 101/Rail Bridge replacement
- Dumbarton Rail ROW/Willow Road Transit Center
- 52 Double-decker buses
- Bus maintenance facility

Alternative 4 (Base) includes the following Highway Bridge/approach improvements, totaling $937.9 million:

- SR 84 eastbound express lanes from toll plaza to I 880/Decoto Road
- SR 84/I 880 express lanes direct connectors
- University Avenue/Bayfront Expressway grade separation (westbound flyover)
- Bayfront Expressway express lanes (Dumbarton Highway Bridge to Willow Road)
- Highway Bridge reversible express lanes
- Willow Road/Bayfront Expressway grade separation (SR 84 to Willow Road express lanes direct connection)
- Willow Road express lanes (tunnel) and Willow Road to US 101 express lanes flyover connection
- Marsh Road direct-connect ramps to US 101
- Ardenwood Park-and-Ride expansion (for bus service only)

The estimated capital cost for Alternative 4 (Base) is $1,098.1 million. Costs for sub-options include the following:

- Alternative 4A: Base with Dumbarton ROW to US 101 Connector – $1,121.8 million
- Alternative 4A.1: Base with Bi-directional University Avenue Flyover – $1,114.4 million
- Alternative 4B: Base without Willow Road Express Lanes – $619.9 million
- Alternative 4B.1: Base without Willow Road Express Lanes – $638.6 million
- Alternative 4B.2: Base without Willow Express Lanes, and Willow Road Bus Lanes, and with Dumbarton Right-of-Way to US 101 Connector – $665.4 million
- Alternative 4B.3: Base without Willow Road Express Lanes, and with Willow Road Bus Lanes and Express Lanes to US 101/Marsh Road Interchange – $891.5 million
- Alternative 4C: Base with Ardenwood Park-and-Ride for Bus and Potential Rail Service – $1,104.9 million
- Alternative 4C.1: Base without Willow Express Lanes, with Willow Road Bus Lanes, with Dumbarton Right-of-Way to US 101 Connector, and with Ardenwood Park-and-Ride for Bus and Potential Rail Service – $672.2 million
- Alternative 4D: Base with Ardenwood Park-and-Ride for Bus and Rail Service – $1,115.8 million

Alternative 5 (Base): Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction

Alternative 5 (Base) assumes one express lane in each direction on the Highway Bridge with an express lane connection to US 101 via Willow Road, as well as other transit and Highway Bridge/approach improvements along the SR 84 corridor from I 880 to US 101.

Alternative 5 (Base) includes the following transit improvements, totaling $160.1 million:

- Busway within existing ROW from Middlefield Road to University Avenue with US 101/Rail Bridge replacement
- Dumbarton Rail ROW/Willow Road Transit Center
- 52 Double-decker buses
- Bus maintenance facility

Alternative 5 (Base) includes the following Highway Bridge/approach improvements, totaling $900.7 million:

- SR 84 eastbound express lanes from toll plaza to I 880/Decoto Road
- SR 84/I 880 express lanes direct connectors
- University Avenue/Bayfront Expressway grade separation (westbound flyover)
- Bayfront Expressway express lanes (Highway Bridge to Willow Road)
- Highway Bridge one express lane in each direction
- Willow Road/Bayfront Expressway grade separation (SR 84 to Willow Road express lanes direct connection)
- Willow Road express lanes (tunnel) and Willow Road to US 101 express lanes flyover connection
- Marsh Road direct-connect ramps to US 101
- Ardenwood Park-and-Ride expansion (for bus service only)

The estimated capital cost for Alternative 5 (Base) is $1,060.8 million. Costs for sub-options include the following:

- Alternative 5A: Base with Dumbarton ROW to US 101 Connector – $1,084.5 million
- Alternative 5A.1: Base with Bi-directional University Avenue Flyover – $1,077.2 million
- Alternative 5B: Base without Willow Road Express Lanes – $582.6 million
- Alternative 5B.1: Base without Willow Road Express Lanes and with Willow Road Bus Lanes – $601.4 million

- Alternative 5B.2: Base without Willow Express Lanes, with Willow Road Bus Lanes, and with Dumbarton Right-of-Way to US 101 Connector – $682.1 million
- Alternative 5B.3: Base without Willow Road Express Lanes, and with Willow Road Bus Lanes and Express Lanes to US 101/Marsh Road Interchange – $854.3 million
- Alternative 5C: Base with Ardenwood Park-and-Ride for Bus and Potential Rail Service – $1,067.6 million
- Alternative 5C.1: Base without Willow Express Lanes, with Willow Road Bus Lanes, with Dumbarton ROW to US 101 Connector, and with Ardenwood Park-and-Ride for Bus and Potential Rail Service – $634.9 million
- Alternative 5D: Base with Ardenwood Park-and-Ride for Bus and Rail Service – $1,078.5 million

Alternative 6 (Base): Busway on Rail Bridge

Alternative 6 (Base) includes a busway on the Rail Bridge as well as roadway and intersection improvements along Bayfront Expressway.

Alternative 6 (Base) includes the following transit improvements, totaling $615.1 million:

- West Newark busway and siding to Newark Junction (MP 35.9 to MP 36.9)
- Rail Bridge busway
- Busway within existing ROW from Middlefield Road to University Avenue with US 101/Rail Bridge replacement
- Dumbarton Rail ROW/Willow Road Transit Center
- Newark park-and-ride
- 51 double-decker buses
- Bus maintenance facility

Alternative 6 (Base) includes the following Highway Bridge/approach improvements, totaling $606.1 million:

- University Avenue/Bayfront Expressway grade separation (westbound flyover)
- Willow Road/Bayfront Expressway grade separation (SR 84 to Willow Road express lanes direct connection)
- Willow Road express lanes (tunnel) and Willow Road to US 101 express lanes flyover connection

The estimated capital cost for Alternative 6 (Base) is $1,221.2 million. Costs for sub-options are as follows:

- Alternative 6A: Base with Dumbarton Right-of-Way to US 101 Connector – $1,246.9 million
- Alternative 6B: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes – $615.1 million
- Alternative 6B.1: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes, and with Dumbarton ROW to US 101 Connector – $641.9
- Alternative 6C: Base with Bi-directional University Avenue Flyover – $1,237.6 million

Alternative 7 (Base): Rail Shuttle on Rail Bridge

Alternative 7 (Base) includes the operation of commuter rail "shuttle" service as well as roadway and intersection improvements along Bayfront Expressway.

Alternative 7 (Base) includes the following transit improvements, totaling $1,150.0 million:

- Redwood City Station Option 1 (new elevated shuttle platform above existing station)
- Track and bridge improvements in East Bay (Industrial Parkway to SF Bay)
- Station at Union City
- Niles Connection
- Newark park-and-ride
- Layover Yard
- Dumbarton and Newark Bridge rehabilitation
- Track and bridge improvements in Peninsula (Redwood Junction to SF Bay)
- Dumbarton ROW/Willow Road Transit Center
- 23 DMU cabs and cars
- 28 Standard buses

Alternative 7 (Base) includes the following Highway Bridge/approach improvements, totaling $606.1 million:

- University Avenue/Bayfront Expressway grade separation (westbound flyover)
- Willow Road/Bayfront Expressway grade separation (SR 84 to Willow Road express lanes direct connection)
- Willow Road express lanes (tunnel) and Willow Road to US 101 express lanes flyover connection

The estimated capital cost for Alternative 7 (Base) is $1,756.1 million. Costs for sub-options are as follows:

- Alternative 7A: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes -- $1,150 million
- Alternative 7B: Base with Redwood City Station Option 2 – $1,752.9 million
- Alternative 7C: Base with Bi-directional University Avenue Flyover – $1,772.5 million

Alternative 8 (Base): Rail Commuter Single-Track on Rail Bridge

Alternative 8 (Base) includes the operation of commuter rail "commuter" service (interlining with the Caltrain mainline) with a single tracked Rail Bridge as well as roadway and intersection improvements along Bayfront Expressway.

Alternative 8 (Base) includes the following transit improvements, totaling $1,223.8 million:

- Track and bridge improvements in East Bay (Industrial Parkway to San Francisco Bay)
- Station at Union City
- Niles Connection
- Newark Park-and-Ride
- Layover Yard
- Dumbarton and Newark Bridge rehabilitation
- Track and bridge improvements in Peninsula (Redwood Junction to San Francisco Bay)
- Caltrain Mainline (Redwood City to Atherton)
- Dumbarton Rail ROW/Willow Road Transit Center
- Electrification
- 30 EMU power cars and trailers
- 28 Standard buses

Alternative 8 (Base) includes the following Highway Bridge/approach improvements, totaling $606.1 million:

- University Avenue/Bayfront Expressway grade separation (westbound flyover)
- Willow Road/Bayfront Expressway grade separation (SR 84 to Willow Road express lanes direct connection)
- Willow Road express lanes (tunnel) and Willow Road to US 101 express lanes flyover connection

The estimated capital cost for Alternative 8 (Base) is $1,829.9 million. Costs of sub-options are as follows:

- Alternative 8A: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes – $1,223.8
- Alternative 8B: Base with Bi-directional University Avenue Flyover – $1,846.3

Alternative 9 (Base): Rail Commuter Double Track on Rail Bridge

Alternative 9 (Base) includes the operation of commuter rail "commuter" service (interlining with the Caltrain mainline) with a double-tracked Rail Bridge as well as roadway and intersection improvements along Bayfront Expressway.

Alternative 9 (Base) includes the following transit improvements, totaling $1,351.1 million:

- Track and bridge improvements in East Bay (Industrial Parkway to San Francisco Bay)
- Station at Union City
- Niles Connection
- Newark park-and-ride
- Layover Yard
- Dumbarton and Newark Bridge rehabilitation
- Dumbarton Bridge 2nd Main Track (MP 31.4 to MP 35.7)
- Track and bridge improvements in Peninsula (Redwood Junction to SF Bay)
- Caltrain mainline (Redwood City to Atherton)
- Dumbarton rail ROW/Willow Road Transit Center
- Electrification
- 30 EMU power cars and trailers
- 28 Standard buses

Alternative 9 (Base) includes the following Highway Bridge/approach improvements, totaling $606.1 million:

- University Avenue/Bayfront Expressway grade separation (westbound flyover)
- Willow Road/Bayfront Expressway grade separation (SR 84 to Willow Road express lanes direct connection)
- Willow Road express lanes (tunnel) and Willow Road to US 101 express lanes flyover connection

The estimated capital cost for Alternative 9 (Base) is $1,957.2 million. Costs of sub-options are as follows:

- Alternative 9A: Base without University Avenue/Bayfront Expressway Grade Separation, Willow Road/Bayfront Expressway Grade Separation, and Willow Road Express Lanes – $1,351.1 million
- Alternative 9B: Base with Bi-directional University Avenue Flyover – $1,973.6

Alternative 10: Combination Bus and Rail

Alternative 10 includes all improvements from Alternatives 5 and 9 as described above.

Alternative 10 includes the following transit improvements, totaling $1,503.2 million:

- Track and bridge improvements in East Bay (Industrial Parkway to San Francisco Bay)
- Station at Union City
- Niles Connection
- Newark park-and-ride
- Layover Yard
- Dumbarton and Newark Bridge rehabilitation
- Dumbarton bridge 2nd Main Track (MP 31.4 to MP 35.7)
- Track and bridge Improvements in Peninsula (Redwood Junction to San Francisco Bay)
- Caltrain mainline (Redwood City to Atherton)
- Busway within existing ROW from Middlefield Road to University Avenue with US 101/Rail Bridge replacement
- Dumbarton rail ROW/Willow Road Transit Center
- Electrification
- 30 EMU power cars and trailers

- 28 Standard buses
- 52 double-decker buses
- Bus maintenance facility

Alternative 10 includes the following Highway Bridge/approach improvements, totaling $900.7 million:

- SR 84 eastbound express lanes from toll plaza to I 880/Decoto Road
- SR 84/I 880 express lanes direct connectors
- University Avenue/Bayfront Expressway grade separation (westbound flyover)
- Bayfront Expressway express lanes (Dumbarton Highway Bridge to Willow Road)
- Highway Bridge one express lane in each direction
- Willow Road/Bayfront Expressway grade separation (SR 84 to Willow Road express lanes direct connection)
- Willow Road express lanes (tunnel) and Willow Road to US 101 express lanes flyover connection
- Marsh Road Direct-Connect Ramps to US 101
- Ardenwood Park-and-Ride expansion (for bus service only)

The estimated capital cost for Alternative 10 is $2,403.9 million.

9.2.5 Summary of Cost Estimates for Alternatives 1 through 10

Table 9-8 summarizes the estimated capital costs developed for Alternatives 2, and 4 through 10, as well as each of the alternatives' variations as described in Section 9.2.4.

Table 9-8: Summary of Capital Costs

Alternative		Transit Improvements Cost (millions $)	Highway Bridge/ Approach Improvements Cost (millions $)	Total Cost (millions $)
Alternative 2: Short-Term Enhanced Bus on Highway Bridge	Base	8.5	42.8	51.3
Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lanes	Base	160.1	937.9	1,098.1
	4A	183.9	937.9	1,121.8
	4A.1	160.1	954.3	1,114.4
	4B	160.1	459.7	619.9
	4B.1	178.9	459.7	638.6
	4B.2	205.7	459.7	665.4
	4B.3	178.9	712.6	891.5
	4C	160.1	944.7	1,104.9
	4C.1	205.7	466.5	672.2
	4D	160.1	955.7	1,115.8
Alternative 5: Long-term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	Base	160.1	900.7	1,060.8
	5A	183.9	900.7	1,084.5
	5A.1	160.1	917.0	1,077.2
	5B	160.1	422.5	582.6
	5B.1	178.9	422.5	601.4
	5B.2	205.7	422.5	628.1
	5B.3	178.9	675.3	854.3
	5C	160.1	907.5	1,067.6
	5C.1	205.7	429.2	634.9
	5D	160.1	918.4	1,078.5
Alternative 6: Busway on Rail Bridge	Base	615.1	606.1	1,221.2
	6A	640.9	606.1	1,246.9
	6B	615.1	-	615.1
	6B.1	641.9	-	641.9
	6C	615.1	622.5	1,237.6
Alternative 7: Rail Shuttle on Rail Bridge	Base	1,150.0	606.1	1,756.1
	7A	1,150.0	-	1,150.0
	7B	1,146.8	606.1	1,752.9
	7C	1,150.0	622.5	1,772.5
Alternative 8: Rail Commuter Single-Track on Rail Bridge	Base	1,223.8	606.1	1,829.9
	8A	1,223.8	-	1,223.8
	8B	1,223.8	622.5	1,846.3
Alternative 9: Rail Commuter Double-Track on Rail Bridge	Base	1,351.1	606.1	1,957.2
	9A	1,351.1	-	1,351.1
	9B	1,351.1	622.5	1,973.6
Alternative 10: Combination Bus and Rail	Base	1,503.2	900.7	2,403.9

Source: HDR, 2017

9.2.6 Cost Estimate for Bicycle and Pedestrian Multiuse Path

The following summarizes the estimated capital cost for the bicycle and pedestrian multiuse path. At the 15 percent design level, the multiuse path was determined to require overpasses in four areas: Marsh Road, US 101, Willow Road, and University Avenue. The grade separated crossing of US 101 was mandated by Caltrans. The other three crossings could result in substantive impacts to vehicular traffic as well as potential safety issues for bicyclists and pedestrians and so they are proposed to be grade separated. The costs outlined below include the bridge structures, retaining wall approaches as well as the multiuse path itself. The total cost is approximately $60 million.

Table 9-9: Bicycle and Pedestrian Multiuse Path Capital Costs

Cost Elements	Cost (millions)
Marsh Road Overpass	$6.9
US 101 Overpass	$9.1
Willow Road Overpass	$11.4
University Avenue Overpass	$9.8
Remaining Multiuse Path	$22.8
Total	$60.0

Source: Arup, 2017

10 Travel Forecasting

This chapter describes the travel behavior forecasting methodology and results for the Dumbarton Transportation Corridor Study (DTCS) alternatives carried forward. The results help to evaluate the potential productivity of study alternatives. Chapter sections document the model assumptions, validation and calibration, and results with implications for selecting preferred alternatives. A description of the socio-economic and demographic data used as the basis of the forecasts is described in Chapter 4.

10.1 Methodology

10.1.1 The C/CAG Model

The DTCS uses the City/County Association of Governments of San Mateo County (C/CAG) travel model developed by the Santa Clara Valley Transportation Authority (VTA). This model was current as of March 2016, and is consistent with the current Metropolitan Transportation Commission (MTC) Plan Bay Area Regional Transportation Plan (RTP). The DTCS incorporates updates to the model beginning in April 2016 that include minor calibration, land use projections or transportation projects. The model forecasts vehicle traffic and transit ridership for 2020 and 2040. 2013 was used as the baseline year.

Models use geographic units called Transportation Analysis Zones (TAZs) to aggregate socio-economic data. Each TAZ is designed to be roughly proportional in terms of population size. The C/CAG model contains almost 3,000 TAZs with detailed coverage of areas most influential to travel in the study area such as San Mateo, Santa Clara, and Alameda Counties.

10.1.2 Calibration and Validation

Because the C/CAG model encompasses most of the Bay Area, it must be calibrated to local conditions by attempting to recreate observed travel volumes. Model parameters are then adjusted to confirm that the forecasts are contextually sensitive to the project area.

The model was calibrated specifically for the DTCS. Primary elements of the calibration process included:

- Updating 2013 employment to match actual employee counts at Facebook, Google, and Stanford University campuses.
- Incorporating actual mode shares in cases where they are monitored and enforced, including trip caps applied to Stanford, Facebook, and the North Bayshore area of Mountain View.
- Correcting the original coding of the Dumbarton Express bus services across the Dumbarton Highway Bridge and validation of directional transbay bus ridership.
- Including transbay corporate shuttles on the Dumbarton Highway Bridge for aggregate forecasting of public and private transbay bus ridership.

- Factoring of county-to-county movements in the highway pre-assignment origin-destination matrix in consultation with VTA model technicians.

Model validation tests focused on the accuracy of origin/destination travel estimates; mode shares; and traffic volumes. A variety of validation and sensitivity tests were performed on the model to confirm that it reasonably captured the effects of population and employment growth on performance characteristics of DTCS alternatives. These tests also helped identify necessary model adjustments. The testing also included validation of transit ridership and traffic volumes, and the assessment of the model's responsiveness to land use change, employment growth, jobs/housing balance, and transportation network changes. Per California Transportation Commission guidelines, static and dynamic tests were applied.

Static validation checked the model's ability to replicate 2013 traffic and transit volumes in the study area as detailed below.

- Caltrain segment and station demand estimated by the model compared with actual ridership and the Caltrain Electrification Environmental Impact Report (EIR).
- BART segment and station demand estimated by the model compared with actual ridership and calibrated values from the BART Metro Vision plan.
- Transbay bus peak period trips estimated by the model compared with actual ridership.
- Peak period traffic volumes on SR 84, SR 237, SR 92, US 101, and I 880 estimated by the model compared with actual volumes.

Dynamic validation tests the model's responsiveness to changes in the transportation network and land use. Model outputs are then compared to what the expected changes would be based on research and experience. The dynamic tests are described below:

- Land use change only: combined 2020 and 2040 land use on the 2013 network to assess reasonableness of change in per capita demand by mode.
- Network change only: combined 2013 land use with the 2020 and 2040 networks to assess the reasonableness of change in the redistribution of traffic volumes, mode share, and trip distribution.
- Both land use and network: assessed the reasonableness of 2020 and 2040 growth by mode and facility or service type in total and per capita.
- Examined trip length distribution among all the above outputs and assess the reasonableness relative to job/housing balance.

Overall, the calibrated C/CAG model was validated[1] in terms of the following performance standards:

- **Highway:** The Dumbarton Highway Bridge, San Mateo Bridge and segments of US 101 and I 880 from north of the San Mateo Bridge to south of the Dumbarton Highway Bridge achieved a model/count ratio of 1.03 or better, and meet standard objectives for percent within Caltrans maximum deviation, root mean square error, R-square, and correlation coefficient[2] during the morning and evening peaks.
- **Caltrain:** System-wide boardings are within two percent of counts. Boardings for the Redwood City station are within five percent of counts, and combined boardings for the stations in Redwood City, Menlo Park, and Mountain View are within two percent of counts.
- **BART:** System boardings are within less than one-half percent of counts. Boardings for the Union City and Fremont stations combined are within 10 percent of counts.
- **Transbay bus ridership:** Boardings on the Dumbarton Express lines and corporate shuttles combined are within nine percent of counts; the split between public and private transit ridership is within one percent of actual.

10.1.3 Sensitivity to Pricing and Travel Time

A literature review on regional and national experience with road pricing and related behavior forecasting formed the basis for judging the reasonableness of the model's sensitivity to road congestion and pricing.[3] **Table 10-1**, below, summarizes the literature review and the elasticities and related adjustments included in testing. These findings were used to adjust the C/CAG model to predict pricing effects in keeping with experience and research.

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[1] The validation is based on the criteria set by the following manual or guideline: 2010 California Regional Transportation Plan Guidelines (California Transportation Commission, April 2010) and Travel Model Validation and Reasonableness Check Manual (Federal Highway Administration, September 2010)

[2] In statistics, the R-square (R^2) and correlation coefficient are used to generally indicate the accuracy of a model.

[3] The literature review is presented in **Appendix J.**

Table 10-1: Elasticity with Respect to Changes in Toll Pricing

Toll Facilities	Elasticity with Respect to Changes in Toll Pricing			
	All Day	Peak Period	Off-Peak	Notes
Bay Bridge - Carpools		-0.15		Controlled for gas price, unemployment
Bay Bridge – Non-Pools		-0.12		
Bay Bridge – All Traffic		-0.08	+0.34*	* Effect of peak toll
Seven Bay Area Bridges	-0.05			Controlled for gas price, unemployment
Golden Gate Bridge	-0.15 to -0.19			
Seattle		-0.12		Varies -0.04 to -0.16 depending on transit availability
New York bridges	-0.14	-0.12 to –0.22	-0.11 to –0.24	Varies by cash vs pass use
National	-0.10 to -0.35			
Proposed DTCS C/CAG Elasticity Adjustment for Bridge Tolls	*-0.10 to -0.15*	*-0.10 to -0.20*	*-0.15 to -0.20*	*+0.03 off-peak response to peak tolls*
Minnesota HOT lanes		+0.03 to +0.85		Toll offset by perceived travel time reliability benefit
Proposed DTCS C/CAG Elasticity Adjustment for HOT Lanes	*If C/CAG model response does not meet expected elasticities within + 0.03, apply value-of-time to convert travel time savings to cost savings net of toll cost and calculate elasticity adjustment based on expected toll elasticities*			

Source: Fehr & Peers, 2017

Based on the research, tests were performed to assess the model's ability to capture pricing effects of all-day or peak tolling changes and High-Occupancy Toll (HOT) lanes, including variations in road price and auto travel times in the C/CAG 2013 model.

Italicized text in the table above indicate ranges of elasticities used for the analysis, with the value within the range to be selected based on the relative volume/capacity ratios projected for the Dumbarton Highway Bridge and SR 237 diversion route.

10.1.4 Model Forecasts

Off-model adjustments and other model output post-processing methods used in the production of travel forecasts are described below.

Road Pricing

Post process calibration of pricing sensitivity is used to the extent that model sensitivity does not reflect evidence from recent experience and research. This was accomplished through the application of research-based elasticities from national studies and Bay Area experience as described in the preceding section.

Growth of Major Employers

The projected growth of major Silicon Valley employers in the DTCS study area provides the basis of their planned enhancements to travel demand strategies and services such as shuttle bus operations. The approach quantifies the employment growth projections of the major employers affecting the Dumbarton Corridor using information from the sources listed below.

- Published documents such as the Mountain View North Bayshore Specific Plan, the Menlo Park General Plan Update, and Facebook Master Plan EIR.
- Individual projections by the major employers themselves or other appropriate sources.

Published development applications, specific plans, and precise plan EIRs set more aggressive reductions in single-occupancy vehicle (SOV) generation than presently achieved and services intended to achieve those targets. As an adjustment to the C/CAG model forecasts, the DTCS traffic and transit demand forecasts use information on achievable and enforceable reductions to corridor SOV rates from the employers. Consistent with the base-year model calibration, major employment centers obligated to meet vehicle trip generation caps and/or SOV or mode share targets are controlled within the model to meet their monitored and enforced targets. This applies, for example, to Facebook, Google and Mountain View's North Bayshore area, and the Stanford campus.

The Plan Bay Area 2020 and 2040 forecasted job growth was tabulated and compared with private sector projections. Forecasted employment was thus increased in the model to the extent that job growth exceeded the official projections. The official projections underlying this process are discussed in more detail in the forecasted demographics subsections of Chapter 4.

10.1.5 Alternatives to Which Forecasting is Not Sensitive

The combination of base C/CAG model capabilities and added sensitivities to pricing and other potential off-model adjustments allow for consideration of most individual transportation improvements included in the project alternatives. However, due to the nature of travel models the forecasts do not reflect the factors listed below:

- Bus enhancements not directly manifesting in travel time and cost (such as on-board amenities or marketing).
- Diesel versus electric commuter rail locomotives.
- Innovative modes and concepts such as Transportation Network Companies, autonomous vehicles, personal rapid transit, or Hyperloop, as these have limited measured evidence of performance and market demand.
- Minor changes to toll plaza operations that do not produce notable changes to travel time.
- Dynamic road pricing that does not produce predictable changes to travel cost for individuals or the average driver.
- Highly localized improvements related to modes not presently represented in transbay corridor activity such as bicycle and pedestrian facilities and related travel demand management strategies.

Because the C/CAG travel demand model cannot capture use of the proposed bicycle and pedestrian multiuse path, potential use was estimated via another methodology, though one with limitations. This effort is detailed in **Appendix K**.

10.2 Socio-economic Model Inputs and Assumptions

Models rely on employment and population data to forecast travel volumes between origins and destinations. The C/CAG model uses the "Projections '13" (P'13) set of socio-economic forecasts, which is produced by the Association of Bay Area Governments (ABAG). As of 2016, job growth had already outpaced these official predictions. Therefore, adjustments were made to the C/CAG model socio-economic data to better align with observed trends.

10.2.1 2020 Forecast

As of 2015, actual regional jobs exceeded the P'13 forecasts for 2020 by about one percent (at the time of this study, ABAG was considering raising its forecasts by about four percent for Plan Bay Area 2040). As such, for a plausible but still conservative 2020 forecast, the DTCS added another one-half percent to today's actual employment total to account for growth between 2015 and 2020. DTCS forecasts allocated the growth to cities within the study area that have exhibited the greatest growth (40 percent greater rate than San Francisco from 2001-2015 and four times the regional average rate), and which show continued momentum and are in the process of approving more employment-related development: Mountain View, Stanford, Menlo Park, and Redwood City. The forecasts take into consideration the North Bayshore Precise Plan, completion of the 2000 Stanford campus General Use Permit (GUP) and application for its 2018 GUP, approved Stanford medical center expansions in Palo Alto and Redwood City, and Facebook's expansion and pending applications on conversion of adjacent industrial properties.

In total, the DTCS forecasts added 59,000 jobs to these cities above Plan Bay Area, increasing the regional total by one-and-a-half percent above the P'13 forecasts, one percent for what has already occurred and one-half percent for added growth between now and 2020.

10.2.2 2040 Plan Bay Area Forecast

DTCS 2040 forecasts preserve the 2020 forecasts described above and also maintain the P'13 2040 employment totals on a sub-regional basis. The DTCS forecasts reallocate the sub-regional forecasts at the city level based on development that has already occurred or is imminent. The 2020-2040 growth increment added to TAZs in Mountain View, Stanford, Menlo Park, and Redwood City is the P'13 2020-2040 employment increment, not a continuation of 2013-2020 accelerated growth rate. However, because of the actual growth from 2013 to 2020, the 2040 forecast is about 35,000 more jobs in those cities than P'13 forecasts for that same year. This is balanced out in the four cities by reducing the 2040 employment forecast by two percent in all Santa Clara and San Mateo County TAZs.

10.2.3 2040 High-Growth Trend

DTCS Alternative 11, which is discussed in more detail in Section 10.3, applies a more ambitious employment growth projection than the other alternatives analyzed. This trend scenario projects 2040 employment in study area cities based on the factors listed below.

- Sustained, sector-weighted trends and momentum in the study area cities taking into consideration that study sub-region growth from 2001-2015 was four times the regional average and 40 percent higher than the San Francisco growth rate.

- Approved/pipelined development projects and pending applications, including the North Bayshore Plan, Stanford GUP, Facebook campus expansion, and Stanford Redwood City medical center.

- ABAG's report that its Projections '13 2040 employment forecast will be updated for the next Plan Bay Area RTP to include an additional 200,000 jobs.

- Plan Bay Area projections that reflect a top-down allocation of state and regional jobs forecasts to individual cities based on available land, economic forces and consistency with regional planning objectives and policies.

- City General Plan and specific plan projections of growth and plan development capacity, taking into account trends toward higher building occupancies in high-tech job categories.

- Evidence from real-estate transactions with developer and employer insights on where, for business reasons, major employers and developers will choose to locate.

The trend forecast is for growth of 266,000 jobs in the study area from 2013 to 2040. This alternative contains about 170,000 more jobs than the Plan Bay Area forecast of 4,505,220 jobs, or a four percent increase region-wide. Within the corridor cities of Menlo Park, Palo Alto, Redwood City, and Mountain View, the trend forecast has approximately 150 percent the number of jobs as the Plan Bay Area forecast. The growth is distributed within the study area as follows in **Table 10-2**:

Table 10-2: Allocation of 2013-2040 Jobs Growth for Trend Scenario

Primary Jobs	Secondary Jobs	Total
Menlo Park	12,640	4,210
East Palo Alto	24,000	11,000
Stanford	7,000	2,000
Redwood City	9,500	3,000
North Bayshore	32,850	7,120
Other Mountain View	13,000	500
Sunnyvale	75,000	15,000
Moffett NASA	24,130	17,530
TOTAL	**204,120**	**62,360**

Source: Fehr & Peers, 2017

10.3 Travel Forecast Results

This section documents the results of the travel behavior forecasts for DTCS alternatives. Transit ridership and related metrics for short- and long-term alternatives were produced along with several variations. As noted previously, the C/CAG model produces forecasts for 2040, so the ridership forecasts and supporting metrics for the long-term alternatives are for 2040 as opposed to 2030.

First, an overall summary of the results for the base alternatives and several important takeaways are discussed, followed by a more in-depth discussion of results for all alternatives and their variants.

Travel forecasts were produced for the following alternatives as shown below in **Table 10-3**. In total, 14 were modeled: Alternatives 1-10; Alternative 11 and Alternatives 6a, 6-1 and 7-1. The variants 6a, 6-1 and 7-1, will be described further in Section 10.3.1.

Table 10-3: DTCS Alternatives and Variants

Short-Term (2020) Alternatives
Alternative 1: No Build
Alternative 2: Enhanced Bus on Highway Bridge
Long-Term (2040) Alternatives
Alternative 3: No Build
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction
Alternative 6: Busway on Rail Bridge
Alternative 7: Rail Shuttle on Rail Bridge
Alternative 8: Rail Commuter Single-Track on Rail Bridge
Alternative 9: Rail Commuter Double-Track on Rail Bridge
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)
Alternative 11: High Employment (with Alternative 9)
6a. Busway with Dumbarton Right-of-Way (ROW) to 101 Connection
6-1. Busway with Private Shuttles on Rail Bridge
7-1. Rail Shuttle with Half of Private Shuttle Fleet

Source: Fehr & Peers, 2017

Key takeaways from the forecasting analysis are discussed below.

10.3.1 Key Takeaways for Base Alternatives

Ridership forecasts for the base alternatives in 2040 are presented in **Table 10-4**, below.

Table 10-4: Daily Transit Ridership for Base 2040 Alternatives

Alternative	Rail	Bus	Private Shuttles	Transfers*	Total
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	0	22,300	5,400	2,600	25,100
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	0	23,800	5,500	2,900	26,400
Alternative 6: Busway on Rail Bridge	0	23,700	4,600	3,000	25,300
Alternative 7: Rail Shuttle on Rail Bridge	13,900	3,300	6,300	1,100	22,400
Alternative 8: Rail Commuter Single-Track on Rail Bridge	12,500	1,000	6,900	0	20,400
Alternative 9: Rail Commuter Double-Track on Rail Bridge	15,300	1,100	6,800	0	23,200
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	11,400	18,600	5,000	2,100	32,900

Source: Fehr & Peers, 2017
* Transfers represent passengers transferring from one proposed Dumbarton service to another proposed Dumbarton service

In total, the bus alternatives generate about 25 percent more ridership than the rail alternatives. This can be explained in part by more frequent bus service: ten-minute peak headways for four different transbay bus routes versus 15-minute headways for the Rail Shuttle (Alternative 7) and 60-minute headways for the Rail Commuter alternatives (Alternatives 8 and 9). In addition, the bus alternatives provide direct service to multiple destinations and in the case of the One Express Lane in Each Direction alternative (Alternative 5), diminish the corridor capacity for autos. This reduction induces a modal shift from auto to transit. One Express Lane in Each Direction reduces the peak direction SOV carrying capacity of the Dumbarton Highway Bridge the most, providing a single express lane in each direction in place of existing mixed-flow lanes. As a result, Alternative 5 induces about five percent greater transit use than Reversible Express Lanes (Alternative 4), which provides one peak-direction express lane in addition to three general-purpose lanes in the peak direction, providing more capacity.

In the rail alternatives, train services attract about two-thirds of the demand that public express buses would carry in the express lanes alternatives. Private shuttle ridership also increases to compensate for the reduction in public bus service. Among the rail alternatives, Rail Commuter Double-Track (Alternative 9) carries the most ridership by collecting transbay trips, local trips within the Dumbarton Corridor (e.g., Redwood City Caltrain Station to Facebook), and trips along the Peninsula to San Francisco and San Jose. Strictly focusing on transbay ridership, the Rail Shuttle (Alternative 7) carries the highest rail ridership due to its higher frequencies compared with the Rail Commuter alternatives. The range of rail forecasts, 12,500 to 15,300 daily riders, is within the range found on comparable segments of existing Bay Area rail services, such as Bay Area Rapid Transit (BART) through Union City to Fremont and Caltrain through Redwood City, Menlo Park, and Palo Alto.

Person and Vehicle Delay

An important consideration in the comparison of the bus and rail alternatives is the overall Corridor travel demand throughput and the consequent levels of traffic congestion on the Dumbarton Highway Bridge and approaches. As previously mentioned, One Express Lane in Each Direction (Alternative 5) reduces the capacity of the Dumbarton Highway Bridge and approaches for automobile travel by converting general-purpose lanes to express lanes. As a result, for all traffic combined, congestion in terms of total vehicle-hours delay and per person minutes delay is substantially worse for this express lane alternative. Vehicle-hours of delay are also almost twice as high in the One Express Lane in each Direction Alternative compared to the Reversible Express Lanes Alternative (Alternative 4), and higher than the busway and rail alternatives, which use the Dumbarton Rail Bridge and preserve existing capacity on the Dumbarton Highway Bridge. Trends observed related to total vehicle-hours of delay are generally similar when examining per person minutes delay. These findings are summarized in **Table 10-5** below.

Table 10-5 Transbay Morning Peak Person Trip Accommodation - Modal Balance

Alternative	Rail	Bus	Private Shuttles	Auto (persons)	Total	Total Vehicle-Hours Delay	Per Person Minutes Delay
Alternative 3: No Build	0	1,200	2,600	24,900	28,700	1,200	2.5
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	0	5,800	2,700	26,900	35,400	700	1.2
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	0	6,100	2,800	23,400	32,300	1,400	2.6
Alternative 6: Busway on Rail Bridge	0	5,100	2,300	24,900	32,300	1,100	2.0
Alternative 7: Rail Shuttle on Rail Bridge	3,700	100	3,200	25,000	32,000	1,200	2.3
Alternative 8: Rail Commuter Single-Track on Rail Bridge	3,700	100	3,400	25,100	32,300	1,200	2.2
Alternative 9: Rail Commuter - Double-Track on Rail Bridge	3,700	100	3,400	25,000	32,200	1,200	2.2
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	2,400	4,700	2,700	23,300	33,100	1,400	2.5

Source: Fehr & Peers, 2017

Key Variations on Primary Alternatives

Table 10-6 summarizes the effects of four variations on the base alternative forecasts.

Table 10-6: Key Variations

Alternatives and Variations	Rail Ridership	Bus Ridership	Private Shuttles Ridership	Total
Alternative 6: Busway on Rail Bridge	0	14,000	4,600	18,600
6a. Busway with Dumbarton ROW to US 101 Connection	0	14,900	7,500	22,400
Difference:	***0***	***900***	***2,900***	***3,800***
6-1. Busway with Private Shuttles on Rail Bridge	0	13,600	6,100	19,700
Difference:	***0***	***-400***	***1,500***	***1,100***
Alternative 7: Rail Shuttle on Rail Bridge	9,100	200	6,300	15,600
7-1. Rail Shuttle with Half of Private Shuttle Fleet	9,200	200	5,800	15,200
Difference:	***100***	***0***	***-500***	***-400***
Alternative 9: Rail Commuter Double-Track on Rail Bridge	8,800	200	6,800	15,800
11. High-Employment	20,300	100	6,600	27,000
Difference:	**11,500**	**-100**	**-200**	**11,200**

Source: Fehr & Peers, 2017

The first variation, Alternative 6a, which was first introduced in Chapter 8, adds a direct connection in Menlo Park from the Dumbarton Rail ROW to a new interchange on US 101. In this case, the new connection would allow the Busway to connect via a protected ROW across the Bay on the Dumbarton Rail Bridge, through Menlo Park on the Dumbarton Rail ROW, to direct ramps into planned US 101 express lanes. The connection would add 3,800 passengers (20 percent) to the Busway transbay forecast due to improved travel times. While the Dumbarton ROW to US 101 improvement is also applicable to the express lanes alternatives (Alternative 4 and 5), for the purposes of travel forecasting, it was just tested with the Busway on Rail Bridge Alternative (Alternative 6).

Alternative 6-1 would allow private shuttles to use the Dumbarton Rail Bridge Busway along with public transit. The allowance would reduce public bus ridership slightly and increase private shuttle transbay ridership by 1,500 passengers or about 25 percent due to improved travel times.

Alternative 7-1 assumes the reduction of the private shuttle fleet by about 50 percent in conjunction with the Rail Shuttle. The result would be a modest reduction in overall transit ridership (including private shuttles), with an eight percent reduction in shuttle use not offset by a negligible increase in rail ridership. This alternative was tested to better understand the consequences of study area employers reducing their private shuttle fleet due the presence of high-quality rail service.

Alternative 11 assumes strong employment growth beyond official forecasts, and as a result yielded the largest increase in transit ridership compared to all other alternatives. Based on the network assumptions listed under the Rail Commuter Double-Track Alternative (Alternative 9) total transbay transit ridership would be about 70 percent higher than the baseline employment assumptions. While the high-employment scenario was tested with Alternative 9, it can be assumed that if it was tested with the network assumptions of any other alternative, ridership would be similarly inflated.

In terms of transit ridership and overall Corridor performance, the Busway Alternative (Alternative 6) offers the combined benefit of increasing Corridor throughput through use of the Dumbarton Rail Bridge, avoiding exacerbation of traffic congestion by preserving existing Highway Bridge lanes, and providing direct single-seat service connections for major origin-destination pairs including Union City and Fremont BART, Altamont Commuter Express (ACE), Redwood City Caltrain, and the major Corridor employers such as Stanford, Facebook and Google. Adding the direct connection in the form of a new US 101 interchange at the Dumbarton ROW crossing and allowing private shuttles to use the Dumbarton Rail Bridge along with public Busway services would raise the transbay transit ridership level for the Busway to the highest among the single-mode alternatives.

The rail alternatives also offer the Corridor throughput and traffic congestion control advantages as well as the ability to establish a fixed and visible public transit investment in the Corridor suited to stimulating compact transit-oriented development in one of the region's primary jobs-growth markets. While a high-employment scenario (Alternative 11) would boost the projected ridership of all alternatives, Alternative 11 provides some evidence of the potential consequences by evaluating a rail presence through the Corridor along with high-density development with strict mode share goals in the East Palo Alto, Menlo Park, and Redwood City areas. If the projections of the Corridor's major employers bear out and densities reach the high levels accommodated in the cities' general plans, the rail alternatives could see transit ridership exceeding that of all the other alternatives.

10.3.2 Forecast Results for All Alternatives and Variants

All the transportation alternatives show substantial increases in transit ridership over 2013 conditions. This includes both public service and private shuttle buses operated by major employers. Total transit ridership (**Table 10-7**) includes trips that use those services to cross the Bay and trips that remain on one side of the Bay, such as those between the Redwood City Caltrain Station and the planned Willow Road station in Menlo Park. Transbay ridership (**Table** 10-8) include all trips that cross the Bay.

As previously mentioned, the bus alternatives generate about 25 to 28 percent more ridership than the rail alternatives in 2040 in terms of both total transit ridership and transbay transit ridership. However, the alternatives with one express lane in each direction (Alternatives 5 and 10) reduce the peak period/peak direction capacity of the congested Dumbarton Highway Bridge.

While both the 2020 and 2040 enhanced bus alternatives show significant ridership increases above their No Build comparisons, the growth in private shuttle ridership is much more modest. This is attributed to the fact that the enhanced bus alternatives significantly increase bus frequency and the number of destinations served, in addition to the approach improvements that benefit both buses and private shuttles. Thus, it is reasonable to conclude that the changes to frequency and direct access to destinations account for much more of the increase in transit ridership than the approach improvements.

Table 10-7: Daily Transit Ridership for all Alternatives

Alternative	Rail	Bus	Private Shuttles	Transfers	Total
Base Year 2013	0	2,700	1,700		4,400
Short-Term (2020) Alternatives					
Alternative 1: No Build 2020	0	4,800	5,900	0	10,700
Alternative 2: Enhanced Bus on Highway Bridge	0	10,200	6,200	500	15,900
Long-Term (2040) Alternatives					
Alternative 3: No Build 2040	0	3,500	5,200	0	8,700
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	0	22,300	5,400	2,600	25,100
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	0	23,800	5,500	2,900	26,400
Alternative 6: Busway on Rail Bridge	0	23,700	4,600	3,000	25,300
Alternative 7: Rail Shuttle on Rail Bridge	13,900	3,300	6,300	1,100	22,400
Alternative 8: Rail Commuter Single-Track on Rail Bridge	12,500	1,000	6,900	0	20,400
Alternative 9: Rail Commuter Double-Track on Rail Bridge	15,300	1,100	6,800	0	23,200
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	11,400	18,600	5,000	2,100	32,900
Alternative 11: High-Employment (with Alternative 9)	27,100	1,100	6,600	100	34,700
6a. Busway with Dumbarton ROW to 101 Connection	0	26,200	7,500	3,700	30,000
6-1 Busway with Private Shuttles on Rail Bridge	0	23,100	6,100	3,000	26,200
7-1 Rail Shuttle with Half Private Shuttle Fleet	14,200	3,500	5,800	1,200	22,300

Source: Fehr & Peers, 2017

Table 10-8 Daily Transbay Ridership for all Alternatives

Alternative	Rail	Bus	Private Shuttles	Total
Base Year 2013	0	2,600	1,700	4,300
Alternative 1: No Build 2020	0	4,300	5,900	10,200
Alternative 2: Enhanced Bus on Highway Bridge	0	7,500	6,200	13,700
Alternative 3: No Build 2040	0	3,400	5,200	8,600
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	0	14,900	5,400	20,300
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	0	15,800	5,500	21,300
Alternative 6: Busway on Rail Bridge	0	14,000	4,600	18,600
Alternative 7: Rail Shuttle on Rail Bridge	9,100	200	6,300	15,600
Alternative 8: Rail Commuter Single-Track on Rail Bridge	8,400	200	6,900	15,500
Alternative 9: Rail Commuter Double-Track on Rail Bridge	8,800	200	6,800	15,800
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	5,600	12,700	5,000	23,300

Alternative	Rail	Bus	Private Shuttles	Total
Alternative 11: High-Employment (with Alternative 9)	20,300	100	6,600	27,000
6a. Busway with Dumbarton ROW to 101 Connection	0	14,900	7,500	22,400
6-1 Busway with Private Shuttles on Rail Bridge	0	13,600	6,100	19,700
7-1 Rail Shuttle with Half Private Shuttle Fleet	9,200	200	5,800	15,200

Source: Fehr and Peers, 2017

Increasing congestion on the Dumbarton Highway Bridge will continue to erode the effectiveness of transbay transit services that use it. The forecasts predict lower transit ridership in the 2040 No Build scenario than the 2020 No Build scenario. This demonstrates that without the enhancements provided in the bus alternatives, transbay Dumbarton transit service is predicted to degrade significantly between 2020 and 2040 as buses are increasingly delayed in congested conditions.

The three 2040 bus alternatives (Alternatives 4, 5, and 6) are fairly similar in terms of overall transit ridership and transbay transit ridership, with One Express Lane in Each Direction (Alternative 5) showing the largest totals in both categories. As previously mentioned, the five percent increase in transit ridership for One Express Lane in Each Direction versus Reversible Express Lanes (Alternative 4) can be attributed to the fact that with two peak-direction express lanes, Reversible Express Lanes provides additional capacity for autos crossing the bridge, making transit less attractive by comparison.

The Busway on Rail Bridge Alternative (Alternative 6), where buses use major East Bay arterials and the Dumbarton Rail Bridge, allows for relatively large amounts of non-transbay trips. As a result, while its total ridership is within the range of the express lane alternatives, its transbay ridership is about 11 percent lower. This change can be attributed to two factors: first, the busway operating plan calls for routes to run along Thornton Avenue rather than Decoto Road and SR 84; second, the busway operating plan calls for more East Bay stops (eight versus three). These factors combine to add approximately ten minutes to the peak direction runtime on the Busway. Another factor working to reduce transbay ridership is that the operating plan calls for buses running in the reverse-peak direction to make limited stops, eliminating a number of stops for the reverse-peak direction. While many of these stops are low-ridership, two stops in particular (Willow Road / Durham Street for the DB, and 2nd Avenue in Redwood City for the Menlo Park/Redwood City route) generate a significant amount of reverse-peak ridership in the express lane alternatives, which is absent from the Busway on Rail Bridge.

Among the three base rail alternatives (Alternatives 7, 8, and 9), total transit ridership is comparable with both the Rail Shuttle (Alternative 7) and Rail Commuter Double-Track (Alternative 9) out-performing the Rail Commuter Single-Track (Alternative 8). Although the reverse-peak-direction ridership in the Rail Commuter Double-Track is modest, it is sufficient to explain the difference between this and the Rail Commuter Single-Track, where reverse-peak-direction service does not exist. The similarity in the Rail Shuttle and the Rail Commuter Double-Track can be viewed as a trade-off between the higher-frequency trains of the Rail Shuttle (15-minute headways versus 60-minute), versus the convenience of a one-seat ride as far as San Francisco or a South Bay destination (Palo Alto, Mountain View, Sunnyvale or San Jose). The forecasted ridership on the San Francisco branch of the Rail Commuter alternatives was somewhat higher than on the San Jose branch. Within the alternatives, focusing on the rail ridership specifically, the Rail Shuttle carries about five percent more rail passengers across the Bay than do the Rail Commuter options. The Rail Commuter Double-Track more than makes up the difference by carrying more passengers along the Peninsula.

The range of rail ridership forecasts is consistent with expectations based on existing Bay Area rail ridership. For comparable short segments of rail not immediately adjacent to or oriented toward the regional core and its high parking costs, the Union City and Fremont BART segment currently has daily boardings of 11,800 and the Caltrain segment including Redwood City, Menlo Park, and Palo Alto has 9,100 daily boardings. For comparison, Altamont Commuter Express (ACE) system ridership is 5,000.

The Combined Bus and Rail Alternative (Alternative 10) consists of the highway improvements and express bus service from One Express Lane in Each Direction (Alternative 5) and the rail service from the Rail Commuter Double-Track (Alternative 9) — the highest-ridership individual bus and rail alternatives. As such, it can be viewed as a best-case scenario for transit crossing the Dumbarton Corridor. Within the Bus and Rail Alternative, while the bus and rail elements trade-off against one another and do not perform as well individually as they do in the One Express Lane in Each Direction and Rail Commuter Double-Track scenarios, the combined benefits of the two modes increase total transit ridership by 21 to 52 percent. In other words, the Bus and Rail Alternative is forecast to have slightly lower bus ridership than One Express Lane in Each Direction and lower rail ridership than Rail Commuter Double-Track, but the Combined Bus and Rail Alternative exhibits the highest aggregate and transbay ridership for any alternative based on *Plan Bay Area* employment projections.

The high-employment scenario (Alternative 11) differs from the Rail Commuter Double-Track only in its land use assumptions, and not in the transportation networks. Nevertheless, the high-employment scenario is forecast to generate approximately 50 percent more total transit riders as compared to the Rail Commuter Double-Track. This increase is commensurate with the 150 percent increase in employment within the Corridor cities of Menlo Park, Palo Alto, Redwood City, and Mountain View in the high-employment forecast. Transbay transit ridership for the high-employment scenario is approximately 170 percent of Rail Commuter Double-Track transbay transit ridership. The forecasts also assume businesses in this area will be subject to trip caps requiring them to achieve higher transit shares. The substantial increase in transfers to Dumbarton Rail from ACE in the high-employment scenario highlights a need for the Altamont corridor to absorb the housing growth required to support such a large increase in employment.

BART and Caltrain Ridership in DTCS Area

Ridership at BART and Caltrain stations in the study area is listed in **Table 10-9**. Stations represented are the Fremont and Union City BART stations, and the Redwood City, Menlo Park, and Palo Alto Caltrain stations.

Table 10-9: BART and Caltrain Ridership in DTCS Area

	BART	Caltrain
Base Year 2013	11,900	9,200
Short-Term (2020) Alternatives		
Alternative 1: No Build 2020	13,500	18,200
Alternative 2: Enhanced Bus on Highway Bridge	14,300	18,000
Long-Term (2040) Alternatives		
Alternative 3: No Build 2040	19,500	27,000
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	22,100	24,600
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	22,400	23,900
Alternative 6: Busway on Rail Bridge	20,300	25,700
Alternative 7: Rail Shuttle on Rail Bridge	19,500	28,900
Alternative 8: Rail Commuter Single-Track on Rail Bridge	18,900	27,000
Alternative 9: Rail Commuter Double-Track on Rail Bridge	19,100	26,200
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	21,700	24,800
Alternative 11: High-Employment (with Alternative 9)	20,700	37,600
6a. Busway with Dumbarton ROW to 101 Connection	21,600	24,900
6-1 Busway with Private Shuttles on Rail Bridge	20,700	25,500
7-1 Rail Shuttle with Half Private Shuttle Fleet	19,400	28,800

Source: Fehr and Peers, 2017

BART ridership within the study area is forecast to increase between six percent and 15 percent for the bus alternatives (Alternatives 4, 5, 6, and 10). This increase can be attributed to the utility of having high-frequency express buses connected to both the Union City and Fremont BART stations. Forecasts for the Rail Commuter Alternatives (Alternatives 8 and 9) show decreases of two to three percent in BART ridership within the study area, while forecasts for the Rail Shuttle Alternative (Alternative 7) show no change in BART ridership. These changes can be attributed to the fact that the Rail Commuter Alternatives are infrequent and do not enjoy timed transfers with BART, making the BART-Dumbarton rail connection less attractive than it might otherwise be.

Caltrain ridership within the study area is forecast to decrease slightly for most alternatives as compared with the 2040 No Build scenario. Study area Caltrain ridership in the bus alternatives (Alternatives 4, 5, and 6, as well as 10) is forecast to decrease between five percent and 12 percent from the No Build, while Caltrain ridership in the Rail Commuter Alternatives (Alternatives 8 and 9) is either steady or decreases only three percent from the No Build scenario. Express bus service in the bus alternatives extends from Willow Road station north to the Redwood City Caltrain station, and south to Sunnyvale, so in these alternatives the more-frequent express buses provide a parallel service to Caltrain. On the other hand, while the Rail Commuter alternatives also provide a parallel service to Caltrain, the forecasts show no more than a three percent decrease in Caltrain boardings within the study area. This is reasonable given that the Rail Commuter Alternatives are not sufficiently frequent to draw many riders away from Caltrain. Under the Rail Shuttle Alternative, Caltrain ridership is forecast to increase by seven percent, as it does not duplicate Caltrain service at all. This is the largest increase for any alternative using the *Plan Bay Area* employment projections.

10.3.3 Transfers from Altamont Commuter Express

Forecasting suggests that ACE will be a significant source of ridership for any Dumbarton transit service, particularly for the rail alternatives. Transfer volumes between ACE and Dumbarton transit services are shown in **Table 10-10**. These forecasts also predict a significant increase in total ACE ridership from the current 5,000 daily riders to 8,000 - 10,000 daily riders (and 20,000 in the high-growth alternative). These forecasts are consistent with ACE planning, which suggests a doubling of ridership by 2020. They also suggest that a high-quality transit connection from the Central Valley and Tri-Valley region to the high-employment areas in Silicon Valley would serve a currently un-met need. Thus, ensuring that the connection is as easy as possible with high-frequency express buses (as in Alternatives 4, 5, and 6) or a timed transfer to rail (as in Alternatives 7, 8, 9, and 10) is an important component of these large transfer volumes.

Table 10-10: Transfer Volumes from ACE to Dumbarton Transit

Alternative	Rail	Bus	Total
Base Year 2013	0	0	0
Short-Term (2020) Alternatives			
Alternative 1: No Build 2020	0	0	0
Alternative 2: Enhanced Bus on Highway Bridge	0	300	300
Long-Term (2040) Alternatives			
Alternative 3: No Build 2040	0	100	100
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	0	1,300	1,300
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	0	1,300	1,300
Alternative 6: Busway on Rail Bridge	0	1,500	1,500
Alternative 7: Rail Shuttle on Rail Bridge	3,000	0	3,000
Alternative 8: Rail Commuter Single-Track on Rail Bridge	3,500	0	3,500
Alternative 9: Rail Commuter Double-Track on Rail Bridge	4,000	0	4,000
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	3,800	100	3,900
Alternative 11: High-Employment (with Alternative 9)	10,400	0	10,400
6a. Busway with Dumbarton ROW to 101 Connection	0	1,700	1,700
6-1 Busway with Private Shuttles on Rail Bridge	0	1,500	1,500
7-1 Rail Shuttle with Half Private Shuttle Fleet	3,000	0	3,000

Source: Fehr and Peers, 2017

10.3.4 Park-and-Ride Demand

Forecast park-and-ride demand for the Ardenwood and Newark park-and-ride lots is shown in **Table 10-11**. In general, the bus alternatives are predicted to generate higher demand for parking (1,300 to 1,500 autos) than the rail alternatives (1,000 – 1,100 autos). These demand levels are consistent with the overall higher ridership that is forecast for the bus alternatives as compared to rail.

The Combination Bus and Rail Alternative (Alternative 10), which combines the bus service and highway improvements from One Express Lane in Each Direction (Alternative 5) with the commuter rail service from Rail Commuter Double-Track (Alternative 9), is forecast to produce more than five times the park-and-ride demand for the express bus services at Ardenwood versus the rail service at Newark. This difference is attributed primarily to the much higher frequency of express bus service as compared to rail service in this alternative and Ardenwood's easier access for auto drivers from a larger area.

Table 10-11: Park-and-Ride Demand

Alternative	Ardenwood (autos)	Newark (autos)	Total (autos)
Base Year 2013	400	0	400
Short-Term (2020) Alternatives			
Alternative 1: No Build 2020	1,000	0	1,000
Alternative 2: Enhanced Bus on Highway Bridge	1,200	0	1,200
Long-Term (2040) Alternatives			
Alternative 3: No Build 2040	800	0	800
Alternative 4: Enhanced Bus on Highway Bridge with Reversible Express Lanes	1,500	0	1,500
Alternative 5: Enhanced Bus on Highway Bridge with One Express Lane in Each Direction	1,500	0	1,500
Alternative 6: Busway on Rail Bridge	200	1,100	1,300
Alternative 7: Rail Shuttle on Rail Bridge	600	500	1,100
Alternative 8: Rail Commuter Single-Track on Rail Bridge	600	400	1,000
Alternative 9: Rail Commuter Double-Track on Rail Bridge	600	400	1,000
Alternative 10: Combination Bus and Rail (Alternative 5 and Alternative 9)	1,300	200	1,500
Alternative 11: High-Employment (with Alternative 9)	600	1,000	1,600
6a. Busway with Dumbarton ROW to 101 Connection	0	1,400	1,400
6-1 Busway with Private Shuttles on Rail Bridge	0	1,300	1,300
7-1 Rail Shuttle with Half Private Shuttle Fleet	500	500	1,000

Source: Fehr and Peers, 2017

11 Comparative Analysis

To evaluate the alternatives described in Chapter 7 and developed in more detail in Chapters 8 through 10, a comparative analysis was performed based on the goals of the Dumbarton Transportation Corridor Study (DTCS):

- Identify capital improvements and operational programs in the Dumbarton Corridor that enhance multimodal mobility for local and regional travelers, with an emphasis on improving person throughput by expanding transit service.
- Pursue cost-effective capital, operational and maintenance improvements with a return on investment, if feasible, including the effective repurposing of the Dumbarton Rail Bridge.
- Manage and minimize environmental impacts and financial risk, and maximize safety.
- Ensure local communities in the East Bay and Peninsula are protected from adverse impacts related to the development and operation of regional mobility solutions.

Based on each goal, specific evaluation metrics were developed to quantify the performance of the long-term base alternatives (Alternatives 4 through 10).

11.1 Goals and Metrics

The goals and corresponding metrics used to evaluate the alternatives are discussed below. As shown in **Table 11-1**, each of the four goals was weighted equally, with a maximum score of 20 points for each goal, and a total maximum score of 80 points.

11.1.1 Enhance Mobility

Five factors were considered to support the goal of enhanced mobility:

- **Daily Transbay Transit Ridership -** Daily transbay transit ridership is based on projections from the DTCS's travel behavior modeling results, and includes estimated ridership for bus, rail, and private shuttles. The higher the estimated ridership, the higher the ranking, with a maximum of 4 points.
- **Load Factor -** The load factor describes the percentage of available capacity (on the Highway and Rail Bridges) that would be used during the peak hour. This metric evaluates how much of an alternative's capacity is being used at this point in time (how full the buses or train cars are). The higher the percentage, the higher the ranking, with a maximum of 4 points.
- **Peak Period Transbay Passengers per Seat Mile -** This metric describes the number of passengers for each transbay seat mile, and normalizes the alternatives based on length. To calculate the available peak period seat miles, the number of seats per bus and/or train car is multiplied by the number of miles all buses and/or trains would run; this value includes traveling to San Francisco and San Jose in the Rail Commuter alternatives (Alternatives 8, 9,

and 10). Available peak period seat miles are then divided by the transbay transit ridership per peak period to get the peak period transbay passengers per seat mile. The higher the value, the higher the ranking, with a maximum of 4 points.

- **Peak Period per Person Minutes Delay -** This metric describes the minutes of delay each passenger (including rail, bus, shuttle and automobile passengers) would experience under each alternative as compared to free-flow conditions. The shorter the delay, the higher the ranking, with a maximum of 4 points.
- **Operational Benefit -** Operational benefit is a qualitative assessment based on the alternative's ability to provide predictable travel times, by having the flexibility or capacity to recover from delays and the potential to accommodate future demand. The greater the perceived operational benefit, the higher the ranking, with a maximum of 4 points.

11.1.2 Pursue Cost-Effective Improvements with a Return on Investment

Three factors were considered to support the goal of cost-effective improvements with a return on investment:

- **Annualized Capital Cost per New User -** The annualized capital cost per new user considers the total capital cost for each alternative (including all Highway Bridge and approach and Rail Bridge and right-of-way (ROW) improvements) and normalizes it based on the increase in expected transit ridership and highway passengers over the No Build Alternative. This metric considers the cost of Rail Bridge deconstruction, if applicable. The lower the cost, the higher the ranking, with a maximum of 5 points.
- **Annual Operating and Maintenance (O&M) Cost per New User -** The annual O&M cost per new user considers the O&M costs for each alternative (considering all transit and express lanes operating scenarios) and normalizes it based on the increase in expected transit ridership and highway passengers over the No Build Alternative). The lower the cost, the higher the ranking, with a maximum of 5 points.
- **Fundability -** The fundability metric describes each alternative's likelihood of being funded, considering both the potential for public-private partnerships (P3) (6 points maximum) as well as federal grant competitiveness (4 points maximum). The potential for P3s considers three factors that guide whether the private sector is likely to provide funding, including whether projected revenues would be realized at the start of the project; whether there are existing P3s for similar projects in other parts of the country; and whether projected revenues would exceed projected operating costs. Federal funding competitiveness considers criteria that are common to obtaining federal funding. This criterion includes safety, increased mobility, economic development, impacts to the community and the environment, partnerships and innovation, and cost share. The higher the ratings for the subcategories, the higher the ranking, with a maximum of 10 points.

Cost-effectiveness was viewed as important as fundability so the two cost-effectiveness metrics added together equate to the same point value as the fundability metric.

11.1.3 Minimize Environmental and Financial Risk, and Maximize Safety

Three factors were considered as part of this goal:

- **Environmental Impacts -** This metric qualitatively considers the potential environmental impacts of each alternative. Criteria included auto passengers (mode shift from automobiles to transit), and the environmental impacts related to demolishing the Rail Bridge, considering all associated environmental mitigation. The lesser the environmental impacts, the higher the ranking, with a maximum of 8 points.

- **Financial Risk -** This metric qualitatively considers the financial risk of each alternative. The lesser the financial risk, the higher the ranking, with a maximum of 4 points.

- **Safety -** This metric qualitatively considers the safety of each alternative. Dedicated guideways with additional capacity are considered to have a higher level of safety. The safer the alternative, the higher the ranking, with a maximum of 8 points.

It should be noted that financial risk was viewed to be similar for all alternatives at this phase of study. Therefore, the financial risk metric was given a smaller point value than the environmental impacts and safety metrics.

11.1.4 Avoid Disproportionate Burden and Disparate Impacts

When planning, expanding, or removing bus services, SamTrans is subject to a federally mandated Title VI analysis, which considers both disproportionate burden and disparate impacts. The policies specify thresholds for determining whether a given action or project has a disproportionate burden on low-income populations or a disparate impact on minority populations. A similar approach is used to evaluate the alternatives as part of the DTCS. The main focus is whether the alternatives provide similar levels of access to either low-income or minority populations. The lower the disproportionate burden and the lower the disparate impact, the higher the ranking, with a maximum of 10 points for each metric.

It should be noted that at this stage of analysis, all alternatives were considered to provide a similar level of access.

11.2 Comparative Analysis and Results

Table 11-1 illustrates how the alternatives perform against the goals and metrics described in Section 11.1. (See **Appendix L** for the detailed Comparative Analysis tables). Alternatives 1 and 3 are not included and ranked in **Table 11-1** because they are the short-and long-term No Build Alternatives, respectively. Additionally, Alternative 2 is not included as it is the only short-term alternative. Generally, it is believed that any short-term bus enhancements and corresponding approach improvements should be pursued to provide some immediate relief to congested conditions in the Dumbarton Corridor.

It should be noted that although the bicycle and pedestrian multiuse path on the Peninsula ROW is carried forward as a viable improvement option to be paired with either bus or rail, it was not evaluated against the base alternatives since the complete set of evaluation metrics could not be applied to the bicycle and pedestrian facility. Not only is ridership difficult to estimate for a bicycle and pedestrian multiuse path (See Chapter 10 and **Appendix K** for additional detail), but other evaluation metrics such as load factor and passenger seat miles are not applicable to a non-transit mode. However, this does not preclude the possibility of a multiuse path in the Peninsula ROW. The potential multiuse path will be investigated further in the next phase of study after the DTCS.

Finally, Alternative 11 represents the Rail Commuter Double-Track Alternative (Alternative 9) modeled using a more ambitious employment growth projection than Alternatives 4 through 10 (see Chapter 10, Section 10.2.3 for additional information). This alternative is intended to serve as a proxy for how more robust employment growth in the study area cities could impact the performance of all proposed alternatives via higher ridership, lower annualized costs per passenger, increased delay, etc. Although Alternative 11 presents a viable combination of improvements, it is not considered a base alternative or one that could be fairly compared with the other alternatives given its more robust land use assumptions. While Alternative 11 is included in the evaluation tables shown in **Appendix L** for exploratory purposes, it is not rated or scored against the other long-term alternatives.

The following sections breakdown the results of the comparative analysis by goal and metric.

Table 11-1: Comparative Analysis Summary

Alternative	Evaluation Metrics and Scoring																			Cumulative Score
	1. Enhance Mobility (25%)									2. Pursue Cost-Effective Improvements with a Return on Investment (25%)					3. Minimize Environmental and Financial Risk, Maximize Safety (25%)			4. Avoid Disproportionate Burden and Disparate Impacts (25%)		
	1.1 Daily Transbay Transit Ridership		1.2 Load Factor		1.3 Peak Period Transbay Passengers per Seat Mile		1.4 Peak Period Per Person Minutes Delay (AM)		1.5 Operational Benefit (Reliability, Accommodating Future Demand)	2.1 Annualized Capital Cost per New User		2.2 Annual Operating and Maintenance Cost per New User		2.3 Fundability	3.1 Environ-mental Impacts	3.2 Financial Risk	3.3 Safety	4.1 Disproportionate Burden	4.2 Disparate Impacts	
	4		4		4		4		4	5		5		10	8	4	8	10	10	80
	4= high ridership		4 = High load		4 = high passengers		4 = low delay		4 = high robustness	5 = low cost		5 = low cost		5 = high fundability	8 = low risk	4 = low risk	8 = low risk	10 = low burden	10 = low impact	80 = max score
Alternative 4: Long-Term Enhanced Bus on Highway Bridge with Reversible Express Lane (2030)	20,300	3	0.27	1	0.04002	4	1.2	4	1	$7	5	$3	5	8	2	2	3	8	8	54
Alternative 5: Long-Term Enhanced Bus on Highway Bridge with One Express Lane in Each Direction (2030)	21,300	3	0.32	4	0.04265	4	2.6	1	1	$10	4	$5	5	8	4	2	3	8	8	55
Alternative 6: Busway on Rail Bridge (2030)	18,600	2	0.29	2	0.03086	2	2.0	2	2	$8	5	$3	5	7	7	2	5	8	8	57
Alternative 7: Rail Shuttle on Rail Bridge (2030)	15,600	1	0.25	1	0.02763	1	2.3	1	3	$12	2	$10	1	9	7	2	7	8	8	51
Alternative 8: Rail Commuter Single-Track on Rail Bridge (2030)	15,500	1	0.26	1	0.02418	1	2.2	2	3	$14	1	$10	1	9	7	2	7	8	8	51
Alternative 9: Rail Commuter Double-Track on Rail Bridge (2030)	15,800	1	0.26	1	0.02993	2	2.2	2	3	$13	1	$10	1	9	7	2	8	8	8	53
Alternative 10: Combination Bus and Rail (with Alternatives 5 and 9) (2030)	23,300	4	0.32	4	0.02625	1	2.5	1	4	$13	1	$11	1	10	8	2	8	8	8	60

Source: SamTrans, 2017

11.2.1 Enhance Mobility

The Combined Bus and Rail Alternative (Alternative 10) scored the highest for enhanced mobility at 14 points, followed by Enhanced Bus on the Highway Bridge with One Express Lane in Each Direction (Alternative 5) and Enhanced Bus on the Highway Bridge with Reversible Express Lanes (Alternative 4) at 13 points each.

- **Daily Transbay Transit Ridership** – The travel behavior forecasting results show that Combined Bus and Rail Alternative (Alternative 10) would have the highest daily transbay transit ridership at 23,300 riders per day. The express lanes alternatives (Alternatives 4 and 5) perform slightly less well with 20,300 to 21,300 daily transbay riders and the Busway Alternative (Alternative 6) follows with 18,600 daily transbay riders. In contrast, the rail alternatives (Alternatives 7, 8, and 9) would have lower ridership (15,500 to 15,800). Overall, Alternative 10 received the maximum of 4 points for this metric.

- **Load Factor** - Load factors ranged from 25 percent for the Rail Shuttle (Alternative 7) to 32 percent for Combined Bus and Rail Alternative (Alternative 10) and the Enhanced Bus on Highway Bridge with One Express Lane in Each Direction (Alternative 5). The next best performing alternative was the Busway Alternative (Alternative 6) at 29 percent. Alternatives 10 and 5 received the maximum of 4 points for this metric.

- **Peak Period Transbay Passengers per Seat Mile** - The long-term enhanced bus alternatives along the Highway Bridge (Alternatives 4 and 5), fared the best for this criterion with the highest ratio of available peak period seat miles to transbay transit ridership during the peak period, while the Rail Commuter Single-Track (Alternative 8) fared the worst. Alternatives 4 and 5 received the maximum of 4 points for this metric.

- **Peak Period Per Person Minutes Delay** – Enhanced Bus on the Highway Bridge with One Express Lane in Each Direction (Alternative 5) had the highest peak period person minutes delay of all the base alternatives at 2.6 minutes delay per person. This can primarily be attributed to a reduction in Highway Bridge capacity to accommodate one express lane in each direction. In contrast, Enhanced Bus on the Highway Bridge with Reversible Express Lanes (Alternative 4) had the smallest delay of only 1.2 minutes delay per person because it provides an additional lane of capacity on the Highway Bridge and thus earns the maximum of 4 points for this metric.

- **Operational Benefit** - In evaluating this qualitative metric, the express lanes alternatives (Alternatives 4 and 5) were seen as the least reliable with the least ability to accommodate future demand because transit would operate outside of a dedicated ROW into the future. The Busway Alternative (Alternative 6) performs slightly better as it includes similar bus service but on partially dedicated ROW while the rail alternatives (Alternatives 7 through 9) score even higher with a greater length of dedicated ROW. Alternative 10 was considered to be the most reliable with the greatest ability to accommodate future demand as it includes transit services on both the Highway as well as the Rail Bridge. Alternative 10 received the maximum of 4 points for this metric.

11.2.2 Pursue Cost-Effective Improvements with a Return on Investment

Under the goal to pursue cost-effective improvements with a return on investment, Enhanced Bus on the Highway Bridge with Reversible Express Lanes (Alternative 4) scored the highest with a total of 18 points followed closely by Enhanced Bus on the Highway Bridge with One Express Lane in Each Direction (Alternative 5) and the Busway Alternative (Alternative 6) at 17 points each.

- **Annualized Capital Cost per New User** - The annualized capital cost per new user for Enhanced Bus on the Highway Bridge with Reversible Express Lanes (Alternative 4) was the lowest at approximately $7 with the Busway Alternative (Alternative 6) a close second at roughly $8. Rail Commuter Single-Track on the Rail Bridge (Alternative 8) fared the worst; its annualized capital cost per new user is roughly two times the cost of Alternative 4. Alternatives 4 and 6 received the maximum score of 5 points for this metric.

- **Annual O&M Cost per New User** – The enhanced bus alternatives (Alternatives 4, 5, and 6) had the lowest annualized O&M cost per new user with values under $5. These alternatives received the maximum of 5 points for this metric.

- **Fundability** - The rail alternatives (Alternatives 7, 8, 9, and 10) present the highest potential to be funded by P3; these four alternatives would realize projected revenues at the start of the project, there are similar P3 projects to these across the country, and projected revenues could potentially exceed projected operating costs. Regarding federal grant competitiveness, the express lanes alternatives (Alternatives 4 and 5) and the Combination Bus and Rail (Alternative 10) would meet the objectives, while the other alternatives do not score as highly for one or more of the following factors: safety (Alternative 6), mobility (Alternatives 7, 8, and 9), or partnership/innovation (Alternatives 6, 7, 8, and 9). Considering both the potential for P3 funding and federal grant competitiveness, Alternative 10 ranks the highest and received the maximum of 10 points for this metric.

11.2.3 Minimize Environmental and Financial Risk, and Maximize Safety

Combined Bus and Rail (Alternative 10) scored the highest when it comes to minimizing environmental and financial risk and maximizing safety.

- **Environmental Impacts** – The express lanes alternatives (Alternatives 4 and 5), which would require demolition of the Rail Bridge, would have the greatest environmental impacts and therefore received the lowest scores. Combination Bus and Rail (Alternative 10) ranked highest and received the maximum of 8 points for this metric as it includes the restoration of the Rail Bridge and also cuts down the number of passengers on the Highway Bridge compared to the other alternatives.

- **Financial Risk** - After the initial screening, all alternatives were considered to have the same level of financial risk; all alternatives were weighted equally with 2 points.

- **Safety** - Because high-capacity dedicated guideways are considered to have a higher level of safety, Alternatives 9 and 10, which include the Rail Commuter Double-Track on Rail

Bridge Alternative, ranked the highest and received the maximum of 8 points for this metric. The enhanced bus on the Highway Bridge alternatives (Alternatives 4 and 5) ranked the lowest as they operate without dedicated guideway.

11.2.4 Avoid Disproportionate Burden and Disparate Impacts

After the initial screening, all alternatives were considered to have the same low level of disproportionate burden on low-income communities and disparate impacts on minority communities as they all provide a similar level of local and regional transit access on both criteria; all alternatives were scored equally with 8 points for both metrics.

11.2.5 Results

As discussed above, the various long-term alternatives would meet the DTCS goals to varying degrees. Overall, the Combined Bus and Rail (Alternative 10) and the Busway on the Rail Bridge (Alternative 6) scored the highest with 60 and 57 total points, respectively. These alternatives were followed by the Enhanced Bus on the Highway Bridge with One Express Lane in Each Direction (Alternative 5) at 55 points. Alternative 10 ranked highest or equally best under three of the four DTCS goals. As a result, Alternative 10, which presents a combination of roadway, bus, and rail improvements, is considered the top-ranking alternative with the greatest potential to enhance corridor mobility, while also factoring in cost-effectiveness and financial feasibility, managing risk, maximizing safety, and minimizing environmental and community impacts to the extent possible. Based on the findings of the comparative analysis the DTCS recommends moving forward with Alternative 10 using a phased approach.

12 Recommendations and Phasing

12.1 Findings Compared to Study Goals

As described in Chapter 3, and reiterated in Chapter 6 and Chapter 11, the goals of the Dumbarton Transportation Corridor Study (DTCS) are as follows:

1. Identify capital improvements and operational programs in the Dumbarton Corridor that enhance multimodal mobility for local and regional travelers, with an emphasis on improving person throughput by expanding transit service.
2. Pursue cost-effective capital, operational and maintenance improvements with a return on investment, including the effective repurposing of the Dumbarton Rail Bridge.
3. Manage and minimize environmental impacts and financial risk, and maximize safety.
4. Ensure local communities in the East Bay and Peninsula are protected from adverse impacts from the development and operation of regional mobility solutions.

The DTCS considered current and projected travel markets and screened a universe of operational, infrastructure, and transit improvements related to both the Dumbarton Highway and Rail Bridge with the goal of increasing mobility and prioritizing transit in the Corridor. The subsequent alternatives development process and detailed comparative analysis of alternatives demonstrated that a combination of roadway, bus, and rail improvements would be the most productive at addressing all the goals combined—enhancing Dumbarton Corridor mobility, while also factoring in cost-effectiveness and financial feasibility, maximizing safety, and minimizing financial risk and environmental/community impacts to the extent possible. This chapter outlines how the findings the DTCS compare to project goals, followed by recommendations and proposed phasing.

12.1.1 Enhanced Mobility

The Dumbarton Rail Bridge is an underutilized asset in the San Francisco Bay Area, where the handful of bridges that cross the Bay provide critical linkages between housing and jobs. The Rail Bridge's potential for improving mobility was considered at the corridor level, in the study area, as well as regionally.

The Corridor travel demand analysis shows that there is a need for significant transportation investments in the Dumbarton Corridor, both in the short-term and long-term. Current traffic conditions on the Dumbarton Highway Bridge approaches are severely congested. Travel forecasts show that congestion on the approaches and Highway Bridge itself will continue to worsen if no improvements are made to the existing infrastructure. Further, current employment and development growth on the Peninsula is outpacing the regional growth forecasts and a continuation of this trend could increase the region's unmet infrastructure needs.

There are also several travel markets within the study area that use the Dumbarton Corridor and could be served well by different travel modes on different facilities. By improving Dumbarton

Corridor efficiency and travel time reliability, short-distance commuters coming from the Union City / Fremont / Newark (Tri-Cities) area to Peninsula employment destinations would be attracted by a one-seat ride via enhanced bus service on the Highway Bridge. Roadway improvements that allow high-occupancy vehicles (HOVs) to bypass single-occupancy vehicles (SOVs) encourage carpooling and also improve bus speed and reliability. Long-distance travelers from the Central Valley / Tri-Valley and Capitol Corridor (beyond the Bay Area Rapid Transit (BART) service area) could drive demand for rail service if there were timed connections with Altamont Commuter Express (ACE).

The following are key findings from the DTCS related to mobility:

The Highway Bridge approaches in the morning and evening peak periods are severely congested and could benefit from improvements that encourage transit use and HOVs, by providing these vehicles a bypass through congested areas (i.e., the toll plaza, and at Bayfront Expressway intersections at University Avenue and Willow Road). Improvements at the approaches are likely to do more for alleviating congestion than converting general-purpose lanes on the Highway Bridge to express lanes. Addressing capacity on the Highway Bridge alone will not alleviate traffic congestion in the Dumbarton Corridor, as this study confirms that the chokepoints where congestion occurs are at the approaches to the Dumbarton Highway Bridge. With proposed approach improvements, the express lanes alternatives perform well but one configuration of express lanes – the One Express Lane in Each Direction (Alternative 5) – would increase congestion in the study area for general traffic and SOVs. This alternative is preferred, however, because it encourages transit and HOV travel over SOV travel in the general-purpose lanes and is a more sustainable long-term option for mitigating the impacts of growth on the transportation network.

The bus alternatives produce 25 percent more ridership than rail due to the former's higher frequencies, greater coverage, and direct connections to employment centers; enhanced bus on the Highway Bridge (Alternatives 4 and 5) provides a one-seat ride from the Tri-Cities to the Peninsula. When outside of a dedicated right-of-way, bus service is subject to delays because of traffic congestion. Providing a dedicated busway on the Rail Bridge and ROW (Alternative 6) with a connector to the planned US 101 express lanes would improve reliability for buses, especially the Mountain View/Sunnyvale route that travels on US 101 over 12 miles. However, the Busway Alternative routes still would operate in mixed flow traffic in the East Bay, where they would be subject to congestion-related delay, but Highway Bridge express lanes could be connected with future express lanes on I 880 for a continuous managed lane in the corridor.

Rail alternatives as defined in this study do not perform as well as the bus alternatives from a ridership standpoint because they are less frequent. Even so, ridership estimates are on par with existing services in similar areas such as BART in Fremont and Union City and Caltrain between Redwood City and Palo Alto. Improvements, such as double-tracking across the Rail Bridge, would provide added operational flexibility that would contribute to the reliability of rail travel. ACE transfers are an important source of rail ridership in the travel behavior forecast, signifying that the Tri-Valley/Central Valley to Peninsula market is likely underserved. Thus, the rail alternatives may provide substantially more ridership potential in the future given the nature of fixed-guideway investments that are independent of highway and arterial conditions and the alternatives' ability to broaden travel markets by attracting longer-distance commuters. The potential for Dumbarton rail services to connect to a larger regional rail network is compelling as the region's employment and housing supply continue to grow in different areas of the Bay Area.

12.1.2 Cost-Effectiveness and Financial Feasibility

The most cost-effective alternatives are those that can attract enough riders and or users to cover operating and maintenance (O&M) costs. The DTCS showed that the bus alternatives performed the best in terms of cost-effectiveness. The Busway on Rail Bridge Alternative (Alternative 6), in particular, does well from a mobility / ridership standpoint, but the cost to retrofit the Rail Bridge for less long-term capacity and the inability to connect with the regional rail system is a costly tradeoff.

While the bus alternatives perform well from a cost perspective, they do not perform as well from a fundability perspective. The rail alternatives, while most costly, have the greatest potential for private investment and long-term ridership gains. While the bus alternatives serve the Union City / Fremont / Newark market very well and do not require as many connecting complementary bus services for the last mile of travel, the rail alternatives, particularly the Rail Commuter Double-Track Alternative (Alternative 9), bring the most value by connecting the Peninsula with travelers from farther away. By connecting to the ACE and Capitol Corridor routes, the rail alternatives can safely and reliably connect travelers from cities such as Stockton and Sacramento, to destinations as far north or south on the Peninsula as possible. Using the Rail Bridge for rail service allows the Highway Bridge to continue accommodating enhanced bus service. Further, converting the Rail Bridge to a bus-only facility would preclude the possibility of serving the long-distance market that the rail alternatives can.

12.1.3 Environmental Risk, Financial Risk, Safety

In addition to causing substantial environmental impacts, demolition and removal of the Rail Bridge would eliminate a much-needed Bay crossing in the region. Therefore, DTCS concludes that rebuilding the Rail Bridge is necessary to improve mobility in the Dumbarton Corridor and in the region. The DTCS also considered increasing the share of transit and HOV trips in the future and found that a combined approach (bus, highway improvements, and rail) fared the best in terms of reducing automobile passengers.

Financial risk will need to be investigated further in the next phase of study to determine what the risks would be with each improvement project and how they could be mitigated, if possible.

Rail is considered one of the safest ground transportation modes because it does not generally mix with other modes of transportation.

12.1.4 Potential Impacts on Communities

After the initial screening, all alternatives were considered to have the same low level of disproportionate burden and disparate impacts. The improvement projects identified in DTCS will be evaluated further in the environmental clearance phase to closely analyze the potential impacts of each project on the communities in which they are located.

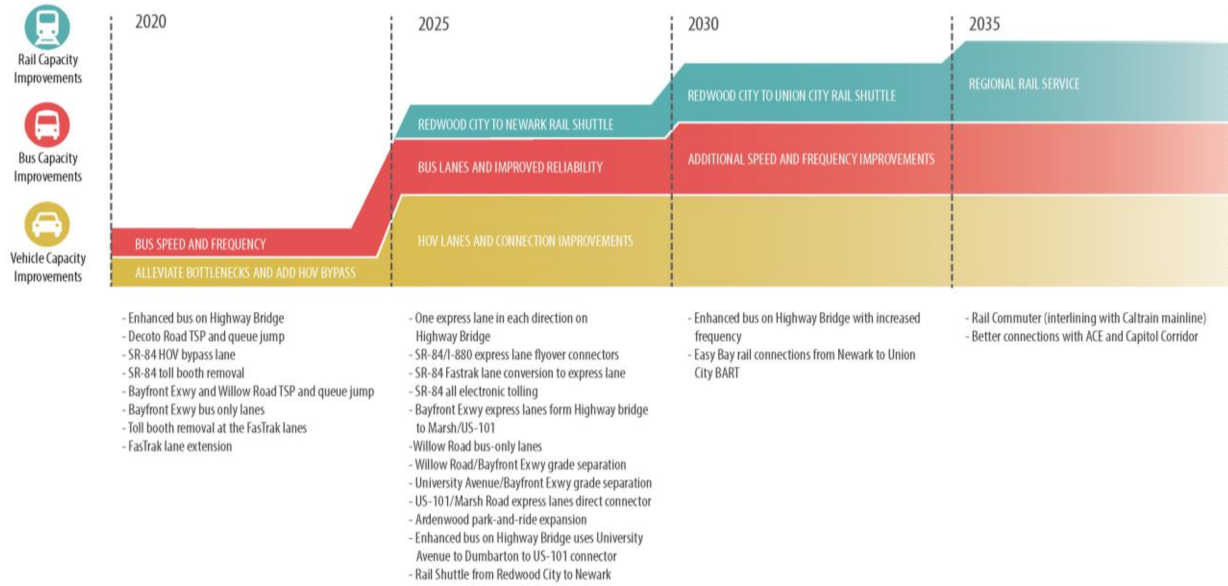
12.2 Recommendations and Phasing

Based on a comprehensive assessment of mobility, cost-effectiveness, environmental, financial and safety considerations, in addition to equity, the recommended long-term solution focuses on improvements to both the Dumbarton Highway and Rail Bridge as well as local roadways. This is a departure from the "either/or" approach of typical alternatives analyses, including previous studies of the Dumbarton Corridor where "the Project" was defined as a rail project and the alternative was a form of bus service. This is the first time that a combination of rail, enhanced bus service, express lanes and other roadway improvements comprise a Dumbarton project alternative, although these elements were also analyzed separately for their individual benefits. While the required capital investment in the Corridor will be significant, the opportunity to involve partners from the private sector is unprecedented, and the urgency to address congestion is critical to health of the Bay Area economy.

This multimodal, multifacility approach can serve different travel markets that use the Corridor and represents a more sustainable solution to long-term travel challenges through its focus on fixed-guideway investments that are independent of the arterial and highway network. In addition, roadway and highway improvements designated for transit and HOVs can increase the person throughput in the area. It should be noted that the No Build Alternative is not considered a viable option, as it would ultimately involve dismantling the Dumbarton Rail Bridge and mitigating the potential environmental impacts associated with this action, requirements by the U.S. Coast Guard if the Rail Bridge is not rehabilitated.

Due to the complexity and multitude of improvements needed to make a significant impact on mobility in the Dumbarton Corridor, a phased approach is proposed. **Table 12-1** illustrates how the improvements could be phased over time. Certainly, other phasing strategies may also be viable based on available funding.

Table 12-1 Timeline of Proposed Phased Improvements in the Dumbarton Corridor



Source: CDM Smith, 2017

Short-term improvements that could be implemented by 2020 include a handful of enhanced bus service and corresponding Highway Bridge approach improvements. These improvements include the following:

- Adding two new transbay bus routes from Union City BART to Menlo Park/Redwood City and Mountain View/Sunnyvale while increasing the frequency of Route DB and Route DB1 bus service to every 15 minutes and extending the peak period of service to 4 hours in the morning, and 4 hours in the evening
- Adding transit signal priority and queue jump lanes to Decoto Road from I 880 east to Union City BART or where possible given ROW constraints
- Constructing an HOV bypass lane on the westbound approach to the Highway Bridge at Newark Boulevard
- Highway Bridge toll booth removal at the FasTrak lanes and a FasTrak extension to Paseo Padre Parkway
- Adding transit signal priority and queue jump lanes to Bayfront Expressway and Willow Road where possible
- Implementing bus-only lanes on Bayfront Expressway

In addition to the improvements described above, the following strategies were identified as having the potential to improve mobility in the Corridor but were difficult to evaluate quantifiably. Therefore, these strategies are proposed in conjunction with the recommended short-term improvements.

- Enhanced Incident Management: This option seeks to enhance traffic incident management through the addition of closed-circuit television cameras and dedicated Freeway Service Patrol vehicles within the study area.
- Employer Incentive Programs: These programs could provide funding for employers in the region to incentivize carpooling, vanpooling, and transit.
- Provide Comparative Travel Time Information: Dynamic message signs could be installed at strategic locations within the study area to provide travel time information for alternate routes and modes.
- Active Traffic Management Strategies: These strategies could include queue warning, speed harmonization, and lane control signals to improve traffic flow.
- Partnerships with Transportation Network Companies: Partner with Transportation Network Companies to provide services that match passengers with drivers, or to provide last mile solutions.
- Autonomous Vehicles: Consider dedicating lanes for use by high-capacity autonomous vehicles or using autonomous vehicles as last mile solutions.

If pursued aggressively in the short-term, mid-term projects targeted for the 2025 timeframe could include the following:

- Implementing one express lane in each direction on the Highway Bridge with supporting arterial express lanes and other improvements:
    - Implementing eastbound express lanes from the Highway Bridge toll plaza to I 880/Decoto Road
    - Converting the FasTrak lane to an express lane
    - Constructing flyover connections between the I 880 and SR 84 express lanes
    - Instituting all-electronic tolling to cross the Highway Bridge
    - Constructing express lanes on Bayfront Expressway from the Highway Bridge to Marsh Road, in lieu of Willow Road express lanes due to the potential for property acquisitions
    - Implementing peak bus-only lanes on Willow Road, in lieu of Willow Road express lanes due to the potential for property acquisitions
    - Constructing a Willow Road / Bayfront Expressway grade separation
    - Constructing a University Avenue / Bayfront Expressway grade separation
    - Pursing a US 101 / Marsh Road express lanes direct connector, in lieu of Willow Road express lanes due to the potential for property acquisitions with an express lanes connection to US 101 at Willow Road
    - Expanding the Ardenwood park-and-ride facility (including an express lanes direct connector at Newark Boulevard)

- Operating enhanced bus service from University Avenue to the Dumbarton Rail ROW to planned US 101 express lanes via a direct connector, which could speed bus service and enhance reliability
- Implementing Rail Shuttle service between Redwood City and Newark until unknowns related to regional freight rail and connections to the Union City BART station are resolved. The Rail Shuttle is proposed to be double-tracked to allow for additional capacity into the future. With coordination, this interim rail terminus at Newark could begin to forge connections with ACE and Capitol Corridor. This phase would include a new Newark Park-and-Ride facility.

In the mid-to-long-term with a target year of 2030, improvements would include the following:

- Increasing the frequency of enhanced bus service to 10 minutes in the peak period and 15 minutes in the off peak period
- Extending the Rail Shuttle from Newark to Union City to connect to BART

In the long-term (i.e., 2035 or beyond), the following is proposed:

- Facilitating commuter rail service that interlines with the Caltrain mainline to offer a one-seat ride to commuters traveling between the Tri-Valley / Central Valley to the Peninsula and up to San Francisco or down to San Jose. This option would require further investment in the Dumbarton Corridor to electrify the line in addition to new electric rolling stock that will be compatible with the Caltrain mainline. Additionally, the Caltrain mainline will also require upgrades at Redwood Junction and other locations to minimize the potential impacts to mainline operations.

Another option considered in DTCS includes converting a portion of the Dumbarton ROW on the Peninsula to a bicycle and pedestrian multiuse path that could operate next to either bus and/or rail service. While there are width constraints on the Peninsula ROW as detailed in Appendix D, this option will continue to be examined in the next phase of study. Additionally, alternative and more localized pedestrian and bicycle improvements will also be examined further. These are described in Chapter 5 as well as below:

- Pursuing the Bay Trail option described in Chapter 5, which proposes to use sections of the current and proposed Bay Trail between Seaport Boulevard and University Avenue with on-street connections as required. Starting at the Redwood City Caltrain Station, a new Class II bikeway would be constructed on Broadway, connected to a similar path heading north on Chestnut Street. A Class I bikeway would then follow the Rail Corridor under US 101 to Blomquist Street, tying into the planned section of the Bay Trail on Cargill Levee between Seaport Boulevard and Bayfront Park[1] and the existing section of the Bay Trail between Bayfront Park and University Avenue, ultimately leading to the Highway Bridge. This option would have a total length of 5.9 miles to University Avenue.

[1] Bay Trail proposed segment No. 2089.0

- Upgrading the existing bicycle and pedestrian multiuse path on the Highway Bridge (including extending the Class I facility on Marshlands Road and implementing pavement and striping improvements along the entire facility)
- Pursuing improvements identified in county and city bicycle and pedestrian plans with the potential to fill gaps in bicycle facilities and enhance local and regional access to the Dumbarton Highway Bridge from key origins within the study area. These improvements are listed in **Table 12-2**.

Table 12-2: Proposed Local Bicycle Improvement Projects

City	Proposed Project	Planning Document	Year Adopted	Page
Peninsula				
Atherton	Class 3 bikeway on Marsh Road between Middlefield Road and Bay Road	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-6
East Palo Alto	Class 2 bikeway at US 101 overcrossing – 300’ north of Donohoe Street to Woodland Avenue	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-2
East Palo Alto	Improvements to existing University Avenue overcrossing at US 101	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-6, A-15
East Palo Alto	Widen and restripe class 2 bikeway on University Avenue	East Palo Alto Bicycle Transportation Plan	March 2011	10
Menlo Park	Ringwood Avenue Class 3 bike route between Bay Road and the Ringwood Bicycle and Pedestrian Bridge crossing at U.S.101	Menlo Park Comprehensive Bicycle Development Plan	January 2005	5-32
Menlo Park	Hamilton Ave Class 3 bike route from Ringwood Bicycle and Pedestrian Bridge crossing to Willow Road.	Menlo Park Comprehensive Bicycle Development Plan	January 2005	5-28
Menlo Park/East Palo Alto	Newbridge Street Class 2 bike route from Ringwood Bicycle and Pedestrian Bridge crossing to Bay Road	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-7
Menlo Park	Marsh Road Class 2 Bikeway from Bay Road to Bayfront Expressway*	Menlo Park Comprehensive Bicycle Development Plan	January 2005	5-63
Redwood City	Complete Marshall Street on-street bikeway from Arguello Avenue to Chestnut Street (Arguello Ave to Walnut St is complete)	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-3
Redwood City	Chestnut Street on-street bikeway from Marshall Street to Veterans Boulevard	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-3
Redwood City	Chestnut Street path from Veterans Boulevard to Stein Am Rhein Ct.**	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-3
Redwood City	Seaport Boulevard on-street bikeway from Stein Am Rhein Ct to Seaport Boulevard**	San Mateo County Comprehensive Bicycle and Pedestrian Plan	September 2011	A-7

City	Proposed Project	Planning Document	Year Adopted	Page
East Bay				
Newark	Class 3 bicycle boulevard on Lake Boulevard between SR 84 and Cedar Boulevard	City of Newark Pedestrian and Bicycle Plan	February 2017	138
Newark	Improve access to Ardenwood Historic Park on Lake Boulevard	City of Newark Pedestrian and Bicycle Plan	February 2017	138
Newark	Pavement improvements on Marshlands Road between Thornton Avenue and the Newark city limits	City of Newark Pedestrian and Bicycle Plan	February 2017	139
Newark	Class 2 buffered bicycle lanes on Thornton Avenue between Willow Street and Peachtree Avenue; Class 4 separated bikeway on Thornton between Peachtree Avenue and Gateway Boulevard; and Class 2 bike lanes on Thornton between Gateway Boulevard and SR 84	City of Newark Pedestrian and Bicycle Plan	February 2017	106
Newark	Class 2 bicycle lane on Willow Street between Thornton Ave and Central Avenue.	City of Newark Pedestrian and Bicycle Plan	February 2017	41
Newark	Class 2 bicycle lanes on Central Avenue between Willow Street and Filbert Street. Interim Class 3 bicycle lanes on Central Avenue between Filbert Street and Newark Boulevard with Class 2 bicycle lanes proposed in the long-term.	City of Newark Pedestrian and Bicycle Plan	February 2017	41, 136
Newark	Class 4 separated bikeway on Newark Boulevard between SR 84 and Central	City of Newark Pedestrian and Bicycle Plan	February 2017	40, 139
Union City	Bicycle improvements on Decoto Road between Mission Boulevard and the Fremont border.	City of Union City Pedestrian and Bicycle Master Plan	January 2012	5-13
Union City	Bicycle improvements on Union City Boulevard between Smith Street and Fremont border.	City of Union City Pedestrian and Bicycle Master Plan	January 2012	5-29

Note: These projects were identified based on their potential to improve network connectivity and access to the Dumbarton Bridge. Further study and local coordination would be necessary prior to the development and implementation of any proposed facility.
* The San Mateo county Comprehensive Bicycle and Pedestrian plan identifies a similar project broken out by jurisdictions.
**Project included in US 101/SR 84 Interchange Project.

Ferry service is another mode currently used by the private sector to transport employees to and from their places of work. This is certainly a viable mode for serving travelers, but requires good first-last mile connections to ferry terminals, since Bay Area ferries do not have the boat or terminal capacity to accommodate automobiles. Since ferries would not use the Highway or Rail Bridge, they were not studied in depth in this phase of analysis.

Appendix M contains additional information about the capital and O&M costs of these proposed improvements phased over time.

12.2.1 Next Steps Regarding Recommendations

In regard to these recommendations, SamTrans will continue to seek feedback and consensus from communities and public stakeholders around the Dumbarton Corridor in future phases of work.

Additionally, the Metropolitan Transportation Commission is undertaking a study of short-term HOV/transit priority treatments and potentially express lanes in the Dumbarton Corridor. This effort will delve into the operational details of these potential improvements to a greater extent than this broad planning study.

Additional phases of work are needed to progress the program proposed in DTCS. These phases could include the following:

- A technical refinement including additional conceptual design of the Peninsula Dumbarton ROW to determine if there are creative ways to accommodate a bicycle and pedestrian multiuse path while also complying with required modal widths to ensure safe transit services into the future. The technical refinement will also include additional study of bicycle/pedestrian connections outside of the Dumbarton ROW that would further mobility objectives for the communities along the Corridor, like increasing connectivity to the Bay Trail. Additional rail operations analysis and a deeper look at high-capacity, standard gauge rail technologies will also occur.
- Coordination with CalSTA, ACTC, ACE, Capitol Corridor, Union Pacific Railroad (UP), etc. regarding East Bay rail operations
- Additional regional travel behavior forecasting in an attempt to better quantify the potential benefit of the rail alternatives, especially with more streamlined connections with other regional rail services such as ACE and Capitol Corridor
- In addition to the funding strategy and public-private partnership opportunities discussed in Chapters 13 and 14, an in-depth public-private partnership analysis to investigate the viability of the rail alternatives (in addition to other alternatives) given more regional-based rail connections and operating plans
- Design and environmental documentation
- Additional analysis of a busway or enhanced bus on the Rail Bridge as a phasing option (regulatory requirements and processes and coordination with UP) or a secondary option to commuter rail service (in the environmental clearance context)

13 Funding and Financial Strategy

To complete a full plan of funding and finance for the Dumbarton Transportation Corridor Study (DTCS) $2.58 billion in capital and $90 million in annual operating funds will need to be identified for full build-out to help advance the project to implementation. Given the size of the project cost, multiple sources, including new sources that may arise in the future, and innovative financing strategies will need to be pursued and acquired. Nine such strategies are summarized in **Table** 13-1 and detailed below. The first three involve public funds that require voter approval or competition with other public projects for public funds. Strategies five through eight require partnership with the private sector. The last depends on creating a robust and cost-effective service that is partially self-sustaining.

Table 13-1: Funding and Financing Strategies for the Dumbarton Transportation Corridor Study Recommendations

	Strategy	Anticipated Revenue
1	Dedicate funding currently available for Dumbarton-related improvements	$30 million
2	Seek additional state and regional funding	$200-300 million
3	Seek additional local funding	Unknown at this time
4	Acquire private contributions	Unknown at this time
5	Pursue federal grant funding	Unknown at this time
6	Pursue federal and state financing	Unknown at this time
7	Explore Value Capture	$250-930 million
8	Identify elements that would be attractive for a Public Private Partnership (P3)	Unknown at this time
9	Use fares / tolls to help cover operating costs	$62-76 million (per year)
TARGETED TOTAL		**$2.58 billion**

Source: WSP, 2017

Additional information on traditional public funding sources and innovative financing opportunities, value capture, and toll and farebox revenues are available in **Appendix N, O, and P**, respectively.

13.1 Strategy #1: Dedicate Funding Currently Available for Dumbarton-Related Improvements: $30 million

13.1.1 San Mateo County Transportation Authority Measure A Half-Cent Sales Tax Revenue: $30 million

The Measure A sales tax provides funding for transportation improvements in San Mateo County. Measure A was initially approved by County voters in 1988, and was reauthorized in 2004 to extend the sales tax from 2009 through 2033. SamTrans receives Measure A funds for San Mateo County's share of capital and operating support to Caltrain, support for the SFO Bay Area Rapid Transit (BART) extension, SamTrans shuttle services and a Paratransit Trust Fund that provides interest income in perpetuity to support accessible paratransit service.

Approximately $30 million is currently available under Measure A for Dumbarton-related station facilities and Rail Corridor improvements in the communities of Redwood City, Menlo Park, and East Palo Alto in conjunction with the Dumbarton Corridor. SamTrans could dedicate these funds towards the $1.59 billion capital cost for the rail transit portion of the DTCS's recommendations.

13.2 Strategy #2: Seek Additional State and Regional Funding: $200–$300 million

13.2.1 Senate Bill 1

Senate Bill (SB) 1, the Transportation Infrastructure and Economic Investment Act, enacted in April 2017, is a $52.4 billion funding package to improve the State's roads and transportation infrastructure. The revenues come from the elimination of the Board of Equalization's annual adjustment of the gas excise tax, restoration of the price-based gas excise tax rate to 17.3 cents, increasing and indexing the base gas excise tax by an additional 12 cents over three years, increasing the diesel excise tax by 20 cents and sales tax by 4 percent, an annual $100 fee for zero-emission vehicles, a vehicle registration adjustment of $38 per vehicle, restoration of existing weight fees, increasing the Cap and Trade allocation for transit, Caltrans efficiency improvements, and acceleration of General Fund loan repayment obligations.

In addition to a number of funding programs, SB 1 offers funding for self-help counties, setting aside $200 million annually to local agencies that have adopted local sales tax measures and fees (e.g., uniform developer fees) that are used for transportation improvements. It also contains additional funding for the State Transit Assistance program and intercity and commuter passenger rail improvements.

13.2.2 Cap and Trade

Assembly Bill 32 (2006) calls for the reduction of greenhouse gas (GHG) emissions to 1990 levels by 2020. To meet this goal, the California Air Resources Board (ARB) adopted "cap-and-trade." This market mechanism policy places a "cap" on entities responsible for 85 percent of the state's GHG emissions. As part of the cap-and-trade program, ARB conducts quarterly auctions and sells emission allowances. Proceeds from the state's cap-and-trade program auctions are deposited into the Greenhouse Gas Reduction Fund (GGRF) and are appropriated by the Legislature. The GGRF supports several of programs that provide funding for low carbon transportation projects, including the following:

- The Transit and Intercity Rail Capital Program, administered by the California State Transportation Agency, which supports connectivity to existing/future rail systems by adding new rail cars/engines, increased service and reliability, and decreased travel times of intercity and commuter rail systems, and rail integration (e.g., integrated ticketing and scheduling).
- The Low Carbon Transit Operations Program, administered by Caltrans in coordination with the ARB and the State Controller's Office, which supports new/expanded bus/rail services, or expanded intermodal transit facilities, and service or facility improvements

(e.g., equipment, fueling and maintenance). Projects must be able to demonstrate reductions in GHG emissions.

Four Bay Area transit operators recently competed successfully to receive a total of almost $94 million in Transit and Intercity Rail Capital Program funds, including San Francisco Municipal Transportation Agency ($45 million for light-rail fleet expansion), Santa Clara Valley Transportation Authority ($20 million for railcar procurement to support BART extension), Caltrain ($20 million for electrification project), and Capitol Corridor ($9 million for track and facility improvements to support increased service).

13.2.3 Metropolitan Transportation Commission (MTC)

The Metropolitan Transportation Commission (MTC) regularly issues Calls for Projects inviting project sponsors to compete for grants and other federal, state or regional funds that flow through it. MTC routinely issues Calls for Projects through various funding programs, including the Active Transportation Program, Climate Initiatives Grants, Federal Highway Administration Congestion Mitigation and Air Quality Program (CMAQ) program, Program for Arterial System Synchronization, Pavement Technical Assistance Program.

The Regional Transportation Plan (RTP) developed by MTC, in cooperation with local agencies every four years, sets the stage for all major capital and operating programs within the Bay Area. The RTP is the region's long-range plan that charts a course for transportation investment and land-use priorities through the year 2040. RTP projects are reprioritized every two years during the update process (most recently in 2016). While the funding is largely allocated based on formulas and existing agreements, advocacy on the part of agencies and business and civic leaders could lead projects in the vision plan to be prioritized and funded sooner.

MTC also programs state transportation funds from the State Transportation Improvement Program (STIP) through its Regional Transportation Improvement Program (RTIP). Every California county receives a designated amount of STIP funding known as a county share. These funds are directly programmed in the Bay Area by MTC on a biennial basis. While the California Transportation Commission allocates STIP funds, decisions on what should be included in the program and the responsibility for amending, delivering and managing the program fall to MTC, which receives STIP investment proposals from the congestion management agency in each of the nine Bay Area counties. The proposals are reviewed for consistency with the goals of the RTP, Plan Bay Area, and compiled into a single Bay Area RTIP. The 2018 RTIP process is anticipated to begin in summer 2017, with MTC adopting the Program in December 2017.

MTC has budget authority to fund the implementation of express lanes projects throughout the Bay Area. The current authorized budget does not include funding beyond the environmental phase for the westerly approach to the Dumbarton Highway Bridge; however, being a conversion project, the Dumbarton approach could take priority for future express lanes funds.

13.2.4 Regional Measure 3 (RM3)

As a response to recent and anticipated future growth in the Bay Area’s economy and population, and the resulting increase in demand on the transportation system, MTC is currently working with the State Legislature on SB 595 (Beall), which would require MTC to place a new bridge toll measure known as Regional Measure 3 (RM3) on the ballot in all nine Bay Area counties. While SB 1 provides a substantial increase in state funds focused primarily on repairing local roads and the state highway system—the state's *aging* pains—SB 595 and RM3 will address the Bay Area's *growing* pains, by improving mobility and enhancing travel options in the region's bridge corridors.

The toll level, expenditure plan, and timing of this vote are not yet specified in the bill, and are subject to discussions with members of the Legislature and key stakeholders. At this time, MTC and the State Legislature are considering a $1, $2, and $3 bridge toll increase for the Bay Area's seven state-owned toll bridges (Dumbarton Bridge, San Francisco-Oakland Bay Bridge, San Mateo-Hayward Bridge, Carquinez Bridge, Benicia-Martinez Bridge, Antioch Bridge, and Richmond-San Rafael Bridge). MTC estimates that a $1 to $3 increase in bridge tolls starting in 2019 would make between $1.7 billion and $5 billion available as a 25-year capital bond (i.e., between $127 and $381 million in annual revenue). There are also discussions considering the inclusion of a program that funds operations. The timing of RM3 is yet to be determined, but may be placed on the 2018 Primary or General Election ballot. RM3 would be a fee, so it would require only a simple majority vote of the public to be approved.

Though target amounts for projects have not been determined, they could potentially factor in the fact that San Mateo County generates approximately 16 percent of the Bay Area's bridge tolls. This would result in up to $800 million ($61 million annual revenue) from a $3 toll increase for Dumbarton Bridge if RM3 were to be approved and 16 percent of the revenues were to come back to Dumbarton Bridge. Further, since one of RM3's proposed principles is to invest in "Multimodal" projects, or multiple modes of transportation that provide alternative travel options in the bridge corridors, including bus, rail, ferry, bicycle and pedestrian projects, RM3 revenues for the Dumbarton Corridor could potentially be used for both highway and transit elements of the DTCS.

13.3 Strategy #3: Seek Additional Local Funding

In California, county sales taxes are commonly used to raise new funds for transportation and are increasingly standing in for federal funding. Sales taxes for general funds require 50 percent plus one votes to pass, while dedicated sales taxes (tied to an expenditure plan) require two-thirds of voter approval to pass.

Since 1982, merchants in San Mateo County have collected a permanent Transit District half-cent sales tax. Proceeds help underwrite the SamTrans operating budget as well as a portion of the capital budget, including as local match to leverage federal, state and regional funding sources.

The San Mateo County Transportation Authority's Measure A sales tax provides funding for transportation improvements in San Mateo County. Measure A was initially approved by County voters in 1988, and was reauthorized in 2004 to extend the sales tax from 2009 through 2033. SamTrans receives Measure A funds for San Mateo County's share of capital and operating support to Caltrain, support for the SFO BART extension, SamTrans shuttle services and a Paratransit Trust Fund that provides interest income in perpetuity to support accessible paratransit service.

San Mateo County could impose a new sales tax for countywide infrastructure improvements subject to 50 percent plus one vote approval from County cities on the 2018 general election ballot. The County last imposed a new one-half percent sales tax following the November 2016 election when 70.4 percent of voters approved Measure K, which would "ensure San Mateo County quality of life by retaining/improving critical facilities/services, such as: providing affordable homes for seniors, people with disabilities, veterans, families; enhancing public transit; combatting human trafficking; addressing sea level rise; maintaining safe schools and neighborhoods; high-quality preschool and reading programs; park maintenance; and low-income healthcare … providing $85,000,000 annually for 20 years that the State cannot take away."

A new, voter-approved half-cent sales tax in San Mateo County would provide a similar amount for countywide infrastructure—$1.7 billion over 20 years. A portion of this could be dedicated to the DTCS recommendations since improvements to the Dumbarton Corridor would benefit a substantial number of current and projected SamTrans customers traveling to and from San Mateo County. SamTrans would have to work with its partners at San Mateo County to determine the amount that could be allotted to the DTCS recommendations for purposes of advocacy for the new Measure despite the fact that an expenditure plan will not be required for passage.

13.4 Strategy #4: Solicit Private Contributions

SamTrans may have access to contributions from private partners, including Facebook, which has the ability to build momentum with other companies with an interest in providing enhanced mobility and access for its employees. This effort could replicate the current example of Amazon buying transit assets (rail sets) for the City of Seattle and Sound Transit in exchange for service improvements and advertising space (train cars).

13.5 Strategy #5: Pursue Federal Grant Funding

13.5.1 Section 5339

SamTrans has won discretionary federal grant funds as well. This includes Federal Transit Administration (FTA) Section 5339 Bus and Bus Facilities Program funding for its San Carlos Transit Center and hybrid bus purchase projects. Such funds could go towards replacing, rehabilitating, and purchasing buses and related equipment, and constructing bus-related facilities.

13.5.2 CMAQ

SamTrans also succeeded in acquiring Federal Highway Administration (FHWA) CMAQ funding through MTC for bus retrofit projects to install clean air emission devices on urban coaches. However, these programs only generated small dollar amounts for SamTrans that pale in comparison to the amount needed to construct the Dumbarton Rail Bridge and express lanes that are a part of the DTCS recommendations. They also require local matching funds, which are often derived from regional bridge toll revenues provided to SamTrans by MTC.

13.5.3 Nationally Significant Freight and Highway Projects (INFRA)

The United States Department of Transportation's (USDOT) Nationally Significant Freight and Highway Projects program, named Fostering Advancements in Shipping and Transportation for the Long-term Achievement of National Efficiencies during the Obama administration and now termed the Infrastructure for Rebuilding America (INFRA) competitive grant program, could be pursued as a potential source of federal funds for the project. The program is authorized at $4.5 billion from Fiscal Year (FY) 2016 through FY 2020. USDOT awarded $759 million to 18 projects in the initial FY 2016 round. Up to $1.5 billion in FY 2017 and FY 2018 INFRA funds are available for projects and programs that improve safety and hold the greatest promise to eliminate freight bottlenecks and improve critical freight movements. Applications are due in early November 2017. Unlike the FTA Section 5339, FHWA CMAQ, and USDOT TIGER programs, INFRA grants are somewhat larger, ranging from $5 million to $165 million in the FY 2016 round. The highway/express lanes component of the DTCS may be suitable candidates for the INFRA program to the extent that they support national or regional economic vitality by providing freight safety, mobility, and economic benefits, leverage federal funds with non-federal and private funds, demonstrate innovation in environmental review and permitting, project delivery, or safety and technology, and propose an approach to measure project performance and hold SamTrans accountable for expenditure of funds.

13.5.4 Section 5309

FTA Section 5309 Capital Investment Grants (Core Capacity, New Starts, Small Starts) is a significant funding source for many of the nation's largest transit capital projects. These grant programs are very competitive, and a project must proceed through a rigorous set of development and engineering processes and evaluations before being awarded a "Full Funding Grant Agreement" from FTA. Additionally, the annual funding authorization amount for the Section 5309 program is under debate, and given the length of time it would take for Dumbarton improvements to apply and proceed through development process, there is some uncertainty as to whether or not program funding will be available.

Considering these challenges, the Dumbarton Corridor improvements could qualify for New Starts or Small Starts funding, depending on the project element and amount of funding sought. Generally, projects costing $300 million or more and requesting $100 million or more in grant funding are geared to the New Starts program while projects under these thresholds qualify for Small Starts funding. For instance, carving out the bus elements could be a viable Small Starts program option for SamTrans.

13.6 Strategy #6: Pursue Federal and State Financing

Innovative transportation project finance tools and institutional arrangements are available as alternatives or augmentations to traditional, formula and grant-based funding strategies. They are designed to bridge investment gaps between available resources and infrastructure needs and intended to maximize the ability of states to leverage federal capital, attract new sources of funds to transportation investment, accelerate project completion dates, and more effectively utilize existing funds. Often, debt issuance or other forms of credit enhancement have helped facilitate access to a wider range of capital or leverage future revenue streams. USDOT and the

California Infrastructure and Economic Development Bank (IBank) offer financial tools to help project sponsors access credit to expedite the implementation of needed transportation improvements.

Federal credit assistance can take one of two forms: (1) loans, where project sponsors borrow federal highway funds directly from a state DOT or the federal government; and (2) credit enhancements, where a state DOT or the federal government makes federal funds available on a contingent (or standby) basis. Credit enhancements help reduce risk to investors and thus allow project sponsors to borrow at lower interest rates. Loans can provide the capital necessary to proceed with a project, reduce the amount of capital borrowed from other sources and may also serve a credit enhancement function by reducing the risk borne by other investors.

13.6.1 Transportation Infrastructure Finance and Innovation Act (TIFIA)

Four types of federal credit assistance should be considered for financing the DTCS recommendations. One, the Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA), provides direct loans, loan guarantees, and standby lines of credit to finance surface transportation projects of national and regional significance. To be eligible, projects also must be supported in whole or in part from user charges or other non-federal dedicated funding sources.

Qualified projects are evaluated by USDOT against eight statutory criteria, including, among others, impact on the environment, significance to the national transportation system, and the extent to which they generate economic benefits, leverage private capital, and promote innovative technologies. TIFIA credit assistance is available for construction activities for both the transit and highway components of the DTCS recommendations and may increase the interest of the private sector under a public-private partnership arrangement (see Section 13-7 Strategy #8: Identify Elements that Would be Attractive for a Public-Private Partnership).

13.6.2 Rehabilitation and Improvement Financing (RRIF)

Second, the Federal Railroad Administration (FRA)'s Railroad Rehabilitation and Improvement Financing (RRIF) provides direct loans and loan guarantees to acquire, improve, or rehabilitate intermodal or rail equipment or facilities, including track, bridges, yards, buildings and shops, and develop or establish new intermodal or railroad facilities. Direct loans can fund up to 100 percent of a railroad project with repayment periods of up to 35 years and interest rates equal to the cost of borrowing to the government. The RRIF and TIFIA lending programs are similar but have slightly different administrative provisions and RRIF is focused on rail projects, while TIFIA applies to a broader segment of project types.

13.6.3 Grant Anticipation Revenue Vehicles (GARVEE)

A third type of federal credit assistance are Grant Anticipation Revenue Vehicles (GARVEEs), which are debt-financing instruments repaid with future federal-aid highway funds. As of March 2016, 25 states and three territories have issued over $19.1 billion in GARVEEs, which have been used to generate up-front capital for major highway projects at generally tax-exempt rates. By paying with future federal highway reimbursements, the cost of GARVEE-financed facilities is spread over their useful life, rather than just the construction period. GARVEEs can also expand access to capital markets as a supplement to general obligation or revenue bonds.

This approach is appropriate for large, long-lived, non-revenue generating assets, so its applicability to the highway component of the DTCS recommendations may be limited. In addition, GARVEE financing would require formal agreements with Caltrans and MTC whose future federal-aid highway funds would be encumbered for debt service. They may be concerned with the potential for GARVEE financing to reduce financial, programmatic, and political flexibility for those years in which debt service consumes a portion of the annual transportation program.

13.6.4 Transit Revenue Bonds

Finally, another potential form of federal credit assistance that could provide financing for the DTCS recommendations are Transit Revenue Bonds. There are two types of Transit Revenue Bonds – farebox revenue bonds and Grant Anticipation Notes. Farebox revenue bonds use farebox revenues and anticipated FTA grant receipts as collateral for revenue bonds, which can only be backed by fare box revenues if the level of state and local funding committed to transit for the three years following the bond issue are higher than the funds that were committed in the three years prior to the bond issue. Transit agencies must identify another source of funds for the agency's operating expenses before issuing a farebox revenue bond, which make them less desirable than other project financing mechanisms. Similar to GARVEEs, Grant Anticipation Notes allow transit agencies to borrow against future federal-aid funds (FTA Title 49 grants) that are allocated by formula (Section 5307) or by project (Section 5309). SamTrans is unlikely to have its federal transit aid encumbered for debt service, thereby reducing its financial, programmatic, and political flexibility for those years in which debt service consumes a portion of its annual transportation program.

13.6.5 IBank

The California Infrastructure and Economic Development Bank (IBank) has broad statutory authority to issue tax-exempt and taxable revenue bonds and provide loans to state and local governments for public infrastructure and economic expansion projects. IBank's Infrastructure State Revolving Fund Program provides financing to public agencies for a wide variety of infrastructure projects in amounts ranging from $50,000 to $25 million, with loan terms for the useful life of the project up to a maximum of 30 years. The Bond Financing Program makes tax-exempt and taxable conduit revenue bond financing available in the form of Exempt Facility Bonds, tax-exempt financing for projects that are government-owned or consist of private improvements within publicly owned facilities.

While federal and state financing programs may seem like an attractive option, they will require an extra level of effort and competency within SamTrans to pursue, acquire, administer, and service the debt provided. Because the DTCS recommendations will be revenue-generating once completed (i.e., through tolls and farebox), TIFIA, RRIF, and IBank financing may be most appropriate, especially if such financing is paired with a Public-Private Partnership (P3) delivery method and the private concessionaire takes on the risk of paying back the debt principal and interest.

13.7 Strategy #7: Explore Value Capture Opportunities: $250–$930 million

Value capture funding approaches aim to link the beneficiaries of a public infrastructure investment to the project by allowing them to pay for portions of the capital or operations and maintenance cost. Value capture includes many types of revenue generating mechanisms, including special assessment district financing, tax increment financing, and development impact fees. As opposed to real estate developments, regional transportation improvements like the DTCS recommendations are more difficult to associate value generated by it directly to individuals and businesses. However, value capture tools can still play a very important part in project funding.

Additional information on the value capture estimate for DTCS is provided in **Appendix O**.

13.7.1 Special Assessment District

A potential approach for SamTrans is to explore creating a special assessment district for financing of transportation improvements. A special assessment district is an officially designated area from which additional property taxes are collected for a specific use. The properties (or subset of properties) located within the district boundary would be assessed with a higher tax rate or at a fee expressly to fund the DTCS recommendations. The benefit of a special assessment district – in addition to the revenue raised from the new tax – is that the revenue stream would exist outside of SamTrans' or other government entities' existing budget structures, allowing for greater flexibility and independence in decisions about how the funds are used for the Dumbarton Corridor.

Special assessment districts can be organized in a variety of ways, depending on the intent of the revenue raised from the district. A special assessment district may levy the additional taxes or fees based on distance from the project, type of land use, total acreage, or frontage. Special assessment districts are typically structured to generate either a specified level of revenue or to last a set number of years. Since special assessment districts are a distinct legal entity, such districts can serve as a vehicle to accept more state and federal funds for transportation needs. Some examples of special assessment districts are: (1) public transit assessment districts (governed by SB 142, enables assessments within a half-mile of transit stations); (2) community facilities or Mello-Roos districts (self-imposed taxes on property owners to finance public services and improvements surrounding a particular development or development area); (3) business-based improvement districts (which levy a tax on participating businesses within a geographic area); and (4) property-based business improvement districts (a self-governed district to augment services).

An approach where variable rates are charged to residential and non-residential properties could be an appropriate solution for the Dumbarton Corridor. For instance, businesses across several jurisdictions could be taxed as part of one district or assessment area, or taxed at a higher rate than residential properties. Given the geographic scope of the Corridor, a business-focused special assessment district would raise revenue from private parties most likely to benefit from Corridor improvements, given their need to attract employees from areas with more affordable housing options.

13.7.2 Tax Increment Financing (TIF)

There are other value capture approaches that could be applicable for the Dumbarton Corridor, however, they may not have the same revenue strength and stability that a special assessment district would have. Tax Increment Financing (TIF), for example, is commonly used in real estate redevelopment projects where the assessed value of a parcel will increase substantially and a portion of that increase is diverted to associated infrastructure or project uses (or the repayment of debt). TIF typically involves local governments financing infrastructure projects within a discrete, defined district.

Unlike special tax assessment districts, TIF does not involve a tax rate increase. Instead, the rise in property values resulting from the real estate project (or in this case, the transportation project) generates additional revenues that would not have materialized without the new project. Local governments are typically cautious about TIF because it obligates bonding capacity and future property taxes, but are more willing to approve a TIF deal if the new development will stimulate economic growth in the short-term that would not materialize without it. TIF is not commonly used over large areas because it is difficult to identify the portion of the assessed value increase associated with the infrastructure improvement.

13.7.3 Developer Contributions

Developer impact fees can be collected by a city or county to fund capital infrastructure costs. Direct developer contributions may result from a negotiation between a large developer and the project sponsor during the planning stages of development review or under an Adequate Public Facilities Ordinance. A developer may propose an extension to the new system, additional stops, or a change in alignment that will provide direct benefit to their property (as well as generate additional ridership). In exchange, the project sponsor may request a financial contribution to balance the larger public benefits resulting from greater ridership with the private benefits to the developer.

Value capture methods could finance specific portions of the project, such as transit stations and park-and-ride facilities, similar to how the City of Alexandria, Virginia financed the Potomac Yard Metrorail Station through a planned mixed-use, transit-oriented district. The new station is being entirely self-financed from new development surrounding the station, with $240 million in revenue from a combination of tax-increment financing, two different special tax districts, and developer contributions.

Possibly the largest challenge for using value capture is securing uniform political support for the revenue stream, particularly for the Dumbarton Transportation Corridor given that the impacts are spread over three counties. A champion for using this funding approach is critical. Facebook has been an important project sponsor to date and would fill the champion role well. It could be influential in selling the value that these corridor improvements will provide to industry peers, who together can help generate the political will to support the new tax.

13.8 Strategy #8: Identify Elements that Would be Attractive for a Public-Private Partnership

Two general forms of P3 structures are common: availability payment- and concession-based P3s. In availability payment-based P3s, the public authority contracts with a private sector entity to provide a public good (transportation asset) or service (operation and maintenance of said transportation asset) for a fee, based on a set payment schedule. In concession-based P3s, the government grants the private sector the right to charge users of the public good or service a fee or tariff (for instance a bridge toll).

There are a number of P3 delivery approaches, such as Design-Build-Operate-and-Maintain (DBOM), Design-Build-Finance (DBF), and Design-Build-Finance-Operate-and-Maintain (DBFOM), which reflect the different appetites for risk and the role of the private partner.

The benefit of private sector engagement through P3 delivery is enhanced capital and operating performance through a whole-lifecycle management approach to project execution and mitigating for public sector risks. For instance, P3 delivery can provide schedule and cost certainty through appropriate transfer of responsibility from the public to the private partner(s).

SamTrans could lease the Dumbarton Toll and Rail Bridges to a private partner to design, build, finance, operate and maintain the preferred alternative in return for the right to collect tolls and other fees. However, it is worth noting that the Dumbarton Toll Bridge is owned and operated by Bay Area Toll Authority/Caltrans. Such revenues could be kept by the private partner, meaning they would be accepting the demand / revenue risk, or this risk could be retained by SamTrans. Assuming net toll revenue will not cover the total cost of the DTCS recommendations, an availability payment structure will likely be needed to replace or supplement toll revenues. The availability payments would be linked to performance metrics and a payment schedule, with the contract dictating the facility standards that must be maintained for the private partner to receive the full availability payment in a given period.

Several analytical steps in deciding if, and what, P3 contractual approach is appropriate should be undertaken, including a screening process, several risk workshops (as the project develops), and P3 Value for Money analysis (to assess the value for money of the different procurement and delivery options). Some examples of availability payment-based P3 arrangements for transit P3s (**Table 13-2**) include:

Table 13-2: Availability-Based P3 Projects in the Transit Sector

	Eagle Commuter Rail Transit Project, Colorado	Purple Line Light Rail Transit, Maryland
Total Cost	$2,043.1 million	$2,650 million
Project Sponsor	Regional Transportation District (RTD)	Maryland Department of Transportation Maryland Transit Administration (MTA) Purple Line Transit Partners, LLC
Project Delivery Method	DBFOM	DBFOM
Funding Sources	• FTA New Starts Full Funding Grant Agreement - $1,030.4 million • Private Activity Bonds - $396.1 million	• Progress Payments - $860 million • Revenue Service Availability Payment - $100 million

	Eagle Commuter Rail Transit Project, Colorado	Purple Line Light Rail Transit, Maryland
	• TIFIA loan - \$280.0 million • Other federal grants - \$57 million • RTD sales tax revenue - \$128.1 million • Revenue bond proceeds - \$56.8 million • Local/CDOT/other contributions - \$40.3 million • Equity - \$54.3 million	• Final Completion Payment - \$30 million • Short-term Private Activity Bonds (PABs) - \$100 million • Long-term PABs - \$213 million • PABS Premium - \$54.3 million • TIFIA Loan - \$874.6 million • Equity - \$138.5 million • Interest Income - \$6.8 million • MTA Funds - \$608.879 million
Major Conditions	The TIFIA loan is secured by a senior lien gross revenue pledge of RTD's 0.4 percent sales tax revenues and a subordinate lien pledge of RTD's 0.6 percent sales tax revenues. The 0.4 percent sales tax may only be used to construct and operate the FasTracks mass transit system. The TIFIA lien is on parity with RTD's existing FasTracks senior revenue bonds. The TIFIA loan has been rated "Aa2" by Moody's Investors Service.	The TIFIA credit agreement was signed on June 14, 2016. Principal repayment of the TIFIA loan will begin with substantial completion of delivery and will amortize through a 29-year maturity with final maturity anticipated in 2050.

Source: WSP, 2017

If SamTrans intends to explore P3 delivery of the DTCS recommendations further, it should take certain steps to develop the program management, planning, and procurement processes to ensure a successful project. Chapter 14 provides a list of institutional readiness items that SamTrans should explore before investing in a P3 approach. Once the legal hurdles and other potential institutional fatal flaws are mitigated, it can proceed to developing internal capacity to deliver a P3 project, including training staff on P3 delivery and establishing processes for project analysis, review, and approval.

At the appropriate time special legal, financial, and technical consultants should be brought on to provide the necessary analyses that will inform whether and how to proceed with P3 delivery of the project. The consultant team will also assist SamTrans in P3 procurement strategy and execution, as well as program administration once the contract is in place.

P3 projects are best suited for large, complex efforts that harness the power of project finance and risk transfer. As a result, the P3 delivery method requires a different approach to program management and procurement processes to ensure project success.

Government agencies considering the P3 delivery method evaluate its relative benefits in terms of cost, schedule, performance and lifecycle. The Dumbarton Corridor may benefit from the P3 delivery method in the following ways:

- Cost Certainty: The private partner's capital providers would drive rigorous fiscal management, which results in greater budget certainty. Cost overruns, unexpected design or construction issues, and other financial pitfalls would be the responsibility of the private partner with financial penalties for late delivery.
- Schedule Certainty and Speed: Since the private partner is responsible for the project financing, there is a greater motivation to adhere to the agreed-upon schedule to unlock the revenue streams needed to repay the private partner's lenders. P3 projects also typically require robust security packages to further ensure delivery and performance.
- Cost Savings: The private partner engaged in a P3 is responsible for risks in the design, construction and operating phases of the project. As a result, the private partner – often comprised of a number of private firms – must integrate its design, construction, and operations assumptions in the bidding process. This drives down project costs as there is less friction between project phases.
- Lifecycle Cost Optimization: Instead of paying for maintenance "as-you-go," the private partner is required to estimate maintenance and capital expenditure renewals over the term of the concession – typically a 25- to 35-year period. These assumptions are built into the private party's financial model, which is presented to the government agency at the time of bid.
- Service Performance: Output/performance specifications are guaranteed, particularly if an availability payment-based P3 is in place.
- Optimal allocation of Risk: A P3 contract transfers risks and responsibilities normally assumed by the public agency to a private partner, which creates the Value for Money for the public agency and its constituents.
- Innovation: Instead of prescriptive specifications, the P3 delivery model relies on a functional specification approach. This gives the private partner greater design freedom and emphasizes the integrated design and construction nature of the project.

As a next step, SamTrans should initiate the P3 screening process outlined Chapter 14. This screening process would consider a number of critical elements that would need to be aligned for project success, including legal, planning and environmental, public support, organizational capacity, project scope and complexity, affordability, financial feasibility, and industry interest. Screening the DTCS's recommendations will allow SamTrans to select the best project that not only delivers improved regional and local mobility to support the regional economy, but also ensure successful project development and execution.

13.9 Strategy #9: Use Fares and Tolls to Cover Part of Transit Capital and Operating Costs: $62-76 million annually

User fees such as tolls and transit fares are a potential funding source for transportation projects and should be considered in terms of covering operating and maintenance costs as well as potential for covering periodic repair and replacement contributions and potential for repayment of debt used for capital financing. In some cases, costs to run efficient peak period transit systems can be covered through fare-box recovery—and even potential to provide additional funds that can be reinvested in repair and replacement programs or potentially used to contribute to debt repayment. For the Dumbarton Corridor using today's average fares (approximately $6 per passenger) and the current demand assumptions has the potential to provide transit fare revenue after consideration of routine operating and maintenance costs.

Express toll lane revenue on the Highway Bridge and the approaches have the potential to generate additional funding for transit projects on or near the bridge corridors that will also help to relieve bridge congestion by providing alternative and improved public transit services. In addition to using tolls to support routine transit operating and maintenance costs, there is potential to leverage toll revenue to fund roadway and Rail Bridge maintenance, periodic repair and replacement costs, and repayment of debt issued in support of construction.

Additional information about how potential fare and toll box revenues have been calculated is included in **Appendix P**.

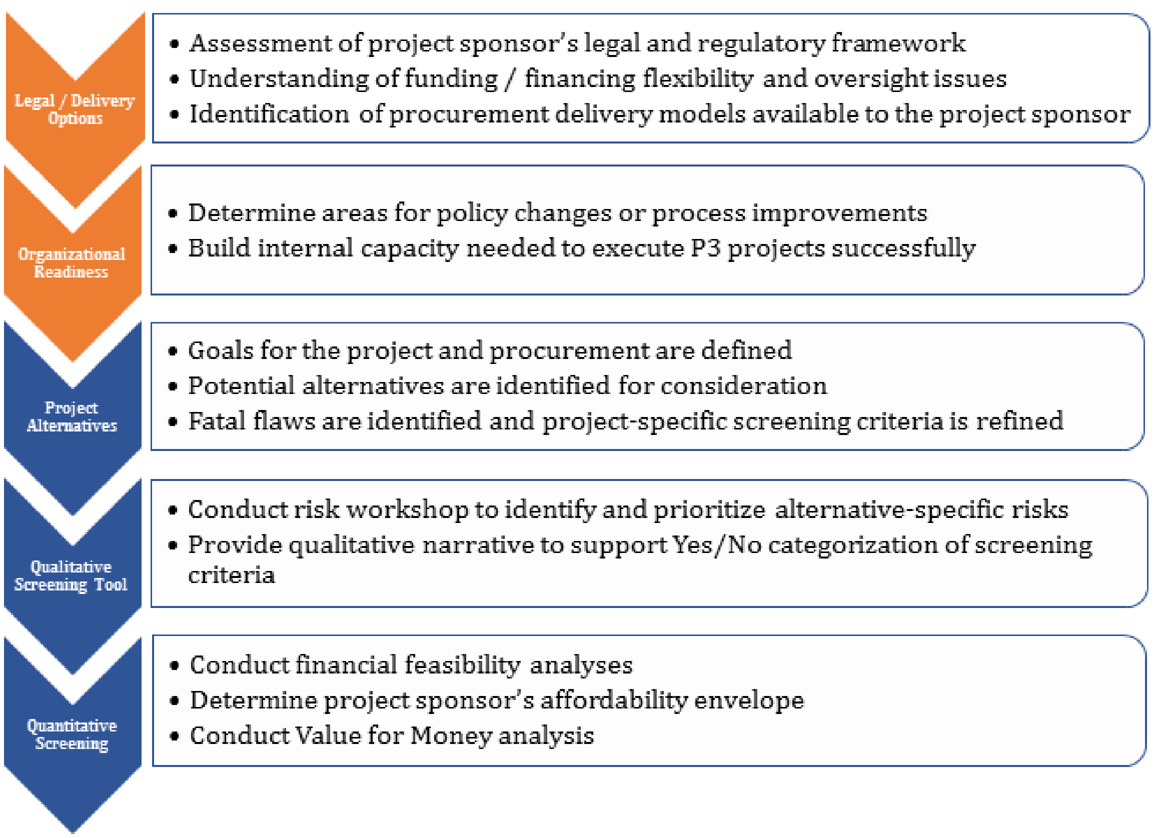
14 Screening for Public-Private Partnerships

14.1 Summary of Screening Approach

Determining whether a public-private partnership (P3) is an appropriate delivery method is a complex endeavor that includes the review of many aspects of a project and the project sponsor's capabilities. This chapter will describe the components of a screening approach, how best to customize the project screening for the Dumbarton Transportation Corridor Study recommendations, and provide some background on legal issues and agency readiness.

P3 screening should consider a number of elements in a decision framework that focuses on SamTrans' goals for the Dumbarton Corridor, such as mitigating certain types of risks, increasing reliability, or promoting innovation. Before considering P3 project screening, SamTrans should first consider the legal framework it must operate within, the P3 structures available for use, and its organizational readiness to carry out P3 procurement. These items are highlighted in orange in **Figure 14-1**. After SamTrans is confident there is a viable path forward, it can embark on the project level screening, and assessing alternatives that may benefit from the P3 project delivery method. These items are highlighted in blue in **Figure 14-1**.

Figure 14-1: P3 Screening Approach



Source: WSP, 2017

Screening for P3 suitability is an iterative exercise that marries both qualitative and quantitative analyses of project alternatives. The goal is to confirm that SamTrans is capable of achieving its goals with the selected delivery recommendation. The screening framework will also help SamTrans understand which P3 approaches provide the greatest public benefit in light of the higher transactional, financial, and organizational costs inherent in P3 project delivery.

14.2 Organizational Readiness and Procurement Delivery Options

Before beginning qualitative and quantitative screening, SamTrans should consider its own ability to successfully procure a P3 project by evaluating its organizational readiness. P3 procurement requires greater oversight by the project sponsor and additional expertise to manage risks. There are also a number of legal and financial needs that a project sponsor must address before embarking on a P3 project, such as confirming the regulatory framework for P3 and determining the agency's ability to be flexible in how it uses available funding/financing. At a high-level, SamTrans should consider the following:

- Does the agency have adequate legal authority to pursue delivery of the project?
- Does the agency have the adequate organizational capacity to deliver the project?

SamTrans has the ability to enter into P3 agreements per the California Infrastructure Financing Act. The Infrastructure Financing Act, however, contains a number of provisions that limits SamTrans' ability to use P3 as described in the Act. For instance, Infrastructure Financing Act does not allow for the use of state grant funds, limits concession terms, does not exempt projects from property taxes, and requires bonding for 100 percent of project value. This limits SamTrans' ability to use P3, particularly those models that use private finance or require a significant term length to allow private parties to make their return on investment.

The other piece of applicable enabling legislation, Section 143 of the Streets and Highways Code, expired on January 1, 2017. Since Democratic majorities in the Legislature and strong labor opposition do not create an optimal climate for P3, it is unlikely that California will pass new enabling legislation. As a result, SamTrans should seek out alternative delivery methods or other forms of cooperative agreements may be employed outside of the scope of existing P3 legislation.

Once SamTrans understands the legal and regulatory framework that may impact its decision-making regarding to P3 delivery, SamTrans can identify the available P3 structure options available for Dumbarton Corridor recommendations (i.e., DB, DBF, or DBFOM).

14.3 P3 Qualitative Screening

After assessing its organizational capacity and legal authority, as well as determining which delivery methods are available for SamTrans to use, SamTrans can use a qualitative analysis to examine each alternative for the Dumbarton Corridor. Qualitative screening focuses on assessing ability to transfer risk, increase cost and schedule certainty, and result in a quality product. At a high-level, the qualitative screening allows SamTrans to consider the following:

- Is the project in line with statewide transportation planning objectives and are there sufficient environmental approvals in place to move forward with P3 delivery?
- Is there sufficient local, regional and political support for the recommended improvements?
- Does the project's scope and complexity best fit the P3 delivery model or is a traditional delivery method most cost-effective?
- Does the project fit within the agency's affordability envelope and does the recommendation possess the financial characteristics to be sufficient to cover anticipated project costs?
- Would the project have the capability to attract a competitive field of potential private partners?

P3 qualitative screening evaluates each project in light of four major categories:

1. Status of planning and environmental processes,
2. Public support,
3. Project scope and complexity,
4. Affordability and financial feasibility.

Under each of these categories, the screening framework poses questions that allow SamTrans to consider the context under which a particular alternative would be delivered. While each alternative is in the same corridor, its unique characteristics may influence SamTrans ability to use the P3 method.

14.3.1 Status of Planning and Environmental Processes

Qualitative factors under the "planning and environmental processes" category help SamTrans consider the status of each project. Planning and environmental processes typically run in advance of P3 procurement processes. If environmental reviews cannot be completed in a timely manner, then project procurement may be delayed. Since most environmental and planning processes are labor- and cost-intensive, it is particularly important that SamTrans look at which projects pose the fewest barriers to successful project delivery. SamTrans may also want to include other factors, such as local agency coordination and other local planning needs, under this categorization that are specific to the agency's internal processes or planning environment. Planning and environmental screening questions are shown in **Table 14-1** below.

Table 14-1: P3 Planning and Environmental Screening Questions

Category: Planning and Environmental	
Factor	**Screening Question**
▪ Environmental Review	Will the required environmental approvals be completed within two to three years?
▪ Planning Goals	Is the project consistent with the statewide transportation plan and the long-term transportation goals of the region? Are additional approvals needed?

Source: WSP, 2017

14.3.2 Public Support

Public support is another crucial factor to consider when evaluating P3 feasibility. P3 projects and procurements are complex and often draw more attention from the public and project stakeholders than traditionally procured projects. Informed and motivated stakeholders can often provide the political will needed to delay or cancel the project, especially if the project faces any perceived "fatal flaws." Land ownership issues and opposition groups may also pose obstacles to timely execution of a P3 procurement process. Public support screening questions are shown in **Table 14-2**.

Table 14-2: P3 Public Support Screening Questions

Category: Public Support	
Factor	**Screening Question**
▪ Political and Local Support	Is there consensus among local and regional stakeholders to pursue the project?
▪ Land Ownership Issues	Are there land ownership issues likely to stop the project?
▪ Opposition	Is the project free of organized or other significant opposition?

Source: WSP, 2017

14.4 Project Scope and Complexity

Understanding the scope and complexity of projects is also an important consideration in using a P3 delivery option. Often, an arbitrary capital value or project type is determined to be a better fit for P3 than others (such as, "only projects valued greater than $100 million are worthwhile as P3 projects"). There is some validity to this, as many seasoned P3 investors/contractors are looking for large projects that can absorb the up-front pursuit costs. This threshold is best established and evaluated during the quantitative phase of P3 screening and should be confirmed during the market sounding effort, if this is conducted.

There are two reasons why the more complex a project scope, the more appropriate it is for a P3 delivery. First, complex projects are naturally prone to change orders, and under a traditional DBB delivery format, these unforeseen items are costs the project sponsor must pay for. Second, complex projects provide opportunities for innovation, which is one way that P3 teams are able to deliver efficiency and potentially cost savings. Complexity is one of many considerations in the screening framework, but generally, P3 contractors are better suited to deal with complexity-related risks than the public partner under a DBB format. Project scope and complexity screening questions are shown in **Table 14-3**.

Table 14-3: P3 Project Scope and Complexity Screening Questions

Category: Project Scope and Complexity	
Factor	**Screening Question**
▪ Complexity	Is the project scope highly complex and prone to change orders?
▪ Schedule	Is schedule certainty particularly important for this project given financial, political, or operational needs?
▪ Risk Allocation	Is there some other special need to allocate certain risks to a private entity who is more capable of managing those risks?
▪ Innovation	Is there potential to derive benefits from technological or other types of innovation through private sector delivery of the project?
▪ Efficiency	Is there potential to achieve cost savings by delivering the project as a P3?
▪ Quality	Is there potential for higher quality product/service delivery with a P3?
▪ Economies of Scale	Does the project provide opportunities to capture benefits associated with economies of scale?

Source: WSP, 2017

14.4.1 Affordability and Financial Feasibility

The project sponsor's ability to afford the projects and each project's financial feasibility are integral factors in assessing project delivery. P3 partners do not invest money without relatively high certainty of a reasonable return on investment. As such, the sponsor should consider the risk/return tradeoffs that the various parties in each project would assume. The project sponsor must consider its resources to support the procurement and any funding/financing needed to deliver the project. These questions are qualitative at this point, but will feed into the quantitative analyses that occur in later phases for r projects that progress through the screening. Affordability and financial feasibility screening questions are shown in **Table 14-4.**

Table 14-4: P3 Project Affordability and Financial Feasibility Screening Questions

Category: Affordability and Financial Feasibility	
Factor	**Screening Question**
▪ Revenue Potential	Does the project have the revenue generation potential to repay any or all of the project costs?
▪ Risk	Does the return justify risk?
▪ Whole Life Costing	Has the project sponsor developed an overall cost estimate for the sum of all project elements anticipated throughout a project's life, including capital, operations, maintenance, and lifecycle costs, and are they affordable?

Source: WSP, 2017

14.4.2 Other Project-Specific Characteristics

SamTrans should consider other project-specific items that are relevant to P3 delivery and incorporate these into the more general items listed in **Figure 14-1** and **Table 14-1** through **Table 14-4**. For instance, right-of-way (ROW) may be an issue that is central to a specific project. Perhaps the project sponsor views the ROW costs and issues to be far too cost prohibitive to execute the project using traditional delivery methods. Using a P3 agreement, the project sponsor could require a private developer to assume ROW responsibilities and risks before starting construction. The value of this risk transfer—or, conversely the potential cost of such a risk—may be a crucial element in understanding whether P3 delivery will help the project sponsor reach its goals. Other project-specific characteristics could include the following:

- Safety
- Traffic
- Labor
- Communication
- Real Estate
- Contracts
- Legal
- Finance
- Oversight
- Planning (including service planning)
- Operations
- Maintenance
- Facilities
- Information Technology
- Marketing
- Civil Rights
- Sustainability
- Environment

14.4.3“Fatal Flaws”

“Fatal flaws” are specific factors that will be legally unfeasible or cost prohibitive. The qualitative screening framework identifies several factors that, based on SamTrans’ goals and risk tolerance, could be considered fatal flaws. The agency’s existing legal framework for P3, funding availability, and ability to obtain certain approvals are examples of items that may be fatal flaws, but every project is different and fatal flaws may change as the procurement evolves.

14.4.4 Market Sounding

In addition to completing the qualitative screening tool, it is important for SamTrans to assess the private market appetite for a potential P3 project in the Dumbarton Corridor. If recommendations are unable to generate sufficient market interest and competition, then the P3 delivery method is not feasible. At this stage, the alternatives are well-defined enough to provide tangible insight into the agency’s options for the Dumbarton Corridor. Yet, design has not progressed to the point of limiting the usefulness of market responses to the alternatives under consideration.

Market sounding—in the form of a Request for Information and industry forum events—will allow SamTrans to assess the level of interest from potential private proposers, which is a good indication of the potential competitive field the project may attract during a P3 procurement. Market sounding also helps SamTrans obtain feedback from potential proposers that may help the agency better formulate the procurement to drive more value or project or produce better results.

Typically, market participants will be very interested in the items identified by the project sponsor as potential fatal flaws. There are many potential P3 opportunities in the US today, and investors have their own screening processes in place because P3 pursuits are expensive and risk tolerances vary greatly across the spectrum of different market participants. SamTrans should go through the qualitative screening process before conducting any market sounding to make sure it has a firm grasp of its goals and ability to conduct a P3 procurement. Private participants are very interested in the public partner's qualifications and ability to execute a P3, so SamTrans needs to convey that it has a sound plan and ability to move forward under reasonable terms when conducting any market sounding.

14.5 P3 Quantitative Screening

Quantitative screening consists of a detailed financial feasibility assessment and a Value for Money analysis. A financial feasibility assessment considers the financial elements of each recommendation at hand, taking them a step further from the general considerations of the qualitative screening. This form of assessment looks at the cash flows for each recommendation from the perspective of the project sponsor. Financial feasibility assessment helps the project sponsor consider if the project is affordable to the agency and what specific financing tools it would use to deliver it. This form of analysis also helps the project sponsor consider if P3 delivery enhances the financial position of the agency in any way.

A Value for Money analysis is a way to express the difference in dollar value between traditional delivery and P3 delivery. This form of analysis first establishes a Public Sector Comparator, which is the cost of traditional delivery (design-bid-build) as procured by the project sponsor. The Public Sector Comparator is then compared to a P3 "shadow bid," which estimates the cost of P3 delivery to the project sponsor. A Value for Money analysis includes not only the base cost and financing fees associated with the recommendations or project under the various delivery approaches, but also the risks inherent in each recommendation and the value of the transfer of those risks to a private party. As such, several risk workshops would be necessary with technical and legal staff to value risks, such as schedule delay, unforeseen construction or site challenges, materials price escalation, and shifts in the financial markets.

Using the quantitative analyses, the results of the qualitative screening tool, and impressions gathered during market sounding, SamTrans will have a strong knowledge of which alternatives are best suited for P3 delivery and will be prepared to draft procurement documents.