Methodology 2

This section discusses the three-step methodology followed for measuring LOS during the current monitoring cycle. In the first step, Alameda CTC screened days within the monitoring period to ensure that only days that were expected to result in normal commuter traffic conditions were retained. Days that may have produced lighter than usual traffic conditions such as public holidays or heavier than usual conditions such as special events were identified for later removal.

The second step consisted of the actual data collection using either commercial speed data or floating car surveys. Data was collected for the Tier 1/Tier 2 CMP network, HOV/express lanes, bridges, OD surveys, and free flow speed surveys on arterials (Tier 2). In the final step, data was analyzed separately for commercial speed data and floating car surveys to obtain the average speed and converted to LOS using HCM methodologies.

2.1 | Screening for Data Collection Periods

As a preliminary step in the analysis, it was necessary to identify all the days and time periods during which the CMP network could be monitored. Since travel time data for 2014 was collected using a combination of commercial speed data and in-field floating car surveys, monitoring days for both data sources were reviewed and identified separately.

As a part of the preliminary analysis, all potential factors that may affect the monitoring effort were carefully examined. This included identifying school holidays across the county and any events that occurred during the monitoring period. Analyzing these additional factors was necessary to identify good quality data for the current monitoring. This in turn ensured that the LOS results are representative of normal traffic conditions experienced by a daily commuter.

2.1.1 | Base Monitoring Times

Data for the LOS Monitoring is typically collected in spring when the schools are in session. Commercial speed data collection and floating car surveys were conducted in the months of March, April and May 2014 when schools were in session. When additional floating car surveys were required, some data collection efforts extended into the first week of June, but were completed before the schools closed for summer.

Weekday data was collected on Tuesdays, Wednesdays and Thursdays for the nominated morning and afternoon peak periods. The morning peak period was

Figure 2-1: 2013 Public Holidays & Spring Break Periods in Alameda County

from 7:00 AM to 9:00 AM, and the afternoon peak period was from 4:00 PM to 6:00 PM. This resulted in a total of 39 monitoring days from which additional days were excluded for public holidays and school spring break. Freeways (Tier 1) were also monitored separately on weekends between 1:00 AM to 3:00 PM, which were verified to be the weekend peak period.

2.1.2 | Public Holidays and Spring Breaks

Weeks containing public holidays and school spring break periods were expected to produce non-representative traffic patterns. The associated data were therefore removed from the commercial speed datasets. **Figure 2-1** shows public holidays and spring break periods.

Spring break of Alameda County schools varied by the school district and occurred as early as March 24th and ended as late as April 25th. For spring break periods, data was not collected on the arterial network within the school district boundaries during their designated spring break. However, travel time data collection on the freeway and ramp networks continued during spring break periods as these facilities are expected to serve more inter-county and interregional traffic.

2.1.3 | Special Events

Special events in Alameda County were reviewed to see if they occurred during or near the specified weekday monitoring times. Traffic data associated with such events was removed from monitoring due to expected irregularities.

While there were some significant regional events, the majority of the events did not occur within the monitoring period. Events in Oracle Arena, such as Warrior Basketball games and Oakland A's Baseball games, were the notable exception (**Figure 2-1**). Games were played on a number of Tuesdays, Wednesdays, and Thursdays starting at 12:35 PM, 7:05 PM, or 7:30 PM. These games could have had an impact on the afternoon peak period and therefore data for all the relevant CMP segments near or approaching Oracle Arena were excluded in the afternoon peak on these event days.

2.1.4 | Weather Events

Weather data was also monitored as a part of the analysis, however, no events were observed to impact traffic conditions.

2.1.5 | Construction and Maintenance

Announcements were reviewed to identify significant construction impacts during the monitoring period. Sources of data included the following (**Figure 2-2**):

- Alameda CTC projects page;
- Other government websites (including Caltrans District 4);
- Specific construction project websites (including the new San Francisco-Oakland Bay Bridge);
- Facebook and Twitter feeds (including the I-880 Corridor Improvement Project); and
- Caltrans Performance Measurement System (PeMS) lane closure database.

Further, cities and the county were requested to share their construction and maintenance schedules.

Figure 2-2: Sources of Information aboutConstruction Activities and Lane Closures

Both long and short term construction activities were identified. As an example of a long term construction activity, I-80 eastbound along the San Francisco-Oakland Bay Bridge experienced ongoing construction work for the majority of the monitoring period in the morning peak, including a regular closure of one travel lane. In this instance, there would not be adequate alternative days to gather a suitable sample size if all the days impacted by construction were removed. Therefore, data collection days were not restricted based on such long term construction. **Table 2-1** lists segments impacted by ongoing long term construction.

Short term construction activities were reviewed and evaluated separately. For example, the I-880 Marina Boulevard on-ramp was closed from April 8th at 10 PM to April 11th at 5 AM. The days impacted by construction were removed from the monitoring data set for the adjacent freeway CMP segment as the presence of construction may impact traffic flows. Given the short duration of the construction activities compared to the total monitoring period, the remaining data provided an adequate sample size for monitoring.

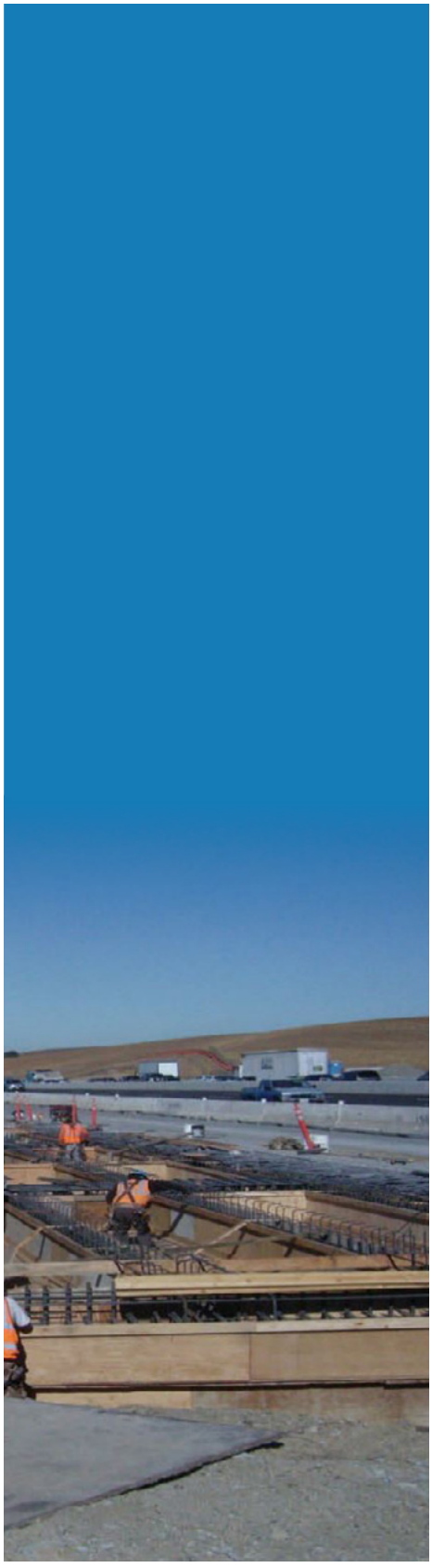


Table 2-1: Monitoring of HOV/Express Lanes and Bridges added to 2014 LOS Monitoring

Tier	Impacted Roads	Extents	Description of Work
Freeway (Tier 1)/ HOV	I-580 in East County	Between Isabel Ave. & Greenville Rd.	HOV/express lanes
Freeway (Tier 1)/ HOV	I-80	Between San Francisco-Oakland Bay Bridge Toll Plaza to Contra Costa county border	Integrated Corridor Management Project
Freeway (Tier 1)/ HOV	I-880 in South County	At SR 262 Interchange	Interchange reconstruction and new BART connection
Freeway (Tier 1)/ HOV	I-880 in North County	Near 5th Ave. in Oakland	Major Freeway work
Freeway (Tier 1)/ HOV	I-880 in Central County	Hegenberger to Marina	Southbound HOV lane
Freeway (Tier 1)	I-80 SFOBB EB (AM)	Bay Bridge (West span)	Long term maintenance works
Arterial (Tier 1)	SR 112 Davis St.	Between Doolittle Dr. and East 14th St.	Overcrossing replacement at I-880
Arterial (Tier 1)	Mowry Blvd.	Between Parkside Dr. to Bonner Ave.	Pavement work
Arterial (Tier 2)	Dougherty Rd.	At Mariposa Cir.	Construction of new signal
Arterial (Tier 2)	Fremont Blvd .	Between Mowry Ave. to Central Ave.	Pavement work

Incident hotspots observed were on freeways connecting to the Bay Bridge and San Mateo Bridge.

2.1.6 | Incidents

Incidents are generally expected to impact traffic conditions, and therefore data associated with incidents has been excluded. For floating car surveys, where the driver observed an incident, the floating car survey run was repeated. For commercial speed data, freeway incident data sets from PeMS were reviewed and the speed data records for the corresponding time period were removed across all the relevant CMP segments. **Figure 2-3** shows a heat map of freeway incidents using data from Freeway Performance Monitoring System (PeMS). Locations with higher densities of incidents are shown in red.

The heat map qualitatively indicates incident hot spots. Two notable hot spots in the county are at the intersection of State Route 92/I-880 and at the intersection of I-80/I-880/I-580. These locations with high incident density reported around 100 to 130 incidents in the vicinity during the monitoring period. Locations with medium incident density, such as around the intersection of I-580/I-680, or along I-880 and I-580 in Oakland, reported around 60 to 70 incidents each during the monitoring period. Other locations with low incident densities, such as around the intersection of I-580 and Vasco Road in Livermore or along Bay Bridge, reported less than 15 incidents during the monitoring period.

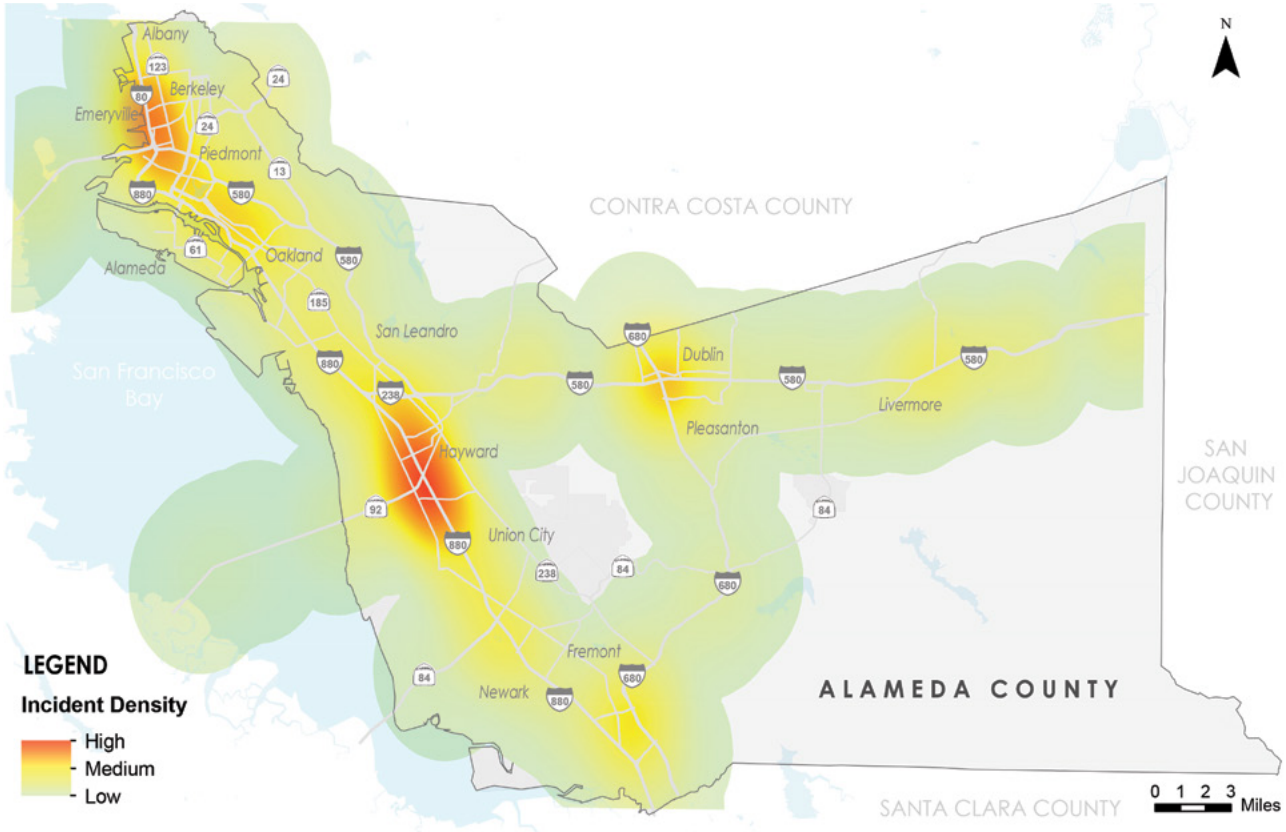


Figure 2-3: Incident Density Heat Map (Source: Freeway PeMS Incident Data)

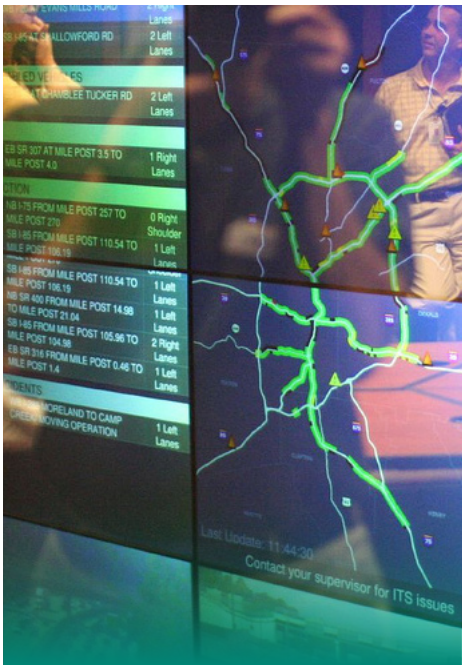
2.2 | Data Collection

As stated earlier, this is the first time that Alameda CTC used both commercial speed data and floating car surveys to measure average speed and LOS. **Table 2-2** summarizes the source of travel time data for each category of CMP segment.

Table 2-2: Summary of Data Collection Methods

CMP Category Network	Miles/#	2012 Data Collection	2014 Data Collection
Freeways (Tier 1)	140 miles	Floating car surveys	Commercial data[1]
Ramp and Special Segments (Tier 1)	23 connections	Floating car surveys	Commercial data[1]
Arterials (Tier 1)	99 miles	Floating car surveys	Floating car surveys
Arterials (Tier 2)	87 miles	Floating car surveys	65 miles Commercial data 25 miles Floating car surveys
HOV/Express Lanes	84 miles	Not monitored	Floating car surveys
Bridges	10 miles	From Caltrans/MTC	Commercial data
OD Surveys	10 routes	Floating car, transit and bike surveys	Floating car, transit and bike surveys

[1] Data for two segments collected using floating car surveys



2.2.1 | Commercial Speed Data

In 2013, MTC contracted with INRIX to obtain region-wide commercial speed data, and has made the data available free of charge to Congestion Management Agencies (CMAs) and other local governments for planning and monitoring purposes. This LOS Monitoring Study used the commercial speed data from INRIX, Inc through MTC's contract.

INRIX "aggregates traffic data from GPS-enabled vehicles and mobile devices, traditional road sensors and hundreds of other sources."[2]

Traffic data is reported by INRIX using discrete roadway links that are termed as Traffic Message Channels (TMCs). Each TMC link is associated with a unique ID represented by a nine-digit code, where each individual number in the TMC code describes a portion of the geography including country, direction of travel, and roadway segment. INRIX data contains speeds aggregated at one-minute level for each TMC code in the network. For the current monitoring period, data at one minute intervals was accessed for the selected monitoring times across all the identified TMCs in Alameda County. This resulted in a sample size of approximately 3,500 data points for the majority of CMP segments. **Appendix F** provides technical details about this data collection.

2.2.2 | Floating Car Survey Data

Where the coverage of commercial speed data was not adequate or results were not expected to be reliable, floating car surveys were used.

The floating car surveys were completed using GPS technology to determine the travel time between the start and end of each CMP segment. Six surveys were completed on the arterials (Tier 1/Tier 2) and HOV/express lanes. If congested segments (LOS F) were experienced in the afternoon and the route was subject to CMP conformity, then two additional runs were generally completed on the entire route. Data was coordinated with the local jurisdiction for two routes in Central County. **Appendix G** provides additional technical details on the floating car data collection effort.

2.2.3 | OD Surveys

Ten origin-destination pairs that reflect typical commute trips in Alameda County (between major residential areas and employment centers) have been monitored by auto and transit, and in one case bicycle, for comparability of travel by auto and alternative modes (**Appendix E**).

[2] INRIX website: http://inrix.com/trafficinformation.asp

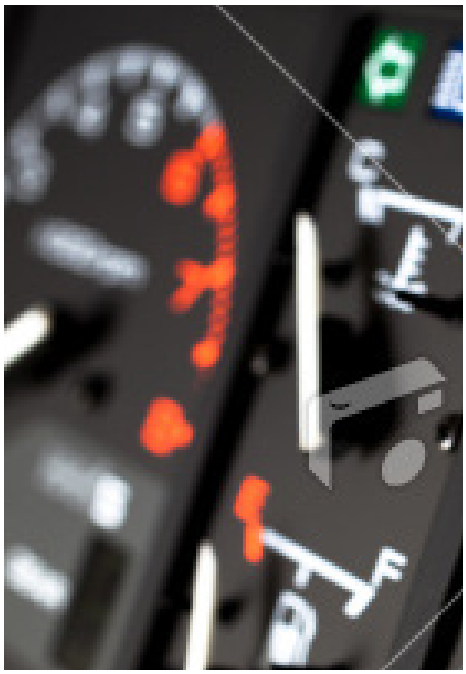
OD surveys were completed using:

- Floating car surveys for the auto and HOV component (4 runs);
- Transit passenger travel surveys for the transit component (2 runs); and
- Bike rider for the bicycle component (2 runs).

The OD routes were monitored either in the morning or afternoon peak depending on the peak direction of the route. Consistent with the general LOS monitoring procedure, Alameda CTC conducted surveys on Tuesdays, Wednesday and Thursdays during the monitoring period on two different days.

A number of surveyors traversed between the designated OD points, documenting their travel times. Transit trips were taken either on buses (AC Transit, UC Transit, VTA, or Wheels), rail (BART or ACE), or a combination of these modes. The bicycle trip was taken on local streets in Emeryville and Berkeley. Whenever necessary, the auto and transit trip started on the same day at the same time. These survey times included walking, waiting, parking and traveling times, as applicable.

2.2.4 | Free Flow Speed



Arterials (Tier 2) were added to the CMP network in 2012. While speed data was collected and reported for these roadways, LOS was not estimated. To estimate the LOS, arterials needed to be classified based on free flow speed surveys.

Therefore, in 2014, Alameda CTC measured free flow speeds on the Tier 2 network using either floating car surveys or commercial speed data. The same data source that was used to determine LOS of a particular arterial (Tier 2), as noted in **Section 2.2** was also used to collect free flow speed.

The times for the free flow speed surveys were chosen to ensure that travel was less impeded by other vehicles and not influenced by excessive speeding behavior (which is sometimes observed during the night when enforcement may be perceived to be lower). Floating car surveys consisted of four runs during these off peak times, and commercial speed data was obtained between 6:00 AM to 6:30 AM, and 8:00 PM to 9:00 PM. **Appendix H** includes additional information on the free flow speed analysis and how the classifications were determined.

2.3 | Data Analysis

The methodology for deriving the LOS from raw commercial speed and floating car survey data includes two key steps. The first step consists of converting the raw speed data into average peak period speeds on every CMP segment. The methodology differs between the two data sources for the conversion process. In the second step, average speeds are converted to estimate LOS using a specific method depending on the type of roadway.

2.3.1 | Calculate Average Peak Period Speed

The data processing steps for converting the raw speed data to average peak period speeds vary based on the source of data.

- **Commercial Speed Data:** Once collected from the INRIX database, the commercial speed data points were associated to the appropriate CMP segment through a spatial mapping process. Next, data outside the monitoring period and data with poor data quality were removed. To calculate the average speed for all the data points, the data was averaged on each CMP segment for each time period. See additional technical details in **Appendix F**.
- **Floating Car Survey Data:** Once the floating car survey data was collected using GPS units, it was processed to extract the average speed and travel time on each sub segment. It was then input into spreadsheets previously developed by Alameda CTC, which automatically calculate the average speed using the travel time and segment length for each CMP segment. **Appendix G** provides additional technical details.

2.3.2 | LOS Estimation

The next step in the analysis process was to assign LOS based on the average speeds calculated on each CMP segment. As adopted in the 2013 CMP, LOS is estimated for the entire CMP network based on HCM 1985 with the exception that arterial classified as Tier 2 will also be reported using HCM 2000 for comparison purposes. This study uses the LOS speed standards as shown in **Tables 2-3, 2-4** and **2-5**.

Table 2-3: Freeway LOS, HCM 1985

Level of Service	Speed (mph)	Density (pc/mi/ln[1])	V/C Ratio	Maximum Service Flow (pcphpl[2])
A	≥ 60	≤ 12	0.35	700
B	≥ 55	≤ 20	0.58	1,000
C	≥ 49	≤ 30	0.75	1,500
D	≥ 41	≤ 42	0.90	1,800
E	≥ 30	≤ 67	1.00	2,000
F	< 30	> 67	- [3]	-

Range for LOS F for Freeway Sections[4]
F30—Average Travel Speed <30
F20—Average Travel Speed <20
F10—Average Travel Speed <10

Source: Adapted from Table 4-1, Special Report 209, HCM 1985

[1] Density measured in passenger cars per mile per lane
[2] Maximum service flow under ideal conditions, expressed as passenger cars per hour per lane
[3] Highly variable, unstable flow; V/C Ratio is not applicable
[4] Approved by Alameda CTC on June 14, 2004 to show degrees of LOS F on congested roadways.

Table 2-4: Arterial LOS, HCM 1985

Arterial Class	I	II	III
Range of Free Flow Speed (mph)	45 to 35	35 to 30	35 to 25
Typical Free Flow Speed (mph)	40	33	27
Level of Service	**Average Travel Speed (mph)**		
A	≥ 35	≥ 30	≥ 25
B	≥ 28	≥ 24	≥ 19
C	≥ 22	≥ 18	≥ 13
D	≥ 17	≥ 14	≥ 9
E	≥ 13	≥ 10	≥ 7
F	< 13	< 10	< 7

Source: Table 12-1, Special report 209, HCM 1985

Table 2-5: Arterial LOS, HCM 2000

Arterial Class	I	II	III	IV
Range of Free Flow Speed (mph)	55 to 45	45 to 35	35 to 30	35 to 25
Typical Free Flow Speed (mph)	50	40	35	30
Level of Service	**Average Travel Speed (mph)**			
A	> 42	> 35	> 30	> 25
B	> 34-42	> 28-35	> 24-30	> 19-25
C	> 27-34	> 22-28	> 18-24	> 13-19
D	> 21-27	> 17-22	> 14-18	> 9-13
E	> 16-21	> 13-17	> 10-14	> 7-9
F	≤ 16	≤ 13	≤ 10	≤ 7

Source: Exhibit 15-2, HCM 2000 (U.S. Customary Units)

Freeways

Based on the average speed of the freeway in the morning and afternoon peaks and using the HCM standards as shown in **Table 2-3**, LOS was estimated for each CMP segment in each time period. For example, the I-80 eastbound segment between Ashby and University had an average speed of 61.5 mph during the morning peak, which is LOS A based on the adopted standards.

Ramps and Special Segments

Based on the suggested guidelines from the HCM, LOS A is deemed to occur when vehicles are traveling at a free-flow speed for the given roadway conditions. LOS F is estimated to occur when speeds have dropped below 50%

of the free flow speeds. Levels of Service B to E are calculated at even intervals between free flow speeds and LOS F speeds. There is one ramp segment that is classified as a weaving segment and is therefore not assigned a LOS. The performance of this segment can be judged on its average speed.

Arterials

Both HCM 1985 and 2000 methods first require classification of the arterial according to its free flow speed and other road characteristics. The road classification based on HCM 1985 could be Class I, II or III and based on HCM 2000 it could be Class I, II, III or IV. For Tier 1, the classification was previously determined and was obtained from previous LOS monitoring reports. For Tier 2, the classification was determined for the first time in 2014 using the typical free flow speed of the road in light traffic conditions as described in **Section 2.2.4**.

Using the classification of the street and the average travel speed, and based on relevant HCM standards as shown in **Tables 2-4** and **2-5**, LOS for the arterial segment is determined for both HCM methodologies. For example, Broadway southbound (between Grand Avenue and 14th Street) had an average speed of 18.3 mph during the morning peak. It was classified as HCM 1985 Class III and therefore assigned a LOS C. Using HCM 2000, it was classified as Class IV and assigned a LOS C again.

Rural Roadways

A few of the Tier 1 and Tier 2 CMP routes (mostly located in the east county) are rural roadways and require a special analysis procedure. Traffic and speed characteristics are fairly uniform on these roadways. Variations in speed are a function of roadway curvature and the presence of slow trucks in the traffic stream. One such Tier 1 roadway is State Route 84 between the southern city limit of Livermore and Mission Boulevard in Fremont. Rural roadways identified in the Tier 2 network include a portion of Vasco Road in Livermore and a part of Crow Canyon Road, both connecting to the county line.

To be consistent with the methodology used in the prior monitoring cycle, based on guidelines from HCM 1985, LOS A is deemed to occur when vehicles are traveling near the free-flow speed for the given roadway conditions. LOS F is estimated to occur when speeds have dropped below 50% of the free flow speeds. Levels of Service B to E are calculated at even intervals between free flow speeds and LOS F speeds. This is adapted from **Table 8-1**, HCM 1985. Based on this methodology, LOS is calculated for rural roadways (both Tier 1 and Tier 2) for the current monitoring cycle.

HCM 2000 presents a different methodology for estimating LOS for rural roadways. Compared to the above methodology that estimates LOS, using observed speed with reference to the free flow speed, HCM 2000 has absolute speed cut off points that assume a single category of rural roadways (**Table 2-6**). When these

cut offs were applied to the 2014 arterial (Tier 2) data, it was apparent that the HCM 2000 methodology was not appropriate for lower speed rural roadways. For example, Vasco Road, with a speed limit of 45 mph could never achieve LOS A, B or C conditions without drivers exceeding the speed limit. Yet, in reality, this rural roadway would most certainly experience free flowing conditions (normally termed LOS A) during certain off peak times. Later versions of the HCM have been modified to accommodate this situation. They now include multiple categories of rural roadway to recognize both higher and lower speed limits. Since only 12% of these arterials are classified as rural roadways, the LOS calculation per HCM 2000 is not reported for rural roads in the current monitoring cycle. These methodologies may be considered in future versions of this LOS Monitoring Report.

Table 2-6: Rural Roadway LOS, HCM 2000

LOS	Average Travel Speed (mph)
A	> 55
B	> 50 - 55
C	> 45 - 50
D	> 40 - 45
E	≤ 40

Source: Exhibit 20-2, HCM 2000 (U.S. Customary Units)