Intersection Control Evaluation Report

California State Polytechnic University, Pomona

Senior Project 2019-2020

This report is created in compliance with the Caltrans Traffic Operations Policy Directive 13-02

Introduction

The Intersection Control Evaluation (ICE) is a study used to evaluate intersection control alternatives at intersections within our design boundary.

Project Overview

The I-215 Palm Ave. and Palm Kendall Dr. Interchange (Palm/Kendall Interchange) Improvement Project is a feasibility study conducted by the Cal Poly Pomona Senior Project. The project is located in San Bernardino, California. The existing interchange connects to Interstate-215. The study area can be seen in **Figure 1**. The study was performed to examine a variety of proposed interchange upgrades to accommodate future increases in traffic and known operational issues around the current interchange. For the proposed interchange, four alternatives were tested against the existing configuration using both current and future volumes. **Table 1** shows all the intersections within our study area.

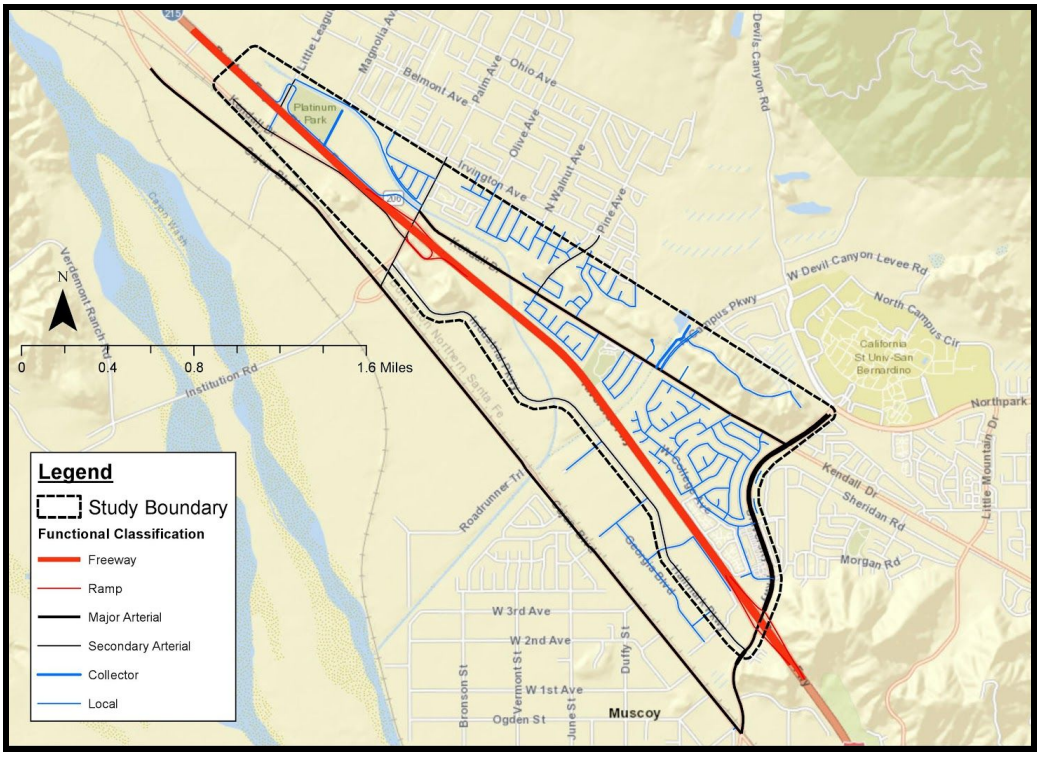


Figure 1- Study Area

Palm/Kendall Interchange Intersections	
1	Palm Ave (NS) / I-215 SB Ramps (EW)
2	Palm Ave (NS) / I-215 NB Ramps (EW)
3	Palm Ave (NS) / W Little League Dr (EW)

Table 1. Analyzed Intersections within the Study Area

The team conducted all traffic analyses using Trafficware's Synchro 10 and SimTraffic. The program utilizes different traffic control types, geometric design data, and traffic volume data to produce thorough results. Traffic volumes and patterns were found using traffic data from resources provided to us to conduct the analysis. Resources include the Jack in the Box Traffic Impact Analysis (TIA) and HDR Traffic Operation Analysis Report (TOAR). Using their forecasted 2040 peak hour traffic volumes, we were able to determine the growth rate used for their analysis and used the same growth rate for our traffic data.

The level of service (LOS) is used as a measure for traffic operation on roadway segment or intersections. The LOS reported by Synchro must meet a "D" as stated by the San Bernardino County Congestion Management Plan 2016 Update. For signalized intersections, LOS is measured by average control delay per vehicle. This includes deceleration time, queue delay, stop delay, and acceleration time. The PHF factor for this analysis was the Synchro 10 default.

Palm/Kendall Interchange: No Build

Project	I-215 Palm Ave. & Kendall Dr. Interchange
Alternative	Existing
Clients	Caltrans
Location	I-215 Palm Ave. & Kendall Dr. Interchange
Number of Intersections	3
Current Control	Signalized

Description:

The existing interchange at the I-215 Interchange includes four ramps that provide access to the I-215. Additionally there is an intersection on Palm Ave. and Kendall Dr. that plays a crucial role in the local accessibility of the freeway. The first intersection provides access to the I-215 southbound. This intersection was our most critical intersection as our early traffic analysis

identified the large volume of left turn movements into the I-215 southbound. The second intersection provides access to the I-215 NB. This intersection services people leaving the freeway as well as people attempting to enter the freeway. The third intersection is Palm Ave. and Kendall Dr. This intersection plays a crucial role in our 2045 analysis as our forecasted volumes for our alternatives anticipates a high number of users for that intersection. To mitigate the high demand, we proposed expansion of this interchange. As a result the intersection will remain operational and provide acceptable LOS as will be demonstrated in the ICE.

Intersection Control Types:

Stop Control

An intersection with a stop control consists of a three or four legged intersection that has a stop sign at the necessary approaches. The stop signs require vehicles to stop and proceed through the intersection with caution. All of the current intersections have this control type. The stop control intersection type will be further explained throughout our analysis.

Signal Control

An intersection with a signal control consists of a three or four legged intersection that has traffic lights used to control the traffic in this intersection. The signals will have multiple phases to provide the most efficient way for vehicles to safely proceed through the intersection. These signals will be optimized to provide better flow at different intersection at different times of the day. Our project will demonstrate optimized phases for the peak hours at each intersection for both the AM and PM peaks.

Roundabout Control

An intersection with a roundabout control is a three or four legged intersection that requires vehicles to slow and yield (when necessary) as they enter the circular intersection. The intersection provides different entrance/exit routes for vehicles causing minimal conflicts with vehicles approaching from different directions. The roundabout control acquires more right of way when compared to a stop and signal control. This control will be further explained in the further analysis performed.

No.	Intersection	Existing		No Build			
		2020		2025		2045	
		AM	PM	AM	PM	AM	PM
1	Palm Ave (NS) / I-215 SB Ramps (EW)	F	C	F	D	F	F

2	Palm Ave (NS) / I-215 NB Ramps (EW)	F	F	F	F	F	F
3	Palm Ave (NS) / W Little League Dr (EW)	F	C	F	D	F	F

Alternative 1-Kendall Plaza T

Project	I-215 Palm Ave. & Kendall Dr. Interchange
Alternative	Spread Diamond Kendall Dr. Exit
Clients	Caltrans
Location	I-215 Palm Ave. & Kendall Dr. Interchange
Number of Intersections	3
Proposed Control	Signal

Description:

The Kendall Plaza Tee design will relocate the northbound on- and off-ramps further south and will implement a dedicated southbound on-ramp for each direction of traffic on Palm Avenue to improve access to the freeway. A new signalized intersection will also be added at the relocated northbound ramps. The project also aims to improve the existing traffic conditions in the corridor as well as address the current need for pedestrian access passing under the freeway.

Intersection Control Types:

Signal Control

An intersection with a signal control consists of a three or four legged intersection that has traffic lights used to control the traffic in this intersection. The signals will have multiple phases to provide the most efficient way for vehicles to safely proceed through the intersection. These signals will be optimized to provide better flow at different intersections at different times of the day. Our project will demonstrate optimized phases for the peak hours at each intersection for both the AM and PM peaks.

Control Analysis:

Intersection 1: Palm Ave (NS) / I-215 SB Off Ramps (EW)

Signal Control

A simulation was run on Trafficware Synchro 10 with the three studied intersections utilizing signal control. The simulation was conducted with projected 2045 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. Optimum cycle length was only selected if it lied between the industry standard of 60 to 120 seconds. Any length beyond that range was rounded accordingly. The LOS for each intersection are shown in **Table 2** and the corresponding traffic volumes are shown in Table 6, below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of B/C, respectively. This meets the minimum requirements set by the County of San Bernardino and Caltrans of LOS D or higher and LOS C or higher, respectively. Due to the calculated level of service, we have selected signal control as a viable alternative.

Intersection 3: Palm Ave (NS) / W Little League Dr (EW)

Signal Control

A simulation was run on Trafficware Synchro 10 with the three studied intersections utilizing signal control. The simulation was conducted with projected 2045 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. Optimum cycle length was only selected if it lied between the industry standard of 60 to 120 seconds. Any length beyond that range was rounded accordingly. The LOS for each intersection are shown in **Table 2** and the corresponding traffic volumes are shown in Table 6, below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of D/D, respectively. This meets the minimum requirement of LOS D or higher per San Bernardino County standards, however, it does not meet Caltrans recommendation of LOS C or higher. Due to the calculated level of service, we suggest optimizing the cycle length at the existing signalized intersection and for the City of San Bernardino to consider adding an additional right turn lane from Kendall Drive onto Palm Avenue.

Intersection 7: Kendall Dr (EW) / I-215 NB Ramps (NS)

Signal Control

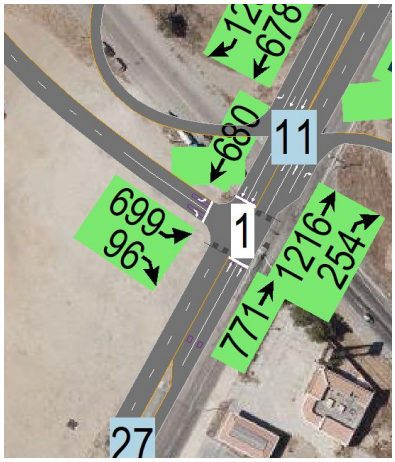
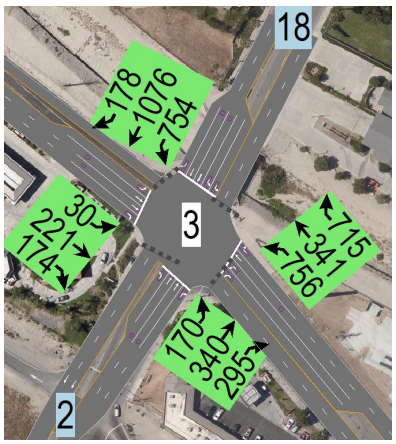
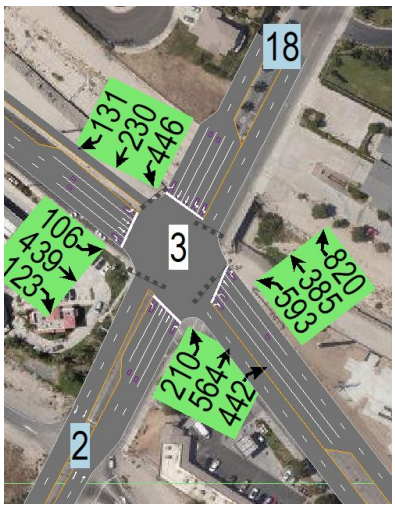
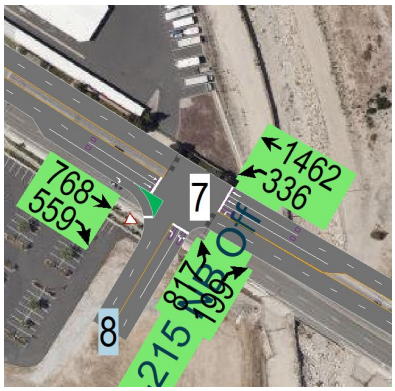
A simulation was run on Trafficware Synchro 10 with the three studied intersections utilizing signal control. The simulation was conducted with projected 2045 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. Optimum cycle length was only selected if it lied between the industry standard of 60 to 120 seconds. Any length beyond that range was rounded accordingly. The LOS for each intersection are shown in **Table 2** and the corresponding traffic volumes are shown in Table 6, below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of B/C, respectively. This meets the minimum requirements set by the County of San Bernardino and Caltrans of LOS D or higher and LOS C or higher, respectively. Due to the calculated level of service, we have selected signal control as a viable alternative for the proposed intersection.

Table 2. LOS values found when implementing the Kendall Plaza T alternative at Palm Ave. & Kendall Dr..

No.	Intersection	2025		2045	
		AM	PM	AM	PM
1	Palm Ave (NS) / I-215 SB Off Ramps (EW)	B	B	B	C
3	Palm Ave (NS) / W Little League Dr (EW)	D	C	D	D
7	Kendall Dr (EW) / I-215 NB Ramps (NS)	B	B	B	C

Table 3. Volumes for 2045 implemented on Spread Diamond Kendall Dr. Exit alternative.

Signal Control	2045 AM	2045 PM
1) Palm Ave (NS)/ I-215 SB Off Ramps (EW)		
3) Palm Ave (NS) / W Little League Dr (EW)		
7) Kendall Dr (EW) / I-215 NB Ramps (NS)		

Alternative 2 - Single Point Urban Interchange

Project	I-215 Palm Ave. & Kendall Dr. Interchange
Alternative	Single Point Urban Interchange
Clients	Caltrans
Location	I-215 Palm Ave. & Kendall Dr. Interchange
Number of Intersections	2
Proposed Control	Signal

Description:

The Single Point Urban Interchange (SPUI) design will replace the existing ramp intersections. The SPUI is a grade-separated interchange design where all freeway ramps begin or end at a single signalized intersection. A single traffic signal at the center of the SPUI will control all left turns. This alternative will combine the two diamond ramp interchanges into one large at-grade intersection. The SPUI requires a minimal amount of right of way compared to other forms of interchanges. Traffic analysis shows that with a signal control, operation efficiency and safety will be improved than that of the no build condition.

Intersection Control Types:

Signal Control

An intersection with a signal control consists of a three or four legged intersection that has traffic lights used to control the traffic in this intersection. The signals will have multiple phases to provide the most efficient way for vehicles to safely proceed through the intersection. These signals will be optimized to provide better flow at different intersection at different times of the day. Our project will demonstrate optimized phases for the peak hours at each intersection for both the AM and PM peaks.

Control Analysis:

Intersection 3: Palm Ave (NS) / W Little League Dr (EW)

Signal Control

A simulation was run on Trafficware Synchro 10 with all intersection utilizing signal control. The simulation was conducted with the anticipated 2040 peak hour traffic volumes. Within the

program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. Optimum cycle length was only selected if it lied between the industry standard of 60 to 120 seconds. Any length beyond that range was rounded accordingly. The LOS for each intersection are shown in **Table 4** below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of C/D, respectively. This does meet the minimum requirement of LOS D or higher per San Bernardino County standards. Additionally, this partly does meet Caltrans recommendation of LOS C or higher. Due to to the calculated level of service, we have selected signal control as a viable alternative.

Intersection 11: Single Point Urban Interchange

Signal Control

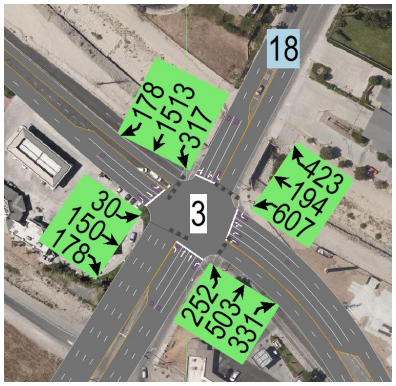
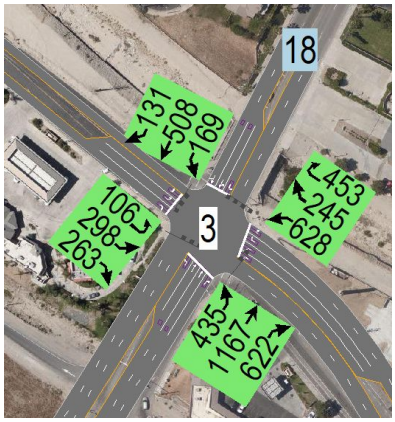
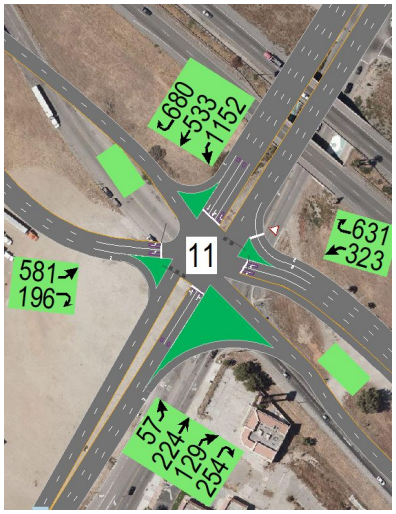
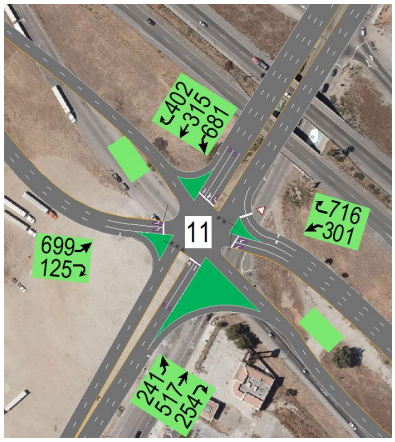
A simulation was run on Trafficware Synchro 10 with all intersection utilizing signal control. The simulation was conducted with the anticipated 2040 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. Optimum cycle length was only selected if it lied between the industry standard of 60 to 120 seconds. Any length beyond that range was rounded accordingly. The LOS for each intersection are shown in **Table 4** below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of A/C, respectively. This does meet the minimum requirement of LOS D or higher per San Bernardino County standards. Additionally, this partly does meet Caltrans recommendation of LOS C or higher. Due to the calculated level of service, we have selected signal control as a viable alternative.

Table 4. LOS values found when implementing the Single Point Urban Interchange alternative.

No.	Intersection	2025		2045	
		AM	PM	AM	PM
3	Palm Ave (NS) / W Little League Dr (EW)	C	C	D	D
11	Single Point Urban Interchange	C	C	D	D

Table 5. 2045 Volumes implemented on Single Point Urban Interchange alternative.

Signal Control	2045 AM	2045 PM
3) Palm Ave (NS) / W Little League Dr (EW)		
11) Single Point Urban Interchange		

Alternative 3 - Par-Clo

Project	I-215 Palm Ave. & Kendall Dr. Interchange
Alternative	Partial Cloverleaf Interchange
Clients	Caltrans
Location	I-215 Palm Ave. & Kendall Dr. Interchange
Number of Intersections	3
Proposed Control	Signal

Description:

The partial cloverleaf interchange uses loop ramps to eliminate the left-turns to access the I-215. A partial cloverleaf interchange accommodates the high volume of left turning movements used to access the southbound segment of the I-215. The primary benefit of this alternative is that no left turns are required at the ramps to access the freeway.

Intersection Control Types:

Signal Control

An intersection with a signal control consists of a three or four legged intersection that has traffic lights used to control the traffic in this intersection. The signals will have multiple phases to provide the most efficient way for vehicles to safely proceed through the intersection. These signals will be optimized to provide better flow at different intersections at different times of the day. Our project will demonstrate optimized phases for the peak hours at each intersection for both the AM and PM peaks.

Control Analysis:

Intersection 1: Palm Ave (NS)/ I-215 SB Off Ramps (EW)

Signal Control

A simulation was run on Trafficware Synchro 10 with all intersection utilizing signal control. The simulation was conducted with the anticipated 2045 peak hour traffic volumes for the AM and PM time frame. Within the program, the phasing and cycle lengths were optimized to attain

maximum LOS for each intersection.The LOS for each intersection are shown in Table 10 below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of B/C, respectively. This does meet the minimum requirement of LOS D or higher per San Bernardino County standards.

Intersection 3: Palm Ave (NS) / W Little League Dr (EW)

Signal Control

A simulation was run on Trafficware Synchro 10 with all intersection utilizing signal control. The simulation was conducted with the anticipated 2045 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. The LOS for each intersection are shown in **Table 6** below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of D/C, respectively. This does meet the minimum requirement of LOS D or higher per San Bernardino County standards.

Intersection 7: Kendall Dr (EW) / I-215 NB Ramps

Signal Control

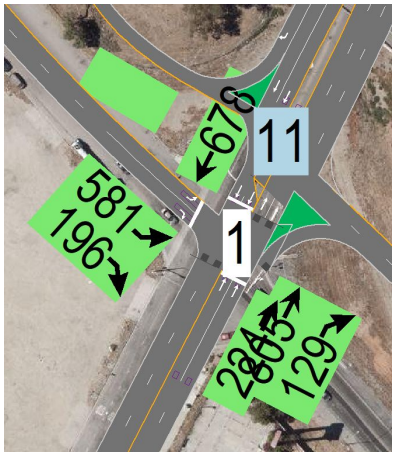
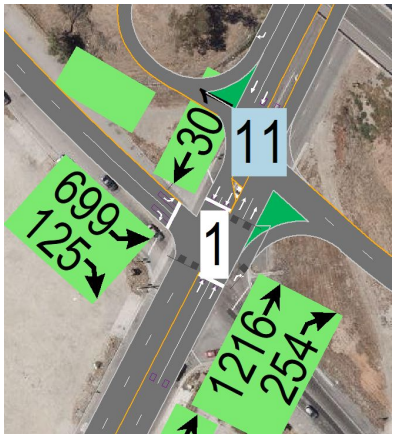
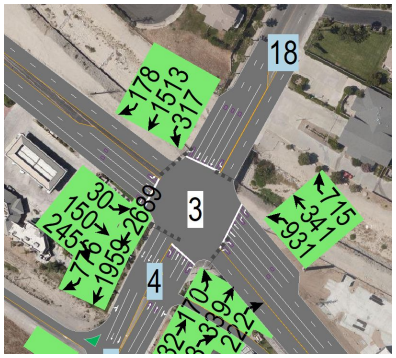
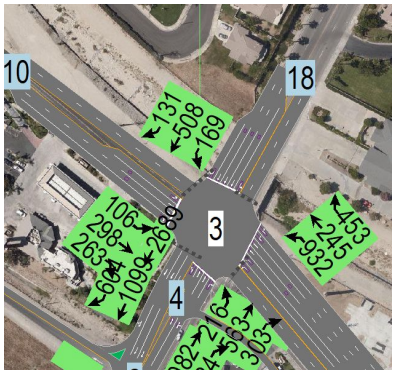
A simulation was run on Trafficware Synchro 10 with all intersection utilizing signal control. The simulation was conducted with the anticipated 2045 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection.

Following the traffic analysis, we found an AM/PM level of service for this intersection of B/C, respectively. This does meet the minimum requirement of LOS D or higher per San Bernardino County standards.

Table 6. LOS Summary

No.	Intersection	2025		2045	
		AM	PM	AM	PM
1	Palm Ave (NS) / I-215 SB Off Ramps (EW)	B	B	B	C
3	Palm Ave (NS) / W Little League Dr (EW)	D	C	D	C
7	Kendall Dr (EW) / I-215 NB Ramps	B	B	B	C

Table 7. 2045 Volumes implemented on Partial Cloverleaf

Signal Control	2045 AM	2045 PM
1) Palm Ave (NS)/ I-215 SB Off Ramps (EW)		
3) Palm Ave (NS) / W Little League Dr (EW)		
7) Kendall Dr (EW) / I-215 NB Ramps		

Alternative 4- Little League Tee

Project	I-215 Palm Ave. & Kendall Dr. Interchange
Alternative	Spread Diamond Little League Dr. Exit
Clients	Caltrans
Location	I-215 Palm Ave. & Kendall Dr. Interchange
Number of Intersections	3
Proposed Control	Signal

Description:

The Little League Tee design will relocate the ramps further apart from each other. The purpose was to improve traffic flow and to reduce traffic conflict and delay. The I-215 north ramps will be moved further north from its original location to a new signalized intersection. The I-215 south ramps will be split into three and be placed along Kendall Drive. There will be two dedicated on-ramps for traffic entering from either direction. The traffic exiting the off-ramp will approach a signalized intersection control. The Alternative 4 design will require a relocation of the local road and utility. It will also require realignment of Little League Drive and Kendall Drive.

Intersection Control Types:

Signal Control

An intersection with a signal control consists of a three or four legged intersection that has traffic lights used to control the traffic in this intersection. The signals will have multiple phases to provide the most efficient way for vehicles to safely proceed through the intersection. These signals will be optimized to provide better flow at different intersections at different times of the day. Our project will demonstrate optimized phases for the peak hours at each intersection for both the AM and PM peaks.

Control Analysis:

Intersection: I-215 & Little League Drive

Signal Control

A simulation was run on Trafficware Synchro 10 with all intersection utilizing signal control. The simulation was conducted with the anticipated 2045 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. Optimum cycle length was only selected if it lied between the industry standard of 60 to 120 seconds. Any length beyond that range was rounded accordingly. The LOS for each intersection are shown in **Table 8** below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of B/C, respectively. This does meet the minimum requirement of LOS D or higher per San Bernardino County standards. Additionally, this does meet Caltrans recommendation of LOS C or higher. Due to minor horizontal design changes needed for implementation and level of service calculated, we have selected signal control as a viable alternative.

Intersection: I-215 & Palm Ave

Signal Control

A simulation was run on Trafficware Synchro 10 with all intersection utilizing signal control. The simulation was conducted with the anticipated 2045 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. Optimum cycle length was only selected if it lied between the industry standard of 60 to 120 seconds. Any length beyond that range was rounded accordingly. The LOS for each intersection are shown in **Table 8** below.

Following the traffic analysis, we found an AM/PM level of service for this intersection of B/D, respectively. This does meet the minimum requirement of LOS D or higher per San Bernardino County standards. Additionally, this does not meet Caltrans recommendation of LOS C or higher. Due to minor horizontal design changes needed for implementation and level of service calculated, we have selected signal control as a viable alternative.

Intersection: Palm Ave & Kendall Dr.

Signal Control

A simulation was run on Trafficware Synchro 10 with all intersection utilizing signal control. The simulation was conducted with the anticipated 2045 peak hour traffic volumes. Within the program, the phasing and cycle lengths were optimized to attain maximum LOS for each intersection. Optimum cycle length was only selected if it lied between the industry standard of

60 to 120 seconds. Any length beyond that range was rounded accordingly. The LOS for each intersection are shown in **Table 8** below.

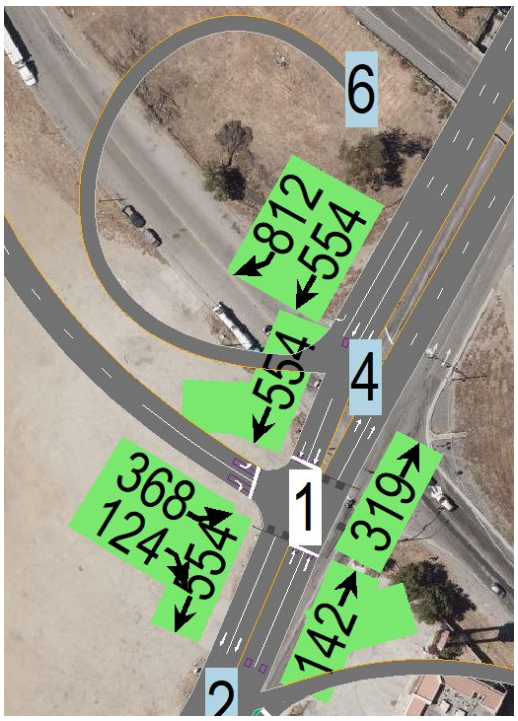
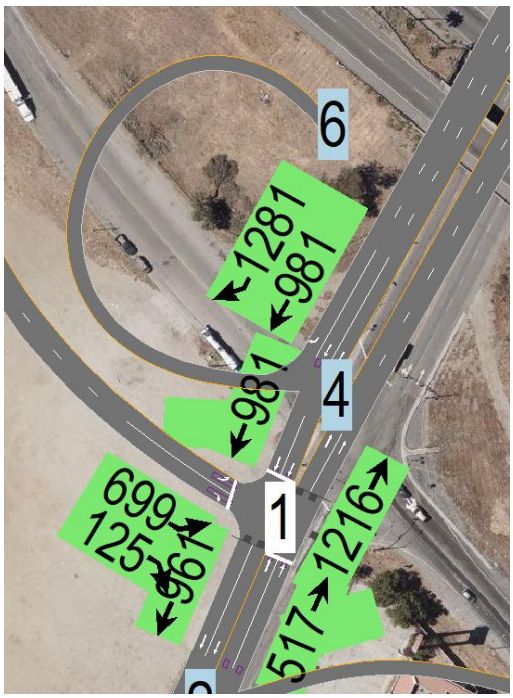
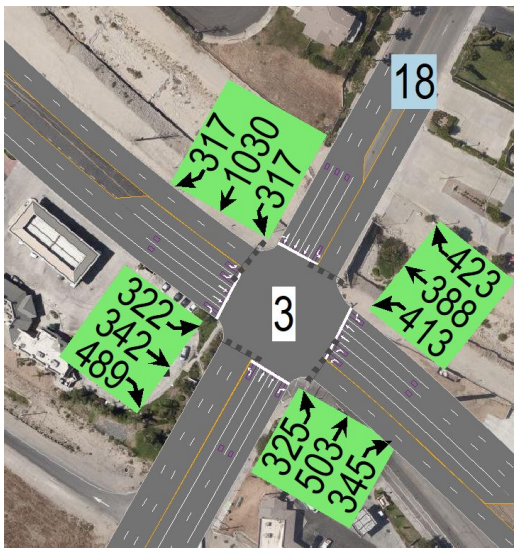
Following the traffic analysis, we found an AM/PM level of service for this intersection of D/C, respectively. This does meet the minimum requirement of LOS D or higher per San Bernardino County standards. Additionally, this does not meet Caltrans recommendation of LOS C or higher. Due to minor horizontal design changes needed for implementation and level of service calculated, we have selected signal control as a viable alternative.

Table 8. LOS values found implementing the Little League Tee alternative on the I-215.

No.	Intersection	2025		2045	
		AM	PM	AM	PM
1	Palm Ave (NS) / I-215 SB Off Ramps (EW)	B	B	C	D
3	Palm Ave (NS) / W Little League Dr (EW)	C	C	D	C
10	I-215 NB Ramps (NS) / W Little League Dr (EW)	B	C	D	C

Table 9. 2045 Volumes implemented on Little League Tee alternative.

Signal Control	**2045 AM**	**2045 PM**

1)Palm Ave (NS) / I-215 SB Off Ramps (EW)		
3) Palm Ave (NS) / W Little League Dr (EW)		

10) I-215 NB Ramps (NS) / W Little League Dr (EW)