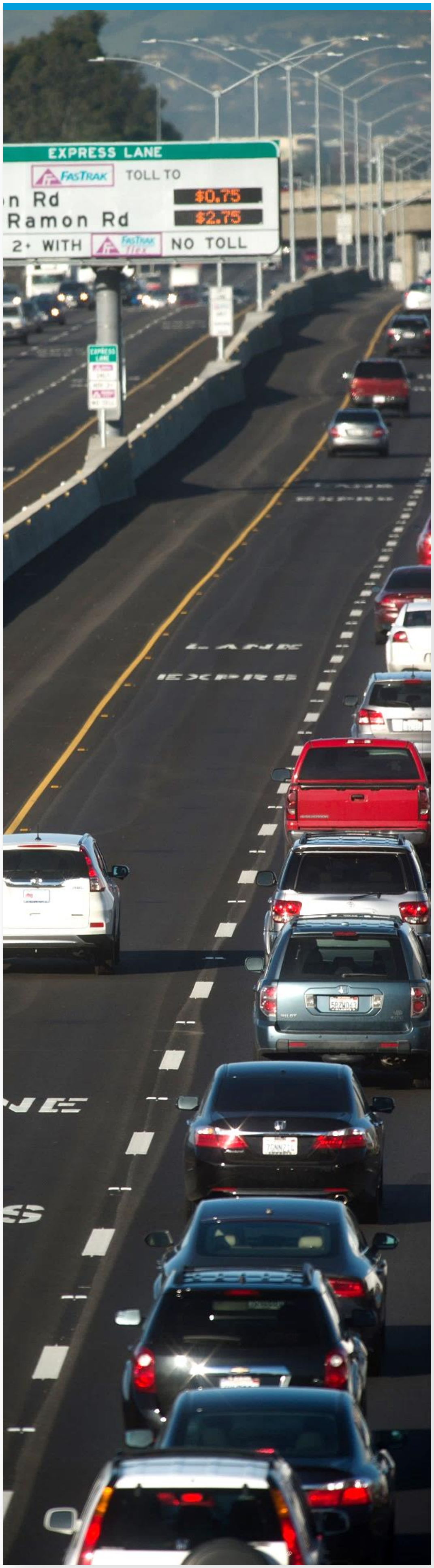

I-580 Express Lanes After Study: Report to the California State Legislature

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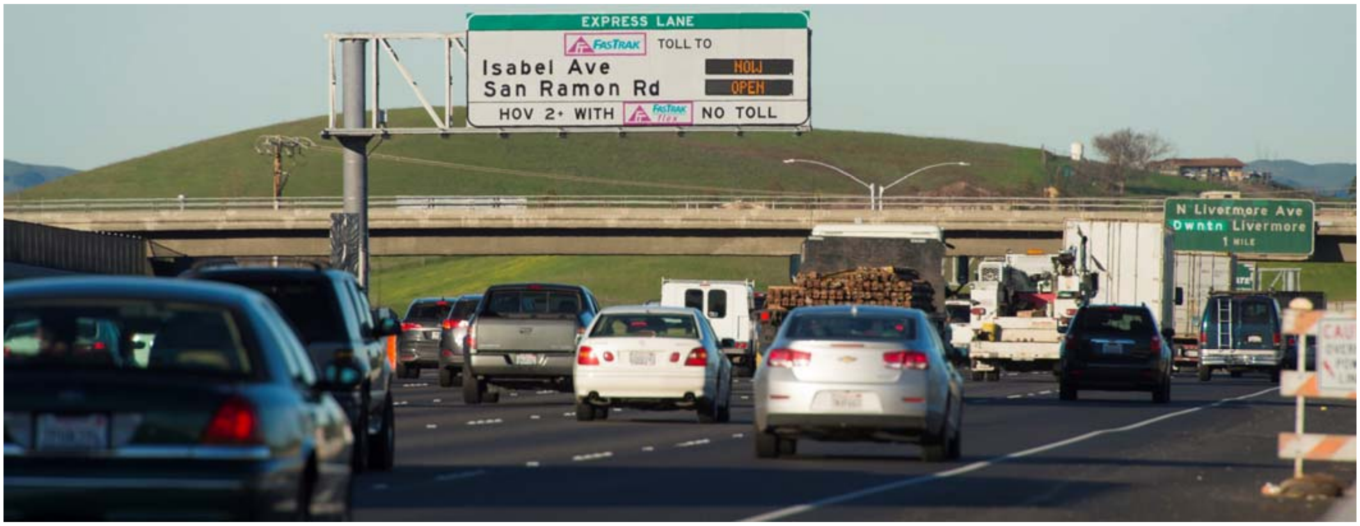


Initial opening days of Interstate 580 Express Lanes.

Executive Summary

In February 2016, the Alameda County Transportation Commission (Alameda CTC) opened the I-580 Express Lanes in eastern Alameda County through the Dublin-Pleasanton-Livermore area. Assembly Bill 2032 (Dutra) authorized Alameda CTC to build and operate these lanes and also required an "after" study of the project to be submitted to the Legislature within three years following the opening of the facility.

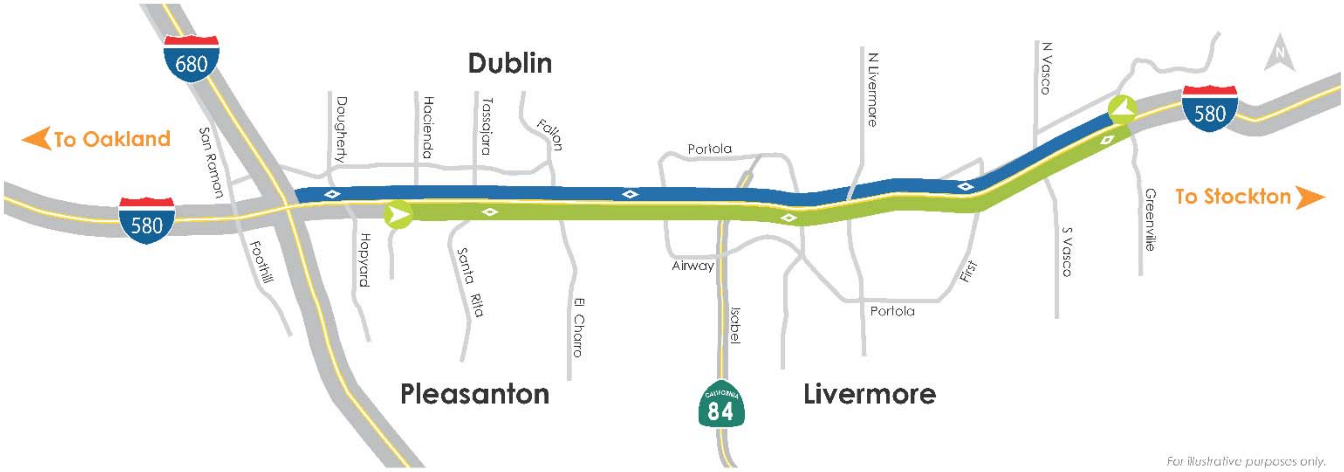
The I-580 Express Lanes After Study Report to the Legislature assesses the effectiveness of the I-580 Express Lanes against a set of evaluation measures and project goals. The evaluation focuses on changes in performance between the "before" conditions of spring 2015 (one year prior to the opening of the lanes) and spring 2018 (two years following the opening). Overall, the I-580 Express Lanes improved mobility and reliability across all lanes within the express lanes corridor during a period of increasing travel demand along the corridor.

Background

Alameda CTC is the project sponsor and operating agency of the I-580 Express Lanes, which were opened to traffic in 2016 on February 19th (in the eastbound direction) and February 22nd (in the westbound direction). The I-580 express lane corridor is the second of two corridors authorized by AB 2032 for express lane operations in Alameda County and is the first continuous-access express lane facility in California. Prior to construction of the I-580 Express Lanes, the only managed lane facility on I-580 was an eastbound high occupancy vehicle (HOV) lane between Hacienda Drive and Greenville Road that opened in November 2010.

In the westbound direction, the I-580 Express Lanes extend from Greenville Road in Livermore to just east of the I-680 overcrossing in Dublin, and in the eastbound direction, the express lanes extend from Hacienda Drive in Pleasanton to Greenville Road in Livermore. The project limits are shown in Figure ES-1.

Figure ES-1: I-580 Express Lanes Project Limits



In the westbound direction, the project constructed a 12.1 mile, single express lane facility from Greenville Road to just east of the I-680 overcrossing. The majority of the westbound facility is continuous access with the exception of a buffered portion from Hacienda Drive to the I-680 overcrossing.

In the eastbound direction, the 10.2 mile express lanes converted the existing HOV lane from Hacienda Drive to Greenville Road to an express lane and constructed a second eastbound express lane from El Charro Road to Vasco Road. The eastbound express lanes have near-continuous access, with a single-lane buffered section between Hacienda Drive and El Charro Road. East of El Charro Road the express lanes expand into a two-lane continuous access facility until approximately ¼ mile west of Vasco Road where the express lanes are reduced to a single-lane, but still maintain the continuous-access configuration to the end of the facility at Greenville Road.

Project Goals

Based on the environmental documents for the I-580 Express Lanes and the authorizing legislation, seven goals were identified for purposes of this evaluation. These goals were reviewed by the California Department of Transportation (Caltrans). The goals for the I-580 Express Lanes include the following:

- Provide congestion relief.
- Project enhanced operational and safety improvements.
- Expand available capacity for HOVs.
- Expand the mobility options in the corridor.
- Provide reliable travel time savings to express lane users.
- Increase the efficiency of the transportation system by charging single occupant vehicles for use of available capacity without impacting carpool lane operations.
- Maintain Level of Service (LOS) C in the express lanes.

Evaluation Approach

From the project goals, several evaluation measures were developed and assessed for the "before" and "after" conditions. Data collection and analysis included available existing data, automated data sources, and field observations. Evaluation measures are reported for the "express lane corridor", reflecting the limits in Figure ES-1.

The "before" condition is based on data from spring 2015 (March through May). Data for the "after" condition were collected in spring 2018 over the same three months. Given the high degree of travel demand directionality in the corridor, results are generally reported for the two peak demand directions (westbound AM peak period or eastbound PM peak period), unless otherwise noted. The peak period in the westbound direction is 5 AM to 10 AM and the peak period in the eastbound direction is from 3 PM to 7 pm.

Throughout the evaluation process, Alameda CTC coordinated with Caltrans and CHP to present findings and seek their input.

Findings and Conclusions

Overall, the I-580 Express Lanes project reduced travel times, mitigated or eliminated bottlenecks, and increased travel time reliability over a period of time when the corridor experienced a significant increase in vehicle travel. The key findings of the study include the following:

- Daily traffic volumes have increased by 2 to 4% per year in the express lane corridor yet the project has reduced peak period travel times by 20 to 30% and improved reliability by up to 33% compared to the "before" condition of spring 2015.

- As of spring 2018, travel within the express lanes is also up to 4 minutes faster than the adjacent general purpose lanes and is more reliable as indicated by lower variations in travel times. These mobility benefits have led to a high growth in use of the express lanes. Between 2017 and 2018, the number of daily vehicles in the express lanes increased by 14% in the westbound direction and 11% in the eastbound direction.

- The project added capacity for carpools and single occupant vehicles which has enabled a higher number of vehicles and people to travel the corridor during the peak periods. Vehicle throughput increased in both peak directions across all lanes and person throughput generally increased where the project added HOV capacity, especially in the westbound AM peak period. Average vehicle occupancy declined slightly after implementation of the express lanes, which is consistent with findings related to express lane performance across the state.

The I-580 Express Lanes project met nearly all of its goals with one goal being met partially. Table ES-2 summarizes overall findings from the evaluation. A green check mark indicates meeting the goal while a yellow check mark indicates the project partially met the goal.

Table ES-1: Project Goals and Related Evaluation Measures

	Project Goals	Did the Project meet its Goals?	
1	Provide congestion relief.	✓	The project reduced overall travel times in the westbound AM peak direction by 5 minutes (28%) and in the eastbound PM peak direction by 3 minutes (19%). Annual vehicle hours of severe delay[1] decreased by 151,000 vehicle-hours (47%).
2	Provide enhanced operational and safety improvements.	✓ (yellow)	The project removed bottlenecks and reduced queuing from El Charro Road to Greenville Road in both directions. Total collisions and the number of fatal and injury collisions per million vehicle-miles traveled increased in the express lane corridor at similar rates as across Alameda County freeways and an I-880 comparison corridor. Over the last year, the severe collision rate decreased by approximately 5% in the express lane corridor.
3	Expand available capacity for HOVs.	✓	The project added carpool capacity in both directions in the form of a new express lane in the westbound direction and a new express lane in the eastbound direction.
4	Expand the mobility options in the corridor.	✓	Express lanes are faster and more reliable than the adjacent general purpose lanes, creating an attractive mobility option in the corridor.
5	Provide reliable travel time savings to express lane users.	✓	Express lanes provide 2-4 minutes faster travel time than general purpose lanes on average. The variation of travel times is also lower in the express lanes than the general purpose lanes.
6	Increase the efficiency of the transportation system by charging single occupant vehicles for use of available capacity without impacting carpool lane operations.	✓	The project improved travel time and reliability across all lanes during the AM and PM peak periods. The corridor carries 27-30% more vehicles in the AM peak period and up to 12% more vehicles in the PM peak period in the eastbound direction.
7	Maintain Level of Service (LOS) C in the express lanes.	✓	The express lanes operate at LOS C in the AM and PM peak hours[2]. During other operational hours the express lanes operate at LOS C or better.

Notes

1. Severe delay is considered to occur when average speeds are slower than 35 mph.
2. Per Caltrans standard methodology, LOS was estimated for the peak hours which are 8 AM to 9 AM for the AM peak hour and 5 PM to 6 PM for the PM peak hour.

1. Introduction

In February 2016, the Alameda County Transportation Commission (Alameda CTC) opened the I-580 Express Lanes project in eastern Alameda County through the Dublin-Pleasanton-Livermore area. Assembly Bill (AB) 2032 (Dutra) authorized Alameda CTC to build and operate these lanes and also required an "after" study of the express lanes to be submitted to the state legislature within three years of the opening of the express lanes.

The I-580 Express Lanes After Study Report to the Legislature presents the findings and conclusions on performance of the I-580 Express Lanes and primarily focuses on changes in corridor performance between the spring of 2015 (one year prior to the opening of the express lanes) and 2018 (two years following the opening of the express lanes). Throughout the evaluation process, Alameda CTC coordinated with Caltrans and CHP to present findings and seek their input.

1.1 Organization of the Report

This report is divided into the following sections:

- **Background** provides an overview of the Alameda CTC and its role as the project sponsor and operator of the I-580 Express lanes. The project background is presented along with a description of the corridor.
- **Evaluation Approach** presents the performance measures used for the evaluation and briefly discusses the methodology and data collected for conducting the evaluation.
- **Evaluation Results** presents the outcomes of the evaluation and key findings.
- **Conclusions** presents key findings identified as a result of the evaluation.

Appendix A presents more detailed information on the evaluation approach and data used for the analysis.

2. Background

Alameda CTC is the project sponsor and operating agency of the I-580 Express Lanes, which were opened to traffic in 2016 on February 19th (in the eastbound direction) and February 22nd (in the westbound direction).

The I-580 corridor is the second of two corridors authorized by AB 2032 for express lane operations in Alameda County. AB 2032 requires an "after" study to be completed no later than three years after the project opened to traffic and is codified in law as Streets and Highways Code Section 149.5 (g), which states:

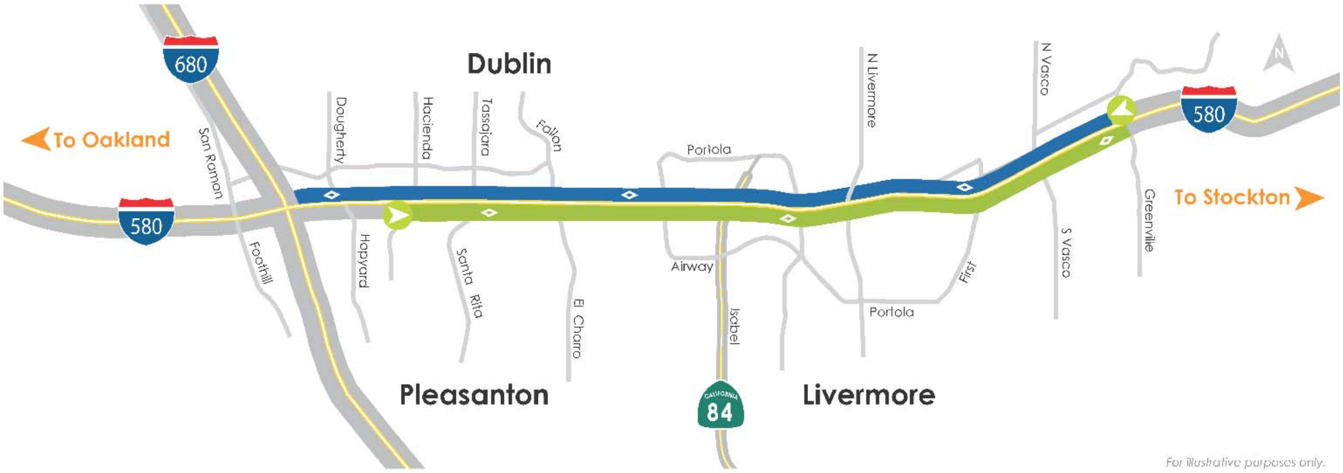
> *Not later than three years after the administering agency first collects revenues from the program authorized by this section, the administering agency shall submit a report to the Legislature on its findings, conclusions, and recommendations concerning the demonstration program authorized by this section. The report shall include an analysis of the effect of the HOT lanes on the adjacent mixed-flow lanes and any comments submitted by the department and the Department of the California Highway Patrol regarding operation of the lane.*

2.1 Project Description

The I-580 express lane corridor is the second of two corridors authorized by AB 2032 for express lane operations in Alameda County and is the first continuous-access express lane facility in California. The first express lane corridor in the county opened in 2010 on I-680 in the southbound direction from State Route 84 south of Pleasanton to State Route 237 in Milpitas. Prior to construction of the I-580 Express Lanes, the only managed lane on I-580 was an eastbound high occupancy vehicle (HOV) lane between Hacienda Drive and Greenville Road that opened in November 2010.

In the westbound direction, the I-580 Express Lanes extend from Greenville Road in Livermore to just east of the I-680 overcrossing in Dublin, and in the eastbound direction, from Hacienda Drive in Pleasanton to Greenville Road in Livermore. The project limits are shown in Figure 1.

Figure 1: I-580 Express Lanes Project Limits



The I-580 Express Lanes have been implemented with several geometric configurations, including a single lane with buffered access, a single lane with continuous access, and two lanes with continuous access, as shown on Figure 2.

In the westbound direction, the project constructed a 12.1 mile near-continuous access express facility from Greenville Road to just east of the I-680 overcrossing. Most of the westbound facility provides single-lane continuous access as shown in Figure 2, with the exception of a single-lane buffered portion from Hacienda Drive to the I-680 overcrossing.

In the eastbound direction, the project constructed a 10.2 mile facility with near-continuous access. The facility has a single-lane buffered section between Hacienda Drive and El Charro Road, as shown in Figure 2. East of El Charro Road, the express lanes include a two-lane continuous access facility until approximately ¼ mile west of Vasco Road where the express lanes become a single-lane with continuous access to Greenville Road.

Figure 2: I-580 Express Lanes Geometric Configurations

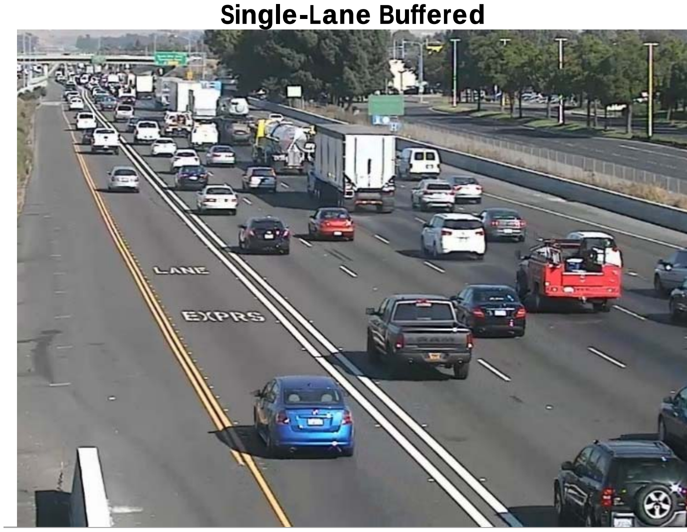
Westbound Direction

Single-Lane Continuous Access

Single-Lane Buffered

Eastbound Direction

Single-Lane Buffered



Two-Lane Continuous Access

Single-Lane Continuous Access

Source: Alameda CTC.

The project was constructed in several phases and included multiple components as follows:

- Eastbound auxiliary Lanes between the Isabel Avenue interchange and the North Livermore Avenue interchange and between the North Livermore Avenue interchange and the North First Street interchange (opened in 2014).
- Eastbound conversion of the existing HOV lane to an express lane from Hacienda Drive to Greenville Road, and construction of a second express lane from El Charro Road to around North First Street (opened in February 2016).
- Westbound express lane from Greenville Road to just east of the I-680 overcrossing (opened in February 2016).

A separate Caltrans project constructed an eastbound truck climbing lane from Greenville Road to one mile east of the North Flynn Road interchange that opened for use on June 30, 2016.

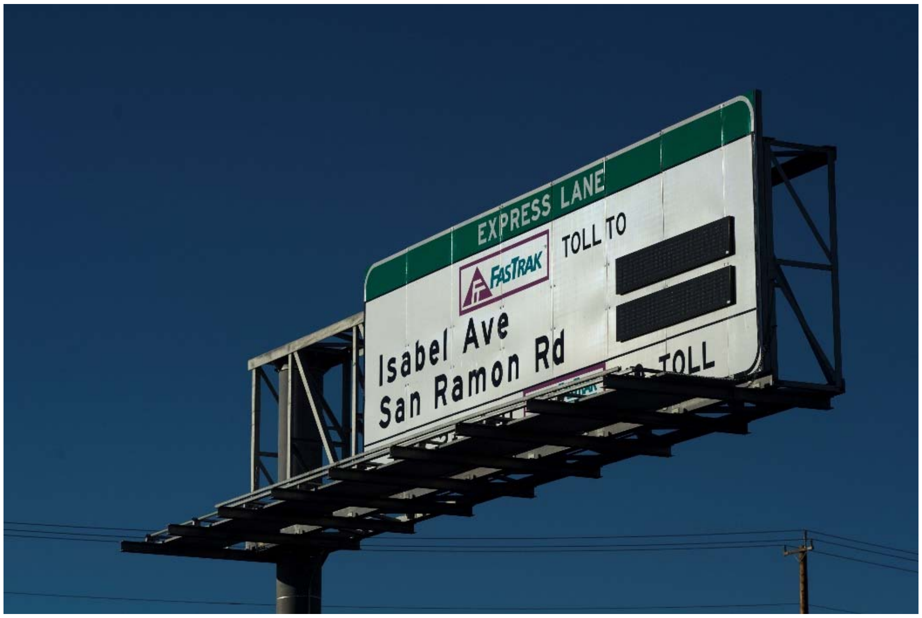
2.2 Current Express Lane Operating Parameters

The I-580 Express Lanes are operational Monday through Friday between the hours of 5 AM and 8 PM. Outside of these hours, the lanes are open to all vehicles at no charge. All vehicles using the express lanes during operational hours must have a valid FasTrak account and may use the lanes subject to the following restrictions:

- Carpools with a FasTrak Flex toll tag set to “2” or “3+” to indicate vehicle occupancy may travel toll free.
- Single occupancy vehicles (SOVs) may pay a toll to use the express lanes and must use a standard FastTrack or bumper tag or a FastTrack Flex (i.e., switchable) toll tag set to “1”.
- Clean Air Vehicles (CAVs) with qualifying California Department of Motor Vehicles (DMV) stickers and FasTrak Flex toll tag set to “2” or “3+” may travel toll-free.
- Motorcycles with a FasTrak Flex toll tag set to “2” or “3+” may travel toll-free.
- Transit Vehicles with a FasTrak Flex toll tag set to “2” or “3+” may travel toll-free.

The overhead sign, shown in Figure 3, indicates dynamic pricing within the corridor and includes the toll amount to travel to the next zone represented by the top display of the sign. In this example, the next zone is “Isabel Ave”. The price to travel to the end of the express lane is shown in the bottom display, which is to San Ramon Road in the westbound direction. Toll prices are dynamic, which means they vary based on congestion levels and can change every 3 minutes. Customers are locked in to a toll rate controlled by the overhead sign prior to location of entry. The locked-in rate does not change if the price goes up or down while the customer is still in the express lane.

Figure 3: I-580 Westbound Express Lanes Toll Gantry Sign



Source: Alameda CTC.

3. Express Lane Project Goals and Evaluation Performance Measures

Based on the environmental documents for the I-580 Express Lanes project and the authorizing legislation for express lanes in California described above, the following seven goals were identified for purposes of this evaluation and were reviewed by Caltrans:

1) Provide congestion relief.
2) Provide enhanced operational and safety improvements.
3) Expand available capacity for HOVs.
4) Expand the mobility options in the corridor.
5) Provide reliable travel time savings to express lane users.
6) Increase the efficiency of the transportation system by charging single occupant vehicles for use of available capacity without impacting carpool lane operations.
7) Maintain Level of Service (LOS) C in the express lanes.

To evaluate if the project addressed these goals, evaluation measures were established in coordination with Caltrans and CHP to perform the analysis documented in this report. The evaluation measures are listed in Table 1.

Table 1: Project Goals and Related Evaluation Measures

Project Goals		Evaluation Measures
1	Provide congestion relief	Travel Time Bottlenecks and Queues Level of Service Delay
2	Provide enhanced operational and safety improvements	Travel Time Bottlenecks and Queues Level of Service Collisions
3	Expand available capacity for HOVs	Roadway capacity[1]
4	Expand the mobility options in the corridor	Travel Time by Lane Traffic Volume by Lane Level of Service by Lane Transit Ridership
5	Provide reliable travel time savings to express lane users	Reliability by Lane Travel Time by Lane
6	Increase the efficiency of the transportation system by charging single occupant vehicles for use of available capacity without impacting carpool lane operations	Vehicle and Person Throughput Level of Service Travel Time Average Vehicle Occupancy/Classification
7	Maintain Level of Service (LOS) C in the express lanes.	Level of Service

[1] Roadway capacity is discussed in the definition of the project. The project added carpool capacity in both directions in the form of a new express lane in the westbound direction and a new express lane in the eastbound direction.

4. Evaluation Approach and Data Collection

The project evaluation compared before and after conditions using the evaluation measures discussed in the previous section. Data collection and analysis included existing data, automated sources for measures such as travel times and reliability, and observations in the field for measures such as vehicle occupancy. Other public agency data from the state and local transit operators were used where needed. Evaluation measures are reported for the "express lane corridor", which extends from Greenville Road to the I-680 overcrossing in the westbound direction and from Hacienda to Greenville Road in the eastbound direction.

The evaluation measures were grouped into evaluation categories for reporting purposes. The following categories are used throughout the report to organize the findings and report on the goals as listed in Table 14:

- **Travel Demand Profile** reports on corridor travel demand trends and includes measures that represent factors that potentially influence how many vehicles and people use the express lanes corridor, which directly affects measures related to Goals 1, 2, 4, 5, and 6.
- **Mobility** measures assess how the corridor addressed Goals 1, 2, 4, 5, 6, and 7 relating to congestion relief, travel time savings, mobility options, and LOS.
- **Use & Productivity** measures assess how well the corridor is being utilized by several modes such as transit or carpooling, which is related to Goals 4 and 6.
- **Reliability** is a measure that captures the extent of unexpected delays that can occur on a freeway. While average travel times can give an indication of congestion levels, reliability metrics quantify the frequency of extreme travel times that travelers remember, which is related to Goal 5.
- **Safety** measures assess how collisions on the express lanes corridor have changed over time, which is related to Goal 2.

To compare "before" and "after" results, the study team determined the peak period by direction and calculated measures for those time periods. Given the high degree of directionality in the corridor, results are generally reported for either the westbound AM peak period (5 AM to 10 AM) or eastbound PM peak period (3 PM to 7 PM). To meet federal or state reporting standards for the Level of Service and express lane degradation measures, the peak hour was used, defined as 8 AM to 9 AM in the westbound direction and from 5 PM to 6 PM in the eastbound direction. Other measures, such as traffic volumes, were evaluated on an annual basis to identify long-term trends.

The "before" condition include data primarily for non-holiday, mid-week days (Tuesday-Thursday) during the spring of 2015 (March through May). "After" condition data were collected in spring 2018 during the same time periods and months as in 2015.

Table 2 presents the evaluation measures used in this study and shows the data sources used to calculate each measure by facility type and for the "before" and "after" conditions. As required by the authorizing legislation for the express lanes, AB 2032, the express lanes and adjacent general purpose lanes were evaluation as part of this study. More details on the evaluation methodology and field data collection can be found in **Appendix A**.

Table 2: Performance Measures Category, Evaluation Measures, and Data Sources

Evaluation Categories and Measures	Facility Type	Data Sources	
		"Before" (Spring 2015)	"After" (Spring 2018)
Travel Demand Profile			
Traffic Volumes	All Lanes: I-680 to County Line	Caltrans Traffic Census, 2013-2018	
	Express Lanes	n/a	Alameda CTC Electronic Toll System (ETS)
Vehicle Miles Traveled (VMT)	All Lanes: I-680 to County Line	Caltrans Traffic Census, 2013-2018	
	Express Lanes	n/a	Alameda CTC ETS
Mobility			
Travel Times	All Lanes	Inrix	Inrix
	Express/General Purpose	Field Data Collection	Field Data Collection, Alameda CTC ETS
Bottlenecks and Queueing	All Lanes	Inrix	Inrix
Vehicle Hours of Delay	All Lanes	Alameda CTC ETS, PeMS	Alameda CTC ETS
Person Hours of Delay	All Lanes	Alameda CTC ETS, PeMS, Field Data Collection	Alameda CTC ETS, Field Data Collection
Level of Service	Express Lanes	n/a	Alameda CTC ETS
Degradation	Express Lanes	n/a	Alameda CTC ETS
Use & Productivity			
Vehicle Occupancy	All Lanes	Field Data Collection	Field Data Collection
Transit Ridership	Tri-Valley BART Stations	Provided by transit operators	
	LAVTA Routes		
Vehicle Throughput	All Lanes	Field Data Collection	Field Data Collection
Person Throughput	All Lanes		
Reliability			
Planning Time	All Lanes	Inrix	Inrix
	By Lane	n/a	Alameda CTC ETS
Safety			
Total Collisions	All Lanes	SWITRS, 2006-2017	
Severe Collisions per Million VMT	All Lanes	SWITRS, Caltrans Traffic Census; 2006-2017	

Field Data Collection

Hourly probe vehicle runs were performed for the express lane facility, the general purpose lane adjacent to the express lanes, and the general purpose lane adjacent to the truck climbing lane. Hourly floating car runs[2] were conducted for non-holiday, mid-week days for the weeks of April 17-19, 2018 and May 15-17, 2018.

Vehicle classification and passenger occupancy counts were conducted using field observations at two locations along the express lanes corridor:

- Tassajara/Santa Rita Road overcrossing
- Isabel Avenue/Airway Boulevard overcrossings.

Vehicles were classified and counted for two mid-week days at each location for the following categories: SOV, High Occupancy Vehicle with two people (HOV2), High Occupancy Vehicle with 3 or more persons (HOV3+), Vanpool, Transit Bus, Corporate/Casino Shuttle, Motorcycle, or Truck.

[2] The probe vehicle data collection method, also known as the floating vehicle method, uses cars equipped with Global Positioning System (GPS) devices that drive at regularly spaced intervals along the study corridor. Computer software identifies the direction of travel, travel times, and average speeds of each vehicle used in the analysis.

5. Evaluation Results

Overall, the I-580 Express Lanes project reduced travel times, reduced bottlenecks, and increased travel reliability over a period of time when the corridor experienced a significant increase in vehicle travel. The express lane corridor is also carrying more vehicles and people compared to spring 2015. As of spring 2018, travel within the express lanes is faster and more reliable than the adjacent general purpose lanes.

This section presents the detailed findings for the I-580 Express Lanes evaluation. Each performance category and specific measure identifed in Sections 3 and 4 are presented and key findings are discussed.

5.1 Travel Demand Profile

Summary of Key Findings

Overall demand for travel has been increasing on the I-580 corridor over the past several years with the express lanes carrying much of this additional demand. Increases in population and employment in the Tri-Valley area of Alameda and Contra Costa counties as well as strong economic growth in the San Francisco Bay Area has contributed to the increases in person travel on the corridor.

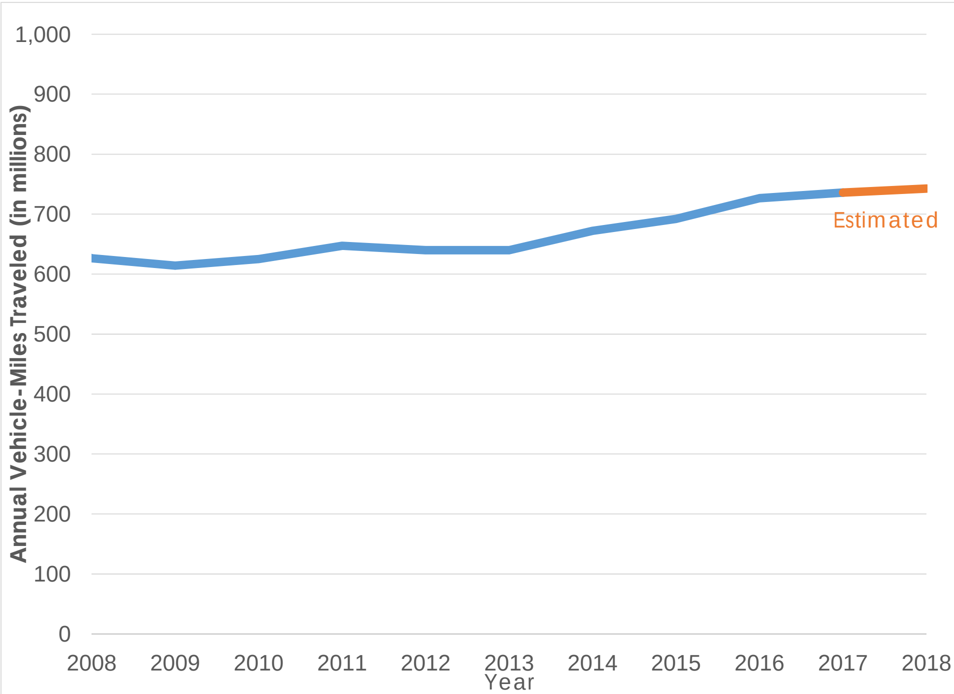
Travel demand on the express lane corridor influences how well the project performs in terms of mobility, productivity, reliability, and safety. Two measures were used for this assessment: Vehicle Miles Traveled (VMT) and daily traffic volumes.[3]

5.1.1 Vehicle Miles Traveled

Annual VMT on the express lane corridor has grown over the past decade as illustrated in Figure 4. The economic recession that lasted from around 2007 to 2009 caused a decline in vehicular traffic during that time. However, VMT has increased by an average of 3% per year on the corridor since the downturn ended in 2009. By 2018, annual VMT is estimated to exceed 740 million annual VMT in comparison to 692 million VMT in 2015, the year prior to the opening of the I-580 Express Lanes.

[3] Caltrans reports Average Annual Daily Traffic (AADT) which is an estimated of total annual traffic volume divided by 365 days. The Alameda CTC ETS reports traffic volumes during express lane operational hours from 5 AM to 8 PM and is reported in this evaluation report as Average Daily Traffic (ADT) during operational hours.

Figure 4: Express Lane Corridor Annual Million Vehicle-Miles Traveled



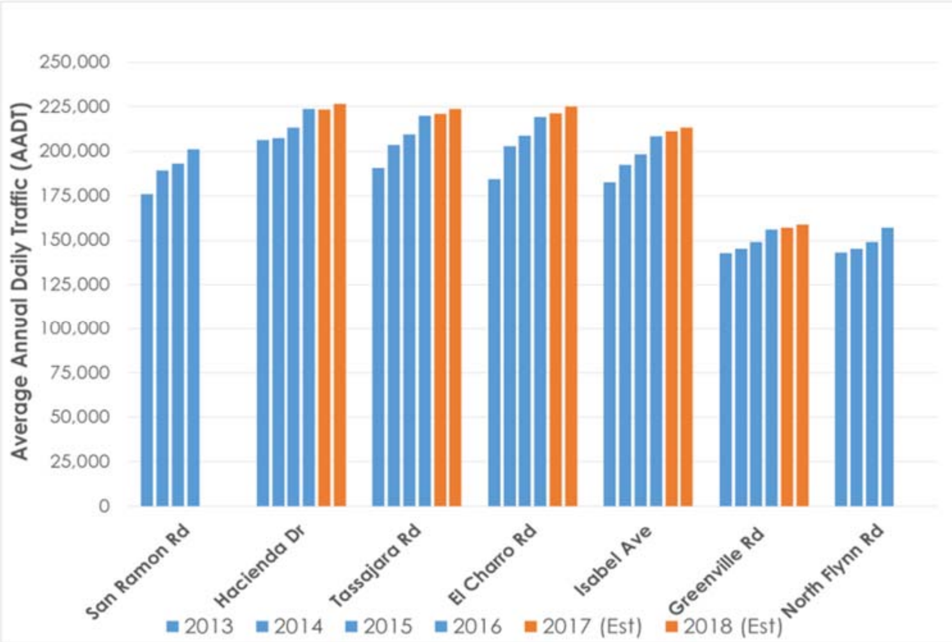
Sources: Caltrans Traffic Census (2013-2016). Estimates from Alameda CTC ETS Data (2017-2018).

5.1.2 I-580 Corridor Traffic Volumes

The I-580 corridor carries some of the highest traffic volumes in Alameda County and has experienced high growth rates over the past several years following the end of the recent economic recession. Figure 5 shows bi-directional Average Annual Daily Traffic (AADT) at select locations along, and adjacent to the express lanes using data from Caltrans for years 2013-2016 and from Alameda CTC's toll sensors for estimates of AADT for 2017 and 2018.

Daily volumes between Hacienda Drive and Isabel Avenue are around 225,000 vehicles in 2018. Daily volumes at Foothill/San Ramon Road, west of the express lanes and the I-680 interchange, were estimated to be around 200,000 vehicles in 2018. Beyond the Tri-Valley on the Altamont Pass, I-580 carries just under 160,000 vehicles. Volumes for Foothill/San Ramon Road and at North Flynn Road in 2017 and 2018 were not estimated since these two locations are outside of the express lane facility.

Figure 5: Average Annual Daily Traffic (AADT) at Select Locations



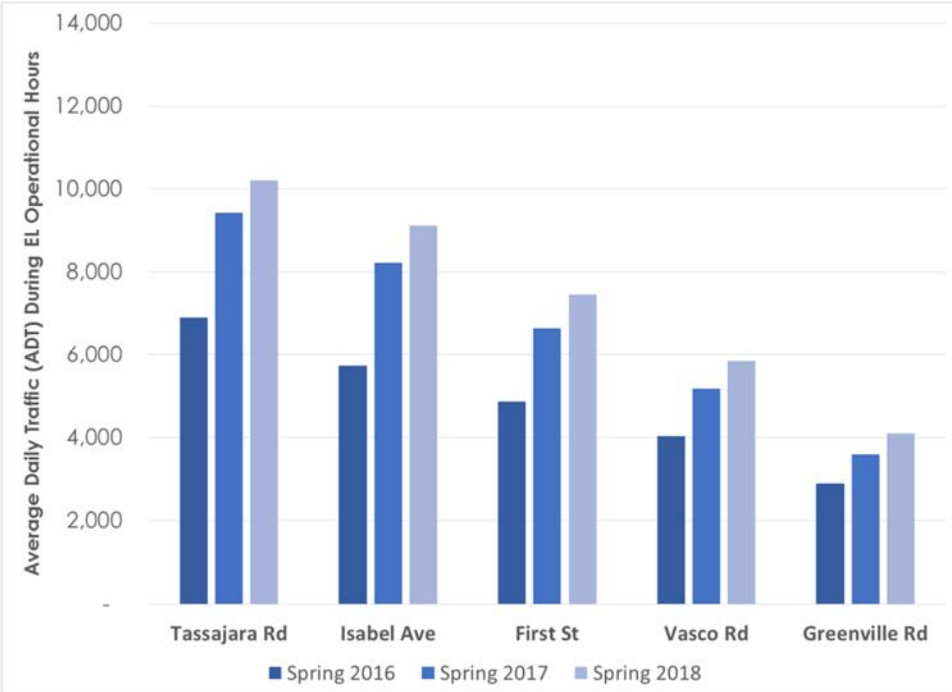
Sources: Caltrans Traffic Census (2013-2016). Estimates from Alameda CTC ETS Data (2017-2018).

Traffic volumes on the corridor have grown by 2 to 4% per year over the past 5 years since 2013. Volumes at El Charro/Fallon Road, which is in the middle of the express lane corridor, grew by approximately 4.1% per year between 2013 and 2018. Santa Rita/Tassajara Road and Isabel Avenue both grew at similar 3.3% and 3.2% annual rates, respectively over the same 5-year period. Evaluating volume data from 2017 suggests that traffic growth is slowing to around 2% per year.

5.1.3 I-580 Express Lanes Traffic Volumes

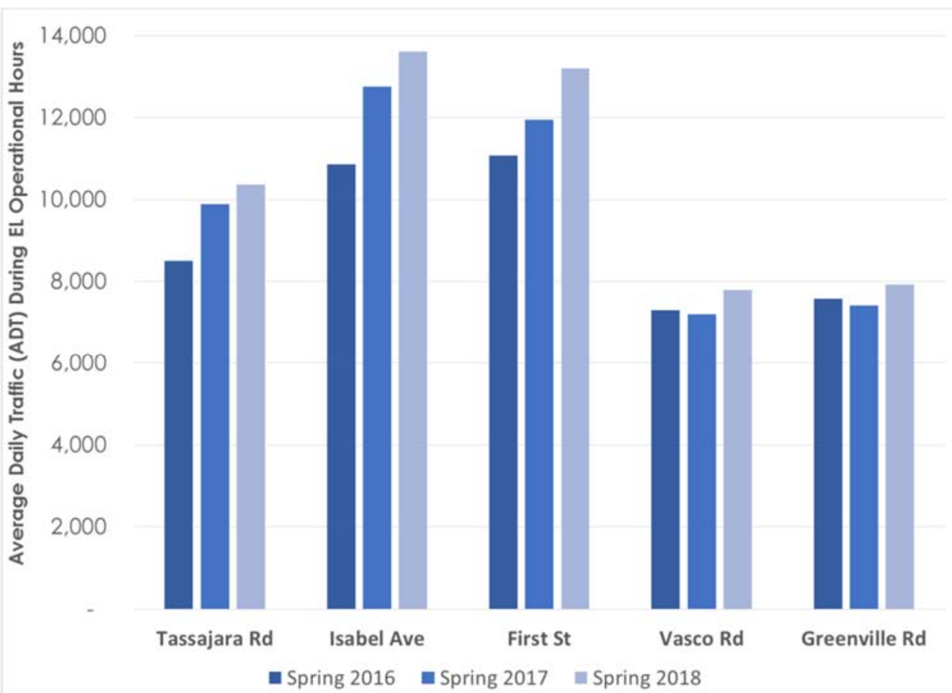
While traffic volumes have increased overall on the corridor, most of this additional demand has been accommodated by the express lane facilities rather than on the adjacent general purpose lanes. Figures 6 and 7, show daily traffic volumes in the westbound and eastbound directions during the hours that the express lanes are operational (weekdays between 5 AM and 8 PM).

Figure 6: Westbound Express Lane Average Daily Traffic (ADT) at Select Locations



Source: Alameda CTC ETS.

Figure 7: Eastbound Express Lane Average Daily Traffic (ADT) at Select Locations



Source: Alameda CTC ETS.

While overall volumes along the corridor grew by around 3-4% per year as discussed above, volumes on the westbound express lane grew at much higher rates from 19% per year at Greenville Road to 26% per year at Isabel Avenue between spring 2016 (when the express lanes opened) and spring 2018. At Isabel Avenue, volumes on the westbound general purpose lanes remained relatively flat between 2016 and 2018, while express lane volumes accounted for growth at that location. At Santa Rita/Tassajara Road, express lane traffic accounted for over 60% of all growth.

Express lane demand in the eastbound direction increased at lower rates than in the westbound direction. The largest increase in demand was at Isabel Road with a 12% increase in express lane usage. As with the westbound direction, much of the total corridor increase was accommodated by the express lanes. The eastbound express lanes at Santa Rita/Tassajara Road carried 60% of demand growth at that location and 56% of all demand growth at Isabel Avenue. At the eastbound terminus of the express lane at Greenville Road, the lane only represented 10% of traffic growth.

By the spring of 2018, the westbound express lane carried approximately 17% of all vehicular traffic during the AM peak period, which is a similar percentage as other managed facilities in the Bay Area. The eastbound express lanes carried approximately 22% of all vehicular traffic on average the PM peak period.

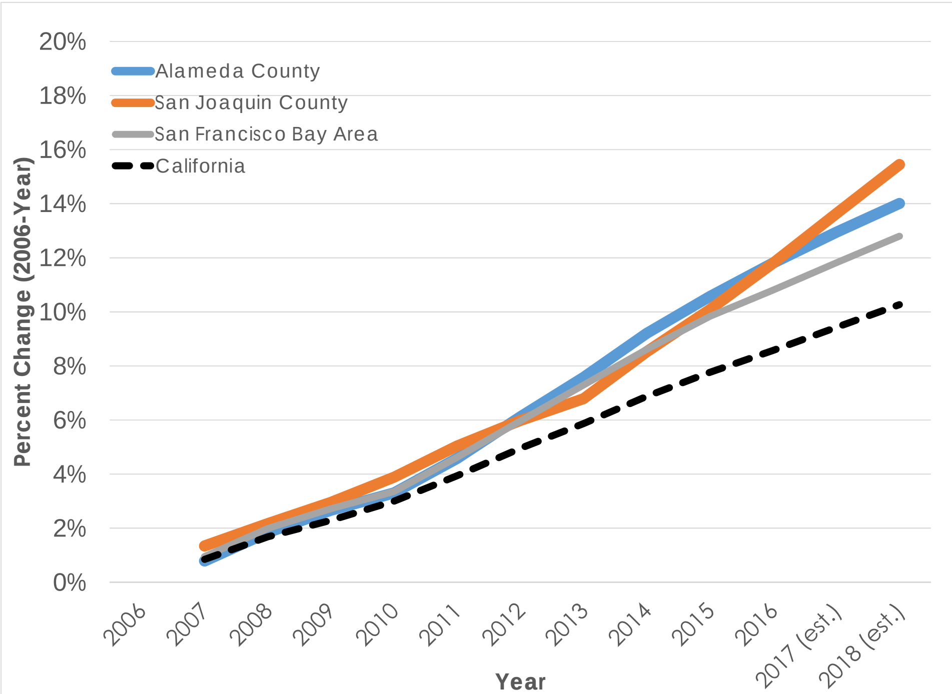
5.1.4 Other Factors Potentially Influencing Corridor Travel Demand

Traffic volume increases have likely been influenced by high growth rates in population and employment in the areas served by the I-580 corridor. These areas include the San Francisco Bay Area, the Tri-Valley in eastern Alameda County, and communities of northern San Joaquin County.

Population

Since 2006 (before the economic recession), Alameda County's population has grown by around 14% from just under 1.46 million residents in 2006 to around 1.67 million residents in 2018. San Joaquin County grew by a similar rate of 15% over the same period from 0.66 million residents in 2016 to nearly 0.76 million residents in 2018, as shown in Figure 8. These rates are faster than the population growth for the Bay Area or for the state of California.

Figure 8: Population Percent Change by Year 2006-2018



Source: CA Dept. of Finance Demographic Research Unit (DRU). Year 2017 & 2018 estimated by DRU.

Economy

Since 2009, employment throughout California, the San Francisco Bay Area, and the counties of Alameda and San Joaquin has been increasing since the last year of pre-recession growth in 2006, as shown in Figure 9. Since 2006, employment in both Alameda and San Joaquin Counties has grown by 12% and 10%, respectively. Employment in the nine-county Bay Area grew at a higher rate of 19% since 2006.

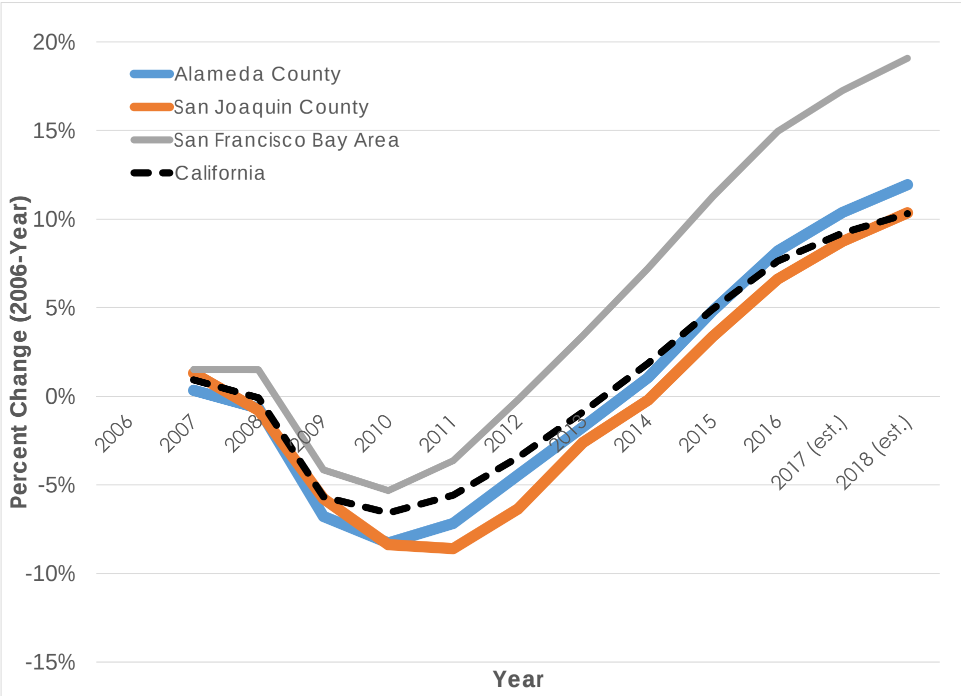
Not only has there been high employment growth in San Francisco and Silicon Valley during this timeframe, but there has also been significant employment growth in the area around the I-580 corridor in the Tri-Valley[4]. The Tri-Valley has experienced population growth of 8% and employment growth of 12% since 2014, according to a report by the Bay Area Economic Council called *Tri-Valley Rising 2018*[5].

Also noted in the Tri-Valley Rising report, the number of commuters from San Joaquin County into the region also significantly increased during this time, by nearly 30% between 2013 and 2016. A survey of commuters from the City of Tracy revealed that a majority work in the Tri-Valley, with 69% choosing to

[4] The Tri-Valley area covers the Town of Danville and city of San Ramon in Contra Costa County as well as the three cities in eastern Alameda County of Dublin, Livermore, and Pleasanton.
[5] http://www.bayareaeconomy.org/files/pdf/Tri-Valley2018FULL.compressed.pdf

drive alone and 19% traveling by Altamont Corridor Express (ACE) rail. Additionally, 23% of Tri-Valley workers commute to San Francisco or Silicon Valley (Santa Clara and San Mateo Counties).

Figure 9: Employment Percent Change by Year 2006-2018



Source: California Employment Development Department.

The I-580 corridor is also a major freight corridor, including part of the Primary National Freight Network, with truck volumes comprising between 9% and 12% of all vehicles on the corridor according to Caltrans traffic volume data. This truck traffic is generated, in part, by shipping activity at the Port of Oakland and warehousing facilities in San Joaquin County, as well as agricultural products from the Central Valley. Shipping activity has increased with total annual twenty-foot equivalent unit (TEU) containers entering and exiting the port growing by approximately 3% per year since 2015. By the end of 2018 the number of TEUs will likely surpass historic highs and reach 2.5 million annual containers.

5.2 Mobility

Summary of Key Findings

Overall, the I-580 Express Lanes project reduced travel times and improved speeds as well as mitigated several bottlenecks over a period of time when the corridor experienced a significant increase in vehicular volumes. Travel times on the project corridor also improved for the general purpose lanes adjacent to the express lanes. The express lanes operate at Level of Service "C" or better and meet legislative requirements for operations. Outside of the express lane facility, growing congestion affects express lane and overall corridor performance, particularly near the I-680 interchange and over the Altamont Pass.

The mobility evaluation measures assess how well the I-580 Express Lanes meet the congestion relief, reliable travel time savings, and LOS goals. Six measures were used for mobility: travel time and the related measure of speed, the location and extent of bottlenecks, total congestion changes measured by vehicle- and person-hours of delay (VHD and PHD, respectively), LOS, and the Federal Highway Administration (FHWA) and Caltrans degradation measure of percent of time that express lane speeds drop below 45 mph[6].

5.2.1 Travel Times and Speeds

The I-580 Express Lanes have contributed to improved AM and PM peak period travel times and travel speeds in both directions and provide faster travel times and speeds compared to the adjacent general purpose lanes. This analysis was performed comparing all lanes within the express lane corridor limits between spring 2015 and 2018 and then comparing express lane and general purpose performance for spring 2018. Travel time comparisons were also performed for the eastbound direction managed lanes where the HOV lane was operational in 2015 prior to the opening of the express lanes.

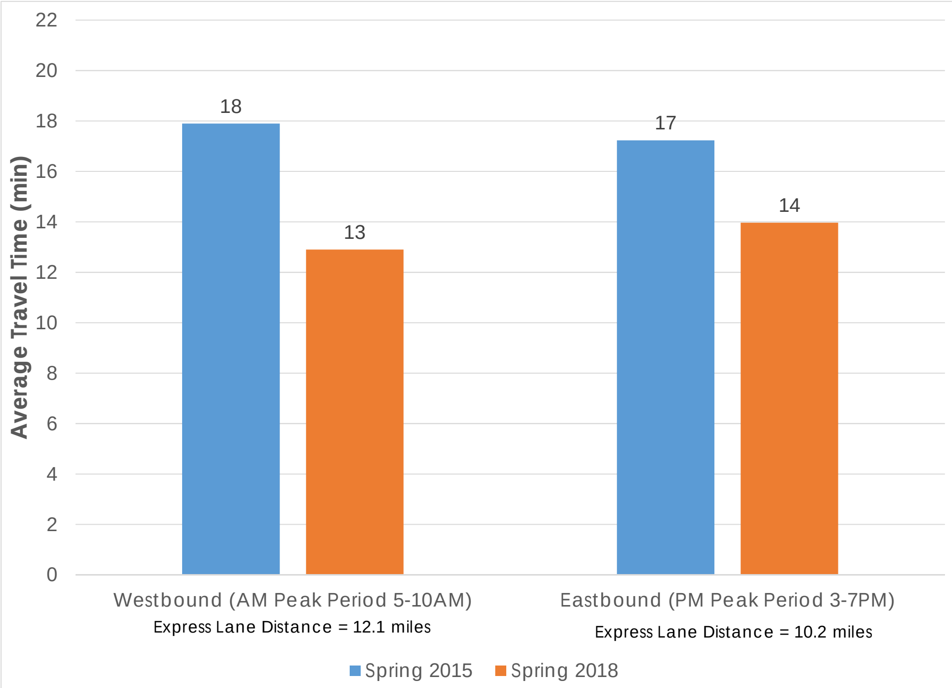
Travel Times across All Lanes

Figure 10 summarizes the spring 2015 and 2018 peak period average travel times across all lanes for both directions of the express lane corridor. The 12.1 mile westbound corridor during the AM peak period experienced a 5 minute improvement in travel time between 2015 and 2018, from 18 minutes in 2015 to around 13 minutes in 2018 (a 28% improvement).

The 10.2 mile eastbound corridor improved by 3 minutes from 17 minutes to 14 minutes (a 19% improvement) during the PM peak period.

[6] An express or HOV lane is considered degraded if the average traffic speed during the morning or evening weekday peak commute hour is less than 45 miles per hour for more than 10 percent of the time over a consecutive 180-day period.

Figure 10: Express Lane Corridor Peak Period Travel Times 2015-2018 across All Lanes



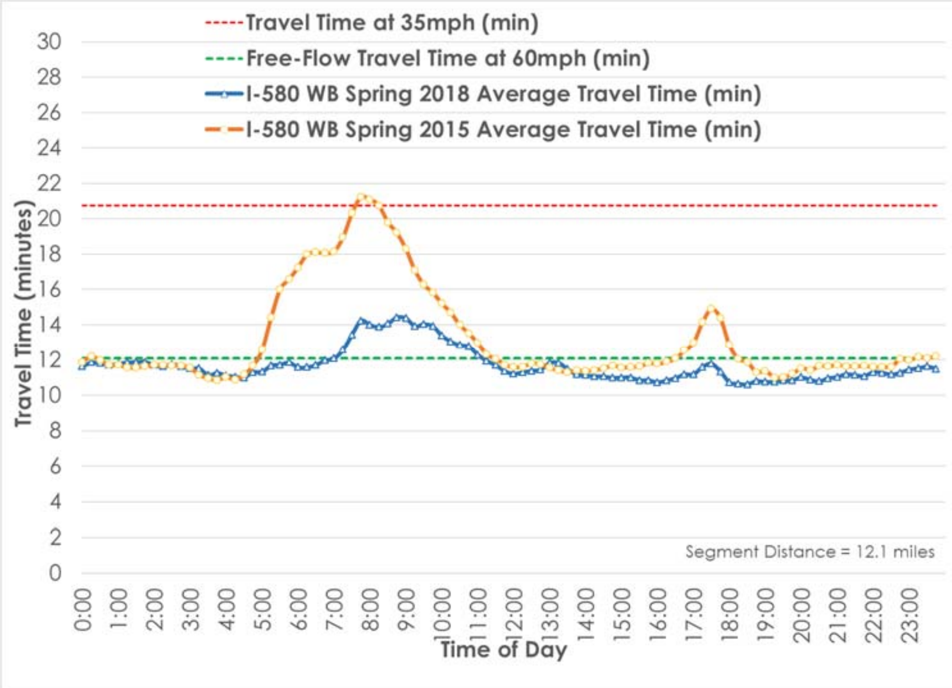
Source: Inrix.

Westbound Travel Time across All Lanes

Travel time improvements were more pronounced during the "peak of the peak" 15-minute time interval for the westbound direction. Figure 11 presents westbound travel times across all lanes averaged for 15-minute intervals during spring 2015 and spring 2018 midweek days.

In the spring of 2015, the slowest time of day to travel occurred at 7:45 AM when it took more than 21 minutes to traverse the corridor at an average speed of 34 miles per hour (mph). By 2018, after the express lane had opened, travel times at 7:45 AM had improved by 33% to 14 minutes (or at 51 mph). Additionally, smaller afternoon congestion occurred in 2015 around 5:30 PM, but by 2018 this slowing had been eliminated and speeds had returned to free-flow conditions.

Figure 11: Westbound Express Lane Corridor Travel Times by Time of Day across All Lanes

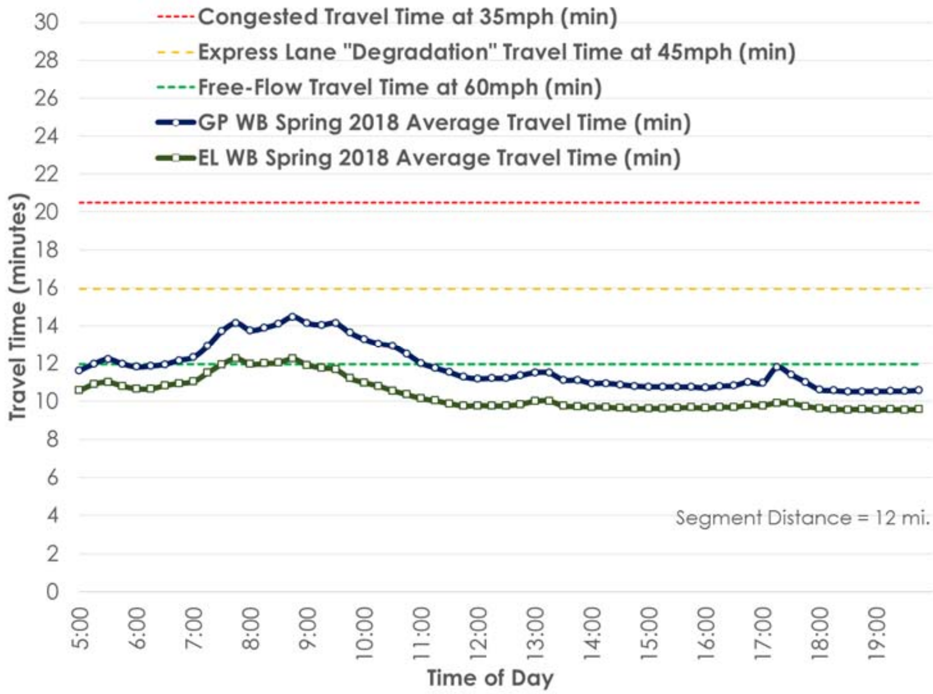


Source: Inrix.

Westbound Travel Time for Express Lanes Compared to General Purpose Lanes

As of spring 2018, the westbound express lane provides consistently faster travel times than the adjacent general purpose lanes. Figure 12 shows that in spring 2018, average travel times between 5 AM and 10 AM were between 1 to 2.5 minutes faster (10-22%) on the express lane than on the adjacent general purpose lanes. In addition, travel times on the westbound general purpose lanes rarely exceeded 14 minutes (representing an average speed of 50 mph) during the AM peak period, indicating that the express lane project also improved general purpose lane travel times compared to the spring 2015 travel times shown in Figure 12.

Figure 12: Westbound Express Lane and General Purpose Lanes Travel Times 2018

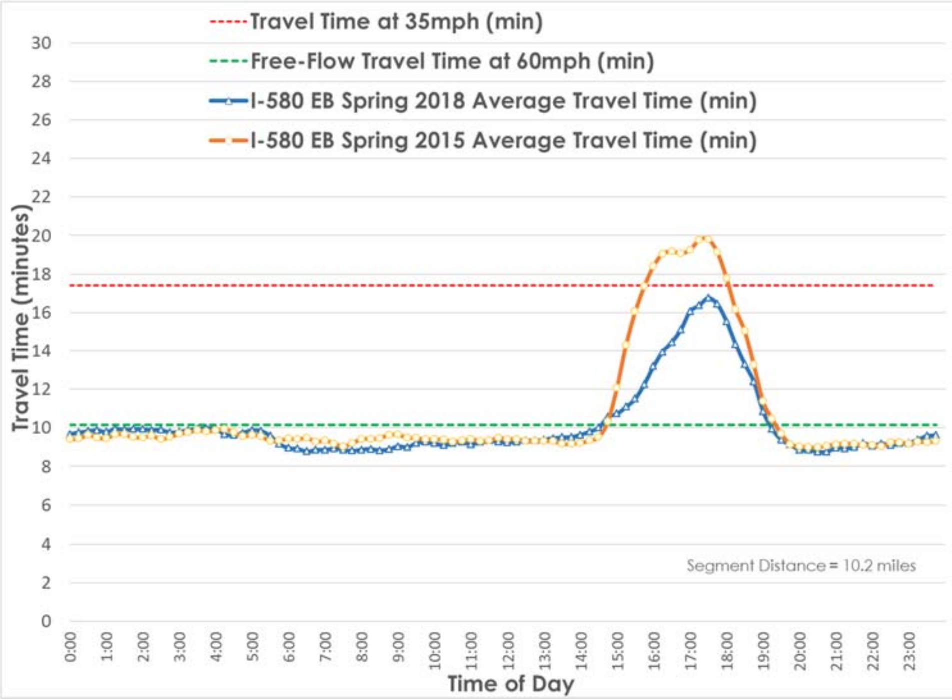


Source: Alameda CTC ETS.

Eastbound Travel Time across All Lanes

Eastbound travel times across all lanes also showed an improvement within the PM peak period, as shown in Figure 13. Figure 13 presents the eastbound direction 15-minute interval travel times. Travel times during the peak 15-minute interval at 5:30 PM improved from 20 minutes (at 31 mph) in 2015 to 17 minutes (36 mph) in 2018, a 15% improvement. At 4:15 PM there was a smaller peak in 2015 that required 19 minutes to travel the corridor. By 2018, however, this travel time had been reduced by 5 minutes to a 14 minute travel time, a 26% improvement.

Figure 13: Eastbound Express Lane Corridor Travel Times by Time of Day 2015-2018 across All Lanes

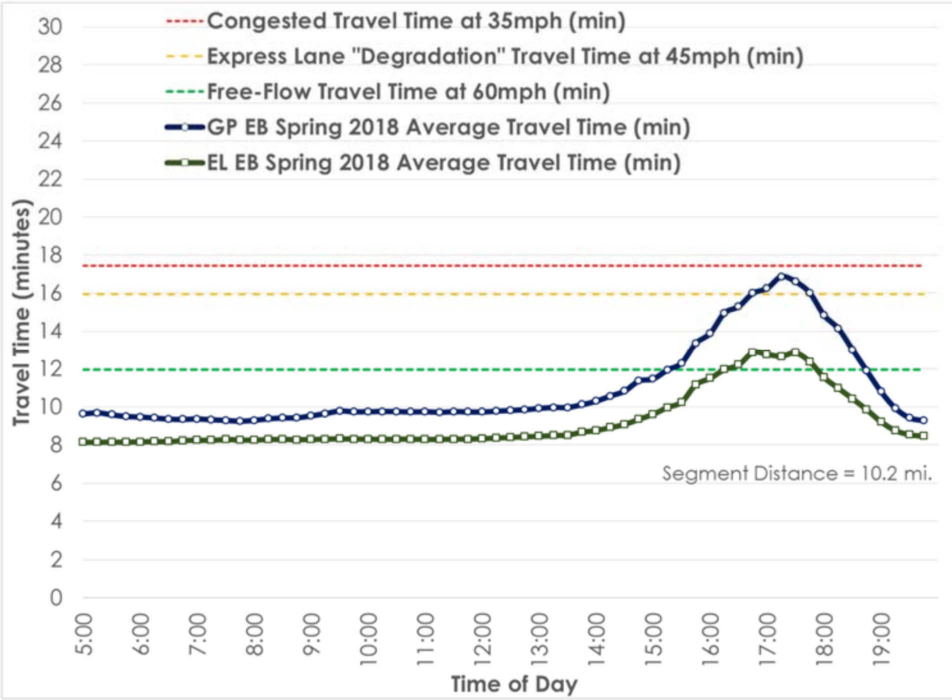


Source: Inrix.

Eastbound Travel Time for Express Lanes Compared to General Purpose Lanes

As of spring 2018, the eastbound express lanes also provide consistently faster travel times than the adjacent general purpose lanes, similar to the westbound direction discussed above. Figure 14 shows that in the spring 2018, travel times on the express lanes ranged from 2 to 4 minutes faster (10% to 22%) than on the general purpose lanes during the PM peak period. Compared to spring 2015 travel times in Figure 13, eastbound general purpose lane travel times do not exceed 17 minutes (e.g. travel at 37 mph) meaning that severe congestion, or travel below 35 mph, is not as common as was the case in spring 2015 and that the express lane project provided benefits for the general purpose lanes.

Figure 14: Eastbound Express Lane and General Purpose Lanes Travel Times 2018



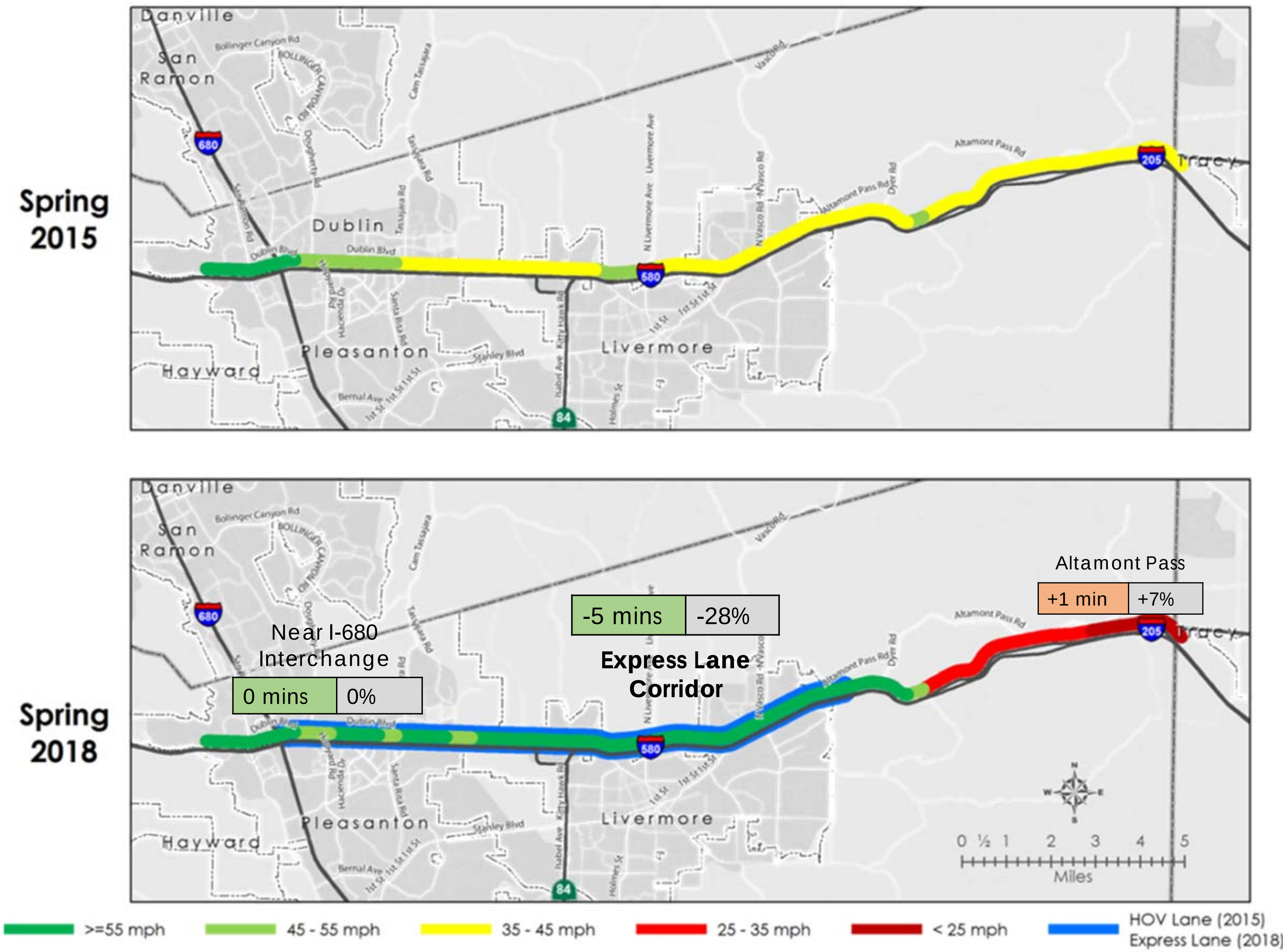
Source: Alameda CTC ETS.

Travel Speeds

Travel speeds are generally faster along the express lane corridor, but congestion caused by bottlenecks outside of the express lane corridor have affected express lane operational performance at the start and end of the facility. This is assessed by evaluating changes in speeds over a longer corridor from west of I-680 to the San Joaquin County line.

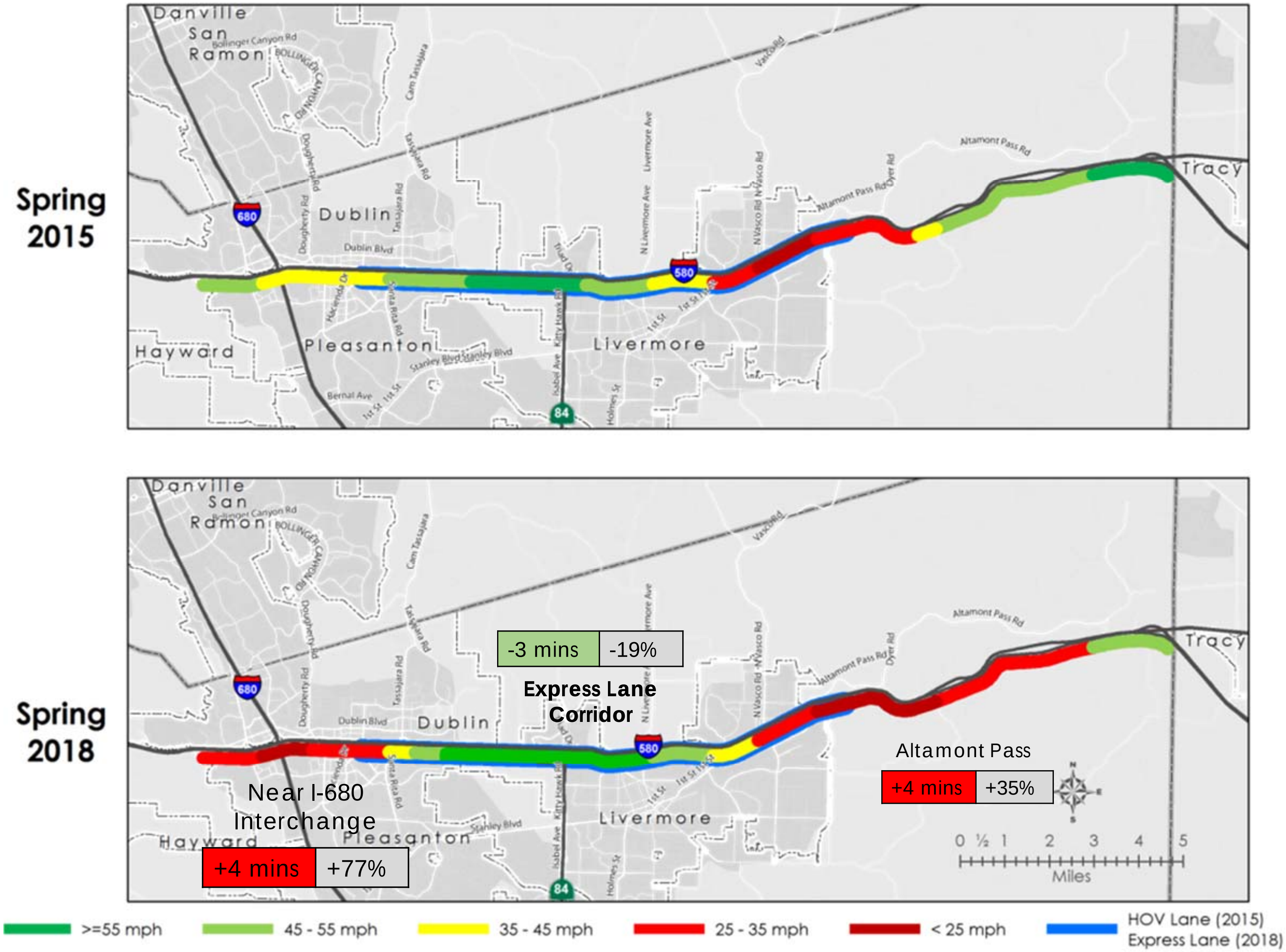
Figures 15 and 16 show average speeds for the westbound AM and eastbound PM peak directions, respectively. The first map in each figure presents spring 2015 conditions and the second map shows spring 2018 conditions. The spring 2018 maps also show the change in travel times for three segments from the spring 2015, both in minutes and the associated percentage change. These three segments include the segment from San Ramon Road to the express lane facility, the express lane corridor, and the Altamont Pass, east of the express lanes. The Altamont Pass spans from Greenville Road to the San Joaquin County line.

Figure 15: Westbound AM Peak Period Average Speeds and Travel Time Changes



Source: Inrix.

Figure 16: Eastbound PM Peak Period Average Speeds and Travel Time Changes



Source: Inrix.

For the westbound AM peak period, 2015 speeds were in the 35-mph to 45-mph range along most of the corridor. By 2018, speeds had improved to free-flow along most of the express lane segment and, as described previously, travel times improved by 5 minutes (28%). Traffic congestion entering the county over the Altamont Pass has worsened in the AM peak since 2015 (an increase of 1 minute or a 7% decline on average) and there is a bottleneck at North Flynn Road with speeds now below 35 mph along that segment.

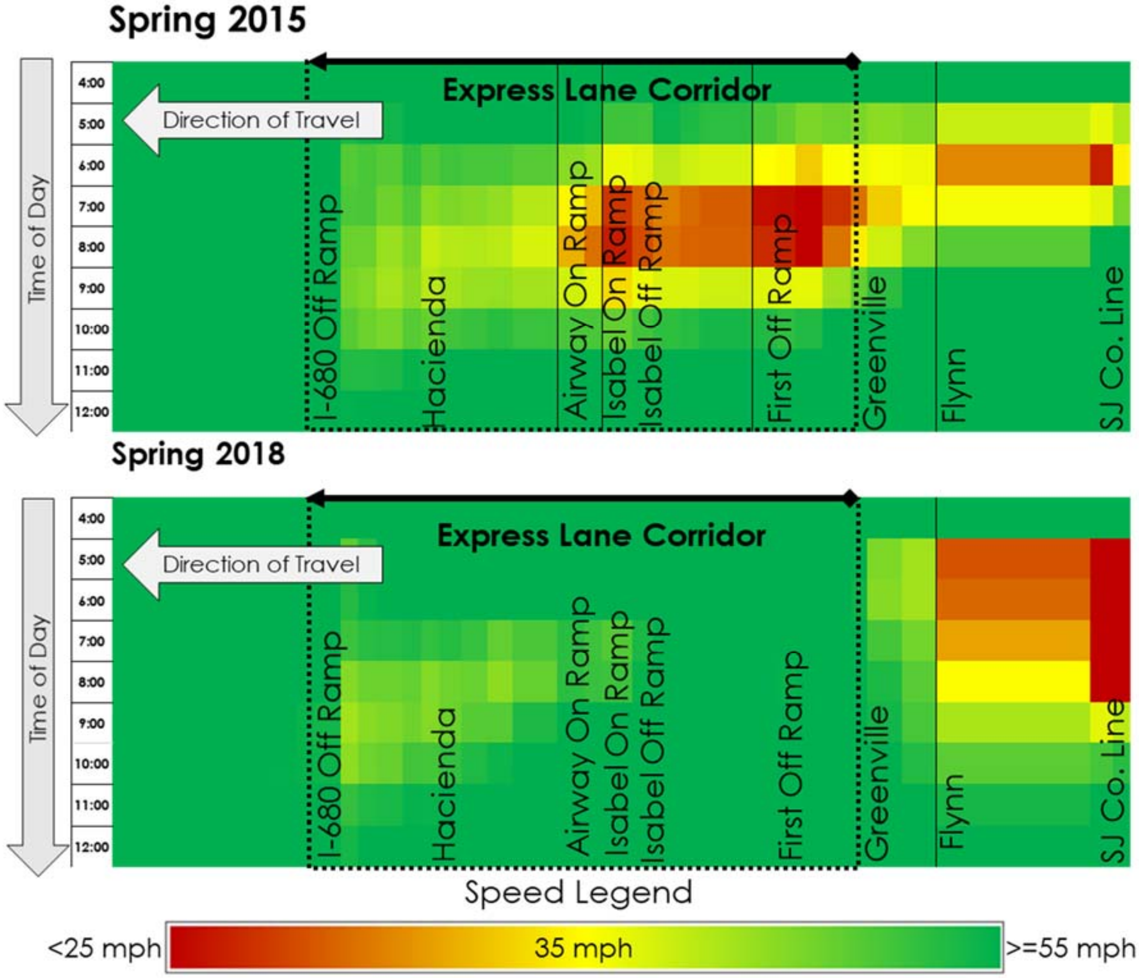
For the eastbound PM peak period, the express lanes improved speeds and travel times along the 10.2-mile corridor (3 minutes of travel time saved). The improvement in travel times is likely partially attributed to the new Caltrans truck climbing lane from Greenville Road to North Flynn Road that opened in June 2016. Outside of the eastbound express lane facility, travel times increased between Greenville Road and I-205 by about 4 minutes and near the I-680 interchange by about 4 minutes. Increases in travel demand as described in Section 5.1 likely have contributed to declining speeds in these segments as well as an on-going roadway rehabilitation project on the Altamont Pass, which is scheduled for completion by the end of 2018.

5.2.2 Bottlenecks and Queuing

The I-580 Express Lanes project eliminated or mitigated several bottlenecks on the express lanes corridor. The westbound express lane eliminated three bottlenecks: Airway Boulevard, Isabel Avenue and First Street. The eastbound express lanes eliminated a bottleneck at El Charro/Fallon Road. The eastbound bottleneck at Greenville Road appears to have been mitigated, primarily by the opening of the eastbound truck climbing lane that was first described in Section 2.1.

Figure 17 shows two speed contour plots for the westbound direction AM peak period for spring 2015 and spring 2018. Speeds are shown for the time period starting at 4 AM (approximately one-hour before the beginning of the AM peak period) to noon. Speeds range from severe congestion (i.e., speeds less than 35 mph) to operating at free-flow conditions (greater than 55 mph). Figure 17 shows that the express lanes eliminated the westbound bottlenecks within the express lane corridor.

Figure 17: Westbound Bottlenecks and Queuing 2015 and 2018 across All Lanes

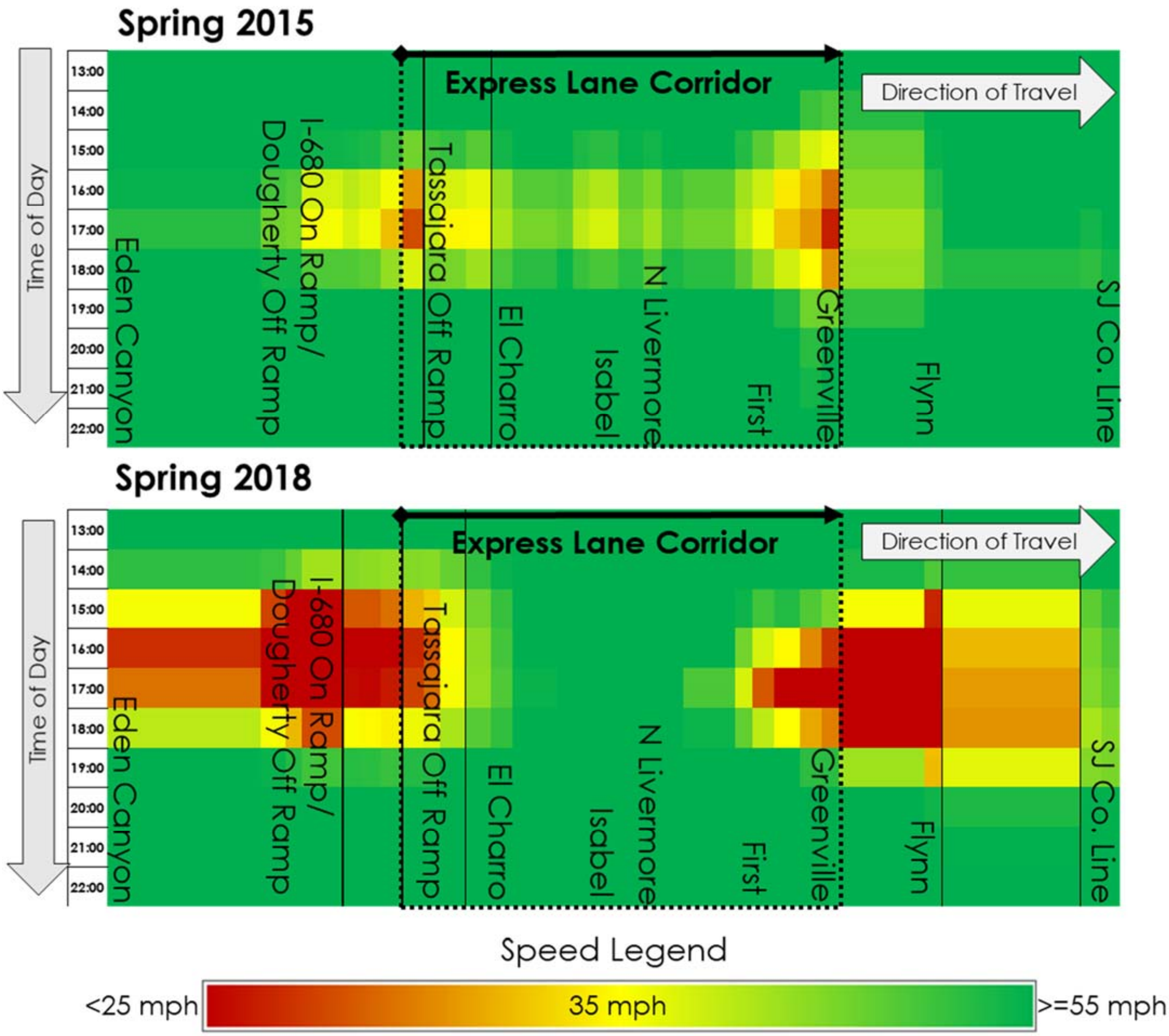


Source: Inrix. Note speed contours based on 15-minute average weekday speeds.

Figure 18 is a similar speed contour plot, but for the eastbound direction showing the afternoon and evening time periods (1 PM to 9 PM). The express lanes smoothed traffic flow between El Charro Road and North First Street. Along this segment (approximately 6 miles long), speeds have mostly returned to free-flow conditions throughout the PM peak period, indicating that the express lanes have improved traffic conditions.

At the eastern end of the facility, the express lanes and the subsequent truck climbing lane slightly reduced queuing at Greenville Road and moderately reduced the duration of severe congestion on the express lane corridor. As described in the discussion of traffic speeds in Section 5.2.1, growing traffic volumes over the Altamont Pass is contributing to a bottleneck that is extending back into the express lane facility. At the western end of the express lane segment, bottlenecks intensified near the I-680 interchange in the PM peak period. The bottleneck in the vicinity of Hacienda Boulevard (at the start of the express lanes) has worsened since 2015. However, the El Charro/Fallon Road bottleneck has been improved.

Figure 18: Eastbound Bottlenecks and Queuing 2015 and 2018 across All Lanes



Source: Inrix. Note speed contours based on 15-minute average weekday speeds.

5.2.3 Vehicle/Person Hours of Delay

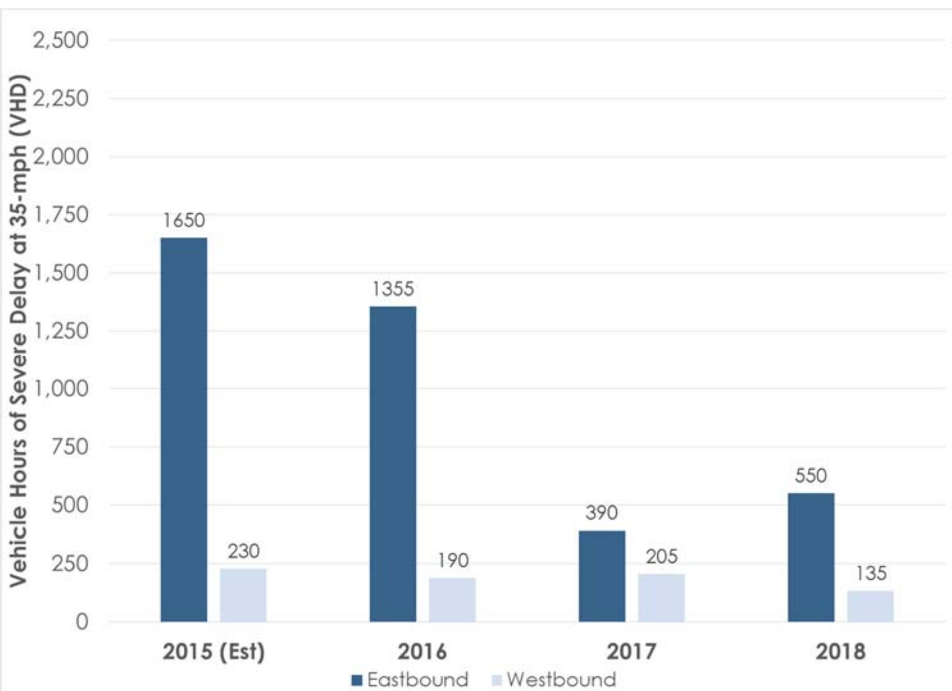
Assessing travel time savings in aggregate, the project significantly reduced delay for both vehicles and people along the express lane corridor between 2015 and 2018.

Vehicle-hours of delay (VHD) and person-hours of delay (PHD) are measured by how much longer vehicles or people spend traveling relative to a referenced travel time. The difference in travel time between traveling at the threshold speed is then multiplied by the number of vehicles and people that travel the corridor. For this assessment, delay is defined as traveling slower than 35 mph, which is considered to be the threshold below which vehicles are experiencing “severe” delay.

Figure 19 shows severe vehicle hours of delay for an average weekday in the years 2015 through 2018. Most delay on the project corridor is in eastbound direction for all years. Between 2015 and 2018, eastbound VHD has dropped significantly from 1,355 vehicle-hours to around 550 vehicle-hours, a decrease of 59%.

Delay continues to be lower in the westbound direction compared to eastbound. The westbound direction experienced an 18% decrease in vehicle-hours between 2015 and 2018, from an estimated 230 vehicle-hours to 145 vehicle-hours (a 37% decline).

Figure 19: Express Lanes Corridor Severe Vehicle-Hours of Delay at 35 mph 2015-2018



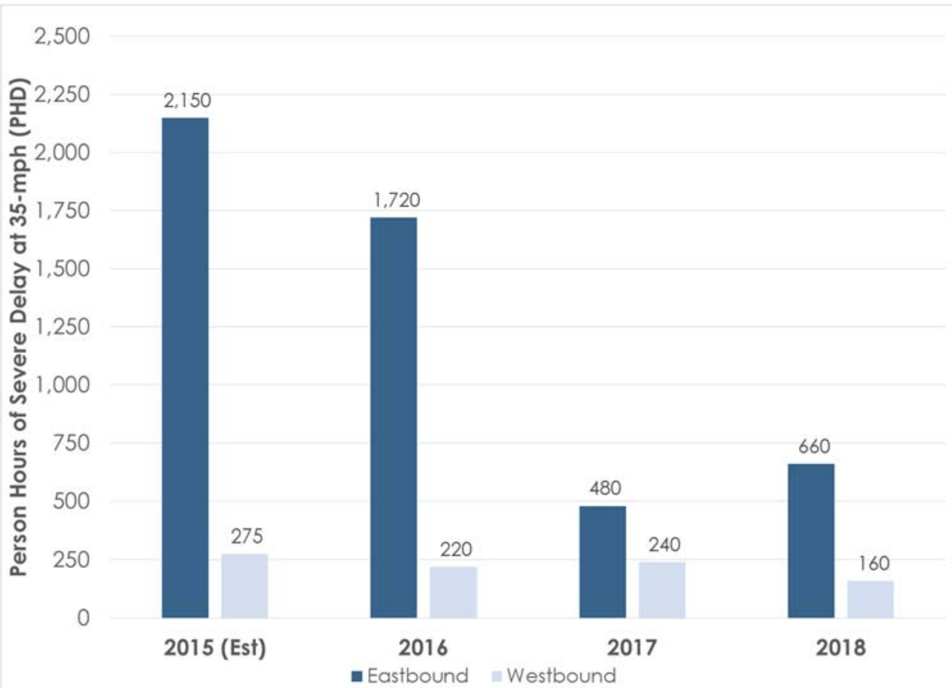
Sources: Alameda CTC ETS; Caltrans PeMS, Field Data Collection for hours that express lanes are operational. Year 2015 estimated. Year 2015 derived from 2016 ETS data by using available PeMS data for adjustments.

Figure 20 shows similar trends for person delay measured at 35 mph. In 2015, it is estimated that people traveling the eastbound express lane corridor experienced 2,150 hours of delay during an average weekday, which declined by 20% to 1,720 person-hours following the opening of the express lanes. By 2018, eastbound delay was estimated to be 660 person-hours, a net decline of 69% from 2015 levels.

Westbound congestion declined from 275 to 220 person-hours of delay after the express lane opened in 2016, a reduction of 20%. By 2018, westbound delay had decreased to 160 person-hours, a net reduction of 42% since 2015.

When considering annual delay estimates, the express lanes reduced annual severe VHD on the express lane corridor from around 322,000 annual vehicle-hours in 2015 to just under 172,000 by 2018, a reduction of 150,000 annual hours or around 47%.

Figure 20: Express Lanes Corridor Severe Person-Hours of Delay 2015-2018



Sources: Alameda CTC ETS; Caltrans PeMS, Field Data Collection for hours that express lanes are operational. Year 2015 derived from 2016 ETS data by using available PeMS data for adjustments.

5.2.4 Level of Service and Express Lane Degradation

The AB 2032 legislation, Caltrans, and the FHWA have established requirements for express lanes operations. In the "after" conditions, the express lanes operate at acceptable levels of service per the legislation and Caltrans standards and exceed FHWA degradation standards.

The AB 2032 legislation specifies that the I-580 Express Lanes maintain at all times a LOS C as measured by the Highway Capacity Manual as adopted by the Transportation Research Board. LOS is a qualitative mobility measure that assesses how well a driver can maneuver in traffic. Using a "report card" letter grade, LOS rates traffic conditions from "A" (free-flow speeds with complete mobility between lanes) to "F" (congested conditions with slow speeds and limited mobility).

For a vehicle that travels the length of the express lane facility during the peak hour, the express lanes operate at LOS C in both the westbound 8 AM and in the eastbound 5 PM peak hours. The express lane facilities also operate at LOS C or better throughout the day. The general purpose lanes operate at LOS D in both directions during the AM and PM peak hours.

FHWA rules further state that an HOV or express lane is degraded if the average traffic speed during the morning or evening weekday peak commute hour is slower than 45 miles per hour for more than 10% of the time over a consecutive 180-day (i.e., six month) period. For the statewide Managed Lanes Degradation Report, Caltrans reports degradation for the 8 AM and 5 PM peak hours.[7] For this analysis, the entire express lane corridor in each direction was evaluated as a segment and the same peak hours were used as in the Caltrans Managed Lanes Degradation Report.

Prior to opening the express lanes in 2016, the degradation of the eastbound carpool lane was evaluated by Caltrans using PeMS, but only at locations where there was sufficient data. After February 2016, Alameda CTC ETS data became available and was used to evaluate peak hour degradation during the first five months of 2018 (January through May). June data was not available to perform the full 180-day evaluation.

The westbound express lane operated in a degraded condition only 4% of the time during the 8 AM peak hour during the evaluation period, well below the 10% threshold established by FHWA. In the eastbound direction, the express lanes experienced degradation 7% of the time. This is also below the 10% threshold required by FHWA.

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[7] The 2016 Statewide Managed Lanes Degradation Report can be found here: http://www.dot.ca.gov/trafficops/tm/docs/2016-HOV-degradation-report.pdf

5.3 Use & Productivity

Summary of Key Findings

The I-580 Express Lanes added capacity for carpools and SOVs which has enabled a higher number of vehicles and people to travel the corridor. Average vehicle occupancy declined slightly after implementation of the express lanes, which is in line with findings related to express lane performance across the state. Within the express lane corridor, vehicle throughput increased in both peak directions across all lanes and person throughput generally increased where the project added HOV capacity, especially in the westbound AM peak period.

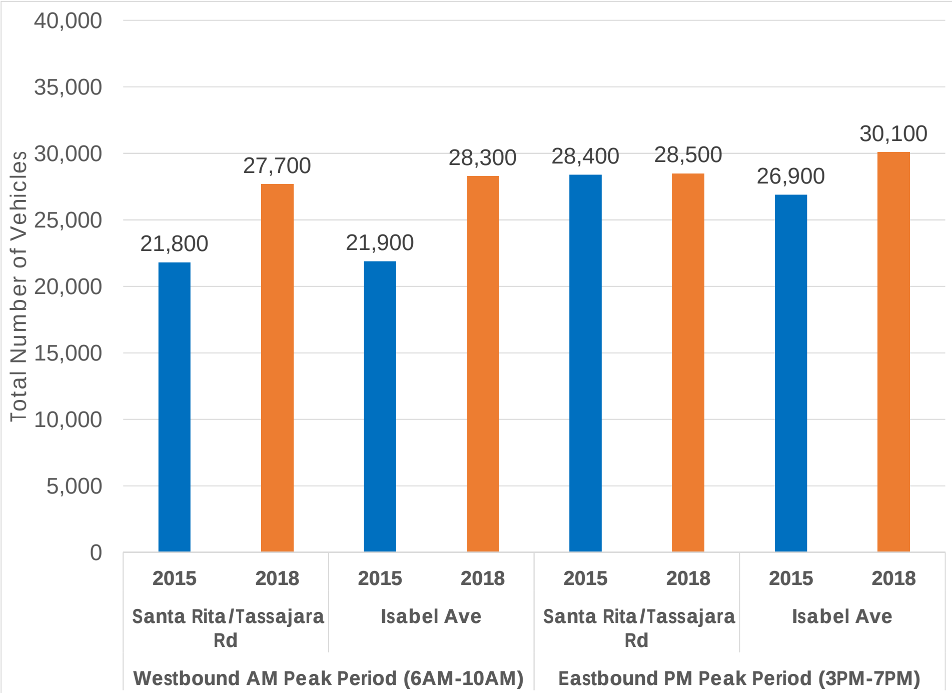
The use measures assess how well the corridor is being utilized by people using any mode such as transit or carpooling. Productivity is a system efficiency measure used to analyze how efficiently the capacity of the corridor is being used and is defined as the ratio of output (or service) per unit of input. In the case of highways, productivity is evaluated for a facility under peak period traffic conditions and is the number of vehicles or people traversing a section of roadway during peak travel periods. Several measures are used to assess use and productivity including: vehicle classifications (e.g. carpools, buses), average vehicle occupancy, transit ridership, as well as vehicle and person throughput during the peak periods.

The findings presented in this section are approximate. The use and productivity statistics are based on a limited sample of data collected in the field over a span of a few non-holiday, midweek days in the spring 2015 and 2018 and are subject to error. However, there are few feasible ways to collect these types of data. Also, because of a limited ability to perform field data collection in low light conditions around sunrise, the early morning field data results do not reflect the entire AM peak period defined for the study. The AM peak period for this analysis is from 6 AM to 10AM because of the limited lighting conditions, while the PM peak period remains from 3 PM to 7 PM.

5.3.1 Vehicle Throughput

The I-580 express lanes corridor carried more vehicles and people in spring 2018 than in spring 2015 in both directions across all lanes. Vehicle throughput was measured during the AM and PM peak periods based on the same field data collection described in Section 4 in 2015 and 2018. Within the express lane corridor, vehicle throughput increased in both peak directions across all lanes as shown in Figure 21.

Figure 21: Peak Period Vehicle Throughput at Select Locations by Direction 2015-2018



Source: 2015 and 2018 field data collection. AM peak period for this analysis begins at 6AM due to limited visibility due to low daylight at 5AM.

The westbound direction in the AM peak period had a larger percentage increase in throughput compared to the eastbound direction in the PM peak period. At Isabel Avenue, the number of westbound AM peak period vehicles increased by just under 30% over the three years from 21,900 vehicles in 2015 to around 28,300 vehicles in 2018. A similar trend is seen at Santa Rita/Tassajara Road where AM peak period traffic increased by 27% (from around 21,800 vehicles to approximately 27,700 vehicles).

The eastbound direction experienced relatively flat PM peak period growth at Santa Rita/Tassajara Road. At Isabel Avenue, approximately 12% more vehicles are traveling the corridor from around 26,900 vehicles in 2015 to around 30,100 in 2018.

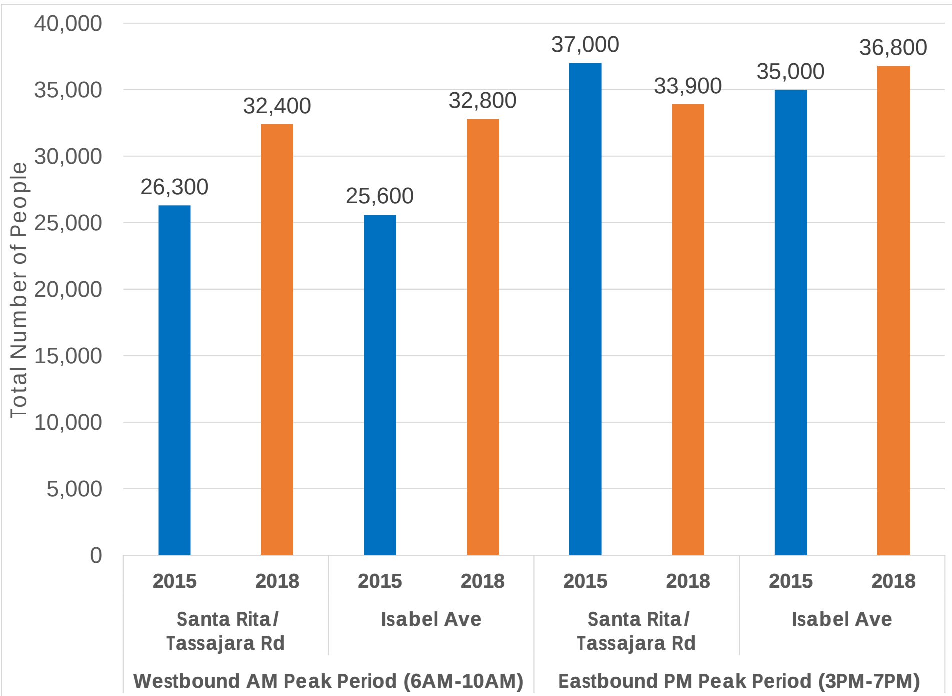
5.3.2 Person Throughput

In addition to increases in vehicle throughput, person throughput had also increased by spring 2018.

As shown in Figure 22, person throughput generally increased where the express lanes project added HOV capacity, especially in the westbound AM peak period. At Isabel Avenue, the number of people traveling westbound in the AM peak period increased by around 28% from approximately 25,600 people in 2015 to around 32,800 by the spring of 2018. Santa Rita/Tassajara Road experienced a 23% increase from 26,300 people to around 32,400 over the same period.

During the PM peak period in the eastbound direction, 5% more people are passing by Isabel Avenue in 2018 compared to 2015 (35,000 to 36,800 people in the PM peak period). At Santa Rita/Tassajara Road in the eastbound PM peak period and where the project converted the HOV lane to an express lane but did not add HOV capacity, fewer people are traveling at this location in 2018 compared to 2015 (an approximate 8% decline).

Figure 22: Peak Period Person Throughput at Select Locations by Direction 2015-2018



Source: 2015 and 2018 field data collection. AM peak period for this analysis begins at 6AM due to limited visibility due to low daylight at 5 AM.

5.3.3 Average Vehicle Occupancy and Vehicle Classifications

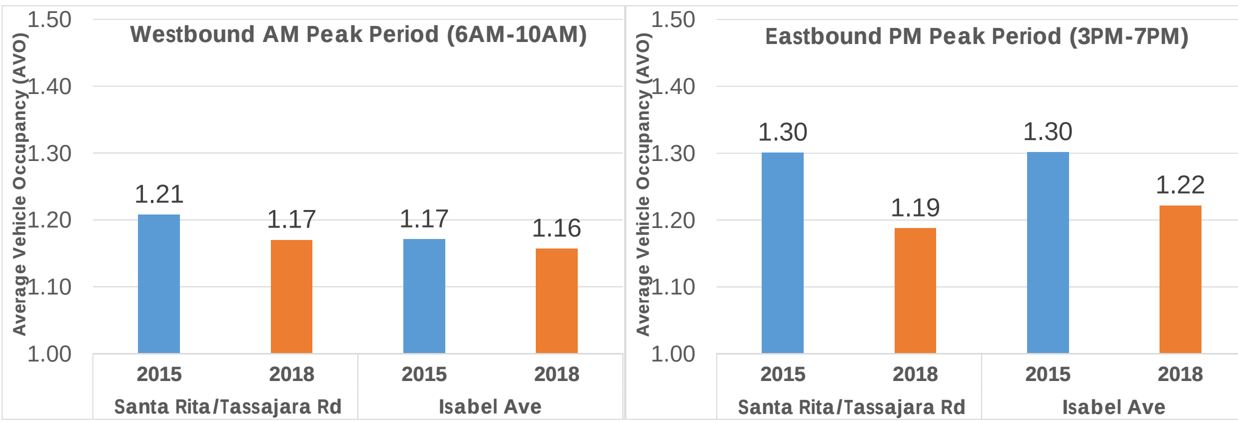
The average number of people traveling the corridor per vehicle slightly declined after implementation of the project while the share of SOV use increased. This is consistent with findings from other express lane implementations in California where fewer people per vehicle travel the corridor after conversions of carpool lanes to express lanes than before.

Average vehicle occupancy estimates are computed from the vehicle classification field data by dividing the total number of people observed in each vehicle classification by the total number of vehicles counted during the observation period. These estimates are approximate as the data collection is done over a few mid-week days. Additionally, the vehicle classification counts were not performed during the 5 AM hour because of limited daylight during that time of the day.

Figure 23 presents the average vehicle occupancy results for both peak directions. At Santa Rita/Tassajara Road, occupancy decreased from 1.21 to 1.17 people per vehicle (a 3.1% decline) in the westbound AM peak period, and from 1.30 to 1.19 people per vehicle (an 8.7% decline) in the eastbound direction during the PM peak period.

At Isabel Avenue, a second location within the express lane corridor where occupancy data were collected, occupancy declined modestly from 1.17 to 1.16 people per vehicle (a1.2% decline) in the westbound direction during the AM peak period and from 1.30 to 1.22 people per vehicle (a 6.1% decline) in the eastbound direction during the PM peak period.

Figure 23: Peak Period Average Vehicle Occupancy across all lanes



Source: 2015 and 2018 field data collection. AM peak period for this analysis begins at 6AM due to limited visibility due to low daylight at 5 AM.

Several factors can contribute to declines in average vehicle occupancy after a project is constructed. Improved operating conditions in the general purpose lanes, the opportunity for single drivers to pay to use new express lanes, and trends related to carpooling can contribute to more people choosing to drive alone. Also, since the project opened, the I-580 corridor in the Tri-Valley experienced a large increase in traffic volume across both general purpose and express lanes. These factors together may have contributed to the slight decline in the number of people per vehicle in the project corridor.

These decreases in the number of people per vehicle are also consistent with findings from other corridors in the state where lanes were converted from HOV to express lanes. On I-110 in Los Angeles, 10.7 miles of HOV lane were converted to express lanes in 2011. By 2016, the average number of people per vehicle during the peak period declined by 13% in the AM peak from 1.57 to 1.36 people per vehicle. The I-10 express lanes in Los Angeles experienced a similar decline following the opening of that facility in 2012.[8]

The decline in vehicle occupancy is commensurate with an increase in the use of SOVs as summarized in Figure 24 and Figure 25 for the westbound and eastbound directions, respectively.

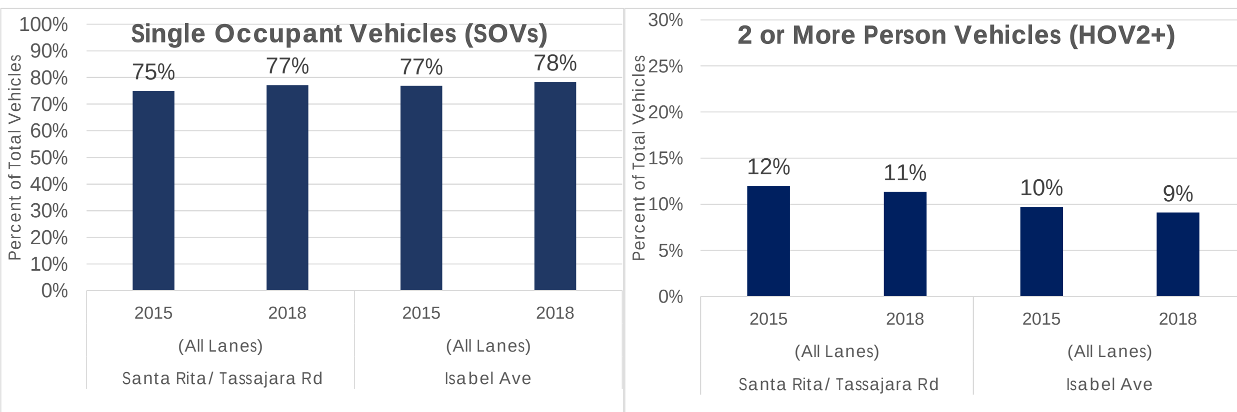
[8] Caltrans District 7 Managed Lanes Annual Report (2011-2016). District 7 annual reports can be found at: www.dot.ca.gov/d7/programs/managed-lanes/

Each figure has two charts that show the percent of SOVs and the same information for vehicles carrying two- or more people (HOV2+) at the count locations along the westbound express lanes during the AM peak period.

In the westbound direction, shown in Figure 24, the percent of traffic across all lanes that are SOVs increased at the two express lane count locations. Santa Rita/Tassajara Road experiences a slight increase in the number of SOVs from 75% to 77% between 2015 and 2018 while the percentage of HOVs declined slightly from 12% to 11%. Similar changes are shown for Isabel Avenue where a slight 1% increase in SOVs was matched by a 1% decrease in HOV2+ vehicles.

On the westbound express lanes, the percentage of SOVs in 2018 was similar to the overall corridor with an SOV share of 75% Santa Rita/Tassajara Road and around 77% at Isabel Avenue.

Figure 24: Westbound AM Peak Period Percent SOVs and HOV2+ 2015-2018 across All Lanes



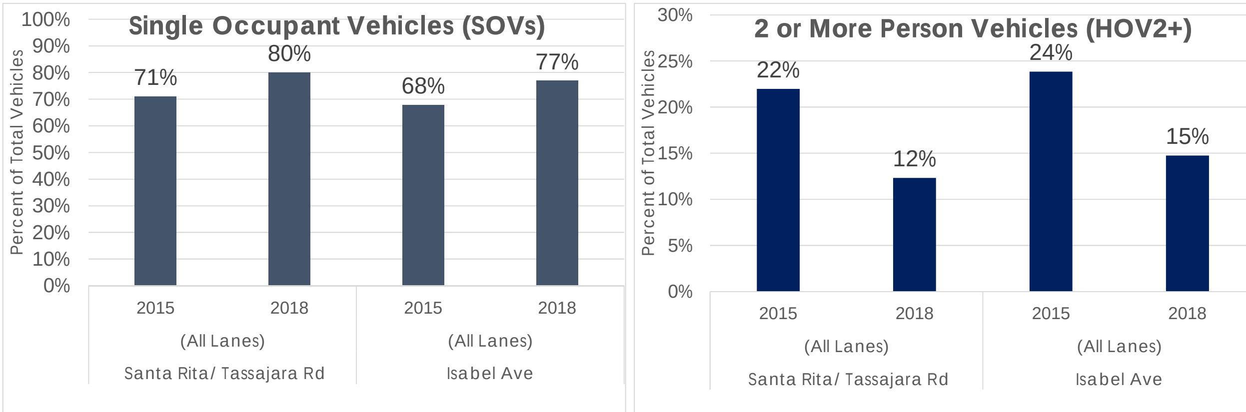
Source: 2015 and 2018 field data collection. AM peak period for this analysis begins at 6AM due to limited visibility due to low daylight at 5 AM.

Figure 25 shows the eastbound PM peak period SOV and HOV2+ findings. At Santa Rita/Tassajara Road, near the western end of the express lane, the number of SOVs increased between 2015 and 2018 by 9% (from 71% to 80%). Commensurately, HOV use declined from 22% to 12%. A similar change occurred at Isabel Avenue (68% SOVs in 2015 to 77% in 2018). A review of Caltrans managed lane field data counts in Alameda County reveals that SOV percentages grew by 1%-2% on average across over an extended time period between 2014 and 2016, the most recent year for which data is available.[9]

In the express lanes, approximately 72% of vehicles were SOVs in 2018 at Santa Rita/Tassajara Road and at Isabel Avenue.

[9] Caltrans District 4 Bay Area Managed Lanes Annual Report (2015-2017). Annual reports can be found at: www.dot.ca.gov/d4/highwayoperations/

Figure 25: Eastbound PM Peak Period Percent SOVs and HOV2+ 2015-2018 across all lanes



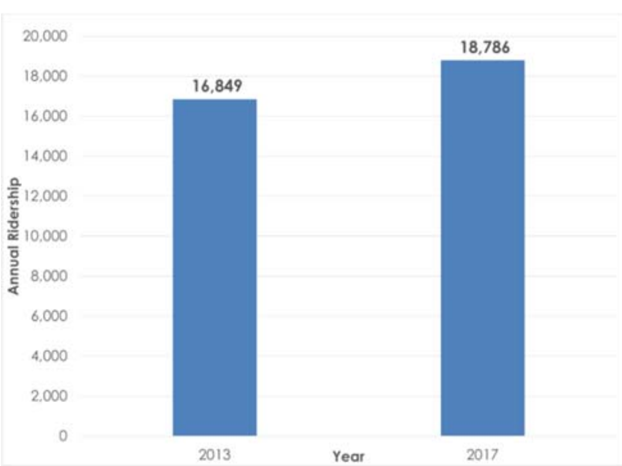
Source: 2015 and 2018 field data collection. AM peak period for this analysis begins at 6AM due to limited visibility due to low daylight at 5AM.

5.3.4 *Transit Ridership*

Transit ridership at the two Tri-Valley Bay Area Rapid Transit District (BART) stations (Dublin/Pleasanton and West Dublin/Pleasanton) and the Livermore-Amador Valley Transportation Authority (LAVTA) express bus routes that directly use the I-580 express lane corridor have experienced increases in ridership for those services in recent years, although a direct correlation could not be established. Station entry and exit data for the two BART stations and LAVTA ridership data were used for this analysis.

Dublin/Pleasanton and West Dublin/Pleasanton BART station entries and exits have been growing at 3% per year since 2013. Even though system-wide ridership for LAVTA has declined by around 4% since 2013, express bus routes along I-580 have increased annual ridership on the corridor between 2013 and 2017 by around 2,000 annual riders over four years (11% increase) on routes 20X and 580X as shown in Figure 26.

Figure 26: LAVTA I-580 Express Bus Service (20X, 580X) Annual Ridership 2013 and 2017



Source: Contra Costa Transportation Authority (CCTA) 2017 Multimodal Transportation Service Objectives (MTSO) Monitoring Report.

5.4 Reliability – Planning Time

Summary of Key Findings

The express lanes have significantly improved the reliability of travel on the corridor. The duration of the peak periods has been reduced and the express lane corridor has a lower variation in travel times throughout the day compared to the before conditions. The express lanes also provide more reliable service than the adjacent general purpose lanes in the after conditions.

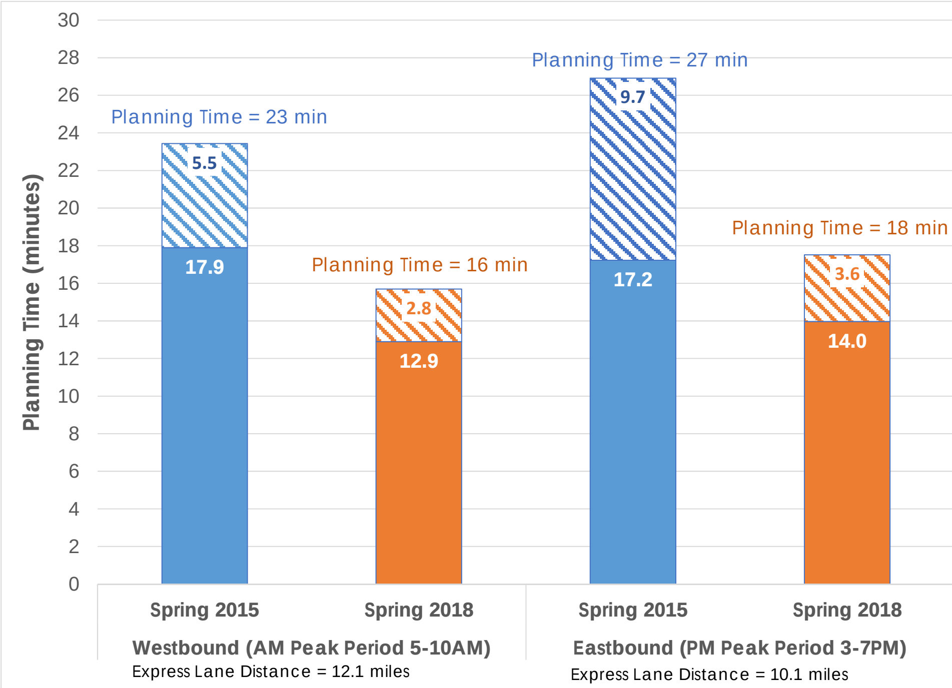
Reliability captures the extent of unexpected delays that can occur on a freeway. While average travel times can give an indication of how bad congestion can be, reliability metrics quantify the frequency of extreme travel times that travelers experience.

The reliability evaluation uses the planning time measure, which is defined as the 95th percentile travel time. This 95th percentile time is the time that a person's travel is faster 95 days out of 100 (or, in contrast, was slower on five days out of 100). For the express lanes, the planning time measure is used in conjunction with average travel time to identify how reliable the travel time savings along the express lane facility have been over time.

Figure 27 shows how peak period planning time across all lanes changed after the express lanes opened. In spring 2015 the average westbound corridor travel time during the AM peak period was 18 minutes. In order to arrive on time 95% of the time, one would have to add 5 to 6 minutes to their average travel time for a planning time of 23 minutes. By 2018, the planning time was reduced by 7 minutes to 16 minutes (an approximate 30% improvement).

In the eastbound direction during the PM peak period, the planning time also was significantly reduced by around 9 minutes from 27 minutes to 18 minutes (an approximate 33% improvement).

Figure 27: Express Lane Corridor Peak Period Reliability 2015-2018



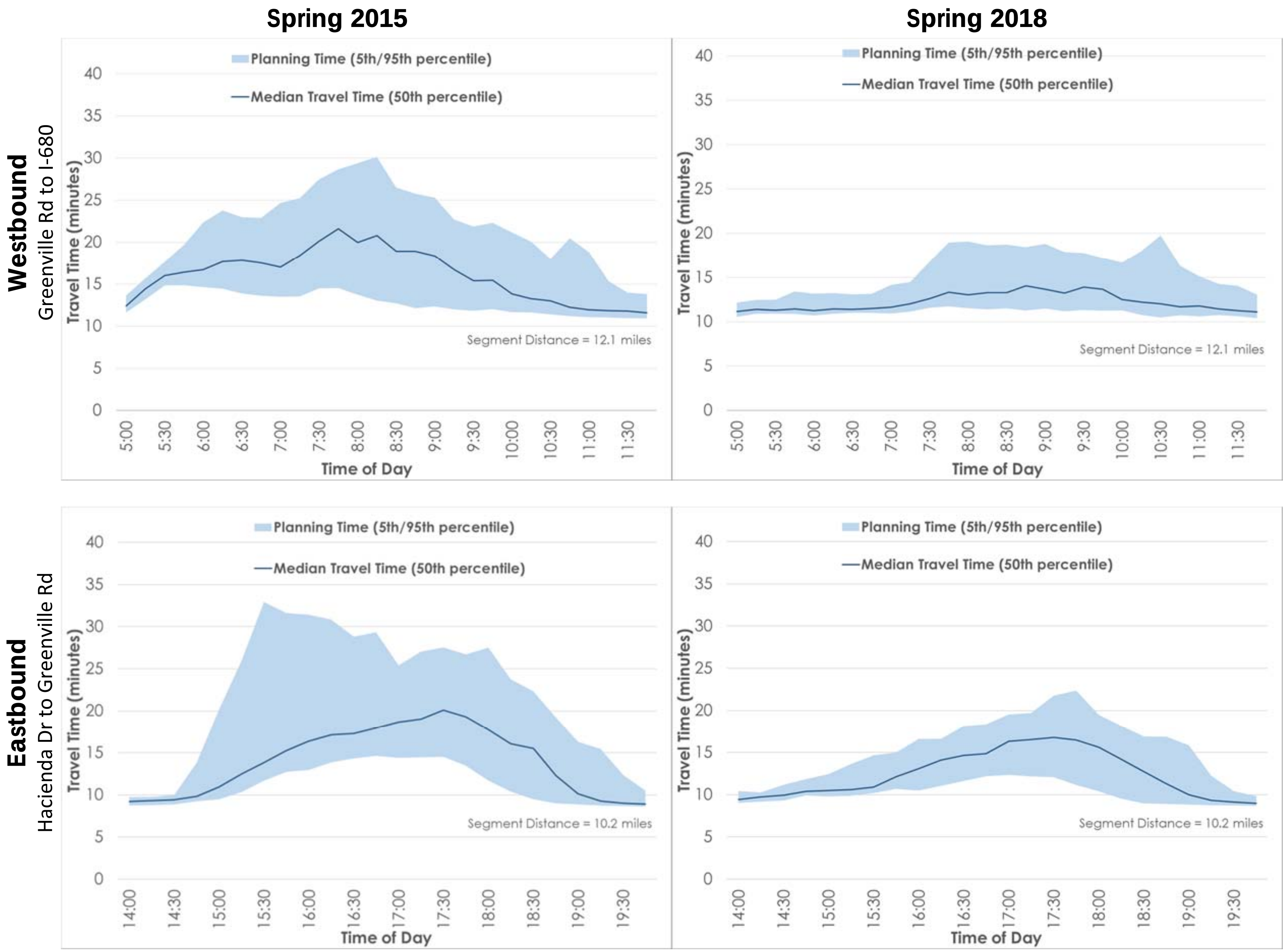
Source: Inrix.

Figure 28 presents a series of plots that shows the corridor planning time and median travel time for 2015 and 2018 for both directions. In the westbound direction, a driver traversing the corridor at 8:15 AM in 2015 needed to plan for a 30 minute travel time in order to ensure an "on time" arrival 95 days out of 100. By 2018, this planning time had been reduced to 19 minutes (an 11 minute reduction, or 38% improvement in planning time).

The most unreliable travel time in the eastbound direction in 2015 occurred at 3:30 PM, when the planning time was just under 33 minutes, which was more than double the average travel time. By 2018, planning time had been reduced to around 15 minutes, a 55% reduction.

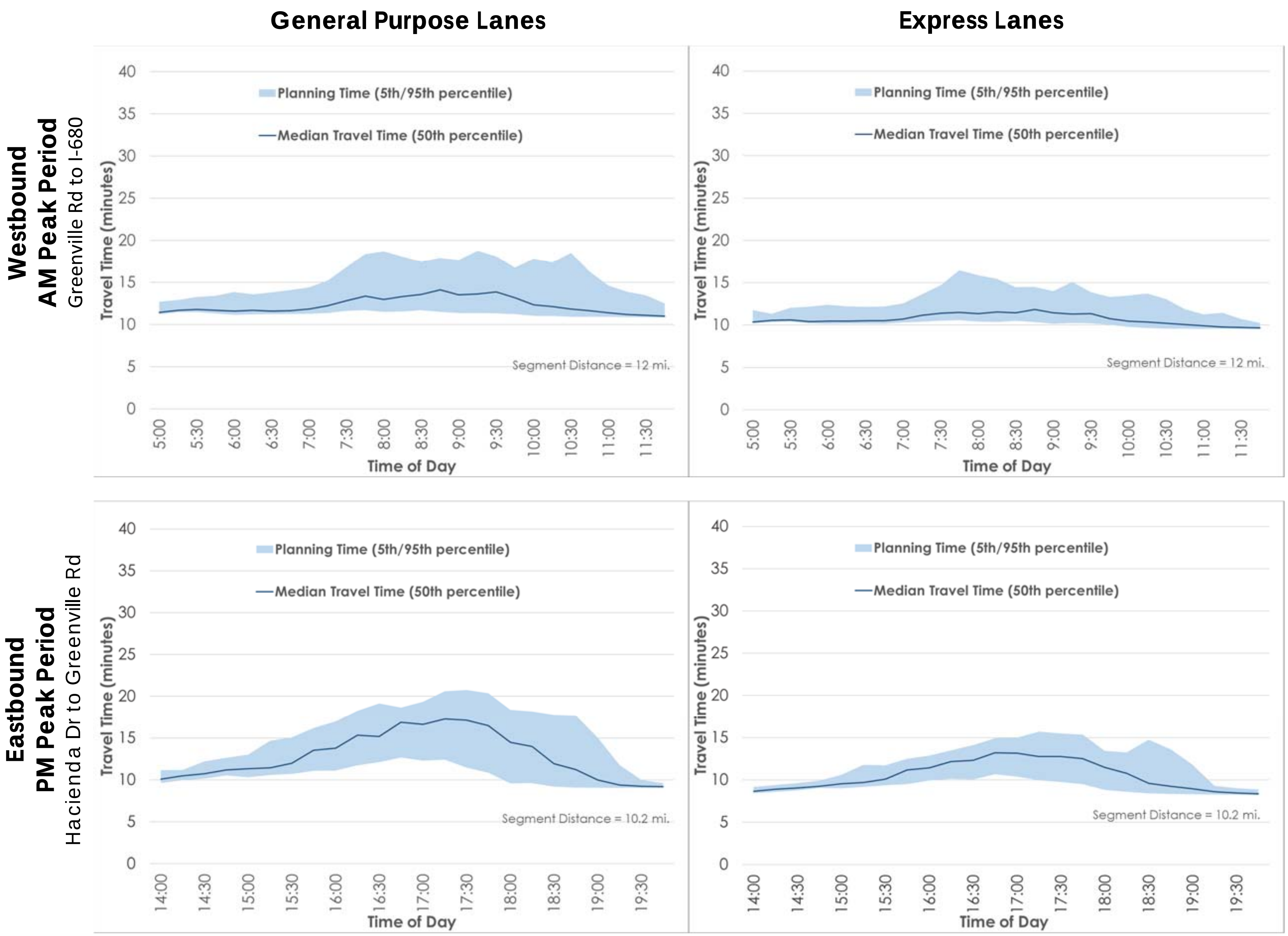
Figure 29, compares the reliability between the express lanes and the adjacent general purpose lanes for each direction in the spring of 2018. The figure shows that the express lanes not only provide faster travel times on average throughout the day, but also have lower planning times and less variability throughout the day.

Figure 28: Express Lane Corridor Travel Time Reliability by Direction and Time of Day 2015-2018



Source: Inrix.

Figure 29: Express Lane Corridor Reliability by Facility and Direction Spring 2018



Source: Alameda CTC ETS.

5.5 Safety

Summary of Key Findings

Total collisions and number of fatal and injury collisions per million vehicle-miles traveled (severe collision rate) increased in the express lane corridor at similar rates as across Alameda County freeways and an I-880 comparison corridor. The safety evaluation for the express lanes project does not suggest an issue with the express lanes, but it does reveal that collisions and the rate of severe collisions across heavily used freeway corridors in Alameda County are increasing, which is consistent with statewide and national trends.

Safety was evaluated by measuring the number and types of collisions reported to the CHP Statewide Integrated Traffic Records System (SWITRS) that provides detailed historical collision data through 2017. CHP Dublin Area also provided updated statistics to help validate findings as well as provided their perspective on collisions on the corridor.

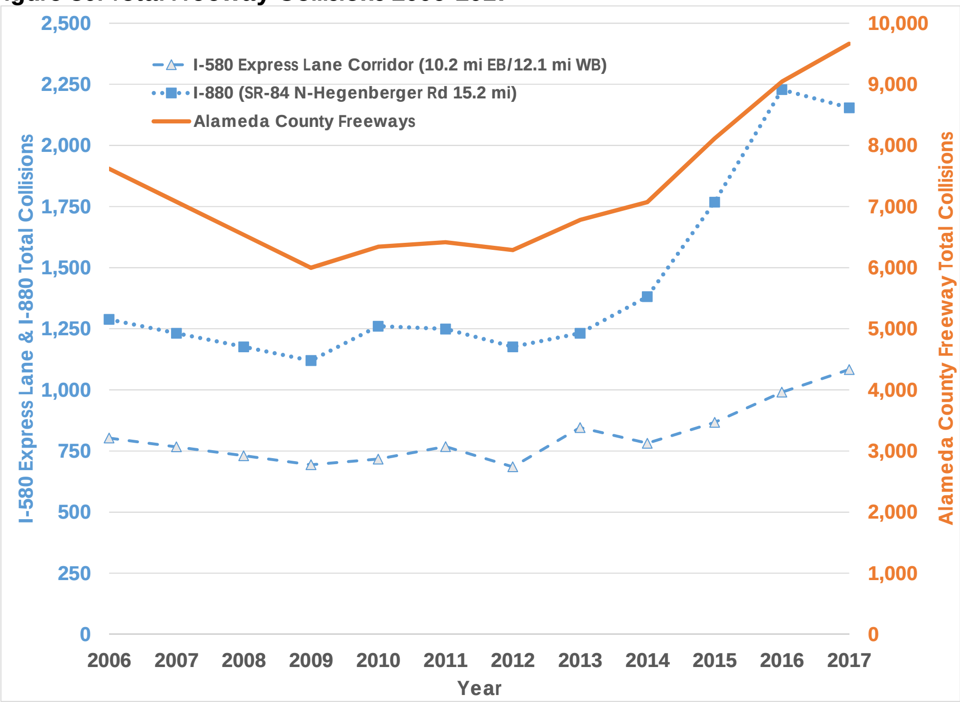
Total annual collisions were analyzed as well as fatal and injury collisions for the following corridors:

- I-580 Express Lanes (10.2 eastbound/12.1 miles westbound)
- I-880 comparison corridor between SR-84 (Decoto Road) and Hegenberger Road in Alameda County
- All Alameda County freeways.

The I-880 corridor and the Alameda County freeways were included to provide a contextual basis of comparison. The I-880 corridor has relatively high truck volumes, an HOV lane along portions of that corridor, and several major interchanges similar to the I-580 express lane corridor.

The total number of collisions along both the I-580 express lane corridor and the I-880 comparison corridor and on freeways in Alameda County all have increased since 2006 as shown in Figure 30.

Figure 30: Total Freeway Collisions 2006-2017



Source: CHP SWITRS.

As shown in Figure 30, collision trends among the different analysis corridors have remained relatively consistent with each other over time. The economic downturn between 2007 and 2009 caused a reduction in total collisions due to reduced traffic volumes and lower levels of exposure to potential incidents. Since 2009, total collisions have been increasing.

Since 2009 (the lowest year for total collisions on the two evaluation corridors and Alameda County freeways) collisions have increased at around 6% per year on all Alameda County freeways combined and on the I-580 express lane corridor. Collisions along the I-880 comparison corridor grew at a higher rate of 9% per year.

Over the same period, the total number of fatal and injury collisions, or "severe collisions" along Alameda County freeways increased by 6% per year with the I-580 express lane corridor experiencing a similar 5% per year increase. The I-880 comparison corridor grew by a higher 9% per year. This finding is consistent with statewide and national trends that fatalities from traffic collisions are increasing. Some potential explanations relate to driver behavior – distracted driving, driver fatigue, and drug or alcohol impaired driving.[10]

Fatal and injury collision rates per annual million vehicle miles (MVM) are summarized for the I-580 express lane and I-880 corridors in Table 3. Severe collision rates on the I-580 express lane corridor grew from 0.33 severe collisions/MVM in 2006 to 0.46 severe collisions/MVM by 2017, one year after the

[10] California Office of Traffic Safety. Highway Safety Plan, Federal Fiscal Year 2018 (October 1, 2017 through September 30, 2018).

I-580 Express Lanes opened. Over the past three years (2015-2017) the rate on the express lanes grew from 0.39 severe collisions/MVM to 0.46 severe collisions/MVM (17% or around 8%/year). The severe collision rate on the express lanes declined over the past year by approximately 5%.

In comparison, the I-880 comparison corridor has consistently experienced higher fatal and injury collision rates than the I-580 Express Lanes corridor, and over the three years between 2015 and 2017, I-880 corridor rates increased from 0.42 severe collisions/MVM in 2015 to 0.49 severe collisions/MVM – an increase of around 18% (9%/year), which is similar to the rate of increase experienced along the I-580 Express Lanes.

Table 3: Fatal and Injury Collisions and Rates by Year

Corridor	Data Item	2006	2015	2016	2017
I-580 Express Lane Corridor (10.2 mi EB/12.1 mi WB)	Fatal and Injury Collisions	221	273	349	337
	Million Vehicle Miles (MVM)	680	692	727	736
	Severe Collision Rate (Fatal and Injury Collisions/MVM)	0.33	0.39	0.48	0.46
I-880 Comparison Corridor (SR-84/Decoto to Hegenberger 15.2mi)	Fatal and Injury Collisions	465	524	669	648
	Million Vehicle Miles (MVM)	1,291	1,251	1,289	1,313
	Severe Collision Rate (Fatal and Injury Collisions/MVM)	0.36	0.42	0.52	0.49

Sources: California Highway Patrol SWITRS, Caltrans Traffic Operations Census.

Comparing total collisions and severe collision rates of the express lane corridor to Alameda County freeways and the I-880 comparison corridor suggests that the express lanes project did not contribute to safety issues, but it does reveal that collisions and the rate of severe collisions across heavily used freeway corridors in Alameda County are increasing, which is consistent with statewide and national trends.

6. Conclusions

Overall, the I-580 Express Lanes have reduced travel times, improved speeds, mitigated or eliminated bottlenecks, and improved the reliability of travel through eastern Alameda County while accommodating increased demand for travel along the corridor. The I-580 Express Lanes have addressed the project goals established for the project as summarized below in Table 4. A green check mark indicates that the project met the established goal, while a yellow check mark indicates that the project partially met the goal.

Table 4: Project Goals and Related Evaluation Measures

Project Goals		Did the Project meet its Goals?	
1	Provide congestion relief.	✓	The project reduced overall travel times in the westbound AM peak direction by 5 minutes (28%) and in the eastbound PM peak direction by 3 minutes (19%). Annual vehicle hours of severe delay[1] decreased by 151,000 vehicle-hours (47%).
2	Provide enhanced operational and safety improvements.	✓	The project removed bottlenecks and reduced queuing from El Charro Road to Greenville Road in both directions. Total collisions and the number of fatal and injury collisions per million vehicle-miles traveled increased in the express lane corridor at similar rates as across Alameda County freeways and an I-880 comparison corridor. Over the last year, the severe collision rate decreased by approximately 5% in the express lane corridor.
3	Expand available capacity for HOVs.	✓	The project added carpool capacity in both directions in the form of a new express lane in the westbound direction and a new express lane in the eastbound direction.
4	Expand the mobility options in the corridor.	✓	Express lanes are faster and more reliable than the adjacent general purpose lanes, creating an attractive mobility option in the corridor.
5	Provide reliable travel time savings to express lane users.	✓	Express lanes provide 2-4 minutes faster travel time than general purpose lanes on average. The variation of travel times is also lower in the express lanes than the general purpose lanes.
6	Increase the efficiency of the transportation system by charging single occupant vehicles for use of available capacity without impacting carpool lane operations.	✓	The project improved travel time and reliability across all lanes during the AM and PM peak periods. The corridor carries 27-30% more vehicles in the AM peak period and up to 12% more vehicles in the PM peak period in the eastbound direction.
7	Maintain Level of Service (LOS) C in the express lanes.	✓	The express lanes operate at LOS C in the AM and PM peak hours. During other operational hours the express lanes operate at LOS C or better.[2]

Notes

1. Severe delay is considered to occur when average speeds are slower than 35 mph.
2. Per Caltrans standard methodology, LOS was estimated for the peak hours which are 8 AM to 9 AM for the AM peak hour and 5 PM to 6 PM for the PM peak hour.

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Alameda County

Transportation Commission

I-580 EXPRESS LANES AFTER STUDY

Appendix A

Evaluation Methodology and Field Data Collection

Appendix A: Evaluation Methodology and Field Data Collection

This appendix provides information on the evaluation methodology and the field data collected for the I-580 Express Lane Evaluation.

A-1: Field Data Collection

Field data was collected on non-holiday, midweek days (Tuesday-Thursday) that also excluded spring break weeks for local schools during April and May of 2018. Historical field data was provided by Alameda CTC including 2013 and 2015 vehicle occupancy and classification count data as well as 2015 probe vehicle (also referred to as floating vehicle runs) data collection results and corresponding results memorandum.

For the spring 2018 field data collection, proper encroachment permits for access to the State Highway right-of-way on I-580 were obtained from the California Department of Transportation (Caltrans) Office of Permits. The California Highway Patrol (CHP) Dublin office was also informed of the data collection dates and times.

The remainder of this section details the approach for field data collection for the probe vehicle travel time runs and the vehicle passenger occupancy/vehicle classification counts.

A-1.1 Probe Vehicle Travel Time Runs

Hourly probe vehicle runs were performed for the express lane facility, the general purpose lane adjacent to the express lanes and the general purpose lane adjacent to the truck climbing lane. Hourly floating car runs for non-holiday, midweek days for one week in April (4/17 – 4/19/2018) and one week in May (5/15-5/17/2018). Three lanes were monitored in each direction:

- 1 express lane
- The general purpose lane immediately adjacent to the express lane (#3 lane in the eastbound direction and the #2 lane in the westbound direction).
- The general purpose lane immediately adjacent to the truck climbing lane in the eastbound direction (#4 lane eastbound and #3 lane in the westbound).

Vehicles departed from Foothill Road in Pleasanton in an eastbound direction on the hour at the hour. Vehicles exited at Flynn Road and returned back to Foothill Road for the next run on the half hour.

A-1.2 Vehicle Passenger Occupancy/Vehicle Classification Counts

Vehicle classification and passenger occupancy counts were conducted using real-time field staff at four locations along the corridor:

- Isabel Ave/Airway Blvd overcrossings (express lane facility)
- Tassajara/Santa Rita Rd overcrossing (express lane facility)

Vehicles were classified and counted for the following categories: Single Occupancy Vehicle (SOV), High Occupancy Vehicle with two people (HOV2), High Occupancy Vehicle with 3 or more persons (HOV3+), Vanpool, Transit Bus, Corporate/Casino Shuttle, Motorcycle, or Truck.

The data collection spanned from April 24 to May 9 on mid-week days. This timeframe and weekday sampling generally aligns with the occupancy counts performed in spring 2015.

A-2: Evaluation Methodology

In this section, each evaluation measure used in the evaluation is defined, the source of data used is detailed, and the necessary calculations are briefly described. Table A1 summarizes the evaluation measures and the data sources associated with each measure. The before and after evaluation periods occur in the spring time, which for the purposes of this evaluation begin March 1st and end May 31st.

Table A1: Evaluation Measures Summary

Evaluation Categories and Measures	Facility Type	Data Sources	
		"Before" (Spring 2015)	"After" (Spring 2018)
Travel Demand Profile			
Traffic Volumes	All Lanes: I-680 to County Line	Caltrans Traffic Census, 2013-2018	
	Express Lanes	n/a	Alameda CTC Electronic Toll System (ETS)
Vehicle Miles Traveled (VMT)	All Lanes: I-680 to County Line	Caltrans Traffic Census, 2013-2018	
	Express Lanes	n/a	Alameda CTC ETS
Mobility			
Travel Times	All Lanes	Inrix	Inrix
	Express/General Purpose	Field Data Collection	Field Data Collection, Alameda CTC ETS
Bottlenecks and Queueing	All Lanes	Inrix	Inrix
Vehicle Hours of Delay	All Lanes	Alameda CTC ETS, PeMS	Alameda CTC ETS
Person Hours of Delay	All Lanes	Alameda CTC ETS, PeMS, Field Data Collection	Alameda CTC ETS, Field Data Collection
Level of Service	Express Lanes	n/a	Alameda CTC ETS
Degradation	Express Lanes	n/a	Alameda CTC ETS

Evaluation Categories and Measures	Facility Type	Data Sources	
		"Before" (Spring 2015)	"After" (Spring 2018)
Use & Productivity			
Vehicle Occupancy	All Lanes	Field Data Collection	Field Data Collection
Transit Ridership	Tri-Valley BART Stations	Provided by transit operators	
	LAVTA Routes		
Vehicle Throughput	All Lanes	Field Data Collection	Field Data Collection
Person Throughput	All Lanes		
Reliability			
Planning Time	All Lanes	Inrix	Inrix
	By Lane	n/a	Alameda CTC ETS
Safety			
Total Collisions	All Lanes	SWITRS, 2006-2017	
Severe Collisions per Million VMT	All Lanes	SWITRS, Caltrans Traffic Census; 2006-2017	

A-2.1 Travel Demand Profile

Several measures were used to estimate the demand for travel along the I-580 Express Lanes, both before and after the express lanes opened. These include vehicle volumes, vehicle miles traveled (VMT), and other exogenous factors related to driver demand.

Vehicle Miles Traveled and Traffic Volumes

VMT is a measure of the miles traveled by traffic volumes (see below) over a segment. VMT was calculated by multiplying the traffic volume from a specific sensor or count location by the segment distance. Additionally, Annual Average Daily Traffic (AADT) data from Caltrans Traffic Census was used to estimate corridor wide annual VMT. AADT is the total volume of traffic for the entire year divided by 365 days.

Traffic volume represents the number of vehicles that pass specific locations along the corridor within a certain time period. Volumes were estimated by facility (express/HOV lane, general purpose lane at specific locations along the freeway corridor. Traffic volumes were determined using the I-580 Electronic Tolling System (ETS) sensor data, Caltrans' Performance Measurement System (PeMS, Caltrans Traffic Census, and field count data. Hourly traffic volumes and Average Daily Traffic (ADT) were calculated by averaging mid-week traffic volumes. Note that the ETS system is only active during the express lane operational hours (5 AM to 8 PM), whereas PeMS detection is active 24-hours per day.

The PeMS website was accessed with a user's accounts at: pems.dot.ca.gov/. Caltrans Traffic Census data was downloaded from the Traffic Census Program webpage located at: http://www.dot.ca.gov/trafficops/census/.

In spring 2015, PeMS had a limited number of sensors with high percent observed data within the express lanes facility boundaries and virtually no physical detection infrastructure east of the facility over the Altamont Pass. To address this limitation, PeMS was validated against, and supplemented by Caltrans AADT data, and manual count data from 2015. At select locations where reliable data exists before and after the express lanes opened, PeMS was used to compare volume and speed on the I-580 eastbound HOV lane (prior to February 2016) and the I-580 eastbound Express Lane (after February 2016), and general purpose lane trends over time.

The ETS data from overhead gantries, spaced approximately every 3/4 mile, provided a detailed traffic volume dataset for the express lanes after the opening day of the I-580 Express Lanes in late February 2016.

In spring 2018, volumes for the express lanes are calculated using ETS and PeMS data are used to estimate volume in the express lanes. The volumes for the general purpose lanes are estimated using only PeMS data.

Traffic volumes at select locations were reported as average daily traffic and VMT for the entire corridor was reported annually.

Other Factors Potentially Influencing Corridor Travel Demand

Exogenous factors such as socio-economic data (e.g., population, employment, and Port of Oakland Container traffic) was used to identify drivers that lead to changes in demand on the corridor (measured by ADT or VMT described above). For example, the continual growth in population in the Central Valley contributes to the historical growth in demand on the corridor.

Population

The percent change in population between 2006 and subsequent years for Alameda County, San Joaquin County, the San Francisco Bay Area, and for the State of California was calculated using population values from California Department of Finance Demographic Research Unit (DRU) for years 2006 through 2018, with years 2017 and 2018 being estimated by DRU. EDD numbers were obtained from the *California County-Level Economic Forecast 2017-2050; this report is available at http://dot.ca.gov/hq/tpp/offices/eab/socio_economic_files/2017/FullReport2017.pdf*.

Economy: Employment

The percent change in total employment between 2006 and subsequent years for Alameda County, San Joaquin County, the San Francisco Bay Area, and for the State of California was calculated using total employment values from California Employment Development Department (EDD) for years 2006 through 2018, with years 2017 and 2018 estimated by the department. EDD numbers were obtained from the *California County-Level Economic Forecast 2017-2050; this report is available at* *http://dot.ca.gov/hq/tpp/offices/eab/socio_economic_files/2017/FullReport2017.pdf*.

Employment and commuting estimates for the Tri-Valley area of Alameda and Contra Costa counties and for northern San Joaquin County were obtained from the Tri-Valley Rising 2018 report by the Bay Area Economic Institute. This report is available at *http://www.bayareaeconomy.org/files/pdf/Tri-Valley2018FULL.compressed.pdf*

A-2.2 Mobility

Mobility covers travel times, speeds, bottlenecks, queues, delay, level of service, and degradation measures. Across all of these measures, major incidents were not removed.

Travel Times and Speeds

The average travel time is the mean time across all non-holiday, midweek days during the spring of 2015 and 2018. Speeds normalize travel delays over a distance (i.e., Speed = Distance/Travel Time). A combination of Inrix and ETS data was used to estimate travel time and speeds before and after the facility opened. Probe vehicle runs (also referred to as floating vehicle runs) were also used to validate travel times and speeds.

Bottlenecks and Queuing

A bottleneck is a location where traffic demand exceeds the effective carrying capacity of the roadway. This capacity can be reduced by a physical loss of a lane, or when heavy merging and weaving take place near on and off ramps; merging at express or HOV ingress/egress points can also contribute to bottlenecks. On the demand side, surges in demand, often from on-ramps, can be greater than the freeway can accommodate when the road is approaching its maximum capacity.

The result is that volumes immediately upstream of the bottleneck decrease and a queue forms behind the bottleneck location. This condition lasts until the demand for the road decreases. The extent of the bottleneck is the point at the end of the queue where speeds exceed 35 mph, and the duration is the time period when speeds first drop below 35mph and then recover to above 35mph.

Bottlenecks were visually identified using speed contour plots using a combination of Inrix speed data and ETS speed and volume data. These data was supplemented by probe runs conducted in spring

2018 and by a review of Google Maps Typical Traffic feature that were used to verify the other data sources.

Vehicle/Person-Hours of Delay

Delay is reported as Vehicle-Hours of Delay (VHD) or Person-Hours of Delay (PHD), which measures how much longer vehicles or people spend traveling compared to a relative travel time based on a threshold speed of 35 mph.

The delay measures are computed by multiplying the number of vehicles (or people) impacted by the difference in measured travel time when traveling less than the reference speed by the reference travel time over the same distance) as illustrated in the following formula:

$$\text{VHD} = \text{Vehicles Affected x } (\text{Travel Time}_{\text{measured}} - \text{Travel Time}_{\text{threshold speed}})$$

The data for calculating VHD came from a combination of ETS, PeMS, and Inrix. The PHD was calculated by multiplying the VHD by the average vehicle occupancies (AVOs) obtained from the field data collection conducted in 2015 and in 2018.

Level of Service

Level of Service (LOS) is a qualitative mobility evaluation measure that attempts to measure how well a driver can maneuver in traffic. Using a “report card” letter grade, LOS rates traffic conditions from “A” (free-flow speeds with complete mobility between lanes) to “F” (congested conditions with slow speeds and limited mobility).

The LOS Analysis used in the Transportation Research Board’s Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis (HCM 2016) **lane density** approach (passenger car per mile per lane) and speed standard (e.g., A= speeds >=60 mph, F= speeds <30 mph) approaches. LOS was calculated using volumes from PeMS or Caltrans AADT data prior to the opening of the express lanes and from the Alameda CTC ETS speed and volume data after February 2016.

Express Lane Degradation

The Federal Highway Administration (FHWA) definition for degradation was used to assess the express lanes. The FHWA considers an HOV (or express) lane to be degraded if the average traffic speed during the morning or evening weekday peak commute hour is slower than 45 miles per hour for more than 10 percent of the time over a consecutive 180-day period. For that report, only the 8 AM and 5 PM peak hours are analyzed over a six month period.

A-2.3 Use & Productivity

Productivity is a system efficiency measure used to analyze the capacity of the corridor and is defined as the ratio of output (or service) per unit of input. In the case of highways, productivity is evaluated for a facility under peak congested conditions and is the number of vehicles (or persons) traversing that section during peak travel periods. Typically, under congested conditions, the maximum throughput can be found at the queue approaching a bottleneck.

Vehicle Throughput

Vehicle throughput is the number of vehicles per hour successfully passing a specified location.

Throughput was reported for each hour of the day, and maximum flow rates were identified during congested time periods. This was calculated using ETS volume data and reliable PeMS data as discussed in Traffic Volumes above. PeMS data was used only at select locations where reliable data was available in both the before and after periods to have consistent results over time.

Person Throughput

Person throughput is calculated by multiplying the vehicle throughput by the AVO (see Average Vehicle Occupancy below) of the corridor and is reported in a similar manner as vehicle throughput.

Average Vehicle Occupancy

Average Vehicle Occupancy (AVO) is calculated from the vehicle classification (see Vehicle Classification Counts in Section A-2.3 of this appendix) field data by summing the number of people represented by each vehicle classification and dividing by the total number of vehicles counted.

Transit Ridership

Transit ridership was route or station-based. The following transit operators provide transit service on the I-580 freeway in the study corridor:

- Bay Area Rapid Transit District (BART) – Dublin/Pleasanton and West Dublin/Pleasanton stations
- Wheels (Livermore-Amador Valley Transportation Authority) – 20X, 580X, and 30R.

Monthly station entry and exit data for the Bay Area Rapid Transit District (BART) Dublin/Pleasanton and West Dublin/Pleasanton stations came from www.bart.gov/about/reports/ridership. Annual route ridership data for the Livermore-Amador Valley Transportation Authority (LAVTA) routes came from the *Contra Costa Transportation Authority (CCTA) 2017 Multimodal Transportation Service Objectives (MTSO) Monitoring Report*, available at: http://www.ccta.net/_resources/detail/7/1.

A-2.4 Reliability

Reliability is defined as the Planning Time in this report. For this measure, major incidents were not removed.

Planning Time

Planning time is a measure of reliability and is defined as the 95th percentile travel time. The 95th percentile travel time is the time that a person's travel will be faster on 95 days out of 100, or slower on five days out of 100. For example, a person leaving for work on a weekday at 8:00 AM will experience a travel time to work 95 days out of 100 that is less than the planning time for that departure time. For five days, that person will experience a travel time that takes longer than the planning time. Thus, if a commuter needs to be at work on time 95 days out of 100 (or 19 days out of 20 for a typical work month), that person should allow for the 95th percentile travel time to get to work.

Planning time was calculated by taking the travel times for each 15-minute interval for each weekday under analysis and selecting the 95th percentile time, which is based on the rank-sorted order from the shortest travel time to the longest travel time. The 95th percentile is calculated by using a standard percentile function. As an illustrative example, if there are 100 days (i.e., records) of travel time data, the 95th percentile travel time is the 95th record when rank sorted in ascending order.

A-2.5 Safety

Safety was evaluated by measuring the number and types of collisions over time along the corridor.

This measure was evaluated by using the California Highway Patrol (CHP) Statewide Integrated Traffic Records System (SWITRS). SWITRS provides detailed collision data statewide and has historical data through 2017. The SWITRS data was downloaded from: https://www.chp.ca.gov/programs-services/services-information/switrs-internet-statewide-integrated-traffic-records-system.

The Dublin CHP area also provided aggregate collision data that was used to identify recent trends in collisions. Collision rates for fatal and injury collisions (i.e., collisions per million vehicle miles traveled) were calculated using VMT estimates obtained from a combination of Caltrans AADT and Alameda CTC ETS data.