

Fehr & Peers

Effects of COVID-19 Pandemic on Localized Travel Behavior

**At Residential, Business Professional, Retail, and
Mixed-Use Sites in California**

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1. Introduction

This chapter provides a brief overview of this important research topic, which was undertaken through the Fiscal Year 2023 and 2024 Fehr & Peers Research & Development (R&D) program.

Background and Study Purpose

Clients often ask Fehr & Peers whether the transportation industry has figured out how the COVID-19 pandemic affected travel behavior. State DOTs, COGs, MPOs, and transit agencies have documented how travel has rebounded in the 4+ years since the virus was detected in the US (though transit ridership remains down). That data is primarily macro in scale, examining changes in total traffic on freeways/arterials, monthly or daily ridership on transit systems, or 'big data' that tracks mobile device activity to understand average resident travel patterns.

In late 2021, the Institute of Transportation Engineers released the *Trip Generation Manual, 11th Edition*. Fehr & Peers staff were among a dozen professionals who volunteered their time to assist in its development. From that experience, we can say unequivocally that the ITE database of trip generation surveys does not include any trip generation measurements at land uses since the COVID-19 pandemic began. Nor should it have as conditions in 2020 and 2021 were far from settled.¹ Based on the above, there is a glaring lack of understanding of how travel behavior at a local land use level has changed since the COVID-19 pandemic. This study aims to quantitatively describe how travel conditions have changed at typical land uses such as housing, retail, and office uses by focusing on same site year-over-year trip generation comparisons.

Correlation Versus Causality

While the title of this research uses the word 'effects', readers should not infer that this study is attempting to establish direct causality between the COVID-19 pandemic and changes in travel patterns. There are other factors that have clearly influenced travel that are indirectly related to the COVID-19 pandemic, but also influenced by governmental policies. One example is the State of California allowing its employees to be fully remote (with a return to the office twice per week mandated in June 2024). Another example is the change in instruction start/end times at California high schools. Additionally, the need for social distancing during the peak of the pandemic brought about substantial increases in ecommerce and food delivery, the effects of which remain with us today.

¹ To illustrate, a January 30, 2023 Policy Directive from Caltrans Traffic Operations specified that traffic data collected between March 13, 2020, and January 31, 2022, should not be used for analysis of projects on the State Highway System due to the abnormal traffic patterns created by the COVID-19 pandemic.

Geographic Extent of Study

Between 2021 and 2023, Fehr & Peers staff from around the company provided input regarding any traffic data collected by the firm at residential, office, retail, and mixed-use sites between January 2017 and December 2019. This led to the creation of a database of pre-COVID conditions. The initial database included not only data in California, but also in other states such as Colorado, Oregon, Florida, Utah, Washington, Georgia, and Maryland. However, due to cost considerations (see below), the dataset is limited to only locations in California.

Traffic Data Collection Methods

Traffic data collection for trip generation purposes typically relies on either hose tube counts laid across a roadway or placement of a video camera at the desired location. Hose tubes yield accurate results if vehicles pass over them at a speed of at least 10 to 15 mph. They are typically placed on public streets, and not within private driveways (due not only to the need to receive approvals, but also because such driveways are typically associated with slower speed travel).

When a hose tube is not feasible, the alternative is the video camera. Because video cameras require an analyst to observe (albeit sped up to 2x or 4x) the recording and then document the number of entering/exiting vehicles during each 15-minutes of a 24-hour period, they are expensive. A two-day hose tube count costs little more than \$200 while a video camera recording of the same location for 48 hours is well over \$1,500. As this research was fully funded through Fehr & Peers' R&D budget, decisions were made to prioritize study locations whose access points could be collected using hose tubes. This eliminated all non-California locations, all of which were originally counted with video cameras (with many funded through project work or prior Fehr & Peers research).

Traffic data collection at chosen land uses was performed in one of the following three ways:

1. Complete Multi-Day Observations Using Hose Tube Counts – This was the preferred approach, allowing for Monday – Friday counts at a reasonable cost.
2. Complete Single-Day Observations Using Video Cameras – To reduce cost, an 18-hour count from 6 AM to 8 PM was collected (with factoring completed using ITE data to arrive at 24-hour volumes).
3. Use City of Roseville Traffic Volume Database – The City of Roseville has an Intelligent Transportation Systems (ITS) traffic count database whereby vehicles passing over loop detectors at signalized intersections are automatically counted and cataloged in a database (see **Image 1** for example). This data source saves data into an enormous spreadsheet. But since the data collection is only focused on a single point of access to those sites, it was not possible to quantify the trip generation rates of those uses, but only to compare how the number of trips generated compared between pre-COVID versus current conditions at a given location.



Image 1: Signalized access to the Deer Valley Apartments in Roseville, CA

Sites Selected for Analysis

A total of 11 sites were chosen for “Pre-COVID versus Current Condition Year Over Year” analysis.

Table 1 shows the general land use type, name, and location of each site. As shown, 8 of the 11 sites are located in Roseville or Granite Bay, CA, with the remaining three situated in Sacramento, Sunnyvale, or Hollywood. Refer to **Figure 1** for locations. Project land use details and geographic context are presented later.

Table 1 also shows the type of equipment used at each site to collect traffic data and date of counts. Hose tubes were used at 3 locations, video cameras were used at 2 locations, and the City of Roseville traffic count database was used at 6 locations. All counts were collected during the months of September, October or November during 2017 or 2019 (i.e., pre-COVID), or during 2022 or 2023 (i.e., current conditions).

Table 1: Pre-COVID Versus Current Conditions Year-Over-Year Data Collection Sites

General Type	Name	Location	Type of Count	Dates of Counts
Single Family Residential	Shelborne	Granite Bay, CA	Hose tubes	Oct. 2017 & Oct. 2023
	Weddington	Granite Bay, CA	Hose tubes	
Multi-Family Residential	The Village	Roseville, CA	City of Roseville count database	Sept./Oct. 2019 & Sept./Oct. 2022
	Deer Valley	Roseville, CA	City of Roseville count database	
	Slate Creek Apartments	Roseville, CA	City of Roseville count database	
Retail Centers	Roseville Center	Roseville, CA	City of Roseville count database	
	Roseville Square	Roseville, CA	City of Roseville count database	
	Highland Pointe	Roseville, CA	City of Roseville count database	
Mixed-Use Projects	Columbia Square Hollywood	Hollywood, CA	Video cameras	Nov. 2019 & Nov. 2023
	Gateway Oaks	Sacramento, CA	Hose tubes	Oct. 2019 & Oct. 2023
	Cityline Sunnyvale	Sunnyvale, CA	Video cameras	Nov. 2019 & Nov. 2023

Source: Fehr & Peers, 2024.

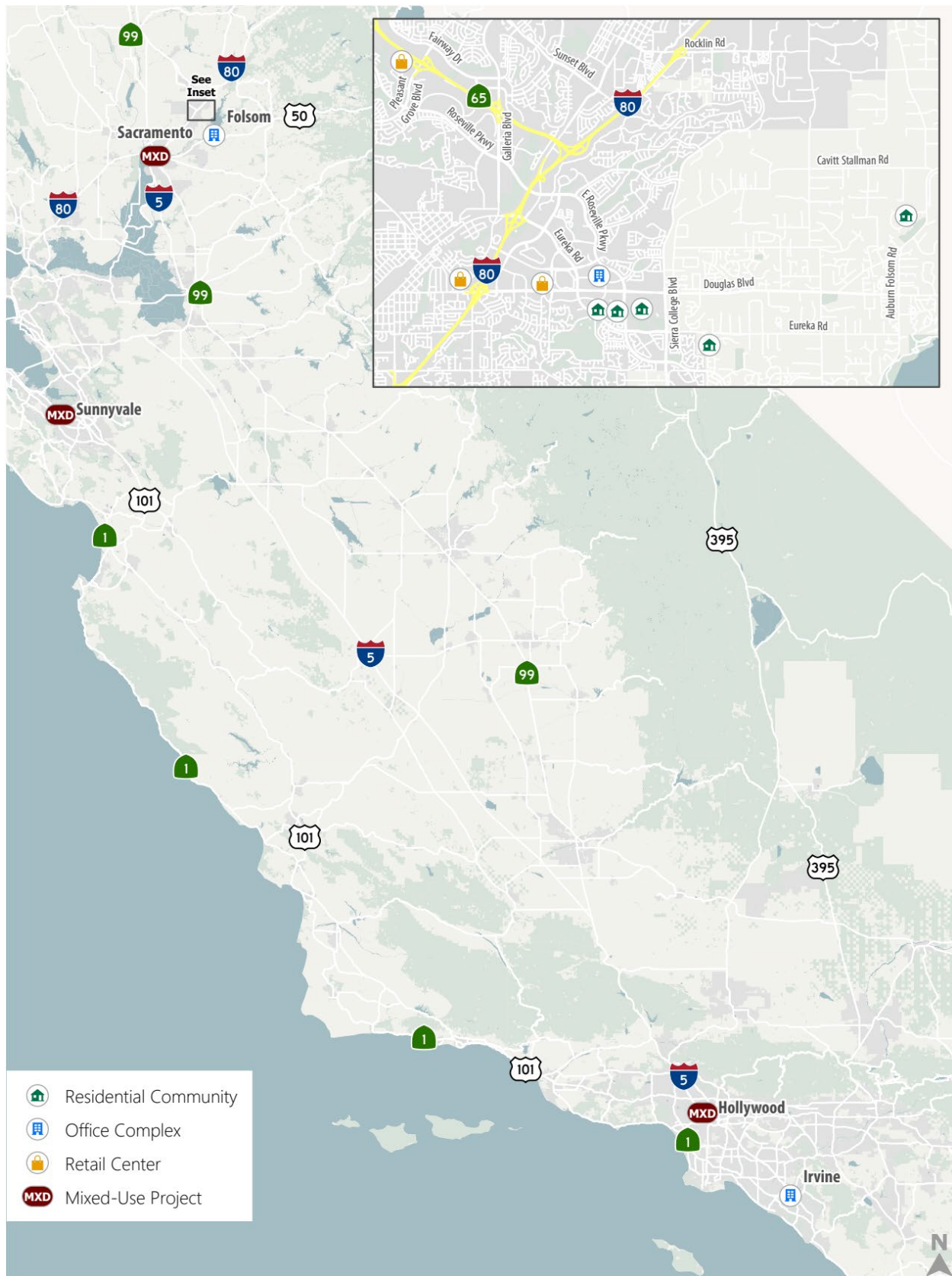


Figure 1: Site Locations

Unfortunately, Fehr & Peers did not perform any trip generation surveys at office buildings or office complexes between 2017 and 2019. However, given the vital importance of understanding current travel behavior at these uses, three large office complexes were selected for data collection in October 2023. Those sites are listed in **Table 2** along with the type of count equipment used. Two sites are situated in Northern California and one is situated in Southern California. Their locations are shown on Figure 1.

Table 2: Office Complex Study Sites		
Name	Location	Type of Count
Blue Ravine Folsom Office Complex	Folsom, CA	Hose tubes
Pacifica Irvine Office Complex	Irvine, CA	Hose tubes
Lava Ridge Roseville Office Complex	Roseville, CA	Hose tubes and video cameras

Source: Fehr & Peers, 2024.

Senate Bill 328

Senate Bill (SB) 328, which became effective on July 1, 2022, requires all public high schools in California to begin classes no earlier than 8:30 AM. In 2017 and 2019, high schools in the City of Roseville and Granite Bay began instruction around 7:30 AM with instruction concluding around 2:30 PM. To the extent SB 328 affected travel behavior, it is reflected in the Fall 2022 and 2023 traffic data.

Report Organization

Chapters 2 – 5 present the detailed traffic data and technical analysis for the residential, business professional, retail, and mixed-use projects, respectively. Each chapter consists of Study Locations, Data Collection, and Analysis Results subsections. Chapter 6 presents the study recommendations, which are oriented toward practitioners.

2. Residential

This chapter focuses exclusively on pre-COVID and current levels of trip generation at five different residential projects in Northern California.

Study Locations

Table 3 presents details of the single-family and multi-family sites chosen for study. As shown, all five sites are located within Placer County, which is part of the Sacramento Metropolitan Area.

Three of the five sites are located in the City of Roseville, a city with a population of 150,000 persons. Roseville is a typical suburban city: transit service is limited, parking is free, and the automobile is the predominant mode of travel. Roseville has numerous retail, restaurant, and entertainment options available to its citizens. According to data from the California State Controllers office, the City of Roseville ranked 9th highest in sales tax revenue per capita for Fiscal Year 2021 among the 182 California cities with at least 50,000 people.

Granite Bay is a generally affluent community located adjacent to Roseville in unincorporated Placer County. It has similar built environment characteristics as Roseville, though tends to be slightly more rural. **Image 2** shows an aerial image of the Shelborne Residential Community. Although it is situated in a rural setting, the community is only one mile from grocery stores, hardware stores, restaurants, etc.

Table 3: Residential Study Sites			
General Type	Name	Location	Description
Single Family Residential	Shelborne	Granite Bay, CA (Northern California)	88 single-family detached housing units
	Weddington	Granite Bay, CA (Northern California)	35 single-family detached housing units
	The Village	Roseville, CA (Northern California)	137 single-family detached housing units
Multi-Family Residential	Deer Valley Apartments	Roseville, CA (Northern California)	262 apartment units
	Slate Creek Apartments	Roseville, CA (Northern California)	612 apartment units

Source: Fehr & Peers, 2024.

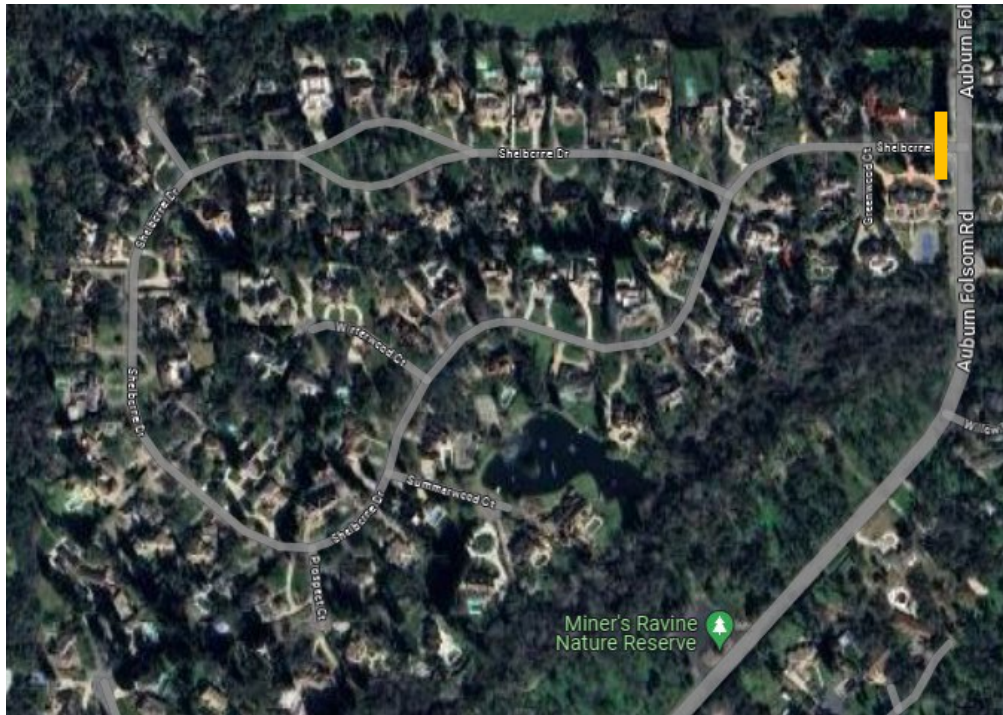


Image 2: Aerial of Shelborne Residential Community in Granite Bay, CA. Line shows hose tube location.

Data Collection Details

The following data collection methods were used for the five case study sites:

- Shelborne and Weddington Communities (Granite Bay, CA) – Hose tube counts were placed at the single entry/exit to each community for a Wednesday and Thursday in October 2017 and October 2023. Care was taken in the 2023 data collection to perform the count during the same week of October to control for any seasonal effects. The configuration of these communities allowed hose tubes to provide accurate readings of incoming and outgoing vehicles.
- The Village, Deer Valley Apartments, and Slate Creek Apartments (Roseville, CA) – The City of Roseville maintains a historic traffic count database² from which 15-minute volume data is recorded at all signalized intersections using the in-pavement loop detectors. For these three sites, average trip generation was calculated for every Tuesday, Wednesday, and Thursday between September 24, 2019 – October 31, 2019 and September 20, 2022 – October 27, 2022.

² One of the known limitations of the Roseville count database is how it handles vehicles turning right from a shared through/right lane (i.e., loop detector cannot differentiate between a through and right-turn vehicle). Review of this data showed unreasonably low right-turning traffic at these locations (though seemingly following a consistent estimation approach throughout the counts).

Analysis Results

Table 4 compares the two-day, averaged AM peak hour, PM peak hour, and daily trip generation rates at the single-family Shelborne and Weddington communities in Granite Bay, CA. At each location, the Thursday count day was found to be busier than the Wednesday count day (by 1% to 10%).

Table 4: Change in Residential Trip Rates (Pre-COVID to Fall 2023) at Granite Bay, CA Locations				
Time Period	ITE Trip Rate ¹	Pre-COVID (2017) Trip Rate ²	Fall 2023 Trip Rate ²	Change (Fall 2023 vs. Pre-COVID) ³
Shelborne (88 single family units)				
AM Peak Hour	0.70	0.97	0.89	-8%
PM Peak Hour	0.94	1.04	0.85	-18%
Daily	9.43	11.17	9.75	-13%
Weddington (35 single family units)				
AM Peak Hour	0.70	0.87	1.00	+15%
PM Peak Hour	0.94	0.93	1.19	+28%
Daily	9.43	10.46	10.59	+1%

Notes:

¹ Land Use Code 210 Single-Family Detached Housing weighted average trip rates from *Trip Generation Manual, 11th Edition* (Institute of Transportation Engineers, 2021).

² Based on an average of two count days.

³ Negative percentage means fewer trips in Fall 2023 versus pre-COVID condition. Positive percentage means the opposite.

Source: Fehr & Peers, 2024.

Table 4 reveals the following critical findings:

1. Trip rates at the Shelborne Community were 8% to 18% lower across all time periods in Fall 2023 versus pre-COVID conditions.
2. The Weddington Community showed considerable variation in trip making between the Fall 2023 Wednesday and Thursday counts. This could be due to the small sample size (i.e., 35 units) or the effect of a nearby (about one mile) public high school³ operating with regular instruction (3:20 PM release time) on Thursday, but a (non-mandatory) intervention period from 2:50 to 3:20 PM on Wednesday. Not surprisingly, the PM peak hour trip rate, which occurred from 3 to 4 PM was 37% greater on Thursday than Wednesday.

³ High schools (at least in California) have a much greater trip generation footprint than generations ago due to the combined effects of ineffective school bus programs (reduced funding for operation and lack of drivers), driving laws that result in more single occupant student drivers, and lower percentages of teens obtaining a drivers license (resulting in double the number of trips as student is dropped off and picked-up by parent, sibling, etc.).

This table also shows the weighted average trip generation rates⁴ for Single Family Detached Units (Land Use Code 210) contained in the *ITE TGM*. It is worth noting that these rates consist entirely of data collected in the pre-COVID era.

Table 5 compares pre-COVID versus current (Fall 2022) levels of trip-making during the AM peak hour, PM peak hour, and on a daily basis at The Village, Deer Valley Apartments, and Slate Creek Apartments. This table shows fewer trips being generated in Fall 2022 (relative to pre-COVID conditions) at each facility during each time period. On a daily basis, there were 5% to 11% fewer trips generated.

Table 5: Change in Trips Generated (Pre-COVID to Current) at Roseville, CA Residential Locations		
Time Period	Location	Change (Fall 2022 vs. Pre-COVID) ¹
AM Peak Hour	The Village	-7%
	Deer Valley Apartments	-3%
	Slate Creek Apartments	0%
PM Peak Hour	The Village	-1%
	Deer Valley Apartments	-8%
	Slate Creek Apartments	-26%
Daily	The Village	-5%
	Deer Valley Apartments	-8%
	Slate Creek Apartments	-11%

¹ For this comparison, data from September/October 2019 was compared against data from September/October 2022. Negative percentage means fewer trips in Fall 2022 versus pre-COVID condition.
Source: Fehr & Peers, 2024.

⁴ Throughout this report, weighted average trip rates are reported instead of applying the fitted curve equations provided in the *Trip Generation Manual*. This is out of necessity because the fitted curve equation will return different trip rates depending on the amount of land use. Using fitted curve equations would have resulted in unnecessary confusion when trying to explain trends.

Table 6 presents the weighted average (based on overall trip generation, which is a function of total units) reduction in trips at the five communities that were studied. Data collected in Fall 2022 or 2023 showed overall decreases in travel from 3% to 15% relative to pre-COVID conditions at the same sites.

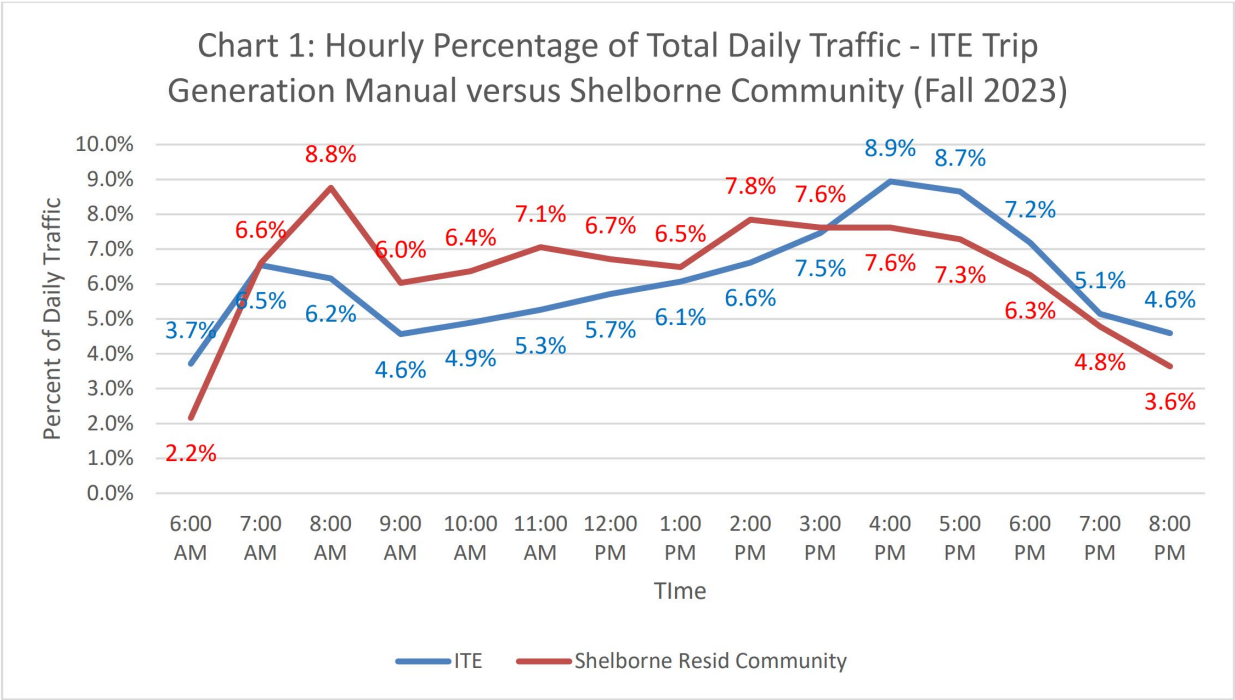
Table 6: Weighted Average Reduction in Residential Trips in 2022/2023 Versus Pre-COVID Conditions

Location	AM Peak Hour	PM Peak Hour	Daily
All Five Communities	-3%	-15%	-9%

Notes: Total trips in sample in the range of 500 to 600 during AM and PM peak hours, and 6,000 on a daily basis. Trip levels are equivalent of about 220 single-family units and 600 multi-family units.
Source: Fehr & Peers, 2024.

Chart 1 shows the percentage of daily traffic that occurred each hour between 6 AM and 9 PM for the Fall 2023 (Thursday) count at the Shelborne Community versus the published hourly volume data in the *Trip Generation Manual* (using Land Use Code 230, Single Family Detached Dwelling Units). The ITE data show two distinct spikes: 6.5% of total trips from 7–8 AM and 8.9% of total trips from 4–5 PM. The Shelborne Fall 2023 data shows different characteristics, notably:

- The AM peak hour occurs from 8–9 AM, with 8.8% of all trips being generated.
- The PM peak hour occurs from 2–3 PM, with 7.8% of all trips generated.
- For each hour between 8 AM and 3 PM, the percentage of daily trips at the Shelborne community is greater than the percentage from the *Trip Generation Manual*.



Key Takeaways (Residential):

1. Public high school start/end times in California are likely affecting peaks in residential travel, most notably bringing a strong potential for the PM peak hour to occur from 3-4 PM in areas near high schools.
2. Continued work-from-home preferences are likely contributing to less pronounced peaks in PM peak (commute period) travel and more dispersed travel across the course of the day. This trend may also be accelerated by increased ecommerce activities.

3. Business Professional

This chapter presents an in-depth review of measured trip generation at three business professional (office) complexes situated in Northern and Southern California.

Unlike residential, Fehr & Peers did not perform any pre-COVID counts at these locations or at other office complexes in the 2017–2019 timeframe. Thus, pre-COVID versus current condition comparisons are not possible. However, comparisons against *ITE TGM* rates are made and provide a barometer (along with other sources of data) for how travel to office complexes has changed since the COVID-19 pandemic.

Study Locations

As shown in **Table 7**, the three complexes are located in Roseville (Northern California), Folsom (Northern California), and Irvine (Southern California). This table also shows the total leasable square footage and the amount that was leased in Fall 2023. This data was derived from a variety of sources including the City of Roseville travel demand model, online literature reviews of available suites for lease, and measurement of smaller buildings using Google Maps. Table 7 shows that parking is free at all three locations, and transit service is modest (in terms of service quality/frequency) or not present. Refer to **Image 3** for aerial of the Pacifica Irvine Office Complex, which is the mid-point size of the 3 study sites.

Table 7: Office Complexes Counted in Fall 2023				
Name	Site Description	Square Footage	Transit Available?	Parking Free?
Blue Ravine Folsom Office Complex (Folsom, CA)	Includes 16 buildings accessed from Blue Ravine Road and Woodmere Road	768 KSF (736 KSF leased)	Yes, 30-minute headways peak commute periods only.	Yes
Lava Ridge Roseville Office Complex (Roseville, CA)	Includes 10 buildings accessed primarily from Lava Ridge Court, with a secondary driveway access onto Professional Drive	405 KSF (371 KSF leased)	No	Yes
Pacifica Irvine Office Complex (Irvine, CA) ¹	Includes 10 buildings accessed entirely from Pacifica.	604 KSF (604 KSF leased)	Yes. 45-minute headways.	Yes

Note:
¹ Located within the larger Irvine Spectrum development area. Project titled “Pacifica” to clarify its location within this larger development area.
KSF = thousand square feet.
Source: Fehr & Peers, 2024.

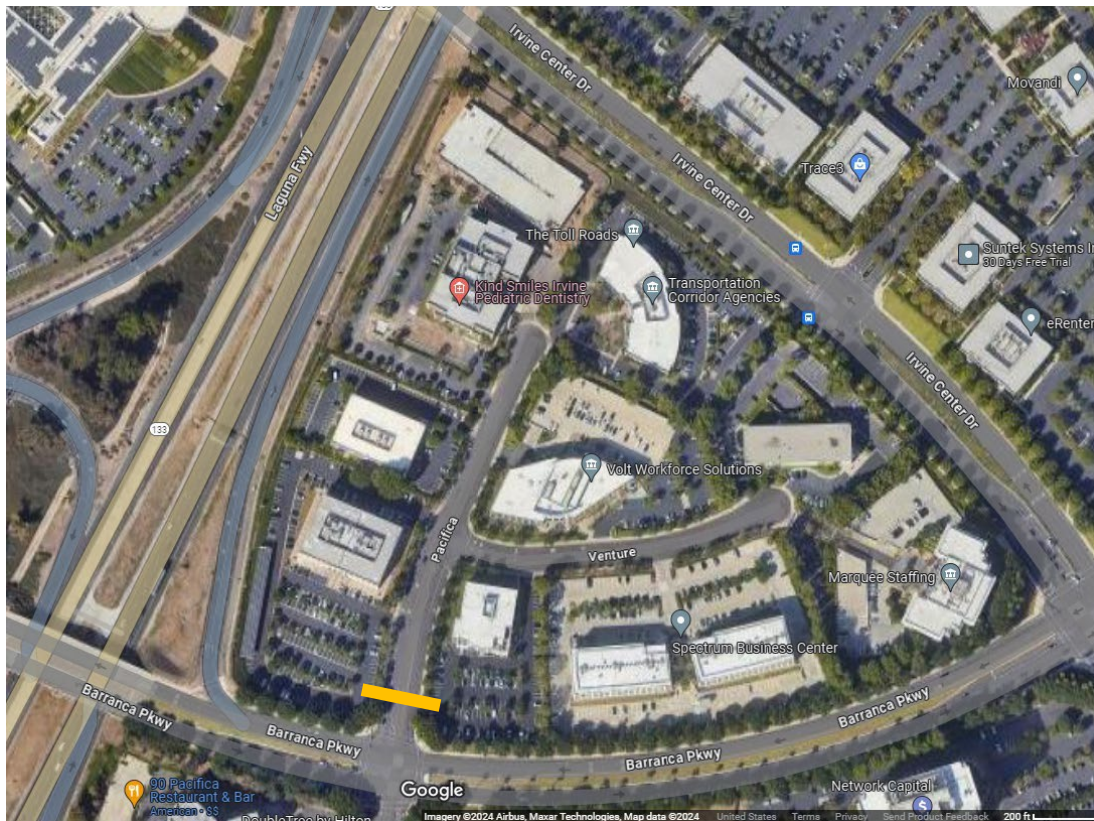


Image 3: Aerial of Pacifica Irvine Office Complex in Irvine, CA. Line shows hose tube location.

The data collection approach enabled understanding of which days of the week have higher versus lower levels of trips generated and how trip patterns entering/exiting each office complex have changed (as many employees now enjoy more flexibility regarding work start/end times). Finally, since the data collection includes the totality of all trips generated by these office complexes (and no other land use trips), it is possible to calculate and then compare the measured trip generation rates against *ITE TGM* averages.

Data Collection Details

Hose tube counts were placed at all three count locations in October 2023 to capture an entire workweek. The only exception was at the secondary access to the Lava Ridge Office Complex in Roseville, in which the driveway required the use of a video camera⁵. Given the configurations of each complex, the hose tubes could be situated along roadways where accurate readings are achieved and the office complex trips can be isolated in order to calculate trip generation rates.

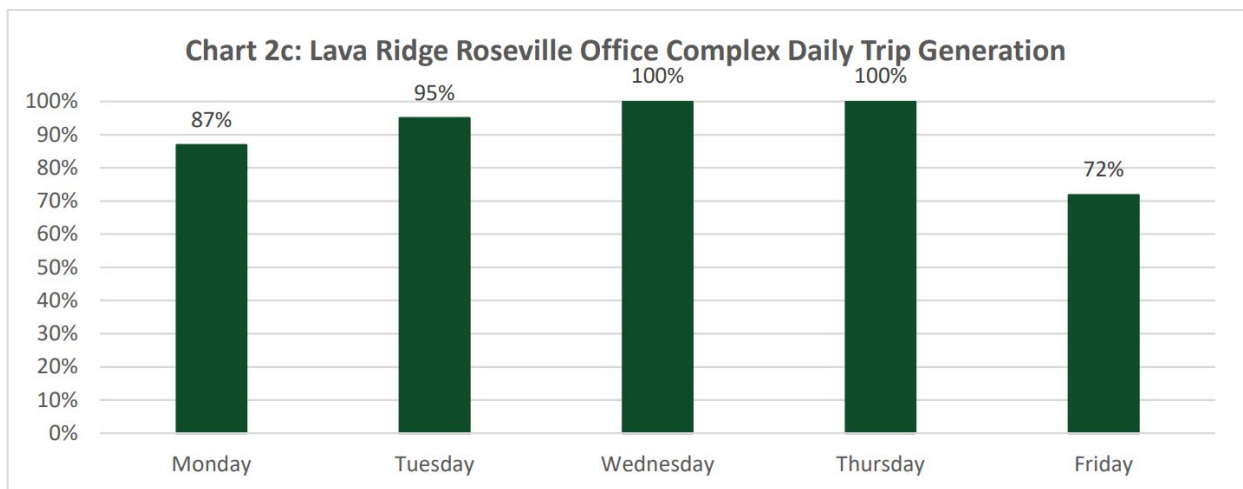
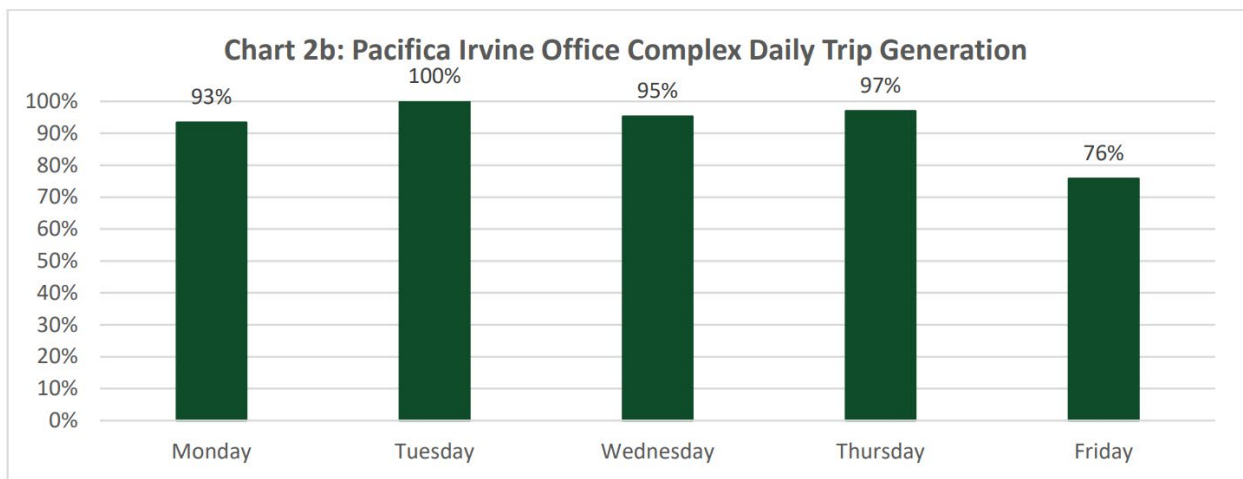
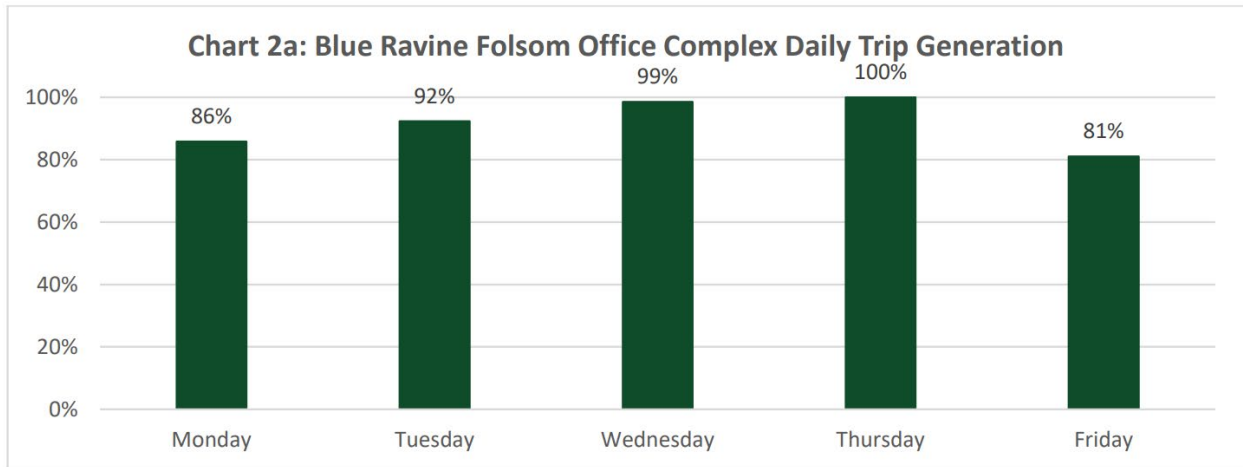
⁵ Due to cost considerations and knowing when office uses are busy versus not, the video camera was operational from 6 AM to 7 PM on the three mid-week days. To estimate usage on Monday and Friday and during the non-office hours, factoring of data from the hose tube counts was performed.

Analysis Results

Charts 2a – 2c on the following page show how each day of the workweek compares to the busiest day in terms of daily trips generated for each office complex. Key findings from this data are:

- Wednesdays and Thursdays were the busiest days at the Lava Ridge Roseville and Blue Ravine Folsom office complexes, while Tuesday was the busiest day at the Pacifica Irvine Office Complex.
- At each location, Friday was the least busy day.

This data was compared with data published by Kastle Systems, which is a company that specializes in managed security solutions for commercial and multifamily real estate and office workplaces nationwide. Kastle tracks access activity data from its KastlePresence app, keycard, and fob usage in the 2,600 buildings and 41,000 businesses they secure across 47 states. This enables anonymized data to identify trends in how employees are returning to the office.



According to Kastle data⁶, average office occupancy rates⁷ (for 10 large metropolitan areas across the US) have been steadily increasing from about 50% in 2022 to 61% in Fall 2024. However, this varies significantly by geographic area. In Spring 2024, metropolitan areas such as Austin, Houston, and Chicago were slightly above 70%, while San Jose and Philadelphia were slightly below 50%. In terms of busiest day of the week, they report Tuesday to be the busiest with Wednesday, and Thursday following close behind. Fridays are by far the lowest occupancy day of the week (33%).

Chart 3 shows the average daily trip rate per ksf of leased office space for each site during the three mid-week days. As shown, each site generated between 5.3 and 6.5 daily trips per ksf. This is substantially less than the *ITE TGM* average (for land use code 710, General Office Building) of 10.84 daily trips per ksf.

⁶ [Kastle Systems – Data Assisting in Return to Office Plans](#)

⁷ Expressed as the percentage of employees entering a given office building relative to pre-COVID conditions when visitation was nearly 100% across all five workdays.

Table 8 shows how each site compares against *ITE TGM* rates during all three time periods during each midweek day. The far right column is a helpful summary statistic that shows the average decrease of all three sites relative to the *ITE TGM* rates. Key findings from this data are:

1. During the AM and PM peak hours, the three sites show an approximate 56% to 59% decrease in trip rates when compared to the weighted average *ITE TGM* rate.
2. But on a daily basis, the average decrease is 45%, suggesting that a greater percentage of daily trips are now being made outside of the peak hours.⁸

Table 8: Comparison of Observed Trip Rates Versus ITE Averages at Office Complexes							
Time Period	Day of Week	ITE Rate ¹	Observed Trip Rates			Range of Decrease Relative to ITE TGM Rate	Average Decrease
			Blue Ravine Folsom	Pacifica Irvine	Lava Ridge Roseville		
AM	Tuesday	1.52	0.59	0.68	0.69	-55% to -61%	-57%
	Wednesday		0.67	0.56	0.77	-49% to -63%	-56%
	Thursday		0.64	0.62	0.59	-58% to -61%	-59%
PM	Tuesday	1.44	0.61	0.58	0.60	-57% to -60%	-59%
	Wednesday		0.72	0.61	0.57	-50% to -60%	-56%
	Thursday		0.70	0.57	0.58	-51% to -60%	-57%
Daily	Tuesday	10.84	6.01	6.39	5.31	-41% to -51%	-46%
	Wednesday		6.42	6.09	5.56	-41% to -49%	-44%
	Thursday		6.51	6.20	5.57	-40% to -49%	-44%

Note:
¹ *Trip Generation Manual, 11th Edition* (Institute of Transportation Engineers, 2021) for Land Use Code 710 General Office Building (Weighted Average Rate)
 Source: Fehr & Peers, 2024.

Charts 4a and 4b show the percentage of daily traffic entering and exiting, respectively, each site on an hourly basis from 6 AM to 7 PM. Also shown for comparison purposes is the hourly percent of daily traffic for office buildings from the *ITE TGM*.

⁸ This is confirmed through a simple AM+PM peak hour k-factor comparison:

- *ITE TGM* K-factor = (1.52+1.44) / 10.84 = 0.27
- 3 office complex k-factor (using averaged results) = (0.65+0.62) / 6.01 = 0.2

Chart 4A: Comparison of Hourly Inbound Traffic Percentage at Each Site Versus ITE TGM Estimates

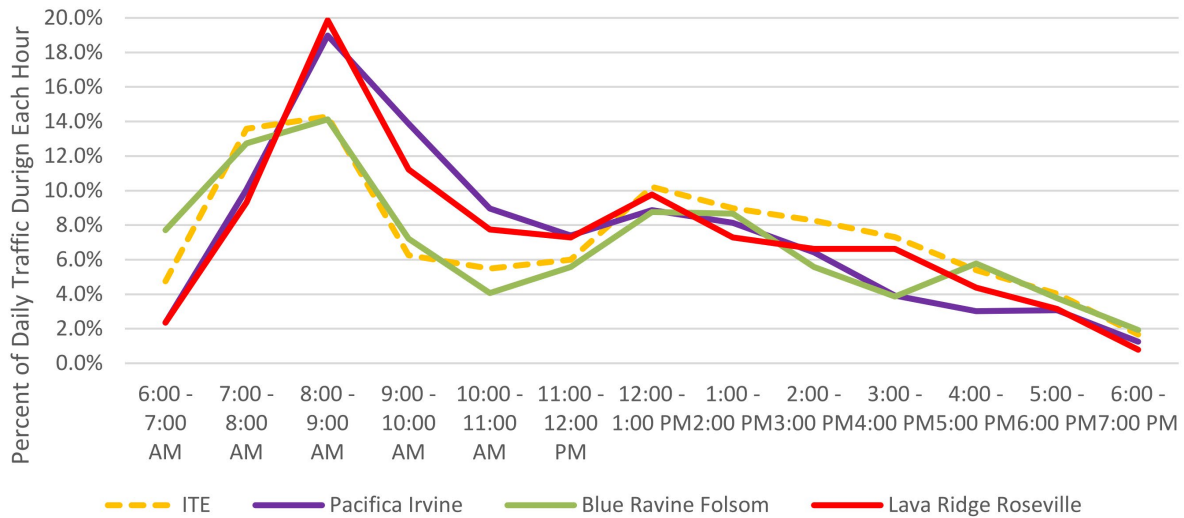
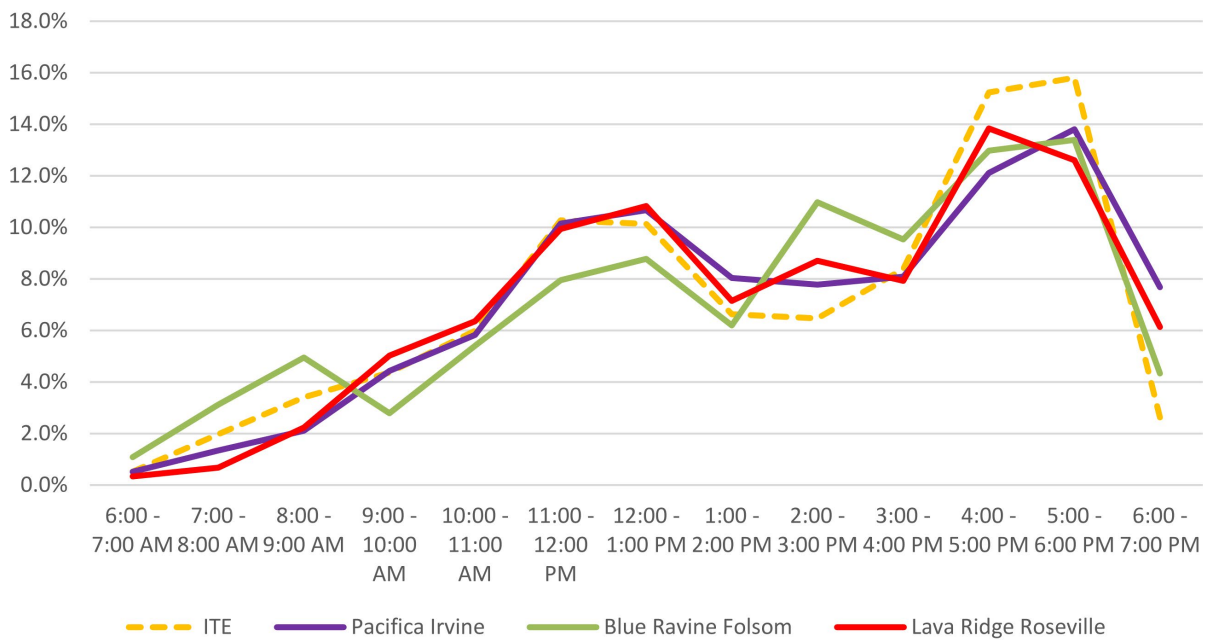


Chart 4B: Comparison of Hourly Outbound Traffic Percentage at Each Site Versus ITE TGM Estimates



Key findings from these charts are the following:

- **Inbound:** Arriving traffic at Lava Ridge Roseville and Pacifica Irvine has distinct spikes in arrivals from 8–9 AM (19–20% of all inbound traffic). This represents a much larger percentage of arriving traffic than ITE estimate of 14% during the AM peak hour. Yet despite this, the overall AM peak hour trip rates per ksf at both sites are much lower than the ITE weighted average.
- **Outbound:** Departing traffic during the traditional PM peak period (4–6 PM) at each site is about 26% of all departing trips, which is less than the ITE estimate of 31%. All three sites show a ‘mini-spike’ in departing traffic from 2–3 PM, representing a 40% increase over the ITE estimate for that hour.

Key Takeaways (Business Professional):

1. Office complexes are much busier on Tuesdays, Wednesdays and Thursdays than other weekdays, though there is not one specific day that is consistently the busiest.
2. Even during their single busiest day, the daily trip rate of each studied office complex was 40% to 50% lower than the *ITE TGM* trip rate. This result is consistent with Kastle Systems data indicating that employee occupancy is currently about 39% below pre-COVID levels (the general timeframe being what *ITE TGM* trip rates are based upon).
3. Inbound travel to each site peaked from 8-9 AM. At two of the sites, nearly 20% of all inbound traffic occurred during this hour (a sizeable increase over the ITE percentage of 14%).
4. Outbound travel from the three office complexes was dispersed throughout the afternoon/evening peak period.
5. Aside from the obvious trend of fewer employees in an office on a given day, several other factors may be at play including greater employee arrival/departure flexibility, later California high school start/end times, and less need for midday employee work travel (i.e., particularly noticeable in the inbound direction between noon and 4 PM).

4. Retail Centers

This chapter focuses on pre-COVID versus current (Fall 2022) levels of trip generating activity at three retail centers in Roseville, CA.

Study Locations

Table 9 lists the three retail centers chosen for study, all of which are situated within Roseville, CA. This table also displays the size of each center and its main tenants. Each site is situated in an area with limited transit service and abundant free parking. Refer to **Image 4** for the Roseville Center site.

Table 9: Retail Study Sites in Roseville, CA			
Name	Approximate Size	Main Tenants	Specific Count Location
Roseville Center	23 acres	Target, Petco, and Raley’s Grocery Store	Main signalized access off Douglas Blvd; site accessed by 6 other driveways
Roseville Square	20 acres	Trader Joe’s Grocery Store, Smart & Final, Planet Fitness, Rite Aid	Main signalized access off Harding Blvd; site accessed by 5 other driveways
Highland Pointe	44 acres	Walmart Supercenter, Sam’s Club, Chick Fil A	Main signalized access off Pleasant Grove Blvd; site accessed by 1 other driveway

Source: Fehr & Peers, 2024.



Image 4: Aerial of Roseville Center Shopping Center in Roseville, CA. Arrow shows signalized study intersection.

Data Collection Details

Similar to the three residential sites in Roseville studied in Chapter 2, this evaluation relies on the City of Roseville historic traffic count database to perform the analysis. Table 9 describes the specific signalized intersection, which is the main access to each site, chosen for the analysis.

For each site, the average number of trips generated during weekday PM peak hour and daily conditions was calculated for every Tuesday, Wednesday, and Thursday between September 24, 2019 – October 31, 2019 and September 20, 2022 – October 27, 2022. This equates to about 18 days of observations during each study period. Those values were then averaged to yield the results that follow. Data are not reported for AM peak hour conditions because retail centers generate relatively few trips during that time period.

Analysis Results

Table 10 compares pre-COVID (Fall 2019) versus current (Fall 2022) levels of trip-making during the PM peak hour and on a daily basis at Roseville Center, Roseville Square, and Highland Pointe.

Table 10: Change in Trips Generated (Pre-COVID to Current) at Roseville, CA Retail Locations				
Time Period	Change (Fall 2022 vs. Pre-COVID) ¹			
	Roseville Center	Roseville Square	Highland Pointe	Average Change
PM Peak Hour	+3%	-10%	-3%	-4%
Daily	-2%	-7%	-4%	-4%

¹ For this comparison, data from September/October 2019 was compared against data from September/October 2022. Negative percentage means fewer trips in Fall 2022 versus pre-COVID condition.
Source: Fehr & Peers, 2024.

Key findings from this table are:

- The Roseville Square and Highlight Pointe facilities showed decreases of 4% to 10% in Fall 2022 versus pre-COVID conditions.
- The Roseville Center site showed very modest changes between the two periods.

It is conceivable that increased levels in ecommerce activity could have played a role in the slight overall decrease.⁹ However, other factors may also be contributing to the results such as overall economic conditions (inflation, consumer confidence, gas prices, and store vacancies / understocking of shelves, etc.).

Key Takeaways (Retail):

1. A limited survey of retail centers in Roseville, CA found vehicle trip generation levels in Fall 2019 and Fall 2022 to be mostly unchanged. As a large number of observations at each site were recorded, the slight decreases were not caused by random variation but may have been attributable in part to other factors such as inflation, consumer confidence, gas prices, and store vacancies / understocking of shelves, etc.

⁹ According to Statista, ecommerce as a percentage of total retail sales in the US increased from 11% in 2019 to 15% in 2022. Source: [U.S. e-commerce share of retail sales 2019-2027 | Statista](#)

5. Mixed-Use Projects

This chapter focuses on pre-COVID versus current levels of trip generation at three mixed-use projects situated in Northern and Southern California.

Study Locations

Table 11 shows the location, acreage, approximate land uses and ADT as of 2019 (to provide a sense of scale), and dates of counts for each site. It is apparent from this table (based on trip generation totals and acreage) that the Columbia Square Hollywood and Cityline Sunnyvale sites are much denser than Gateway Oaks Sacramento. Columbia Square, situated directly on renowned Sunset Boulevard in Hollywood, is defined as high-rise multi-family. In contrast, Gateway Oaks residential is either low-rise multi-family or single-family detached units.

Table 11: Mixed-Use Study Sites						
General Type	Name	Location	Acreage	2019 Land Uses	2019 ADT	Dates of Counts
Mixed-Use Projects	Columbia Square Hollywood	Hollywood, CA	5	About 200 units, 500 ksf office, and retail.	5,500	November 2019 and November 2023
	Gateway Oaks Sacramento	Sacramento, CA	220	About 1,500 units, one million ksf office, and hotels.	19,400	October 2019 and October 2023
	Cityline Sunnyvale	Sunnyvale, CA	12	About 400 units, 550 ksf office, and retail.	8,700	November 2019 and November 2023

Source: Fehr & Peers, 2024.

Data Collection Details

The following data collection methods were used for the three case study sites:

- Gateway Oaks Sacramento – Hose tube counts were placed at the two points of access to this site (i.e., along Gateway Oaks Drive). Because this north-south road connects a pair of east-west arterials, it was necessary to exclude through trips from the trip generation calculations. Through trips were estimated using SACOG’s regional travel demand model and excluded from the site’s trip generation.
- Cityline Sunnyvale and Columbia Square Hollywood – Because trips generated by these uses enter/exit garages via driveways connecting to public streets, placing hose tubes was not possible. Instead, it was necessary to situate video cameras at various driveways to measure trips. Additionally, cameras were placed where project residents, employees, or customers were using on-street parking or getting dropped off or picked-up by taxi, Uber, or Lyft.

Analysis Results

Table 12 displays the relative change in AM and PM peak hour and daily trips generated at the three mixed-use sites.

Table 12: Change in Trip Generated (Pre-COVID to Current) at Mixed-Use Project Locations			
Time Period	Change (Fall 2023 vs. Fall 2019) ¹		
	Columbia Square Hollywood	Gateway Oaks Sacramento	Cityline Sunnyvale ²
AM Peak Hour	-34%	-34%	+4%
PM Peak Hour	-33%	-24%	+20%
Daily	-18%	-23%	-1%

¹ For this comparison, data from Fall 2019 was compared against data from Fall 2023. Negative percentage means fewer trips in Fall 2023 versus pre-COVID condition.

² Refer to text below for explanation of unique conditions adjacent to this site, which materially affected its trip generation. Source: Fehr & Peers, 2024.

Key findings from this table (along with additional explanatory information) are:

- During the Fall 2023 counts, all three projects had varying levels of vacant office space (this office space was occupied in Fall 2019):
 - 52,000 square feet of vacant office space in Columbia Square Hollywood in Fall 2023;
 - 240,000 square feet of vacant office space in Gateway Oaks Sacramento in Fall 2023; and
 - 380,000 square feet of vacant office space in Cityline Sunnyvale in Fall 2023.
- Assuming each ksf of office generates 6 trips per day (in accordance with findings from Chapter 3), this would account for 300 ‘missing’ daily trips generated by Columbia Square. This is not nearly sufficient to explain the 1,000 daily trip decrease from Fall 2019 to Fall 2023.
- Similarly, 6 daily trips per ksf for 240 ksf of vacant space at Gateway Oaks Sacramento would account for 1,400 ‘missing’ daily trips. Again, this is not sufficient to explain the 4,400 daily trip decrease from Fall 2019 to Fall 2023.
- Cityline Sunnyvale is a unique situation that requires more explanation and offers some lessons learned. Despite 380,000 square feet of vacant office space, only a 1% decrease in daily trips was observed between Fall 2019 and 2023. There are several factors that help explain this unexpected outcome:
 - A portion of the office building at 190 Mathilda Place (within the Cityline Sunnyvale study area) was undergoing renovations in Fall 2019. In 2020 or 2021, Uber Technologies opened a corporate office in this building, which may have been a

contributor to more trips being generated.

- Cityline Sunnyvale is situated immediately adjacent to a Caltrain rail station. According to Caltrain¹⁰, monthly ridership decreased by 67% from November 2019 to November 2023. This suggests that more workers and shoppers may have chosen to drive to Sunnyvale Station versus take the train.
- Just outside the Cityline Sunnyvale study area (just east of Frances Street) is a row of buildings (totaling about 80,000 square feet) that contain 20 different restaurants, breweries, a billiard hall, and specialty retail. Off-street parking for about 140 vehicles is provided (at a sufficient rate of 1.75 spaces per ksf). Importantly, a sign was erected sometime after November 2019 but before November 2023 indicating the additional parking is available to the west on Olsen Way. This effectively adds more vehicles into and out of the Cityline Sunnyvale cordon area, which are not associated with Cityline Sunnyvale land uses.

Key Takeaways (Mixed-Use Projects):

1. A pair of mixed-use projects originally counted in Fall 2019 showed sizeable across-the-board reductions (18% to 34%) in trips generated in Fall 2023. While each site had greater levels of vacant office space in Fall 2023, that empty space does not fully explain the degree of trip generation decrease. Absent any other explanatory factors (such as those identified at Skyline Sunnyvale), it is likely that the leased office space and residential are also generating trips at lower levels (similar to findings from Chapters 2 and 3).

¹⁰ [Statistics & Reports | Caltrain](#)

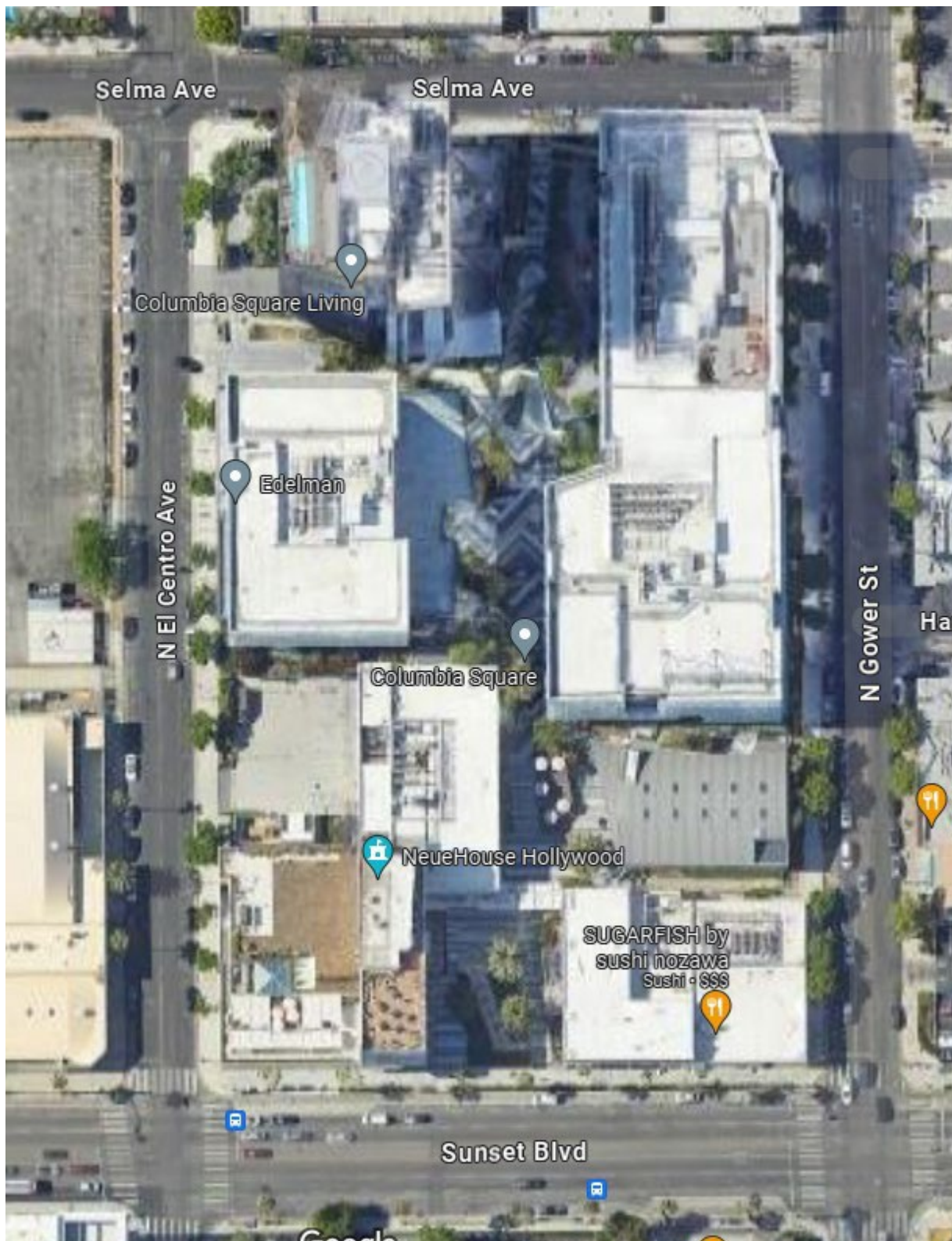


Image 5: Aerial of Columbia Square Hollywood Mixed-Use Project

6. Recommendations

The following recommendations are offered based on the data collected and analyses performed in the study.

Residential

1. Account for shifting trends in residential's peak hour of generator, which may include expanding the PM peak study period to cover 3 to 4 PM to account for school-related peaks (in California).
2. Locally-based data collection is recommended to establish trip rates for residential projects. Also applies to other land use types as well.
3. Use ITE hour of day percentage of daily trips data with caution as the data may no longer match current conditions.
4. Anticipate midday trips being higher than ITE observed data as more people are working from home and delivery trips are increasing with ecommerce.

Non-Residential

1. Direct use of ITE trip rates for office will significantly overestimate trips (provided current work-from-home preferences remain).
2. ITE rates appear to remain suitable for use when studying general shopping center type uses.
3. MXD+ applications for mixed-use projects should begin by carefully choosing which gross trip rates (prior to any internalization or external non-auto reductions) to use for residential and office uses. The MXD+ calculations themselves are believed to still provide reasonable estimates of external auto trips generated by mixed-use projects.