Hexagon Transportation Consultants, Inc.

Memorandum

Date: February 26, 2013

To: Mr. Josh Walker, Palo Alto Housing Corporation

From: Michelle Hunt
Trisha Dudala

Subject: Traffic Impact Analysis for the Proposed Residential Development at Maybell Avenue and Clemo Avenue in Palo Alto, California

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Introduction

Hexagon Transportation Consultants, Inc. has completed this traffic impact analysis for the proposed residential development near the corner of Maybell Avenue and Clemo Avenue in Palo Alto, California. The proposed project would consist of 15 single family homes and 60 attached senior housing units. The project would replace four single family homes currently on the project site. Access to the project site would be provided by one driveway on Clemo Avenue and an access easement through the Arastradero Park Apartment Complex (APAC) to the north that would connect to an existing driveway on Maybell Avenue. The project location and study intersections are shown on Figure 1, and the project site plan is shown on Figure 2. Alternative project access scenarios without the proposed access easement in which the project would be accessed via a single driveway on Clemo Avenue with a connection to Maybell Avenue or Arastradero Road also were analyzed.

Scope of Study

This study was conducted for the purpose of identifying the potential traffic impacts and site circulation and access issues related to the proposed residential development. The potential impacts of the project were evaluated in accordance with the standards set forth by the California Environmental Quality Act (CEQA), City of Palo Alto, and the Valley Transportation Agency (VTA). The VTA administers the county Congestion Management Program (CMP). However, because the project would generate fewer than 100 peak-hour trips, a CMP analysis is not required. The traffic analysis was based on peak-hour levels of service for three signalized intersections, three unsignalized intersections, and one roadway segment. The traffic analysis also includes an evaluation of peak-hour signal warrants for the unsignalized intersections. The study intersections and roadway segment are identified below.

Study Intersections:

1. Maybell Avenue/El Camino Way and El Camino Real
2. Arastradero Road/Charleston Road and El Camino Real
3. Arastradero Road and Clemo Avenue (Unsignalized)
4. Arastradero Road and Coulombe Drive
5. Maybell Avenue and Coulombe Drive (Unsignalized)
6. Maybell Avenue and Amaranta Avenue (Unsignalized)

Study Roadway Segment:

1. Maybell Avenue, between Thain Way and Pena Court

Figure 1
Site Location and Study Intersections

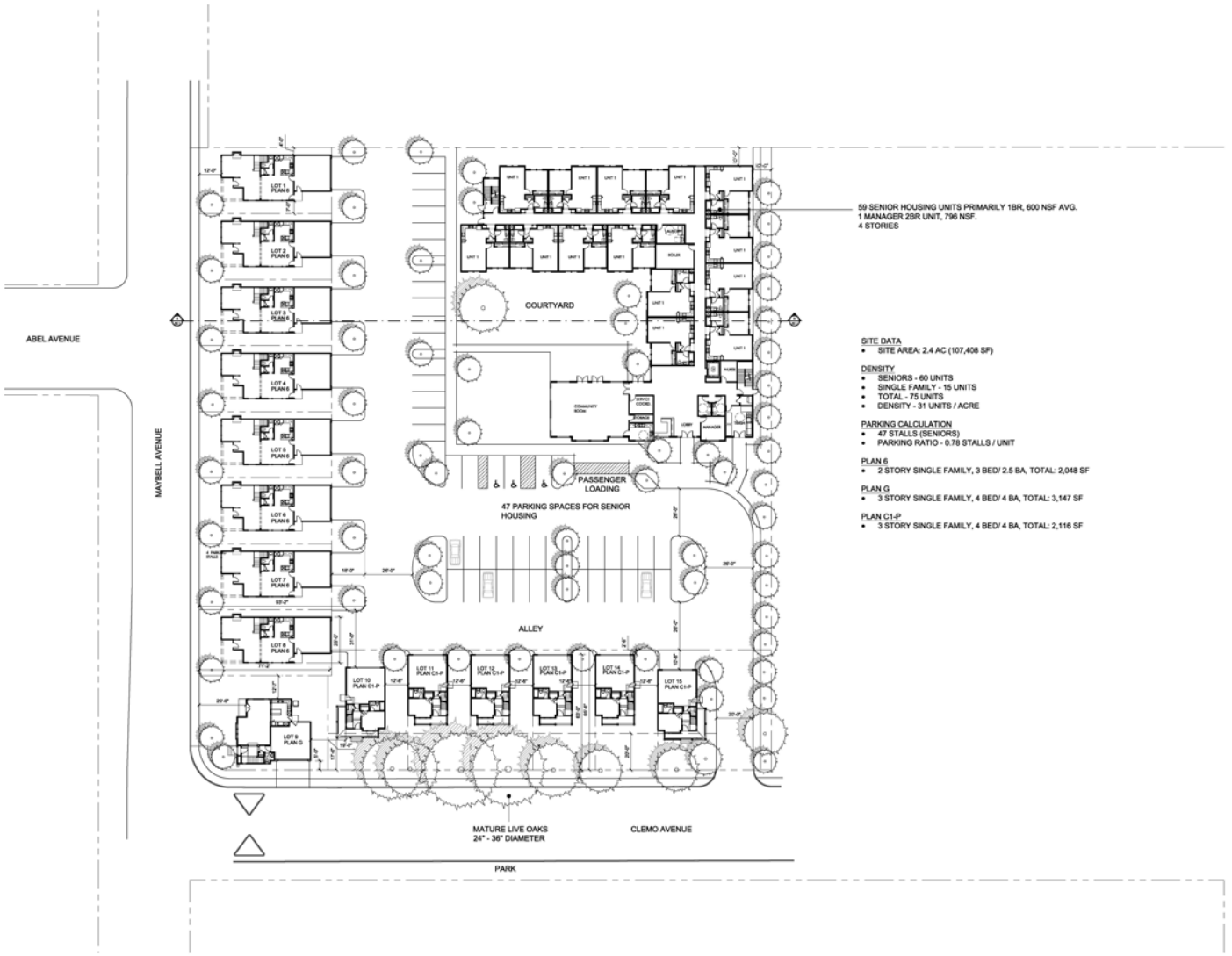


Figure 2

Site Plan

Traffic conditions at the study intersections were analyzed for the weekday AM and PM peak hour of traffic. The AM peak hour is typically between 7:00 and 9:00 AM and the PM peak hour is typically between 4:00 and 6:00 PM. It is during these periods that the most congested traffic conditions occur on an average day. The operations of the study intersections were evaluated for the following conditions:

Scenario 1: *Existing Conditions.* Existing traffic volumes were obtained from new traffic counts.

Scenario 2: *Existing Plus Project Conditions.* Project conditions were estimated by adding to existing traffic volumes the additional traffic generated by the project. Project conditions were evaluated relative to existing conditions in order to determine potential project impacts.

Scenario 3: *Cumulative Conditions.* Cumulative conditions represent forecasted far-term future (year 2020) traffic conditions. Cumulative without project traffic volumes were estimated by applying to existing traffic volumes an annual growth factor of 1.1 percent over a period between the date of the existing traffic counts and year 2020. Project trips were then added to estimate cumulative with project conditions.

Level of Service Standards and Analysis Methodologies

Traffic conditions at the study intersections were evaluated using level of service (LOS). *Level of Service* is a qualitative description of operating conditions ranging from LOS A, or free-flow conditions with little or no delay, to LOS F, or jammed conditions with excessive delays. The various analysis methods are described below.

Signalized Intersections

All of the signalized study intersections are located in the City of Palo Alto and are therefore subject to the City of Palo Alto level of service standards. The City of Palo Alto evaluates level of service at signalized intersections based on the *2000 Highway Capacity Manual* (HCM) level of service methodology using TRAFFIX software. This method evaluates signalized intersection operations on the basis of average control delay time for all vehicles at the intersection. Since TRAFFIX also is the CMP-designated intersection level of service methodology, the City employs the CMP default values for the analysis parameters. The City of Palo Alto level of service standard for signalized intersections is LOS D or better. Table 1 shows the level of service definitions for signalized intersections.

One of the study intersections is a CMP intersection and, therefore, also was analyzed according to the CMP requirements. The CMP level of service methodology is the same as that used by the City of Palo Alto, except that the CMP level of service standard for signalized intersections is LOS E or better.

Unsignalized Intersections

Level of service at unsignalized intersections was based on the *2000 Highway Capacity Manual* (2000 HCM) method. TRAFFIX software is used to apply the 2000 HCM operations method for evaluation of conditions at unsignalized intersections. This method is applicable for one-way, two-way, and all-way stop-controlled intersections. The delay and corresponding level of service at unsignalized, stop-controlled intersections is presented in Table 2. For all-way stop controlled intersections, the reported LOS represents the average delay of all intersection movements. For side-street stop controlled intersections, the reported LOS represents the average delay on the worst approach. The levels of service at unsignalized study intersections are presented for informational purposes only as the City of Palo Alto has not established a level of service standard for unsignalized intersections.

Signal Warrant Methodology

The level of service analysis at unsignalized intersections is supplemented with an assessment of the need for signalization of the intersections. This assessment is made on the basis of signal warrant criteria adopted by Caltrans. For this study, the need for signalization is assessed on the basis of the operating conditions at the intersections (i.e., level of service) and on the peak-hour volume signal warrant – warrant #3 – described in the *2010 California Manual on Uniform Traffic Control Devices* (MUTCD). This method

provides an indication of whether traffic conditions and peak-hour traffic levels are, or would be, sufficient to justify installation of a traffic signal.

Table 1
Signalized Intersection Level of Service Definitions Based on Delay

Level of Service	Description	Average Control Delay Per Vehicle (sec.)
A	Signal progression is extremely favorable. Most vehicles arrive during the green phase and do not stop at all. Short cycle lengths may also contribute to the very low vehicle delay.	10.0 or less
B	Operations characterized by good signal progression and/or short cycle lengths. More vehicles stop than with LOS A, causing higher levels of average vehicle delay.	10.1 to 20.0
C	Higher delays may result from fair signal progression and/or longer cycle lengths. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant, though may still pass through the intersection without stopping.	20.1 to 35.0
D	The influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable signal progression, long cycle lenghts, or high volume-to-capacity (V/C) ratios. Many vehicles stop and individual cycle failures are noticeable.	35.1 to 55.0
E	This is considered to be the limit of acceptable delay. These high delay values generally indicate poor signal progression, long cycle lengths, and high volume-to-capacity (V/C) ratios. Individual cycle failures occur frequently.	55.1 to 80.0
F	This level of delay is considered unacceptable by most drivers. This condition often occurs with oversaturation, that is, when arrival flow rates exceed the capacity of the intersection. Poor progression and long cycle lengths may also be major contributing causes of such delay levels.	greater than 80.0

Source: Transportation Research Board, *2000 Highway Capacity Manual* (Washington, D.C., 2000) p10-16.

Table 2
Unsignalized Intersection Level of Service Definitions Based on Delay

Level of Service	Description	Average Delay Per Vehicle (Sec.)
A	Little or no traffic delay	10.0 or less
B	Short traffic delays	10.1 to 15.0
C	Average traffic delays	15.1 to 25.0
D	Long traffic delays	25.1 to 35.0
E	Very long traffic delays	35.1 to 50.0
F	Extreme traffic delays	greater than 50.0

Source: Transportation Research Board, *2000 Highway Capacity Manual* (Washington, D.C., 2000) p17-2.

Neighborhood Streets

The methodology for measuring potential project impacts on neighborhood streets is based not on street capacity but is instead based on neighborhood "livability". The tool used to measure livability is called the TIRE (Traffic Infusion on Residential Environments) index. This index measures the amount of daily traffic that can be added to a residential street before the local residents would perceive an increase. As shown in the table in the Appendix, the amount of daily traffic that can be added before residents would notice directly correlates to the amount of daily traffic already present on the street.

Existing Transportation Setting

Regional access to the project is provided via El Camino Real. Local access to the site is provided by Maybell Avenue, Clemo Avenue, Arastradero Road, Coulombe Drive, and Amaranta Avenue. These roadways are described below.

El Camino Real is a six-lane roadway that serves as a north-south route of travel, but is aligned in a predominantly east-west orientation in the vicinity of the site. El Camino Real extends westward and then northward through San Francisco and eastward then southward through San Jose. El Camino Real provides access to the project via Maybell Avenue.

Maybell Avenue is a two-lane north-south residential roadway that begins at Donald Drive in the south and continues north to El Camino Real, where it becomes El Camino Way. Maybell Avenue forms the western border of the project site and provides direct access to the site.

Clemo Avenue is a two-lane east-west roadway that runs between Maybell Avenue and Arastradero Road. Just east of Maybell Avenue, Clemo Avenue has concrete bulb-outs preventing vehicle access to and from Maybell Avenue. Clemo Avenue forms the southern border of the project site and provides direct access to the site.

Arastradero Road runs in a predominantly north-south direction near the project site. Arastradero Road extends from Page Mill Road in the west to El Camino Real, where it becomes W. Charleston Road and continues to US 101. In the vicinity of the project site it is primarily a two-lane roadway. Arastradero Road provides access to the project site via Clemo Avenue.

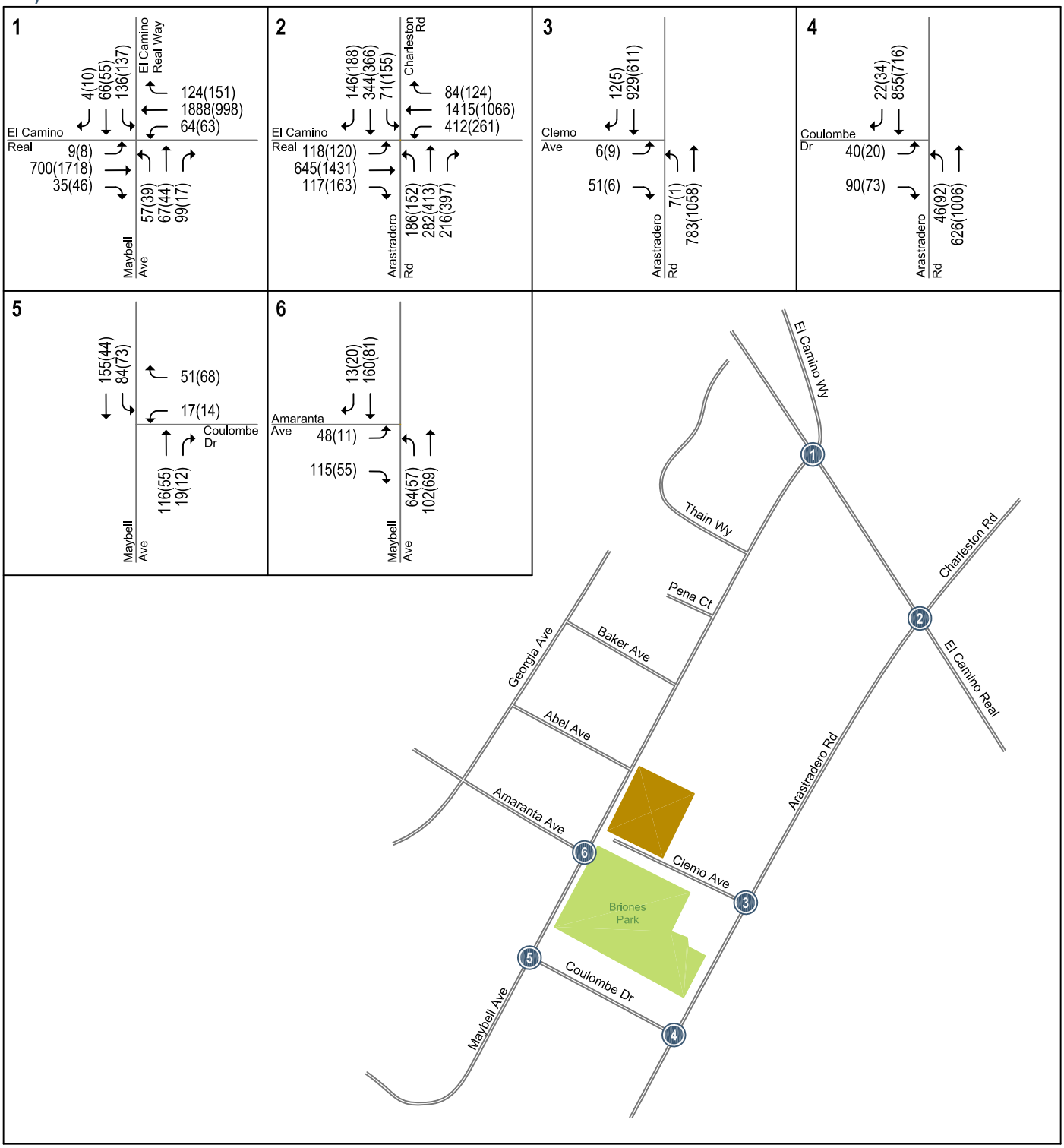
Coulombe Drive is a two-lane east-west residential roadway that extends between Maybell Avenue in the west and Arastradero Road in the east. Coulombe Drive provides access to the project site via Maybell Avenue.

Amaranta Avenue is a two-lane east-west residential roadway that extends between Los Robles Avenue in the west and Maybell Avenue in the east. Amaranta Avenue provides access to the project site via Maybell Avenue.

Existing Traffic Volumes

Daily traffic counts were collected in May 2012 on Maybell Avenue in the vicinity of the project site. These data included the volume and direction of vehicles over a three-day time period. The results showed there are approximately 3,320 daily trips (both directions) on Maybell Avenue, between Thain Way and Pena Court, during a typical weekday.

Existing peak-hour traffic volumes were also obtained from recent and new manual turning-movement counts at all of the study intersections (see Figure 3).



LEGEND

= Project Site Location

X = Study Intersection

XX(XX) = AM(PM) Peak-Hour Project Volumes

Figure 3
Existing Traffic Volumes

Existing Intersection Operations

Table 3 shows that, measured against City of Palo Alto and CMP standards, the signalized study intersections currently operate at acceptable levels of service during both the AM and PM peak hours. All of the unsignalized study intersections currently operate with reasonable delays. The levels of service calculation sheets are included in the Appendix.

Table 3
Existing Intersection Levels of Service

Intersection	Traffic Control	Peak Hour	Count Date	Existing Avg. Delay[12]	Existing LOS
Signalized Intersections:					
Maybell Ave and El Camino Real	Signal	AM	02/28/12	24.9	C
		PM	02/28/12	20.2	C
Arastradero Rd and El Camino Real*	Signal	AM	04/05/11	39.2	D
		PM	04/05/11	40.6	D
Arastradero Rd and Coulombe Dr	Signal	AM	05/23/12	6.0	A
		PM	04/05/12	4.9	A
Unsignalized Intersections:					
Arastradero Rd and Clemo Ave [3]	SSSC	AM	11/27/12	0.8(22.7)	C
		PM	11/27/12	0.3(30.7)	D
Maybell Ave and Coulombe Dr	AWSC	AM	08/28/12	8.4	A
		PM	08/28/12	7.6	A
Maybell Ave and Amaranta Ave	AWSC	AM	08/28/12	8.5	A
		PM	08/28/12	7.6	A

* Denotes CMP Intersection.

[1] Signalized and all-way stop controlled intersection levels of service and delays reported are for overall average delay.

[2] Side-street stop controlled intersection delays reported are for overall average delay and (worst approach movement delay) and LOS is reported for worst movement delay.

[3] The level of service reported above does not reflect the additional delays caused by queues observed on Arastradero Road during the AM peak hour that extend from Coulombe Drive past Clemo Avenue.

AWSC = All-way stop control

SSSC = Side street stop control

Existing Site Observations

Traffic conditions in the field were observed in order to identify existing operational deficiencies and to confirm the accuracy of calculated levels of service. The purpose of this effort was (1) to identify any existing traffic problems that may not be directly related to intersection level of service, and (2) to identify any locations where the level of service calculation does not accurately reflect level of service in the field.

Most of the study intersections operate adequately during the weekday AM and PM peak hours, and the level of service analysis appears to accurately reflect actual existing traffic conditions. However, field observations showed the following operational issues that are not reflected in the level of service calculations:

- Arastradero Road is congested between 7:50 AM and 8:25 AM between Coulombe Drive and El Camino Real. The Clemo Avenue/Arastradero Road intersection is intermittently blocked during this period by the southbound vehicle queue on Arastradero Road from its intersection with Coulombe Drive. At its peak, this southbound queue extends to El Camino Real, which blocks the

sight distance for a left turning vehicle from Clemo Avenue. In addition, there are a significant number of pedestrians and bikes that cross Arastradero Road at Clemo Avenue, which adds to the difficulty of making a left turn from Clemo Avenue.

- Maybell Avenue is congested between 7:45 AM and 8:15 AM. Southbound vehicle queues on Maybell Avenue extend from the intersection of Coulombe Drive/Maybell Avenue past Amaranta Avenue and a short distance past Clemo Avenue. In addition, there are hundreds of pedestrians and bikes that use the Maybell corridor during this period to access the nearby schools. This reduces the capacity for motor vehicle traffic through the corridor. At the intersection of Coulombe Drive/Maybell Avenue, the vehicle queues westbound on Coulombe Drive extend approximately 150 feet during the peak morning period. The intersection of Coulombe Drive/Maybell Avenue is controlled by a crossing guard during school hours to assist with the heavy pedestrian and bike traffic.
- There were no significant problems noted during the PM peak hour.

Project Traffic Estimates

The magnitude of traffic produced by a new development and the locations where that traffic would appear are estimated using a three-step process: (1) trip generation, (2) trip distribution, and (3) trip assignment. In determining project trip generation, the magnitude of traffic entering and exiting the site is estimated for the AM and PM peak hours. As part of the project trip distribution, an estimate is made of the directions to and from which the project trips would travel. In the project trip assignment, the project trips are assigned to specific streets and intersections. These procedures are described further in the following sections.

Through empirical research, data have been collected that correlate to common land uses their propensity for producing traffic. Thus, for the most common land uses there are standard trip generation rates that can be applied to help predict the future traffic increases that would result from a new development. The magnitude of traffic added to the roadway system by a particular development is estimated by multiplying the applicable trip generation rates to the size of the development. The standard trip generation rates are published in the Institute of Transportation Engineers (ITE) manual entitled *Trip Generation, 8th Edition*, 2008. Based on ITE's trip generation rates for single family units and senior housing units, the project would generate 276 gross daily vehicle trips, with 19 gross trips occurring during the AM peak hour and 25 gross trips occurring during the PM peak hour.

Since the proposed residential development would replace existing residences, the trips generated by the existing residences were subtracted prior to adding the estimated project traffic to the roadway network. After applying the appropriate existing trip credits, the project is expected to generate 238 net new daily trips, with 16 net new trips occurring during the AM peak hour and 21 net new trips occurring during the PM peak hour. The project trip generation estimates are presented in Table 4.

Table 4
Project Trip Generation Estimates

			ITE	Daily		AM Peak Hour				PM Peak Hour			
Land Use	Size		Code	Rate[1]	Total	Rate[1]	Total	In	Out	Rate[1]	Total	In	Out
Proposed Uses													
Single Family Residential	15	D.U.	210	9.57	144	0.75	11	3	8	1.01	15	10	5
Senior Housing	60	D.U.	252	2.20	132	0.13	8	3	5	0.16	10	6	4
Gross Project Trips					276		19	6	13		25	16	9
Existing Use													
Single Family Residential	4	D.U.	210	9.57	38	0.75	3	1	2	1.01	4	3	1
Net Project Trips					**238**		**16**	**5**	**11**		**21**	**13**	**8**

[1] All rates per ITE Trip Generation Manual, 8th Edition.

The trip distribution pattern for the proposed project was estimated based on a select zone analysis for residential uses from the VTA travel demand forecast model. The new peak-hour trips generated by the proposed project (the project trips) were added to the roadway network in accordance with the project trip generation and distribution described above. The proposed connection to the Arastradero Park Apartment Complex (APAC) would allow traffic from this existing development to use the new project driveway on Clemo Avenue as an alternative route that provides access to Arastradero Road. However, because the APAC already has a driveway on Arastradero Road, the number of existing trips that divert to the new driveway on Clemo Avenue is expected to be negligible. The project trip distribution and assignment are shown on Figures 4 and 5, respectively.

Intersection Level of Service Analysis

Traffic operations at the study intersections were evaluated using TRAFFIX software to determine level of service with and without the project for the AM and PM peak hours under existing and cumulative conditions. In addition, peak-hour signal warrants were conducted for the unsignalized intersections. The TRAFFIX calculation sheets are included in the attached appendix.

Existing Plus Project Conditions Intersection Analysis

Existing plus project conditions are defined as existing traffic volumes plus the addition of project traffic. The results show that, measured against City of Palo Alto and CMP standards, all of the signalized study intersections would continue to operate at acceptable levels of service during the AM and PM peak hours under existing plus project conditions. All of the unsignalized study intersections would continue to operate with reasonable delays. The level of service results for the existing plus project scenario is summarized in Table 5. Figure 6 presents the existing plus project traffic volumes at the study intersections.

Table 5
Existing Plus Project Intersection Levels of Service Summary

			Existing		Existing + Project			
Intersection	Traffic Control	Peak Hour	Avg. Delay[1,2]	LOS	Avg. Delay[1,2]	LOS	Incr. In Crit. Delay	Incr. In Crit. V/C
Signalized Intersections:								
Maybell Ave and El Camino Real	Signal	AM	24.9	C	25.0	C	0.1	0.001
		PM	20.2	C	20.4	C	0.2	0.003
Arastradero Rd and El Camino Real*	Signal	AM	39.2	D	39.2	D	0.1	0.001
		PM	40.6	D	40.6	D	0.1	0.001
Arastradero Rd and Coulombe Dr	Signal	AM	6.0	A	6.0	A	0.0	0.002
		PM	4.9	A	4.9	A	0.0	0.002
Unsignalized Intersections:								
Arastradero Rd and Clemo Ave [3]	SSSC	AM	0.8(22.7)	C	0.9(25.0)	C	--	--
		PM	0.3(30.7)	D	0.4(31.1)	D	--	--
Maybell Ave and Coulombe Dr	AWSC	AM	8.4	A	8.4	A	--	--
		PM	7.6	A	7.6	A	--	--
Maybell Ave and Amaranta Ave	AWSC	AM	8.5	A	8.5	A	--	--
		PM	7.6	A	7.6	A	--	--

* Denotes CMP Intersection.

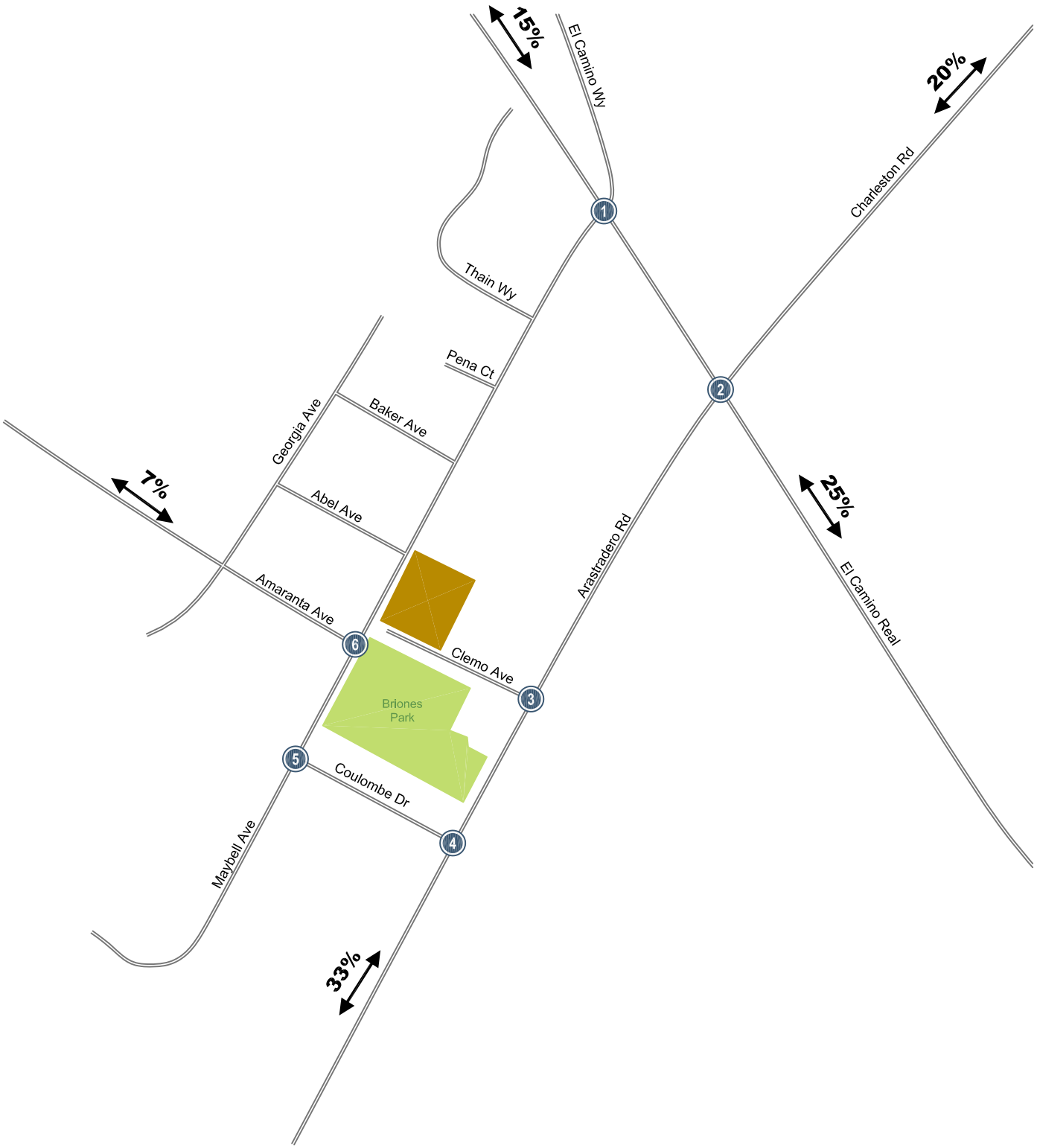
[1] Signalized and all-way stop controlled intersection levels of service and delays reported are for overall average delay.

[2] Side-street stop controlled intersection delays reported are for overall average delay and (worst approach movement delay) and LOS is reported for worst movement delay.

[3] The level of service reported above does not reflect the additional delays caused by queues observed on Arastradero Road during the AM peak hour that extend from Coulombe Drive past Clemo Avenue.

AWSC = All-way stop control

SSSC = Side street stop control



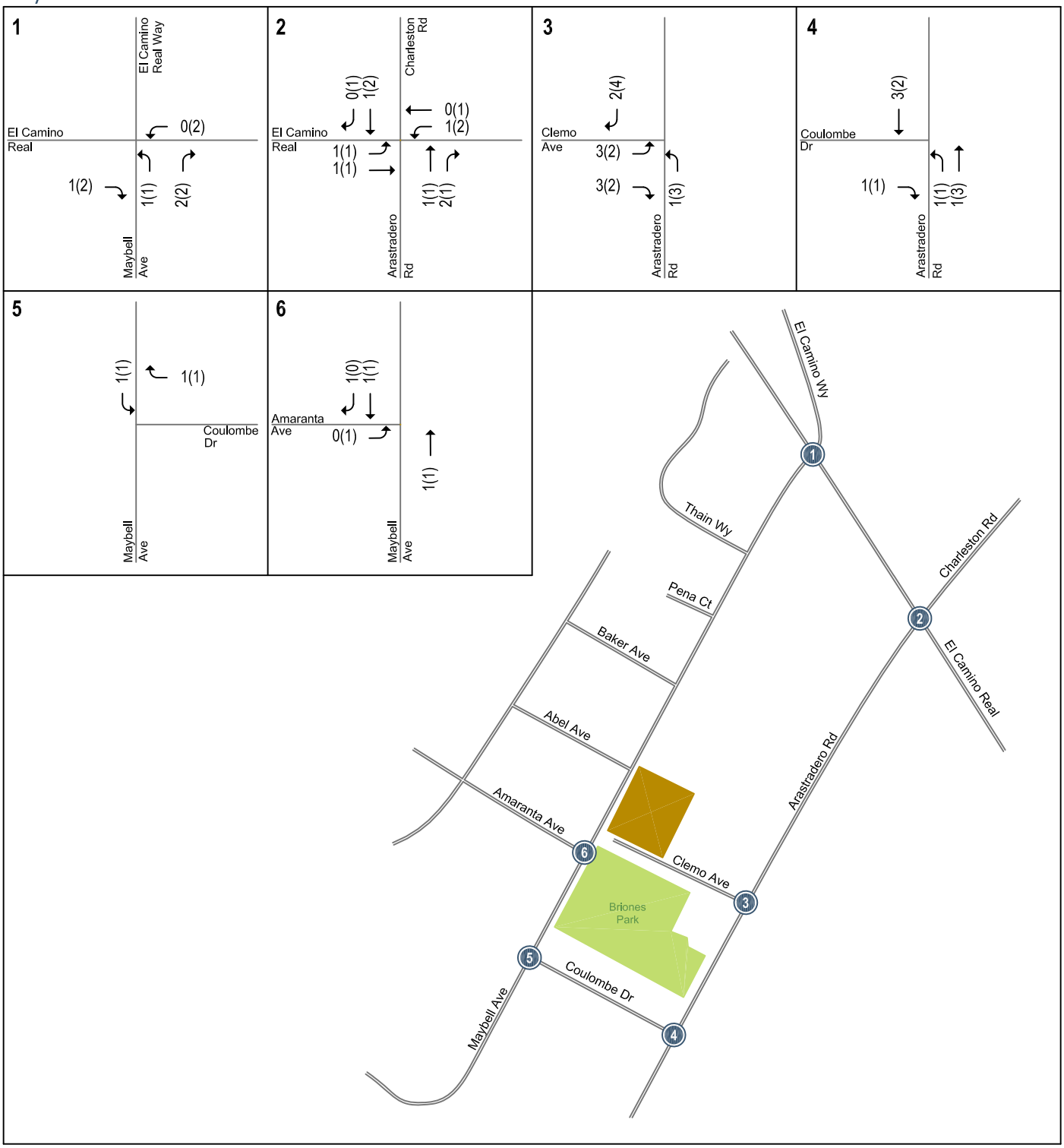
LEGEND

= Project Site Location

X = Study Intersection

XX = Project Trip Distribution

Figure 4
Project Trip Distribution



LEGEND

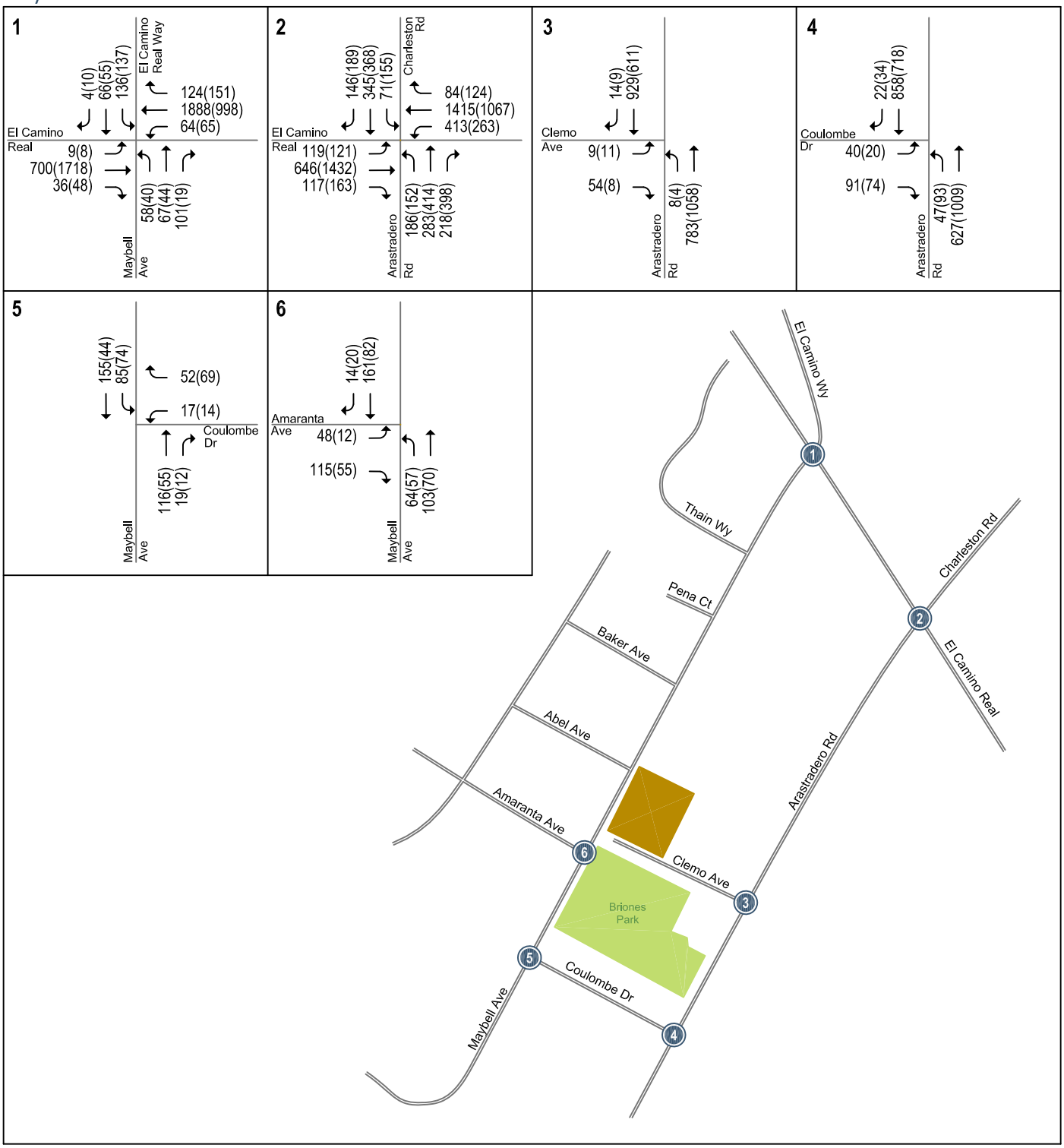
= Project Site Location

X = Study Intersection

XX(XX) = AM(PM) Peak-Hour Project Volumes

Figure 5
Project Trip Assignment

NORTH
Not to Scale



LEGEND

= Project Site Location

X = Study Intersection

XX(XX) = AM(PM) Peak-Hour Project Volumes

Figure 6
Existing Plus Project Traffic Volumes

Cumulative Conditions Intersection Analysis

Cumulative conditions represent forecasted far-term future (year 2020) traffic conditions. Cumulative without project traffic volumes were estimated by applying to existing traffic volumes an annual growth factor of 1.1 percent over a period between the date of the existing traffic counts and year 2020. Project trips were then added to estimate cumulative plus project conditions. The level of service results for the existing plus project scenario is summarized in Table 6. The cumulative no project and cumulative plus project traffic volumes at the study intersections are shown in Figures 7 and 8, respectively.

The results show that, measured against City of Palo Alto and CMP standards, all of the signalized study intersections would operate at acceptable levels of service during the AM and PM peak hours under both cumulative no project and cumulative with project conditions. The unsignalized study intersections would operate with reasonable overall average delays. However, the side-street delay on Clemo Avenue would operate at a poor LOS during the PM peak hour. The poor LOS is primarily a result of future traffic growth projected to occur between existing and cumulative conditions. Furthermore, the level of service analysis at this intersection does not reflect the significant number of pedestrian crossings and frequent blockages by through queues on Arastradero Road that were observed during the AM peak hour. The project would add 6 and 4 project trips to the westbound approach on Clemo Avenue during the AM and PM peak hours, respectively. The City staff will determine if improvements are required at this intersection.

Table 6
Cumulative Conditions Intersection Levels of Service Summary

			Cumulative Conditions					
			No Project		Plus Project			
Intersection	Traffic Control	Peak Hour	Avg. Delay[12]	LOS	Avg. Delay[12]	LOS	Incr. In Crit. Delay	Incr. In Crit. V/C
Signalized Intersections:								
Maybell Ave and El Camino Real	Signal	AM	25.7	C	25.8	C	0.1	0.001
		PM	20.7	C	20.8	C	0.2	0.003
Arastradero Rd and El Camino Real*	Signal	AM	40.5	D	40.6	D	0.1	0.001
		PM	42.8	D	42.9	D	0.1	0.001
Arastradero Rd and Coulombe Dr	Signal	AM	6.4	A	6.5	A	0.0	0.002
		PM	5.5	A	5.5	A	0.0	0.002
Unsignalized Intersections:								
Arastradero Rd and Clemo Ave [3]	SSSC	AM	0.9(27.5)	D	1.1(30.9)	D	--	--
		PM	0.3(37.2)	E	0.4(38.1)	E	--	--
Maybell Ave and Coulombe Dr	AWSC	AM	8.6	A	8.7	A	--	--
		PM	7.6	A	7.7	A	--	--
Maybell Ave and Amaranta Ave	AWSC	AM	8.7	A	8.8	A	--	--
		PM	7.7	A	7.7	A	--	--

* Denotes CMP Intersection

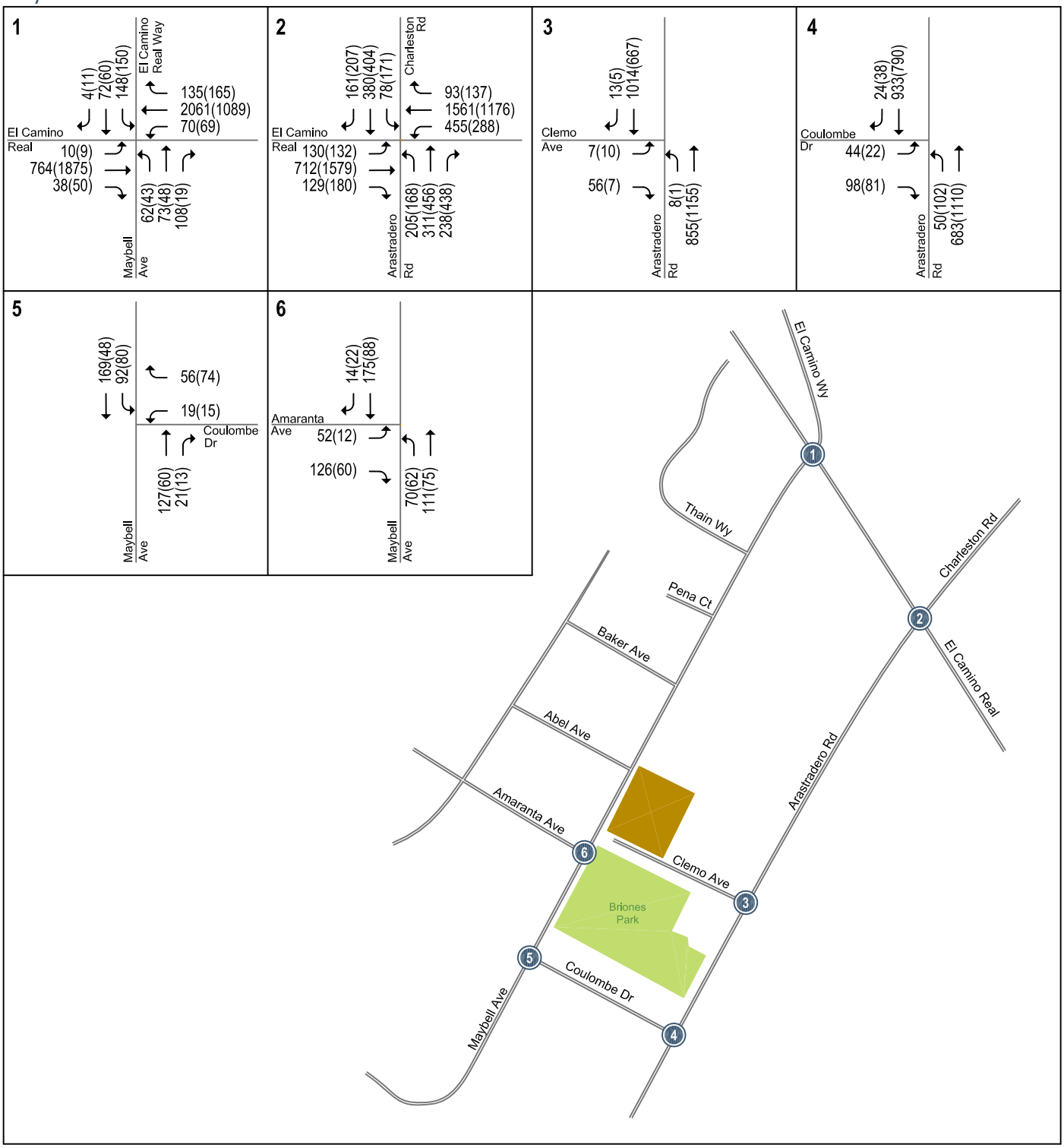
[1] Signalized and all-way stop controlled intersection levels of service and delays reported are for overall average delay.

[2] Side-street stop controlled intersection delays reported are for overall average delay and (worst approach movement delay) and LOS is reported for worst movement delay.

[3] The level of service reported above does not reflect the additional delays caused by queues observed on Arastradero Road during the AM peak hour that extend from Coulombe Drive past Clemo Avenue.

AWSC = All-way stop control

SSSC = Side street stop control



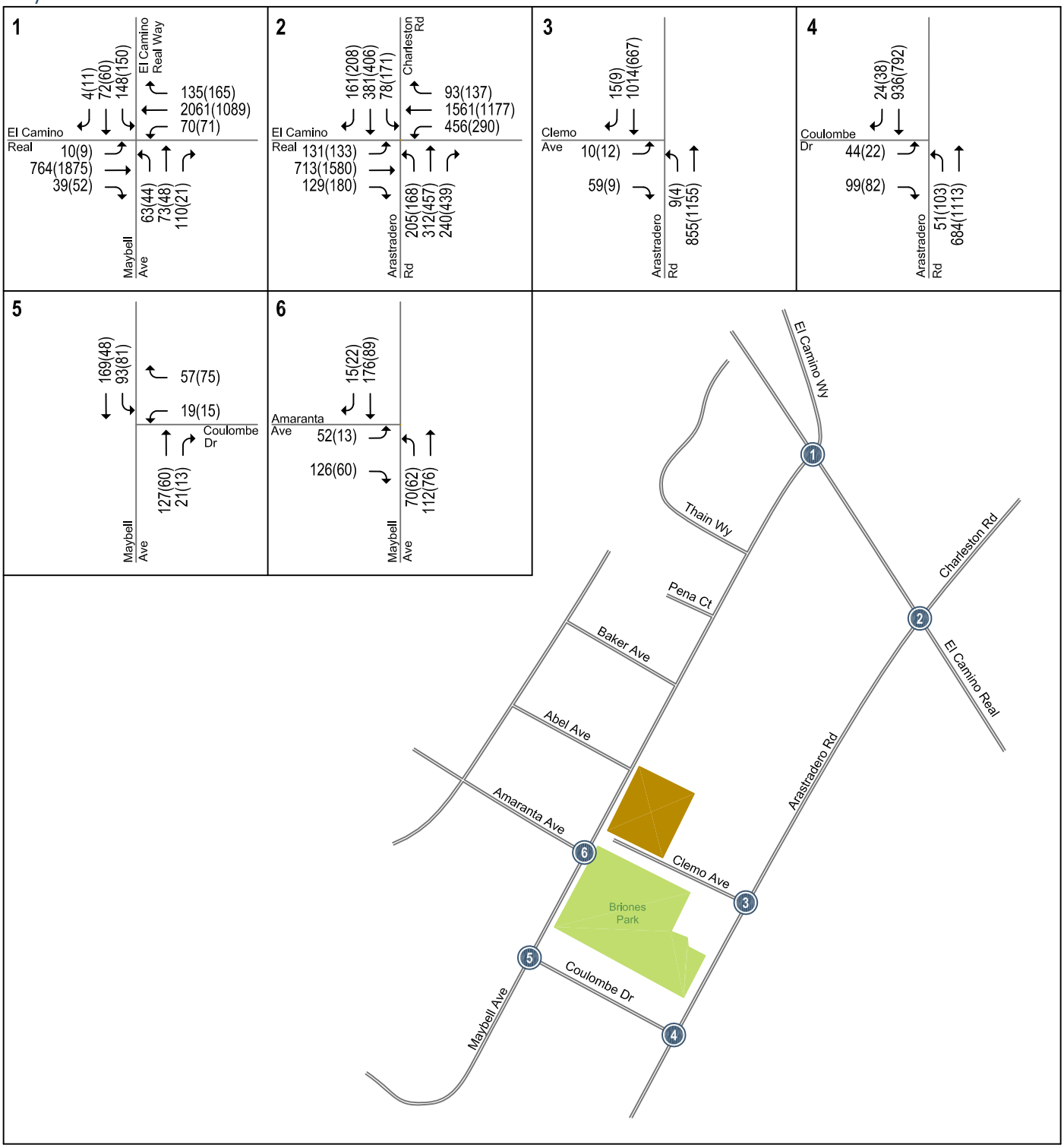
LEGEND

= Project Site Location

X = Study Intersection

XX(XX) = AM(PM) Peak-Hour Project Volumes

Figure 7
Cumulative No Project Traffic Volumes



LEGEND

= Project Site Location

X = Study Intersection

XX(XX) = AM(PM) Peak-Hour Project Volumes

Figure 8
Cumulative Plus Project Traffic Volumes

Traffic Signal Warrants

For stop-controlled intersections, an assessment was made of the need for signalization of the intersection. This assessment was made on the basis of the Peak-Hour Volume Signal Warrant, Warrant #3 described in the *California Manual on Uniform Traffic Control Devices*, 2010. This method makes no evaluation of intersection level of service, but simply provides an indication whether peak-hour traffic volumes are, or would be sufficient to justify installation of a traffic signal. The signal warrant check summary is shown in Table 7. The signal warrant analysis sheets are included in the Appendix. The analysis showed that the peak hour volume warrants would not be satisfied at the unsignalized study intersections during the AM and PM peak hours under existing or cumulative conditions with or without the proposed project.

Table 7
Peak Hour Traffic Signal Warrant Check Summary

			Existing +	2020 Cumulative	
	Peak	Existing	Project	No Project	With Project
	Hour	Warrant Met?	Warrant Met?	Warrant Met?	Warrant Met?
Arastradero Rd and Clemo Ave	AM	No	No	No	No
	PM	No	No	No	No
Maybell Ave and Coulombe Dr	AM	No	No	No	No
	PM	No	No	No	No
Maybell Ave and Amaranta Ave	AM	No	No	No	No
	PM	No	No	No	No

Neighborhood Traffic Volume

Residential areas are especially sensitive to traffic because otherwise relatively small increases in traffic can impact the livability of the neighborhood. A concern common to many residents is the possibility that a new development will cause an increase in traffic volume on their streets. A tool for measuring the effects of increases in traffic on neighborhood "livability" was developed by D.K. Goodrich. The tool is named the TIRE index, or Traffic Infusion on Residential Environments.

The TIRE index uses average daily traffic (ADT) volume to determine the amount of daily traffic that could be added to a roadway before residents would perceive the increase in traffic. The amount of daily traffic that can be added before residents would notice directly correlates to the amount of daily traffic already present on the street. According to this methodology, a noticeable traffic increase occurs when the difference in index between no project and project conditions is 0.10 or more. An increase in index of 0.10 corresponds to an increase in ADT of between 20 and 30 percent.

To quantify the perceptions of its residents, the TIRE index was applied to Maybell Avenue (see Table 8). Daily traffic counts were conducted on May 29th, 30th, and 31st of 2012 (Tuesday, Wednesday and Thursday, respectively) to determine the existing traffic on this street. According to the TIRE index, 825 daily trips could be added to Maybell Avenue before residents would perceive a change. The proposed project would add 80 daily trips to Maybell Avenue. According to the TIRE index, it is unlikely that residents along Maybell Avenue would notice an increase in traffic as a result of the proposed development.

Table 8
Neighborhood Street Volume

Street Segment	Existing Weekday ADT	ADT Threshold*	Net Change in ADT: ADT Added by Project	Net Change in ADT: Noticeable Increase
Maybell Ave, between Thain Way and Pena Court	3,320	825	80	No

* Denotes trips required for a noticeable increase.

Site Access, On-Site Circulation and Parking

This section describes the site access, on-site circulation, and parking for the proposed project. This review is based on the project a conceptual site plan provided by Dahlin Group, dated November 2, 2012 (see Figure 2).

Site Access

Access to the site will be provided by two driveways: one driveway on Clemo Avenue and an access easement through the Arastradero Park Apartment Complex (APAC) to the north that connects to an existing driveway on Maybell Avenue. The Clemo Avenue driveway would be a full-access driveway that would provide direct access to the project site. However, Clemo Avenue dead-ends at the west end and would not provide access to Maybell Avenue. Therefore, the site driveway on Clemo Avenue would provide access only to Arastradero Road via a stop-controlled intersection. The proposed site driveway at the north end of the project site would provide access to the adjacent property's internal roadway, which in turn provides access to Maybell Avenue. Although it is possible that some traffic from the adjacent APAC sight could use the driveway to Clemo Avenue to access Arastradero Road, it is unlikely for this to occur as the APAC sight already has a driveway that connects to Arastradero Road approximately 500 feet north of Clemo Avenue.

Clemo Avenue Driveway

Under existing plus project conditions, the project driveway would have 3 inbound trips and 6 outbound trips during the AM peak hour and 7 inbound trips and 4 outbound trips during the PM peak hour. Given the low ambient traffic volume on Clemo Avenue, this driveway would operate with little delay. The driveway width is shown on the site plan to be 20 feet. This meets the required minimum width per section 18.83.090 of the Palo Alto municipal code. However, prior to final design, the Clemo Avenue driveway design should be reviewed by City staff to insure adequate design standards are met.

Maybell Avenue Driveway

Under existing plus project conditions, the project would add 2 inbound and 5 outbound trips during the AM peak hour and 6 inbound and 4 outbound trips during the PM peak hour to the existing Maybell Avenue driveway shared with the adjacent APAC. Given the low ambient traffic volume on the adjacent property roadway and Maybell Avenue, this driveway would operate with little delay. The width of the driveway is not specified on the site plan. Prior to final design, the north driveway (Maybell Avenue) design should be reviewed by City staff to insure adequate design standards are met.

Sight Distance at Project Access Points

Adequate corner sight distance (sight distance triangles) should be provided at all site access points in accordance with Caltrans standards. Sight distance triangles should be measured approximately 10 feet back from the traveled way. Sight distance requirements vary depending on the roadway speeds. For example, for roadways which have a posted speed limit of 25 mph, the Caltrans standard corner sight

distance is 275 feet. Thus, according to Caltrans design standards, a driver exiting from a driveway should be able to see 275 feet down the street in both directions in order to safely complete a turn onto a 25 mph street. It should be noted, however, that the Caltrans corner sight distance requirement is considered ideal design and is most applicable to heavy volume state highway intersections. In many situations, this standard is not feasible. The minimum acceptable sight distance is often considered the Caltrans stopping sight distance. For roadways with a posted speed limit of 25 mph, the Caltrans stopping sight distance is 150 feet. This design approach would be more appropriate for this project.

The current site plan does not show any walls or signs that could obstruct the line of sight for drivers entering the street from the project driveways. The site plan does show landscaping. On Clemo Avenue the project intends to retain existing live oak trees located on the north side of the street and west of the driveway. As shown on the site plan, the trees are approximately 10 feet back from the curb, which should allow sufficient distance for an exiting vehicle to pull forward of the trees so that the driver can see approaching traffic. In order to ensure that on-street parking does not obscure the view for outbound traffic, it is recommended that the curb be painted red for a distance of 65 feet east of the driveway.

For drivers using the APAC driveway to turn onto Maybell Avenue, the existing sight distance is adequate. There are no walls or landscape elements that obscure the view of outbound vehicles. Furthermore, a red curb is painted on the south side of the driveway to ensure the required sight distance.

On-Site Circulation and Parking

The on-site circulation was reviewed in accordance with generally accepted traffic engineering standards. Generally, the proposed plan would provide adequate circulation throughout the site. The site would include 47 uncovered surface parking spaces for the senior housing units including three accessible parking spaces. Parking stalls are oriented at 90 degrees to the drive aisles. Aisle widths are appropriate for 90-degree parking, and there are no dead end aisles. A passenger loading zone is shown in front of the community room at the proposed senior housing component. Parking for the single-family residential units would occur in attached two-car garages. In addition, all but one of the single family units adjacent to Maybell Avenue has driveway aprons that are 18 feet deep, which would allow for two additional parking spaces per unit. With the exception of one unit at the corner of Maybell Avenue and Clemo Avenue that would have direct access to Clemo Avenue, all single-family units would be accessed by internal drive aisles. As described previously, access to the public street system from the northern driveway requires traveling through the adjacent property. Prior to final design, the on-site parking, roadway design and connection to the adjacent property should be reviewed by City staff to insure adequate design standards are met.

Relocation of the Clemo Avenue Barrier

At the request of the City of Palo Alto, an alternative site access scenario was analyzed. Under this alternative scenario, the barrier on Clemo Avenue would be relocated from its existing location at the west end of Clemo Avenue near Maybell Avenue to immediately east of the proposed project site driveway on Clemo Avenue. This relocation of the barrier would require the project trips to access Clemo Avenue from Maybell Avenue rather than from Arastradero Road. The change would not affect access to other properties on Clemo Avenue. Likewise, access to the Maybell Avenue driveway through the APAC easement would remain unchanged.

Under this alternative access scenario, the number of project trips that would access the project site via Clemo Avenue would remain relatively unchanged: 3 inbound trips and 6 outbound trips in the AM peak hour and 7 inbound trips and 4 outbound trips in the PM peak hour. The directional split of project trips on Maybell Avenue is such that, under this alternative access scenario, there would be approximately 2 more inbound and approximately 4 more outbound trips on Maybell Avenue north of the project site during the AM peak hour and approximately 2 more inbound and approximately 2 more outbound trips on Maybell Avenue north of the project site during the PM peak hour. On Maybell Avenue south of the project site, there would be approximately 1 more inbound and approximately 2 more outbound trip in the AM peak hour and approximately 5 more inbound and approximately 1 more outbound trip in the PM peak hour. The changes in the paths of project trips would not affect the levels of service at the study intersections.

Moving the Clemo barrier east of the project driveway would cause a slight increase in project traffic on Maybell Avenue north and south of the project site. To quantify this increase in traffic volume, a TIRE index was performed for this scenario (see Table 9). Similar to the previous TIRE index, 825 trips could be added to Maybell Avenue before residents would perceive a change. Under this scenario, the project would add 120 daily trips to Maybell Avenue. According to the TIRE index, it is unlikely that residents along Maybell Avenue would notice an increase in traffic as a result of the proposed development.

Table 9
Neighborhood Street Volume

Street Segment	Existing Weekday ADT	ADT Threshold*	Net Change in ADT: ADT Added by Project	Net Change in ADT: Noticeable Increase
Maybell Ave, between Thain Way and Pena Court	3,320	825	120	No

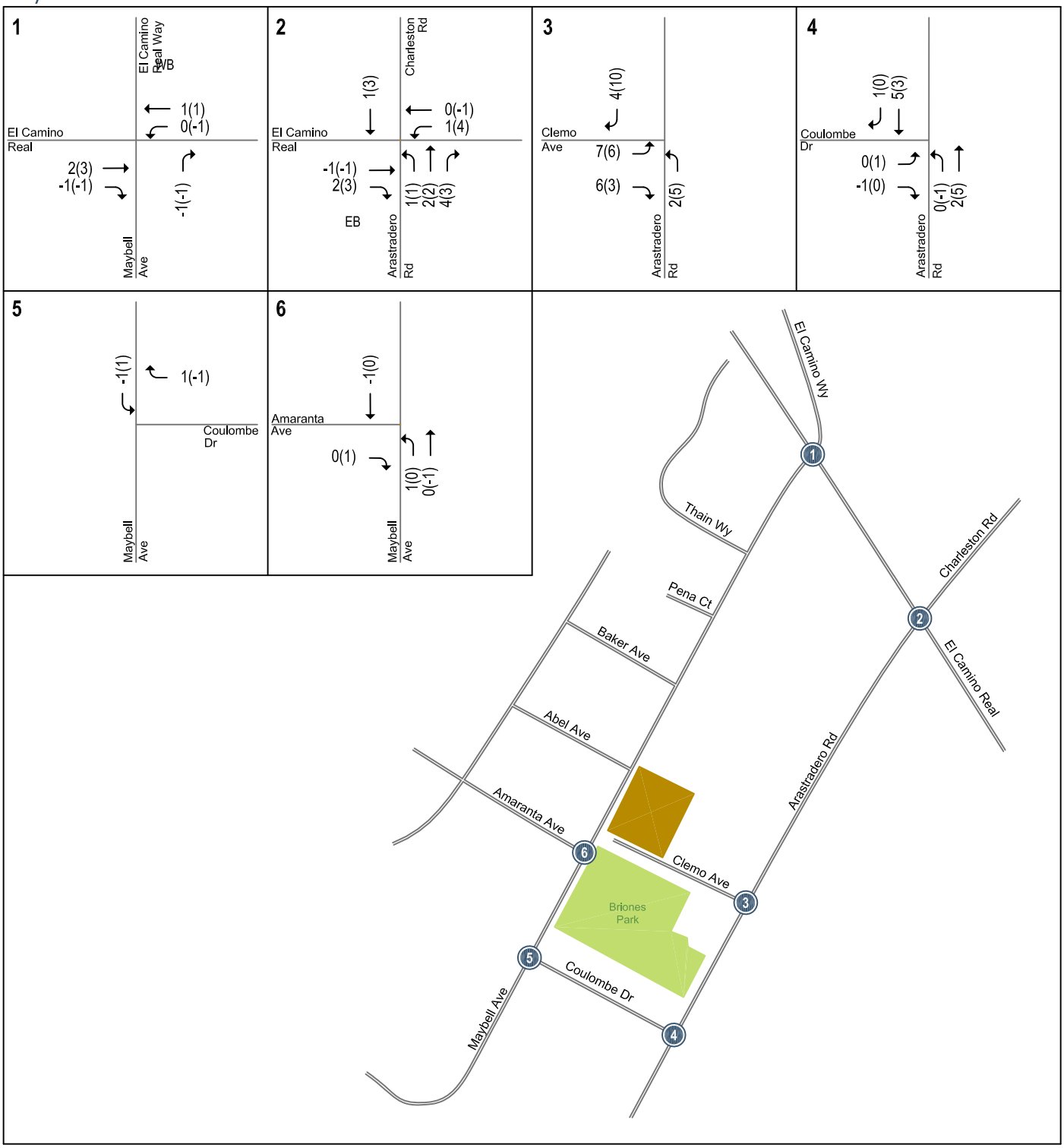
* Denotes trips required for a noticeable increase.

The possible relocation of the Clemo barrier may be beneficial in that it would prevent project trips from attempting to access Arastradero Road from a stop-controlled approach that is affected by significant queuing issues and bike and pedestrian trips during peak periods. While similar issues are present at the Maybell/Clemo intersection, they are less severe as the traffic volume on Maybell is much lower than on Arastradero.

Alternative Project Access Analysis

In the event the access easement through the adjacent APAC property cannot be obtained, the project would be accessed via a single driveway on Clemo Avenue. Thus, two additional alternative site access scenarios were analyzed. Both alternatives would include a single access point to Clemo Avenue. The first alternative, hereafter referred to as “Clemo via Arastradero Access”, presumes the Clemo barrier would remain in its current location so that all trips to and from the project site would access Clemo Avenue via Arastradero Road. Under this alternative, there would be an increase in trips on Arastradero Road, as all project trips would access the project site via Arastradero Road. This alternative would result in a slight decrease in traffic on Maybell Avenue, as the project would replace existing homes that currently have access via Maybell Avenue. Net project trips under this alternative, after receiving credit for existing residential uses on site, are shown on Figure 9.

The second alternative, hereafter referred to as “Clemo via Maybell Access”, assumes that the Clemo barrier would be moved to the other side of the project driveway allowing access from Clemo Avenue to Maybell Avenue. The project site would not be accessible via Arastradero Road because of the barrier. Under this alternative, all project traffic will be added to the Clemo/Maybell intersection and no traffic will be added to the Clemo/Arastradero intersection. Net project trips under this alternative are shown on Figure 10.



LEGEND

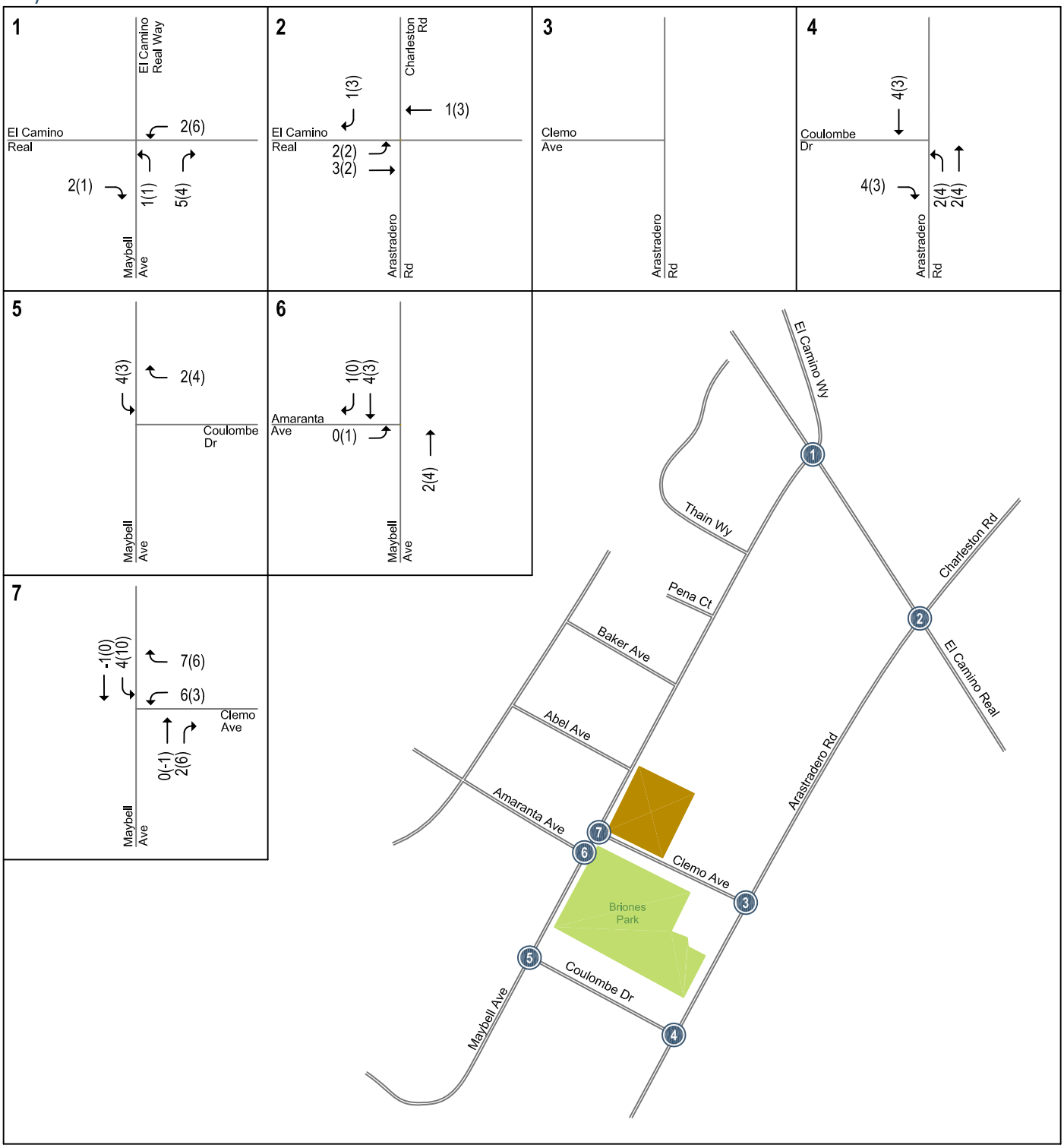
= Project Site Location

X = Study Intersection

XX(XX) = AM(PM) Peak-Hour Project Volumes

Figure 9
Net Project Trips - Clemo via Arastradero Access

NORTH
Not to Scale



LEGEND

= Project Site Location

X = Study Intersection

XX(XX) = AM(PM) Peak-Hour Project Volumes

Figure 10
Net Project Trips - Clemo via Maybell Access

Level of Service Analysis

Intersection levels of service under existing plus project and cumulative plus project conditions for the two alternative access scenarios are shown in Table 10. Under either access alternative, the peak-hour levels of service would be unchanged at all but one of the study intersections. The intersection of Arastradero Road and Clemo Avenue would incur a substantial increase in delay and deterioration in the level of service during the AM peak hour if the project were limited to a single driveway on Clemo Avenue with the current barrier location. As previously noted, this intersection is currently subject to frequent blockages as queues extend along Arastradero Road from the downstream intersection at Coulombe Drive past Clemo Avenue. Thus, the "Clemo via Arastradero" access alternative, which would funnel all of the project traffic through the Clemo/Arastradero intersection, would exacerbate the existing congestion at this intersection. In contrast, moving the Clemo barrier to the east of the project driveway so that all project trips would access Clemo Avenue via Maybell Avenue would result in less delay. An analysis of the projected traffic volumes at the newly created Maybell/Clemo intersection shows that the stop-controlled Clemo Avenue approach would operate at LOS A in the AM and PM peak hours. Furthermore, compared to the Clemo/Arastradero intersection, queue blockages were observed to occur less frequently at the Clemo/Maybell intersection.

Traffic Signal Warrants

Table 11 presents the traffic signal warrant analysis for both site access alternatives. The signal warrant analysis sheets are included in the Appendix. The analysis shows that the peak-hour volume warrants would not be satisfied at the unsignalized study intersections during the AM and PM peak hours under existing or cumulative conditions with the proposed project under either access alternative.

Neighborhood Traffic Volume

Under the "Clemo via Arastradero Access" alternative, the project would not add any trips to Maybell Avenue between Thain Way and Pena Court. On the contrary, the project would result in a decrease in volumes on this segment as the project would replace existing homes that currently have direct access to Maybell Avenue. Under the "Clemo via Maybell Access" alternative, the proposed project would add approximately 150 daily trips to Maybell Avenue. As shown in Table 12, according to the TIRE index, it is unlikely that residents along Maybell Avenue would notice this projected increase in traffic as a result of the proposed development.

Table 10
Alternative Access Scenarios – Level of Service Analysis

			Existing		Existing + Project								Cumulative		Cumulative + Project							
					Clemo via Maybell Access				Clemo via Arastradero Access				No Project		Clemo via Maybell Access				Clemo via Arastradero Access			
	Traffic Control	Peak Hour	Avg. Delay[1,2]	LOS	Avg. Delay[1,2]	LOS	Incr. In Crit. Delay	Incr. In Crit. V/C	Avg. Delay[1,2]	LOS	Incr. In Crit. Delay	Incr. In Crit. V/C	Avg. Delay[1,2]	LOS	Avg. Delay[1,2]	LOS	Incr. In Crit. Delay	Incr. In Crit. V/C	Avg. Delay[1,2]	LOS	Incr. In Crit. Delay	Incr. In Crit. V/C
Signalized Intersections:																						
Maybell Ave and El Camino Real	Signal	AM	24.9	C	25.1	C	0.3	0.003	24.8	C	-0.1	0.000	25.7	C	26.0	C	0.3	0.003	25.7	C	-0.1	0.000
		PM	20.2	C	20.5	C	0.5	0.007	20.2	C	-0.1	-0.001	20.7	C	21.0	C	0.5	0.007	20.6	C	-0.1	-0.001
Arastradero Rd and El Camino Real *	Signal	AM	39.2	D	39.2	D	0.1	0.002	39.2	D	0.1	0.001	40.5	D	40.6	D	0.1	0.002	40.6	D	0.1	0.001
		PM	40.6	D	40.6	D	0.0	0.000	40.7	D	0.1	0.002	42.8	D	42.9	D	0.0	0.000	43.0	D	0.2	0.002
Arastradero Rd and Coulombe Dr	Signal	AM	6.0	A	6.2	A	0.1	0.000	5.9	A	0.0	0.004	6.4	A	6.6	A	0.1	0.000	6.4	A	0.0	0.004
		PM	4.9	A	5.0	A	0.0	0.000	5.0	A	0.1	0.003	5.5	A	5.6	A	0.0	0.000	5.6	A	0.1	0.003
Unsignalized Intersections:																						
Arastradero Rd and Clemo Ave [3]	SSSC	AM	0.8(22.7)	C	0.8(22.7)	C	--	--	1.1(28.1)	D	--	--	0.9(27.5)	D	0.9(27.5)	D	--	--	1.4(35.8)	E	--	--
		PM	0.3(30.7)	D	0.3(30.7)	D	--	--	0.5(34.3)	D	--	--	0.3(37.2)	E	0.3(37.2)	E	--	--	0.6(42.7)	E	--	--
Maybell Ave and Coulombe Dr	AWSC	AM	8.4	A	8.5	A	--	--	8.4	A	--	--	8.6	A	8.7	A	--	--	8.6	A	--	--
		PM	7.6	A	7.6	A	--	--	7.6	A	--	--	7.6	A	7.7	A	--	--	7.7	A	--	--
Maybell Ave and Amaranta Ave	AWSC	AM	8.5	A	8.5	A	--	--	8.5	A	--	--	8.7	A	8.8	A	--	--	8.7	A	--	--
		PM	7.6	A	7.7	8	--	--	7.6	A	--	--	7.7	A	7.8	A	--	--	7.7	A	--	--
Maybell Ave and Clemo Ave [4]	SSSC	AM	N/A	N/A	0.4(9.7)	A	--	--	N/A	N/A	--	--	N/A	N/A	0.4(9.8)	A	--	--	N/A	N/A	--	--
		PM	N/A	N/A	0.6(9.0)	A	--	--	N/A	N/A	--	--	N/A	N/A	0.6(9.1)	A	--	--	N/A	N/A	--	--

* Denotes CMP intersection.
[1] Signalized and all-way stop controlled intersection levels of service and delays reported are for overall average delay.
[2] Side-street stop controlled intersection delays reported are for overall average delay and (worst approach movement delay) and LOS is reported for worst movement delay.
[3] The level of service reported above does not reflect the additional delays caused by queues observed on Arastradero Road during the AM peak hour that extend from Coulombe Drive past Clemo Avenue.
[4] intersection would exist only if the Clemo barrier were moved to the east of the project driveway.
AWSC = All-way stop control
SSSC = Side street stop control

Table 11
Alternative Access Scenarios - Peak Hour Traffic Signal Warrant Summary

	Peak Hour	Existing + Project Warrant Met?	2020 Cumulative + Project Warrant Met?
Clemo via Arastradero Access			
Arastradero Rd and Clemo Ave	AM	No	No
	PM	No	No
Maybell Ave and Coulombe Dr	AM	No	No
	PM	No	No
Maybell Ave and Amarante Ave	AM	No	No
	PM	No	No
Clemo via Maybell Access			
Arastradero Rd and Clemo Ave	AM	No	No
	PM	No	No
Maybell Ave and Coulombe Dr	AM	No	No
	PM	No	No
Maybell Ave and Amarante Ave	AM	No	No
	PM	No	No

Table 12
Alternative Access Scenarios - Neighborhood Street Volume

Street Segment	Existing Weekday ADT	ADT Threshold*	Net Change in ADT: ADT Added by Project	Net Change in ADT: Noticeable Increase
Maybell Ave, between Thian Way and Pena Court	3,320	825		
- Clemo via Arastradero Access			-35	No
- Clemo via Maybell Access			120	No

* Denotes trips required for a noticeable increase.

Conclusion

As currently proposed, the project would be served by two driveways—one driveway on Clemo Avenue and an access easement through the Arastradero Park Apartment Complex (APAC) to the north that would connect to an existing driveway on Maybell Avenue. The analysis of the proposed project shows that it is unlikely that residents along Maybell Avenue would notice an increase in traffic as a result of the proposed development. In addition, all of the signalized study intersections would operate at acceptable levels of service under existing, existing plus project, and cumulative conditions during both the AM and PM peak hours. The analysis also showed that none of the unsignalized intersections would meet the peak hour signal warrants and the unsignalized study intersections would operate with reasonable overall average delays. However, the side-street delay on Clemo Avenue would operate at a poor LOS during the PM peak hour under cumulative conditions with or without the project. The poor LOS is primarily a result of future traffic growth projected to occur between existing and cumulative conditions. Furthermore, the level of service analysis at this intersection does not reflect the significant number of pedestrian crossings and frequent blockages by through queues on Arastradero Road that were observed during the AM peak hour. The project would add 6 and 4 project trips to the westbound approach on Clemo Avenue during the AM and PM peak hours, respectively. City staff will determine if improvements are required at this intersection.

As described previously, access to the public street system to and from the Maybell Avenue driveway requires traveling through the APAC. Prior to final design, the on-site parking, roadway design, and connection to the APAC should be reviewed by City staff to insure adequate design standards are met.

Generally, the proposed plan would provide adequate circulation throughout the site. The existing live oak trees located along the project frontage on Clemo Avenue are not expected to interfere with the visibility of drivers exiting the proposed Clemo Avenue driveway. In order to ensure that on-street parking does not obscure the view for outbound traffic, it is recommended that the curb be painted red for a distance of 65 feet east of the driveway. Adequate sight distance is provided at the existing Maybell Avenue driveway at the APAC.

The City of Palo Alto has suggested the possibility of relocating the barrier on Clemo Avenue from its existing location near Maybell Avenue to immediately east of the proposed project site driveway on Clemo Avenue. This relocation of the barrier would require the project trips to access Clemo Avenue from Maybell Avenue rather than from Arastradero Road. The change would not affect access to other properties on Clemo Avenue. Likewise, access to the Maybell Avenue driveway through the APAC easement would remain unchanged. The change would not affect the levels of service at the study intersections or cause a noticeable increase in traffic on Maybell Avenue. The barrier relocation may be beneficial in that it would prevent project trips from attempting to access Arastradero Road from a stop-controlled approach that is affected by significant queuing issues and bike and pedestrian trips during peak periods. While similar issues are present at the Maybell/Clemo intersection, they are less severe as the traffic volume on Maybell is much lower than on Arastradero.

In the event the access easement through the adjacent APAC property cannot be obtained, the project would be accessed via a single driveway on Clemo Avenue. With the current Clemo barrier, all project trips would access Clemo Avenue via Arastradero Road. Alternatively, the Clemo barrier could be relocated east of the project driveway so that all project trips would access Clemo Avenue via Maybell Avenue. An analysis of both site access alternatives shows that all of the signalized study intersections would operate at acceptable levels of service under existing plus project and cumulative plus project conditions during both the AM and PM peak hours. The analysis also showed that none of the unsignalized intersections would meet the peak hour signal warrants and the unsignalized study intersections would operate with reasonable overall average delays. The stop-controlled Clemo Avenue approach at Arastradero Road would incur a substantial increase in delay and deterioration in the level of service during the AM peak hour if the project were limited to a single driveway on Clemo Avenue with the current barrier location. In contrast, moving the Clemo barrier to the east of the project driveway so that all project trips would access Clemo Avenue via Maybell Avenue would result in reasonable delays and acceptable levels of service at the stop-controlled Clemo Avenue approach at Maybell Avenue. Furthermore, residents along Maybell Avenue would not notice a change in traffic as a result of the proposed development. As stated earlier, given the severity of queuing, bike and pedestrian trips on Arastradero Road, it would be beneficial to relocate the barrier on Clemo Avenue to east of the project driveway, so that the project trips cannot access Arastradero Road via Clemo Avenue.

Maybell Avenue Residential Appendix