SR 25-487
Attachment 1

Mission Boulevard Transit Signal Priority

Before and After Study

June 2025

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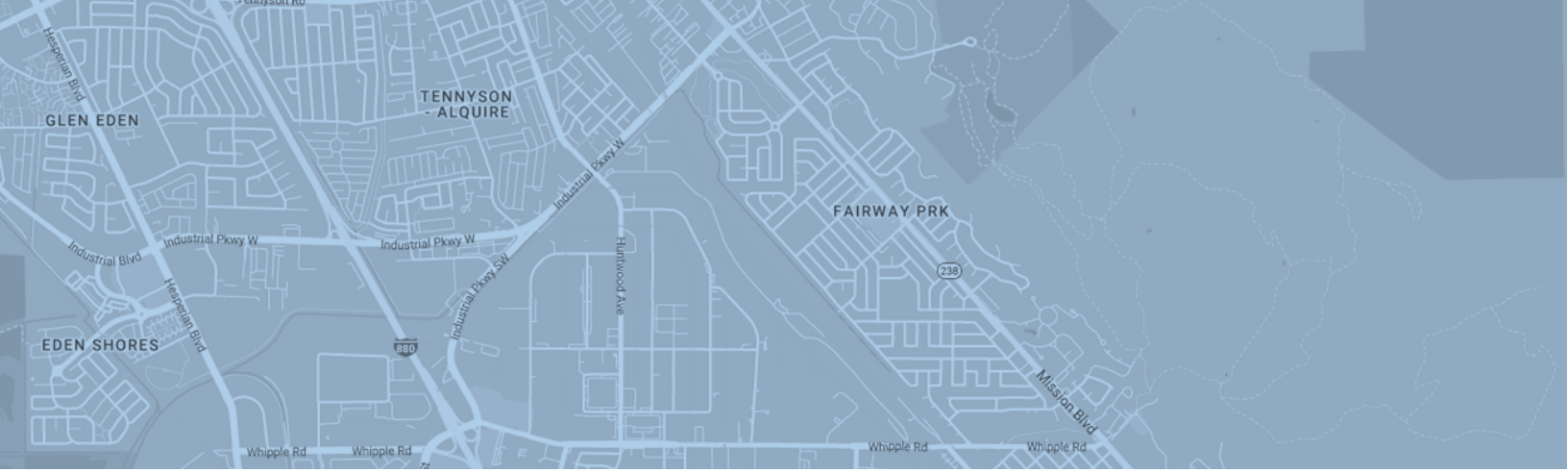

EXECUTIVE SUMMARY

Transit Signal Priority (TSP) was implemented along a major portion of AC Transit Line 99. AC Transit provides fixed route transit services throughout western Alameda and Contra Costa Counties. The TSP project was implemented primarily on Mission Boulevard which connects the major transit hubs of Hayward BART Station and Union City BART Station with the surrounding neighborhoods. TSP was implemented at all intersections between these two major transit hubs. In total, 32 intersections across the jurisdictions of Hayward, Union City, and Caltrans were equipped with TSP. The goal of this project was to enhance efficiency to transit users by reducing transit delays while maintaining highly efficient traffic signal operations for all other users by applying transit signal priority.

The purpose of this report is to introduce the project scope, summarize how TSP works, discuss the data sources, comparison methodology, and communicate the transit performance analysis results before and after TSP implementation. The report will also summarize the conclusions and overall findings.

The before and after study contains two analysis periods: before TSP was installed and after TSP was implemented, turned on, and verified. The "Before" (TSP off) study dates were from April 9th to April 15th, 2024, and the "After" (TSP on) study dates were from January 23rd to January 29th, 2025. The data and analysis results are shown both as daily averages and are broken down into morning peak (7:00 to 9:00 am), midday peak (11:00 am to 1:00 pm), and afternoon peak (4:00 to 6:00 pm) periods. Bus travel time and on-time performance were the two major data sources used to analyze and compare bus performance for the study. Data was gathered using Swiftly, which is an online service that AC Transit subscribes to that aggregates transit vehicle trip data. Swiftly data was validated as part of the study to ensure the data used for this analysis was accurate.

The data analysis shows that the implementation of **TSP reduced overall route travel times by 8%,** which corresponds to an average **reduction of 2 minutes and 40 seconds per trip.** Also, bus **performance on time trips improved by 3.3%, and reduced late arrivals by 4.3%.** Based on improved bus travel times, bus fuel consumption is expected to **decrease by approximately 1,653 gallons per year and save almost 33,754 pounds of greenhouse gas (GHG) emissions per year. The benefit-cost ratio for the whole project was 4.86 to 1,** which represents an excellent return on investment.

INTRODUCTION

Transit Signal Priority (TSP) systems optimize urban transit by dynamically adjusting traffic signals to favor transit vehicles. As a transit vehicle approaches an intersection, the TSP communicates with the signal controller to extend the green phase for transit or reduce the red phase for other traffic. This proactive management minimizes waiting times, shortens overall travel durations, and improves schedule reliability. Our Before and After study examines how these adjustments not only enhance operational efficiency and reduce delays but also encourage increased transit use, ultimately contributing to a more sustainable urban mobility system.

The TSP implemented in this project is a form of "Active" transit signal priority. This means that the TSP system actively sends a request for a specific bus for a specific intersection signal phase to receive priority. While timing revisions and construction activities are inevitable, Hayward, Union City, and Caltrans did their best to minimize changes between study periods. This means that improvements discussed in this report were from the TSP system granting priority to buses on the Mission Boulevard route, and not because of any altered signal timing for Line 99's 32 intersections. Changing the signal timing bandwidths/offsets, for example, to favor buses is one example of "Passive" transit signal priority and was not implemented during this project timeline.

Project Route

The evaluation of TSP will be entirely focused on the performance of AC Transit Line 99. However, dozens of other lines share intersections with this line and buses equipped with the same TSP system will be able to receive potential operating and travel time benefits.

Line 99 is a core route of AC Transit's network that connects communities, schools, and employment areas between Hayward BART and Fremont BART stations. The line also stops at South Hayward BART and Union City BART stations. Service is provided every 20 minutes from 5:00 am to midnight on weekdays and every 30 minutes from 6:00 am to midnight on weekends. This line travels in both northbound and southbound directions, with northbound going from Union City BART to Hayward BART and southbound going from Hayward BART to Union City BART. Figure 1 shows the project area of Line 99.

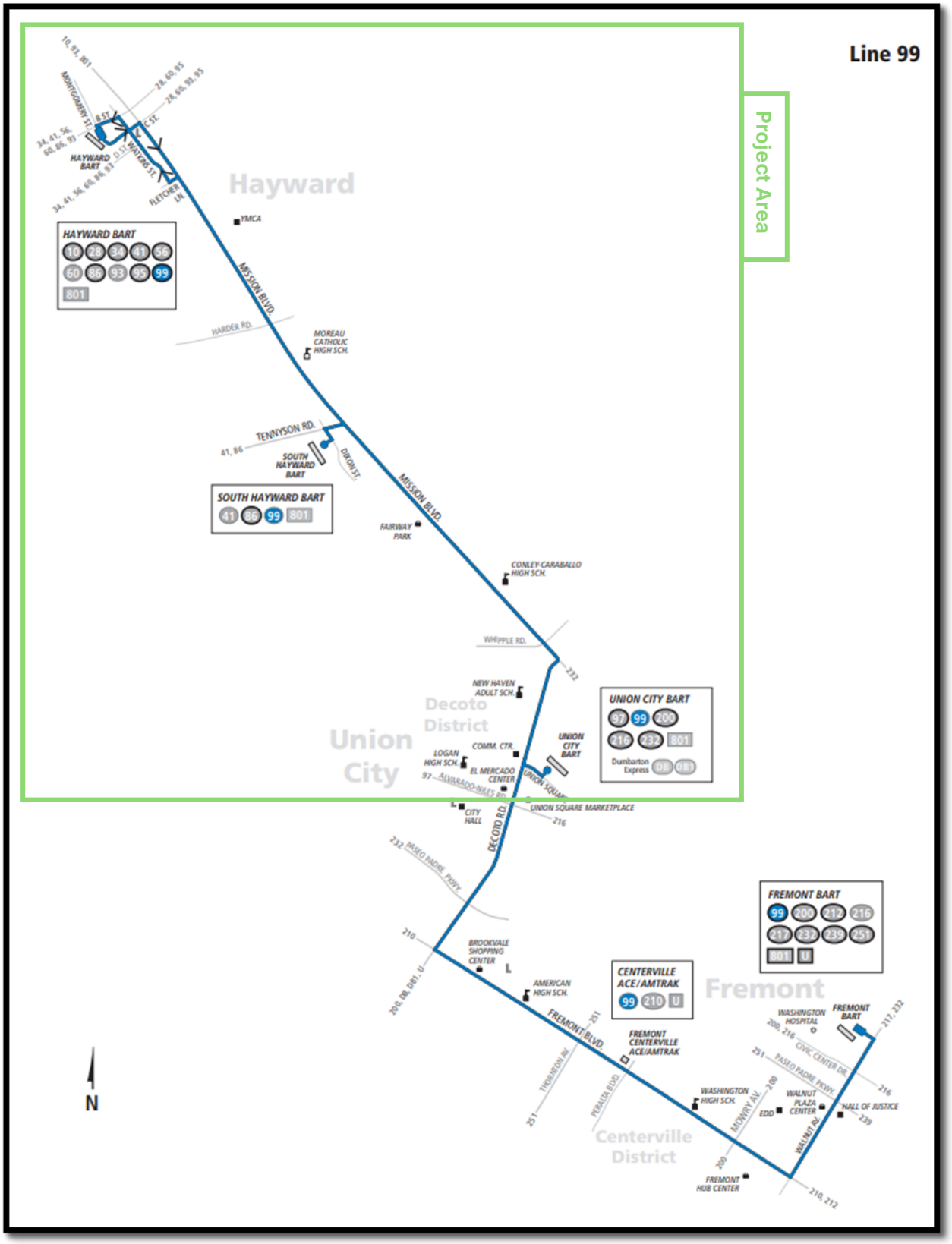

Figure 1: Line 99 Map and Project Area

Number and Location of Traffic Signals

The project included 32 signalized intersections, divided between Hayward with 24 intersections, Union City with 4 intersections, and Caltrans with 4 intersections, as shown in Table 1 and Figure 2. These traffic signals are critical for managing vehicle (auto, truck, and bus) flow along Mission Boulevard, especially given the presence of buses and regular vehicular traffic. Prior to TSP implementation, there was no priority given for buses along this route.

Table 1: List of TSP Intersections by City

List of TSP Intersections			
#	**City**	**Main Street**	**Cross Street**
1	Hayward	Watkins St	B St
2	Hayward	Watkins St	C St
3	Hayward	Watkins St	D St
4	Hayward	Watkins St	Jackson St
5	Hayward	Mission Blvd	D St
6	Hayward	Mission Blvd	Jackson St
7	Hayward	Mission Blvd	Fletcher
8	Hayward	Mission Blvd	Highland Blvd/Sycamore Ave
9	Hayward	Mission Blvd	Carlos Bee Blvd/Orchard Ave
10	Hayward	Mission Blvd	Berry Avenue
11	Hayward	Mission Blvd	Harder Road
12	Hayward	Mission Blvd	Sorenson Road
13	Hayward	Mission Blvd	Moreau Catholic HS Access
14	Hayward	Mission Blvd	Calhoun Street
15	Hayward	Mission Blvd	Hancock Street
16	Hayward	Mission Blvd	Tennyson Rd
17	Hayward	Mission Blvd	Valle Vista Ave
18	Hayward	Mission Blvd	Industrial Pkwy/Alquire Pkwy
19	Hayward	Mission Blvd	Garin
20	Hayward	Mission Blvd	Arrowhead
21	Hayward	Mission Blvd	Fairway
22	Hayward	Mission Blvd	Rousseau
23	Hayward	Mission Blvd	Gressel St/Corrine St
24	Hayward	Mission Blvd	Blanche St
25	Union City	Decoto Rd.	5th St.
26	Union City	Decoto Rd.	7th St.
27	Union City	Decoto Rd.	11th St.
28	Union City	Decoto Rd.	Station Way
29	Caltrans	Mission Blvd.	Lafayette Ave.
30	Caltrans	Mission Blvd.	Tamarack Dr.
31	Caltrans	Mission Blvd.	Whipple Rd.
32	Caltrans	Mission Blvd.	Decoto Rd.

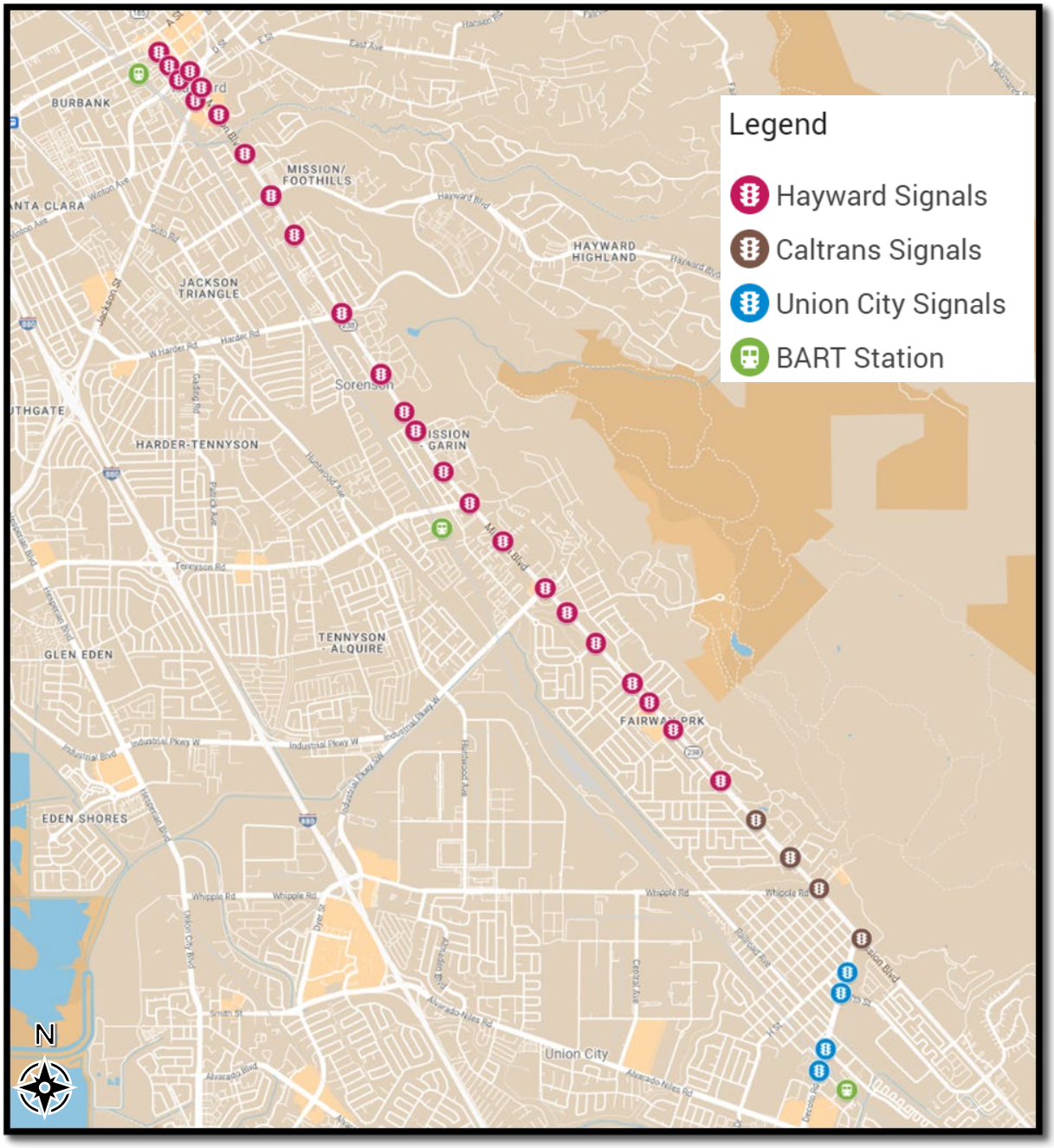

Figure 2: Signal Jurisdiction Along the Project Area of Line 99

Stakeholder Involvement

The success of the TSP deployment along the Mission Boulevard corridor was driven by a collaborative effort across two key project phases—construction and operation/maintenance—with each stakeholder contributing unique expertise:

Construction Phase

- **DC Electric**
  Serving as the general contractor, DC Electric was pivotal during the construction phase. They installed the essential hardware components—including GPS-Radio units and the requisite wiring—that enabled the TSP system to function. Their expertise ensured that all installations met the necessary technical standards and timelines.

- **City of Hayward and City of Union City**
  The cities, responsible for owning and maintaining the majority (28 of the 32) of the traffic signals along Mission Boulevard, played a critical role during construction. They facilitated the project by issuing construction permits, approving the installation of TSP equipment, and ensuring that the traffic infrastructure was ready for the new technology. Their close coordination with DC Electric helped guarantee that the installation process was smooth and compliant with local regulations.

- **Caltrans**
  With control over four intersections along Mission Boulevard, Caltrans was essential for ensuring system compatibility at its sites. They provided oversight during the integration of the TSP system with existing signal control systems at these intersections, ensuring that the new technology would function seamlessly with their operational protocols.

Operation and Maintenance Phase

- **AC Transit**
  As the primary operator of the bus fleet that benefits directly from TSP, AC Transit took the lead in the operation phase. They oversaw the integration of the TSP system with their transit operations, working closely with city agencies to fine-tune signal timings and monitor system performance. AC Transit's ongoing commitment to resource allocation and system oversight has been key to sustaining operational efficiency and maintaining improved service reliability.

- **City of Hayward and City of Union City**
  Beyond the construction phase, both cities continue to play a vital role in the project's success. They maintain responsibility for the ongoing upkeep of the traffic signals, monitor TSP performance at their intersections, and collaborate with AC Transit to make any necessary adjustments to optimize transit operations.

Each partner's dedicated efforts during both the construction and operation/maintenance phases have been essential in realizing the full benefits of the TSP system, ultimately enhancing transit efficiency and service reliability along Mission Boulevard.

TSP SYSTEM COMPONENTS

This section summarizes the project installation phases and how the components of a TSP system work together. Hardware was installed at intersections, testing was performed, then priority requests were able to be generated, and finally sent to the controller to be served.

System Design and Installation

The implementation of the TSP system on Mission Boulevard was executed in multiple phases, ensuring a seamless integration of the new technology with the existing traffic infrastructure:

- ### Phase 1: Initial Assessment and Upgrades
  A thorough assessment of the existing traffic signal systems was conducted at the 32 intersections along the corridor, spanning Hayward, Union City, and Caltrans-managed intersections. During this phase, it was determined that while many intersections already had 2070 signal controllers installed, several required upgrades to ensure compatibility with TSP. This phase also included evaluating existing emergency vehicle preemption systems and integrating them with the TSP technology.

- ### Phase 2: Hardware Installation
  The second phase involved the installation of weather-resistant GPS radio units and phase selectors at intersections. These devices were connected to the signal controllers via a Phase Selector to allow the processing of TSP requests. Additional hardware, such as multimode phase selectors, was installed where needed to ensure that both emergency vehicles and transit vehicles could communicate with the signals without interference.

- ### Phase 3: Software Configuration and Testing
  In this phase, software configurations were made to the signal control systems to ensure they could process TSP requests while maintaining normal signal operations for non-prioritized vehicles. Adaptive traffic control software (such as SCATS) was used at many intersections to dynamically adjust signal timings based on traffic conditions. Extensive testing was conducted to validate the system's functionality and ensure it operated effectively within the predefined parameters for both buses and emergency vehicles.

TSP Call Generation and Transmission

There are a variety of options available to detect and receive a transit priority call. The oldest system consists of an optical or infrared light emitter on the bus and a receiver on the intersection signal's mast arm. As soon as a bus comes into range of the receiver, the light is received, and a low priority signal is sent to the signal controller. The advantages of an infrared TSP system include TSP call reliability, ease of installation and maintenance, and proven technology. The disadvantages are that the bus detection zones are not accurately defined, and light cannot travel around corners.

At the opposite end of the spectrum is the cloud-based system in which a bus's GPS signal is transmitted to the cloud-based server. Then, based on flexible detection zones and estimated arrival times, a priority call is sent to the connected signal controller using standard communication protocol (NTCIP). This system can be used to predict future bus arrivals, but its

disadvantage is that the signal controller, TSP call processing server, and GPS unit onboard the bus all need to be online for the call to be placed.

In the middle of the technology spectrum is the GPS-Radio system. Figure 3 below shows how the components of the GPS-Radio TSP work together. It consists of a GPS-Radio device mounted at the intersection that receives a radio signal directly transmitted from a bus. The location of the bus is then calculated. Bus detection zones are drawn on a map using GPS coordinates by connecting to a Phase Selector card in the signal cabinet. The GPS-Radio unit and phase selector are shown in Figure 4.

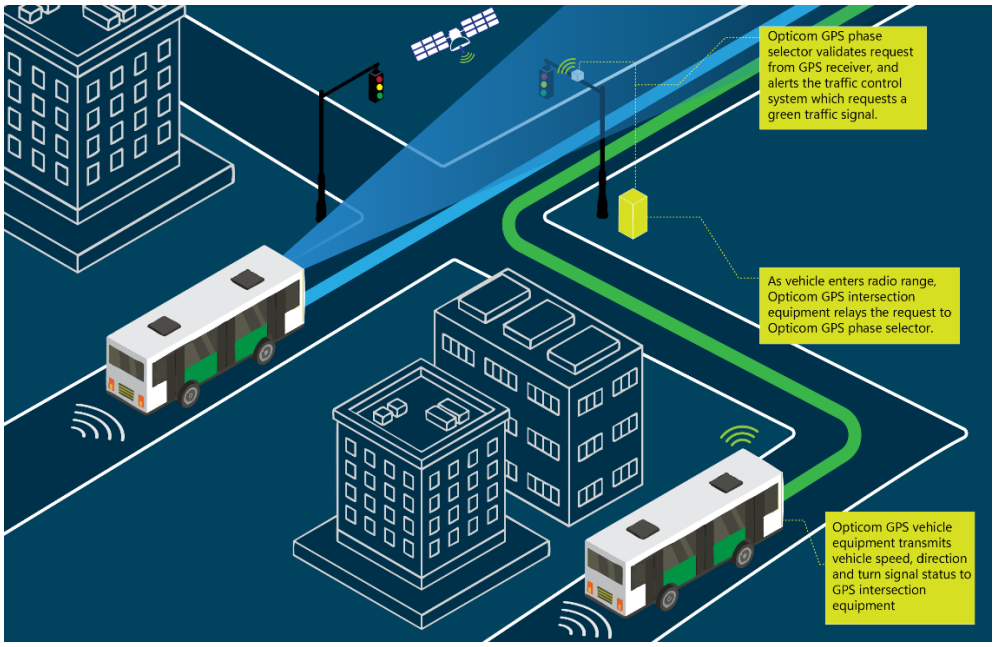

Figure 3: Components of an Opticom TSP System (Source: GTT.com)

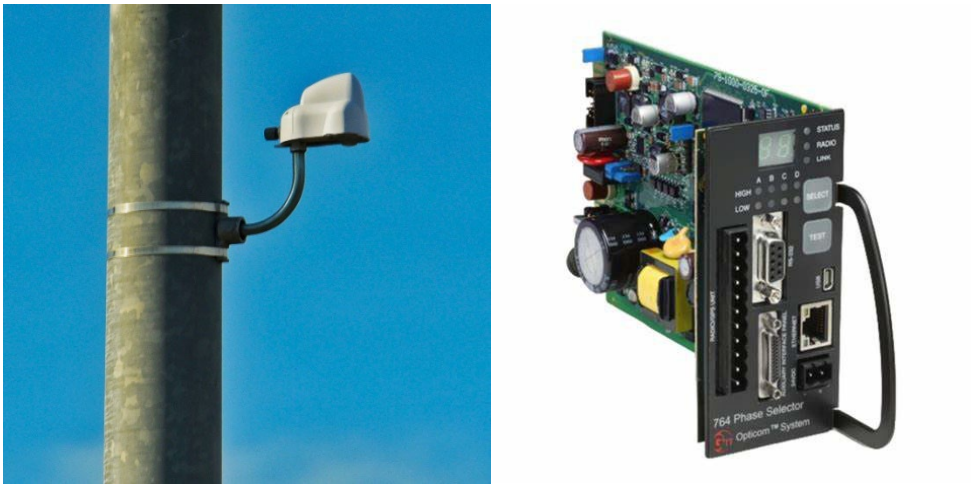

Figure 4: TSP Components: GPS-Radio Receiver (Left) and Phase Selector (Right)

The GPS-Radio solution was chosen for this project. This system has been shown nationally to maintain high reliability, accuracy, and customizability. Another benefit of this system is that AC

Transit owns all the components of the TSP system and upkeep costs are lower compared to cloud TSP subscription rates.

Jurisdictional Signal Timing and TSP Overview

The signal control methodology remained mostly unchanged for general vehicles during the implementation of TSP. The changes in the signal operations before and after TSP can be grouped into five categories as defined by Table 2.

Table 2: Signal Operations by Jurisdiction

Signal Operations by Jurisdiction		
Jurisdiction	**Before**	**After**
Hayward (2 signals)	Free/TOD coordination operation using traditional ring-barrier phases	SCATS MasterLink (adaptive) with TSP stages
Hayward (22 signals)	SCATS MasterLink (adaptive)	SCATS MasterLink (adaptive) with TSP stages
Caltrans (4 signals)	Free operation using traditional ring-barrier phases	Free operation using traditional ring-barrier phases with TSP for major phases
Union City (1 signal)	Free operation using traditional ring-barrier phases	Free operation using traditional ring-barrier phases with TSP for transit phases
Union City (3 signals)	Maxtime Adaptive coordination using traditional ring-barrier phases	Maxtime Adaptive coordination using traditional ring-barrier phases with TSP for transit phases

Hayward TSP Operation

The method of operating TSP for the project intersection signals located in Hayward is using the existing Sydney Coordinated Adaptive Traffic System (SCATS). The advantage of SCATS over traditional signal control is that the system adjusts for real-time vehicle arrivals and automatically improves signal timing to enhance the flow of vehicles as a system. Two intersections, Watkins Street & B Street and Watkins Street & C Street, were upgraded from traditional control to SCATS. When SCATS controlled intersections are online and communicating, the signal timings are constantly being optimized using the SCATS algorithm which is located on a central server. This is called MasterLink and is the highest level of control offered by SCATS. All SCATS intersections along the project route are online and in communication with the SCATS central system.

TransCore, the SCATS vendor, implemented the TSP stages and verified their operation. In the SCATS system, TSP is served using specific timing stages that are only called when the TSP system detects a bus. For most intersections, the TSP stages typically consist of a 7 second “Early Green”

stage and a 10-second “Green Extend” stage. Figure 5 below shows the typical stages A, C1, C2, C, and B, as well as the early green transit stage D, and the late green extension transit stage E. If an equipped bus approaches the intersection on an existing green signal and successfully passes through the intersection before the green extension stage needs to be called, no TSP stage will be recorded. If a bus arrives on green and the regularly called stage is about to end, the green extension stage will be called to get the bus through the intersection. If a bus arrives on red, then the early green stage will be called.

Figure 5: SCATS Intersection View With Signal Stages

Caltrans TSP Operation

The Caltrans intersections use a standard mode of operation using two rings and barriers to serve phases (as opposed to sequential stages in SCATS). In order to efficiently balance local intersections and corridor needs, the four intersections are fully actuated at all times of day.

The Caltrans controller software has been programmed to provide up to a maximum of 10 seconds of early green per mainline phase. Also, the program will hold the mainline phases green for up to 10 seconds. The program does not have the ability to provide priority to side street bus phases; therefore, at Mission Boulevard & Decoto Road, buses turning left from Decoto Road to Mission Boulevard do not have the ability to be served by TSP.

Union City TSP Operation

The intersections within the City of Union City are operated by the Q-Free MaxTime firmware which uses standard ring-barrier phases. Decoto Road & 5th Street is running free using fully actuated operation while the remaining three intersections use MaxTime Adaptive which proactively adjusts the signal timing to achieve desirable corridor progression.

TSP works in the Q-Free realm by enabling a "Prioritor" which contains green phase extension, red reduction and numerous other flexible TSP options. Upon the presence of an equipped bus, the Prioritor automatically adjusts the signal timing to either extend the green or reduce the non-bus phases.

TSP SYSTEM VERIFICATION

The TSP system was verified to be working before the "after" study began. Calls coming into the controller were verified both in the field during TSP implementation and remotely by downloading TSP call history. Ultimately, a working TSP system means that TSP calls are granted and served by the controller.

An intersection that receives a priority call for every bus would record 114 calls per day, which is based on 19 service hours per day (5 am to midnight), three buses per hour, and two directions. However, since a TSP call will not be placed if the bus does not need priority (arrives on green), a bus can travel smoothly down a corridor with few TSP calls. An adequate number of calls per intersection is assumed to be approximately 25-100 for service in both directions and 15-50 for service in one direction. The bandwidth and vehicle platoons vary largely between intersections and by time of day as the directional priority of the adaptive systems change. The verification process is described for each of the three different controller types encompassing the route for this project.

- Verification of Hayward intersections consisted of reviewing "stage" history logs, which showed the historic frequency and duration of vehicle and bus stages. An adequate number of TSP stages were recorded for all intersections.
- TSP for the Caltrans intersections were verified by reviewing the number and duration of TSP calls from a report obtained from the Caltrans central signal system. The number of calls granted was determined to be adequate for all intersections.
- For signals in Union City, controller reports were generated from the City's central signal system, which showed that an adequate number of TSP calls were granted by the Prioritor at all intersections.

TSP reports for each intersection are presented in Appendix A.

DATA VALIDATION

Upon the TSP system's verification to be functional, the data used to quantify the improvements in bus performance was validated for accuracy. AMG rode several trips along the line and collected video and GPS data. The same trips were extracted from the transit performance dashboard called Swiftly. Swiftly is an online transit-focused performance dashboard that records and stores bus travel times, on-time performance, and more. In this section, travel time and on-time performance from Swiftly were validated against real-world trips recorded on the bus to support the study.

Travel Time Validation

Bus travel time from data collected in the field and from Swiftly was compared. Figure 6 shows a detailed breakdown by direction and time of day. The figure shows that travel times across all time periods are very similar, with a maximum deviation of approximately 30 seconds, with most being less. These small deviations between Swiftly travel times and field-collected travel times mean that Swiftly accurately records travel time and can be used for the study.

Slight differences in travel time occur due to the definition of a stop and the buffer distance from the stop. For example, at the BART stations, there are many possible places for the bus to stop, which can consist of multiple bus bays. The presence of a stop sign near the bus bays can change the Swiftly departure time.

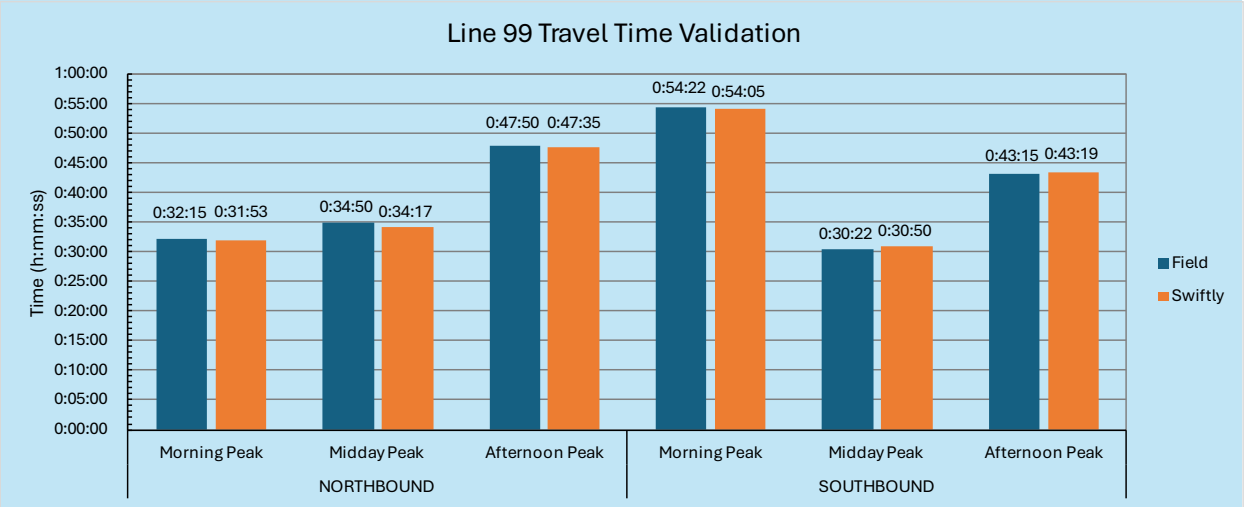

Figure 6: Travel Time Validation

On-Time Performance Validation

The times that Swiftly records a bus departing from a bus stop need to accurately highlight the time that the bus actually departs the stop. This information is needed to determine whether the bus departed at the stop early, late, or on time. For the same trips used to verify travel times, the times that the bus departed every bus stop were compared to the identical Swiftly and field-collected trips. This difference in departure time was averaged for all bus stops, which resulted in the average difference in departure time between Swiftly and the field-observed trips. The difference is defined as the Swiftly departure time minus the field departure time.

For example, if the Swiftly departure time was 7:30:10 am and the field departure time was 7:30:02 am, then the difference would be 8 seconds. Then, if the next stop had a difference of 4 seconds, the average difference in departure time for the two stops would be 6 seconds.

Figure 7 shows that the average difference in departure time was between 24 seconds and 1 second, based on the time of day and bus service direction. Importantly, all six trips analyzed had a later Swiftly departure time compared to the field-observed trip. This could be due to the algorithm Swiftly uses to estimate the bus stop departing times. Because 24 seconds was the greatest average difference between the data sources, this means that Swiftly accurately recorded the bus stop departure times. A bus is considered on time when it is less than one minute early and 5 minutes late.

One reason the southbound afternoon peak trip included the largest inconsistency was the additional stopping close to bus stops that occurred during traffic congestion. These added stops could have caused Swiftly to incorrectly identify the bus stop's dwell time and departure time. Similar to the travel time deviations, another explanation for the departure time variations could be that the bus stopped at a signal, which is near to the bus stop, and Swiftly thought the bus stopped at the bus stop, when it didn't. Even with these inconsistencies, the average deviation of departure times was far less than the definition of an on-time departure.

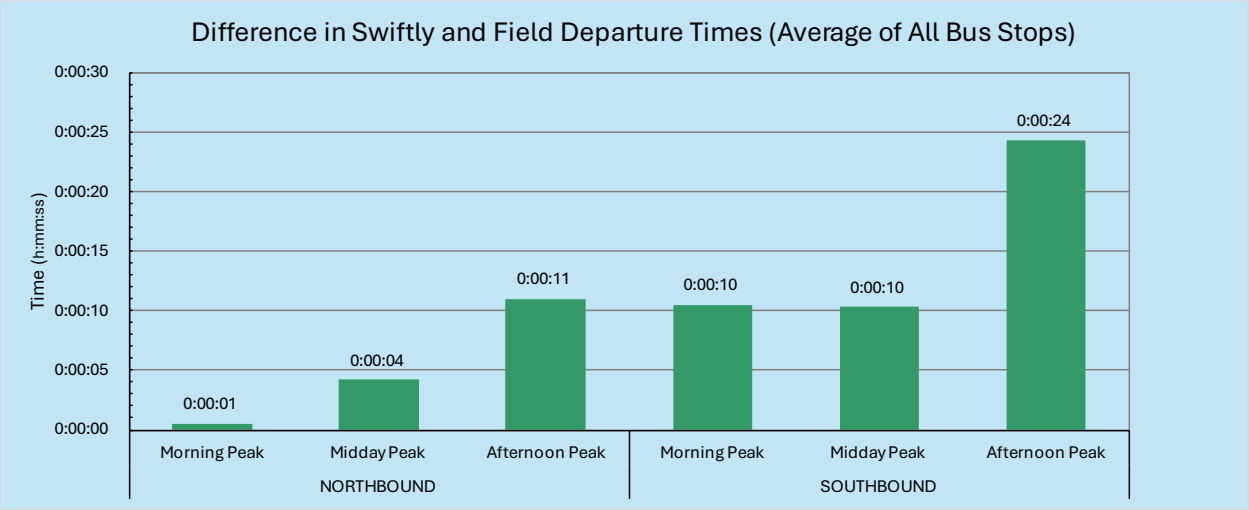

Figure 7: On-Time Performance Validation

Dwell Time

Dwell time is available from Swiftly but was not used for this analysis due to several reasons. For example, dwell time, as recorded by Swiftly, refers to the time a bus spends near a bus stop while at a slow speed. The range is approximately 200 feet from the bus stop. The occurrence of a dwell time event is irrespective of whether the bus doors open or not. Based on reviewing on-board videos, a recorded dwell time event could mean one or more of the following occurred:

- The bus stopped at the bus stop and exchanged passengers

- The bus stopped at a red signal where there is also a nearside bus stop, and did not exchange passengers
- The bus stopped at a red signal where there is a nearside bus stop, exchanged passengers, then waited longer for a green signal
- The bus stopped at a red signal where there is a far side bus stop, waited for a green signal, and did not stop at the far side bus stop
- The bus slowed to approximately 3-5 miles per hour but did not stop while within the range of approximately 200 feet from the bus stop

Due to the unpredictable nature of the events that occurred during dwell time, this data was not used to support this analysis.

BEFORE AND AFTER ANALYSIS METHODOLOGY

This section outlines the procedures used to perform the before and after study, including the identification of the times and dates of the study, a discussion of the techniques, tools, and procedures used to assess travel time and on-time performance, and the processes for estimating emissions and the benefit-cost ratio.

Times and Dates Analyzed

The data presented in this study is specific to Line 99 in both the northbound and southbound directions. The data is also separated by the Morning Peak (7:00 am to 9:00 am), Midday Peak (11:00 am – 1:00 pm), and Afternoon Peak (4:00 pm – 6:00 pm) Periods.

The before and after study consisted of analyzing dates before and after the TSP system was implemented. The "before" period included one week from April 9th to April 15th, 2024. The "after" period included January 23rd to January 29th, 2025. Data from weekends were not included in this study. Both before and after periods had 5 regular working days and the same number of days of the week. A normal school schedule was in effect for both periods. No major changes to traffic operations were recorded during both the before and after study.

Travel Time Methodology

Travel time was collected using Swiftly, which was verified to show accurate observed field travel times. Since only a portion of the travel time for Line 99 falls within the project area, the travel time experienced by buses outside of the project area was removed from the analysis.

It was assumed that all buses in the "after" period were equipped with TSP. To maintain a consistent and fair comparison, exactly corresponding trips were compared against each other. For example, the 7:20 am southbound trip on the Monday of the "before" period was compared to the same trip on Monday for the "after" period.

A total of 30 trips were scheduled during the five weekdays for each time of day. However, not all trips were recorded on the Swiftly dashboard for a variety of technical reasons. Approximately 20% of all trips either were missing or had incomplete data recorded within Swiftly. To also prepare a consistent and fair comparison, overly delayed trips and faster trips were removed in equal

proportions from both "before" and "after" analysis periods. If more than 22 valid trips were recorded during a given time of day, extra trips were removed randomly from the analysis to obtain 22 trips. The resulting number of trips is shown in Table 3.

Table 3: Number of Bus Trips Used for the Before-After Analysis by Peak Period

Before/After	Time of Day	Number of Bus Trips Analyzed
Before	Morning Peak	22
	Midday Peak	22
	Afternoon Peak	22
After	Morning Peak	22
	Midday Peak	22
	Afternoon Peak	22
Overall		132

On-Time Performance Methodology

The on-time performance analysis shows the percentage of bus stop departures that occurred early, on-time, or late. The source of this data was from Swiftly, which recorded the actual departure time from every bus stop and compared it to the scheduled departure time.

A bus is considered on time if it departs from the bus stop up to one minute early and/or 5 minutes late. This was entered into Swiftly and the resulting percentages of early, on-time, and late departures were recorded.

Data was separated by time of day but was not differentiated by direction or segment of the route due to limitations of the Swiftly platform. Therefore, any delays occurring outside of the project segment will be included in this part of the analysis. No adjustments to incomplete or outlier trips were conducted.

Emissions Methodology

To estimate bus emissions savings as a result of TSP implementation, the fuel consumption needed to be first estimated. The fuel consumption for each peak period was calculated based on the average speed observed by the bus, miles traveled, and fuel economy of a bus. Fuel economy of a bus is based on the bus speed, which was adjusted for. The amount of Greenhouse Gas (GHG) emissions was based on the amount of fuel burned.

The following emissions were calculated by using emission factors by bus speed per mile, which were obtained from the California Air Resources Board EMFAC (Emission Factor) 2021 Model:

- ROG (Reactive Organic Gases)
- NOx (Nitrogen Oxides)
- PM 2.5 (Fine particles)
- CO (Carbon Monoxide)

The emissions were calculated for each morning, midday, and afternoon peak period (six hours), before and after TSP implementation. To calculate the overall emissions per year, the emissions during the peak hours were inflated to cover the whole day of emissions, then multiplied by the number of working days per year.

Benefit-Cost Analysis Methodology

The benefit-cost ratio is calculated by dividing the benefits the project brings by the costs of the project. A benefit-cost ratio greater than 1 means that the benefits over a period of time outweigh the project costs. For this analysis, a project lifespan of 10 years was assumed. Since most of the project implemented TSP on adaptive-controlled signals, 10 years is a reasonable project lifespan. Traditional signal control typically needs to be updated every 3-5 years, but Adaptive Signal Control typically lasts longer before updates are needed since it is automatically fine-tuning traffic flow.

The benefit of the project was based on the value of time bus passengers save and the monetary value of emissions saved. The value of time that bus passengers saved was based on the average weekday ridership of Line 99, travel time savings as calculated in this before and after study, and the average off-duty wage in the Bay Area. The second component of benefits are emissions reductions. The monetary value per unit of weight of GHG, ROG, NOx, PM 2.5, and CO is based on the California Department of Transportation Office of Transportation Economics 2009 Benefit-Cost Analysis Model.

The cost of the project was separated into two categories: engineering and implementation costs and total costs (with construction and hardware upgrades). Engineering and implementation costs included all “soft costs”, such as project management, preparation of plans and specifications for equipment upgrades, TSP timing development and implementation, TSP system verification, and evaluation of operational improvements. This value represents the costs if signal controllers and TSP hardware did not need to be upgraded/installed. The total project costs included the soft costs plus the cost of new hardware/upgrades and hardware installation costs.

POST-IMPLEMENTATION ANALYSIS RESULTS

In this section, the comparative analysis results of the TSP Before and After study are presented. Travel time and on-time performance were the primary performance measures monitored for the Before and After study. Bus emissions results and the overall benefit-cost ratio are also presented.

Travel Time Results

Bus travel times for both directions within the project area of Line 99 were analyzed. When bus travel time was compared across all time periods and directions, the overall corridor **travel time decreased 8%** with TSP implemented. Table 4 and Figure 8 shows an improvement in travel time because of TSP implementation. Southbound trips saw more travel time improvement than northbound trips as shown below. An average of **2 minutes and 40 seconds were saved on each trip**.

Table 4: Overall Travel Time Percent Improvement from the Before-After Period

Line 99 Travel Time				
Direction	**Before**	**After**	**Time Savings**	**Percent Change**
Northbound	0:37:16	0:35:50	0:01:26	-4%
Southbound	0:35:05	0:31:10	0:03:55	-12%
Overall	0:36:10	0:33:30	0:02:40	-8%

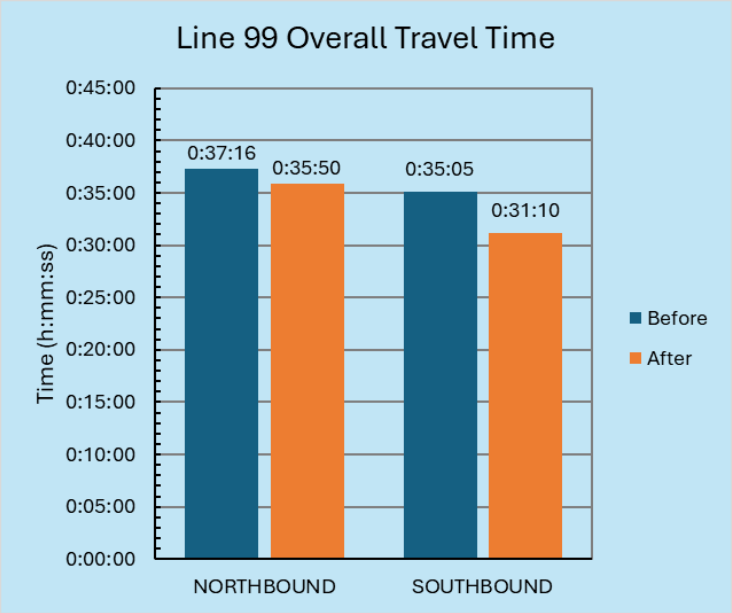

Figure 8: Overall Before-After Travel Time Comparison – Day Average

Line 99 travel time performance was broken down further into morning, midday, and afternoon peak periods/times of day as shown in Table 5 and Figure 9. The actual time savings for passengers range between almost 5 minutes in the southbound morning peak to 15 seconds in the northbound midday peak.

Table 5: Before-After Travel Time Comparison and Percent Change

Line 99 Travel Time					
Direction	**Time of Day**	**Before**	**After**	**Time Savings**	**Percent Change**
Northbound	Morning Peak	0:35:27	0:34:10	0:01:17	-4%
	Midday Peak	0:34:49	0:34:34	0:00:15	-1%
	Afternoon Peak	0:41:32	0:38:47	0:02:45	-7%
Southbound	Morning Peak	0:36:54	0:32:05	0:04:50	-14%
	Midday Peak	0:33:11	0:29:14	0:03:57	-13%
	Afternoon Peak	0:35:08	0:32:11	0:02:57	-9%

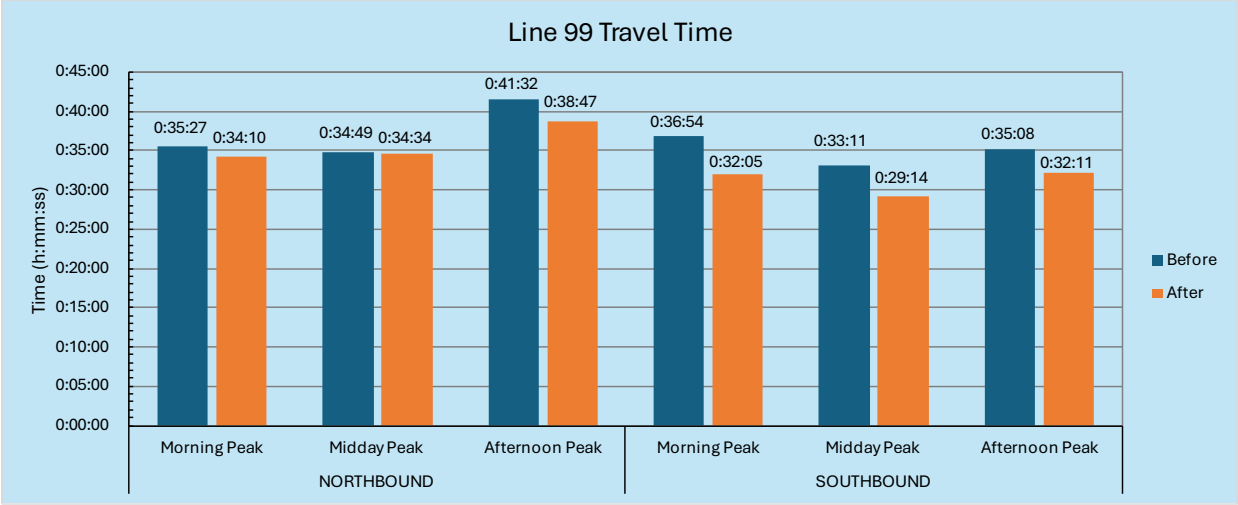

Figure 9: Before-After Travel Time Comparison – By Time of Day

Data shows improvement for both northbound and southbound bus directions in the afternoon peak period. For all three time periods in the southbound direction, travel times improved with the after study. The northbound direction showed travel time improvement but less improvement than the southbound direction. Potentially, the lower northbound travel time improvements could be due to the design of the adaptive signal coordination. For example, there may be signal coordination preference for all southbound traffic which could potentially make it more difficult to provide noticeable early green and late extensions for buses travelling northbound. The greatest travel time improvements were for the southbound morning and midday peak periods. The smallest travel time improvements were for the northbound midday peak period.

On-Time Performance Results

The analysis results below show the percentage of early, on-time, and late departures before and after TSP implementation. Table 6 and Figure 10 show the overall on-time performance for all bus trips throughout the day. The on-time performance values in this section were reported for the whole route, which runs in both directions to/from Hayward BART to Fremont BART.

Table 6: Before-After Overall On-Time Performance and Percent Change

Line 99 Overall On-Time Performance								
Before			After			% Change		
Early	On-Time	Late	Early	On-Time	Late	Early	On-Time	Late
8.6%	68.0%	23.3%	9.7%	71.3%	19.0%	1.1%	3.3%	-4.3%

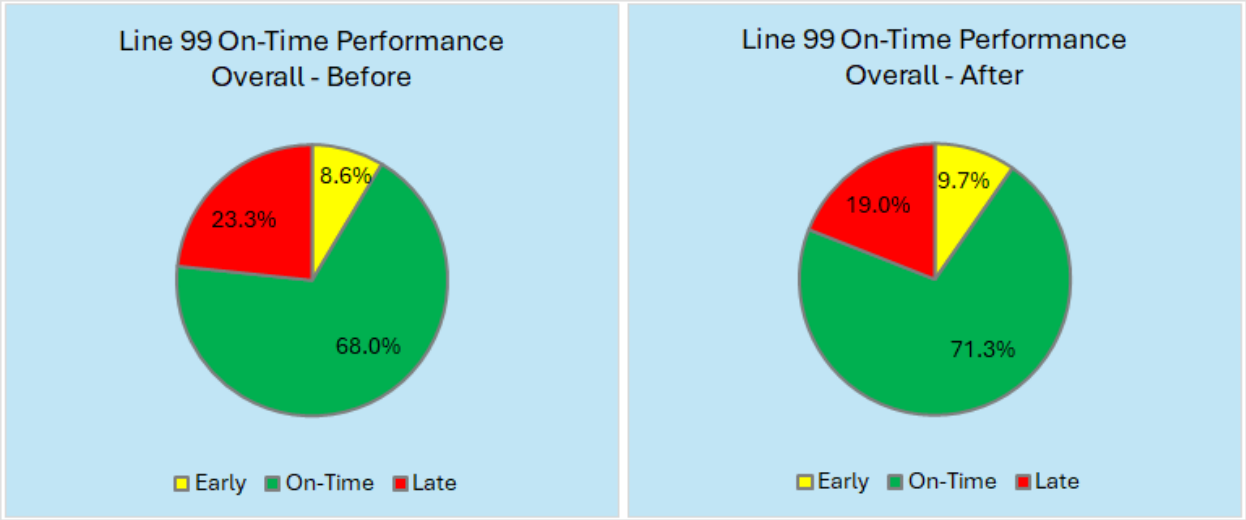

Figure 10: Before-After Overall On-Time Performance Results

Overall, Line 99 saw improvement in on-time, early, and late departures. An increase of 3.3% in on-time departures means that more bus stops were served by an on-time bus. Also, since the percentage of late departures reduced by 4.3% with TSP implementation, fewer bus stops were served by late buses, an improvement. A 1.1% increase in early departures was also a positive sign in the after analysis, meaning a smaller number of buses departed the bus stop early, which is an improvement.

On-time performance was further broken down into morning, midday, and afternoon peak periods as shown in Table 7 and Figure 11. The data shows that early departures improved by 2% in the morning peak period, on-time departures improved by 5% in the midday peak period, and on-time departures improved by 6.5% in the afternoon peak period. It should be noted that delays outside of the project area can impact on the on-time performance of buses operating in the project area.

Table 7: Before-After On-Time Performance Comparison – By Time of Day

Line 99 On-Time Performance									
Time of Day	Before			After			% Change		
	Early	On-Time	Late	Early	On-Time	Late	Early	On-Time	Late
Morning Peak	3.2%	70.1%	26.7%	5.1%	62.5%	32.4%	1.9%	-7.6%	5.7%
Midday Peak	12.4%	75.3%	12.4%	10.3%	80.4%	9.3%	-2.1%	5.1%	-3.1%
Afternoon Peak	2.9%	43.8%	53.4%	3.0%	50.3%	46.7%	0.1%	6.5%	-6.7%

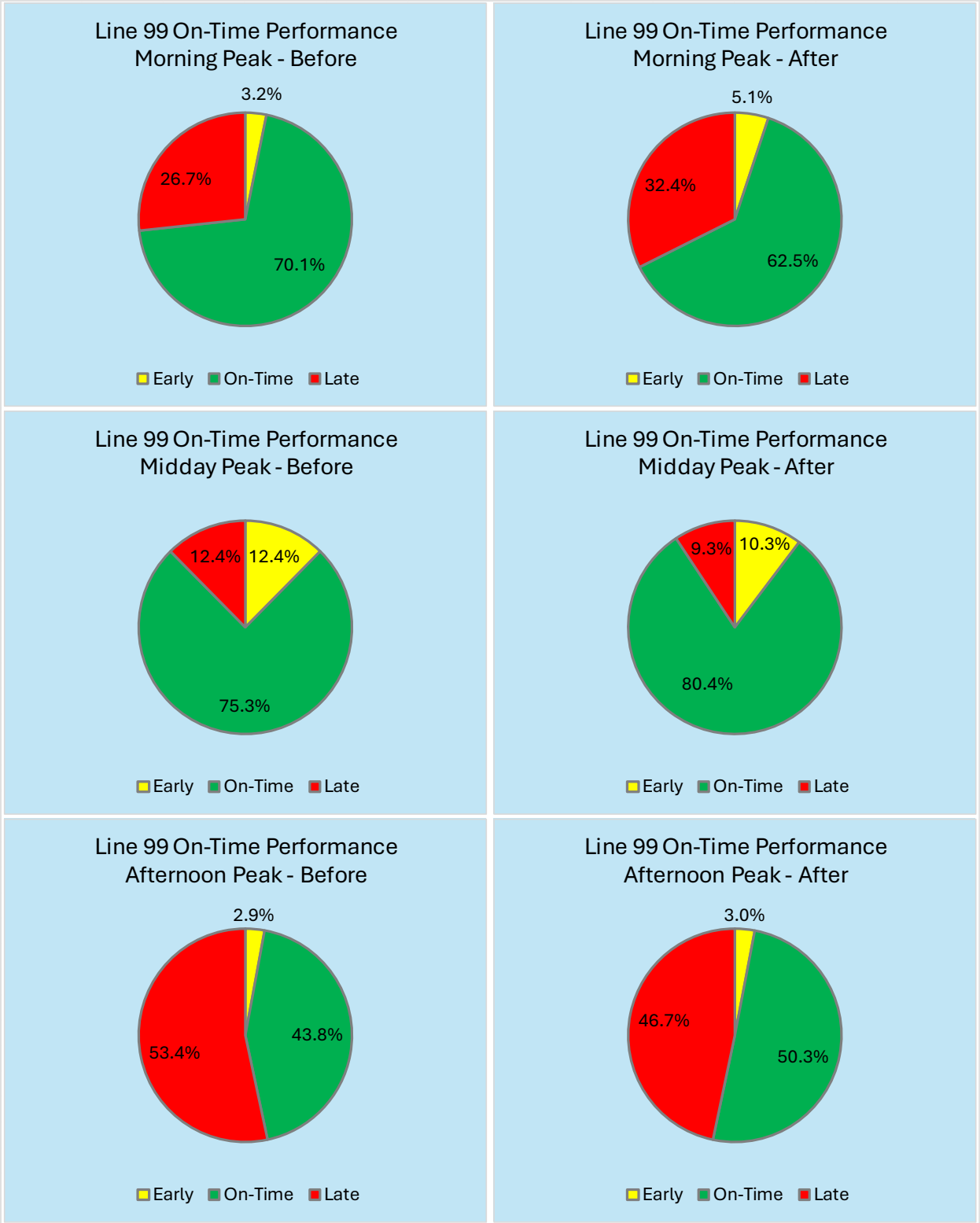

Figure 11: Before-After On-Time Performance by Peak Period

Emissions Results

The results of the annual emissions savings are presented in this section. Fuel savings and emissions on an annual basis are broken down into morning, midday, and afternoon peak periods, as well as overall (all day) results. Overall fuel consumption and emissions include a factor to adjust for the fact that the peak analysis periods account for only 6 out of the overall 19 hours of service scheduled on Line 99.

Annual fuel savings from the implementation of TSP are shown in Table 8. Data shows a total of **1,653 gallons of fuel saved per year**. Similar outcomes were observed compared to travel time where the southbound direction achieved greater improvements (fuel savings) than northbound.

Table 8: Before-After Fuel Consumption Results

Line 99 Fuel Consumption (gallons/year)				
Direction	**Time of Day**	**Before**	**After**	**Annual Fuel Savings**
Northbound	Morning Peak	1,287	1,245	43
	Midday Peak	1,287	1,245	43
	Afternoon Peak	1,458	1,373	85
Southbound	Morning Peak	1,330	1,202	128
	Midday Peak	1,202	1,064	138
	Afternoon Peak	1,287	1,202	85
Overall				1,653

Table 9 shows an **overall reduction of 33,754 pounds of annual greenhouse gases** (GHG) emitted from the project.

Table 9: Before-After GHG Emissions Results

Line 99 GHG Emissions (Pounds/year)				
Direction	**Time of Day**	**Before**	**After**	**Annual GHG Reduction**
Northbound	Morning Peak	26,289	25,418	871
	Midday Peak	26,289	25,418	871
	Afternoon Peak	29,774	28,031	1,742
Southbound	Morning Peak	27,160	24,546	2,614
	Midday Peak	24,546	21,728	2,818
	Afternoon Peak	26,289	24,546	1,742
Overall				33,754

Table 10 shows the annual reduction of Reactive Organic Gases, Nitrogen Oxides, Particulate Matter 2.5, and Carbon Monoxide emissions by peak period and by weekday typical service day. Uniquely, the CO factor per mile per hour is at a local minimum at 15 miles per hour and increases slightly to 20 miles per hour, then goes back down for speeds above 20 miles per hour. This explains the increase in CO emissions in the southbound midday period, which recorded an average speed of 14 miles per hour in the "before" to 16 miles per hour in the "after" period. 16 miles per hour was the highest recorded average speed for the whole day before and after study.

Table 10: Reduction of ROG, NOx, PM 2.5, and CO Emissions

Line 99 ROG, Nox, PM2.5, and CO Emissions (Pounds/year)					
Direction	**Time of Day**	**ROG Reduction**	**NOx Reduction**	**PM 2.5 Reduction**	**CO Reduction**
Northbound	Morning Peak	0.12	1.2	0.01	7.0
	Midday Peak	0.12	1.2	0.01	7.0
	Afternoon Peak	0.31	2.8	0.03	15.6
Southbound	Morning Peak	0.38	3.6	0.04	21.3
	Midday Peak	0.45	5.3	0.07	-9.1
	Afternoon Peak	0.24	2.4	0.03	14.0
Overall		5.1	52	0.62	177

Side Street and Pedestrian Impacts

TSP resulted in little to no impacts on side street vehicles and pedestrians because TSP was designed to not make drastic changes to phase duration and not skip phases to serve transit vehicles. After reviewing the TSP reports, transit phases received approximately 10 seconds of extra time, which meant that side street vehicles crossing the major street needed to wait up to 10 seconds longer while a TSP call is being served. Pedestrians crossing the major street may also be delayed slightly, but they will receive the same amount of crossing time. However, pedestrians crossing the side street (parallel to the transit phase) can see shorter wait times because the pedestrian phase will get an early Walk indication at the same time as the transit phase gets an early green. Any impact on vehicles and pedestrians only occurs when a transit vehicle is approaching the intersection, which happens approximately 3-6 times per hour.

Benefit-Cost Analysis Results

A benefit-cost analysis for this TSP project was performed to understand long term benefits for the traveling public and for AC Transit. The benefits of the project include travel time savings for the passengers and emissions reductions and are shown in Table 11.

Table 11: Monetary Benefits of TSP Implementation

BENEFITS		
Benefit	**First Year**	**Ten Years**
Travel Time Savings	$ 550,249	$ 5,502,491
Fuel Consumption Savings	$ 8,264	$ 82,644
ROG Emissions Reduction	$ 2.50	$ 25
NOx Emissions Reduction	$ 357	$ 3,566
PM2.5 Emissions Reduction	$ 34	$ 341
CO Emissions Reduction	$ 5.30	$ 53
CO2 Emissions Reduction	$ 388	$ 3,882
Total Benefits		**$ 5,593,001**

The project management, engineering, and implementation costs of the project were approximately $738,155. This resulted in a benefit-cost ratio of **7.58 to 1**, which represents an excellent return on investment for the community.

When considering the total project costs (including hardware costs and installation), the total cost was approximately $1,150,000. This resulted in a benefit-cost ratio of **4.86 to 1**, which still represents a good return on investment.

CONCLUSIONS

TSP was implemented at 32 signals along AC Transit Line 99. The TSP system was verified to be functional after reviewing TSP calls in detail at every signal and data sources used for the project were validated against field-collected onboard bus videos. Due to TSP making calculated and minor changes to phase duration, side street vehicle and pedestrian impacts were minimal. Extensive data analysis showed that bus travel time, on-time performance, and emissions improved after the implementation of TSP. These positive results indicate the signal system is adequately prioritizing buses along the route. Comparing the project costs to these improvements provides an excellent benefit-cost ratio.

The implementation of TSP along Line 99 has resulted in several positive outcomes for bus operations and overall traffic efficiency. Key findings include:

- **Reduction in bus travel times:** Both directions showed an improvement in travel times. Northbound travel times improved by 4% and southbound travel times improved by 12%. This represents a travel time savings for bus passengers and operators of approximately 1.5 minutes to 4 minutes per trip. The TSP system enabled buses to move more efficiently through intersections, minimizing the time spent idling at red lights.
- **Increase in on-time departures:** Overall, 3.3% more bus stops recorded an on-time departure. 4.3% fewer bus stops experienced a late departure after TSP was implemented. Better schedule adherence results in more reliable transit operations, which attracts more bus passengers, leading to higher ridership and a more successful transit system.
- **Lower fuel consumption and emissions**: The improvements in travel times translate to approximately 1,653 gallons of bus fuel saved and 33,754 fewer pounds of GHG emissions per year.
- **Good benefit-cost ratio:** When evaluated over a 10-year period of expected benefits, the benefit-cost ratio was 7.58 to 1 when not including hardware costs and installation. When considering the total project cost, the benefit-cost ratio was 4.86 to 1. This represents a good return on investment due to saving bus passengers' valuable time and the environmental costs of emissions.

Appendix A:

Controller TSP Reports

AMG ADVANCED MOBILITY GROUP

Controller TSP History Reports

Hayward SCATS

Highlighted Phases are TSP Phases

Intersection Location: Watkins St & B St

Intersection Number: 5

Date: 11/8/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	11	11	11	11
A phase	1272	15	752	38	49414
B phase	754	15	37	17	13039
C phase	1044	11	64	22	23552
D phase	18	7	12	9	165
E phase	29	7	15	7	218
Nominal cycle length	66	80	82	80	5343
Active cycle length	66	80	82	80	5343
Actual cycle	1273	11	770	67	86399
Split plan 1	1	86056	86056	86056	86056
Signal group 2	1259	12	806	35	44315
Signal group 3	752	10	25	12	9689
Signal group 4	1044	9	59	15	16613
Signal group 6	1259	12	806	35	44398
Signal group 18	290	7	8	7	2058
Signal group 20	439	6	8	6	3070
Signal group 22	1244	7	8	7	8812
MSS 16	5	25	37	30	153
Pedestrian movement 2	290	5	8	6	2014
Pedestrian movement 4	439	6	8	6	3071
Pedestrian movement 6	1244	5	8	6	8632

Intersection Location: Watkins St & C St

Intersection Number: 6

Date: 2/10/25

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	53	53	53	53
A phase	1228	11	1214	51	62667
B phase	1209	4	99	19	23138
C phase	14	11	12	11	157
D phase	34	11	13	11	384
Nominal cycle length	98	80	99	82	8090
Active cycle length	98	80	99	82	8090
Actual cycle	1229	22	1235	70	86399
Split plan 1	1	83291	83291	83291	83291
Signal group 2	1209	3	95	14	17481
Signal group 4	1208	6	1210	48	58018
Signal group 13	234	7	8	7	1649
Signal group 14	149	7	8	7	1067
MSS 16	2	20	32	26	52
Pedestrian movement 2	234	7	8	7	1649
Pedestrian movement 4	149	5	8	6	1041

Intersection Location: Watkins St & D St

Intersection Number: 42

Date: 2/6/25

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	69	69	69	69
A phase	989	12	541	55	54446
B phase	420	12	46	15	6347
C phase	734	11	120	23	16917
D phase	514	12	69	16	8269
E phase	2	8	11	9	19
F phase	19	11	35	17	332
Nominal cycle length	152	80	142	95	14563
Active cycle length	295	80	176	122	36100
Actual cycle	990	23	553	87	86399
Split plan 1	1	61331	61331	61331	61331
Signal group 1	249	7	40	9	2394
Signal group 2	814	6	116	20	16315
Signal group 3	335	7	61	9	3128
Signal group 4	968	5	633	54	52451
Signal group 5	317	5	26	9	3074
Signal group 6	825	6	116	18	15377
Signal group 7	364	7	64	11	4138
Signal group 8	954	6	697	53	51384
Signal group 18	85	6	8	7	596
Signal group 20	37	6	7	6	257
Signal group 22	90	6	7	6	629
Signal group 24	53	6	7	6	368
XSF 9	742	2	111	31	23470
XSF 10	742	2	111	31	23470
MSS 16	61	22	41	25	1529
Pedestrian movement 2	85	4	8	6	573
Pedestrian movement 4	37	5	7	6	245
Pedestrian movement 6	90	4	7	6	620

Intersection Location: Watkins St & Jackson St

Intersection Number: 101

Date: 2/6/25

Data item	Frequency	Minimum	Maximum	Average	Total
A phase	716	17	462	68	49164
B phase	533	14	41	22	12103
C phase	586	14	73	26	15474
D phase	450	16	74	20	9412
E phase	1	8	8	8	8
F phase	29	7	13	8	238
Nominal cycle length	13	100	112	107	1392
Active cycle length	370	88	165	139	51587
Actual cycle	716	33	477	120	86399
Split plan 1	1	65869	65869	65869	65869
Signal group 1	450	12	70	16	7575
Signal group 2	716	12	457	63	45451
Signal group 3	534	10	37	18	9681
Signal group 4	586	10	69	22	12944
Signal group 6	683	27	639	80	55033
Signal group 13	37	6	8	7	261
Signal group 14	89	6	8	7	623
Signal group 15	1707	6	8	6	11922
Signal group 16	118	6	8	6	825
XSF 9	781	1	86	34	26602
XSF 10	781	1	89	36	28344
MSS 16	1	30	30	30	30
Pedestrian movement 2	37	4	8	6	241
Pedestrian movement 3	118	6	8	6	825
Pedestrian movement 4	89	4	8	6	609
Pedestrian movement 6	1707	4	8	6	11742

Intersection Location: Mission Blvd & D Street

Intersection Number: 1304

Date: 2/10/25

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	8	8	8	8
A phase	704	14	123	47	33537
B phase	698	13	48	22	15943
C phase	704	25	72	52	36640
D phase	23	7	17	8	190
E phase	11	7	9	7	81
Nominal cycle length	2	97	100	98	197
Active cycle length	341	87	164	140	47774
Actual cycle	705	8	212	122	86399
Split plan 1	1	66522	66522	66522	66522
Signal group 2	707	10	115	43	30796
Signal group 4	708	10	94	69	48970
Signal group 7	705	8	43	17	12478
Signal group 8	704	20	67	46	32987
Signal group 13	139	7	81	32	4498
Signal group 14	79	6	8	6	551
Signal group 16	126	6	7	6	881
MSS 16	10	19	48	31	310
Pedestrian movement 2	139	5	79	32	4453
Pedestrian movement 4	79	4	8	6	483

Intersection Location: Mission Blvd & Foothill Blvd

Intersection Number: 1305

Date 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	33	33	33	33
A phase	770	15	155	62	48145
B phase	769	39	65	49	38118
C phase	11	7	8	7	82
D phase	3	7	7	7	21
Active cycle length	291	91	140	121	35289
Actual cycle	771	15	199	112	86399
Split plan 1	1	64001	64001	64001	64001
Signal group 2	771	16	97	58	45187
Signal group 4	771	12	61	45	35001
Signal group 9	116	31	19116	701	81328
Signal group 13	54	9	9	9	486
Signal group 14	81	4	7	6	564
Signal group 16	110	7	7	7	770
MSS 16	7	20	45	32	227
Pedestrian movement 2	54	9	9	9	486
Pedestrian movement 4	81	4	7	6	564
Pedestrian movement 5	110	5	7	6	768

Intersection Location: Mission Blvd & Fletcher Ln

Intersection Number: 1306

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	18	18	18	18
A phase	727	12	456	66	48157
B phase	649	13	49	22	14297
C phase	630	13	79	26	16983
D phase	412	13	20	14	6018
E phase	7	7	22	10	73
F phase	102	7	15	7	815
G phase	5	7	9	7	38
Active cycle length	297	80	165	121	35987
Actual cycle	729	12	470	118	86399
Split plan 1	1	80170	80170	80170	80170
Signal group 1	649	8	36	17	11440
Signal group 2	712	13	478	73	52080
Signal group 4	630	9	44	22	14024
Signal group 5	422	3	34	10	4276
Signal group 6	660	13	1280	91	60384
Signal group 8	631	9	44	22	14034
Signal group 9	648	8	36	17	11420
Signal group 13	720	7	435	54	39598
Signal group 14	50	7	7	7	350
Signal group 15	730	7	431	45	32894
Signal group 16	42	7	8	7	296
XSF 9	770	6	83	39	30513
XSF 10	770	5	82	38	29744
MSS 16	5	22	72	40	203
Pedestrian movement 2	720	7	435	54	39468
Pedestrian movement 4	50	7	7	7	350
Pedestrian movement 6	730	6	431	44	32723

Intersection Location: Mission Blvd & Highland Blvd

Intersection Number: 1307

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	8	8	8	8
A phase	929	15	226	44	41277
B phase	641	18	45	19	12724
C phase	747	5	52	23	17732
D phase	645	17	42	21	13958
E phase	56	7	16	8	459
F phase	31	7	9	7	241
Nominal cycle length	216	97	150	122	26536
Active cycle length	220	97	188	122	27053
Actual cycle	930	8	243	92	86399
Split plan 1	1	62373	62373	62373	62373
Signal group 1	436	13	30	14	6429
Signal group 2	883	11	254	48	42984
Signal group 3	452	14	22	14	6718
Signal group 4	824	6	70	21	17589
Signal group 5	594	10	38	17	10297
Signal group 6	907	10	350	42	38502
Signal group 7	581	14	41	15	8885
Signal group 8	779	6	63	19	15182
Signal group 13	97	7	8	7	745
Signal group 14	53	7	8	7	410
Signal group 15	75	7	8	7	575
Signal group 16	22	7	8	7	170
XSF 9	952	1	98	27	26106
XSF 10	952	1	87	19	18228
MSS 16	4	25	49	35	143
Pedestrian movement 2	97	5	8	7	726
Pedestrian movement 4	53	5	8	7	392
Pedestrian movement 6	75	5	8	7	557

Intersection Location: Mission Blvd & Orchard Ave

Intersection Number: 1308

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	8	8	8	8
A phase	929	15	226	44	41277
B phase	641	18	45	19	12724
C phase	747	5	52	23	17732
D phase	645	17	42	21	13958
E phase	56	7	16	8	459
F phase	31	7	9	7	241
Nominal cycle length	216	97	150	122	26536
Active cycle length	220	97	188	122	27053
Actual cycle	930	8	243	92	86399
Split plan 1	1	62373	62373	62373	62373
Signal group 1	436	13	30	14	6429
Signal group 2	883	11	254	48	42984
Signal group 3	452	14	22	14	6718
Signal group 4	824	6	70	21	17589
Signal group 5	594	10	38	17	10297
Signal group 6	907	10	350	42	38502
Signal group 7	581	14	41	15	8885
Signal group 8	779	6	63	19	15182
Signal group 13	97	7	8	7	745
Signal group 14	53	7	8	7	410
Signal group 15	75	7	8	7	575
Signal group 16	22	7	8	7	170
XSF 9	952	1	98	27	26106
XSF 10	952	1	87	19	18228
MSS 16	4	25	49	35	143
Pedestrian movement 2	97	5	8	7	726
Pedestrian movement 4	53	5	8	7	392
Pedestrian movement 6	75	5	8	7	557

Intersection Location: Mission Blvd & Berry Ave

Intersection Number: 1309

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	44	44	44	44
A phase	690	11	1264	100	69482
B phase	480	14	36	18	8846
C phase	482	12	41	15	7709
D phase	7	7	8	7	54
E phase	35	7	10	7	264
Active cycle length	219	97	214	122	26726
Actual cycle	691	19	1276	125	86399
Split plan 1	1	62373	62373	62373	62373
Signal group 1	305	8	22	10	3270
Signal group 2	580	7	3208	120	69612
Signal group 4	480	9	31	13	6537
Signal group 5	362	8	37	11	4325
Signal group 6	601	7	1804	113	68283
Signal group 8	480	9	31	13	6537
Signal group 13	48	7	139	60	2910
Signal group 14	34	7	7	7	238
Signal group 15	22	11	112	60	1335
Signal group 16	34	7	7	7	238
XSF 9	881	1	143	50	44097
XSF 10	881	1	143	50	44097
MSS 16	1	23	23	23	23
Pedestrian movement 2	48	7	139	60	2901
Pedestrian movement 4	34	7	7	7	238
Pedestrian movement 6	22	11	112	60	1331

Intersection Location: Mission Blvd & Harder Rd

Intersection Number: 1310

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	6	6	6	6
A phase	890	14	236	44	39643
B phase	720	15	59	23	16975
C phase	542	13	44	22	12025
D phase	668	15	63	25	16840
E phase	66	7	13	8	533
F phase	47	7	12	8	377
Nominal cycle length	107	100	150	127	13614
Active cycle length	251	71	160	127	31924
Actual cycle	892	6	269	96	86399
Split plan 1	1	86131	86131	86131	86131
Signal group 1	645	11	59	20	13389
Signal group 2	867	10	261	42	36845
Signal group 3	654	11	55	19	12557
Signal group 4	598	9	55	17	10467
Signal group 5	430	11	55	16	7214
Signal group 6	802	10	494	55	44125
Signal group 7	526	11	41	14	7601
Signal group 8	688	9	70	22	15264
Signal group 9	89	7	8	7	640
Signal group 10	79	7	8	7	580
Signal group 11	34	7	8	7	251
Signal group 12	41	7	8	7	304
MSS 16	1	35	35	35	35
Pedestrian movement 2	89	4	8	6	620
Pedestrian movement 4	79	4	8	7	559
Pedestrian movement 6	34	5	8	6	237

Intersection Location: Mission Blvd & Sorenson Rd

Intersection Number: 1311

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	80	80	80	80
A phase	597	13	1634	121	72769
B phase	440	13	72	19	8490
C phase	283	11	36	14	4072
D phase	24	7	8	7	180
E phase	110	7	8	7	808
Nominal cycle length	107	100	150	127	13614
Active cycle length	238	71	162	128	30487
Actual cycle	598	21	1642	144	86399
Split plan 1	1	62373	62373	62373	62373
Signal group 1	285	7	68	10	3014
Signal group 2	520	8	2297	135	70658
Signal group 6	440	9	4440	170	75229
Signal group 8	440	8	68	14	6415
Signal group 13	56	7	10	8	452
Signal group 16	53	7	8	7	372
XSF 9	839	2	125	48	40729
MSS 16	2	23	81	52	104
Pedestrian movement 2	56	7	10	7	446

Intersection Location: Mission Blvd & Moreau Catholic

Intersection Number: 1312

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	28	28	28	28
A phase	514	11	1576	147	75754
B phase	88	12	33	31	2798
C phase	416	11	89	17	7319
D phase	6	7	8	7	44
E phase	61	7	8	7	456
Active cycle length	246	82	196	127	31460
Actual cycle	516	20	1584	167	86399
Split plan 1	1	62373	62373	62373	62373
Signal group 2	90	7	15507	628	56574
Signal group 5	467	7	85	17	8241
Signal group 6	467	6	2448	158	73915
Signal group 14	87	7	7	7	609
Signal group 15	7	7	7	7	49
MSS 16	2	24	42	33	66
Pedestrian movement 4	87	7	7	7	609
Pedestrian movement 6	7	7	7	7	49

Intersection Location: Mission Blvd & Calhoun St

Intersection Number: 1313

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	71	71	71	71
A phase	502	15	1521	147	73956
B phase	232	14	52	20	4857
C phase	446	12	48	16	7229
D phase	6	7	8	7	47
E phase	32	7	9	7	239
Active cycle length	246	82	196	127	31460
Actual cycle	503	31	1529	171	86399
Split plan 1	1	80676	80676	80676	80676
Signal group 1	240	7	34	10	2611
Signal group 2	359	6	6349	209	75060
Signal group 4	232	9	47	15	3696
Signal group 5	345	7	43	11	3899
Signal group 6	405	26	2994	181	73678
Signal group 14	33	7	7	7	231
Signal group 15	8	7	8	7	59
XSF 10	759	0	153	63	48466
MSS 16	2	40	42	41	82
Pedestrian movement 4	33	7	7	7	231
Pedestrian movement 6	8	7	8	7	59

Intersection Location: Mission Blvd & Hancock St

Intersection Number: 1314

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	13	13	13	13
A phase	834	12	161	57	47795
B phase	834	6	40	36	30680
C phase	452	12	37	16	7260
D phase	48	7	13	9	466
E phase	25	7	8	7	185
Active cycle length	253	82	214	127	32331
Actual cycle	836	12	218	103	86399
Split plan 1	1	85931	85931	85931	85931
Signal group 1	269	8	25	10	2709
Signal group 2	837	11	176	56	47569
Signal group 4	834	7	35	32	27307
Signal group 5	364	8	33	12	4411
Signal group 6	834	11	156	54	45581
Signal group 8	834	7	35	32	27307
Signal group 13	805	7	160	38	31323
Signal group 14	48	7	7	7	336
Signal group 15	801	7	139	36	29217
Signal group 16	825	7	7	7	5775
MSS 16	3	30	53	40	122
Pedestrian movement 2	805	6	160	38	31167
Pedestrian movement 4	48	7	7	7	336
Pedestrian movement 6	801	7	137	36	29024

Intersection Location: Mission Blvd & Tennyson Rd

Intersection Number: 1315

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	3	3	3	3
A phase	877	16	334	50	44212
B phase	366	17	52	26	9679
C phase	738	18	89	24	18185
D phase	647	18	42	21	13775
E phase	76	6	11	7	545
Active cycle length	248	82	193	128	31789
Actual cycle	878	3	352	98	86399
Split plan 1	1	62373	62373	62373	62373
Signal group 1	679	2	38	15	10645
Signal group 2	907	1	329	44	40412
Signal group 3	742	10	83	20	15233
Signal group 4	365	13	47	22	8112
Signal group 5	370	14	28	14	5484
Signal group 6	789	11	361	59	47236
Signal group 13	113	6	8	6	790
Signal group 14	95	6	7	6	664
Signal group 15	70	7	8	7	499
Signal group 16	78	6	7	6	543
MSS 16	7	31	47	38	272
Pedestrian movement 2	113	4	8	6	764
Pedestrian movement 4	95	4	7	6	647
Pedestrian movement 6	70	5	8	6	481

Intersection Location: Mission Blvd & Valle Vista Ave

Intersection Number: 1316

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	82	82	82	82
A phase	713	13	991	86	61646
B phase	477	15	63	19	9515
C phase	171	14	42	23	4084
D phase	525	13	50	18	9587
E phase	58	8	14	8	502
F phase	113	3	13	8	983
Active cycle length	245	91	188	127	31253
Actual cycle	714	19	1008	121	86399
Split plan 1	1	85156	85156	85156	85156
Signal group 1	449	8	46	14	6510
Signal group 2	605	7	1530	100	60996
Signal group 3	437	10	57	14	6543
Signal group 4	202	10	50	19	3959
Signal group 5	288	8	34	10	2946
Signal group 6	581	7	1676	112	65236
Signal group 7	236	10	35	12	2832
Signal group 8	391	10	78	19	7547
Signal group 13	80	7	8	7	615
Signal group 14	22	7	8	7	170
Signal group 15	14	7	8	7	103
Signal group 16	55	7	8	7	413
XSF 9	868	7	140	43	37666
XSF 10	868	7	140	43	37666
MSS 16	4	19	57	38	152
Pedestrian movement 2	80	5	8	7	606
Pedestrian movement 4	22	4	8	7	162
Pedestrian movement 6	14	5	8	7	99

Intersection Location: Mission Blvd & Industrial Pkwy

Intersection Number: 1317

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	15	15	15	15
A phase	673	30	125	50	34191
B phase	673	16	70	32	21543
C phase	459	16	48	29	13589
D phase	673	3	42	23	16016
E phase	85	7	13	8	697
F phase	43	7	11	8	348
Nominal cycle length	135	97	180	144	19454
Active cycle length	193	71	203	142	27492
Actual cycle	674	15	230	128	86399
Split plan 1	1	64836	64836	64836	64836
Signal group 1	675	4	38	19	13319
Signal group 2	675	10	128	47	31811
Signal group 3	205	11	22	11	2415
Signal group 4	673	15	87	42	28802
Signal group 5	675	4	38	19	13342
Signal group 6	675	11	96	47	31787
Signal group 7	673	12	65	27	18634
Signal group 8	459	12	44	25	11695
Signal group 13	38	7	7	7	266
Signal group 14	34	7	8	7	240
Signal group 15	102	7	7	7	714
Signal group 16	92	7	8	7	646
MSS 16	6	22	44	34	209
Pedestrian movement 2	38	7	7	7	266
Pedestrian movement 4	34	5	8	6	234
Pedestrian movement 6	102	5	7	6	712

Intersection Location: Mission Blvd & Garin Ave

Intersection Number: 1318

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	82	82	82	82
A phase	686	15	947	99	68242
B phase	384	14	44	18	7049
C phase	513	13	112	20	10506
D phase	17	7	13	8	142
E phase	46	7	12	8	378
Nominal cycle length	135	97	180	135	18359
Active cycle length	186	97	201	140	26219
Actual cycle	687	24	955	125	86399
Split plan 1	1	84267	84267	84267	84267
Signal group 2	386	10	2434	198	76800
Signal group 4	384	10	40	13	5313
Signal group 5	514	9	108	16	8313
Signal group 6	654	10	1063	99	65262
Signal group 14	32	7	7	7	224
Signal group 15	31	7	8	7	219
XSF 10	841	1	152	46	39173
MSS 16	3	23	47	37	112
Pedestrian movement 4	32	5	7	6	220
Pedestrian movement 6	31	5	8	7	217

Intersection Location: Mission Blvd & Arrowhead Way

Intersection Number: 1319

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	12	12	12	12
A phase	863	13	1388	74	64683
B phase	476	14	50	18	8876
C phase	610	12	76	18	11310
D phase	43	7	13	8	357
E phase	143	7	10	8	1161
Nominal cycle length	138	97	180	135	18705
Active cycle length	194	97	201	139	27058
Actual cycle	864	12	1396	99	86399
Split plan 1	1	62784	62784	62784	62784
Signal group 1	349	8	72	16	5640
Signal group 2	645	9	2521	103	67078
Signal group 4	476	10	46	14	6934
Signal group 5	440	8	72	12	5484
Signal group 6	670	8	4633	99	66723
Signal group 8	476	10	46	14	6934
Signal group 13	45	7	8	7	320
Signal group 15	40	7	8	7	285
Signal group 16	70	7	8	7	492
XSF 9	1166	1	76	15	17814
XSF 10	1166	1	72	12	15021
MSS 16	3	38	42	40	121
Pedestrian movement 2	45	5	8	7	315
Pedestrian movement 6	40	5	8	7	282

Intersection Location: Mission Blvd & Fairway St

Intersection Number: 1320

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	34	34	34	34
A phase	786	13	961	83	65743
B phase	626	14	89	22	14120
C phase	383	12	43	14	5436
D phase	40	7	13	8	336
E phase	88	7	13	8	730
Nominal cycle length	138	97	180	135	18705
Active cycle length	194	97	201	139	27058
Actual cycle	788	14	969	109	86399
Split plan 1	1	81454	81454	81454	81454
Signal group 1	160	8	39	10	1634
Signal group 2	664	7	2271	100	66532
Signal group 4	626	10	85	18	11553
Signal group 5	305	8	39	10	3062
Signal group 6	700	7	1904	91	64315
Signal group 8	626	10	85	18	11553
Signal group 13	22	7	8	7	156
Signal group 14	47	7	7	7	329
Signal group 15	21	7	8	7	151
Signal group 16	45	7	7	7	315
XSF 9	928	1	133	44	41039
XSF 10	928	1	132	43	40346
MSS 16	3	32	43	38	114
Pedestrian movement 2	22	7	9	7	158
Pedestrian movement 4	47	5	7	6	321
Pedestrian movement 6	21	5	8	7	148

Intersection Location: Mission Blvd & Rousseau St

Intersection Number: 1321

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	26	26	26	26
A phase	677	10	828	103	69914
B phase	527	14	67	20	10738
C phase	314	12	71	15	4946
D phase	26	7	10	8	211
E phase	70	7	10	8	564
Nominal cycle length	138	97	180	135	18705
Active cycle length	194	97	201	139	27058
Actual cycle	678	22	841	127	86399
Split plan 1	1	82133	82133	82133	82133
Signal group 1	315	8	65	11	3711
Signal group 2	626	9	965	107	67439
Signal group 6	529	9	1202	137	72667
Signal group 8	528	10	63	16	8630
Signal group 13	22	7	8	7	159
MSS 16	4	30	66	44	178
Pedestrian movement 2	22	5	8	7	154

Intersection Location: Mission Blvd & Corrine St

Intersection Number: 1322

Date: 2/10/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	11	11	11	11
A phase	1012	13	644	56	56861
B phase	731	14	122	22	16738
C phase	631	0	101	18	11864
D phase	42	7	13	8	353
E phase	72	7	9	7	572
Nominal cycle length	120	97	180	118	14199
Active cycle length	150	71	219	127	19050
Actual cycle	1013	11	658	85	86399
Split plan 1	1	86305	86305	86305	86305
Signal group 1	509	8	81	14	7138
Signal group 2	901	8	1635	61	55386
Signal group 4	731	9	118	18	13342
Signal group 5	275	1	97	14	4060
Signal group 6	821	8	1219	73	60009
Signal group 8	731	9	118	18	13342
Signal group 13	37	7	8	7	266
Signal group 14	71	7	7	7	497
Signal group 15	49	7	8	7	349
Signal group 16	31	7	7	7	217
Pedestrian movement 2	37	4	8	7	262
Pedestrian movement 4	71	5	7	6	465
Pedestrian movement 6	49	4	8	6	336

Intersection Location: Mission Blvd & Blanche St

Intersection Number: 1323

Date: 8/29/24

Data item	Frequency	Minimum	Maximum	Average	Total
Unknown phase	1	53	53	53	53
A phase	664	13	1222	108	71929
B phase	436	15	61	19	8383
C phase	291	13	36	15	4652
D phase	35	7	13	8	283
E phase	137	7	10	8	1099
Nominal cycle length	115	97	180	136	15658
Active cycle length	164	97	203	140	23099
Actual cycle	666	15	1230	129	86399
Split plan 1	1	83782	83782	83782	83782
Signal group 1	159	9	21	11	1773
Signal group 2	501	9	3903	145	72929
Signal group 4	436	10	57	14	6286
Signal group 5	196	9	32	12	2416
Signal group 6	518	8	3299	139	72056
Signal group 8	440	10	57	14	6326
Signal group 13	21	7	8	7	148
Signal group 14	51	7	7	7	357
Signal group 15	26	7	8	7	184
MSS 16	4	23	25	23	94
Pedestrian movement 2	21	4	8	6	143
Pedestrian movement 4	51	5	7	6	347
Pedestrian movement 6	26	4	8	6	177

Caltrans Intersections

Raw TSP reports are available upon request.

Intersection Location: Mission Blvd & Lafayette

Date: 10/31/24

Number of TSP calls granted: 146

Intersection Location: Mission Blvd & Tamarack

Date: 10/31/24

Number of TSP calls granted: 132

Intersection Location: Mission Blvd & Whipple

Date: 10/31/24

Number of TSP calls granted: 110

Intersection Location: Mission Blvd & Decoto Rd

Date: 10/31/24

Number of TSP calls granted: 78

Union City Intersections

Raw TSP reports are available upon request.

Intersection Location: Decoto Rd & 5th St

Date: 1/30/25

Number of TSP calls granted: 162

Intersection Location: Decoto Rd & 7th St

Date: 1/30/25

Number of TSP calls granted: 162

Intersection Location: Decoto Rd & 11th St

Date: 1/30/25

Number of TSP calls granted: 323

Intersection Location: Decoto Rd & Station Way

Date: 1/30/25

Number of TSP calls granted: 706