



MEMORANDUM

To: Dat Nguyen, P.E.
BKF Engineers

From: Adam Dankberg, P.E.
Kimley-Horn & Associates

Date: July 13, 2022

Subject: Sunnyvale Grade Separations Feasibility Study – Traffic and Circulation Memorandum

INTRODUCTION AND OVERVIEW

Project Background

The City of Sunnyvale currently has two at-grade railroad crossings of the rail corridor owned by the Peninsula Corridor Joint Powers Board (PCJPB) at Mary Avenue and Sunnyvale Avenue. PCJPB operates Caltrain commuter trains along this corridor. The Sunnyvale Caltrain Station lies between the two at-grade crossings. Caltrain currently operates five trains in each direction during the peak hour. With completion of the currently under-construction electrification of the rail corridor, the number of Caltrain trains operating on the corridor will increase to six trains per hour per direction. As part of the recently completed Caltrain Business Plan, Caltrain is working towards expanding service to eight trains per hour per direction. In addition, California High-Speed Rail (CHSRA) is planned to operate an additional four trains per hour per direction on the same corridor. This will result in more than double the number of train crossings during the peak hour compared to current conditions.

Due to the proximity of adjacent intersections to both at-grade crossings, the train crossings have a substantial effect on roadway capacity, congestion levels, and overall functionality of the multimodal circulation network in Sunnyvale. The City of Sunnyvale currently experiences high levels of congestion on its north-south roadways during peak travel periods. Gate down times and associated rail pre-emption events further exacerbate congestion and safety hazards in the vicinity of the two at-grade crossings. In addition, the Sunnyvale Avenue crossing is near the Sunnyvale Caltrain Station and downtown Sunnyvale, and thereby experiences high volumes of pedestrian and bicycle activity.

Kimley-Horn, as a subconsultant to BKF Engineers, evaluated project grade separation alternatives for both at-grade rail crossings, Mary Avenue and Sunnyvale Avenue, to assess their implications on traffic operations and multimodal circulation.

Traffic Analysis Scope

The study network includes 18 study intersections, as listed below. The study intersections and the study area can be seen in **Figure 1**. The study intersections were analyzed using the VISSIM micro-simulation tool to fully reflect the intersection operations associated with the at-grade crossings and



network-wide effects of the grade separation alternatives. Three scenarios were analyzed: Existing Conditions, 2035 No-Build, and 2035 Build.

The grade separation alternatives analyzed at Mary Avenue are not anticipated to result in any substantial traffic diversion to other corridors. The grade separation alternatives analyzed at Sunnyvale Avenue are anticipated to potentially divert traffic to the Mathilda Avenue and Fair Oaks Avenue corridors. Therefore, the impacts of each of the two grade separation are mutually independent (i.e., the solutions considered at Mary Avenue do not influence the performance of the solutions considered at Sunnyvale Avenue, and vice versa). Two separate VISSIM models were constructed, one for Mary Avenue, which includes the Mary Avenue corridor (Intersections #1-4), and one for Sunnyvale Avenue, which includes the remainder of the study area (Intersections #5-18).

Mary Avenue Modeling Area

1. Mary Avenue/Central Expressway
2. Mary Avenue/California Avenue
3. Mary Avenue/Evelyn Avenue
4. Mary Avenue/Washington Avenue

Sunnyvale Avenue Modeling Area

5. Mathilda Avenue/California Avenue
6. Mathilda Avenue SB Off-Ramp/Evelyn Avenue
7. Mathilda Avenue NB Off-Ramp/Evelyn Avenue
8. Mathilda Avenue/Washington Avenue
9. Evelyn Avenue/Frances Street
10. Washington Avenue/Frances Street
11. Evelyn Avenue/Murphy Avenue
12. Sunnyvale Avenue/California Avenue
13. Sunnyvale Avenue/Hendy Avenue
14. Sunnyvale Avenue/Evelyn Avenue
15. Sunnyvale Avenue/Washington Avenue
16. Fair Oaks Avenue/California Avenue
17. Fair Oaks Avenue/Kifer Road
18. Fair Oaks Avenue/Evelyn Avenue



Figure 1: Study Area





Alternatives Overview and Description

Five grade separation project alternatives were selected for this analysis. Three alternatives proposed for the Mary Avenue grade crossing include the Mary Avenue Underpass Tunnel, the Mary Avenue Underpass Tunnel with Jughandle option, and the Mary Avenue Underpass Tunnel with Jughandle and Connector Ramps option. Two alternatives proposed for the Sunnyvale Avenue grade crossing include the Sunnyvale Avenue Underpass Tunnel option and the Sunnyvale Avenue Bicycle/Pedestrian Undercrossing option. This section summarizes each of the individual alternatives.

Figure 2 illustrates the Mary Avenue Underpass with Jughandle Alternative. As shown, Mary Avenue would be depressed beneath the railroad tracks and Evelyn Avenue. To accommodate turning movements between Mary Avenue and Evelyn Avenue, a jughandle roadway is proposed to connect the two roadways, southeast of the current Mary Avenue/Evelyn Avenue intersection. New signalized intersections are proposed at either end of the jughandle, one on Mary Avenue opposite the existing Magnolia Square Apartments and the other on Evelyn Avenue. As shown in **Figure 2**, the jughandle was initially envisioned to consist of a four-lane cross section. However, initial performance of the traffic analysis found this cross-section deficient, and the alternative was revised to assume a five-lane cross-section, with the inclusion of an additional westbound right-turn lane approaching Mary Avenue. All results included in this memo assume the five-lane jughandle cross-section.

Figure 3 illustrates the Mary Avenue Underpass with Jughandle and Connector Ramps Alternative. As shown, the underpass and jughandle connections are the same as in the Mary Avenue Underpass with Jughandle Alternatives. This alternative also includes single-lane connector ramps to connect westbound Evelyn Avenue traffic with northbound Mary Avenue and southbound Mary Avenue traffic with westbound Evelyn Avenue. These movements were identified for the direct connector ramps as a result of their high volumes and the opportunity to reduce left-turn volumes at one or both jughandle ramp intersections. Both ramp connections are right-turn only at their connections with Mary Avenue. A half traffic signal will be installed for the westbound Evelyn Avenue to northbound Mary Avenue ramp. All other approaches at non-signalized intersections will be free flow and yield to bike lanes.

Figure 4 illustrates the Mary Avenue Underpass Tunnel Alternative. As shown, both Mary Avenue and Evelyn Avenue would be depressed, while the railroad remains at-grade. Pedestrian and bicycle access would be maintained via the depressed intersection. Under this alternative, Mary Avenue and Evelyn Avenue remain connected and the current intersection lane geometry is preserved.

Figure 5 illustrates the Sunnyvale Avenue Underpass Tunnel Alternative. As shown, Sunnyvale Avenue would be depressed beneath the railroad tracks, Hendy Avenue, and Evelyn Avenue in a tunnel. As a result, all turning movements at the Sunnyvale Avenue/Evelyn Avenue intersection would be redistributed to nearby intersections and only the westbound right-turn and southbound right-turn movements would be maintained at the Sunnyvale Avenue/Hendy Avenue intersection. Pedestrian and bicycle access would be maintained via dedicated space within the tunnel.

Figure 6 illustrates the Sunnyvale Avenue Bicycle/Pedestrian Undercrossing Alternative. As shown, while the road would be closed to autos, pedestrian and bicycle access would be preserved beneath



Figure 2: Mary Avenue Underpass Tunnel with Jughandle Alternative (Plan View)

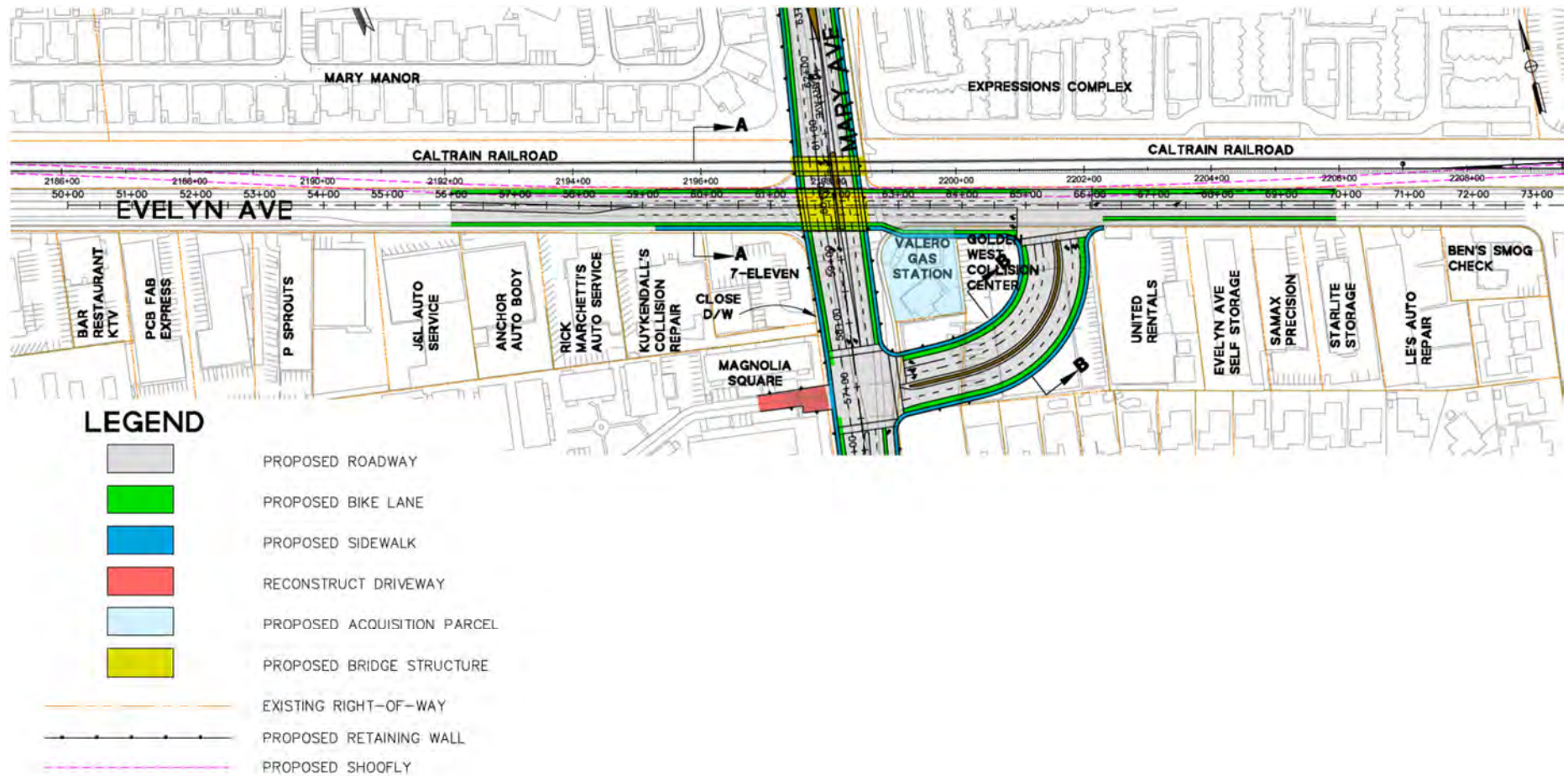
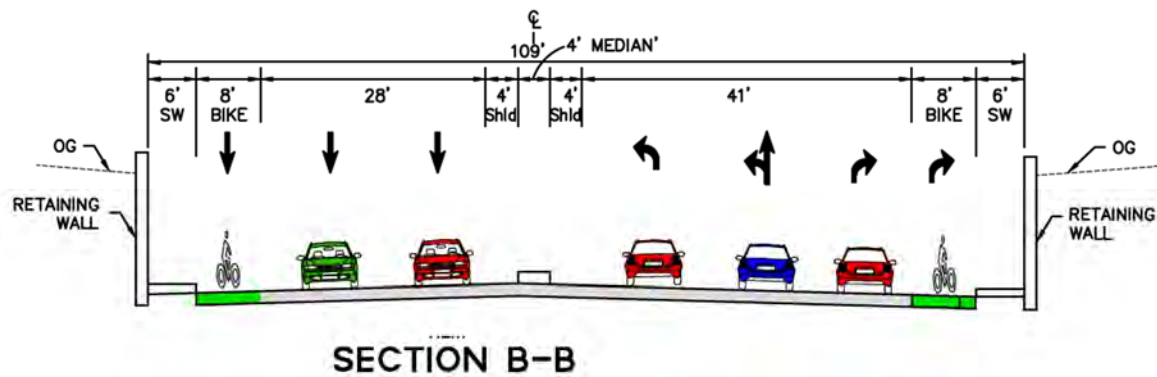
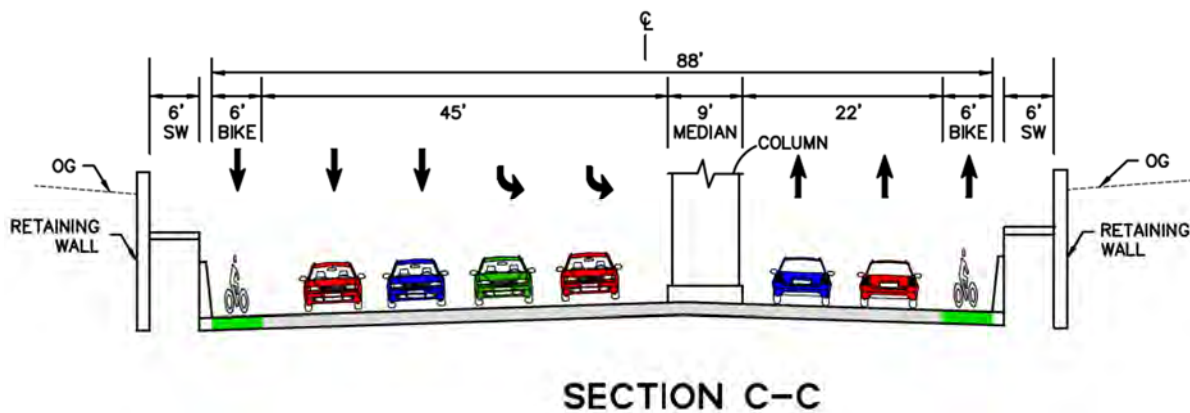




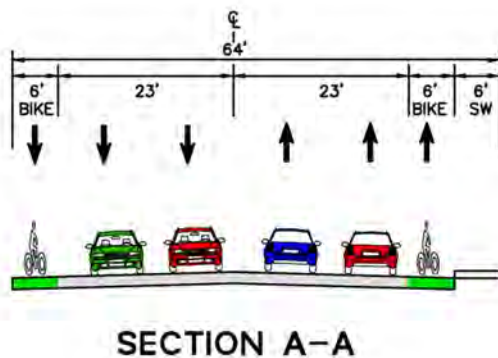
Figure 2 (cont'): Mary Avenue Underpass Tunnel with Jughandle Alternative (Cross-Sections)



Jughandle Cross Section



Mary Avenue Cross Section north of Jughandle



Evelyn Avenue Cross Section west of Mary Avenue

Source: BKF Engineers, received June 28, 2022



Figure 3: Mary Avenue Underpass with Jughandle and Connector Ramps Alternative (Plan View)

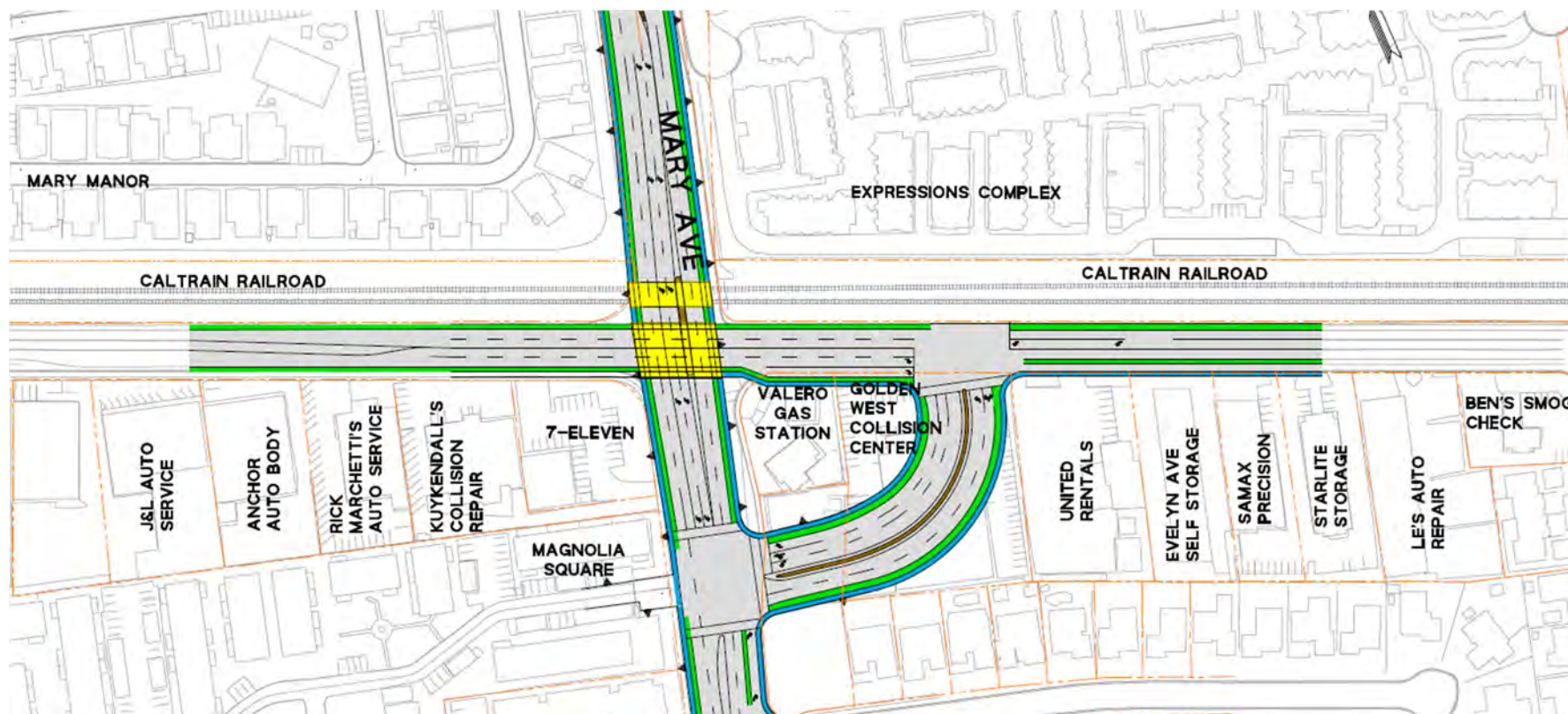
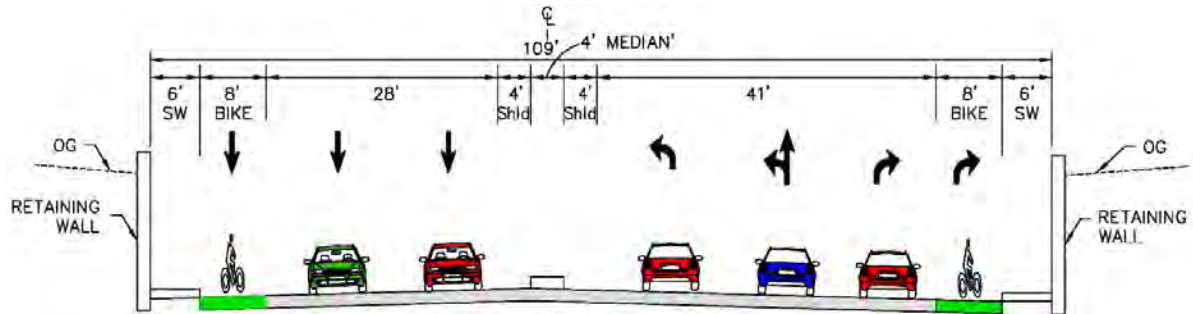


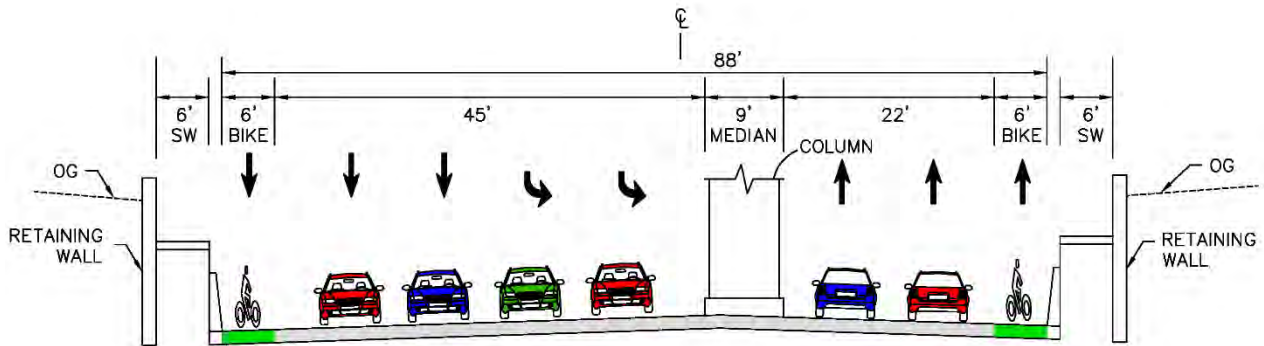


Figure 3 (cont'): Mary Avenue Underpass with Jughandle and Connector Ramps Alternative

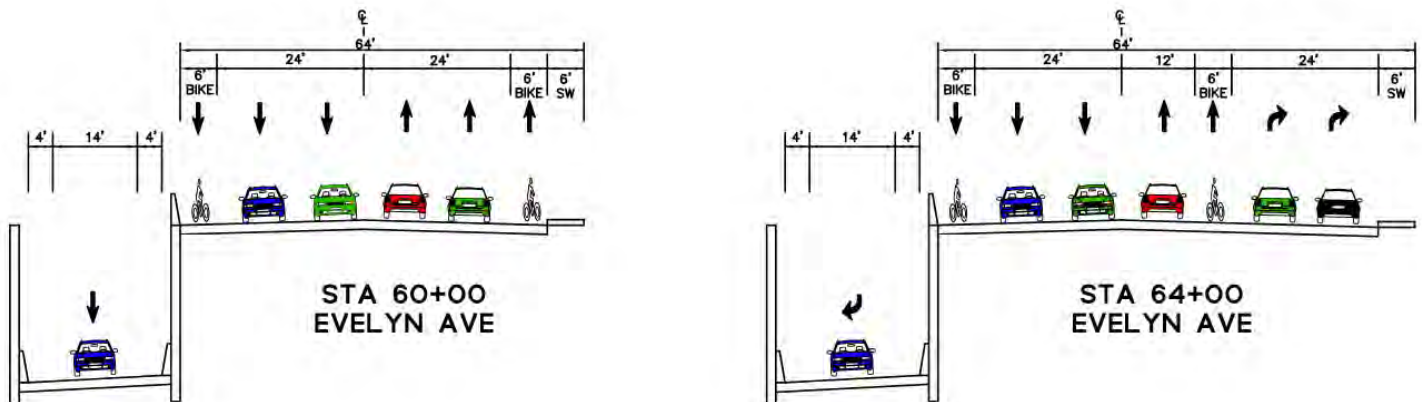
(Cross-Sections)



Jughandle Cross Section



Mary Avenue Cross Section north of Jughandle



Evelyn Avenue Cross Section east and west of Mary Avenue

Source: BKF Engineers, received January 19, 2022



Figure 4: Mary Avenue Underpass Tunnel Alternative (Plan View)

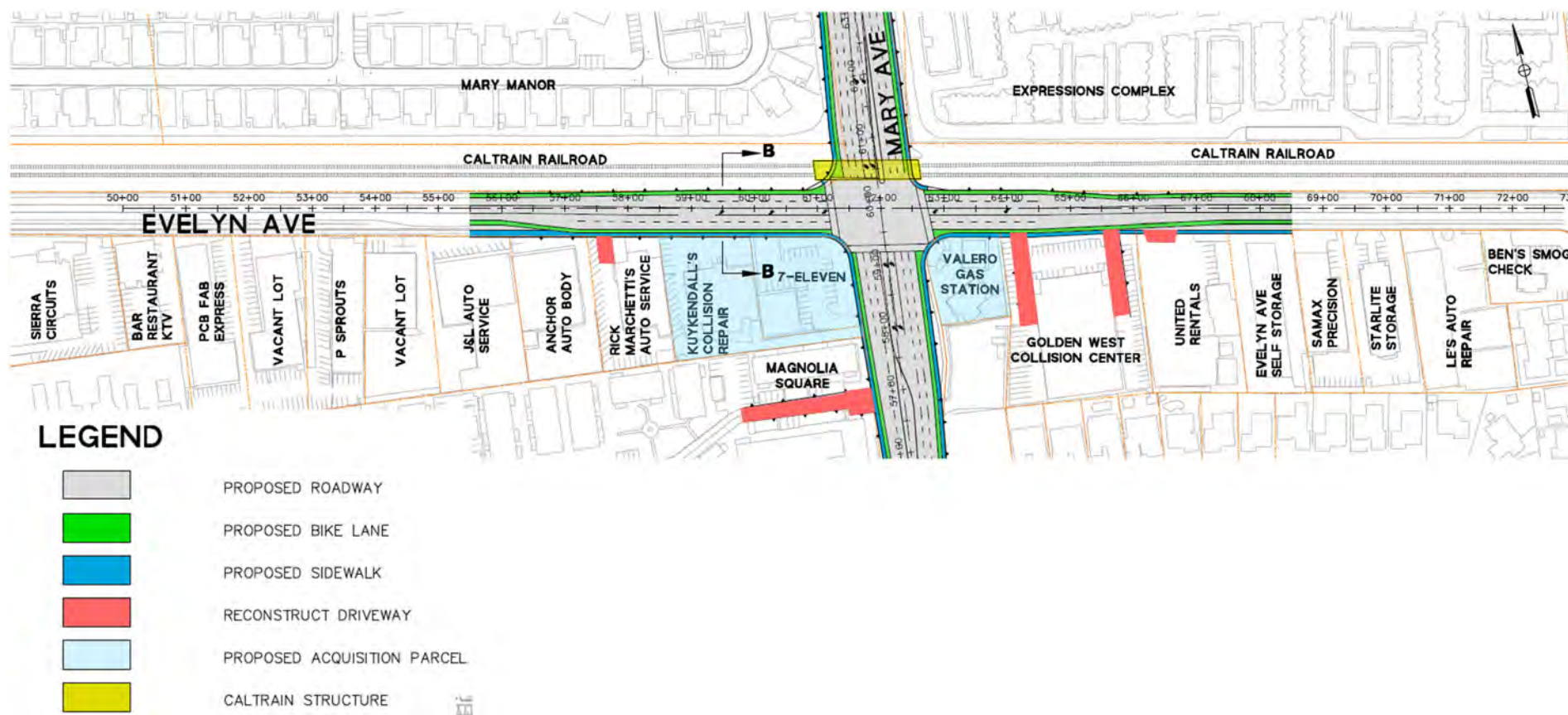
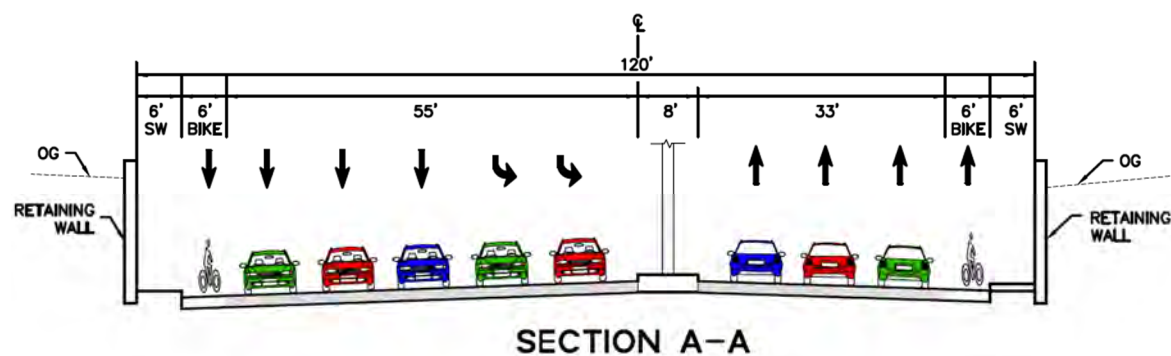
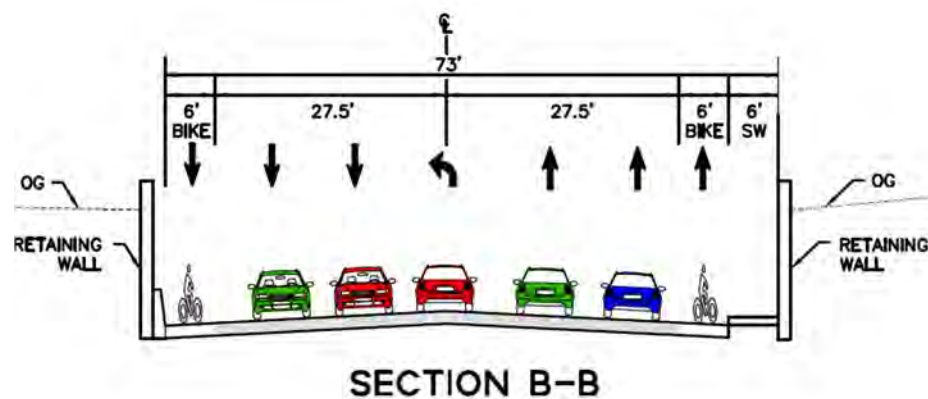




Figure 4 (cont.): Mary Avenue Underpass Tunnel Alternative (Cross-Sections)



Mary Avenue Cross Section North of Evelyn Avenue



Evelyn Avenue Cross Section east of Mary Avenue

Source: BKF Engineers, received June 28, 2022

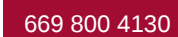
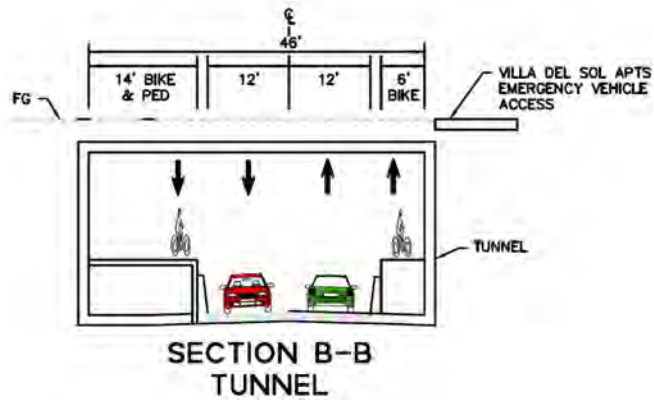
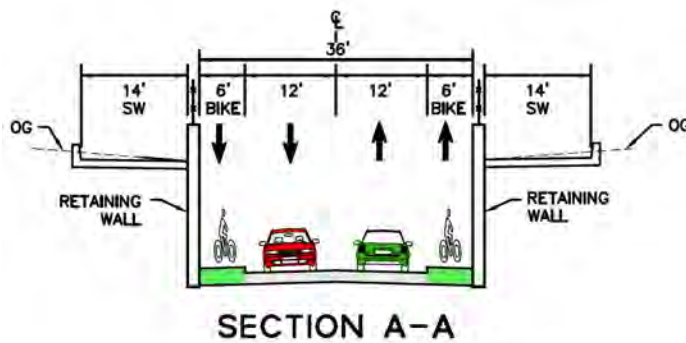




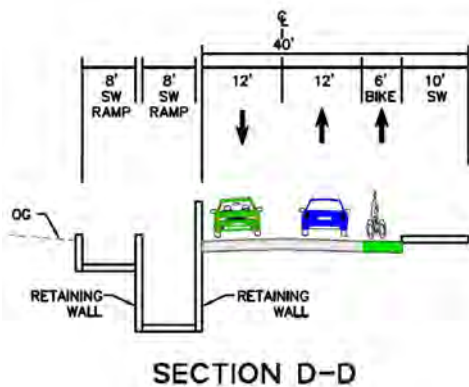
Figure 5 (cont.): Sunnyvale Avenue Underpass Tunnel Alternative (Cross-Sections)



Sunnyvale Avenue Underpass Tunnel Cross Section beneath Caltrain



Sunnyvale Avenue Cross Section south of Evelyn Avenue



Hendy Avenue Cross Section west of Sunnyvale Avenue

Source: BKF Engineers, received June 28, 2022



Figure 6: Sunnyvale Avenue Bicycle/Pedestrian Undercrossing Alternative (Plan View)

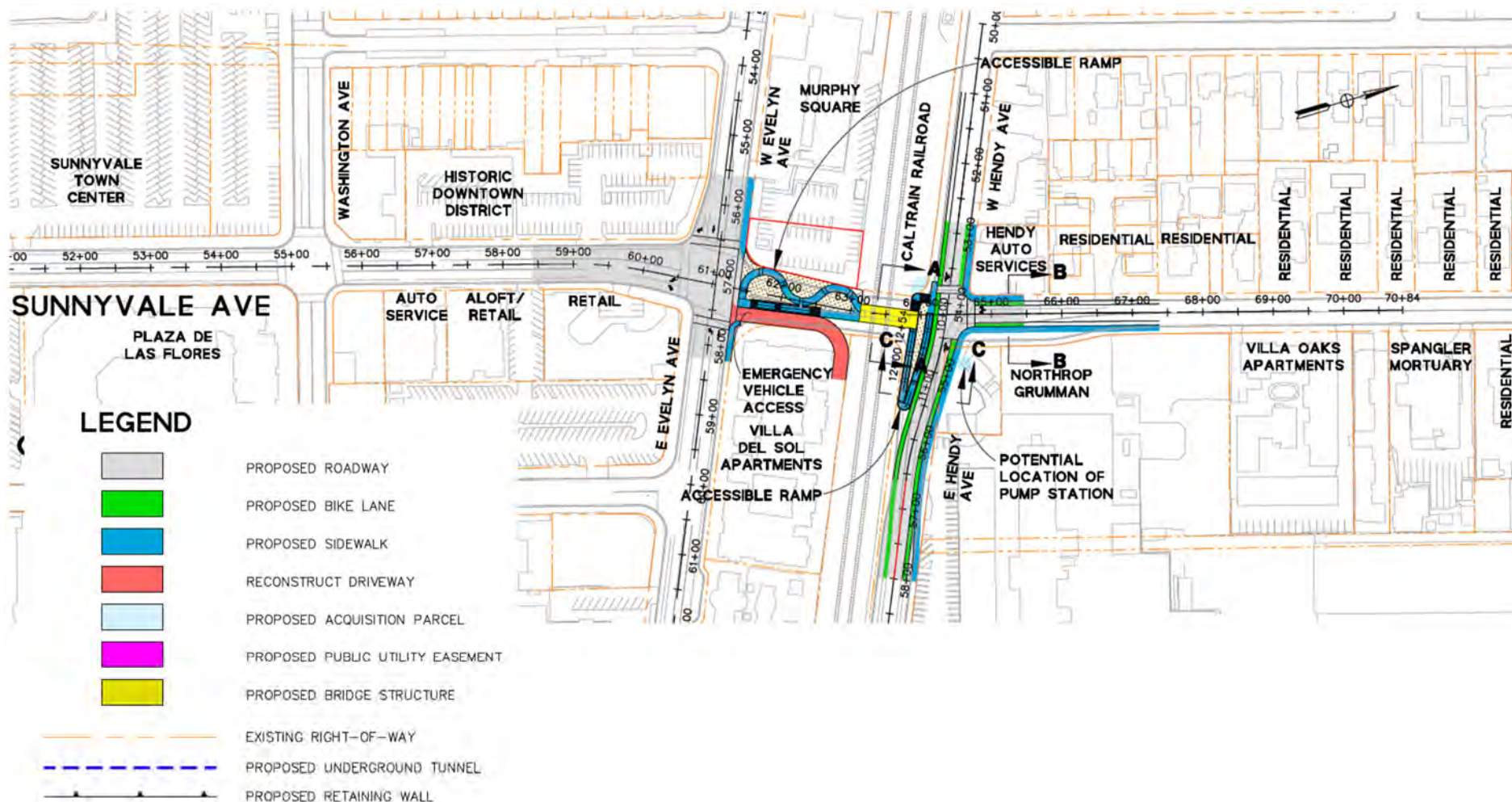
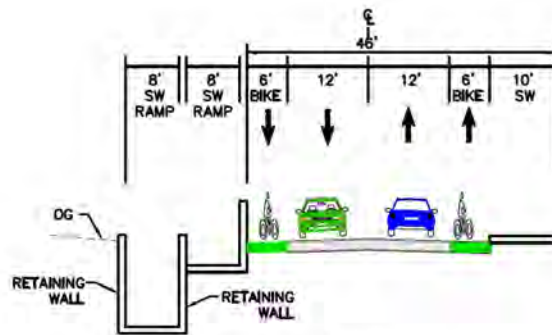


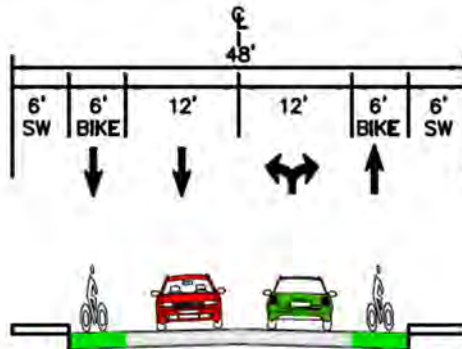


Figure 6 (cont.): Sunnyvale Avenue Bicycle/Pedestrian Undercrossing Alternative (Cross-Sections)



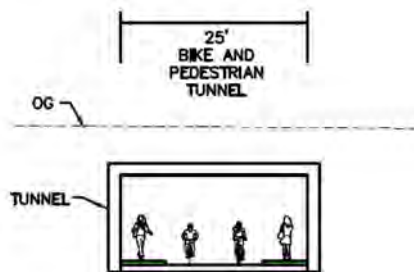
SECTION C-C

Hendy Avenue Cross Section west of Sunnyvale Avenue



SECTION B-B

Sunnyvale Avenue Cross Section north of Hendy Avenue



SECTION A-A TUNNEL

Bicycle and Pedestrian Tunnel Cross Section

Source: BKF Engineers, received June 28, 2022

the tracks via a pedestrian and bicycle undercrossing. Both the Sunnyvale Avenue/Evelyn Avenue and Sunnyvale Avenue/Hendy Avenue intersections would be converted to T-intersections with this alternative.

METHODOLOGY AND APPROACH

2016-2017 Existing Traffic Counts

Existing AM and PM peak period turning movement counts were collected in March 2017, except for the three study intersections along Fair Oaks Avenue which were collected in January 2018. In addition, to maintain consistency between overlapping studies, six previously collected turning movements counts were utilized for study intersections that overlap with the Mary Avenue Overcrossing EIR Traffic Analysis. The six study intersections where Mary Avenue Overcrossing EIR Traffic Analysis counts were utilized include the four study intersections along Mary Avenue, the Mathilda Avenue/California Avenue intersection and the Mathilda Avenue/Washington Avenue intersection.

2035 No-Build Model Development

Future turning movement volumes were developed by growing existing turning movement counts based on traffic growth projected by the City of Sunnyvale travel demand model. The most recent completed Sunnyvale model was utilized in this analysis. It includes recently approved plans, such as the Downtown Specific Plan, the Lawrence Station Area Plan, and the El Camino Real Specific Plan. **Attachments A and C** illustrate the 2035 No-Build volumes at each study intersection.

2035 No-Build and Build models include City projects that have been implemented subsequent to collection of existing conditions data in 2017/2018 as well as additional approved projects that have not yet been implemented.

Caltrain schedules were updated to assume three additional trains in each direction per hour as well as the assumption that all trains would stop at the Sunnyvale Station with the implementation of electrification (no express trips skipping the station). CHSRA is assumed to operate along the corridor in the future. It was assumed that four CHSRA trains per hour would pass through the Sunnyvale study area in each direction. These trains would not stop at the Sunnyvale station and would be traveling at up to 110 mph. This rail operating scheme is consistent with the adopted Caltrain Business Plan of 8 Caltrain + 4 CHSRA trains in the Peninsula corridor.

Gate operations and signal preemption parameters were adjusted to reflect the understanding that electrification of the corridor will eliminate the “double-pump” operation of the gates which are for southbound trains stopping at the Sunnyvale Station. Currently, southbound Caltrain trainsets stopping at the Sunnyvale Station are detected two times, once on the approach to the station, and once after leaving. This forces the traffic signal to preempt and gates to be lowered twice in a short period of time. Gate down times are consistent with the Caltrain Electrification Environmental Impact Report Transportation Analysis (February 2014).

2035 Build Model Development

A select link analysis was run with the City's travel demand model to identify origin-destination patterns for traffic currently using the Sunnyvale Avenue at-grade crossing. Based on that select link output, current traffic patterns, and an understanding of the traffic network, affected traffic flows were shifted to alternate routes with each of the Sunnyvale Avenue Underpass Tunnel and Sunnyvale Avenue Bicycle/Pedestrian Undercrossing Alternatives. Traffic volumes for the Mary Avenue Underpass Tunnel with Jughandle Alternative were redistributed through the new jughandle intersections. Traffic volumes for the Mary Avenue Underpass Tunnel with Jughandle and Connector Ramps included additional redistribution through the new connector ramps. Traffic volumes for the Mary Avenue Underpass Tunnel Alternative were kept the same as No-Build. The respective geometries of each grade separation alternative were incorporated into the analysis models.

Operations Analysis

All study intersections were modeled using VISSIM software. Existing Conditions models were calibrated according to guidance from the Federal Highway Administration's (FHWA's) *Traffic Analysis Toolbox, Volume III*¹. This included a calibration of field-counted traffic volumes against modeled throughputs as well as field-collected travel times against modeled travel times. Modeled throughputs and travel times were found to meet FHWA-recommended calibration criteria. It is noted that while VISSIM provides approach and intersection delay values that have been translated into a Level of Service grade in accordance with Highway Capacity Manual (HCM) delay thresholds, it is not an HCM-derived methodology and thus findings would deviate from an HCM analysis approach. VISSIM was selected as the analysis tool because of its ability to accurately model the upstream and downstream effects of at-grade rail crossings, including the effect of rail pre-emption sequences on adjacent signalized intersection phasing. As rail crossings are inherently random in their occurrence and are associated with a distinctive signal sequence at any adjacent signals, they cannot be accurately reflected in an HCM-derived analysis.

RESULTS METHODOLOGY

The following section provides a summary of results for the No-Build and Build scenarios, including the Mary Avenue Underpass with Jughandle Alternative, the Mary Avenue Underpass with Jughandle and Connector Ramps Alternative, the Mary Avenue Underpass Tunnel Alternative, the Sunnyvale Avenue Underpass Tunnel Alternative, and the Sunnyvale Avenue Bicycle/Pedestrian Undercrossing Alternative. For each Build alternative, the following is summarized:

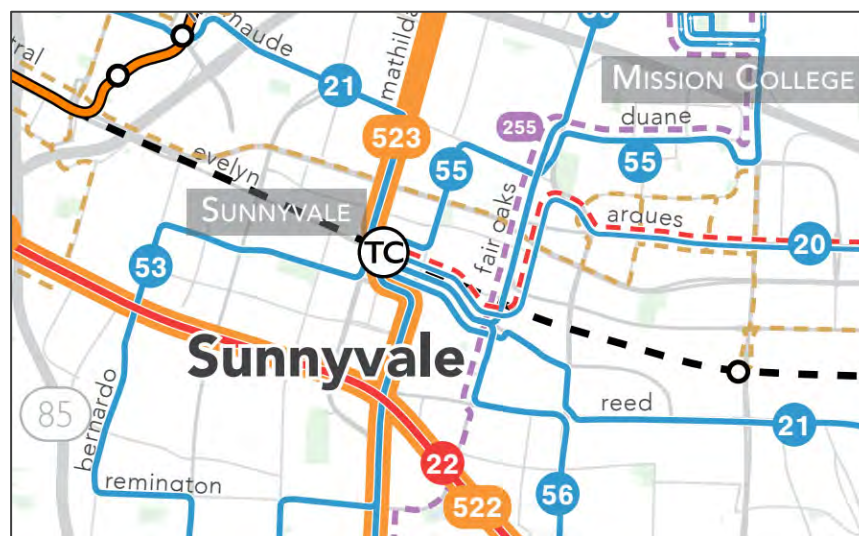
- **Volume redistribution and assignment:** Each Build alternative except for the Mary Avenue Underpass Tunnel Alternative assumes volume redistribution due to turning movement restrictions or modifications associated with the grade separation alternative.
- **Traffic measures of effectiveness:** The measures of effectiveness for the Mary Avenue grade separation alternatives include the change in delay and queue length by movement as well as the change in travel time along Mary Avenue. The measures of effectiveness for the

¹ https://ops.fhwa.dot.gov/trafficanalysisistools/tat_vol3/vol3_guidelines.pdf

Sunnyvale Avenue grade separation alternatives include change in intersection delay, corridor travel time, and network performance.

- **Multimodal impacts:** A qualitative multimodal impact analysis was conducted based on the proposed alternatives. Effects on pedestrian, bicycle, and transit circulation was evaluated, including out-of-direction travel, safety, and other circulation considerations.² The transit assessment assumes the Santa Clara Valley Transportation Authority's (VTA) FY18-19 transit service plan (i.e., Next Network), which was implemented prior to the COVID pandemic. **Figure 7** shows the Next Network service map within the City of Sunnyvale.

Figure 7: VTA Next Network Plan (Pre-Pandemic Service Pattern)



Source: <http://nextnetwork.vta.org/transit-service-maps>

Attachments B, D, E, and F illustrate the volume distribution and assignment for each alternative by study intersection, summarizing the current conditions, and conditions with the No-Build and Build scenarios. Volume distribution and assignment for the Mary Avenue Underpass Tunnel Alternative was not included as all No-Build turning movements are expected to remain the same.

² Out-of-direction travel refers to an increase in distance and associated travel time to travel from two termini. The out-of-direction travel metric is the difference between the length of the route alignment and the straight-line distance between the route's termini. This metric increases the more the route's alignment deviates from a straight-line path.

MARY AVENUE

Volume Distribution and Assignment

Underpass with Jughandle Alternative

All turning movements at the Mary Avenue/Evelyn Avenue intersection under the No-Build scenario are redistributed through the jughandle. For example, all vehicles who make a northbound left at the Mary Avenue/Evelyn Avenue intersection under the No-Build scenario will make a northbound right at the new signal at Mary Avenue/Jughandle (Int. #19) and a northbound left at the new signal at Evelyn Avenue/Jughandle (Int. #20) under this alternative. All through vehicles under the 2035 No-Build scenario are not rerouted under this alternative.

Underpass with Jughandle and Connector Ramps Alternative

Similar to the Underpass with Jughandle Alternative, most turning movements at the Mary Avenue/Evelyn Avenue intersection under the No-Build scenario are redistributed through the jughandle. However, in this alternative, traffic heading westbound on Evelyn Avenue to northbound Mary Avenue will be routed through a direct connector ramp and will make a right turn at the new half signal on Mary Avenue. Volumes travelling southbound on Mary Avenue and heading westbound on Evelyn Avenue will also be routed via a free right-turn to a connector ramp to Evelyn Avenue.

Underpass Tunnel Alternative

Since both Mary Avenue and Evelyn Avenue are depressed and remain connected, all turning movements at the intersection remain the same as represented under the No-Build scenario. No volumes under the 2035 No-Build scenario will be rerouted under this alternative.

Intersection Operations Results

Since there would be no redistribution of traffic associated with the Build Alternatives other than routing of vehicles through the jughandle and/or connector ramps, operations for other intersections along Mary Avenue do not change. See **Table 1** for a comparison of LOS and delay at the Mary Avenue/Evelyn Avenue or jughandle intersections with No-Build and Build conditions.

Table 1: Mary Avenue Jughandle Operations by Movement – 2035 No-Build and Build

Movement	2035 AM Peak Hour				2035 PM Peak Hour			
	No-Build (sec)	2035 Build (Jughandle)	2035 Build (Connector Ramps)	2035 Build (Tunnel)	No-Build (sec)	2035 Build (Jughandle)	2035 Build (Connector Ramps)	2035 Build (Tunnel)
Eastbound Evelyn Ave to Northbound Mary Ave	F (195.7)	D (48.0)	B (19.3)	E (75.6)	F (454.8)	E (56.4)	B (18.3)	F (254.2)
Eastbound Evelyn Ave	C (27.7)	E (59.1)	B (15.1)	C (28.5)	F (141.7)	D (49.0)	D (49.0)	F (128.4)
Eastbound Evelyn Ave to Southbound Mary Ave	C (23.0)	F (92.4)	E (68.9)	B (14.9)	F (139.1)	F (88.7)	F (83.0)	F (178.0)
Westbound Evelyn Ave to Southbound Mary Ave	F (297.2)	F (136.4)	F (119.7)	F (158.1)	F (291.3)	F (238.0)	F (151.2)	F (98.5)
Westbound Evelyn Ave	F (332.6)	D (37.0)	B (14.3)	F (163.8)	F (333.3)	F (122.7)	D (42.6)	F (252.3)
Westbound Evelyn Ave to Northbound Mary Ave	F (389.8)	F (92.0)	E (59.0)	F (166.7)	F (372.7)	F (205.8)	F (86.3)	F (88.0)
Northbound Mary Ave to Westbound Evelyn Ave	F (374.6)	F (189.2)	F (183.3)	F (245.2)	F (89.4)	D (40.5)	D (38.0)	E (78.3)
Northbound Mary Ave	F (333.6)	F (176.4)	F (178.8)	F (186.9)	E (78.2)	D (47.1)	D (46.2)	D (46.4)
Northbound Mary Ave to Eastbound Evelyn Ave	F (228.4)	F (183.1)	F (172.4)	F (134.3)	E (45.8)	D (37.4)	C (23.2)	C (23.4)
Southbound Mary Ave to Eastbound Evelyn Ave	E (73.5)	F (85.0)	E (71.1)	D (45.4)	F (141.1)	E (64.9)	D (49.6)	F (89.0)
Southbound Mary Ave	D (54.6)	A (8.8)	A (9.6)	C (33.9)	E (78.0)	B (18.0)	B (17.6)	E (62.0)
Southbound Mary Ave to Westbound Evelyn Ave	F (116.7)	F (91.1)	A (2.3)	F (130.0)	F (84.7)	E (67.9)	A (3.1)	E (63.8)
Overall Mary Ave/ Evelyn Ave Intersection Delay	F (230.3)	N/A	N/A	F (135.8)	F (167.8)	N/A	N/A	F (113.4)
Overall Mary Ave/ Jughandle Intersection Delay	N/A	F (99.5)	F (109.5)	N/A	N/A	C (34.4)	C (27.0)	N/A
Overall Evelyn Ave/ Jughandle Intersection Delay	N/A	D (39.5)	B (16.8)	N/A	N/A	E (65.5)	C (28.9)	N/A
Mary Avenue Half Signal	N/A	N/A	B (10.2)	N/A	N/A	N/A	B (14.5)	N/A

Note: Numbers in table reflect movement Level of Service (seconds of delay). The bolded text represents those movements that experience higher delays under the given Build scenario relative to the No-Build scenario.

Underpass with Jughandle Alternative

With the 2035 No-Build scenario, the Mary Avenue/Evelyn Avenue intersection operates at Level of Service (LOS) F in both peak periods. In the Build scenario, the Mary Avenue jughandle intersection operates at LOS F in the AM peak hour and LOS C in the PM peak hour and the Evelyn Avenue jughandle intersection operates at LOS D in the AM peak hour and LOS E in the PM peak hour.

Underpass with Jughandle and Connector Ramps Alternative

Under this alternative, the Mary Avenue jughandle intersection operates at LOS F in the AM peak hour and LOS C in the PM peak hour and the Evelyn Avenue jughandle intersection operates at LOS

B in the AM peak hour and LOS C in the PM peak hour. The westbound connector ramp half signal at Mary Avenue operates at LOS B in both peak hours.

Underpass Tunnel Alternative

Since no redistribution of traffic is proposed under this alternative, operations for other intersections along Mary Avenue do not change. With the 2035 No-Build Scenario, the Mary Avenue/Evelyn Avenue intersection operates at LOS F in both peak periods. With the Underpass Tunnel Alternative, the Mary Avenue/Evelyn Avenue intersection is no longer subject to gate closures as the railroad tracks would remain at-grade while all auto traffic is lowered. See **Table 1** for a comparison of overall intersection delay between No-Build and the Underpass Tunnel Alternative. While the Mary Avenue/Evelyn Avenue intersection would still operate at LOS F for the AM and PM peak hours with the depressed intersection, delay would be substantially reduced (50 seconds or greater) in both peak periods.

Vehicle Route Delay

Underpass with Jughandle Alternative

In the underpass with jughandle scenario, through vehicles traveling north and south on Mary Avenue will only experience delay at one intersection, similar to today. However, turning vehicles will need to pass through both jughandle intersections, thereby experiencing delay at two locations. Therefore, in order to compare delay in the No-Build condition with the Build, delay along the entire vehicle routing through the jughandle is recorded. See **Table 1** for a comparison of delay between movements through the jughandle and baseline movements at the Mary Avenue/Evelyn Avenue intersection. For example, the delay associated with the eastbound Evelyn Avenue to Northbound Mary Avenue movement in the No-Build scenario refers to the delay of the eastbound left movement at the No-Build at-grade Mary Avenue/Evelyn Avenue intersection, whereas in the Build scenario, the delay is the cumulative delay through both jughandle intersections (eastbound right at the Mary Avenue/Jughandle intersection and a westbound right at the Mary Avenue/Jughandle intersection).

As shown in the table, the delay for the majority of movements substantially decreases with the implementation of the jughandle. Based on movement delay and vehicular volume, the weighted average intersection delay is substantially lower in the underpass with jughandle scenario than in the No-Build, in both the AM and PM peak hour.

Underpass with Jughandle and Connector Ramps Alternative

In the underpass with jughandle and connector ramps scenario, through vehicles travelling south on Mary Avenue will only experience delay at the jughandle intersection. Vehicles travelling north will experience delay at two locations, one at the jughandle intersection and one north of Evelyn Avenue where a half signal is used to control traffic coming from the westbound connector ramp. Turning vehicles that need to pass through the jughandle will experience delays at both jughandle intersections. Vehicles travelling southbound on Mary Avenue and using the connector ramp to head westbound on Evelyn Avenue will experience only minimal delays associated with yielding to pedestrians and cyclists. Vehicles travelling westbound on Evelyn Avenue and using the connector ramp to head northbound on Mary Avenue will experience delay at the half signal only.

As shown in **Table 1**, nearly all movements in the AM and PM peak hours experience equal or less delays compared to the Underpass with Jughandle Alternative (without connector ramps). The only exceptions are on northbound and southbound Mary Avenue in the AM peak hour, where delay increases by up to three seconds. This additional delay is associated with the half signal (northbound direction) and nominal delay associated with queue delays for right-turning vehicles yielding to pedestrians.

Underpass Tunnel Alternative

As shown in **Table 1**, the delay for the nearly all movements decrease with the implementation of the Underpass Tunnel Alternative. The only movement with a sizeable increase in delay (> 15 seconds) is the eastbound Evelyn Avenue to southbound Mary Avenue movement. That movement receives a substantial amount of green time in the No-Build because it is not precluded by the train movement. Therefore, it would receive less green time relative to the No-Build alternative.

Vehicle Queuing

Underpass with Jughandle Alternative

Table 2 shows queue lengths by movement for the underpass with jughandle alternative for the 2035 Build scenario. The length of the proposed jughandle is approximately 400 feet.

Table 2: Average Queue Lengths at the Proposed Jughandle – 2035 No-Build and Build

Roadway ¹	Approach	Movement	Available Turn Pocket Storage Length		2035 AM Peak Hour		2035 PM Peak Hour	
			2035 No-Build Turn Pocket Storage (ft)	2035 Build Turn Pocket Storage (ft)	2035 No-Build ² Queue Length (ft)	2035 Build Queue Length (ft)	2035 No-Build ² Queue Length (ft)	2035 Build Queue Length (ft)
Mary Avenue Movements	Northbound	Left	125	-	-	-	25	25
		Through	-	-	1,350	1,050	75	75
		Right	-	200	-	750	-	25
	Southbound	Left	125	475	75	75	275	50
		Through	-	-	125	25	350	75
		Right	-	-	-	-	-	-
Evelyn Avenue Movements	Eastbound	Left	150	-	250	-	1,050	-
		Through	-	-	125	75	1,050	175
		Right	-	200	-	25	-	125
	Westbound	Left	125	150	1,650	300	1,700	775
		Through	-	-	1,725	300	1,700	775
		Right	-	-	-	-	-	-
Jughandle Movements	Westbound (at Mary Ave)	Left	N/A	370	N/A	125	N/A	225
		Through		370		-		-
		Right		370		125		225
	Northbound (at Evelyn Ave)	Left		370		75		50
		Through		-		-		-
		Right		370		100		75

¹ For the No-Build, queues reflect queues at the Mary Avenue/Evelyn Avenue intersection. For the Build, queues represent queues at the jughandle intersections with the noted streets

² Note that because the intersection location shifts from the No-Build to the Build, the queue length measurement does not start at the same point between the two scenarios.

Notes: Queue lengths in feet rounded to the nearest 25 feet. Movements shaded reflect queues that exceed the length of the storage pocket and would impede adjacent through movements and/or movements through upstream intersections. Storage lengths by definition cannot exceed distance to upstream intersection. Queue length only provided where dedicated lanes are provided. 2035 Build Queue Length Storage is based on current design assumptions.

As shown in the table, there would be minimal queue spillback within the jughandle roadway. However, the westbound left-turn movement from Evelyn Avenue to the jughandle would have an average queue length over 700 feet in the PM peak hour, exceeding any reasonable turn pocket length. Queue spillbacks and lane blockages would likely occur. In addition, the northbound right-turn movement from Mary Avenue to the jughandle would have an average queue length of 750 feet in the AM peak hour, exceeding any reasonable turn pocket length. For this movement, the long queue length is a produce of very long queues for the northbound through movement, limiting access to the right turn storage pocket. Therefore, no additional queue spillbacks and lane blockages would occur.

Underpass with Jughandle and Connector Ramps Alternative

Table 3 shows queue lengths by movement for the Underpass with Jughandle and Connector Ramps Alternative for the 2035 Build scenario. The length of the proposed jughandle is approximately 400 feet.

Table 3: Average Queue Lengths at the Proposed Jughandle – 2035 No-Build and Build

Roadway ¹	Approach	Movement	Available Turn Pocket Storage Length		2035 AM Peak Hour		2035 PM Peak Hour	
			2035 No-Build Turn Pocket Storage (ft)	2035 Build Turn Pocket Storage (ft)	2035 No-Build ² Queue Length (ft)	2035 Build Queue Length (ft)	2035 No-Build ² Queue Length (ft)	2035 Build Queue Length (ft)
Mary Avenue Movements	Northbound	Left	125	-	-	-	25	25
		Through	-	-	1,350	1,050	75	50
		Right	-	200	-	675	-	25
	Southbound	Left	125	475	75	25	275	25
		Through	-	-	125	25	350	50
		Right	-	-	-	-	-	-
Evelyn Avenue Movements	Eastbound	Left	150	-	250	-	1,050	-
		Through	-	-	125	25	1,050	150
		Right	-	200	-	25	-	25
	Westbound	Left	125	150	1,650	100	1,700	225
		Through	-	-	1,725	100	1,700	225
		Right	-	-	-	-	-	-
Jughandle Movements	Westbound (at Mary Ave)	Left	N/A	370	N/A	25	N/A	75
		Through		370		-		-
		Right		370		25		75
	Northbound (at Evelyn Ave)	Left		370		25		25
		Through		-		-		-
		Right		370		50		25

¹ For the No-Build, queues reflect queues at the Mary Avenue/Evelyn Avenue intersection. For the Build, queues represent queues at the jughandle intersections with the noted streets

² Note that because the intersection location shifts from the No-Build to the Build, the queue length measurement does not start at the same point between the two scenarios.

Notes: Queue lengths in feet rounded to the nearest 25 feet. Movements shaded reflect queues that exceed the length of the storage pocket and would impede adjacent through movements and/or movements through upstream intersections. Storage lengths by definition cannot exceed distance to upstream intersection. Queue length only provided where dedicated lanes are provided. 2035 Build Queue Length Storage is based on current design assumptions.

As shown in the table, there would be no queue spillback within the jughandle roadway during both the AM and PM peak hour. The northbound right-turn movement from Mary Avenue to the jughandle would have an average queue length of 675 feet in the AM peak hour, exceeding any reasonable turn pocket length. For this movement, the long queue length is a produce of very long queues for the

northbound through movement, limiting access to the right turn storage pocket. Therefore, no queue spillbacks and lane blockages would occur from this right-turn movement.

Underpass Tunnel Alternative

Table 4 shows queue lengths by movement for the depressed intersection for the 2035 Build scenario.

Table 4: Average Queue Lengths at the Proposed Underpass Tunnel Intersection – 2035 No-Build and Build

Approach	Movement	Available Turn Pocket Storage Length	2035 AM Peak Hour		2035 PM Peak Hour	
		2035 Turn Pocket Length Storage (ft)	2035 No-Build ² Queue Length (ft)	2035 Build Queue Length (ft)	2035 No-Build ² Queue Length (ft)	2035 Build Queue Length (ft)
Northbound	Left	125	1,350	1,250	25	25
	Through	-	1,350	1,250	75	200
	Right	-	-	-	-	-
Southbound	Left	125	75	75	275	100
	Through	-	125	75	350	250
	Right	-	-	-	-	-
Eastbound	Left	150	250	100	1,050	950
	Through	-	125	25	1,050	950
	Right	-	-	-	-	-
Westbound	Left	125	1,650	1,250	1,700	300
	Through	-	1,725	1,375	1,700	600
	Right	-	-	-	-	-

Notes: Queue lengths in feet rounded to the nearest 25 feet. Movements shaded reflect queues that exceed the length of the storage pocket and would impede adjacent through movements and/or movements through upstream intersections. Storage lengths by definition cannot exceed distance to upstream intersection. Queue length only provided where dedicated lanes are provided at the intersection of Sunnyvale Avenue and Evelyn Avenue.

As shown in the table, the queue lengths would be reduced for the majority of the movements under this alternative, although they would remain long.

Multimodal Considerations

Pedestrian

No-Build. In the No-Build scenario, there are no sidewalks on the north side of Evelyn Avenue fronting the rail tracks. Both sides of Mary Avenue have sidewalks. At the Mary Avenue/Evelyn Avenue intersection, pedestrians can cross the south, east, and west legs of the intersection. Pedestrians on Mary Avenue would continue to cross the rail tracks at-grade.

Underpass with Jughandle. The grade separation of Mary Avenue has substantial safety benefits for pedestrians as pedestrians would no longer be exposed to conflicts with trains. All conflicts between rail and pedestrians would be grade-separated.

Grade changes are introduced in the Build alternative with the depression of Mary Avenue. Pedestrians will experience up to a 3 percent grade as they travel along the jughandle and up to 2.5 percent along Mary Avenue. Currently, no pedestrian or bicycle facilities are provided on the north side of Evelyn Avenue adjacent to the Caltrain corridor. Provision of pedestrian facilities in that location are not a part of this project. However, the City is currently developing a plan to build a multi-use trail on the north side of Evelyn Avenue between Bernardo Avenue and Mathilda Place. Such an improvement would not be precluded by this alternative and no new conflicts would be introduced. Through pedestrian movements on the south side of Evelyn Avenue and on Mary Avenue would be maintained, with the only impact being the additional grade for pedestrians on Mary Avenue. However, due to the grade separation, most pedestrian movements originating on Mary Avenue and destined for Evelyn Avenue, and vice versa, would experience out-of-direction travel along the jughandle. Out-of-direction travel would be longest for pedestrians traveling between Mary Avenue north of the intersection and Evelyn Avenue west of the intersection amounting to an additional walk distance of approximately 650 feet. The intersection crossings would be similar to current conditions given the large number of turning lanes at each of the jughandle intersections.

Underpass with Jughandle and Connector Ramps. This alternative is expected to maintain the same pedestrian movements as the previous alternative, as no pedestrian facilities will be added to the connector ramps. As there are currently no pedestrian facilities on the north side of Evelyn Avenue, no new conflicts will be added on that roadway as a result of the connector ramps. If the City implements a multi-use trail on the north side of Evelyn Avenue in the future, it should be configured to remain at the same elevation as Evelyn Avenue alongside the Caltrain tracks to avoid a conflict with the connector ramp. The connector ramps will pose additional conflict points on Mary Avenue as pedestrians cross where the connector ramps meet Mary Avenue. The westbound to northbound connector ramp will be signalized at Mary Avenue, providing a protected crossing for pedestrians. The current concept does not have any traffic control at the southbound to westbound connector ramp, although it is a tight turn radius that will require vehicles to complete the turn at lower speed.

Underpass Tunnel. The grade separation of Mary Avenue has substantial safety benefits for pedestrians as pedestrians would no longer be exposed to conflicts with trains. All conflicts between rail and pedestrians would be grade-separated.

Grade changes are introduced in the Build alternative with the depression of Mary Avenue and Evelyn Ave. Pedestrians will experience up to 2.5 percent along Mary Avenue and Evelyn Avenue will be similarly depressed to connect with Mary Avenue. Similarly to the No-Build scenario, no sidewalks are provided on the north side of Evelyn Avenue under the Build scenario. The intersection crossings would be similar to current conditions.

Bicycle

No Build. In the No-Build scenario, Class II bike lanes are provided on both Mary Avenue and along eastbound Evelyn Avenue. Westbound Evelyn Avenue has sharrows through the Mary Avenue intersection in order to provide a second westbound through lane at the intersection. Bicyclists on Mary Avenue would continue to cross the tracks at-grade.

Underpass with Jughandle. The grade separation of Mary Avenue has substantial safety benefits for cyclists as they would no longer be exposed to conflicts with trains. In addition, the crossing of the rails themselves represents a hazardous condition, as bicycle tires can get stuck in the tracks, which would be removed with the project. With the jughandle, six-foot wide Class II bike lanes are currently planned along all roadways, including Mary Avenue, Evelyn Avenue, and the proposed jughandle, closing a current gap in the bicycle network along Evelyn Avenue. The City is in planning stages of a multi-use trail on the north side of Evelyn Avenue, which would be provided in lieu of dedicated bike lanes on both sides of Evelyn Avenue. This alternative would work well with such a plan, as no conflicts would occur along the multi-use trail in the vicinity of Mary Avenue.

Grade changes are introduced in the Build alternative with the depression of Mary Avenue. Cyclists will experience up to a 3 percent grade as they travel along the jughandle and up to 7 percent along Mary Avenue. Similar to pedestrians, cyclists would be routed through the jughandle to make any turning movements at the Mary Avenue/Evelyn Avenue intersection. With the provision of multiple vehicle turn lanes, two-stage turn boxes and demarcated bike stencils across intersections should be considered in future project phases at both intersections of the jughandle with Evelyn Avenue and Mary Avenue to provide a safe way for cyclists to make turning movements. This is particularly critical for the westbound left-turn bicycle movement from Evelyn Avenue to the jughandle, the westbound left-turn bicycle movement from the jughandle to Mary Avenue, the southbound left-turn bicycle movement from Mary Avenue to the jughandle, and the northbound left-turn bicycle movement from the jughandle to Evelyn Avenue. These treatments would avoid the need for a challenging auto-bicycle weave movement along the short length of the jughandle. Appropriate yield and caution signs should be installed at the intersections to make motorists aware of bicycles.

Underpass with Jughandle and Connector Ramps. The concepts included in this memo do not include any bicycle facilities on the connector ramps. The provision of exclusive bicycle lanes on the ramps should be evaluated in future project phases should this alternative advance. That would allow for convenient connections between bicycle facilities on Evelyn Avenue and Mary Avenue without having to navigate the jughandle intersections. The connector ramps add conflicts for bicyclists traveling through on both Mary Avenue and Evelyn Avenue. As currently shown in the concept, on Evelyn Avenue, vehicles accessing or merging from the connector ramps will be required to weave across the westbound bike lanes. With the City's plan for a multi-use trail on the north side of Evelyn Avenue, that conflict could be removed if the multi-use trail stays at the same elevation at Evelyn Avenue alongside the Caltrain tracks, avoiding the need to cross either connector ramp. On Mary Avenue, the connector ramps will add an additional conflict for through cyclists. The westbound to northbound connector ramp will be signalized at Mary Avenue, providing for a protected crossing for

Mary Avenue cyclists. The southbound to westbound connector ramp will not be signalized and thus would introduce a new uncontrolled conflict point for through cyclists.

Underpass Tunnel. The grade separation of Mary Avenue has substantial safety benefits for cyclists as they would no longer be exposed to conflicts with trains. In addition, the crossing of the rails themselves represents a hazardous condition, as bicycle tires can get stuck in the tracks, which would be removed with the project. With the provision of multiple vehicle turn lanes, two-stage turn boxes and demarcated bike stencils across intersections should be considered in future project phases to provide a safe way for cyclists to make turning movements. The Underpass Tunnel Alternative design allows for the City's planned multi-use trail on the north side of Evelyn Avenue.

Grade changes are introduced in the Build alternative with the depression of Mary Avenue and Evelyn Ave. Cyclists will experience up to 7 percent along Mary Avenue and Evelyn Avenue will be similarly sloped to connect with Mary Avenue. The grade changes can act as a deterrent for those unaccustomed to biking at steep slopes. In addition, a downhill slope of 7 percent can cause bicyclists to speed down towards the Mary Avenue/Evelyn Avenue intersection, which poses risks for potential bicycle-pedestrian or bicycle-vehicle conflicts, particularly if other negative variables, such as low visibility or bad weather, are present.

Transit

There are no transit routes on Mary Avenue or Evelyn Avenue; as such, there are no impacts to transit routing.

Corridor Travel Time

The VISSIM model was utilized to calculate the change in travel time on Mary Avenue between the 2035 No-Build and the two Build alternatives. Travel times were assessed for movements along Mary Avenue between Washington Avenue and California Avenue. This is summarized in **Table 5**.

Table 5: Mary Avenue - Corridor Travel Time

Segment	Dir	AM Peak Hour				PM Peak Hour			
		2035 No-Build	2035 Build (Jughandle)	2035 Build (Ramps)	2035 Build (Tunnel)	2035 No-Build	2035 Build (Jughandle)	2035 Build (Ramps)	2035 Build (Tunnel)
Washington to Evelyn	NB	562 sec.	331 sec.	332 sec.	336 sec.	149 sec.	118 sec.	116 sec.	115 sec.
California to Evelyn	SB	104	45	45	80	171	82	81	130

Note: Travel times in the peak direction of travel for each peak period are shaded

Mary Avenue is forecast to experience saturated conditions in the peak direction in each peak period in 2035 No-Build and Build scenarios. For southbound movements, Central Expressway and California Avenue both serve as meters on the amount of traffic that can approach Evelyn Avenue and the grade crossing. While Washington Avenue similarly meters northbound traffic, it has less conflicting east-west movement and therefore allows for higher throughput on Mary Avenue, and thus

a larger component of the northbound traffic demand than the southbound traffic demand reaches the Evelyn Avenue intersection and the grade crossing. As a result, northbound travel times and congestion is more readily apparent in the travel time results even though both directions have similar levels of underlying demand.

As shown in the table, travel times along Mary Avenue are substantially higher under the 2035 No-Build scenario than each of the build scenarios in the peak directions of travel in both peak periods. Travel time reductions in the northbound direction in the AM peak hour exceed three minutes with all alternatives and in the southbound direction in the PM peak hour exceed 40 seconds under the Underpass Tunnel Alternative and nearly 90 seconds with the two other build alternatives. The elimination of the at-grade crossing under all Build alternatives is observed to substantially reduce travel time.

Travel times are lowest under the Underpass with Jughandle and Underpass with Jughandle and Connector Ramp Alternatives, except for travel times in the northbound direction are slightly lower for the Underpass Tunnel Alternative during the PM peak hour. This is as expected, as the jughandle reduces the overall number of conflicts at the Mary Avenue/Jughandle intersection, relative to either the No-Build or Underpass Tunnel Alternative. The connector ramps and the additional northbound Mary Avenue half-signal have negligible effect on travel times on Mary Avenue.

SUNNYVALE AVENUE

Volume Distribution and Assignment

Attachment D depicts the redistribution of 2035 volumes with the Sunnyvale Avenue Underpass Tunnel Alternative. As shown, turning movements at the Sunnyvale Avenue/Evelyn Avenue intersection are redistributed to streets including Fair Oaks Avenue, Mathilda Avenue, and Washington Avenue. Through movements on Sunnyvale Avenue are maintained. Turning movements at the Sunnyvale Avenue/Hendy Avenue intersection are primarily redistributed to Fair Oaks Avenue via the Fair Oaks Avenue/Kifer Road intersection.

Attachment E shows the redistribution of 2035 volumes with the Sunnyvale Avenue Bicycle/Pedestrian Undercrossing Alternative. Volumes along Sunnyvale Avenue at the grade-crossing are redistributed to Mathilda Avenue and Fair Oaks Avenue.

Intersection Operations Results

Attachment F summarizes the No-Build and Build intersection operation results for all study intersections. The following highlights the intersections that degrade to a deficient LOS and those that are already deficient by four or more seconds in delay, per VTA traffic analysis standards.

- Sunnyvale Underpass Tunnel and Bicycle/Pedestrian Undercrossing Alternatives
 - o No-Build scenario deficient, Build scenario increases delay
 - Sunnyvale Avenue/Washington Avenue (AM Peak Hour)
 - Fair Oaks Avenue/Kifer Road (PM Peak Hour)
 - Fair Oaks Avenue/Evelyn Avenue (AM and PM Peak Hours)

- Sunnyvale Avenue Underpass Tunnel Alternative
 - o Build scenario renders intersection deficient
 - Sunnyvale Avenue/California Avenue (AM Peak Hour)
 - o No-Build scenario deficient, Build scenario increases delay
 - Sunnyvale Ave/California Avenue (PM Peak Hour)
 - Sunnyvale Avenue/Washington Avenue (PM Peak Hour)
 - Washington Avenue/Frances Street (PM Peak Hour)
- Sunnyvale Avenue Bicycle/Pedestrian Undercrossing Alternatives
 - o Build scenario renders intersection deficient
 - Fair Oaks Avenue/California Avenue (AM Peak Hour)
 - Fair Oaks Avenue/Kifer Rd (AM Peak Hour)
 - o No-Build scenario deficient, Build scenario increases delay
 - Sunnyvale Avenue/Evelyn Avenue (AM Peak hour)
 - Fair Oaks Avenue/California Avenue (PM Peak Hour)

Both grade separation alternatives typically result in delay reductions at two intersections adjacent to the grade-crossing: Sunnyvale Avenue/Hendy Avenue and Sunnyvale Avenue/Evelyn Avenue. The lone exception is at Sunnyvale Avenue/Evelyn Avenue in the AM Peak Hour with the Bicycle/Pedestrian Undercrossing Alternative due to an increase in turning movements from Sunnyvale Avenue to Evelyn Avenue. The intersection operations analysis found that both Sunnyvale Avenue alternatives increase traffic volumes and congestion primarily at study intersections along Fair Oaks Avenue and Sunnyvale Avenue. Intersection operations on Mathilda Avenue generally are shown to improve, particularly in the AM Peak Hour, as a result of the removal of forecast backups along Evelyn Avenue caused by very high left turn volumes from Evelyn Avenue to Sunnyvale Avenue.

Corridor Travel Time

The Synchro model was used to calculate corridor travel times along the three north-south corridors in the study area: Mathilda Avenue, Sunnyvale Avenue, and Fair Oaks Avenue.

Table 6 shows travel times in each direction along each of the major north-south roadways within the project limits in the model (Mathilda Avenue, Sunnyvale Avenue, and Fair Oaks Avenue) for each scenario.

Table 6: Sunnyvale Avenue - Corridor Travel Time

Corridor	Segment	Direction	AM Peak Hour			PM Peak Hour		
			2035 No-Build	2035 Build (Tunnel)	2035 Build (Bicycle/Ped UC)	2035 No-Build	2035 Build (Tunnel)	2035 Build (Bicycle/Ped UC)
Mathilda	Indio to Washington	SB	181 sec.	178 sec.	174 sec.	565 sec.	582 sec.	622 sec.
	McKinley to California	NB	367	374	389	161	162	175
Fair Oaks	Arques to Evelyn	SB	160	126	291	466	428	660
	McKinley to California	NB	389	431	624	213	329	362
Sunnyvale	Arques to McKinley	SB	325	186	-	775	409	-
	McKinley to Arques	NB	306	88	-	335	121	-

Note: Travel times in the peak direction of travel for each peak period are shaded

The following section provides a brief summary and explanation of these results.

- AM Travel Time Results
 - o The shift of traffic from Sunnyvale Avenue to Mathilda Avenue and Fair Oaks Avenue results in increased delays for the two parallel roadways. Along Mathilda Avenue and Fair Oaks Avenue, travel times are generally highest under the Bicycle/Pedestrian Undercrossing Alternative because the volume shift to Mathilda and Fair Oaks Avenue is less with the Underpass Tunnel than the Bicycle/Pedestrian Undercrossing option. The finding from the VISSIM model of improved operations along Mathilda Avenue with the Build alternatives is not evident in the Synchro travel time results as Synchro does not consider downstream queue spillbacks when determining delay.
 - o Along Sunnyvale Avenue, travel times are substantially lower under the Underpass Tunnel Alternative than the No-Build. The elimination of the at-grade crossing results in substantial reductions in travel time. No similar measurement of travel time along Sunnyvale Avenue is possible with the Bicycle/Pedestrian Undercrossing Alternative since the roadway would be closed for vehicles at the tracks.
- PM Travel Time results
 - o The shift of traffic from Sunnyvale Avenue to Mathilda Avenue and Fair Oaks Avenue results in increased delays for the two parallel roadways. Along Mathilda Avenue and Fair Oaks Avenue, travel times are highest under the Bicycle/Pedestrian Undercrossing Alternative because the volume shift to Mathilda and Fair Oaks Avenue is much less with the Underpass Tunnel than the Bicycle/Pedestrian Undercrossing Alternative.

- o Along Sunnyvale Avenue, a substantial drop in travel times is observed in the Underpass Tunnel Alternative in the northbound direction. The elimination of the at-grade crossing results in substantial reductions in travel time. No similar measurement of travel time along Sunnyvale Avenue is possible with the Bicycle/Pedestrian Undercrossing Alternative since the roadway would be closed at the tracks.

Network Performance

The VISSIM model allows for analysis of overall network performance under each of the alternatives. While alternatives may affect individual movements in different and often complex ways, a comparison of network performance accounts for how the overall change in geometrics and volumes affects network level congestion and throughput. Two network-wide metrics were analyzed: average vehicular delay for the entire vehicular path through the network and unserved demand, which reflects the traffic volume that was stuck in congestion and not able to traverse through the network.

Table 7: Sunnyvale Avenue – Network Performance Metrics

Performance Metrics	AM Peak Hour			PM Peak Hour		
	2035 No-Build	2035 Build (Tunnel)	2035 Build (Bicycle/Ped UC)	2035 No-Build	2035 Build (Tunnel)	2035 Build (Bicycle/Ped UC)
Average Vehicle Delay (sec.)	252	163	184	259	238	240
Unserved Demand	22%	19%	22%	31%	37%	39%

As shown in **Table 7**, both Build alternatives result in a measurable reduction in average vehicle delay in both peak periods of at least seven percent. The Sunnyvale Underpass Tunnel Alternative results in a slightly greater delay reduction than the Bicycle/Pedestrian Undercrossing Alternative, particularly in the AM Peak Hour. The unserved demand calculation finds that the amount of traffic stuck in congestion through the peak hour is pretty similar between the No-Build and the Build in the AM Peak Hour but is somewhat higher with both Build Alternatives in the PM Peak Hour. This is likely associated with increased traffic on already over-saturated corridors.

Multimodal Considerations

The proposed alternatives at Sunnyvale Avenue have the following considerations for multimodal operations:

Pedestrian

No-Build. Sidewalks are present on both sides of all approaches at both the Sunnyvale Avenue/Evelyn Avenue and Sunnyvale Avenue/Hendy Avenue intersections, except on the south

side of Hendy Avenue. Due to the adjacency of the railroad tracks, no crosswalk is present on the south leg of the Sunnyvale Avenue/Hendy Avenue intersection.

Underpass Tunnel Alternative. The grade separation of Sunnyvale Avenue has substantial safety benefits for pedestrians since they would no longer be exposed to conflicts with trains.

Grade changes are introduced in the Build alternative with the depression of the pedestrian walkway along Sunnyvale Avenue. In the Build scenario, an 8-foot pedestrian walkway with 10 feet of vertical clearance is provided on the west side of the proposed tunnel on Sunnyvale Avenue. The pedestrian walkway is separated and elevated above the bicycles and vehicles by a column wall and can be accessed through pedestrian ramps. The pedestrian ramps are located on northwest corner of the Sunnyvale Avenue/Evelyn Avenue intersection and the southwest corner of the Sunnyvale Avenue/Hendy Avenue intersection. The location of the access ramps causes out-of-direction travel for pedestrians that do not originate west of Sunnyvale Avenue on both Evelyn Avenue and Hendy Avenue. The switchback ramps will also lengthen the pedestrian path of travel for users of the undercrossing. Pedestrians on Evelyn Avenue will have reduced vehicle conflicts, as pedestrians on the north sidewalk of Evelyn Avenue will not have to cross Sunnyvale Avenue, and pedestrians on the south sidewalk would only have to cross a cul-de-sac with little traffic. It is recommended to provide a new sidewalk on the south side of Hendy Avenue, between Sunnyvale Avenue and the north entrance to Caltrain Station at North Frances Street, to connect the Caltrain Station to the at-grade Sunnyvale Avenue/Hendy Avenue intersection.

Bicycle/Pedestrian Undercrossing Alternative. Similar to the Underpass Tunnel alternative, a pedestrian undercrossing will be constructed to remove the conflict between pedestrians and trains, which would provide substantial safety benefits. A sidewalk would be constructed on the south side of Hendy Avenue, which is recommended to connect to the Sunnyvale Caltrain Station. Pedestrians will continue to have access along Sunnyvale Avenue between Evelyn Avenue and Hendy Avenue via the proposed pedestrian/bike undercrossing. Access to the undercrossing would be along a pathway with a maximum slope of 5 percent from both Evelyn Avenue and Hendy Avenue. Access from Hendy Avenue would be from a switchback ramp or stairs at the Sunnyvale Avenue/Hendy Avenue intersection. Access from Evelyn Avenue would be via a curved ramp or stairs at the Sunnyvale Avenue/Evelyn Avenue intersection. Pedestrians at both Sunnyvale Avenue/Evelyn Avenue and Sunnyvale Avenue/Hendy Avenue intersections would experience fewer conflicts with vehicles since one leg would be closed at each intersection and much of the traffic would be detoured to other routes.

Bicycle

No-Build. In the No-Build, Sunnyvale Avenue has a Class II bike facility south of Evelyn Avenue and a Class III bike facility north of Evelyn Avenue. A project was recently approved to add Class II buffered bike lanes on Sunnyvale Avenue between just north of Hendy Avenue and Maude Avenue. Evelyn Avenue has Class II bike lanes in each direction on both sides of Sunnyvale Avenue and Hendy Avenue has Class II bike lanes east of Sunnyvale Avenue only.

Underpass Tunnel Alternative. The tunnel crossing for bicyclists on Sunnyvale Avenue would remove conflicts with the train which is a major safety improvement. In addition, cyclists would no longer be exposed to the physical hazard of crossing the rails. The Sunnyvale Avenue tunnel would include 6-foot Class II bike lanes. A 6-foot Class II bike lane would also be provided on Hendy Avenue west of Sunnyvale Avenue in the westbound direction only. Sufficient space is not available for a Class II bike lane in the eastbound direction on Hendy Avenue due to the placement of the pedestrian ramps. Therefore, a Class III bike route would be designated for eastbound Hendy Avenue. Northbound cyclists on Sunnyvale Avenue accessing Hendy Avenue would need to use the 8-foot sidewalk on the west side of the tunnel similar to pedestrians and use the provided switchback ramp. The narrow nature of the pedestrian area and the ramps could create a conflict between cyclists and pedestrians.

Cyclists on Evelyn Avenue destined northbound on Sunnyvale Avenue would need to use the pedestrian ramps on the northwest side of the Sunnyvale Avenue/Evelyn Avenue intersection and travel along the pedestrian route through the tunnel. Similarly, cyclists traveling on Hendy Avenue destined southbound along Sunnyvale Avenue would need to use the pedestrian ramps on the southwest corner of the Sunnyvale Avenue/Hendy Avenue intersection. On the west side of the tunnel, a multi-use facility would serve cyclists traveling southbound on Sunnyvale Avenue and on the east side of the tunnel, a dedicated bicycle facility would serve cyclists traveling northbound on Sunnyvale Avenue. Through the tunnel, cyclists would experience up to 6.5 percent grades (within the tunnel grades would be limited to 3 percent, but grades on the roadway approach would be greater). The proposed multi-use path on the west side of the tunnel would be 14 feet wide and the bicycle-only facility on the east side would be 6 feet wide. Both facilities would be placed at an elevation above vehicles for vertical separation. Cyclists could alternatively elect to share the lane with auto and use the tunnel roadway. A detailed wayfinding plan for cyclists should be implemented to ensure cyclists know which facility to use depending on their final destination.

Bicycle/Pedestrian Undercrossing Alternative. The proposed undercrossing will remove conflicts between cyclists and trains thereby substantially improving safety. In addition, cyclists would no longer be exposed to the physical hazard of crossing the rails. In the Bicycle/Pedestrian Undercrossing Alternative, Evelyn Avenue would continue to have a Class II bike facility. Cyclists traveling northbound or southbound on Sunnyvale Avenue would have continued access through the proposed pedestrian/bike path and undercrossing. North of Hendy Avenue, a Class II bike facility will be provided that will connect to the buffered Class II bike lanes on Sunnyvale Avenue recently approved by the City. A 6-foot bike lane would also be developed in both directions on Hendy Avenue west of Sunnyvale Avenue, although the limits of that improvement are not yet defined.

Transit.

No-Build. VTA Route 55 operates across the Caltrain alignment along Sunnyvale Avenue. It departs the Sunnyvale Caltrain Station on Evelyn Avenue and then turns onto Sunnyvale Avenue. It currently operates on 16-minute frequencies during peak service periods. It is planned to continue operating along this route with the VTA Next Network Plan, but at 30-minute all-day frequency.

Underpass Tunnel Alternative. Route 55 would need to be re-routed since it would no longer be able to make turns at the Sunnyvale Avenue/Evelyn Avenue intersection. The bus route would need to be rerouted to the Caltrain Station via Washington Avenue instead of Evelyn Avenue. No other bus routes included in the Next Network plan would be affected by the Underpass Tunnel Alternative.

Bicycle/Pedestrian Undercrossing Alternative. Route 55 would need to be re-routed with the vehicular closure of Sunnyvale Avenue. The route would need to be shifted to Mathilda Avenue or Fair Oaks Avenue; thereby requiring a longer route to access the Sunnyvale Station and no longer serving Sunnyvale Avenue between California Avenue and Evelyn Avenue. As both Mathilda Avenue and Fair Oaks Avenue are more congested roadways, travel time on Route 55 may increase as well. No other bus routes included in the Next Network plan would be affected by the vehicular closure of Sunnyvale Avenue.

Summary

Both the Bicycle/Pedestrian Undercrossing and Underpass Tunnel Alternatives will provide substantial safety improvements to pedestrians as pedestrian-train conflicts will be removed. The path of travel for pedestrians traveling on Sunnyvale Avenue is slightly longer in the Underpass Tunnel Alternative due to the switchback ramping on both sides of the rail tracks that is lessened on the Evelyn Avenue side in the Bicycle/Pedestrian Undercrossing Alternative. Cyclists in both alternatives will also benefit from having grade separated crossings from the rail tracks. The Underpass Tunnel Alternative will require cyclists to use pedestrian ramps based on their destinations whereas they will have access to both Hendy and Evelyn Avenue via the pedestrian/bike path in the Bicycle/Pedestrian Undercrossing Alternative. Both alternatives will impact VTA transit Route 55 and require it to be rerouted to continue serving the Sunnyvale Station; however, the detour associated with the Bicycle/Pedestrian Undercrossing Alternative is longer.

SUMMARY AND FINDINGS

This section provides findings based on the analysis summarized herein for all of the grade separation alternatives considered.

Mary Avenue

Three alternatives were evaluated for the grade separation at Mary Avenue.

The Underpass Tunnel Alternative proposed depressing both Mary Avenue and Evelyn Avenue beneath the tracks, replicating the existing intersection at a lower grade, eliminating the rail conflict.

The Underpass Tunnel with Jughandle Alternative proposes the depression of Mary Avenue under Evelyn Avenue and the railroad tracks, eliminating the rail conflict and existing connection with Evelyn Avenue. To accommodate existing turning movements at the Mary Avenue/Evelyn Avenue intersection, a jughandle is proposed on the southeast side of the existing intersection. The initially-proposed four-lane jughandle was not sufficient to handle projected traffic volumes. Therefore, a modified 5-lane jughandle was analyzed and documented in this report.

The Underpass Tunnel with Jughandle and Connector Ramps Alternative proposes the depression of Mary Avenue under Evelyn Avenue and the railroad tracks, a jughandle on the southeast side of the existing intersection, and connector ramps for the westbound to northbound and southbound to westbound movements between Mary Avenue and Evelyn Avenue. The rail conflict is still eliminated, as is the connection with eastbound Evelyn Avenue.

Mary Avenue is heavily saturated with traffic in the No-Build scenario. While the three Build alternatives eliminate the rail crossing conflict, as they are focused on the Mary Avenue/Evelyn Avenue intersection, they do not address overall capacity constraints on the corridor. Therefore, while the Build alternatives substantially reduce delay for most movements through the Mary Avenue/Evelyn Avenue area, movements with deficient levels of delay still persist.

The analysis finds that all three Build alternatives provide substantial delay and queuing benefits to traffic movements on Evelyn Avenue and Mary Avenue relative to No-Build conditions. By distributing vehicle conflicts amongst two intersections and providing direct ramps for two movements, the Underpass Tunnel with Jughandle and Connector Ramps Alternative achieves the greatest reduction in the amount of delay along both the Mary Avenue and Evelyn Avenue corridors, improving overall traffic flow and reducing travel time on both streets relative to the No-Build and the Underpass Tunnel Alternative. The Underpass Tunnel with Jughandle and Connector Ramps Alternative provides the greatest delay reduction for most intersection movements. All of the Build alternatives provide substantial queuing benefits relative to the No-Build, with the Underpass Tunnel with Jughandle and Connector Ramps Alternative achieving the greatest queue length reductions for most movements.

All grade-separation alternatives of the Mary Avenue at-grade crossing substantially improve safety for pedestrians and bicyclists by eliminating conflicts with trains and the tripping/falling hazard of crossing the rail tracks themselves. With the two Underpass Tunnel with Jughandle Alternatives, most pedestrians and bicyclists through the intersection would experience some out-of-direction travel and would be required to ascend/descend moderate grades. Most pedestrian and bicycle movements would see shorter crossings. With the Underpass with Jughandle and Connector Ramps Alternative, the number of conflict points would increase for several bicycle and pedestrian movements. Most notably would be the additional conflicts across the westbound bicycle lane on Evelyn Avenue for vehicles accessing and merging from the connector ramps. However, that additional conflict would be eliminated if the City's current planning efforts for a multi-use path along the north side of Evelyn Avenue comes to fruition. In addition, with the Underpass Tunnel with Jughandle and Connector Ramps Alternative, one new uncontrolled vehicle conflict with bicycles and pedestrian arises where the southbound to westbound connector ramp is accessed from Mary Avenue. With the Underpass Tunnel Alternative, all pedestrians and bicyclists would have to ascend/descend moderate grades but would not be subject to out-of-direction travel. There would be no reduction in the number of conflicts or the length of crossings in the Underpass Tunnel Alternative relative to the No-Build.

A modified configuration of the Mary Avenue Underpass Tunnel with Jughandle and Connector Ramps Alternative was developed that leverages the additional connector ramps to reduce turn lane and roadway geometrics for movements that would see reduced traffic volumes as a result of the connector ramps. That configuration is shown in Attachment G. Modifications include: converting the

jughandle northbound shared left/right-turn lane to a right-turn only lane, allowing for a reduction of westbound Evelyn Avenue from two lanes to one lane over Mary Avenue; reducing the southbound left-turn from Mary Avenue to the jughandle from two lanes to one; and reducing the overall width of the jughandle from five lanes to four. This geometry was not modeled for the traffic analysis and no quantitative information is available on how it would perform. Qualitatively, it is expected that this alternative will still provide significant benefits to the No-Build condition, in a manner similar to the Underpass Tunnel with Jughandle and Connector Ramps Alternative described in more detail in this document. Should the reduced right-of-way impacts of this modified alternative warrant further consideration of the Underpass Tunnel with Jughandle and Connector Ramps Alternative, then it is recommended to model this reduced geometry option.

Sunnyvale Avenue

Two alternatives were evaluated for the grade separation at Sunnyvale Avenue. Due to the preservation of through movements on Sunnyvale Avenue with the Underpass Tunnel Alternative, it requires less detour traffic to Mathilda Avenue and Fair Oaks Avenue and thus performs generally better than the Bicycle/Pedestrian Undercrossing Alternative in terms of vehicular corridor travel time on study area roadways and overall network delay. The Underpass Tunnel Alternative results in a large decrease in corridor travel time on Sunnyvale Avenue relative to No-Build.

The Underpass Tunnel Alternative results in less vehicular detour and thus relatively better performance along Mathilda Avenue and Fair Oaks Avenue than the Bicycle/Pedestrian Undercrossing Alternatives but does increase turning activity at a number of intersections in the immediate vicinity of the grade crossing, resulting in a number of intersections experiencing increased delay. However, of the two Build alternatives, the Bicycle/Pedestrian Undercrossing Alternative detours a greater volume of vehicles to Mathilda Avenue and Fair Oaks Avenue, resulting in less delay at the intersections immediately around the existing grade crossing, but three intersections along Fair Oaks Avenue become deficient or are already deficient and experience greater delay. In addition, the peak direction travel time along those detour roadways more substantially increases with the Bicycle/Pedestrian Undercrossing Alternative. Considered together, the metrics indicate that the congestion effects associated with the Bicycle/Pedestrian Undercrossing Alternative are moderately greater than with the Underpass Tunnel Alternative.

Both alternatives provide accommodations for pedestrians and bicyclists, although the Bicycle/Pedestrian Undercrossing Alternative provides a much higher-quality facility across the rail tracks since it would be a dedicated bicycle/pedestrian undercrossing. It also results in less out-of-direction travel for both cyclists and pedestrians by allowing for more direct ramping. However, the Bicycle/Pedestrian Undercrossing Alternative would require a much longer detour for VTA Route 55 than the Underpass Tunnel Alternative due to the vehicular closure of Sunnyvale Avenue. Therefore, while the Underpass Tunnel Alternative is generally superior from a traffic circulation and transit routing standpoint, it does have trade-offs for cyclists and pedestrians.



Attachments:

Attachment A: Mary Avenue Grade Separation 2035 No-Build Intersection Volumes

Attachment B: Mary Avenue Underpass Tunnel with Jughandle Alternative and Mary Avenue Underpass Tunnel with Jughandle and Connector Ramps Alternative 2035 Build Intersection Volumes

Attachment C: Sunnyvale Avenue Grade Separation 2035 No-Build Intersection Volumes

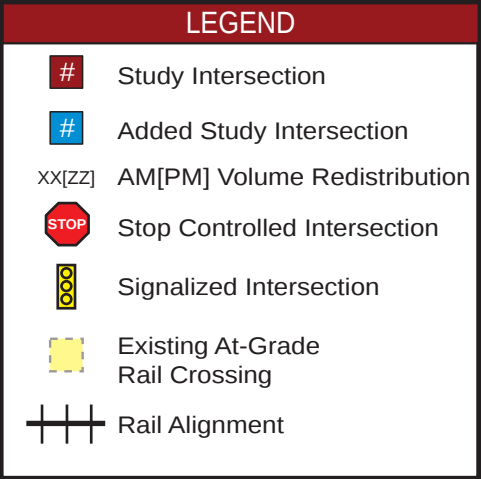
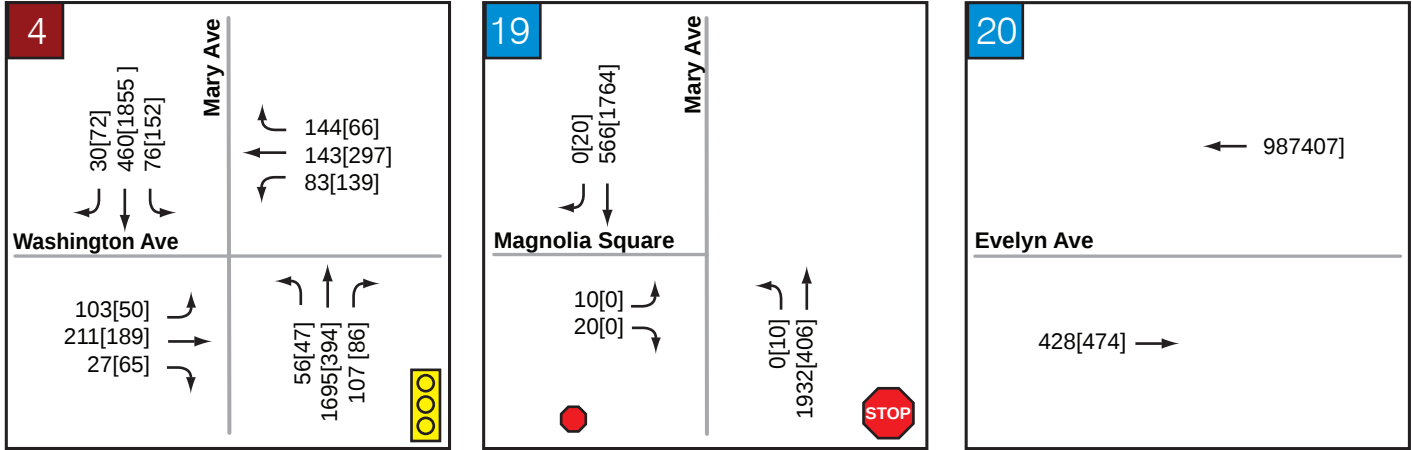
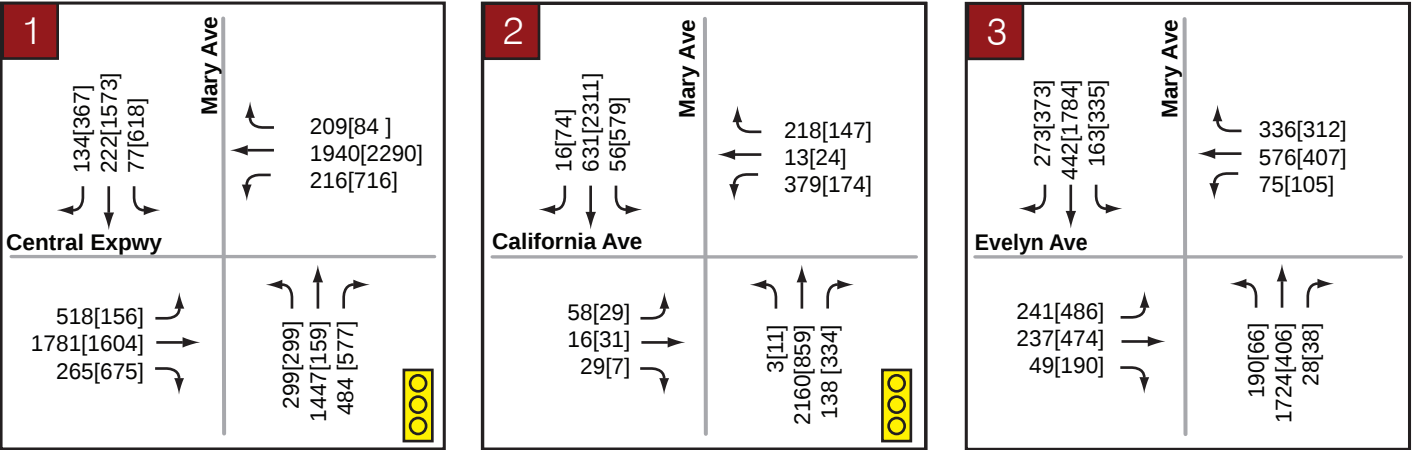
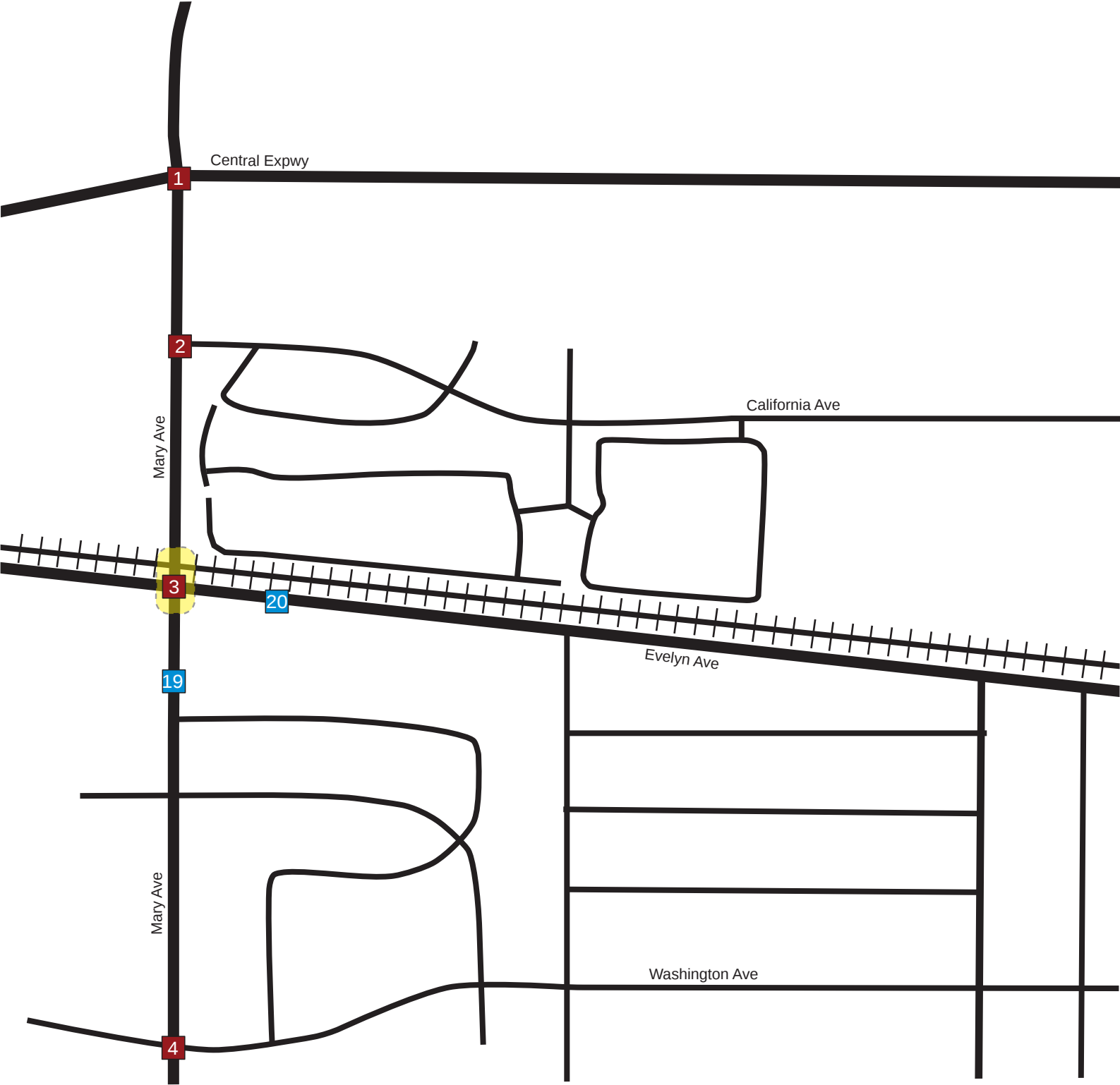
Attachment D: Sunnyvale Avenue Underpass Tunnel Alternative Change in Volumes and Build Intersection Volumes

Attachment E: Sunnyvale Avenue Bicycle/Pedestrian Undercrossing Alternative Change in Volumes and Build Intersection Volumes

Attachment F: Sunnyvale Avenue 2035 No-Build and Build Intersection Operations Results

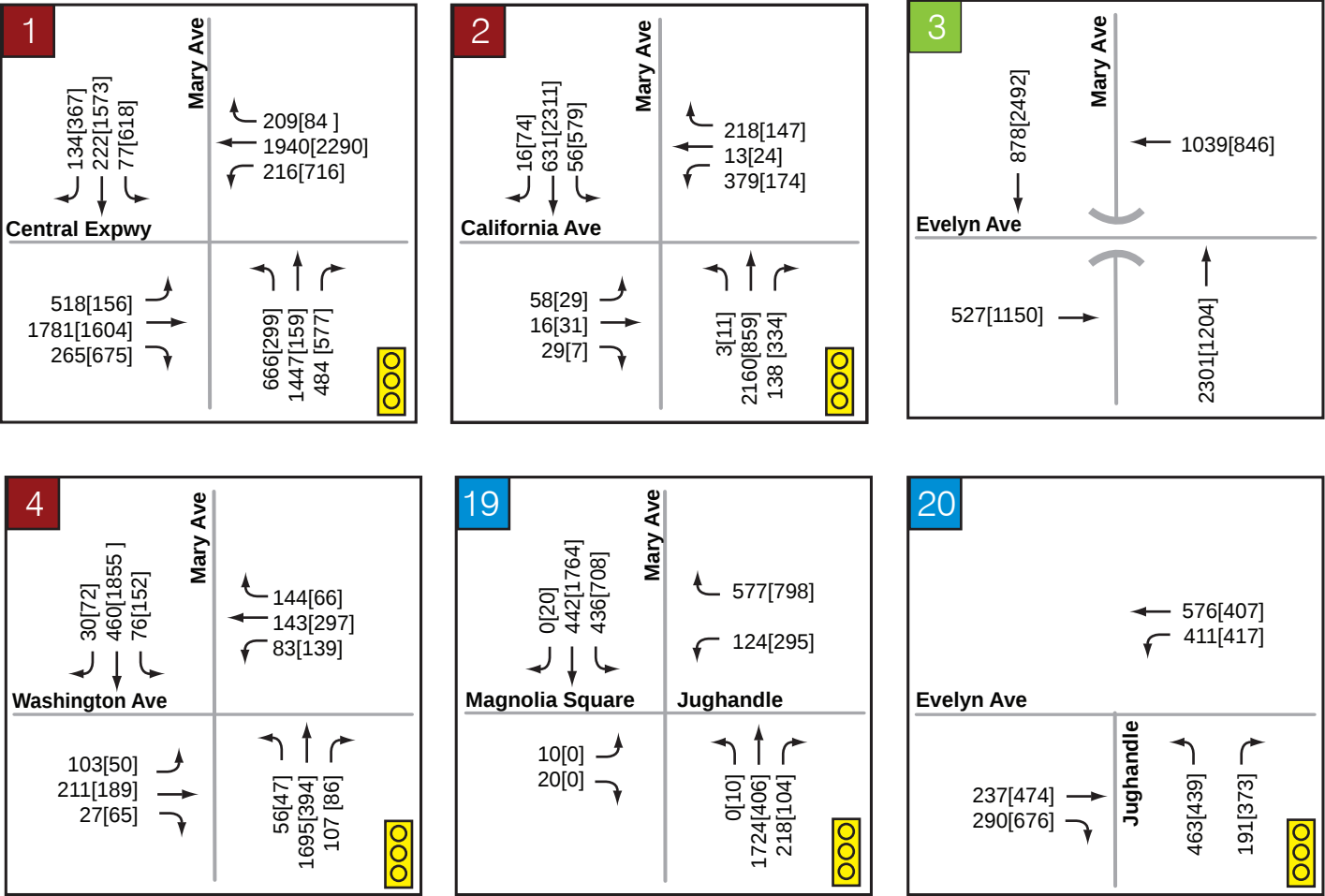
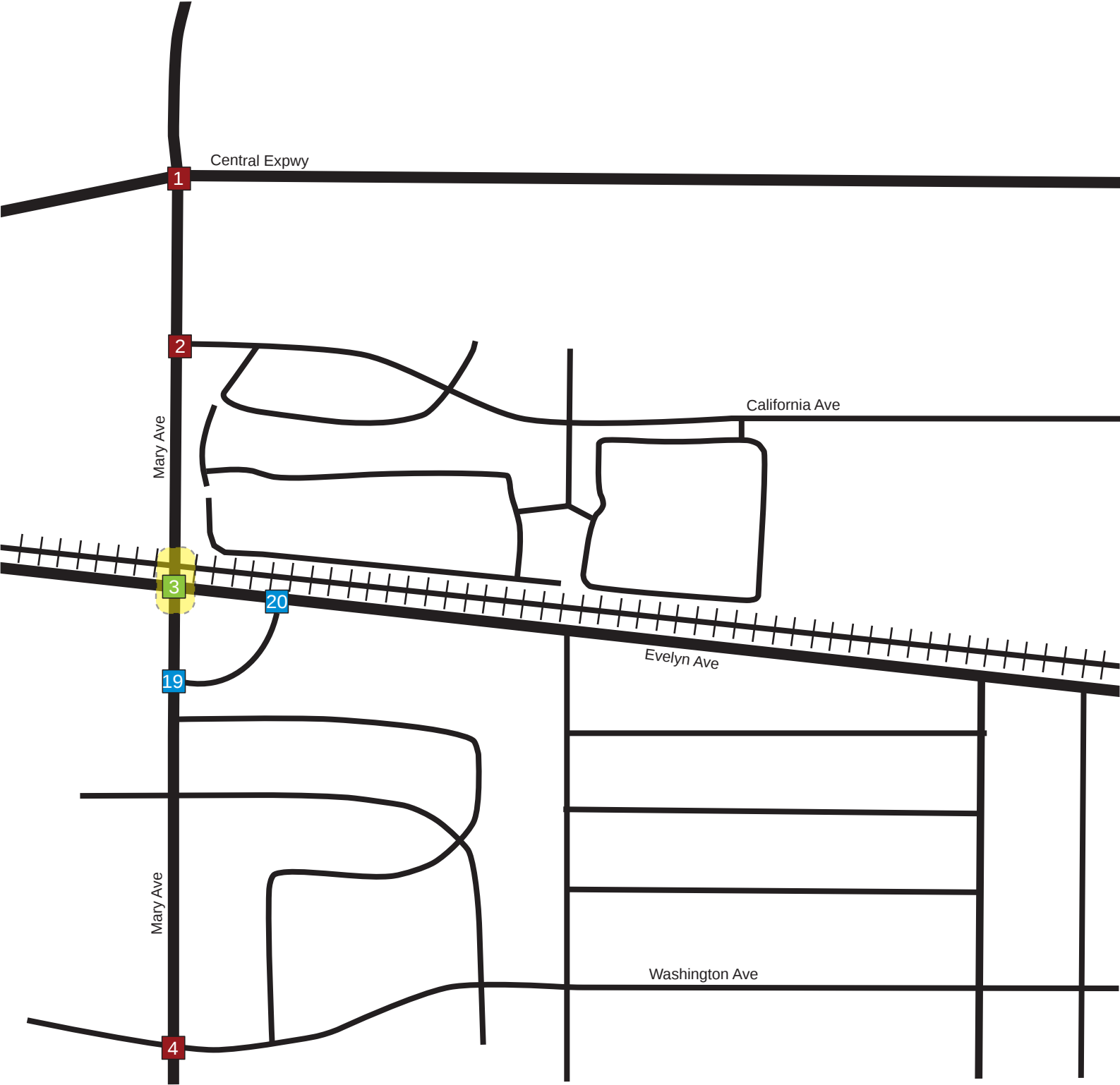
Attachment G: Modified Mary Avenue Underpass Tunnel with Jughandle and Connector Ramps – Reduced Geometry Option

Sunnyvale Caltrain Grade Separations Feasibility Study



Volumes into and out of Magnolia Square are estimated.

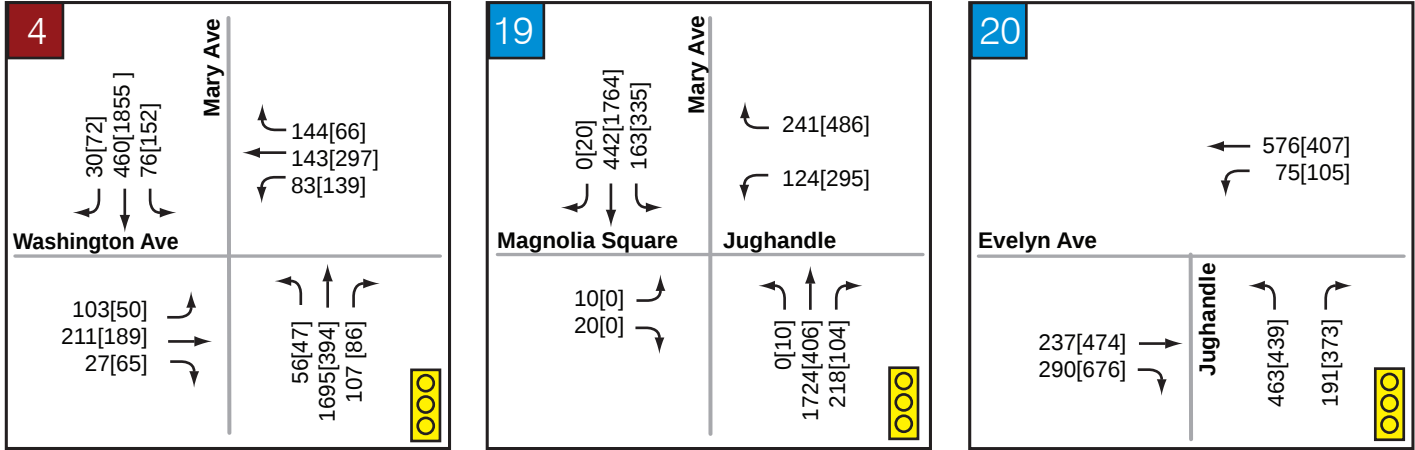
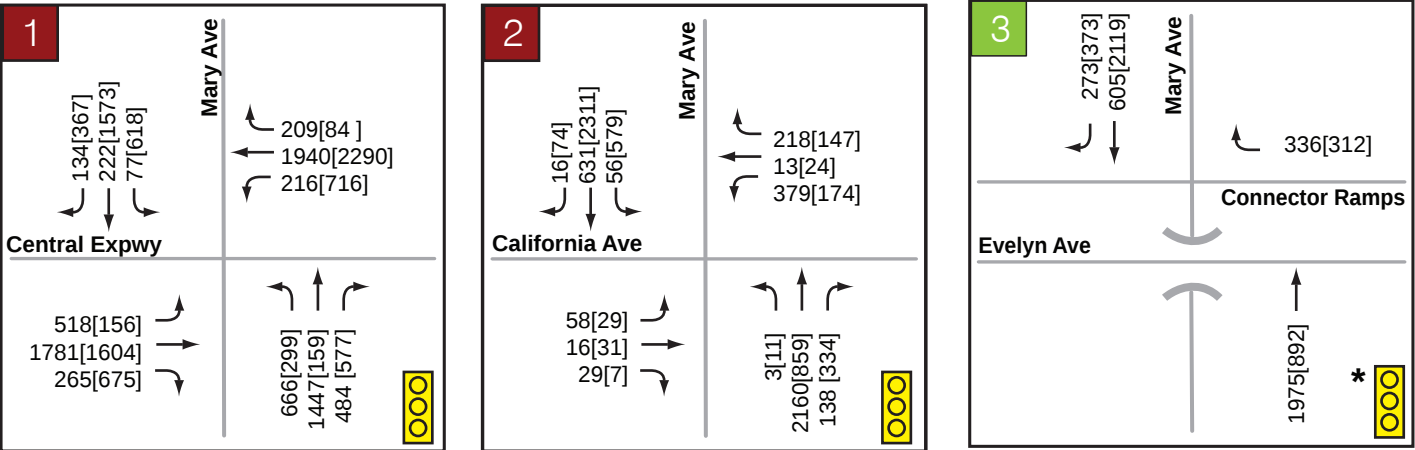
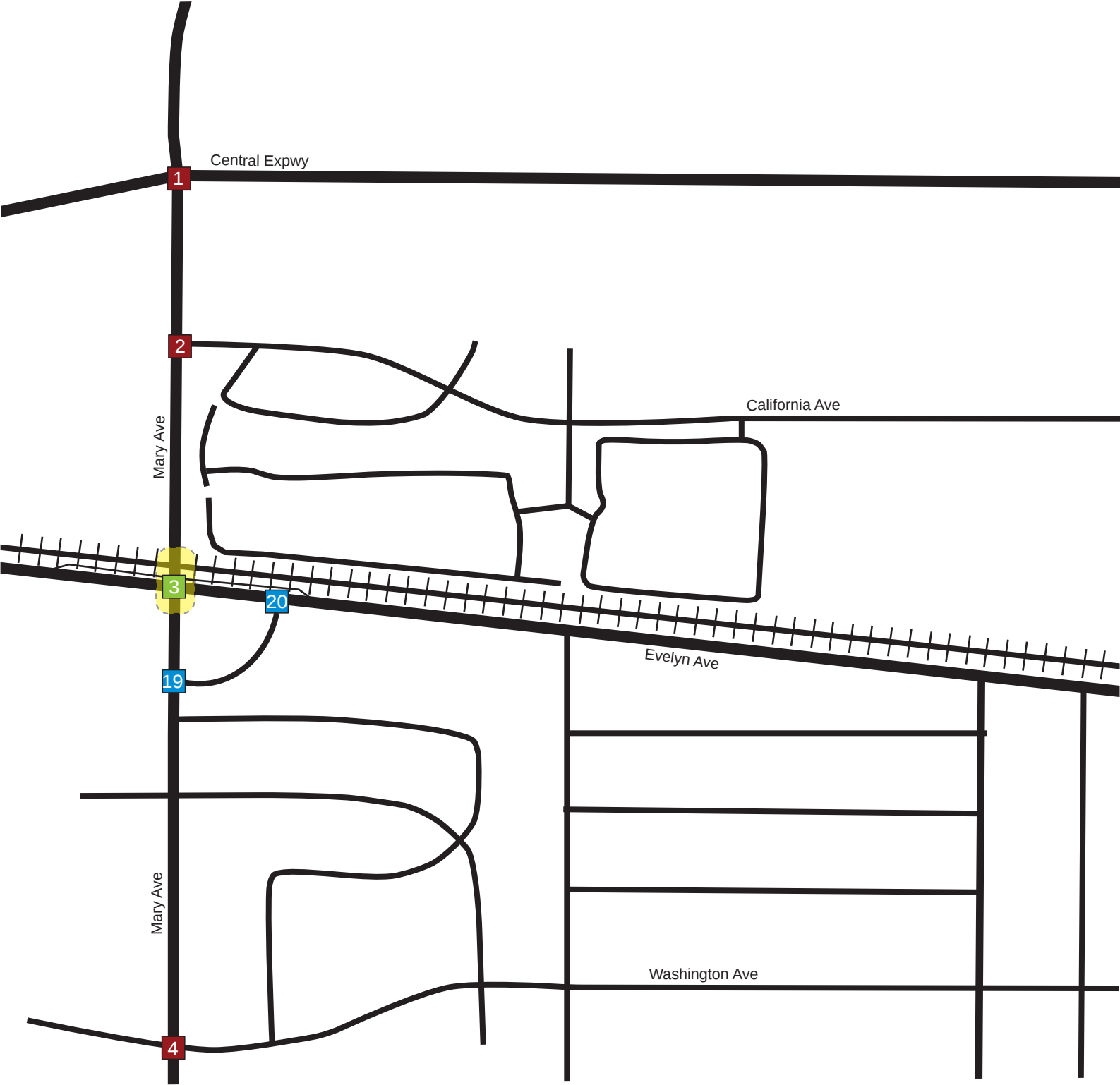
Sunnyvale Caltrain Grade Separations Feasibility Study



LEGEND

- # Study Intersection
- # Added Study Intersection
- # Modified Study Intersection
- xx[zz] AM[PM] Volume Redistribution
- Signalized Intersection
- Existing At-Grade Rail Crossing
- Rail Alignment

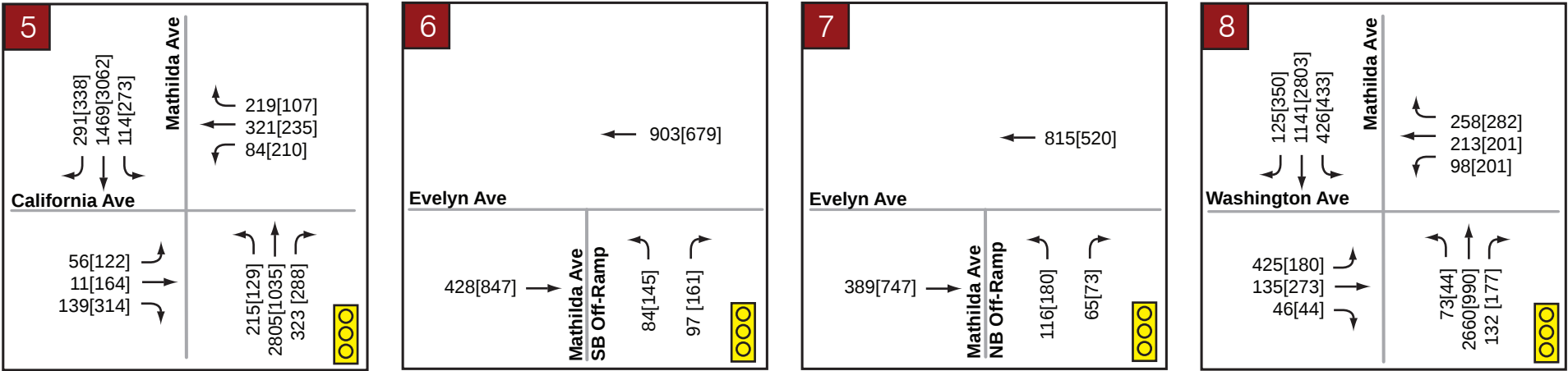
Sunnyvale Caltrain Grade Separations Feasibility Study



LEGEND

- # Study Intersection
- # Added Study Intersection
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- xx[zz] AM[PM] Volume Redistribution
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Sunnyvale Caltrain Grade Separations Feasibility Study



LEGEND

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Study Intersection

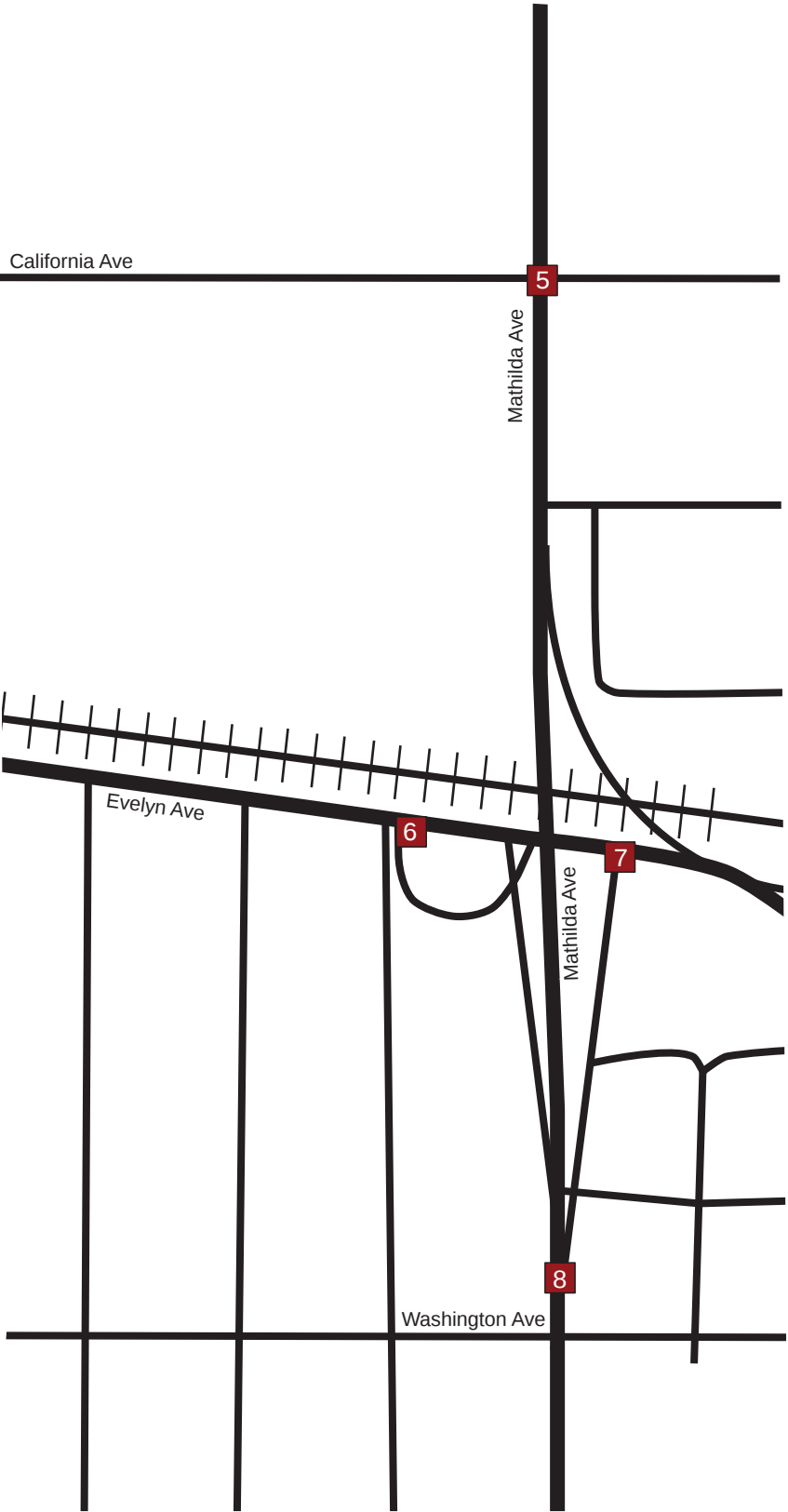
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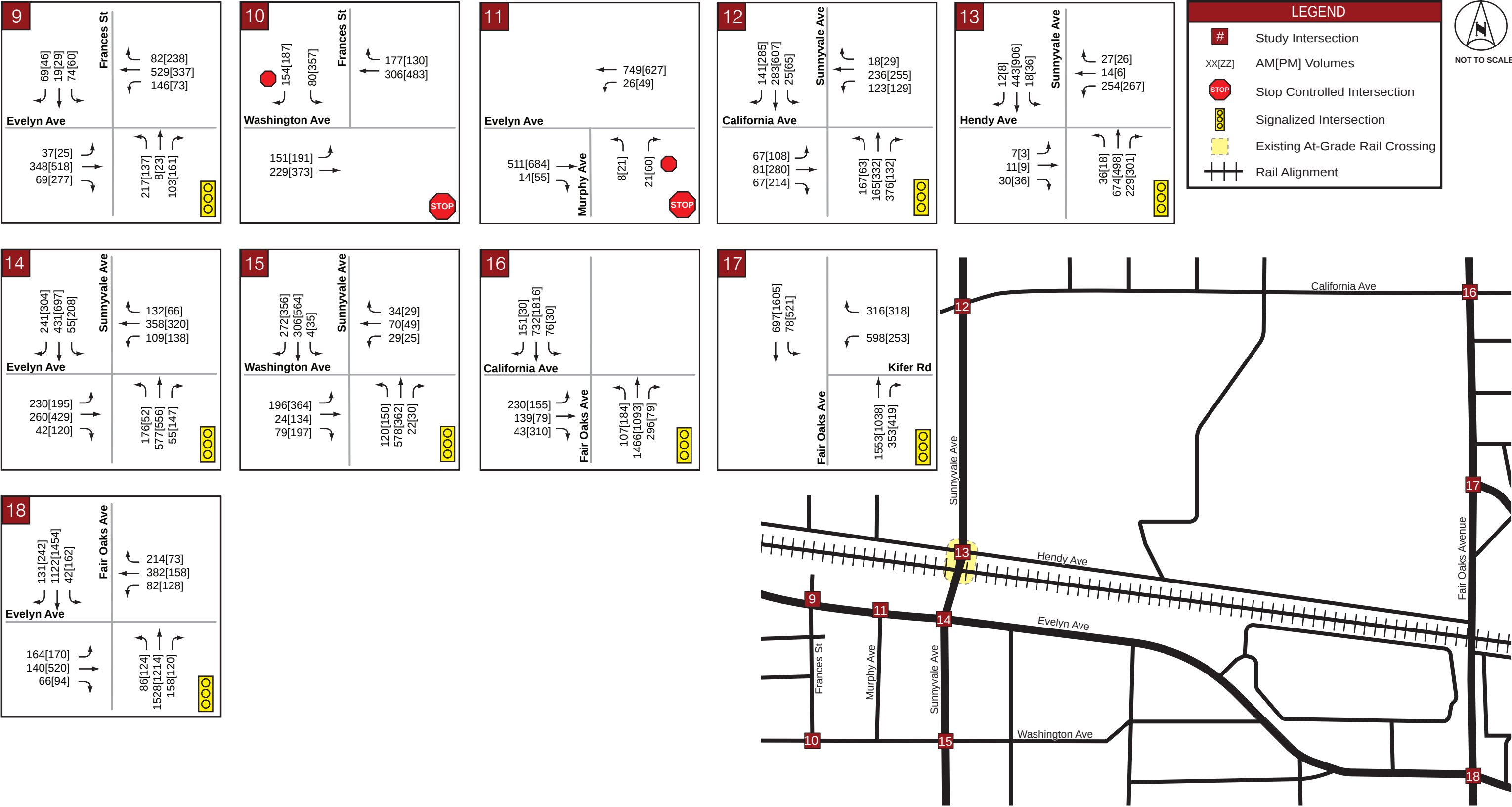
Signalized Intersection

Existing At-Grade
Rail Crossing

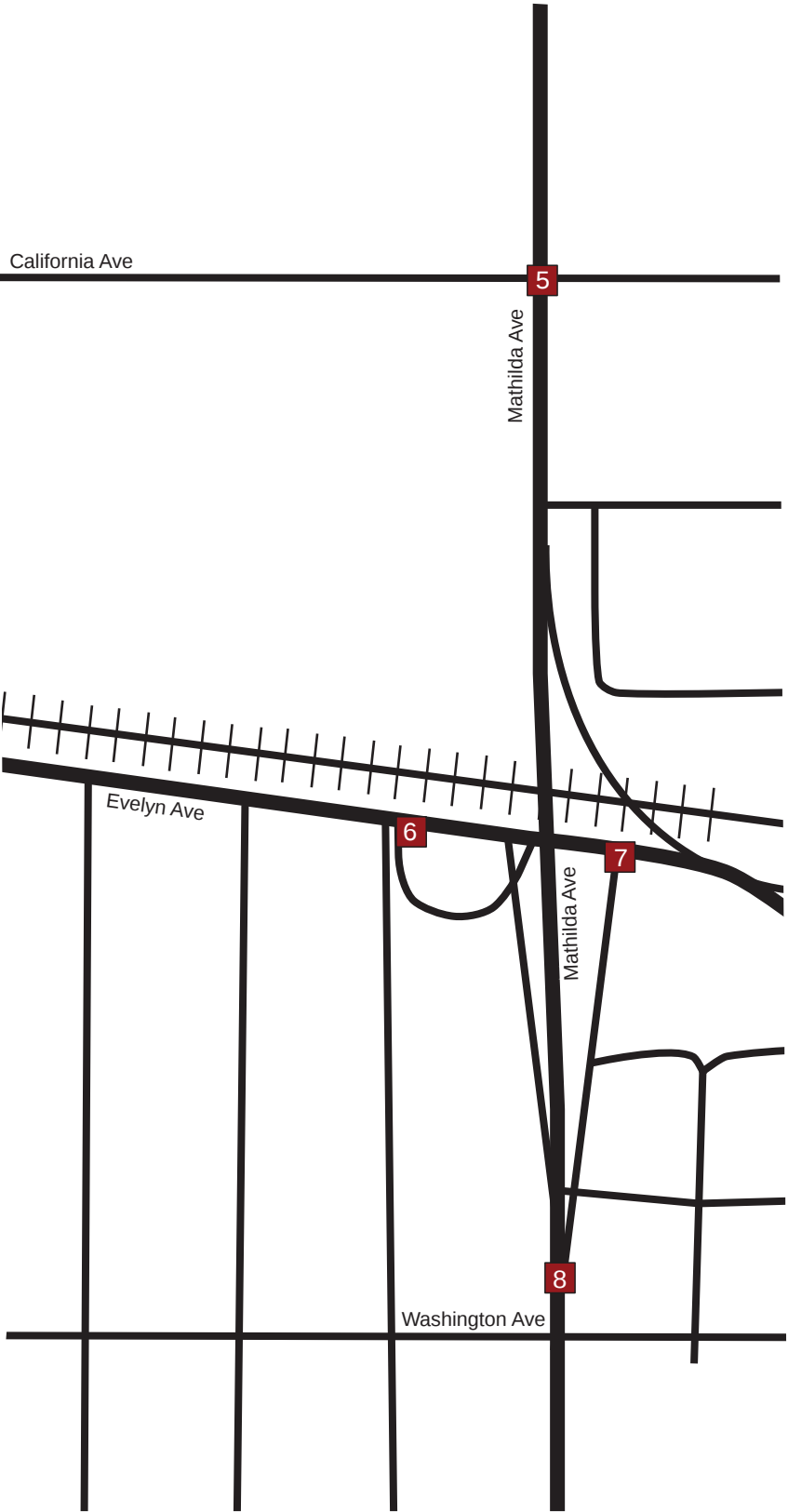
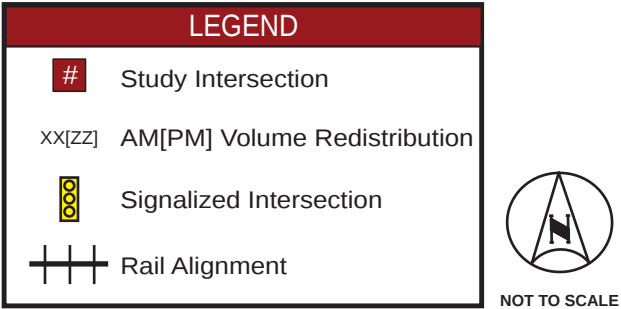
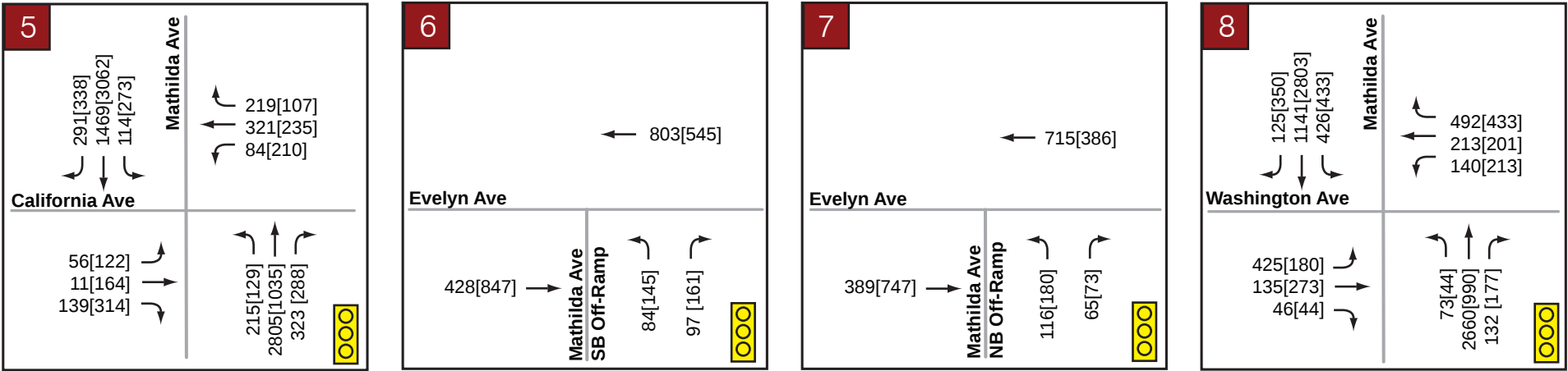
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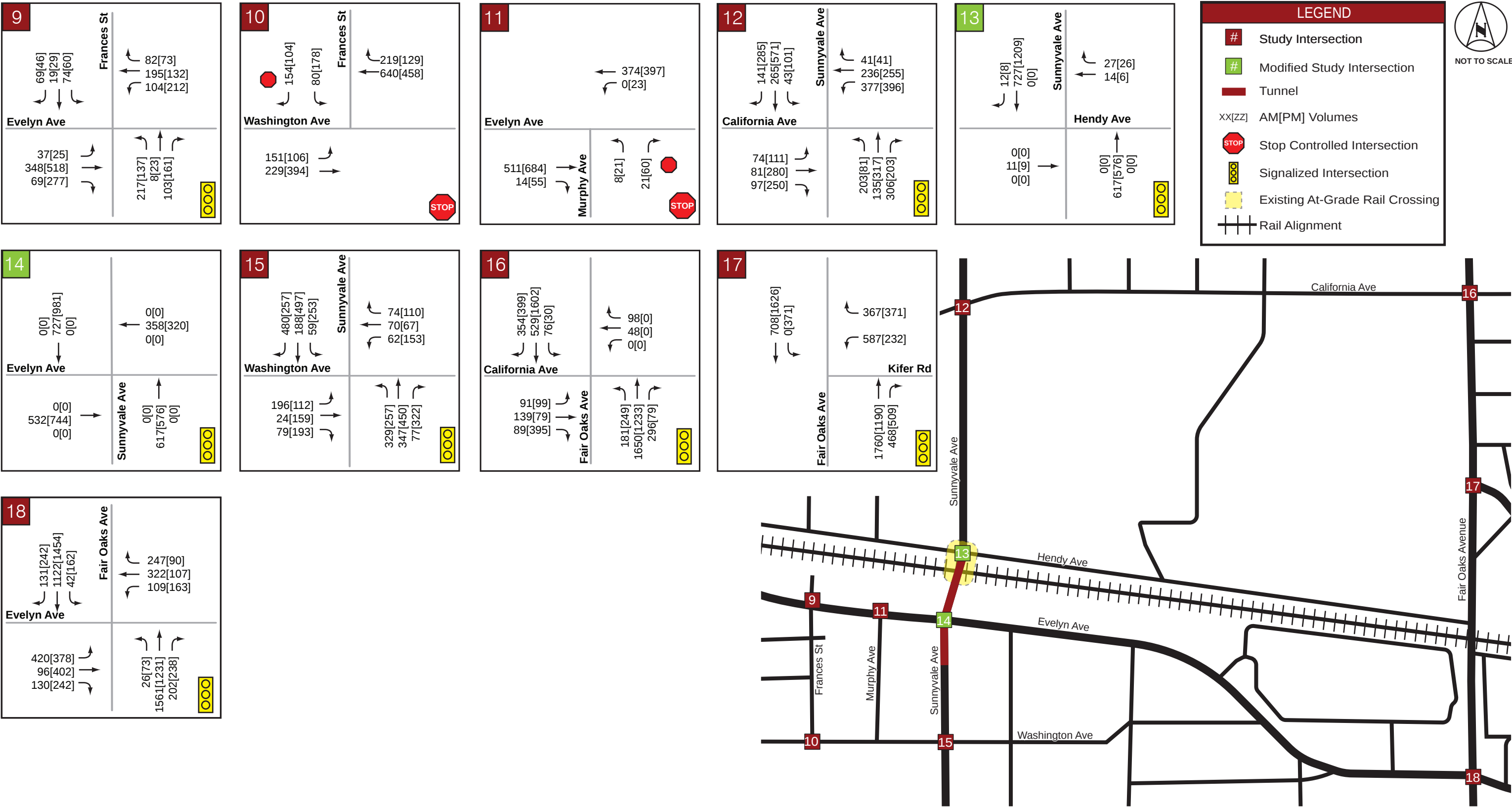
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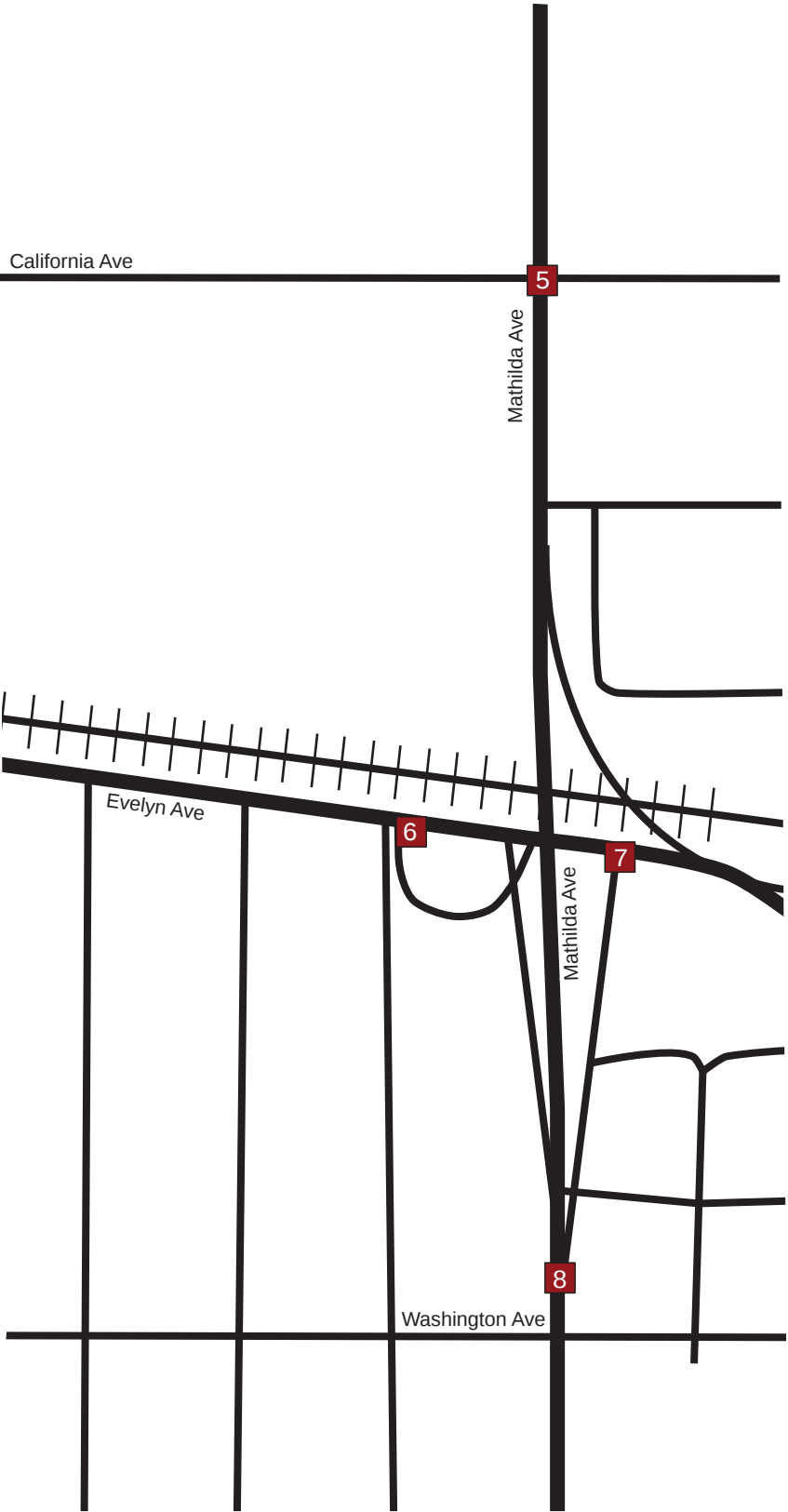
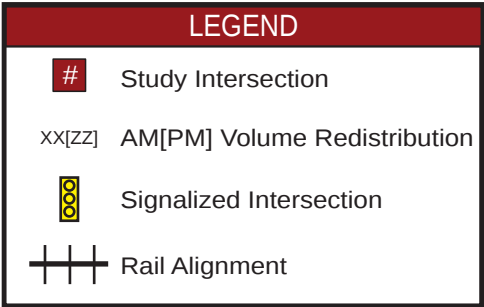
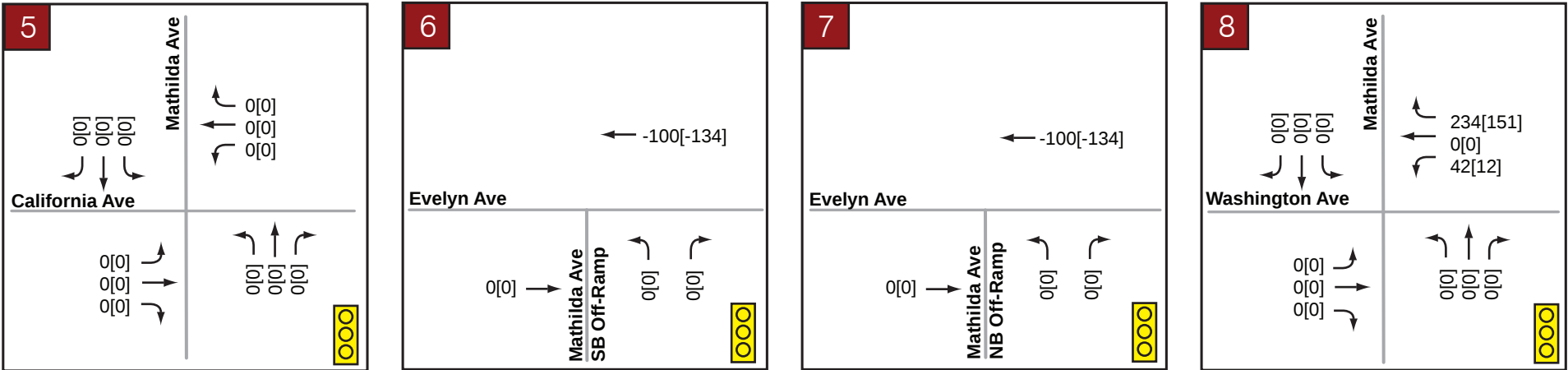
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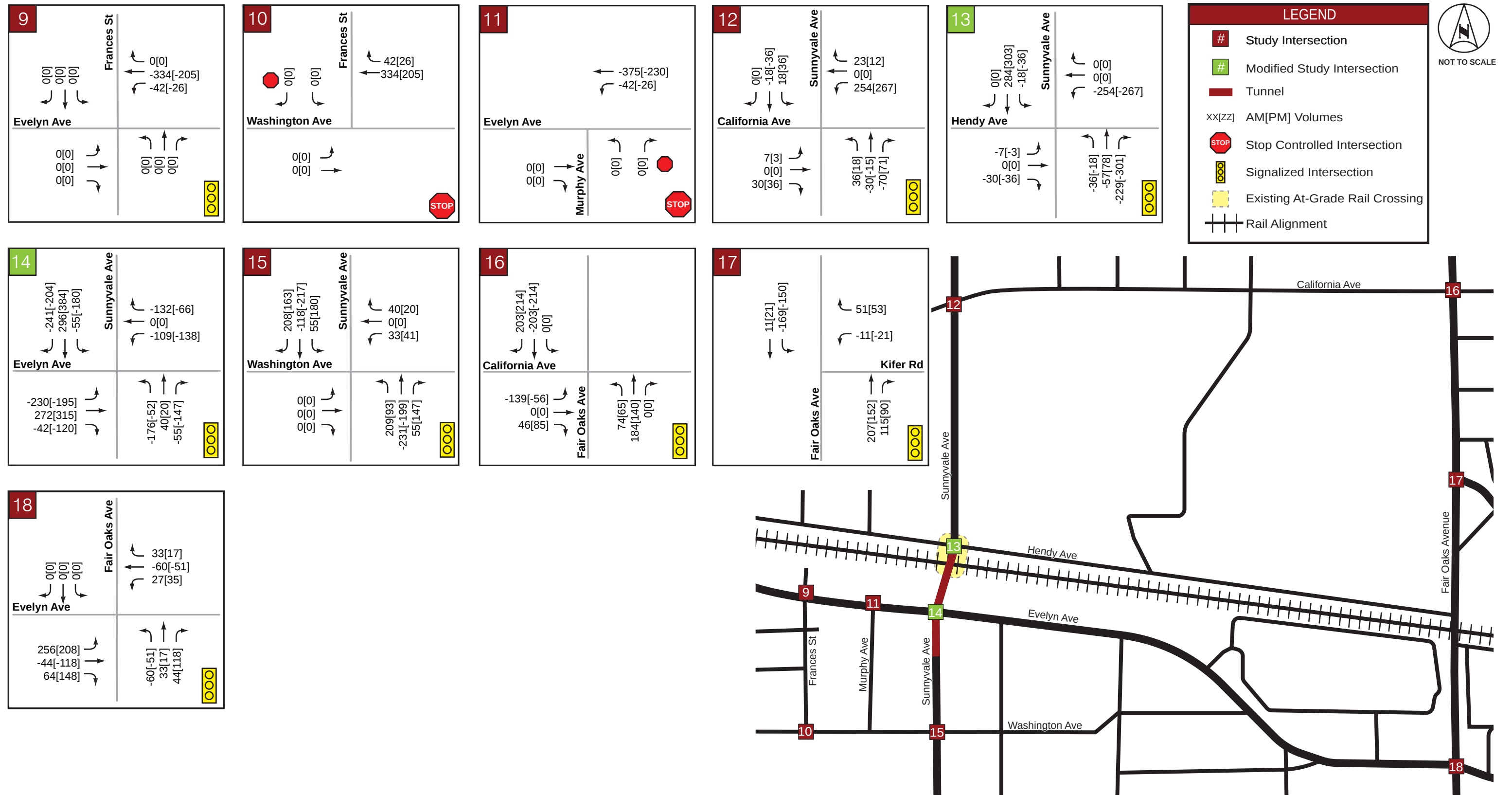
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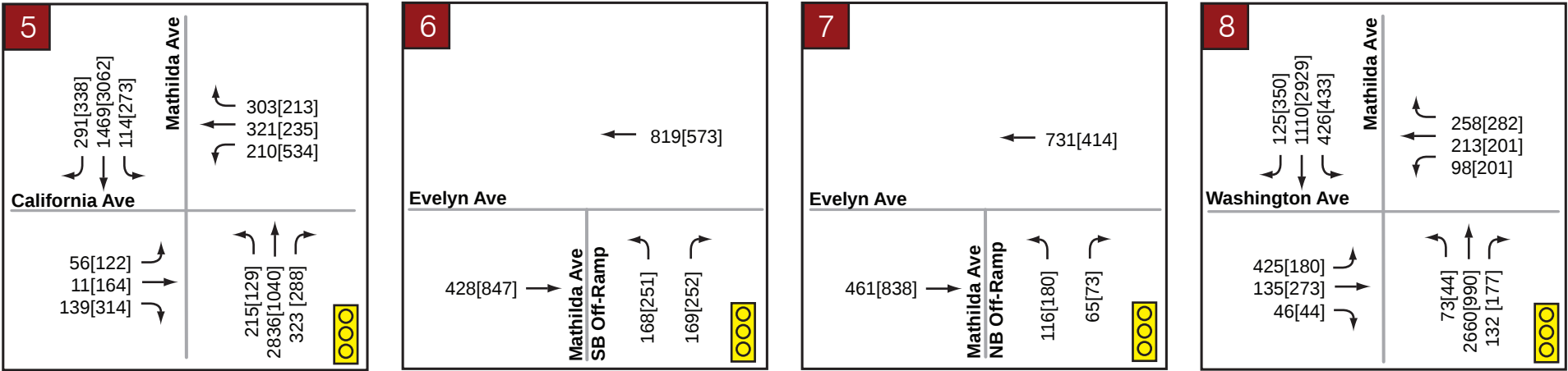
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Sunnyvale Caltrain Grade Separations Feasibility Study



Sunnyvale Caltrain Grade Separations Feasibility Study



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Study Intersection

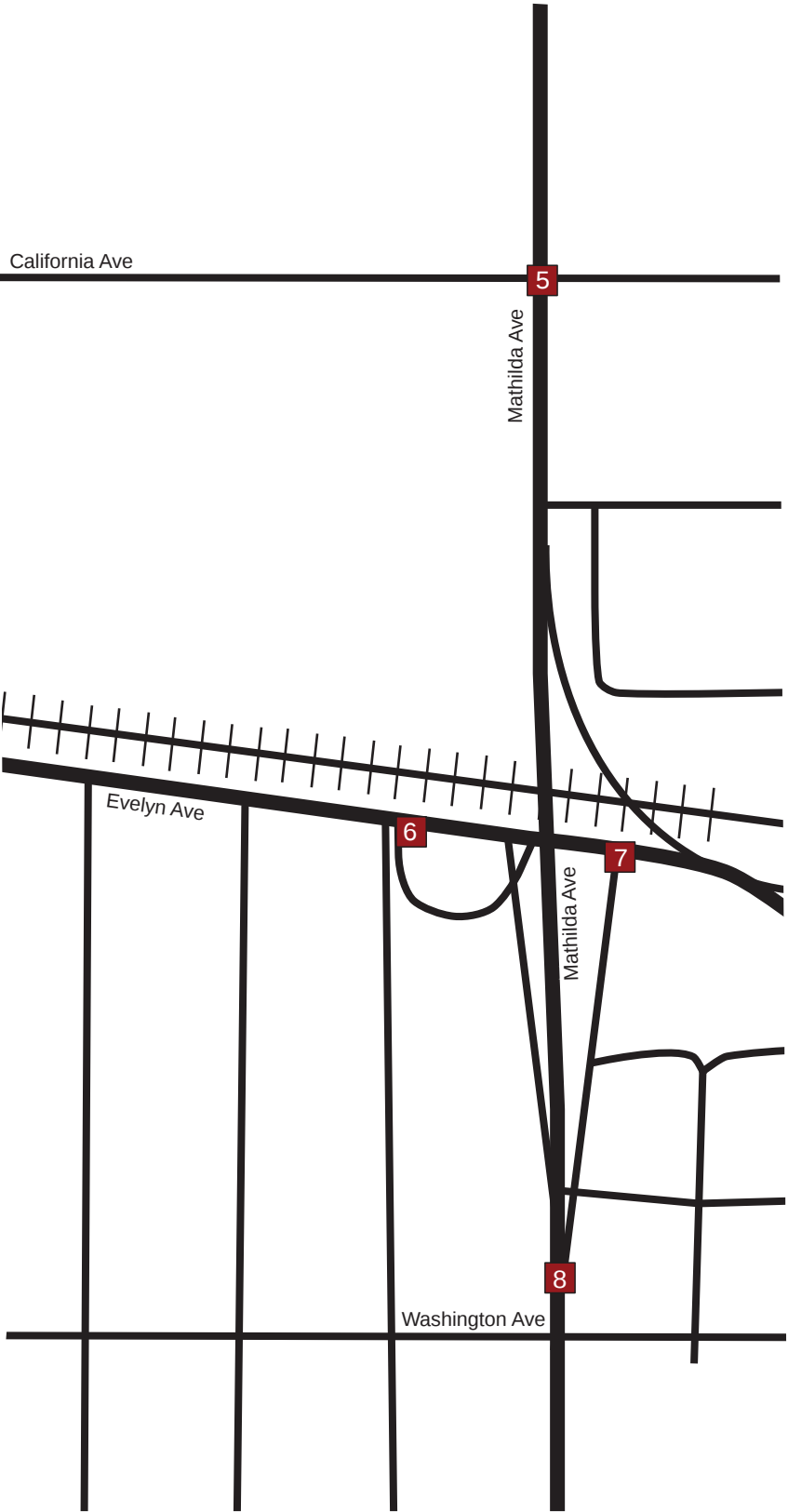
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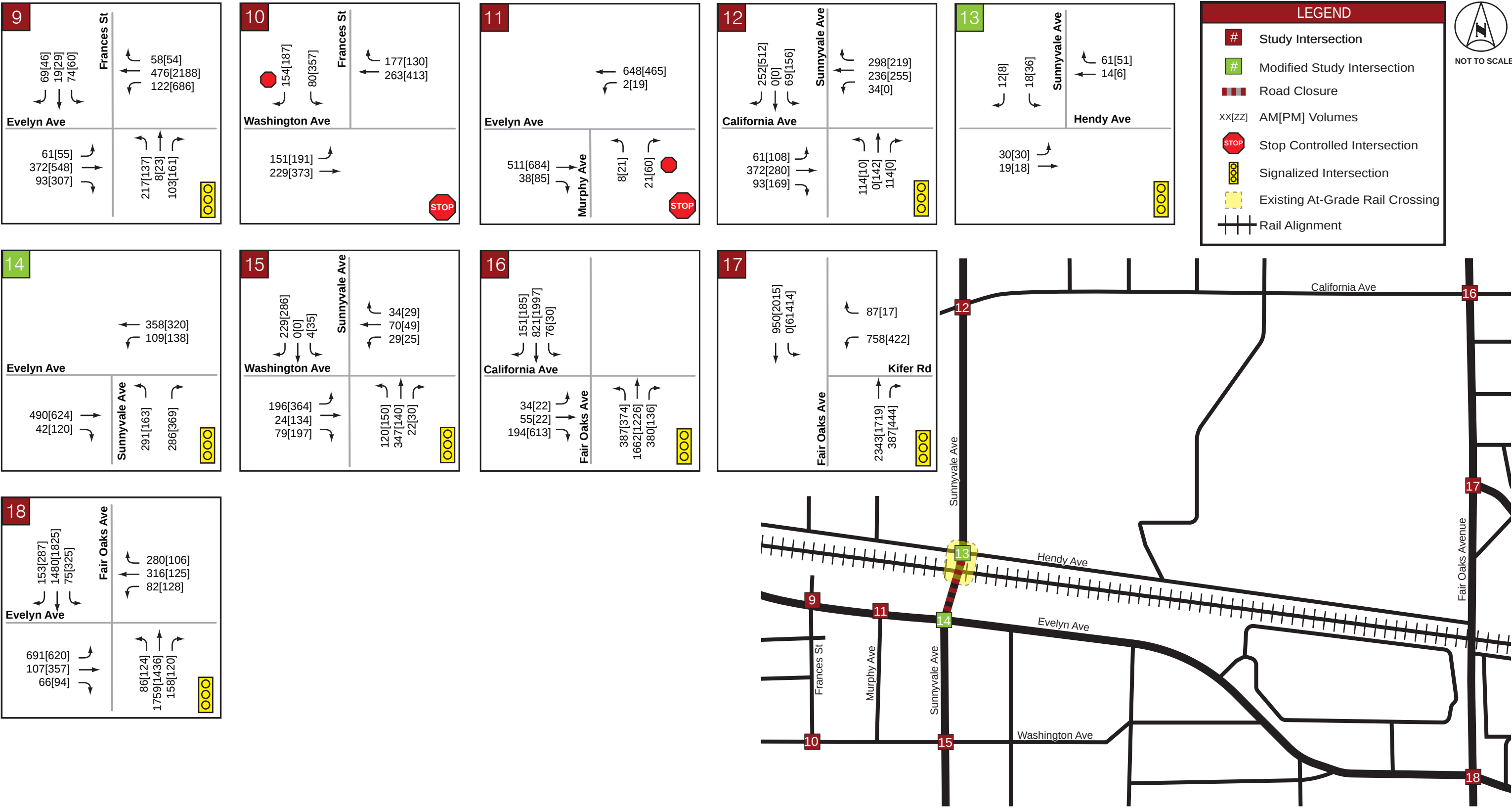
Signalized Intersection

Rail Alignment

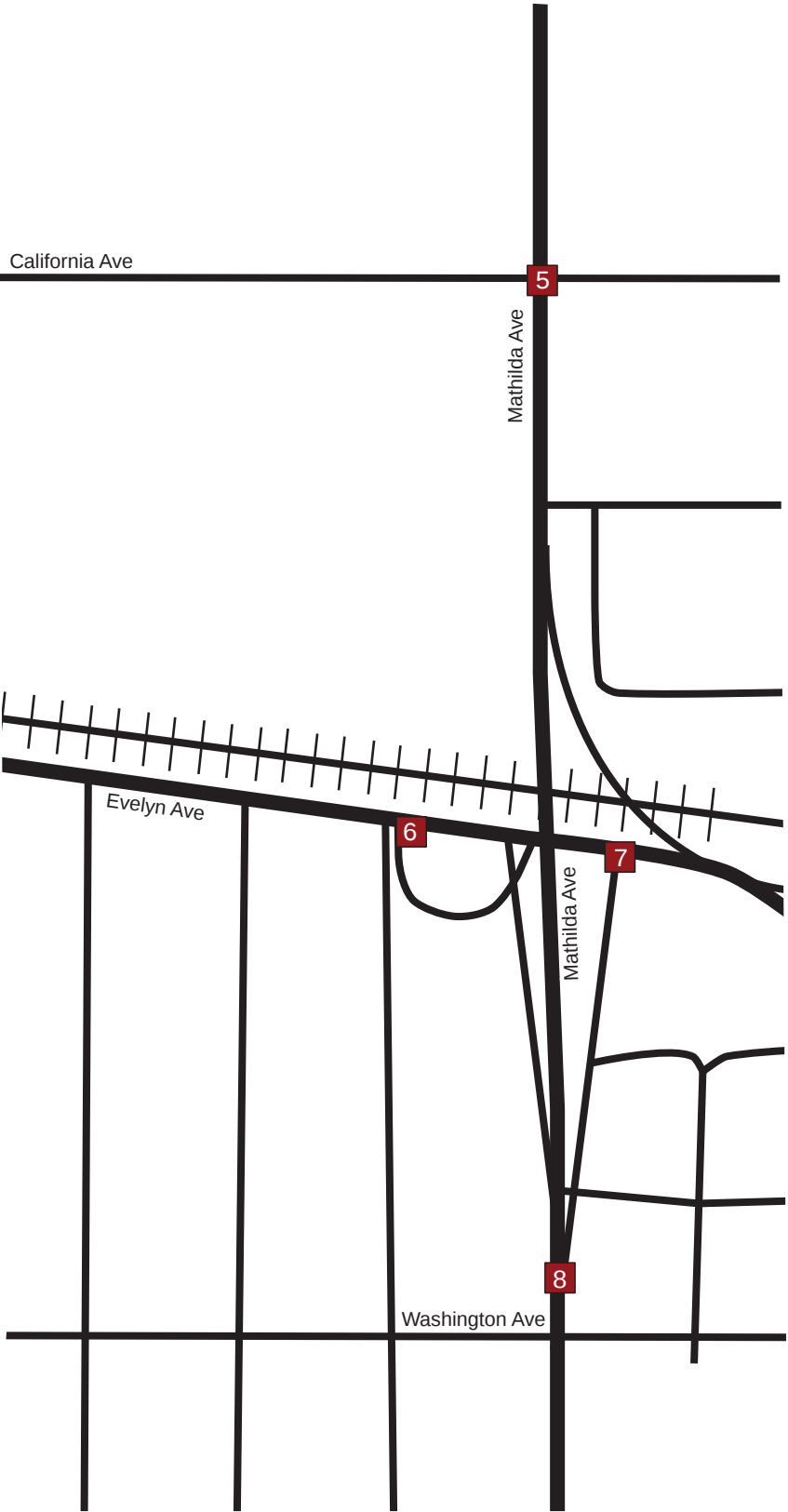
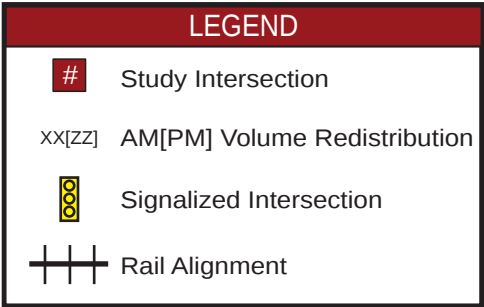
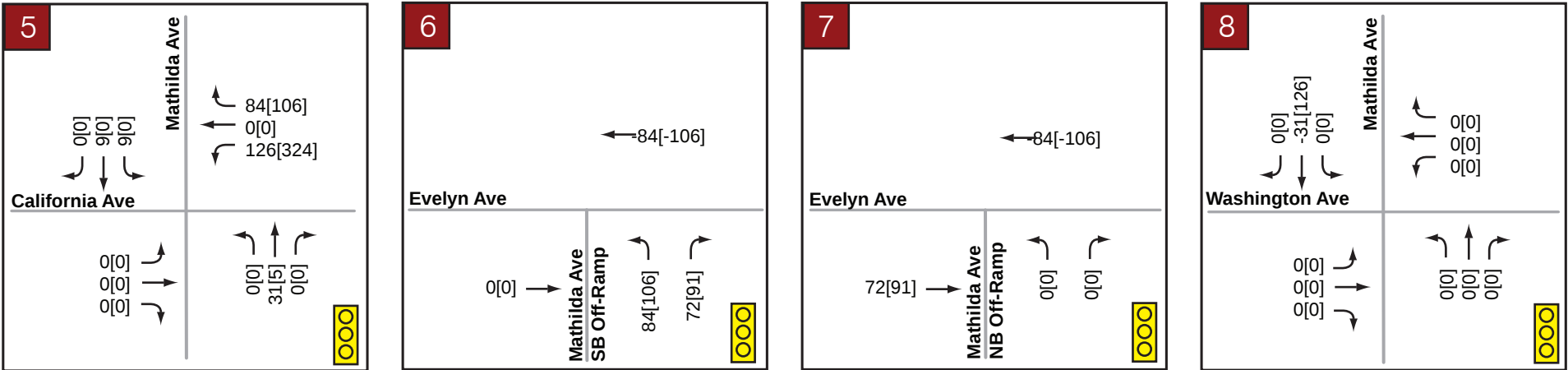
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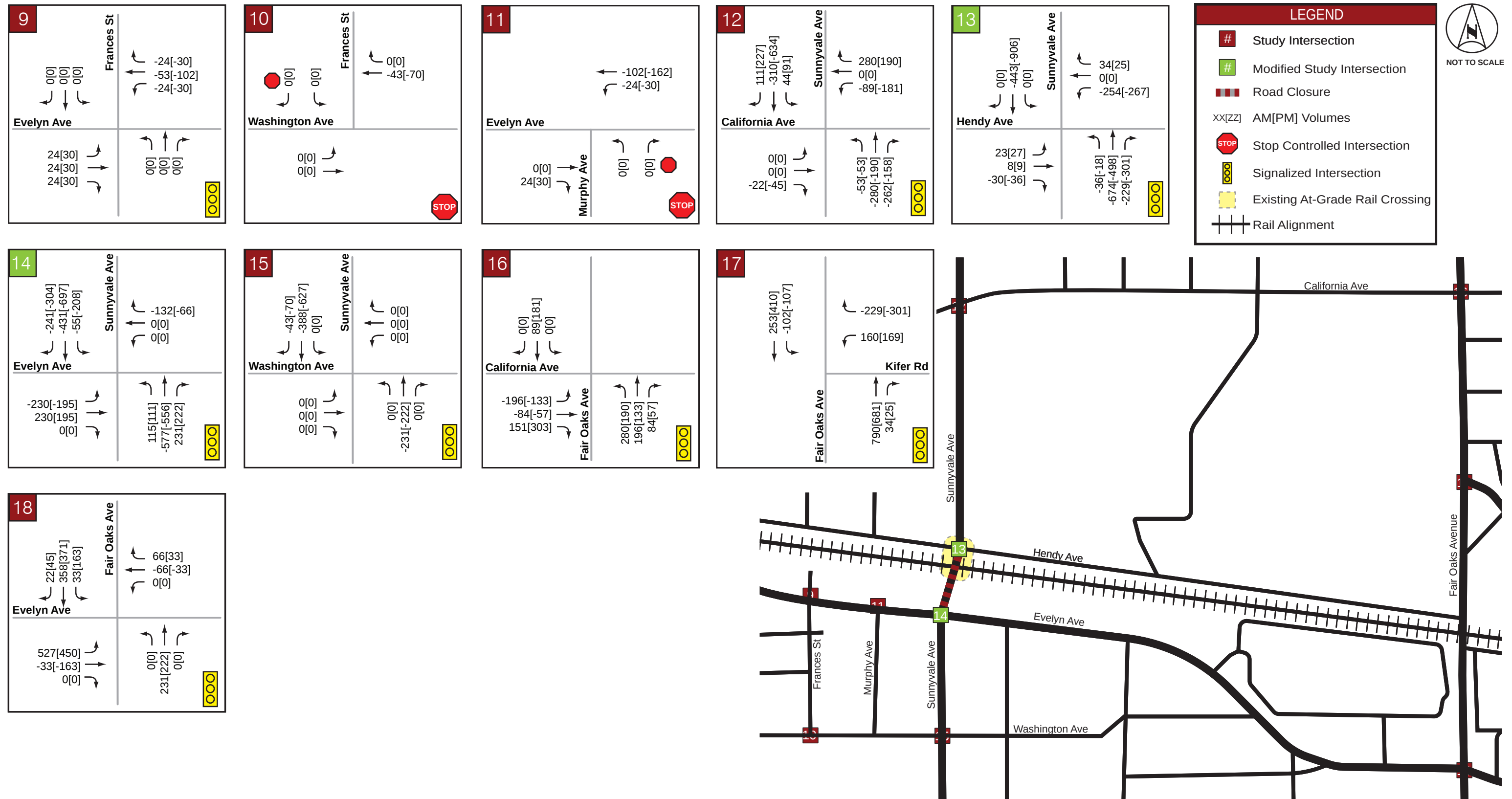
Sunnyvale Caltrain Grade Separations Feasibility Study



Sunnyvale Caltrain Grade Separations Feasibility Study



Sunnyvale Caltrain Grade Separations Feasibility Study



Sunnyvale Caltrain Grade Separations Feasibility Study

Mathilda Ave / California Ave				
5	AM Peak		PM Peak	
	Scenarios	LOS	Delay (sec)	Delay (sec)
	No-Build	F	201.3	271.8
	Tunnel	F	99.8	263.1
	Bike/Ped UC	F	123.8	273.0

Mathilda Ave SB Off Ramp / Evelyn Ave				
6	AM Peak		PM Peak	
	Scenarios	LOS	Delay (sec)	Delay (sec)
	No-Build	F	446.2	158.2
	Tunnel	B	14.1	14.5
	Bike/Ped UC	C	33.5	25.8

Mathilda Ave NB Off Ramp / Evelyn Ave				
7	AM Peak		PM Peak	
	Scenarios	LOS	Delay (sec)	Delay (sec)
	No-Build	F	270.9	119.9
	Tunnel	B	11.6	26.4
	Bike/Ped UC	B	12.8	39.8

Mathilda Ave / Washington Ave				
8	AM Peak		PM Peak	
	Scenarios	LOS	Delay (sec)	Delay (sec)
	No-Build	F	270.2	71.4
	Tunnel	F	159.0	72.0
	Bike/Ped UC	F	135.9	63.3

LEGEND

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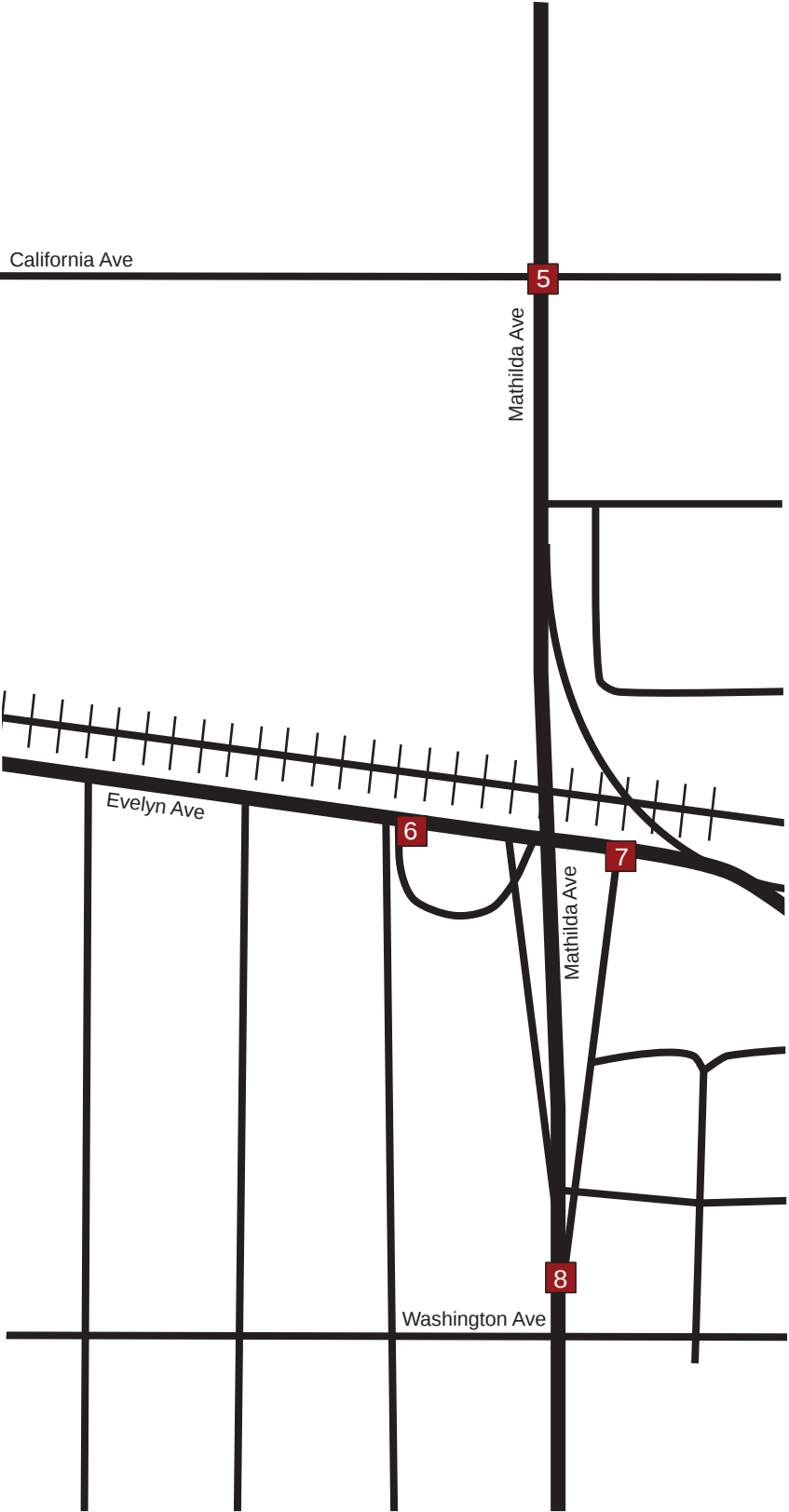
Study Intersection

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NOT TO SCALE



Sunnyvale Caltrain Grade Separations Feasibility Study

Frances St - Sunnyvale
Station Access / Evelyn Ave

9				
	AM Peak		PM Peak	
Scenarios	LOS	Delay (sec)	LOS	Delay (sec)
No-Build	F	192.8	F	138.4
Tunnel	C	23.3	E	55.3
Bike/Ped UC	E	65.0	C	29.7

Washington Ave / Frances St

10	AM Peak		PM Peak		
	Scenarios	LOS	Delay (sec)	LOS	Delay (sec)
	No-Build	F	72.1	F	60.7
	Tunnel	A	5.9	F	141.7
	Bike/Ped UC	A	6.3	A	5.2

Murphy Ave / Evelyn Ave

11

Scenarios	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
No-Build	F	51.6	E	46.4
Tunnel	C	18.0	B	10.1
Bike/Ped UC	E	37.2	B	12.3

Sunnyvale Ave / California Ave

12	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
No-Build	D	46.7	F	155.9
Tunnel	F	124.6	F	182.4
Bike/Ped UC	C	34.0	F	97.4

Sunnyvale Ave / Hendy Ave

13				
	AM Peak		PM Peak	
Scenarios	LOS	Delay (sec)	LOS	Delay (sec)
No-Build	F	174.1	F	234.4
Tunnel	-	-	-	-
Bike/Ped UC	A	8.9	C	29.7

LEGEND

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Study Intersection

#

Modified Study Intersection

Roadway Modification (Sunnyvale Tunnel or Closure)

Existing At-Grade Rail Crossing

Rail Alignment



14

Sunnyvale Ave / Evelyn Ave				
Scenarios	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
No-Build	F	165.5	F	110.3
Tunnel	-	-	-	-
Bike/Ped UC	F	216.2	C	23.3

Sunnyvale Ave / Washington Ave

15				
Scenarios	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
No-Build	F	150.7	F	111.0
Tunnel	F	400.1	F	375.5
Bike/Ped UC	F	245.9	D	47.6

Fair Oaks Ave / California Ave

16

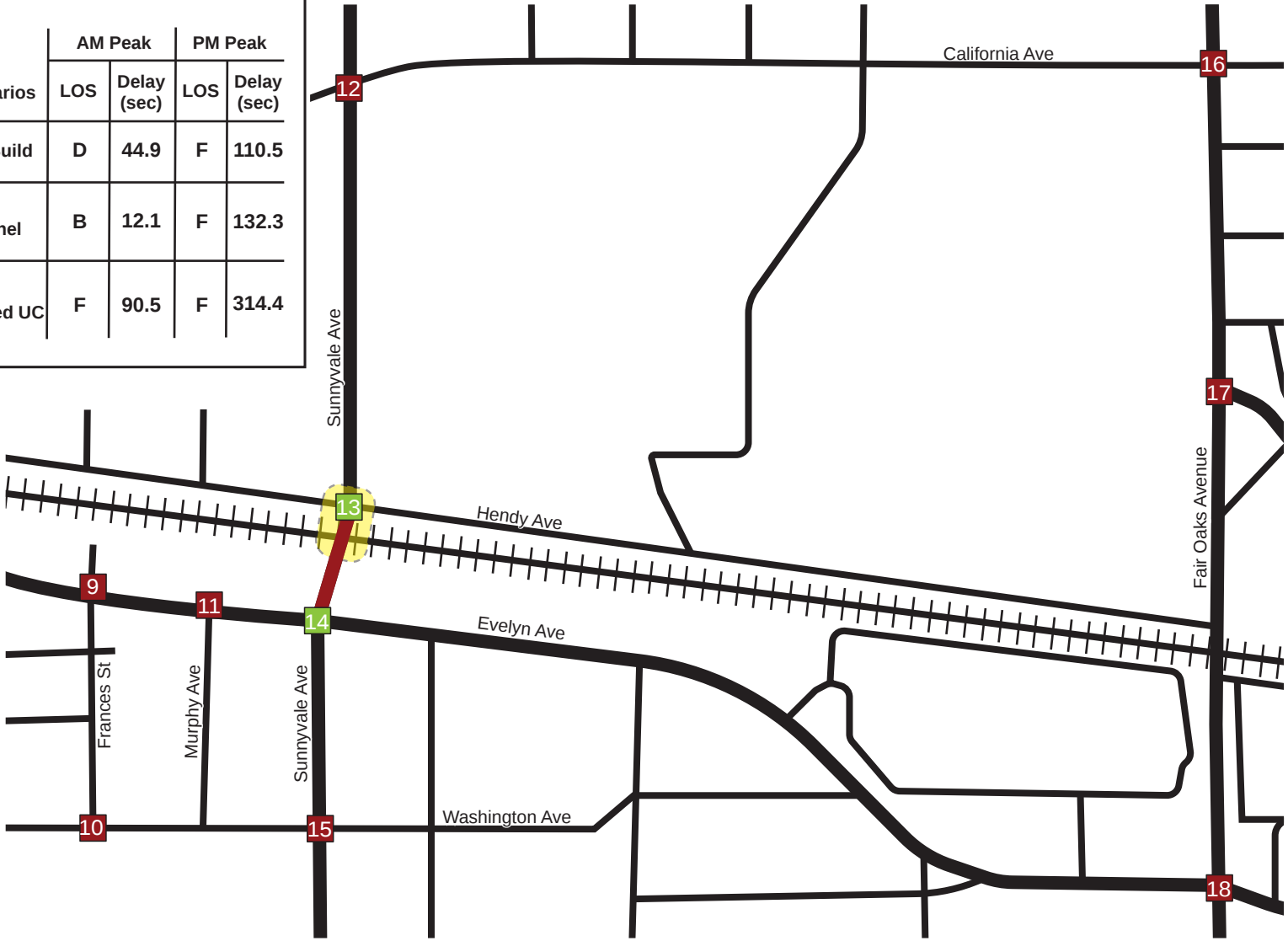
Scenarios	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
No-Build	D	50.0	F	129.2
Tunnel	D	35.6	F	115.7
Bike/Ped UC	E	63.0	F	220.7

Fair Oaks Ave / Kifer Rd

17	AM Peak		PM Peak		
	Scenarios	LOS	Delay (sec)	LOS	Delay (sec)
	No-Build	D	44.9	F	110.5
	Tunnel	B	12.1	F	132.3
	Bike/Ped UC	F	90.5	F	314.4

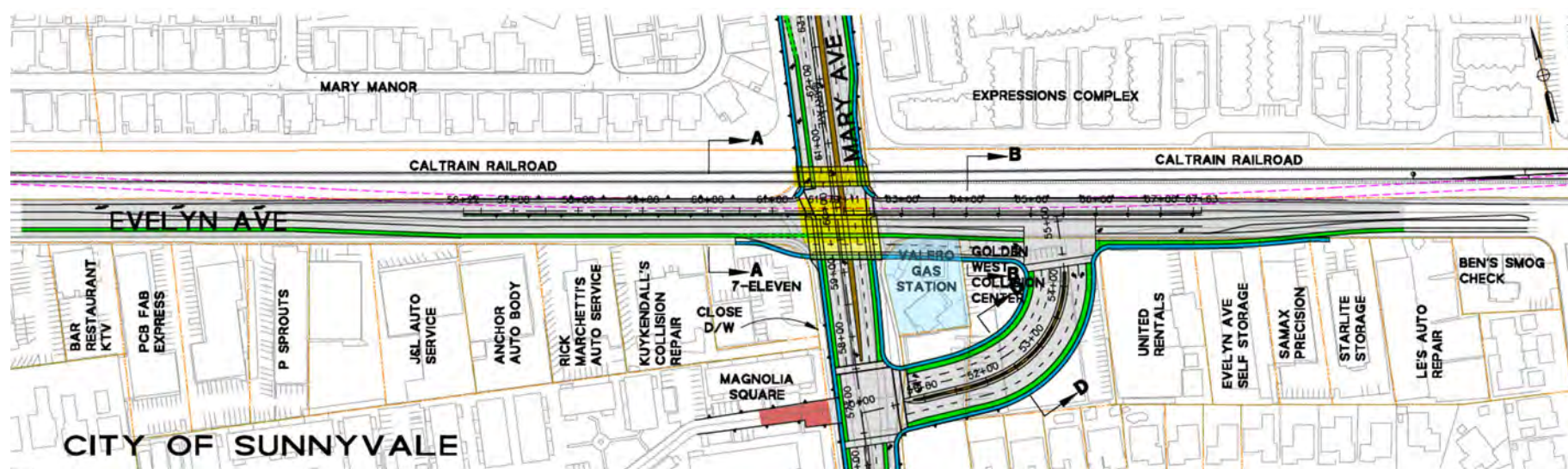
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Fair Oaks Ave / Evelyn Ave				
Scenarios	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
No-Build	E	74.8	F	82.5
Tunnel	F	95.6	F	110.7
Bike/Ped UC	F	139.9	F	231.4



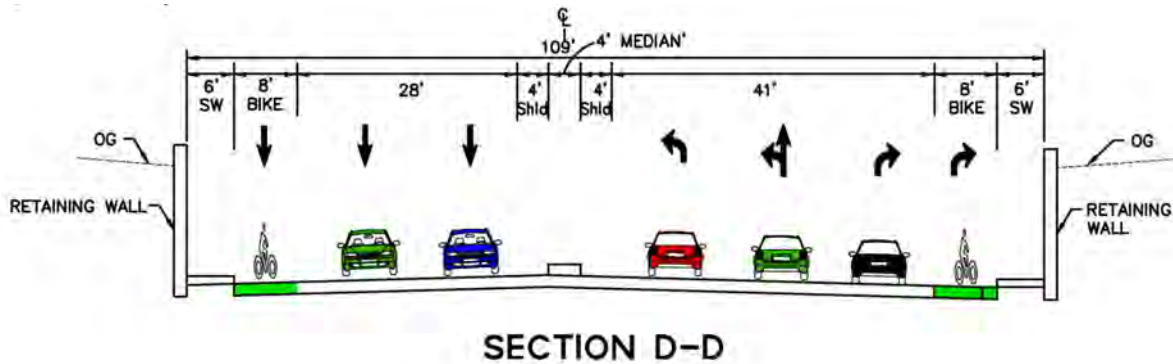
Attachment G

Mary Avenue Underpass with Jughandle and Connector Ramps Alternative – Reduced Geometry Option (Plan View)

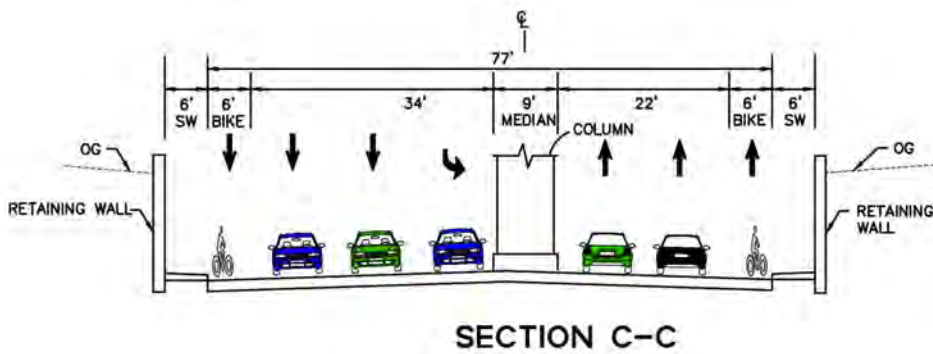


Mary Avenue Underpass with Jughandle and Connector Ramps Alternative Reduced Geometry Option

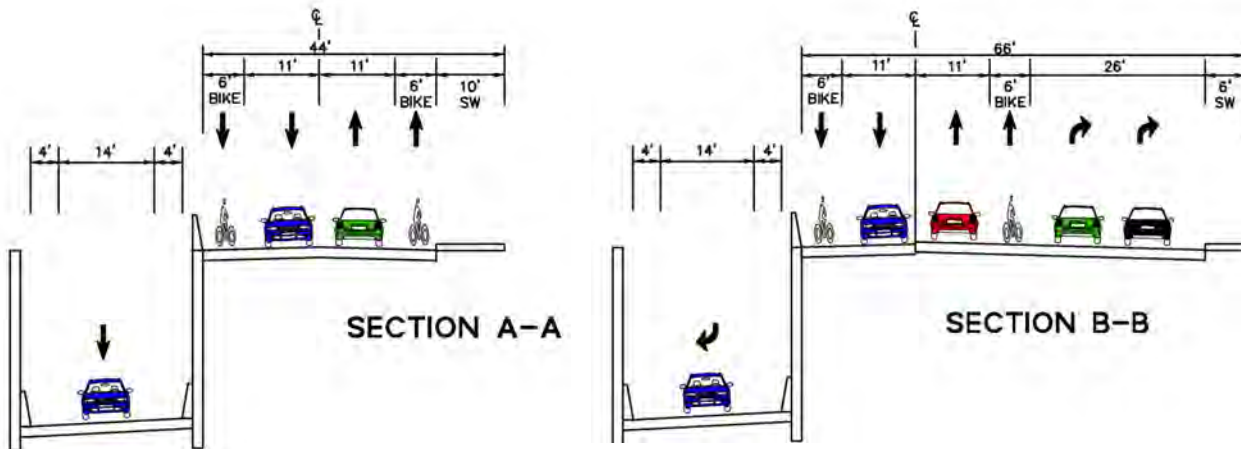
(Cross-Sections)



Jughandle Cross Section



Mary Avenue Cross Section north of Jughandle



Evelyn Avenue Cross Section east and west of Mary Avenue

Source: BKF Engineers, received June 28, 2022