

# **Fresno/Madera Origin-Destination Study**

Prepared for:  
Fresno Council of Governments  
Madera County Transportation Commission

May 4, 2016

WC15-3205

FEHR  PEERS



## Table of Contents

<b>INTRODUCTION .....</b>	<b>1</b>
Study Approach.....	2
<b>VEHICLE CLASSIFICATION COUNTS .....</b>	<b>4</b>
Vehicle Classification Count Data Collection.....	4
Vehicle Classification Count Data Summary.....	6
Vehicle Classification Count Findings.....	8
Overall Traffic Pattern.....	8
Traffic Pattern by Survey Data Location.....	9
Traffic Pattern Along SR 99 and SR 41.....	12
Traffic Pattern at the Fresno/Madera County Line.....	15
Vehicle Classification Count Limitations.....	17
<b>LICENSE PLATE ANALYSIS .....</b>	<b>18</b>
License Plate Data Collection.....	18
License Plate Data Summary.....	18
Unique License Plate Numbers .....	20
Summarized by Number of Observations.....	20
Summarized by Vehicle Classification.....	21
License Plate Address Analysis.....	22
County of Vehicle Registration .....	22
City of Vehicle Registration.....	23
License Plate Matching Analysis .....	25
Fresno and Madera County Trips.....	27
License Plate Analysis Limitations.....	29
<b>VEHICLE INTERCEPT MAIL SURVEY.....</b>	<b>30</b>
Mail Survey.....	30
Mail Survey Sample Size.....	30
Mail Survey Instrument.....	32



Mail Survey Response Data.....	33
Mail Survey Limitations.....	34
<b>MOBILE DEVICE DATA.....</b>	<b>35</b>
StreetLight Data Origin-Destination Data.....	35
Relative Rather than Absolute Trips.....	36
Final Absolute Origin-Destination Trip Tables.....	38
Travel Model Comparison.....	40
Mapping of Origin-Destination Data .....	40
<b>CONCLUSIONS.....</b>	<b>54</b>
Summary of Study Approach.....	54
Conclusions .....	55
Key Findings .....	55
Findings from Individual Data Collection Methods.....	55

## Appendices

- Appendix A: Vehicle Classification Count Data
- Appendix B: License Plate Analysis Data
- Appendix C: Vehicle Intercept Mail Survey Data
- Appendix D: Mobile Device Data



## List of Figures

Figure 1 Survey Data Locations .....	5
Figure 2 Final Geographic Layer .....	37
Figure 3 Heat Map of Weekday Daily Trip Origins .....	42
Figure 4 Heat Map of Weekday Daily Select-Link Trips on SR 99 North of the City of Madera .....	43
Figure 5 Heat Map of Weekday Daily Select-Link Trips on SR 99 North of Avenue 12 .....	44
Figure 6 Heat Map of Weekday Daily Select-Link Trips on SR 99 at the Fresno/Madera County Line.....	45
Figure 7 Heat Map of Weekday Daily Select-Link Trips on SR 41 North of North Fork Road.....	46
Figure 8 Heat Map of Weekday Daily Select-Link Trips on SR 41 North of Avenue 12 .....	47
Figure 9 Heat Map of Weekday Daily Select-Link Trips on SR 41 at the Fresno/Madera County Line.....	48
Figure 10 Heat Map of Weekday Daily Select-Link Trips on SR 41 North of SR 180 in Fresno County .....	49
Figure 11 Heat Map of Weekday Daily Select-Link Trips on Avenue 9 just East of SR 99 .....	50
Figure 12 Heat Map of Weekday Daily Select-Link Trips on Avenue 9 just West of SR 41 .....	51
Figure 13 Heat Map of Weekday Daily Select-Link Trips on Avenue 12 just East of SR 99.....	52
Figure 14 Heat Map of Weekday Daily Select-Link Trips on Avenue 12 just West of SR 41.....	53

## List of Tables

Table 1 Study Approach .....	2
Table 2 Vehicle Classification Count Data Summary.....	7
Table 3 Properly Transcribed License Plates by Location.....	19
Table 4 Number of Observations.....	21
Table 5 Vehicle Classification.....	21
Table 6 City of Vehicle Registration .....	24
Table 7 Inferred Trip Purpose.....	26
Table 8 Surveys Mailed by County .....	32
Table 9 Responses by City Where the Trip Began.....	33
Table 10 AM Peak Period County-to-County Flows.....	38
Table 11 PM Peak Period County-to-County Flows .....	38
Table 12 Daily County-to-County Flows .....	39

## INTRODUCTION

The Fresno Council of Governments (Fresno COG), in partnership with the Madera County Transportation Commission (MCTC), directed the Fresno/Madera Origin-Destination Study to gain an understanding of transportation movements between Fresno and Madera counties along SR 99 and SR 41 and the various impacts associated with such movements. This report addresses part one of this study which is an analysis of origin and destination traffic movements between Fresno and Madera counties, with a focus on understanding where Fresno and Madera County residents work and shop. The information presented in this report will be utilized in part two of this study which will analyze the fiscal impacts of transportation movements between Fresno and Madera counties on the local and regional economy. The results of the joint study are intended to better inform local decision-making bodies regarding travel patterns and their economic impacts, while improving the regional planning agencies' abilities to implement their Sustainable Communities Strategies.

### **Goal: Gain an understanding of transportation movements between Fresno and Madera counties along SR 99 and SR 41.**

The traditional approach to gathering data on travel behavior is through the use of a survey as this type of data cannot be collected by the typical traffic count process. Data for trips that pass through the region is usually collected by a license plate survey while data for trips that start from or end inside the region is usually collected by a roadside, mail, or telephone survey. These traditional survey methods tend to be very costly and generally provide very small sample sizes. They are also prone to human error during the data collection process as well as from the survey responders who may misinterpret the questions.

In order to minimize the shortcomings of traditional approaches, Fehr & Peers evaluated various innovative data collection techniques as well as enhancements to traditional methods for use in this study. Pros and cons of each technique and method were identified as well as the ways in which multiple data sources could be combined to maximize the benefits from the data collection plan. Through previous and on-going project experience, the wide range of data collection techniques and methods was narrowed down to four to be used for the Fresno/Madera Origin-Destination Study, combining innovative data collection techniques with enhancements to traditional methods to offer an unprecedented look into travel behavior in the Central Valley. Results from the four data collection methods were then combined to provide a robust, comprehensive dataset, specific to Fresno and Madera counties, which was then presented to Fresno COG, MCTC, Caltrans, and local agencies in an innovative and meaningful way.





## STUDY APPROACH

The Fresno/Madera Origin-Destination Study utilized and combined the results of the four data collection methods described in **Table 1**, which provides a list of the methods along with a list of advantages and limitations of each.

**TABLE 1 STUDY APPROACH**

Method	Advantages	Limitations
Vehicle Classification Counts	<ul style="list-style-type: none"> <li>• Very accurate and only way to directly measure total traffic volume passing through a count location.</li> <li>• Provides control total to refine data collected via other methods.</li> <li>• Can be used to compare to travel demand model roadway volume by class.</li> <li>• Provides overall traffic pattern.</li> <li>• Relatively cheap data collection method.</li> </ul>	<ul style="list-style-type: none"> <li>• Does not provide the origin, destination, or purpose of the vehicle trip or any other trip making or demographic information.</li> <li>• Unable to determine the home, work, or shopping location of an observed vehicle.</li> <li>• Unable to determine if a vehicle is passing through the study area.</li> </ul>
License Plate Analysis	<ul style="list-style-type: none"> <li>• Provides location where vehicle is registered which is likely the home location.</li> <li>• Trip purpose information can be inferred.</li> <li>• Provides information on pass-through travel, entry and exit points, and travel time between points.</li> <li>• Provides data in a format more suitable for comparison and integration with travel demand models.</li> <li>• Provides data necessary to conduct vehicle intercept mail surveys to obtain more detailed trip making and demographic information.</li> </ul>	<ul style="list-style-type: none"> <li>• Only able to provide vehicle registration location which is not necessarily the home location or origin of the trip.</li> <li>• Trip purpose information must be inferred based on location, direction, and number of observations.</li> <li>• Unable to provide information regarding trip frequency, characteristics of travel or demographics.</li> <li>• Only captures trips that pass through a count location.</li> </ul>



**TABLE 1 STUDY APPROACH**

Method	Advantages	Limitations
Vehicle Intercept Mail Survey	<ul style="list-style-type: none"> <li>• Provides detailed information regarding trip purpose, occupancy, frequency of travel, demographics, class of vehicle, and other travel characteristics.</li> <li>• Provides data in a format and at a level of disaggregation more suitable for comparison and integration with travel demand models.</li> </ul>	<ul style="list-style-type: none"> <li>• Depending on the response rate, may only provide detailed trip purpose, occupancy, and class of vehicle information for a percentage of observed trips.</li> <li>• Only captures trips that pass through at least one survey location.</li> <li>• Development and implementation of survey of a sufficient size to be statistically valid can be costly.</li> <li>• Prone to human error during the data collection process as well as from the survey responders who may misinterpret the questions.</li> </ul>
Mobile Device Data	<ul style="list-style-type: none"> <li>• Very large sample size able to provide information regarding all types of trips that occur.</li> <li>• Provides true origin-destination data rather than observed or vehicle registration location.</li> <li>• Provides origin-destination data in a format more suitable for comparison and integration with travel demand models.</li> <li>• Data can be queried, aggregated and disaggregated to match desired level of analysis.</li> <li>• Data collection method does not require set up time or human transcribing of observed field data which can potentially introduce error.</li> </ul>	<ul style="list-style-type: none"> <li>• Unable to directly measure information regarding trip purpose, frequency, characteristics of travel or demographics. However, much of this information can be inferred or supplemented with information from other sources.</li> <li>• Collection and aggregation of data can be costly but provides a significantly larger sample size than other methods.</li> </ul>

Source: Fehr & Peers, 2016.



## VEHICLE CLASSIFICATION COUNTS

Vehicle classification counts play a pivotal role in any data collection or travel behavior study as they provide the total traffic volume by class of vehicle and desired time period at all survey data locations and can be used as a control total to refine the travel data collected from other methods. This data can then be used to determine the overall traffic pattern in the study area.

### VEHICLE CLASSIFICATION COUNT DATA COLLECTION

MioVision coordinated, collected, and summarized the vehicle classification counts collected at seven survey data locations over a 24-hour period on Wednesday, July 29, 2015. The data collection effort was conducted in July to avoid construction at the SR 41/Avenue 12 intersection that was set to begin in August 2015. The date was also selected with the understanding that there was no way to avoid construction at the SR 99/Avenue 12 interchange within the timeframe of this study.

The seven survey data locations where vehicle classification counts were collected are listed below and shown on **Figure 1**. The locations include three locations along SR 99 and four locations along SR 41, including the locations where the highways intersect the Fresno/Madera county line in order to capture all trips that travel between Fresno and Madera counties. The specific data collection locations were selected based on proximity to the desired count location, safety, and logistics.

- Location 1: SR 99 North of the City of Madera
- Location 2: SR 99 North of Avenue 12
- Location 3: SR 99 at the Fresno/Madera County Line
- Location 4: SR 41 North of North Fork Road
- Location 5: SR 41 North of Avenue 12
- Location 6: SR 41 at the Fresno/Madera County Line
- Location 7: SR 41 North of SR 180 in Fresno County

The data was collected through the use of infrared video cameras in order to provide a classification of vehicles into cars, light goods vehicles, single-unit trucks, articulated trucks, buses, and motorcycles over the entire 24-hour period. MioVision also utilized sophisticated computer software to tally the various classes of vehicles, reducing potential human error, man-hour cost, and data delivery time.





N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd

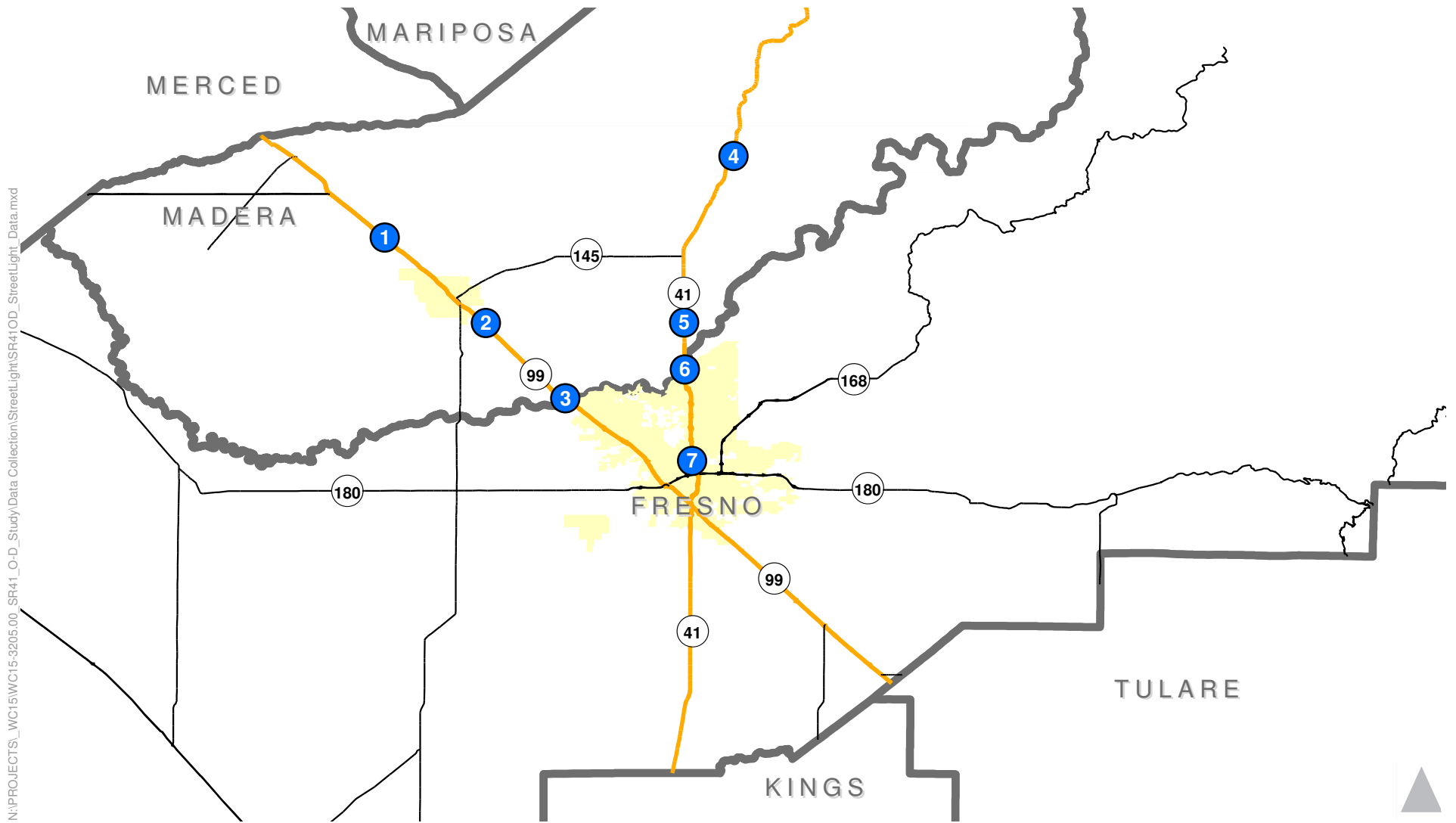


Figure 1  
Survey Data Locations

Upon delivery of the vehicle classification data, Fehr & Peers summarized the data by the vehicle classification categories listed above and the following time periods.

- Early-Morning (Midnight to 6:00 AM)
- AM Peak Period (6:00 to 10:00 AM)
- Mid-Day (10:00 AM to 3:00 PM)
- PM Peak Period (3:00 to 7:00 PM)
- Late Night (7:00 PM to Midnight)
- Daily (24-Hour)

The bidirectional daily vehicle count data was then compared to Caltrans 2014 bidirectional annual average daily traffic (AADT) data at nearby locations to check the reasonableness of the collected count data, an important step as this data will be used to weight the survey and mobile device data to the total population of travelers at each of the survey data locations.

## VEHICLE CLASSIFICATION COUNT DATA SUMMARY

A summary of the bidirectional vehicle classification count data collected by MioVision is shown in **Table 2**. The traffic count sheets and detailed directional vehicle classification count data are provided in **Appendix A**.

As shown in **Table 2** and **Appendix A**, 428,407 total vehicles were observed (many vehicles were likely counted more than once) passing through the seven vehicle classification count locations, approximately 5% higher than the Caltrans 2014 AADT data. This is an acceptable difference given the traffic counts were collected on a mid-week day in 2015 while the Caltrans volumes are intended to represent an average day from 2014. Additionally, of the 428,407 total observed vehicles approximately 22% and 27% were counted during the 4 hour AM and PM peak periods, respectively..

**428,407 total vehicles were counted at the seven locations**



**TABLE 2 VEHICLE CLASSIFICATION COUNT DATA SUMMARY**

#	Survey Data Location	Early AM (12 AM to 6 AM)	AM 4-Hr (6 AM to 10 AM)	Mid-Day (10 AM to 3 PM)	PM 4-Hr (3 PM to 7 PM)	Late Night (7 PM to 12 AM)	Daily	2014 Caltrans AADT
1	SR 99 North of the City of Madera	6,153	12,179	17,793	14,570	8,281	58,976	61,000
2	SR 99 North of Avenue 12	6,907	16,417	21,338	19,204	9,196	73,062	66,000
3	SR 99 at the Fresno/Madera County Line	7,134	15,217	19,957	17,855	9,634	69,797	66,000
4	SR 41 North of North Fork Road in Madera County	643	3,020	4,022	3,641	1,562	12,888	11,000
5	SR 41 North of Avenue 12	870	4,205	5,507	5,279	2,668	18,529	18,500
6	SR 41 at the Fresno/Madera County Line	2,012	11,279	13,878	13,764	6,388	47,321	44,500
7	SR 41 North of SR 180 in Fresno County	7,742	33,375	45,107	40,722	20,888	147,834	141,000
Total		31,461	95,692	127,602	115,035	58,617	428,407	408,001

Source: Fehr & Peers, 2016.





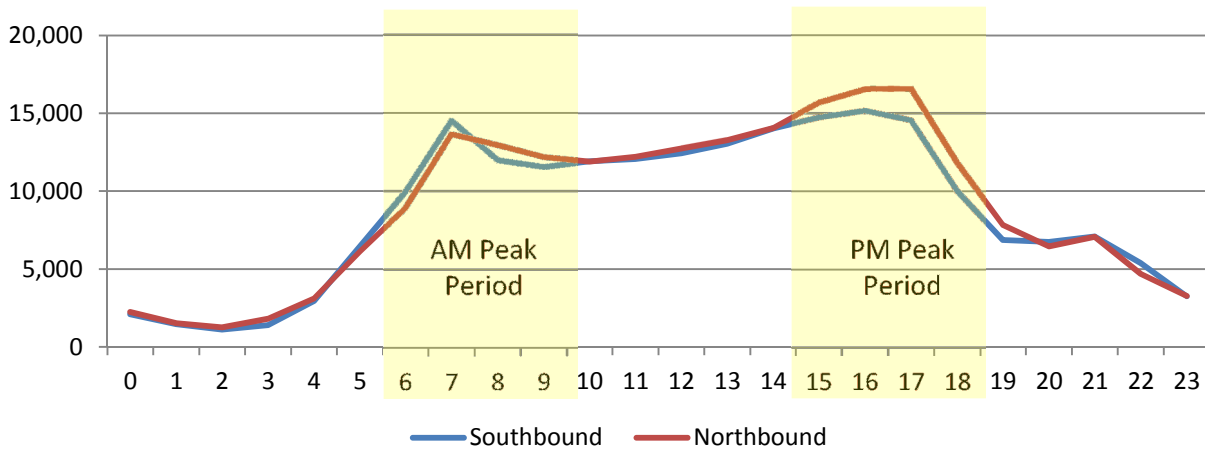
## VEHICLE CLASSIFICATION COUNT FINDINGS

### OVERALL TRAFFIC PATTERN

**Chart 1** illustrates the sum of the traffic volumes counted at each of the seven survey data locations by direction and hour of day, providing a sense of the overall directional traffic pattern across the day. As shown in **Chart 1**, northbound and southbound flows are roughly equal throughout the day, suggesting that work and non-work trips occur in both directions.

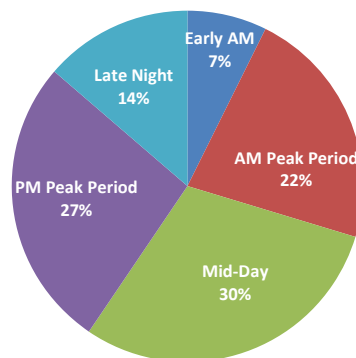
**Key Finding:** Northbound and southbound flows are roughly equal throughout the day.

### Chart 1 - Overall Traffic Pattern by Hour of Day



**Chart 2** illustrates the percentage of total counted traffic that occurs in each time period.

### Chart 2 - Overall Traffic Pattern by Time Period

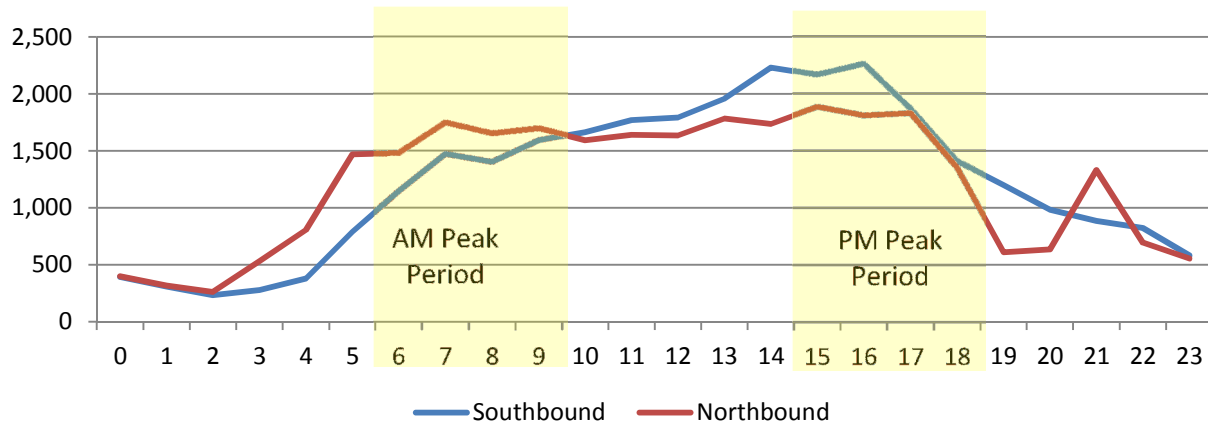




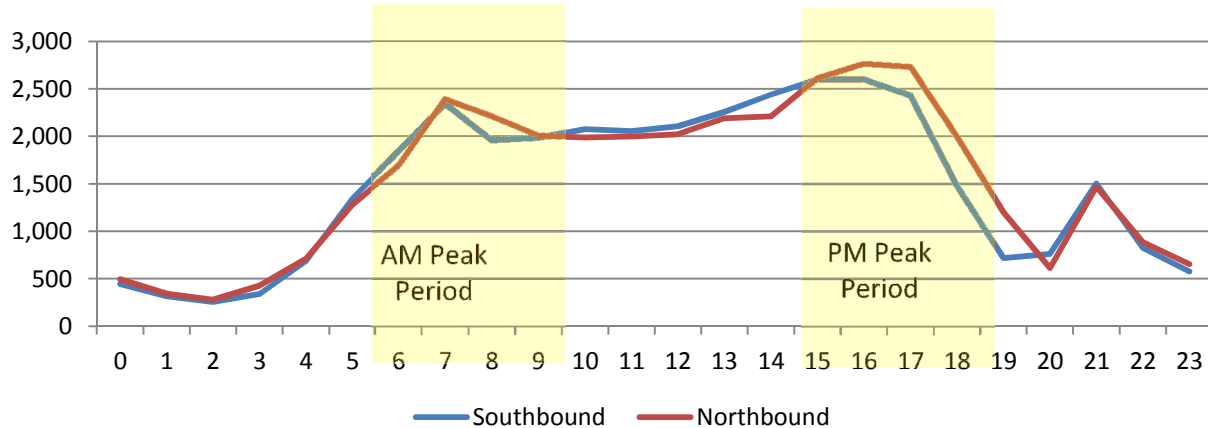
## TRAFFIC PATTERN BY SURVEY DATA LOCATION

**Chart 3 through Chart 9** illustrates the hourly traffic pattern at each of the seven survey data locations. As shown below, the hourly traffic patterns vary by survey data location.

### Chart 3 - SR 99 North of the City of Madera

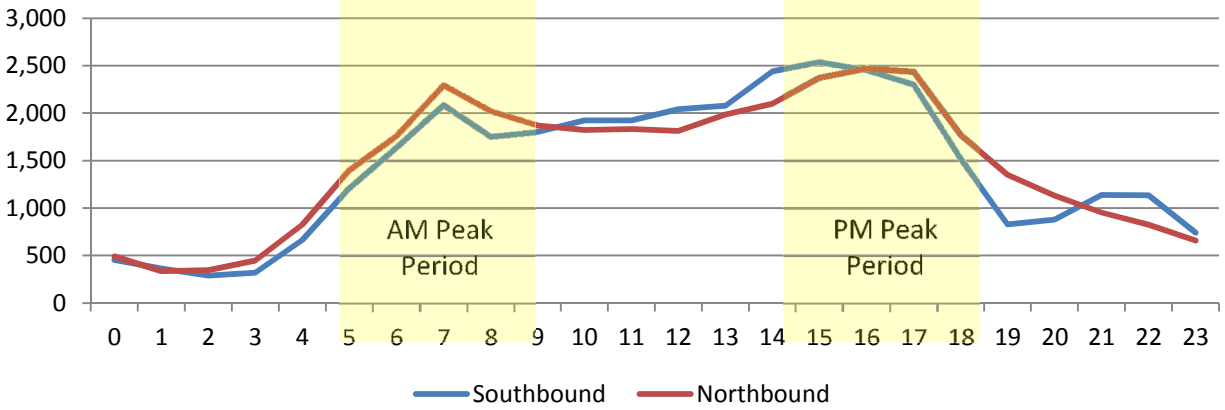


### Chart 4 - SR 99 North of Avenue 12

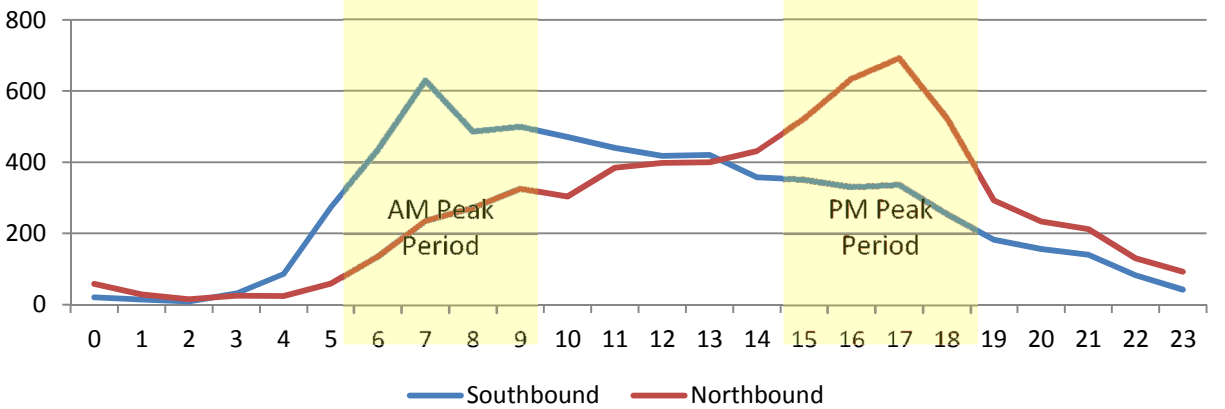




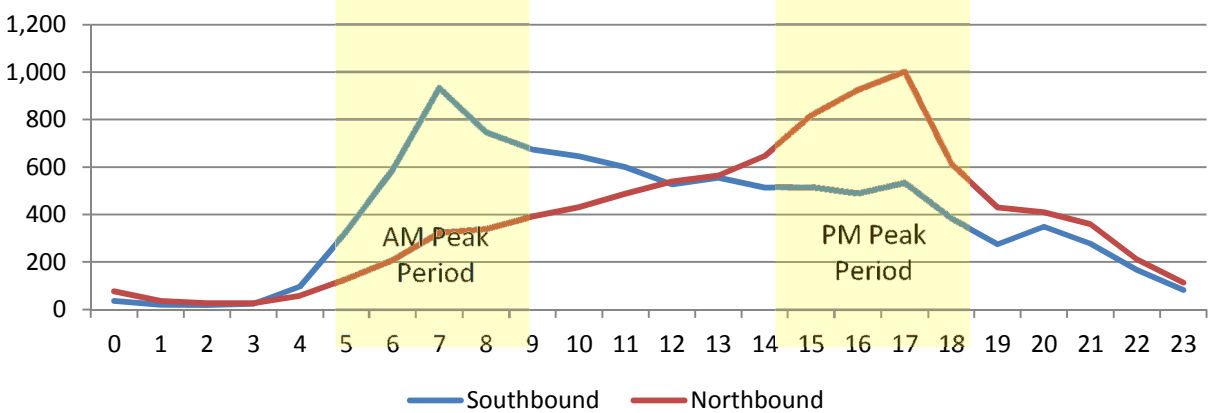
### Chart 5 - SR 99 at the Fresno/Madera County Line



### Chart 6 - SR 41 North of North Fork Road

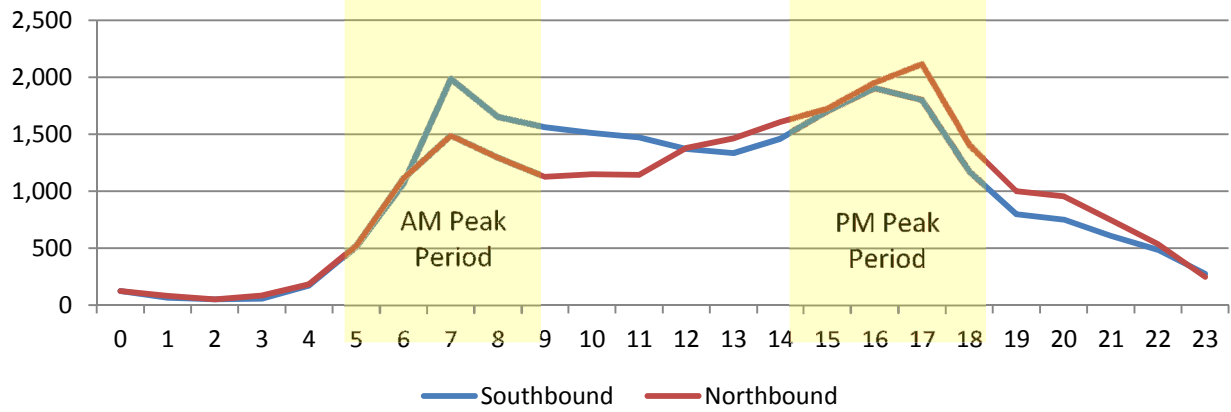


### Chart 7 - SR 41 North of Avenue 12

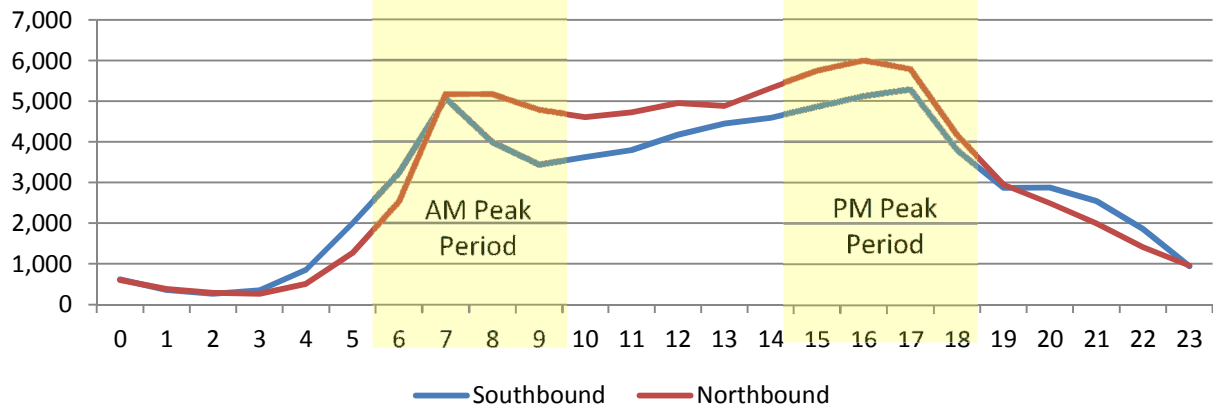




### Chart 8 - SR 41 at the Fresno/Madera County Line



### Chart 9 - SR 41 North of SR 180 in Fresno County

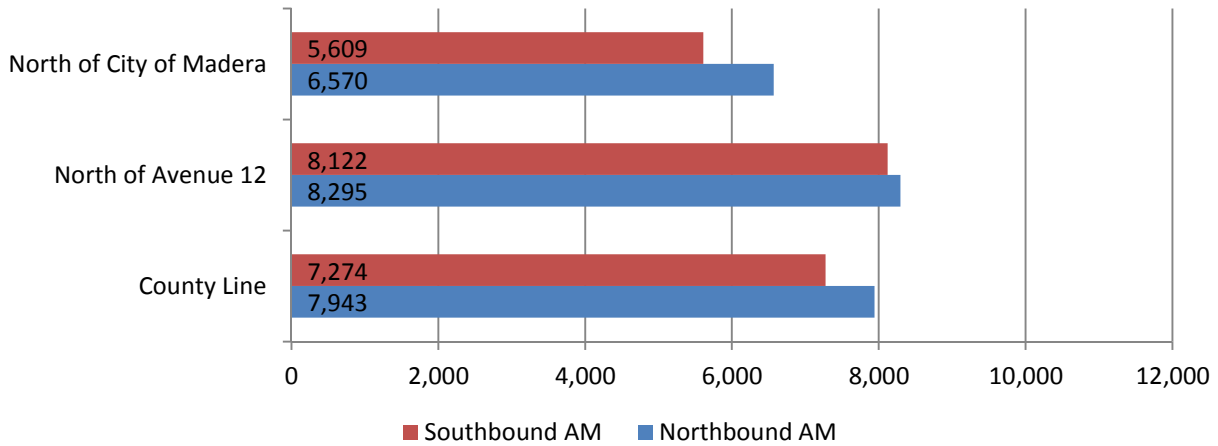




## TRAFFIC PATTERN ALONG SR 99 AND SR 41

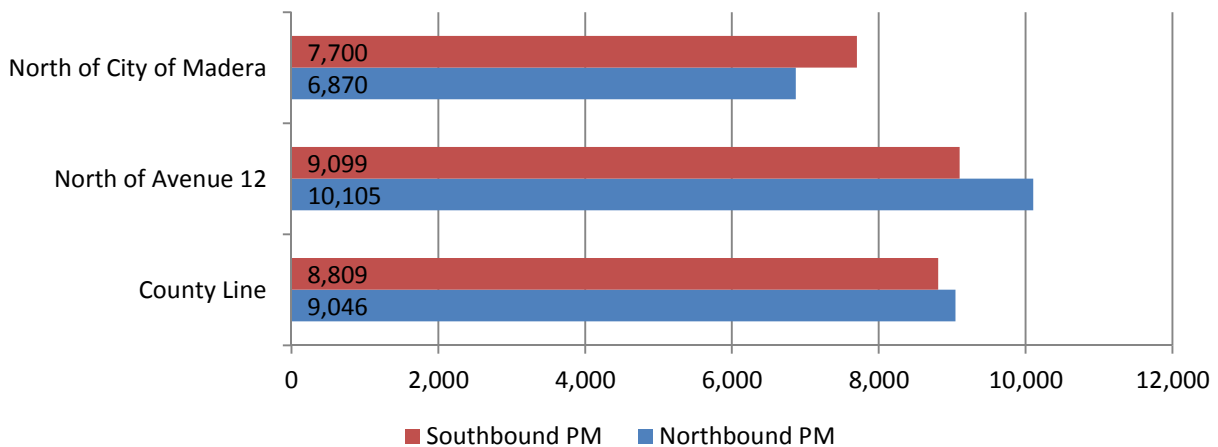
**Chart 10 through Chart 13** illustrates the 4-hour AM and 4-hour PM peak period traffic patterns along SR 99 and SR 41.

### Chart 10 - SR 99 AM Peak Period Travel Patterns



- Net loss of approximately 1,000 Southbound AM vehicles between the survey data location just north of Avenue 12 and the Fresno/Madera county line.
- Net gain of approximately 300 Northbound AM vehicles between the Fresno/Madera county line and the survey data location just north of Avenue 12.

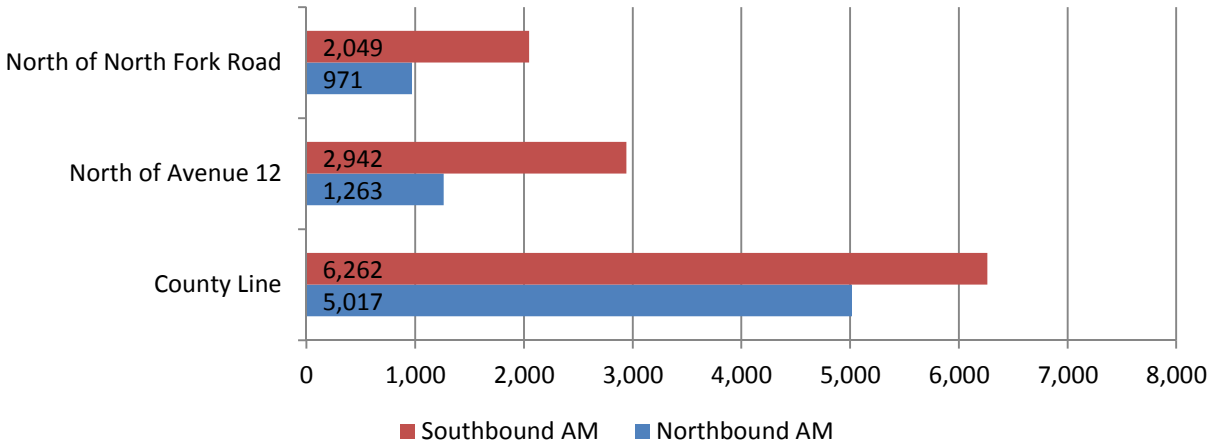
### Chart 11 - SR 99 PM Peak Period Travel Patterns





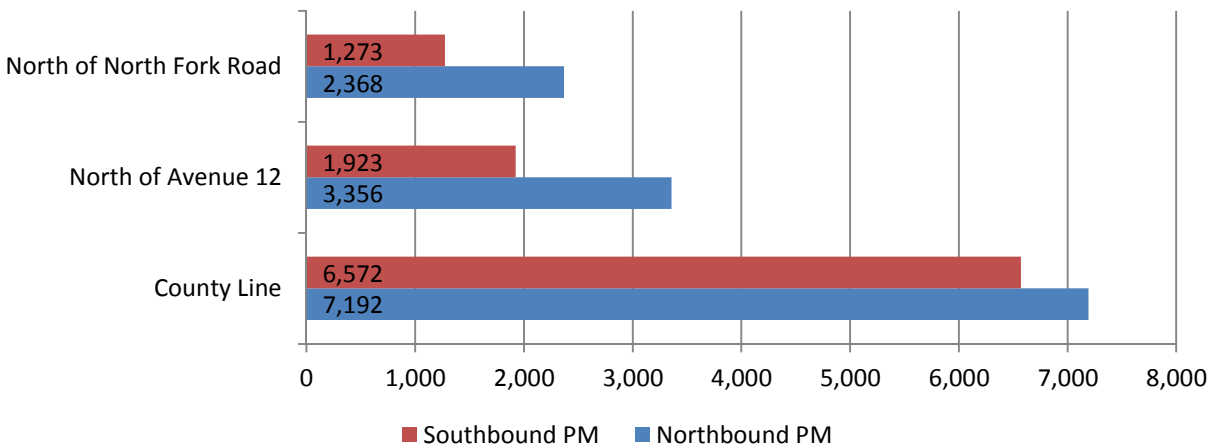
- Net gain of approximately 1,000 Northbound PM vehicles between the Fresno/Madera county line and the survey data location just north of Avenue 12.
- Net loss of approximately 300 Southbound PM vehicles between the survey data location just north of Avenue 12 and the Fresno/Madera county line.

**Chart 12 - SR 41 AM Peak Period Travel Patterns**



- Net gain of approximately 3,500 Southbound AM vehicles between the survey data location just north of Avenue 12 and the Fresno/Madera county line.
- Net loss of approximately 4,000 Northbound AM vehicles between the Fresno/Madera county line and the survey data location just north of Avenue 12.

**Chart 13 - SR 41 PM Peak Period Travel Patterns**



- Net loss of approximately 4,000 Northbound PM vehicles between the Fresno/Madera county line and the survey data location just north of Avenue 12.
- Net gain of approximately 4,500 Southbound PM vehicles between the survey data location just north of Avenue 12 and the Fresno/Madera county line.

The peak period traffic patterns illustrated above suggest that vehicles traveling between Fresno and Madera counties along SR 99 and SR 41 utilize Avenue 12. However, traffic count data does not provide the origin, destination, or purpose of observed vehicles, only the location and time the vehicles were observed. In spite of this, inferences can be made based on observed differences in the direction and magnitude of the travel patterns at different locations. Such inferences are described below.

### **Traffic Pattern along SR 41**

Approximately 5,000 vehicles travel between Fresno County and Madera County on SR 41 in the AM peak period, with 4,000 of those vehicles utilizing Avenue 12. However, a net gain of only 300 vehicles is observed on northbound SR 99 between the Fresno/Madera county line and the survey data location just north of Avenue 12, suggesting that a majority of those vehicles work or utilize services along Avenue 12 in Madera County. A similar pattern in the PM peak period suggests that a majority of these vehicles are commuters.

**Key Finding: Vehicles traveling between Fresno County and Madera County on SR 41 in the AM peak period primarily work or utilize services along Avenue 12 in Madera County.**

### **Traffic Pattern along SR 99**

Approximately 8,000 vehicles travel southbound on SR 99 just north of Avenue 12 in the AM peak period, with a net loss of 1,000 vehicles at the Fresno/Madera county line, suggesting a minimum of 1,000 vehicles utilize Avenue 12. However, a net gain of 3,500 vehicles is observed on southbound SR 41 between the survey data location just north of Avenue 12 and the Fresno/Madera county line, suggesting that residents along SR 99 and Avenue 12 in Madera County use Avenue 12 to work or utilize services along SR 41 in Fresno County. A similar pattern in the PM peak period suggests that a majority of these vehicles are commuters.

**Key Finding: Vehicles traveling between Madera County and Fresno County along SR 99 in the AM peak period use Avenue 12 to work or utilize services along SR 41 in Fresno County.**

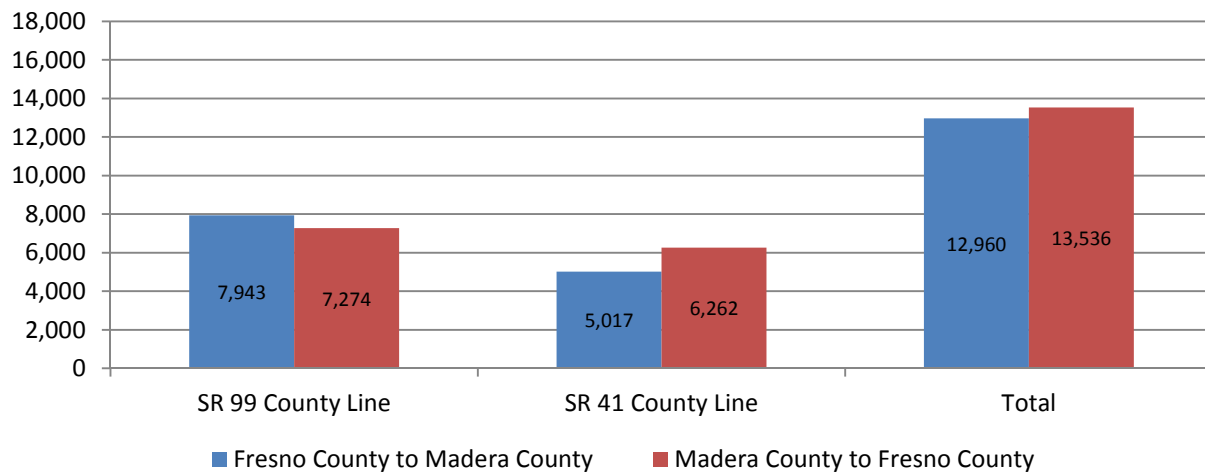




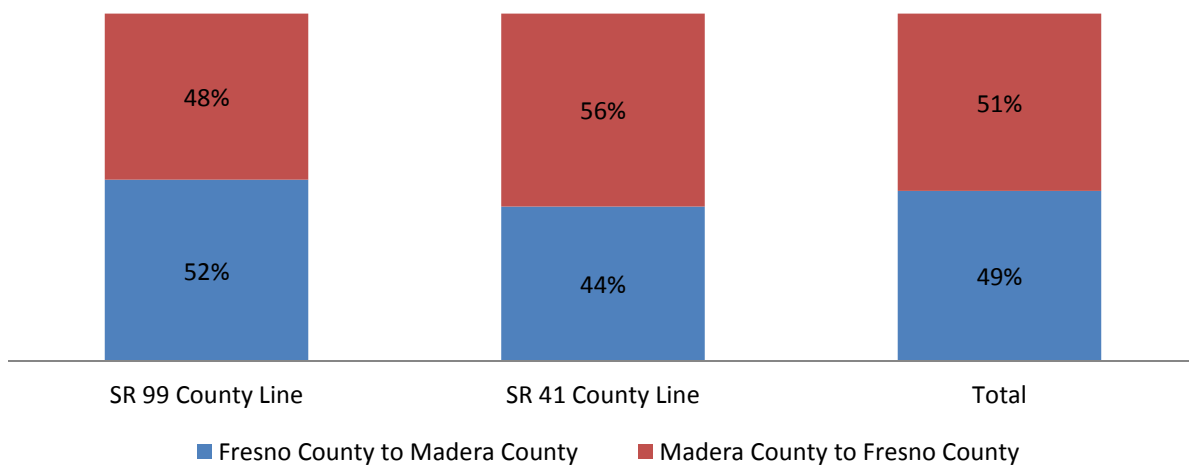
## TRAFFIC PATTERN AT THE FRESNO/MADERA COUNTY LINE

**Chart 14 through Chart 17** illustrates the 4-hour AM and 4-hour PM peak period traffic patterns along SR 99 and SR 41 at the Fresno/Madera county line.

### Chart 14 - Fresno/Madera County Line AM Peak Period Traffic Counts

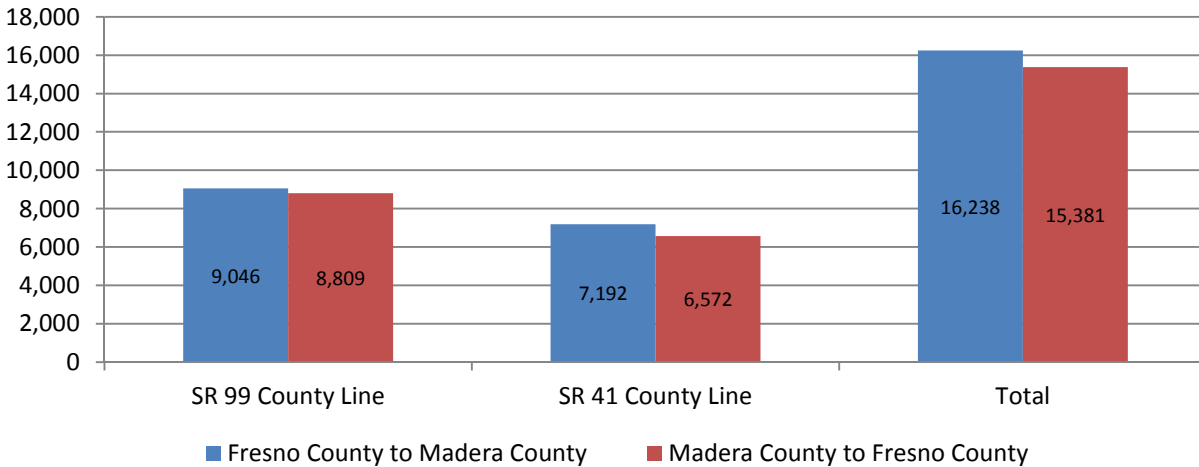


### Chart 15 - Fresno/Madera County Line AM Peak Period Traffic Count Percentages

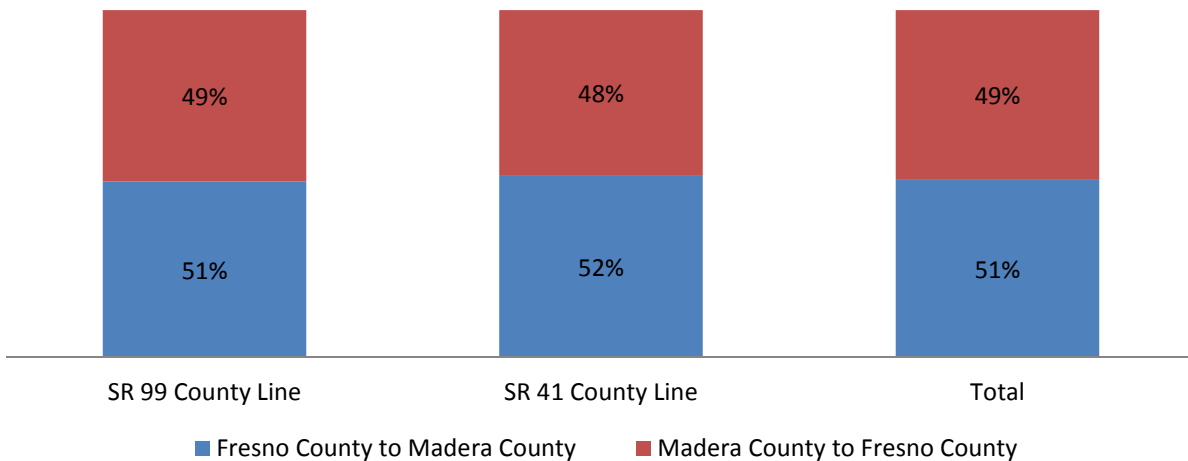




### Chart 16 - Fresno/Madera County Line PM Peak Period Traffic Counts



### Chart 17 - Fresno/Madera County Line PM Peak Period Traffic Count Percentages



The traffic patterns illustrated above indicate that Fresno County to Madera County and Madera County to Fresno County traffic patterns vary by location and time-of-day but are roughly equal in the AM and PM peak periods.

**Key Finding:** Fresno County to Madera County and Madera County to Fresno County traffic patterns vary by location and time-of-day but are roughly equal in the AM and PM peak periods.



## VEHICLE CLASSIFICATION COUNT LIMITATIONS

As discussed in **Table 1**, vehicle classification counts are a very accurate way to directly measure total traffic volume passing through a count location but do not provide origin, destination, purpose, or any other trip making or demographic information. This information can be used to determine the overall traffic pattern but is unable to answer key questions this study seeks to answer.

- Where do Fresno County and Madera County residents work and shop?
- What percentage of trips traveling between Fresno County and Madera County are from people who live or work in Fresno or Madera counties?
- What types of trips occur between Fresno and Madera counties?
- Are different types of trips occurring on SR 41 compared to SR 99?

Therefore, the vehicle classification count data will be used to provide overall traffic patterns and control totals to refine data collected via other methods that are able to answer questions such as those listed above.



## LICENSE PLATE ANALYSIS

License plate analysis involves the positioning of cameras at multiple locations to record the license plate of passing vehicles. The outcome of this method is a list of observed license plate numbers with location and time information that can be compared and matched to infer more detailed traffic patterns than with counts alone. Vehicle registration location can also be obtained from the DMV and used to infer origin and trip purpose information.

## LICENSE PLATE DATA COLLECTION

For the license plate data collection effort, MioVision used the same cameras that were placed at the seven vehicle classification count locations on Wednesday, July 29, 2015 (locations shown on **Figure 1** above). License plate numbers collected as part of this effort were matched between locations and used to develop a list of unique license plate numbers to obtain vehicle registration addresses to analyze and to mail a survey to in order to obtain a sample of very detailed trip making and demographic data. Additionally, the observed travel direction, time of travel, and number of observations was used to infer trip purpose information.

The same infrared technology utilized by MioVision to collect vehicle classification counts over a 24-hour period also allowed license plate data to be collected over the entire 4-hour AM (6 AM to 10 AM) and 4-hour PM (3 PM to 7 PM) peak periods. MioVision also utilized the same sophisticated computer software to transcribe the individual license plates, reducing potential human error, man-hour cost, and data delivery time. The use of computer software rather than manual transcription was especially important for this study given the high speed of travel at the state highway locations where the data was collected.

## LICENSE PLATE DATA SUMMARY

Upon delivery of the license plate data, Fehr & Peers summarized the data to determine the number of observed license plates and the number of properly transcribed license plates for each of the seven survey data locations. The data was then compared to the number of counted vehicles to ensure the reasonableness of the data. The properly transcribed license plate data at each location for the sum of the 4-hour AM and 4-hour PM peak periods is summarized in **Table 3**.



**TABLE 3 PROPERLY TRANSCRIBED LICENSE PLATES BY LOCATION**

#	Location	Counted Vehicles (4-Hour AM + 4-Hour PM)	Properly Transcribed License Plates	% Properly Transcribed License Plates
1	SR 99 North of the City of Madera	26,749	25,291	95%
2	SR 99 North of Avenue 12	35,621	28,937	81%
3	SR 99 at the Fresno/Madera County Line	33,072	25,351	77%
4	SR 41 North of North Fork Road in Madera County	6,661	5,691	85%
5	SR 41 North of Avenue 12	9,484	8,325	88%
6	SR 41 at the Fresno/Madera County Line	25,043	21,051	84%
7	SR 41 North of SR 180 in Fresno County	74,097	58,850	79%
Total		210,727	173,496	82%

Source: Fehr & Peers, 2016.

As shown in **Table 3**, of the 210,727 vehicles observed passing through the seven survey data locations, the sophisticated computer software was able to properly transcribe 173,496 license plate numbers (82% of observed vehicles), a reasonable percentage given the high speed of travel at the survey data locations, all of which were located along state highways.

**Sophisticated computer software was able to properly transcribe**

**173,496 license plate numbers (82% of observed vehicles)**



## UNIQUE LICENSE PLATE NUMBERS

The properly transcribed license plate numbers provided by MioVision were the basis for developing a list of unique license plate numbers to be sent to the DMV for a list of vehicle registration addresses. A total of 101,467 unique license plate numbers were identified from the 173,496 properly transcribed license plate numbers at the seven survey data locations. The 101,467 unique license plate numbers were then sent to the DMV to obtain the vehicle registration address for each of the unique license plate numbers.

Upon receipt of the vehicle registration addresses from the DMV, they were reviewed in order to remove duplicate addresses (likely resulting from the observation of multiple vehicles from the same rental car company or business), incomplete addresses, out-of-state addresses, and addresses of businesses where the likelihood of the survey reaching the observed motorist was low. It was determined that approximately 5,000, or 5%, of the addresses associated with the 101,467 unique license plate numbers met this criteria and were removed. The screened list included 58,680 unique license plate numbers with a valid DMV address.

### **58,680 unique license plate numbers with a valid DMV address**

#### SUMMARIZED BY NUMBER OF OBSERVATIONS

The screened list of unique license plate numbers and addresses was then applied to the license plate observation data provided by MioVision. Only observations of vehicles with a license plate on the screened list of unique license plate numbers and addresses were retained, resulting in 104,305 observations, accounting for roughly 50% of the 210,727 counted vehicles and representing a sample size of roughly 50%.

### **Roughly 50% of the 210,727 counted vehicles were included in the license plate analysis**

A summary of the number of times each screened license plate number was observed is provided in **Table 4**.





**TABLE 4 NUMBER OF OBSERVATIONS**

Number of Observations	Count	Percent of Total
1	32,325	55%
2+	26,355	45%
2	14,945	25%
3	6,751	12%
4+	4,659	8%

Source: Fehr & Peers, 2016.

### SUMMARIZED BY VEHICLE CLASSIFICATION

After summarizing the screened license plate numbers by number of observations, they were divided into passenger car and commercial truck motor vehicle groups based on standard California license plate nomenclature. For instance, California passenger car license plates utilize a “number(n)-letter(l)-l-l-n-n-n” format such as “3SAM123” while California commercial truck plates utilize a “n-l-n-n-n-n-n” format such as “5M32750”. License plate numbers not fitting either category were likely vanity plates and assumed to be passenger car license plates for the license plate analysis. A summary of the vehicle classification of each screened license plate number is provided in **Table 5**.

**TABLE 5 VEHICLE CLASSIFICATION**

Vehicle Classification	Count	Percent of Total
Car (NLLLNNN)	44,311	76%
Truck (NLNNNNN)	7,768	13%
Other (i.e. vanity plate)	6,601	11%

Source: Fehr & Peers, 2016.





As shown in **Table 5**, 13% of screened license plate numbers matched the California commercial truck nomenclature, which roughly matched the vehicle classification count data that indicated commercial trucks comprised 11% of the counted vehicles.

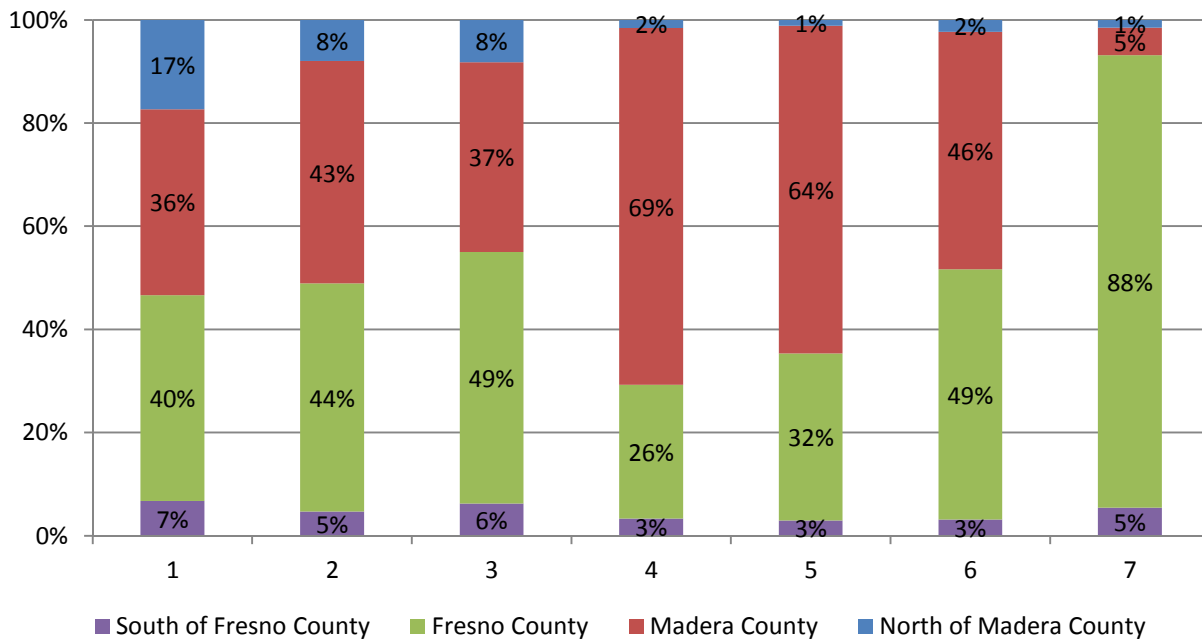
## LICENSE PLATE ADDRESS ANALYSIS

The vehicle registration addresses provided by the DMV represents the location where the vehicle is registered, which is not necessarily the home location of the driver at the time of observation or where the observed trip originated. However, the data can be used as a proxy for home location of observed trips as long as this limitation is recognized. Detailed license plate address analysis data is provided in **Appendix B**.

### COUNTY OF VEHICLE REGISTRATION

**Chart 18** summarizes the county of vehicle registration for all screened license plate numbers observed at each survey data location. As shown in **Chart 18**, roughly 85% of observed vehicles were registered in Fresno County or Madera County.

**Chart 18 - County of Vehicle Registration**



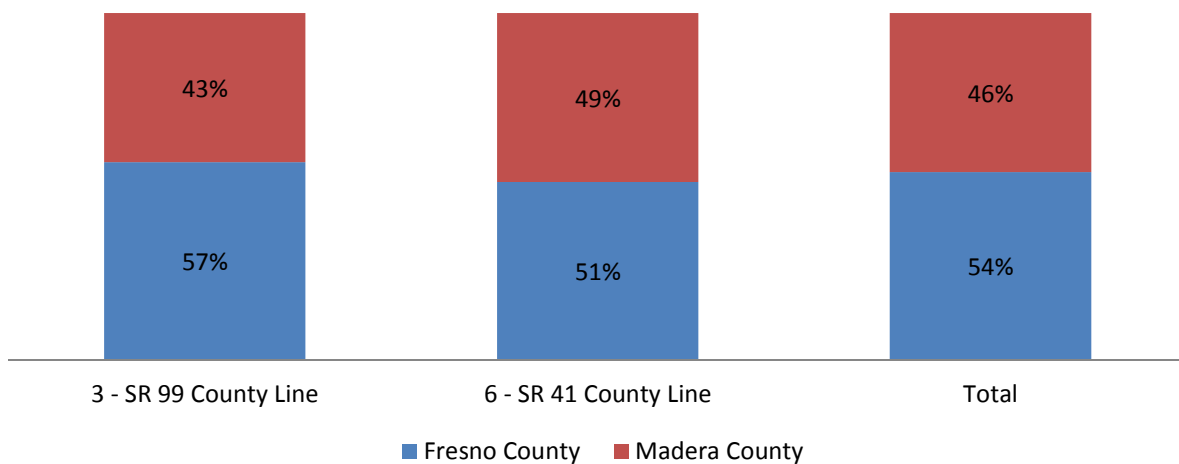


**Key Finding: Roughly 85% of observed vehicles were registered in Fresno County or Madera County.**

Since this study focuses on understanding where Fresno County and Madera County residents work and shop, the remainder of the license plate address analysis focuses on vehicle observations where the vehicle registration address was in Fresno County or Madera County.

**Chart 19** summarizes the county of vehicle registration ratio between Fresno County and Madera County for the SR 99 and SR 41 survey data locations at the Fresno/Madera county line. As shown in **Chart 19**, more vehicles crossing the Fresno/Madera county line on SR 99 or SR 41 were registered in Fresno County than Madera County.

**Chart 19 - County of Vehicle Registration Ratio**



**Key Finding: More vehicles crossing the Fresno/Madera county line on SR 99 or SR 41 were registered in Fresno County than Madera County.**

**CITY OF VEHICLE REGISTRATION**

Vehicle classification count data was used to determine the overall traffic pattern between Fresno and Madera counties and to infer the two key findings listed below.

- Vehicles traveling between Fresno County and Madera County on SR 41 in the AM peak period primarily work or utilize services along Avenue 12 in Madera County.
- Vehicles traveling between Madera County and Fresno County along SR 99 in the AM peak period use Avenue 12 to work or utilize services along SR 41 in Fresno County.



However, as discussed under the data limitations section, traffic counts do not provide the origin or destination of observed vehicles which limited the findings to the direction of travel rather than place of origin. When combined with license plate address analysis, place of origin information can be inferred and the findings expanded upon. It is important to note however that place of origin information derived from vehicle registration location does not necessarily represent the home or start location of a trip, but is being used as a proxy for home location of observed trips noting this limitation.

**Table 6** provides the city of vehicle registration for vehicles observed at each of the seven survey data locations. Please note that the total column sum for the percentages at each survey data location do not add up to 100 percent because only the top seven cities in terms of number of registered vehicles are included. Please also note that blue boxes callout the number of registered vehicles for key northbound movements and the red boxes callout the number of registered vehicles for key southbound movements.

**TABLE 6 CITY OF VEHICLE REGISTRATION**

City	Location 1		Location 2		Location 3		Location 4		Location 5		Location 6		Location 7		
Fresno	4,508	17%	8,687	24%	8,665	26%	946	14%	1,771	19%	7,273	29%	39,614	53%	
			But don't gain between 3 and 2						Lose 5,500 from 6 to 5						
Madera	3,004	11%	9,403	26%	7,138	22%	266	4%	2,071	22%	6,496	26%	1,821	2%	
			Lose 2,300 between 2 and 3						But gain 4,400 between 5 and 6						
Clovis	1,038	4%	1,558	4%	1,245	4%	201	3%	356	4%	1,866	7%	3,297	4%	
Coarsegold	60	0%	82	0%	80	0%	2,234	34%	1,680	18%	1,622	6%	668	1%	
Chowchilla	2,311	9%	1,108	3%	733	2%	28	0%	28	0%	363	1%	134	0%	
			Lose 1,200 between 1 and 2 and 400 between 2 and 3												
Merced	1,402	5%	930	3%	738	2%	9	0%	18	0%	229	1%	228	0%	
Oakhurst	25	0%	36	0%	44	0%	691	10%	585	6%	570	2%	247	0%	

Blue boxes callout the number of registered vehicles for key northbound movements.  
Red boxes callout the number of registered vehicles for key southbound movements.



Source: Fehr & Peers, 2016.

As shown in **Table 6**, the number of vehicles registered in the City of Fresno observed at location 6 is roughly 5,500 more than observed at location 5, suggesting that 5,500 City of Fresno residents use Avenue 12. However, the number of vehicles registered in the City of Fresno observed at locations 3 and 2 are basically identical, suggesting that City of Fresno residents do not use Avenue 12 as a bypass to SR 99.

Similarly, the number of vehicles registered in the City of Madera observed at location 2 is roughly 2,300 more than observed at location 3, suggesting that 2,300 City of Madera residents use Avenue 12. Additionally, the number of vehicles registered in the City of Madera observed at location 6 is roughly 4,400 more than observed at location 5, suggesting that an additional 1,100 City of Madera residents along Avenue 12 use Avenue 12 to connect to SR 41. Furthermore, a similar pattern is observed for City of Chowchilla residents.

**Adjusted Key Finding from Vehicle Classification Counts: Avenue 12 is primarily utilized as a bypass route by City of Madera and City of Chowchilla residents.**

**Adjusted Key Finding from Vehicle Classification Counts: Fresno County residents primarily utilize SR 41 for work and services along Avenue 12 in Madera County but do not use Avenue 12 as a bypass to SR 99.**

## LICENSE PLATE MATCHING ANALYSIS

License plate matching involves the positioning of cameras at multiple locations to record the license plate of passing vehicles. The outcome of this method is a list of observed license plate numbers with location and time information. Each license plate number is checked to see if it matches a license plate number at the same location later in the day or at a different location on the same day in order to infer the travel pattern and trip purpose. Matching license plate numbers between survey data locations supplements travel pattern information obtained from vehicle classification counts by looking at individual vehicles that are observed at multiple locations rather than a single location with no knowledge of prior or future travel locations.

It is important to note that license plate matching at survey data locations does not provide information about the origin or destination of the trip, providing only the location or locations where the vehicle has traveled. It is possible however to use this information to infer not only a general travel pattern but to



infer trip purpose as well. For instance, a vehicle observed heading southbound on SR 99 in the AM peak period at the Fresno/Madera county line and then nine hours later at the same location in the opposite direction is likely a commuter who lives in Madera County and works in Fresno County. Logic such as this was used to categorize vehicles into one of the six inferred trip purpose categories listed below.

- Commute Trip – inferred if a license plate was observed at a location in one direction in the AM, and then at the same location in the opposite direction in the PM, more than 7 hours later.
- Discretionary Trip – inferred if a license plate was observed at a location in one direction in the AM or PM, and then at the same location in the opposite direction in the same period, less than 7 hours later.
- One-Way Multi-Observation Trip – inferred if a license plate was observed at multiple locations in the same direction and time period.
- Single Observation Trip – inferred if a license plate was observed a single time at a single location.
- Pass-Through Trip – inferred if a license plate was observed at all three locations along SR 99 or at all four locations along SR 41 in the same period but in no other time period or direction.
- Other Trip – inferred if a license plate did not fall into one of the categories described above.

A summary of inferred trip type data from the license plate matching analysis for vehicles registered in all counties, Fresno County, and Madera County is presented in **Table 7**. Please note that not all 58,680 unique license plate numbers were included in this analysis as the focus of this study was on trips that travel between Fresno and Madera counties and trips that likely did not were removed.

**TABLE 7 INFERRED TRIP PURPOSE**

Inferred Trip Purpose	All Counties		Fresno County		Madera County	
Commute	10,597	28%	5,437	38%	2,839	27%
Discretionary	3,520	9%	1,843	13%	821	8%
One-Way Multi-Obs.	8,911	23%	2,640	19%	2,828	27%
Single Observation <sup>1</sup>	11,872	31%	3,206	23%	3,721	35%
Pass-Through	2,445	6%	594	4%	183	2%
Other	882	2%	455	3%	197	2%
Total	38,227	100%	14,175	37%	10,589	28%



<sup>1</sup> Does not include single observation vehicles at Location 7 because they likely did not travel between Fresno and Madera County.  
Source: Fehr & Peers, 2016.

As shown in **Table 7**, Fresno County and Madera County vehicles comprised approximately 65% of the vehicles included in the inferred trip purpose analysis. This number is significantly lower than the 85% derived from the license plate address analysis due to the non-inclusion of single observation trips at location 7, which were removed as they likely did not travel between Fresno County and Madera County. Additionally, a higher proportion (38% compared to 27%) of Fresno County trips were commute trips than Madera County trips, suggesting more commute trips between Fresno and Madera County than between Madera County and Fresno County.

**Key Finding: A higher proportion (38% compared to 27%) of Fresno County trips were commute trips than Madera County trips.**

## FRESNO AND MADERA COUNTY TRIPS

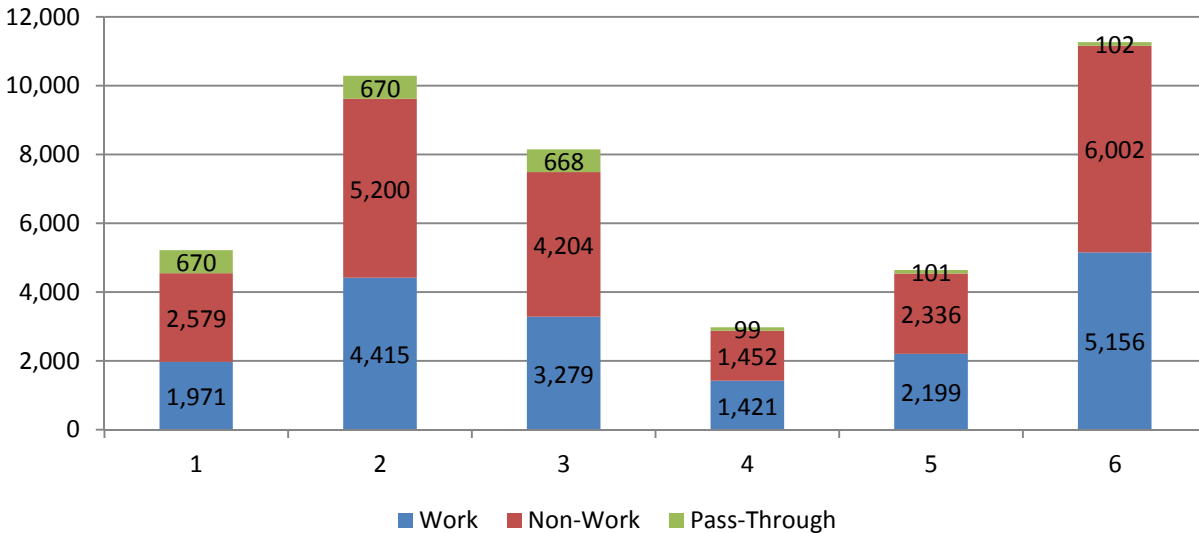
Since this study focuses on understanding where Fresno County and Madera County residents work and shop, the remainder of the license plate matching analysis focuses on vehicle observations where the vehicle registration address was in Fresno County or Madera County. The inferred trip purpose categories were also grouped into work, non-work, and pass-through categories.

**Chart 20** illustrates the Fresno and Madera County work, non-work, and pass-through trips at each of the seven survey data locations. As shown in **Chart 20**, more work and non-work trips were observed on SR 41 at the Fresno/Madera county line than at any other survey data location.



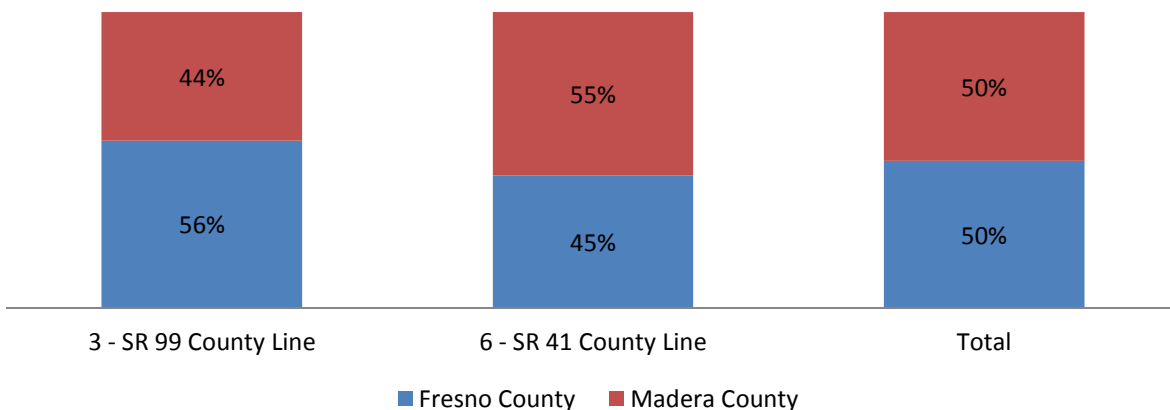


**Chart 20 - Fresno and Madera County Trips by Trip Purpose and Survey Data Location**



**Chart 21** illustrates the origin county of vehicle trips that were observed on SR 99 or SR 41 at the Fresno/Madera county line. As shown in **Chart 21**, on SR 99 more trips originated in Fresno County, on SR 41 more trips originated in Madera County, while overall roughly the same number of trips originated in each county.

**Chart 21 - Origin County of Inter-County Trips**



**Key Finding:** On SR 99 more trips originated in Fresno County, on SR 41 more trips originated in Madera County, while overall roughly the same number of trips originated in each county.

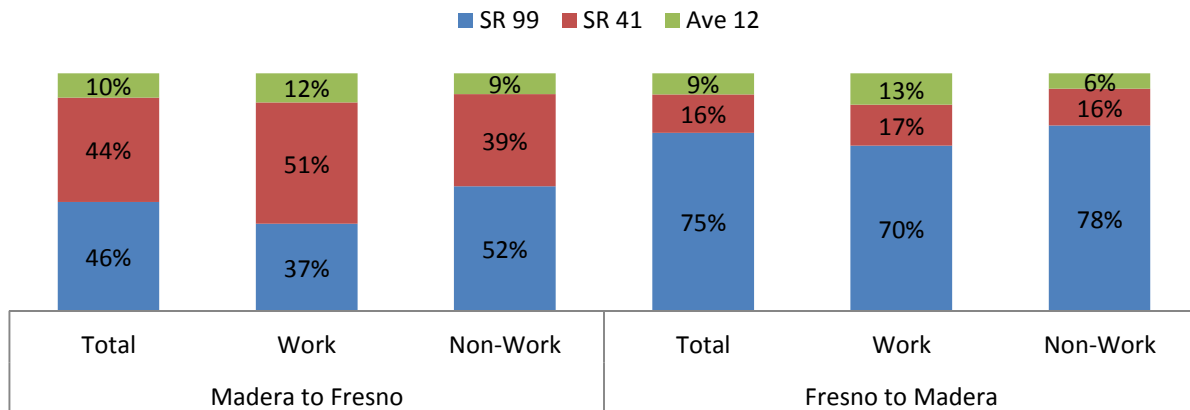






**Chart 22** illustrates the travel route of vehicle trips that were observed on SR 99 or SR 41 at the Fresno/Madera county line. As shown in **Chart 22**, roughly 10% of trips between Fresno and Madera counties use Avenue 12. Additionally, Fresno to Madera trips primarily use SR 99, Madera to Fresno work trips primarily use SR 41.

**Chart 22 - Travel Route for Inter-County Trips**



**Key Finding:** Roughly 10% of trips between Fresno and Madera counties use Avenue 12.

**Key Finding:** Fresno to Madera trips primarily use SR 99, Madera to Fresno work trips primarily use SR 41.

## LICENSE PLATE ANALYSIS LIMITATIONS

As discussed in **Table 1**, license plate analysis is only able to provide vehicle registration location and locations where the vehicle has traveled, neither of which are necessarily the home location or origin of the trip. It is possible however to use this information to infer not only a more specific travel pattern but to infer trip purpose as well. The data is still unable to provide information regarding trip frequency, characteristics of travel, or demographics but does provide the necessary information to conduct a vehicle intercept mail survey to obtain more detailed trip making and demographic information for a relatively small sample of observed trips that can be extrapolated to the entire population of observed trips.



## VEHICLE INTERCEPT MAIL SURVEY

A vehicle intercept mail survey involves the gathering of unique license plate numbers which are then matched to a DMV database of addresses of license plate owners (all of the license plate and address information was destroyed after use for this survey). Typically, short survey questionnaires are implemented by mailer and responses are entered online. The respondent data can then be used to gather information about the origin and destination of the observed trip, the trip purpose, and the demographic characteristics of the driver and their household, data typically not provided by vehicle classification count data, license plate analysis, or mobile device data.

A vehicle intercept mail survey was conducted for this study to gather travel behavior and origin-destination data for residents of Fresno and Madera counties that were observed making trips between the two counties. To increase the survey response rate, an incentive was provided if certain questions were answered and the survey completed by a specific date.

## MAIL SURVEY

In order to obtain information about the origins and destinations of the observed vehicle trips, as well as information regarding trip purpose, trip frequency, and demographic characteristics of the driver and their household, a mail survey was conducted using a survey instrument reflecting the California Household Travel Survey (CHTS) questionnaire and input from Fresno COG, MCTC, Caltrans, and local agencies.

**Will obtain a relatively small sample of very detailed trip making and demographic data**

## MAIL SURVEY SAMPLE SIZE

Normally, the number of random samples to survey is determined by a calculation of the sample size needed to obtain a statistically significant sample of usable surveys based on the number of unique license plate numbers, observed traffic volumes at individual survey data locations, and experience on survey response rates. A 95% overall confidence level and 10% confidence interval are normally used along with an assumed 2-4% response rate to determine the mail survey sample size.

However, since the focus of the study was on transportation movements of Fresno County and Madera County residents who travel between the two counties, the population was not the 210,717 total observed

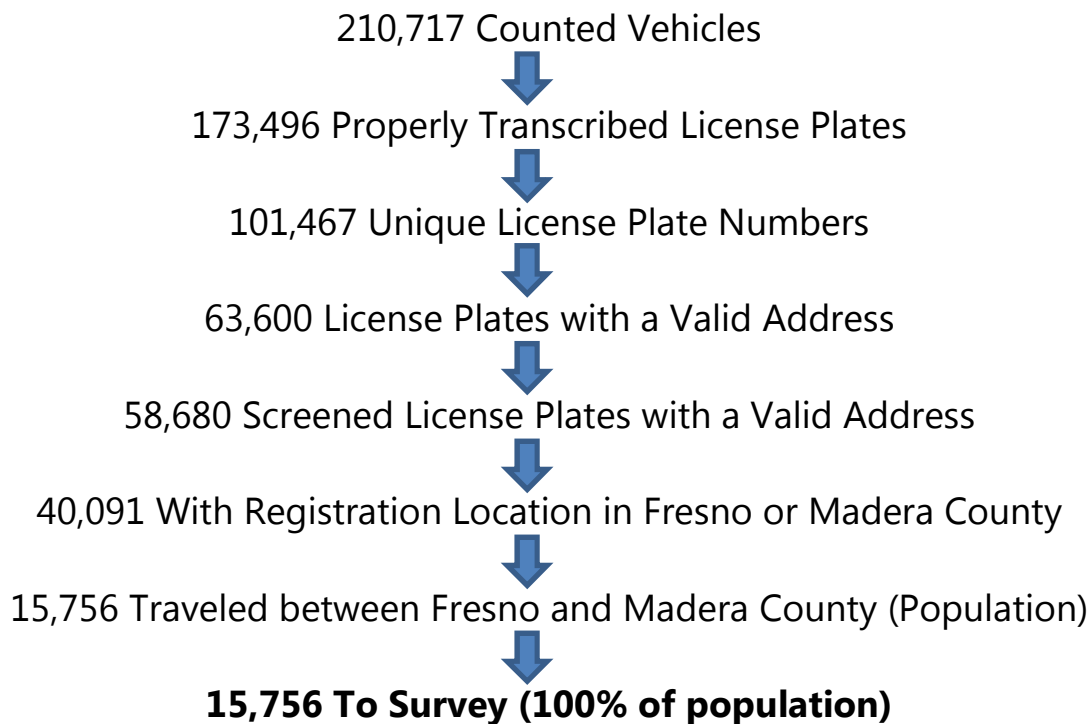


vehicles or 58,680 screened license plate numbers with a valid address. If it were, only a small percentage of the population would be sampled due to budget constraints.

Instead, the screened list of unique license plate numbers with a valid address served as the basis for deriving the population. Addresses outside Fresno County or Madera County were first removed followed by addresses of vehicles that were not observed traveling between Fresno and Madera counties. The resulting population was determined to be 15,756 vehicles of which a random sample would be drawn.

Once the population was derived a cost per mailer was calculated and it was determined that the cost to mail a survey to all 15,756 addresses in the derived population was within the budget. Therefore, a mail survey was mailed to the entire population of 15,756 addresses. It is important to note that the actual population differs from what was derived partially due to only 82% of license plates being properly transcribed but also due to other factors such as the knowledge that vehicle registration location is not necessarily the home or starting location of observed trips between Fresno and Madera counties.

Below is an illustration of how the population and sample to survey were derived.



## MAIL SURVEY INSTRUMENT

The online survey instrument was developed using SurveyMonkey to reflect the CHTS questionnaire along with input from Fresno COG, MCTC, Caltrans, and local agencies, and contained questions including but not limited to: origin and destination of the trip, purpose of the trip, arrival and departure time, frequency, number of vehicles available in the household, number of passengers, household income, household size, age of driver, age of head of household, and education level.

For the questions regarding the origin and destination of the trip, the survey instrument allowed for the specification of an address, cross street, and/or name of the establishment to make it easier on the survey participants. Additionally, the questions regarding the purpose of the trip provided multiple choices that included standard trip purposes such as home-based work and home-based other with the trip purposes rephrased to be more understandable to the survey participants.

An online survey was used in an effort to increase the response rate, as the online version provided a convenient way for participants to complete the survey and utilized branched questions that reduced the survey length and response time. Fehr & Peers staff, acting as mock survey participants, was able to complete the online version of the survey in less than two minutes. An online version, while more work for the survey team to develop, also has the added benefit of minimizing return postage costs, data entry and cleaning time, and post-processing time for the survey team.

The online survey instrument was then reviewed by Fresno COG staff prior to the mailing of a postcard to potential survey participants. The postcard informed the recipient their vehicle had been observed traveling between Fresno and Madera counties and provided a web address to an English and Spanish version of the survey for them to complete online. **Table 8** summarizes the number of surveys mailed by county. The vehicle intercept mail survey postcard mailer is provided in **Appendix C** along with a printout of the online version of the survey.

**TABLE 8 SURVEYS MAILED BY COUNTY**

County	Count	Percent of Total
Fresno County Residents	8,584	54%
Madera County Residents	7,172	46%
Total	15,756	100%

Source: Fehr & Peers, 2016.



A total of 250 surveys were completed with roughly 235 (94%) respondents answering questions in a sufficient manner to make the data usable. The most common unanswered questions were in regards to education level and household income. The response rate for the survey was approximately 1.6%, a much lower response rate than anticipated but still with the desired 95% overall confidence level and 10% confidence interval, which only required 95 responses.

## 250 surveys were completed with a response rate of 1.6%

### MAIL SURVEY RESPONSE DATA

The vehicle intercept mail survey responses to all 21 questions for all 235 sufficiently completed surveys are provided in **Appendix C** along with a detailed summary of the results that focuses on the differences between responses from trips between Fresno County and Madera County and trips between Madera County and Fresno County. The number of vehicle intercept mail survey responses by city where the trip began is summarized in **Table 9**.

**TABLE 9 RESPONSES BY CITY WHERE THE TRIP BEGAN**

City	Count	Percent of Total
Madera	62	26%
Fresno	62	26%
Coarsegold	26	11%
Oakhurst	22	9%
Chowchilla	20	9%
Clovis	13	6%

Source: Fehr & Peers, 2016.



Key takeaways from the vehicle intercept mail survey responses are listed below.

- Although 54% of mail surveys were sent to Fresno County residents, only 34% of respondents indicated their trip started in Fresno County.
- 79% of trips between Fresno County and Madera County were home to work trips, 37% of trips between Madera County and Fresno County were home to work trips. This supports earlier findings that more work trips are made between Fresno County and Madera County and more non-work trips are made between Madera County and Fresno County.
- Madera County to Fresno County trips are more likely to use SR 41 (57%), while Fresno County to Madera County trips are more likely to use SR 99 (35%).
- Fresno County to Madera County trips are more likely to use Avenue 9 (18%) than Madera County to Fresno County trips (7%).
- Madera County to Fresno County trips are on average almost 13 minutes longer than Fresno County to Madera County trips (44.4 minutes compared to 31.6 minutes). This is likely due to commuters from the Yosemite Lakes area of Madera County commuting to Fresno County.
- 73% of Fresno County to Madera County trips make the trip "4 or more times per week" while only 46% of Madera County to Fresno County trips make the trip "4 or more times per week". This is likely due to the higher percentage of work trips from Fresno County to Madera County.
- 79% of Fresno County to Madera County trips are single occupant while only 59% of Madera County to Fresno County trips are single occupant. This is likely due to the higher percentage of work trips from Fresno County to Madera County.
- Roughly 40% of respondents indicated they would be willing to use public transit.
- More than 90% of respondents indicated they rarely or never use public transit.

## MAIL SURVEY LIMITATIONS

As with all user-input surveys, certain data limitations exist that should be taken into consideration before working with the raw or analyzed data as these types of surveys are prone to human error during the data collection process as well as from the survey responders who may misinterpret the questions. Despite these limitations, mail surveys play a pivotal role in any travel behavior study as they provide one of the only methods for gathering detailed demographic and trip making information.



## MOBILE DEVICE DATA

Mobile devices such as cell phones and GPS units (in cars, on phones, and handheld units) frequently communicate with the mobile network, both during use (on a call or sending/receiving text or data) and in idle mode. INRIX and StreetLight Data are able to collect and analyze this data while the device is in use to record the anonymous location (ensuring user privacy) and movement of mobile devices (and thus the population of mobile users) on the roadway network, both in real-time and historically, based on this mobile signaling data.

In order to infer the travel patterns and trip making characteristics of the mobile devices, such as the origin and destination of individual trips as well as the purpose of those trips, StreetLight Data obtained from INRIX movement and usage patterns over a 61-day period from June 1, 2015 to July 31, 2015 for the entire State of California in order to determine the activity patterns of mobile GPS devices moving around the state. Collecting data over such a long period of time provides a very large sample size of real-world observed origin-destination data inferred by computer algorithms. This data differs from origin-destination data collected as part of the other data collection methods as it provides the actual inferred origin and destination of the trip, rather than the vehicle registration location or locations where the vehicle was observed.

StreetLight Data then uses sophisticated algorithms to create trip distribution tables by first identifying mobile devices which were seen in a single zone multiple times over a specified time interval and subsequently seen in a different zone multiple times over a specified time interval. All of the sightings for the mobile device in a single zone over this specified time interval are then combined to create an "Origin-Destination Point". The "Origin-Destination Points" of each mobile device are then paired to create a table of trips with origin and destination coordinate points as well as the observed time period.

## STREETLIGHT DATA ORIGIN-DESTINATION DATA

The table of trips provided by StreetLight Data was derived from 193,680 data samples. After the "Origin-Destination Points" of each mobile device were calculated from the 193,680 data samples, they were paired to create a table of trips with origin and destination coordinate points by day of week, time of day, and vehicle type (personal automobile and commercial vehicle). These trips are then "tagged" to a pre-determined geographic layer based on their origin and destination coordinate points.

### **193,680 data samples provided by StreetLight Data**



For the Fresno/Madera Origin-Destination Study, the starting point was the local travel demand model's traffic analysis zone (TAZ) system to which refinements were made based on input from Fresno COG, MCTC, Caltrans, and local agencies. The final geographic layer included 83 TAZs all of which were contained within Fresno County or Madera County as shown on **Figure 2**.

## **Zone system with 83 zones for Fresno and Madera counties only**

The resulting origin-destination trip tables provide the number of trips for each TAZ to TAZ origin-destination pair for all types of trips that occur within Fresno and Madera counties. The data is provided in a format nearly identical to that produced by a travel demand model which allows for comparison and integration with the local travel demand model. Trips are stratified as described below.

- Day Type – average day, average weekday (Monday to Thursday), average weekend day (Saturday to Sunday)
- Day Part - same as vehicle classification counts, including Early AM, AM Peak Period, Mid-Day, PM peak period, Late-Night, and Daily
- Vehicle type - personal automobile and commercial vehicles

### **RELATIVE RATHER THAN ABSOLUTE TRIPS**

Due to privacy concerns, the trip values in the origin-destination trip tables described above represent "relative" rather than "absolute" trips. In other words, the tables do not provide the total number of trips that occur on a daily basis but provide the relative relationship of trips from each TAZ to every other TAZ. Therefore, the mobile device data trip tables were used as a starting point due to their large sample size and high level of confidence in the GPS origin-destination data and data from the other three data collection methods was used to refine the origin-destination trip tables to represent a single day of absolute data as described below.

- Vehicle classification counts – used to develop control totals to factor the relative trips in order to obtain absolute trips
- License plate analysis – used to help refine origin-destination data
- Vehicle intercept mail survey – used to help further refine origin-destination data

The resulting trip tables represent a single meaningful dataset of all data collected as part of the Fresno/Madera Origin-Destination Study.





N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd

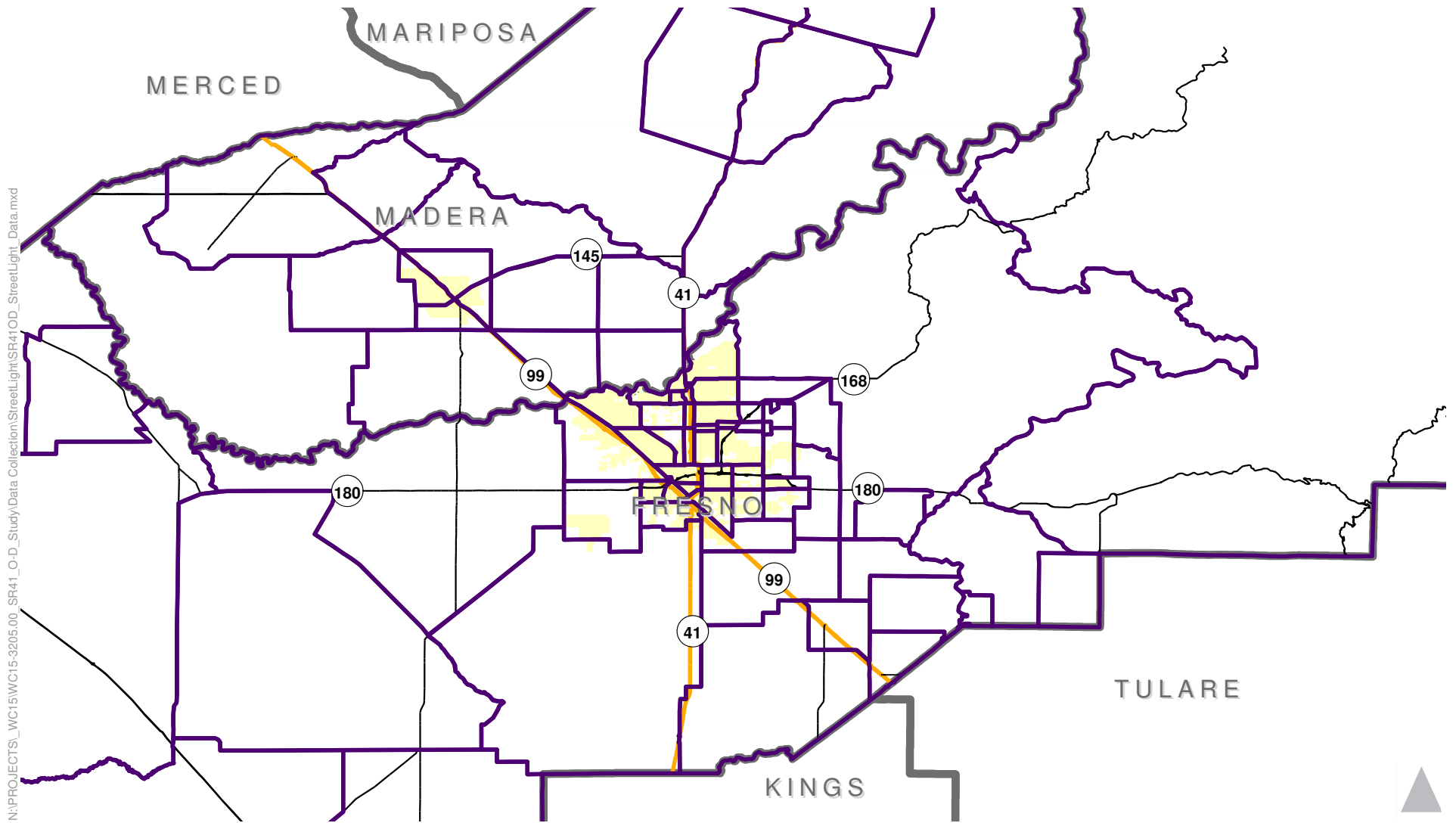


Figure 2  
Final Geographic Layer

## FINAL ABSOLUTE ORIGIN-DESTINATION TRIP TABLES

The final absolute origin-destination trip tables for personal automobile and commercial vehicle trips for an average day, average weekday (Monday to Thursday), and average weekend day (Saturday to Sunday) are provided in tabular format in **Appendix D**. The two types of trip tables provided are described below.

### Origin-Destination Trip Tables

Origin-destination trip tables provide the number of trips between each TAZ in the geographic layer to every other TAZ in the geographic layer. Each trip table provides 6,889 (83 TAZs by 83 TAZs) possible TAZ pairs where each TAZ pair provides the number of trips originating in the corresponding row TAZ that travel to the corresponding column TAZ. This allows for in-depth analysis of the origin-destination data as it allows the user to understand micro-level travel patterns between zones in Fresno and Madera counties. However, this data format also allows for the data to be aggregated to user-specified geographies for understanding and visualization of more macro-level travel patterns. For example, the average weekday (Monday to Thursday) AM peak period, PM peak period, and Daily data was aggregated at the county-level to illustrate the travel flows within and between Fresno and Madera counties. The travel flows are presented in **Table 10 through Table 12**.

**TABLE 10 AM PEAK PERIOD COUNTY-TO-COUNTY FLOWS**

Origin-Destination Pair	Fresno County	Madera County	Total
<b>Fresno County</b>	543,462	13,560	557,022
<b>Madera County</b>	9,827	25,449	35,276
<b>Total</b>	553,289	39,009	592,298

Source: Fehr & Peers, 2016.

**TABLE 11 PM PEAK PERIOD COUNTY-TO-COUNTY FLOWS**

Origin-Destination Pair	Fresno County	Madera County	Total
<b>Fresno County</b>	908,028	11,432	919,460
<b>Madera County</b>	14,206	42,068	56,274
<b>Total</b>	922,234	53,500	975,734

Source: Fehr & Peers, 2016.



**TABLE 12 DAILY COUNTY-TO-COUNTY FLOWS**

Origin-Destination Pair	Fresno County	Madera County	Total
<b>Fresno County</b>	2,965,737	43,414	3,009,151
<b>Madera County</b>	41,966	150,321	192,287
<b>Total</b>	3,007,703	193,735	3,201,438

Source: Fehr & Peers, 2016.

As shown in **Table 12**, average weekday (Monday to Thursday) daily county-to-county flows between Fresno County and Madera County and between Madera County and Fresno County are roughly equal.

**Key Finding: Average weekday (Monday to Thursday) daily county-to-county flows between Fresno County and Madera County and between Madera County and Fresno County are roughly equal.**

**“Select-Link” Origin-Destination Trip Tables**

“Select-link” origin-destination trip tables are very similar to the origin-destination trip tables described above except that they provide the number of trips between each TAZ in the geographic layer to every other TAZ in the geographic layer that travel through a user-specified or “user-selected” roadway link. Each trip table still provides 6,889 (83 TAZs by 83 TAZs) possible TAZ pairs but a separate trip table is provided for each “select-link” location, effectively providing three points of travel for each TAZ pair. The origin location is provided by the corresponding row TAZ, the roadway location the trip traveled through is provided by the “select-link” location, and the destination location is provided by the corresponding column TAZ.

As with the origin-destination trip tables, this allows for in-depth analysis of the origin-destination data as it allows the user to understand micro-level travel patterns between zones in Fresno and Madera counties. This data format also allows for the data to be aggregated to user-specified geographies for understanding and visualization of more macro-level travel patterns.

The “select-link” locations chosen for this project were the seven survey data locations, for which vehicle classification count data provides the control data to factor the data from relative to absolute values, and four additional locations along Avenue 9 and Avenue 12 where vehicle classification count data was not collected. The four additional “select-link” locations are listed below.



- Avenue 9 just east of SR 99
- Avenue 9 just west of SR 41
- Avenue 12 just east of SR 99
- Avenue 12 just west of SR 41

## TRAVEL MODEL COMPARISON

Starting with the local travel model TAZ system allows the final absolute origin-destination trip table data to be easily compared to trip tables generated by the local travel model, providing a substantial amount of observed travel data for base year calibration and validation purposes. It is important to note however that the mobile device trip tables do not represent person-level trip productions and attractions (P-A) similar to those produced in the early stages of traditional four-step travel demand models (i.e. trip generation and trip distribution). Instead, the mobile device trip tables represent vehicle trip origins and destinations (O-D) similar to those used during the trip assignment stage of traditional four-step travel demand models. The main difference is that cell values in a model's productions and attractions trip tables are non-directional, only indicating the magnitude of interaction between two TAZs, whereas the cell values in an origins and destinations trip table are directional, indicating the magnitude and direction of interaction between two TAZs.

### **Provides a substantial amount of observed travel data for base year calibration and validation purposes**

## MAPPING OF ORIGIN-DESTINATION DATA

As shown in **Table 12**, the mobile device data collection effort provided trip making characteristics for over 3,201,438 daily trips, which was then used to create stratified origin-destination trip tables, each consisting of approximately 6,889 cells of trips. While this data had advantages over the other three data collection methods, such as having a very large sample size at a relatively low cost per sample and being less reliant on observed field data and user responses which can potentially introduce error, the method required a lot of inference and lacked the ability to directly obtain demographic characteristics. However, given that the data was aggregated to origin-destination trips tables consistent with the local travel model TAZ system, demographic data can be inferred for observed trips based on census data or other available sources of demographic information.

### **Trip making characteristics for over 3,201,438 daily trips**



Due to the overwhelming amount of data, it was imperative to develop an innovative and meaningful way to display the results.

One effective way to graphically represent origin-destination data is through the use of heat maps. Heat maps apply a gradient to the TAZ system with more intense coloring representing a higher magnitude of trip generation and less intense coloring representing a lower magnitude of trip generation.

**Figure 3** provides a graphical representation of average weekday (Monday to Thursday) daily trip origins.

**Figure 4 through Figure 14** provide a graphical representation of average weekday (Monday to Thursday) daily origins and destinations of users of each of the 11 “select-link” locations. A separate figure is provided for each “select-link” location and each figure shows the percentage of total trips that traveled through the “select-link” location that had their origin or destination in the each TAZ in the geographic layer.



N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd

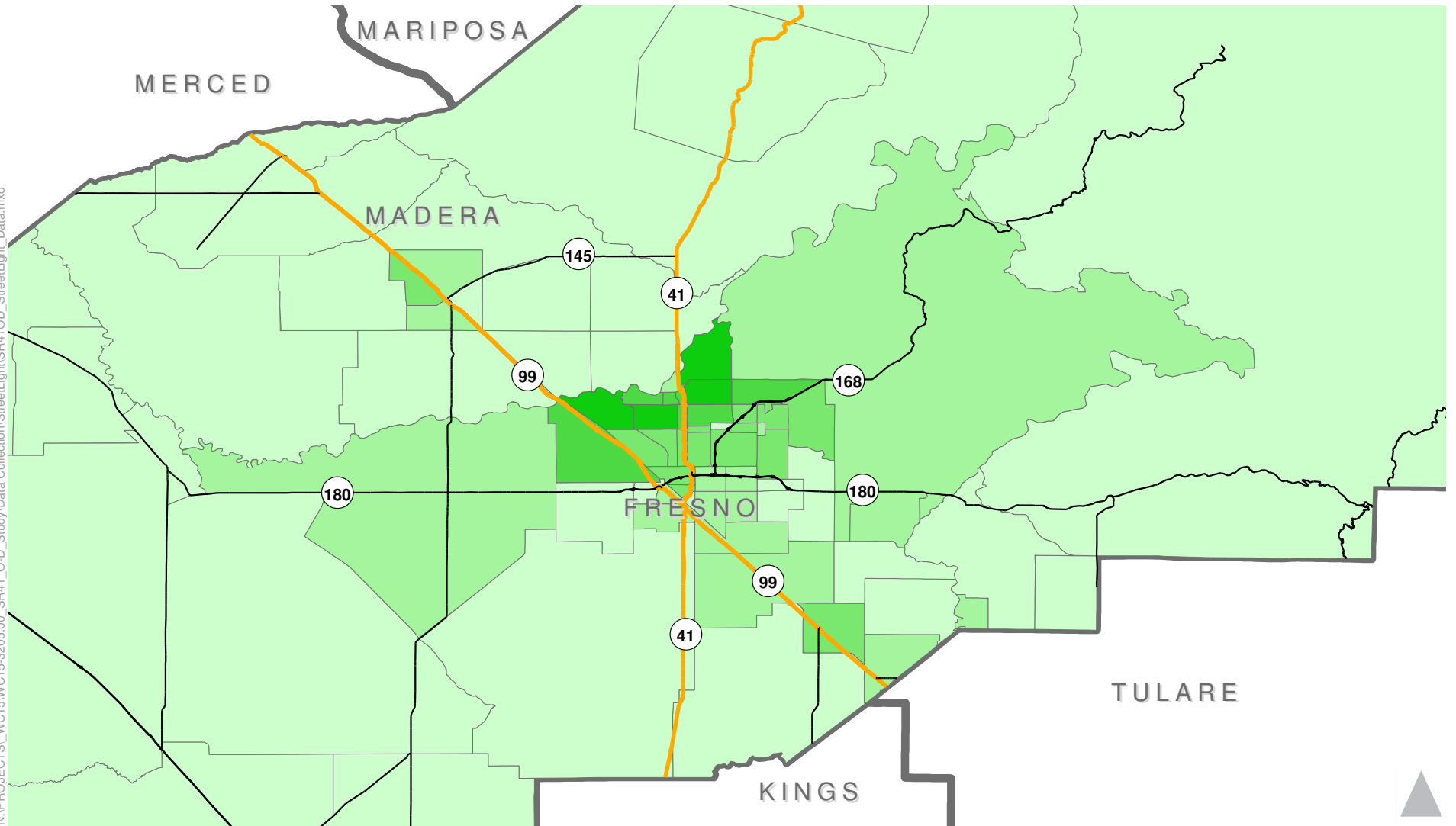
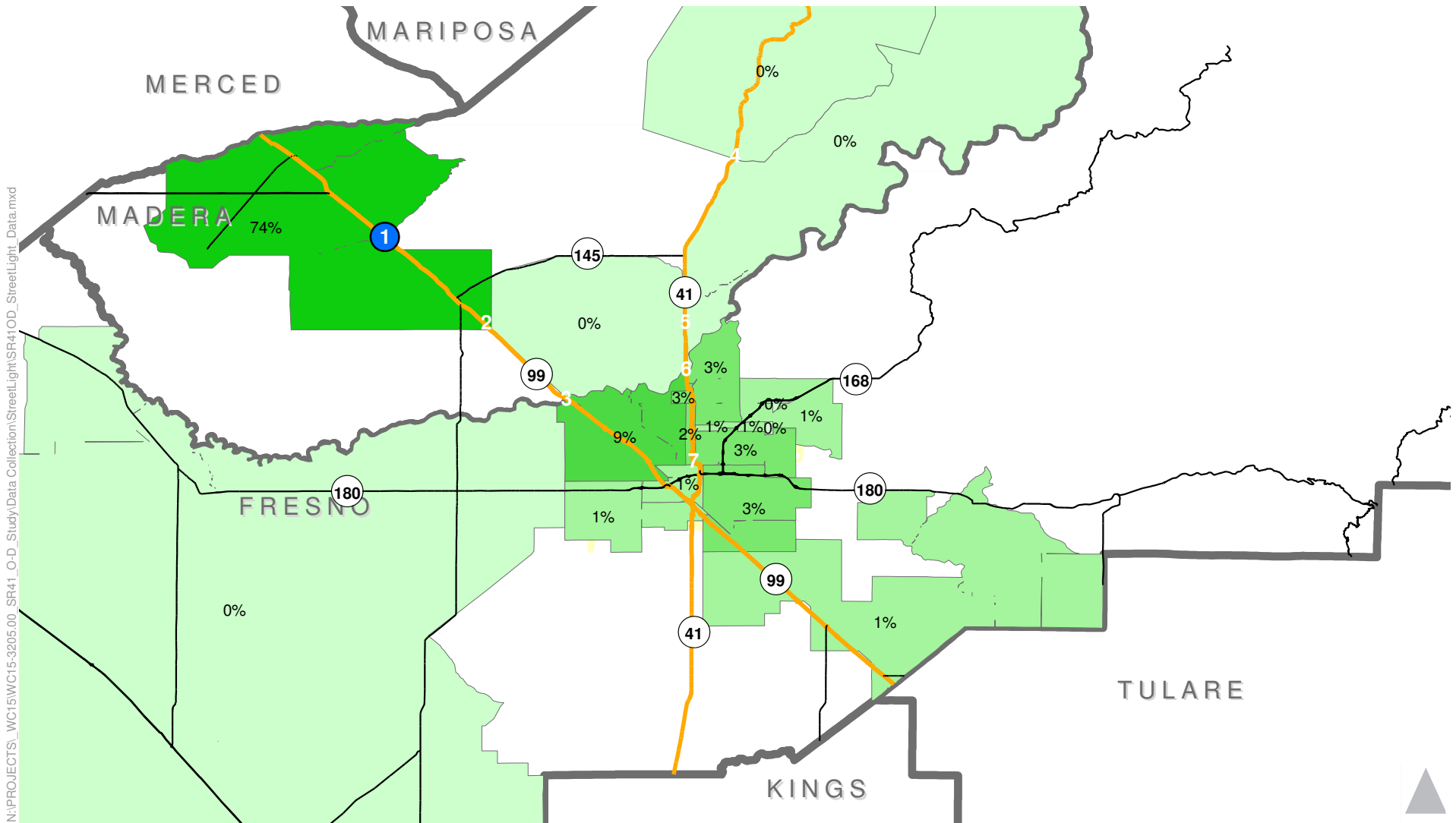


Figure 3  
Heat Map of Weekday Daily Trip Origins



N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd



Figure 4  
Heat Map of Weekday Daily Select-Link Trips on SR 99 North of the City of Madera

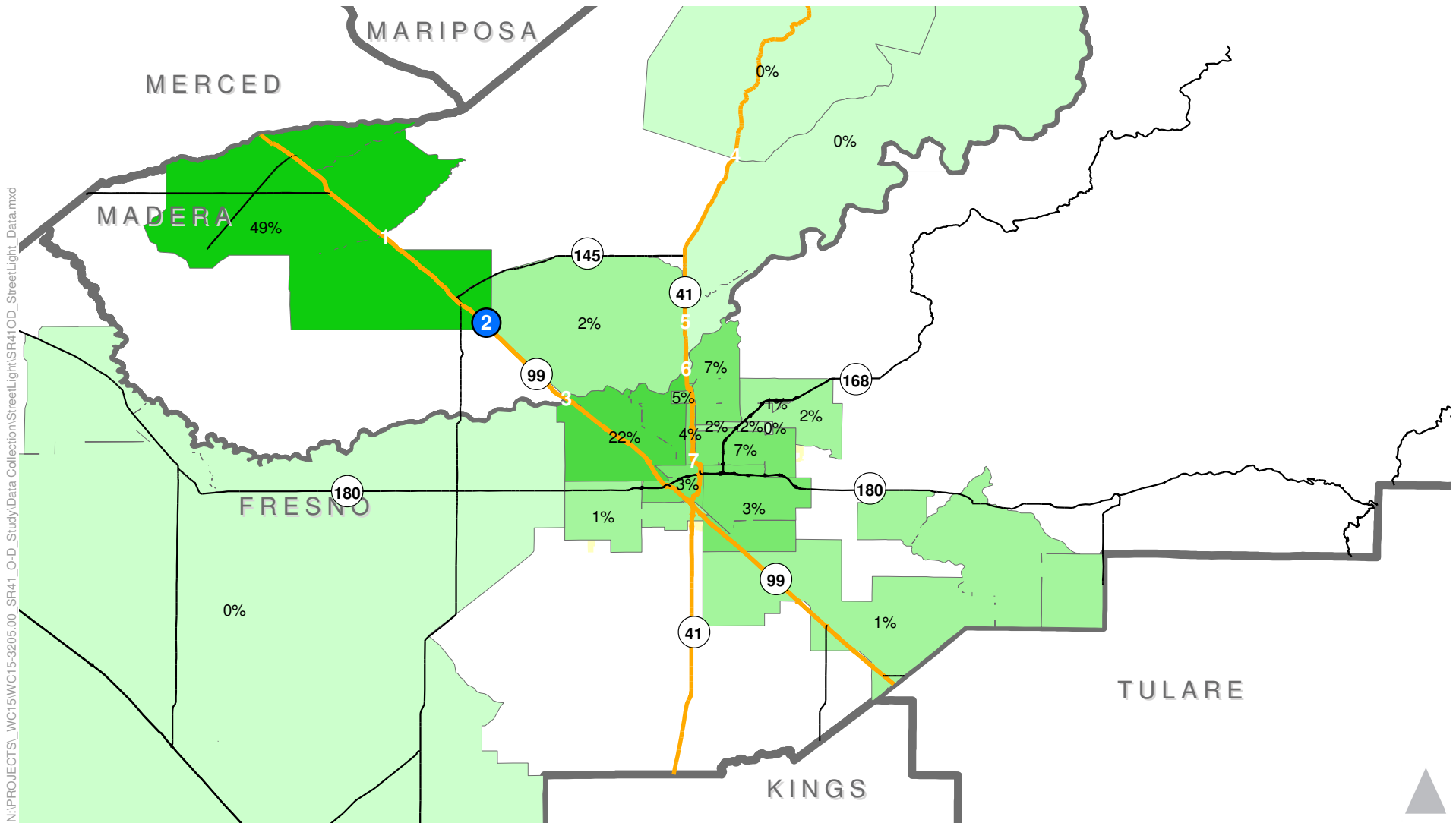
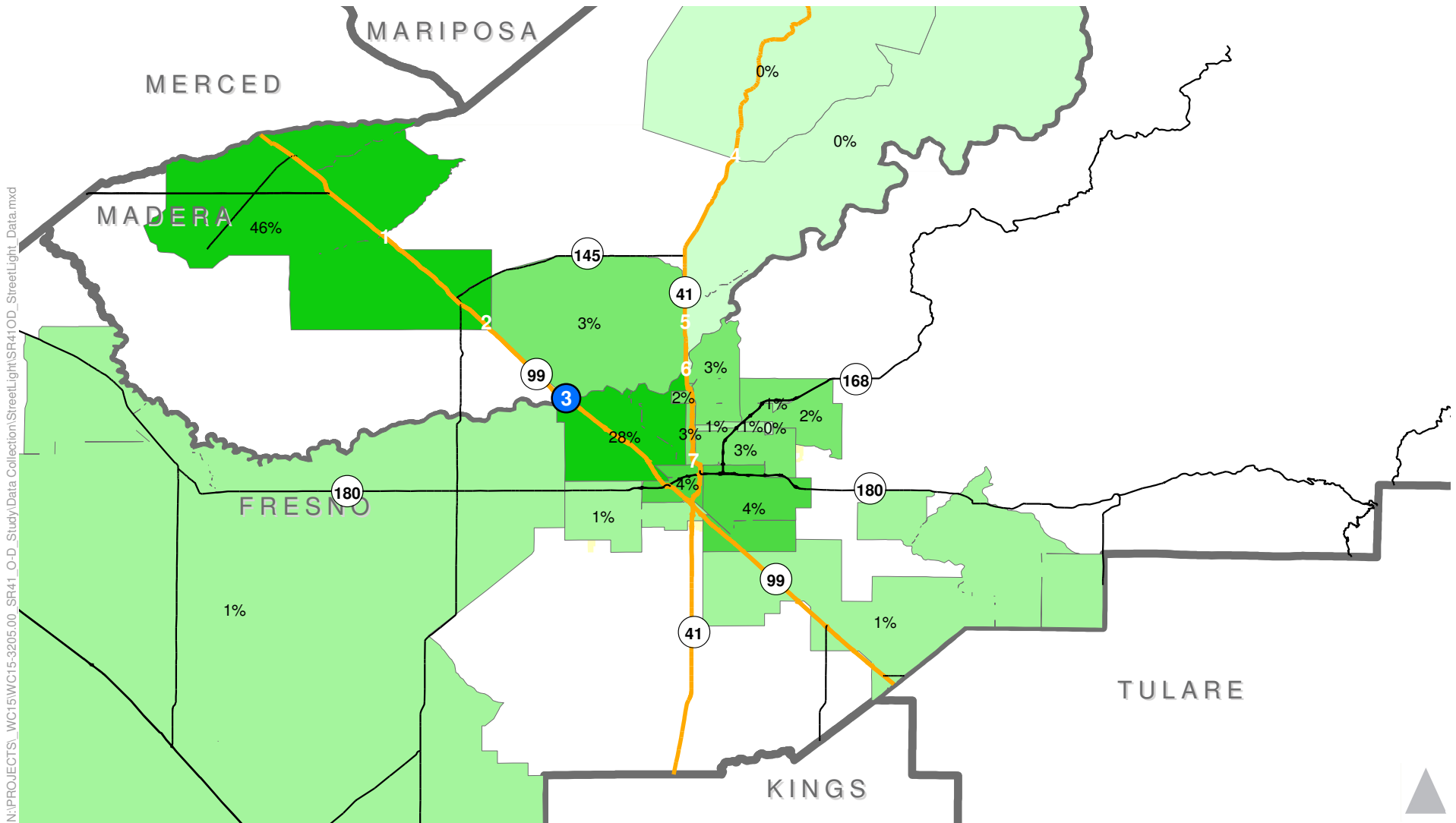


Figure 5  
Heat Map of Weekday Daily Select-Link Trips on SR 99 North of Avenue 12



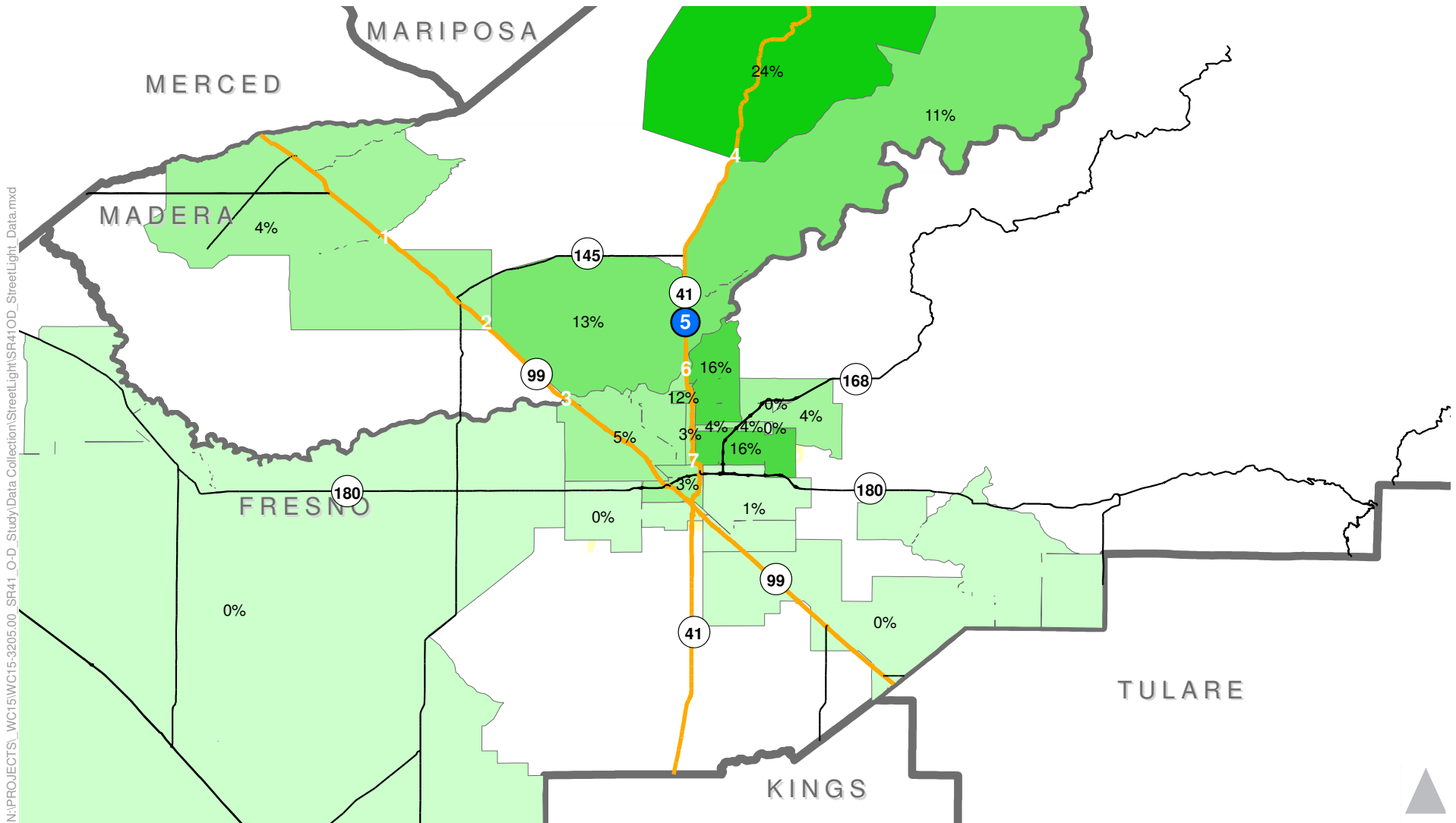


N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd



Figure 6  
Heat Map of Weekday Daily Select-Link Trips on SR 99 at the Fresno/Madera County Line



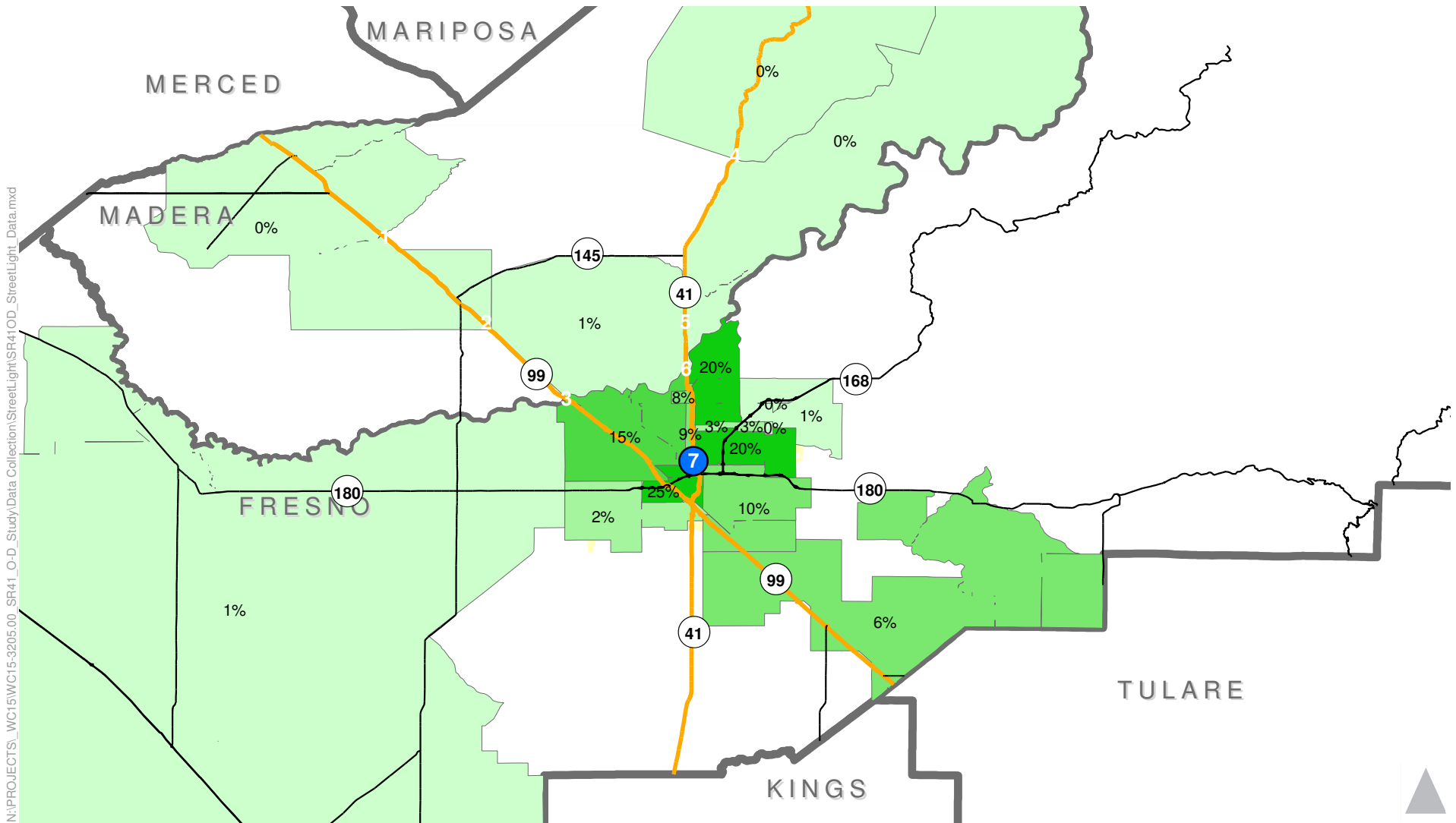


N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd



Figure 8  
Heat Map of Weekday Daily Select-Link Trips on SR 41 North of Avenue 12



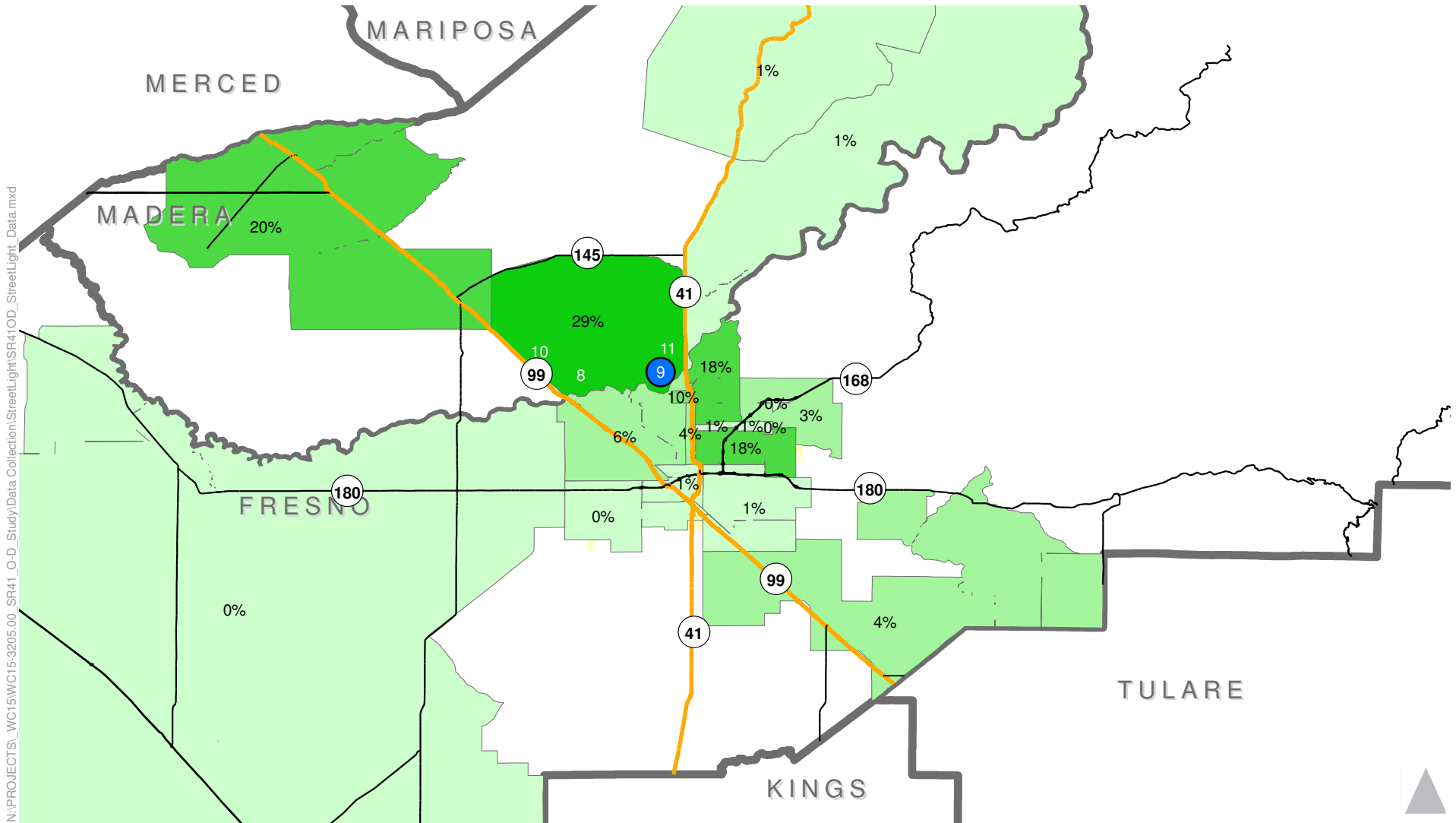


N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd



Figure 10  
Heat Map of Weekday Daily Select-Link Trips on SR 41 North of SR 180 in Fresno County





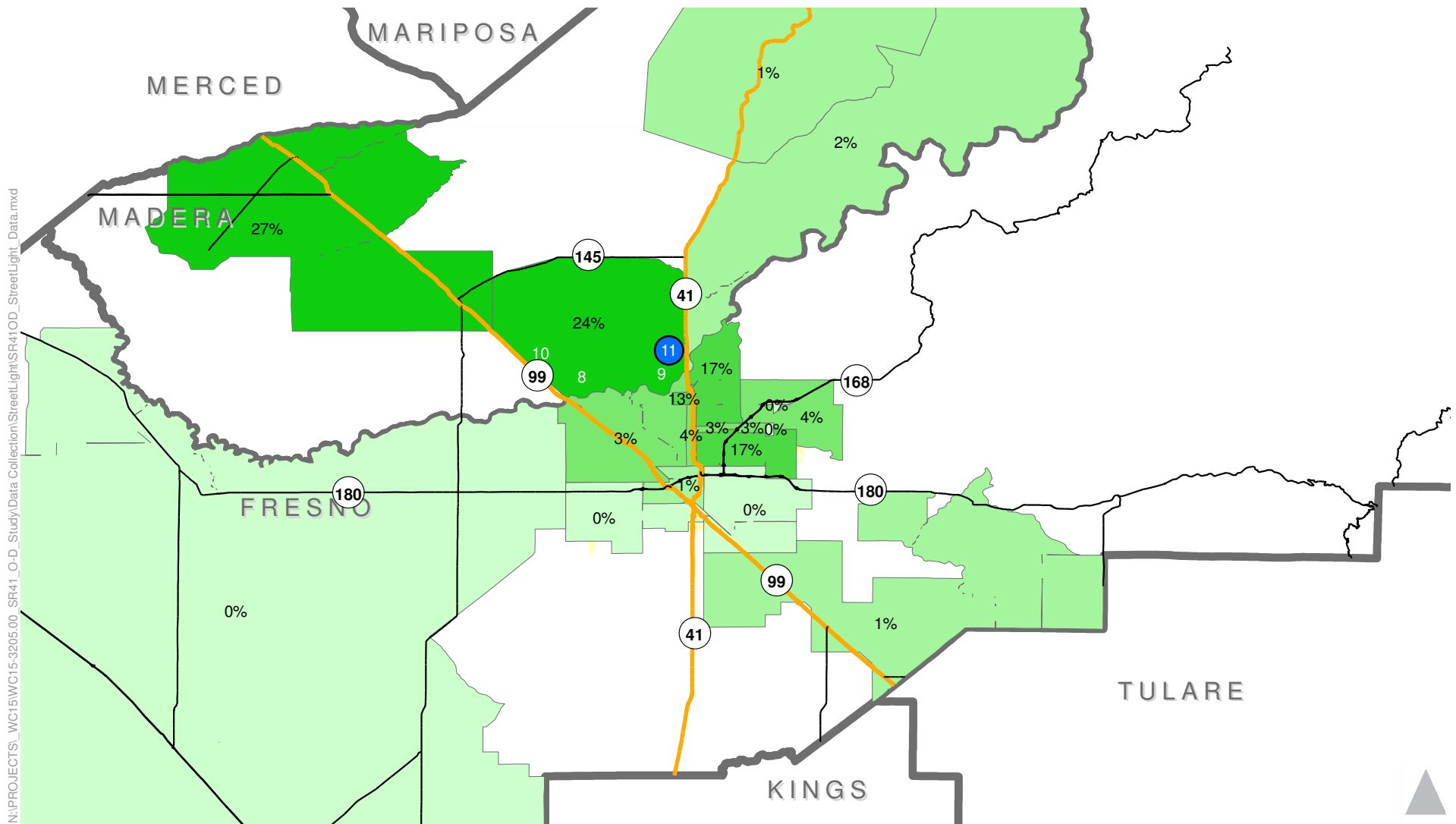
N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd



Figure 12  
Heat Map of Weekday Daily Select-Link Trips on Avenue 9 Just West of SR 41







N:\PROJECTS\WC15\WC15-3205.00\_SR41\_O-D\_Study\Data Collection\StreetLight\SR41OD\_StreetLight\_Data.mxd



Figure 14  
Heat Map of Weekday Daily Select-Link Trips on Avenue 12 Just West of SR 41

## CONCLUSIONS

### SUMMARY OF STUDY APPROACH

The vehicle classification count data collected as part of the Fresno/Madera Origin-Destination Study provided the total number of vehicles (by class and time period) passing through each of the seven survey data locations, providing a control total for other data collection methods but very little information about the travel characteristics or demographic information of the observed trips.

When coupled with license plate analysis data, limited trip type information was inferred based on the number of observations, direction of travel, and time of day. For instance, an estimate of commute trips was obtained when license plate numbers were observed passing through one location in the AM peak period and then passing through the same location in the opposite direction in the PM peak period. Limited information on the origin of trips was obtained from the vehicle registration addresses obtained from the DMV but no information was obtained about the demographic characteristics of the driver or their household.

In order to gather more detailed travel characteristics for trips made by Fresno and Madera county residents between Fresno and Madera counties, a vehicle intercept mail survey was conducted. The completed surveys provided detailed information on the trip making and travel characteristics of a sample of residents but provided a limited amount of sample data at a very high cost with a high potential for error.

When combined, the three data collection methods provided valuable information regarding the trips made by Fresno and Madera County residents between Fresno and Madera counties. To supplement and compliment this data, mobile device data was obtained from INRIX and StreetLight Data, which provided real-world observed origin-destination information for a zone system based on the local travel demand model zone system. While this data had advantages over the other three data collection methods, such as having a very large sample size at a relatively low cost per sample and being less reliant on observed field data and user responses which can potentially introduce error, the method required a lot of inference and lacked the ability to obtain demographic characteristics.

Therefore, data from all four data collection methods was used, with the data for each individual method being compiled into separate datasets for comparison with other data sources. The resulting data offered a substantial amount of information on trips made by Fresno and Madera County residents between Fresno and Madera counties.



## CONCLUSIONS

Below is a bulleted list of key findings from the Fresno/Madera Origin-Destination Study.

### KEY FINDINGS

- Northbound and Southbound flows are roughly equal throughout the day.
- Avenue 12 is utilized as a bypass route by City of Madera and Chowchilla residents.
- Fresno residents utilize services along SR 41 in Madera County but not as a bypass.
- Roughly 85% of observed vehicles were registered in Fresno or Madera County.
- On SR 99, more inter-county trips originated in Fresno County. On SR 41, more inter-county trips originated in Madera County. Overall, roughly the same number of inter-county trips originated in each county.
- Roughly 10% of inter-county trips use Avenue 12.
- Fresno to Madera trips mainly use SR 99, Madera to Fresno work trips mainly use SR 41.

### FINDINGS FROM INDIVIDUAL DATA COLLECTION METHODS

#### Vehicle Classification Counts

- Northbound and southbound flows are roughly equal throughout the day.
- Vehicles traveling between Fresno County and Madera County on SR 41 in the AM peak period primarily work or utilize services along Avenue 12 in Madera County.
- Vehicles traveling between Madera County and Fresno County along SR 99 in the AM peak period use Avenue 12 to work or utilize services along SR 41 in Fresno County.
- Fresno County to Madera County and Madera County to Fresno County traffic patterns vary by location and time-of-day but are roughly equal in the AM and PM peak periods.

#### License Plate Analysis

- Roughly 85% of observed vehicles were registered in Fresno County or Madera County.



- More vehicles crossing the Fresno/Madera county line on SR 99 or SR 41 were registered in Fresno County than Madera County.
- Avenue 12 is primarily utilized as a bypass route by City of Madera and City of Chowchilla residents.
- Fresno County residents primarily utilize SR 41 for work and services along Avenue 12 in Madera County but do not use Avenue 12 as a bypass to SR 99.
- A higher proportion (38% compared to 27%) of Fresno County trips were commute trips than Madera County trips.
- On SR 99 more trips originated in Fresno County, on SR 41 more trips originated in Madera County, while overall roughly the same number of trips originated in each county.
- Roughly 10% of trips between Fresno and Madera counties use Avenue 12.
- Fresno to Madera trips primarily use SR 99, Madera to Fresno work trips primarily use SR 41.

### **Vehicle Intercept Mail Survey**

- 79% of trips between Fresno County and Madera County were home to work trips, 37% of trips between Madera County and Fresno County were home to work trips. This supports earlier findings that more work trips are made between Fresno County and Madera County and more non-work trips are made between Madera County and Fresno County.
- Madera County to Fresno County trips are more likely to use SR 41 (57%), while Fresno County to Madera County trips are more likely to use SR 99 (35%).
- Fresno County to Madera County trips are more likely to use Avenue 9 (18%) than Madera County to Fresno County trips (7%).

### **Mobile Device Data**

- Average weekday (Monday to Thursday) daily county-to-county flows between Fresno County and Madera County and between Madera County and Fresno County are roughly equal.



**APPENDIX A: VEHICLE CLASSIFICATION COUNT DATA**



## **APPENDIX B: LICENSE PLATE ANALYSIS DATA**



**APPENDIX C: VEHICLE INTERCEPT MAIL SURVEY DATA**



**APPENDIX D: MOBILE DEVICE DATA**

