Richards Boulevard – Olive Drive Corridor

Transportation Analysis Report

December 2016

FEHR PEERS

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EXECUTIVE SUMMARY

This transportation analysis report has investigated the multimodal operational and safety effects of the following potential projects for the Richards Boulevard/Olive Drive corridor.

- Olive Drive to L Street Vehicle Connection – an extension of L Street to Olive Drive that is grade-separated from Second Street and the Union Pacific Railroad
- Olive Drive Freeway Exit Ramp Closure - closure of the I-80 westbound off-ramp to Olive Drive
- Olive Drive to Davis Transit Depot Pedestrian/Bike Connection
- Olive Drive and Pole Line Road Bike Path Connection

A transportation simulation analysis model was developed and validated to existing conditions to determine the change in vehicle operations at study intersections with the L Street extension and Olive Drive off-ramp closure alternatives. The analysis model includes pedestrian volumes at crosswalks and bicycle volumes through the study area.

Traffic forecasts were prepared for cumulative year (2035) conditions using the City of Davis travel demand forecasting model. The model included approved land uses plus proposed development projects including the Davis Hotel and Conference Center and Nishi/West Olive Drive Development. A second set of forecasts was analyzed that included project trips estimated for the Lincoln40 residential development, a student housing apartment complex proposed for Olive Drive east of Richards Boulevard.

Cumulative conditions also included three planned infrastructure projects: widening of eastbound Richards Boulevard at Research Park Drive, the Downtown Gateway Arch pedestrian/bicycle bridge over Richards Boulevard adjacent to the railroad, and the Richards Boulevard/I-80 Tight Diamond Interchange project that would reconstruct the I-80 westbound ramps at Richards Boulevard from a cloverleaf to a diamond configuration. In addition, the intersection improvements planned for the Richards Boulevard/Olive Drive intersection and the second Union Pacific Railroad grade crossing to serve the Nishi/West Olive Drive project were assumed to be constructed.

With planned development and transportation infrastructure, intersection operations in the study area are expected to operate with LOS E or better conditions. During the AM peak hour, the Richards Boulevard/I-80 Westbound Ramps intersections would have the highest delay due to inbound traffic heading towards downtown and UC Davis. During the PM peak hour, the First Street/D Street intersection would have the highest intersection delay due to queuing from the adjacent First Street/E Street/Richards Boulevard intersection. None of the proposed infrastructure projects were found to improve operations at this intersection.

The L Street Vehicle Connection would shift traffic volume from Richards Boulevard, Pole Line Road, and (to a lesser extent) Mace Boulevard. However, the roadway extension would bring more traffic to the Olive Drive/Richards Boulevard intersection resulting in the need to provide a second westbound left turn lane on Olive Drive to maintain LOS D conditions. The shift in travel patterns results in more traffic from the west using the Richards Boulevard tunnel causing LOS F conditions at First St/D Street. Additionally, the proposed Olive Drive/L Street intersection would operate at capacity (LOS E) during both peak hours and would be over capacity during both peak hours with the addition of the Lincoln40 traffic. Restricting the connection to only northbound traffic would reduce intersection delay.

The Olive Drive Freeway Exit Ramp Closure would shift westbound I-80 traffic from Olive Drive to the Richards Boulevard interchange. However, the planned signalized intersection at the Westbound I-80 Ramps with the Tight Diamond Interchange would have sufficient capacity to accommodate the additional traffic such that the ramp terminal and Olive Drive intersections would operate with LOS D or better conditions.

If both the L Street Vehicle Connection and Olive Drive Freeway Exit Ramp Closure projects were implemented, intersection delay at the Olive Drive/Richards Boulevard intersection would increase, but the LOS would remain the same as without the exit ramp closure. Additionally, operations at the Olive Drive/L Street intersection would improve. In fact, the volume for the east leg of the intersection would be low enough that the intersection may not need to be signalized. An alternate configuration that eliminates this leg in favor of a grade-separated alignment to serve Olive Drive east of L Street might be a lower-cost configuration.

The L Street Vehicle Connection scenario was further evaluated without the planned Richards Boulevard/ I-80 Tight Diamond Interchange project. While the new connection would divert some westbound I-80 traffic from Richards Boulevard to Olive Drive, the existing uncontrolled off-ramp to northbound Richards Boulevard would operate with LOS F conditions under cumulative conditions and the average maximum queue would extend almost to the freeway mainline during the AM peak hour. The PM peak hour would experience capacity and queuing issues at the eastbound off-ramp without the planned widening of the off-ramp approach to provide two left-turn lanes to southbound Richards Boulevard. Modest improvements to the existing interchange configuration (signalization of the westbound to northbound off-ramp and widening of the eastbound off-ramp) could improve intersection operations; however, safety issues with freeway weaving and pedestrian/bicycle crossings of the freeway ramps would not be addressed without the planned interchange improvements.

A design option for the L Street Vehicle Connection alternative was also evaluated that has a northbound-only connection and no extension of Second Street to K Street. This scenario would shift traffic demand on westbound Olive Drive back to southbound Richards Boulevard and improve operations at the Richards Boulevard/Olive Drive intersection. However, the intersection configuration at Third Street/L Street would be over capacity (LOS F conditions) under PM peak hour conditions. The right-of-way along L Street is not wide enough to fit the lanes needed to serve the demand both from Olive Drive and to/from Second Street.

Pedestrian accessibility provided by the proposed connections over the Union Pacific Railroad were assessed by determining the area occupied by parcels that could be reached within 15 minutes from the East Olive area. The L Street Vehicle Connection would increase accessibility to the area between downtown Davis and Pole Line Road up to Eighth Street on the north, more than doubling the area reachable within 15 minutes. The Davis Transit Depot connection would not increase access to as large an area, but the portion of downtown Davis near the Amtrak Station would be reachable within 10 minutes compared to the current 15 minutes via the Richards Boulevard tunnel. The Pole Line Road connection would provide a similar increase in area as the Davis Transit Depot connection, but the destinations would be primarily along Pole Line Road and include the Safeway-anchored shopping center at Cowell Boulevard to the south and the DMV office at Fifth Street to the north.

1.0 INTRODUCTION

This report presents the transportation analysis results for multimodal circulation improvements in the vicinity of Richards Boulevard and Olive Drive in Davis, CA. The alternatives include a multimodal connection between Olive Drive and Third Street along L Street, closure of the I-80 westbound off-ramp to Olive Drive, and pedestrian/bicycle only connections between Olive Drive at the Davis Transit Depot and at Pole Line Road.

STUDY AREA

Figure 1 shows the traffic study area. The following provides a brief description of key facilities.

First Street serves as the southern border of downtown Davis and serves as the primary connection between downtown and the UC Davis campus. The street serves as a principal commuter route between UC Davis and I-80. The street has a mix of residential, office, and commercial uses with the larger Davis Commons retail center located south of First Street between D Street and Richards Boulevard.

Richards Boulevard is the primary access to I-80 for downtown Davis and serves as one of four connections between south Davis and the rest of the city. The nearest connection to the east, Pole Line Road, does not connect to the triangular area bounded by the Union Pacific Railroad, I-80, and Richards Boulevard. Within the study area, Richards Boulevard connects E Street at First Street to Cowell Boulevard at Research Park Drive. The speed limit is 35 mph and on-street parking is prohibited. Between First Street and Olive Drive, Richards Boulevard passes beneath the Union Pacific Railroad. In this section, the street has one lane in each direction with no on-street bike lanes, but a (Class I) shared-use path on the south side of the roadway is provided for pedestrians and bicyclists.

Between Olive Drive and Research Park Drive, Richards Boulevard is primarily a four-lane street (two lanes in each direction) with (Class II) on-street bicycle lanes. In summer 2016, flexible delineators were installed in the median between Olive Drive and I-80 to restrict driveway access to right-in and right-out movements except for the Caffé Italia driveway. Pedestrian travel is served by an attached sidewalk on the west side of the roadway. Pedestrian crosswalks are provided only at Olive Drive and Research Park Drive. Sidewalks are present on the east side only for the first parcel east of Olive Drive and first parcel north of Research Park Drive. Bus stops are located on northbound Richards Boulevard on the far side of Research Park Drive and on the near side of Olive Drive.

1 Study Intersections

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Figure 1

Study Area

I-80 is primarily an east-west freeway that connects the San Francisco Bay Area with the Sacramento metropolitan area and the Central Valley. The Richards Boulevard interchange has a loop off-ramp and a diagonal on-ramp in the eastbound direction and a full cloverleaf configuration in the westbound direction. The westbound ramp terminal intersection has free movements from the off-ramps where off-ramp traffic merges with local street traffic. The eastbound ramp terminal intersection is signalized. An isolated westbound off-ramp to Olive Drive is provided about 0.6 miles east of Richards Boulevard.

Olive Drive is a two-lane, east-west road serving parcels located between I-80 to the south and the Union Pacific Railroad to the north. East of Richards Boulevard, the street terminates at the westbound off-ramp from I-80. The speed limit is 30 mph, and on-street (Class II) bicycle lanes are provided. To the west, the road ends in a cul-de-sac near Putah Creek, and a connection to the Putah Creek Trail is provided. The speed limit is 25 mph, and on-street parking is prohibited near Richards Boulevard for the westbound approach and departure and the eastbound approach. Sidewalks are provided for pedestrians along both sides of Olive Drive at Richards Boulevard. Land uses along Olive Drive at Richards Boulevard are highway and general commercial. Residential parcels – apartment complexes and a mobile home park – are located to the east.

Research Park Drive is a two-lane street that runs parallel to I-80 to the east and south of the freeway. South of Richards Boulevard/Cowell Boulevard, Research Park Drive serves office buildings and apartment complexes, and the posted speed is 25 mph. To the north, the land uses are office and highway commercial, and the posted speed is 35 mph. On-street (Class II) bicycle lanes are provided along the length of the street.

Third Street is a two-lane collector street that runs east-west through the middle of downtown Davis connecting the UC Davis campus at A Street in the west to L Street in the east. In the study area, three corners of the Third Street/K Street have single family homes. The block bounded by Third Street, K Street, L Street, and Second Street is an electrical substation. The northwest corner of Third Street/L Street is a commercial center.

L Street is a two-lane north-south collector street ends at the Union Pacific Railroad. The south end of the road connects to Second Street, which continues to the east along the north side of the railroad. In the study area, a PG&E maintenance yard is located east of L Street.

The study intersections are listed below.

1. Third Street/K Street
2. Third Street/L Street
3. Olive Drive/Arbor Apartments driveway

4. First Street/D Street
5. First Street/E Street/Richards Boulevard
6. Olive Drive/Richards Boulevard
7. I-80 Westbound Ramps/Richards Boulevard
8. I-80 Eastbound Ramps/Richards Boulevard
9. Research Park Drive/Cowell Boulevard/Richards Boulevard

REPORT ORGANIZATION

The remainder of this report is organized into the following sections:

- *Chapter 2 – Existing Conditions:* summarizes the current AM, midday, and PM peak hour traffic volume, queue length, and travel time data collected in the study area, and presents the analysis results conducted for the study intersections
- *Chapter 3 – Project Alternatives*: describes the planned transportation projects in the study area and the concepts for improving multimodal access along Olive Drive
- *Chapter 4 – Cumulative Conditions Forecasts:* describes the development of the AM and PM peak hour travel demand forecasts
- *Chapter 5 – Cumulative Conditions Analysis:* summarizes the AM and PM peak hour intersection operations analysis of the proposed alternatives and evaluates the effects of the proposed alternatives on accessibility for pedestrians and bicyclists

2.0 EXISTING CONDITIONS

This chapter describes the current operating conditions of the study area.

ANALYSIS METHODOLOGY

The study intersections were analyzed using procedures consistent with the *Highway Capacity Manual* (Transportation Research Board, 2010). The Vissim (version 8.00-06) transportation analysis software was applied to model interactions among travelers and the roadway network. This microsimulation analysis models the behavior of motor vehicles, bicyclists, and pedestrians as they travel along the roadway network and follow traffic control devices.

The level of service (LOS) was assigned to the study intersections to evaluate traffic operations. LOS is a qualitative measure of traffic operating conditions whereby a letter rating, from A (the best) to F (the worst), is assigned. These ratings represent the perspective of drivers and are an indication of the comfort and convenience associated with driving. The descriptions of the level of service (LOS) letter ratings for signalized and unsignalized intersections are provided in **Table 1**. For unsignalized intersections with some movements uncontrolled, the intersection LOS is determined by the controlled movement with the highest delay.

The *City of Davis General Plan* (December 2013) identifies LOS E as the minimum acceptable LOS for intersections during peak hours although LOS F is acceptable for the "Core Area and Richards Boulevard/Olive Drive area."

TABLE 1: INTERSECTION LOS THRESHOLDS

Level of Service	Description	Average Delay[1]	
		Signalized	Unsignalized
A	Operations with very low delay occurring with favorable progression and/or short cycle length.	≤ 10	≤ 10
B	Operations with low delay occurring with good progression and/or short cycle lengths.	> 10 to 20	>10 to 15
C	Operations with average delays resulting from fair progression and/or longer cycle lengths. Individual cycle failures begin to appear.	> 20 to 35	>15 to 25
D	Operations with longer delays due to a combination of unfavorable progression, long cycle lengths, or high V/C ratios. Many vehicles stop and individual cycle failures are noticeable.	> 35 to 55	>25 to 35
E	Operations with high delay values indicating poor progression, long cycle lengths, and high V/C ratios. Individual cycle failures are frequent occurrences.	> 55 to 80	>35 to 50
F	Operation with delays unacceptable to most drivers occurring due to over saturation, poor progression, or very long cycle lengths.	> 80	>50

Note: 1. Average delay is reported in seconds per vehicle.
Source: *Highway Capacity Manual* (Transportation Research Board, 2010).

TRAFFIC DATA

Peak period intersection turning movement counts were collected at eight study intersections on Wednesday, May 18, 2016. Schools, including UC Davis, were in session on this midweek day. Because the Third Street/K Street intersection was added as a study intersection later, the volumes are estimated based on the Third Street/L Street counts collected for this study, the Third Street/J Street counts collected for the Trackside Center study, and adjacent land uses. The AM peak hour was 8:00 to 9:00 AM, the midday peak hour was 12:30 to 1:30 PM, and the PM peak hour was 5:00 to 6:00 PM. The peak hour factors for the study area were 0.91, 0.92, and 0.94 for the AM, midday, and PM peak hours, respectively. Bicycle turning movement volumes were recorded separately from the motor vehicle volumes. Pedestrian counts were collected for the crosswalks at the study intersections. **Figure 2** shows the AM, midday, and PM peak hour intersection turning movement volumes. The bicycle and pedestrian peak hour volumes are shown in **Figure 3**.

Concurrent with the traffic counts, field observations were conducted of the Richards Boulevard corridor. The observations collected travel time along the Richards Boulevard corridor using the floating car method and recorded the maximum queue length at the study intersections.

OPERATIONS MODEL DEVELOPMENT

Development of the street network and traffic volumes that comprise the Vissim models required the input of geometric, traffic control and traffic flow data, each of which is described in this section. An overview of the micro-simulation model development process is described below.

Roadway geometric data (traffic lanes, turn pockets, bus lanes, bus stop locations, etc.) were gathered using aerial photographs and field observations. Lane configurations were initially taken from aerial photographs and were then confirmed or revised based on field observations.

Signal timing plans for the traffic signals in the study area were provided by city staff. The signal timing settings include vehicle and pedestrian signal phases. The posted speed limits for streets in the study area were collected during field observations. Maximum vehicle speeds in the model are consistent with posted speed limits, although random speed variability is assigned to each vehicle, causing them to drive above or below the speed limit, to mimic prevailing driver behavior.

Fehr & Peers collected intersection vehicular turning movement counts at the study intersections during the AM peak period (7:00 to 9:00 AM), midday peak period (11:30 AM to 1:30 PM) and PM peak period (4:00 to 6:00 PM). For each model file, the peak one hour of flow in the AM, midday, and PM peak periods was used as the analysis period. The volumes were then balanced between intersections. Balancing is the adjustment of turning movement volumes to reduce unexpected changes in through volumes between adjacent intersections. Where balancing was performed, the volumes were balanced to the higher volume to provide for a conservative analysis.

The pedestrian and bicycle volumes were directly modeled through use of pedestrian crossing counts and bicycle turning movement counts taken at the same time as the intersection vehicle turning movement counts.

The Vissim models were validated to existing conditions using criteria suggested by the Federal Highway Administration (FHWA) and additional criteria developed by Fehr & Peers. A number of iterations were required to successively adjust the default Vissim parameters for driver behavior until the model was validated to observed conditions. Validation criteria and results are presented later in this memorandum.

Because micro-simulation models like Vissim rely on the random arrival of vehicles, multiple runs are needed to provide a reasonable level of statistical accuracy and validity. The models were run up to twenty times (each using a different random seed number), and then the ten most average runs were selected and averaged to determine model results.

MODEL CALIBRATION

During calibration of a microsimulation model, individual components are adjusted to match collected and field-observed data. Calibration of a model is necessary to ensure that the model provides a visually accurate depiction of the field-observed condition and that model outputs can be trusted to inform the best possible analysis.

Adjustments to the VISSIM models focus on the model components related to driver behavior including yielding right-of-way at intersections, driver performance such as aggressiveness, vehicle fleet mix, and vehicle performance. In particular, roadway links with bicycles traveling in the regular traffic lane have been adjusted so that bikes can be overtaken on the left provided that the lane is wide enough to provide acceptable clearance.

MODEL VALIDATION

During validation, the VISSIM model output is compared against field data to determine if the output is within acceptable levels. FHWA (Traffic Analysis Toolbox Volume III – Guidelines for Applying Traffic Microsimulation Modeling Software, 2003) suggests the following validation criteria:

- Link volumes for more than 85 percent of cases meet the following criteria:
  - For volumes less than 700 vph, within 100 vph
  - For volumes between 700 and 2,700 vph, within 15 percent
  - For volumes greater than 2,700 vph, within 400 vph
- Link volumes for more than 85 percent of cases have a GEH statistic less than 5 (a measure of how well the model replicates actual conditions)
- Sum of link volumes within 5 percent
- Sum of link volumes have a GEH statistic less than 4
- Signals create visually acceptable queuing and agree with observed conditions

Fehr & Peers has developed the following additional validation criterion, which has a narrower tolerance for intersection volumes (which are aggregated link volumes) than the criteria suggested by FHWA.

- Peak-hour volumes for more than 85 percent of intersections within 5 percent of traffic counts

Table 2 shows how the results for the existing conditions Vissim models compare to the validation criteria thresholds. The results reflect the average of 10 micro-simulation model runs.

TABLE 2: VALIDATION CRITERIA THRESHOLDS COMPARISON

Criteria	Criteria Threshold	Target for % Met	Peak Hour	% Met/ Value	Pass/Fail
Link Volumes					
< 700 vph	±100 vph	> 85%	AM Midday PM	100% 100% 100%	Pass Pass Pass
between 700 & 2,700 vph	±15%				
> 2,700 vph	±400 vph				
GEH Statistic	< 5.0	> 85%	AM Midday PM	100% 100% 100%	Pass Pass Pass
Sum of Link Volumes					
Sum of All Links	±5%	--	AM Midday PM	-0.1% -1.8% -0.2%	Pass Pass Pass
GEH Statistic	< 4.0	--	AM Midday PM	0.2 2.4 0.3	Pass Pass Pass
Aggregated Volumes					
Intersections	±5%	>85%	AM Midday PM	89% 100% 100%	Pass Pass Pass
Visual Inspection					
Queuing	match observations		AM Midday PM	-- -- --	Pass Pass Pass

Source: Fehr & Peers, 2016

TRAFFIC OPERATIONS

Existing intersection lane configurations, signal timings, and peak-hour turning movement volumes were used to calculate the intersection operations during each peak hour. The results of the transportation analysis using the Vissim software program for existing conditions are presented in **Table 3**. Detailed results are provided in the appendix.

TABLE 3: INTERSECTION OPERATIONS – EXISTING CONDITIONS

Intersection	Traffic Control	AM Peak Hour	Midday Peak Hour	PM Peak Hour
1. Third St/K St	Side Street Stop	A / 7 (SB RT)	A / 6 (SB RT)	A / 7 (SB LT)
2. Third St/L St	Side Street Stop	A / 8 (EB LT)	B / 10 (EB LT)	C / 16 (EB LT)
3. Olive Dr/Arbor Apartments Driveway	Side Street Stop	A / 8 (NB LT)	A / 6 (NB LT)	A / 7 (NB LT)
4. First St/D St	Signal	B / 16	B / 18	C / 29
5. First St/E St/Richards Blvd	Signal	C / 28	C / 24	C / 28
6. Olive Dr/Richards Blvd	Signal	C / 33	B / 19	D / 36
7. I-80 WB Ramps/Richards Blvd	Uncontrolled	n/a	n/a	n/a
8. I-80 EB Ramps/Richards Blvd	Signal	C / 32	C / 22	E / 63
9. Research Park Dr/Cowell Blvd/Richards Blvd	Signal	C / 29	C / 24	C / 29

Note: LOS and average control delay is reported in seconds per vehicle. For uncontrolled intersections, the movement with the highest delay is reported in parentheses.

Source: Fehr & Peers, 2016

The results show that all study intersections currently operate at acceptable service levels (LOS C or better) during the AM peak hour. Midday peak hour operations are similar to the AM peak hour north of I-80. The midday peak hour average delay for the I-80 Eastbound Ramps and Research Park Drive intersections are lower than the AM peak hour.

During the PM peak hour, the study intersections have LOS C or better conditions with two exceptions. The Olive Drive/Richards Boulevard intersection has a delay of 36 seconds per vehicle, which is just above the LOS C/D threshold. The eastbound and westbound approaches have the highest delay. The I-80 Eastbound Ramps/Richards Boulevard intersection has LOS E conditions. The delay occurs primarily on the off-ramp approach, and the queue can extend back to the Richards Boulevard overcrossing. Although the above study intersections do not exceed their theoretical capacity, the existing peak period traffic demand is high, and long queues have been observed due to the effects of the closely-spaced intersections along Richards Boulevard.

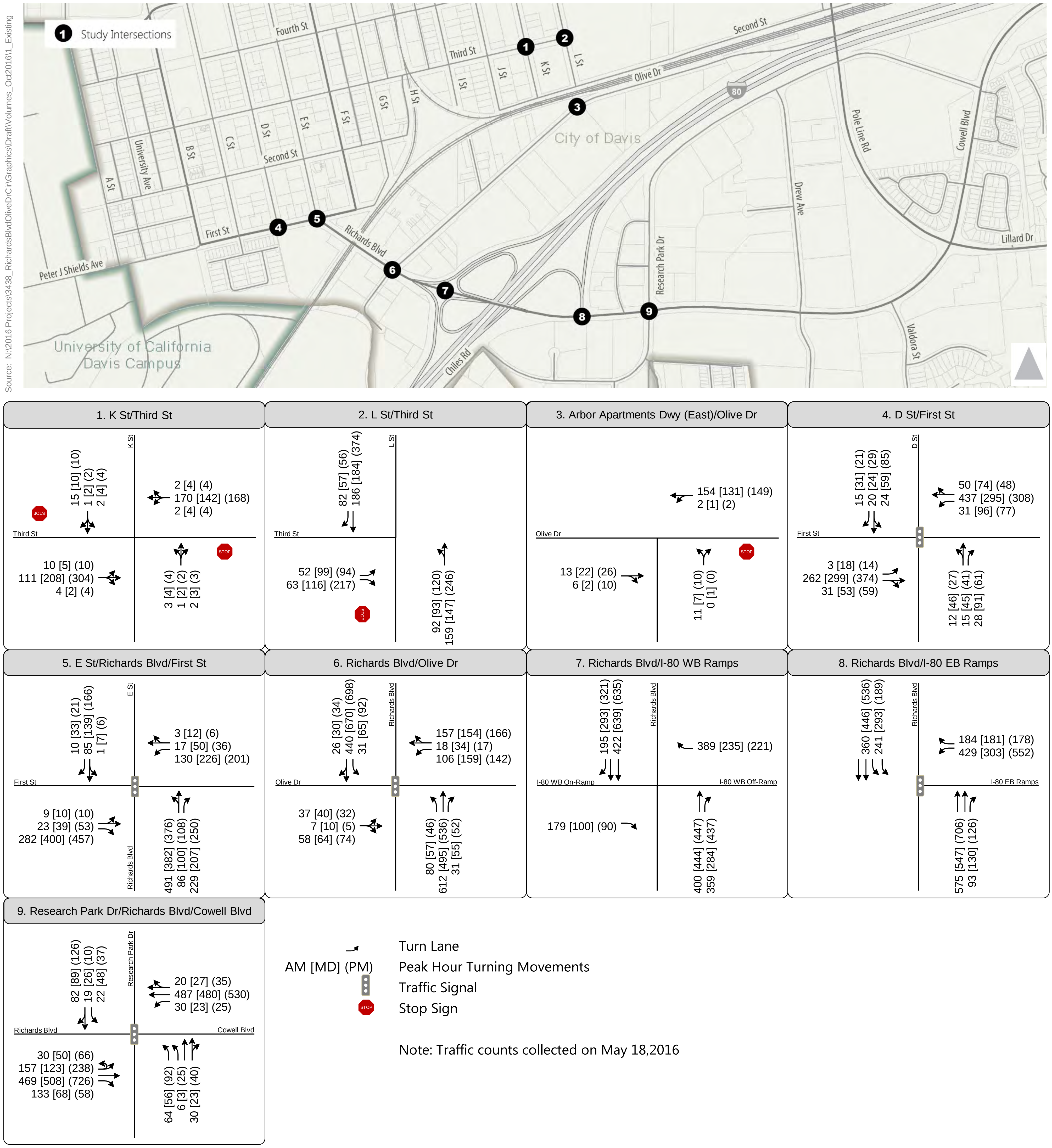

Figure 2

Peak Hour Traffic Volumes and Lane Configurations Existing Conditions

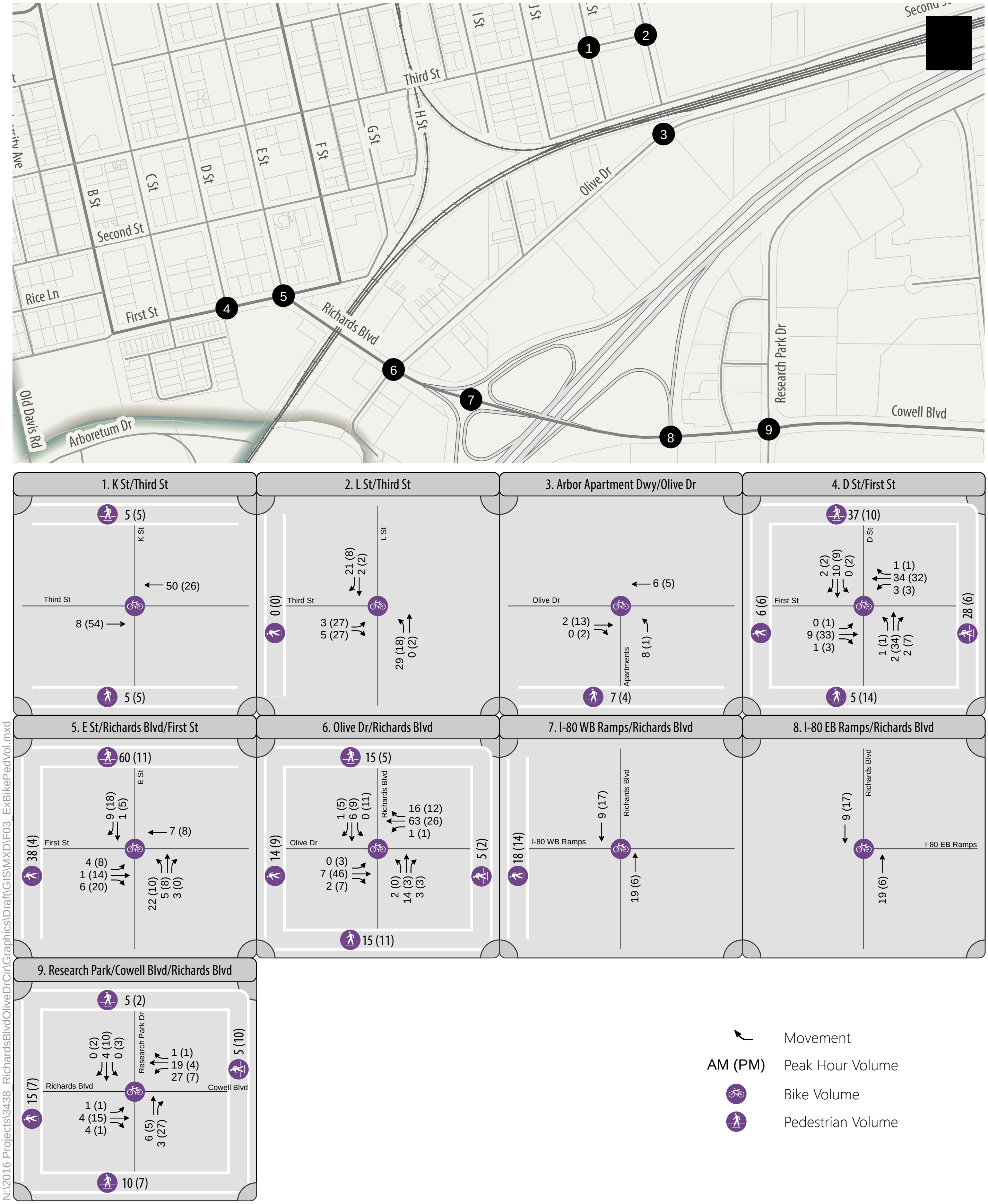

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Figure 3

Peak Hour Bicycle and Pedestrian Volumes
Existing Conditions

[redacted]

COLLISION HISTORY

Collision data from SWITRS was provided for Richards Boulevard by the City of Davis for 2009 to 2014. **Table 4** summarizes the collision data on local streets within the project study limits by analysis location and by collision type, respectively. A total of 46 collisions occurred in the study area. The Olive Drive intersection had the most collisions at 21. Bicycles were involved in 12 of the 46 collisions, but pedestrians were involved in only 1. The most-frequent collision type was rear end (37 percent), followed by other (24 percent) and hit object (15 percent).

TABLE 4: INTERSECTION COLLISIONS BY TYPE

Richards Blvd Intersection	Head On	Side Swipe	Rear End	Broad-side	Hit Object	Over-turn	Auto-Ped	Other
First Street/E Street	1	0	3	1	1	0	1	0
Olive Drive	0	1	9	2	3	0	0	6
I-80 Westbound Ramps	1	0	2	0	1	0	0	3
I-80 Eastbound Ramps	0	0	0	0	0	0	0	0
Research Park Drive/ Cowell Boulevard	1	0	3	3	2	0	0	2
Total	3 (7%)	1 (2%)	17 (37%)	6 (13%)	7 (15%)	0 (0%)	1 (2%)	11 (24%)

Note: All collisions listed under the other category involved a bicyclist.
Source: SWITRS 2009 to 2014 as reported by the City of Davis

At the intersection with the highest number of collisions, Olive Drive, one-third of the collisions involved bicyclists. The narrow roadway at the railroad underpass means that bicyclists use the shared path on the west side of Richards Boulevard. Crossing movements at the intersection increase the conflict points between motorists and bicyclists. The most frequent collision type was rear end collisions, which are associated with the congestion at the intersection. The primary collision factor in six collisions was an auto right-of-way violation. This may be caused by the permissive left-turn signal phasing used to control the Olive Drive approaches to the intersection.

3.0 PROJECT ALTERNATIVES

The planned roadway projects and proposed project alternatives are presented in this chapter.

PLANNED TRANSPORTATION PROJECTS

All cumulative conditions alternatives analyzed in this report assume that the following projects will be constructed.

- Research Park Drive/Cowell Boulevard/Richards Boulevard Intersection Improvements
- Richards Boulevard/I-80 Tight Diamond Interchange Reconfiguration
- Downtown Gateway Arch

Each of these projects is described below.

The eastbound approach to the Research Park Drive/Cowell Boulevard/Richards Boulevard intersection is planned to be widened to provide a left-turn pocket lane. The existing left turn lane would become a second through lane. The east leg of the intersection would be widened to accept the second through lane although the right lane would be dropped a short distance downstream. The widening would minimize queues that can affect the Richards Boulevard/I-80 Eastbound Ramps intersection.

The westbound ramps at the I-80/Richards Boulevard Interchange are proposed to be converted from a cloverleaf to a tight diamond configuration. The Project Study Report shows that the relocated ramp terminal intersection would be signalized with the lane configuration shown in Figure 7. The proposed project incorporates planned widening of the Richards Boulevard/Olive Drive intersection to accommodate growth west of Richards Boulevard (on the Nishi Gateway and Davis Hotel Conference Center sites, which are described below). The project includes a grade-separated multi-use trail on the west side of the roadway between Olive Drive and Research Park Drive. In addition, a raised median would be installed to prohibit left turn movements at driveways located between Olive Drive and I-80. The eastbound off-ramp approach at Richards Boulevard would be widened to provide a second left-turn lane.

The Downtown Gateway Arch is a proposed bicycle/pedestrian bridge located on Richards Boulevard between the Union Pacific Railroad and Olive Drive. The bridge would provide an alternative to crossing Richards Boulevard at the Olive Drive intersection. The improvements at this location include a separate bicycle/pedestrian pathway and tunnel on the east side of Richards Boulevard to match the existing pathway and tunnel on the west side.

L STREET VEHICLE CONNECTION

The Olive Drive to L Street Vehicle Connection alternative would construct a grade-separated crossing of the Union Pacific Railroad by extending L Street south to Olive Drive. Both overpass and underpass options are being considered, but the lane configurations are the same for both. As shown in **Figure 4**, L Street would be grade-separated from both the railroad and Second Street. Second Street would be extended west to K Street and traffic would then be directed north to Third Street. At Olive Drive/L Street, the southbound approach would be limited to right turns, and the eastbound approach would be limited to left turns. On the same alignment, Olive Drive would have a eastbound-only lane at grade level to serve driveways to the south. Due to the grade difference, U-turn movements would be needed east and west of the L Street intersection to serve out-of-direction travel.

DAVIS TRANSIT DEPOT PEDESTRIAN/BIKE CONNECTION

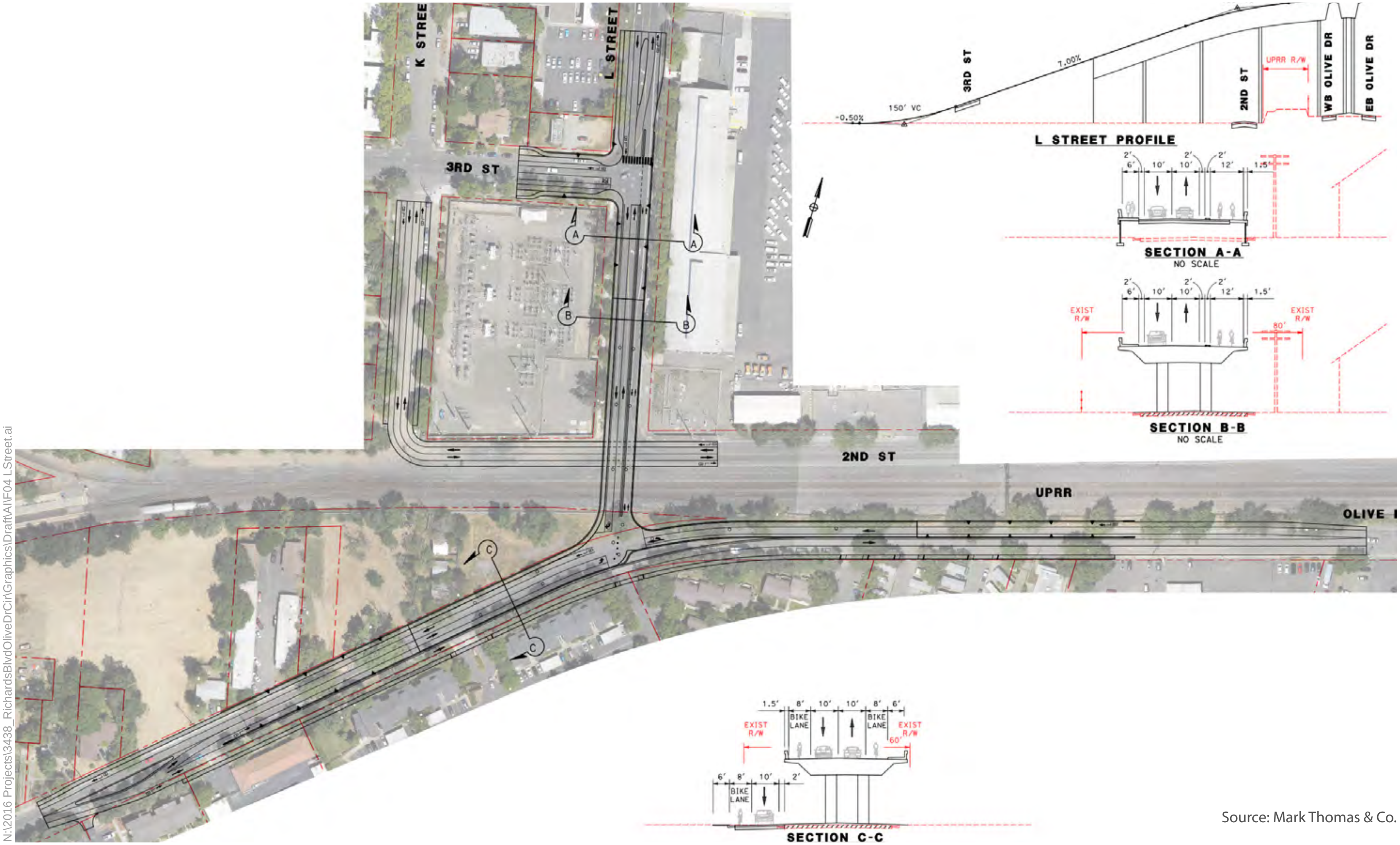
The Olive Drive to Davis Transit Depot Pedestrian/Bike Connection alternative would construct a mixed-use pathway to connect Olive Drive near the Lexington apartments and the Amtrak train station as shown in **Figure 5**. On the south side, the pathway would rise from grade to bridge the railroad tracks. On the north side, a spiral or switchback structure would be used to return back to grade.

POLE LINE ROAD BIKE PATH CONNECTION

The Olive Drive and Pole Line Road Bike Path Connection alternative would construct a bicycle/pedestrian pathway to connect Olive Drive to Pole Line Road near I-80. The path would start from the existing bicycle path that runs between I-80 and Union Pacific Railroad from Olive Drive east towards Sacramento. A switchback structure, as shown in **Figure 6**, would be constructed so that pedestrians and bicyclists could ascend to the Pole Line Road overcrossing of Second Street, the Union Pacific Railroad, I-80, and Research Park Drive.

OLIVE DRIVE FREEWAY EXIT RAMP CLOSURE

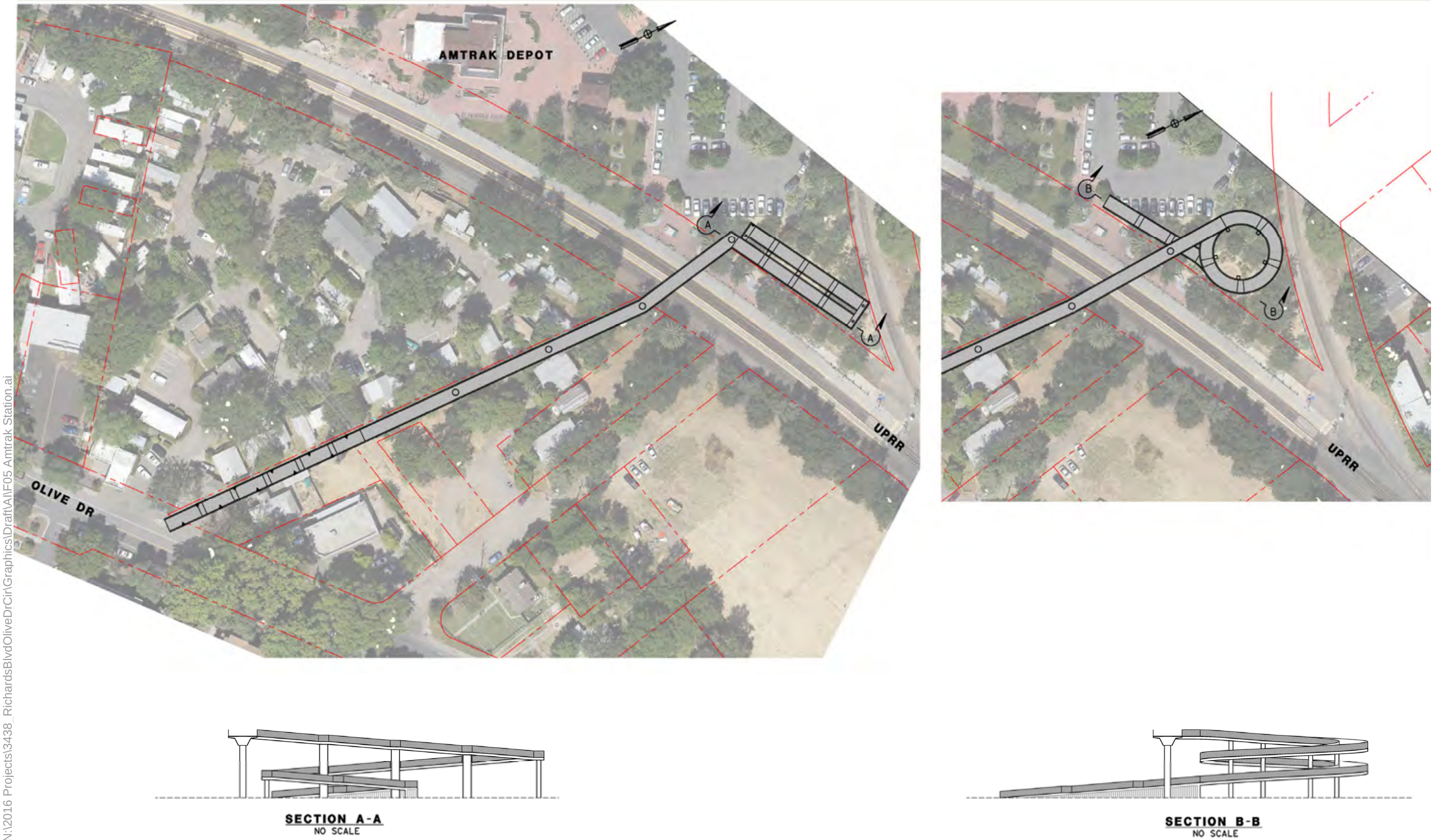
The Olive Drive Freeway Exit Ramp Closure alternative would close the I-80 westbound off-ramp to Olive Drive. Traffic currently using this exit would divert to the westbound off-ramp at Richards Boulevard.



Source: Mark Thomas & Co.

Figure 4

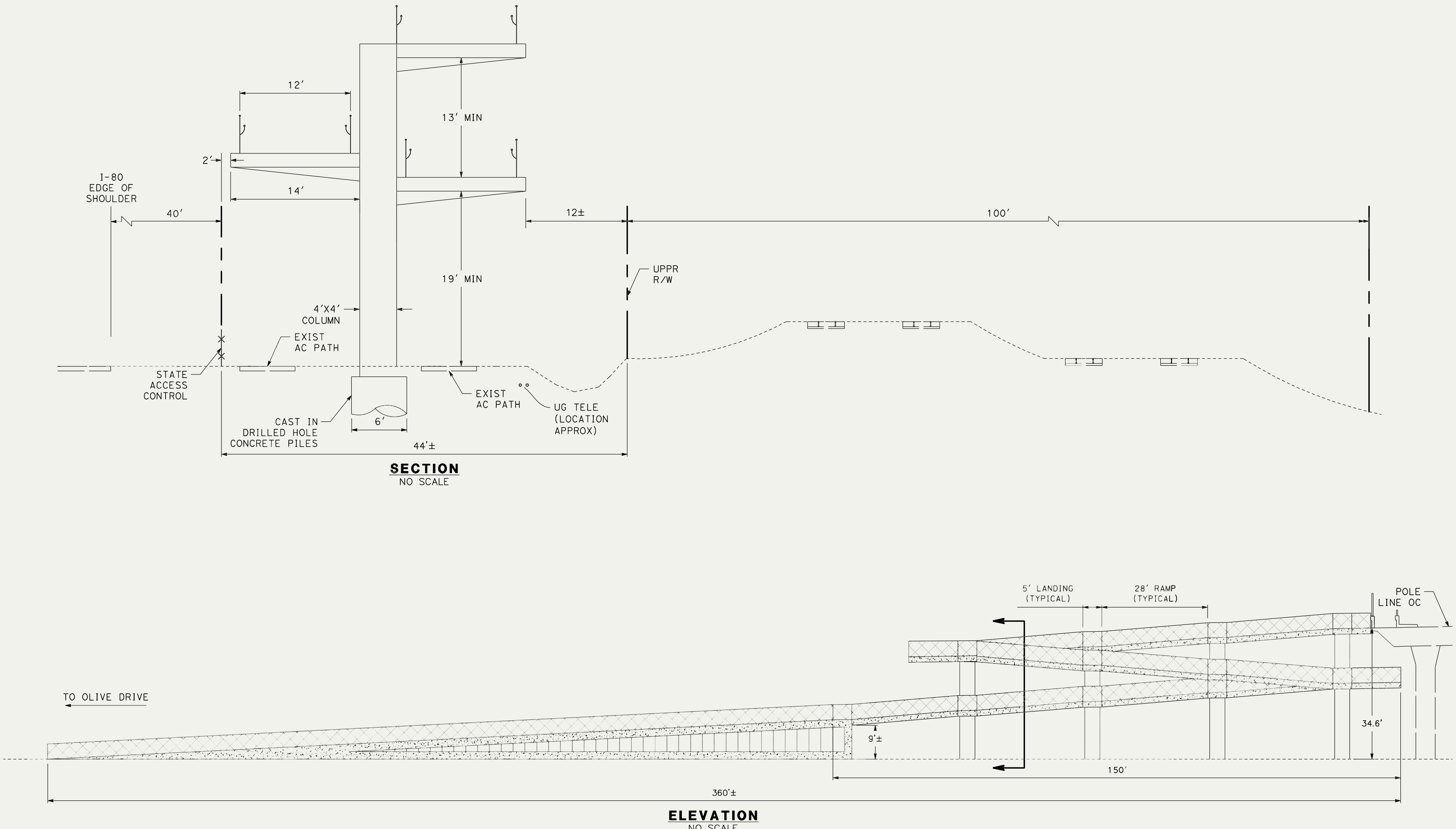
L Street Vehicle Connection



Source: Mark Thomas & Co.

Figure 5

Davis Transit Depot Pedestrian/Bike Connection



Source: Mark Thomas & Co.

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Figure 6

Pole Line Road Bike Path Connection

4.0 CUMULATIVE CONDITIONS FORECASTS

This section describes the development of traffic forecasts for cumulative conditions using the City of Davis travel demand forecasting model.

MODEL REVIEW

The base year model was reviewed for use in the project study area. The model speed was adjusted for several links so that the two-way link volumes in the base year model better matched observed counts. The model uses one traffic analysis zone (TAZ) for the west Olive area (west of Richards Boulevard between the railroad and I-80 and one for the east Olive area (east of Richards Boulevard between the railroad and I-80). To simplify the volume development, the volumes were distributed among the driveway intersections in the operations model rather than subdivide the TAZs in the forecast model.

PLANNED DEVELOPMENT

The City of Davis travel demand forecasting model was used to prepare forecasts that include build-out of the city's general plan under 2035 conditions plus the following proposed projects.

- Mace Ranch Innovation Center – located north of I-80 and east of Mace Boulevard that would include 1.51 million square feet of research and development/office, 884,000 square feet of manufacturing, 150,000 square feet of hotel/conference center, and 100,000 square feet of retail land uses
- Davis Hotel and Conference Center – located west of Richard Boulevard between Olive Drive and I-80 that would replace the 43-room University Inn & Suites Hotel and Caffe Italia restaurant with a 132-room Embassy Suites hotel, a restaurant, and a 14,900 square-foot conference center
- Nishi / West Olive Drive Development – located in the triangle formed by I-80, the Union Pacific Railroad, and Putah Creek that would include 650 residential units, 325,000 square feet of research and development/office, and 20,000 square feet of retail uses

The Mace Ranch Innovation Center is officially "on hold" while the plans are being revised. The site is likely to have some level of development by cumulative conditions, so it has been retained in the transportation forecasting model to provide a conservatively high estimate for future transportation demand.

The Nishi / West Olive Drive project has two circulation options – one or two external connections. The option with two external connections (to Richards Boulevard and to UC Davis) was selected for this assessment. Although the planned Nishi project was defeated in a recent election, the property is likely to be developed in some fashion by cumulative conditions. For this analysis, the previously proposed project was assumed although the actual development may be smaller in scope.

Lincoln40 Residential Development is a planned apartment complex located between Olive Drive and the Union Pacific Railroad. The project proposes to build 130 apartments oriented to students attending UC Davis. The forecasts associated with this project were prepared outside of the city's travel demand forecasting model using data from similar student housing complexes in Davis. The draft memorandum provided in the appendix presents the approach for estimating project vehicle trip generation based on similar student-oriented housing in Davis. Lincoln40 was estimated to generate 62 AM peak hour trips and 85 PM peak hour trips. The three-quarters of the AM peak hour trips are outbound, and the PM peak hour trips are about evenly split between the inbound and outbound directions. The vehicle trips are approximately evenly distributed towards the freeway and towards downtown, with slightly more trips heading to and from downtown. The Lincoln40 scenarios analyzed in this report use these estimates for trip generation and distribution.

The final memorandum on the Lincoln40 trip generation and distribution (also included in the appendix) shows lower traffic volumes of 45 AM and 63 PM peak hour trips based on further trip generation studies. This information was not available in time for the analysis of the Richards Boulevard-Olive Drive corridor. Since the revised trip estimates are lower, the impact of Lincoln40 trips will likely be less than reported below.

The bicycle and pedestrian volume generated by Lincoln40 was estimated by looking at the planned increase in housing units with Lincoln40 compared to the existing housing units along Olive Drive between Richards Boulevard and Arbor Apartments Driveway. The Lincoln40 project would provide about 27 percent more housing units. As a result, the Lincoln40 bicycle volume on Olive Drive east of Richards Boulevard was estimated as 27 percent of the current bicycle volume. Similarly, the pedestrian volume for the crosswalks across Richards Boulevard was assumed to be 27 percent of the current pedestrian volume. The pedestrian volume on the Olive Drive crosswalks was assumed to be a nominal volume of a few additional pedestrians.

PROJECT ALTERNATIVES

The travel demand forecasting model was modified to prepare forecasts for the following project alternatives.

- No Build

- L Street Vehicle Connection
- Olive Drive Freeway Exit Ramp Closure
- L Street Vehicle Connection and Olive Drive Freeway Exit Ramp Closure

Traffic forecasts were prepared separately for the Lincoln40 project based on its expected trip generation and distribution. The Lincoln40 project trips were added to the forecasts prepared with the travel demand forecasting model to generate the traffic forecasts for the scenarios that include the Lincoln40 project.

The No Build alternative model file includes the planned development projects listed above. The L Street Vehicle Connection alternative adds a two-lane link from Third Street/L Street to Olive Drive, disconnects Second Street from L Street, and extends Second Street to K Street. The Olive Drive Freeway Exit Ramp Closure alternative starts with the No Build alternative and removes the connection between westbound I-80 and Olive Drive.

The raw model volumes from the L Street Vehicle Connection alternative were compared to the No Build alternative to check for reasonableness. A screen line taken at the Union Pacific Railroad from Richards Boulevard to Mace Boulevard showed that the L Street Extension would have about 1,000 more vehicles per hour during the AM peak hour and about 900 more vehicles during the PM peak hour. The L Street extension would cause volumes to drop at the three existing crossings (Richards Boulevard, Pole Line Road, and Mace Boulevard) although most would divert from Richards Boulevard.

FORECASTING PROCEDURE

The motor vehicle forecasts were prepared using the difference method on origin-destination matrices. To do this, an origin-destination matrix for the study area under existing conditions was prepared. The base year model was used as a seed matrix, and a matrix estimation procedure was run in the Visum software to adjust the seed matrix until the assigned volume matched the balanced existing conditions intersection turning movements.

The cumulative year matrices for the study area were then extracted from the forecasting model. To develop the forecasts, the difference between the cumulative year and base year origin-destination pair from the model files was added to the existing conditions matrix that matched the counts. Any resulting origin-destination values that were negative were set to zero.

The resulting cumulative conditions matrices were assigned to the study area roadway to determine the forecasted intersection turning movement volumes. The cumulative turning movement volumes were compared to existing turning volumes. For the No Build alternative, volume was manually added to origin-destination pairs so that turning movement volumes did not decrease. For the L Street Vehicle Connection alternative, decreases were allowed where traffic was expected to re-route due to the new roadway connection.

Further review of the origin-destination patterns showed several unlikely volume increases that were corrected.

- For the No Build and alternatives with the L Street Vehicle Connection, some traffic from westbound I-80 used Olive Drive to travel to downtown Davis during the AM peak hour. This traffic was shifted to use the westbound off-ramp at Richards Boulevard.
- For the L Street Vehicle Connection alternatives, the new connection attracted trips from East Davis to the Research Park Drive/Cowell Boulevard intersection. Given the likely congestion at the Olive Drive/Richards Boulevard intersection, this traffic (about 150 vehicles per hour during the AM peak hour and 100 vehicles per hour during the PM peak hour) was shifted to use the Pole Line Road overcrossing.
- Also for the L Street Vehicle Connection alternatives, the re-routing of the Second Street connection to K Street made K Street north of Third Street attractive to vehicles continuing to the north. To prevent this, traffic calming measures could be installed to discourage through traffic. The volume on this leg was reduced to current levels, and the difference was shifted to use the Third Street leg to the west.

Bicycle and pedestrian volumes were assumed to increase by 20 percent by cumulative conditions. For the L Street Vehicle Connection alternatives, about 10 AM and PM peak hour bicycle trips were assumed to shift from Pole Line Road and Richards Boulevard to L Street at the Union Pacific Railroad.

Figures 7 and 8 show the No Build intersection turning movement volumes for motor vehicles, bicycles, and pedestrians under cumulative conditions. **Figures 9 and 10** show the L Street Vehicle Connection intersection turning movement volumes for motor vehicles, bicycles, and pedestrians under cumulative conditions. **Figure 11** shows the Olive Drive Freeway Exit Ramp Closure intersection turning movement volumes for motor vehicles under cumulative conditions, and **Figure 12** shows the volumes for the L Street Vehicle Connection and Olive Drive Freeway Exit Ramp Closure alternative. Since bicycle and pedestrian connections would be unaffected with the off-ramp closure, the bicycle and pedestrian intersection volumes would be the same as the No Build alternative shown in **Figure 8** and the L Street Vehicle Connection alternative shown in **Figure 10**, respectively.

The motor vehicle trips generated by the Lincoln40 apartments were assigned to the network and added to the previously prepared forecasts to create additional scenarios. Bicycle and pedestrian traffic generated by Lincoln40 was added to the network in a similar fashion as the motor vehicle trips. The "with Lincoln40" volumes for the project alternatives are provided in **Figures 13 through 18**.

The need for signal control at the Third Street/K Street, Third Street/L Street, and Olive Drive/L Street under the L Street Vehicle Connection alternative was confirmed by conducting the peak hour signal warrant (California Manual on Uniform Traffic Control Devices, 2014). Based on the cumulative conditions peak hour volumes, the peak hour signal warrant was met under both peak hours at all three study intersections (see appendix for details). In conjunction with the signalization, additional turn pockets would be needed at the Third Street intersections to accommodate the cumulative demand volumes. At Third Street/K Street, a westbound left-turn pocket is needed to accommodate the volume heading towards Second Street and an eastbound left-turn lane can be provided to shadow the lane across the intersection. To handle the opposite direction flow from Second Street, a northbound right turn lane is needed. At Third Street/L Street, the northbound left turn lane should be extended and an eastbound right turn lane should be added to accommodate the demand from Olive Drive. These turn pocket lanes could be created or extended by removing on-street parking adjacent to the intersections.

The L Street Vehicle Connection would increase the traffic volume on Olive Drive between the new connection and Richards Boulevard as a result of the shift in traffic routes from the Richards Boulevard tunnel. With this shift in volume, the westbound left-turn volume from Olive Drive to Richards Boulevard would be higher than 300 vehicles per hour, a planning level threshold for adding a second left turn lane, during both peak hours. An initial model run with a single left-turn lane showed poor operations (high delay and a long queue). As a result, the alternatives with the L Street Vehicle Connection include widening of the Richards Boulevard/Olive Drive intersection to provide a second westbound left-turn lane. **Figures 9, 12, 15** and **18** show this additional lane and the widening of the Third Street and L Street intersections and associated traffic control changes.

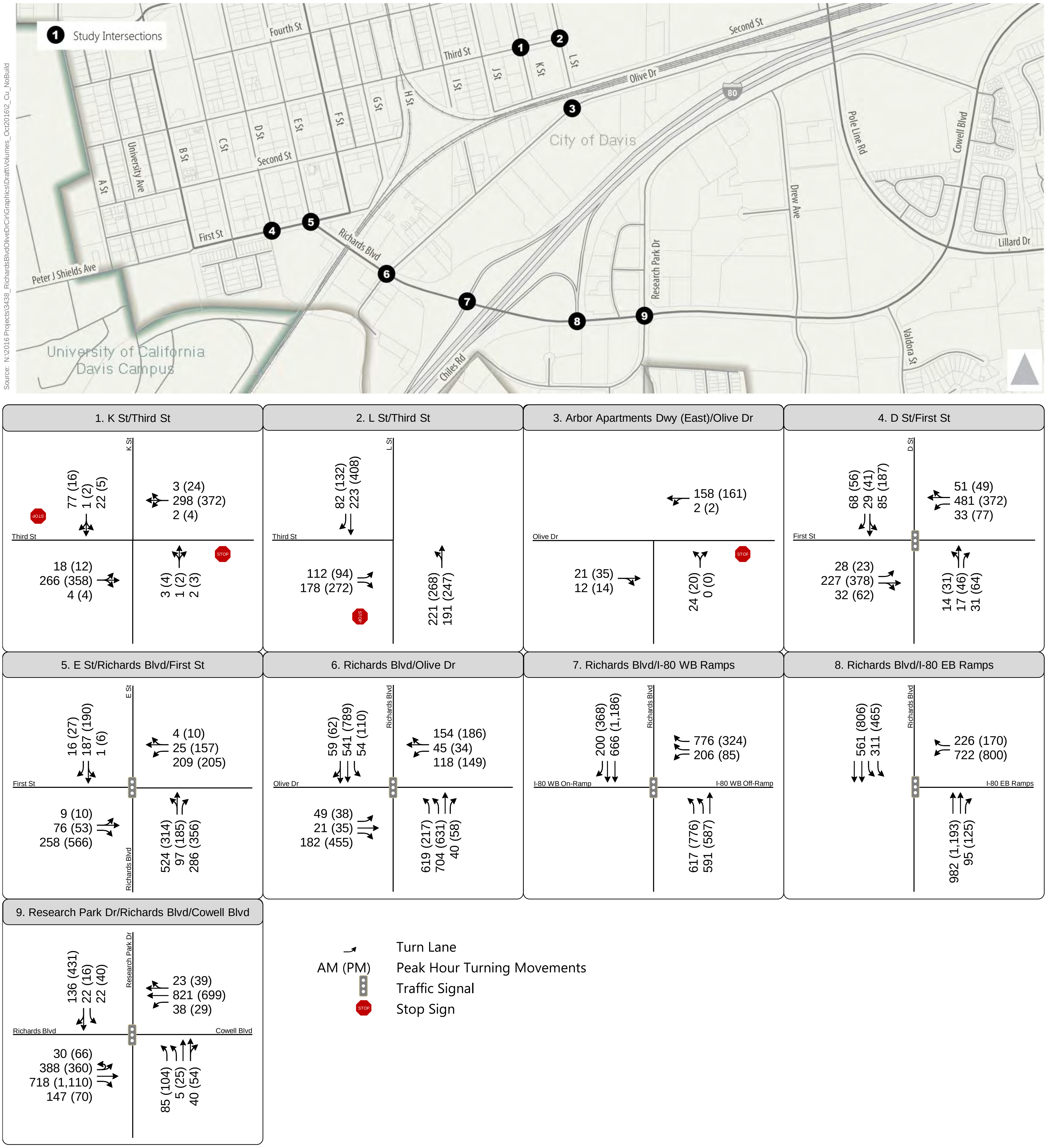

Figure 7

No Build
Peak Hour Traffic Volumes and Lane Configurations
Cumulative Conditions

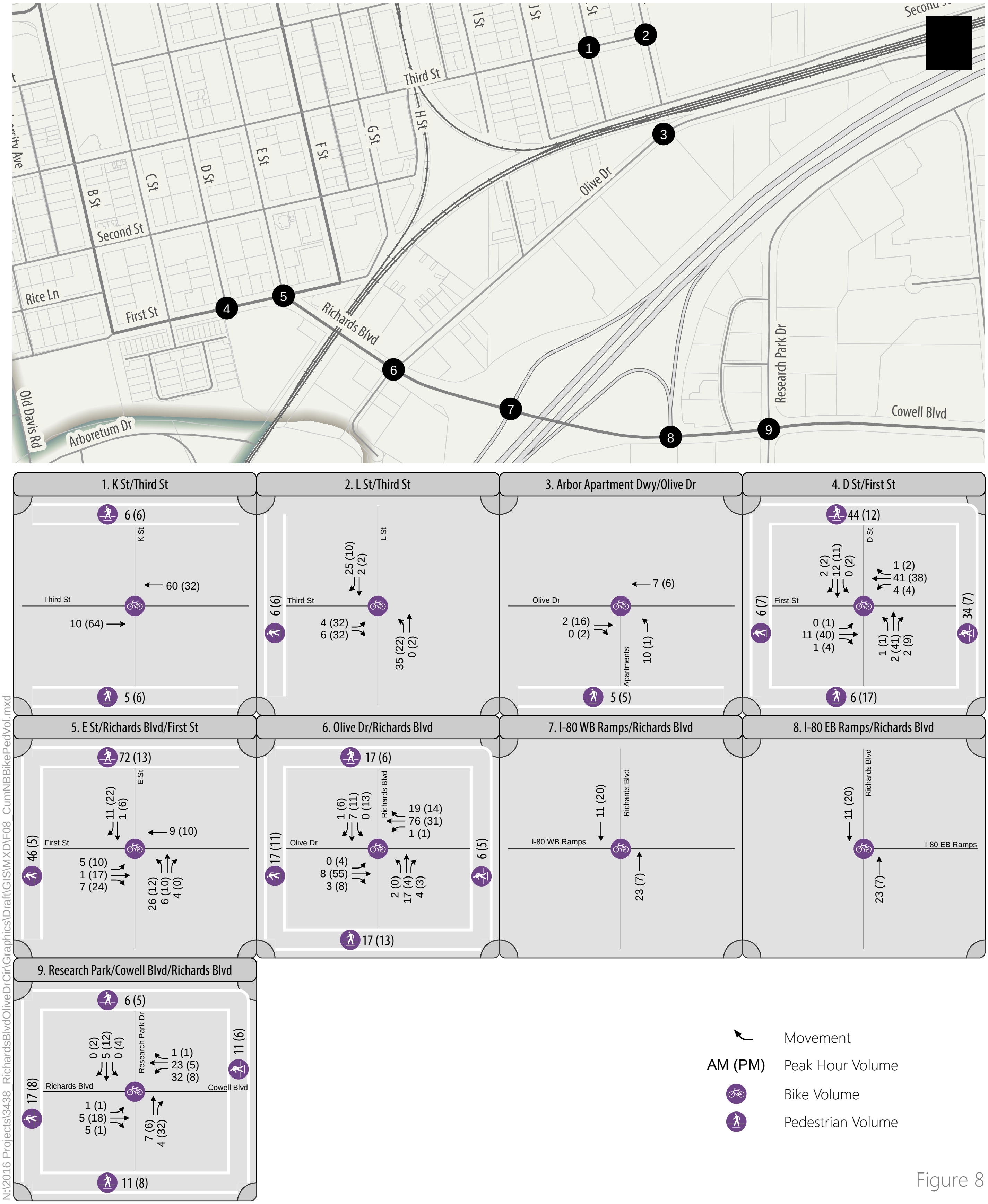

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Figure 8

No Build

Peak Hour Bicycle and Pedestrian Volumes

Cumulative Conditions

[redacted]

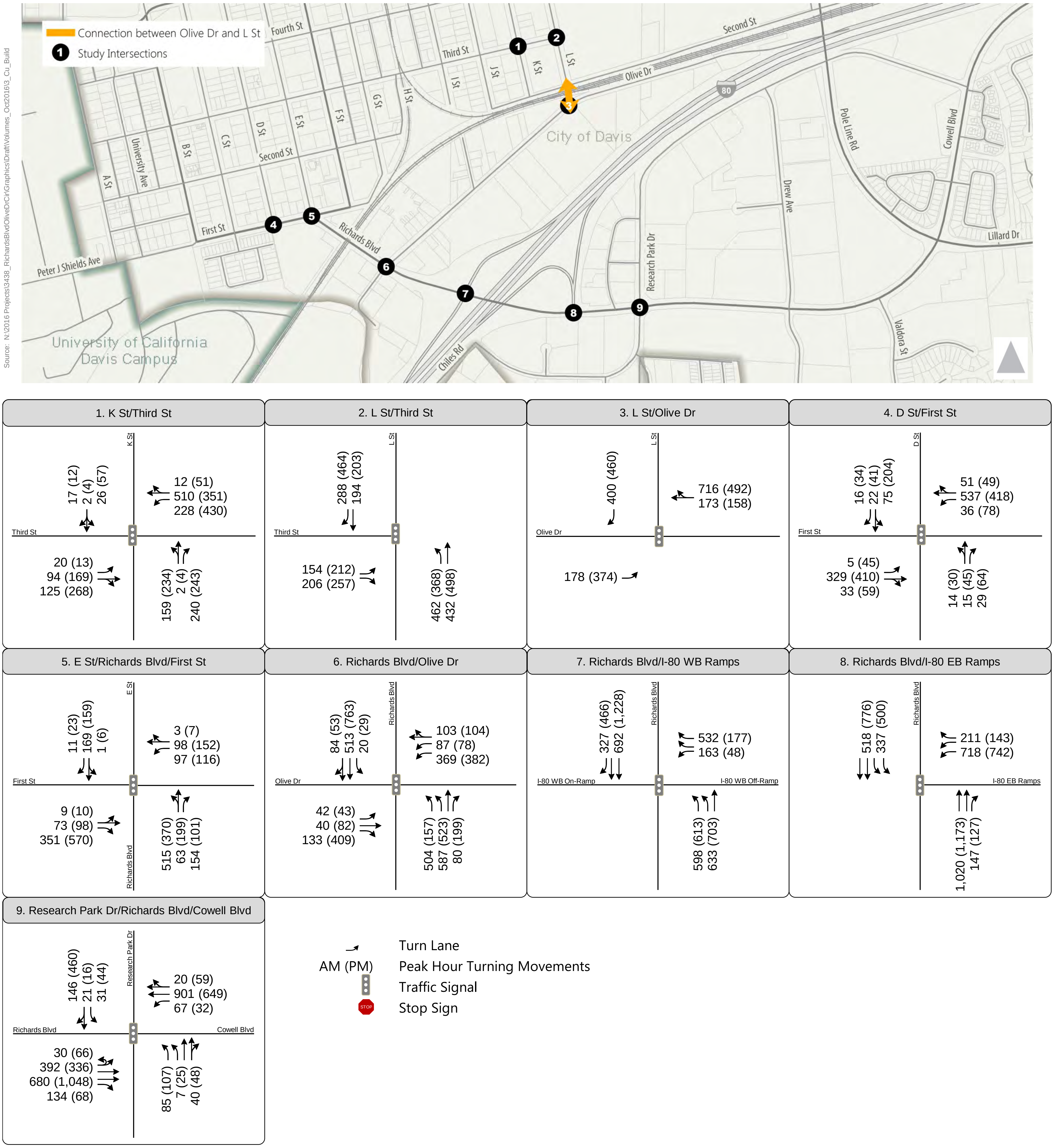

Figure 9

L Street Vehicle Connection

Peak Hour Traffic Volumes and Lane Configurations

Cumulative Conditions

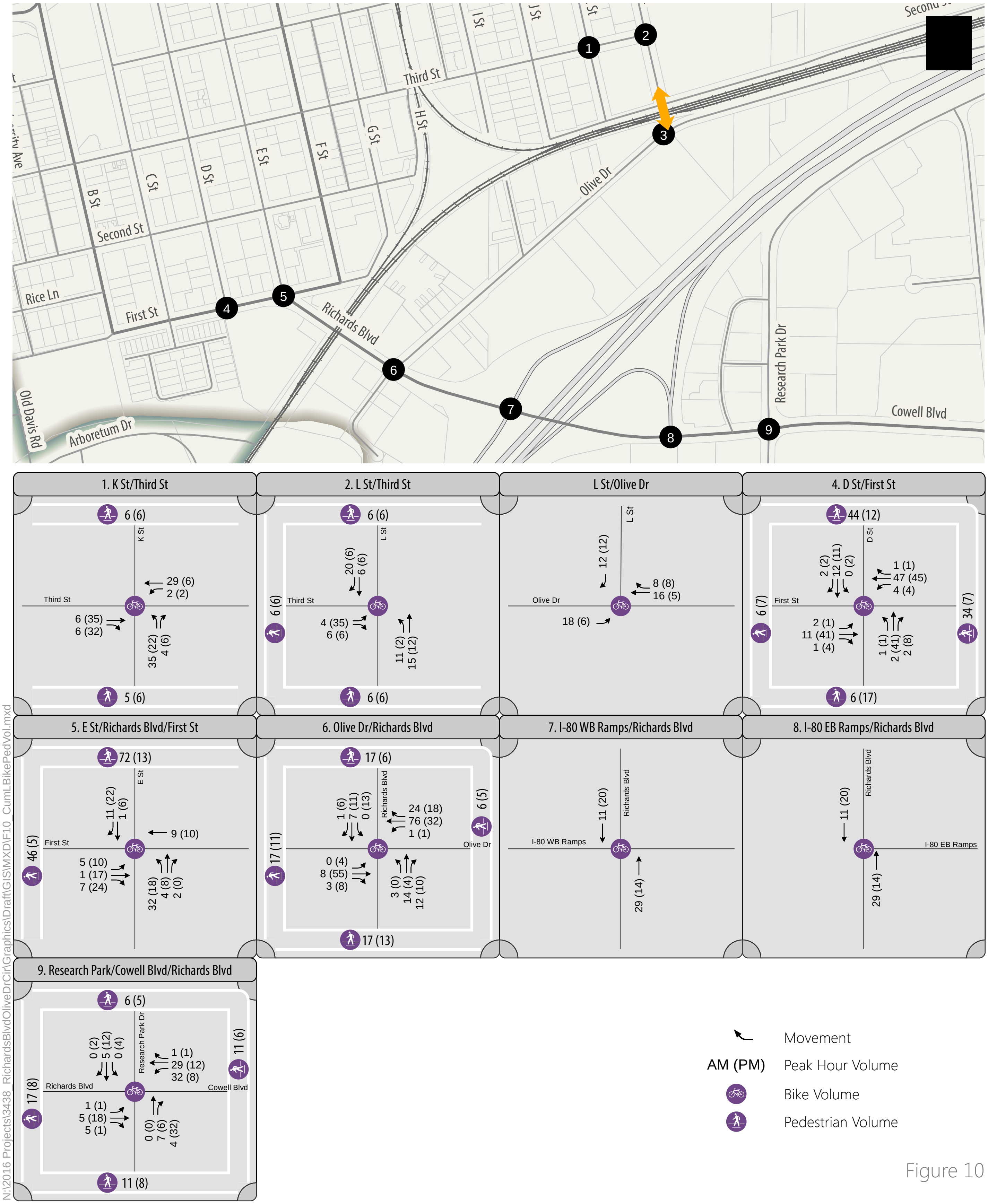

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Figure 10

L Street Vehicle Connection
Peak Hour Bicycle and Pedestrian Volumes
Cumulative Conditions

[redacted]

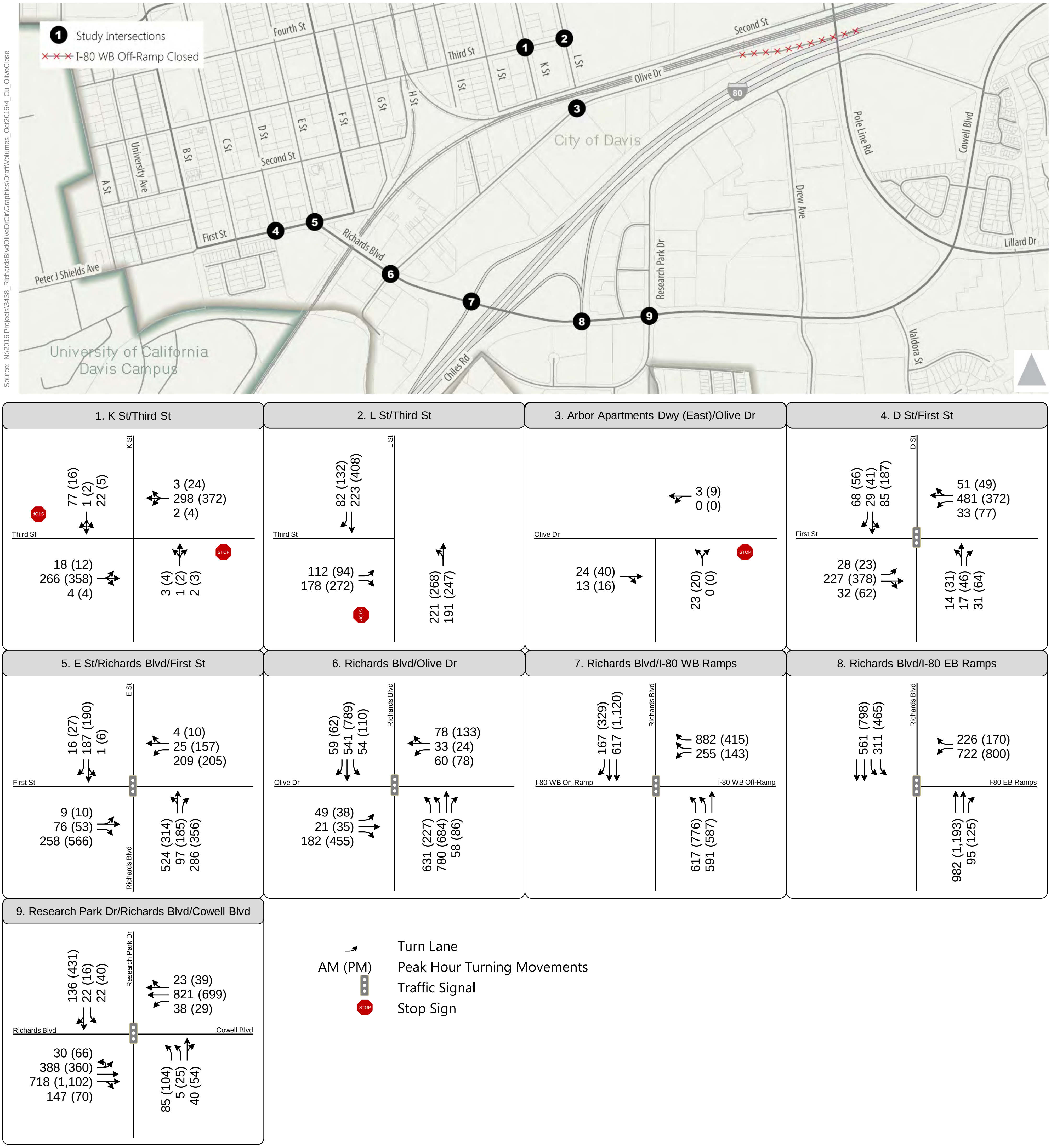


Figure 11

Olive Drive Freeway Exit Ramp Closure
Peak Hour Traffic Volumes and Lane Configurations
Cumulative Conditions

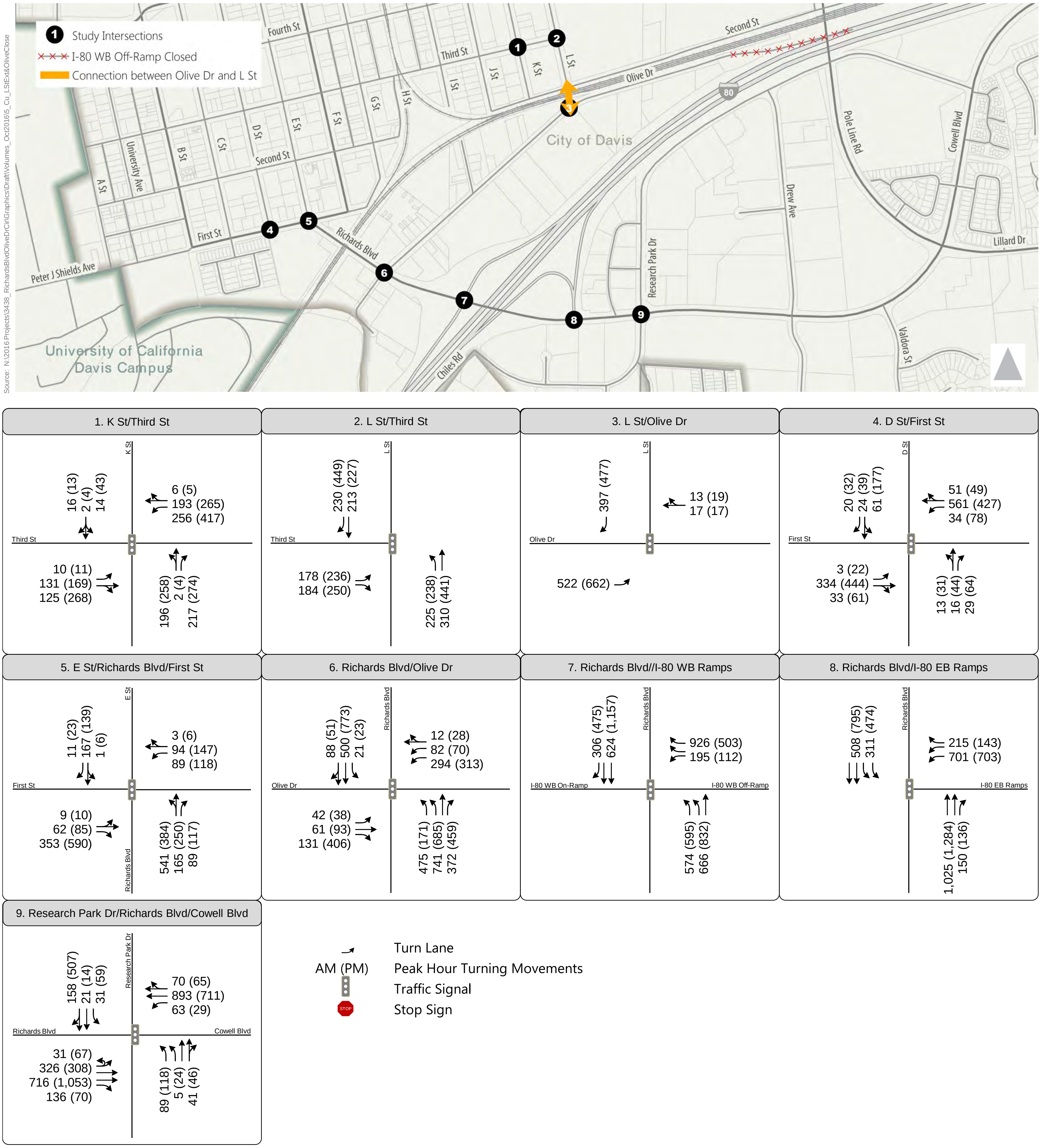
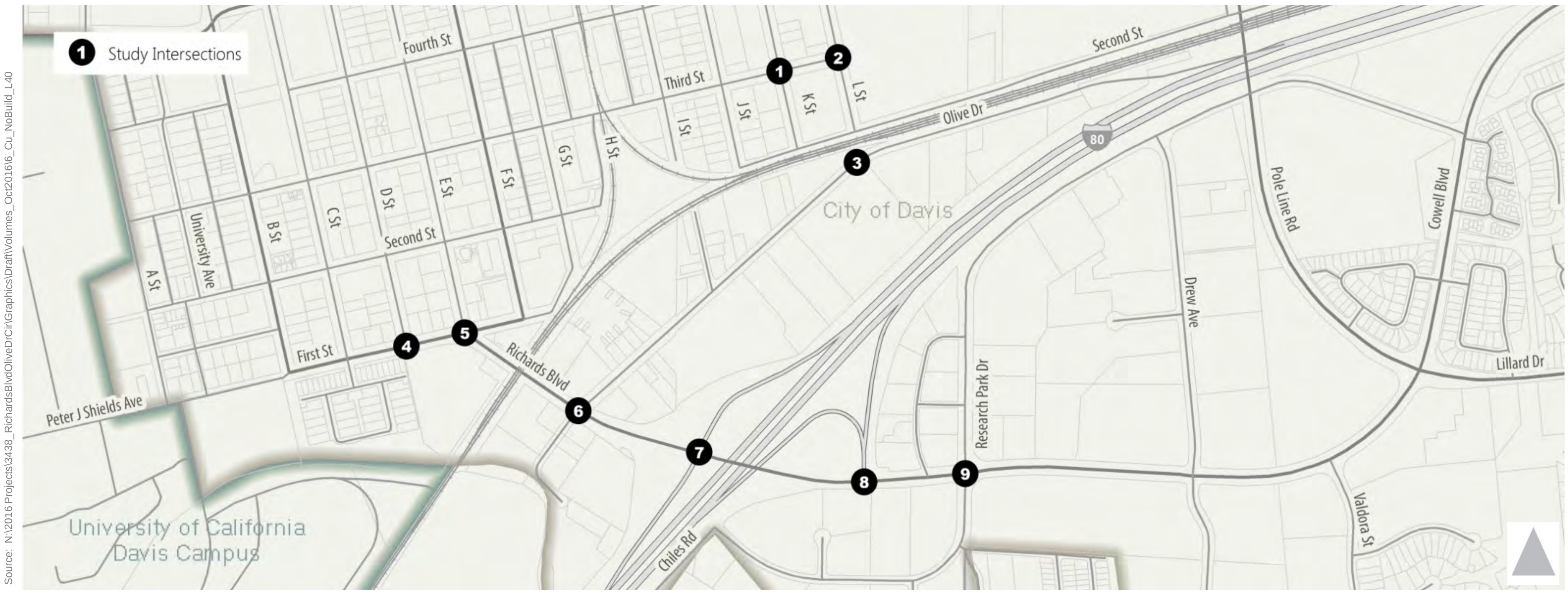


Figure 12

L Street Vehicle Connection and Olive Drive Freeway Exit Ramp Closure
Peak Hour Traffic Volumes and Lane Configurations
Cumulative Conditions



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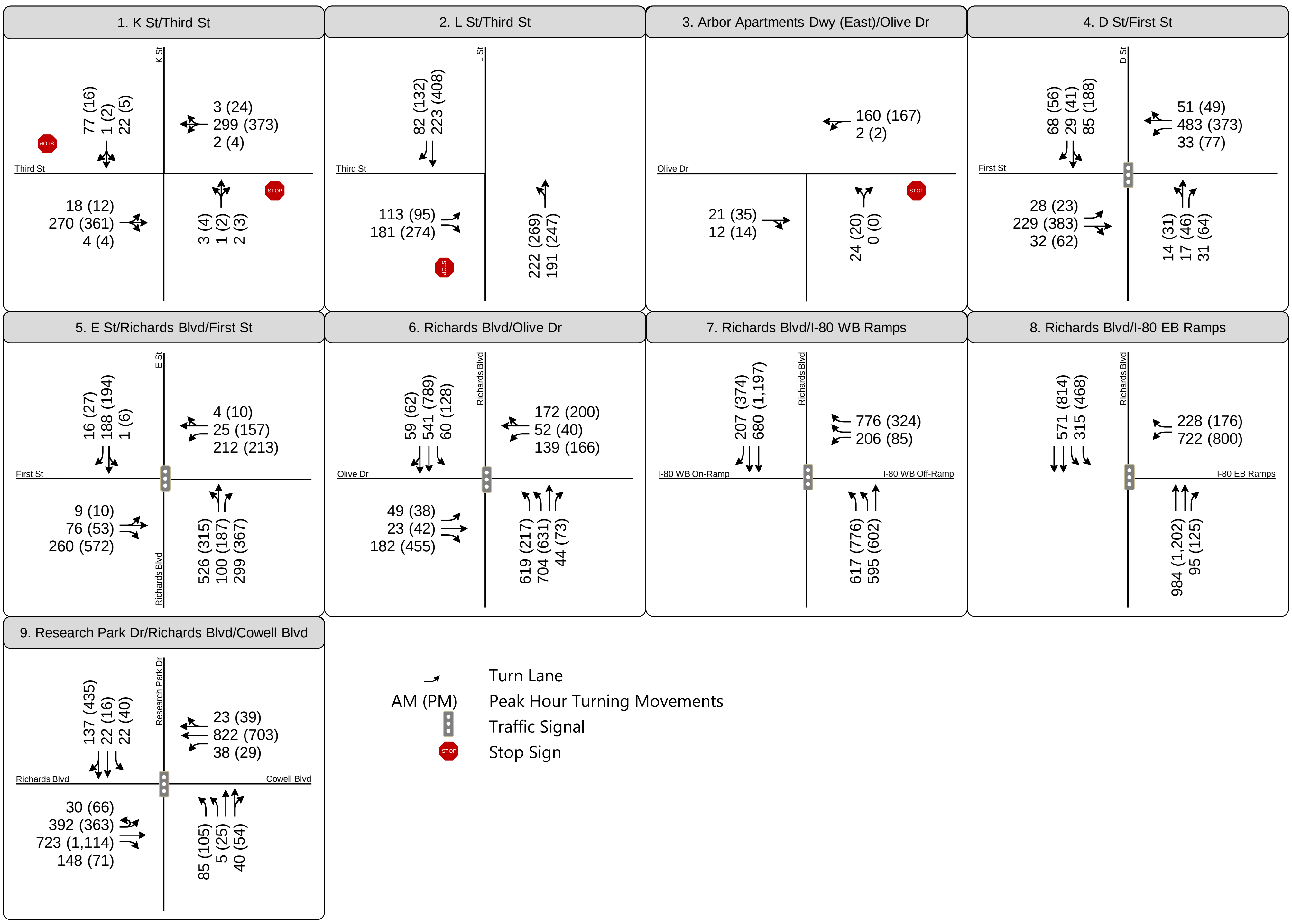


Figure 13

No Build with Lincoln40
Peak Hour Traffic Volumes and Lane Configurations
Cumulative Conditions

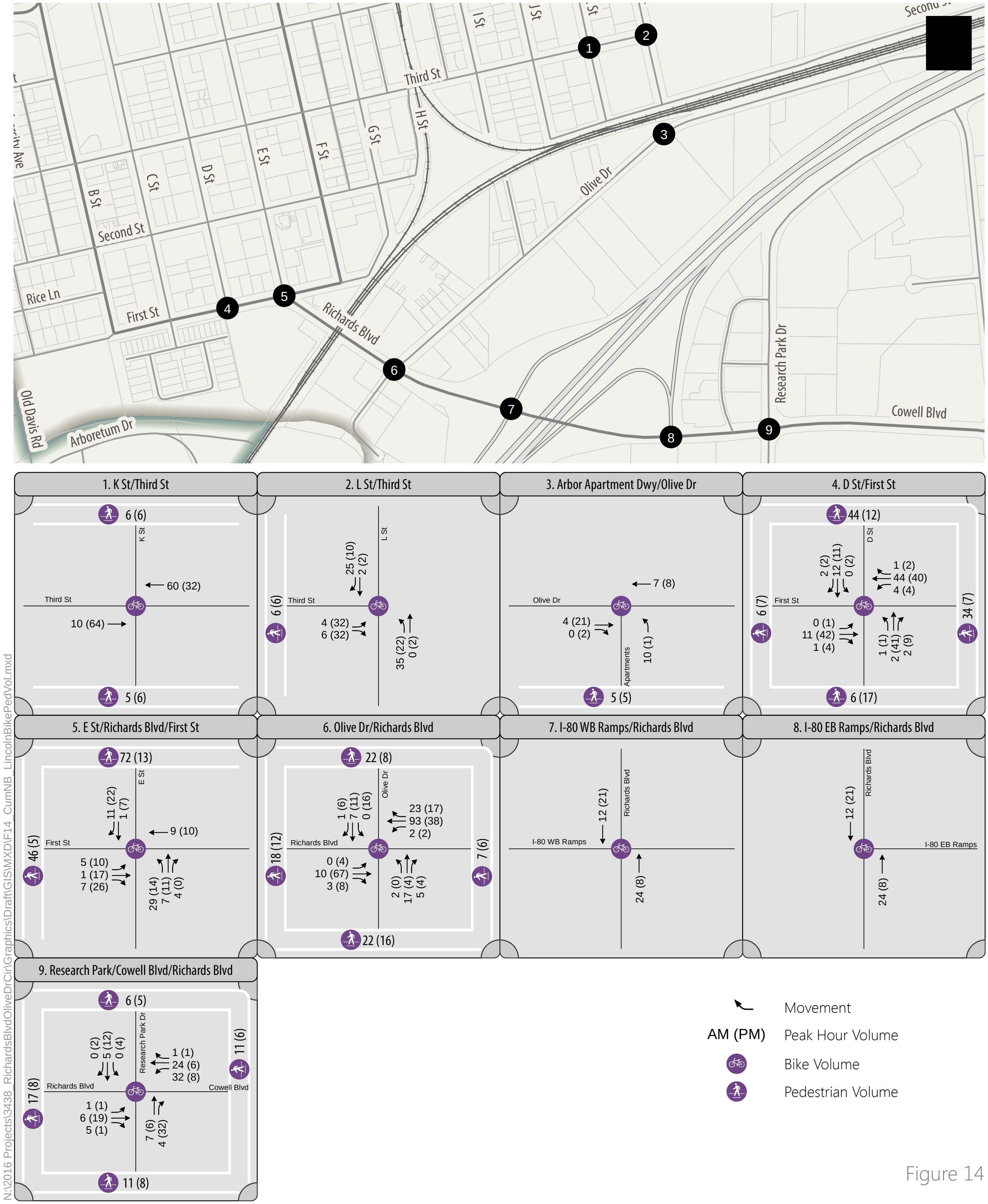


Figure 14

No Build with Lincoln40
Peak Hour Bicycle and Pedestrian Volumes
Cumulative Conditions

[redacted]

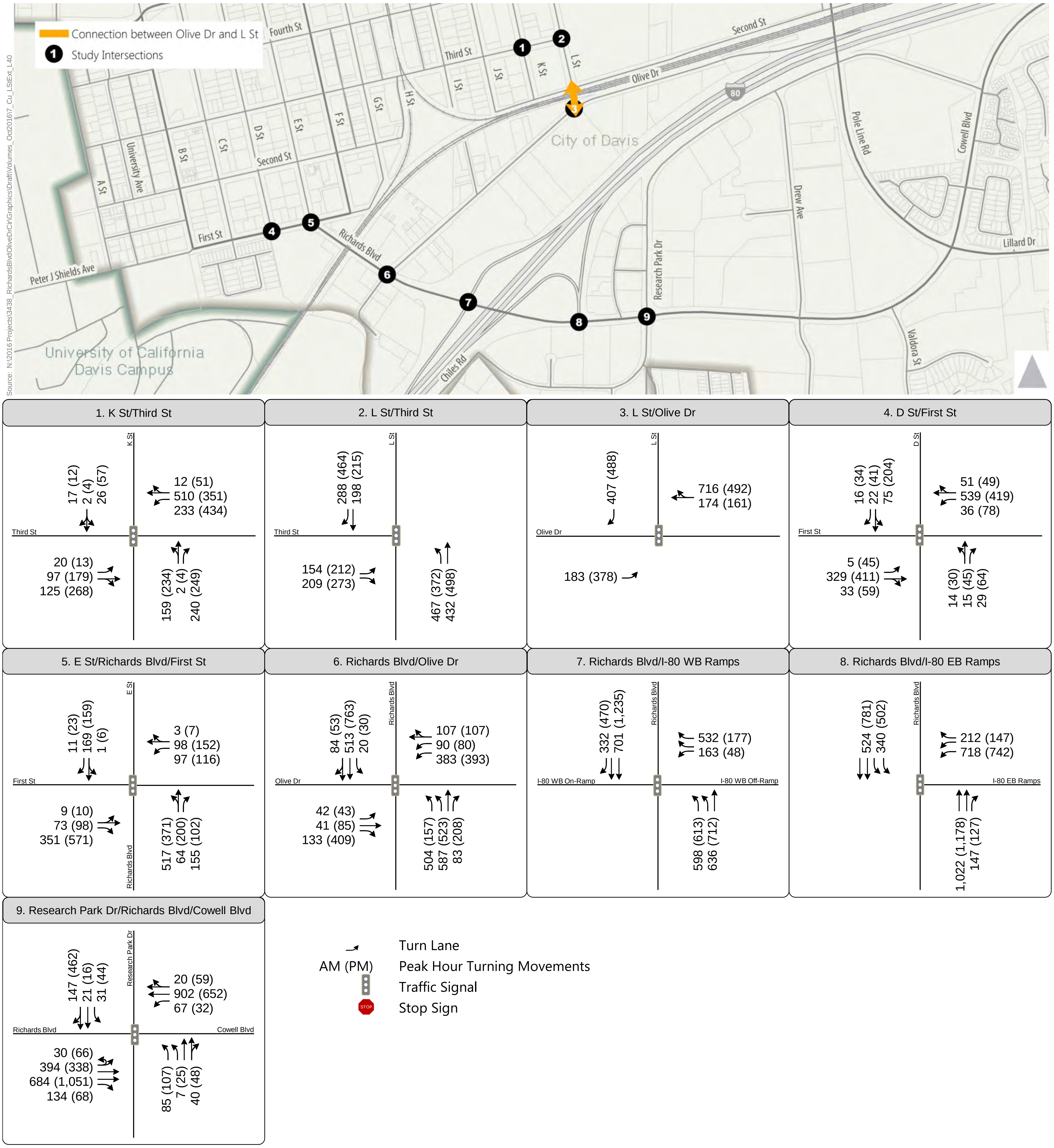


Figure 15

L Street Vehicle Connection with Lincoln40
Peak Hour Traffic Volumes and Lane Configurations
Cumulative Conditions

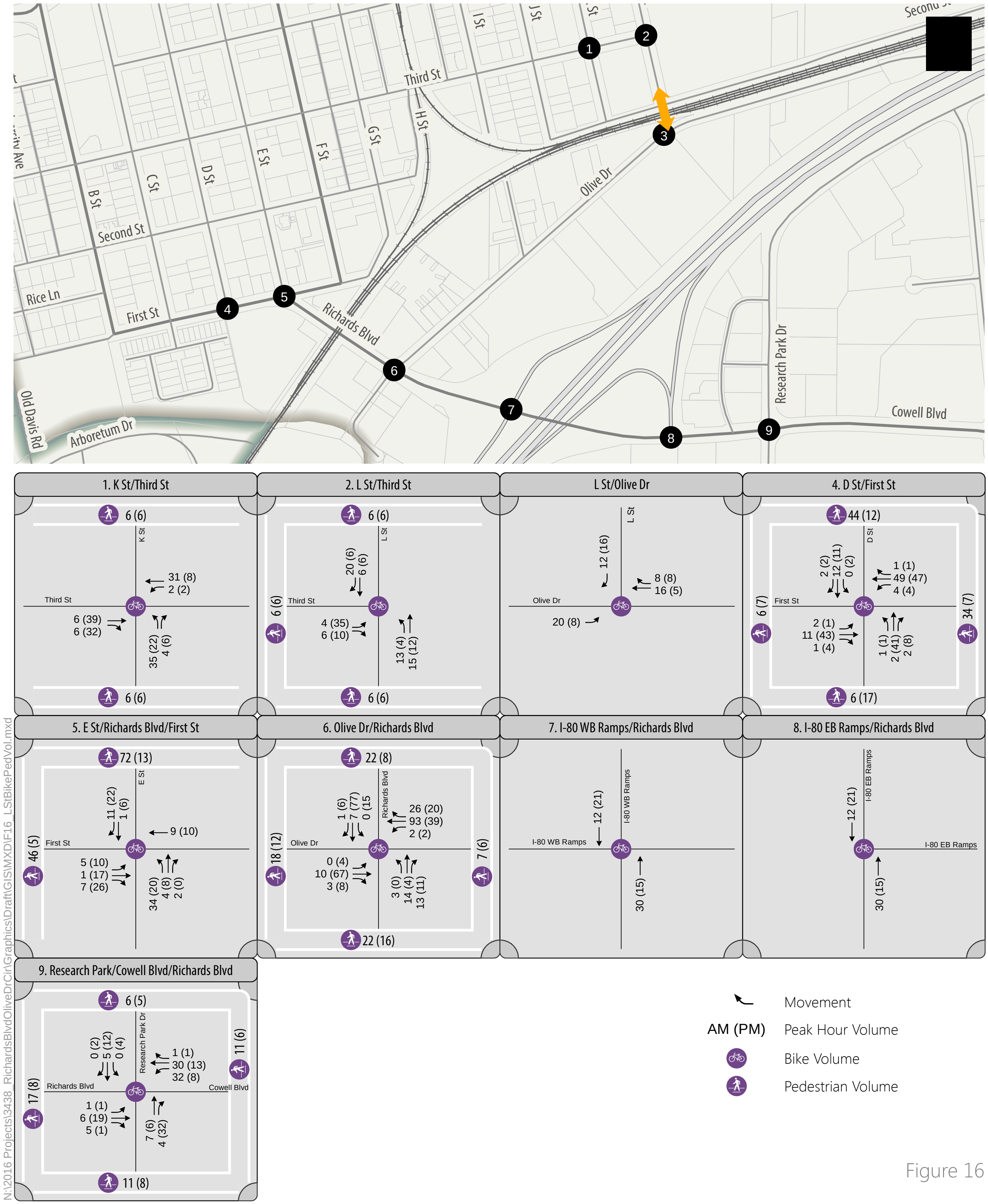
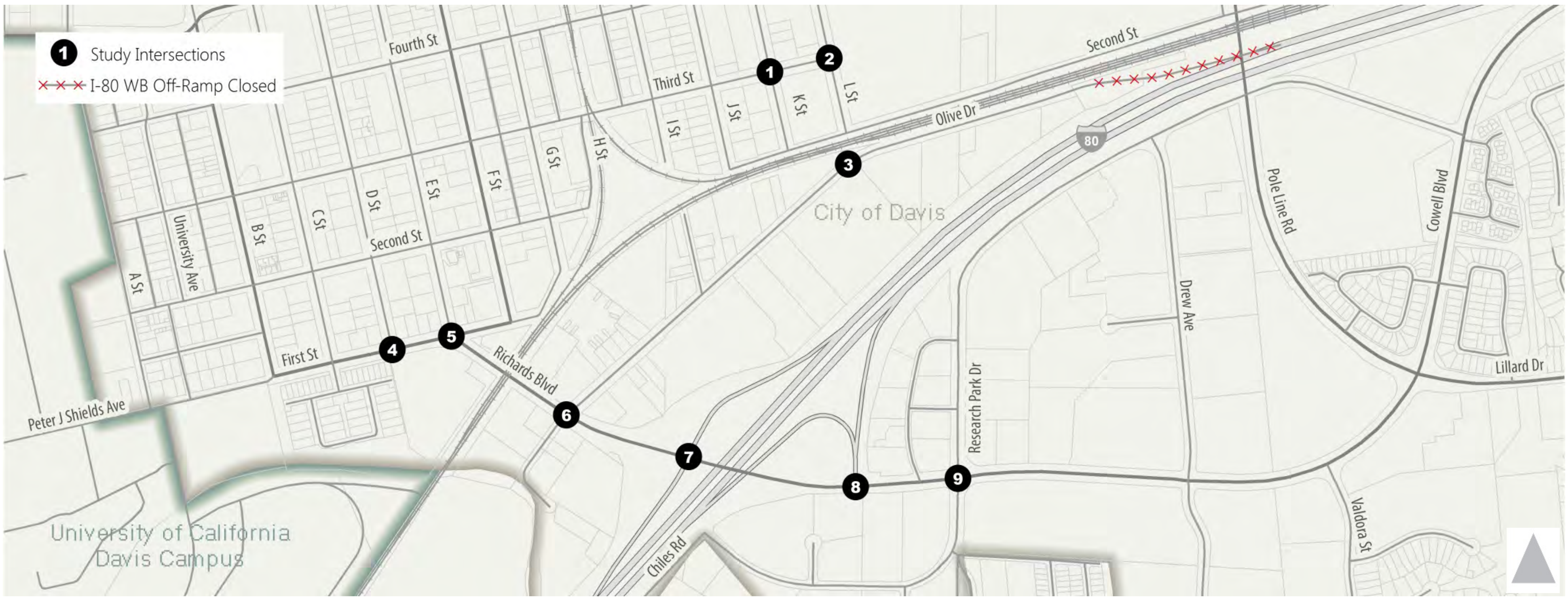


Figure 16

L Street Vehicle Connection with Lincoln40
Peak Hour Bicycle and Pedestrian Volumes
Cumulative Conditions

[redacted]



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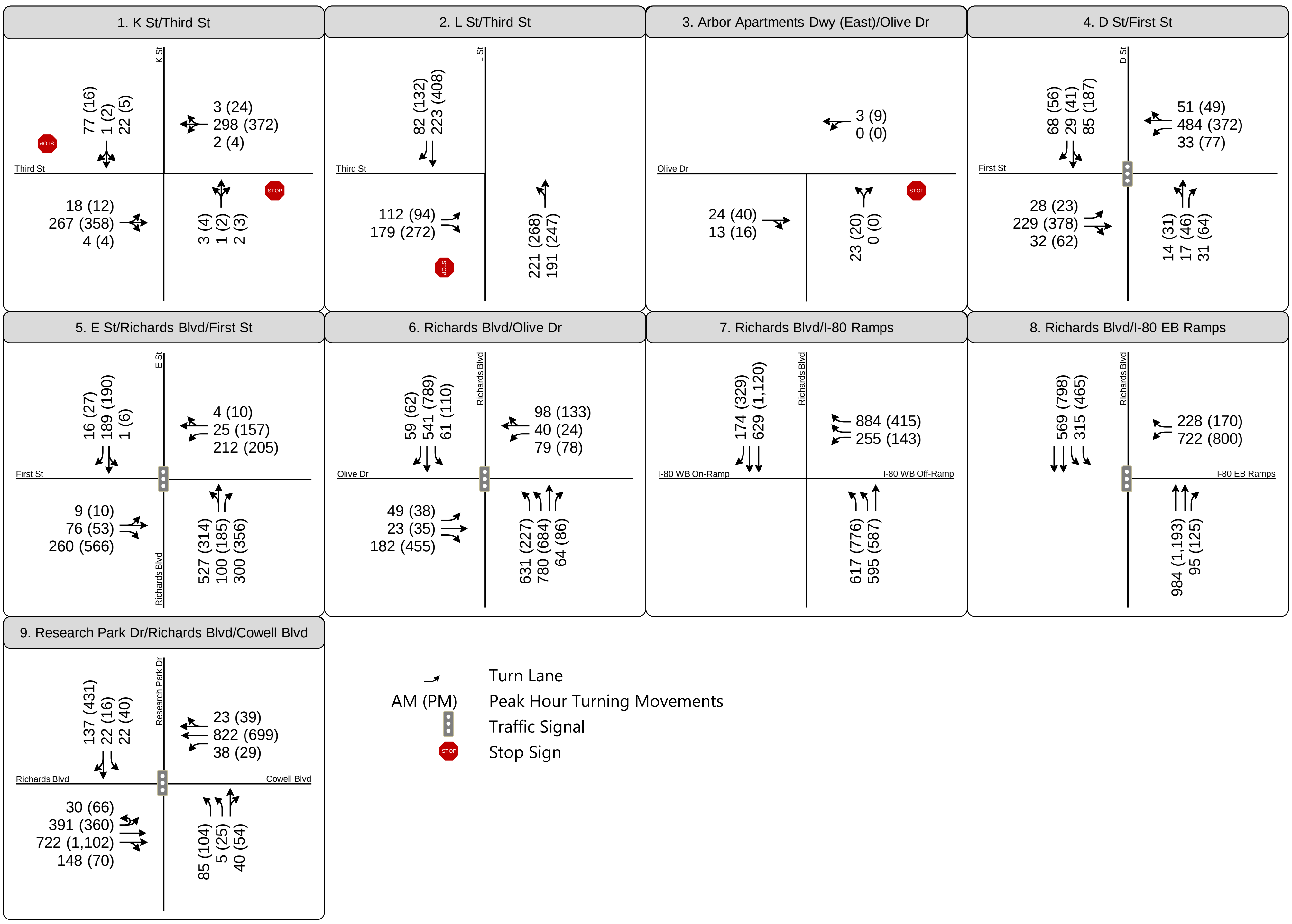

Figure 17

Olive Drive Freeway Exit Ramp Closure with Lincoln40 Peak Hour Traffic Volumes and Lane Configurations Cumulative Conditions

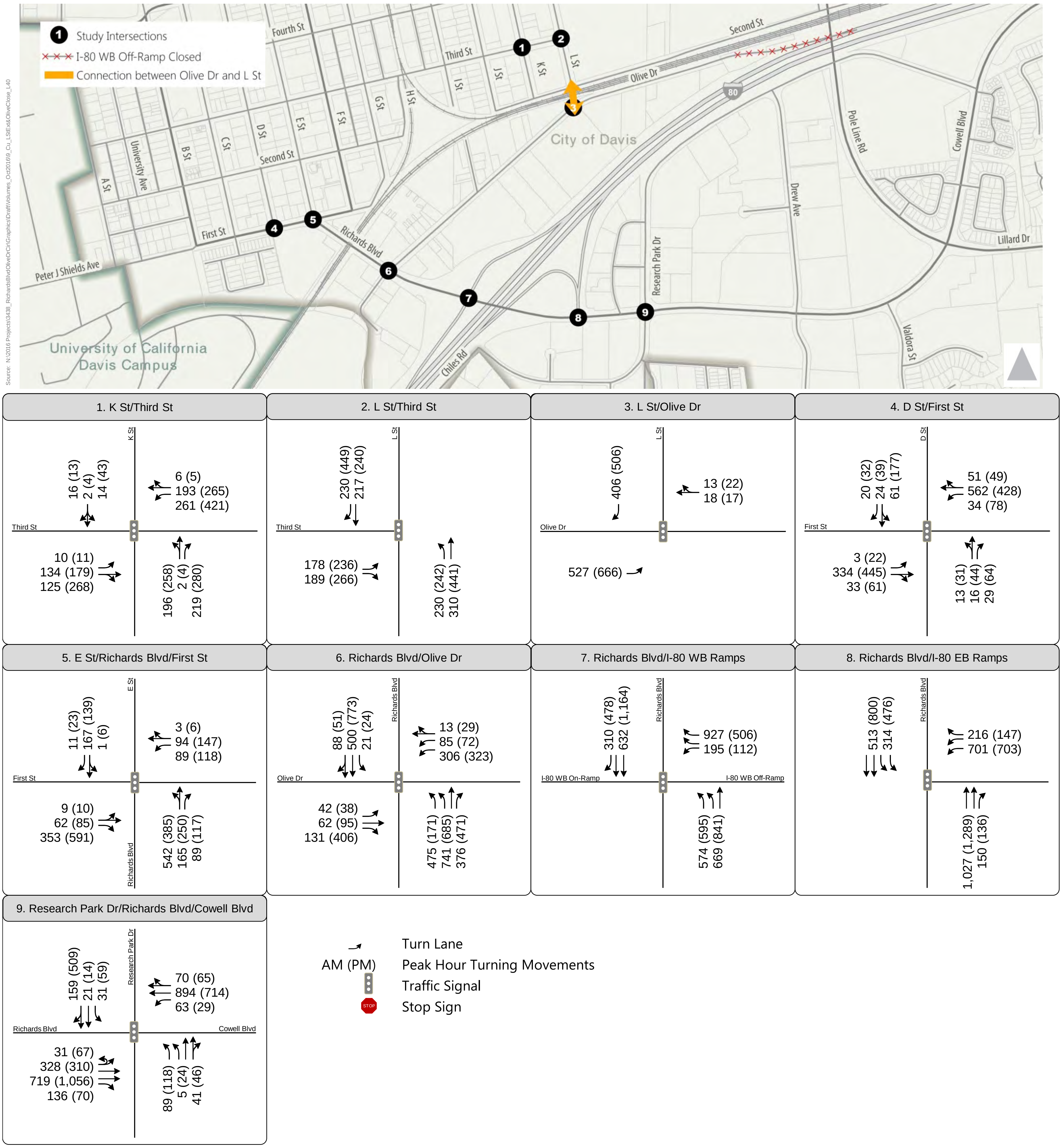

Figure 18

L Street Vehicle Connection and Olive Drive Freeway Exit Ramp Closure with Lincoln40
Peak Hour Traffic Volumes and Lane Configurations
Cumulative Conditions

5.0 CUMULATIVE CONDITIONS ANALYSIS

INTERSECTION OPERATIONS

Table 5 presents the AM and PM peak hour intersection operations under cumulative conditions. Detailed results are provided in the appendix.

The No Build alternative is based on the operations analysis conducted for the Nishi / West Olive Drive Development project and includes the planned mitigation measures at the Richards Boulevard/Olive Drive intersection. As a result, most intersections operate well with LOS D or better conditions during both peak hours. During the AM peak hour, the I-80 Westbound Ramps intersection would have LOS E conditions due to congestion on northbound Richards Boulevard at Olive Drive. During the PM peak hour, the First Street/D Street intersection would have LOS E conditions due to the high demand volume coming from the north and west (primarily UC Davis) heading towards I-80. Although the intersection delay is high at D Street, the bottleneck actually occurs at E Street due to conflicting vehicle and pedestrian volumes and split signal phasing.

Under the L Street Vehicle Connection alternative, the study intersections would have LOS E or better conditions during the AM peak hour and LOS E or better at all but one intersection during the PM peak hour. The shift in traffic from the westbound off-ramp at Richards Boulevard to Olive Drive results in a high westbound demand at the Olive Drive/L Street intersection. With the restricted movements at the intersection, the signal would operate with two phases. However, the single-lane approaches would mean that the intersection would operate near capacity. The signal operation would need to favor the westbound approach at the expense of the eastbound left-turn and southbound right-turn movements so that the westbound queue would not extend to the I-80 freeway mainline. Given the close spacing, the two signals on Third Street north of the Olive Drive/L Street intersection are recommended to be coordinated.

Although through traffic on Richards Boulevard at Olive Drive would decrease compared to the No Build alternative, conflicting traffic traveling to and from the east along Olive Drive would increase. As a result, the average delay at the Olive Drive/Richards Boulevard intersection would increase and the LOS would worsen from C to D conditions. While traffic to and from the east north of the Richards Boulevard tunnel would decrease with the L Street connection, traffic to and from the west would increase to back-fill the roadway. As a result, demand volumes would be higher at the First Street/D Street intersection resulting in LOS F conditions. The intersections at the I-80 interchange would operate with LOS C or better conditions.

TABLE 5: INTERSECTION OPERATIONS – CUMULATIVE CONDITIONS

Intersection	Traffic Control	No Build		L Street Vehicle Connection		Olive Drive Freeway Exit Ramp Closure		L Street Connection & Exit Ramp Closure	
		AM	PM	AM	PM	AM	PM	AM	PM
1. Third St/K St	Side Street Stop/Signal[1]	B / 13 (SB LT)	**F / 53** (EB LT)	B / 15	D / 42	B / 13 (SB LT)	**F / 56** (EB LT)	B / 19	D / 47
2. Third St/L St	Side Street Stop/Signal[1]	C / 21 (EB LT)	E / 45 (EB LT)	C / 21	D / 40	C / 20 (EB LT)	E / 45 (EB LT)	B / 13	C / 28
3. Olive Dr/Arbor Apartments Drwy(/L St)	Side Street Stop/Signal[1]	A / 6 (NB LT)	A / 6 (NB LT)	E / 68	E / 59	A / 5 (NB LT)	A / 5 (NB LT)	B / 19	A / 8
4. First St/D St	Signal	C / 23	E / 63	C / 26	**F / 114**	C / 21	E / 58	B / 14	**F / 123**
5. First St/E St/Richards Blvd	Signal	D / 47	C / 29	D / 42	D / 37	D / 38	C / 30	C / 22	D / 46
6. Olive Dr/Richards Blvd	Signal	D / 44	C / 26	D / 49	D / 39	C / 21	B / 19	D / 38	D / 37
7. I-80 WB Ramps/Richards Blvd	Signal	E / 62	B / 19	B / 18	B / 17	D / 50	C / 21	C / 30	C / 28
8. I-80 EB Ramps/Richards Blvd	Signal	C / 30	C / 27	D / 39	C / 22	C / 22	C / 25	B / 20	C / 24
9. Research Park Dr/Cowell Blvd/Richards Blvd	Signal	D / 54	D / 45	D / 52	D / 44	D / 36	D / 42	D / 45	D / 46

Notes: LOS and average control delay is reported in seconds per vehicle. For uncontrolled intersections, the movement with the highest delay is reported in parentheses. **Bold and underline** font indicates LOS F conditions.
1. The intersection has signal control under the alternatives with the L Street Vehicle Connection.

Source: Fehr & Peers, 2016

TABLE 6: AVERAGE MAXIMUM QUEUE LENGTH – CUMULATIVE CONDITIONS

Approach	Storage (feet)	No Build		L Street Vehicle Connection		Olive Drive Freeway Exit Ramp Closure		L Street Connection & Exit Ramp Closure	
		AM	PM	AM	PM	AM	PM	AM	PM
Northbound Richards Blvd at First St	625	225	175	200	200	225	200	175	225
Southbound Richards Blvd at Olive Dr	650	**<u>700</u>**	**<u>750</u>**	**<u>750</u>**	**<u>750</u>**	650	**<u>700</u>**	**<u>675</u>**	**<u>775</u>**
Westbound Olive Dr at Richards Blvd	1,700	525	250	575	300	175	200	50	50
Northbound Richards Blvd at Olive Dr	580	575	475	500	550	575	525	**<u>700</u>**	**<u>700</u>**
I-80 Westbound Off-ramp at Richards Boulevard	1,150	275	150	250	125	275	200	625	250
I-80 Eastbound Off-ramp at Richards Boulevard	1,260	525	325	650	275	250	300	350	300
Eastbound Olive Dr at L St	750	-	-	200	650	-	-	425	200
Southbound L St at Olive Dr	475	-	-	425	400	-	-	250	125
Westbound Olive Dr at L St	2,000	-	-	1,450	950	-	-	75	75

Note: **<u>Bold and underline</u>** font indicates that the average maximum queue exceeds the storage length.
Source: Fehr & Peers, 2016

With the Olive Drive Freeway Exit Ramp Closure alternative, the volume for the westbound off-ramp to Richards Boulevard would increase. However, the volume for the Olive Drive westbound approach to Richards Boulevard would decrease. This reduction in conflicting traffic would improve AM peak hour conditions at the Olive Drive intersection and consequently at the Westbound I-80 Ramps intersection since northbound queues would be shorter. Intersection delay at the other Richards Boulevard intersections would remain about the same. During the PM peak hour, intersection operations would be about the same as the No Build alternative at all intersections since the westbound off-ramp volume is lower.

In general, the results for the alternative that combines the L Street Vehicle Connection and the Olive Drive Freeway Exit Ramp Closure are similar to the L Street Vehicle Connection alternative. The major difference is at the new L Street/Olive Drive intersection. With the off-ramp closure, the westbound approach volume is very low – such that the peak hour signal warrant would not be met (although a signal may still be needed for safety or other reasons). The low volume suggests that an alternate configuration for the bridge may be appropriate to reduce construction cost. For example, the Olive Drive/L Street intersection could be eliminated by removing the raised or lowered roadway connection to the east in favor of a direct alignment connecting L Street to Olive Drive to the west with a separate roadway to serve Olive Drive east of the bridge. At the Olive Drive/Richards Boulevard intersection, the off-ramp closure would reduce average delay during the AM peak hour because the westbound approach volume would be lower since the freeway traffic is diverted from Olive Drive to the Richards Boulevard interchange. During the PM peak hour, the delay would be about the same. However, the higher traffic on Richards Boulevard during the PM peak hour would lead to higher delay at the First Street/E Street/Richards Boulevard intersection.

The average maximum queue length for selected approaches is provided in **Table 6**. With the No Build alternative, queue lengths along Richards Boulevard would be contained within the storage length during the peak hours for all but one approach. The exception would be southbound Richards Boulevard at Olive Drive. The southbound traffic would queue back into the upstream intersection at First Street due to the conflicting traffic demand for the northbound left turn movement and the east-west demands on Olive Drive. Although dual northbound left-turn lanes would be provided, the demand for the Nishi and West Olive developments would mean that a significant portion of the signal's green time would need to be dedicated to that approach at the expense of the southbound through and left turn phases. The off-ramp queues would be contained on the ramps without affecting freeway mainline traffic.

With the L Street Vehicle Connection, the southbound queue at Richards Boulevard/Olive Drive would be an issue under both AM and PM peak hours. Average maximum queue lengths at both off-ramps would be 650 feet or less during both peak hours. Consistent with the higher average delay, the queue lengths for the westbound approach at the Olive Drive/L Street intersection would be significant during both peak hours. The westbound approach from Olive Drive would have queues longer than 900 feet during both peak hours. The queues would not exceed the available storage, which is about 2,000 feet to the freeway mainline, so the queue would not be an operational or safety concern for the freeway. However, signal operations would need to be closely monitored – that is, treated like a ramp terminal intersection at an interchange – to prevent queues from affecting the freeway mainline.

The Olive Drive Freeway Exit Ramp Closure alternative would have similar queues to the No Build alternative. With the shift in traffic from the westbound off-ramp at Olive Drive to Richards Boulevard, the AM peak hour queue for the westbound off-ramp at Richards Boulevard would about double. However, the queue would be contained on the ramp.

The alternative that combines the L Street Vehicle Connection and the Olive Drive Freeway Exit Ramp Closure also would have queues similar to the No Build alternative for most locations. With the increased conflicting traffic at Richards Boulevard/Olive Drive, the northbound approach queue would extend into the upstream intersection at the I-80 Westbound Ramps. Despite this, the westbound off-ramp queue would only be about 50 feet longer than the exit ramp closure only alternative. Compared to the L Street Vehicle Connection alternative, the queues at Olive Drive/L Street would be lower since the westbound approach demand would be small.

Table 7 presents the AM and PM peak hour intersection operations under cumulative conditions with the Lincoln40 apartments. Detailed results are provided in the appendix.

The addition of the Lincoln40 traffic to the No Build alternative generally affects conditions more during the AM peak hour. The addition of conflicting vehicle traffic traveling to and from Olive Drive and conflicting bicycle traffic along Olive Drive would worsen conditions along the corridor such that three intersections would have LOS E conditions. In the PM peak hour, the average delay would increase, but the level of service would remain the same.

Under the L Street Vehicle Connection alternative, the shift in traffic away from the Richards Boulevard tunnel would result in better AM peak hour conditions along Richards Boulevard. During the PM peak hour, the Richards Boulevard corridor intersection operations would be about the same as without Lincoln40. However, the addition of the Lincoln40 traffic to the Olive Drive/L Street intersection results in LOS F conditions during both peak hours. Since the intersection is adjacent to Lincoln40, project trips are added to conflicting movements at the intersection. As a result, the intersection that would operate at capacity (LOS E) without Lincoln40 would be over capacity (LOS F) with Lincoln40. To improve operations, the L Street connection could be restricted to northbound only. This would both reduce delay at the Olive Drive/L Street intersection and along the Richards Boulevard corridor. See below for more information on this configuration.

TABLE 7: INTERSECTION OPERATIONS – CUMULATIVE CONDITIONS WITH LINCOLN40

Intersection	Traffic Control	No Build		L Street Vehicle Connection		Olive Drive Freeway Exit Ramp Closure		L Street Connection & Exit Ramp Closure	
		AM	PM	AM	PM	AM	PM	AM	PM
1. Third St/K St	Side Street Stop/Signal[1]	B / 12 (SB LT)	**F / 71** (EB LT)	B / 15	D / 45	B / 112 (SB LT)	**F / 64** (EB LT)	B / 19	D / 47
2. Third St/L St	Side Street Stop/Signal[1]	C / 22 (EB LT)	E / 46 (EB LT)	C / 27	D / 45	C / 22 (EB LT)	E / 44 (EB LT)	B / 13	C / 32
3. Olive Dr/Arbor Apartments Drwy(/L St)	Side Street Stop/Signal[1]	A / 6 (NB LT)	A / 6 (NB LT)	**F / 111**	**F / 103**	A / 5 (NB LT)	A / 5 (NB LT)	C / 20	B / 12
4. First St/D St	Signal	E / 68	E / 71	C / 33	**F / 117**	C / 27	E / 61	B / 14	**F / 121**
5. First St/E St/Richards Blvd	Signal	D / 51	C / 34	D / 44	D / 39	D / 42	C / 34	C / 22	D / 45
6. Olive Dr/Richards Blvd	Signal	E / 68	C / 29	E / 60	D / 44	C / 27	C / 21	D / 39	D / 42
7. I-80 WB Ramps/Richards Blvd	Signal	E / 57	B / 19	B / 19	B / 17	D / 47	C / 22	C / 27	C / 30
8. I-80 EB Ramps/Richards Blvd	Signal	D / 46	C / 29	D / 36	C / 20	C / 22	C / 26	B / 19	C / 27
9. Research Park Dr/Cowell Blvd/Richards Blvd	Signal	E / 55	D / 54	D / 54	D / 43	D / 54	D / 46	D / 45	D / 47

Notes: LOS and average control delay is reported in seconds per vehicle. For uncontrolled intersections, the movement with the highest delay is reported in parentheses. **Bold and underline** font indicates LOS F conditions.
1. The intersection has signal control under the alternatives with the L Street Vehicle Connection.

Source: Fehr & Peers, 2016

TABLE 8: AVERAGE MAXIMUM QUEUE LENGTH – CUMULATIVE CONDITIONS WITH LINCOLN40

Approach	Storage (feet)	No Build		L Street Vehicle Connection		Olive Drive Freeway Exit Ramp Closure		L Street Connection & Exit Ramp Closure	
		AM	PM	AM	PM	AM	PM	AM	PM
Northbound Richards Blvd at First St	600	225	200	200	225	225	225	150	225
Southbound Richards Blvd at Olive Dr	640	**<u>725</u>**	**<u>725</u>**	**<u>750</u>**	**<u>750</u>**	**<u>675</u>**	**<u>725</u>**	**<u>700</u>**	**<u>775</u>**
Westbound Olive Dr at Richards Blvd	1,700	1,025	400	875	475	300	225	50	100
Northbound Richards Blvd at Olive Dr	580	575	450	450	525	575	525	700	700
I-80 Westbound Off-ramp at Richards Boulevard	1,150	800	150	225	100	850	200	525	225
I-80 Eastbound Off-ramp at Richards Boulevard	1,260	750	300	600	275	250	275	350	325
Eastbound Olive Dr at L St	750	-	-	250	**<u>850</u>**	-	-	450	275
Southbound L St at Olive Dr	475	-	-	**<u>425</u>**	400	-	-	225	225
Westbound Olive Dr at L St	2,000	-	-	1,650	1,325	-	-	75	75

Note: **<u>Bold and underline</u>** font indicates that the average maximum queue exceeds the storage length.
Source: Fehr & Peers, 2016

Closing the Olive Drive exit ramp would improve AM peak hour conditions but have similar results to the No Build alternative during the PM peak hour. Adding the exit ramp closure to the L Street connection would improve the Olive Drive/L Street intersection from LOS F to LOS C or better conditions. The Richards Boulevard intersections would also improve under AM peak hour conditions by shifting traffic from Olive Drive. During the PM peak hour, delays along Richards Boulevard would increase from LOS C to D conditions, but operations would remain acceptable.

Table 8 shows the AM and PM peak hour average queue lengths for selected intersection approaches under the analysis scenarios with Lincoln40. The addition of the Lincoln40 vehicle and bicycle traffic leads to longer queues primarily at the Richards Boulevard/Olive Drive intersection. The LOS F conditions at the Olive Drive/L Street intersection under the L Street Vehicle Connection alternative would cause the average maximum queue length to be about 300 feet longer for the eastbound approach during the PM peak hour and 200 to 500 feet longer for the westbound approach during both peak hours. Although the westbound off-ramp queue length would be longer under the Lincoln40 scenarios, the queue would not extend to the westbound I-80 freeway mainline lanes.

An additional scenario was analyzed to determine whether the traffic pattern changes associated with the L Street Vehicle Connection would provide sufficient intersection operations improvements such that the planned reconstruction of the I-80/Richards Boulevard interchange would not be needed. The same set of traffic forecasts (without Lincoln40) were used for both scenarios. **Table 9** presents the analysis results of the L Street Vehicle Connection alternative with and without the Richards Boulevard/I-80 Tight Diamond Interchange improvements.

The two versions of the L Street Vehicle Connection alternative would have similar operations north of the railroad tracks. During the AM peak hour, the I-80 Westbound Ramps/Richards Boulevard intersection would have LOS D conditions due to the off-ramp yielding to the conflicting northbound through traffic on Richards Boulevard that would queue back from the adjacent Olive Drive intersection.

During the PM peak hour, the I-80 Westbound Ramps intersection would operate unacceptably with LOS F conditions. The off-ramp would have a correspondingly long average maximum queue that would extend onto the freeway mainline. Due to the volume constraint for the westbound off-ramp, the Olive Drive intersection would operate with a lower average delay than with the interchange improvements in place. Although the overall intersection delay would be at LOS E, the eastbound off-ramp would also have a long queue that would extend onto the freeway mainline. The single left-turn lane from the off-ramp would not have sufficient capacity to serve the demand.

TABLE 9: INTERSECTION OPERATIONS –
CUMULATIVE CONDITIONS WITH L STREET VEHICLE CONNECTION

Intersection	Traffic Control	With I-80/Richards Blvd Interchange Improvements		Without I-80/Richards Blvd Interchange Improvements	
		AM	PM	AM	PM
1. Third St/K St	Signal	B / 15	D / 42	B / 15	D / 43
2. Third St/L St	Signal	C / 21	D / 40	C / 23	D / 40
3. Olive Dr/L St	Signal	E / 68	E / 59	E / 77	E / 64
4. First St/D St	Signal	C / 26	**F / 114**	C / 30	**F / 128**
5. First St/E St/Richards Blvd	Signal	D / 42	D / 37	D / 43	D / 54
6. Olive Dr/Richards Blvd	Signal	D / 49	D / 39	D / 45	D / 53
7. I-80 WB Ramps/ Richards Blvd	Signal/ Uncontrolled	B / 18	B / 17	D / 30 (WB RT)	**F / 146** (WB RT)
8. I-80 EB Ramps/ Richards Blvd	Signal	D / 39	C / 22	E / 57	D / 53
9. Research Park Dr/ Cowell Blvd/Richards Blvd	Signal	D / 52	D / 44	D / 49	D / 40

Notes: LOS and average control delay is reported in seconds per vehicle. For uncontrolled intersections, the movement with the highest delay is reported in parentheses. **Bold and underline** font indicate LOS F conditions.

Source: Fehr & Peers, 2016

As noted above, the L Street Vehicle Connection would reduce demand for the westbound off-ramp at Richards Boulevard by shifting traffic to the Olive Drive exit. However, this volume shift would not solve all operational issues at the I-80/Richards Boulevard interchange under cumulative conditions. While modest improvements (such as widening and signalizing the westbound off-ramp intersection and widening the eastbound off-ramp) could improve intersection operations, these changes would not address the safety issues associated with the westbound freeway weaving section between the loop on- and off-ramps and the pedestrian and bicycle crossings of the ramps to and from westbound I-80.

The L Street Vehicle Connection alternative would worsen operations on the Richards Boulevard corridor due to the increase in westbound left-turn volume from Olive Drive. To reduce this impact and reduce the extent of improvements, an option for this alternative was analyzed with two modifications. First, the L Street connection between Olive Drive and L Street at Third Street was narrowed to one-way northbound only for vehicles (two-way pedestrian and bicycle traffic would be allowed). Second, Second Street would not be extended to K Street. Instead, the connection to Olive Drive would touch down in the median of the existing south leg of the Third Street/L Street intersection. Forecasts for the design option were prepared based on these roadway network changes. **Table 10** presents the analysis results of the original two-way L Street Vehicle Connection alternative and the design option with the one-way northbound-only connection (both without Lincoln40).

TABLE 10: INTERSECTION OPERATIONS – CUMULATIVE CONDITIONS WITH L STREET VEHICLE CONNECTION OPTION

Intersection	Traffic Control	Two-way		One-way Northbound	
		AM	PM	AM	PM
1. Third St/K St	Signal/Side Street Stop[1]	B / 15	D / 42	A / 8 (EB LT)	A / 9 (NB TH)
2. Third St/L St	Signal	C / 21	D / 40	D / 49	**F / 94**
3. Olive Dr/L St	Signal	E / 68	E / 59	E / 73	**F / 381**
4. First St/D St	Signal	C / 26	**F / 114**	D / 40	**F / 112**
5. First St/E St/Richards Blvd	Signal	D / 42	D / 37	D / 50	E / 68
6. Olive Dr/Richards Blvd	Signal	D / 49	D / 39	C / 32	D / 36
7. I-80 WB Ramps/ Richards Blvd	Signal	B / 18	B / 17	C / 24	C / 20
8. I-80 EB Ramps/ Richards Blvd	Signal	D / 39	C / 22	C / 21	C / 27
9. Research Park Dr/ Cowell Blvd/Richards Blvd	Signal	D / 52	D / 44	D / 52	D / 55

Notes: LOS and average control delay is reported in seconds per vehicle. For uncontrolled intersections, the movement with the highest delay is reported in parentheses. **Bold and underline** font indicate LOS F conditions.
1. For the One-way Northbound scenario, the intersection would have side street stop control, like the No Build alternative.

Source: Fehr & Peers, 2016

The one-way northbound scenario would shift southbound traffic back to the Richards Boulevard tunnel, which would result in higher delays at First Street/E Street. At Olive Drive/Richards Boulevard, the AM peak hour intersection delay would be reduced since conflicting traffic from westbound Olive Drive would be lower. However, the Third Street/L Street intersection would have worse operations during both peak hours due to the intersection configuration, which would require all-way split phase operation for the four approaches: eastbound, southbound, northbound from Second Street, and northbound from Olive Drive. On the south leg, the right-of-way allows for one southbound lane to Second Street, a northbound left turn lane from Olive Drive, a northbound through lane from Olive Drive, and a northbound left-turn/through lane from Second Street. At least one more lane is needed to serve the traffic demand from Second Street under the PM peak hour. Without a larger footprint, the intersection would have LOS F conditions. The congestion would extend to the Olive Drive/L Street intersection and result in a queue on westbound Olive Drive that would extend onto the westbound I-80 mainline.

PEDESTRIAN/BICYCLE CONNECTIVITY

The three alternatives that provide new non-motorized connections will improve the accessibility for the East Olive area, which is bounded by the Union Pacific Railroad, I-80, and Richards Boulevard. To assess how the accessibility will change, a spatial analysis was conducted to determine the walk time to neighboring parcels. **Figure 19** shows the parcels under existing conditions that are no more than 15 minutes away by foot from the central parcels in the East Olive area (containing the Lexington and Arbor apartments and the Lincoln40 site). The West Olive and East Olive areas are reachable within 10 minutes, but most of downtown Davis, including the Amtrak station, is more than 10 minutes away. Based on the existing transportation network, 145 acres can be reached within 15 minutes from the central part of the East Olive area.

With the L Street Vehicle Connection alternative, shown in **Figure 20**, the area north of the Union Pacific Railroad and east of the railroad line to Woodland would become accessible by foot within 15 minutes. The acreage accessible within 15 minutes of central East Olive would increase from 145 to 311 acres – more than double.

Figure 21 shows the walk travel time from East Olive with the Davis Transit Depot Pedestrian/Bike Connection alternative. Compared with the L Street Vehicle Connection alternative, less acreage is added to the area within 15 minutes: the increase is about 50 percent. However, the downtown area near the Amtrak station along F, G, and Second Streets can now be reached within 10 minutes.

The Pole Line Road Bike Path Connection, shown in **Figure 22**, would provide a better regional connection to the Pole Line Road corridor including the DMV office at Fifth Street and the Safeway-anchored retail center at Cowell Boulevard. The increase in acreage reachable within 15 minutes would be greater than the Davis Transit Depot Pedestrian/Bike Connection, but less than the L Street Vehicle Connection.

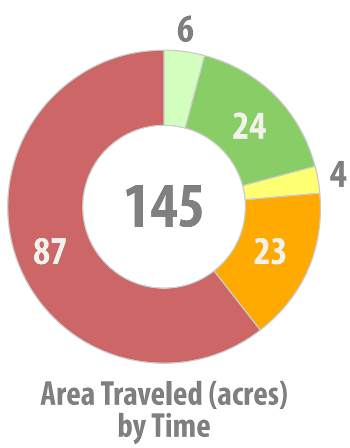

Figure 19

Walk Travel Time Baseline Conditions

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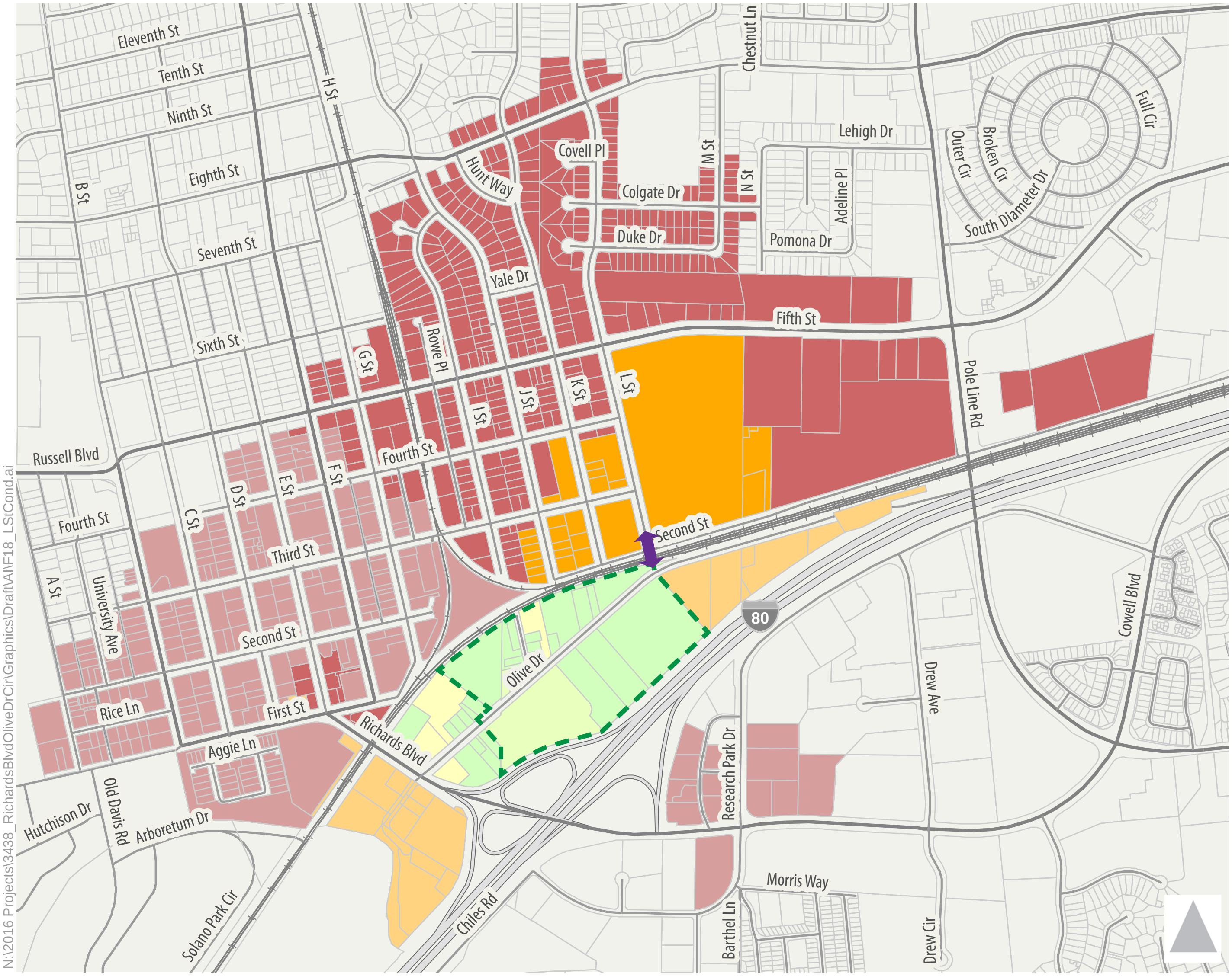


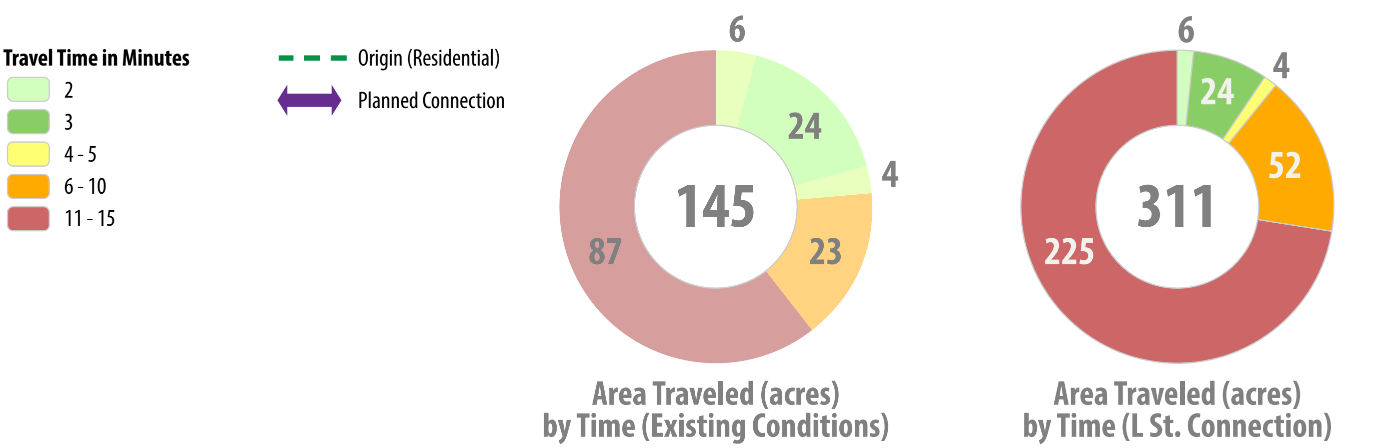
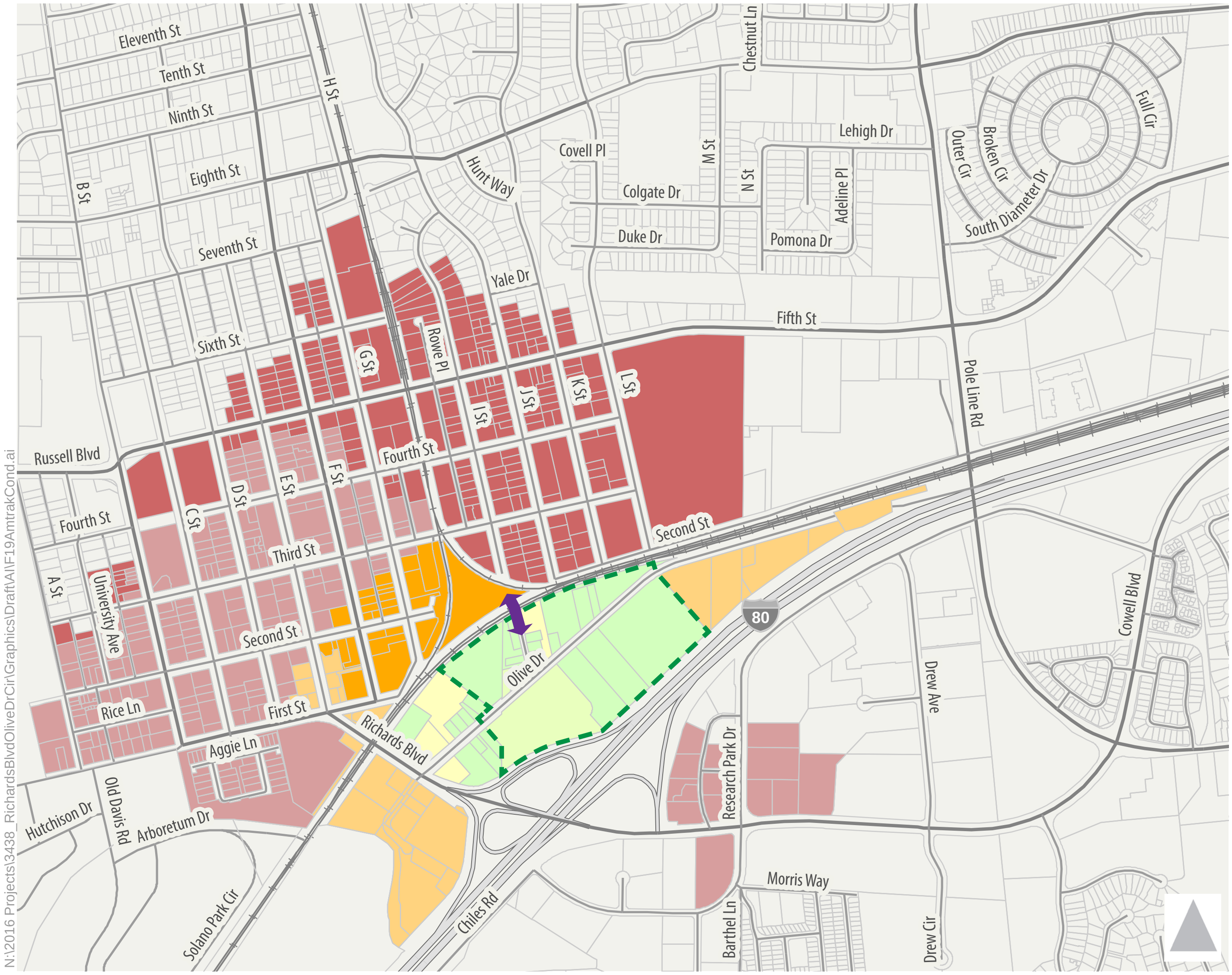


Figure 20

Walk Travel Time

L Street Vehicle Connection



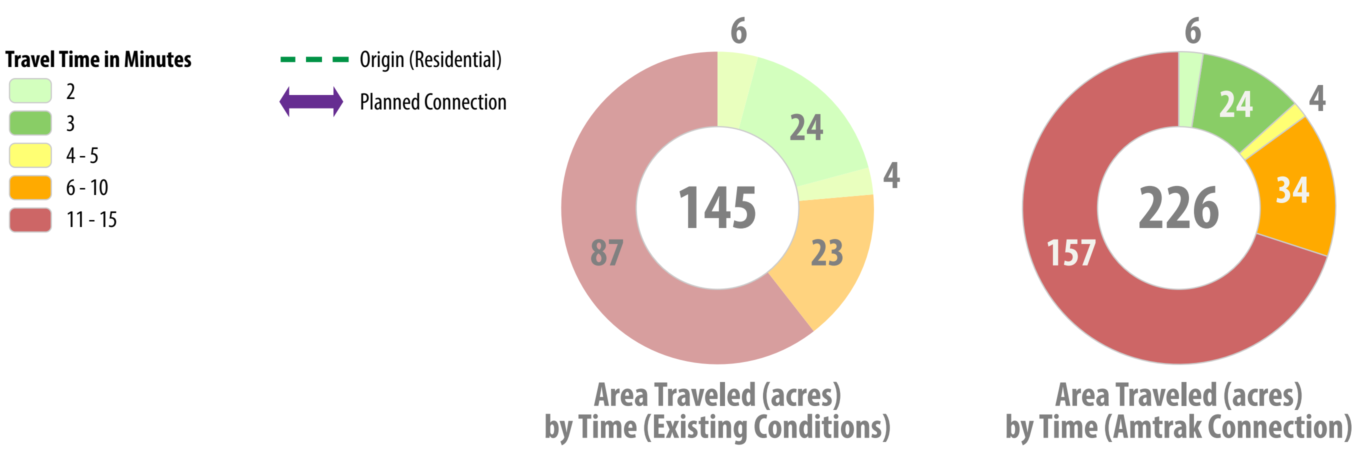


Figure 21

Walk Travel Time

Davis Transit Depot Pedestrian/Bike Connection

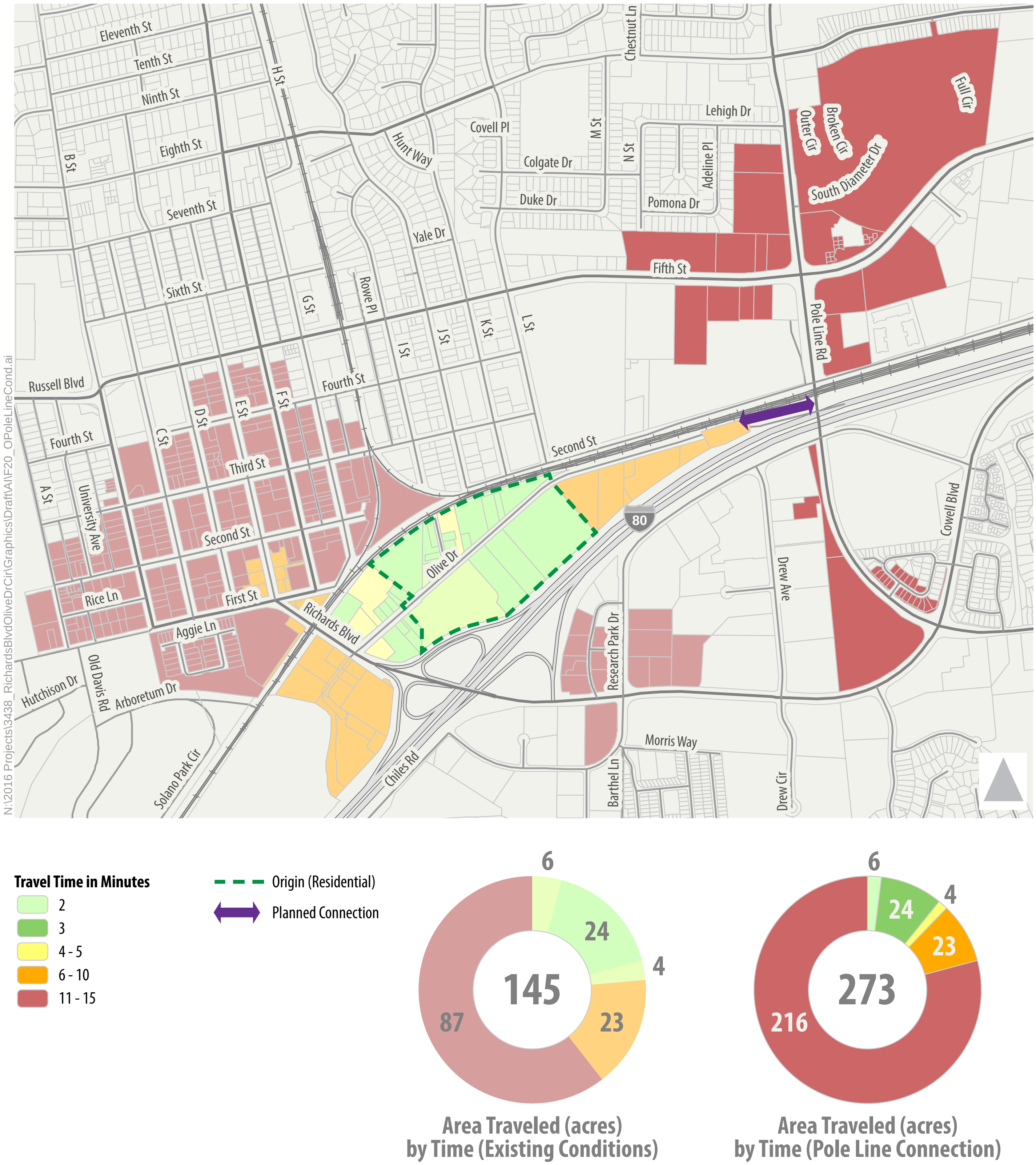


Figure 22

Walk Travel Time

Pole Line Road Bike Path Connection