
PURPOSE

The San Francisco County Transportation Authority (SFCTA) received a request from the California State Transportation Authority for an objective third-party traffic engineer to review the results of the recent phased implementation of traffic lane marking changes along northbound I-280's off-ramp to San Jose Avenue, and to recommend the traffic lane configuration that should be provided as part of the California Department of Transportation (Caltrans) highway resurfacing project which is scheduled for construction later in 2016.

This report summarizes a review conducted by Parisi Transportation Consulting, the transportation planning and traffic engineering firm retained by the SFCTA. Parisi examined various materials provided by the California Highway Patrol, Caltrans, and the San Francisco Metropolitan Transportation Agency (SFMTA) (see Bibliography), conducted a number of field reviews, and met with Caltrans and SFMTA representatives as part of the review process.

BACKGROUND

Prior to 1992 the northbound I-280 off-ramp to San Jose Avenue consisted of a single lane. At the time, I-280, north/east of its junction with US 101, and US 101 (Central Freeway) were closed for post-earthquake (1989 Loma Prieta) removal, repairs and retrofitting, and the off-ramp to San Jose Avenue was widened to two lanes, with the provision of a northbound auxiliary lane, to assist traffic arriving in San Francisco to reach various destinations within the City. When the retrofit work was completed and the freeways were reopened or replaced, the off-ramp was not reverted back to its original single lane configuration and the auxiliary lane remained in place.

The northbound I-280 off-ramp to San Jose Avenue is located approximately 3,500 feet north of the Geneva/Ocean Avenue on-ramp to northbound I-280. The northbound auxiliary lane connects the Geneva/Ocean Avenue on-ramp to the right-most lane of the San Jose Avenue off-ramp. The left-side lane of the off-ramp is accessed via the fourth through traffic lane on northbound I-280. The San Jose Avenue off-ramp is approximately 1,900 feet long from mainline I-280 to the triple merge point with San Jose Avenue and Monterey Boulevard.

For a number of years residents of the neighborhoods adjacent to San Jose Avenue, north of I-280, have expressed concerns about high vehicular speeds on northbound San Jose Avenue and the negative effects this speeding has on safety for pedestrians, bicyclists and motorists. In order to enhance traffic safety, especially for pedestrians and bicyclists who travel along the 3,800-foot roadway from I-280 to Randall Street, the SFMTA proposed traffic calming measures intended to:

- Increase safety for bicyclists, pedestrians, and motorists along the corridor
- Reduce traffic speeds on northbound San Jose Avenue by reducing the number of traffic lanes on the I-280 off-ramp and on San Jose Avenue;
- Upgrade the existing northbound bicycle lane with a wider, more separated bikeway (where space allows);
- Facilitate safer turning movements to and from northbound San Jose Avenue and adjacent residential streets; and
- Reduce cut-through traffic from northbound I-280.

In September 2012, the SFMTA requested Caltrans' assistance for the development of a pilot project to achieve the above objectives. Caltrans agreed to consider a pilot project under the condition that initial assessments be conducted to evaluate the feasibility of different traffic lane configurations, ascertain the potential effectiveness in achieving the desired goals, and identify any adverse impacts and appropriate mitigations.

IMPLEMENTATION OF PHASES 1 AND 2

Through the Fall of 2013 various alternatives were considered by SFMTA and Caltrans (see Exhibit A-1). Based on an analysis of the alternatives, several options were dismissed due to resulting traffic operation and/or safety impacts. Two options were agreed upon for phased implementation. In November 2013 SFMTA and Caltrans approved implementation of a pilot project in two phases:

Phase 1:

- Merge the left lane on the San Jose Avenue off-ramp with the lane from San Jose Avenue coming from the south of I-280 downstream of the existing I-280 tunnel (see Exhibit A-2, Option 5);
- Reduce San Jose Avenue to two lanes north of St. Mary's Avenue and through Randell Street; and
- Upgrade the San Jose Avenue bicycle lane to a more comfortable, separated bikeway (where space allows).

Phase 2:

- Maintain Phase 1 changes on the surface street portion of San Jose Avenue; and

- Merge the two lanes of the off-ramp into a single lane upstream of the existing I-280 tunnel, which then merges with the Monterey Boulevard lane (see Exhibit A-2, Option 2).

According to SFMTA and Caltrans' November 2013 agreement, Phase 1 and Phase 2 improvements, either individually or together, would be considered successful if:

- 1) 85th percentile vehicular speeds decrease to 35 mph or less at the terminus of the off-ramp on the triple merge point with San Jose Avenue and Monterey Boulevard, and/or downstream on the surface street portion of San Jose Avenue;
- 2) Traffic congestion on the I-280 freeway is not impacted significantly, i.e., there is no congestion (stopped traffic) on the freeway mainline or at Ocean-Geneva Avenue interchange resulting from traffic existing at San Jose Avenue extending beyond the off-ramp's reverse gore point; and
- 3) The collision rates and severity (e.g., numbers of property damage, fatal or injury accidents) do not significantly increase.

According to the agreement, if lesser than desired speed reductions are experienced, the project may still be considered successful and implemented unless accompanied by excessive congestion and/or collisions as stated above.

SFMTA and Caltrans agreed to implement each phase for at least six months and to monitor speed, traffic, collision, and other conditions. Phase 1 was implemented in June 2014 (see Exhibit A-3). Phase 2 was implemented one year later, in June 2015 (see Exhibit A-4). Photographs depicting current conditions are provided in Exhibit 1.

The next section summarizes the results of the monitoring results.

MONITORING RESULTS

Based on the agreed-upon project evaluation metrics, SFMTA and Caltrans monitored the following conditions prior to the implementation of the Phase 1 improvements ("Pre-Pilot"), after installation of Phase 1 improvements, and again after installation of Phase 2 improvements:

- 85th percentile vehicular travel speeds, during uncongested traffic periods, at the entry to the San Jose Avenue off-ramp from northbound I-280, along the San Jose Avenue off-ramp near the trip merge point, and on San Jose Avenue between Milton Street and St. Mary's Street;
- Served vehicular traffic volumes, maximum vehicular queues, and average motorist delays during the weekday AM peak hour for traffic exiting northbound I-280 to the San Jose Avenue off-ramp, as well as along northbound San Jose Avenue; and
- Reported vehicular collisions along the San Jose Avenue off-ramp and just upstream of the ramp, by location, day and time of day, type of collision, and whether the collision involved an injury or injuries.



Northbound I-280 south of Baden Street.



Northbound I-280 north of Baden Street.



San Jose Avenue Off-ramp Two-to-One Lane Merge.



San Jose Avenue Off-ramp Two-to-One Lane Merge.



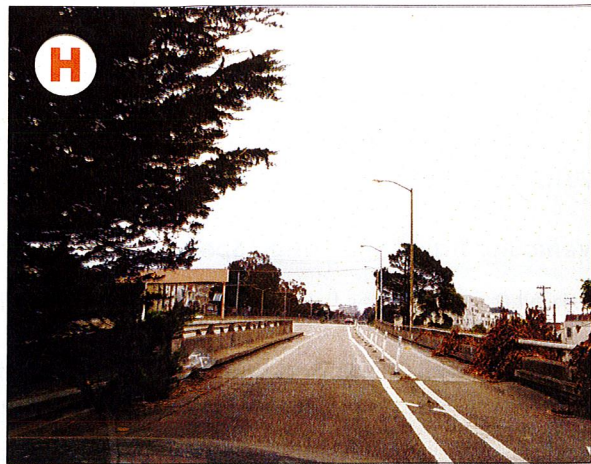
San Jose Avenue Off-ramp Tunnel Under I-280.



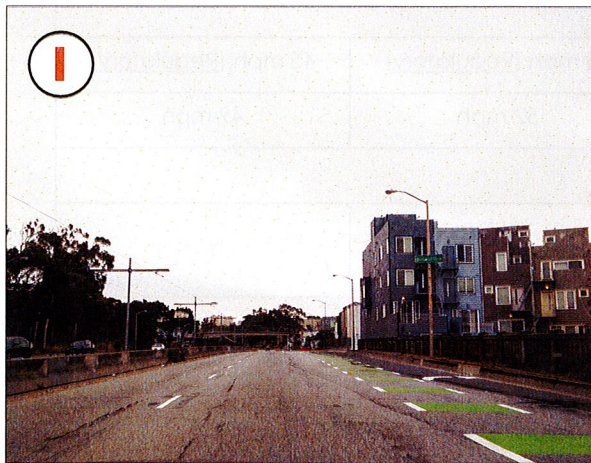
Ramp Entrance onto Northbound San Jose Avenue.



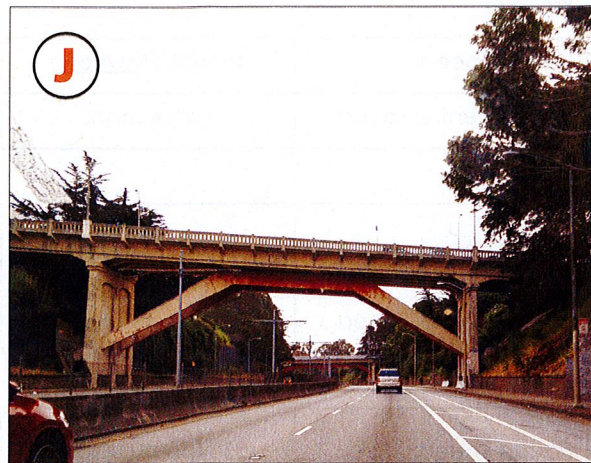
Ramp Entrance onto Northbound San Jose Avenue.



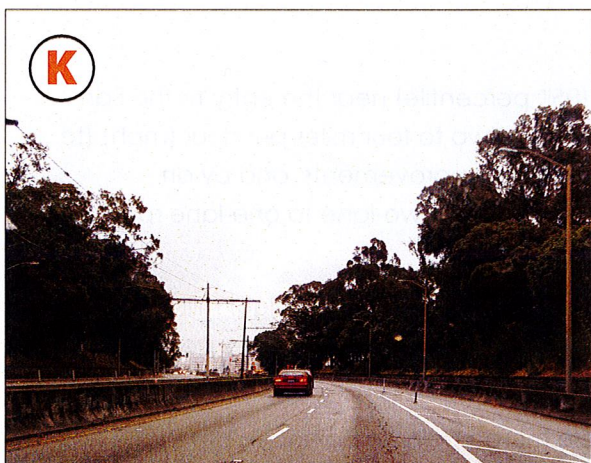
Monterey Boulevard Ramp Entrance to San Jose Avenue.



Northbound San Jose Avenue south of Rousseau Street.



Northbound San Jose Avenue south of Richland Avenue.



Northbound San Jose Avenue south of Randall Street.



Northbound San Jose Avenue at Randall Street.

Exhibit 1. Photographs (2 of 2)

Pre-pilot conditions were measured in January 2014. Phase 1 metrics were collected in September 2014 and again in January 2015. Phase 2 conditions were measured in September 2015.

Vehicular Travel and Posted Speeds

Exhibit 2 summarizes the Pre-Pilot, Phase 1 and Phase 2 vehicular speed conditions.

Exhibit 2. Posted Speed Limits and 85th Percentile Speeds (85th Percentile Speeds Measured During Uncongested Traffic Periods)

Speed	Entry to Off-ramp from NB I-280	Off-ramp Before Entry to San Jose Ave.	San Jose Ave. between Milton and St. Mary's
Pre-Pilot			
Posted Speed	45 mph (<u>Advisory</u>)	45 mph (<u>Regulatory</u>)	45 mph (<u>Regulatory</u>)
85 th Percentile Speed	52-54 mph	52 mph	49 mph
Phase 1			
Posted Speed	35 mph (<u>Advisory</u>)	35 mph (<u>Advisory</u>) w/Speed Feedback	N/A
85 th Percentile Speed	50 mph	46-48 mph	46-47 mph
Phase 2			
Posted Speed	35 mph (<u>Advisory</u>)	35 mph (<u>Advisory</u>) w/Speed Feedback	N/A
85 th Percentile Speed	47 mph	39-43 mph	48 mph

Sources: Caltrans and SFMTA.

As shown in Exhibit 2, uncongested vehicular speeds (85th percentile) near the entry to the San Jose Avenue off-ramp from northbound I-280 decreased by two to four miles per hour (mph) (to 50 mph) as a result of the Phase 1 San Jose Avenue road diet improvements, and by an additional three miles per hour (to 47 mph) based on the Phase 2 two-lane to one-lane ramp merge changes.

Vehicular speeds along the San Jose Avenue off-ramp decreased by four to eight miles per hour (to 46-48 mph) after Phase 1 was installed, and by an additional five to seven miles per hour (to 39-43 mph) when Phase 2 was implemented.

Travel speeds along San Jose Avenue north of the triple merge point remained relatively consistent (46-49 mph) during Pre-Pilot, Phase 1 and Phase 2 conditions, with the lowest speeds (46-47 mph) occurring under the Phase 1 configuration.

Eighty-fifth percentile vehicular speeds never decreased to 35 miles per hour or less along the San Jose Avenue off-ramp before the triple merge point, or on San Jose Avenue to the north. According to the SFMTA/Caltrans agreement, less than desired speed reductions could be deemed acceptable at these locations unless excessive traffic congestion and/or collisions resulted. However, as discussed in the following sections, while these conditions did not occur as a result of the Phase 1 improvements, substantial peak period congestion and a number of vehicular collisions occurred during Phase 2.

Vehicular Traffic Volumes, Queues and Delays

Exhibit 3 summarizes Pre-Pilot, Phase 1, and Phase 2 vehicular traffic volumes, maximum vehicular queues, and average motorist delays during the weekday AM peak hour for traffic exiting northbound I-280 to the San Jose Avenue off-ramp, as well as along northbound San Jose Avenue.

Exhibit 3. Traffic Volumes and Traffic Congestion

Weekday AM Peak Hour	Off-ramp Before Entry to San Jose Ave.	Northbound San Jose Ave.
Pre-Pilot		
Vehicle Volume	2,040 vph	2,070 vph
Maximum Queue	None	2,200 feet (1)
Vehicular Delay	0 min.	~ 3 min.
Phase 1		
Vehicle Volume	1,910 vph	1,630 vph
Maximum Queue	1,200 feet (2)	3,800 feet (1)
Vehicular Delay	~ 2-3 min.	~ 7 min.
Phase 2		
Vehicle Volume	1,630 vph	1,620 vph
Maximum Queue	2,800 feet (3)	2,900 feet (1)
Vehicular Delay	~ 6 min.	~ 5 min.

Sources: Caltrans and SFMTA.

Notes: Minor traffic volume differences likely due to seasonal fluctuations.

- (1) Maximum queue measured from Randall Street.
- (2) Maximum queue measured from I-280 off-ramp merge with San Jose Avenue, resulting from back-up from Randell Street.
- (3) Maximum queue measured from two-lane to one-lane merge on I-280 off-ramp.

After the implementation of the Phase 1 San Jose Avenue road diet, the upstream off-ramp experienced a six percent decrease in AM peak hour traffic volumes (to 1,910 vehicles served), with the occurrence of vehicular queuing along the off-ramp (maximum queue lengths reached 1,200 feet measured from the triple merge point) and vehicular delays of two to three minutes. Phase 2, which merged two lanes to one on the off-ramp, resulted in an additional 14 percent decrease in volumes (to 1,630 vehicles served), but the vehicular queues more than doubled in length (to 2,800 feet), extending upstream within both northbound I-280's auxiliary lane and the adjacent through traffic lane. Motorist delays averaged six minutes. Vehicles that were not served due to the new ramp bottleneck experienced delays and queuing along the off-ramp and northbound I-280, however some motorists avoided the extra delays and queuing and diverted to other travel routes.

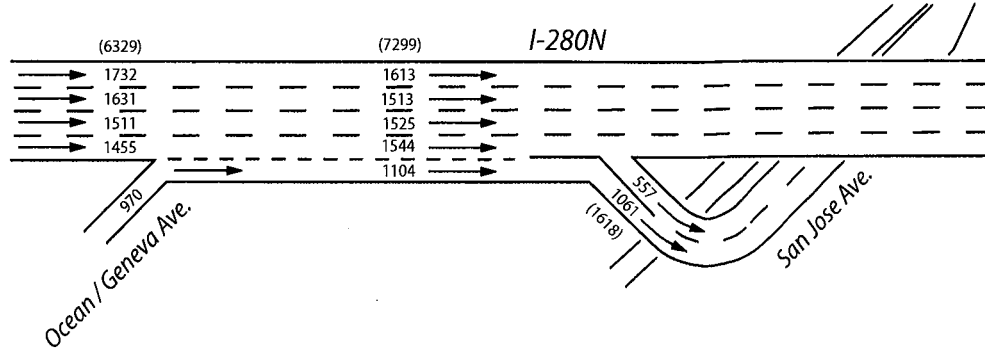
Northbound San Jose Avenue experienced a 21 percent decrease in AM peak hour volumes (to 1,630 vehicles served) under Phase 1, and vehicular queuing along the roadway increased by 1,600 feet (to 3,800 feet, measured from Randell Street), adding an additional four minutes of vehicular delay. Most of traffic volume delay and vehicle queuing increases were a result of the reduction in northbound through traffic lanes at Randell Street from three lanes to two lanes.

In Phase 2, when the traffic capacity constraint was shifted from the road diet to the off-ramp, similar traffic volumes were served along San Jose Avenue compared to the Phase 1 improvements (1,620 vehicles served), but delays along the roadway were reduced by two minutes. However, the upstream off-ramp constraint resulted in added delays and queuing along the higher speed off-ramp and freeway, as previously discussed.

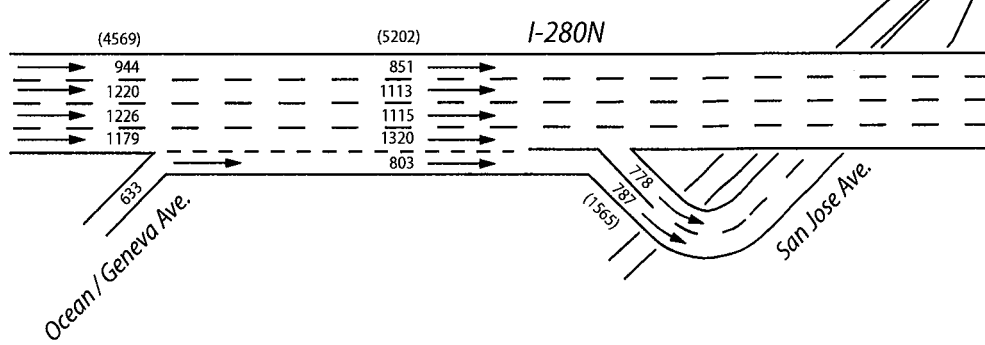
As a part of the independent third-party review, additional traffic counts and observations were conducted in June 2016. Exhibit 4 illustrates AM and PM peak hour traffic volumes, averaged for three consecutive weekdays (Tuesday, Wednesday and Thursday). The AM peak hour counts are similar to those collected in September 2015 after implementation of Phase 2, e.g., the off-ramp to San Jose Avenue continues to serve 1,620 vehicles per hour. Observations indicated that vehicular delays and queuing along the off-ramp, which extended upstream in northbound I-280's auxiliary lane and adjacent through traffic lane, were also similar to those collected in September 2015. These conditions occurred from about 7:15 to 9:00 AM.

Weekday PM peak period traffic data was also collected in June 2016. As shown in Exhibit 4, off-ramp volumes are similar to those occurring during the AM peak hour, i.e., nearly 1,600 vehicles per hour, however, mainline traffic volumes on I-280 are 36 percent lower during the PM peak hour compared to the AM peak hour (potentially resulting in higher travel speed differential for through traffic on mainline I-280 compared to traffic exiting at the San Jose Avenue off-ramp). Based on field observations, vehicle queues resulting from the two-lane to one-lane off-ramp merge occurred from about 3:30 to 6:30 PM, or for about twice as long as during the AM peak period. The maximum observed queues were similar to those seen in September 2015.

AM: 7:30-8:30



PM: 5:15-6:15



NOTE: Traffic volumes have been balanced to account for minor count variations.

Exhibit 4. Northbound I-280 Peak Hour Traffic Volumes

Exhibit 5 compares San Jose Avenue off-ramp traffic volumes served under Phase 1 and Phase 2 conditions during weekday AM and PM peak periods. The graphs demonstrate that off-ramp traffic demands often exceed the capacity provided by a single lane off-ramp, recognizing that the maximum capacity provided by Phase 2 conditions is approximately 1,600 vehicles per hour where the off-ramp transitions from two to one lanes. As shown, traffic demands exceed the Phase 2 off-ramp's capacity for an extended period during weekday afternoons and early evenings

In summary, under Phase 2 conditions traffic congestion on northbound I-280 has become substantially impacted, with vehicular queuing occurring along the freeway's auxiliary lane and adjacent through traffic lane during both the morning and afternoon/early evening periods.

Maximum queue lengths have been observed to exceed 2,800 feet. According to the SFMTA/Caltrans agreement, a phase of improvements would not be considered successful if traffic congestion on the I-280 freeway impacted significantly, i.e., there is stopped traffic on the freeway mainline resulting from traffic existing at San Jose Avenue extending beyond the off-ramp's reverse gore point.

Reported Vehicular Collisions

Exhibit 6 summarizes reported vehicle collisions between January 2012 and June 2016 on northbound I-280 in advance of or along the off-ramp to San Jose Avenue for Pre-Pilot, Phase 1, and Phase 2 conditions.

Thirty months of collision data was reviewed for Pre-Pilot conditions. During this period, five collisions were reported, including two rear-end collisions, two side-swipe collisions, and a single vehicle collision in the off-ramp's tunnel. Four of the reported collisions occurred during peak traffic periods. No injuries were reported in the rear-end collisions. There was an average of 0.17 reported collisions per month during Pre-Pilot conditions.

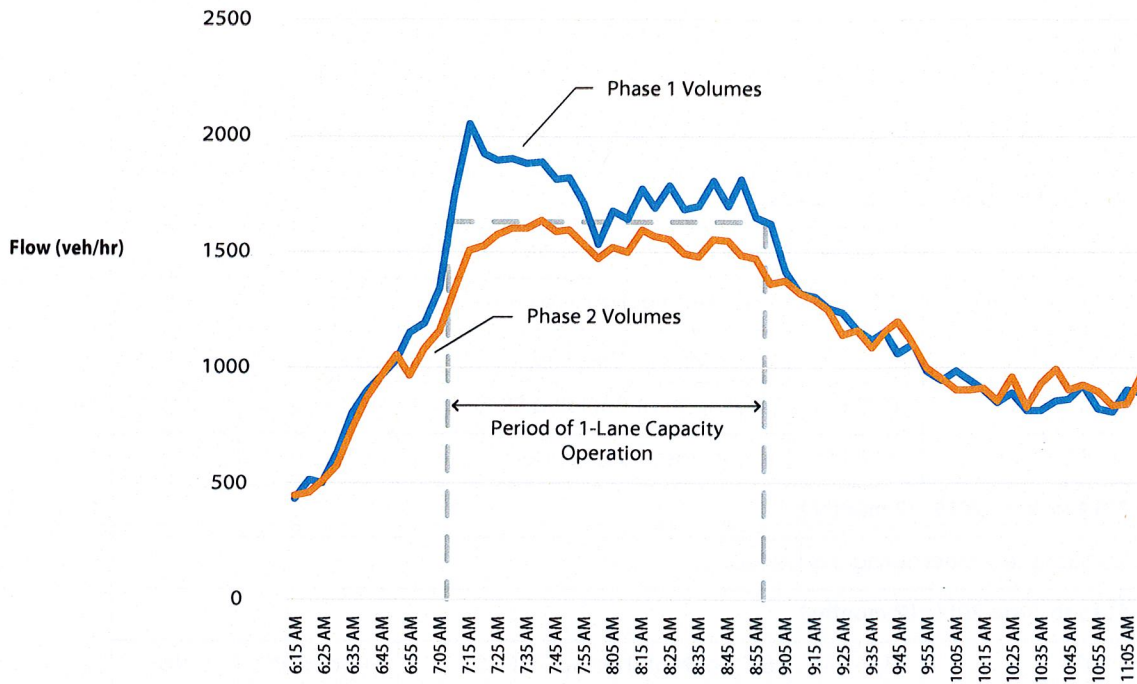
During the one-year Phase 1 period, there were no reported vehicle collisions.

Ten collisions have been reported in 12 months (June 2015 to June 2016) under Phase 2 conditions. Nine of the reported collisions occurred on weekdays during AM or PM peak traffic periods, and all of these were rear-end collisions. Three collisions were responded to between 7:45 and 9:00 AM, with two of these involving injuries. Six collisions were responded to between 3:55 and 7:20 PM; three of these resulted in reported injuries.

Most of the reported collisions that occurred during Phase 2 conditions appear to be reflective of peak period vehicular congestion and extended vehicle queuing along the San Jose Avenue off-ramp, and within northbound I-280's auxiliary lane and adjacent through traffic lane.

In the first six months (June to December 2015) of Phase 2 conditions, there was an average of 1.17 reported collisions each month. In the next six months (January to June 2016), there was an average of 0.50 reported collisions each month. While the monthly collision rate has decreased and is based on a limited sample size, it is still about three times higher than Pre-Pilot conditions.

I-280 / San Jose Ave Off-ramp AM Volumes (Phase 1: 2 lanes, Phase 2: 1 lane)



I-280 / San Jose Ave Off-ramp PM Volumes (Phase 1: 2 lanes, Phase 2: 1 lane)

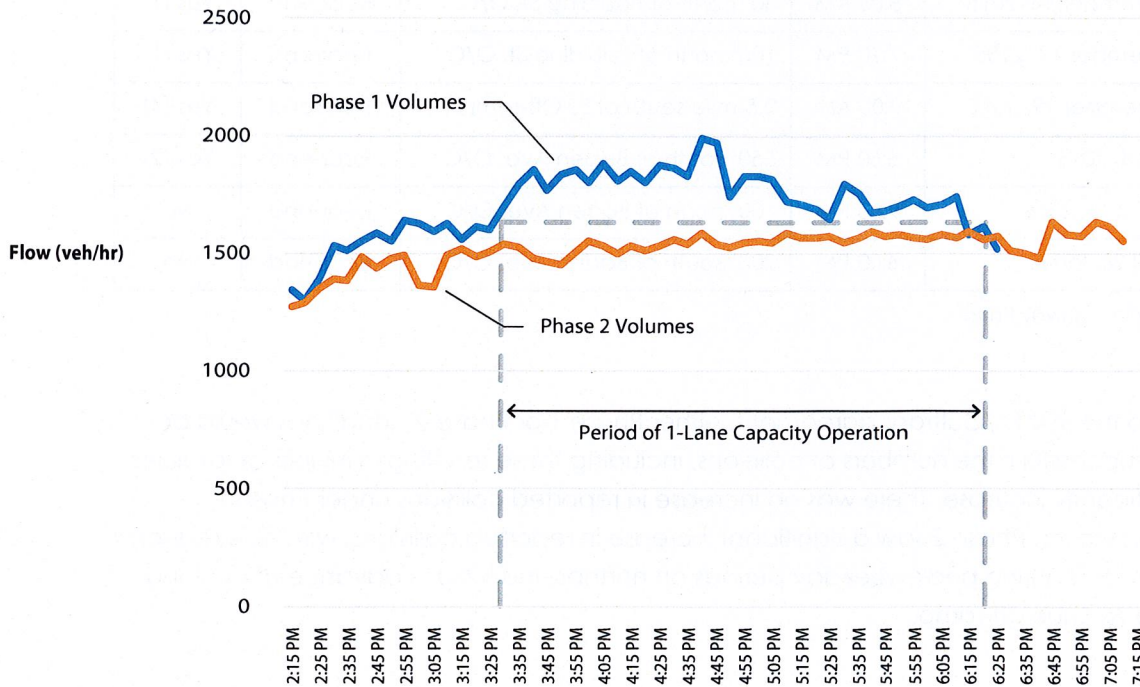


Exhibit 5. San Jose Avenue Off-Ramp Volumes

**Exhibit 6. Reported Collisions During Phase 1 and 2 Operations on Northbound I-280
in Advance of or on San Jose Avenue Off-ramp (Through April 30, 2016)**

Date	Time	Location	Type	Injury
Pre-Pilot (January 2012 to June 2014; 30 months)				
Sunday, August 12, 2012	7:33 PM	50' south of Theresa St. O/C	Rear-end	No
Monday, November 19, 2012	5:35 PM	960' south of San Jose Tunnel	Rear-end	No
Monday, January 28, 2013	9:05 AM	165' north of Paulding St. O/C	Sideswipe	Yes (2)
Thursday, March 21, 2013	8:00 PM	100' north of Paulding St. O/C	Sideswipe	No
Monday, January 20, 2014	4:15 PM	In San Jose Ave. Tunnel	Overtake	Yes (1)
Phase 1 (June 2014 to June 2015; 12 months)				
There were no collisions reported during this period.				
Phase 2 (June 2015 to June 2016; 12 months)				
Friday, June 19, 2015	3:55 PM	80' north of Theresa St. O/C	Rear-end	No
Friday, July 3, 2015	4:25 PM	250' south of San Jose Tunnel	Rear-end	No
Thursday, August 27, 2015	4:55 PM	580' north of Paulding St. O/C	Rear-end	Yes (2)
Friday, August 28, 2015	7:45 AM	60' south of Baden Ave. O/C	Rear-end	No
Monday, September 14, 2015	8:00 AM	30' north of Paulding St. O/C	Rear-end	Yes (1)
Tuesday, November 17, 2015	7:20 PM	100' north of Paulding St. O/C	Rear-end	Yes (1)
Thursday, November 19, 2015	9:00 AM	0.5-mile south of SJ Off-ramp	Rear-end	Yes (4)
Friday, March 4, 2016	6:50 PM	550' south of Baden Ave. O/C	Rear-end	Yes (2)
Saturday, March 5, 2016	9:53 PM	100' north of Baden Ave. O/C	Rear-end	No
Thursday, April 28, 2016	6:00 PM	200' south of Baden Ave. O/C	Rear-end	No

Source: California Highway Patrol.

According to the SFMTA/Caltrans agreement, either Phase 1 or Phase 2 conditions would be considered successful if the numbers of collisions, including those resulting in injuries or fatalities, did not significantly increase. There was no increase in reported collisions under Phase 1 conditions. However, Phase 2 saw a significant increase in reported collisions, with nine rear-end collisions reported during peak weekday periods on northbound I-280 in advance of or along the San Jose Avenue off-ramp.

RECOMMENDATIONS

San Jose Avenue Off-ramp from Northbound I-280

Based upon an independent third-party assessment, it is recommended that the San Jose Avenue off-ramp be restored to Phase 1 conditions, i.e., provision of a continuous two-lane off-ramp through its triple merge point with San Jose Avenue and Monterey Boulevard. Phase 2 conditions do not meet criteria for success based on the SFMTA/Caltrans' November 2013 agreement in regards to resulting vehicular speeds, traffic congestion, and vehicular collisions.

As part of the third-party review, three options to reduce highway and/or ramp capacity upstream of San Jose Avenue were briefly reviewed: one option would merge the on-ramp traffic from Ocean and Geneva Avenues into I-280's fourth mainline traffic lane, eliminate the auxiliary lane through restriping, and provide a one-lane off-ramp to San Jose Avenue; a second option would retain the auxiliary lane but convert the two-lane off-ramp to a one-lane off-ramp, requiring motorists to weave between lanes (see Exhibit A-1, Option 1); and the third option would extend the merging location of the two lanes on the San Jose Avenue off-ramp to within the tunnel under I-280. However, all three options would result in substantial traffic and safety impacts, as discussed below:

- Eliminate I-280's northbound auxiliary lane, merge Ocean/Geneva Avenue on-ramp into the fourth freeway (through traffic) lane, and provide one-lane off-ramp to San Jose Avenue: This option would cause over-saturated traffic conditions in the right-most two traffic lanes on northbound I-280 in advance of the San Jose Avenue off-ramp, particularly during the weekday AM Peak period, resulting in level-of-service "F" conditions along the highway mainline. This, in turn, would cause traffic to back up along both through traffic lanes (neither of which would be an auxiliary lane), increasing the potential for rear-end collisions in these mainline freeway lanes. Please see Exhibit A-5 for level-of-service estimates.
- Convert the off-ramp's diverging configuration to provide a single-lane off-ramp instead of two lanes: This option would create a weaving condition along northbound I-280 between the Ocean/Geneva Avenue on-ramp and the San Jose Avenue off-ramp, requiring all motorists driving along mainline I-280 and destined for the San Jose Avenue off-ramp to switch lanes (i.e., move from the fourth lane to the auxiliary lane), while all motorists entering northbound I-280 from the Ocean/Geneva Avenue on-ramp and desiring to continue along I-280 past San Jose Avenue to switch lanes (i.e., move from the auxiliary lane to the fourth lane). The weaving volumes would exceed the capacity of the weaving area, resulting in congestion within the auxiliary lane and fourth lane, and causing an increase in potential rear-end and side-swipe types of collisions. Please see Exhibit A-5 for level-of-service estimates.
- Extend the off-ramp's two-lane to one-lane merge farther to the north, within the tunnel under I-280: This option would require motorists driving in two lanes to merge into one lane through a horizontal curve within a tunnel with varying illumination conditions. It would continue to provide an over-saturated merging condition on the off-ramp, with

vehicle queues within northbound I-280's auxiliary lane and adjacent through traffic lane, and would pose hazardous conditions with high likelihood of rear-end and sideswipe collisions.

Northbound San Jose Avenue

As noted in the November 2013 SFMTA/Caltrans agreement, if lesser than desired speed reductions are experienced, a phase of the project may still be considered successful if it is not accompanied by excessive traffic congestion and/or vehicle collisions. Thus, it is recommended that the Phase 1 San Jose Avenue road diet be retained as overall congestion levels appeared acceptable and contained mostly within the roadway itself, and not along the I-280 mainline. Furthermore, the Phase 1 improvements resulted in a 21 percent decrease in peak period vehicle throughput along San Jose Avenue, and a slight reduction in travel speeds along the roadway.

One of the original concerns expressed by San Francisco residents and the SFMTA was related to the high vehicular speeds on northbound San Jose Avenue and the negative associated effects this speeding has on safety for pedestrians, bicyclists and motorists. It is therefore recommended that implementation of additional traffic calming measures be considered along northbound San Jose Avenue between the triple merge point with the I-280 off-ramp/Monterey Boulevard and Randall Street. Suggested engineering measures to be considered include, but are not limited to:

- Restriping traffic lanes: The Phase 1 road diet project originally proposed restriping lanes on northbound San Jose Avenue to provide, from west-to-east, a left-side shoulder, two 10-foot wide traffic lanes, a seven-foot buffer, and a nine-foot bicycle lane (see Exhibit A-3). Recently measured conditions show that there is generally an 18-inch left-side shoulder with faded yellow striping, an 11.5-foot left traffic lane, a 10-foot right traffic lane, a 5.5-foot buffer, and a 10-foot bicycle lane. Consideration should be given to striping a wider left-side shoulder clearly designated with yellow markings and reflectors, narrowing the left-side traffic lane to 10 feet, and retaining a 10-foot right-side traffic lane.
- Installing speed reduction pavement markings: Consideration should be given to installing speed reduction markings, i.e., transverse markings that are placed on a roadway within a lane (along both edges of the lane) in a pattern of progressively reduced spacing to give motorists the impression that their speed is increasing. Typically, such markings are not used along long tangent segments of roadways, but they could be considered at intermittent locations along San Jose Avenue in conjunction with a solid white channelizing line separating the two through traffic lanes.
- Providing a series of radar speed feedback signs: Ideally the prevailing uncongested traffic speeds along northbound San Jose Avenue would transition incrementally from the off-ramp speed of 45 miles per hour to 30 miles per hour at Randall Street. A series of speed limit signs and large speed feedback signs over each traffic lane could help reduce speeds (variable speed limits could also be considered). Such signs could be

installed on new mast arm poles or hung from the series of overpasses along San Jose Avenue.

- Changing the pavement or constructing a permanent barrier: The width of pavement along northbound San Jose Avenue, from the face of the concrete barrier on the west side to the face of the curb on the east side, is about 38 feet. All pavement surfaces, including the buffer area and the bicycle lane, are homogeneously asphalt providing the impression of a high-speed expressway. Consideration should be given to either providing a colored pavement treatment within the buffer (and perhaps within the left-side shoulder recommended above), or constructing a raised permanent barrier/median, or both.
- Adding a traffic signal on San Jose Avenue at Rousseau Street: Rousseau Street is located about 500 feet north of the triple merge point with the I-280 off-ramp/Monterey Boulevard, and it is accessible via a right-turn lane. Egress from Rousseau Street onto San Jose Avenue is not permitted. While a traffic signal would not be warranted based on criteria in the California Manual on Uniform Traffic Control Devices, a signal could potentially regulate traffic throughput along northbound San Jose Avenue. However, the further detailed study of a metering signal, if pursued, should consider potential cycle times, vehicular back-ups and sight distance to the back of queues, end of queue detectors to allow the signal to turn green to flush out queues, and enforcement issues since stopped motorists could be tempted to violate the signal. Such a study should be conducted with the involvement of SFMTA, Caltrans, and other key stakeholders.

Several of the above engineering measures could potentially be combined.

BIBLIOGRAPHY

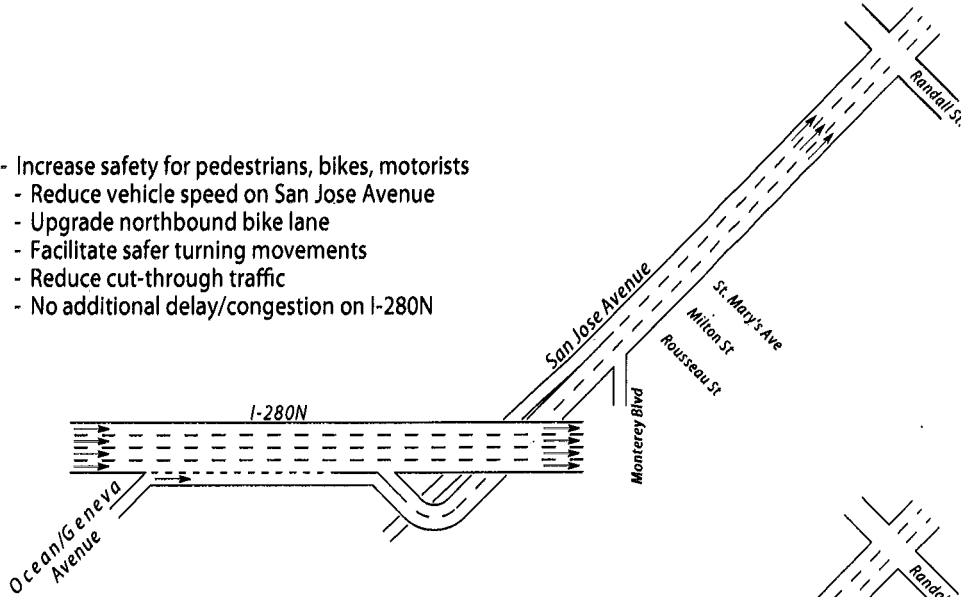
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- SFMTA, Final Report Northbound San Jose Avenue and I-280 Off-ramp Road Diet Pilot Project, January 5, 2016
- SFMTA, Phase 1 Traffic Striping Plan, December, 13, 2012
- SFMTA, San Jose Avenue and I-280 Off-ramp Road Diet Pilot Project Update, January 2016
- SFMTA, Traffic Count Data, 2014 and 2015

APPENDIX

- Exhibit A-1. Original Road Diet Options
- Exhibit A-2. Project Phases
- Exhibit A-3. Phase 1 Traffic Striping
- Exhibit A-4. Phase 2 Traffic Striping
- Exhibit A-5. Level-of-Service Calculations

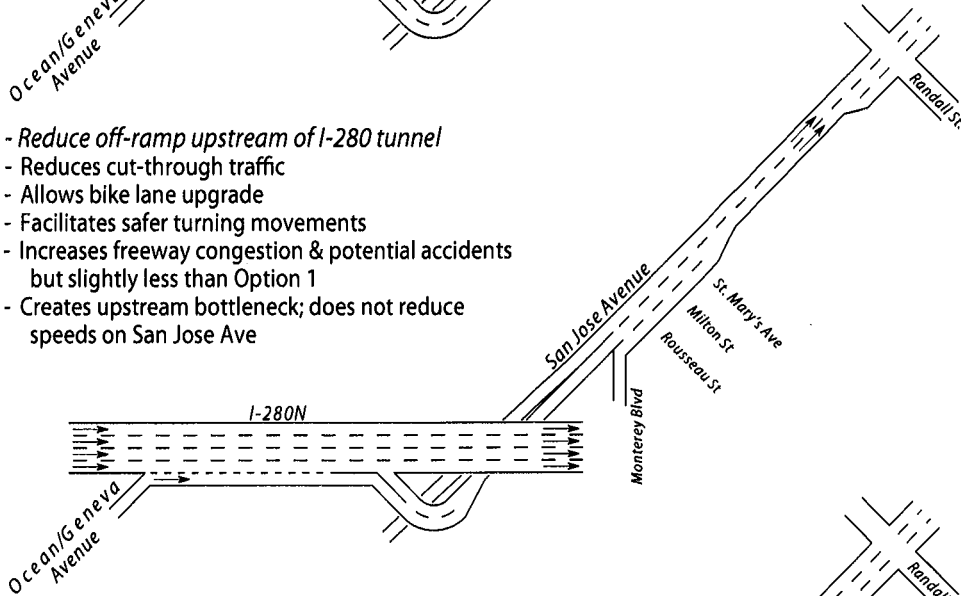
Existing

- Goals:
- Increase safety for pedestrians, bikes, motorists
 - Reduce vehicle speed on San Jose Avenue
 - Upgrade northbound bike lane
 - Facilitate safer turning movements
 - Reduce cut-through traffic
 - No additional delay/congestion on I-280N



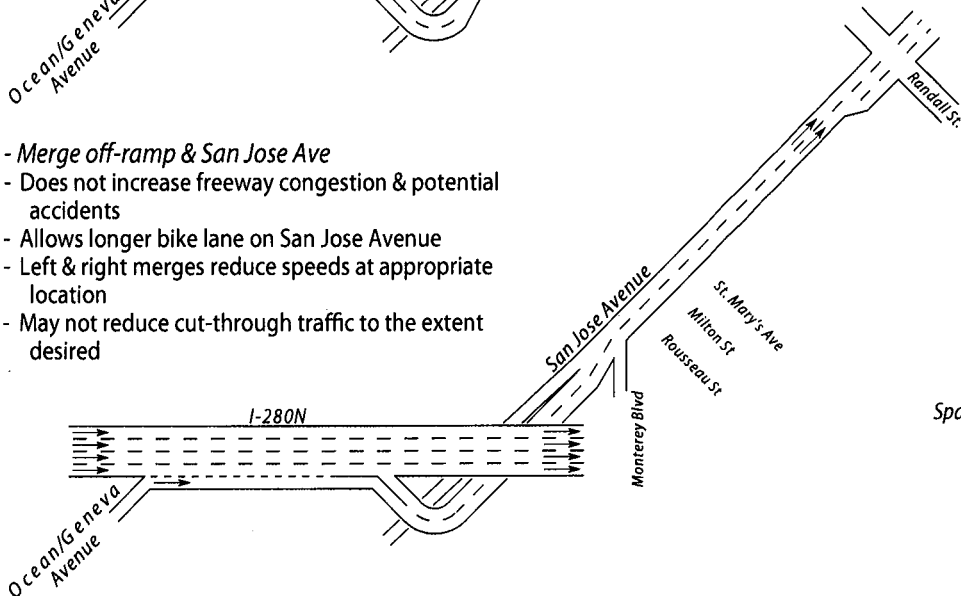
Option 2

- Pro:
- Reduces cut-through traffic
 - Allows bike lane upgrade
 - Facilitates safer turning movements
- Con:
- Increases freeway congestion & potential accidents but slightly less than Option 1
 - Creates upstream bottleneck; does not reduce speeds on San Jose Ave



Option 4

- Pro:
- Does not increase freeway congestion & potential accidents
 - Allows longer bike lane on San Jose Avenue
 - Left & right merges reduce speeds at appropriate location
- Con:
- May not reduce cut-through traffic to the extent desired



Space available for bike lane

Not to scale

29 August 2013
Caltrans - District 4

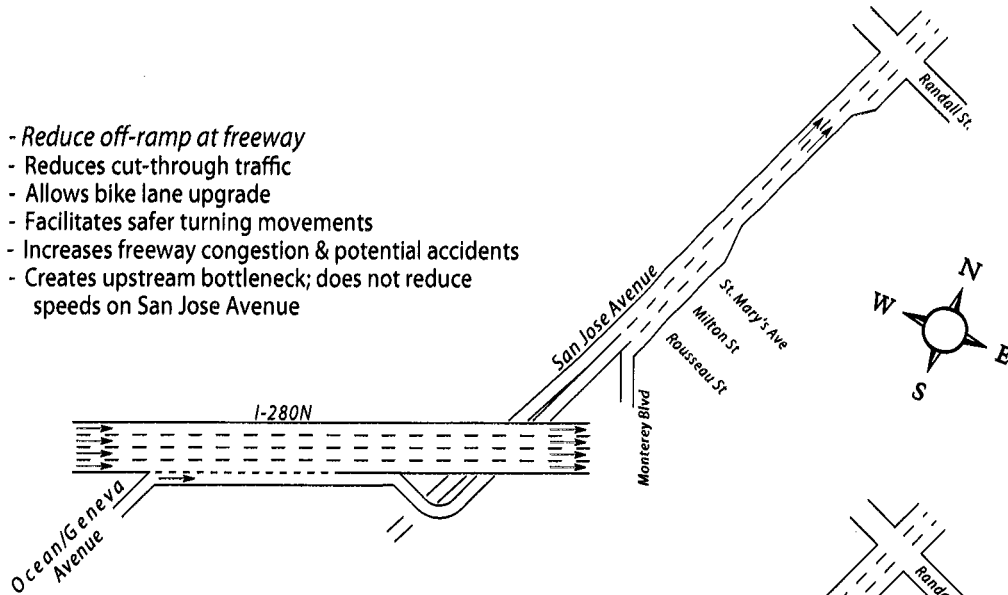
Source: Caltrans

Note, while "pros" and "cons" may reflect anticipated outcomes, they are not foregone conclusions, and the intent of the pilot project is to evaluate various options.

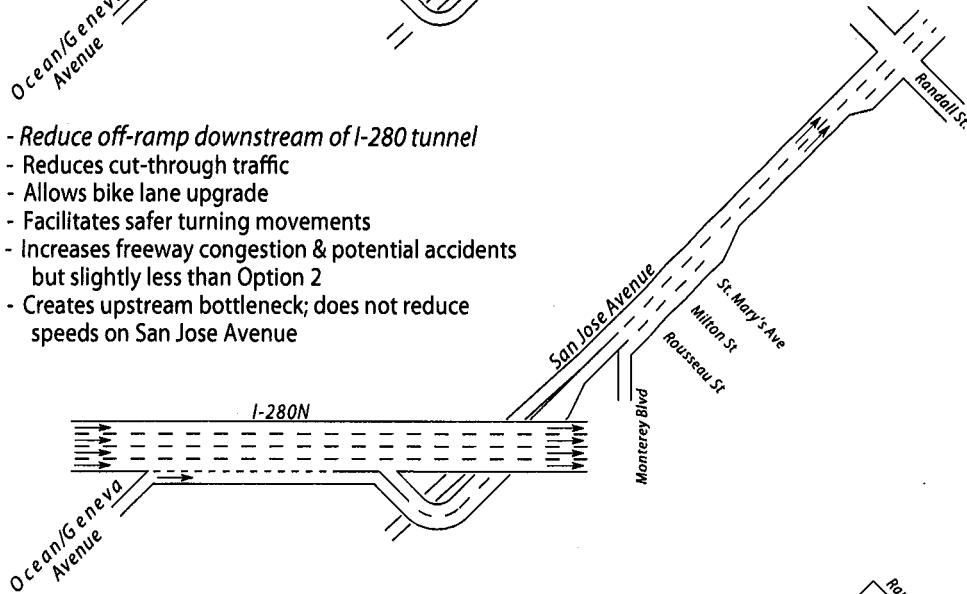
Exhibit A-1. Original Road Diet Options (1 of 2)



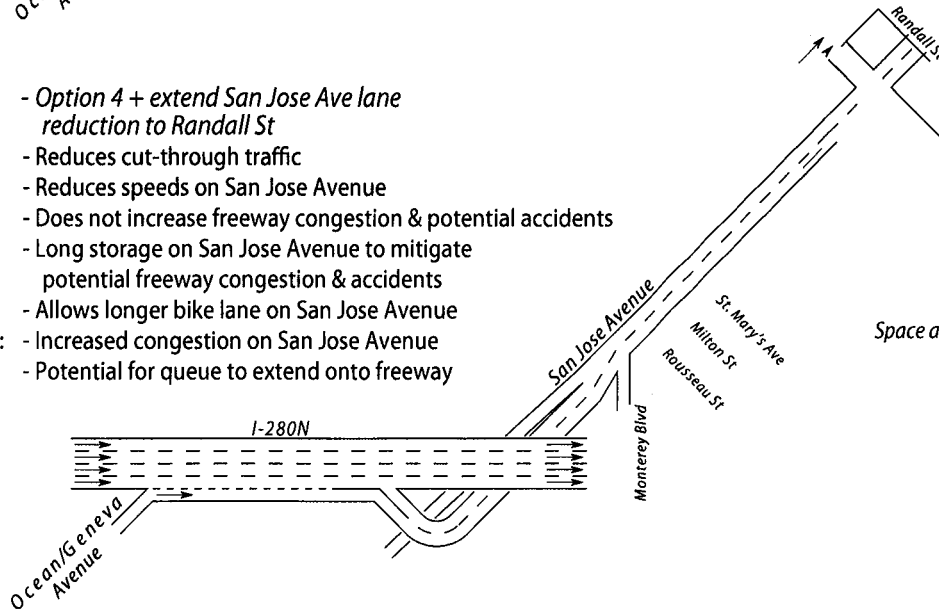
- Option 1** - Reduce off-ramp at freeway
- Pro:
- Reduces cut-through traffic
 - Allows bike lane upgrade
 - Facilitates safer turning movements
- Con:
- Increases freeway congestion & potential accidents
 - Creates upstream bottleneck; does not reduce speeds on San Jose Avenue



- Option 3** - Reduce off-ramp downstream of I-280 tunnel
- Pro:
- Reduces cut-through traffic
 - Allows bike lane upgrade
 - Facilitates safer turning movements
- Con:
- Increases freeway congestion & potential accidents but slightly less than Option 2
 - Creates upstream bottleneck; does not reduce speeds on San Jose Avenue



- Option 5** - Option 4 + extend San Jose Ave lane reduction to Randall St
- Pro:
- Reduces cut-through traffic
 - Reduces speeds on San Jose Avenue
 - Does not increase freeway congestion & potential accidents
 - Long storage on San Jose Avenue to mitigate potential freeway congestion & accidents
 - Allows longer bike lane on San Jose Avenue
- Con:
- Increased congestion on San Jose Avenue
 - Potential for queue to extend onto freeway



Space available for bike lane

Not to scale

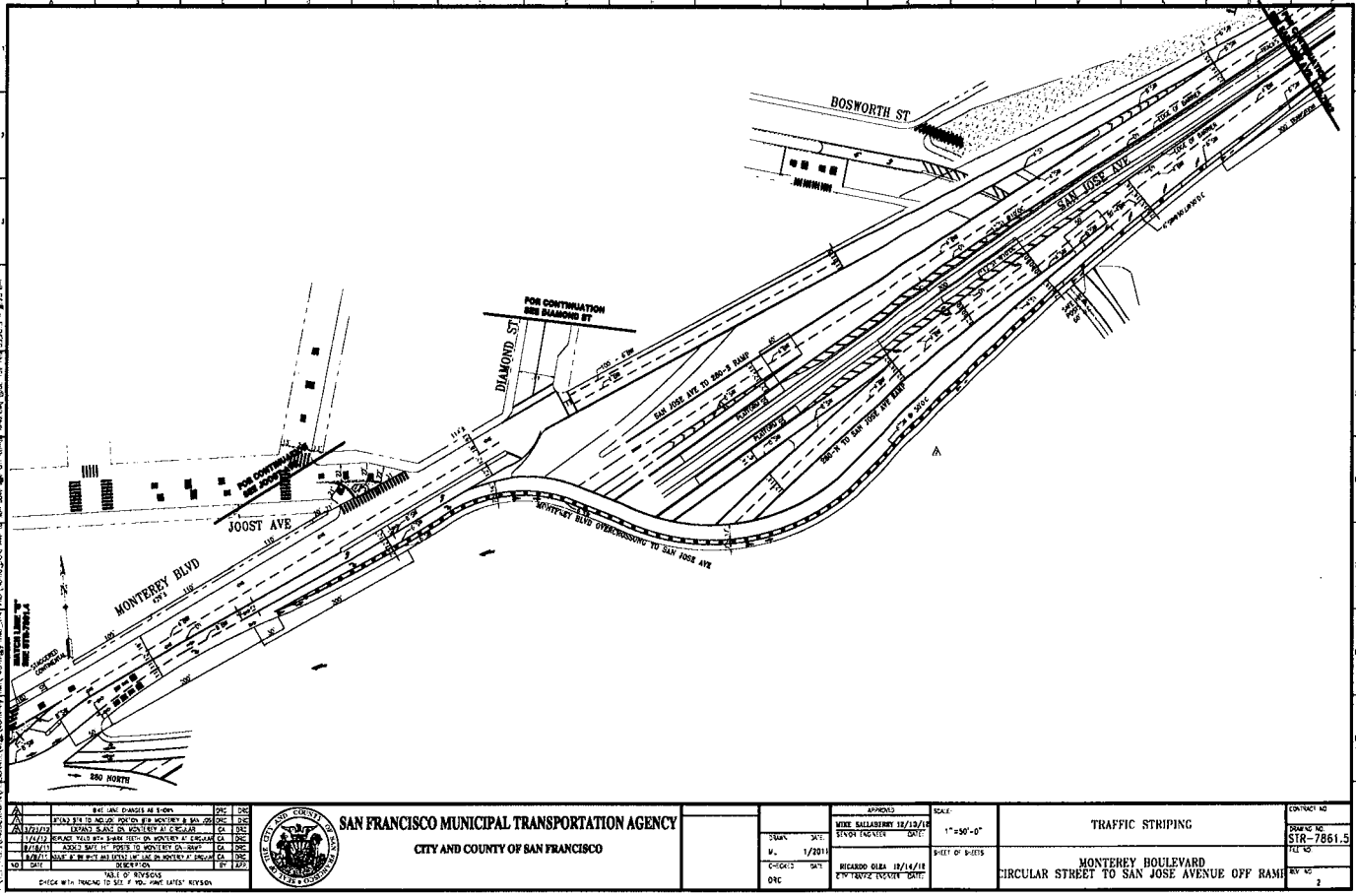
29 August 2013
Caltrans - District 4

Source: Caltrans



Source: Caltrans

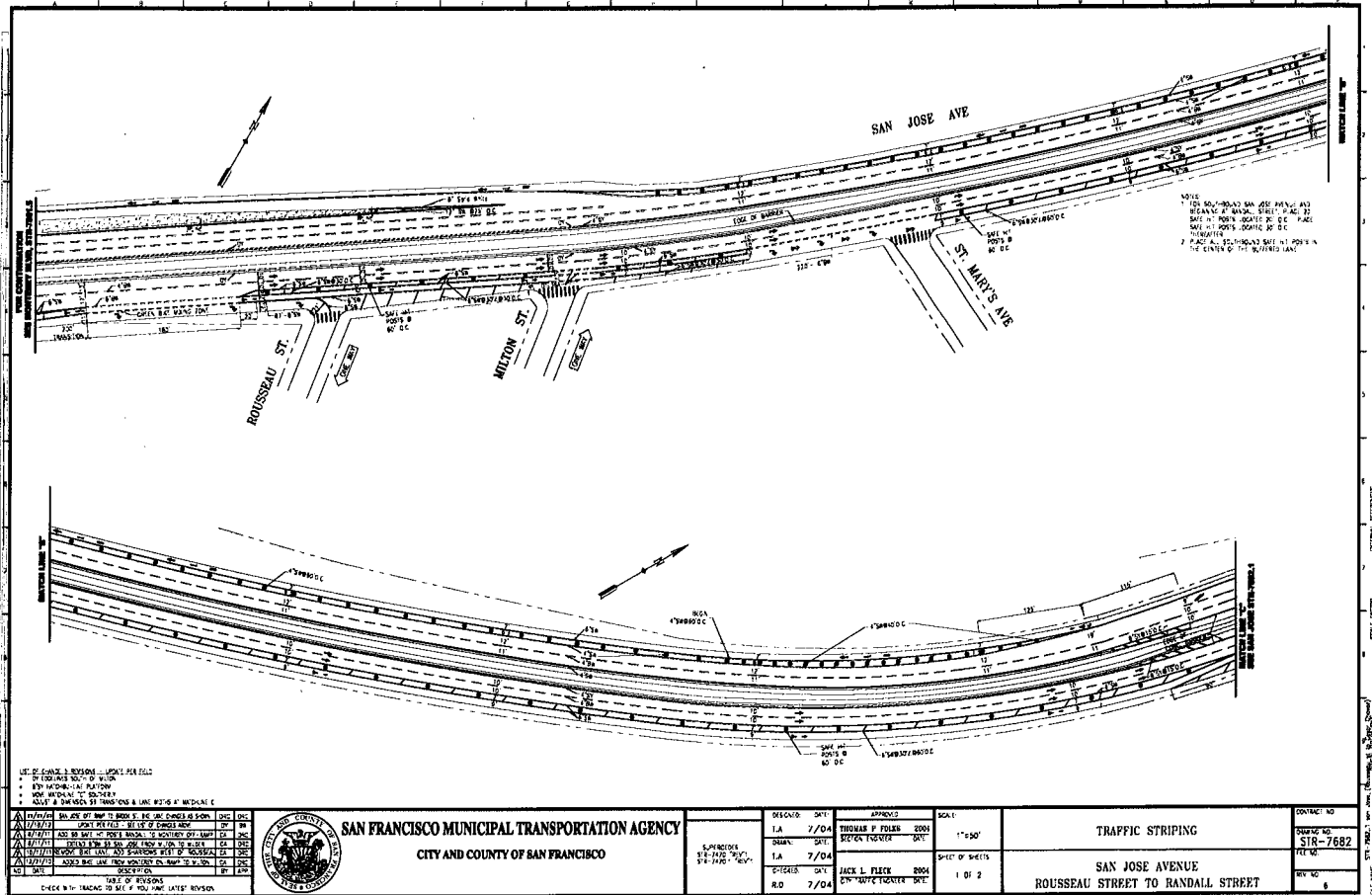
Exhibit A-2. Project Phases



Source: Caltrans

Exhibit A-3. Phase 1 Traffic Striping (1 of 3)





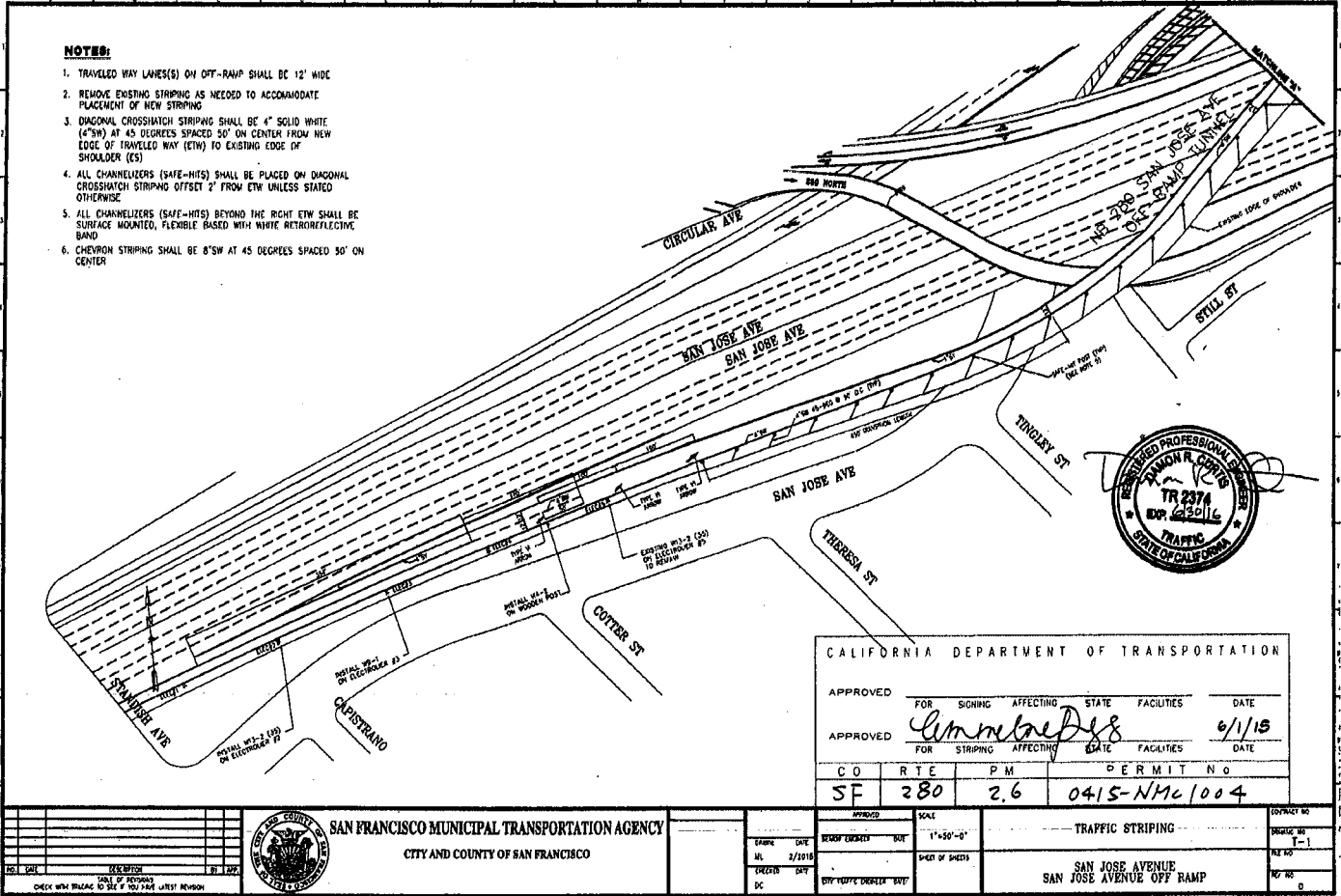
Source: Caltrans

Exhibit A-3. Phase 1 Traffic Striping (2 of 3)



NOTES:

1. TRAVELED WAY LANES(S) ON OFF-RAMP SHALL BE 12' WIDE
2. REMOVE EXISTING STRIPING AS NEEDED TO ACCOMMODATE PLACEMENT OF NEW STRIPING
3. DIAGONAL CROSSHATCH STRIPING SHALL BE 4" SOLID WHITE (4"SW) AT 45 DEGREES SPACED 50' ON CENTER FROM NEW EDGE OF TRAVELED WAY (ETW) TO EXISTING EDGE OF SHOULDER (ES)
4. ALL CHANNELIZERS (SAFE-HITS) SHALL BE PLACED ON DIAGONAL CROSSHATCH STRIPING OFFSET 2' FROM ETW UNLESS STATED OTHERWISE
5. ALL CHANNELIZERS (SAFE-HITS) BEYOND THE RIGHT ETW SHALL BE SURFACE MOUNTED, FLEXIBLE BASED WITH WHITE RETROREFLECTIVE BAND
6. CHEVRON STRIPING SHALL BE 8"SW AT 45 DEGREES SPACED 50' ON CENTER



CALIFORNIA DEPARTMENT OF TRANSPORTATION

APPROVED	FOR SIGNING	AFFECTING	STATE	FACILITIES	DATE
					6/1/15
APPROVED	FOR STRIPING	AFFECTING	STATE	FACILITIES	DATE
CO	RTE	PM	PERMIT NO		
SF	280	2.6	0415-NM61004		

NO.	DATE	DESCRIPTION	BY

SAN FRANCISCO MUNICIPAL TRANSPORTATION AGENCY
CITY AND COUNTY OF SAN FRANCISCO

DATE	2/2015
CREATED BY	
DC	

SCALE	1"=50'-0"
TITLE	TRAFFIC STRIPING
SHEET NO	1-1
PROJECT	SAN JOSE AVENUE SAN JOSE AVENUE OFF RAMP

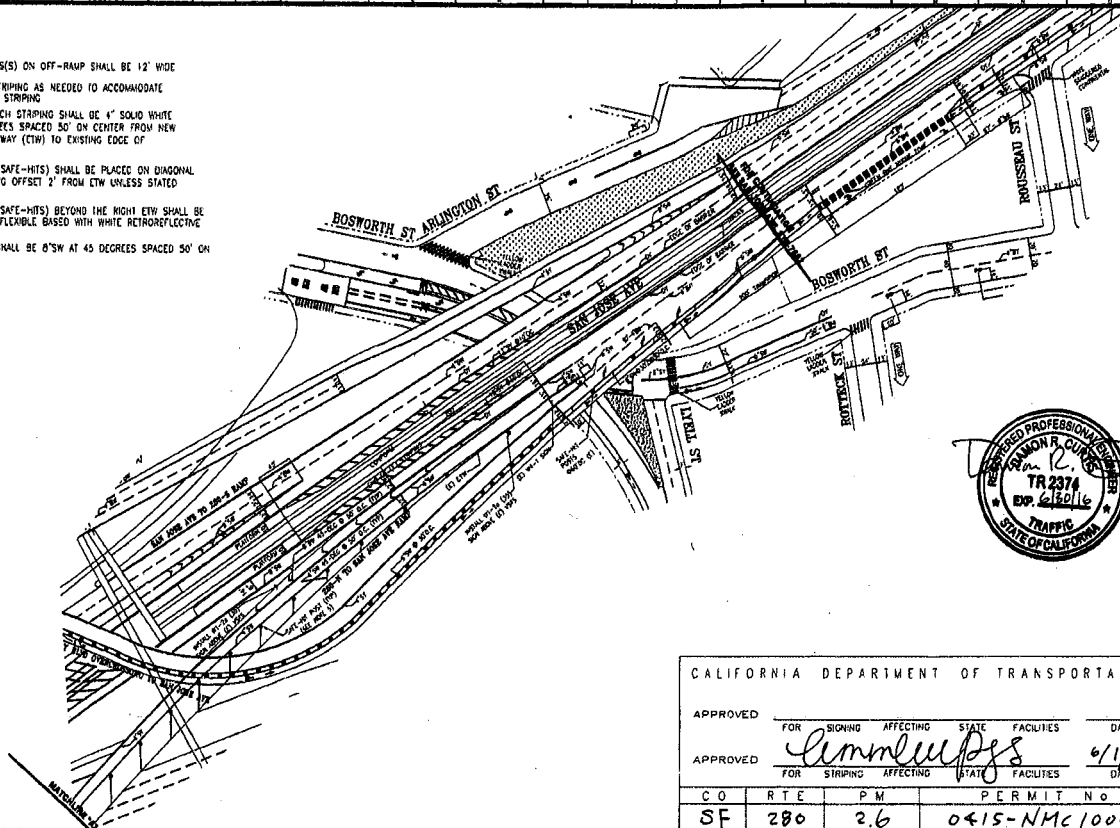
Source: Caltrans and SFMTA

Exhibit A-4. Phase 2 Traffic Striping (1 of 2)



NOTES:

1. TRAVELED WAY LANE(S) ON OFF-RAMP SHALL BE 12' WIDE
2. REMOVE EXISTING STRIPING AS NEEDED TO ACCOMMODATE PLACEMENT OF NEW STRIPING
3. DIAGONAL CROSSHATCH STRIPING SHALL BE 4" SOLID WHITE (4"SW) AT 45 DEGREES SPACED 50' ON CENTER FROM NEW EDGE OF TRAVELED WAY (ETW) TO EXISTING EDGE OF SHOULDER (ES)
4. ALL CHANNELIZERS (SAFE-HITS) SHALL BE PLACED ON DIAGONAL CROSS-HATCH STRIPING OFFSET 2' FROM ETW UNLESS STATED OTHERWISE
5. ALL CHANNELIZERS (SAFE-HITS) BEYOND THE RIGHT ETW SHALL BE SURFACE MOUNTED, FLEXIBLE BASED WITH WHITE RETROREFLECTIVE BAND
6. CHEVRON STRIPING SHALL BE 8"SW AT 45 DEGREES SPACED 50' ON CENTER



CALIFORNIA DEPARTMENT OF TRANSPORTATION			
APPROVED	FOR SIGNING AFFECTING STATE FACILITIES	DATE	
	<i>Amberley</i>	6/11/15	
APPROVED	FOR STRIPING AFFECTING STATE FACILITIES	DATE	
C O	R T E	P M	PERMIT N O
SF	280	2.6	0415-NMC1004

NO.	DATE	DESCRIPTION	BY



SAN FRANCISCO MUNICIPAL TRANSPORTATION AGENCY
CITY AND COUNTY OF SAN FRANCISCO

DESIGNED	DATE
CHECKED	DATE
DISC	

APPROVED	SCALE	PROJECT
	1"=50'-0"	TRAFFIC STRIPING
		SAN JOSE AVENUE SAN JOSE AVENUE OFF RAMP TO ROUSSEAU ST

CONTRACT NO.	
DRAWING NO.	1-2
SHEET NO.	2

Source: Caltrans and SFMTA

Exhibit A-4. Phase 2 Traffic Striping (2 of 2)



HCM 2010 Freeway Weaving Segment Analysis (Ch. 12)

Dist/Rte/Co/PM: 4-280-SF-R2.0 to R2.5

Location: Northbound I-280 between Ocean / Geneva Ave. and San Jose Ave.

Scenario: AM Peak Hour, single lane weaving area

1. Input Data

Freeway and Ramp Volumes	See Exhibit 4, AM
Weaving Segment Length, L_s	2700'
Peak Hour Factor, PHF	.95
Heavy Vehicles	Trucks $P_T = 1.5\%$, RVs $P_R = 0\%$
Driver Population, f_p	Regular commuters, $f_p = 1.0$
Mainline Free Flow Speed, FFS	70 mph
Interchange Density, ID	0.83 / mi (5 I/C within 3 miles north and south)
Terrain	Level, $E_T = 1.5$

2. Volume Adjustment

$$\text{Ideal flow rate } v_i = V_i / (\text{PHF} \times f_{HV} \times f_p) \quad \text{Eqn. 12-1}$$

$$f_{HV} = [1 + P_T (E_T - 1) + P_R (E_R - 1)]^{-1} \quad \text{Eqn. 11-5}$$

$$= 0.9926$$

$$v_i = V_i / (0.9926 \times 0.95) = 1.06 V_i$$

Movement	Base Volume, V_i (Counts + Estimate)	Ideal Flow Rate, v_i
Freeway through, v_{FF}	4808	5096
Freeway to off-ramp, v_{FR}	1521	1612
On-Ramp to freeway, v_{RF}	873	925
On-ramp to off-ramp, v_{RR}	97 (est. 10% of ramp)	103
Total, v	7299	7737

$$\text{Vol. weave, } v_w = v_{FR} + v_{RF} = 2537$$

$$\text{Vol. non-weave, } v_{NW} = 4844 + 98 = 5237$$

$$\text{Volume ratio, } VR = v_w / v = 0.33$$

Exhibit A-5. HCM 2010 Freeway Weaving Analysis (1 of 2)

3. Configuration

$$\text{Min. lane changes per hour, } LC_{\text{MIN}} = (LC_{\text{RF}} \times v_{\text{RF}}) + (LC_{\text{FR}} \times v_{\text{FR}}) \quad \text{Eqn. 12-2}$$

$$\text{Min. lanes to change, ramp to freeway, } LC_{\text{RF}} = 1;$$

$$\text{Min. lane change, freeway to ramp, } LC_{\text{FR}} = 1$$

$$LC_{\text{MIN}} = 2411$$

$$\text{Lanes with weaving maneuvers w\ 0-1 lane change, } N_{\text{WL}} = 2$$

4. Max. Weaving Length, L_{MAX}

$$L_{\text{MAX}} = [5728(1+VR)^{1.6}] - [1566N_{\text{WL}}] \quad \text{Eqn. 12-4}$$

$$L_{\text{MAX}} = 5907 > L_s = 2700 \quad \text{OK (weaving occurs through entire length of segment)}$$

5. Weaving Segment Capacity

Weaving Demand Flows

$$\begin{aligned} C_{\text{IW}} &= 2400 / VR \text{ for } N_{\text{NW}} = 2 \text{ lanes} && \text{Eqn. 12-7} \\ &= 7272 \text{ pc/h (ideal max weaving flow rate, PCE)} \end{aligned}$$

$$\begin{aligned} C_w &= C_{\text{IW}} f_{\text{HV}} f_p \text{ (prevailing max weaving flow rate)} \\ &= 7218 \end{aligned}$$

$$\begin{aligned} v/c &= v f_{\text{HV}} f_p / C_w \\ &= 7737 * 0.993 * 1.0 / 7218 \\ &= 1.06 \end{aligned}$$

Findings:

$v/c > 1$, therefore LOS F

HCM 2010 Freeway Ramp Merge + Diverge Analysis (Ch. 13)

Dist/Rte/Co/PM: 4-280-SF-R2.0 to R2.5

Location: Northbound I-280 between Ocean / Geneva Ave. and San Jose Ave.

Scenario: AM Peak Hour, single lane on-ramp followed by single lane off-ramp

1. Input Data

Freeway and Ramp Volumes	See Exhibit 4, AM
Distance between Ramps, L_s	2700'
Peak Hour Factor, PHF	0.95
Heavy Vehicles	Trucks $P_T = 1.5\%$, RVs $P_R = 0\%$
Driver Population, f_p	Regular commuters, $f_p = 1.0$
Mainline Free Flow Speed, FFS	70 mph
Acceleration Lane, On-Ramp	500'
Acceleration Lane, Off-Ramp	500'
Terrain	Level, $E_T = 1.5$

2. Volume Adjustment

Ideal flow rate $v_i = V_i / (PHF \times f_{HV} \times f_p)$ Eqn. 12-1

$f_{HV} = [1 + P_T (E_T - 1) + P_R (E_R - 1)]^{-1}$ Eqn. 11-5
 $= 0.9926$

$v_i = V_i / (0.9926 \times 0.95) = 1.06 V_i$

Movement	Base Volume, V_i (Counts)	Ideal Flow Rate, v_i
Freeway approaching ramp, V_F	6329	6709
On-Ramp to freeway, v_{R1}	970	1028
Off-Ramp from freeway, v_{R2}	1618	1715

3. Check Capacities in Lanes 1 and 2

On-Ramp

$$V_{12} = (1511+1455)*1.06 \quad \text{Vehicles in lanes 1 \& 2 before the on-ramp, see Exhibit 4, AM}$$
$$= 3144$$

$$V_{R12} = V_{12} + V_{R1} = 4172$$

$$V_{R12} < 4600, \text{ within capacity (not LOS F)} \quad \text{HCM Exhibit 13-8}$$

Off-Ramp

$$V_{12} = (1525+1544+1104)*1.06 \quad \text{Vehicles in lanes 1 \& 2 before the off-ramp, see Exhibit 4, AM}$$
$$= 4423$$

$$V_{12} > 4400, \text{ greater than capacity, therefore LOS F} \quad \text{HCM Exhibit 13-8}$$

Findings:

$v/c > 1$ at off-ramp diverge area, therefore LOS F

