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Technical Memorandum

February 22, 2022

Project# 26855

To: Steven Chang and Leigha Schmidt – City of Hayward
From: Michael Sahimi and Damian Stefanakis – Kittelison & Associates, Inc.
RE: Parcel Group 5 – Additional Bunker Hill Boulevard/Carlos Bee Boulevard Analysis

Kittelison & Associates (Kittelison) recently prepared a local transportation analysis (LTA) for the Parcel Group 5 (PG 5) project which consists of analysis and recommendations focused on multimodal access and safety, traffic controls, traffic calming, and strategies to reduce project-generated vehicle trips. Due to resident concerns, Kittelison has also prepared this separate memo to analyze the proposed project access point at Bunker Hill Boulevard and Carlos Bee Boulevard (the project includes extending Bunker Hill Boulevard from its current terminus). The purpose of this memo is to provide recommendations on the appropriate access control for the proposed intersection.

This memorandum is organized into the following sections:

- Project Description
- Local Transportation Assessment (LTA) Traffic Operations Analysis
- LTA Sight Distance Analysis
- Traffic Signal Warrants Analysis
- Traffic Control Recommendation and Conceptual Driveway Design
- Traffic Operations Analysis w/ Bunker Hill/Carlos Bee Access Control
- Summary of Findings

PROJECT DESCRIPTION

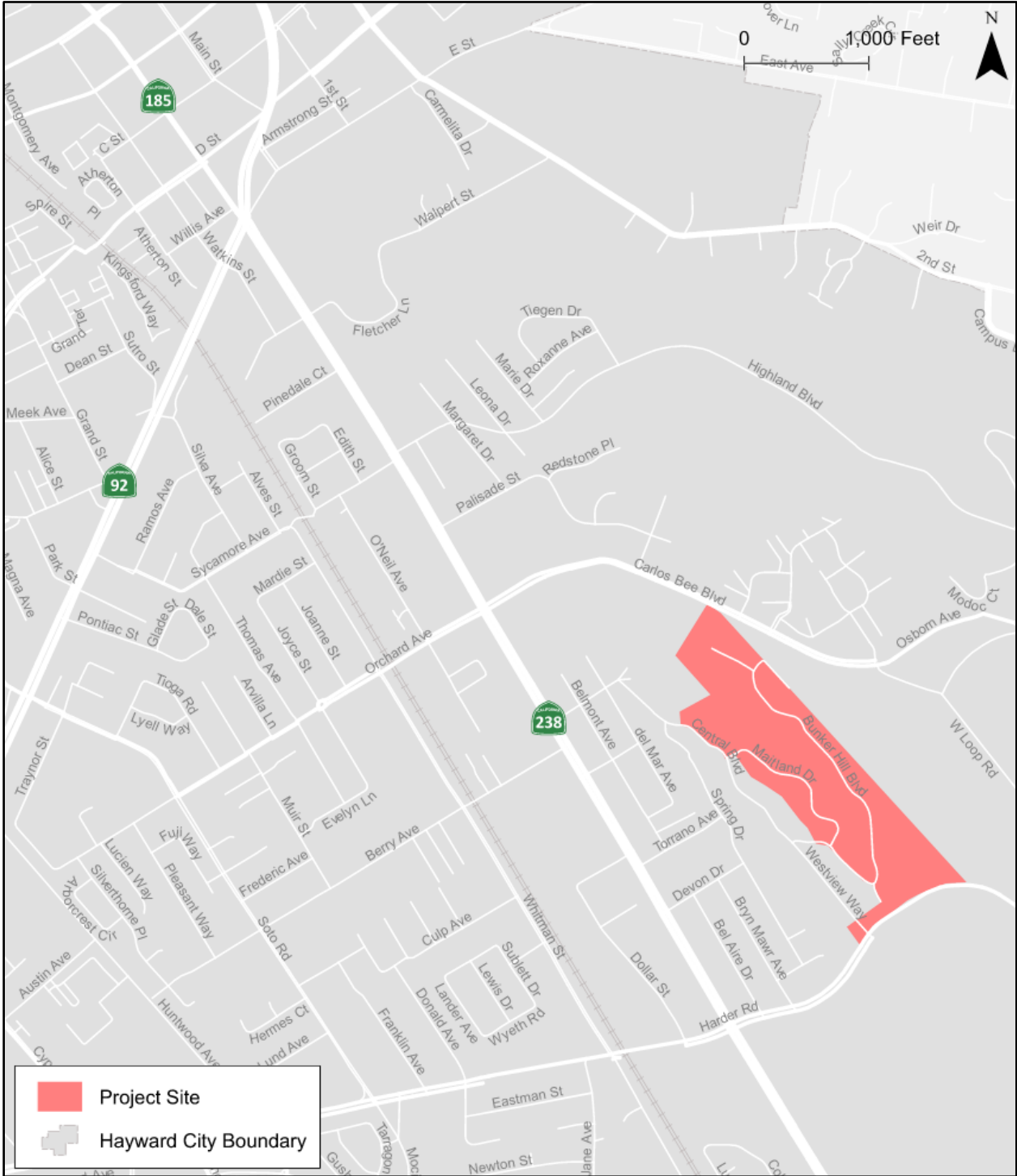
The Parcel Group 5 Project will consist of up to 74 single-family dwelling units and 8 accessory dwelling units (ADUs). The single-family homes will each have four bedrooms, and the ADUs will be a mix of studios and one-bedroom units. A total of 406 parking spaces will be provided, consisting of 100 on-street spaces, 148 driveway spaces, and 158 garage spaces.

Additional project elements include approximately 10.50 acres of open space to preserve riparian areas, a new segment of the Hayward Foothill Trail, and additional street improvements such as curbs, gutters, sidewalks, on-street parking bulb-outs, utilities, and lighting.

The project site is shown in Figure 1. The proposed site plan is shown in Figure 2.

The proposed project includes extending Bunker Hill Boulevard to Carlos Bee Boulevard to form a new intersection that would provide access to the northern portion of the project site. The PG 5 LTA analyzed this proposed access point as a side-street stop-controlled intersection, with vehicles exiting Bunker Hill Boulevard onto Carlos Bee Boulevard needing to stop.

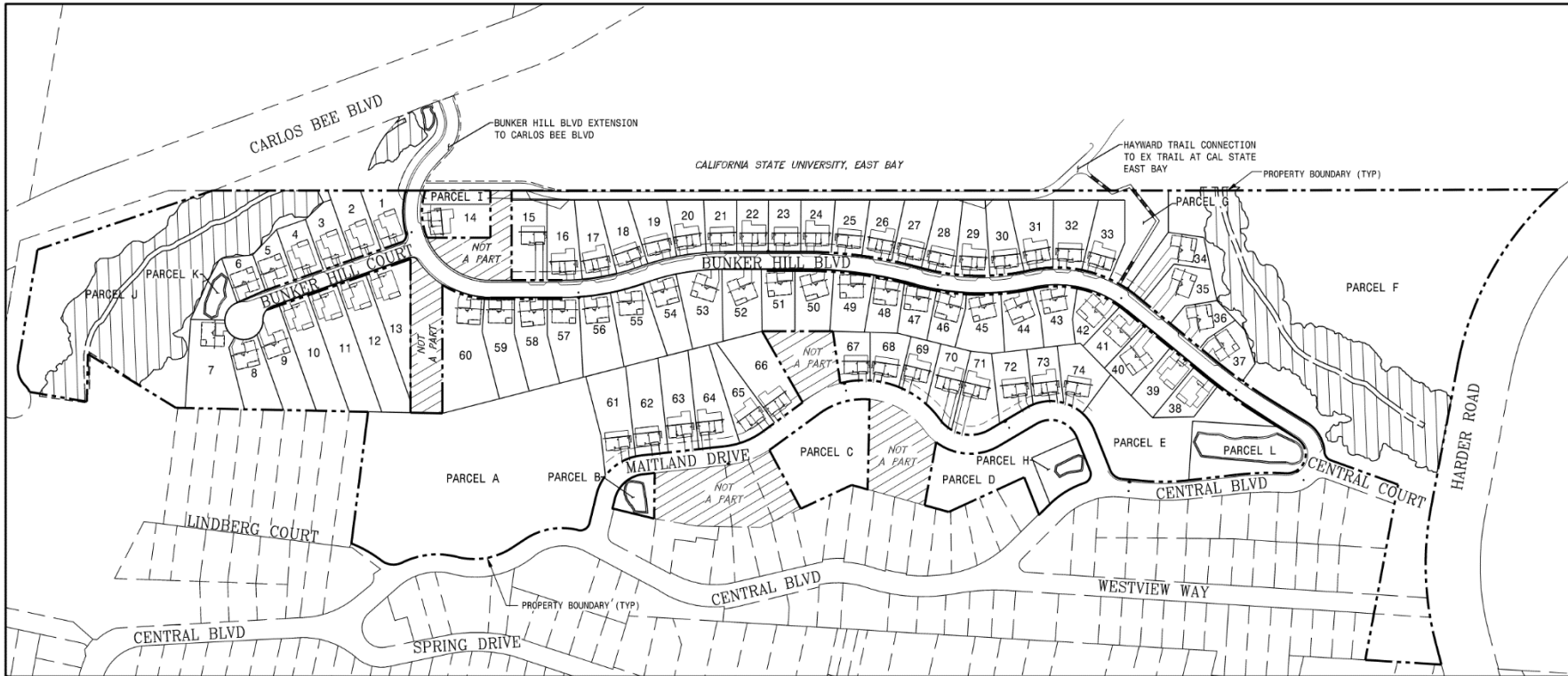
Figure 1: Project Site



February 22, 2022

Parcel Group 5 – Additional Bunker Hill Boulevard/Carlos Bee Boulevard Analysis

Figure 2: Project Site Plan



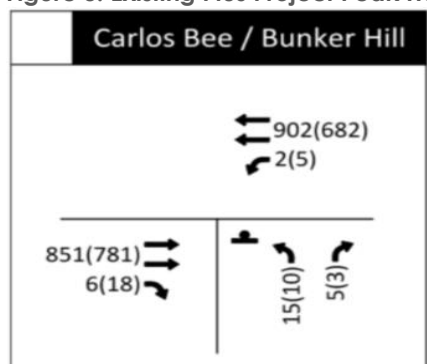
SOURCE: MacKAY & SOMPS

DATED MAY 12, 2021; RECEIVED MAY 18, 2021

PG 5 LTA TRAFFIC OPERATIONS ANALYSIS

In the PG 5 LTA, Kittelson analyzed the proposed access point at Bunker Hill Boulevard and Carlos Bee Boulevard as a full access side-street stop-controlled intersection. The traffic operations analysis included a determination of the proportion of project traffic that will use the new access point plus assessments of level of service (LOS) and queuing with project trips added on top of existing weekday morning and evening peak hours. Figure 3 shows the Existing Plus Project AM and PM peak hour volumes at the intersection. Based on project trip distribution developed using the City of Hayward General Plan Update travel demand model, the project traffic anticipated to use the new access point at Bunker Hill Boulevard and Carlos Bee Boulevard is lower than the amount anticipated to use the other two access points at Harder Road and Mission Boulevard. It was assumed that 20 outbound and 8 inbound vehicles would use the access point during the AM peak hour and 13 outbound and 23 inbound vehicles would use it during the PM peak hour.

Figure 3: Existing Plus Project Peak Hour Volumes (Bunker Hill Blvd./Carlos Bee Blvd.)



LOS is used to describe the quality of intersection operations. LOS grades range from A to F, with LOS A representing free-flow conditions and LOS F indicating high levels of congestion. According to City guidelines, the acceptable level of service at an intersection is LOS E. Additional information regarding City methodologies and standards are provided in the PG 5 LTA.

As shown in Table 1, based on the assessment conducted in the PG 5 LTA, it is anticipated that the Bunker Hill Boulevard access point would operate with acceptable LOS during both peak hours as a side-street stop-controlled intersection.

Table 1: Automobile Level of Service, Existing Plus Project Conditions (Bunker Hill Blvd./Carlos Bee Blvd.)

Peak Hour	Delay (sec)	LOS	Acceptable LOS?
AM	16.1	C	Yes
PM	14.9	B	Yes

SOURCE: KITTELSON & ASSOCIATES, 2022.

Table 2 shows the anticipated 95th percentile queues at the Bunker Hill Boulevard access point. As shown in the table, none of the queues are expected to exceed the available storage.

Table 2: Queues, Existing Plus Project Conditions (Bunker Hill Blvd./Carlos Bee Blvd.)

Peak Hour	Movement		Storage Length (ft)	Queue (ft)	Exceed Storage?
AM	NB	Left	300	< 25	No
		Right	70	< 25	No
PM	WB	Left	600	< 25	No
	NB	Left	300	< 25	No
		Right	70	< 25	No
	WB	Left	600	< 25	No

SOURCE: KITTELSON & ASSOCIATES, 2022.

PG 5 LTA SIGHT DISTANCE ANALYSIS

The PG 5 LTA included an assessment of sight distance at the proposed access point at the new Bunker Hill Boulevard/Carlos Bee Boulevard intersection. The line of sight for the exiting stop-controlled movements at this location was analyzed to ensure that adequate sight distances are provided for vehicles to see pedestrians, bicycles, and vehicles approaching the driveway. Line of sight was analyzed using standards and methodologies described in the American Association of State Highway and Transportation Officials (AASHTO) Geometric Design of Highways and Streets. AASHTO standards were used to develop departure sight triangles at the intersection that should be unobstructed for vehicles to provide sufficient view of approaching vehicles, bicycles, and pedestrians.

Assuming a passenger car time gap of 8.5 seconds (based on AASHTO) and the posted speed limit of 30 mph along Carlos Bee Boulevard, the intersection sight distances were calculated, and recommended departure sight triangles are shown in Figure 4. As shown in the figure, 375 feet of sight distance is needed to the left (for exiting right-turning vehicles) and to the right (for exiting left-turning vehicles). Obstructions currently consist of trees. Therefore, the PG 5 LTA included a recommendation that when the Bunker Hill Boulevard intersection is being constructed, visual obstructions such as brush and landscaping should be cleared from the sight triangle area as shown in Figure 4 to provide adequate visibility.

Figure 4: Bunker Hill Blvd./Carlos Bee Blvd. Departure Sight Triangles



TRAFFIC SIGNAL WARRANTS ANALYSIS

In response to local resident concerns about the proposed traffic controls, Kittelson evaluated the proposed intersection against traffic signal warrants from the *California Manual of Uniform Traffic Control Devices* (CA-MUTCD). Traffic signal warrants are standards that provide guidelines in the determination of the need for a traffic signal (warrants studied are highlighted in bold).

The CA-MUTCD states: "An engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at a particular location...The investigation for a traffic control signal shall include an analysis of the applicable factors contained in the following traffic signal warrants:

- **Warrant 1**, Eight-Hour Vehicular Volume
- **Warrant 2**, Four-Hour Vehicular Volume
- **Warrant 3**, Peak Hour
- Warrant 4, Pedestrian Volume
- Warrant 5, School Crossing
- Warrant 6, Coordinated Signal System
- **Warrant 7**, Crash Experience
- Warrant 8, Roadway Network
- Warrant 9, Intersection near a Grade Crossing

...The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal."¹

This evaluation used available data (peak hour turning movement volumes and crash history) to conduct an analysis with respect to Warrant 3 (Peak Hour) and Warrant 7 (Crash Experience). Additionally, typical assumptions about the distribution of traffic throughout the day, based on peak hour counts, allowed for Warrant 1 (Eight-Hour Vehicular Volume) and Warrant 2 (Four-Hour Vehicular Volume) to be studied. Warrants 4, 5, 6, 8, and 9 were not applicable to this location and were not studied.²

Warrants 1 and 2, the eight-hour and four-hour volume warrants, are computed based on approach geometry (number of lanes) and vehicle volumes. Warrant 3, the peak hour signal warrant, is a function of approach geometry, volume, and vehicle delay. The CA-MUTCD advises that Warrant 3 "shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time."³

Based on the available data, the intersection does not meet Warrants 1, 2, or 3 in the AM peak hour or the PM peak hour. Warrant sheets are provided in Attachment 1.

For an intersection to meet Warrant 7 (crash experience), the intersection needs to have observed at least five crashes "of types susceptible to correction by a traffic control signal" within a 12-month period.⁴ Kittelson obtained the ten most recent years of crash data (January 2011 through December 2020) for the proposed access point location as well as the existing Tanglewood/Carlos Bee Boulevard intersection, which is located approximately 100 feet away from the proposed Bunker Hill Boulevard/Carlos Bee Boulevard access point; reported crashes were obtained from the University of California, Berkeley,

¹ CA-MUTCD, Section 4C.01

² Warrants 4 and 5 are applicable for crossings without existing traffic control (i.e., STOP sign or traffic signal) to assist pedestrian crossings. Warrant 6 pertains to intersections that are part of a coordinated signal system, which this location is not. Warrants 8 and 9 are applicable to contexts not matching this site's context.

³ CA-MUTCD, Section 4C.04, 02

⁴ CA-MUTCD, Section 4C.08, 02B

Transportation Injury Mapping System (TIMS) database and the California Statewide Integrated Traffic Records System (SWITRS) database. This data is shown in Table 3; based on the reported crash history, the proposed access point location does not meet Warrant 7.

Note that while the Bunker Hill Boulevard/Carlos Bee Boulevard intersection currently does not exist, this crash analysis still includes crashes along the adjacent roadway segment which involve factors and traits that would be faced by vehicles using the proposed access point. In addition, it conservatively includes crashes at the adjacent Tanglewood intersection, since the two locations are linked and may need to be signalized as a single location.

Table 3: Reported Crash History, 2011-2020

Crash Year	Road Users Involved	Fatal	Severe Injury	Visible Injury	Complaint of Pain	Property Damage Only	Total
2011-2020	Pedestrian Involved	0	0	0	0	0	0
	Bicycle Involved	0	0	0	0	0	0
	Vehicle Only or Vehicle-Fixed Object	0	0	0	5	2	7
	All Reported Crashes	0	0	0	5	2	7
2011	All Reported Crashes	0	0	0	0	0	0
2012	All Reported Crashes	0	0	0	0	0	0
2013	All Reported Crashes	0	0	0	0	0	0
2014	All Reported Crashes	0	0	0	0	0	0
2015	All Reported Crashes	0	0	0	2	0	2
2016	All Reported Crashes	0	0	0	1	1	2
2017	All Reported Crashes	0	0	0	0	0	0
2018	All Reported Crashes	0	0	0	0	0	0
2019	All Reported Crashes	0	0	0	2	1	3
2020	All Reported Crashes	0	0	0	0	0	0

SOURCE: SWITRS, TIMS, KITTELSON & ASSOCIATES, 2022.

In conclusion, the proposed access point at Bunker Hill Boulevard and Carlos Bee Boulevard does not meet the analyzed traffic signal warrants. As such, a traffic signal is not recommended at this location.

TRAFFIC CONTROL RECOMMENDATION AND CONCEPTUAL DRIVEWAY DESIGN

While the proposed project access point location does not trigger a traffic signal warrant, triggering a warrant is not the sole determinant for an intersection improvement. The City can at its discretion require or not require a signal be installed, based on other factors. Relevant conditions around the access point location are discussed below.

- **Visibility:** It could be difficult for exiting left-turning drivers waiting at a stop sign to see and anticipate westbound vehicles along Carlos Bee Boulevard due to the curve in the road to the east; this can present additional safety concerns when combined with the grade and downhill speeds (discussed below).
- **Grade and downhill speeds:** There is a significant grade along Carlos Bee Boulevard, which could result in higher downhill speeds for westbound vehicles. This could cause conflicts for exiting left-turning vehicles at a stop sign that are waiting for a gap in eastbound and westbound vehicles to exit the project site.
- **Proximity of Carlos Bee Boulevard/Hayward Boulevard intersection:** The proposed Bunker Hill Boulevard/Carlos Bee Boulevard intersection would be approximately 700 feet away from the signalized Carlos Bee Boulevard/Hayward Boulevard intersection, and approximately 500 feet away from that intersection's channelized eastbound right-turn. It is not recommended to install a traffic signal in such close proximity.
- **Proximity of future Parcel Group 6 intersection:** The proposed Bunker Hill Boulevard/Carlos Bee Boulevard intersection would be approximately 950 feet away from the proposed signalized PG 6 access point. It is not recommended to install another traffic signal in such close proximity.
- **Proximity of Tanglewood/Carlos Bee Boulevard intersection:** Tanglewood is located approximately 100 feet west of the proposed project access point and consists of a full-access side-street stop-controlled intersection.
 - It is not recommended to signalize the Bunker Hill Boulevard intersection with the unsignalized full-access Tanglewood intersection in such close proximity.
 - It may be infeasible to align Bunker Hill Boulevard with Tanglewood in order to construct a standard four-legged signalized intersection.
 - Installing a traffic signal would require an offset signalized intersection that would control Bunker Hill Boulevard and Tanglewood with a single traffic signal. However, signalizing access to and from the City View Apartments via Tanglewood may face hurdles related to public/resident support, cost, and fair share contributions.
 - Implementing the Bunker Hill Boulevard access point as full-access side-street stop-controlled could result in conflicts in the two-way left-turn lane for vehicles entering and leaving both sites due to the close proximity.
 - Implementing the Bunker Hill Boulevard access point as right-in-right-out with a median would conflict with exiting vehicles from Tanglewood.

Based on these conditions, the recommendation for the City is to implement limited access at the Bunker Hill Boulevard/Carlos Bee Boulevard access point, allowing inbound left-turns and right-turns but restricting exiting vehicles to right-turn only. With this approach, the City can address potential safety concerns for exiting left-turning vehicles while still allowing full access for vehicles entering from the east or from the west. Drivers that want to exit the project site and travel west along Carlos Bee Boulevard towards Mission Boulevard would need to make a right turn from Bunker Hill Boulevard followed by a U-turn at the adjacent Carlos Bee Boulevard/Hayward Boulevard intersection or another location upstream to continue westbound along Carlos Bee Boulevard. This would add approximately a quarter mile of additional travel for project traffic making the U-turn at the Carlos Bee Boulevard/Hayward Boulevard intersection.

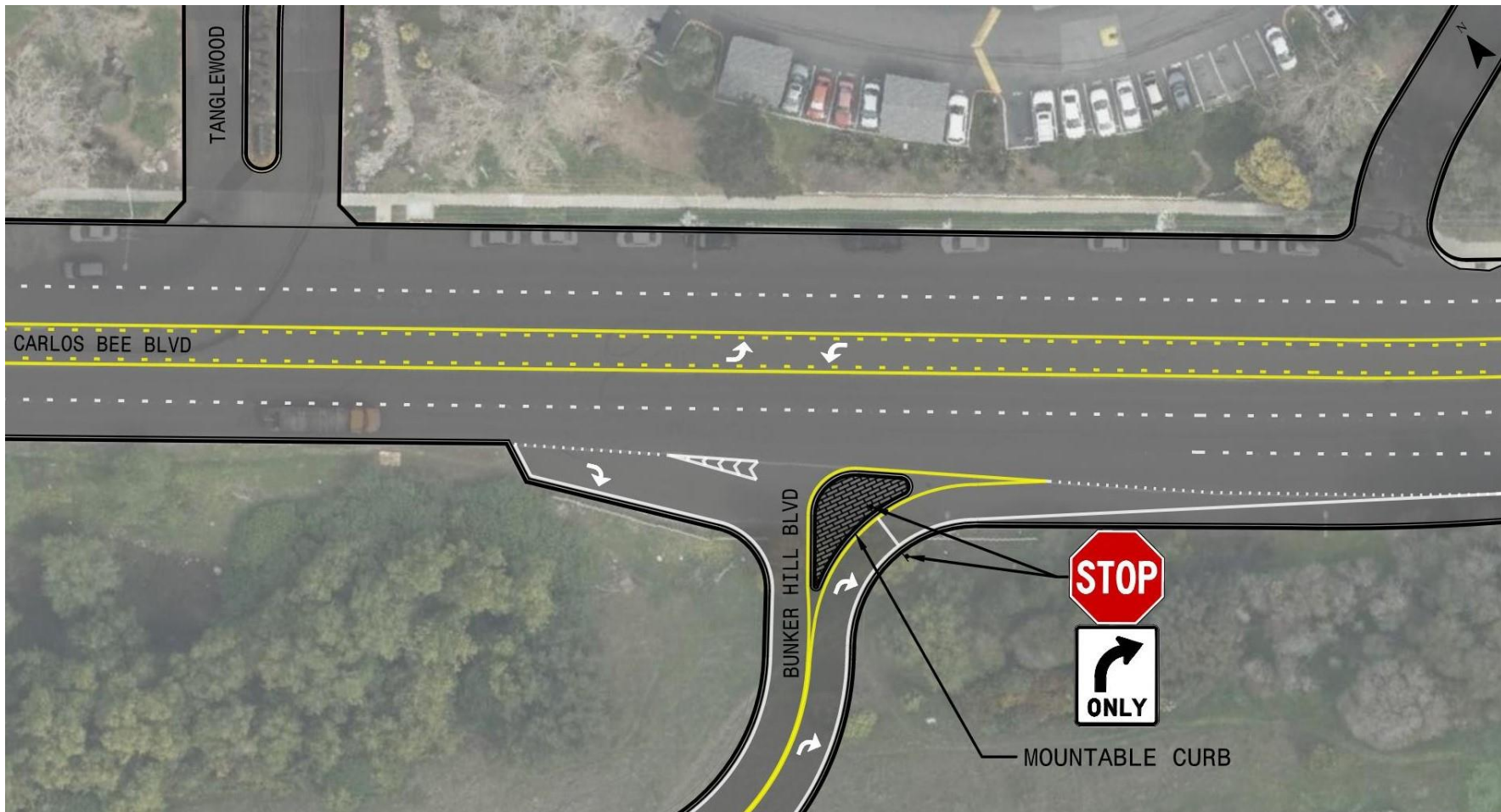
Potential conflicts between eastbound left-turning vehicles exiting Tanglewood onto Carlos Bee Boulevard and PG 5 trips turning westbound from Carlos Bee Boulevard onto Bunker Hill Boulevard, both using the two-way left-turn lane, are not anticipated. This is because there would be approximately 140 feet of storage available between Tanglewood and the new intersection, which is anticipated to be sufficient for vehicles exiting Tanglewood eastbound onto Carlos Bee Boulevard.

A conceptual layout is shown in Figure 5. As shown in the figure, exiting vehicles should be stop-controlled and restricted to right-turns only with a channelized right-turn lane that is physically separated by the inbound lane with a raised median. The channelization would orient vehicles to exit with a right turn into the eastbound direction and prevent a left-turn. The raised median should be mountable to ensure emergency vehicles can freely enter and exit Bunker Hill Boulevard. The inclusion of a channelized right-turn exit lane would require widening Bunker Hill Boulevard at Carlos Bee Boulevard. In addition, since there is a striped shoulder lane on the south side of Carlos Bee Boulevard, a merge lane should be included so that vehicles can merge onto the thru-lanes in advance of the eastbound right-turn lane at the adjacent Carlos Bee Boulevard/Hayward Boulevard intersection. There is also sufficient space to include an inbound eastbound right-turn lane at the access point, to further aid visibility and safety.

As shown in the figure, a merge is recommended instead aligning the channelized right-turn with the third eastbound lane along Carlos Bee Boulevard. This is due to three reasons:

- To avoid extending an additional obstruction (the curbed channelization) into the road.
- To prevent the loss of the taper for eastbound cars to gradually enter the third through/right lane.
- To avoid weaving movements as cars enter and exit the third eastbound lane.

Figure 5: Bunker Hill Blvd./Carlos Bee Blvd. Conceptual Layout



TRAFFIC OPERATIONS ANALYSIS W/ BUNKER HILL/CARLOS BEE ACCESS CONTROL

LOS and queuing at the project access point were reassessed given the recommended changes. In addition, due to the additional U-turns at the intersection of Carlos Bee Boulevard and Hayward Boulevard, LOS and queuing at that intersection were also reassessed. The updated LOS and queuing information is provided in Tables 4 and 5. As shown in Table 4, both intersections would operate with acceptable LOS. Additional delay added to the Carlos Bee Boulevard and Hayward Boulevard intersection associated with project U-turns would be minimal.

Table 4: Updated Automobile Level of Service

Intersection	Peak Hour	Delay (sec)	LOS	Acceptable LOS?
Bunker Hill Blvd./ Carlos Bee Blvd	AM	11.9	B	Yes
	PM	11.4	B	Yes
Carlos Bee Blvd./ Hayward Blvd.	AM	32.7	C	Yes
	PM	29.7	C	Yes

SOURCE: KITTELSON & ASSOCIATES, 2022.

Table 5 shows the queues at both intersections, updated to reflect the recommended changes to the Bunker Hill Boulevard access point. As shown in the table, queues at the Bunker Hill Boulevard access point would continue to remain below the available storage. At the Carlos Bee Boulevard/Hayward Boulevard intersection, the westbound left queue length would exceed the length of the turn pocket during the PM peak hour. However, the queue does not increase as a result of project trips and would exceed the turn pocket lane under no project conditions. In addition, while the left-turn pocket is approximately 185 feet long, vehicles can also use the two-way left-turn lane which runs for the entirety of the block.

Table 5: Updated Queues

Intersection	Peak Hour	Movement	Storage Length (ft)	Queue (ft)	Exceed Storage?
Bunker Hill Blvd./ Carlos Bee Blvd	AM	NB Right	300	< 25	No
		WB Left	600	< 25	No
	PM	NB Right	300	< 25	No
		WB Left	600	< 25	No
Carlos Bee Blvd./ Hayward Blvd.	AM	NB Left	530	46	No
		NB Thru/Right	530	33	No
		SB Left/Thru/Right	60	29	No
		EB Left	80	31	No
		EB Thru	600	142	No
		EB Right	185	< 25	No
		WB Left	285	426	Yes
		WB Thru/Right	1,440	325	No
	PM	NB Left	530	253	No
		NB Thru/Right	530	95	No
		SB Left/Thru/Right	60	25	No
		EB Left	80	31	No
		EB Thru	625	157	No
		EB Right	185	< 25	No
WB	Left	285	174	No	
	Thru/Right	1,440	117	No	

SOURCE: KITTELSON & ASSOCIATES, 2022.

In addition, an AutoTurn template was prepared to determine if passenger vehicles exiting from Bunker Hill Boulevard can make a U-turn at the Carlos Bee Boulevard/Hayward Boulevard intersection to travel westbound towards Mission Boulevard; the AutoTurn template is provided as Attachment 3 to this memo. As shown in the attachment, it is possible for a full-size passenger vehicle to complete a U-turn movement to continue westbound; a U-turn can be made if the vehicle utilizes the extra width within the intersection, since the existing curb limits a U-turn. Relatively few project trips are expected to conduct this maneuver, based on the project trip distribution (15 in the AM peak hour and 10 in the PM peak hour). It is possible that some vehicles might make their U-turn maneuver elsewhere by utilizing the two-way left-turn lane west of the Carlos Bee Boulevard/Hayward Boulevard intersection or by circling back at intersections further downstream and to the east.

SUMMARY OF FINDINGS

The following summarizes the findings based on the analysis Kittelson conducted related to the proposed PG 5 access point at Bunker Hill Boulevard and Carlos Bee Boulevard.

- The proposed access point does not meet eight-hour vehicular volume (Warrant 1), four-hour vehicular volume (Warrant 2), peak hour (Warrant 3), or crash experience (Warrant 7) traffic signal warrants. As such, a traffic signal is not recommended.
- Based on a review of conditions at the proposed access point such as visibility, grade and downhill speeds, and the proximity to other intersections, the recommendation for the City is to implement limited access at the Bunker Hill Boulevard/Carlos Bee Boulevard access point, allowing inbound left-turns and right-turns but restricting exiting vehicles to right-turn only. With this approach, the City can address potential safety concerns for exiting left-turning vehicles while still allowing full access for vehicles entering from the east or from the west. Potential conflicts between eastbound left-turning vehicles exiting Tanglewood onto Carlos Bee Boulevard and PG 5 trips turning westbound from Carlos Bee Boulevard onto Bunker Hill Boulevard, both using the two-way left-turn lane, are not anticipated due to the 140 feet of available storage. Drivers that want to exit the project site and travel west along Carlos Bee Boulevard towards Mission Boulevard would need to make a right turn from Bunker Hill Boulevard followed by a U-turn at the adjacent Carlos Bee Boulevard/Hayward Boulevard intersection to continue westbound along Carlos Bee Boulevard. The attached AutoTurn template shows that this U-turn maneuver is achievable by passenger vehicles; it is possible that some vehicles might make their U-turn maneuver by utilizing the two-way left-turn lane west of the intersection or by circling back at intersections further downstream/east.
- A conceptual layout of the access point was prepared, which shows that exiting vehicles should be stop-controlled and restricted to right-turns only with a channelized right-turn lane that is physically separated by the inbound lane with a raised median. The channelization would orient vehicles to exit with a right turn into the eastbound direction and prevent a left-turn. The raised median should be mountable to ensure emergency vehicles can freely enter and exit Bunker Hill Boulevard. The inclusion of a channelized right-turn exit lane would require widening Bunker Hill Boulevard at Carlos Bee Boulevard. In addition, since there is a striped shoulder lane on the south side of Carlos Bee Boulevard, a merge lane should be included so that vehicles can merge onto the thru-lanes in advance of the eastbound right-turn lane at the adjacent Carlos Bee Boulevard/Hayward Boulevard intersection (aligning the channelized right-turn with the third eastbound lane along Carlos Bee Boulevard is not recommended). There is also sufficient space to include an inbound eastbound right-turn lane at the access point, to further aid visibility and safety.
- This recommended change to the Bunker Hill access point traffic control would not negatively affect traffic operations at that intersection nor at the intersection of Carlos Bee Boulevard/Hayward Boulevard.
- The change would add approximately a quarter mile of additional travel for project traffic making the U-turn at the Carlos Bee Boulevard/Hayward Boulevard intersection.

ATTACHMENTS

Attachment 1 – Traffic Signal Warrant Sheets

Attachment 2 – Updated Existing Plus Project Level of Service and Queuing Worksheets

Attachment 3 – U-Turn at Intersection of Carlos Bee Blvd. and Hayward Blvd.

Attachment 1 – Traffic Signal Warrant Sheets



KITTELSON & ASSOCIATES, INC.
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 Portland, Oregon 97205
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Analysis Traffic Volumes

Hour	Major Street		Minor Street			
	Begin	End	EB	WB	NB	SB
7:45 AM	8:45 AM		857	904	20	0
2nd Highest Hour			811	856	16	0
3rd Highest Hour			800	844	15	0
4th Highest Hour			766	808	13	0
5th Highest Hour			754	796	12	0
6th Highest Hour			754	796	11	0
7th Highest Hour			720	759	11	0
8th Highest Hour			708	747	10	0
9th Highest Hour			686	723	10	0
10th Highest Hour			640	675	10	0
11th Highest Hour			617	651	9	0
12th Highest Hour			606	639	9	0
13th Highest Hour			583	615	7	0
14th Highest Hour			503	530	7	0
15th Highest Hour			400	422	7	0
16th Highest Hour			377	398	6	0
17th Highest Hour			263	277	4	0
18th Highest Hour			217	229	4	0
19th Highest Hour			114	121	1	0
20th Highest Hour			80	84	1	0
21st Highest Hour			69	72	1	0
22nd Highest Hour			46	48	0	0
23rd Highest Hour			23	24	0	0
24th Highest Hour			23	24	0	0

Project #: 26151
Project Name: Hayward Parcel Group 5
Analyst: MZS
Date: 1/20/2022
File: H:\26\26151 - Parcel 5 Local Transportation Analysis\Analysis\Access Point Additional Analysis\warrants\peak hour\ExistingPP AM.xml\War
Intersection: Bunker Hill Blvd. & Carlos Bee Blvd.
Scenario: Existing Plus Project AM

Warrant Summary

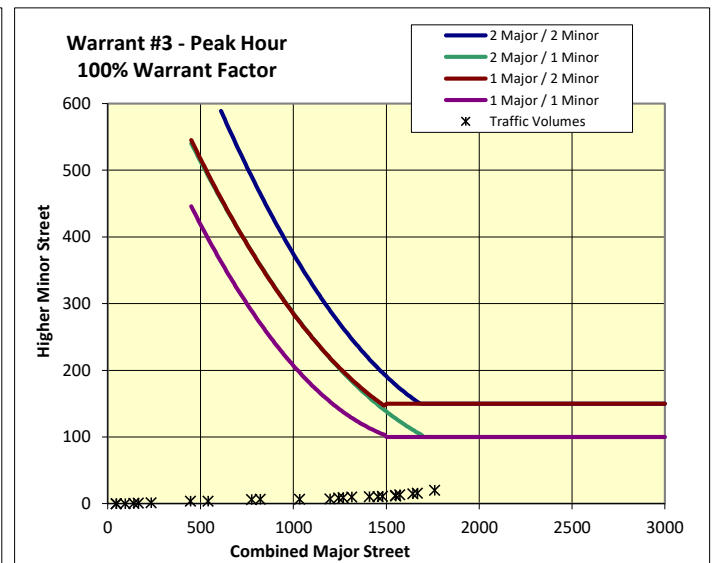
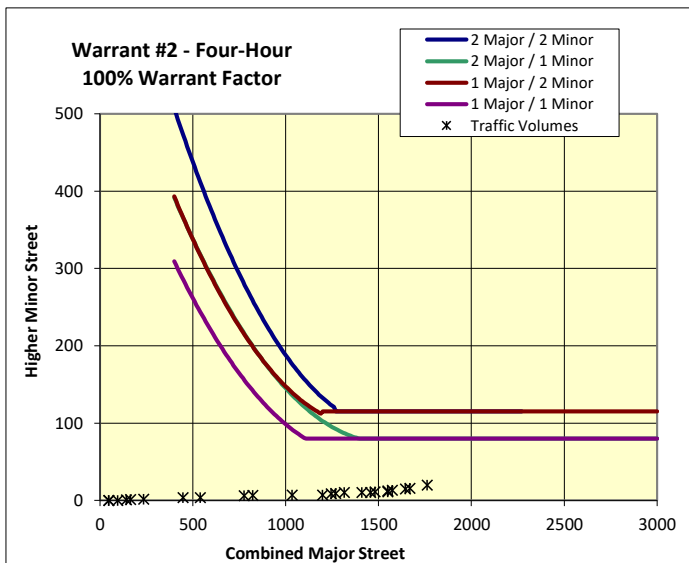
Warrant	Name	Analyzed?	Met?
#1	Eight-Hour Vehicular Volume	Yes	No
#2	Four-Hour Vehicular volume	Yes	No
#3	Peak Hour	Yes	No
#4	Pedestrian Volume	No	-
#5	School Crossing	No	-
#6	Coordinated Signal System	No	-
#7	Crash Experience	Yes	No
#8	Roadway Network	No	-
#9	Intersection Near a Grade Crossing	No	-

Input Parameters

Volume Adjustment Factor =	1.0
North-South Approach =	Minor
East-West Approach =	Major
Major Street Thru Lanes =	2
Minor Street Thru Lanes =	1
Speed > 40 mph?	No
Population < 10,000?	No
Warrant Factor	100%
Peak Hour or Daily Count?	Peak Hour
Major Street: 4th-Highest Hour / Peak Hour	89%
Major Street: 8th-Highest Hour / Peak Hour	83%
Minor Street: 4th-Highest Hour / Peak Hour	66%
Minor Street: 8th-Highest Hour / Peak Hour	52%

Warrant #1 - Eight Hour

Warrant Factor	Condition	Major Street Requirement	Minor Street Requirement	Hours That Condition Is Met	Condition for Warrant Factor Met?	Signal Warrant Met?
100%	A	600	150	0	No	No
	B	900	75	0	No	No
80%	A	480	120	0	No	No
	B	720	60	0	No	No
70%	A	420	105	0	No	No
	B	630	53	0	No	No
56%	A	336	84	0	No	No
	B	504	42	0	No	No





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Analysis Traffic Volumes

Hour	Major Street		Minor Street			
	Begin	End	EB	WB	NB	SB
5:00 PM	6:00 PM		799	687	13	0
2nd Highest Hour			756	650	10	0
3rd Highest Hour			746	641	10	0
4th Highest Hour			714	614	9	0
5th Highest Hour			703	605	8	0
6th Highest Hour			703	605	7	0
7th Highest Hour			671	577	7	0
8th Highest Hour			661	568	7	0
9th Highest Hour			639	550	7	0
10th Highest Hour			597	513	7	0
11th Highest Hour			575	495	6	0
12th Highest Hour			565	485	6	0
13th Highest Hour			543	467	5	0
14th Highest Hour			469	403	4	0
15th Highest Hour			373	321	4	0
16th Highest Hour			352	302	4	0
17th Highest Hour			245	211	2	0
18th Highest Hour			202	174	2	0
19th Highest Hour			107	92	1	0
20th Highest Hour			75	64	1	0
21st Highest Hour			64	55	0	0
22nd Highest Hour			43	37	0	0
23rd Highest Hour			21	18	0	0
24th Highest Hour			21	18	0	0

Project #: 26151
Project Name: Hayward Parcel Group 5
Analyst: MZS
Date: 1/20/2022
File: H:\26\26151 - Parcel 5 Local Transportation Analysis\Analysis\Access Point Additional Analysis\warrants\peak hour\ExistingPP - PM.xlsm\War
Intersection: Bunker Hill Blvd. & Carlos Bee Blvd.
Scenario: Existing Plus Project PM

Warrant Summary

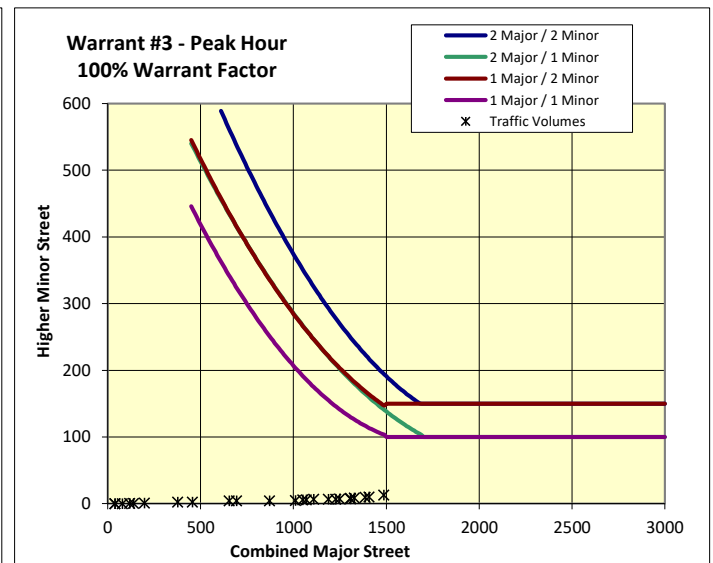
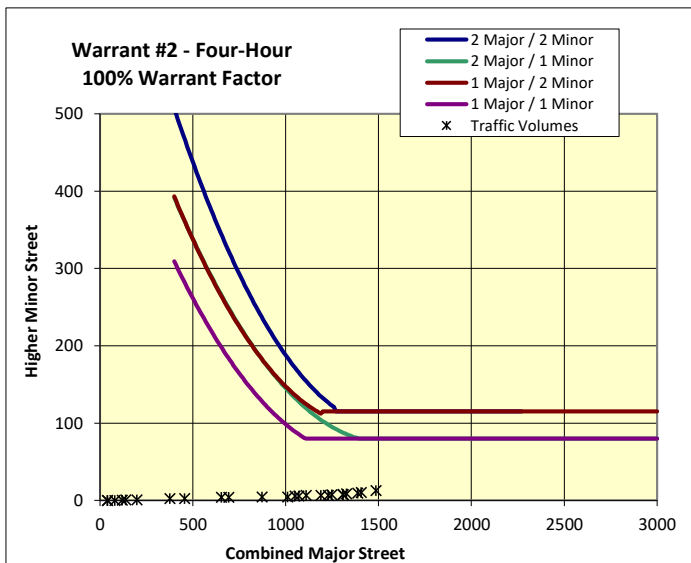
Warrant	Name	Analyzed?	Met?
#1	Eight-Hour Vehicular Volume	Yes	No
#2	Four-Hour Vehicular volume	Yes	No
#3	Peak Hour	Yes	No
#4	Pedestrian Volume	No	-
#5	School Crossing	No	-
#6	Coordinated Signal System	No	-
#7	Crash Experience	Yes	No
#8	Roadway Network	No	-
#9	Intersection Near a Grade Crossing	No	-

Input Parameters

Volume Adjustment Factor =	1.0
North-South Approach =	Minor
East-West Approach =	Major
Major Street Thru Lanes =	2
Minor Street Thru Lanes =	1
Speed > 40 mph?	No
Population < 10,000?	No
Warrant Factor	100%
Peak Hour or Daily Count?	Peak Hour
Major Street: 4th-Highest Hour / Peak Hour	89%
Major Street: 8th-Highest Hour / Peak Hour	83%
Minor Street: 4th-Highest Hour / Peak Hour	66%
Minor Street: 8th-Highest Hour / Peak Hour	52%

Warrant #1 - Eight Hour

Warrant Factor	Condition	Major Street Requirement	Minor Street Requirement	Hours That Condition Is Met	Condition for Warrant Factor Met?	Signal Warrant Met?
100%	A	600	150	0	No	No
	B	900	75	0	No	No
80%	A	480	120	0	No	No
	B	720	60	0	No	No
70%	A	420	105	0	No	No
	B	630	53	0	No	No
56%	A	336	84	0	No	No
	B	504	42	0	No	No



Attachment 2 – Updated Existing Plus Project Level of Service and Queuing Worksheets



























HCM 6th TWSC
91: Bunker Hill Blvd. & Carlos Bee Blvd.

Existing (AM) + PG5

Intersection						
Int Delay, s/veh	0.1					
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑↑	↑	↑	↑↑		↑
Traffic Vol, veh/h	851	6	2	917	0	20
Future Vol, veh/h	851	6	2	917	0	20
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	100	150	-	-	0
Veh in Median Storage, #	0	-	-	0	2	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	925	7	2	997	0	22
Major/Minor	Major1	Major2	Minor1			
Conflicting Flow All	0	0	932	0	-	463
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Critical Hdwy	-	-	4.14	-	-	6.94
Critical Hdwy Stg 1	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-
Follow-up Hdwy	-	-	2.22	-	-	3.32
Pot Cap-1 Maneuver	-	-	730	-	0	546
Stage 1	-	-	-	-	0	-
Stage 2	-	-	-	-	0	-
Platoon blocked, %	-	-	-	-	-	-
Mov Cap-1 Maneuver	-	-	730	-	-	546
Mov Cap-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	EB	WB	NB			
HCM Control Delay, s	0	0	11.9			
HCM LOS						B
Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT	
Capacity (veh/h)	546	-	-	730	-	
HCM Lane V/C Ratio	0.04	-	-	0.003	-	
HCM Control Delay (s)	11.9	-	-	9.9	-	
HCM Lane LOS	B	-	-	A	-	
HCM 95th %tile Q(veh)	0.1	-	-	0	-	

HCM 6th Signalized Intersection Summary
6: Carlos Bee Blvd. & Hayward Blvd.

Existing (AM) + PG5

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		  			 			 			  	
Traffic Volume (veh/h)	15	473	383	370	860	2	42	1	59	1	13	2
Future Volume (veh/h)	15	473	383	370	860	2	42	1	59	1	13	2
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		0.95
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1900	1870	1900	1856	1870	1900	1693	1900	1752	418	1441	1900
Adj Flow Rate, veh/h	17	550	0	430	1000	2	49	1	0	1	15	2
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Percent Heavy Veh, %	0	2	0	3	2	0	14	0	10	100	31	0
Cap, veh/h	35	777		466	1443	3	530	624		3	47	6
Arrive On Green	0.02	0.15	0.00	0.26	0.40	0.40	0.33	0.33	0.00	0.04	0.04	0.04
Sat Flow, veh/h	1810	5106	1610	1767	3639	7	1612	1900	0	78	1167	156
Grp Volume(v), veh/h	17	550	0	430	488	514	49	1	0	18	0	0
Grp Sat Flow(s),veh/h/ln	1810	1702	1610	1767	1777	1869	1612	1900	0	1400	0	0
Q Serve(g_s), s	0.8	8.6	0.0	19.8	19.1	19.1	1.8	0.0	0.0	1.0	0.0	0.0
Cycle Q Clear(g_c), s	0.8	8.6	0.0	19.8	19.1	19.1	1.8	0.0	0.0	1.0	0.0	0.0
Prop In Lane	1.00		1.00	1.00		0.00	1.00		0.00	0.06		0.11
Lane Grp Cap(c), veh/h	35	777		466	705	741	530	624		56	0	0
V/C Ratio(X)	0.48	0.71		0.92	0.69	0.69	0.09	0.00		0.32	0.00	0.00
Avail Cap(c_a), veh/h	108	1098		496	775	815	530	624		301	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	40.6	33.7	0.0	30.0	21.0	21.0	19.4	18.9	0.0	39.1	0.0	0.0
Incr Delay (d2), s/veh	9.8	1.2	0.0	22.1	2.4	2.3	0.3	0.0	0.0	3.2	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	3.5	0.0	10.9	8.0	8.3	0.7	0.0	0.0	0.4	0.0	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	50.4	34.9	0.0	52.1	23.4	23.3	19.8	18.9	0.0	42.3	0.0	0.0
LnGrp LOS	D	C		D	C	C	B	B		D	A	A
Approach Vol, veh/h		567	A		1432			50	A		18	
Approach Delay, s/veh		35.4			32.0			19.8			42.3	
Approach LOS		D			C			B			D	
Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		32.0	26.6	17.2		7.9	6.1	37.7				
Change Period (Y+Rc), s		4.5	4.5	4.5		4.5	4.5	4.5				
Max Green Setting (Gmax), s		27.5	23.5	18.0		18.0	5.0	36.5				
Max Q Clear Time (g_c+I1), s		3.8	21.8	10.6		3.0	2.8	21.1				
Green Ext Time (p_c), s		0.1	0.3	2.2		0.0	0.0	5.9				
Intersection Summary												
HCM 6th Ctrl Delay			32.7									
HCM 6th LOS			C									
Notes												
User approved volume balancing among the lanes for turning movement.												
Unsignalized Delay for [NBR, EBR] is excluded from calculations of the approach delay and intersection delay.												

Queues

6: Carlos Bee Blvd. & Hayward Blvd.



Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	17	550	445	430	1002	44	75	18
v/c Ratio	0.16	0.62	0.28	0.87	0.60	0.09	0.15	0.16
Control Delay	45.1	35.9	0.4	51.5	20.5	23.4	8.4	39.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	45.1	35.9	0.4	51.5	20.5	23.4	8.4	39.7
Queue Length 50th (ft)	8	91	0	196	156	14	2	8
Queue Length 95th (ft)	31	142	0	#426	325	46	33	29
Internal Link Dist (ft)		851			575		459	181
Turn Bay Length (ft)	80		165	290				
Base Capacity (vph)	107	1095	1615	492	1666	494	503	306
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.16	0.50	0.28	0.87	0.60	0.09	0.15	0.06

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.


























HCM 6th TWSC
91: Bunker Hill Blvd. & Carlos Bee Blvd.

Existing (PM) + PG5

Intersection						
Int Delay, s/veh	0.1					
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑↑	↑	↑	↑↑		↑
Traffic Vol, veh/h	781	18	5	692	0	13
Future Vol, veh/h	781	18	5	692	0	13
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	100	150	-	-	0
Veh in Median Storage, #	0	-	-	0	2	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	849	20	5	752	0	14
Major/Minor	Major1	Major2	Minor1			
Conflicting Flow All	0	0	869	0	-	425
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Critical Hdwy	-	-	4.14	-	-	6.94
Critical Hdwy Stg 1	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-
Follow-up Hdwy	-	-	2.22	-	-	3.32
Pot Cap-1 Maneuver	-	-	771	-	0	578
Stage 1	-	-	-	-	0	-
Stage 2	-	-	-	-	0	-
Platoon blocked, %	-	-	-	-	-	-
Mov Cap-1 Maneuver	-	-	771	-	-	578
Mov Cap-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	EB	WB	NB			
HCM Control Delay, s	0	0.1	11.4			
HCM LOS				B		
Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT	
Capacity (veh/h)	578	-	-	771	-	
HCM Lane V/C Ratio	0.024	-	-	0.007	-	
HCM Control Delay (s)	11.4	-	-	9.7	-	
HCM Lane LOS	B	-	-	A	-	
HCM 95th %tile Q(veh)	0.1	-	-	0	-	

HCM 6th Signalized Intersection Summary
6: Carlos Bee Blvd. & Hayward Blvd.

Existing (PM) + PG5

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		  			 			 			 	
Traffic Volume (veh/h)	17	588	196	182	341	1	337	11	388	0	9	9
Future Volume (veh/h)	17	588	196	182	341	1	337	11	388	0	9	9
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		0.99	1.00		1.00	1.00		0.88
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1900	1885	1885	1841	1870	1900	1870	1900	1885	1900	1248	1900
Adj Flow Rate, veh/h	20	676	0	209	392	1	387	13	0	0	10	10
Peak Hour Factor	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Percent Heavy Veh, %	0	1	1	4	2	0	2	0	1	0	44	0
Cap, veh/h	41	908		251	1080	3	625	666		0	51	51
Arrive On Green	0.02	0.18	0.00	0.14	0.30	0.30	0.35	0.35	0.00	0.00	0.10	0.10
Sat Flow, veh/h	1810	5147	1598	1753	3636	9	1781	1900	0	0	532	532
Grp Volume(v), veh/h	20	676	0	209	192	201	387	13	0	0	0	20
Grp Sat Flow(s),veh/h/ln	1810	1716	1598	1753	1777	1869	1781	1900	0	0	0	1065
Q Serve(g_s), s	0.8	9.6	0.0	8.9	6.5	6.5	13.9	0.3	0.0	0.0	0.0	1.3
Cycle Q Clear(g_c), s	0.8	9.6	0.0	8.9	6.5	6.5	13.9	0.3	0.0	0.0	0.0	1.3
Prop In Lane	1.00		1.00	1.00		0.00	1.00		0.00	0.00		0.50
Lane Grp Cap(c), veh/h	41	908		251	528	555	625	666		0	0	102
V/C Ratio(X)	0.49	0.74		0.83	0.36	0.36	0.62	0.02		0.00	0.00	0.20
Avail Cap(c_a), veh/h	118	1110		351	623	655	625	666		0	0	249
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00
Uniform Delay (d), s/veh	37.2	30.1	0.0	32.1	21.3	21.3	20.7	16.3	0.0	0.0	0.0	32.1
Incr Delay (d2), s/veh	8.8	2.2	0.0	11.3	0.4	0.4	4.6	0.1	0.0	0.0	0.0	0.9
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.5	4.0	0.0	4.5	2.7	2.8	6.2	0.2	0.0	0.0	0.0	0.4
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	46.0	32.3	0.0	43.4	21.7	21.7	25.3	16.4	0.0	0.0	0.0	33.0
LnGrp LOS	D	C		D	C	C	C	B		A	A	C
Approach Vol, veh/h		696	A		602			400	A		20	
Approach Delay, s/veh		32.6			29.2			25.0			33.0	
Approach LOS		C			C			C			C	
Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		31.5	15.5	18.1		11.9	6.2	27.4				
Change Period (Y+Rc), s		4.5	4.5	4.5		4.5	4.5	4.5				
Max Green Setting (Gmax), s		27.0	15.4	16.6		18.0	5.0	27.0				
Max Q Clear Time (g_c+I1), s		15.9	10.9	11.6		3.3	2.8	8.5				
Green Ext Time (p_c), s		1.0	0.2	2.0		0.0	0.0	2.1				

Intersection Summary

HCM 6th Ctrl Delay	29.7
HCM 6th LOS	C

Notes

User approved volume balancing among the lanes for turning movement.
Unsignalized Delay for [NBR, EBR] is excluded from calculations of the approach delay and intersection delay.

Queues

6: Carlos Bee Blvd. & Hayward Blvd.



Lane Group	EBL	EBT	EBR	WBL	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	20	676	225	209	393	348	498	20
v/c Ratio	0.16	0.64	0.14	0.67	0.28	0.56	0.59	0.15
Control Delay	39.7	31.0	0.2	41.3	17.6	24.9	7.0	27.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	39.7	31.0	0.2	41.3	17.6	24.9	7.0	27.6
Queue Length 50th (ft)	8	96	0	84	48	122	14	4
Queue Length 95th (ft)	31	157	0	#174	117	253	95	25
Internal Link Dist (ft)		783			575		459	181
Turn Bay Length (ft)	80		165	290				
Base Capacity (vph)	124	1175	1577	368	1436	625	844	354
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.16	0.58	0.14	0.57	0.27	0.56	0.59	0.06

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Attachment 3 – U-Turn at Intersection of Carlos Bee Blvd. and Hayward Blvd.

