Appendix H Public Services

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Final

Transportation Assessment

Capitol Corridor South Bay Connect

Prepared for:
Capitol Corridor Joint Powers Authority

Capitol Corridor South Bay Connect

Transportation Assessment

(including Emergency Vehicle Response Times)

Prepared for:
Capitol Corridor Joint Powers Authority

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Executive Summary

The transportation assessment for the Capitol Corridor South Bay Connect project (the "project") examines the effects on the transportation system associated with the relocation of Capitol Corridor service between Elmhurst and Newark Junction from the Niles Subdivision (including the Centerville portion of the Niles Subdivision) to the Coast Subdivision, consistent with the *2018 California State Rail Plan* and other regional passenger rail planning documents. As part of this project, the existing Hayward and Fremont-Centerville Capitol Corridor stations would no longer be served and a new station at the Ardenwood park-and-ride in Fremont would be served instead.

The transportation assessment examines changes in forecast Capitol Corridor ridership associated with the project and determines how the project would affect regional vehicle-miles traveled (VMT). Analyses of multimodal mobility around the Ardenwood Station area and at at-grade crossings along the Coast, Niles and Oakland subdivisions were also prepared to assess if improvements would be needed to accommodate additional traffic volume growth associated with new ridership at Ardenwood Station and to assess if queues or travel times would noticeably change in the vicinity of at-grade crossings. The assessment also examines potential changes in emergency vehicle access times. The outcomes of the transportation assessment are summarized in the following sections.

Ridership Forecasts and Regional Vehicle-Miles Traveled (VMT)

Ridership forecasts for the proposed project were developed using a combined-model approach, which combined the following models:

- A composite City/County Association of Governments of San Mateo County-Santa Clara Valley Transportation Authority travel demand model (C/CAG-VTA model)
- The Mode Choice Amtrak California Ridership Model (Amtrak model)
- A Direct Ridership Model built specifically for the Capitol Corridor system (DRM)

The DRM was the main source of ridership forecasts for the project; the DRM considers inputs and outputs from the other two models in its forecasting process. Two models were estimated and used in tandem to provide a bracketed analysis of ridership, VMT, and other model-produced metrics. The "Pre-COVID Basis" model assumes that future travel behavior returns to a state that mimics pre-COVID conditions (model based on April 2019 ridership data), and the "Post-COVID Basis" model assumes that post-pandemic effects carry forward into the future (model based on April 2023 ridership data). It is noted that recent 2023 CCJPA ridership data indicates a higher level of ridership above the April 2023 data used for the Post-COVID Basis model (i.e. the Post-COVID Basis model conservatively represents the lower end of the modeling bracket approach).

Forecasts of ridership and VMT were prepared for the Opening Year (Year 2025) and Horizon Year (Year 2040) for the project. **Table E1** and **Table E2** present an overview of the ridership forecasts for the South Bay Connect project.

Table E1: Key Station Daily Boardings + Alightings

Alternative	Pre COVID Basis			Post COVID Basis		
	Total	Range Low	Range High	Total	Range Low	Range High
	Year 2019 – Existing			***Year 2023 – Existing***		
No Project	410	--	--	140	--	--
	Year 2025 – Opening Year			***Year 2025 – Opening Year***		
No Project	820	780	860	400	380	420
Plus Project	1,510	1,430	1,590	710	670	750
	Year 2040 – Horizon Year			***Year 2040 – Horizon Year***		
No Project	1,630	1,550	1,710	980	930	1,030
Plus Project	2,340	2,220	2,460	1,670	1,590	1,750

Notes:
Key stations refer to the Hayward and Fremont-Centerville stations in the No Project scenario and the Ardenwood Station in the Plus Project scenario.
Source: Fehr & Peers, 2023.

Table E2: Systemwide Total Daily Boardings

Alternative	Pre COVID Basis			Post COVID Basis		
	Total	Range Low	Range High	Total	Range Low	Range High
	Year 2019 – Existing			***Year 2023 – Existing***		
No Project	6,110	--	--	2,780	--	--
	Year 2025 – Opening Year			***Year 2025 – Opening Year***		
No Project	10,050	9,550	10,550	4,800	4,560	5,040
Plus Project	11,050	10,500	11,600	5,300	5,040	5,570
	Year 2040 – Horizon Year			***Year 2040 – Horizon Year***		
No Project	18,240	17,330	19,150	12,450	11,830	13,070
Plus Project	19,350	18,380	20,320	13,440	12,770	14,110

Source: Fehr & Peers, 2023.

The South Bay Connect Project is anticipated to result in 500 to 1,000 additional systemwide riders per day in the Year 2025 scenario and 990 to 1,110 additional systemwide riders per day in the Year 2040 scenario. Between 60% and 70% of this ridership increase is due to the new local and Transbay travel market served at the proposed Ardenwood Station. The remaining ridership increase is attributed to additional regional ridership resulting from reduced Capitol Corridor travel times in the study area associated with a more direct route between Elmhurst and Newark Junction and the removal of one stop from the schedule.

Increases in Capitol Corridor ridership indicate that fewer travelers are driving between their destinations, and thus increases in ridership result in a reduction in regional vehicle-miles traveled (VMT). An estimate of the reduction in VMT per weekday resulting from the project is provided below in **Table E3**.

Table E3: Daily Regional Vehicle-Miles Traveled (VMT)

Alternative	Pre COVID Basis Vehicle Miles of Travel (VMT)	Post COVID Basis Vehicle Miles of Travel (VMT)
Year 2025 – Opening Year		
No Project	227,150,000	227,150,000
Plus Project	227,112,000	227,130,000
Delta	*-38,000*	*-20,000*
Year 2040 – Horizon Year		
No Project	256,390,000	256,390,000
Plus Project	256,350,000	256,357,000
Delta	*-40,000*	*-33,000*

Source: Fehr & Peers, 2023.

The increases in ridership associated with the South Bay Connect project implementing one package of improvements outlined in the *2018 California State Rail Plan*, Capitol Corridor's *2016 Vision Implementation Plan*, and other adopted regional passenger rail planning documents are anticipated to be sufficiently accommodated by the Capitol Corridor service.

Multimodal Review of Ardenwood Station Area

While project-related effects on intersection operations (as measured by Level of Service or similar metrics) are automatically considered a less-than-significant impact based on California Environmental Quality Act (CEQA) Guidelines Section 15064.3(b)(2) and Senate Bill 743 (2013), an analysis of multimodal mobility in the Ardenwood Station area was conducted to identify transportation network improvements that may enhance access to and from the proposed Ardenwood Station.

The analysis of ten key intersections around the proposed Ardenwood Station indicated that access to and from the Ardenwood Station could be improved through the construction of the following improvements:

- Interconnection and coordination of traffic signals along the Ardenwood Boulevard-Newark Boulevard corridor from Kaiser Drive to Jarvis Avenue (inclusive of these two intersections)
- Construction of traffic signals at the currently unsignalized intersections of Dumbarton Circle/Paseo Padre Parkway and Dumbarton Circle/Kaiser Drive

As noted previously, these improvements are recommendations and not CEQA mitigation measures. In many cases, the improvements could leverage transportation capacity and operations investments already made by Fremont, Newark, and Caltrans in the study area.

Analysis of At-Grade Crossings

An analysis of 20 intersections and eight additional isolated at-grade crossings was performed to assess if the proposed project would noticeably alter travel times or queues at the at-grade crossing locations. The analysis considered all at-grade crossings along the Coast Subdivision between Elmhurst and Newark Junction, as well as select, representative at-grade crossings on the Oakland and Niles subdivisions where freight service may be altered by the South Bay Connect project. The analysis was performed for the morning peak hour of commute travel (the highest vehicle volume in a 60-minute period between 7:00 AM and 9:00 AM) and the evening peak hour of commute travel (the highest vehicle volume in a 60-minute period between 4:00 PM and 6:00 PM). The project will have a noticeable effect on intersection operations if it results in new LOS deficiencies or increases delay at the intersection by five or more seconds; this principle has historically been used to assess informational, non-CEQA intersection effects in the Bay Area.

The proposed project would result in the shifting of Capitol Corridor services to the Coast Subdivision and potentially shift existing through (non-local) freight service from the Coast Subdivision to the Niles and Oakland Subdivision under Alternatives B-D. Existing Coast Starlight services on the Coast Subdivision would remain as under the No Project Scenario, and local freight services serving customers on the three railroad subdivisions would remain as under the No Project Scenario. Based on published data from the Congressional Budget Office[1], gate down times associated with freight trains are estimated to be as high as 240 seconds per event by Year 2040. Capitol Corridor-associated gate down times are estimated to be as high as 60 seconds per event.

The analysis indicates that two of the study intersections would be noticeably affected by the proposed project in the Year 2025 opening year: Ash Street/Thornton Avenue (along the Coast Subdivision) and Central Avenue/Whipple Road (along the Oakland and Niles subdivisions) - both intersections are affected in the PM peak hour only. For the Year 2040 horizon year analysis, the following intersections are projected to be noticeably affected by the proposed project:

Coast Subdivision:

- Doolittle Drive/Marina Boulevard: AM and PM peak hours
- Catalina Street/Farallon Drive: AM and PM peak hours
- Clawiter Road/Depot Road: AM and PM peak hours
- Union City Boulevard/Whipple Road: PM peak hour
- Fredi Street/Smith Street: PM peak hour
- Dyer Street Alvarado Boulevard: PM peak hour

[1] https://www.cbo.gov/publication/56965

- Ash Street/Thornton Avenue: AM and PM peak hours

Niles and Oakland Subdivisions:

- Railroad Avenue/Whipple Road: AM peak hour
- 11th Street/Decoto Road: AM peak hour
- 12th Street/Decoto Road: AM peak hour
- Station Way/Decoto Road: AM peak hour

Except for Railroad Avenue/Whipple Road, all of the study intersections listed above operate at an over-capacity LOS F condition prior to completion of the project in the Year 2040 horizon year; that is, the intersections are anticipated to already be congested before construction of the proposed project.

An analysis of grade crossings along the Centerville portion of the Niles Subdivision suggests that the shifting of Capitol Corridor trains and a portion of freight service off the Centerville portion of the Niles Subdivision and onto more direct routings would reduce the number of at-grade crossing events, which would reduce delays at the at-grade crossings, and at nearby intersections in Fremont.

Emergency Vehicle Access

A GIS-based analysis of travel times between emergency vehicle facilities (fire stations, police stations and hospitals with emergency services) was performed to assess how the proposed project would affect emergency vehicle access to the surrounding community throughout the course of the day. This analysis is based in part on published passenger rail schedule data and data from Union Pacific regarding freight train movements. The analysis considered how proposed shifts in freight and passenger rail services amongst the Coast, Niles, and Oakland Subdivisions would affect how often trains pass through at-grade crossings and thus require emergency vehicles to take alternative routes. The analysis found that the proposed project would not significantly alter emergency vehicle access times in the study area (less than 30 seconds of change throughout the day).

1. Study Background

The Capitol Corridor South Bay Connect project (the "project") proposes to shift Capitol Corridor passenger rail service from the Niles Subdivision (between Elmhurst and Newark Junction) to the Coast Subdivision. The proposed project is included in the Capitol Corridor Joint Powers Authority's (CCJPA) *2014 Vision Plan Update*, CCJPA's *2016 Vision Implementation Plan*, the *2018 California State Rail Plan*, and *Plan Bay Area 2040*. The project improvements are also included in the Alameda County Transportation Commission (Alameda CTC) *2016 Goods Movement Plan*, Alameda CTC's *Countywide Transit Plan* and *2018 Rail Safety Enhancement Program*, the multi-agency *2017 Dumbarton Transportation Corridor Study*, and the *Dumbarton Forward Design Alternatives Assessment*.

With the shift in the Capitol Corridor route, the existing Hayward and Fremont-Centerville stations on the Niles Subdivision would no longer be served; instead, a new station on the Coast Subdivision at the Ardenwood Boulevard park-and-ride in western Fremont would be served. Additional improvements on the Niles and Oakland Subdivisions are proposed to allow for more efficient freight service in the areas where Capitol Corridor currently operates. The relevant rail subdivisions and station locations are presented on **Figure 1**.

The project would result in changes in ridership patterns along the Capitol Corridor route due to the opening of new travel markets (e.g., Transbay travel connections at Ardenwood Station), reduced service travel times between Oakland and San Jose through the use of a more direct route for Capitol Corridor services, and the bypassing of stations (Hayward and Fremont-Centerville) in areas currently served by nearby BART stations. Increases in ridership anticipated with these changes are expected to reduce regional vehicle-miles traveled (VMT). The presence of additional ridership demand at the Ardenwood Station would result in more demand for capacity in the transportation network accessing the station.

For some (but not all) design alternatives (discussed on the next page), changes in freight service could potentially include rerouted freight trips along the Niles and Oakland subdivisions after completion of the project as these subdivisions represent a more direct routing between Oakland and Niles Canyon (which provides connections eastward to the rest of the national rail network). The effects of the shift in freight services could result in additional delay at rail crossings along the Oakland and Niles subdivisions between Elmhurst Junction and Niles Junction; conversely, a reduction in passenger rail services on the Centerville portion of the Niles Subdivision will likely result in reduced delay at grade crossings along the Centerville portion of the Niles Subdivision (from Niles Junction to Newark Junction). For the Coast Subdivision, shifting Capitol Corridor service could result in reduced delay at at-grade crossings due to the shift in freight services to the Niles and Oakland subdivisions.

It is noted that the proposed project includes a number of design element alternatives. Four alternatives are currently proposed, as summarized below:

ALTERNATIVE B: Alternative B allows Capitol Corridor passenger service to utilize the Coast Subdivision and provides improvements to the Niles Subdivision and the Oakland Subdivision to allow Union Pacific (UP) connectivity between the Oakland and Niles subdivisions. This Alternative proposes track improvements, grade crossing improvements, and new or extended sidings along the Coast, Niles, and Oakland Subdivisions. The existing rail stations in Hayward and Fremont (Centerville) on the Niles Subdivision would no longer be served and a new passenger rail station would be constructed on the Coast Subdivision at the existing Ardenwood park-and-ride facility. This Alternative includes a new grade separated structure elevated over Industrial Parkway on the Niles Subdivision and proposes a new connection south of Industrial Parkway to allow trains traveling southward on the Niles Subdivision to connect with and continue southward on the Oakland Subdivision to reach Niles Canyon (and vice versa for northward trains). Alternative B would construct a new bridge across Alameda Creek on the Oakland Subdivision.

ALTERNATIVE C: This alternative proposes the same rail and ancillary improvements discussed under Alternative B for the Coast Subdivision, Niles Subdivision, and Oakland Subdivision. Similar to Alternative B, Alternative C proposes a slightly different set of track improvements, grade crossing improvements, and new sidings or extension of existing sidings along the Coast, Niles, and Oakland subdivisions. A new passenger rail station would be constructed on the Coast Subdivision at the existing Ardenwood park-and-ride facility (as described under Alternative B). This Alternative also includes a new grade separated structure over Industrial Parkway and the Industrial Parkway Design Option.

ALTERNATIVE D: Alternative D would allow Capitol Corridor passenger service to utilize the Coast Subdivision and would provide a new connection between the Niles and Oakland Subdivisions at Niles Junction. This alternative would include all proposed improvements on the Coast Subdivision as discussed under Alternative B and Alternative C, including a new passenger rail station at the Ardenwood park-and-ride facility. Alternative D would make improvements to the Niles Subdivision north of and in Niles Junction and would establish a new connection between the Niles Subdivision and Oakland Subdivision across and over Mission Boulevard and Alameda Creek in the northeast quadrant of Niles Junction. This alternative would also construct a new grade separated structure at Nursery Avenue by lowering Nursery Avenue and Mission Boulevard to pass under the Niles Subdivision.

ALTERNATIVE E: Alternative E includes shifting of Capitol Corridor passenger service to utilize the Coast Subdivision and installation of second main tracks between either Newark/Alvarado Road (Milepost 25.4 to 27.75) or Mount Eden/Baumberg (Milepost 20.3 to 23.5), as well as installation of siding tracks at the Mulford, Eden Shores, and Avarado sidings.

From a transportation analysis perspective, the key components of the project (e.g., provision for a new station at Ardenwood park-and-ride, shifting Capitol Corridor service to a more direct alignment, etc.) do not fundamentally change between any of the alternatives. For example, all alternatives would result in the same general ridership effects associated with Capitol Corridor serving a new station at the Ardenwood park-and-ride (and no longer serving the existing Hayward and Fremont-Centerville station).

For Alternative E, passenger rail service would shift to the Coast Subdivision (along with a new station at Ardenwood park-and-ride), so ridership effects would be similar to Alternative B-D. However, because freight trains do not have the potential to shift to the Niles and Oakland Subdivisions under Alternative E, the freight train assumptions under Alternative E would be similar to the No Project condition. The analysis throughout this document includes qualitative discussions about how Alternative E would differ from Alternatives B-D.

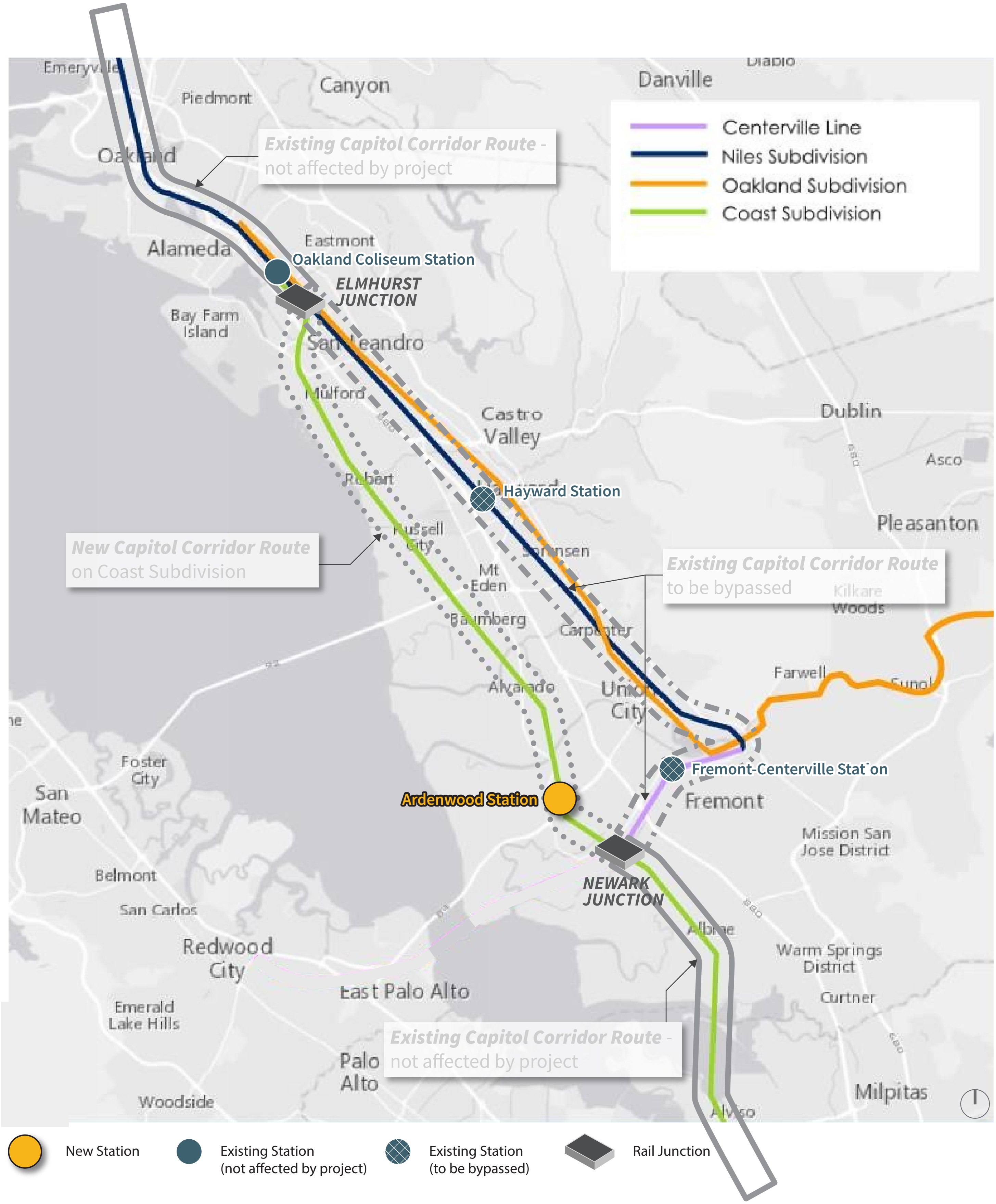


Figure 1

Project Location

WC19-3612.01_1_Location

2. Analysis Methods and Approach

The following sections outline the analysis methods and approaches used to evaluate the South Bay Connect project's effects on the transportation system.

2.1 VMT Analysis Methods

The vehicle-miles traveled (VMT) analysis includes an estimate of the change in regional VMT between the No Project and Plus Project scenarios. The VMT analysis relies on ridership estimates developed from data from the following three travel demand model sources:

1. A composite City/County Associations of Governments of San Mateo County-Santa Clara Valley Transportation Authority travel demand model (C/CAG-VTA model)
2. The Mode Choice Amtrak California Ridership Model (Amtrak model)
3. A Direct Ridership Model built specifically for the Capitol Corridor system (DRM)

The model sources were used to estimate the increase in ridership associated with the proposed project improvements. The C/CAG-VTA model provides inputs of travel time and other travel market service characteristics into the DRM process. The DRM provides ridership data for each origin-destination (OD) pair along the Capitol Corridor system. The Amtrak model provides additional ridership information for ridership along the system and serves as a check against the DRM outputs as the Amtrak model has historically been used to estimate ridership in the corridor. Changes in ridership at the OD level reflect changes in regional VMT as, for example, increased ridership on the Capitol Corridor system reflects travelers choosing to use transit rather than drive a personal automobile (i.e., higher Capitol Corridor ridership leads to lower regional VMT). Two models were estimated and used in tandem to provide a bracketed analysis of ridership, VMT, and other model-produced metrics. The "Pre-COVID Basis" model assumes that future travel behavior returns to a state that mimics pre-COVID conditions, and the "Post-COVID Basis" model assumes that post-pandemic effects carry forward into the future. It is noted that the Fiscal Year 2023 performance report for Capitol Corridor suggests a continued recovery in ridership versus the April 2023 basis used in the Post-COVID Basis model.

More details regarding the forecasting process and development of the DRM are included in the *Capitol Corridor South Bay Connect Environmental Phase – Final Ridership Forecasts* and *Capitol Corridor South Bay Connect Environmental Phase – Post-COVID Pandemic Ridership Forecasts* technical memoranda, provided as **Appendix A1** and **Appendix A2**, respectively.

It is noted that VMT will form the basis of the California Environmental Quality Act (CEQA) Transportation section analysis for the project's effects on the transportation system. This will be governed by CEQA Guidelines Section 15064.3(b)(2), which notes the VMT analysis approach for transportation projects:

> ***Transportation Projects.*** *Transportation projects that reduce, or have no impact on, vehicle-miles traveled should be presumed to cause a less than significant transportation impact. For roadway*

capacity projects, agencies have discretion to determine the appropriate measure of transportation impact consistent with CEQA and other applicable requirements. To the extent that such impacts have already been adequately addressed at a programmatic level, such as in a regional transportation plan EIR, a lead agency may tier from that analysis as provided in Section 15152.

2.2 Operations and Queuing Analysis Methods

The operations of roadway facilities are described with the term "Level of Service" (LOS). LOS is a qualitative description of traffic flow from a vehicle driver's perspective based on factors such as speed, travel time, delay, and freedom to maneuver. Six levels of service are defined ranging from LOS A (free-flow conditions) to LOS F (over capacity conditions). LOS E corresponds to operations "at capacity." When volumes exceed capacity, stop-and-go conditions result, and operations are designated LOS F. While LOS impacts are not considered significant for CEQA purposes under CEQA Guidelines Section 15064.3, the LOS analysis can reveal if the project would increase travel times or queues at key intersections in the study area.

A review of General Plan Circulation/Mobility Elements for agencies along the Coast, Oakland and Niles Subdivisions revealed a variety of LOS-based intersection operations standards. Based on this review, a LOS E standard was identified as an appropriate metric to determine if an intersection is operating at an acceptable or unacceptable level. As noted above, LOS E represents "at capacity" operations, and thus intersections operating at LOS A, B, C, D or E during the peak hours of travel retain capacity to serve demand. The project will have a noticeable effect on intersection operations if it results in new LOS policy deficiencies or increases delay at intersections operating at LOS F under No Project conditions by 5.0 or more seconds; the LOS F/5.0 second delay change principle has historically been used to assess informational, non-CEQA[2] intersection effects in the Bay Area. If the project results in effects on intersections operations beyond these principles, it is not considered a significant CEQA impact under Senate Bill 743 and CEQA Guidelines Section 15064.3 which note that CEQA Transportation impacts should be identified on the basis of vehicle-miles traveled (VMT).

2.2.1 Signalized Intersections

The method described in Chapter 18 of the Transportation Research Board's *Highway Capacity Manual, 6th Edition* (HCM 6th Edition) was used to conduct the LOS calculations for the signalized study intersections. This method is used to estimate the control delay experienced by motorists at an intersection. Control delay includes the initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. The average control delay for signalized intersections was calculated using various traffic analysis software packages and correlated to a LOS designation as shown in **Table 2.1.**

[2] Per SB 743 and CEQA Guidelines Section 15064.3, intersection congestion CEQA impacts are considered to be ***less-than-significant***.

Table 2.1: Signalized Intersection Level of Service Definitions

Level of Service	Description	Average Control Delay per Vehicle (seconds)
A	Operations with very low delay occurring with favorable progression and/or short cycle lengths.	≤ 10.0
B	Operations with low delay occurring with good progression and/or short cycle lengths.	10.1 to 20.0
C	Operations with average delays resulting from fair progression and/or longer cycle lengths. Individual cycle failures begin to appear.	20.1 to 35.0
D	Operations with longer delays due to a combination of unfavorable progression, long cycle lengths, and high volume-to-capacity (V/C) ratios. Many vehicles stop and individual cycle failures are noticeable.	35.1 to 55.0
E	Operations with high delay values indicating poor progression, long cycle lengths, and high V/C ratios. Individual cycle failures are frequent occurrences.	55.1 to 80.0
F	Operations with delays unacceptable to most drivers occurring due to over-saturation, poor progression, or very long cycle lengths.	> 80.0

Source: *Highway Capacity Manual*, 6th Edition, Transportation Research Board, 2016.

2.2.2 Unsignalized Intersections

The method described in Chapter 19 of the HCM 6th Edition was used to conduct the LOS calculations for the side-street stop-controlled intersections. The method described in Chapter 20 of the HCM 6th Edition was used to conduct the LOS calculations for the all-way stop-controlled intersections. The average control delay for unsignalized intersections was also calculated using a variety of traffic analysis software packages. For side-street stop-controlled intersections, the worst movement (for multi-lane approaches) or worst approach (for single-lane approaches) delay was used to determine the LOS for the intersection, using the LOS designations shown in **Table 2.2.** For all-way stop-controlled intersections and roundabouts, the whole-intersection average delay was used to determine the LOS for the intersection.

Table 2.2: Unsignalized intersection Level of Service Definitions

Level of Service	Description	Average Control Delay Per Vehicle (Seconds)
A	Little or no delay.	≤ 10.0
B	Short traffic delays.	10.1 to 15.0
C	Average traffic delays.	15.1 to 25.0
D	Long traffic delays.	25.1 to 35.0
E	Very long traffic delays.	35.1 to 50.0
F	Extreme traffic delays with intersection capacity exceeded.	> 50.0

Source: *Highway Capacity Manual*, 6th Edition, Transportation Research Board, 2016.

2.2.3 Operations and Queueing Analysis Software

Multiple software packages were used to analysis intersection operations near at-grade rail crossings and near the proposed Ardenwood Station.

- The Synchro software analysis package was used to evaluate queues at isolated, at-grade rail crossings where vehicle operations are not affected by nearby intersections. Similarly, the Synchro software package was used to evaluate intersections near the Ardenwood Station where intersection operations are not noticeably affected by congestion at downstream or upstream intersections. The Synchro software package applies the HCM 6th Edition methodologies to evaluate operations and produce queuing, delay, and LOS metrics.
- The SimTraffic microsimulation software analysis package was used to evaluate operations at intersections near at-grade crossings where intersection operations are influenced by at-grade crossings, and vice versa. Railroad traffic signal preemption was coded into the SimTraffic models when traffic signal timing sheets for the intersections noted that preemption is present. The SimTraffic microsimulation software package provides delay and other metrics that are compared to the HCM 6th Edition delay and LOS definitions.
- The VISSIM microsimulation software analysis package was used to evaluate operations at particularly congested or closely spaced intersections (1) near the Ardenwood Station and (2) near at-grade crossings where intersection operations are influenced by at-grade crossings, and vice versa. Railroad traffic signal preemption was coded into the VISSIM models when traffic signal timing sheets for the intersections noted that preemption is present. The VISSIM microsimulation software package provides delay and other metrics that are compared to the HCM 6th Edition delay and LOS definitions.

2.3 Emergency Vehicle Access Analysis

The emergency vehicle access analysis uses a GIS-based analysis approach to estimate the change in emergency vehicle access times for locations along the Coast, Oakland, and Niles Subdivisions. The change in average emergency vehicle access times throughout the course of a typical day was estimated for fire, police and hospitals (with emergency rooms) in the areas alongside the following portions of the study area rail lines:

- Coast Subdivision: Elmhurst Junction to Newark Junction
- Niles Subdivision: Elmhurst Junction to Newark Junction
- Oakland Subdivision: From a point east of Elmhurst Junction (i.e., next to the intersection of Stone Street/San Leandro Boulevard) to Niles Junction

The Centerville portion of the Niles Subdivision is included in the quantitative analysis even though it is expected to see a substantial reduction in the number of grade crossing events as a result of the project.

The GIS analysis assumes that the grade crossings are open to vehicular traffic (i.e., no train is present) for a portion of the day and closed to all vehicular traffic for a portion of the day when a train is present. When grade crossings are closed, emergency vehicles must take a longer diversion route to either provide service or access Fire, Police and Hospital services. The proportion of the day that the crossings are open or closed is based on passenger and freight train movement data developed from grade crossing counts (taken from the public right-of-way) taken during a two-week period in summer 2021; these counts form the basis of the No Project Scenario analysis and are described further in **Chapter 6**. As described in **Chapter 1**, the Plus Project Scenario analysis assumes that freight and passenger rail services shift after completion of the project per the project description for Alternatives B-D, leading to different proportions of the day that a grade crossing would be open or closed. A qualitative assessment of Alternative E is provided, which tiers from the Alternatives B-D analysis.

3. Ridership Forecasting and VMT

This chapter summarizes the ridership forecasting and vehicle-miles traveled (VMT) analysis. The following information is a summary of the forecasting process, background data, analysis, and results of the ridership forecasting and VMT estimation process. Sections 3.1 through 3.6 present the model and forecasted results developed for "Pre-COVID Basis", while Section 3.7 presents the adjustments made to incorporate post-COVID pandemic effects to forecast for a "Post-COVID Basis". As noted in **Chapter 1**, Alternatives B-E include the same shifts in Capitol Corridor service along with a new station at Ardenwood park-and-ride, thus the Plus Project scenario ridership and VMT information presented in this chapter applies to all project alternatives.

More detailed information on this process is included in the ridership forecasts technical memoranda provided as **Appendix A1** and **Appendix A2**, respectively.

3.1 Model Development

The following subsections outline the development of the models used to estimate Capitol Corridor ridership and regional VMT changes associated with the project.

3.1.1 Model Development Summary

The ridership and VMT forecasting process relies on data from three models:

1. A composite City/County Associations of Governments of San Mateo County-Santa Clara Valley Transportation Authority travel demand model (C/CAG-VTA model)
2. The Mode Choice Amtrak California Ridership Model (Amtrak model)
3. A Direct Ridership Model built specifically for the Capitol Corridor system (DRM)

C/CAG-VTA Model

The C/CAG-VTA model provides information about the travel time competitiveness of Capitol Corridor service versus the automobile mode; this information is a key input into the DRM developed for the project (discussed below). The C/CAG-VTA travel demand model also provides a structure for the analysis of land uses around stations (as further discussed in **Section 3.2**). The C/CAG-VTA model also considers the effects of planned regional transportation improvements (as further discussed in **Section 3.3**).

Mode Choice Amtrak California Ridership Model

The Mode Choice version of the Amtrak California Ridership Model (Amtrak model) has historically been used to estimate ridership for the Capitol Corridor system. Ridership estimates from the model were previously used to determine ridership potential for planning purposes. For the environmental analysis, however, the Amtrak model lacks specific detail for land uses that can be reached by new Transbay transfers (such as those provided at the proposed Ardenwood Station). Thus, outputs from the Amtrak model were used to provide guidance as to the reasonability of the DRM forecasts (discussed later in this subsection), especially for long distance trips (e.g., from Sacramento to San Jose).

Direct Ridership Model (DRM)

The Direct Ridership Model is a set of statistical equations that estimate ridership based on several land use, travel time, station design, and Capitol Corridor schedule and frequency variables. The DRM addresses the limitations of the C/CAG-VTA model to forecast Capitol Corridor ridership but preserves the relationship to the C/CAG-VMT model by relying on travel time competitiveness and land use inputs from the C/CAG-VTA model to inform the ridership estimation process. The DRM forecasts ridership along the entire Capitol Corridor route, including in the Sacramento region, for the following periods: AM peak, PM peak and Off Peak (the summation of which equals total daily ridership). Key input variables in the DRM and their level of statistical significance are summarized below in **Table 3.1**.

The DRM is a statistical model that was calibrated to average weekday ridership data from April 2019 (i.e., before the COVID-19 pandemic). Goodness-of-fit statistics of the Base Year (2019) DRM are discussed in **Section 3.1.2**.

Table 3.1: Direct Ridership Model Input Variables – Pre-COVID Basis Model

Category	Variable	AM Peak	PM Peak	Off Peak
Land Use	Population within ¼, ½, 1 mile, or 2 miles of origin	++		+
	Population accessible via transit or walk connection to origin	++		
	Population within ¼, ½, 1 mile, or 2 miles of destination		+	+
	Population accessible via transit or walk connection from destination		++	+
	Employment within ¼, ½, 1 mile, or 2 miles of origin		+++	++
	Employment accessible via transit or walk connection to origin		++	
	Employment within ¼, ½, 1 mile, or 2 miles of destination	+++		++
	Employment accessible via transit or walk connection from destination	++		+
Parking	Auto parking at origin station	++		
	Auto parking at destination station		+	+
Capitol Corridor Service	Train frequency	++	++	++
	Fare / distance	-	-	-
Other Modes	Auto vs Capitol Corridor travel time	++	++	+
	Capitol Corridor vs competing transit travel time	-	-	-
Significance Definitions				
+++	Strong positive significance			
++	Moderate positive significance			
+	Weak positive significance			
-	Weak negative significance			

Source: Fehr & Peers, 2021.

The DRM is segmented into four modules that represent the four travel markets within or between the core Bay Area and core Sacramento areas. The four modules are:

- **Module 1: Within Core Bay Area** – Travel among stations between Martinez and San José Diridon.
- **Module 2: Leaving Core Bay Area** – Travel from Core Bay Area stations (Martinez to San Jose) to stations outside the Bay Area (Auburn to Suisun City).
- **Module 3: Entering Core Bay Area** – Travel from stations outside the Core Bay Area (Auburn to Suisun City) into the Core Bay Area (Martinez to San Jose).
- **Module 4: Outside Core Bay Area** – Travel among stations outside the Core Bay Area (Auburn to Suisun City).

The DRM also includes a Mode of Access (MoA) model which provides information about how Capitol Corridor riders access and depart the station. Separate MoA models were developed for AM peak period mode of inbound access and AM peak period mode of outbound egress. These models represent the critical mode choice period; for example, the choice to drive to a Capitol Corridor station generally leads a rider to drive away from the station after the return trip. The MoA models use input variables that are similar to the input variables used for the DRM.

3.1.2 Direct Ridership Model Goodness-of-Fit

As noted in **Section 3.1.1**, the DRM is a statistical model that was calibrated to April 2019 ridership data. As a statical model, the goodness-of-fit of the Base Year DRM can be established using an R-squared metric. R-squared metrics closer to 1.00 indicate that the model replicates all variation in ridership. Higher R-squared values are not necessarily a good result—in most cases where the R-squared value is high, this indicates a model over-fit condition whereby the model will be a poor predictor of future ridership. Generally speaking, the goodness of fit metrics suggest that the suite of DRMs are performing within expectations. The R-squared statistics for the Base Year DRM is presented below in **Table 3.2**.

Table 3.2: Direct Ridership Model (DRM) Goodness of Fit (R-squared) – Pre-COVID Basis Model

Segment	AM Peak	PM Peak	Off Peak
Segment 1: Within Core Bay Area	0.60	0.56	0.53
Segment 2: Leaving Core Bay Area	0.77	0.81	0.82
Segment 3: Entering Core Bay Area	0.78	0.61	0.83
Segment 4: Outside Core Bay Area	0.75	0.94	0.99

Source: Fehr & Peers, 2021.

3.2 Land Use Forecasts

Land use forecasts used in the modeling process are derived from published data from regional and local transportation agencies. For the Sacramento region, land use forecasts are based on the latest projections from the Sacramento Area Council of Governments (SACOG) as provided in the Sacramento Regional Travel Demand (SACMET) model. For the nine-county San Francisco Bay Area, land use forecasts are based on published information in *Plan Bay Area 2040*. For Alameda, Contra Costa, and Solano counties, the C/CAG-VTA model land use was adjusted for more refined land use assumptions as documented in the Alameda County Transportation Commission (Alameda CTC), Contra Costa Transportation Authority (CCTA), and Solano Transportation Authority (STA) travel demand models, respectively.

Consistent with other regional rail planning projects in the Bay Area, the *Plan Bay Area 2040* land use assumptions were further modified to reflect several land use projects/programs that have been approved in the period since *Plan Bay Area 2040* was released. These approved projects/programs result in additional land use growth beyond *Plan Bay Area 2040* projections. These are located primarily in San Francisco, San Mateo, and Santa Clara counties; one notable rezoning project in the Fremont area includes the addition of about 7,000 additional jobs in the Ardenwood Station area by 2040.

3.3 Transportation Network Assumptions

Several regional transportation network improvements were assumed to be in place by 2025 and 2040 based on recently published information and other regional planning documents (such as *Plan Bay Area 2040*). Key transit-related improvements assumed as part of the background are presented in **Table 3.3**. These assumptions are consistent for both models.

Table 3.3: Future Transit Network Assumptions

Parameter	Forecast Year	Assumption
ACE Service Level	2025	Same as 2018
	2040	10 daily ACE roundtrips (+6 from today)
Caltrain Service Level	2025	6-train per hour Zone Express Service
	2040	8-train per hour Moderate Growth Plan/Service Vision from the Caltrain Business Plan process
Hollister Express Bus Service	2025	Not included
	2040	Hourly integrated express bus service between Gilroy and Hollister
Salinas Rail Service	2025	No service
	2040	Hourly service between Gilroy and Salinas; hub station at Pajaro/Watsonville providing hourly connections to Santa Cruz; hub station at Castroville providing hourly connections to Monterey.
Dumbarton Rail Service	2025	Not included
	2040	Rail shuttle from Union City BART station to Redwood City Caltrain station: 4 trains per hour per direction peak, 2 trains per hour per direction off peak.
US-101 Managed Lanes	2025	Add HOT lane in San Mateo County south of I-380
	2040	Convert a lane to a HOT lane between I-380 and I-280; convert a southbound lane to a HOT lane on I-280 north of US-101.
SamTrans Express Bus Service	2025	Four express routes as presented in SamTrans Express Bus study
	2040	Six more express routes as presented in SamTrans Express Bus study.

Source: Fehr & Peers, 2021.

3.4 Ridership Results

Ridership models were run for the Year 2025 No Project, Year 2025 Plus Project, Year 2040 No Project, and Year 2040 Plus Project scenarios. **Table 3.4** presents the daily boardings and alightings at three key stations: Hayward, Fremont, and Ardenwood, along with the total daily systemwide boardings. **Table 3.5** shows systemwide total boardings by time of day. In general, the South Bay Connect project scenarios are projected to result in a modest increase in system-level ridership as compared to the corresponding No Project scenarios; this ridership is anticipated to be accommodated by the Capitol Corridor rail vehicle fleet as envisioned by the project. For key stations in the project area, the difference between No Project and Plus Project scenarios is more considerable.

Table 3.4: Ridership Forecast Overview – Pre-COVID Basis Model

Alternative	Key Station Daily Boardings + Alightings			Systemwide Total Daily Boardings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2019 – Existing						
No Project	410	--	--	6,110	--	--
Year 2025 – Opening Year						
No Project	820	780	860	10,050	9,550	10,550
Plus Project	1,510	1,430	1,590	11,050	10,500	11,600
Year 2040 – Horizon Year						
No Project	1,630	1,550	1,710	18,240	17,330	19,150
Plus Project	2,340	2,220	2,460	19,350	18,380	20,320

Source: Fehr & Peers, 2021.

Table 3.5: Systemwide Boardings by Time Period – Pre-COVID Basis Model

Alternative	Systemwide Total Boardings			
	Daily	AM Peak	PM Peak	Off Peak
Year 2019 – Existing				
No Project	6,110	2,460	2,380	1,270
Year 2025 – Opening Year				
No Project	10,050	3,930	3,770	2,360
Plus Project	11,050	4,410	4,210	2,430
Year 2040 – Horizon Year				
No Project	18,240	6,950	6,680	4,600
Plus Project	19,350	7,530	7,210	4,620

Source: Fehr & Peers, 2021.

3.5 VMT Results

Using the results of the DRM as described in **Section 3.4**, daily regional vehicle-miles traveled (VMT) was estimated for the project scenarios. For this VMT estimate, the region is defined as the geographic area covered by the C/CAG-VTA travel demand model, which is consistent with the primary area of travel change.

While this estimate covers a large region, it is noted that much of the VMT savings due to the project will be along two congested regional corridors: the I-80 corridor between Sacramento and Oakland and the

I-880 corridor between Oakland and San Jose. The majority of new ridership under the Plus Project alternatives would occur during the AM and PM peak periods.

Table 3.6 presents the outputs of the VMT calculation.

Table 3.6: Daily Regional Vehicle-Miles Traveled (VMT) – Pre-COVID Basis Model

Alternative	Vehicle Miles of Travel (VMT)
Year 2025 – Opening Year	
No Project	227,150,000
Plus Project	227,112,000
Delta	***-38,000***
Year 2040 – Horizon Year	
No Project	256,390,000
Plus Project	256,350,000
Delta	***-40,000***

Source: Fehr & Peers, 2021.

3.6 Mode of Access Modeling

In addition to the forecasting ridership along the Capitol Corridor route, Mode of Access (MoA) models were developed to understand travel to and from Capitol Corridor stations. Two models were developed, focused on the AM peak period: a mode of access model and a mode of egress model. The AM peak period is the focus period as most travelers make their modal choice in the morning and use that same mode in the afternoon (i.e., most Capitol Corridor morning passengers would not make their afternoon reverse trip in their own private automobile). These models shed further light on key differences between the existing Hayward and Fremont-Centerville stations and the proposed Ardenwood Station. These models are described further in **Appendix A**. **Table 3.7** presents the mode of access/egress forecasts for the key stations in the analysis.

The mode of access and egress models were not re-estimated due to insufficient 2023 mode share data. As such, the mode of access and egress forecasts remain the same as the Pre-COVID Basis analysis.

Table 3.7: Key Station AM Peak Period Mode of Access and Egress

Station	2019 (Observed)[1]			2025 (Projected)			2040 (Projected)		
	Auto	Transit	Active[2]	Auto	Transit	Active[2]	Auto	Transit	Active[2]
AM Peak Period Mode of Access (Trips to Station)									
Hayward (No Project Scenario)	89%	0%	11%	89%	0%	11%	89%	0%	11%
Fremont-Centerville (No Project Scenario)	75%	0%	25%	77%	0%	22%	76%	0%	24%
Ardenwood (Plus Project Scenario)	--	--	--	91%	1%	9%	90%	1%	9%
AM Peak Period Mode of Egress (Trips from Station)									
Hayward (No Project Scenario)	50%	50%	0%	43%	34%	24%	43%	34%	24%
Fremont-Centerville (No Project Scenario)	50%	20%	30%	43%	19%	39%	43%	19%	39%
Ardenwood (Plus Project Scenario)	--	--	--	16%	60%	25%	24%	35%	41%

Notes:
1. Based on Capitol Corridor ridership survey data (2019)
2. Active modes include walking and bicycling
Source: Fehr & Peers, 2021.

The MoA forecasts reflect Ardenwood Station's different travel profile versus the Hayward and Fremont-Centerville stations. Ardenwood serves both as an AM origin station with a large automobile contingent, and as an AM destination station with considerable transit connections to employment. The very large (60%) transit mode share for Ardenwood in 2025, which drops to 35% in Year 2040, is attributed to changes in Ardenwood Station-area area employment opportunities between 2025 and 2040, which opens up employment opportunities in the station that can be accessed without an automobile or transit connection.

The MoA forecasts are used to convert ridership at the Ardenwood Station into vehicle volumes accessing Ardenwood Station, as described in **Section 4.3**.

3.7 Post-COVID Basis Model Adjustments

The COVID-19 pandemic has had a substantial effect on travel patterns in the Bay Area. Transit ridership decreased dramatically during the pandemic, with some operators experiencing 80% decreases compared to 2019 ridership levels. The acceleration of remote-working trends and transit hesitancy related to rising concerns about health and safety have made transit services less attractive for potential riders. Additional forecasts were prepared to include post-COVID pandemic effects on Capitol Corridor ridership, assuming that these effects will carry forward into the future. The additional ridership forecasts and VMT estimates do not supersede the Pre-COVID Basis forecasts; instead, the Post-COVID Basis forecasts were used in tandem to provide a bracketed analysis of ridership, VMT, and other model-produced metrics.

To prepare the Post-COVID Basis forecasts, key factors that influenced transit ridership were identified. These factors include the acceleration of remote-working trends, leisure travel pattern changes, and transit hesitancy related to concerns about personal safety and security. While remote work information is available for both 2019 and 2023, data was not available to quantify leisure travel pattern changes or transit hesitancy. Thus, the approach was to re-estimate the Pre-COVID Basis scenario Base Year 2019 DRM with the addition of a remote work variable. This re-estimated model was then used to “forecast” 2023 Capitol Corridor ridership. The “forecasted 2023” ridership—ridership if there were no changes to leisure travel patterns and no travel hesitancy — was then compared with the observed 2023 ridership. The difference is assumed to be leisure travel pattern changes and transit hesitancy related to concerns about personal safety and security. This difference was then applied to future forecasts to accurately reflect the scenario in which post-COVID effects carry forward into the future.

Key input variables in the updated DRM and their level of statistical significance are summarized below in **Table 3.8**. Remote work variables were added to the models to assess the change in travel patterns resulting from the substantial increase on the proportion of workers that can perform their jobs, fully or partially, from home instead of going to a physical workplace. Goodness-of-fit statistics of the updated DRM are presented in **Table 3.9**.

Table 3.8: Direct Ridership Model Input Variables – Post-COVID Basis Model

Category	Variable	AM Peak	PM Peak	Off Peak
Land Use	Population within ¼, ½, 1 mile, or 2 miles of origin	++		++
	Population accessible via transit or walk connection to origin	++		
	Population within ¼, ½, 1 mile, or 2 miles of destination			++
	Population accessible via transit or walk connection from destination		++	++
	Employment within ¼, ½, 1 mile, or 2 miles of origin		+++	+++
	Employment accessible via transit or walk connection to origin		++	++
	Employment within ¼, ½, 1 mile, or 2 miles of destination	+++		+++
	Employment accessible via transit or walk connection from destination	++		+
Parking	Auto parking at origin station	++		
	Auto parking at destination station		++	+++
Capitol Corridor Service	Train frequency	++	++	++
	Fare / distance	-		
Other Modes	Auto vs Capitol Corridor travel time	++	++	+
	Capitol Corridor vs competing transit travel time	-	-	-
Remote Work	Proportion of workers that work from home at jobs localized nearby origin station		-	-
	Proportion of workers that work from home at jobs localized nearby destination station	-		
Significance Definitions				
+++	Strong positive significance			
++	Moderate positive significance			
+	Weak positive significance			
-	Weak negative significance			

Source: Fehr & Peers, 2023.

Table 3.9: Direct Ridership Model (DRM) Goodness of Fit (R-squared) – Post-COVID Basis Model

Segment	AM Peak	PM Peak	Off Peak
Segment 1: Within Core Bay Area	0.60	0.55	0.53
Segment 2: Leaving Core Bay Area	0.77	0.83	0.83
Segment 3: Entering Core Bay Area	0.80	0.61	0.83
Segment 4: Outside Core Bay Area	0.75	0.94	1.00

Source: Fehr & Peers, 2023.

The latest data available was reviewed to create DRM input variables for 2023 conditions. Data from the Census, California Bureau of Labor Statistics, and the National Transit Database were used to update land use and modal station accessibility variables. To isolate the transit hesitancy, the re-estimated 2019 model that included a work from home variable was applied with 2023 inputs and compared the modeled 2023 ridership with the observed Capitol Corridor ridership in April 2023. As expected, the re-estimated model overestimated ridership in 2023. It was found that the re-estimated DRM overestimated daily 2023 systemwide ridership by approximately 20%. This 20% was interpreted as transit hesitancy due related to concerns about health, personal safety, and security. This same 20% reduction was then applied to the 2025 and 2040 forecasts to generate Post-COVID Basis forecasts.

Table 3.10 and **Table 3.11** below show the post-pandemic forecasts for the Opening Year (Year 2025) and Horizon Year (Year 2040). Although the updated model forecasts a smaller number of additional systemwide riders, the project still results in an increase in systemwide ridership. The impact of key stations in the project area remains substantial and represents between 60% and 70% of the ridership increase.

Table 3.10: Ridership Forecast Overview – Post-COVID Basis Model

Alternative	Key Station Daily Boardings + Alightings			Systemwide Total Daily Boardings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2023 – Existing						
No Project	140	--	--	2,780	--	--
Year 2025 – Opening Year						
No Project	400	380	420	4,800	4,560	5,040
Plus Project	710	670	750	5,300	5,040	5,570
Year 2040 – Horizon Year						
No Project	980	930	1,030	12,450	11,830	13,070
Plus Project	1,670	1,590	1,750	13,440	12,770	14,110

Source: Fehr & Peers, 2023.

Table 3.11: Systemwide Boardings by Time Period – Post-COVID Basis Model

Year 2023 – Existing				
No Project	2,780	1,040	1,320	420
Year 2025 – Opening Year				
No Project	4,800	1,810	1,670	1,310
Plus Project	5,300	2,040	1,890	1,370
No Project	12,450	4,760	4,600	3,100

Source: Fehr & Peers, 2023.

Table 3.12 details the daily regional VMT results for the updated model. As shown on this table, the model estimates that the project produces regional VMT savings. Consistent with the ridership results shown in the tables above, VMT savings forecasted by the Post-COVID Basis model are smaller than those shown in **Table 3.6**.

Table 3.12: Daily Regional Vehicle-Miles Traveled (VMT) – Post-COVID Basis Model

Alternative	Vehicle Miles of Travel (VMT)
Year 2025 – Opening Year	
No Project	227,150,000
Plus Project	227,130,000
Delta	***-20,000***
Year 2040 – Horizon Year	
No Project	256,390,000
Plus Project	256,357,000
Delta	***-33,000***

Source: Fehr & Peers, 2023.

4. Station Area Mobility Analysis

The following chapter outlines the purpose, study area, study assumptions and results of the Station Area Mobility Analysis for the proposed Ardenwood Station.

4.1 Purpose of Analysis

The purpose of the Station Area Mobility Analysis is to assess how new ridership at Ardenwood Station creates a need for circulation system operational improvements to efficiently serve new trips going to/coming from the station (that is, trips associated with new Capitol Corridor ridership). The traffic volume forecasting process for the Station Area Mobility Analysis considers the overall Pre-COVID Basis ridership at the proposed Ardenwood Station[3] as well as the mode of access to/from the station; for example, riders accessing the station via transit are assumed to not generate a vehicle trip at the station (as they would be using existing transit services). The Pre-COVID Basis mode of access forecasts were used for this analysis. As noted in **Chapter 3**, because Alternatives B-E include similar changes to Capitol Corridor routing and the installation of a new station at Ardenwood park-and-ride, the Plus Project scenario analyses in this chapter apply to all project alternatives.

While, as noted previously, impacts to traffic operations (as measured by LOS and similar metrics) are not to be considered to be significant for CEQA purposes under SB 743, providing for efficient multimodal operations in and around the Ardenwood Station area will benefit Capitol Corridor riders boarding and alighting at the new station (in addition to providing benefits for all users of the local multimodal transportation system). A review of multimodal site access is also provided to assess the suitability of the planned multimodal transportation system supporting the Ardenwood Station to efficiently serve pedestrians, bicyclists, and other public and private transit services serving the Ardenwood Station.

4.2 Study Intersections and Software Packages

As previously described, different traffic operations analysis software packages were used to evaluate the study intersections. The choice of intersection analysis software for each intersection below was based on existing operating conditions and roadway network characteristics, as outlined in **Section 2.2.3**. The following study intersections were evaluated using the indicated software package:

1. Ardenwood Boulevard/Paseo Padre Parkway – Synchro
2. Ardenwood Boulevard/Kaiser Drive – VISSIM
3. Dumbarton Circle/Kaiser Drive – Synchro
4. Ardenwood Boulevard/Ardenwood Terrace – VISSIM
5. Ardenwood Boulevard/SR 84 Westbound Ramps – VISSIM
6. Newark Boulevard/SR 84 Eastbound Ramps – VISSIM

[3] The consideration of the Pre-COVID Basis ridership forecasts represents the most conservative scenario for study of station area mobility.

7. Newark Boulevard/Jarvis Avenue – VISSIM
8. Paseo Padre Parkway/Dumbarton Circle – Synchro
9. Paseo Padre Parkway/SR 84 Westbound Ramps – Synchro
10. Thornton Avenue/SR 84 Eastbound Ramps – Synchro

4.3 Traffic Volume Assumptions

Existing Conditions traffic volumes reflect Year 2019 conditions based on available traffic counts and retrospective traffic volume data from the StreetLight Data intersection turning movement count database. Year 2025 and Year 2040 No Project scenario traffic forecasts were developed using outputs from the C/CAG-VTA model. The C/CAG-VTA model considers changes in regional land use patterns and planned modifications to the regional transportation system.

Year 2025 and Year 2040 Plus Project scenario traffic volume forecasts were estimated by adding the amount of new automobile trips generated through the new ridership at Ardenwood Station to the No Project forecasts. As noted in **Chapter 3**, the ridership forecasting process includes a mode-of-access model that estimates the amount of travel demand by mode (e.g., automobile, bicycle, transit, etc.) generated by ridership at each Capitol Corridor station. Thus, projected ridership at Ardenwood Station can be converted into automobile demand. The AM and PM peak hour automobile trip generation estimates associated with the ridership at Ardenwood Station are presented below in **Table** 4.1.

Table 4.1: Estimated Peak Hour Trip Generation at Ardenwood Station

Horizon Year	AM Peak Hour				PM Peak Hour			
	In	Out	Total	*Kiss and Ride*[1]	In	Out	Total	*Kiss and Ride*[1]
Year 2025	175	100	275	*95*	90	155	245	*85*
Year 2040	280	170	450	*160*	150	240	390	*140*

Notes:
1. Kiss-and-Ride trips included in presented in/out/total values. Kiss-and-Ride trips are specifically noted as they do not contribute to long-term parking demand.
Source: Fehr & Peers, 2023.

It is assumed that the vast majority (80%) of kiss-and-ride trips are assumed to occur at the existing Ardenwood park-and-ride lot (i.e., these trips will take access from the station using Ardenwood Terrace), and all other trips would take access to/from Ardenwood Station at the proposed parking lot off of Ardentech Court. These trips were assumed to be layered on top of the No Project volumes – no traffic volume reductions to reflect conversion of trips from the automobile mode to Capitol Corridor service were made, to be conservative.

4.4 Intersection Operations Level of Service (LOS) Results

This section describes the AM and PM peak hour intersection LOS results for Existing Conditions (Year 2019), the Year 2025 analysis horizon, and the Year 2040 analysis horizon.

4.4.1 Existing Conditions LOS Results

The AM and PM peak hour LOS results for Existing Conditions are presented below in **Table** 4.2. Intersections with operations that do not meet the LOS E standard for acceptable operations are bolded. The following intersections operate deficiently with respect to the LOS E standard during the indicated peak hour:

- Intersection 1 – Ardenwood Boulevard/Paseo Padre Parkway: LOS F in the PM peak hour
- Intersection 3 – Dumbarton Circle/Kaiser Drive: LOS F in the PM peak hour
- Intersection 4 – Ardenwood Boulevard/Ardenwood Terrance: LOS F in the PM peak hour
- Intersection 8 – Paseo Padre Parkway/Dumbarton Circle: LOS F in the PM peak hour

Table 4.2: Ardenwood Station Intersection Levels of Service – Existing Conditions

Intersection		Intersection Control	Peak Hour	Delay[1]	LOS[2]
1	Ardenwood Boulevard/Paseo Padre Parkway	Signalized	AM PM	32.8 **100.7**	C **F**
2	Ardenwood Boulevard/Kaiser Drive	Signalized	AM PM	26.5 27.5	C C
3	Dumbarton Circle/Kaiser Drive	Side-Street Stop-Controlled	AM PM	6.2 (35.2) **20.8 (53.6)**	A (E) **C (F)**
4	Ardenwood Boulevard/Ardenwood Terrace	Signalized	AM PM	76.3 **83.7**	E **F**
5	Ardenwood Boulevard/SR 84 Westbound Ramps	Signalized	AM PM	67.2 67.6	E E
6	Newark Boulevard/SR 84 Eastbound Ramps	Signalized	AM PM	16.9 16.7	B B
7	Newark Boulevard/Jarvis Avenue	Signalized	AM PM	36.7 35.2	D D
8	Paseo Padre Parkway/Dumbarton Circle	Side-Street Stop-Controlled	AM PM	0.1 (9.5) **14.6 (>120.0)**	A (A) **B (F)**
9	Paseo Padre Parkway/SR 84 Westbound Ramps	Signalized	AM PM	10.8 8.9	B A
10	Thornton Avenue/SR 84 Eastbound Ramps	Signalized	AM PM	8.0 64.9	A E

Notes:

1. Intersection delay presented as whole-intersection average delay for signalized, roundabout, and all-way stop-controlled intersections. Delay presented as "whole-intersection average delay (worst approach or worse movement delay)" for side-street stop-controlled intersections.
2. LOS per delay definitions in the HCM 6th Edition.
Bold indicates LOS F operations.
Source: Fehr & Peers, 2023.

4.4.2 Year 2025 LOS Results

Table 4.3 presents the Year 2025 AM and PM peak hour intersection LOS results. The Year 2025 scenario analysis assumes that traffic signals in the study area are retimed to reflect increased traffic volumes. Intersections with operations that do not meet the LOS E standard for acceptable operations are bolded. The following intersections operate deficiently under Year 2025 No Project Conditions with respect to the LOS E standard during the indicated peak hour:

- Intersection 2 – Ardenwood Boulevard/Kaiser Drive: LOS F in the PM peak hour
- Intersection 3 – Dumbarton Circle/Kaiser Drive: LOS F in the AM and PM peak hours
- Intersection 4 – Ardenwood Boulevard/Ardenwood Terrance: LOS F in the AM and PM peak hours
- Intersection 5 – Ardenwood Boulevard/SR 84 Westbound Ramps: LOS F in the AM and PM peak hours
- Intersection 7 – Newark Boulevard/Jarvis Avenue: LOS F in the PM peak hour
- Intersection 8 – Paseo Padre Parkway/Dumbarton Circle: LOS F in the AM and PM peak hours
- Intersection 10 – Thornton Avenue/SR 84 Eastbound Ramps: LOS F in the PM peak hour

Table 4.3: Ardenwood Station Intersection Levels of Service – Year 2025 Conditions

Intersection		Peak Hour	Year 2025 No Project		Year 2025 Plus Project	
			Delay[1]	LOS[2]	Delay[1]	LOS[2]
1	Ardenwood Boulevard/Paseo Padre Parkway	AM PM	36.6 72.6	D E	37.9 72.6	D E
2	Ardenwood Boulevard/Kaiser Drive	AM PM	36.7 **>120.0**	D **F**	**100.4** **119.2**	**F** **F**
3	Dumbarton Circle/Kaiser Drive	AM PM	**11.1 (72.5)** **51.3 (>120.0)**	**B (F)** **F (F)**	**21.3 (>120.0)** **97.1 (>120.0)**	**C (F)** **F (F)**
4	Ardenwood Boulevard/Ardenwood Terrace	AM PM	**80.9** **>120.0**	**F** **F**	**>120.0** **>120.0**	**F** **F**
5	Ardenwood Boulevard/SR 84 Westbound Ramps	AM PM	**90.9** **100.7**	**F** **F**	79.6 **93.2**	E **F**
6	Newark Boulevard/SR 84 Eastbound Ramps	AM PM	36.8 73.0	D E	32.2 68.9	C E
7	Newark Boulevard/Jarvis Avenue	AM PM	47.0 **>120.0**	D **F**	44.5 **>120.0**	D **F**
8	Paseo Padre Parkway/Dumbarton Circle	AM PM	0.2 (9.7) **29.5 (>120.0)**	A (A) **D (F)**	**0.3 (52.5)** **39.3 (>120.0)**	**A (F)** **E (F)**

Table 4.3: Ardenwood Station Intersection Levels of Service – Year 2025 Conditions

Intersection		Peak Hour	Year 2025 No Project		Year 2025 Plus Project	
			Delay[1]	LOS[2]	Delay[1]	LOS[2]
9	Paseo Padre Parkway/SR 84 Westbound Ramps	AM PM	30.1 10.0	C A	29.5 10.1	C B
10	Thornton Avenue/SR 84 Eastbound Ramps	AM PM	12.4 **85.1**	B **F**	12.6 **82.1**	B **F**

Notes:
1. Intersection delay presented as whole-intersection average delay for signalized, roundabout, and all-way stop-controlled intersections. Delay presented as "whole-intersection average delay (worst approach or worse movement delay)" for side-street stop-controlled intersections.
2. LOS per delay definitions in the HCM 6th Edition.
Bold indicates LOS F operations. **Bold and highlighted** indicates locations where the project results in a noticeable worsening of deficient intersection operations.
Source: Fehr & Peers, 2023.

4.4.3 Year 2040 LOS Results

Table 4.4 presents the Year 2040 AM and PM peak hour intersection LOS results. The Year 2040 scenario analysis assumes that traffic signals in the study area are retimed to reflect increased traffic volumes. Intersections with operations that do not meet the LOS E standard for acceptable operations are bolded. The following intersections operate deficiently under Year 2040 No Project Conditions with respect to the LOS E standard during the indicated peak hour:

- Intersection 1 – Ardenwood Boulevard/Paseo Padre Parkway: LOS F in the PM peak hour
- Intersection 2 – Ardenwood Boulevard/Kaiser Drive: LOS F in the AM and PM peak hours
- Intersection 3 – Dumbarton Circle/Kaiser Drive: LOS F in the AM and PM peak hours
- Intersection 4 – Ardenwood Boulevard/Ardenwood Terrance: LOS F in the AM and PM peak hours
- Intersection 5 – Ardenwood Boulevard/SR 84 Westbound Ramps: LOS F in the AM and PM peak hours
- Intersection 7 – Newark Boulevard/Jarvis Avenue: LOS F in the AM and PM peak hours
- Intersection 8 – Paseo Padre Parkway/Dumbarton Circle: LOS F in the PM peak hour
- Intersection 10 – Thornton Avenue/SR 84 Eastbound Ramps: LOS F in the PM peak hour

Table 4.4: Ardenwood Station Intersection Levels of Service – Year 2040 Conditions

Intersection		Peak Hour	Year 2040 No Project		Year 2040 Plus Project	
			Delay[1]	LOS[2]	Delay[1]	LOS[2]
1	Ardenwood Boulevard/Paseo Padre Parkway	AM PM	52.5 **>120.0**	D **F**	52.7 **>120.0**	D **F**
2	Ardenwood Boulevard/Kaiser Drive	AM PM	**>120.0** **>120.0**	**F** **F**	**>120.0** **>120.0**	**F** **F**
3	Dumbarton Circle/Kaiser Drive	AM PM	**39.3 (>120.0)** **>120.0 (>120.0)**	**E (F)** **F (F)**	**>120.0 (>120.0)** **>120.0 (>120.0)**	**F (F)** **F (F)**
4	Ardenwood Boulevard/Ardenwood Terrace	AM PM	**>120.0** **>120.0**	**F** **F**	**>120.0** **>120.0**	**F** **F**
5	Ardenwood Boulevard/SR 84 Westbound Ramps	AM PM	**82.3** **101.2**	**F** **F**	**86.0** **97.4**	**F** **F**
6	Newark Boulevard/SR 84 Eastbound Ramps	AM PM	35.7 76.1	D E	43.8 72.4	D E
7	Newark Boulevard/Jarvis Avenue	AM PM	**80.6** **>120.0**	**F** **F**	**>120.0** **>120.0**	**F** **F**
8	Paseo Padre Parkway/Dumbarton Circle	AM PM	0.1 (10.1) **104.4 (>120.0)**	A (B) **F (F)**	**0.6 (>120.0)** **>120.0 (>120.0)**	**F (F)** **F (F)**
9	Paseo Padre Parkway/SR 84 Westbound Ramps	AM PM	42.7 21.1	D C	41.5 22.5	D C
10	Thornton Avenue/SR 84 Eastbound Ramps	AM PM	19.6 **>120.0**	B **F**	19.9 **>120.0**	B **F**

Notes:
1. Intersection delay presented as whole-intersection average delay for signalized, roundabout, and all-way stop-controlled intersections. Delay presented as "whole-intersection average delay (worst approach or worse movement delay)" for side-street stop-controlled intersections.
2. LOS per delay definitions in the HCM 6th Edition.
Bold indicates LOS F operations. **Bold and highlighted** indicates locations where the project results in a noticeable worsening of deficient intersection operations.
Source: Fehr & Peers, 2023.

4.4.4 Recommended Intersection Improvements

As noted in **Table** 4.3 and **Table** 4.4, the project would result in a noticeable worsening of deficient intersection operations (the addition of project trips resulting in an increase of 5.0 or more seconds of delay) at several intersections in the study area. In most cases, study intersections are supersaturated with travel demand under the No Project scenario even after traffic signal timing adjustments. For example, most of the congestion along Ardenwood Boulevard and Newark Boulevard in the study area is due to supersaturation of the ramp terminal intersections at the SR 84/Ardenwood Boulevard-Newark Boulevard interchange. As per CEQA Guidelines Section 15064.3 and Senate Bill 743, impacts to intersection operations are less-than-significant by statute, but improvement measures could aid in facilitating access to and from the station site.

Ardenwood Boulevard-Newark Boulevard Corridor

Signal timing information sheets along the Ardenwood Boulevard and Newark Boulevard corridor indicate limited traffic signal coordination along the corridor (mainly only along Ardenwood Boulevard north of the SR 84 interchange). This is to be expected as multiple agencies (Fremont, Newark, and Caltrans) maintain and operate the signals along the corridor in the study area. The intersections of Ardenwood Boulevard/SR 84 westbound ramps and Newark Boulevard/SR 84 eastbound ramps run on a single signal controller and are not coordinated with any nearby intersections; these nearby intersections are very near the two SR 84 ramp intersections, and thus the lack of coordination results in poor traffic progression in the corridor.

Interconnecting and coordinating signals along the corridor would result in improved traffic progression, and thus lower delays and reduced queuing along Ardenwood Boulevard and Newark Boulevard. The mode of access modeling summarized in **Table 3.7** indicated a large proportion of riders boarding at Ardenwood Station in the morning would arrive in an automobile (either personal automobile or kiss-and-ride) and thus improving vehicular access to the station through more efficient signal operations would enhance access for the majority of users at the station. Improving signal operations would also benefit connecting public and private transit services accessing Ardenwood Station. Therefore, it is recommended that (as part of the South Bay Connect project), Capitol Corridor should work with Fremont, Newark, and Caltrans to identify a funding contribution towards interconnection and coordination of signals along the Ardenwood Boulevard and Newark Boulevard corridor in the vicinity of the Ardenwood Station (in particular for intersections between Kaiser Drive and Jarvis Avenue, inclusive of these intersections).

Unsignalized Study Intersections

The intersections of Dumbarton Circle/Kaiser Drive and Paseo Padre Parkway/Dumbarton Circle are unsignalized intersections where the minor street is controlled by stop signs, while the major street flows without delay. The South Bay Connect project adds trips to the stop-controlled approaches at these intersections, which noticeably increases delay. Therefore, it is recommended that Capitol Corridor (as part of the South Bay Connect project) contribute funding towards the installation of traffic signals at these two intersections. Signalizing these intersections would reduce delay at the intersections by a noticeable amount.

Based on field reconnaissance, the intersection of Paseo Padre Parkway/Dumbarton Circle already includes light poles with mast arm connectors, indicating that there may be plans to signalize this intersection in the future.

4.5 Review of Multimodal Site Access

The proposed Ardenwood Station includes two platforms on either side (east and west) of the Coast Subdivision and a new parking area on the northwest corner of the station area site. The following multimodal transportation connections are proposed to be provided at this time:

- Pedestrian Connections:
  - A grade-separated connection over the Coast Subdivision is proposed to be provided between the existing Ardenwood park-and-ride and the Ardenwood Station center platform.
  - A grade-separated connection over the Coast Subdivision between the new parking area and the proposed center platform. This connection would be compliant with ADA regulations.
  - A pedestrian pathway running from the south end of the station platform with a connection to Overlake Place. A grade-separated connection over the Coast Subdivision would be provided. This connection would be compliant with ADA regulations.
- Bicycle Connections:
  - Class II bike lanes are proposed to be included along Ardentech Court and Ardenwood Terrace connecting the site to local roadways. Class II bike lanes already exist along Ardenwood Boulevard.
  - Bicyclists may use the grade-separated pedestrian connections noted above.
- Transit Connections:
  - The existing Ardenwood park-and-ride transit loop is not proposed to be modified as part of the project.
- Vehicular and Emergency Access:
  - A new driveway will be provided at the Ardentech Court cul-de-sac to connect the new parking area to the public roadway system.
  - No modifications are proposed to access for the Ardenwood park-and-ride lot.

The site plan for the station is subject to change as the project is being developed. While the details of the connections noted above may change, it is recommended that these connections are maintained to promote efficient site access and multimodal circulation.

5. At-Grade Crossing Analysis

The following chapter outlines the purpose, study area, study assumptions and results of the at-grade crossing analysis.

5.1 Purpose of Analysis

The purpose of the at-grade crossing analysis is to identify how shifts in Capitol Corridor service patterns may affect traffic operations near at-grade crossings along the Coast Subdivision. Focused intersection analysis along the Oakland and Niles subdivisions was also conducted to assess how rerouting of freight service between the two subdivisions may affect operations. The at-grade crossing analysis identifies the expected change in general purpose traffic vehicle delays at study intersections near key at-grade crossings; emergency vehicles retain the ability to preempt traffic signals and to bypass congestion (for a more detailed emergency vehicle access analysis, see **Chapter 6**). For isolated at-grade crossings not near intersections, the expected change in vehicle queues at the at-grade crossings were computed to estimate the effects of the project on traffic operations at the crossing. The analysis presented in **Sections 5.5, 5.6, and 5.7** relates to Alternatives B-D, while the analysis presented in **Section 5.8** relates to Alternative E.

5.2 Study Intersections and Software Packages

As previously described, different traffic operations analysis software packages were used to evaluate the study intersections. The choice of intersection analysis software for each intersection below was based on existing operating conditions and roadway network characteristics, as outlined in **Section 2.2.3**. The following study intersections (locations graphically shown on **Figure 2A, 2B, 2C,** and **2D**) were evaluated using the indicated software package:

<u>Coast Subdivision Intersections</u>

1. Doolittle Drive/Williams Street – SimTraffic
2. Doolittle Drive/Marina Boulevard – SimTraffic
3. Catalina Street/Farallon Drive – SimTraffic
4. Anchorage Drive/Lewelling Boulevard – VISSIM
5. Bockman Road/Grant Avenue – SimTraffic
6. Clawiter Road/Depot Road – VISSIM
7. Industrial Boulevard/Baumberg Avenue — SimTraffic
8. Union City Boulevard/Whipple Road – VISSIM
9. Fredi Street/Smith Street – SimTraffic
10. Dyer Street/Smith Street – SimTraffic
11. Dyer Street/Alvarado Boulevard – SimTraffic
12. Galaxy Drive/Alvarado Boulevard – VISSIM
13. Falcon Drive/Alvarado Boulevard – VISSIM
14. Ash Street/Thornton Avenue – SimTraffic

15. Sycamore Street/Thornton Avenue – SimTraffic

Niles and Oakland Subdivisions Representative Intersections

16. Central Avenue/Whipple Road – SimTraffic
17. Railroad Avenue/Whipple Road – SimTraffic
18. 11th Street/Decoto Road – VISSIM
19. 12th Street/Decoto Road – VISSIM
20. Station Way/Decoto Road – VISSIM

The representative intersections chosen for the Niles and Oakland subdivisions were selected based on their location south of the proposed project-sponsored flyover between the Niles and Oakland subdivisions near Industrial Parkway; the Whipple Road and Decoto Road corridors are the two most-heavily traveled corridors in this portion of the Oakland and Niles subdivisions.

The following isolated rail crossings along the Coast Subdivision were evaluated using Synchro. Vehicle queues at the at-grade crossings were extracted at these locations, as shown on **Figure 2E:**

21. Edes Avenue
22. Kerwin Avenue
23. Fairway Drive
24. Winton Avenue
25. Jarvis Avenue
26. Haley Street
27. Mayhews Landing Road
28. Filbert Street

The Centerville portion of the Niles Subdivision is expected to see considerable decreases in peak hour gate down time as a result of removing Capitol Corridor service from the rail line. Therefore, no study intersections have been included on the Centerville portion of the Niles Subdivision; a qualitative analysis has been provided in **Section 5.7**.

W:\Walnut Creek N Drive\PROJECTS_WC19\WC19-3612.01_CCJPA_Oakland_San_Jose_Environmental\Graphics\GIS\MXD\Fig2A_NorthCoast.mxd

Figure 2A

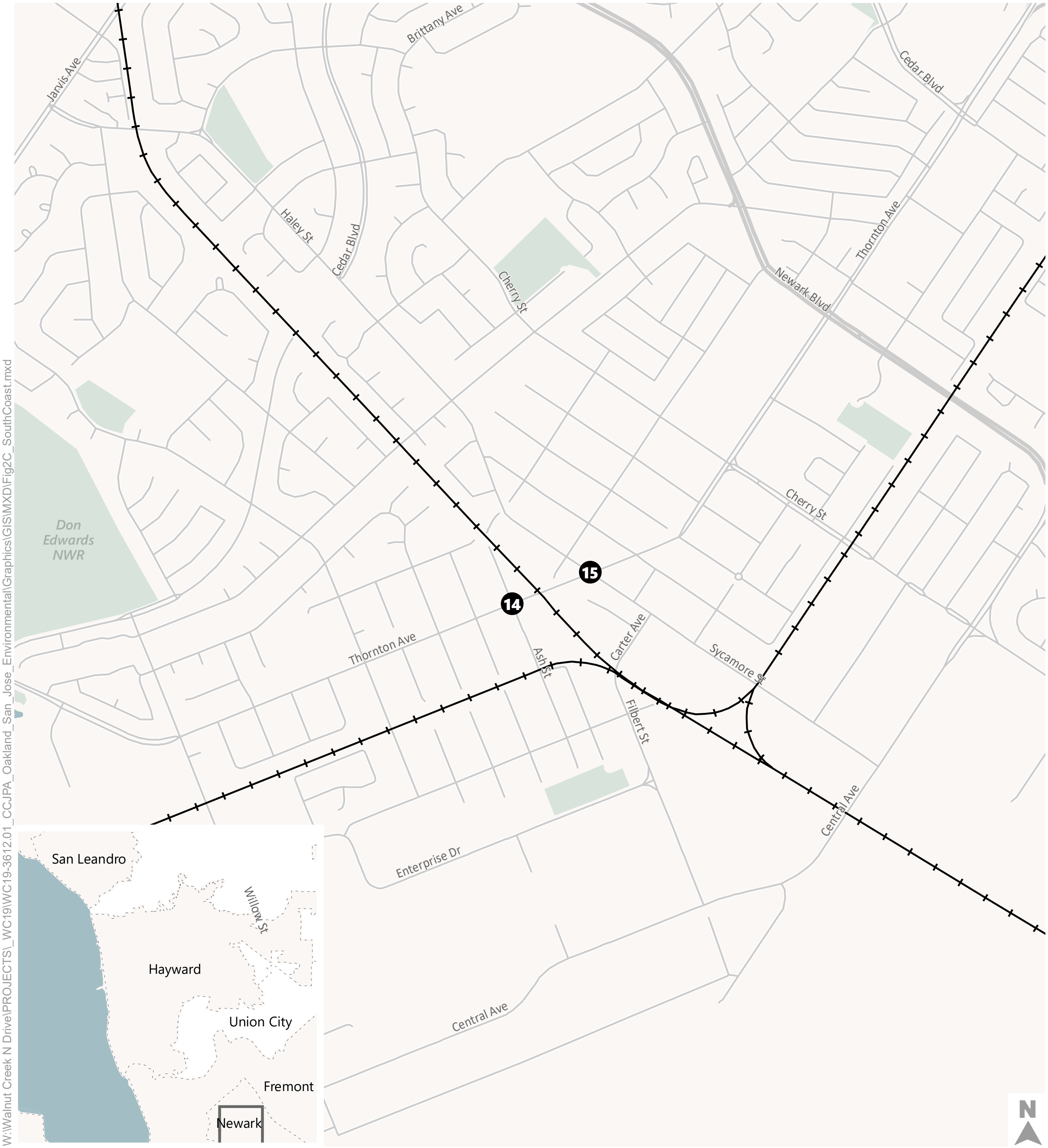
Northern Coast Subdivision Study Intersections

Study Intersections — Railroad — Cities — Parks

W:\Walnut Creek N Drive\PROJECTS_WC19\WC19-3612.01_CCJPA_Oakland_San_Jose_Environmental\Graphics\GIS\MXD\Fig2B_CentralCoast.mxd

Figure 2B

Central Coast Subdivision Study Intersections



W:\Walnut Creek N Drive\PROJECTS_WC19\WC19-3612.01_CCJPA_Oakland_San_Jose_Environmental\Graphics\GIS\MXD\Fig2C_SouthCoast.mxd

X Study Intersections | Railroad | Cities | Parks

Figure 2C

Southern Coast Subdivision Study Intersections

Figure 2D

Oakland & Niles Subdivision Representative Study Intersections

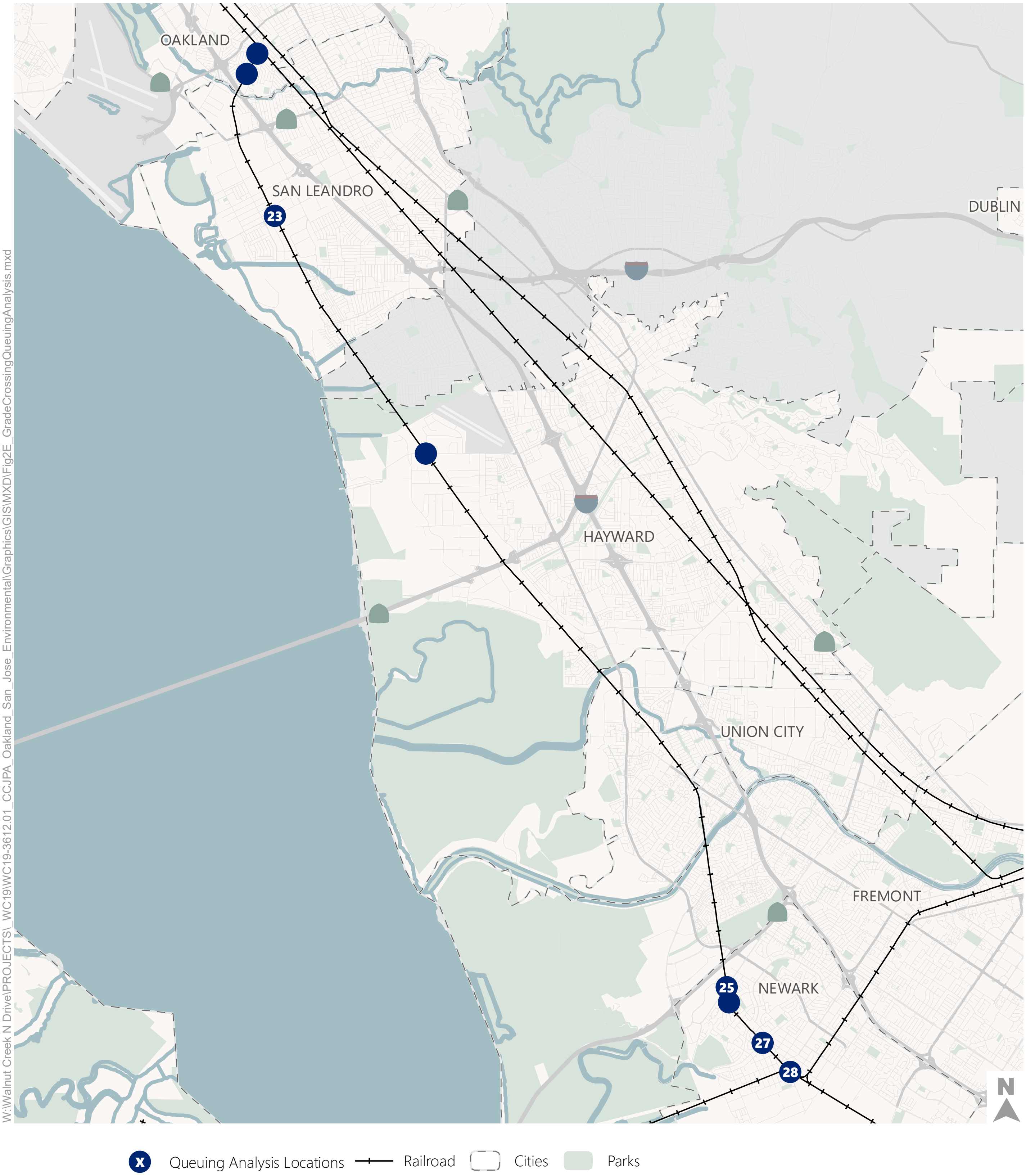


Figure 2E

Grade Crossing Queuing Analysis Locations

5.3 Traffic Volume Assumptions

Existing Conditions traffic volumes reflect Year 2019 conditions based on available traffic counts and retrospective traffic volume data from the StreetLight Data intersection turning movement count database. Year 2025 and Year 2040 scenario traffic forecasts were developed using outputs from the C/CAG-VTA model. The C/CAG-VTA model considers changes in regional land use patterns and planned modifications to the regional transportation system. Future year No Project and Plus Project scenario traffic volume forecasts are identical between scenarios (but differ between the Year 2025 and Year 2040 scenarios) as the shift in passenger rail service from the Niles Subdivision to the Coast Subdivision does not fundamentally alter traffic volumes at the analyzed at-grade crossings. Traffic volume growth associated with new trips generated from new ridership at the Ardenwood Station is presented in analyzed in **Chapter 4**.

5.4 Railroad At-Grade Crossing Analysis Assumptions

The following assumptions were used in the evaluation of operations at intersections and at-grade crossings in the at-grade crossing analysis. These assumptions apply to the Year 2025 and Year 2040 analysis scenarios for Alternatives B-D; assumptions and project-related effects for Alternative E are discussed in **Section 5.8**. The assumptions below represent reasonable worst-case train movement scenarios during the peak hours of automobile travel given the overall level of train movements (discussed further in **Chapter 6**).

- **No Project scenario – Coast Subdivision:** 1 freight train in the AM and PM peak hour (each) with an average gate down time of 240 seconds
- **Plus Project Alternatives B-E scenario – Coast Subdivision:** 2 passenger trains in the AM and PM peak hour (each) with an average gate down time of 60 seconds and 1 freight train in the AM and PM peak hour (each) with an average gate down time of 240 seconds
- **No Project scenario – Niles Subdivision:**[4] 2 passenger trains in the AM and PM peak hour (each) with an average gate down time of 60 seconds
- **Plus Project Alternatives B-D scenario – Niles Subdivision[4]:** 1 freight train in the AM and PM peak hour (each) with an average gate down time of 240 seconds
- **Plus Project Alternative E scenario – Niles Subdivision[4]**: Same as No Project scenario
- **No Project scenario – Oakland Subdivision:** No passenger or freight service
- **Plus Project Alternatives B-D scenario – Oakland Subdivision:** 1 freight train in the AM and PM peak hour (each) with an average gate down time of 240 seconds
- **Plus Project Alternative E scenario – Oakland Subdivision**: Same as No Project Scenario

[4] These assumptions are applicable to the portion of the Niles Subdivision between Elmhurst Junction and Niles Junction only.

The gate down time assumptions were based on published information regarding train lengths and operating speeds. Field observations of train movements taken in late summer 2021 indicate that the assumptions above are generally conservative.

Based on data from the Congressional Budget Office[5], the average freight train length in Year 2040 will be approximately 13,000 feet in length; as a conservative assumption, these assumptions apply to the Year 2025 analysis. For the purposes of this analysis, gate down time refers to the amount of time where it is illegal for motorists to enter a grade crossing (generally, any time that the red lights at the grade crossing are flashing). Gate down time calculations are provided in **Appendix B.**

Under the No Project scenario, Centerville portion of the Niles Subdivision (from Niles Junction to Newark Junction) carries freight service (acting as the connection between the Coast Subdivision and Niles Canyon), Capitol Corridor passenger rail service (acting as the connection between the Niles Subdivision and the Coast Subdivision), and ACE passenger rail service. Under the Plus Project Alternatives B-D scenario, Capitol Corridor service would be removed from the Centerville portion of the Niles Subdivision and freight service may be reduced. The effects of these changes are discussed qualitatively in **Section 5.7.**

5.5 Intersection Level of Service (LOS) Results

This section describes the AM and PM peak hour intersection LOS results for Existing Conditions (Year 2019), the Year 2025 analysis horizon, and the Year 2040 analysis horizon.

5.5.1 Existing Conditions LOS Results

The AM and PM peak hour LOS results for Existing Conditions are presented below in **Table 5.1**. Intersections with operations that do not meet the LOS E standard for acceptable operations are bolded. The following intersections operate deficiently with respect to the LOS E standard during the indicated peak hour:

- Intersection 3 – Catalina Street/Farallon Drive: LOS F in the AM peak hour
- Intersection 14 – Ash Street/Thornton Avenue: LOS F in the PM peak hour

Table 5.1: At-Grade Crossing Intersection Levels of Service – Existing Conditions

Intersection		Intersection Control	Peak Hour	Delay[1]	LOS[2]
Coast Subdivision Study Intersections					
1	Doolittle Drive/Williams Street	Signalized	AM PM	35.9 30.4	D C
2	Doolittle Drive/Marina Boulevard	Signalized	AM PM	64.2 37.9	E D

[5] https://www.cbo.gov/publication/56965

Table 5.1: At-Grade Crossing Intersection Levels of Service – Existing Conditions

Intersection		Intersection Control	Peak Hour	Delay[1]	LOS[2]
3	Catalina Street/Farallon Drive	Side-Street Stop-Controlled	AM PM	**12.7 (71.6)** 7.9 (43.5)	**B (F)** A (E)
4	Anchorage Drive/Lewelling Boulevard	Roundabout	AM PM	9.1 3.4	A A
5	Bockman Road/Grant Avenue	All-Way Stop-Controlled	AM PM	8.3 8.2	A A
6	Clawiter Road/Depot Road	Signalized	AM PM	30.1 72.3	C E
7	Industrial Boulevard/Baumberg Avenue	Signalized	AM PM	41.8 47.7	D D
8	Union City Boulevard/Whipple Road	Signalized	AM PM	21.0 39.7	C D
9	Fredi Street/Smith Street	All-Way Stop-Controlled	AM PM	13.1 20.2	B C
10	Dyer Street/Smith Street	Signalized	AM PM	29.3 43.9	C D
11	Dyer Street/Alvarado Boulevard	Signalized	AM PM	45.8 57.1	D E
12	Galaxy Drive/Alvarado Boulevard	Signalized	AM PM	10.3 10.6	B B
13	Falcon Drive/Alvarado Boulevard	Signalized	AM PM	11.7 15.7	B B
14	Ash Street/Thornton Avenue	Side-Street Stop-Controlled	AM PM	6.5 (34.1) **15.7 (>120)**	A (D) **C (F)**
15	Sycamore Street/Thornton Avenue	Signalized	AM PM	34.0 32.1	C C
Niles and Oakland Subdivisions Study Intersections					
16	Central Avenue/Whipple Road	Signalized	AM PM	29.3 54.1	C D
17	Railroad Avenue/Whipple Road	Signalized	AM PM	39.3 15.1	D B
18	11th Street/Decoto Road	Signalized	AM PM	22.7 22.8	C C
19	12th Street/Decoto Road	Side-Street Stop-Controlled	AM PM	1.3 (13.2) 7.3 (17.0)	A (B) A (C)
20	Station Way/Decoto Road	Signalized	AM PM	5.5 9.6	A A

Notes:

1. Intersection delay presented as whole-intersection average delay for signalized, roundabout, and all-way stop-controlled intersections. Delay presented as "whole-intersection average delay (worst approach or worse movement delay)" for side-street stop-controlled intersections.
2. LOS per delay definitions in the HCM 6th Edition.
Bold indicates LOS F operations.
Source: Fehr & Peers, 2023.

5.5.2 Year 2025 LOS Results – Alternatives B-D

Table 5.2 presents the Year 2025 AM and PM peak hour intersection LOS results. Intersections with operations that do not meet the LOS E standard for acceptable operations are bolded. The following intersections operate deficiently with respect to the LOS E standard during the indicated peak hour under Year 2025 No Project Conditions:

- Intersection 2 – Doolittle Drive/Marina Boulevard: LOS F in the AM and PM peak hours
- Intersection 3 – Catalina Street/Farallon Drive: LOS F in the AM and PM peak hours
- Intersection 6 – Clawiter Road/Depot Road: LOS F in the AM and PM peak hours
- Intersection 7 – Industrial Boulevard/Baumberg Avenue: LOS F in the AM peak hour
- Intersection 8 – Union City Boulevard/Whipple Road: LOS F in the PM peak hour
- Intersection 11 – Dyer Street/Alvarado Boulevard: LOS F in the PM peak hour
- Intersection 14 – Ash Street/Thornton Avenue: LOS F in the AM and PM peak hours

Table 5.2: At-Grade Crossing Intersection Levels of Service – Year 2025 Conditions

Intersection		Peak Hour	Year 2025 No Project		Year 2025 Plus Project	
			Delay[1]	LOS[2]	Delay[1]	LOS[2]
Coast Subdivision Study Intersections						
1	Doolittle Drive/Williams Street	AM PM	44.7 59.2	D E	46.0 48.7	D D
2	Doolittle Drive/Marina Boulevard	AM PM	**82.0** **95.3**	**F** **F**	74.5 **95.9**	E **F**
3	Catalina Street/Farallon Drive	AM PM	**52.9 (>120)** **31.7 (>120)**	**F (F)** **D (F)**	**42.1 (>120)** **34.1 (>120)**	**E (F)** **D (F)**
4	Anchorage Drive/Lewelling Boulevard	AM PM	24.6 12.8	C B	16.5 11.3	C B
5	Bockman Road/Grant Avenue	AM PM	11.6 10.3	B B	12.1 17.7	A C
6	Clawiter Road/Depot Road	AM PM	**89.3** **90.6**	**F** **F**	78.7 **89.9**	E **F**
7	Industrial Boulevard/Baumberg Avenue	AM PM	**108.2** 48.1	**F** D	**109.6** 48.6	**F** D

Table 5.2: At-Grade Crossing Intersection Levels of Service – Year 2025 Conditions

Intersection		Peak Hour	Year 2025 No Project		Year 2025 Plus Project	
			Delay[1]	LOS[2]	Delay[1]	LOS[2]
8	Union City Boulevard/Whipple Road	AM PM	49.7 **87.3**	D **F**	42.0 74.8	D E
9	Fredi Street/Smith Street	AM PM	31.4 33.7	D C	19.6 34.3	C D
10	Dyer Street/Smith Street	AM PM	33.2 58.4	C E	32.7 56.9	C E
11	Dyer Street/Alvarado Boulevard	AM PM	61.4 **85.3**	E **F**	56.4 **82.7**	E **F**
12	Galaxy Drive/Alvarado Boulevard	AM PM	19.9 21.7	B C	14.1 19.2	B B
13	Falcon Drive/Alvarado Boulevard	AM PM	20.3 21.6	C C	17.4 20.4	B C
14	Ash Street/Thornton Avenue	AM PM	**20.3 (111.9)** **36.6 (>120)**	**C (F)** **E (F)**	**24.3 (118.1)** **50.9 (>120)**	**C (F)** **F (F)**
15	Sycamore Street/Thornton Avenue	AM PM	56.4 58.6	E E	62.4 62.9	E E
Niles and Oakland Subdivisions Study Intersections						
16	Central Avenue/Whipple Road	AM PM	45.7 64.1	D E	34.5 **87.4**	C **F**
17	Railroad Avenue/Whipple Road	AM PM	49.5 16.0	D B	64.6 42.4	E D
18	11th Street/Decoto Road	AM PM	26.3 35.3	C D	46.2 38.5	D D
19	12th Street/Decoto Road	AM PM	3.0 (15.7) 19.2 (19.6)	A (C) C (C)	18.7 (17.6) 20.9 (27.0)	C (C) C (D)
20	Station Way/Decoto Road	AM PM	10.2 40.2	B D	25.5 45.7	C D

Notes:
1. Intersection delay presented as whole-intersection average delay for signalized, roundabout, and all-way stop-controlled intersections. Delay presented as "whole-intersection average delay (worst approach or worse movement delay)" for side-street stop-controlled intersections.
2. LOS per delay definitions in the HCM 6th Edition.
Bold indicates LOS F operations. **Bold and highlighted** indicates locations where the project results in a noticeable worsening of deficient intersection operations.
Source: Fehr & Peers, 2023.

As shown in **Table** 5.2, the results of the Year 2025 analysis indicate that the proposed project would result in two new LOS deficiencies: at Ash Street/Thornton Avenue in the PM peak hour and at Central Avenue/Whipple Road in the PM peak hour. The project would not result in new LOS deficiencies at the other study intersections. For other intersections operating at LOS F before implementation of the project, the project would not result in noticeable increases in average delay at the intersections nor would it result in decreases in the average delay after implementation of the project.

5.5.3 Year 2040 LOS Results – Alternatives B-D

Table 5.3 presents the Year 2040 AM and PM peak hour intersection LOS results. Intersections with operations that do not meet the LOS E standard for acceptable operations are bolded. The following intersections operate deficiently with respect to the LOS E standard during the indicated peak hour under Year 2040 No Project Conditions:

- Intersection 1 – Doolittle Drive/Williams Street: LOS F in the AM and PM peak hours
- Intersection 2 – Doolittle Drive/Marina Boulevard: LOS F in the AM and PM peak hours
- Intersection 3 – Catalina Street/Farallon Drive: LOS F in the AM and PM peak hours
- Intersection 5 – Bockman Road/Grant Avenue: LOS F in the PM peak hour
- Intersection 6 – Clawiter Road/Depot Road: LOS F in the AM and PM peak hours
- Intersection 7 – Industrial Boulevard/Baumberg Avenue: LOS F in the AM and PM peak hours
- Intersection 8 – Union City Boulevard/Whipple Road: LOS F in the PM peak hour
- Intersection 9 – Fredi Street/Smith Street: LOS F in the PM peak hour
- Intersection 11 – Dyer Street/Alvarado Boulevard: LOS F in the PM peak hour
- Intersection 14 – Ash Street/Thornton Avenue: LOS F in the AM and PM peak hours
- Intersection 15 – Sycamore Street/Thornton Avenue: LOS F in the AM peak hour
- Intersection 18 – 11th Street/Decoto Road: LOS F in the AM peak hour
- Intersection 19 – 12th Street/Decoto Road: LOS F in the AM and PM peak hours
- Intersection 20 – Station Way/Decoto Road: LOS F in the AM peak hour

Table 5.3: At-Grade Crossing Intersection Levels of Service – Year 2040 Conditions

Intersection		Peak Hour	Year 2040 No Project		Year 2040 Plus Project	
			Delay[1]	LOS[2]	Delay[1]	LOS[2]
Coast Subdivision Study Intersections						
1	Doolittle Drive/Williams Street	AM PM	**101.9** **116.4**	**F** **F**	**106.7** **107.5**	
2	Doolittle Drive/Marina Boulevard	AM PM	**>120** **103.9**	**F** **F**	 **108.7**	 **F**
3	Catalina Street/Farallon Drive	AM PM	**43.6 (>120)** **40.9 (>120)**	**E (F)** **E (F)**	**70.3 (>120)** **48.7 (>120)**	**F (F)** **E (F)**
4	Anchorage Drive/Lewelling Boulevard	AM PM	37.2 4.2	E A	24.7 12.8	C B
5	Bockman Road/Grant Avenue	AM PM	39.9 **57.2**	E **F**	37.5 **52.9**	E **F**
6	Clawiter Road/Depot Road	AM PM	**>120** **82.7**	**F** **F**	**>120** **97.1**	**F** **F**

Table 5.3: At-Grade Crossing Intersection Levels of Service – Year 2040 Conditions

Intersection		Peak Hour	Year 2040 No Project		Year 2040 Plus Project	
			Delay[1]	LOS[2]	Delay[1]	LOS[2]
7	Industrial Boulevard/Baumberg Avenue	AM PM	**>120** **89.0**	**F** **F**	**117.8** **88.5**	
8	Union City Boulevard/Whipple Road	AM PM	57.6 **>120**	E **F**	51.4	D
9	Fredi Street/Smith Street	AM PM	32.9 **85.8**	D **F**	31.2 **>120**	
10	Dyer Street/Smith Street	AM PM	45.6 77.0	D E	46.3 76.77	D E
11	Dyer Street/Alvarado Boulevard	AM PM	71.8 **94.9**	E **F**	74.2 **101.8**	
12	Galaxy Drive/Alvarado Boulevard	AM PM	23.6 18.2	C B	17.8 24.1	B C
13	Falcon Drive/Alvarado Boulevard	AM PM	20.8 20.8	C C	18.8 23.44	B C
14	Ash Street/Thornton Avenue	AM PM	**40.2 (>120)** **41.7 (>120)**	**E (F)** **E (F)**	**45.1 (>120)** **46.5 (>120)**	**E (F)** **E (F)**
15	Sycamore Street/Thornton Avenue	AM PM	**86.6** 70.5	**F** E	**90.0** 72.9	**F** E
Niles and Oakland Subdivisions Study Intersections						
16	Central Avenue/Whipple Road	AM PM	77.6 71.2	E E	57.8 77.5	E E
17	Railroad Avenue/Whipple Road	AM PM	63.0 20.1	E C	**84.8** 53.1	**F** D
18	11th Street/Decoto Road	AM PM	**90.8** 42.0	**F** D	**>120** 44.3	**F** D
19	12th Street/Decoto Road	AM PM	**44.5 (85.2)** **24.4 (82.6)**	**E (F)** **C (F)**	**46.9 (92.4)** **23.8 (62.5)**	**E (F)** **C (F)**
20	Station Way/Decoto Road	AM PM	**96.6** 47.6	**F** D	**103.5** 51.0	**F** D

Notes:
1. Intersection delay presented as whole-intersection average delay for signalized, roundabout, and all-way stop-controlled intersections. Delay presented as "whole-intersection average delay (worst approach or worse movement delay)" for side-street stop-controlled intersections.
2. LOS per delay definitions in the HCM 6th Edition.
Bold indicates LOS F operations. **Bold and highlighted** indicates locations where the project results in a noticeable worsening of deficient intersection operations.
Source: Fehr & Peers, 2023.

As shown in **Table** 5.3, the results of the Year 2040 analysis indicate that the proposed project would result in new LOS deficiencies or noticeable worsening of LOS F conditions at the following intersections:

- Intersection 2 – Doolittle Drive/Marina Boulevard: AM and PM peak hours
- Intersection 3 – Catalina Street/Farallon Drive: AM and PM peak hours
- Intersection 6 – Clawiter Road/Depot Road: AM and PM peak hours
- Intersection 8 – Union City Boulevard/Whipple Road: PM peak hour
- Intersection 9 – Fredi Street/Smith Street: PM peak hour
- Intersection 11 – Dyer Street Alvarado Boulevard: PM peak hour
- Intersection 14 – Ash Street/Thornton Avenue: AM and PM peak hours
- Intersection 17 – Railroad Avenue/Whipple Road: AMA peak hour
- Intersection 18 – 11th Street/Decoto Road: AM peak hour
- Intersection 19 – 12th Street/Decoto Road: AM peak hour
- Intersection 20 – Station Way/Decoto Road: AM peak hour

The project would not result in new LOS deficiencies at the other study intersections. For other intersections operating at LOS F before implementation of the project, the project would not result in noticeable increases in average delay at the intersections or would result in decreases in the average delay after implementation of the project.

5.6 Isolated At-Grade Crossing Queues

This section describes the expected queues at isolated at-grade rail crossings. The 95th percentile queues were estimated using Synchro software and the HCM 6th Edition methodologies.

5.6.1 Existing Conditions Isolated At-Grade Crossing Queues

Table 5.4 presents the 95th percentile queue lengths for the Existing Conditions. Generally, queues at these locations are short and are anticipated to dissipate quickly after train crossing events.

Table 5.4: Isolated At-Grade Crossing 95th Percentile Queues – Existing Conditions

Isolated Crossing Location		Peak Hour	95th Percentile Queue by Approach (Feet)	
			Northbound/ Eastbound	Southbound/ Westbound
21	Edes Avenue	AM PM	450 270	220 370
22	Kerwin Avenue	AM PM	120 60	120 100
23	Fairway Drive	AM PM	550 620	430 720
24	Winton Avenue	AM PM	170 810	1,250 180
25	Jarvis Avenue	AM PM	100 370	470 170
26	Haley Street	AM PM	230 580	270 160
27	Mayhews Landing Road	AM PM	550 170	150 250
28	Filbert Street	AM PM	160 210	200 160

Source: Fehr & Peers, 2023.

5.6.2 Year 2025 Isolated At-Grade Crossing Queues – Alternatives B-D

Table 5.5 presents the 95th percentile queue lengths at the isolated at-grade crossings in Year 2025 under No Project and Plus Project conditions. With the project, the number of rail crossings in the AM and PM peak hours is expected to increase; however, the average duration of an at-grade crossing event in the AM and PM peak hours along the Coast Subdivision is expected to decrease with the implementation accounting for the shorter length of passenger trains (compared to longer freight trains).

Table 5.5: Isolated At-Grade Crossing 95th Percentile Queues – Year 2025 Conditions

Isolated Crossing Location		Peak Hour	95th Percentile Queue by Approach (Feet)			
			Year 2025 No Project		Year 2025 Plus Project	
			Northbound/ Eastbound	Southbound/ Westbound	Northbound/ Eastbound	Southbound/ Westbound
21	Edes Avenue	AM PM	1,820 1,330	1,180 1,640	980 720	640 890
22	Kerwin Avenue	AM PM	670 290	630 540	360 150	340 290
23	Fairway Drive	AM PM	2,220 2,300	1,850 2,590	1,200 1,240	1,000 1,390
24	Winton Avenue	AM PM	990 3,120	4,500 1,040	520 1,650	2,370 550
25	Jarvis Avenue	AM PM	570 1,630	1,940 950	300 860	1,020 500
26	Haley Street	AM PM	1,250 2,300	1,370 910	680 1,240	740 490
27	Mayhews Landing Road	AM PM	2,180 950	870 1,330	1,180 510	470 720
28	Filbert Street	AM PM	910 1,180	1,100 910	490 640	590 490

Source: Fehr & Peers, 2023.

As detailed in **Table 5.5,** vehicle queues at the isolated at-grade crossings along the Coast Subdivision are expected to decrease after implementation of the proposed project.

5.6.3 Year 2040 Isolated At-Grade Crossing Queues – Alternatives B-D

Table 5.6 presents the 95th percentile queue lengths at the isolated at-grade crossings in Year 2040 under No Project and Plus Project conditions. With the project, the number of rail crossings in the AM and PM peak hours is expected to increase; however, the average duration of an at-grade crossing event in the AM and PM peak hours along the Coast Subdivision is expected to decrease with the implementation accounting for the shorter length of passenger trains (compared to longer freight trains).

Table 5.6: Isolated At-Grade Crossing 95th Percentile Queues – Year 2040 Conditions

Isolated Crossing Location		Peak Hour	95th Percentile Queue by Approach (Feet)			
			Year 2040 No Project		Year 2040 Plus Project	
			Northbound/ Eastbound	Southbound/ Westbound	Northbound/ Eastbound	Southbound/ Westbound
21	Edes Avenue	AM PM	2,000 16,40	1,250 1,990	1,080 890	680 1,070
22	Kerwin Avenue	AM PM	870 330	830 710	470 170	450 380
23	Fairway Drive	AM PM	2,260 3,090	1,890 3,480	1,220 1,660	1,020 1,870
24	Winton Avenue	AM PM	1,010 3,150	4,560 1,040	530 1,670	2,400 550
25	Jarvis Avenue	AM PM	610 2,210	2,070 1,280	320 1,170	1,090 670
26	Haley Street	AM PM	1,590 2,940	1,740 1,140	860 1,590	940 620
27	Mayhews Landing Road	AM PM	2,840 1,180	1,100 1,630	1,530 640	590 880
28	Filbert Street	AM PM	1,140 1,440	1,440 1,140	620 780	780 620

Source: Fehr & Peers, 2023.

As detailed in **Table 5.6**, vehicle queues at the isolated at-grade crossings along the Coast Subdivision are expected to decrease after implementation of the proposed project.

5.7 Project Alternatives B-D Effects on Intersections and At-Grade Crossings Along the Centerville Portion of Niles Subdivision

As noted previously, the net effect of the project along the Centerville portion of the Niles Subdivision will be the removal Capitol Corridor passenger trains (and potentially freight trains). While not all trains will be removed from the Centerville corridor (e.g., ACE passenger trains or freight trains traveling between Niles Canyon and San Jose), over one dozen trains are anticipated to be removed from the corridor. By doing so, the number of peak hour at-grade crossing events is expected to sharply decrease at the following at-grade crossings:

- Sycamore Street
- Cherry Street
- Cedar Boulevard
- Blacow Road

- Dusterberry Way
- Maple Street
- Fremont Boulevard
- Shinn Street

Decreasing the number of peak hour at-grade crossing events at these locations will also reduce delay at adjacent intersections, particularly at intersections along Blacow Road, Maple Street, and Fremont Boulevard where there are intersections immediately adjacent to the at-grade crossings. This benefit would extend to improved emergency vehicle access, which is discussed further in **Chapter 6**.

5.8 Project Alternative E Effects

Project Alternative E implements the shift in Capitol Corridor services to the Coast Subdivision without a corresponding shift in freight movement to the Niles and Oakland subdivisions. Therefore, the effects of Alternative E on intersections and at-grade crossings in the study area are a subset of the analysis presented for Alternatives B-D. Project Alternative E results in the following modifications to passenger and freight services along the study subdivisions for the peak hours of automobile travel at the crossings.

- **Plus Project Alternative E scenario – Coast Subdivision:** 2 passenger trains in the AM and PM peak hour (each) with an average gate down time of 60 seconds and 1 freight train in the AM and PM peak hour (each) with an average gate down time of 240 seconds (same as Alternatives B-D)
- **Plus Project Alternative E scenario – Niles Subdivision:** Removal of Capitol Corridor service from Niles Subdivision (i.e. substantially fewer peak hour trains than No Project scenario)
- **Plus Project Alternative E scenario – Oakland Subdivision:** No passenger or freight service (same as No Project)
- **Plus Project Alternative E scenario – Centerville Portion of Niles Subdivision:** Similar to Project Alternatives B-D scenario, including removal of Capitol Corridor trains. Potential retention of one No Project scenario freight train remaining (versus the Project Alternatives B-D scenario).

Based on the above information, the following effects on intersections and at-grade crossings for Project Alternative E have been qualitatively established:

- Coast Subdivision: Alternative E will result in operations similar to Alternatives B-D
- Niles Subdivision: Alternative E will result in operations similar to, or better than, the No Project scenario.
- Oakland Subdivision: Alternative E will result in operations similar to the No Project scenario
- Centerville Portion of Niles Subdivision: Alternative E will result in operations between the No Project and Project Alternatives B-D scenarios. Two passenger rail grade crossing events will be removed during the peak hour (associated with the shift in Capitol Corridor services), which should generally improve vehicular operations versus the No Project scenario.

5.9 Management of Construction Impacts

Construction impacts on the transportation system range from temporary and longer-term closures of transportation facilities, including sidewalks, bike lanes, and roadway travel lanes. These closures have the ability to noticeably affect all modes of travel including walking, bicycling, automobile, public transit, freight, and emergency vehicle access. Disruption to these modes must be accounted for in the construction plans for the project. The planning of managing construction impacts should include, at a minimum, the following elements:

- Identifying full closures, short-term closures, and detour routes for all modes of travel, including the pedestrian, bicycle, vehicular, public transit, freight, and emergency vehicle modes
- Identifying locations of short-term and long-term capacity reductions on the transportation system and coordinating with local agencies to minimize congestion effects
- Installing temporary traffic control measures to promote safety in construction zones
- Installing signage to alert drivers to upcoming closures and lane reductions
- Coordinating with public transit agencies to notify riders about stop closures or diversions
- Identifying construction vehicle routings that minimize effects on the transportation system
- Identifying construction worker shift schedules that minimize effects on the transportation system

6. Emergency Vehicle Access Analysis

This chapter summarizes the emergency vehicle access analysis completed for the project. The following information is a summary of the background data, analysis, and results of emergency vehicle access analysis calculations. The analysis of Project Alternatives B-D is discussed in **Sections 6.1 through 6.4**, and the analysis of Alternative E is discussed in **Section 6.5**.

6.1 Study Area

The study area for the analysis considers areas served by grade crossings on the Coast, Niles, and Oakland subdivisions where the project would result in changes in train volumes. Generally, the analysis considers grade crossing along the following rail lines between the indicated limits:

- Coast Subdivision: Elmhurst Junction to Newark Junction
- Niles Subdivision: Elmhurst Junction to Newark Junction
- Oakland Subdivision: From a point east of Elmhurst Junction (i.e., next to the intersection of Stone Street/San Leandro Boulevard) to Niles Junction

The Centerville portion of the Niles Subdivision is included in the quantitative analysis even though it is expected to see a substantial reduction in the number of grade crossing events as a result of the project. The Fire, Police and Hospital (with Emergency Room facilities) considered in the analysis are shown in **Figure 3**. The analysis considers all land uses within the study area and their access to the fire, police and hospital facilities.

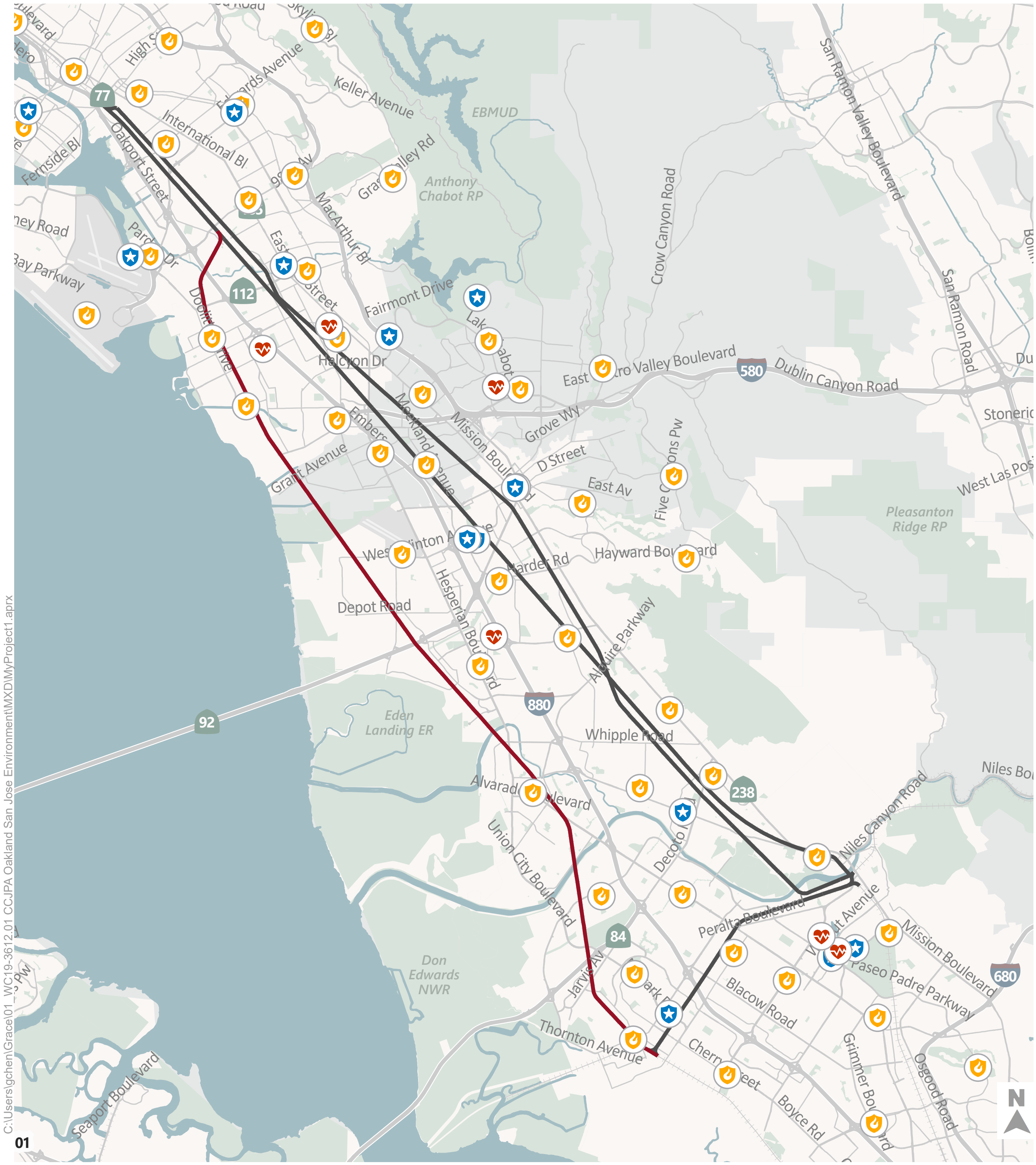


Figure 3

Emergency Vehicle Access Study Area

6.2 Train Movement Data

Data on existing conditions train movements were developed using data from published passenger train schedules and freight train data provided by Union Pacific in an effort to establish the average level of passenger and freight train activity along the Coast, Niles, and Oakland subdivisions. A summary of train movement data for the No Project and Plus Project Scenarios B-D are provided below in **Table 6.1.** The analysis for Alternative E is discussed in **Section 6.5**. These train movements form the basis of the train movement assumptions used in the emergency vehicle access analysis.

Table 6.1: At-Grade Crossing Train Movement Assumptions for Typical Day

Segment	Number of Trains Per Day					
	No Project Scenario		Worst Case Plus Project Alternatives B D Scenario[1]		Worst Case Plus Project Alternative E Scenario[1]	
	Freight	Passenger	Freight	Passenger	Freight	Passenger
Coast Subdivision (Elmhurst Junction to Newark Junction)	2.3	2	2.3	16	2.3	16
Niles Subdivision & Oakland Subdivision (Elmhurst Junction to Industrial Parkway)[2]	2.7	14	5.0	0	2.7	0
Niles Subdivision (Industrial Parkway to Niles Junction)[2]	2.7	14	5.0	0	2.7	0
Oakland Subdivision (Industrial Parkway to Niles Junction/Fremont)[2]	0.3	0	5.3	0	0.3	0
Niles Subdivision (Centerville Line: Niles Junction to BART overcrossing)	6.3	22	9.3	8	6.3	8
Niles Subdivision (Centerville Line: BART overcrossing to Newark Unction)	6.3	22	8.6	8	6.3	8

Notes:
1. Worst-Case Build Scenario assumption based on highest level of freight train activity expected on each segment over all project alternatives.
2. Analysis assumes that a train event on either the Oakland or Niles subdivisions functionally results in a closure of the crossing on the other subdivision due to the close proximity between the two rail lines between Elmhurst Junction and Niles Junction.
Source: Fehr & Peers, 2023.

6.3 Study Scenario Assumptions

The following subsections outline the No Project Scenario and Plus Project Scenario analysis assumptions.

6.3.1 No Project Scenario Assumptions

The No Project Scenario uses the background train movement data (discussed in **Section 6.2**) as a basis for the number of trains on each subdivision. Because of the close proximity of the Oakland and Niles subdivisions, it was assumed that the grade crossings along the Oakland Subdivision would be considered closed to traffic whenever the Niles Subdivision grade crossings were closed (i.e., a closure of a crossing on either the Oakland or Niles subdivisions effectively closes off access for the grade crossing of the other subdivision) and vice versa. Similar to the at-grade intersection operations analysis gate down time assumptions, it was assumed that a freight train grade crossing event would close a crossing for 240 seconds and a passenger train grade crossing event would close a crossing for 60 seconds; based on data from the Congressional Budget Office and Union Pacific, these assumptions are conservative and the gate down times per event are likely to be less than the values assumed. The combination of the number of trains and gate down time/grade crossing closures results in the following assumptions (presented in **Table 6.2**) for percentages of the typical day that the grade crossings are open/closed on each subdivision (i.e., the percentages of the day that an emergency vehicle must divert to another route that does not rely on an at-grade crossing).

Table 6.2: At-Grade Crossing Open/Closed Assumptions by Percentage of Typical Day

Subdivision	Percentage of the Day that Crossings Are Open/Closed					
	No Project Scenario		Plus Project Alternatives B D Scenario		Plus Project Alternative E Scenario	
	Closed	Open	Closed	Open	Closed	Open
Coast Subdivision (Elmhurst Junction to Newark Junction)	0.78%	99.22%	1.75%	98.25%	1.75%	98.25%
Niles Subdivision & Oakland Subdivision (Elmhurst Junction to Industrial Parkway)[1]	1.72%	98.28%	1.39%	98.61%	<1.72%	>98.28%
Niles Subdivision (Industrial Parkway to Niles Junction)[1] Oakland Subdivision (Industrial Parkway to Niles Junction/Fremont)[1]	1.81%	98.19%	2.86%	97.14%	<1.81%	>98.19%
Niles Subdivision (Centerville Line: Niles Junction to BART overcrossing)	3.28%	96.72%	3.14%	96.86%	3.14%-3.28%	96.72%-96.86%
Niles Subdivision (Centerville Line: BART overcrossing to Newark Junction)	3.28%	96.72%	2.94%	97.06%	2.94%-3.28%	96.72%-97.06%

Notes:
1. Analysis assumes that a train event on either the Oakland or Niles subdivisions functionally results in a closure of the crossing on the other subdivision due to the close proximity between the two rail lines between Elmhurst Junction and Niles Junction.
Source: Fehr & Peers, 2022.

When a grade crossing is closed due to presence of a train, emergency vehicles must divert to another route that relies on a grade separated crossing. As noted in **Table 6.2**, the grade crossings in the study area are open for the vast majority of the day in the No Project Scenario. Maps of emergency vehicle access times for the No Project Scenario are included in **Appendix C1**.

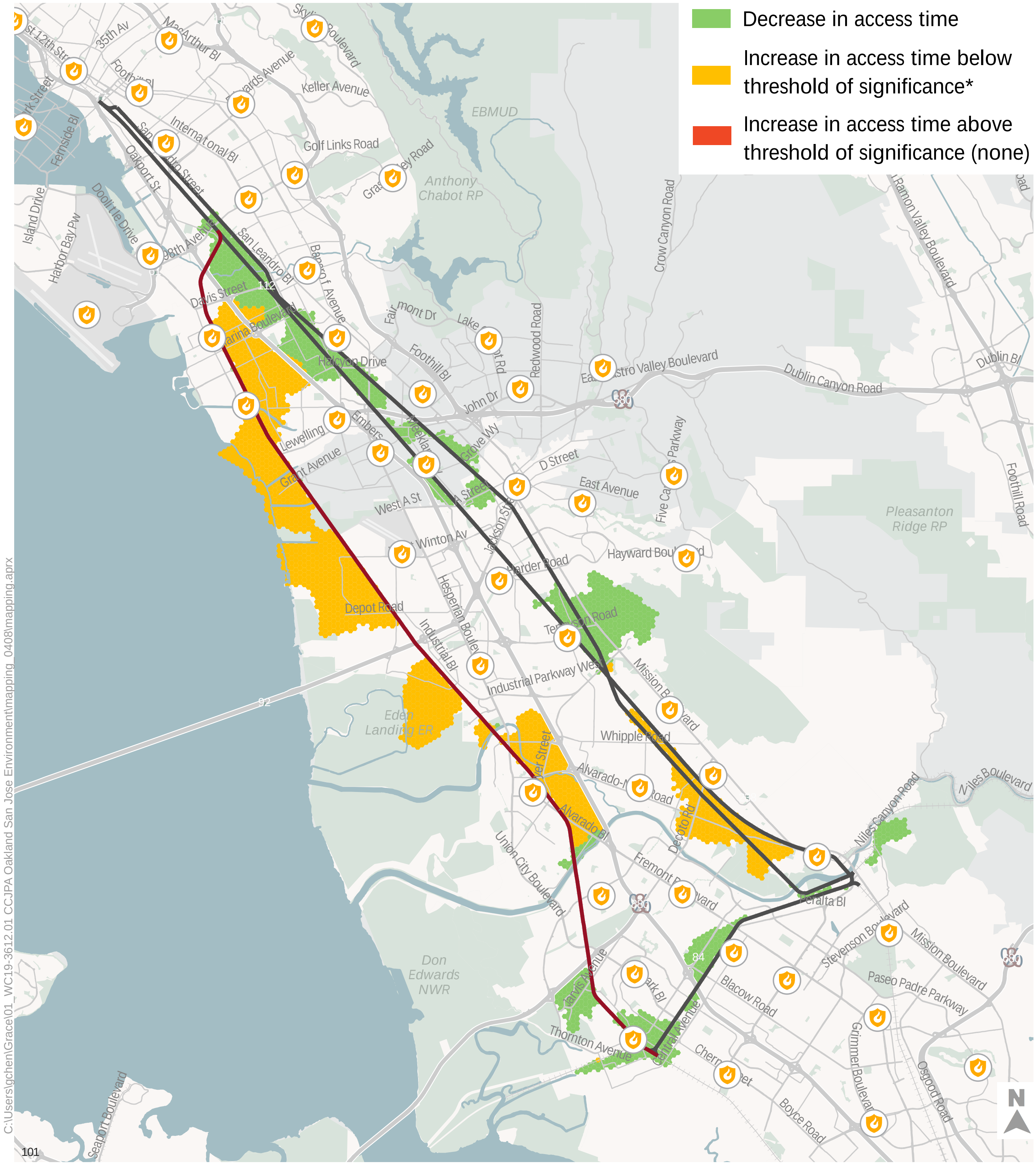
6.3.2 Plus Project Scenario Assumptions

As noted previously, the project will result in potential shifts in freight services and shifts in scheduled passenger rail services between the Coast Subdivision and the Niles and Oakland subdivisions. The assumed Plus Project Alternatives B-E scenario number of trains per day were previously presented in **Table 6.1**. The Plus Project Scenario analysis assumes that gate down times also remain the same as in the No Project Scenario (including the 13,000 feet train length assumption). The resulting percentages of the typical day that the grade crossings are open/closed on each subdivision (i.e., the percentages of the day that an emergency vehicle must divert to another route that does not rely on an at-grade crossing) were previously presented in **Table 6.2.** Maps of emergency vehicle access times for the Plus Project Scenario are included in **Appendix C2**.

6.4 Alternatives B-D Access Analysis and Conclusions

The Alameda County Fire Department (which also serves as the Fire Department for Union City, Newark, San Leandro, and unincorporated Alameda County) maintains a five-minute response time standard for fire and medical emergencies. It is assumed that other fire agencies in the study area maintain similar response time standards; response time standards for other fire agencies were not readily available on these other agency websites. While no established state or federal standards for response times have been established for the purposes of identifying CEQA thresholds of significance, the *California High-Speed Rail Authority San Jose to Merced Project Section Draft EIR/EIS* indicated that a conservative CEQA threshold of significance for change in emergency vehicle access times would be 30 seconds (i.e., 10% of 300 seconds or five minutes).

Delta plots showing the change in emergency vehicle access times for fire, police and hospitals (with emergency services) are provided as **Figure 4A, 4B** and **4C**. The plots indicate locations where emergency response times (at the daily average level) are projected to decrease, increase by a less-than-significant amount (less than 30 seconds), or increase by a significant amount (30 seconds or more). The plots indicate that areas along the Oakland and Niles subdivisions are expected to see a less-than-significant increase in emergency vehicle access times for fire, police and hospitals (with emergency services) largely because the proposed project results in a swapping of freight and passenger rail services rather than a concentration of all services on one corridor; the increases in emergency vehicle access times in these areas along the Oakland and Niles subdivisions would be less than five seconds throughout the course of the day. Areas along the Coast Subdivision are expected to see a slight increase in access times. The gate down times assumed in the analysis are conservative (as discussed in **Section 6.3.1**); the anticipated increase in EV access times along the Oakland and Niles subdivisions is expected to be less than predicted by this analysis. Access times along the Centerville portion of the Niles Subdivision would likely decrease after completion of the project.



Fire Station

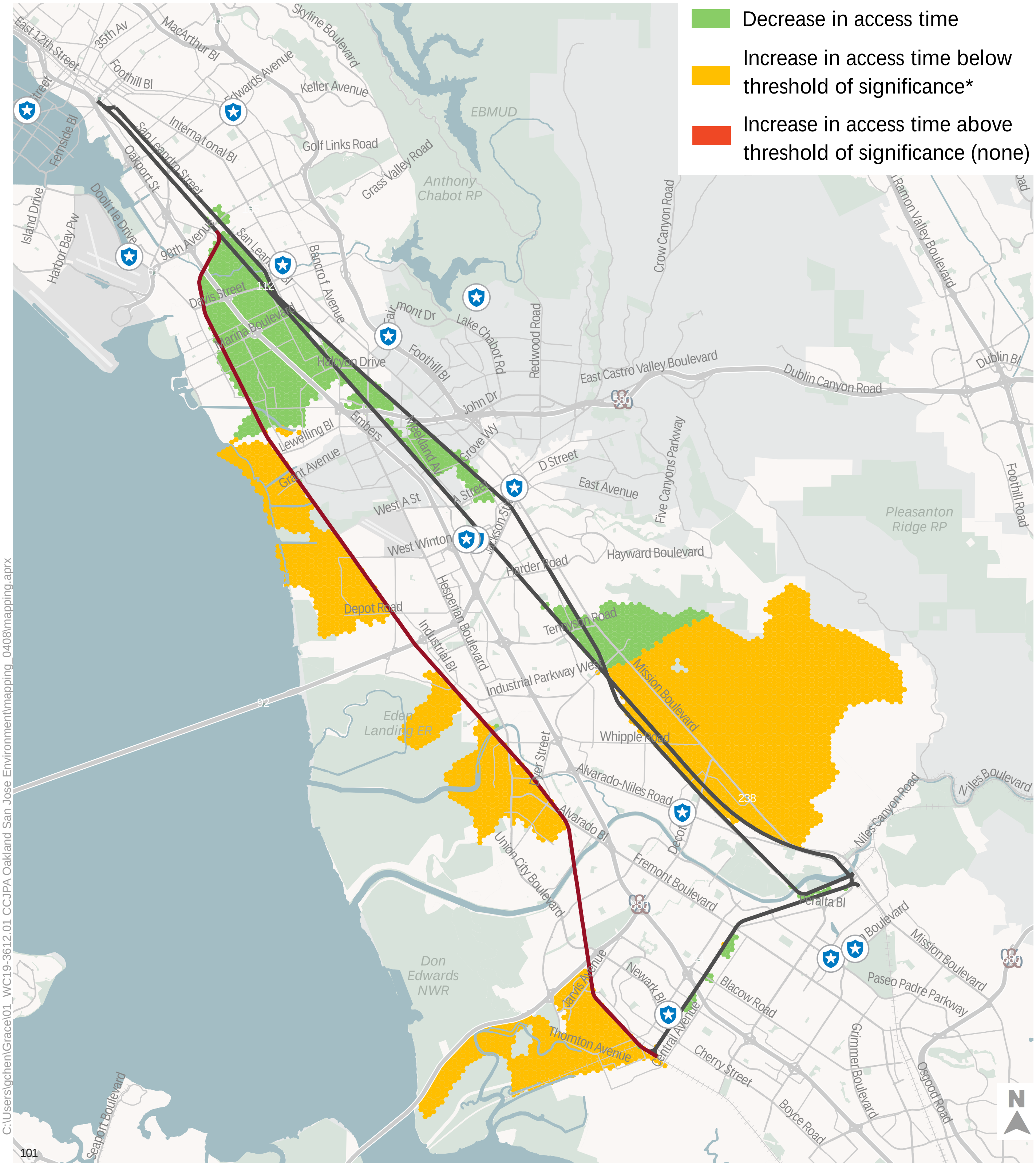
Coast Subdivision

Niles & Oakland Subdivisions

*The threshold for a substantial delay in response time is defined as 30 seconds, or 10 percent of 5 minutes, a conservative standard for emergency response times.

Figure 4A

Change in Fire Station Response Times



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Police Station

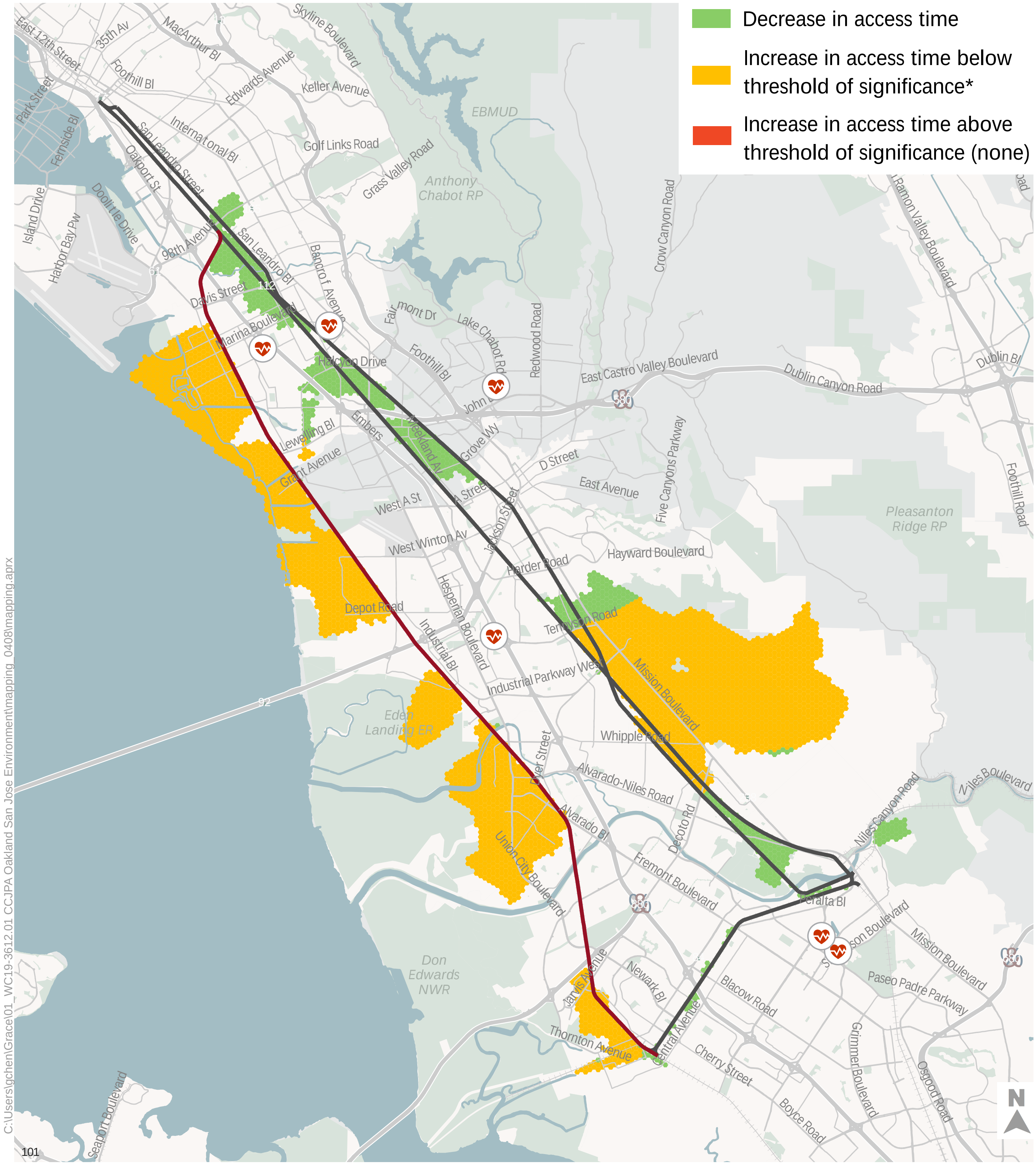
Coast Subdivision

Niles & Oakland Subdivisions

*The threshold for a substantial delay in response time is defined as 30 seconds, or 10 percent of 5 minutes, a conservative standard for emergency response times.

Figure 4B

Change in Police Response Times



Hospital

Coast Subdivision

Niles & Oakland Subdivisions

*The threshold for a substantial delay in response time is defined as 30 seconds, or 10 percent of 5 minutes, a conservative standard for emergency response times.

Figure 4C

Change in Travel Times to Hospitals with Emergency Rooms

6.5 Alternative E Access Analysis and Conclusions

As noted in **Chapter 1**, Alternative E would result in the shifting of Capitol Corridor service from the Niles Subdivision to the Coast Subdivision but would not result in a shift in freight service from the Coast Subdivision to the Oakland and Niles subdivisions. Based on the train movement data in **Table 6.1**, the crossing open/closure data in **Table 6.2** and the results described in **Section 6.4**, the following conclusions can be drawn for Alternative E:

- **Niles and Oakland Subdivisions**: Shifting of Capitol Corridor service to the Coast Subdivision without a shift in freight trains to the Niles and Oakland Subdivisions will result in a decrease in aggregate crossing closure times. Thus, emergency response times are expected to be minimally affected (or improve) as a result of Alternative E.
- **Centerville portion of Niles Subdivision**: Shifting of Capitol Corridor service to the Coast Subdivision and retention of No Project-level freight trains will result in emergency access times that are in between the No Project and Alternatives B-D scenarios. Therefore, a decrease in access times is projected under Alternative E.
- **Coast Subdivision:** As noted in **Table 6.1**, the Alternative B-D analysis assumed that freight service on the Coast Subdivision stays similar to No Project levels (to be conservative). Alternative E would result in passenger and freight services similar to the levels presented in **Table 6.1**. Therefore, the effect on access times under Alternative E would be similar to the effect analyzed for Alternatives B-D (i.e. only a slight increase in access times).

Appendix A1:
Capitol Corridor South Bay Connect Environmental Phase – Final Ridership Forecasts Technical Memorandum

FEHR PEERS

FEHR & PEERS

Final Memorandum

Date: May 6, 2021

To: Michael Brown and Ben Tripousis, HNTB

From: Jennifer Ziebarth, PhD and Ian Barnes, PE, Fehr & Peers

Subject: Capitol Corridor South Bay Connect Environmental Phase – Final Ridership Forecasts

WC19-3612.01

This memo presents Fehr & Peers' ridership forecasting work undertaken for the modeling of station-level and systemwide Capitol Corridor ridership as part of the South Bay Connect project. This memo contains the following sections:

- Executive Summary
- Study Forecasting Tools and Process
- C/CAG-VTA Model
- Direct Ridership Model
- Ridership Forecasts
- Mode of Access and Egress
- Vehicle-Miles Traveled Estimates
- Attachment A: Model Development Memo
- Attachment B: Forecasting Methodology Details
- Attachment C: Detailed Forecasts

Executive Summary

The Capitol Corridor South Bay Connect project proposes to shift Capitol Corridor passenger rail service from the Niles Subdivision (between Elmhurst and Newark Junction) to the Coast Subdivision. With the shift in the Capitol Corridor route, the existing Hayward and Fremont-Centerville stations on the Niles Subdivision would no longer be served, and these stations would be replaced by a new station on the Coast Subdivision at the Ardenwood Boulevard park-and-ride in western Fremont.

The proposed project is consistent with the *2018 California State Rail Plan* and would allow for Capitol Corridor to serve new job centers and Transbay markets in lieu of focusing existing markets that are duplicated by existing and future BART service (including markets to be served by the Silicon Valley BART Extension project). For example, April 2019 ridership data indicates that over 60 percent of trips with a start or end at Hayward Station come from/go to the Great America, Santa Clara or San Jose Diridon stations. These trips are expected to be served by BART in the future. The remaining 40 percent of trips could use BART or other local transit options to access Capitol Corridor service at the Coliseum, Richmond or (proposed) Ardenwood stations.

Ridership Forecasts

Ridership forecasts were produced for opening year and horizon year scenarios, with and without the South Bay Connect project. In general, the South Bay Connect project scenarios result in a modest increase in system-level ridership compared to the corresponding no-project scenarios. For stations in the immediate project area (Hayward, Fremont-Centerville, and the proposed Ardenwood station), the difference between no-project and with-project scenarios is more substantial. In particular, the new station at Ardenwood opens up a potential new travel pattern for Capitol Corridor, in which many riders travel to Ardenwood during the AM peak and use connecting transit across the Dumbarton Bridge to access substantial employment centers. While the Hayward and Fremont-Centerville stations will be bypassed by Capitol Corridor after completion of the project, the BART Silicon Valley extension is anticipated to serve many of the current users of Capitol Corridor that travel between the Hayward or Fremont-Centerville stations and points south in the Capitol Corridor system.

Table 1 presents the forecast daily boardings and alightings at the three Key Stations: Hayward, Fremont-Centerville, and Ardenwood, along with the total daily systemwide boardings. Hayward and Fremont-Centerville stations are active in the No Project scenarios, and the Ardenwood station is the only station active in the With Project scenarios.

Table 1: Ridership Forecasts

Alternative	Key Stations Boardings + Alightings			System Wide Total Daily Boardings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2019 - Existing						
No Project	410	--	--	6,110	--	--
Year 2025 – Opening Year						
No Project	820	780	860	10,050	9,550	10,550
With Project	1,510	1,430	1,590	11,050	10,500	11,600
Year 2040 – Horizon Year						
No Project	1,630	1,550	1,710	18,240	17,330	19,150
With Project	2,340	2,220	2,460	19,350	18,380	20,320

Source: Fehr & Peers, 2021.

For purposes of forecasting, AM and PM peaks were defined by train number. AM peak trains arrive or depart Oakland Jack London Square essentially between 6:00 AM and 10:00 AM, while PM peak trains arrive or depart Jack London Square between 3:00 PM and 7:00 PM.

Table 2 presents forecast AM peak boardings and alightings at the same three key stations. In the No Project scenarios, Hayward and Fremont-Centerville stations serve primarily as AM peak origins, with substantially more boardings than alightings. However, in the With Project scenarios, Ardenwood station serves both as an AM peak origin and as an AM peak destination, primarily for passengers transferring to westbound services in the Dumbarton Corridor.

Table 2: AM Peak Boardings and Alightings at Key Stations

Alternative	Key Stations AM Boardings			Key Stations AM Alightings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2019 - Existing						
No Project	160	--	--	40	--	--
Year 2025 – Opening Year						
No Project	260	250	270	70	70	70
With Project	400	380	420	300	290	320
Year 2040 – Horizon Year						
No Project	500	480	530	150	140	160
With Project	590	560	620	470	450	490

Source: Fehr & Peers, 2021.

Mode of Access/Egress Forecasts

Table 3 and **Table 4** present forecast mode splits for access to/egress from the three key stations during the AM peak period. These forecasts also reflect Ardenwood's different travel profile versus Hayward and Fremont-Centerville. Ardenwood serves both as an AM origin station with large auto mode share, but also as an AM destination station with substantial transit connections to employment. The very large (76%) transit mode share for Ardenwood in 2025, which drops in to 45% in 2040, is attributed to changes to station area employment opportunities between 2025 and 2040, opening up employment opportunities in the station area even without a transit connection.

Table 3: AM Mode of Access to Key Stations

Station	2019 (Observed)			2025 (Forecast)			2040 (Forecast)		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Hayward (No Project scenario)	89%	0%	11%	89%	0%	11%	89%	0%	11%
Fremont (No Project scenario)	75%	0%	25%	77%	0%	22%	76%	0%	24%
Ardenwood (With Project scenario)	--	--	--	91%	1%	9%	90%	1%	9%

Source: Fehr & Peers, 2021.

Table 4: AM Mode of Egress from Key Stations

Station	2019 (Observed)			2025 (Forecast)			2040 (Forecast)		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Hayward (No Project scenario)	50%	50%	0%	43%	34%	24%	43%	34%	24%
Fremont (No Project scenario)	50%	20%	30%	43%	19%	39%	43%	19%	39%
Ardenwood (With Project scenario)	--	--	--	16%	60%	25%	24%	35%	41%

Source: Fehr & Peers, 2021.

Vehicle-Miles Traveled (VMT) Reduction

The proposed South Bay Connect project is projected to result in increased ridership along the Capitol Corridor system; many of these additional trips will be the result of riders choosing to not travel by personal automobile, thus resulting in a reduction in regional vehicle-miles traveled (VMT). **Table 5** details the outputs of the VMT calculations, which quantify the weekday daily regional VMT reduction resulting from the project.

Table 5: Weekday Daily Regional Vehicle Miles Traveled

Alternative	Vehicle-Miles of Travel (VMT)
Year 2025 – Opening Year	
No Project	227,150,000
With Project	227,112,000
Delta	*-38,000*
Year 2040 – Horizon Year	
No Project	256,390,000
With Project	256,350,000
Delta	*-40,000*

Source: Fehr & Peers, 2021.

Study Forecasting Tools and Process

The Capitol Corridor South Bay Connect project proposes to shift Capitol Corridor passenger rail service from the Niles Subdivision (between Elmhurst and Newark Junction) to the Coast Subdivision. With the shift in the Capitol Corridor route, the existing Hayward and Fremont-Centerville stations on the Niles Subdivision would no longer be served and would be replaced by a new station at the Ardenwood Boulevard park-and-ride in western Fremont/Newark on the Coast Subdivision. This section provides an overview of the forecasting tools used in the present ridership and VMT forecasts, along with a brief history of the forecasting work Fehr & Peers has done for South Bay Connect.

Study Tools and Inputs

This section provides a high-level description of the forecasting tools used in the ridership and VMT analysis of the project.

C/CAG-VTA Travel Demand Model

The City/County Associations of Governments of San Mateo County – Santa Clara Valley Transportation Authority (C/CAG-VTA) travel demand model is a trip-based regional travel demand model that accounts for regional land use patterns, approximated highway congestion, and connecting transit service within the nine-county MTC region. The C/CAG-VTA model includes the portion of the Capitol Corridor route between Suisun City-Fairfield Station and San Jose Diridon Station. The C/CAG travel model also contains data on the multimodal transportation system surrounding the Capitol Corridor route, including roadways and parallel/connecting public transit routes.

As noted in the previous Work Directive #1 documentation, the C/CAG-VTA travel demand model used in that analysis was not calibrated or validated for base year (2015) conditions. As part of Work Directive #1, the C/CAG-VTA travel demand model was used to assess the competitiveness of automobile travel against Capitol Corridor in-vehicle travel time per the Capitol Corridor timetable. The Model Development Memo (included as **Attachment A**) detailed the calibration and validation of the C/CAG-VTA travel demand model undertaken as part of the current phase (Work Directive #2) of this work.

SACOG Land Use Forecasts

Part of the Capitol Corridor service area includes the Sacramento area whose regional land use forecasts are produced by the Sacramento Area Council of Governments (SACOG). Forecasts of station area population and employment for stations in the SACOG region are derived from TAZ-level land use forecasts.

Work Directive 2 Direct Ridership Model (DRM)

To address the limitations of the C/CAG-VTA travel demand model for forecasting Capitol Corridor ridership, forecasts were developed using a Capitol Corridor-specific direct ridership model (DRM). This allows the forecasting process to use data from the C/CAG-VTA model where appropriate and statistical analysis of demographic, accessibility, and quality of service data where needed.

The DRM leverages work previously completed for the South Bay Connect project, using a similar model specification and variables already identified as influential, while expanding both the input variables and the time periods being modeled.

For detailed base year validation of the C/CAG-VTA model and more information on the decision to rely on a direct ridership model, see the model development memo included as **Attachment A**.

Mode of Access and Egress Models

In addition to forecasts of Capitol Corridor ridership, Mode of Access (MoA) models were developed to understand travel to and from Capitol Corridor stations. Two models were developed, focused solely on the AM peak period: a mode of access model and a mode of egress model. The AM peak period is the focus period as most travelers make their modal choice in the morning, and use that same mode in the afternoon (i.e. most riders choosing to take Capitol Corridor in the morning would not make the afternoon reverse trip in their own private automobile). These models shed further light on key differences between the existing Hayward and Fremont-Centerville stations and the proposed Ardenwood station.

Mode Choice Amtrak California Ridership Model

The Mode Choice version of the Amtrak California Ridership Model (Amtrak Model) has historically been used to estimate ridership for the Capitol Corridor system. Ridership estimates from the model were previously used to determine ridership potential for planning purposes. For the environmental analysis, however, the Amtrak Model lacks specific detail for land uses that can be reached by new Transbay transfers (such as those provided at the proposed Ardenwood Station). Thus, outputs from the Amtrak Model were used to provide guidance as to the reasonability of the DRM forecasts, especially for long distance trips (e.g. from Sacramento to San Jose).

Study Forecasting Process

As part of the Work Directive #1 initial analysis phase completed in 2019, Fehr & Peers prepared opening year (2025) and horizon year (2040) ridership and VMT estimates using a composite City/County Associations of Governments of San Mateo County – Santa Clara Valley Transportation Authority (C/CAG-VTA) travel demand model and Direct Ridership Model (DRM) methodology. This approach incorporated land use forecasts and automobile travel times from the C/CAG-VTA travel demand model with a DRM derived from April 2019 Capitol Corridor ridership.

Work Directive #2 – the current phase of the project – includes additional calibration and static validation of the C/CAG-VTA model. It also includes an update of the direct ridership model (DRM) using the calibrated C/CAG-VTA model data to ensure that the DRM reflects the calibration performed on the C/CAG-VTA model, to expand the DRM input variables, and to include a specific model for PM peak travel. In addition to the DRM, from that estimates of station-to-station ridership are output, models for mode-of-access (MOA) to stations and mode-of-egress (MOE) from stations were developed for the AM peak period. These models are multinomial logistic regression models which estimate MOA to and from Capitol Corridor stations during the AM peak. The AM peak is the critical period, as most mode choice decisions are made on the basis of AM travel (i.e. a Capitol Corridor rider who arrives on foot in the morning is unlikely to drive alone for the reverse-direction trip in the afternoon).

Effects of COVID-19 Pandemic on Forecasting Process

It is noted that the COVID-19 pandemic has altered travel patterns, and the permanent effect of the pandemic on travel patterns is still unknown. The model tools used in the ridership forecast represent the best available tools for forecasting the effect of the project on ridership and vehicle-miles traveled (VMT). Data on work-from-home (WFH) and shifts in residential locations in the Northern California megaregion suggests that more Bay Area workers are living in the Sacramento region; those workers represent a new market opportunity for Capitol Corridor as the primary transit provider between the Bay Area and Sacramento regions.

C/CAG-VTA Model

This section details the assumptions and inputs (both transportation networks and model land use) used in developing scenarios within the C/CAG-VTA model. The ridership results of these model scenarios were used as inputs to the Capitol Corridor direct ridership model, which produced the final forecasts.

As detailed in the June 2020 technical memorandum *South Bay Connect – Base Year Model Development* (provided as **Attachment A**), the following assumptions and process were used to set up the future year C/CAG-VTA model scenarios. Generally, the forecasting approach uses the latest transportation network and land use assumptions available for the project area.

Future Transportation Network

Table 6 summarizes the transportation network changes (versus the base year model assumptions) assumed in the 2025 and 2040 scenarios.

Table 6: Future Network Assumptions$

Parameter	Forecast Year	Assumption
ACE Service Level	2025	Same as 2018
	2040	10 daily ACE roundtrips (+4 from today)
Caltrain Service Level	2025	6-train per hour Zone Express Service
	2040	8-train per hour Moderate Growth Plan/Service Vision from the Caltrain Business Plan process
Hollister Express Bus Service	2025	Not included
	2040	Hourly integrated express bus service between Gilroy and Hollister
Salinas Rail Service	2025	No service
	2040	Hourly service between Gilroy and Salinas; hub station at Pajaro/ Watsonville providing hourly connections to Santa Cruz; hub station at Castroville providing hourly connections to Monterey.
Dumbarton Rail Service	2025	Not included
	2040	Rail shuttle from Union City BART station to Redwood City Caltrain station: 4 trains per hour per direction peak, 2 trains per hour per direction off peak.
US-101 Managed Lanes	2025	Add HOT lane in San Mateo County south of I-380
	2040	Convert a lane to a HOT lane between I-380 and I-280; convert a southbound lane to a HOT lane on I-280 north of US-101.
SamTrans Express Bus Service	2025	Four express routes as presented in SamTrans Express Bus study
	2040	Six more express routes as presented in SamTrans Express Bus study.

Source: Fehr & Peers, 2021.

Future Land Uses

This section outlines the future land use assumptions used to generate the interim ridership inputs from the C/CAG-VTA model to the Direct Ridership Model.

Regional Land Use Assumptions

The 2040 Plan Bay Area land use forecasts, updated to be consistent with the base year land use updates described in the base year model development memo (provided in **Attachment A**), were used for future year land use assumptions. The Bay Area has seen land use growth and approvals beyond what was assumed in 2040 Plan Bay Area and this additional land use was accounted for in this project's future scenarios. **Table 7** details additional land use from approved projects beyond 2040 Plan Bay Area that was incorporated into future year land use assumptions. These projects were assumed to be fully built by 2040. For the 2025 scenario, projects already well underway in the development pipeline were included.

Table 7: Additional Assumed Year 2040 Regional Planned Land Uses

City	Plan	Population Added beyond Plan Bay Area	Employment Added beyond Plan Bay Area	Notes
San Francisco	Central SoMa	12,000	38,000	Approved by Planning Commission; Board of Supervisors has not approved yet
South San Francisco	East of US 101 employment	-	11,000	Approved / Under construction. ~13 individual biotech projects approved/under construction totaling 7 MSF
San Bruno	Transit Corridors Plan	-	3,000	Approved
Millbrae	Station Plan	-	3,000	Approved
Redwood City	Stanford Healthcare Camus	-	4,000	Approved
Palo Alto / Stanford	Stanford Research Park expansion and Stanford Hospital expansion	-	6,000	Approved
Mountain View	North Bayshore Precise Plan	-	21,000	Approved
Cupertino	Apple Campus	-	8,000	Complete
Sunnyvale	Peery Park Specific Plan	-	10,000	Approved
	Moffett Towers	-	3,000	Approved
Santa Clara	City Place	-	8,000	Approved
Total		**12,000**	**115,000**	

Source: Fehr & Peers, 2021.

Ardenwood Station Area Land Use Update Assumptions

To better account for travel behavior near the proposed Ardenwood station, two additional changes were made related to Ardenwood station-area land use assumptions. First, the City of Fremont has adopted land use rezoning to increase density near the Ardenwood station. For the year 2040 scenario, this rezoning adds approximately 7,000 additional employees in the immediate Ardenwood station area. The rezoned land use was not assumed to be present in the 2025 scenario.

Additionally, the C/CAG-VTA model TAZs around the proposed Ardenwood station were revised to provide more spatial detail. The off-the-shelf TAZs near the proposed station cover large areas including empty land, parks, and water bodies that may not properly capture the changes in travel demand resulting from land use changes in the immediate areas around the proposed station. To address this issue, these TAZs were split into smaller TAZs to allow the model to estimate travel behavior for land use in close proximity to the proposed station. Specifically, the four off-the-shelf C/CAG-VTA model TAZs that cover the approximately one-mile buffer from the proposed station were split into twelve TAZs based on geographic detail from the Alameda CTC model in the same area. The values from the C/CAG-VTA model TAZs were assigned proportionally to the new TAZs, thus maintaining the land use control totals.

Direct Ridership Model

To address the limitations of the C/CAG-VTA travel demand model described in the model methodology memo (**Attachment A**), a Capitol Corridor-specific Direct Ridership Model was developed that allows the forecasting process to use data from the C/CAG-VTA model where appropriate and statistical analysis of demographic and accessibility data where needed. This section outlines the broad approach and the variables used in the DRM; a more detailed description of the statistical modeling is included in **Attachment B**.

DRM Approach

The approach to developing Direct Ridership Models (DRM) for updated forecasting is similar to the approach previously used for DRM development as part of Work Directive #1. A series of statistical models were developed to estimate ridership at the level of origin-destination station pairs. A total of twelve linear regression models were developed, accounting for three time periods (AM peak, PM peak, and Off Peak) and four market segments. These market segments were modeled separately because Capitol Corridor ridership and service patterns showed clearly different markets (e.g. more westbound trains during the AM peak, more eastbound trains during the PM peak). In addition, the C/CAG-VTA model area only covers part of the Capitol Corridor service area, so the market segmentation allowed the option of using C/CAG-VTA model forecasts where appropriate. The four market segments were defined as follows:

- **Segment 1: Within Core Bay Area** - Travel among stations between Martinez and San Jose Diridon.
- **Segment 2: Leaving Core Bay Area** - Travel from Core Bay Area stations (Martinez to San Jose) to stations outside the Bay Area (Auburn to Suisun City)
- **Segment 3: Entering Core Bay Area** - Travel from stations outside the Core Bay Area (Auburn to Suisun City) into the Core Bay Area (Martinez to San Jose)
- **Segment 4: Outside Core Bay Area** - Travel among stations outside the Core Bay Area (Auburn to Suisun City).

Capitol Corridor Observed Ridership and Travel Patterns

Observed Capitol Corridor ridership was defined as the average weekday ridership for April 2019 (i.e. before the COVID-19 pandemic). This ridership was calculated for each origin-destination pair and each time period, using passenger counts from ticket lift data. Time periods were defined by train number, as shown in **Table 8**. AM peak trains arrive or depart Oakland Jack London Square essentially between 6:00 AM and 10:00 AM, while PM peak trains arrive or depart Jack London Square between 3:00 PM and 7:00 PM.

Table 8: Time Period Definitions

Time Period	Eastbound Train Numbers	Westbound Train Numbers
AM Peak	522, 524, 528	521, 523, 525, 527, 529
PM Peak	536, 538, 540, 542, 544, 546	541, 543, 545
Off Peak	520, 530, 532, 534, 548, 550	531, 535, 537, 547, 549, 551, 553

Source: Fehr & Peers, 2021.

The April 2019 data provide information on travel patterns for existing Capitol Corridor service before the opening of the Silicon Valley BART Extension project to the Berryessa/North San Jose Station. **Table 9** presents the existing travel patterns for the Hayward and Fremont-Centerville stations.

Table 9: Time Period Definitions

Existing Station	April 2019 Ridership Data	
	Trips To/From North of Study Area	Trips To/From South of Study Area
Hayward	2,503 (39%)	3,957 (61%)
Fremont-Centerville	3,282 (83%)	662 (17%)

Source: Capitol Corridor, 2019 and Fehr & Peers, 2021.

The data presented in **Table 9** indicate that the majority of trips at Hayward Station have a trip start or end at the three Silicon Valley stations (Great America, Santa Clara, San Jose Diridon stations). These trips are expected to shift to BART service associated with the opening of the Silicon Valley BART Extension given the higher frequency of BART service. Conversely, most trips at the Fremont-Centerville station have a trip start or end north of the study area; trips with a start or end north of the study area trips may connect to Capitol Corridor service by either using the proposed Ardenwood Station in Fremont or by taking BART and transferring to Capitol Corridor service at the Coliseum or Richmond stations.

The April 2019 data also indicates that over 75 percent of weekday boardings at the Hayward and Fremont-Centerville stations occur during the four-hour AM peak period and about 65 percent of weekday alightings occur during the four-hour PM peak period. This indicates that the stations primarily serve as commute trip origins for the weekday, and the travel market for these existing stations is primarily defined by the residential areas surrounding the stations.

DRM Variables

Two types of variables are used in the DRM: station-specific and origin-destination (OD). The station-specific variables provide information on the stations and their surrounding land uses, while the OD-specific variables provide information regarding the trip between stations.

Station-Specific Variables

The station-specific variables provide information on the stations and their surrounding area. These variables describe characteristics of the stations themselves, including land use surrounding the station and accessibility to the station. **Table 10** lists the broad categories of station-specific variables considered in developing the DRM.

Table 10: Station-Specific Variables

Variable	Notes
Population within ¼, ½, 1 mile, or 2 miles of station	Population within straight-line buffers, calculated in GIS using TAZ-level land use data from C/CAG-VTA model and SACOG.
Employment within ¼, ½, 1 mile, or 2 miles of station	Employment within straight-line buffers, calculated in GIS using TAZ-level land use data from C/CAG-VTA model and SACOG.
Population accessible via transit or walk connection to station	-
Employment accessible via transit or walk connection to station	-
Auto parking at station	No changes to parking at any station except Ardenwood, which increases to 500 spaces in with-project scenarios.

Source: Fehr & Peers, 2021.

Land Use Straight-Line Buffers

The land use straight-line buffers sum the population and employment within defined buffers of the station, using the TAZ-level land use information from the C/CAG-VTA and SACMET models. The proportion by area of each model TAZ that falls within the buffer area is applied to the TAZ population and employment.

Station Accessibility by Walk and Transit Modes

The land use straight-line buffer variables provide useful information on the surrounding area; however, they do not portray accessibility to the stations well. Additional variables were calculated to understand more clearly how the surrounding environment influences travel to and from the stations by walking and taking transit. These variables were developed using a process that considers the surrounding road network, transit lines, and transit service to create isochrones: geographic regions that represent the travel time required to access stations by walking or by transit.

Network data from Open Street Maps was used to calculate walking paths to stations and connecting transit. The transit lines and service frequencies were calculated using General Transit Feed Specification (GTFS) data from TransitLand[1] for the transit agencies listed in **Table 11.**

Table 11: Transit Agencies Represented in Transit Accessibility Calculations

Transit Agencies Represented in Transit Accessibility Calculations		
AC Transit	Dumbarton Express	SolTrans
ACE	Emery GoRound	Union City Transit
BART	FAST	Vacaville Coach Bus
Caltrain	SacRT	VTA
Capitol Corridor (Thruway bus)	SamTrans	WestCat
County Connection	SFMTA	

Source: Fehr & Peers, 2021.

Examples of walk and transit isochrones are shown in **Figure 1** and **Figure 2** (presented on the next pages).

Finally, walk and transit isochrones were used to develop variables measuring the ease of reaching population and employment from Capitol Corridor stations. A distance decay was applied so that land use close to stations was weighted more heavily than land use farther away. Final accessibility values were developed using distance decay formulas for accessibility consistent with NCHRP Report 365[2].

[1] https://transit.land/feed-registry/operators/

[2] Martin, W., and N. McGuckin. Travel Estimation Techniques for Urban Planning. NCHRP Report 365, 1998.

Figure 1 Example of walk accessibility isochrones

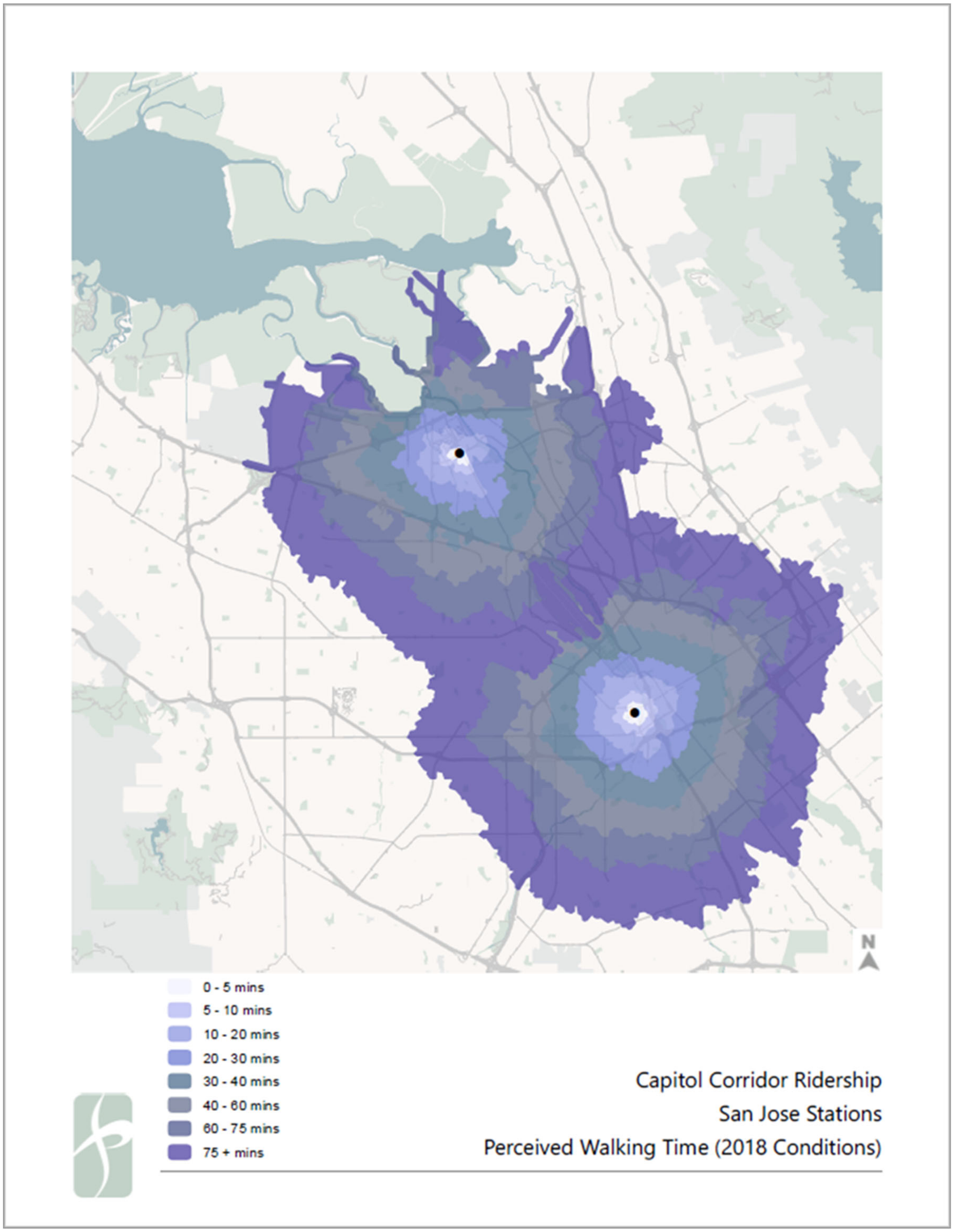
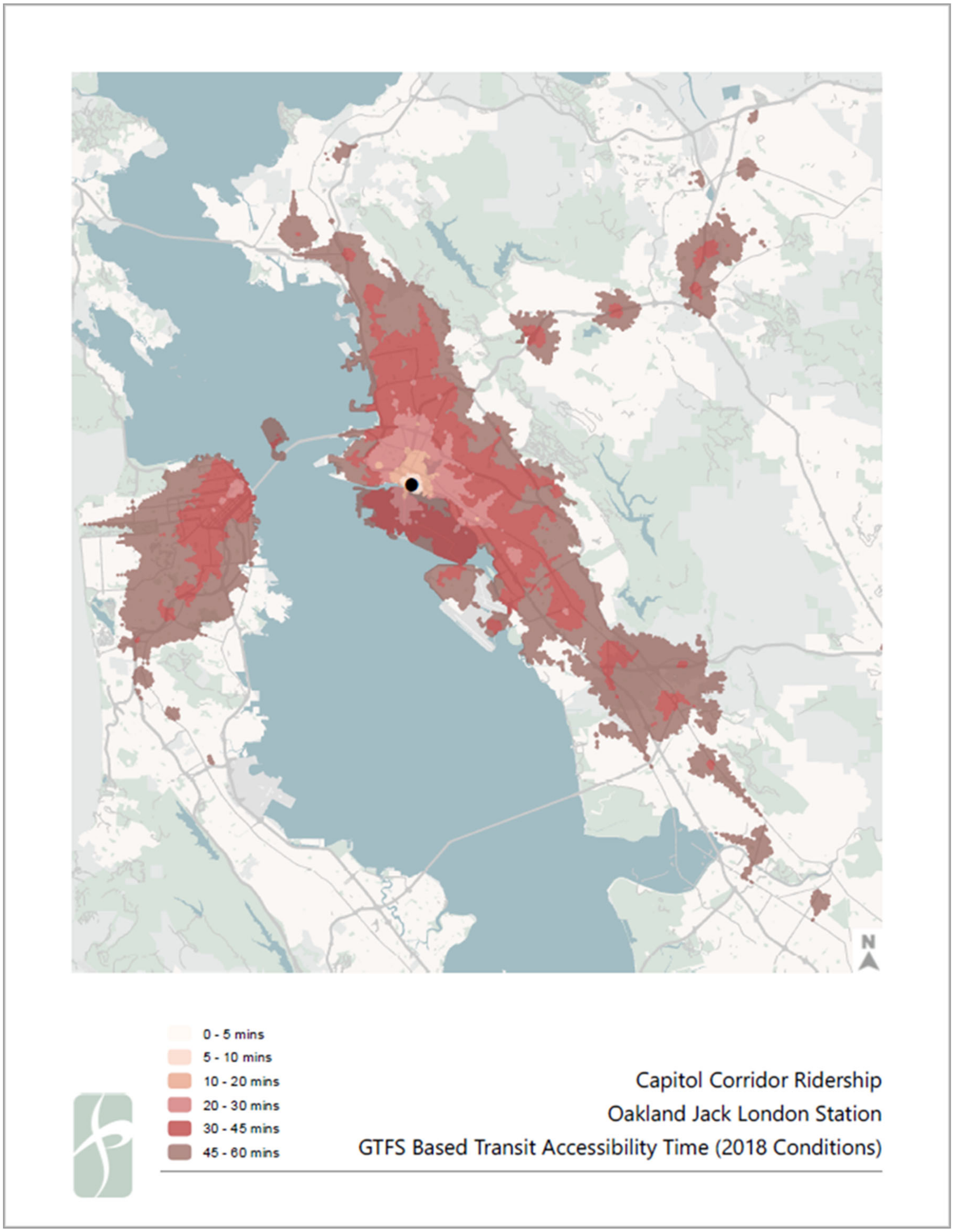


Figure 2 Example of transit accessibility isochrones



OD-Specific Variables

Table 12 describes the different OD variables used to develop the DRM, including their sources. The table also identifies how the future representation of the variables was calculated. The OD variables are composed of cost, travel time, and frequency of trains between each station combination.

Table 12: OD-Specific Variables

Variable	Description	Notes
C/CAG-VTA model ridership	Capitol Corridor ridership estimated by C/CAG-VTA model	Although this variable was tested in the DRM, it did not provide useful explanatory power and was dropped from final models.
Capitol Corridor IVTT	Capitol Corridor in-vehicle travel time.	Consistent with the project description and in-vehicle times provided, the with-project scenarios reflect a slight decrease in travel times through the project area as compared to the no-project scenarios.
Competing Transit IVTT	Estimated in-vehicle time for competing transit.	The isochrone analysis conducted for transit accessibility also allowed estimation of in-vehicle time for competing transit serving selected Capitol Corridor station pairs. In future scenarios, these competing times were adjusted specifically to account for BART to San Jose.
Capitol Corridor Frequency	Number of trains per time period (AM, PM, Off Peak, or Daily)	No change to frequencies was assumed in future scenarios, either in the no-project scenarios or the with-project scenarios.
Capitol Corridor Fares	Single-ride fare between origin and destination stations.	No change to Capitol Corridor fares beyond inflation was assumed for future scenarios.
Auto Travel Time	Station to station auto travel time on parallel routes.	2018 INRIX data was used for the region from San Jose to Davis. Outside of this region (Davis to Auburn), estimates from Google Maps were used. For future scenarios, the change in travel time from the C/CAG-VTA model was used as a factor applied to 2018 travel times. Outside the C/CAG-VTA model region, similar factors were used to the eastern portion of the model area.

Source: Fehr & Peers, 2021.

Statistical Models

This section provides an overview of the statistical models developed as the Direct Ridership Model for Capitol Corridor. Twelve independent linear regression models were developed, one for each combination of time period and market segment, each with similar structure and variables

As noted previously, the DRM equations are derived using existing conditions ridership data, along with data on land use, Capitol Corridor service, and competing auto and transit travel time information from the C/CAG-VTA travel demand model. To align with a standard statistical process, only variables that are statistically significant with intuitive coefficients are included in the final derived DRM equations. The variables included in each travel market/time period DRM equation are allowed to fluctuate between equations.

Variable Overview

Table 13 summarizes the variables in the DRM, by time period. It also identifies the strength and direction (positive or negative) of the variables' relationship to Capitol Corridor ridership.

Table 13: Direct Ridership Model Variables

Category	Variable	AM Peak	PM Peak	Off Peak
Land Use	Population within ¼, ½, 1 mile, or 2 miles of origin	++		+
	Population accessible via transit or walk connection to origin	++		
	Population within ¼, ½, 1 mile, or 2 miles of destination		+	+
	Population accessible via transit or walk connection from destination		++	+
	Employment within ¼, ½, 1 mile, or 2 miles of origin		+++	++
	Employment accessible via transit or walk connection to origin		++	
	Employment within ¼, ½, 1 mile, or 2 miles of destination	+++		++
	Employment accessible via transit or walk connection from destination	++		+
Parking	Auto parking at origin station	++		
	Auto parking at destination station		+	+
Capitol Corridor Service	Train frequency	++	++	++
	Fare / distance	-	-	-
Other Modes	Auto vs Capitol Corridor travel time	++	++	+
	Capitol Corridor vs competing transit travel time	-	-	-
Significance Definition				

+++	Strong positive significance
++	Moderate positive significance
+	Weak positive significance
-	Weak negative significance

Source: Fehr & Peers, 2021.

Even with the model's re-calibration and updates, the C/CAG-VTA model results were not in line with existing conditions and were skewing the model inaccurately. In particular, they predicted much higher than observed ridership between Solano County stations and the Core Bay Area, as well as higher ridership within Santa Clara County. Therefore, the C/CAG-VTA model outputs ultimately were not used in the DRM.

The employment land use variables were generally stronger predictors for ridership than the population variables. The transit and walk accessibility variables worked well together as they summarize who can access the Capitol Corridor stations, via what mode, and with how much effort. Transit accessibility variables were most successful when they focused on specific high-quality transit: the Amtrak Thruway bus at Emeryville, BART connections at Richmond and Coliseum, and connections to the VTA transit system at Great America, Santa Clara, and Diridon. Parking, while not directly related to land use, provides information on station accessibility by driving oneself. Ultimately, parking at the AM station origin (PM and Off Peak destination) was a moderate predictor for Capitol Corridor ridership.

As noted in **Table 13,** the land use variables are focused on land uses within a radius of up to two miles from the station area. While the DRM and ridership forecasting process does not presume that existing riders at the Hayward and Fremont-Centerville stations take BART/other transit to connect to Capitol Corridor service (or shift to Ardenwood Station), the two-mile radii around the existing Fremont-Centerville Station and proposed Ardenwood Station substantially overlap, thus the forecasting process is sensitive to a portion of the existing Fremont-Centerville Station ridership shifting to Ardenwood Station. The overlap of service area for the Fremont-Centerville and Ardenwood stations is critical because, as evidenced by the existing ridership data, over 80 percent of existing trips at Fremont-Centerville Station do not involve trips to/from Silicon Valley, and thus would exhibit a higher propensity to shift to Ardenwood station.

Components of the Capitol Corridor service are important in predicting ridership. Frequency, by time period, is a significant predictor of ridership. Fare versus distance travelled on Capitol Corridor is a weak but noticeable predictor for within-region travel, and better describes the value of the trip than stand-alone fare. Auto travel time (on its own) as a variable is too closely related to Capitol Corridor travel time, therefore auto travel time compared to train travel time was used in order to illustrate the travel time gains or losses of a trip when choosing Capitol Corridor.

Competing transit (measured as ratio of Capitol Corridor in-vehicle time to competing transit in-vehicle time) has a weak but intuitively sensible relationship in the AM and PM models for within the Core Bay Area. Its sign is the reverse of auto versus Capitol Corridor time, because for this variable Capitol Corridor time appears in the numerator instead of the denominator. This variable is especially important in the ridership forecasting process because BART will provide a faster, more frequent connection between the study area and Silicon Valley than the Capitol Corridor service.

Goodness of Fit

Table 14 presents the model goodness of fit (R-squared) metrics for the DRMs developed. R-squared metrics closer to 1.00 indicate that the model replicates all of the variation in ridership. Higher R-squared values are not necessarily a good result – in most cases where the R-squared value is high, this indicates a model over-fit condition whereby the model will be a poor predictor of future ridership. Generally speaking, the goodness of fit metrics suggest that the suite of DRMs are performing within expectations.

Table 14: Model Goodness of Fit (R-squared)

Segment	AM Peak	PM Peak	Off Peak
Segment 1: Within Core Bay Area	0.60	0.56	0.53
Segment 2: Leaving Core Bay Area	0.77	0.81	0.82
Segment 3: Entering Core Bay Area	0.78	0.61	0.83
Segment 4: Outside Core Bay Area	0.75	0.94	0.99

Source: Fehr & Peers, 2021.

Figures 3, 4 and 5 (presented on the next page) detail the relationship between DRM base year ridership estimates and actual observed ridership data for the AM peak period, PM peak period and Off Peak period (respectively).

Figure 3 AM Observed versus Modeled Ridership

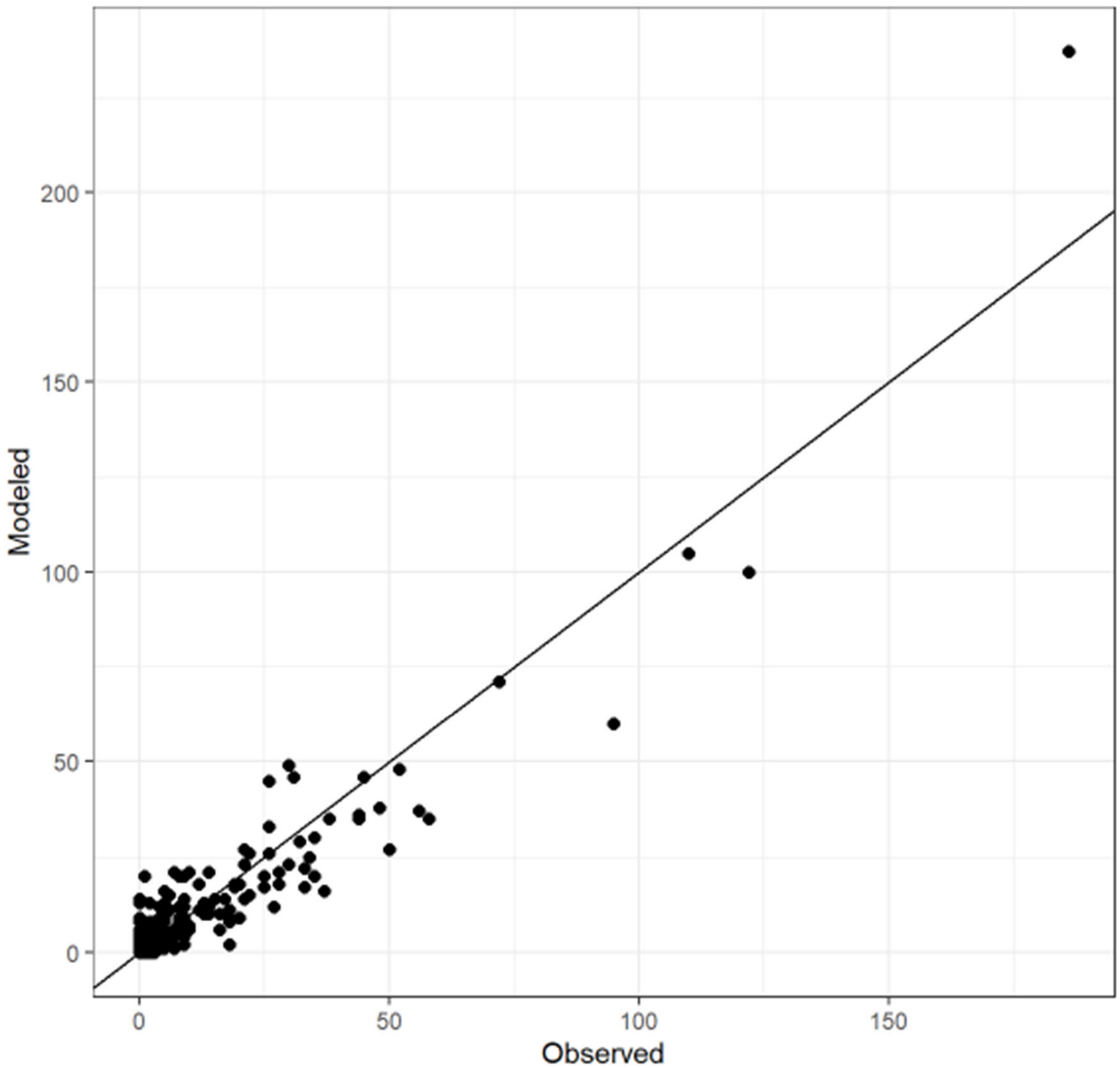


Figure 4 PM Observed versus Modeled Ridership

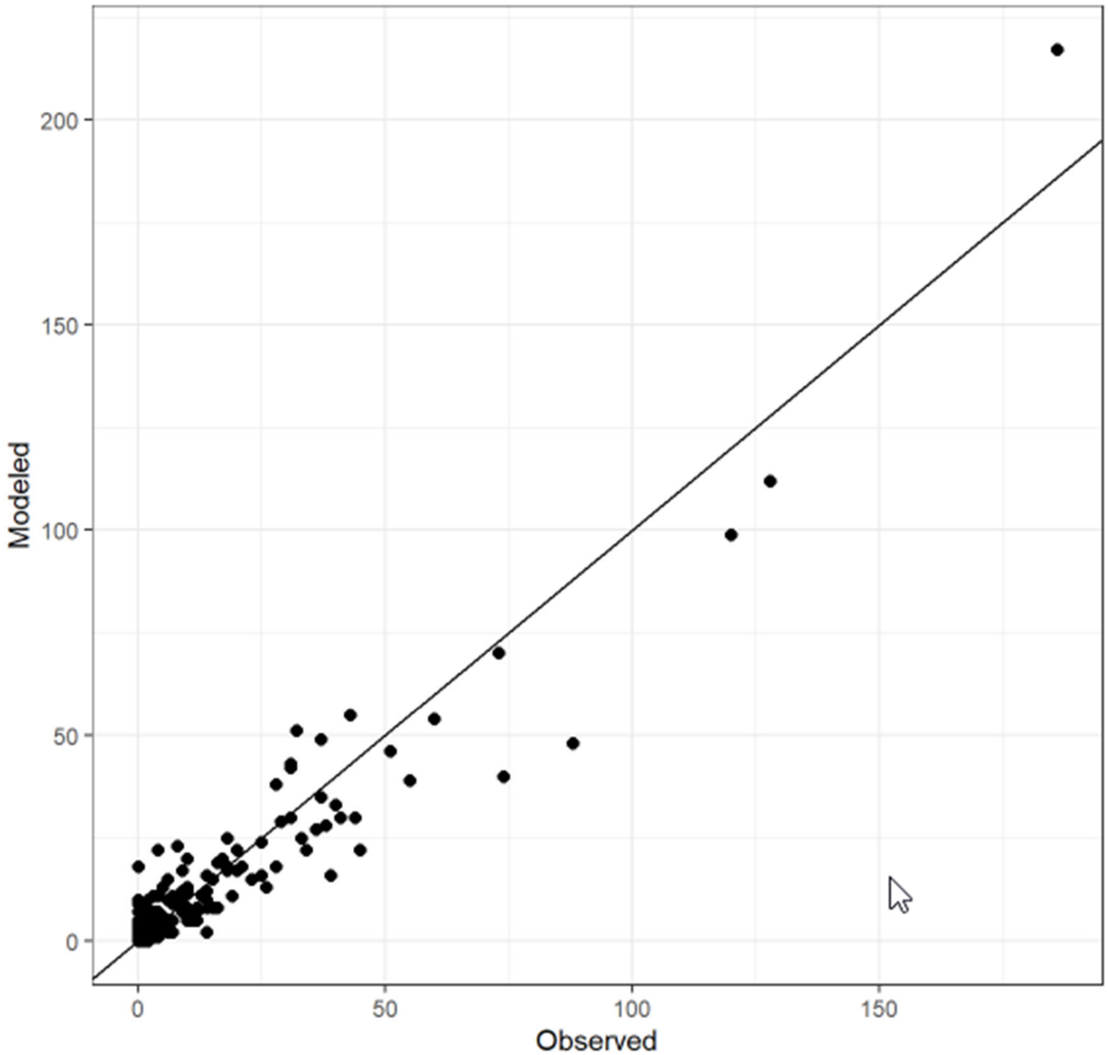
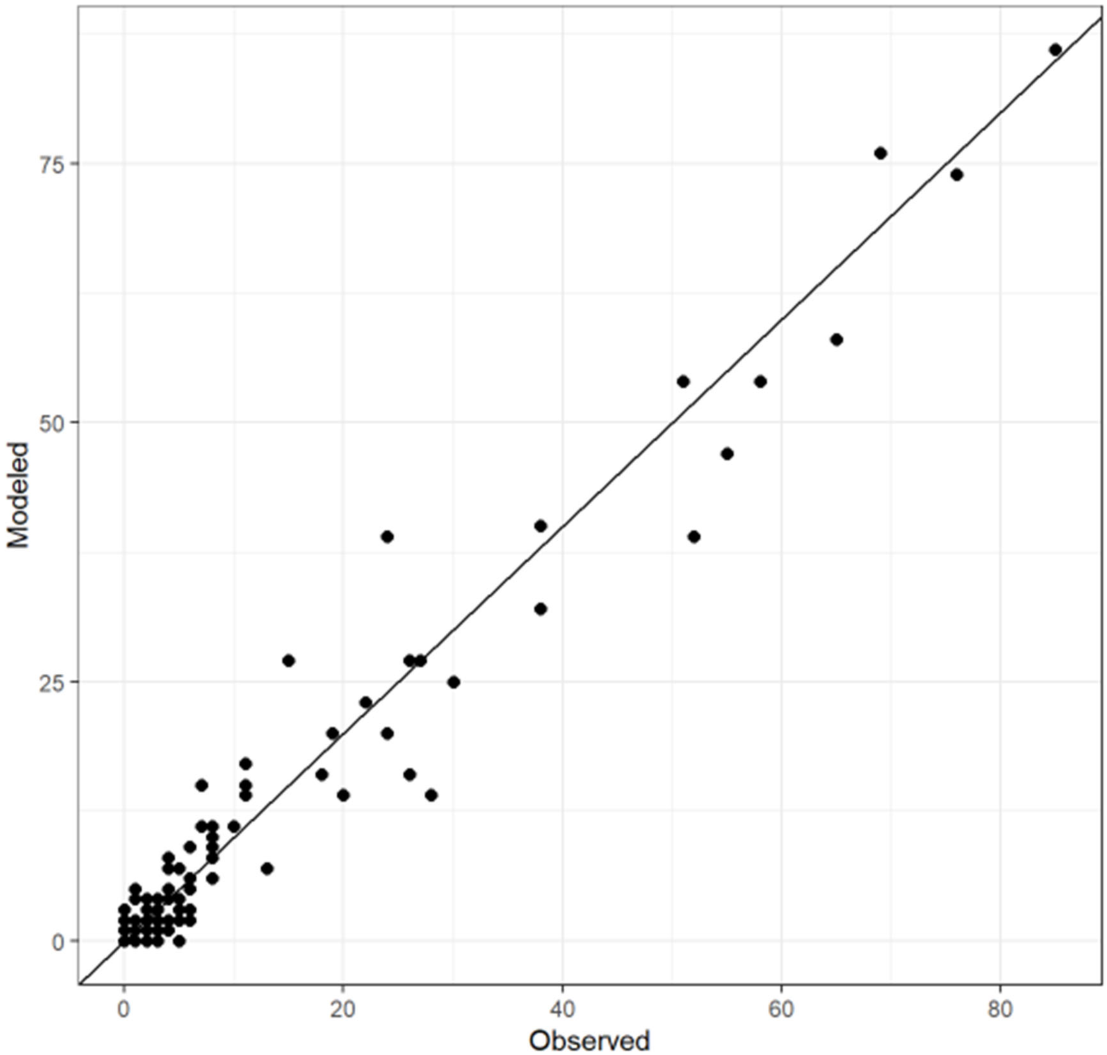


Figure 5 Off Peak Observed versus Modeled Ridership



Ridership Forecasts

This section provides detailed tables of systemwide ridership, and station-level boardings and alightings based on the methodology described in the previous sections.

Systemwide Ridership Totals

Table 15 shows the daily boardings and alightings at three key stations: Hayward, Fremont, and Ardenwood, along with the total daily systemwide boardings. **Table 16** shows system wide total boardings by time of day. In general, the South Bay Connect project scenarios are projected to result in a modest increase in system-level ridership as compared to the corresponding No Project scenarios. For key stations in the project area, the difference between No Project and With Project scenarios is more substantial.

Table 15: Ridership Forecast Overview

Alternative	Key Station Boardings + Alightings			System Wide Total Daily Boardings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2019 - Existing						
No Project	410	--	--	6,110	--	--
Year 2025 – Opening Year						
No Project	820	780	860	10,050	9,550	10,550
With Project	1,510	1,430	1,590	11,050	10,500	11,600
Year 2040 – Horizon Year						
No Project	1,630	1,550	1,710	18,240	17,330	19,150
With Project	2,340	2,220	2,460	19,350	18,380	20,320

Source: Fehr & Peers, 2021.

Table 16: System Wide Boardings by Time Period

Alternative	System Wide Total Boardings			
	Daily	AM Peak	PM Peak	Off Peak
Year 2019 - Existing				
No Project	6,110	2,460	2,380	1,270
Year 2025 – Opening Year				
No Project	10,050	3,930	3,770	2,360
With Project	11,050	4,410	4,210	2,430
Year 2040 – Horizon Year				
No Project	18,240	6,950	6,680	4,600
With Project	19,350	7,530	7,210	4,620

Source: Fehr & Peers, 2021.

Individual Station Boardings

Systemwide station boarding information by time of day is summarized in tabular form in **Attachment C**.

AM Peak Boardings and Alightings at Key Stations

Table 17 presents AM Peak boardings and alightings for the three key stations in the project area: Hayward, Fremont-Centerville, and Ardenwood.

Table 17: AM Peak Period Boardings and Alightings

Alternative	Key Stations AM Boardings			Key Stations AM Alightings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2019 - Existing						
No Project	160	--	--	40	--	--
Year 2025 – Opening Year						
No Project	260	250	270	70	70	70
With Project	400	380	420	300	290	320
Year 2040 – Horizon Year						
No Project	500	480	530	150	140	160
With Project	590	560	620	470	450	490

Source: Fehr & Peers, 2021.

The new station at Ardenwood opens up a new travel market for Capitol Corridor, in which riders travel to Ardenwood during the AM peak and use connecting transit across the Dumbarton Bridge to access substantial employment centers. This is in contrast to the Hayward and Fremont-

Centerville stations, which generally have substantially more AM boardings than alightings because they serve primarily residential areas. It is also noted that AM peak period boardings at Ardenwood Station are also greater than under the No Project scenario, indicating that the Ardenwood Station is likely recapturing existing demand from Fremont-Centerville Station as well as new demand from new residential markets served (either in the local station area or from Transbay transit connections). These trips are also likely longer distance in nature given the differences in travel markets.

Origin-Destination Matrices

Origin-destination (OD) matrices for the Capitol Corridor system are summarized in tabular form in **Attachment C**.

Ridership Conclusions

The data in **Tables 15, 16, and 17** indicates that the project results in a net increase in ridership over No Project conditions. Systemwide boardings are anticipated to increase by six to nine percent after completion of the project; boardings are anticipated to grow faster in the AM and PM peak periods than the Off-peak period, which is in-line with expectations as the proposed Ardenwood Station serves a major employment hub in the local station area, as well as provides an opportunity to serve a Transbay travel market to serve job centers in San Mateo County. The projected increase in AM peak period boardings at Ardenwood Station (versus the No Project condition where Hayward and Fremont-Centerville stations remain open) indicates that the project is recapturing at least some of the existing Hayward and Fremont-Centerville ridership demand, while also capturing other trips. The underserved existing Hayward and Fremont-Centerville ridership demand may use BART or other transit options to connect to Capitol Corridor service.

Mode of Access and Egress

In addition to estimating Capitol Corridor ridership, Mode of Access (MoA) models were developed to understand travel to and from Capitol Corridor stations. Two models were developed, focused solely on the AM Peak period: a mode of access model and a mode of egress model. In the following sections, both models are referred to as MoA models.

MoA Model Variables

Independent variables for the MoA models were the same set of station-specific variables as used in the ridership models. Variables used in the mode of access and mode of egress models are listed in **Table 18** on the next page. The overall measures of population and employment were generally less useful than the comparisons between accessibility variables and straight-line buffers, probably because overall population and employment density varies widely across the Capitol Corridor service region. Finally, parking at stations was only a weak predictor of AM access, and only when measured as a yes-no variable indicating whether there are at least 50 spaces. This may be because almost all stations have parking, and the amount provided is generally more connected to the overall ridership at the station than the access and egress mode share.

Table 18: Overview of AM Mode of Access / Egress Model Variables

Category	Variable	AM Access	AM Egress
Transit Accessibility	BART-accessible population versus 2-mile population	+	
	Thruway-bus-accessible population versus 2-mile population	+	
	BART-accessible employment versus 2-mile employment		++
	Thruway-bus-accessible employment versus 2-mile employment		+
	VTA-accessible employment versus 1-mile employment		+
Walk Accessibility	Walk-accessible population versus ½-mile population	++	
	Walk-accessible employment versus ¼-mile employment		+
Parking	Auto parking at station: Over 50 spaces?	+	
Significance Definition			
+++	Strong positive significance		
++	Moderate positive significance		
+	Weak positive significance		
-	Weak negative significance		

Source: Fehr & Peers, 2021.

Mode of Access Forecasts

The tables and figures on the following pages list the AM mode of access and mode of egress model forecasts for each station. The mode of access and egress models are generally only modestly sensitive to station changes over time.

Table 19 and **Table 20** show forecast mode splits for access to and egress from the same three key stations during the AM peak. These forecasts also reflect Ardenwood's status as both an AM origin station similar to Hayward and Fremont-Centerville, and also an AM destination station with good transit connections to employment. The very large (76%) transit mode share for Ardenwood in 2025, which drops in to 45% in 2040, is attributed to changes to station area employment opportunities between 2025 and 2040, opening up employment opportunities in the station area even without a transit connection. **Figure 6** and **Figure 7** present AM peak period mode of access and egress forecasts for all stations in the Capitol Corridor system; detailed numerical forecasts are detailed in **Attachment C**.

Table 19: AM Peak Period Mode of Access to Key Stations

Station	2019 (Observed)			2025 (Projected)			2040 (Projected)		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Hayward (No Project scenario)	89%	0%	11%	89%	0%	11%	89%	0%	11%
Fremont (No Project scenario)	75%	0%	25%	77%	0%	22%	76%	0%	24%
Ardenwood (With Project scenario)	--	--	--	91%	1%	9%	90%	1%	9%

Source: Fehr & Peers, 2021.

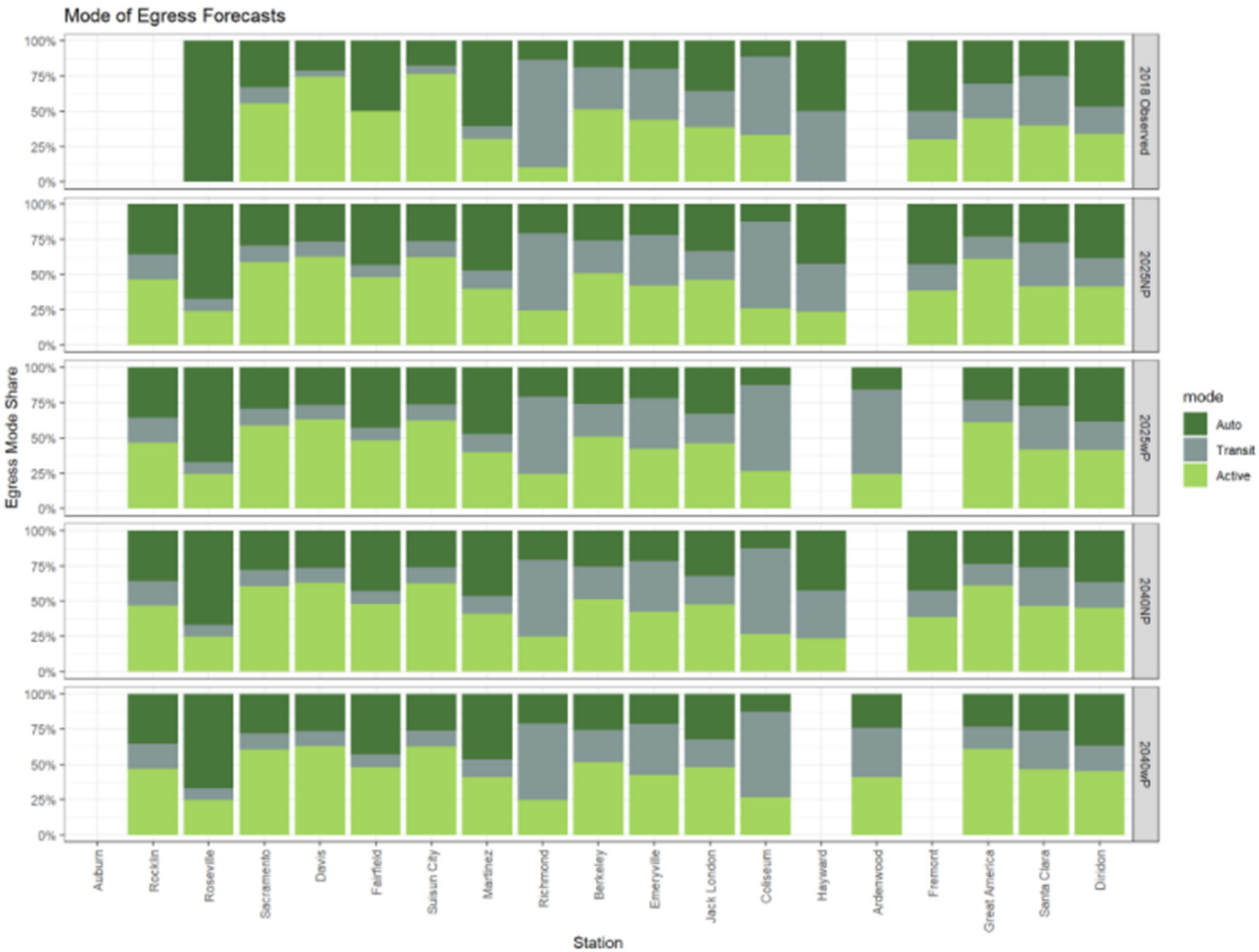
Table 20: AM Peak Period Mode of Egress from Key Stations

Station	2019 (Observed)			2025 (Projected)			2040 (Projected)		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Hayward (No Project scenario)	50%	50%	0%	43%	34%	24%	43%	34%	24%
Fremont (No Project scenario)	50%	20%	30%	43%	19%	39%	43%	19%	39%
Ardenwood (With Project scenario)	--	--	--	16%	60%	25%	24%	35%	41%

Source: Fehr & Peers, 2021.

Figure 6 AM Peak Period Mode of Access Forecasts

Figure 7 AM Peak Period Mode of Egress Forecasts



Vehicle-Miles Traveled Estimates

Using the C/CAG-VTA travel demand model and the results of the DRM as described above, daily regional vehicle-miles traveled (VMT) was estimated for the project scenarios. For this VMT estimate, the region is defined as the geographic area covered by the C/CAG-VTA travel demand model. s

While this estimate includes a large region, it is noted that much of the VMT savings due to the project will be along the I-80 corridor between Sacramento and Oakland and the I-880 corridor between Oakland and San Jose. It is also noted that based on existing conditions, these two corridors are extremely congested during the AM and PM peak period and the majority of new ridership under the plus project alternatives would occur during the AM and PM peak periods.

Table 21 details the outputs of the VMT calculations.

Table 21: Daily Regional Vehicle Miles Traveled

Alternative	Vehicle-Miles of Travel (VMT)
Year 2025 – Opening Year	
No Project	227,150,000
With Project	227,112,000
Delta	*-38,000*
Year 2040 – Horizon Year	
No Project	256,390,000
With Project	256,350,000
Delta	*-40,000*

Source: Fehr & Peers, 2021.

FEHR PEERS

Attachment A: Model Development Memo

Final Memorandum

Date: June 18, 2020

To: Michael Brown and Ben Tripousis, HNTB

From: Mackenzie Watten and Ian Barnes, Fehr & Peers

Subject: South Bay Connect – Base Year Model Development

WC19-3612.01

This memo presents Fehr & Peers' model development work undertaken for the modeling of station-level and systemwide Capitol Corridor ridership as part of the South Bay Connect project. This memo includes the following sections:

- Summary of Findings
- Project Overview
- Forecasting Tools
  - C/CAG-VTA Travel Demand Model
  - Direct Ridership Model
- C/CAG-VTA Travel Demand Model
  - Off-the-Shelf Model Validation
  - Updates to Inputs
  - Calibrated Model Validation
- Supplementing the Forecasting Tools
  - Calibrated Model Post-Processing
  - Direct Ridership Model
- Next Steps

Summary of Findings

The C/CAG-VTA Travel Demand Model was validated against a variety of metrics relevant to the model's ability to accurately estimate travel behavior within and on the outskirts of the project area. The "off-the-shelf" version model did not perform particularly well in a variety of areas.

Subsequently, the model was calibrated and updated with new land use information and changes to the transportation network, resulting in some limited improvement in performance; this limited improvement in performance after calibration highlights the need for off-model tools and processes that utilize the better-performing aspects of the model.

The previous Direct Ridership Model (DRM) was updated to provide these needed off-model tools, in addition to supplemental post-processing of the C/CAG-VTA model outputs to give the combined model (C/CAG-VTA model plus DRM) better accuracy and predictive power. This memo outlines supplemental post-processing to the C/CAG-VTA model so that it can be used for project evaluation. This post-processing includes high-level adjustments factors for auto travel times and trip distribution as well as the development of an off-model Direct Ridership Model to estimate Capitol Corridor ridership.

Project Overview

The Capitol Corridor South Bay Connect project proposes to shift Capitol Corridor passenger rail service from the Niles Subdivision (between Elmhurst and Newark Junction) to the Coast Subdivision. With the shift in the Capitol Corridor route, the existing Hayward and Fremont-Centerville stations would no longer be served and would be replaced by a new station at the Ardenwood park-and-ride in western Fremont.

As part of the Work Directive #1 initial analysis phase completed in 2019, Fehr & Peers prepared opening year (2025) and horizon year (2040) ridership and VMT estimates using a composite VTA-C/CAG model and Direct Ridership Model (DRM) methodology. This approach incorporates land use forecasts and automobile travel times from the City/County Associations of Governments of San Mateo County – Santa Clara Valley Transportation Authority (C/CAG-VTA) travel demand model with a DRM derived from April 2019 Capitol Corridor ridership.

Work Directive #2 – the current phase of the project – includes calibration and static validation of the C/CAG-VTA model and an update of the DRM using the calibrated C/CAG-VTA model data to ensure that the DRM used for further forecasting reflects the calibration performed on the C/CAG-VTA model. In addition to the DRM, from which estimates of station-to-station ridership are output, models for mode-of-access (MOA) to stations and mode-of-egress (MOE) from stations were developed for the AM peak period. These models are multinomial logistic regression models which estimate mode shares to and from Capitol Corridor stations during the AM peak. The AM peak is the critical period, as most mode choice decisions are made on the basis of AM travel (i.e. a Capitol

Corridor rider in the morning is unlikely to drive alone for the reverse-direction trip in the afternoon).

Forecasting Tools

This section provides a high-level description of the forecasting tools to be used in the ridership and VMT analysis of the project.

C/CAG-VTA Travel Demand Model

The C/CAG-VTA model is a trip-based regional travel demand model that takes into account regional land use patterns, approximated highway congestion, and connecting transit service within the nine-county MTC region. The C/CAG-VTA model includes the portion of the Capitol Corridor route between Suisun City-Fairfield Station and San Jose Diridon Station. The C/CAG travel model also contains data on the multimodal transportation system surrounding the Capitol Corridor route, including roadways and parallel/connecting public transit routes.

As noted in the previous Work Directive #1 documentation, the C/CAG-VTA travel demand model used in the previous analysis was not calibrated or validated for base year (2015) conditions. As part of Work Directive #1, the C/CAG-VTA travel demand model was used to assess the competitiveness of automobile travel against Capitol Corridor in-vehicle travel time per the Capitol Corridor timetable. Further sections in this memorandum detail the calibration and validation of the C/CAG-VTA travel demand model undertaken as part of the current phase (Work Directive #2) of this work. The calibration and validation procedure generally results in a travel demand model that is a more appropriate tool for the development of forecasts.

Work Directive 1 Direct Ridership Model (DRM)

Regional travel demand models often are not sensitive to transit station area characteristics because these characteristics are below the scale at which the model was originally designed for (i.e. regional models versus local-level characteristics). Direct ridership models (DRMs) can be used to supplement regional travel demand models in estimating transit ridership and other associated metrics.

Direct Ridership Models use multivariable regression and other statistical models based on empirical local data to determine the station characteristics that most influence rail transit patronage. They can respond directly to factors such as parking, feeder bus levels, station-area households and employment, and the effects of transit-oriented development (TOD). Direct Ridership Models are a more efficient and responsive means of forecasting the effects of individual station activities than regional travel demand models, which often represent transportation networks and land use at an aggregate scale. Regional models are relatively unresponsive to changes in station-level land use and transit service characteristics. Direct Ridership Models can be directly and quantitatively responsive to land use and transit service characteristics within the immediate vicinity and within the catchment area of existing transit stations.

The CCJPA Work Directive #1 DRM estimated Year 2025 and Year 2040 systemwide and station-to-station ridership, taking into account station area characteristics such as catchment-area population and jobs, service characteristics such as travel time and frequency/headways, transit connections to other population and job centers, and station accessibility by multiple modes. The DRM was estimated for four separate market segments corresponding to markets within or not within the C/CAG-VTA model area:

- Travel between stations exclusively within the MTC area
- Travel between stations exclusively within the SACMET area
- Travel from the SACMET area to the MTC area
- Travel from the MTC area to the SACMET area

In addition to the four travel markets, the DRM has been estimated for two time-of-day periods:

- AM peak "commute"
- Off-peak "non-commute"

A PM peak model was not derived as the AM peak model could be inverted to reasonably reflect PM peak travel. The Direct Ridership Models in Work Directive #1 did not include ridership estimates from the C/CAG-VTA travel demand model as predictor variables because C/CAG-VTA travel demand model performance was deemed to be unsuitable for use without further refinement.

C/CAG-VTA Travel Demand Model

The following subsections outline the performance of the unadjusted off-the-shelf C/CAG-VTA travel demand model, the calibration steps performed, and the improved performance of the model relative to validation targets after calibration.

Off-The-Shelf Model: Project Area Static Validation Statistics

The following sections outline the performance of the off-the-shelf model as compared to validation targets.

Validation Criteria/Thresholds from Industry Standard References

The calibration and validation standards used in this effort followed the industry standards outlined in the following reference documents:

- California Transportation Commission 2017 RTP Guidelines for MPOs
- FHWA/TMIP Travel Model Validation and Reasonableness Checking Manual
- Second Edition (2010), and NCHRP 716 Travel Demand Forecasting: Parameters and Techniques (2012).

Analysis of the C/CAG-VTA model during Work Directive #1 indicated that the level of effort to calibrate the model to reach validation targets may extend beyond Work Directive #2's constraints; in addition, forcing the model to meet validation targets can also lead to model over-fit, which is a condition where a model does not produce reliable forecasts because it is too fixed-in to a particular base year condition. As is typical for most travel demand model calibration and validation efforts (as well as CEQA in general), the standard of performance for calibration and validation efforts for the efforts described in this memorandum was that a good-faith effort was made to improve the performance of the model beyond its state in an off-the-shelf configuration.

The other relevant national guidance on model applications and forecasting is the *NCHRP Report 765, Analytical Travel Forecasting Approaches for Project-Level Planning and Design*, Transportation Research Board, 2014. This is a detailed resource with many applicable sections. A few direct excerpts worth noting about forecasting expectations for models are listed below.

- *A travel forecasting model should be sensitive to those policies and project alternatives that the model is expected to help evaluate*.

- *A travel forecasting model should be capable of satisfying validation standards that are appropriate to the application*.

- *Project-level travel forecasts, to the extent that they follow a conventional travel model, should be validated following the guidelines of the Travel Model Validation and Reasonableness Checking Manual, Second Edition from FHWA. Similar guidelines are provided in NCHRP Report 716. This level of validation is necessary, but not sufficient, for project-level forecasts. Project-level forecasts often require better accuracy than can be obtained from a travel model alone.*

- *The model should be subject to frequent recalibrations to ensure that validation standards are continuously met.*

The following sections describe the static validation tests conducted for the C/CAG-VTA model.

The calibration and validation efforts performed for this phase of the project were focused on the static validation of the C/CAG-VTA travel demand model; that is, improving of the performance of the model relative to a consistent set of land use, demographics and transportation system inputs. Dynamic validation – testing the response of the model to various changes – was not completed as part of this effort because the model has already gone through dynamic testing as part of the overall development of the model, and the DRM provides additional responsiveness to localized land use and transportation network changes relative to the South Bay Connect project description.

Base Year Definition

The base year as defined by the off-the-shelf C/CAG-VTA model is 2015. The various data used in this calibration and validation effort spans from 2010 to 2019. This limitation will be considered while determining conclusions from the calibration and validation effort.

Land Use

Table 1 compares the county and region-level households and employment between the travel model and available data for the year 2015.

Table 1: Off-The-Shelf C/CAG-VTA Model Year 2015 Land Use Comparison

County	Observed Data 2015		C/CAG-VTA Model 2015 Land Use		Difference (%)	
	Households[1]	Employment[2]	Households	Employment	Households	Employment
Alameda	558,907	751,240	583,005	749,069	4%	0%
Contra Costa	384,646	359,762	397,837	359,323	3%	0%
Marin	103,670	112,471	107,283	112,046	3%	0%
Napa	49,494	73,604	51,608	73,590	4%	0%
San Francisco	353,287	700,616	366,052	700,037	4%	0%
San Mateo	259,711	387,932	267,564	377,206	3%	-3%
Santa Clara	621,463	1,006,868	627,871	1,001,555	1%	-1%
Solano	143,612	144,473	147,905	144,242	3%	0%
Sonoma	187,782	193,045	192,226	192,976	2%	0%
Bay Area	***2,662,572***	***3,730,011***	***2,741,351***	***3,710,044***	***3%***	***-1%***

1. Census American Community Survey, 2015 Data Profile.
2. Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES), 2015.

Source: Fehr & Peers, 2020.

The off-the-shelf model reasonably captures land use in the nine-county Bay Area at the county level. The model slightly over-represents households, which may be due to the fact that the observed data measures occupied housing units. The model slightly under-represents employment in San Mateo and Santa Clara counties. This is consistent with other planning tools that have had issues keeping current with the explosion of employment growth on the Peninsula.

Highway Assignment

The *2017 RTP Guidelines* published by the California Transportation Commission references the following list of possible validation measures (as originally specified in the *Travel Forecasting Guidelines*, Caltrans, 1992):

<u>Volume-to-Count Ratio</u> – divides the model volume by the traffic count for individual roadways within the sub-area of the model being validated.

<u>Percent of Links Within Caltrans Deviation Allowance</u> – the difference between the model and actual traffic count divided by the actual traffic count. The result is evaluated against prescribed deviation thresholds.

Correlation Coefficient – estimates the correlation (strength and direction of the linear relationship) between the actual traffic counts and the estimated volumes from the model.

Percent Root Mean Square Error (%RMSE) – the square root of the model volume minus the actual count squared divided by the number of counts. The %RMSE is similar to standard deviation in that it assesses the accuracy of the model.

These tests were performed at locations designed to test the model's ability to replicate traffic volumes on major interregional facilities (e.g. I-880, SR 92 and SR 84), where data was readily available. The decision to focus on these major interregional facilities was made on the basis of Capitol Corridor generally serving longer-distance interregional trips.

Table 2 presents a comparison of model volumes against traffic count data using the validation thresholds for AM peak period, PM peak period, and daily conditions. Green shading indicates the threshold was met, orange shading indicates the threshold was not met.

Table 2: Off-The-Shelf C/CAG-VTA Model Year 2015 Highway Validation

Validation Measure	AM Peak Period	PM Peak Period	Daily	Threshold
Volume-to-Count Ratio	1.21	1.01	1.05	+/- 10%
Percent of Links Within Deviation Allowance	41.7%	75.0%	58.3%	At Least 75%
Percent Root Mean Square Error	28.1%	15.5%	18.6%	Below 40%
Correlation Coefficient	0.96	0.96	0.95	At Least 0.88
Number of Validation Locations	12	12	12	

Source: Fehr & Peers, 2020.

The performance of the off-the-shelf model is generally acceptable, although it is important to note that validation was performed on a limited number of locations. However, the model performance during the AM peak period is of concern, particularly given the importance of the AM peak in overall traveler behavior, especially for a commuter rail service such as Capitol Corridor.

Transit Assignment

The *2017 RTP Guidelines* published by the California Transportation Commission recommends the following transit assignment standards:

- Difference between actual counts and model results for a given year by route group (e.g. local bus, express bus, etc.): +/- 20%

- Difference between actual counts and model results for a given year by Transit Mode (e.g., light rail, bus, etc.): +/- 10%

For the purposes of this evaluation, the +/- 10% threshold was used and evaluated at the transit operator system and station level. The major transit operators were evaluated at the system level, while Capitol Corridor was also evaluated at the station level. Green shading indicates the threshold was met, orange shading indicates the threshold was not met.

Table 3 presents the system level validation. Note that Capitol Corridor ridership is presented two ways: one as the entire system and another including ridership only within the MTC nine-county Bay Area, which is closer to the extents of the C/CAG-VTA model.

Table 3: Off-The-Shelf C/CAG-VTA Model Year 2015 Daily Transit Systemwide Boardings Validation

Operator	Observed Data[1] 2015/2019	C/CAG-VTA Model 2015	Difference	Threshold
BART	452,126	492,003	9%	+/- 10%
Caltrain	66,921	79,547	19%	+/- 10%
Capitol Corridor	6,114	3,285	-46%	+/- 10%
Capitol Corridor (within MTC)	1,942	3,285	69%	+/- 10%
ACE	4,782	4,480	-6%	+/- 10%
AC Transit (Transbay)	14,500	18,683	29%	+/- 10%

1. National Transit Database (NTD), 2015. Capitol Corridor, 2019.
Source: Fehr & Peers, 2020.

The performance of the off-the-shelf model is generally poor but at a higher, systemwide level does perform adequately for very large operators such as BART. The model does not accurately represent Capitol Corridor ridership well, partially because the model boundary does not extend to Sacramento. After filtering the observed ridership to match the representation of Capitol Corridor in the model (only within the MTC nine-county Bay Area), the model is shown to overestimate Capitol Corridor ridership at a system level.

Table 4 presents the Capitol Corridor station level validation.

Table 4: Off-The-Shelf C/CAG-VTA Model Year 2015 Daily Capitol Corridor Station Boardings Validation

Station	Observed Data[1] 2019	Observed Data within MTC 2019	C/CAG-VTA Model 2015	Difference within MTC	Threshold
Auburn	30	-	-	-	-
Berkeley	308	133	92	-31%	+/- 10%
Davis	616	-	-	-	-
Emeryville	691	236	538	128%	+/- 10%
Fairfield	192	162	0	-100%	+/- 10%
Fremont	70	41	292	612%	+/- 10%
Great America	346	292	95	-67%	+/- 10%
Hayward	139	112	133	19%	+/- 10%
Martinez	319	116	44	-62%	+/- 10%
Coliseum	140	89	268	201%	+/- 10%
Jack London	554	257	385	50%	+/- 10%
Richmond	377	74	469	534%	+/- 10%
Rocklin	42	-	-	-	-
Roseville	92	-	-	-	-
Sacramento	1,553	-	-	-	-
Santa Clara	124	102	331	225%	+/- 10%
Diridon	293	191	237	24%	+/- 10%
Suisun City	228	138	401	191%	+/- 10%
Systemwide	**6,114**	**1,942**	**3,285**	**69%**	**+/- 10%**

1. Capitol Corridor Ridership Data, April 2019.
Source: Fehr & Peers, 2020.

Consistent with the system level summaries, the model does not accurately represent Capitol Corridor ridership well. After filtering the observed ridership to match the representation of Capitol Corridor in the model (only within the MTC nine-county Bay Area), the model is shown to overestimate Capitol Corridor ridership, significantly so in locations with connections to other major operators such as Fremont and Richmond.

Auto Travel Times

Table 5 compares CCJPA corridor auto travel time validation.

Table 5: Off-The-Shelf C/CAG-VTA Model Year 2015 Auto Travel Times (Minutes) Validation

Segment	Observed Data[1] 2018			C/CAG-VTA Model 2015			Difference		
	AM Period	Midday	PM Period	AM Period	Midday	PM Period	AM Period	Midday	PM Period
Westbound I-80 and Southbound I-880 (Davis to San Jose)									
SR 113 (Davis) to I-680	27.4	26.4	25.8	32.2	30.9	30.5	18%	17%	18%
I-680 to SR 4	21.1	15.5	15.4	22.3	17.8	17.2	6%	15%	12%
SR 4 to MacArthur Maze	32.5	28.4	29.0	27.2	18.8	18.0	-16%	-34%	-38%
MacArthur Maze to SR 92	24.1	23.1	32.6	21.6	19.2	23.4	-10%	-17%	-28%
SR 92 to SR 84	13.2	6.6	7.6	10.0	8.4	9.8	-24%	28%	29%
SR 84 to I-280	28.2	20.4	26.0	30.5	24.8	26.4	8%	22%	2%
SR 113 (Davis) to I-280	*146.5*	*120.4*	*136.4*	*143.8*	*119.9*	*125.2*	*-2%*	*0%*	*-8%*
Northbound I-880 and Eastbound I-80 (San Jose to Davis)									
I-280 to SR 84	21.0	19.7	35.4	27.6	28.0	34.9	31%	42%	-1%
SR 84 to SR 92	6.8	7.0	17.7	15.9	16.8	24.9	134%	139%	41%
SR 92 to MacArthur Maze	28.7	23.1	22.1	14.6	16.9	28.8	-49%	-27%	30%
MacArthur Maze to SR 4	15.0	16.9	55.0	20.4	18.5	23.9	36%	10%	-57%
SR 4 to I-680	16.0	16.3	26.3	8.1	7.1	10.6	-49%	-56%	-60%
I-680 to SR 113 (Davis)	26.7	26.4	31.6	25.0	22.9	32.9	-6%	-13%	4%
I-280 to SR 113 (Davis)	*114.2*	*109.4*	*188.1*	*111.6*	*110.2*	*156.0*	*-2%*	*1%*	*-17%*

1. INRIX, 2018.
Source: Fehr & Peers, 2020.

The performance of the off-the-shelf model is generally good at the Davis to San Jose corridor level but is volatile on individual segment level. In particular, the model performs the worst in highly congested areas such as the I-80 corridor between SR 4 and the MacArthur Maze and the I-880 corridor between the MacArthur Maze and SR 84 in both directions. This is to be expected as travel demand models frequently overestimate or underestimate the physical extents of congestion.

Transit Mode Share

To help validate spatial metrics from the C/CAG-VTA model, the nine-county Bay Area was split into "market areas". **Figure 1** presents the five markets: Northern Market, San Francisco Market, South Bay & Peninsula Market, Eastern Market, and South Alameda County.

Table 6 presents the market-to-market transit mode share, including all transit modes (e.g. bus, light rail, heavy rail, commuter rail).

Figure 1 *Capitol Corridor Market Areas*

Table 6: Off-The-Shelf C/CAG-VTA Model Year 2015 Market-to-Market All Transit Mode Share Validation

C/CAG-VTA Model (2015)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	3%	27%	2%	2%	11%
San Francisco	8%	18%	5%	4%	18%
South Bay & Peninsula	6%	13%	4%	1%	4%
Eastern	2%	33%	1%	2%	2%
South Alameda County	10%	43%	2%	3%	5%
Observed Data[1] (2012)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	2%	43%	16%	0%	17%
San Francisco	31%	14%	13%	33%	52%
South Bay & Peninsula	16%	17%	3%	1%	5%
Eastern	2%	27%	4%	0%	4%
South Alameda County	14%	58%	6%	2%	4%
Difference (Percentage Points)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	1%	-16%	-14%	2%	-6%
San Francisco	-23%	4%	-8%	-29%	-34%
South Bay & Peninsula	-10%	-4%	1%	0%	-1%
Eastern	0%	6%	-3%	2%	-2%
South Alameda County	-4%	-15%	-4%	1%	1%

1. California Household Travel Survey (CHTS), 2012.

Source: Fehr & Peers, 2020.

The model estimates all transit mode share relatively well with the South Bay & Peninsula and South Alameda County markets. As this is the C/CAG-VTA model, it makes sense that those would be a priority to be the most accurate. Performance relative to validation targets is reduced for areas farther away from the core C/CAG-VTA area.

Table 7 presents the market-to-market transit mode share for rail transit modes.

Table 7: Off-The-Shelf C/CAG-VTA Model Year 2015 Market-to-Market Rail Transit Only Mode Share Validation

C/CAG-VTA Model (2015)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	0%	25%	2%	1%	8%
San Francisco	6%	9%	4%	4%	17%
South Bay & Peninsula	5%	12%	1%	1%	2%
Eastern	1%	33%	1%	0%	2%
South Alameda County	5%	42%	2%	1%	2%
Observed Data[1] (2012)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	1%	35%	16%	0%	15%
San Francisco	29%	6%	12%	33%	49%
South Bay & Peninsula	9%	16%	1%	1%	5%
Eastern	1%	27%	3%	0%	4%
South Alameda County	10%	52%	2%	1%	1%
Difference (Percentage Points)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	-1%	-10%	-14%	1%	-7%
San Francisco	-23%	3%	-8%	-29%	-32%
South Bay & Peninsula	-4%	-4%	0%	0%	-3%
Eastern	0%	6%	-2%	0%	-2%
South Alameda County	-5%	-10%	0%	0%	1%

1. California Household Travel Survey (CHTS), 2012.
Source: Fehr & Peers, 2020.

Similar to the all transit mode share, the model estimates rail transit mode share relatively well within the South Bay & Peninsula and South Alameda County markets. As this is the C/CAG-VTA model, it makes sense that those would be a priority to be the most accurate. Performance relative to validation targets is reduced for areas farther away from the core C/CAG-VTA area.

Trip Distribution

Table 8 presents the market-to-market person trip flow distribution. The results shown are the percentage of trips from market-to-market by row. The table reads as "according to the C/CAG-VTA model, 89% of trips that start in the Northern Market end in the Northern Market." This comparison is step is key to ascertain how the model routes overall trips between regions. The checks in the trip distribution step are focused on the nine-county Bay Area.

Table 8: Off-The-Shelf C/CAG-VTA Model Year 2015 Market-to-Market Person Trip Flow Trip Distribution Validation

C/CAG-VTA Model (2015)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	89%	4%	1%	2%	4%
San Francisco	7%	82%	7%	0%	4%
South Bay & Peninsula	1%	3%	92%	0%	4%
Eastern	18%	2%	5%	61%	14%
South Alameda County	8%	4%	8%	3%	77%
Observed Data[1] (2018)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	96%	1%	0%	1%	2%
San Francisco	2%	89%	7%	0%	2%
South Bay & Peninsula	1%	2%	95%	0%	2%
Eastern	4%	0%	1%	91%	4%
South Alameda County	6%	3%	9%	3%	79%
Difference (Percentage Points)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	-7%	3%	1%	1%	2%
San Francisco	5%	-7%	0%	0%	2%
South Bay & Peninsula	0%	1%	-3%	0%	2%
Eastern	14%	2%	4%	-30%	10%
South Alameda County	2%	1%	-1%	0%	-2%

1. StreetLight Data, 2018.
Source: Fehr & Peers, 2020.

The model appears to estimate trip distribution relatively well for most markets, with the exception of the Eastern Market. Performance relative to validation targets is reduced for areas farther away from the core C/CAG-VTA area.

Vehicle Trip Length

Table 9 presents the average vehicle trip lengths by county in miles.

Table 9: Off-The-Shelf C/CAG-VTA Model Year 2015 Vehicle Trip Length Validation

County	C/CAG-VTA Model 2015	Observed Data[1] 2012	Difference (%)
Alameda	8.7	6.0	43%
Contra Costa	9.3	6.1	52%
Marin	8.4	6.4	31%
Napa	8.2	6.1	34%
San Francisco	8.5	6.5	31%
San Mateo	8.3	6.6	26%
Santa Clara	7.8	6.0	30%
Solano	9.6	6.5	47%
Sonoma	9.8	6.1	60%
Bay Area	***8.6***	***6.2***	***38%***

1. California Household Travel Survey (CHTS), 2012.
Source: Fehr & Peers, 2020.

The model appears to be significantly over-estimating trip lengths model-wide.

Model Input Updates

To help calibrate the C/CAG-VTA model to existing conditions, the land use and transportation networks were updated to better reflect 2018 conditions.

Land Use

The model land use inputs were updated based on the best local data available from the C/CAG-VTA, AMBAG, CCTA, Alameda CTC, and STA models. The C/CAG-VTA Model land use was used as a base, but the household, population, income, age, employment, and education variables were updated using the "local" regional models that cover the nine-county Bay Area.

Prior to using the C/CAG-VTA model as a base, the land use was updated for the most recent employment forecasts in San Mateo County, which indicate a growth in technology sector jobs that far outpaces the estimates as presented in Plan Bay Area.

Table 10 compares the county and region-level households and employment between off-the-shelf 2015 and updated 2018 model.

Table 10: C/CAG-VTA Model Year 2018 Land Use Comparison

County	C/CAG-VTA Model 2015 Land Use		C/CAG-VTA Model 2018 Land Use		Difference (%)	
	Households	Employment	Households	Employment	Households	Employment
Alameda	583,005	749,069	595,896	770,457	2%	3%
Contra Costa	397,837	359,323	389,338	399,415	-2%	11%
Marin	107,283	112,046	108,006	116,170	1%	4%
Napa	51,608	73,590	50,837	77,362	-1%	5%
San Francisco	366,052	700,037	375,861	738,095	3%	5%
San Mateo	267,564	377,206	269,741	403,840	1%	7%
Santa Clara	627,871	1,001,555	637,398	1,069,901	2%	7%
Solano	147,905	144,242	146,490	141,093	-1%	-2%
Sonoma	192,226	192,976	195,873	202,086	2%	5%
Bay Area	***2,741,351***	***3,710,044***	***2,769,439***	***3,918,419***	***1%***	***6%***

Source: Fehr & Peers, 2020.

Transportation Network Updates

The transportation network from the 2015 off-the-shelf model was updated to represent 2018 existing conditions more accurately.

Highway Network

The highway network in the project area was reviewed and it was determined that no changes were needed to be made to reflect improvements that would have a substantial effect on model outputs.

Transit Network

Various transit network changes were made to better reflect operator service patterns in 2018. Operators that were reviewed and updated include BART, Caltrain, Capitol Corridor, ACE, and AC Transit.

The most significant change was the inclusion of the BART Warm Springs station, which opened in 2017.

Active Transportation Network

The active transportation network in the project area was reviewed and it was determined that no changes were needed to be made to reflect improvements that would have a substantial effect on model outputs.

Calibrated Model: Project Area Static Validation Statistics

The following sections outline the performance of the off-the-shelf model as compared to validation targets.

Land Use

Table 11 compares the county and region-level households and employment between the updated travel model and available data for the year 2018.

Table 11: C/CAG-VTA Model Year 2018 Land Use Comparison

County	Observed Data[1] (2017/2018)		C/CAG-VTA Model 2018 Land Use		Difference (%)	
	Households[1]	Employment[2]	Households	Employment	Households	Employment
Alameda	572,870	788,852	595,896	770,457	4%	-2%
Contra Costa	392,277	375,252	389,338	399,415	-1%	6%
Marin	105,258	113,255	108,006	116,170	3%	3%
Napa	49,032	74,858	50,837	77,362	4%	3%
San Francisco	359,673	723,907	375,861	738,095	5%	2%
San Mateo	261,969	399,024	269,741	403,840	3%	1%
Santa Clara	635,525	1,060,260	637,398	1,069,901	0%	1%
Solano	149,067	148,424	146,490	141,093	-2%	-5%
Sonoma	189,339	201,244	195,873	202,086	3%	0%
Bay Area	***2,715,010***	***3,885,076***	***2,769,439***	***3,918,419***	***2%***	***1%***

1. Census American Community Survey, 2018 Data Profile.
2. Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES), 2017.

Source: Fehr & Peers, 2020.

The calibrated 2018 model reasonably captures land use in the nine-county Bay Area at the county level. The calibrated model still slightly over-represents households which may be due to the fact that the observed data measures occupied housing units. The calibrated model better represents employment in San Mateo and Santa Clara counties, capturing the explosion of employment growth on the Peninsula.

Highway Assignment

Table 12 presents a comparison of model volumes to traffic count data using the validation thresholds for AM peak period, PM peak period, and daily conditions. Green shading indicates the threshold was met, orange shading indicates the threshold was not met.

Table 12: Calibrated C/CAG-VTA Model Year 2018 Highway Validation

Validation Measure	AM Peak Period	PM Peak Period	Daily	Threshold
Volume-to-Count Ratio	1.22	1.03	1.09	+/- 10%
Percent of Links Within Deviation Allowance	41.7%	66.7%	50.0%	At Least 75%
Percent Root Mean Square Error	30.2%	16.3%	21.1%	Below 40%
Correlation Coefficient	0.96	0.96	0.94	At Least 0.88
Number of Validation Locations	12	12	12	

Source: Fehr & Peers, 2020.

The calibrated model performs similarly to the off-the-shelf model. The performance is generally acceptable, although it is important to note that validation was performed on a limited number of locations. However, the model performance during the AM peak period is of concern, particularly given the importance of the AM peak in overall traveler behavior, especially for a commuter rail service such as Capitol Corridor.

Transit Assignment

Table 13 presents the system level validation.

Table 13: Calibrated C/CAG-VTA Model Year 2018 Daily Transit Systemwide Boardings Validation

Operator	Observed Data[1] 2018/2019	C/CAG-VTA Model 2018	Difference	Threshold
BART	447,776	589,389	32%	+/- 10%
Caltrain	66,311	82,518	24%	+/- 10%
Capitol Corridor	6,114	4,096	-33%	+/- 10%
Capitol Corridor (within MTC)	1,942	4,096	111%	+/- 10%
ACE	5,529	4,830	-13%	+/- 10%
AC Transit (Transbay)	13,763	16,882	23%	+/- 10%

1. National Transit Database (NTD), 2018. Capitol Corridor, 2019.
Source: Fehr & Peers, 2020.

The performance of the calibrated model is similar to the off-the-shelf model. It is generally poor for all operators. The model does not accurately represent Capitol Corridor ridership well, partially because the model boundary does not extend to Sacramento. After filtering the observed ridership to match the representation of Capitol Corridor in the model (only within the MTC nine-county Bay Area), the model is shown to overestimate Capitol Corridor ridership at a system level.

Table 14 presents the Capitol Corridor station level validation.

Table 14: Calibrated C/CAG-VTA Model Year 2018 Daily Capitol Corridor Station Boardings Validation

Station	Observed Data[1] 2019	Observed Data within MTC 2019	C/CAG-VTA Model 2018	Difference	Threshold
Auburn	30	-	-	-	-
Berkeley	308	133	66	-50%	+/- 10%
Davis	616	-	-	-	-
Emeryville	691	236	304	29%	+/- 10%
Fairfield	192	162	0	-100%	+/- 10%
Fremont	70	41	418	920%	+/- 10%
Great America	346	292	359	23%	+/- 10%
Hayward	139	112	168	50%	+/- 10%
Martinez	319	116	64	-45%	+/- 10%
Coliseum	140	89	296	233%	+/- 10%
Jack London	554	257	301	17%	+/- 10%
Richmond	377	74	716	868%	+/- 10%
Rocklin	42	-	-	-	-
Roseville	92	-	-	-	-
Sacramento	1,553	-	-	-	-
Santa Clara	124	102	451	342%	+/- 10%
Diridon	293	191	284	49%	+/- 10%
Suisun City	228	138	669	385%	+/- 10%
Systemwide	30	-	-	-	**+/- 10%**

1. Capitol Corridor Ridership Data, April 2019.
Source: Fehr & Peers, 2020.

Consistent with the system level summaries, the calibrated model does not accurately represent Capitol Corridor ridership well. After filtering the observed ridership to match the representation of Capitol Corridor in the model (only within the MTC nine-county Bay Area), the model is shown to overestimate Capitol Corridor ridership, significantly so in locations with connections to other major operators such as Fremont and Richmond.

Auto Travel Times

Table 15 compares CCJPA corridor auto travel time validation.

Table 15: Calibrated C/CAG-VTA Model Year 2018 Auto Travel Times (Minutes) Validation

Segment	Observed Data[1] 2018			C/CAG-VTA Model 2018			Difference		
	AM Period	Midday	PM Period	AM Period	Midday	PM Period	AM Period	Midday	PM Period
Westbound I-80 and Southbound I-880 (Davis to San Jose)									
SR 113 (Davis) to I-680	27.4	26.4	25.8	35.6	31.8	29.9	30%	20%	16%
I-680 to SR 4	21.1	15.5	15.4	26.2	19.9	18.5	24%	28%	20%
SR 4 to MacArthur Maze	32.5	28.4	29.0	32.2	20.0	19.8	-1%	-29%	-32%
MacArthur Maze to SR 92	24.1	23.1	32.6	22.1	19.6	24.3	-8%	-15%	-26%
SR 92 to SR 84	13.2	6.6	7.6	10.4	8.4	9.8	-21%	27%	29%
SR 84 to I-280	28.2	20.4	26.0	35.2	25.7	26.5	25%	26%	2%
SR 113 (Davis) to I-280	*146.5*	*120.4*	*136.4*	*161.7*	*125.5*	*128.8*	*10%*	*4%*	*-6%*
Northbound I-880 and Eastbound I-80 (San Jose to Davis)									
I-280 to SR 84	21.0	19.7	35.4	27.5	28.0	37.5	31%	42%	6%
SR 84 to SR 92	6.8	7.0	17.7	16.1	17.2	28.0	136%	146%	58%
SR 92 to MacArthur Maze	28.7	23.1	22.1	14.8	17.8	34.4	-48%	-23%	55%
MacArthur Maze to SR 4	15.0	16.9	55.0	20.2	18.6	23.7	35%	10%	-57%
SR 4 to I-680	16.0	16.3	26.3	7.8	7.0	10.5	-51%	-57%	-60%
I-680 to SR 113 (Davis)	26.7	26.4	31.6	24.3	23.0	35.6	-9%	-13%	13%
I-280 to SR 113 (Davis)	*114.2*	*109.4*	*188.1*	*110.8*	*111.7*	*169.7*	*-3%*	*2%*	*-10%*

1. INRIX, 2018.
Source: Fehr & Peers, 2020.

The performance of the calibrated model is generally in line with the off-the-shelf model; it performs well at the entire corridor level but remains volatile depending on individual segments. The calibrated model does better represent San Jose to Davis travel times on a corridor level. The model still performs the worst in highly congested areas such as the I-80 corridor between SR 4 and the MacArthur Maze and the I-880 corridor between the MacArthur Maze and SR 84 in both directions. This is to be expected as travel demand models frequently overestimate or underestimate the physical extents of congestion.

Transit Mode Share

Table 16 presents the market-to-market transit mode share, including all transit modes (e.g. bus, light rail, heavy rail, commuter rail).

Table 16: Calibrated C/CAG-VTA Model Year 2018 Market-to-Market All Transit Mode Share Validation

C/CAG-VTA Model (2018)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	3%	28%	3%	2%	12%
San Francisco	8%	18%	5%	4%	18%
South Bay & Peninsula	5%	13%	4%	1%	5%
Eastern	2%	39%	2%	2%	3%
South Alameda County	12%	45%	3%	3%	5%
Observed Data[1] (2012)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	2%	43%	16%	0%	17%
San Francisco	31%	14%	13%	33%	52%
South Bay & Peninsula	16%	17%	3%	1%	5%
Eastern	2%	27%	4%	0%	4%
South Alameda County	14%	58%	6%	2%	4%
Difference (Percentage Points)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	1%	-15%	-13%	2%	-5%
San Francisco	-23%	4%	-8%	-29%	-34%
South Bay & Peninsula	-11%	-4%	1%	0%	0%
Eastern	0%	12%	-2%	2%	-1%
South Alameda County	-2%	-13%	-3%	1%	1%

1. California Household Travel Survey (CHTS), 2012.
Source: Fehr & Peers, 2020.

The calibrated model generally performs similar to the off-the-shelf model, with some improvements in the South Alameda County market. Model performance relative to validation targets continues to be impaired in areas farther away from the C/CAG-VTA core area.

Table 17 presents the market-to-market transit mode share for rail transit modes.

Table 17: Calibrated C/CAG-VTA Model Year 2018 Market-to-Market Rail Transit Only Mode Share Validation

C/CAG-VTA Model (2018)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	1%	27%	3%	1%	9%
San Francisco	7%	9%	4%	4%	17%
South Bay & Peninsula	5%	12%	1%	1%	2%
Eastern	1%	39%	2%	0%	2%
South Alameda County	8%	44%	2%	1%	2%
Observed Data[1] (2012)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	1%	35%	16%	0%	15%
San Francisco	29%	6%	12%	33%	49%
South Bay & Peninsula	9%	16%	1%	1%	5%
Eastern	1%	27%	3%	0%	4%
South Alameda County	10%	52%	2%	1%	1%
Difference (Percentage Points)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	0%	-8%	-13%	1%	-6%
San Francisco	-22%	3%	-8%	-29%	-32%
South Bay & Peninsula	-4%	-4%	0%	0%	-3%
Eastern	0%	12%	-1%	0%	-2%
South Alameda County	-2%	-8%	0%	0%	1%

1. California Household Travel Survey (CHTS), 2012.

Source: Fehr & Peers, 2020.

Similar to the all transit mode share, the calibrated model generally performs similar to the off-the-shelf model, with some improvement with the South Alameda County market. Performance relative to validation targets is reduced for areas farther away from the core C/CAG-VTA area.

Trip Distribution

Table 18 presents the market-to-market person trip flow distribution. The results shown are the percentage of trips from market-to-market by row. The table reads as "according to the C/CAG-VTA model, 89% of trips that start in the Northern Market end in the Northern Market." This comparison is step is key to ascertain how the model routes overall trips between regions. The checks in the trip distribution step are focused on the nine-county Bay Area.

Table 18: Calibrated C/CAG-VTA Model Year 2018 Market-to-Market Person Trip Flow Trip Distribution Validation

C/CAG-VTA Model (2018)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	89%	4%	1%	2%	4%
San Francisco	8%	81%	7%	0%	4%
South Bay & Peninsula	1%	3%	92%	0%	4%
Eastern	19%	2%	4%	61%	14%
South Alameda County	8%	5%	9%	3%	75%
Observed Data[1] (2018)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	96%	1%	0%	1%	2%
San Francisco	2%	89%	7%	0%	2%
South Bay & Peninsula	1%	2%	95%	0%	2%
Eastern	4%	0%	1%	91%	4%
South Alameda County	6%	3%	9%	3%	79%
Difference (Percentage Points)					
Market	Northern	San Francisco	South Bay & Peninsula	Eastern	South Alameda County
Northern	-7%	3%	1%	1%	2%
San Francisco	6%	-8%	0%	0%	2%
South Bay & Peninsula	0%	1%	-3%	0%	2%
Eastern	15%	2%	3%	-30%	10%
South Alameda County	2%	2%	0%	0%	-4%

1. StreetLight Data, 2018.
Source: Fehr & Peers, 2020.

The calibrated model generally performs similar to the off-the-shelf model, with some improvement in the South Bay & Peninsula and South Alameda County markets. Performance relative to validation targets is reduced for areas farther away from the core C/CAG-VTA area.

Vehicle Trip Length

Table 19 presents the average vehicle trip lengths by county in miles.

Table 19: Off-The-Shelf C/CAG-VTA Model Year 2015 Vehicle Trip Length Validation

County	C/CAG-VTA Model 2015	Observed Data[1] 2012	Difference (%)
Alameda	8.7	6.0	43%
Contra Costa	9.3	6.1	52%
Marin	8.4	6.4	31%
Napa	8.2	6.1	34%
San Francisco	8.5	6.5	31%
San Mateo	8.3	6.6	26%
Santa Clara	7.8	6.0	30%
Solano	9.6	6.5	47%
Sonoma	9.8	6.1	60%
Bay Area	**8.6**	**6.2**	**38%**

1. California Household Travel Survey (CHTS), 2012.
Source: Fehr & Peers, 2020.

The calibrated model performs similarly to the off-the-shelf model and does not accurately represent vehicle trip lengths, significantly over-estimating trip lengths model-wide.

Conclusions

Although the calibration updates to the C/CAG-VTA model have slightly improved both its overall validation, significant gaps remain. Specifically, it continues to do a fall short with respect to validation checks to determine how the model is representing Capitol Corridor ridership. Additionally, the model extent only reaches the nine-county Bay Area region, and so the significant effects of ridership to and from the Sacramento region cannot be captured by the C/CAG-VTA model alone.

Off-Model Tool Development

To address the limitations of the C/CAG-VTA travel demand model, two sets of off-model tools and procedures have been developed to allow the forecasting process to use data from the C/CAG-VTA model where appropriate. The first tool is enhanced post-processing of data outputs from the calibrated C/CAG-VTA travel demand model to better account for auto travel times and trip distribution parameters. The second tool is a Capitol Corridor-specific Direct Ridership Model, which leverages work previously completed for the South Bay Connect project.

Calibrated Model Post-Processing

This section describes the factors applied to model outputs for use in evaluation of the South Bay Connect project.

Auto Travel Times

Based on the validated model, a high-level comparison of modeled base year auto travel times between existing CCJPA stations and travel times from the INRIX database was completed. This comparison yields a set of factors to be applied to the modeled auto travel times so that modeled travel times better reflect real-world conditions.

Trip Distribution

Based on the validated model, a high-level comparison of modeled base year origin-destination matrix from the Streetlight database was completed. This comparison yields a set of factors to be applied to the modeled origin-destination matrix so that modeled VMT better reflect real-world conditions.

Direct Ridership Model

The proposed approach to developing Direct Ridership Models (DRM) for updated forecasting is similar to the approach from Work Directive #1. DRMs for three periods were developed: AM peak, PM peak, and off-peak. Four separate market segments will be modeled, as in the prior approach. These four market segments correspond to markets within or not within the C/CAG-VTA model area:

- Travel between stations exclusively within the MTC area
- Travel between stations exclusively within the SACMET area
- Travel from the SACMET area to the MTC area
- Travel from the MTC area to the SACMET area

Estimates of mode of access to and egress from Capitol Corridor for the AM peak period have been developed. The approach for mode of access is a blended approach including both the C/CAG-VTA model and an approach similar to the ridership DRM described above. The C/CAG-VTA model forecasts of Capitol Corridor ridership by mode of access have evaluated for their performance in the DRM. The estimates have also been compared to observed data about Capitol Corridor mode of access and egress, at the station level (if available) and at the system level if not. In addition, improved calculations of population and jobs accessible via transit, via walking or biking, and via driving have been incorporated into the DRM and evaluated for their usefulness in addressing the question of mode of access and egress.

The following section describes the potential variables that are included for consideration in the DRM and mode of access models.

Variables

Table 20 lists the variables included in the DRMs from Work Directive #1 as well as two levels of potential inclusion in the revised models. Variables listed as "planned inclusion" are variables for which there is a reasonable level of confidence in their appearance in the final models, while variables listed as "consideration" are variables that are planned to be included in further tests, but for where there is less confidence about whether the final model will reasonably include them.

Table 20: Direct Ridership Model Variables

Variable	Work Directive #1	Work Directive #2	Notes
Employment within ½ or 1 mile of destination	AM (+), OP (+)	AM(+), OP (+)	Test ¼ mile buffer and walk shed as potential replacements
Population within ½ or 1 mile of origin	AM (+), OP (+)	AM (+), OP (+)	Test ¼ mile buffer and walk shed as potential replacements
Employment accessible via transit connection to destination	AM (+), OP (+)	AM (+), OP (+). Replace with improved calculation	
Population accessible via transit connection to origin	AM (+), OP (+)	AM (+), OP (+). Replace with improved calculation	
Capitol Corridor IVT	AM (Sac to Bay only) (-)		Retest for all markets
Auto congested drive time versus Capitol Corridor IVT	AM (+), OP (+)	Replace with improved calculation of auto travel times	
Capitol Corridor frequency	AM (+), OP (+)	AM (+), OP (+)	
C/CAG model Capitol Corridor boardings at origin		AM (+), OP (+)	Possibly segment by mode of access (walk, drive, transit)
C/CAG model Capitol Corridor alightings at destination		AM (+), OP (+)	Possibly segment by mode of egress (walk, drive, transit)
C/CAG model Capitol Corridor station-to-station ridership			Unclear whether C/CAG model will be useful at this level of detail
Auto parking at origin station			Was not significant in Work Directive #1 but will retest
Competing transit IVT			If base year has markets better served by local transit, this variable might help account for effects of BART to San Jose
Fare			May already be sufficiently accounted for in C/CAG-VTA model results.

Source: Fehr & Peers, 2020.

Of note among the planned variables are improved calculations of both jobs and population access to and from Capitol Corridor stations. These calculations are based on modal isochrones which calculate locations reachable by walking, biking, transit, or driving within specific time frames. These isochrones allow the DRM to potentially develop sensitivity not only to nearby population and employment but to the ease of reaching that population and employment via various modes of access or egress. Example maps of the isochrone analysis are shown in **Figures 2 and 3** below.

Figure 2. Example of walk accessibility isochrones

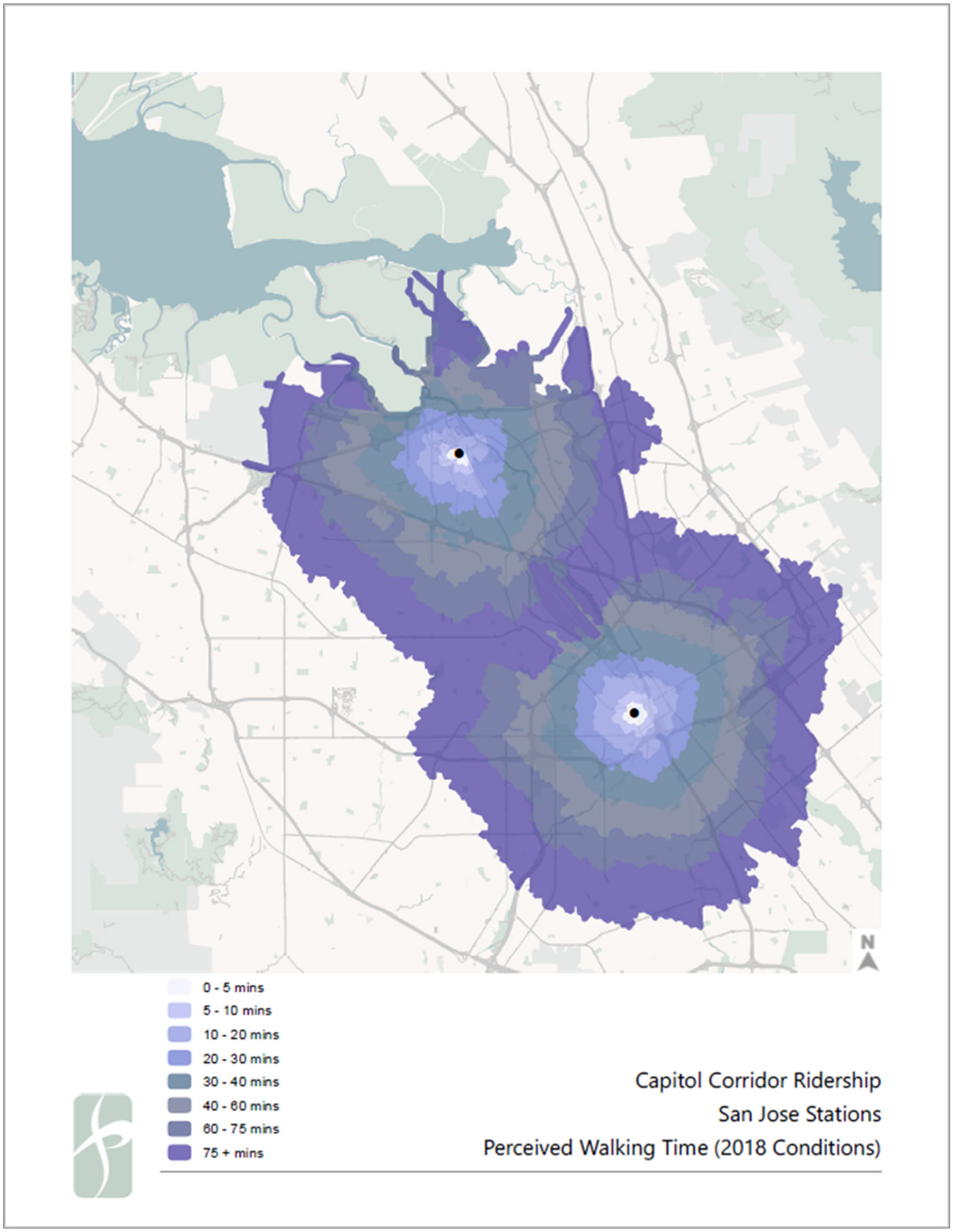
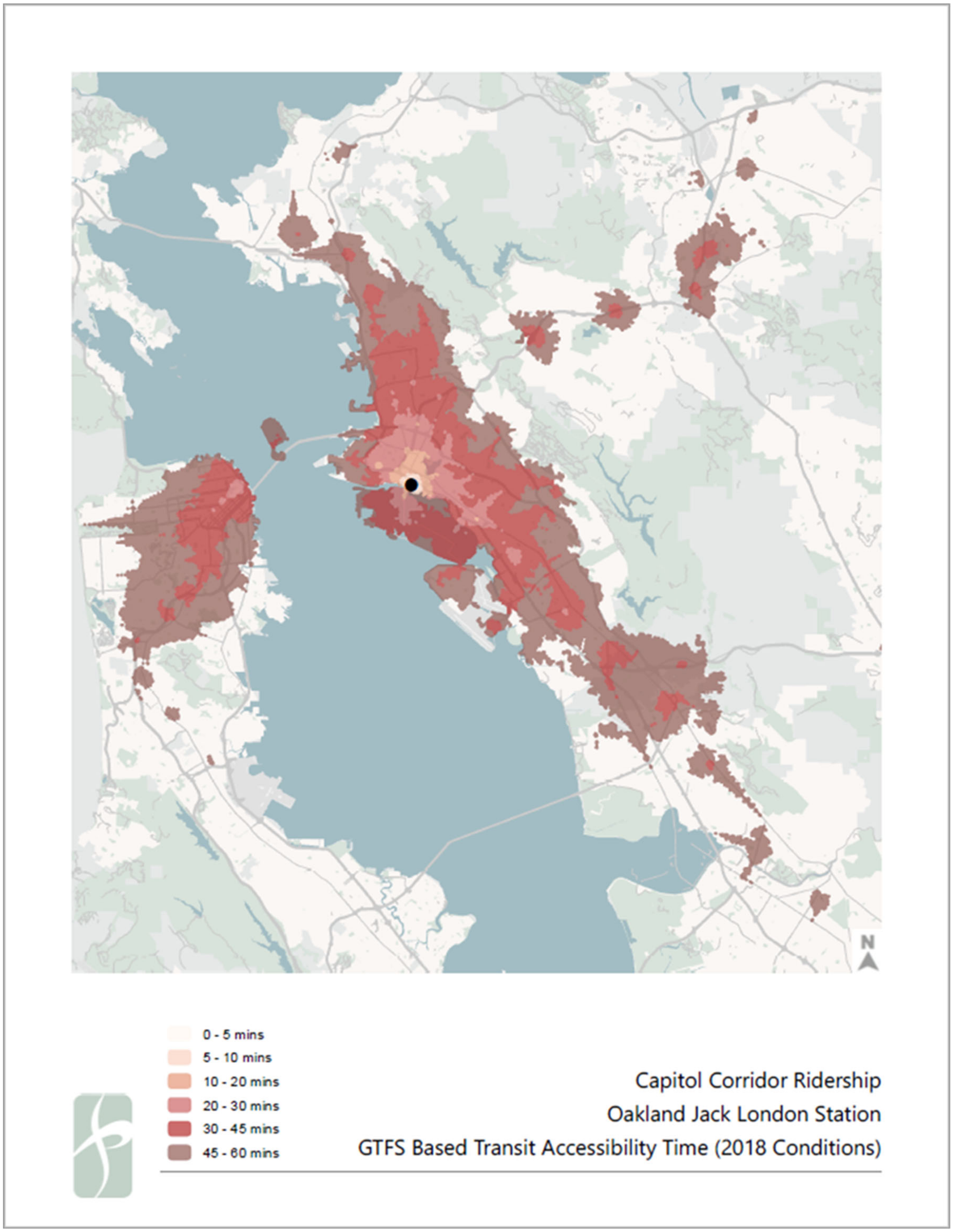


Figure 3. Example of transit accessibility isochrones



Next Steps

The next steps in the forecasting process is to begin the setup of future year No Project and Plus Project model analysis scenarios. The following transportation network and land use assumptions are proposed to be used in the future year forecasting efforts; these assumptions are largely unchanged from the previous forecasting efforts, with minor modifications to reflect the latest land use and transportation plans for the Bay Area region.

Future Transportation Network Assumptions

Table 21 summarizes proposed transportation network changes (versus the base year model assumptions) in the 2025 and 2040 scenarios.

Table 21: Proposed Future Network Assumptions

Project	Forecast Year	Approach
ACE	2025	Same as 2018
	2040	10 daily ACE roundtrips (+4 from today)
Caltrain	2025	6-train per hour Zone Express Service
	2040	8-train per hour Moderate Growth Plan
Hollister Express Bus	2025	Not included
	2040	Hourly integrated express bus service between Gilroy and Hollister
Salinas Rail	2025	No service
	2040	Hourly service between Gilroy and Salinas; hub station at Pajaro/Watsonville providing hourly connections to Santa Cruz; hub station at Castroville providing hourly connections to Monterey.
Dumbarton Rail	2025	Not included
	2040	Rail shuttle from Union City BART station to Redwood City Caltrain station: 4 trains per hour per direction peak, 2 trains per hour per direction off-peak.
US-101 Managed Lanes	2025	Add HOT lane in San Mateo County south of I-380
	2040	Convert a lane to a HOT lane between I-380 and I-280; convert a southbound lane to a HOT lane on I-280 north of US-101.
SamTrans Express Bus	2025	Four express routes as presented in SamTrans Express Bus study
	2040	Six more express routes as presented in SamTrans Express Bus study.

Future Land Use Assumptions

For 2040 Land Use, two options are available for consideration. One option is to use the 2040 Plan Bay Area forecasts, updated to be consistent with the base year land use updates described above. However, the peninsula has already seen a significant number of additional projects not included in Plan Bay Area forecasts but nevertheless approved by the relevant cities. These projects account for an additional 12,000 population and 115,000 jobs as shown in **Table 22**, and could optionally be incorporated into the 2040 land use assumptions.

Table 22: Potential Additional 2040 Land Use Beyond Plan Bay Area

City	Plan	Population Added beyond Plan Bay Area	Employment Added beyond Plan Bay Area	Notes
San Francisco	Central SoMa	12,000	38,000	Approved by Planning Commission; Board of Supervisors has not approved yet
South San Francisco	East of US 101 employment	-	11,000	Approved / Under construction. ~13 individual biotech projects approved/under construction totaling 7 MSF
San Bruno	Transit Corridors Plan	-	3,000	Approved
Millbrae	Station Plan	-	3,000	Approved
Redwood City	Stanford Healthcare Camus	-	4,000	Approved
Palo Alto / Stanford	Stanford Research Park expansion and Stanford Hospital expansion	-	6,000	Approved
Mountain View	North Bayshore Precise Plan	-	21,000	Approved
Cupertino	Apple Campus	-	8,000	Complete
Sunnyvale	Peery Park Specific Plan	-	10,000	Approved
	Moffett Towers	-	3,000	Approved
Santa Clara	City Place	-	8,000	Approved
Total		**12,000**	**115,000**	

Attachment B: Forecasting Methodology Details

Direct Ridership Models

Methodology

This section outlines the details of the statistical models developed as the Direct Ridership Model for Capitol Corridor. Twelve independent linear regression models were developed, one for each combination of time period and market segment. Each of the twelve statistical models comprising the DRM has a similar structure. Broadly speaking, these models can be defined by the following equation for a linear model:

$$Y_{i,j} = \alpha * X_i * + \beta * X_j + \gamma * X_{i.j}$$

where:

- *$Y_{i,j}$ is the estimated ridership going from origin station i to destination station j*
- *X_i is a vector of station-specific input variables associated with the origin station i*
- *X_j is a vector of station-specific input variables associated with destination station j*
- *$X_{i,j}$ is a vector of input variables associated with the station origin-destination (OD) pair i and j*
- *$\alpha, \beta,$ and γ are vectors of model coefficients associated with X_i, X_j, and $X_{i,j}$ respectively*

In practice, it was found that station-specific input variables on their own did not perform well in the models, so these variables were always combined by multiplying together an origin-specific variable and a destination-specific variable to create a variable associated with the OD-pair.

Mode of Access/Egress Models

Methodology

The MoA models are logit models that have been transformed via Berkson's method[3] to linear regression models. These models jointly predict mode shares for each of three modes of access and egress: auto, transit, and walk. The model dependent variable was developed using results from the Capitol Corridor on-board survey conducted in June 2019.

3 Li, W. et al. "Assessing the Performance of Berkson-Theil Method on Multiple Choice Sets and Aggregated Choice Data." (2017).

The model assigns each access mode a utility equation which describes the benefits and costs of travel by that mode. Variables were selected for the final models based on their contribution to the overall goodness-of-fit of the respective model.

The MoA modes were developed such that as the proportion (or likelihood) of one mode increases, the likelihood of using the other modes decreases. The station access mode share is estimated according to the following equation:

$$P_i = \frac{e^{V_i}}{\sum_{j \in J} e^{V_j}}$$

$where\ i, j = particular\ modes\ of\ access$
$Pi = probability\ of\ using\ mode\ i\ to\ access\ the\ station$
$J = the\ set\ of\ all\ possible\ modes\ of\ access$
$= \{\text{Auto, Transit, Active}\}$
$Vi = linear - in - parameters\ utility\ fucntion = \boldsymbol{\beta} * \boldsymbol{X}$
$\boldsymbol{X} = a\ vector\ of\ explanatory\ variables$
$\boldsymbol{\beta} = a\ vector\ of\ coefficients$

Model Fit

To measure the fit of the mode of access and egress models, percent root-mean-square error (RMSE) was calculated for each model and each mode. The results of the goodness of fit tests are presented in **Table B1.**

Table B1: Model Goodness of Fit (Percent RMSE)

Model	Active	Transit	Auto
AM Mode of Access	1.36	1.74	0.39
AM Mode of Egress	0.53	0.59	0.52

Source: Fehr & Peers, 2021.

The percent RMSE values are relatively high, indicating that there is variation in mode of access that is not being fully captured by the MoA models. In the future, additional data from the on-board survey could prove helpful, as demographic data including vehicle ownership or household income might help improve these models. However, the MoA models are suitable for use in the translation of forecasted ridership at the new Ardenwood station to walk, bike, and vehicle volumes, as well as to understand the number of Capitol Corridor passengers transferring to connecting transit service at Ardenwood station.

Attachment C: Detailed Forecasts

This section contains detailed tables from the forecasts of ridership, mode of access, and C/CAG-VTA model results.

Station-Level Ridership

Table C1 shows forecast daily boardings for all stations.

Table C1: Forecast Daily Boardings by Station

Station	Observed Data[1] 2019	No project 2025	With Project 2025	No project 2040	With Project 2040
Auburn	30	36	36	56	56
Rocklin	41	72	72	114	114
Roseville	91	115	115	1,058	1,039
Sacramento	1,553	2,410	2,423	4,106	4,139
Davis	616	906	922	1,456	1,467
Fairfield	191	352	371	666	670
Suisun City	228	497	516	946	951
Martinez	320	478	503	777	802
Richmond	377	555	587	949	983
Berkeley	306	477	517	773	823
Emeryville	691	1,021	1,080	1,786	1,853
Jack London	555	869	944	1,478	1,575
Coliseum	141	295	342	627	685
Hayward	139	235	0	434	0
Ardenwood	0	0	754	0	1,170
Fremont	71	180	0	389	0
Great America	346	818	981	1,135	1,320
Santa Clara	123	271	347	648	756
Diridon	294	465	544	838	950
Systemwide	***6,113***	**10,052**	**11,054**	**18,236**	**19,353**

Source: Fehr & Peers, 2021.

Table C2 shows forecast AM peak boardings for all stations.

Table C2 Forecast AM Peak Boardings by Station

Station	Observed Data[1] 2019	No project 2025	With Project 2025	No project 2040	With Project 2040
Auburn	30	35	35	52	52
Rocklin	41	69	69	108	108
Roseville	91	112	112	339	344
Sacramento	636	1,028	1,048	1,831	1,882
Davis	281	374	381	557	569
Fairfield	153	196	200	291	294
Suisun City	153	231	236	387	393
Martinez	156	245	258	386	402
Richmond	73	129	148	264	285
Berkeley	140	232	255	370	403
Emeryville	130	227	257	431	465
Jack London	222	366	415	545	611
Coliseum	78	129	164	258	302
Hayward	115	164	0	284	0
Ardenwood	0	0	396	0	591
Fremont	43	100	0	220	0
Great America	28	74	124	195	263
Santa Clara	19	81	130	193	253
Diridon	71	136	185	241	309
Systemwide	***2,460***	**3,928**	**4,413**	**6,952**	**7,526**

Source: Fehr & Peers, 2021.

Table C3 shows forecast PM peak boardings for all stations.

Table C3: Forecast PM Peak Boardings by Station

Station	Observed Data[1] 2019	No project 2025	With Project 2025	No project 2040	With Project 2040
Auburn	0	0	0	0	0
Rocklin	0	0	0	0	0
Roseville	0	2	2	332	317
Sacramento	451	672	662	1,030	1,012
Davis	157	250	244	410	400
Fairfield	14	60	61	154	148
Suisun City	30	111	112	236	232
Martinez	79	120	133	231	243
Richmond	219	258	271	360	373
Berkeley	122	161	178	273	290
Emeryville	434	597	627	1,048	1,081
Jack London	237	364	390	696	727
Coliseum	46	100	107	231	244
Hayward	18	37	0	77	0
Ardenwood	0	0	286	0	446
Fremont	20	38	0	75	0
Great America	289	619	712	769	859
Santa Clara	87	138	158	328	365
Diridon	177	242	266	432	471
Systemwide	***2,380***	**3,769**	**4,209**	**6,682**	**7,208**
Source: Fehr & Peers, 2021.					

Table C4 shows forecast Off Peak boardings for all stations.

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Table C4: Forecast Off Peak Boardings by Station

Station	Observed Data[1] 2019	No project 2025	With Project 2025	No project 2040	With Project 2040
Auburn	0	1	1	4	4
Rocklin	0	3	3	6	6
Roseville	0	1	1	387	378
Sacramento	468	710	713	1,245	1,245
Davis	178	282	297	489	498
Fairfield	26	96	110	221	228
Suisun City	43	155	168	323	326
Martinez	85	113	112	160	157
Richmond	83	168	168	325	325
Berkeley	44	84	84	130	130
Emeryville	125	197	196	307	307
Jack London	97	139	139	237	237
Coliseum	15	66	71	138	139
Hayward	6	34	0	73	0
Ardenwood	0	0	72	0	133
Fremont	6	42	0	94	0
Great America	28	125	145	171	198
Santa Clara	18	52	59	127	138
Diridon	45	87	93	165	170
Systemwide	**1,267**	**2,355**	**2,432**	**4,602**	**4,619**

Source: Fehr & Peers, 2021.

Origin-Destination Matrices

Tables C5-C8 on the following pages present the daily OD matrices for the Year 2025 and Year 2040 horizon years for the No Project and Plus Project scenarios.

AM Mode of Access and Egress

Table C9 and **Table C10** on the following pages list the AM mode of access and AM mode of egress model forecasts for each station.

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Table C5: Year 2025 No Project Scenario Daily Ridership Origin-Destination Matrix

Station	Auburn	Rocklin	Roseville	Sacramento	Davis	Fairfield	Suisun City	Martinez	Richmond	Berkeley	Emeryville	Jack London	Coliseum	Hayward	Ardenwood	Fremont	Great America	Santa Clara	Diridon	Total
Auburn	0	0	0	6	2	1	2	4	8	4	5	4	0	0		0	0	0	0	**36**
Rocklin	0	0	2	21	6	2	4	6	11	6	8	6	0	0		0	0	0	0	**72**
Roseville	0	2	0	39	10	4	6	8	16	8	13	9	0	0		0	0	0	0	**115**
Sacramento	6	21	39	0	152	43	84	160	276	167	522	336	120	65		46	212	55	106	**2,410**
Davis	2	6	10	152	0	10	17	70	91	60	152	100	44	32		26	71	25	38	**906**
Fairfield	1	2	4	43	10	0	0	29	35	22	56	33	19	17		17	32	14	18	**352**
Suisun City	2	4	6	84	17	0	0	40	48	31	82	49	23	20		17	40	14	20	**497**
Martinez	4	6	8	160	70	29	40	0	6	15	22	26	4	4		5	52	9	18	**478**
Richmond	8	11	16	276	91	35	48	6	0	0	2	8	0	2		4	16	14	18	**555**
Berkeley	4	6	8	167	60	22	31	15	0	0	8	26	2	5		6	67	18	32	**477**
Emeryville	5	8	13	522	152	56	82	22	2	8	0	29	0	4		7	52	21	38	**1,021**
Jack London	4	6	9	336	100	33	49	26	8	26	29	0	4	9		10	126	32	62	**869**
Coliseum	0	0	0	120	44	19	23	4	0	2	0	4	0	0		3	28	20	28	**295**
Hayward	0	0	0	65	32	17	20	4	2	5	4	9	0	0		4	36	15	22	**235**
Ardenwood																				
Fremont	0	0	0	46	26	17	17	5	4	6	7	10	3	4		0	19	6	10	**180**
Great America	0	0	0	212	71	32	40	52	16	67	52	126	28	36		19	0	20	47	**818**
Santa Clara	0	0	0	55	25	14	14	9	14	18	21	32	20	15		6	20	0	8	**271**
Diridon	0	0	0	106	38	18	20	18	18	32	38	62	28	22		10	47	8	0	**465**
TOTAL	**36**	**72**	**115**	**2,410**	**906**	**352**	**497**	**478**	**555**	**477**	**1,021**	**869**	**295**	**235**		**180**	**818**	**271**	**465**	**10,052**

Source: Fehr & Peers, 2021.

Table C6: Year 2025 Plus Project Scenario Daily Ridership Origin-Destination Matrix

Station	Auburn	Rocklin	Roseville	Sacramento	Davis	Fairfield	Suisun City	Martinez	Richmond	Berkeley	Emeryville	Jack London	Coliseum	Hayward	Ardenwood	Fremont	Great America	Santa Clara	Diridon	Total
Auburn	0	0	0	6	2	1	2	4	8	4	5	4	0		0		0	0	0	**36**
Rocklin	0	0	2	21	6	2	4	6	11	6	8	6	0		0		0	0	0	**72**
Roseville	0	2	0	39	10	4	6	8	16	8	13	9	0		0		0	0	0	**115**
Sacramento	6	21	39	0	152	43	84	160	276	167	522	336	120		106		218	63	110	**2,423**
Davis	2	6	10	152	0	10	17	70	91	60	152	100	44		44		80	36	48	**922**
Fairfield	1	2	4	43	10	0	0	29	35	22	56	33	19		22		43	24	28	**371**
Suisun City	2	4	6	84	17	0	0	40	48	31	82	49	23		26		50	24	30	**516**
Martinez	4	6	8	160	70	29	40	0	6	15	22	26	4		28		53	12	20	**503**
Richmond	8	11	16	276	91	35	48	6	0	0	2	8	0		30		20	16	20	**587**
Berkeley	4	6	8	167	60	22	31	15	0	0	8	26	2		46		68	20	34	**517**
Emeryville	5	8	13	522	152	56	82	22	2	8	0	29	0		62		55	24	40	**1,080**
Jack London	4	6	9	336	100	33	49	26	8	26	29	0	4		86		128	37	63	**944**
Coliseum	0	0	0	120	44	19	23	4	0	2	0	4	0		38		34	24	30	**342**
Hayward																				
Ardenwood	0	0	0	106	44	22	26	28	30	46	62	86	38		0		164	36	66	**754**
Fremont																				
Great America	0	0	0	218	80	43	50	53	20	68	55	128	34		164		0	22	46	**981**
Santa Clara	0	0	0	63	36	24	24	12	16	20	24	37	24		36		22	0	9	**347**
Diridon	0	0	0	110	48	28	30	20	20	34	40	63	30		66		46	9	0	**544**
TOTAL	**36**	**72**	**115**	**2,423**	**922**	**371**	**516**	**503**	**587**	**517**	**1,080**	**944**	**342**		**754**		**981**	**347**	**544**	**11,054**

Source: Fehr & Peers, 2021.

Table C7: Year 2040 No Project Scenario Daily Ridership Origin-Destination Matrix

Station	Auburn	Rocklin	Roseville	Sacramento	Davis	Fairfield	Suisun City	Martinez	Richmond	Berkeley	Emeryville	Jack London	Coliseum	Hayward	Ardenwood	Fremont	Great America	Santa Clara	Diridon	Total
Auburn	0	0	2	11	4	2	2	6	9	6	8	6	0	0		0	0	0	0	**56**
Rocklin	0	0	10	34	9	4	6	9	14	8	12	8	0	0		0	0	0	0	**114**
Roseville	2	10	0	128	30	12	20	84	93	72	135	96	70	57		51	78	56	64	**1,058**
Sacramento	11	34	128	0	220	60	128	239	448	254	904	600	242	104		84	312	144	194	**4,106**
Davis	4	9	30	220	0	16	27	101	136	92	238	164	82	54		50	101	60	72	**1,456**
Fairfield	2	4	12	60	16	0	2	54	62	45	96	64	44	38		37	54	36	40	**666**
Suisun City	2	6	20	128	27	2	0	70	87	58	150	100	56	40		40	70	42	48	**946**
Martinez	6	9	84	239	101	54	70	0	6	20	26	36	6	8		10	51	21	30	**777**
Richmond	9	14	93	448	136	62	87	6	0	2	4	10	0	4		7	22	20	25	**949**
Berkeley	6	8	72	254	92	45	58	20	2	0	12	34	4	8		10	68	34	46	**773**
Emeryville	8	12	135	904	238	96	150	26	4	12	0	36	2	8		10	56	37	52	**1,786**
Jack London	6	8	96	600	164	64	100	36	10	34	36	0	8	13		16	132	64	91	**1,478**
Coliseum	0	0	70	242	82	44	56	6	0	4	2	8	0	2		7	34	32	38	**627**
Hayward	0	0	57	104	54	38	40	8	4	8	8	13	2	0		8	36	24	30	**434**
Ardenwood																				
Fremont	0	0	51	84	50	37	40	10	7	10	10	16	7	8		0	25	14	20	**389**
Great America	0	0	78	312	101	54	70	51	22	68	56	132	34	36		25	0	36	60	**1,135**
Santa Clara	0	0	56	144	60	36	42	21	20	34	37	64	32	24		14	36	0	28	**648**
Diridon	0	0	64	194	72	40	48	30	25	46	52	91	38	30		20	60	28	0	**838**
TOTAL	**56**	**114**	**1,058**	**4,106**	**1,456**	**666**	**946**	**777**	**949**	**773**	**1,786**	**1,478**	**627**	**434**		**389**	**1,135**	**648**	**838**	**18,236**

Source: Fehr & Peers, 2021.

Table C8: Year 2040 Plus Project Scenario Daily Ridership Origin-Destination Matrix

Station	Auburn	Rocklin	Roseville	Sacramento	Davis	Fairfield	Suisun City	Martinez	Richmond	Berkeley	Emeryville	Jack London	Coliseum	Hayward	Ardenwood	Fremont	Great America	Santa Clara	Diridon	Total
Auburn	0	0	2	11	4	2	2	6	9	6	8	6	0		0		0	0	0	**56**
Rocklin	0	0	10	34	9	4	6	9	14	8	12	8	0		0		0	0	0	**114**
Roseville	2	10	0	128	30	12	20	84	93	72	135	96	70		72		84	62	69	**1,039**
Sacramento	11	34	128	0	220	60	128	239	448	254	904	600	242		199		318	154	200	**4,139**
Davis	4	9	30	220	0	16	27	101	136	92	238	164	82		82		112	72	82	**1,467**
Fairfield	2	4	12	60	16	0	2	54	62	45	96	64	44		44		67	48	50	**670**
Suisun City	2	6	20	128	27	2	0	70	87	58	150	100	56		51		82	54	58	**951**
Martinez	6	9	84	239	101	54	70	0	6	20	26	36	6		38		54	22	31	**802**
Richmond	9	14	93	448	136	62	87	6	0	2	4	10	0		36		26	23	27	**983**
Berkeley	6	8	72	254	92	45	58	20	2	0	12	34	4		58		71	37	50	**823**
Emeryville	8	12	135	904	238	96	150	26	4	12	0	36	2		76		60	40	54	**1,853**
Jack London	6	8	96	600	164	64	100	36	10	34	36	0	8		114		136	69	94	**1,575**
Coliseum	0	0	70	242	82	44	56	6	0	4	2	8	0		52		40	37	42	**685**
Hayward																				
Ardenwood	0	0	72	199	83	44	51	38	36	58	76	114	52		0		172	72	103	**1,170**
Fremont																				
Great America	0	0	84	318	112	67	82	54	26	71	60	136	40		172		0	37	61	**1,320**
Santa Clara	0	0	62	154	72	48	54	22	23	37	40	69	37		72		37	0	29	**756**
Diridon	0	0	69	200	82	50	58	31	27	50	54	94	42		103		61	29	0	**950**
TOTAL	**56**	**114**	**1,039**	**4,139**	**1,468**	**670**	**951**	**802**	**983**	**823**	**1,853**	**1,575**	**685**		**1,169**		**1,320**	**756**	**950**	**19,353**

Source: Fehr & Peers, 2021.

Fehr & Peers

Table C9: Forecast AM Peak Period Mode of Access

Station	Observed Data 2019			No project 2025			With Project 2025			No project 2040			With Project 2040		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Auburn	83%	0%	17%	68%	0%	31%	68%	0%	31%	66%	0%	33%	66%	0%	33%
Rocklin	86%	0%	14%	89%	0%	11%	89%	0%	11%	88%	0%	12%	88%	0%	12%
Roseville	85%	4%	11%	89%	2%	9%	89%	2%	9%	90%	3%	8%	90%	3%	8%
Sacramento	81%	7%	12%	96%	4%	0%	96%	4%	0%	96%	4%	0%	96%	4%	0%
Davis	65%	0%	35%	79%	0%	20%	79%	0%	20%	79%	0%	20%	79%	0%	20%
Fairfield	98%	2%	0%	97%	1%	1%	97%	1%	1%	97%	1%	1%	97%	1%	1%
Suisun City	85%	3%	12%	86%	2%	12%	86%	2%	12%	89%	2%	9%	89%	2%	9%
Martinez	81%	4%	15%	83%	2%	15%	83%	2%	15%	88%	2%	10%	88%	2%	10%
Richmond	47%	41%	13%	71%	22%	8%	71%	22%	8%	72%	21%	6%	72%	21%	6%
Berkeley	35%	8%	57%	45%	4%	51%	45%	4%	51%	42%	4%	54%	42%	4%	54%
Emeryville	50%	16%	34%	71%	10%	19%	71%	10%	19%	68%	14%	18%	68%	14%	18%
Jack London	49%	5%	46%	66%	3%	31%	66%	3%	31%	69%	3%	28%	69%	3%	28%
Coliseum	69%	13%	19%	68%	18%	13%	68%	18%	13%	71%	20%	9%	71%	20%	9%
Hayward	89%	0%	11%	89%	0%	11%	--	--	--	89%	0%	11%	--	--	--
Ardenwood	--	--	--	--	--	--	91%	1%	9%	--	--	--	90%	1%	9%
Fremont	75%	0%	25%	77%	0%	22%	--	--	--	76%	0%	24%	--	--	--
Great America	86%	0%	14%	92%	0%	7%	92%	0%	7%	90%	0%	9%	90%	0%	9%
Santa Clara	100%	0%	0%	51%	0%	49%	51%	0%	49%	56%	0%	44%	56%	0%	44%
Diridon	84%	0%	16%	90%	0%	10%	90%	0%	10%	91%	0%	9%	91%	0%	9%

Source: Fehr & Peers, 2021.

Table C10: Forecast AM Peak Period Mode of Egress

Station	Observed Data[1] 2019			No project 2025			With Project 2025			No project 2040			With Project 2040		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Auburn	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rocklin	0%	0%	0%	36%	18%	47%	36%	18%	47%	36%	18%	47%	36%	18%	47%
Roseville	100%	0%	0%	67%	9%	24%	67%	9%	24%	67%	8%	25%	67%	8%	25%
Sacramento	33%	11%	56%	29%	12%	59%	29%	12%	59%	28%	11%	61%	28%	11%	61%
Davis	21%	5%	74%	27%	10%	63%	27%	10%	63%	27%	10%	63%	27%	10%	63%
Fairfield	50%	0%	50%	43%	9%	48%	43%	9%	48%	43%	9%	48%	43%	9%	48%
Suisun City	18%	6%	76%	26%	12%	62%	26%	12%	62%	26%	11%	62%	26%	11%	62%
Martinez	61%	9%	30%	47%	13%	40%	47%	13%	40%	46%	13%	41%	46%	13%	41%
Richmond	13%	76%	10%	21%	55%	24%	21%	55%	24%	21%	54%	25%	21%	54%	25%
Berkeley	19%	30%	51%	26%	23%	51%	26%	23%	51%	26%	23%	51%	26%	23%	51%
Emeryville	20%	36%	44%	22%	36%	42%	22%	36%	42%	21%	36%	42%	21%	36%	42%
Jack London	35%	26%	39%	33%	21%	46%	33%	21%	46%	32%	20%	48%	32%	20%	48%
Coliseum	11%	56%	33%	12%	61%	26%	12%	61%	26%	13%	61%	27%	13%	61%	27%
Hayward	50%	50%	0%	43%	34%	24%	--	--	--	43%	34%	24%	--	--	--
Ardenwood	--	--	--	--	--	--	16%	60%	25%	--	--	--	24%	35%	41%
Fremont	50%	20%	30%	43%	19%	39%	--	--	--	43%	19%	39%	--	--	--
Great America	30%	25%	45%	23%	16%	61%	23%	16%	61%	23%	16%	61%	23%	16%	61%
Santa Clara	25%	35%	40%	27%	31%	42%	27%	31%	42%	26%	27%	47%	26%	27%	47%
Diridon	47%	19%	34%	39%	20%	41%	39%	20%	41%	37%	18%	45%	37%	18%	45%

Source: Fehr & Peers, 2021.

Validated C/CAG-VTA Model Initial Ridership Outputs

Using the transportation network and land use assumptions outlined above, the C/CAG-VTA model was run for the future project scenarios to provide an informational first set of results. **Table C11** details the capitol corridor ridership estimates from those model runs.

Table C11: C/CAG-VTA Model Initial Capitol Corridor Ridership Outputs

Alternative	C/CAG-VTA Model Capitol Corridor Systemwide Ridership
Year 2025 – Opening Year	
No Project	9,220
With Project	9,820
Delta	*+600*
Year 2040 – Horizon Year	
No Project	10,340
With Project	10,870
Delta	*+530*

Source: Fehr & Peers, 2021.

The main reasons that the ridership outputs are not accurate enough for use on the project are that C/CAG-VTA travel model does not contain the Sacramento region and thus misses out on a significant intercity ridership market for Capitol Corridor. Additionally, the C/CAG-VTA model overpredicts ridership in certain markets (such as Solano County to Northern Alameda County) and underpredict others (internal Bay Area to Bay Area stations such as the proposed Ardenwood station). The June 2020 technical memorandum *South Bay Connect – Base Year Model Development* (provided in **Attachment A**) contains an accounting of these potential methodological shortfalls of using the C/CAG-VTA model alone. The results of these future scenarios reinforce the need for an off-model tool in the form of a DRM.

As such, to address the limitations of the C/CAG-VTA travel demand model, a Capitol Corridor-specific Direct Ridership Model was prepared. The DRM relies on key outputs from the C/CAG-VTA model, thus retaining a linkage between the regional travel demand model and the DRM.

Appendix A2:
Capitol Corridor South Bay Connect Environmental Phase – Post-COVID Pandemic Ridership Forecasts Technical Memorandum

FEHR PEERS

Final Memorandum

Date: December 31, 2023

To: Michael Brown and Ben Tripousis, HNTB

From: Ian Barnes, PE, and Mackenzie Watten, PTP, Fehr & Peers

Subject: Capitol Corridor South Bay Connect Environmental Phase – Post-COVID Pandemic Ridership Forecasts

WC19-3612.01

This memo presents Fehr & Peers' ridership forecasting work for the modeling of station-level and systemwide Capitol Corridor ridership as part of the South Bay Connect project. Forecasts were previously prepared in the *Capitol Corridor South Bay Connect Environmental Phase – Final Ridership Forecasts* memorandum dated May 6, 2021. This memo presents additional forecasts that incorporate post-COVID pandemic effects on ridership. These effects were then carried forward to future conditions to create "Post-COVID Basis" forecasts. The additional ridership forecasts and VMT estimates do not supersede the "Pre-COVID Basis" forecasts completed in 2021; instead, the "Post-COVID Basis" forecasts were used in tandem to provide a bracketed analysis of ridership, VMT, and other model-produced metrics. In this framework, the "Pre-COVID Basis" forecasts presume a return to some semblance of travel behavior in the future that mimics pre-COVID conditions. This memo contains the following sections:

- Executive Summary
- Capitol Corridor Travel Pattern and Service Changes between 2019-2023
- Study Forecasting Tools and Process
- C/CAG-VTA Model
- Re-estimated Direct Ridership Model
- 2023 Ridership and Pandemic Effects
- Post-COVID Basis Ridership Forecasts
- Mode of Access and Egress
- Post-COVID Basis Vehicle-Miles Traveled Estimates

Executive Summary

The Capitol Corridor South Bay Connect project proposes to shift Capitol Corridor passenger rail service from the Niles Subdivision (between Elmhurst and Newark Junction) to the Coast Subdivision. With the shift, the existing Hayward and Fremont-Centerville stations on the Niles Subdivision would no longer be served, and these stations would be replaced by a new station on the Coast Subdivision at the Ardenwood Boulevard park-and-ride in western Fremont.

The proposed project is consistent with the *2018 California State Rail Plan* and would allow Capitol Corridor to serve new job centers and Transbay markets in lieu of focusing on existing markets that are duplicated by existing and future BART service (including markets to be served by the Silicon Valley BART Extension project).

Post-COVID Basis Ridership Forecasts

An additional direct ridership model (DRM) was re-estimated considering ridership and other operational data from April 2023. This additional DRM was used to produce forecasts of ridership, mode of access, and VMT for the No Project and Project Alternative 1 scenarios assuming that post-pandemic effects carry forward into the future. Ridership forecasts were produced for opening year and horizon year scenarios, with and without the South Bay Connect project. In general, the South Bay Connect project scenarios result in a modest increase in system-level ridership compared to the corresponding no-project scenarios. For stations in the immediate project area (Hayward, Fremont-Centerville, and the proposed Ardenwood station), the difference between no-project and with-project scenarios is more substantial. In particular, even assuming that the impacts of the pandemic on travel behavior will remain in the future, the new station at Ardenwood still provides a potential new travel pattern for Capitol Corridor, in which many riders travel to Ardenwood during the AM peak and use connecting transit across the Dumbarton Bridge to access major employment centers. While Capitol Corridor will bypass the Hayward and Fremont-Centerville stations after completion of the project, the BART Silicon Valley extension is anticipated to serve many of the current users of Capitol Corridor that travel between the Hayward or Fremont-Centerville stations and points south in the Capitol Corridor system.

Table 1 presents the Post-COVID Basis forecast daily boardings and alightings at the three key stations: Hayward, Fremont-Centerville, and Ardenwood, along with the total daily systemwide boardings. Hayward and Fremont-Centerville stations are active in the No Project scenarios, and the Ardenwood station is the only station active in the With Project scenarios.

Table 1: Post-COVID Basis Ridership Forecasts

Alternative	Key Stations			System Wide		
	Boardings + Alightings			Total Daily Boardings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2023 – Existing						
No Project	140	--	--	2,780	--	--
Year 2025 – Opening Year						
No Project	400	380	420	4,800	4,560	5,040
With Project	710	670	750	5,300	5,040	5,570
Year 2040 – Horizon Year						
No Project	980	930	1,030	12,450	11,830	13,070
With Project	1,670	1,590	1,750	13,440	12,770	14,110

Source: Fehr & Peers, 2023.

For purposes of forecasting, AM and PM peaks were defined by train number. AM peak trains arrive or depart Oakland Jack London Square essentially between 6:00 AM and 10:00 AM, while PM peak trains arrive or depart Jack London Square between 3:00 PM and 7:00 PM.

Table 2 presents Post-COVID Basis forecast AM peak boardings and alightings at the same three key stations. In the No Project scenarios, Hayward and Fremont-Centerville stations serve primarily as AM peak origins, with substantially more boardings than alightings. However, in the With Project scenarios, Ardenwood station serves both as an AM peak origin and as an AM peak destination, primarily for passengers transferring to westbound services in the Dumbarton Corridor.

Table 2: Post-COVID Basis AM Peak Boardings and Alightings at Key Stations

Alternative	Key Stations			Key Stations		
	AM Boardings			AM Alightings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2023 – Existing						
No Project	30	--	--	20	--	--
Year 2025 – Opening Year						
No Project	160	150	170	10	10	10
With Project	240	230	250	80	80	80
Year 2040 – Horizon Year						
No Project	390	370	410	20	20	20

With Project	450	430	470	310	290	330

Source: Fehr & Peers, 2023.

Mode of Access/Egress Forecasts

Table 3 and **Table 4** present forecast mode splits for access to/egress from the three key stations during the AM peak period. The mode of access and egress models were not re-estimated due to insufficient available 2023 mode share data. As such, the mode of access and egress forecasts remain the same as the previous analysis. These forecasts also reflect Ardenwood's different travel profile versus Hayward and Fremont-Centerville. Ardenwood serves both as an AM origin station with large auto mode share, but also as an AM destination station with substantial transit connections to employment. The very large (60%) transit mode share for Ardenwood in 2025, which drops to 35% in 2040, is attributed to changes to station area employment opportunities between 2025 and 2040, opening up employment opportunities in the station area even without a transit connection.

Table 3: AM Mode of Access to Key Stations

Station	2019 (Observed)			2025 (Forecast)			2040 (Forecast)		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Hayward (No Project scenario)	89%	0%	11%	89%	0%	11%	89%	0%	11%
Fremont (No Project scenario)	75%	0%	25%	77%	0%	22%	76%	0%	24%
Ardenwood (With Project scenario)	--	--	--	91%	1%	9%	90%	1%	9%

Source: Fehr & Peers, 2023.

Table 4: AM Mode of Egress from Key Stations

Station	2019 (Observed)			2025 (Forecast)			2040 (Forecast)		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Hayward (No Project scenario)	50%	50%	0%	43%	34%	24%	43%	34%	24%
Fremont (No Project scenario)	50%	20%	30%	43%	19%	39%	43%	19%	39%
Ardenwood (With Project scenario)	--	--	--	16%	60%	25%	24%	35%	41%

Source: Fehr & Peers, 2023.

Post-COVID Basis Vehicle-Miles Traveled (VMT) Reduction

The proposed South Bay Connect project is projected to result in increased ridership along the Capitol Corridor system; many of these additional trips will be the result of riders choosing to not travel by personal automobile, thus resulting in a reduction in regional vehicle-miles traveled (VMT). **Table 5** details the outputs of the VMT calculations, which quantify the weekday daily regional VMT reduction resulting from the project.

Table 5: Post-COVID Basis Weekday Daily Regional Vehicle-Miles Traveled

Alternative	Vehicle Miles of Travel (VMT)
Year 2025 – Opening Year	
No Project	227,150,000
With Project	227,130,000
Delta	***-20,000***
Year 2040 – Horizon Year	
No Project	256,390,000
With Project	256,357,000
Delta	***-33,000***

Source: Fehr & Peers, 2023.

Capitol Corridor Travel Pattern and Service Changes between 2019-2023

The COVID-19 pandemic has had a substantial effect on travel patterns in the Bay Area. Transit ridership decreased dramatically during the pandemic, with some operators experiencing 80% decreases compared to 2019 ridership levels. The acceleration of remote-working trends and transit hesitancy related to rising concerns about health and safety made transit services less attractive for potential riders. **Table 6** shows systemwide Capitol Corridor ridership between April 2019 and April 2023. The approximately 55% ridership decrease confirms that Capitol Corridor has been affected by pandemic travel pattern changes.

Table 6: Capitol Corridor Average Daily Weekday Ridership Comparison

Year	Daily	AM Peak	PM Peak
April 2019 (Pre-COVID)	6,170	2,470	2,380
April 2023 (Post-COVID)	2,800	1,050	1,320
% Change	-54%	-57%	-44%

Source: Capitol Corridor, 2023 and Fehr & Peers, 2023.

One additional contributing factor to the ridership decrease is the change in Capitol Corridor service frequency. At a systemwide level, there were 15 trains operating per weekday per direction in 2019, and 12 operating per weekday in each direction in 2023, a 20% decrease in service frequency. **Table 7** details the change in service frequency, defined as the number of trains serving origin-destination pairs, by time period. From 2019 to 2023, the overall service frequency decreased by approximately 25%, with an approximate 20% decrease in the AM peak and an approximate 55% decrease during off peak. PM peak service frequency remained roughly the same.

Table 7: Capitol Corridor Service Frequency Comparison

Period	April 2019 (Pre COVID)	April 2023 (Post COVID)	% Change
AM Peak	820	680	-17%
PM Peak	710	720	1%
Off Peak	840	390	-54%
Total	**2,370**	**1,790**	**-24%**

1. Service frequency defined as number of trains serving origin-destination pairs.
Source: Capitol Corridor, 2023 and Fehr & Peers, 2023.

Study Forecasting Tools and Process

The Capitol Corridor South Bay Connect project proposes to shift Capitol Corridor passenger rail service from the Niles Subdivision (between Elmhurst and Newark Junction) to the Coast Subdivision. With the shift in the Capitol Corridor route, the existing Hayward and Fremont-Centerville stations on the Niles Subdivision would no longer be served and would be replaced by a new station at the Ardenwood Boulevard park-and-ride in western Fremont/Newark on the Coast Subdivision. This section provides an overview of the forecasting tools used in the present ridership and VMT forecasts, along with a brief history of the forecasting work Fehr & Peers has done for South Bay Connect.

Study Tools and Inputs

This section provides a high-level description of the forecasting tools used in the ridership and VMT analysis of the project.

C/CAG-VTA Travel Demand Model

The City/County Associations of Governments of San Mateo County – Santa Clara Valley Transportation Authority (C/CAG-VTA) travel demand model is a trip-based regional travel demand model that accounts for regional land use patterns, approximated highway congestion, and connecting transit service within the nine-county MTC region. The C/CAG-VTA model includes the portion of the Capitol Corridor route between Suisun City-Fairfield Station and San Jose Diridon Station. The C/CAG travel model also contains data on the multimodal transportation system surrounding the Capitol Corridor route, including roadways and parallel/connecting public transit routes.

As noted in the previous Work Directive #1 documentation, the C/CAG-VTA travel demand model used in that analysis was not calibrated or validated for base year (2015) conditions. As part of Work Directive #1, the C/CAG-VTA travel demand model was used to assess the competitiveness of automobile travel against Capitol Corridor in-vehicle travel time per the Capitol Corridor timetable. The Model Development Memo (included as **Attachment A**) detailed the calibration and validation of the C/CAG-VTA travel demand model undertaken as part of the current phase (Work Directive #2) of this work.

SACOG Land Use Forecasts

Part of the Capitol Corridor service area includes the Sacramento area whose regional land use forecasts are produced by the Sacramento Area Council of Governments (SACOG). Forecasts of station area population and employment for stations in the SACOG region are derived from TAZ-level land use forecasts.

Work Directive 2 Direct Ridership Model (DRM)

To address the limitations of the C/CAG-VTA travel demand model for forecasting Capitol Corridor ridership, forecasts were developed using a Capitol Corridor-specific direct ridership model (DRM).This allows the forecasting process to use data from the C/CAG-VTA model where appropriate and statistical analysis of demographic, accessibility, and quality of service data where needed.

The DRM leverages work previously completed for the South Bay Connect project, using a similar model specification and variables already identified as influential, while expanding both the input variables and the time periods being modeled.

Forecasts for Work Directive 2 were previously prepared in the *Capitol Corridor South Bay Connect Environmental Phase – Final Ridership Forecasts* memorandum dated May 6, 2021. Additional forecasts were prepared that incorporate post-COVID pandemic effects on ridership. These effects were then carried forward to future conditions to create Post-COVID Basis forecasts. The additional ridership forecasts and VMT estimates do not supersede the Pre-COVID Basis forecasts; instead, the Post-COVID Basis forecasts were used in tandem to provide a bracketed analysis of ridership, VMT, and other model-produced metrics.

To prepare Post-COVID Basis forecasts, key factors that influenced transit ridership were identified. These factors include the acceleration of remote-working trends and transit hesitancy related to concerns about health, personal safety, and security. While work from home information is available for both 2019 and 2023, data was not available to quantify transit hesitancy. Thus, the approach was to re-estimate the Pre-COVID Basis scenario year 2019 DRM with the addition of a work from home variable. This re-estimated model was used to "forecast" 2023 Capitol Corridor ridership. The "forecasted 2023" ridership—ridership if transit hesitancy due to health concerns were not there— was then compared with the observed 2023 ridership. The difference is assumed to be transit hesitancy related to concerns about health, personal safety, and security. This transit hesitancy was then applied to future forecasts to accurately reflect the scenario in which post-COVID effects carry forward into the future. For detailed base year validation of the C/CAG-VTA model and more information on the decision to rely on a direct ridership model, see the model development memo included as **Attachment A**.

Mode of Access and Egress Models

In addition to forecasts of Capitol Corridor ridership, Mode of Access (MoA) models were developed to understand travel to and from Capitol Corridor stations. Two models were developed, focused solely on the AM peak period: a mode of access model and a mode of egress model. Due to insufficient 2023 mode share data, the mode of access and egress models were not re-estimated. As such, the mode of access and egress forecasts remain the same as the previous analysis.

The AM peak period is the focus period as most travelers make their modal choice in the morning, and use that same mode in the afternoon (i.e., most Capitol Corridor morning passengers would not make the afternoon reverse trip in their own private automobile). These models shed further light on key differences between the existing Hayward and Fremont-Centerville stations and the proposed Ardenwood station.

Mode Choice Amtrak California Ridership Model

The Mode Choice version of the Amtrak California Ridership Model (Amtrak Model) has historically been used to estimate ridership for the Capitol Corridor system. Ridership estimates from the model were previously used to determine ridership potential for planning purposes. For the environmental analysis, however, the Amtrak Model lacks specific detail for land uses that can be reached by new Transbay transfers (such as those provided at the proposed Ardenwood Station). Thus, outputs from the Amtrak Model were used to provide guidance as to the reasonability of the DRM forecasts, especially for long distance trips (e.g., from Sacramento to San José).

Study Forecasting Process

As part of the Work Directive #1 initial analysis phase completed in 2019, Fehr & Peers prepared opening year (2025) and horizon year (2040) ridership and VMT estimates using a composite City/County Associations of Governments of San Mateo County – Santa Clara Valley Transportation Authority (C/CAG-VTA) travel demand model and Direct Ridership Model (DRM) methodology. This approach incorporated land use forecasts and automobile travel times from the C/CAG-VTA travel demand model with a DRM derived from April 2019 Capitol Corridor ridership.

Work Directive #2—the current phase of the project—includes additional calibration and static validation of the C/CAG-VTA model. It also includes new direct ridership model (DRM) runs using the calibrated C/CAG-VTA model data to ensure the DRM reflects the calibration performed on the C/CAG-VTA model, to expand the DRM input variables, and to include a specific model for PM peak travel. Estimates of station-to-station ridership are output from the DRM, and models for mode-of-access (MOA) to stations and mode-of-egress (MOE) from stations were developed for the AM peak period. These models are multinomial logistic regression models which estimate MOA to and from Capitol Corridor stations during the AM peak. As mentioned earlier, the AM peak is the critical period, as most mode choice decisions are made on the basis of AM travel (i.e., a Capitol Corridor rider who arrives on foot in the morning is unlikely to drive alone for the reverse-direction trip in the afternoon).

Effects of COVID-19 Pandemic on Forecasting Process

There is little doubt the COVID-19 pandemic altered travel patterns. For this reason, the models used in this ridership forecast include variables to represent work-from-home, as well as short term migration and land use patterns, Capitol Corridor and connecting transit service frequency, and transit hesitancy caused by the pandemic. Although the permanent effect of the pandemic on travel patterns is still unknown, the models used in the ridership forecast represent the best available tools for forecasting the effect of the project on ridership and vehicle-miles traveled (VMT). These additional forecasts will not supersede the Pre-COVID Basis forecasts; instead, the Post-COVID Basis forecasts are used in tandem to provide a bracketed analysis of ridership, VMT, and other model-produced metrics.

C/CAG-VTA Model

This section details the assumptions and inputs (both transportation networks and model land use) used in developing scenarios within the C/CAG-VTA model. The ridership results of these model scenarios were used as inputs to the Capitol Corridor direct ridership model, which produced the final forecasts.

As detailed in the June 2020 technical memorandum *South Bay Connect – Base Year Model Development* (provided as **Attachment A**), the following assumptions and process were used to set up the future year C/CAG-VTA model scenarios. Generally, the forecasting approach uses the latest transportation network and land use assumptions available for the project area.

Future Transportation Network

Table 8 summarizes the transportation network changes (versus the base year model assumptions) assumed in the 2025 and 2040 scenarios.

Table 8: Future Network Assumptions

Parameter	Forecast Year	Assumption
ACE Service Level	2025	Same as 2018
	2040	10 daily ACE roundtrips (+4 from today)
Caltrain Service Level	2025	6-train per hour Zone Express Service
	2040	8-train per hour Moderate Growth Plan/Service Vision from the Caltrain Business Plan process
Hollister Express Bus Service	2025	Not included
	2040	Hourly integrated express bus service between Gilroy and Hollister
Salinas Rail Service	2025	No service
	2040	Hourly service between Gilroy and Salinas; hub station at Pajaro/ Watsonville providing hourly connections to Santa Cruz; hub station at Castroville providing hourly connections to Monterey.
Dumbarton Rail Service	2025	Not included
	2040	Rail shuttle from Union City BART station to Redwood City Caltrain station: 4 trains per hour per direction peak, 2 trains per hour per direction off peak.
US-101 Managed Lanes	2025	Add HOT lane in San Mateo County south of I-380
	2040	Convert a lane to a HOT lane between I-380 and I-280; convert a southbound lane to a HOT lane on I-280 north of US-101.

Parameter	Forecast Year	Assumption
SamTrans Express Bus Service	2025	Four express routes as presented in SamTrans Express Bus study
	2040	Six more express routes as presented in SamTrans Express Bus study.

Source: Fehr & Peers, 2023.

Future Land Uses

This section outlines the future land use assumptions used to generate the interim ridership inputs from the C/CAG-VTA model to the Direct Ridership Model.

Regional Land Use Assumptions

The *2040 Plan Bay Area* land use forecasts, updated to be consistent with the base year land use updates described in the base year model development memo (provided in **Attachment A**), were used for future year land use assumptions. The Bay Area has seen land use growth and approvals beyond what was assumed in *2040 Plan Bay Area* and this additional land use was accounted for in this project's future scenarios. **Table 9** details additional land use from approved projects beyond *2040 Plan Bay Area* that was incorporated into future year land use assumptions. These projects were assumed to be fully built by 2040. For the 2025 scenario, projects already well underway in the development pipeline were included.

Table 9: Additional Assumed Year 2040 Regional Planned Land Uses

City	Plan	Population Added beyond Plan Bay Area	Employment Added beyond Plan Bay Area	Notes
San Francisco	Central SoMa	12,000	38,000	Approved by Planning Commission; Board of Supervisors has not approved yet
South San Francisco	East of US 101 employment	-	11,000	Approved / Under construction. ~13 individual biotech projects approved/under construction totaling 7 MSF
San Bruno	Transit Corridors Plan	-	3,000	Approved
Millbrae	Station Plan		3,000	Approved
Redwood City	Stanford Healthcare Camus	-	4,000	Approved
Palo Alto / Stanford	Stanford Research Park expansion and Stanford Hospital expansion	-	6,000	Approved
Mountain View	North Bayshore Precise Plan	-	21,000	Approved
Cupertino	Apple Campus		8,000	Complete
Sunnyvale	Peery Park Specific Plan	-	10,000	Approved
	Moffett Towers		3,000	Approved
Santa Clara	City Place	-	8,000	Approved
Total		**12,000**	**115,000**	

Source: Fehr & Peers, 2023.

Ardenwood Station Area Land Use Update Assumptions

To better account for travel behavior near the proposed Ardenwood station, two additional changes were made related to Ardenwood station-area land use assumptions. First, the City of Fremont has adopted land use rezoning to increase density near the Ardenwood station. For the year 2040 scenario, this rezoning adds approximately 7,000 additional employees in the immediate Ardenwood station area. The rezoned land use was not assumed to be present in the 2025 scenario.

Additionally, the C/CAG-VTA model TAZs around the proposed Ardenwood station were revised to provide more spatial detail. The off-the-shelf TAZs near the proposed station cover large areas including empty land, parks, and water bodies that may not properly capture the changes in travel demand resulting from land use changes in the immediate areas around the proposed station. To address this issue, these TAZs were split into smaller TAZs to allow the model to estimate travel behavior for land use in close proximity to the proposed station. Specifically, the four off-the-shelf C/CAG-VTA model TAZs that cover the approximately one-mile buffer from the proposed station were split into twelve TAZs based on geographic detail from the Alameda CTC model in the same area. The values from the C/CAG-VTA model TAZs were assigned proportionally to the new TAZs, thus maintaining the land use control totals.

Re-estimated Direct Ridership Model

To address the limitations of the C/CAG-VTA travel demand model described in the model methodology memo (**Attachment A**), a Capitol Corridor-specific Direct Ridership Model was developed that allows the forecasting process to use data from the C/CAG-VTA model where appropriate and statistical analysis of demographic and accessibility data where needed. As detailed in the previous section, due to 2023 data limitations, an additional DRM was re-estimated for 2019 to include pandemic related variables, and then used to forecast 2023. This approach allowed for isolation of other influences on Post-COVID Basis forecasts, including transit hesitancy. This section outlines the broad approach and the variables used in the DRM; a more detailed description of the statistical modeling is included in **Attachment B**.

DRM Approach

The approach to developing Direct Ridership Models (DRM) for additional forecasting is similar to the approach previously used for DRM development as part of Work Directive #1. A series of statistical models were developed to estimate ridership at the level of origin-destination station pairs. A total of twelve linear regression models were developed, accounting for three time periods (AM peak, PM peak, and Off Peak) and four market segments. These market segments were modeled separately because Capitol Corridor ridership and service patterns showed clearly different markets (e.g., more westbound trains during the AM peak, more eastbound trains during the PM peak). In addition, the C/CAG-VTA model area only covers part of the Capitol Corridor service area, so the market segmentation allowed the option of using C/CAG-VTA model forecasts where appropriate. The four market segments were defined as follows:

- **Segment 1: Within Core Bay Area** – Travel among stations between Martinez and San Jose Diridon.
- **Segment 2: Leaving Core Bay Area** – Travel from Core Bay Area stations (Martinez to San Jose) to stations outside the Bay Area (Auburn to Suisun City).
- **Segment 3: Entering Core Bay Area** – Travel from stations outside the Core Bay Area (Auburn to Suisun City) into the Core Bay Area (Martinez to San Jose).
- **Segment 4: Outside Core Bay Area** – Travel among stations outside the Core Bay Area (Auburn to Suisun City).

Capitol Corridor Observed Ridership and Travel Patterns

Observed Capitol Corridor ridership was defined as the average weekday ridership for April 2019 (i.e., before the COVID-19 pandemic). This ridership was calculated for each origin-destination pair and each time period, using passenger counts from ticket lift data. Time periods were defined by train number, as shown in **Table 10**. AM peak trains arrive or depart Oakland Jack London Square essentially between 6:00 AM and 10:00 AM, while PM peak trains arrive or depart Jack London Square between 3:00 PM and 7:00 PM.

Table 10: Time Period Definitions

Time Period	Eastbound Train Numbers	Westbound Train Numbers
AM Peak	522, 524, 528	521, 523, 525, 527, 529
PM Peak	536, 538, 540, 542, 544, 546	541, 543, 545
Off Peak	520, 530, 532, 534, 548, 550	531, 535, 537, 547, 549, 551, 553

Source: Fehr & Peers, 2023.

The April 2019 data provide information on travel patterns for existing Capitol Corridor service before the opening of the Silicon Valley BART Extension project to the Berryessa/North San José Station. The April 2019 data also indicates that over 75% of weekday boardings at the Hayward and Fremont-Centerville stations occur during the four-hour AM peak period and about 65% of weekday alightings occur during the four-hour PM peak period. This indicates that the stations primarily serve as commute trip origins for the weekday, and the travel market for these existing stations is primarily defined by the residential areas surrounding the stations.

DRM Variables

Two types of variables are used in the DRM: station-specific and origin-destination (OD). The station-specific variables provide information on the stations and their surrounding land uses, while the OD-specific variables provide information regarding the trip between stations.

Station-Specific Variables

The station-specific variables provide information on the stations and their surrounding area. These variables describe characteristics of the stations themselves, including land use surrounding the station and accessibility to the station. **Table 11** lists the broad categories of station-specific variables considered in developing the DRM.

Table 11: Station-Specific Variables

Variable	Notes
Population within ¼, ½, 1 mile, or 2 miles of station	Population within straight-line buffers, calculated in GIS using TAZ-level land use data from C/CAG-VTA model and SACOG.
Employment within ¼, ½, 1 mile, or 2 miles of station	Employment within straight-line buffers, calculated in GIS using TAZ-level land use data from C/CAG-VTA model and SACOG.
Population accessible via transit or walk connection to station	--
Employment accessible via transit or walk connection to station	--
Auto parking at station	No changes to parking at any station except Ardenwood, which increases to 500 spaces in with-project scenarios.
Proportion of workers that work from home	Share of job postings that are remote or hybrid in the city where station is located.

Source: Fehr & Peers, 2023.

Land Use Straight-Line Buffers

The land use straight-line buffers sum the population and employment within defined buffers of the station, using the TAZ-level land use information from the C/CAG-VTA and Sacramento Regional Travel Demand (SACMET) models. The proportion by area of each model TAZ that falls within the buffer area is applied to the TAZ population and employment.

Station Accessibility by Walk and Transit Modes

The land use straight-line buffer variables provide useful information on the surrounding area; however, they do not portray accessibility to the stations well. Additional variables were calculated to understand more clearly how the surrounding environment influences travel to and from the stations by walking and taking transit. These variables were developed using a process that considers the surrounding road network, transit lines, and transit service to create isochrones: geographic regions that represent the travel time required to access stations by walking or by transit.

Network data from Open Street Maps was used to calculate walking paths to stations and connecting transit. The transit lines and service frequencies were calculated using General Transit Feed Specification (GTFS) data from TransitLand[1] for the transit agencies listed in **Table 12.**

[1] https://transit.land/feed-registry/operators/

Table 12: Transit Agencies Represented in Transit Accessibility Calculations

Transit Agencies Represented in Transit Accessibility Calculations		
AC Transit	Dumbarton Express	SolTrans
ACE	Emery GoRound	Union City Transit
BART	FAST	Vacaville Coach Bus
Caltrain	SacRT	VTA
Capitol Corridor (Thruway bus)	SamTrans	WestCat
County Connection	SFMTA	

Source: Fehr & Peers, 2023.

Examples of walk and transit isochrones are shown in **Figure 1** and **Figure 2** (presented on the next pages).

Finally, walk and transit isochrones were used to develop variables measuring the ease of reaching population and employment centers from Capitol Corridor stations. A distance decay was applied so that land use close to stations was weighted more heavily than land use farther away. Final accessibility values were developed using distance decay formulas for accessibility consistent with NCHRP Report 365.[2]

Work-from-Home Share

The COVID-19 pandemic altered travel patterns and substantially increased the proportion of workers that can perform their jobs, fully or partially, from home instead of going to a physical workplace. This has a direct impact on transit ridership as people working from home are not required to commute to work. To assess this change in travel patterns, a variable that estimates the proportion of workers that work from home was introduced to the re-estimated DRM. Remote work data based on job postings from recent research[3] was used to estimate the share of jobs that allow remote work arrangements in the city where each station is located.

[2] Martin, W., and N. McGuckin. Travel Estimation Techniques for Urban Planning. NCHRP Report 365, 1998.
[3] Hansen, S., Lambert, P. J., Bloom, N., Davis, S. J., Sadun, R., & Taska, B. Remote Work across Jobs, Companies, and Space. National Bureau of Economic Research, 2023. https://doi.org/10.3386/w31007.

Figure 1. Example of Walk Accessibility Isochrones

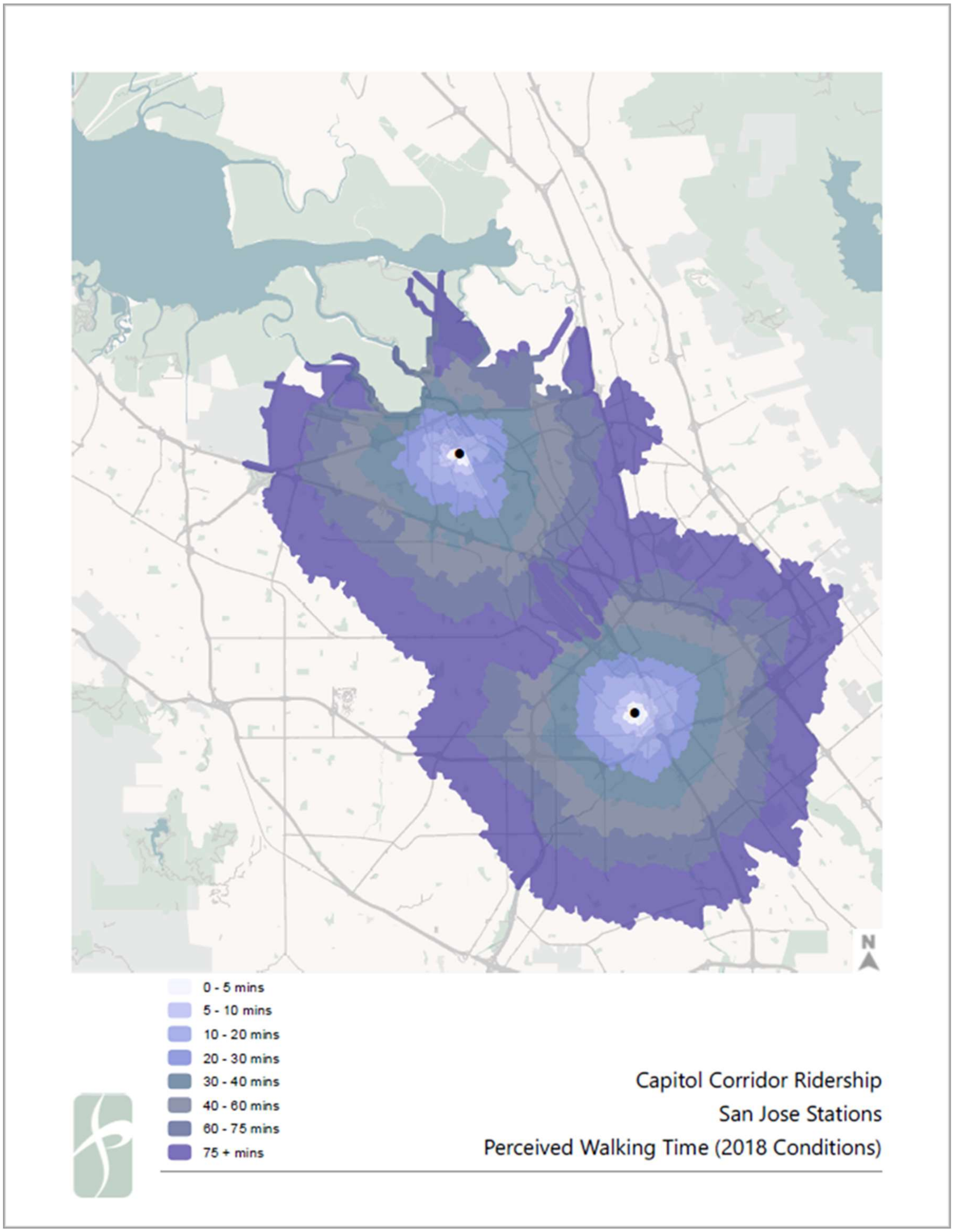
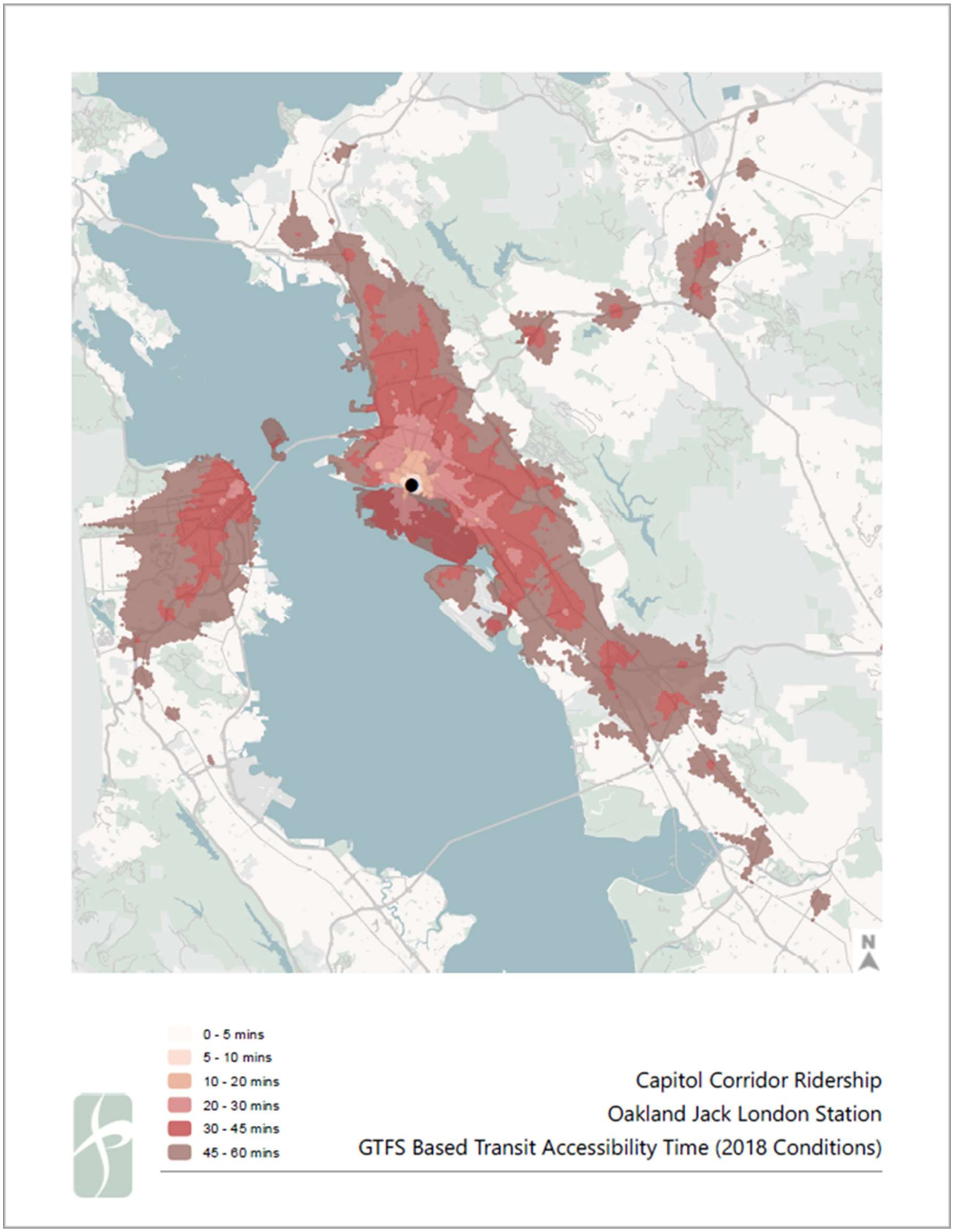


Figure 2. Example of Transit Accessibility Isochrones



OD-Specific Variables

Table 13 describes the OD variables used to develop the DRM, including their sources. The table also identifies how the future representation of the variables was calculated. The OD variables are composed of cost, travel time, and frequency of trains between each station combination.

Table 13: OD-Specific Variables

Variable	Description	Notes
C/CAG-VTA model ridership	Capitol Corridor ridership estimated by C/CAG-VTA model.	Although this variable was evaluated in the DRM, it did not provide useful explanatory power and was dropped from final models.
Capitol Corridor IVTT	Capitol Corridor in-vehicle travel time.	Consistent with the project description and in-vehicle times provided, the with-project scenarios reflect a slight decrease in travel times through the project area as compared to the no-project scenarios.
Competing Transit IVTT	Estimated in-vehicle time for competing transit.	The isochrone analysis conducted for transit accessibility also allowed estimation of in-vehicle time for competing transit serving selected Capitol Corridor station pairs. In future scenarios, these competing times were adjusted specifically to account for BART to San Jose.
Capitol Corridor Frequency	Number of trains per time period (AM, PM, Off Peak, or Daily).	No change to frequencies was assumed in future scenarios, either in the no-project scenarios or the with-project scenarios.
Capitol Corridor Fares	Single-ride fare between origin and destination stations.	No change to Capitol Corridor fares beyond inflation was assumed for future scenarios.
Auto Travel Time	Station to station auto travel time on parallel routes.	2018 INRIX data was used for the region from San Jose to Davis. Outside of this region (Davis to Auburn), estimates from Google Maps were used. For future scenarios, the change in travel time from the C/CAG-VTA model was used as a factor applied to 2018 travel times. Outside the C/CAG-VTA model region, similar factors were used to the eastern portion of the model area.

Source: Fehr & Peers, 2023.

Statistical Models

This section provides an overview of the statistical models developed as the Direct Ridership Model for Capitol Corridor. Twelve independent linear regression models were developed, one for each combination of time period and market segment, each with similar structure and variables.

As noted previously, the DRM equations are derived using existing conditions ridership data, along with data on land use, Capitol Corridor service, and competing auto and transit travel time information from the C/CAG-VTA travel demand model. To align with a standard statistical process, only variables that are statistically significant with intuitive coefficients are included in the final derived DRM equations. The variables included in each travel market/time period DRM equation are allowed to fluctuate between equations.

Variable Overview

Table 14 summarizes the variables in the DRM, by time period. It also identifies the strength and direction (positive or negative) of the variables' relationship to Capitol Corridor ridership.

Table 14: Direct Ridership Model Variables

Category	Variable	AM Peak	PM Peak	Off Peak
Land Use	Population within ¼, ½, 1 mile, or 2 miles of origin	++		++
	Population accessible via transit or walk connection to origin	++		
	Population within ¼, ½, 1 mile, or 2 miles of destination			++
	Population accessible via transit or walk connection from destination		++	++
	Employment within ¼, ½, 1 mile, or 2 miles of origin		+++	+++
	Employment accessible via transit or walk connection to origin		++	++
	Employment within ¼, ½, 1 mile, or 2 miles of destination	+++		+++
	Employment accessible via transit or walk connection from destination	++		+
Parking	Auto parking at origin station	++		
	Auto parking at destination station		++	+++
Capitol Corridor Service	Train frequency	++	++	++
	Fare / distance	-	-	-
Other Modes	Auto vs Capitol Corridor travel time	++	++	+
	Capitol Corridor vs competing transit travel time	-	-	-
Work-from-home	Proportion of workers that work from home at jobs localized nearby origin station		-	-

Category	Variable	AM Peak	PM Peak	Off Peak
	Proportion of workers that work from home at jobs localized nearby destination station	-		
Significance Definition				
+++	Strong positive significance			
++	Moderate positive significance			
+	Weak positive significance			
-	Weak negative significance			

Source: Fehr & Peers, 2023.

Even with model re-calibration, the C/CAG-VTA model results were not in line with existing conditions and were skewing the model inaccurately. In particular, they predicted much higher than observed ridership between Solano County stations and the Core Bay Area, as well as higher ridership within Santa Clara County. Therefore, the C/CAG-VTA model outputs ultimately were not used in the DRM.

The employment land use variables were generally stronger predictors for ridership than the population variables. The transit and walk accessibility variables worked well together as they summarize who can access the Capitol Corridor stations, via what mode, and with how much effort. Transit accessibility variables were most successful when they focused on specific high-quality transit: the Amtrak Thruway bus at Emeryville, BART connections at Richmond and Coliseum, and connections to the VTA transit system at Great America, Santa Clara, and Diridon. Parking, while not directly related to land use, provides information on station accessibility by driving oneself. Ultimately, parking at the AM station origin (PM and Off Peak destination) was a moderate predictor for Capitol Corridor ridership.

As noted in **Table 14**, the land use variables are focused on land uses within a radius of up to two miles from the station area. While the DRM and ridership forecasting process does not presume that existing riders at the Hayward and Fremont-Centerville stations take BART/other transit to connect to Capitol Corridor service (or shift to Ardenwood Station), the two-mile radii around the existing Fremont-Centerville Station and proposed Ardenwood Station substantially overlap, thus the forecasting process is sensitive to a portion of the existing Fremont-Centerville Station ridership shifting to Ardenwood Station. The overlap of service area for the Fremont-Centerville and Ardenwood stations is critical because, as evidenced by the existing ridership data, over 80% of existing trips at Fremont-Centerville Station do not involve trips to/from Silicon Valley, and thus would exhibit a higher propensity to shift to Ardenwood station.

Components of the Capitol Corridor service are important in predicting ridership. Frequency, by time period, is a significant predictor of ridership. Fare versus distance traveled on Capitol Corridor is a weak but noticeable predictor for intra-regional travel, and better describes the value of the trip than stand-alone fare. Auto travel time (on its own) as a variable is too closely related to Capitol Corridor travel time, therefore auto travel time compared to train travel time was used in order to illustrate the travel time gains or losses of a trip when choosing Capitol Corridor.

Competing transit (measured as ratio of Capitol Corridor in-vehicle time to competing transit in-vehicle time) has a weak but intuitively sensible relationship in the AM and PM models within the Core Bay Area. Its sign is the reverse of auto versus Capitol Corridor time, because for this variable Capitol Corridor time appears in the numerator instead of the denominator. This variable is especially important in the ridership forecasting process because BART will provide faster, more frequent connections between the study area and Silicon Valley than the Capitol Corridor service.

Finally, as expected, the availability of jobs that can be performed from home instead of needing workers to commute to their workplace has a negative impact on ridership.

Goodness of Fit

Table 15 presents the model goodness of fit (R-squared) metrics for the DRMs developed. R-squared metrics closer to 1.00 indicate the model replicates all variations in ridership. Higher R-squared values are not necessarily a good result—in most cases where the R-squared value is high, this indicates a model over-fit condition whereby the model will be a poor predictor of future ridership. Generally speaking, the goodness of fit metrics suggest that the suite of DRMs are performing within expectations.

Table 15: Model Goodness of Fit (R-squared)

Segment	AM Peak	PM Peak	Off Peak
Segment 1: Within Core Bay Area	0.60	0.55	0.53
Segment 2: Leaving Core Bay Area	0.77	0.83	0.83
Segment 3: Entering Core Bay Area	0.80	0.61	0.83
Segment 4: Outside Core Bay Area	0.75	0.94	0.99

Source: Fehr & Peers, 2023

Figures 3, 4, and **5** (presented on the next pages) detail the relationship between DRM base year ridership estimates and actual observed ridership data for the AM peak period, PM peak period, and Off Peak period (respectively).

Figure 3. AM Observed versus Modeled Ridership (Year 2019)

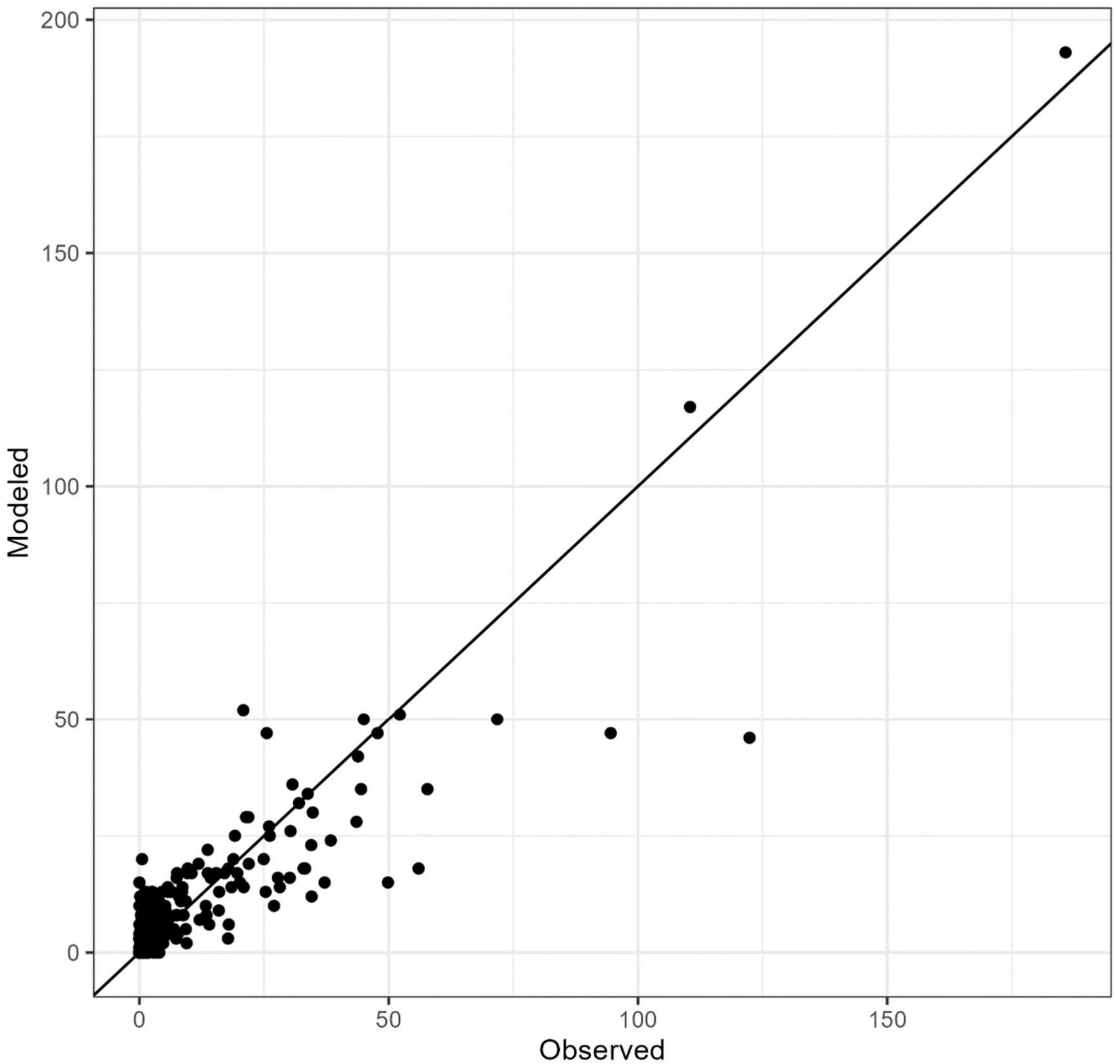


Figure 4. PM Observed versus Modeled Ridership (Year 2019)

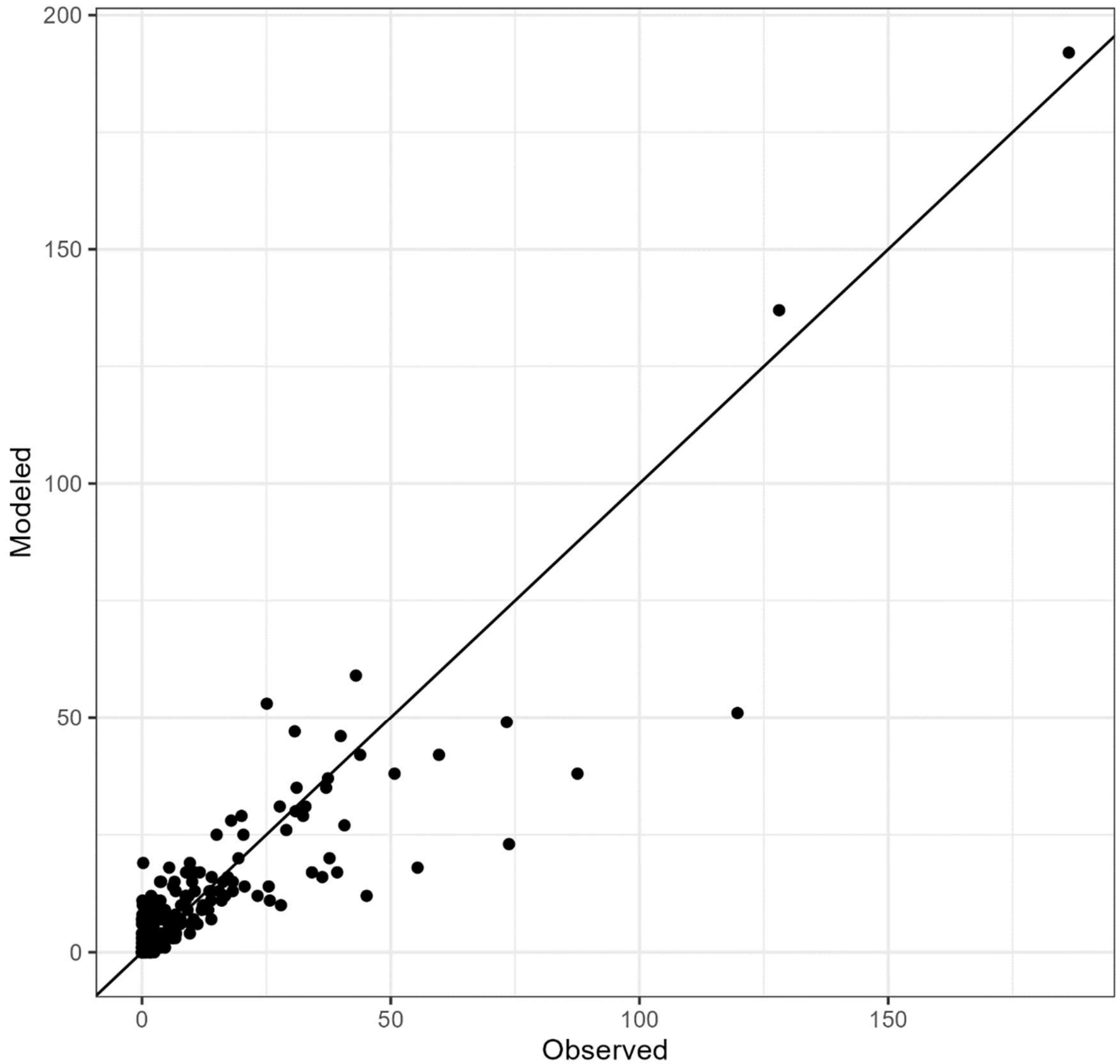
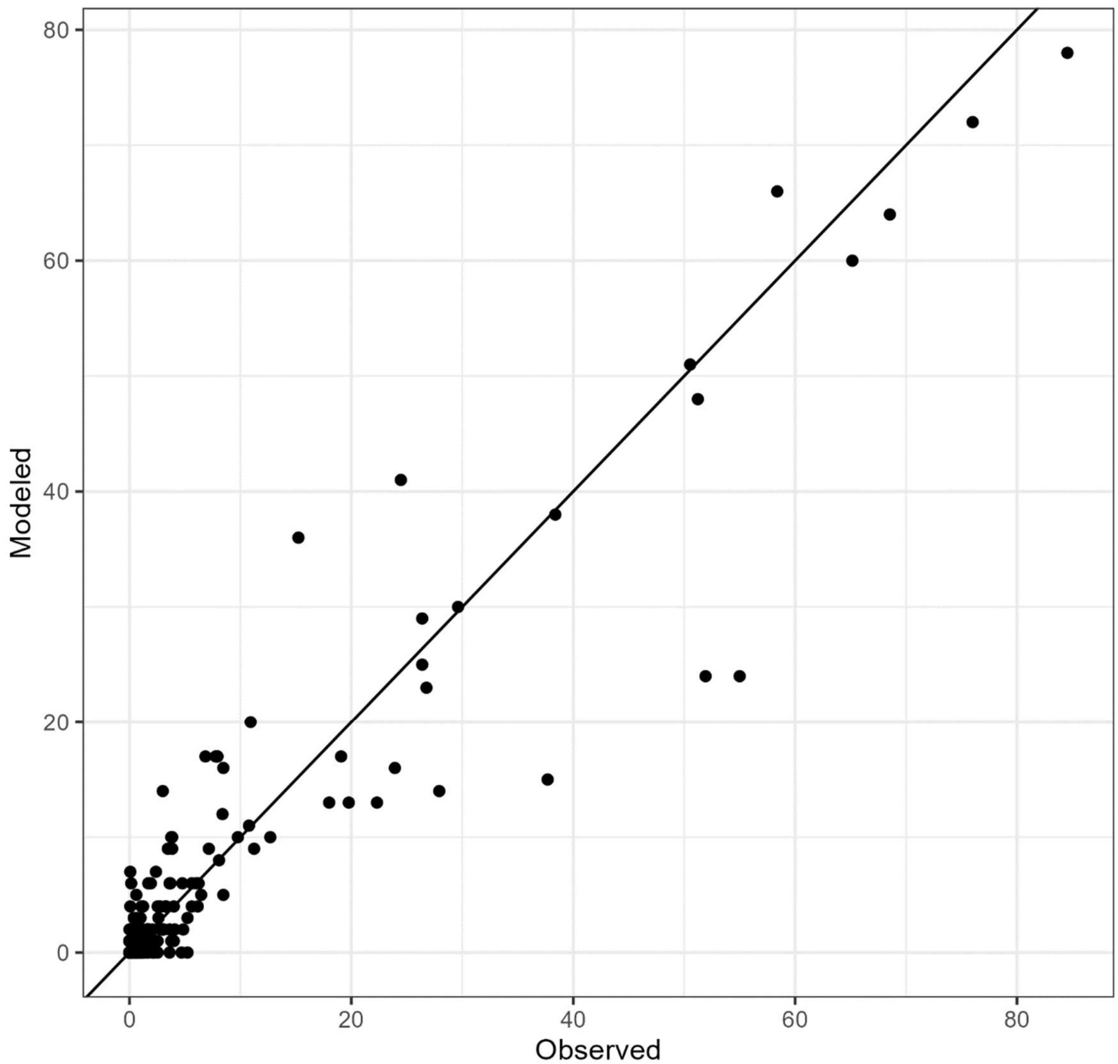


Figure 5. Off Peak Observed versus Modeled Ridership (Year 2019)



2023 Ridership and Pandemic Effects

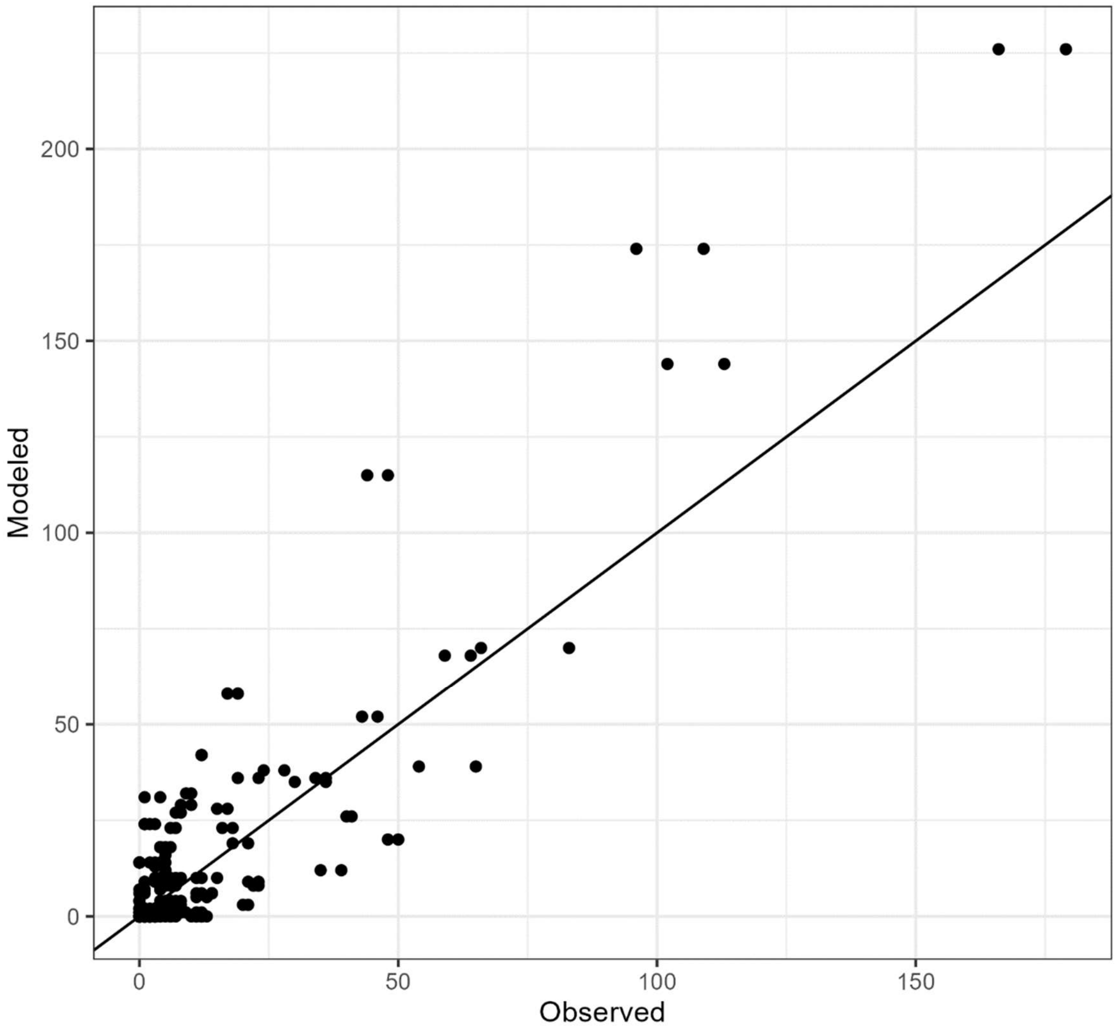
As mentioned before, the re-estimated DRM includes post-COVID related variables such as the share of jobs that allow remote work, but the model is estimated based on 2019 pre-COVID ridership data. This approach was deliberately chosen to be able to capture transit hesitancy that has reduced demand for transit services given pandemic-related health, safety, and security concerns. To isolate transit hesitancy, the re-estimated 2019 model that included a work from home variable was applied with 2023 inputs, and compared the modeled 2023 ridership with the observed Capitol Corridor ridership in April 2023. As expected, the re-estimated model overestimated ridership in 2023 (**Figure 6**). It was found that the re-estimated DRM overestimated daily 2023 systemwide ridership by approximately 20%. This 20% was interpreted as transit hesitancy due to concerns about health, personal safety, and security. This same 20% reduction was then applied to the 2025 and 2040 forecasts to generate Post-COVID Basis forecasts.

The latest data available was reviewed to create DRM input variables for 2023 conditions. Data from Census and the California Bureau of Labor Statistics was reviewed for population and employment variables, respectively. While population in cities outside of the core Bay Area increased between 2019 and 2023 by around 3%, the number of residents within the Core Bay Area decreased by approximately the same percentage. Employment increased both inside and outside the core Bay Area, with Sacramento/Roseville and San Jose/Santa Clara areas representing the majority of the growth.

Modal station accessibility variables were also updated based on the latest data available from the National Transit Database. Service frequencies for most of the transit agencies along Capitol Corridor decreased between 2019 and 2023. In general, the 2023 service patterns reflect approximately a 20%-40% decrease in service frequency relative to 2019.

Finally, 2023 work-from-home data based on job postings from recent research was incorporated into the re-estimated DRM. The average share of jobs that are remote or hybrid for the cities in the study area increased from 2% in 2019 to 10% in 2023.

Figure 6. Daily Observed versus Modeled Ridership (Year 2023)



Post-COVID Basis Ridership Forecasts

This section provides detailed tables of systemwide Post-COVID Basis ridership, and station-level boardings and alightings based on the methodology described in the previous sections.

Systemwide Post-COVID Basis Ridership Totals

Table 16 shows the daily boardings and alightings at three key stations: Hayward, Fremont, and Ardenwood, along with the total daily systemwide boardings. **Table 17** shows systemwide total boardings by time of day. In general, the South Bay Connect project scenarios are projected to result in a modest increase in system-level ridership compared to the corresponding No Project scenarios. For key stations in the project area, the difference between No Project and With Project scenarios is more substantial.

Table 16: Post-COVID Basis Ridership Forecast Overview

Alternative	Key Station Boardings + Alightings			Systemwide Total Daily Boardings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2023 – Existing						
No Project	140	--	--	2,780	--	--
Year 2025 – Opening Year						
No Project	400	380	420	4,800	4,560	5,040
With Project	710	670	750	5,300	5,040	5,570
Year 2040 – Horizon Year						
No Project	980	930	1,030	12,450	11,830	13,070
With Project	1,670	1,590	1,750	13,440	12,770	14,110

Source: Fehr & Peers, 2023.

Table 17: Post-COVID Basis Systemwide Boardings by Time Period

Alternative	Systemwide Total Boardings			
	Daily	AM Peak	PM Peak	Off Peak
Year 2023 – Existing				
No Project	2,780	1,040	1,320	420
Year 2025 – Opening Year				
No Project	4,800	1,810	1,670	1,310
With Project	5,300	2,040	1,890	1,370
Year 2040 – Horizon Year				
No Project	12,450	4,760	4,600	3,100

With Project	13,440	5,240	5,040	3,160

Source: Fehr & Peers, 2023.

Post-COVID Basis Individual Station Boardings

Systemwide station boarding information by time of day is summarized in tabular form in **Attachment C**.

Post-COVID Basis AM Peak Boardings and Alightings at Key Stations

Table 18 presents AM Peak boardings and alightings for the three key stations in the project area: Hayward, Fremont-Centerville, and Ardenwood.

Table 18: Post-COVID Basis AM Peak Period Boardings and Alightings

Alternative	Key Stations AM Boardings			Key Stations AM Alightings		
	Total	Range Low	Range High	Total	Range Low	Range High
Year 2023 – Existing						
No Project	30	--	--	20	--	--
Year 2025 – Opening Year						
No Project	160	150	170	10	10	10
With Project	240	230	250	80	80	80
Year 2040 – Horizon Year						
No Project	390	370	410	20	20	20
With Project	450	430	470	310	290	330

Source: Fehr & Peers, 2023.

The new station at Ardenwood opens up a new travel market for Capitol Corridor, in which riders travel to Ardenwood during the AM peak and use connecting transit across the Dumbarton Bridge to access substantial employment centers. It is also noted that AM peak period boardings at Ardenwood Station are also greater than under the No Project scenario, indicating that the Ardenwood Station is likely recapturing existing demand from Fremont-Centerville Station as well as new demand from new residential markets served (either in the local station area or from Transbay transit connections). These trips are also likely longer distance in nature given the differences in travel markets.

Origin-Destination Matrices

Origin-destination (OD) matrices for the Capitol Corridor system are summarized in tabular form in **Attachment C**.

Post-COVID Basis Ridership Conclusions

The data in **Table 16, Table 17,** and **Table 18** indicates that the project results in a net increase in ridership over No Project conditions. Systemwide boardings are anticipated to increase by eight to 10% after completion of the project; boardings are anticipated to grow faster in the AM and PM peak periods than the Off Peak period, which is in-line with expectations as the proposed Ardenwood Station serves a major employment hub in the local station area, as well as provides an opportunity to serve a Transbay travel market to serve job centers in San Mateo County. The projected increase in AM peak period boardings at Ardenwood Station (versus the No Project condition where Hayward and Fremont-Centerville stations remain open) indicates that the project is recapturing at least some of the existing Hayward and Fremont-Centerville ridership demand, while also capturing other trips. The underserved existing Hayward and Fremont-Centerville ridership demand may use BART or other transit options to connect to Capitol Corridor service.

Mode of Access and Egress

In addition to estimating Capitol Corridor ridership, Mode of Access (MoA) models were developed to understand travel to and from Capitol Corridor stations. Two models were developed, focused solely on the AM Peak period: a mode of access model and a mode of egress model. In the following sections, both models are referred to as MoA models. The mode of access and egress models were not re-estimated due to insufficient available 2023 mode share data. As such, the mode of access and egress forecasts remain the same as the previous analysis.

MoA Model Variables

Independent variables for the MoA models were the same set of station-specific variables as used in the ridership models. Variables used in the mode of access and mode of egress models are listed in **Table 19** on the next page. The overall measures of population and employment were generally less useful than the comparisons between accessibility variables and straight-line buffers, probably because overall population and employment density varies widely across the Capitol Corridor service region. Finally, parking at stations was only a weak predictor of AM access, and only when measured as a yes-no variable indicating whether there are at least 50 spaces. This may be because almost all stations have parking, and the amount provided is generally more connected to the overall ridership at the station than the access and egress mode share.

Table 19: Overview of AM Mode of Access / Egress Model Variables

Category	Variable	AM Access	AM Egress
Transit Accessibility	BART-accessible population versus 2-mile population	+	
	Thruway-bus-accessible population versus 2-mile population	+	
	BART-accessible employment versus 2-mile employment		++
	Thruway-bus-accessible employment versus 2-mile employment		+
	VTA-accessible employment versus 1-mile employment		+
Walk Accessibility	Walk-accessible population versus ½-mile population	++	
	Walk-accessible employment versus ¼-mile employment		+
Parking	Auto parking at station: Over 50 spaces?	+	
Significance Definition			
+++	Strong positive significance		
++	Moderate positive significance		
+	Weak positive significance		
-	Weak negative significance		

Source: Fehr & Peers, 2023.

Mode of Access Forecasts

The tables and figures on the following pages list the AM mode of access and mode of egress model forecasts for each station. The mode of access and egress models are generally only modestly sensitive to station changes over time.

Table 20 and **Table 21** show forecast mode splits for access to and egress from the same three key stations during the AM peak. These forecasts also reflect Ardenwood's status as both an AM origin station similar to Hayward and Fremont-Centerville, and also an AM destination station with good transit connections to employment. The very large (60%) transit mode share for Ardenwood in 2025, which drops to 35% in 2040, is attributed to changes to station area employment opportunities between 2025 and 2040, opening up employment opportunities in the station area even without a transit connection. **Figure 6** and **Figure 7** present AM peak period mode of access and egress forecasts for all stations in the Capitol Corridor system; detailed numerical forecasts are detailed in **Attachment C**.

Table 20: AM Peak Period Mode of Access to Key Stations

Station	2019 (Observed)			2025 (Projected)			2040 (Projected)		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Hayward (No Project scenario)	89%	0%	11%	89%	0%	11%	89%	0%	11%
Fremont (No Project scenario)	75%	0%	25%	77%	0%	22%	76%	0%	24%
Ardenwood (With Project scenario)	--	--	--	91%	1%	9%	90%	1%	9%

Source: Fehr & Peers, 2023.

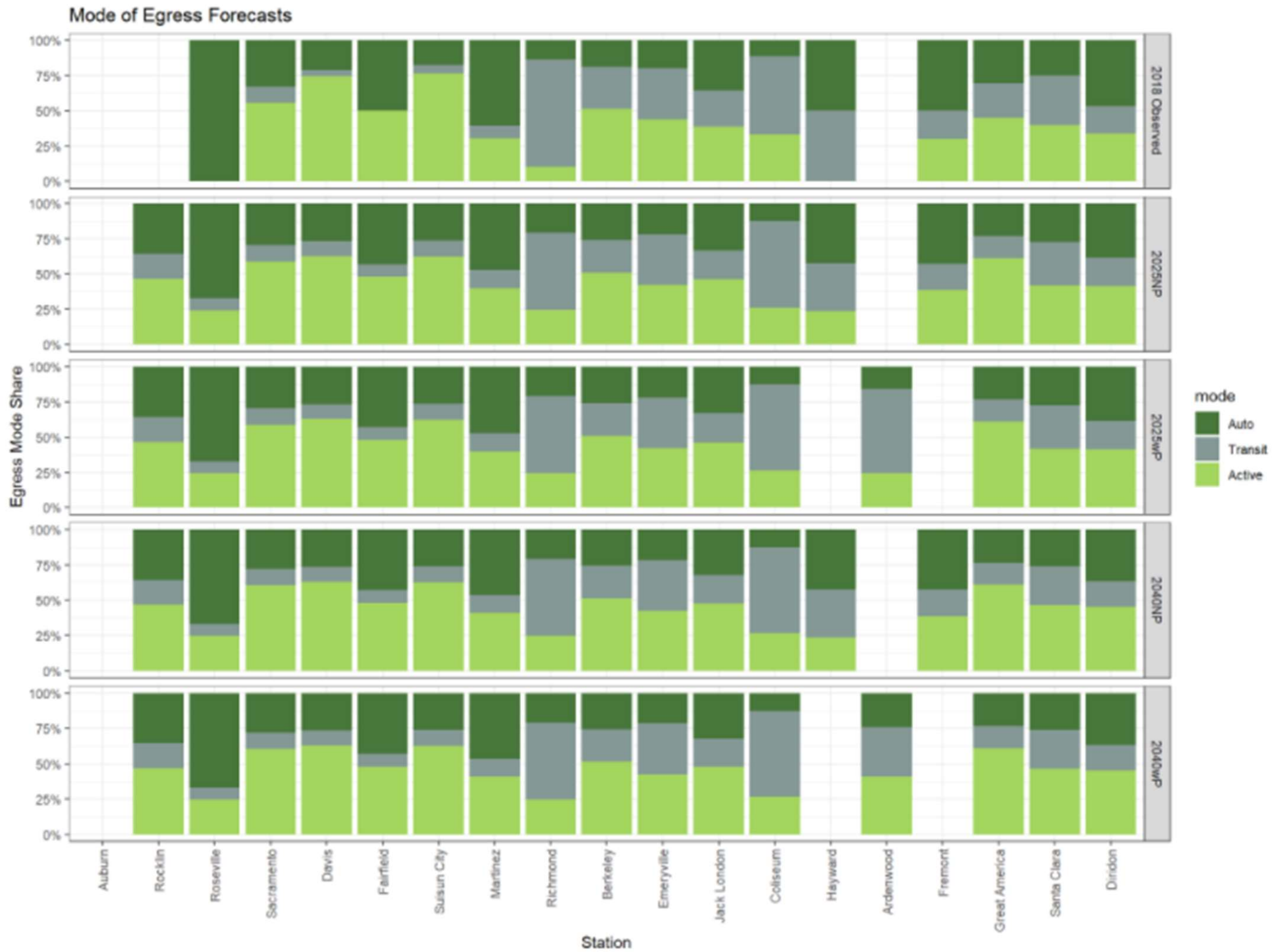
Table 21: AM Peak Period Mode of Egress from Key Stations

Station	2019 (Observed)			2025 (Projected)			2040 (Projected)		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Hayward (No Project scenario)	50%	50%	0%	43%	34%	24%	43%	34%	24%
Fremont (No Project scenario)	50%	20%	30%	43%	19%	39%	43%	19%	39%
Ardenwood (With Project scenario)	--	--	--	16%	60%	25%	24%	35%	41%

Source: Fehr & Peers, 2023.

Figure 6. AM Peak Period Mode of Access Forecasts

Figure 7. AM Peak Period Mode of Egress Forecasts



Post-COVID Basis Vehicle-Miles Traveled Estimates

Using the C/CAG-VTA travel demand model and the results of the DRM as described above, daily regional vehicle-miles traveled (VMT) was estimated for the project scenarios. For this VMT estimate, the region is defined as the geographic area covered by the C/CAG-VTA travel demand model.

While this estimate covers a large region, it is noted that much of the VMT savings due to the project will be along the I-80 corridor between Sacramento and Oakland and the I-880 corridor between Oakland and San Jose. It is also noted that based on existing conditions, these two corridors are extremely congested during the AM and PM peak period and the majority of new ridership under the plus project alternatives would occur during the AM and PM peak periods.

Table 22 details the outputs of the VMT calculations.

Table 22: Post-COVID Basis Daily Regional Vehicle-Miles Traveled

Alternative	Vehicle Miles of Travel (VMT)
No Project	227,150,000
Delta	***-20,000***
Year 2040 – Horizon Year	
No Project	256,390,000
With Project	256,357,000
Delta	***-33,000***

Source: Fehr & Peers, 2023.

Attachment A:
Model Development Memo

See Attachment A in Appendix A1 of CCJPA TIA for Model Development Memo

Attachment B: Forecasting Methodology Details

Direct Ridership Models

Methodology

This section outlines the details of the statistical models developed as the Direct Ridership Model for Capitol Corridor. Twelve independent linear regression models were developed, one for each combination of time period and market segment. Each of the twelve statistical models comprising the DRM has a similar structure. Broadly speaking, these models can be defined by the following equation for a linear model:

$$Y_{i,j} = \alpha * X_i * + \beta * X_j + \gamma * X_{i.j}$$

where:

- *$Y_{i,j}$ is the estimated ridership going from origin station i to destination station j*
- *X_i is a vector of station-specific input variables associated with the origin station i*
- *X_j is a vector of station-specific input variables associated with destination station j*
- *$X_{i,j}$ is a vector of input variables associated with the station origin-destination (OD) pair i and j*
- *$\alpha, \beta,$ and γ are vectors of model coefficients associated with X_i, X_j, and $X_{i,j}$ respectively*

In practice, it was found that station-specific input variables on their own did not perform well in the models, so these variables were always combined by multiplying together an origin-specific variable and a destination-specific variable to create a variable associated with the OD-pair.

Mode of Access/Egress Models

Methodology

The MoA models are logit models that have been transformed via Berkson's method4 to linear regression models. These models jointly predict mode shares for each of three modes of access

[4] Li, W. et al. "Assessing the Performance of Berkson-Theil Method on Multiple Choice Sets and Aggregated Choice Data." (2017).

and egress: auto, transit, and walk. The model dependent variable was developed using results from the Capitol Corridor on-board survey conducted in June 2019.

The model assigns each access mode a utility equation which describes the benefits and costs of travel by that mode. Variables were selected for the final models based on their contribution to the overall goodness-of-fit of the respective model.

The MoA modes were developed such that as the proportion (or likelihood) of one mode increases, the likelihood of using the other modes decreases. The station access mode share is estimated according to the following equation:

$$P_i = \frac{e^{V_i}}{\sum_{j \in J} e^{V_j}}$$

$where\ i, j = particular\ modes\ of\ access$
$Pi = probability\ of\ using\ mode\ i\ to\ access\ the\ station$
$J = the\ set\ of\ all\ possible\ modes\ of\ access$
$= \{\text{Auto, Transit, Active})\}$
$Vi = linear - in - parameters\ utility\ fucntion = \boldsymbol{\beta} * \boldsymbol{X}$
$\boldsymbol{X} = a\ vector\ of\ explanatory\ variables$
$\boldsymbol{\beta} = a\ vector\ of\ coefficients$

Model Fit

To measure the fit of the mode of access and egress models, percent root-mean-square error (RMSE) was calculated for each model and each mode. The results of the goodness of fit tests are presented in **Table B1.**

Table B1: Model Goodness of Fit (Percent RMSE)

Model	Active	Transit	Auto
AM Mode of Access	1.36	1.74	0.39
AM Mode of Egress	0.53	0.59	0.52

Source: Fehr & Peers, 2023.

The percent RMSE values are relatively high, indicating that there is variation in mode of access that is not being fully captured by the MoA models. In the future, additional data from the on-board survey could prove helpful, as demographic data including vehicle ownership or household income might help improve these models. However, the MoA models are suitable for use in the translation of forecasted ridership at the new Ardenwood station to walk, bike, and vehicle volumes, as well as to understand the number of Capitol Corridor passengers transferring to connecting transit service at Ardenwood station.

Attachment C: Detailed Post-COVID Basis Forecasts

This section contains detailed tables from the forecasts of ridership, mode of access, and C/CAG-VTA model results.

Station-Level Post-COVID Basis Ridership

Table C1 shows Post-COVID Basis forecast daily boardings for all stations.

Table C1: Post-COVID Basis Forecast Daily Boardings by Station

Station	Observed Data[1] 2023	No project 2025	With Project 2025	No project 2040	With Project 2040
Auburn	10	1	1	2	2
Rocklin	10	12	12	34	34
Roseville	32	41	41	647	633
Sacramento	772	1,297	1,306	3,076	3,105
Davis	344	485	494	992	995
Fairfield	112	133	141	363	368
Suisun City	103	174	185	581	587
Martinez	165	234	244	469	492
Richmond	176	289	312	642	672
Berkeley	136	212	226	472	516
Emeryville	323	510	541	1,305	1,367
Jack London	210	444	488	1,121	1,210
Coliseum	37	118	133	439	488
Hayward	36	120	0	254	0
Ardenwood	0	0	354	0	836
Fremont	29	81	0	238	0
Great America	105	298	381	811	956
Santa Clara	51	102	148	427	506
Diridon	133	246	293	580	669
Systemwide	**2,784**	**4,797**	**5,300**	**12,453**	**13,436**

Source: Fehr & Peers, 2023.

Table C2 shows Post-COVID Basis forecast AM peak boardings for all stations.

Table C2 Post-COVID Basis Forecast AM Peak Boardings by Station

Station	Observed Data[1] 2023	No project 2025	With Project 2025	No project 2040	With Project 2040
Auburn	10	1	1	0	0
Rocklin	10	12	12	32	32
Roseville	32	40	40	138	142
Sacramento	325	409	420	1,341	1,386
Davis	152	138	140	330	339
Fairfield	81	47	47	119	122
Suisun City	64	31	31	194	200
Martinez	76	160	168	296	309
Richmond	29	86	92	205	223
Berkeley	48	144	152	287	317
Emeryville	61	122	128	336	369
Jack London	74	206	230	421	482
Coliseum	11	86	94	204	244
Hayward	16	108	0	220	0
Ardenwood	0	0	240	0	454
Fremont	14	54	0	165	0
Great America	11	48	76	147	203
Santa Clara	3	39	64	138	187
Diridon	25	80	105	182	234
Systemwide	**1,042**	**1,811**	**2,040**	**4,755**	**5,243**

Source: Fehr & Peers, 2023.

Table C3 shows Post-COVID Basis forecast PM peak boardings for all stations.

Table C3: Post-COVID Basis Forecast PM Peak Boardings by Station

Station	Observed Data[1] 2023	No project 2025	With Project 2025	No project 2040	With Project 2040
Auburn	0	0	0	0	0
Rocklin	0	0	0	0	0
Roseville	0	0	0	263	250
Sacramento	279	445	437	809	792
Davis	130	179	175	323	314
Fairfield	16	45	46	120	116
Suisun City	18	74	75	187	183
Martinez	74	0	1	77	87
Richmond	126	103	120	205	217
Berkeley	73	30	36	113	127
Emeryville	218	260	286	753	782
Jack London	115	150	172	526	554
Coliseum	20	5	10	147	157
Hayward	10	0	0	0	0
Ardenwood	0	0	82	0	290
Fremont	13	12	0	26	0
Great America	90	212	255	549	618
Santa Clara	47	40	56	205	229
Diridon	86	119	136	294	321
Systemwide	**1,315**	**1,674**	**1,887**	**4,597**	**5,037**

Source: Fehr & Peers, 2023.

Table C4 shows Post-COVID Basis forecast Off Peak boardings for all stations.

Table C4: Post-COVID Basis Forecast Off Peak Boardings by Station

Station	Observed Data[1] 2019	No project 2025	With Project 2025	No project 2040	With Project 2040
Auburn	0	0	0	2	2
Rocklin	0	0	0	2	2
Roseville	0	1	1	246	241
Sacramento	167	443	449	926	927
Davis	62	168	179	339	342
Fairfield	16	41	48	124	130
Suisun City	20	69	79	200	204
Martinez	18	74	75	96	96
Richmond	21	100	100	232	232
Berkeley	13	38	38	72	72
Emeryville	40	128	127	216	216
Jack London	23	88	86	174	174
Coliseum	3	27	29	88	87
Hayward	8	12	0	34	0
Ardenwood	0	0	32	0	92
Fremont	4	15	0	47	0
Great America	3	38	50	115	135
Santa Clara	1	23	28	84	90
Diridon	20	47	52	104	114
Systemwide	**419**	**1,312**	**1,373**	**3,101**	**3,156**
Source: Fehr & Peers, 2023.					

Origin-Destination Matrices

Tables C5-C8 on the following pages present the Post-COVID Basis daily OD matrices for the Year 2025 and Year 2040 horizon years for the No Project and Plus Project scenarios.

AM Mode of Access and Egress

Table C9 and **Table C10** on the following pages list the AM mode of access and AM mode of egress model forecasts for each station.

Table C5: Year 2025 No Project Scenario Daily Post-COVID Basis Ridership Origin-Destination Matrix

Station	Auburn	Rocklin	Roseville	Sacramento	Davis	Fairfield	Suisun City	Martinez	Richmond	Berkeley	Emeryville	Jack London	Coliseum	Hayward	Ardenwood	Fremont	Great America	Santa Clara	Diridon	Total
Auburn	0	0	1	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	**1**
Rocklin	0	0	0	6	2	2	2	0	0	0	0	0	0	0		0	0	0	0	**12**
Roseville	1	0	0	26	7	3	4	0	0	0	0	0	0	0		0	0	0	0	**41**
Sacramento	0	6	26	0	121	37	38	84	183	81	276	194	50	35		23	63	22	58	**1,297**
Davis	0	2	7	121	0	10	11	38	44	27	83	54	18	20		12	13	9	16	**485**
Fairfield	0	2	3	36	9	0	0	13	7	4	18	7	5	8		7	5	4	5	**133**
Suisun City	0	2	4	38	11	0	0	20	14	10	21	13	8	9		8	6	4	6	**174**
Martinez	0	0	0	85	38	13	20	0	5	4	14	13	0	0		2	24	3	13	**234**
Richmond	0	0	0	183	44	7	15	5	0	0	2	8	0	0		2	9	4	10	**289**
Berkeley	0	0	0	81	27	5	10	4	0	0	7	14	0	2		2	32	8	20	**212**
Emeryville	0	0	0	276	82	20	21	14	2	6	0	22	0	2		3	27	10	25	**510**
Jack London	0	0	0	194	54	6	13	12	8	14	21	0	0	3		5	59	14	41	**444**
Coliseum	0	0	0	50	18	6	8	0	0	0	0	0	0	0		1	14	6	15	**118**
Hayward	0	0	0	35	19	8	10	0	0	2	2	3	0	0		2	19	6	14	**120**
Ardenwood																				
Fremont	0	0	0	23	13	7	8	2	2	2	4	5	1	2		0	5	2	5	**81**
Great America	0	0	0	63	13	6	6	24	9	32	27	59	14	19		5	0	5	16	**298**
Santa Clara	0	0	0	22	9	4	5	3	4	7	10	15	6	7		2	5	0	3	**102**
Diridon	0	0	0	57	16	5	7	13	10	20	25	42	14	14		4	16	3	0	**246**
TOTAL	**1**	**12**	**41**	**1,296**	**483**	**139**	**178**	**232**	**288**	**209**	**510**	**449**	**116**	**121**		**78**	**297**	**100**	**247**	**4,797**

Source: Fehr & Peers, 2023.

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Table C6: Year 2025 Plus Project Scenario Daily Post-COVID Basis Ridership Origin-Destination Matrix

Station	Auburn	Rocklin	Roseville	Sacramento	Davis	Fairfield	Suisun City	Martinez	Richmond	Berkeley	Emeryville	Jack London	Coliseum	Hayward	Ardenwood	Fremont	Great America	Santa Clara	Diridon	Total
Auburn	0	0	1	0	0	0	0	0	0	0	0	0	0		0		0	0	0	**1**
Rocklin	0	0	0	6	2	2	2	0	0	0	0	0	0		0		0	0	0	**12**
Roseville	1	0	0	26	7	3	4	0	0	0	0	0	0		0		0	0	0	**41**
Sacramento	0	6	26	0	121	37	38	84	183	81	276	194	50		56		66	29	59	**1,306**
Davis	0	2	7	121	0	10	11	38	44	27	83	54	18		21		19	16	23	**494**
Fairfield	0	2	3	36	9	0	0	13	7	4	18	7	5		7		12	9	9	**141**
Suisun City	0	2	4	38	11	0	0	20	14	10	21	13	8		9		12	11	12	**185**
Martinez	0	0	0	85	38	13	20	0	5	4	14	13	0		11		23	5	13	**244**
Richmond	0	0	0	183	44	7	15	5	0	0	2	8	0		15		12	8	13	**312**
Berkeley	0	0	0	81	27	5	10	4	0	0	7	14	0		18		30	9	21	**226**
Emeryville	0	0	0	276	82	20	21	14	2	6	0	22	0		32		28	12	26	**541**
Jack London	0	0	0	194	54	6	13	12	8	14	21	0	0		44		60	18	44	**488**
Coliseum	0	0	0	50	18	6	8	0	0	0	0	0	0		5		19	10	17	**133**
Hayward																				
Ardenwood	0	0	0	56	21	7	9	11	14	19	31	44	5		0		80	17	40	**354**
Fremont																				
Great America	0	0	0	65	19	11	13	23	12	31	28	59	19		80		0	6	15	**381**
Santa Clara	0	0	0	28	16	9	10	5	8	9	11	17	10		16		6	0	3	**148**
Diridon	0	0	0	59	23	10	12	13	13	21	25	43	17		40		14	3	0	**293**
TOTAL	**1**	**12**	**41**	**1,304**	**492**	**146**	**186**	**242**	**310**	**226**	**537**	**488**	**132**		**354**		**381**	**153**	**295**	**5,300**

Source: Fehr & Peers, 2023.

Table C7: Year 2040 No Project Scenario Daily Post-COVID Basis Ridership Origin-Destination Matrix

Station	Auburn	Rocklin	Roseville	Sacramento	Davis	Fairfield	Suisun City	Martinez	Richmond	Berkeley	Emeryville	Jack London	Coliseum	Hayward	Ardenwood	Fremont	Great America	Santa Clara	Diridon	Total
Auburn	0	0	0	2	0	0	0	0	0	0	0	0	0	0		0	0	0	0	**2**
Rocklin	0	0	5	19	5	2	3	0	0	0	0	0	0	0		0	0	0	0	**34**
Roseville	0	5	0	101	24	10	15	49	52	38	85	61	41	34		29	42	28	33	**647**
Sacramento	2	19	102	0	181	50	98	150	345	164	704	495	191	58		54	228	98	137	**3,076**
Davis	0	5	25	181	0	13	21	60	89	51	177	121	55	31		29	63	31	40	**992**
Fairfield	0	2	10	50	13	0	2	27	30	18	59	37	22	20		21	24	14	14	**363**
Suisun City	0	3	15	98	21	2	0	40	53	27	97	66	34	23		23	37	20	22	**581**
Martinez	0	0	49	150	60	27	40	0	5	12	17	25	3	2		5	40	13	21	**469**
Richmond	0	0	52	345	89	31	53	5	0	1	3	8	0	2		4	16	14	19	**642**
Berkeley	0	0	38	165	51	18	27	12	1	0	9	25	3	2		4	54	26	37	**472**
Emeryville	0	0	86	704	176	59	98	18	2	9	0	28	1	3		6	46	28	41	**1,305**
Jack London	0	0	61	495	121	37	66	25	7	25	28	0	6	6		10	108	51	75	**1,121**
Coliseum	0	0	39	190	55	21	34	3	0	2	1	6	0	0		4	28	24	32	**439**
Hayward	0	0	34	58	31	20	23	2	2	2	4	6	0	0		3	29	18	22	**254**
Ardenwood																				
Fremont	0	0	29	54	28	20	22	5	4	5	6	10	4	4		0	21	11	15	**238**
Great America	0	0	42	228	62	23	37	40	16	54	45	108	27	29		21	0	29	50	**811**
Santa Clara	0	0	28	97	31	14	19	14	15	26	29	51	24	18		11	28	0	22	**427**
Diridon	0	0	32	138	39	15	22	21	19	37	41	75	32	22		15	49	23	0	**580**
TOTAL	**2**	**34**	**647**	**3,075**	**987**	**362**	**580**	**471**	**640**	**471**	**1,305**	**1,122**	**443**	**254**		**239**	**813**	**428**	**580**	**12,453**

Source: Fehr & Peers, 2023.

Table C8: Year 2040 Plus Project Scenario Daily Post-COVID Basis Ridership Origin-Destination Matrix

Station	Auburn	Rocklin	Roseville	Sacramento	Davis	Fairfield	Suisun City	Martinez	Richmond	Berkeley	Emeryville	Jack London	Coliseum	Hayward	Ardenwood	Fremont	Great America	Santa Clara	Diridon	Total
Auburn	0	0	0	2	0	0	0	0	0	0	0	0	0		0		0	0	0	**2**
Rocklin	0	0	5	19	5	2	3	0	0	0	0	0	0		0		0	0	0	**34**
Roseville	0	5	0	101	24	10	15	49	52	38	85	61	41		38		46	32	36	**633**
Sacramento	2	19	102	0	181	50	98	150	345	164	704	495	191		128		230	104	142	**3,105**
Davis	0	5	25	181	0	13	21	60	89	51	177	121	55		45		69	39	44	**995**
Fairfield	0	2	10	50	13	0	2	27	30	18	59	37	22		22		32	22	22	**368**
Suisun City	0	3	15	98	21	2	0	40	53	27	97	66	34		28		46	28	29	**587**
Martinez	0	0	49	150	60	27	40	0	5	12	17	25	3		26		41	14	23	**492**
Richmond	0	0	52	345	89	31	53	5	0	1	3	8	0		29		17	18	21	**672**
Berkeley	0	0	38	165	51	18	27	12	1	0	9	25	3		44		58	27	38	**516**
Emeryville	0	0	86	704	176	59	98	18	2	9	0	28	1		61		48	32	45	**1,367**
Jack London	0	0	61	495	121	37	66	25	7	25	28	0	6		92		112	56	79	**1,210**
Coliseum	0	0	39	190	55	21	34	3	0	2	1	6	0		42		32	28	35	**488**
Hayward																				
Ardenwood	0	0	37	128	43	21	27	26	29	44	61	93	42		0		143	57	85	**836**
Fremont																				
Great America	0	0	47	230	69	32	46	42	18	58	48	113	32		142		0	29	50	**956**
Santa Clara	0	0	32	104	38	22	27	15	17	26	33	56	29		56		29	0	22	**506**
Diridon	0	0	37	142	44	21	30	22	20	39	45	78	34		85		50	22	0	**669**
TOTAL	**2**	**34**	**635**	**3,104**	**990**	**366**	**587**	**494**	**668**	**514**	**1,367**	**1,212**	**493**		**838**		**953**	**508**	**671**	**13,436**

Source: Fehr & Peers, 2023.

Table C9: Forecast AM Peak Period Mode of Access

Station	Observed Data 2023			No project 2025			With Project 2025			No project 2040			With Project 2040		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Auburn	83%	0%	17%	68%	0%	31%	68%	0%	31%	66%	0%	33%	66%	0%	33%
Rocklin	86%	0%	14%	89%	0%	11%	89%	0%	11%	88%	0%	12%	88%	0%	12%
Roseville	85%	4%	11%	89%	2%	9%	89%	2%	9%	90%	3%	8%	90%	3%	8%
Sacramento	81%	7%	12%	96%	4%	0%	96%	4%	0%	96%	4%	0%	96%	4%	0%
Davis	65%	0%	35%	79%	0%	20%	79%	0%	20%	79%	0%	20%	79%	0%	20%
Fairfield	98%	2%	0%	97%	1%	1%	97%	1%	1%	97%	1%	1%	97%	1%	1%
Suisun City	85%	3%	12%	86%	2%	12%	86%	2%	12%	89%	2%	9%	89%	2%	9%
Martinez	81%	4%	15%	83%	2%	15%	83%	2%	15%	88%	2%	10%	88%	2%	10%
Richmond	47%	41%	13%	71%	22%	8%	71%	22%	8%	72%	21%	6%	72%	21%	6%
Berkeley	35%	8%	57%	45%	4%	51%	45%	4%	51%	42%	4%	54%	42%	4%	54%
Emeryville	50%	16%	34%	71%	10%	19%	71%	10%	19%	68%	14%	18%	68%	14%	18%
Jack London	49%	5%	46%	66%	3%	31%	66%	3%	31%	69%	3%	28%	69%	3%	28%
Coliseum	69%	13%	19%	68%	18%	13%	68%	18%	13%	71%	20%	9%	71%	20%	9%
Hayward	89%	0%	11%	89%	0%	11%	--	--	--	89%	0%	11%	--	--	--
Ardenwood	--	--	--	--	--	--	91%	1%	9%	--	--	--	90%	1%	9%
Fremont	75%	0%	25%	77%	0%	22%	--	--	--	76%	0%	24%	--	--	--
Great America	86%	0%	14%	92%	0%	7%	92%	0%	7%	90%	0%	9%	90%	0%	9%
Santa Clara	100%	0%	0%	51%	0%	49%	51%	0%	49%	56%	0%	44%	56%	0%	44%
Diridon	84%	0%	16%	90%	0%	10%	90%	0%	10%	91%	0%	9%	91%	0%	9%

Source: Fehr & Peers, 2023.

Table C10: Forecast AM Peak Period Mode of Egress

Station	Observed Data[1]			No project			With Project			No project			With Project		
	2023			2025			2025			2040			2040		
	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active	Auto	Transit	Active
Auburn	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rocklin	0%	0%	0%	36%	18%	47%	36%	18%	47%	36%	18%	47%	36%	18%	47%
Roseville	100%	0%	0%	67%	9%	24%	67%	9%	24%	67%	8%	25%	67%	8%	25%
Sacramento	33%	11%	56%	29%	12%	59%	29%	12%	59%	28%	11%	61%	28%	11%	61%
Davis	21%	5%	74%	27%	10%	63%	27%	10%	63%	27%	10%	63%	27%	10%	63%
Fairfield	50%	0%	50%	43%	9%	48%	43%	9%	48%	43%	9%	48%	43%	9%	48%
Suisun City	18%	6%	76%	26%	12%	62%	26%	12%	62%	26%	11%	62%	26%	11%	62%
Martinez	61%	9%	30%	47%	13%	40%	47%	13%	40%	46%	13%	41%	46%	13%	41%
Richmond	13%	76%	10%	21%	55%	24%	21%	55%	24%	21%	54%	25%	21%	54%	25%
Berkeley	19%	30%	51%	26%	23%	51%	26%	23%	51%	26%	23%	51%	26%	23%	51%
Emeryville	20%	36%	44%	22%	36%	42%	22%	36%	42%	21%	36%	42%	21%	36%	42%
Jack London	35%	26%	39%	33%	21%	46%	33%	21%	46%	32%	20%	48%	32%	20%	48%
Coliseum	11%	56%	33%	12%	61%	26%	12%	61%	26%	13%	61%	27%	13%	61%	27%
Hayward	50%	50%	0%	43%	34%	24%	--	--	--	43%	34%	24%	--	--	--
Ardenwood	--	--	--	--	--	--	16%	60%	25%	--	--	--	24%	35%	41%
Fremont	50%	20%	30%	43%	19%	39%	--	--	--	43%	19%	39%	--	--	--
Great America	30%	25%	45%	23%	16%	61%	23%	16%	61%	23%	16%	61%	23%	16%	61%
Santa Clara	25%	35%	40%	27%	31%	42%	27%	31%	42%	26%	27%	47%	26%	27%	47%
Diridon	47%	19%	34%	39%	20%	41%	39%	20%	41%	37%	18%	45%	37%	18%	45%

Source: Fehr & Peers, 2023.

Validated C/CAG-VTA Model Initial Ridership Outputs

Using the transportation network and land use assumptions outlined above, the C/CAG-VTA model was run for the future project scenarios to provide an informational first set of results. **Table C11** details the capitol corridor ridership estimates from those model runs.

Table C11: C/CAG-VTA Model Initial Capitol Corridor Ridership Outputs

Alternative	C/CAG VTA Model Capitol Corridor Systemwide Ridership
Year 2025 – Opening Year	
No Project	9,220
With Project	9,820
Delta	*+600*
Year 2040 – Horizon Year	
No Project	10,340
With Project	10,870
Delta	*+530*

Source: Fehr & Peers, 2023.

The main reasons that the ridership outputs are not accurate enough for use on the project are that C/CAG-VTA travel model does not contain the Sacramento region and thus misses out on a significant intercity ridership market for Capitol Corridor. Additionally, the C/CAG-VTA model overpredicts ridership in certain markets (such as Solano County to Northern Alameda County) and underpredict others (internal Bay Area to Bay Area stations such as the proposed Ardenwood station). The June 2020 technical memorandum *South Bay Connect – Base Year Model Development* (provided in **Attachment A**) contains an accounting of these potential methodological shortfalls of using the C/CAG-VTA model alone. The results of these future scenarios reinforce the need for an off-model tool in the form of a DRM.

As such, to address the limitations of the C/CAG-VTA travel demand model, a Capitol Corridor-specific Direct Ridership Model was prepared. The DRM relies on key outputs from the C/CAG-VTA model, thus retaining a linkage between the regional travel demand model and the DRM.

Appendix B:
Freight Train Length Assumptions

DRAFT Train Length Assumptions for SBC Traffic Analysis. April 12, 2021.

Gray cells are automatic calculations

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	
						2.3% Assumed CAGR for 2024 and 2025 per CBO		1.7% Assumed CAGR During Each of <u>Six</u> Years 2026						2.0% Assumed CAGR During Each of <u>Nine</u> Years <-- We have seen on other projects where FRA assumes a 2% growth rate. However, we do not have a citation for FRA's 2% growth rate.									
Assumed Compound Growth Rate During Calendar Year:			4.6%	2.9%	2.2%	2.3%	2.3%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	

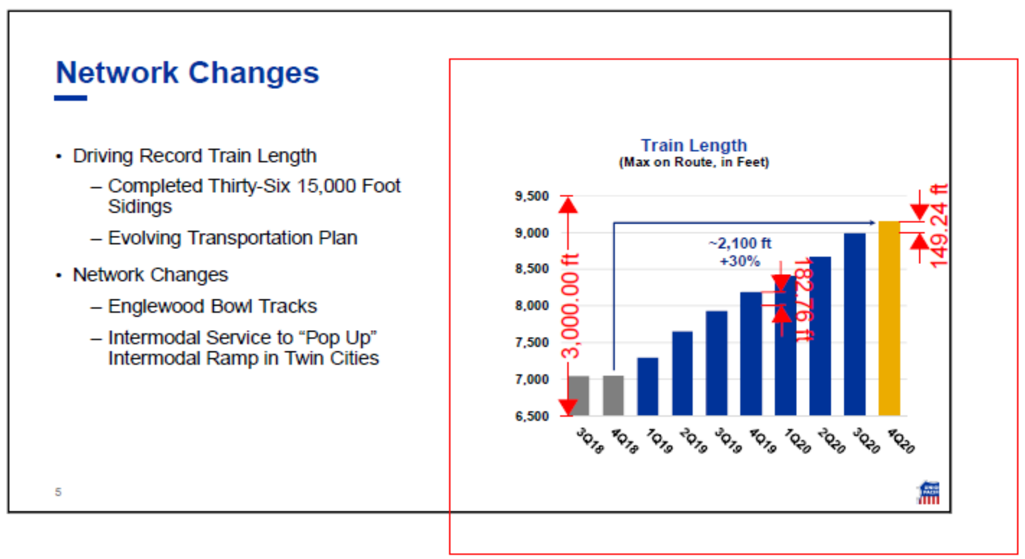
Year (Assumes <u>2020</u> is the Base Year)	**2020 (From UP**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	
Train Length:	9,149	9,570	9,847	10,064	10,295	10,532	10,711	10,893	11,079	11,267	11,458	11,653	11,886	12,124	12,367	12,614	12,866	13,123	13,386	13,654	13,927	<--Assuming **Q4 2020** as basis for train length (see graphic below)
Rounded Train Length:	9,150	9,570	9,850	10,060	10,300	10,530	10,710	10,890	11,080	11,270	11,460	11,650	11,890	12,120	12,370	12,610	12,870	13,120	13,390	13,650	13,930	

Year (Assumes <u>2019</u> is the Base Year)	**2019 (From UP table below)**	**2020 (From UP**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	
Train Length:	8,183	9,149	9,570	9,847	10,064	10,295	10,532	10,711	10,893	11,079	11,267	11,458	11,653	11,886	12,124	12,367	12,614	12,866	13,123	13,386	13,654	13,927	<--Assuming **Q4 2019** as basis for train length (see graphic below)
Rounded Train Length:	8,180	9,150	9,570	9,850	10,060	10,300	10,530	10,710	10,890	11,080	11,270	11,460	11,650	11,890	12,120	12,370	12,610	12,870	13,120	13,390	13,650	13,930	

Data on 2019 and 2020 system average train lengths from UP 2020 4th Quarter Earnings Release

Link: UP: Quarterly Earnings Release

See excerpt below (red dimensions represent train lengths above the 8000' and 9000' increment lines, scaled from graphic)



Excerpt below illustrates data for years through 2031 from Congressional Budget Office. Subsequent years assume 2% constant growth rate.
Link to full report: https://www.cbo.gov/publication/56965

Table 1.

CBO's Economic Projections for Calendar Years 2021 to 2031

					Annual Average	
	2020	2021	2022	2023	2024–2025	2026–2031
			Percentage Change From Fourth Quarter to Fourth Quarter			
Gross Domestic Product						
Real[a]	-2.5	3.7	2.4	2.3	2.2	1.6
Nominal	-1.2	5.6	4.5	4.3	4.4	3.8
Inflation						
PCE price index	1.2	1.7	1.9	1.9	2.1	2.1
Core PCE price index[b]	1.4	1.5	1.9	1.9	2.1	2.1
Consumer price index[c]	1.2	1.9	2.2	2.3	2.4	2.4
Core consumer price index[b]	1.6	1.5	2.2	2.3	2.4	2.4
GDP price index	1.3	1.9	2.0	2.0	2.1	2.1
Employment Cost Index[d]	2.8	2.3	2.8	3.0	3.2	3.3
			Fourth-Quarter Level (Percent)			
Unemployment Rate	6.8	5.3	4.9	4.6	4.0[e]	4.3[f]
			Percentage Change From Year to Year			
Gross Domestic Product						
Real[a]	-3.5	4.6	2.9	2.2	2.3	1.7
Nominal	-2.3	6.3	4.9	4.2	4.4	3.8

Yellow highlight = manual entry req'd

Freight Trains (*Estimated* gate down time)

Train Length	14000	ft (from train length tab)	
Train Speed	50	mph	
Lights Start Flashing to Gate Horizontal	25	seconds	(min 20 sec)
Equipment Response Time	5	seconds	
Total Warning time	30	seconds	
Train crossing time	191	seconds	
Recovery/Gate Rise	12	seconds	
Total GDT	233	seconds	
Assume	**240**	**seconds**	

CCJPA Passenger Trains (*Estimated* gate down time)

Train Length	665	ft	(Assume 7 cars @ 85 ft/car + 70' loco)
Train Speed	60	mph	
Lights Start Flashing to Gate Horizontal	25	seconds	(min 20 sec)
Equipment Response Time	5	seconds	
Total Warning time	30	seconds	
Train crossing time	8	seconds	
Recovery/Gate Rise	12	seconds	
Total GDT	50	seconds	
Assume	**50**	**seconds**	

Appendix C1:
No Project Scenario Emergency Vehicle Access Times

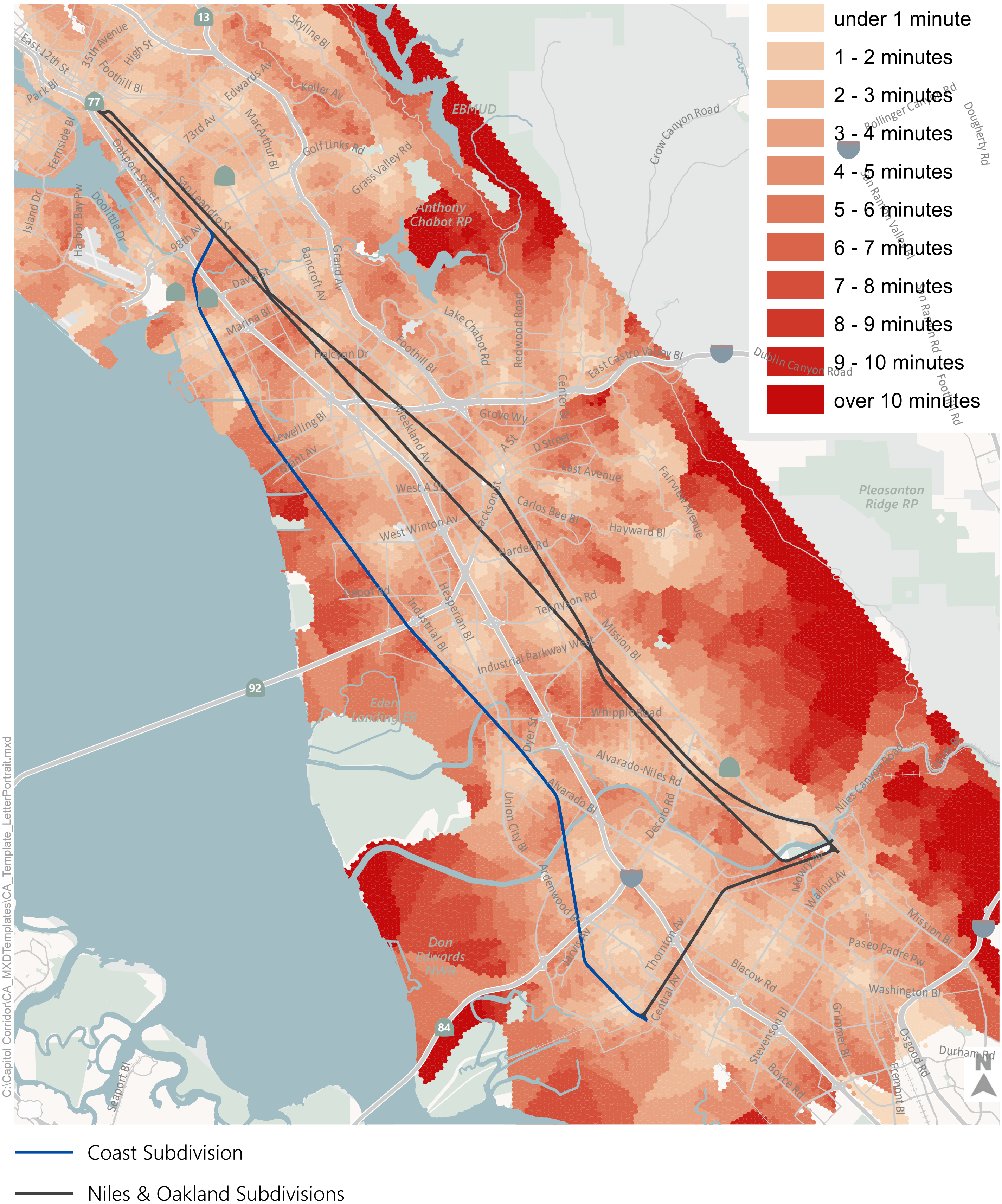
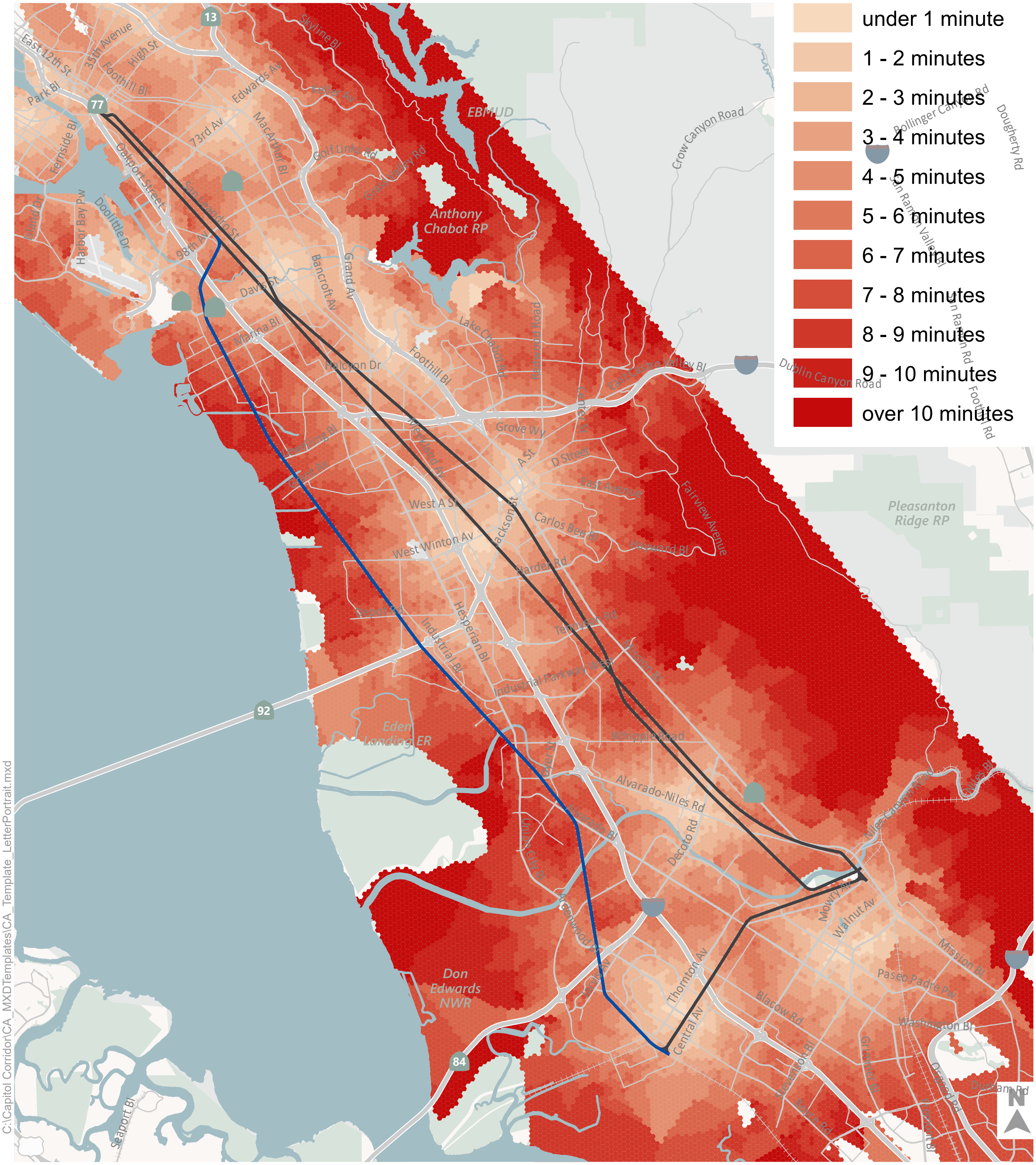


Figure C1-1

Fire Station Access Times - No Project



Coast Subdivision

Niles & Oakland Subdivisions

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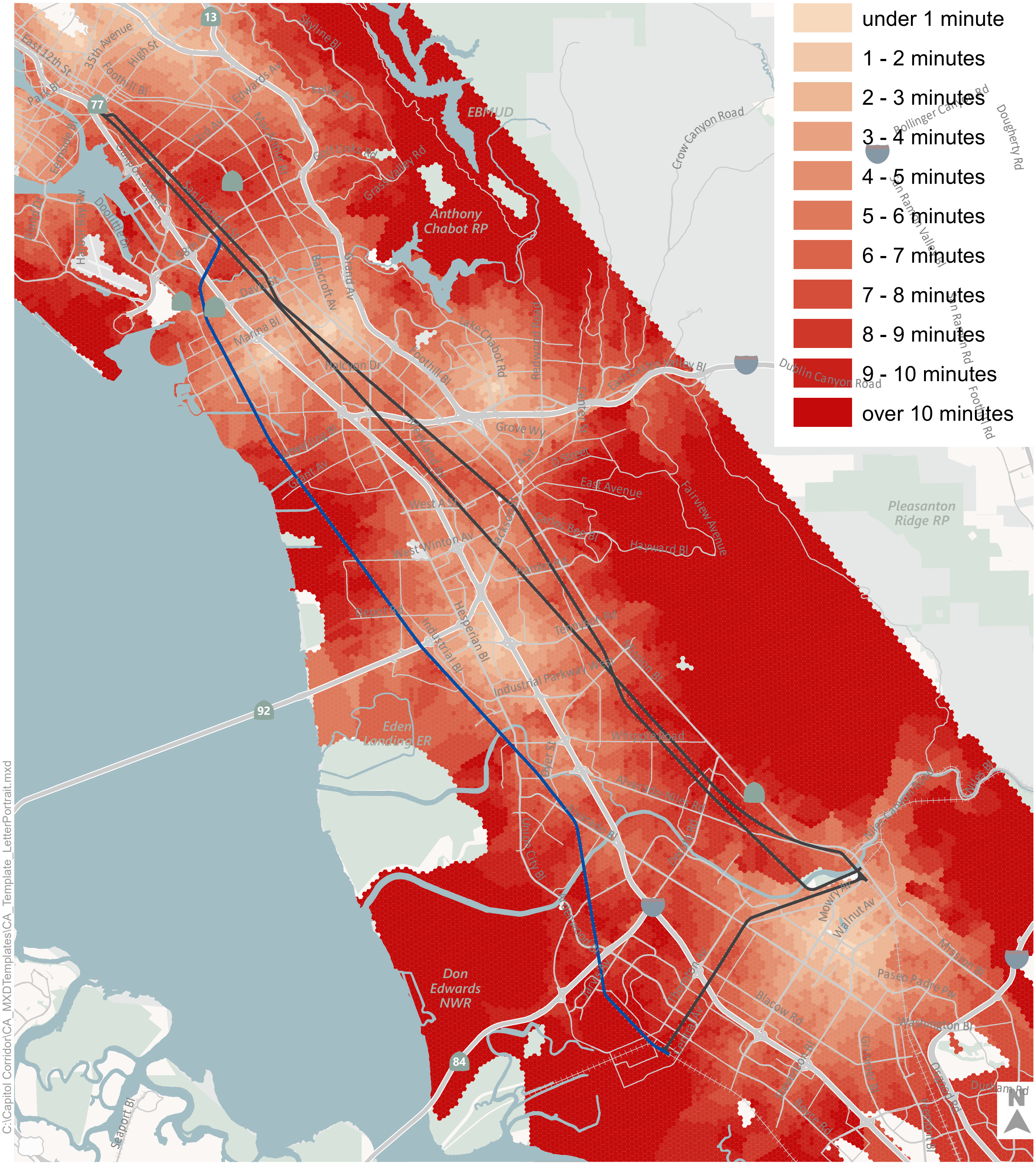
Figure C1-2

Police Station Access Times - No Project



Coast Subdivision

Niles & Oakland Subdivisions

Figure C1-3

Hospital with Emergency Room Access Times - No Project

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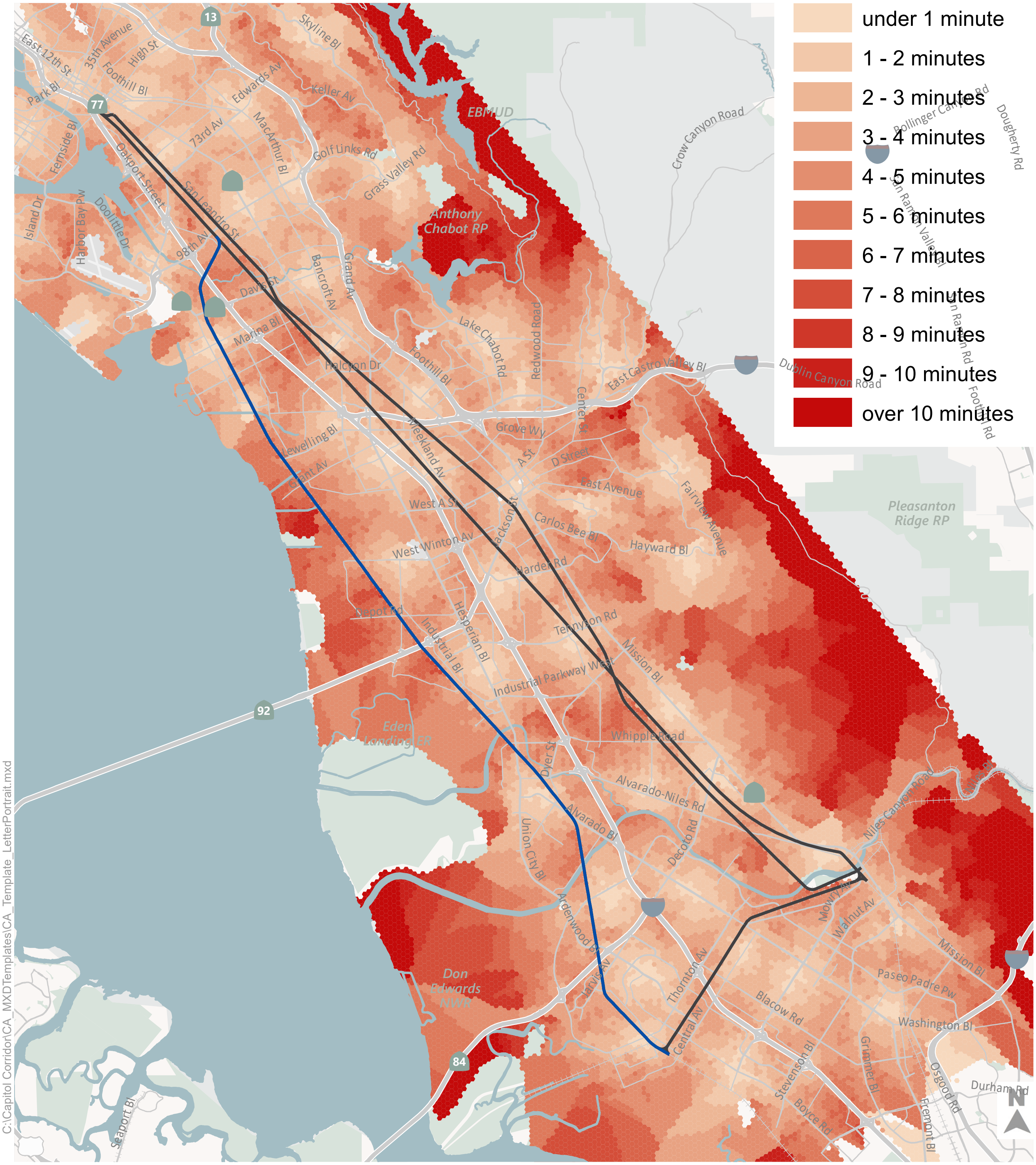
Appendix C2: Plus Project Scenario Emergency Vehicle Access Times

FEHR PEERS



Coast Subdivision

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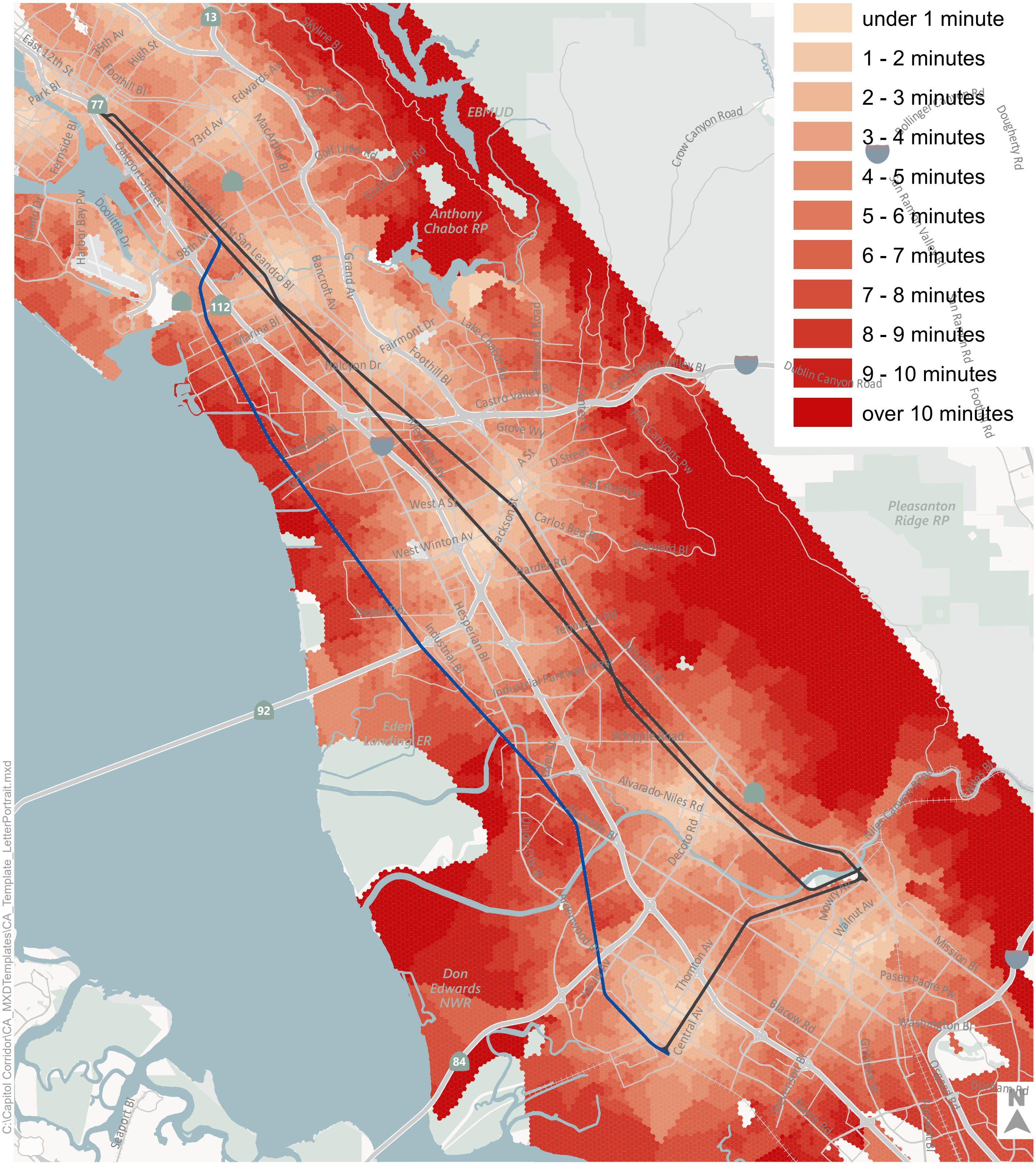
Figure C2-1

Fire Station Access Times - With Project



Coast Subdivision

Niles & Oakland Subdivisions

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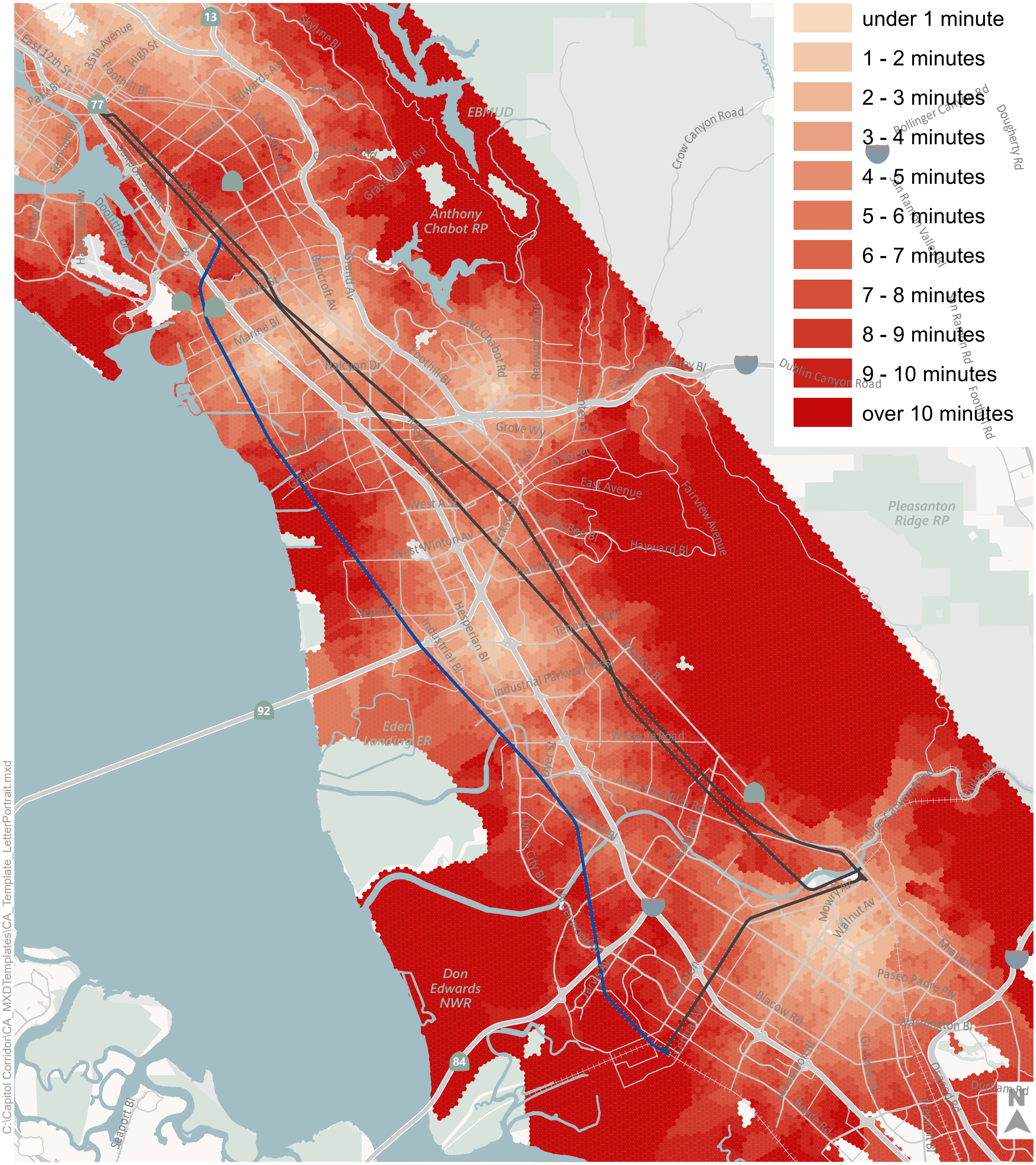
Figure C2-2

Police Station Access Times - With Project



Coast Subdivision

Niles & Oakland Subdivisions

Figure C2-3

Hospital with Emergency Room Access Times - With Project