

**RAPID CITY AREA
ORIGIN-DESTINATION STUDY**

FINAL REPORT

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FHU Reference No. 113315-01

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EXECUTIVE SUMMARY

The Rapid City Area Metropolitan Planning Organization (RCMPO) maintains the regional travel demand model for areas including the jurisdictions of Rapid City, Box Elder, Summerset, Piedmont, Ellsworth Air Force Base, the unincorporated areas of Black Hawk and Rapid Valley, and the developing areas of Pennington and Meade Counties. The regional travel demand model is a traditional trip-based, four-step model that runs on the TransCAD platform. The existing model has been calibrated and validated against average daily traffic (ADT) counts; vehicle miles traveled (VMT), trip length distributions, and screen line counts. As there is always room for improvement in the calibration and validation process, this Rapid City Area Origin-Destination Study aimed to collect data that will be used during the next model update process to more accurately calibrate the regional travel demand model.

The data collection effort was completed by AirSage, a firm which boasts a new type of data source – mobile signals. AirSage collects and analyzes real-time mobile signals to provide anonymous data of the location and movement of mobile devices. This data set provides insight into where people are located and how they move about over time. AirSage’s WiSE (Wireless Signal Extraction) technology extracts data from wireless carrier networks, as generated by devices in the normal course of operation (e.g., making phone calls, texting, surfing the Web). Mobile devices frequently communicate with the network, both during use and when the mobile is in idle mode. AirSage technology anonymizes the data stream ensuring user privacy, and performs multiple stages of analysis to monitor the location movement of mobile devices, and thus the population of mobile users.

The final AirSage data has been summarized and illustrated to provide a basis for reviewing the data for consistency and adherence to the survey method. The data summarization has been completed by AirSage through the development of summary reports. Two separate reports have been completed, for April-May and June. Included are details about the types of trips generated with magnitudes and comparison to recognized standards, information about trip making by residents and visitors, and time of day trip making details. Overall, these data summaries find the Rapid City area to be within the expected norms for trip making. The data review process began with translating the origin-destination data into TransCAD matrices and a review of the data set for outliers. In order to review the data more thoroughly, several figures have been developed to illustrate the data. These figures focus on the origin-destination patterns of home-based work trips and those of visitors to the region.

Overall, the data review process confirms that the origin-destination data provided by AirSage meets the request contained in the Methods and Assumptions Report and the data has been successfully verified. In addition to this report, the raw data has been transmitted to Rapid City MPO through a share point on May 30, 2014.

PROJECT OBJECTIVES

The Rapid City Area Metropolitan Planning Organization (RCMPO) maintains the regional travel demand model for areas including the jurisdictions of Rapid City, Box Elder, Summerset, Piedmont, Ellsworth Air Force Base, the unincorporated areas of Black Hawk and Rapid Valley, and the developing areas of Pennington and Meade Counties. The regional travel demand model is a traditional trip-based, four-step model that runs on the TransCAD platform. The existing model has been calibrated and validated against average daily traffic (ADT) counts; vehicle miles traveled (VMT), trip length distributions, and screen line counts. As there is always room for improvement in the calibration and validation process, this Rapid City Area Origin-Destination Study aimed to collect data that will be used during the next model update process to more accurately calibrate the regional travel demand model.

STUDY METHODOLOGY

For this project, origin-destination data was purchased from AirSage, a data firm specializing in the procurement and post-processing of mobile device location data. The data collection process used mobile device location data for select wireless carriers in the study area and relied on data already collected and archived by the wireless carriers. Felsburg Holt and Ullevig served as the project manager responsible for coordinating the Methods and Assumption documentation process, coordinating data collection with the provider AirSage, reviewing the provided data for consistency and adherence to the data needs, and documenting the process with this Final Report.

The study process was overseen by the Study Advisory Team, including the following members.

| Name | Organization | Contact Address |
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SURVEY METHODOLOGY

The data collection effort was completed by AirSage, a firm which boasts a new type of data source – mobile signals. AirSage collects and analyzes real-time mobile signals to provide anonymous data of the location and movement of mobile devices. This data set provides insight into where people are located and how they move about over time. AirSage’s WiSE (Wireless Signal Extraction) technology extracts data from wireless carrier networks, as generated by devices in the normal course of operation (e.g., making phone calls, texting, surfing the Web). Mobile devices frequently communicate with the network, both during use and when the mobile is in idle mode. AirSage technology anonymizes the data stream ensuring user privacy, and performs multiple stages of analysis to monitor the location movement of mobile devices, and thus the population of mobile users.

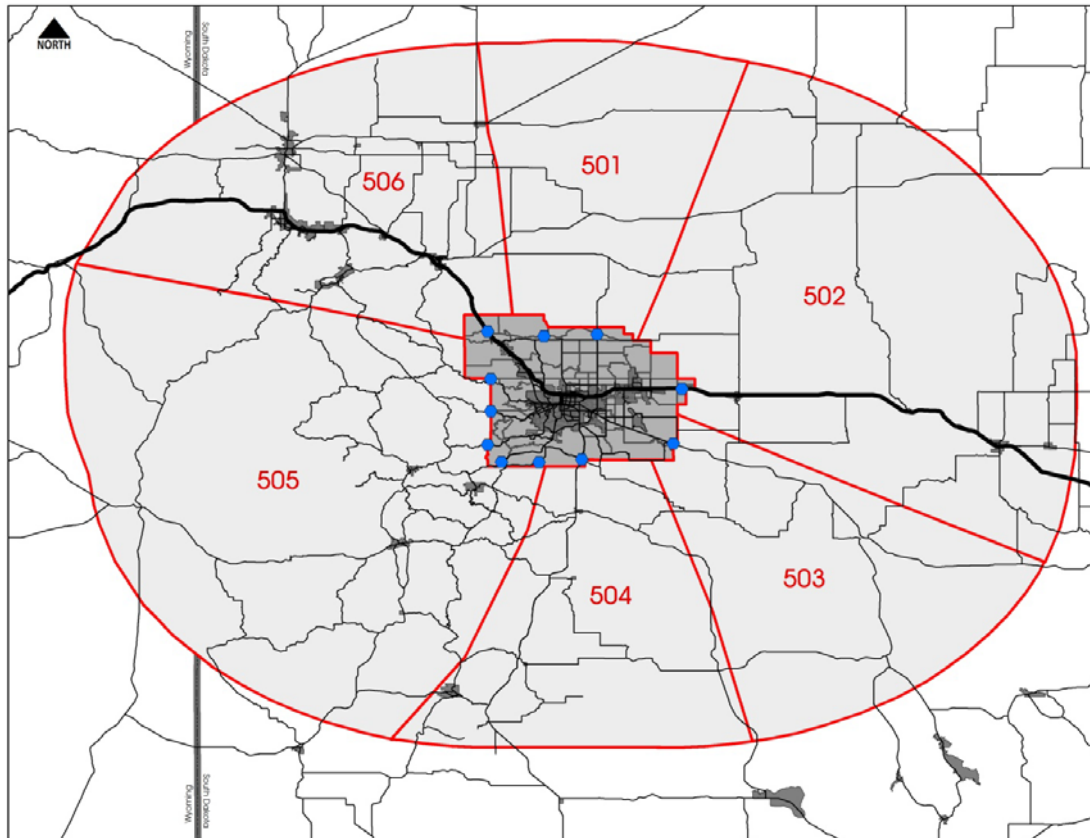
The AirSage data collection process relied on cellular data provided by wireless carriers. The cellular carrier information available to AirSage does not represent the entirety of carrier services, and therefore the complete population was not collected but instead a representative sample was obtained. Since the

data available represented only a sample of devices in the study area, AirSage utilized statistical methodologies to convert the data set into a complete population. The adjusted origin-destination tables are the final deliverable.

Traffic analysis zones defined by the travel demand model served as the basis for this project's study area. The origin-destination data collected for this study identified trips by the origination and destination zones consistent with the travel demand model zonal structure. The traffic analysis zones defined by the travel demand model were supplemented to properly capture external trips. External trips are those originating from or destined for zones outside of the model area and those trips that pass through the model area.

The travel demand model currently defines external zones through a set of eleven external nodes; trips loaded onto the network pass through these zones during the trip assignment process. In order for the AirSage data collection process to account for these trips, external zones were developed to convert the point based loading to an area representing the loading point. Per AirSage methodology, this area represented approximately a 45 minute buffer outside the model zone area. Due to the structure of the AirSage process combined with the lack of distinct travel sheds for each node (where one area can be clearly attributed to each node to represent a 45 minute travel time), the model's 11 external zones have been combined into six zones depicted in **Figure 1**. Locations where nodes were combined focus on the hills west of Rapid City. Also shown are the external zones as blue dots to gain an understanding of where external nodes have been combined.

Figure 1. Traffic Analysis Zones with External Zones



In determining the approach to various study parameters and assumptions, **Table 1** identifies the study definitions. The key study parameters include study area, month of year, day of week, day part aggregations, resident classes, and trip purpose. The Methods and Assumptions Report has been included as **Appendix A**.

Table 1. Study Parameters and Assumptions

| Parameter | Description | Final Assumptions |
|-----------------------|--|--|
| Study Area | O-D tables were developed using a TAZ map corresponding to the travel demand model | Utilize the existing TAZ structure from the RCMPO travel demand model with established external zones (280 TAZ's and 6 defined external zones [from 11 external nodes]) (note: this process will allow development of Internal-Internal, Internal-External, and External-External trip pairs) |
| Month of Year | O-D tables were developed for a one month period | To capture travel during a typical month (school in session), analyze April 15, 2013 to May 14, 2013. Additional summary data was collected for June 2013 to quantify trip making during peak season. |
| Day of Week | Study included separate O-D tables for average weekday day and average weekend day | Average Weekday Days: Tues-Thurs Average Weekend Days: Sat & Sun |
| Day Part Aggregations | Determines the periods into which the final O-D matrices are divided (note: must be at least 3 hours long due to data collection accuracy limitations) | Morning: Midnight-6 AM AM Peak Period: 6AM-9AM Midday: 9AM-3PM PM Peak Period: 3PM-6PM Evening: 6PM-Midnight (note: in order to develop data for the peak hour (consistent with the travel demand model), the three hour period must be factored manually) |
| Resident Classes | Trip characteristics were used to characterize users as residents and visitors | Resident/Visitor |
| Trip Purpose | Trip purpose characterizes the originating and destination ends of each trip through the network based on the developed home and work locations for each device. | Trip purposes were divided into 4 separate classes: <ol style="list-style-type: none"> 1. HBW: Home-based work 2. HBO: Home-based other 3. WBO: Work-based other 4. OBO: Other-based other (note: while the RCMPO travel demand model utilizes a Home-based shopping trip purpose, this category is not available from the data collection process and was incorporated into the Home-based other category) |

The above study parameters define the assumptions that were used to develop the principal data set. The resulting origin-destination tables will be used to recalibrate the existing Rapid City MPO travel demand model within the next year.

Additionally, the Study Advisory Team expressed interest in understanding the trip pattern differences between the typical month and peak tourist season. AirSage utilized the buffer month data to produce generalized trip origin-destination tables for the summer month of June 2013. These trip tables are useful in comparing the general origin-destination trip differences throughout the region giving a high-level picture of trip making during the tourist season, especially among visitors to the region.

DESIGN OF SURVEY INSTRUMENTS

Not applicable.

SUMMARIZED RESULTS

The final AirSage data has been summarized and illustrated to provide a basis for reviewing the data for consistency and adherence to the survey method. The data summarization has been completed by AirSage through the development of summary reports. Two separate reports have been completed, for April-May and June. These documents have been included as **Appendix B** and give basic information about the trip characteristics captured during the data collection process. Included are details about the types of trips generated with magnitudes and comparison to recognized standards, information about trip making by residents and visitors, and time of day trip making details. Overall, these data summaries find the Rapid City area to be within the expected norms for trip making.

During the Methods and Assumptions process, a threshold for measure of effectiveness was set to collect at least 25% of the population in the sample size. During the data collection process, AirSage met this threshold by including 28% of users throughout the region in the raw data collection effort.

The data review process began with translating the origin-destination data into TransCAD matrices with a review of the data set for outliers. In order to review the data more thoroughly, several figures have been developed to illustrate the data. The first two figures, **Figure 2** and **Figure 3**, have been compiled using the AM and PM peak period data for home-based work trips from the April-May average weekday. Each figure provides the origin zone on the left and destination zone on the right for the peak period trips; with each dot representing five trips made during the period. As would be expected, the AM and PM peak period maps are essentially mirror images of each other as the AM represents the workbound trip and the PM represents the homebound trip for most travelers. Additionally, these figures demonstrate that the data set accurately accounts for the locations of homes and jobs throughout the region.

The second set of figures, **Figure 4** and **Figure 5**, illustrate the results of visitor trip making. The figures show magnitude of April-May and June origin and destination trips, respectively. These figures are interesting in their ability to demonstrate the significant increase in trip making experienced during the summer tourist season. These findings are bolstered through further examination of the visitor data which reveals that trip making during the weekend between the April-May and June data shows an increase from 2,250 trips/hour to 7,000 trips/hour between the month periods, a threefold increase.

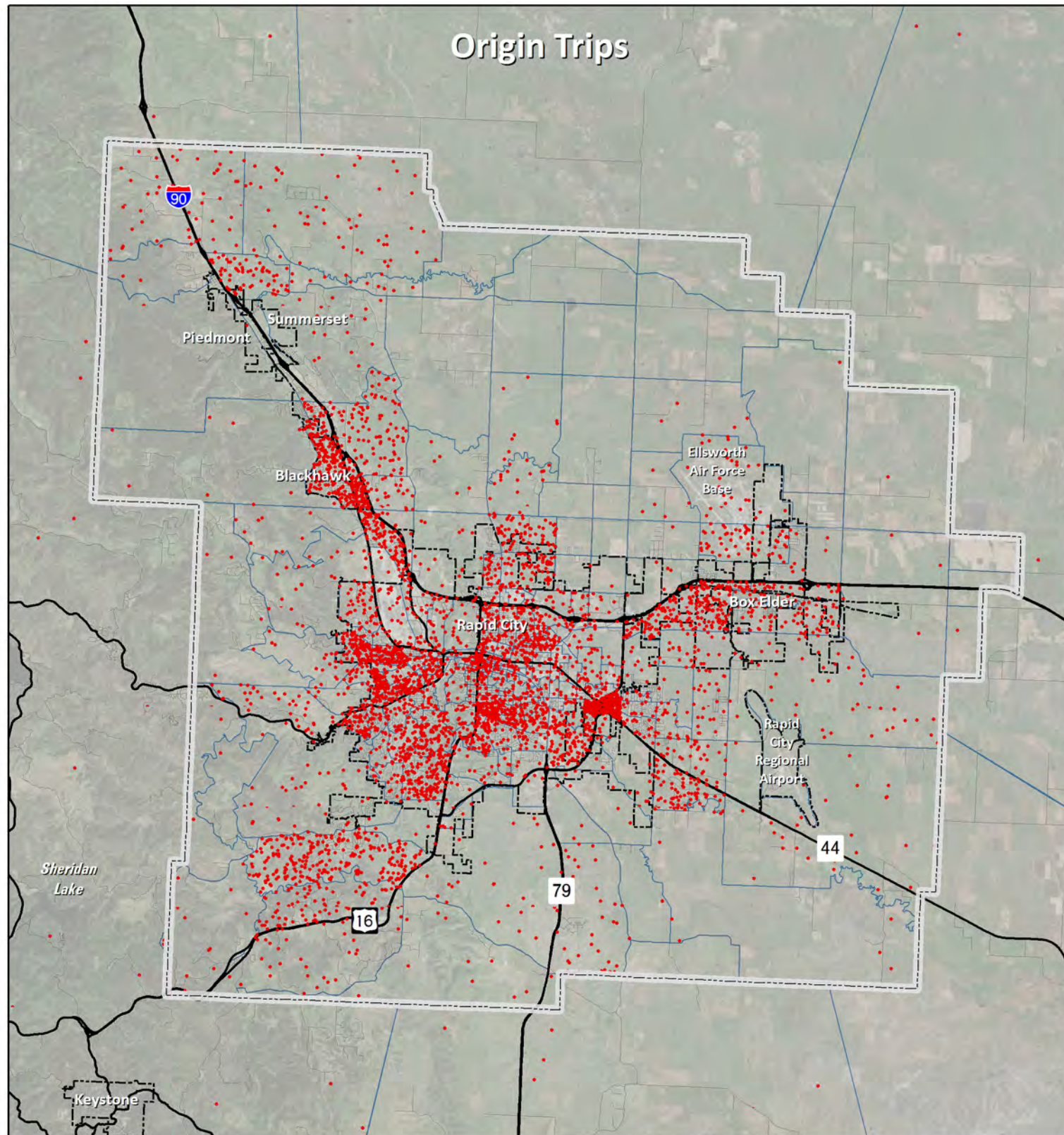
The final figure, **Figure 6**, demonstrates the frequency of Internal-External and External-External trips occurring during the April-May average weekday. Internal-External trips are those that leave or enter the MPO boundary, as can be seen 22,140 trips are oriented towards west I-90, 13,327 trips are oriented towards the Black Hills, and 7,422 trips are oriented to the south. Overall, 13 percent of trips of the approximately 375,000 daily trips captured on the average weekday can be classified as Internal-External. External-External trips are those that pass through the MPO boundary, this map shows the largest four External-External trip pairs, with the greatest number of trips occurring between I-90 west and east at 938 trips per day. Overall, 6 percent of trips of the approximately 375,000 daily trips captured on the average weekday can be classified as External-External.

The data review process confirms that the origin-destination data provided by AirSage meets the request contained in the Methods and Assumptions Report and the data has been successfully verified. In addition to this report, the raw data has been transmitted to Rapid City MPO through a share point on May 30, 2014.

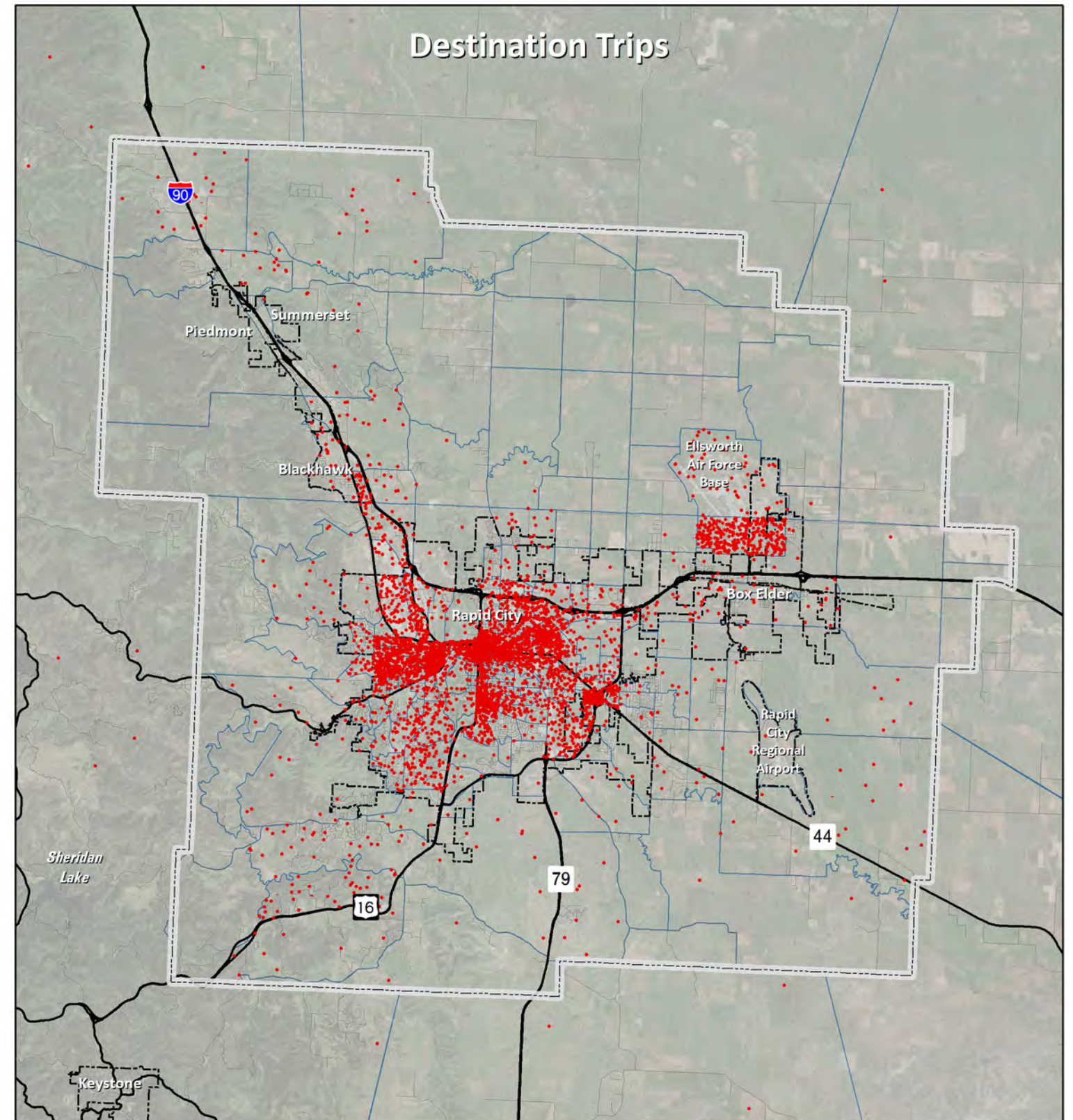
During the course of the Methods and Assumptions process a number of specific questions were recorded about how this origin-destination data will be used during the calibration of the travel demand model. Due to this project's limited scope as a data purchase and verification process, those questions have been documented below for reference. It is recommended that during the future calibration, the project team review and incorporate these questions into the process.

- Non-work trips are often more difficult to impute; perhaps it makes sense to collapse the work-based other and other-based other purposes into one bin. Experience in other locations indicates that trip matrices for these purposes are less reliable in general, and it may be difficult to differentiate these trips.
- Verification of estimated data based on "ground truth" information can be helpful as a reality check; potential sources of observed data include American Community Survey flows (for work trips). It may also be helpful to take a sample and manually verify the OD patterns (and imputed trip purposes) using more detailed land use data, such as Google Earth imagery.
- One added value for using large samples is that they afford the opportunity to more closely reflect the temporal distribution of travel; some areas have derived time dependent OD matrices from cell phone derived seed matrices and high resolution traffic count data. This approach could be helpful for supporting operation planning methods (Dynamic Traffic Assignment or micro simulation methods).
- The proposal to develop matrices that reflect variation between peak and shoulder periods, as well as weekday and weekend travel, makes sense. Access to a month's worth of data also affords the opportunity to evaluate travel patterns for other special markets, generators, or other events that may be helpful for calibration efforts. For example, airports and large regional generators often have unique trip distribution patterns that may differ from traditional non-work trips.

Origin Trips

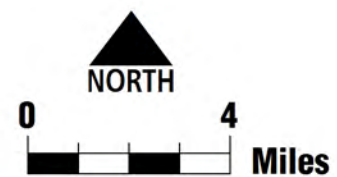


Destination Trips



Legend

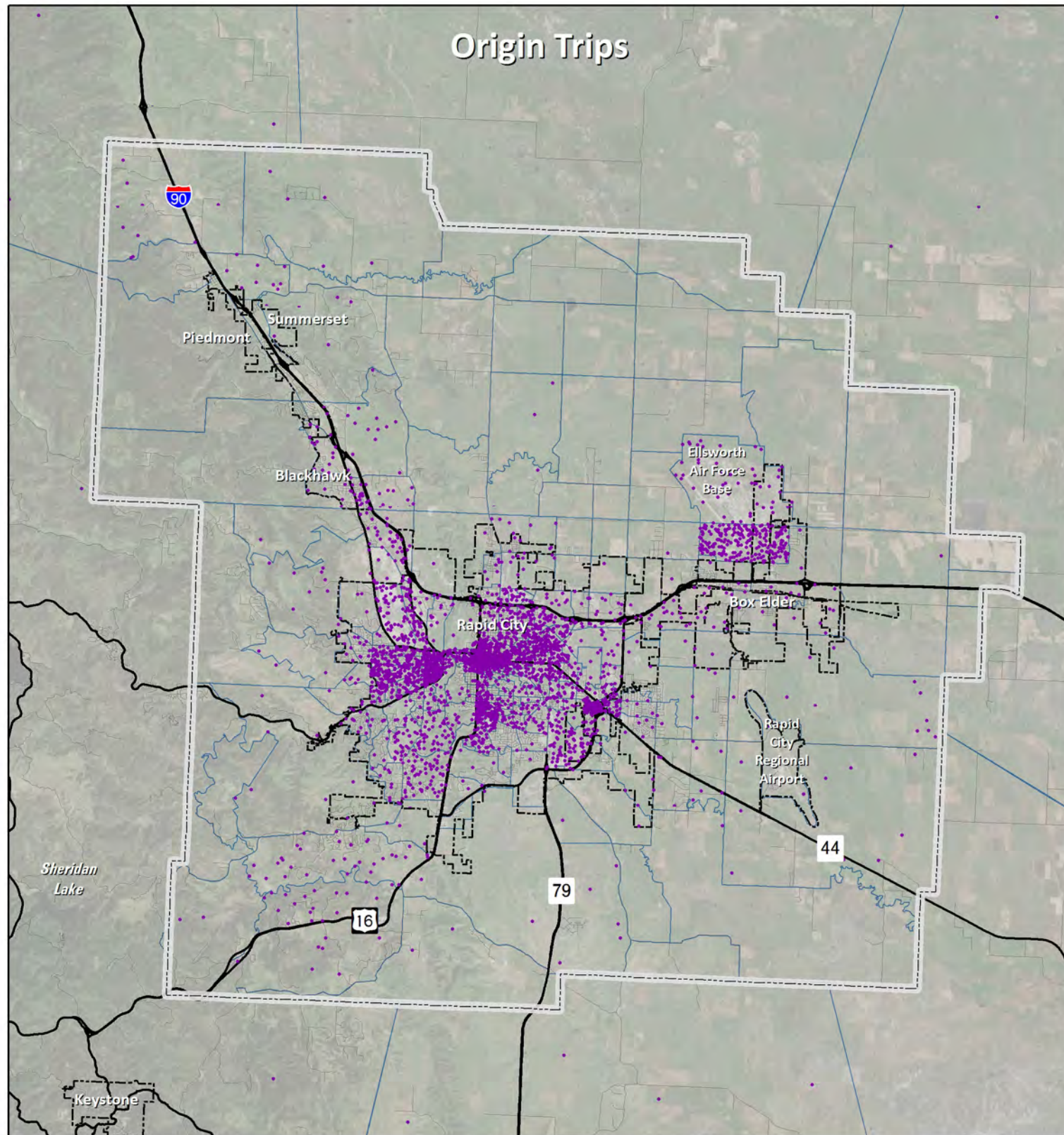
- 1 Dot = 5 Trips (AM Peak Period)
- State_highways
- ⊕ Traffic Analysis Zone Boundaries
- ⊕ City & Town Boundaries
- ⊕ Rapid City MPO Boundary



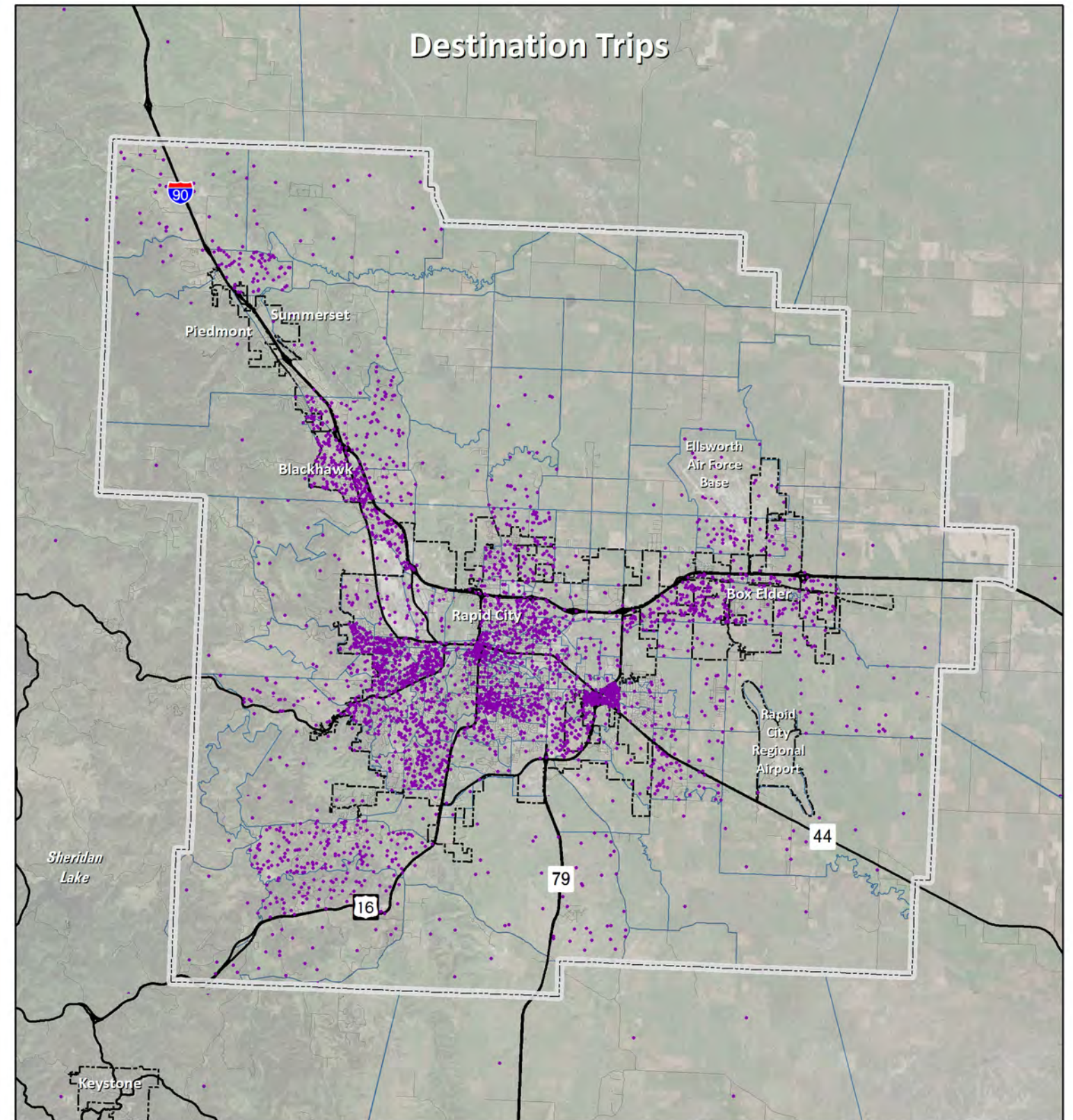
Rapid City Area Origin-Destination Study
 April/May Weekday Home-Based Work AM Peak Period Trip Dot Density



Origin Trips

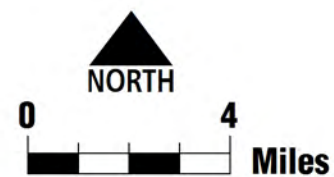


Destination Trips



Legend

- 1 Dot = 5 Trips (PM Peak Period)
- State_highways
- ⊕ Traffic Analysis Zone Boundaries
- ⊕ City & Town Boundaries
- ⊕ Rapid City MPO Boundary

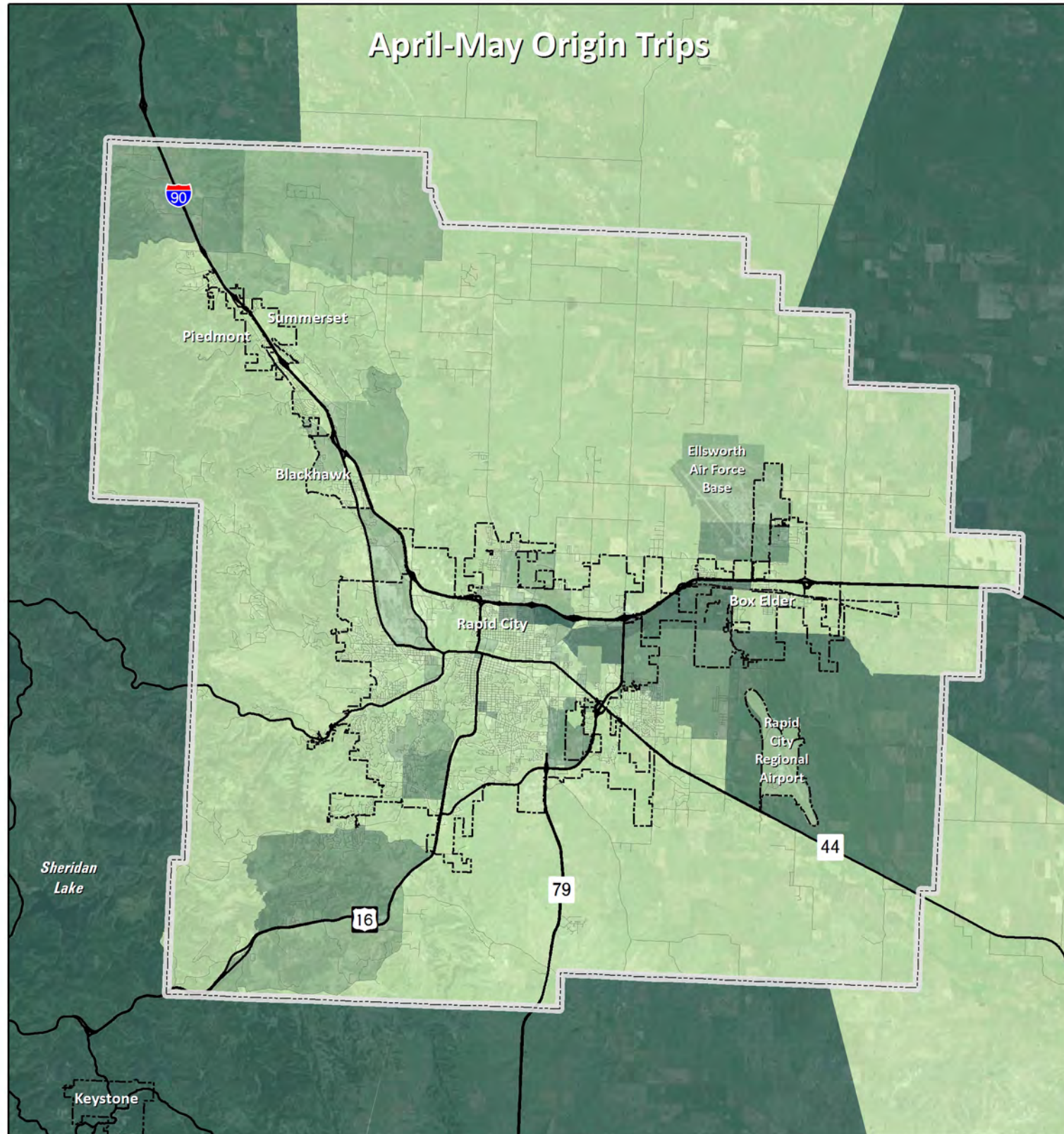


Rapid City Area Origin-Destination Study
 April/May Weekday Home-Based Work PM Peak Period Trip Dot Density

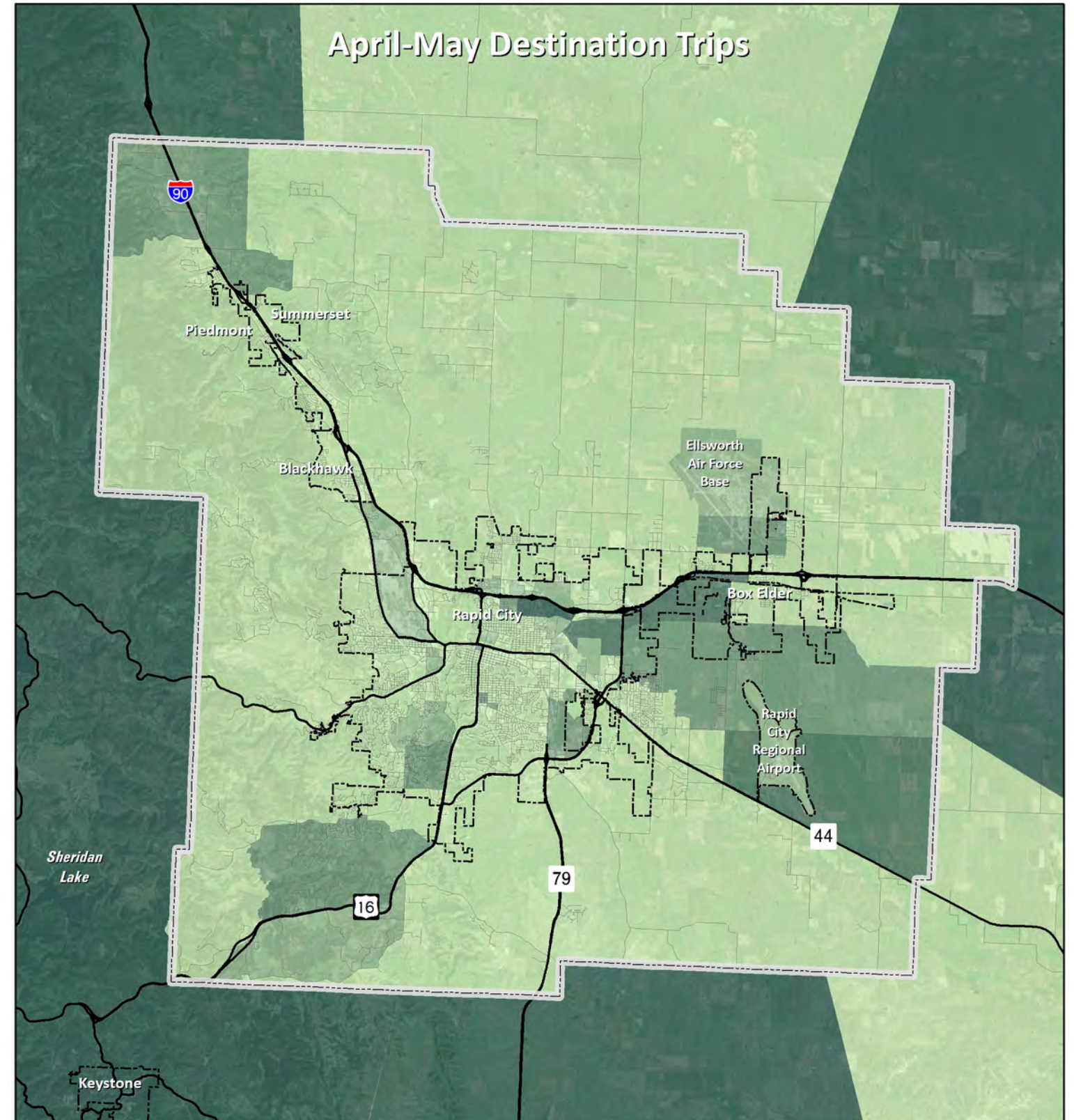


Figure 3

April-May Origin Trips

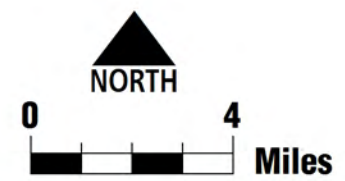


April-May Destination Trips



Legend

| | | |
|--|------------------------|-------------------------|
| April-May Origin and Destination Counts | | — State_highways |
| 0 - 100 Trips | 200 - 400 Trips | City & Town Boundaries |
| 100 - 200 Trips | 400 - 800 Trips | Rapid City MPO Boundary |
| | Greater Than 800 Trips | |

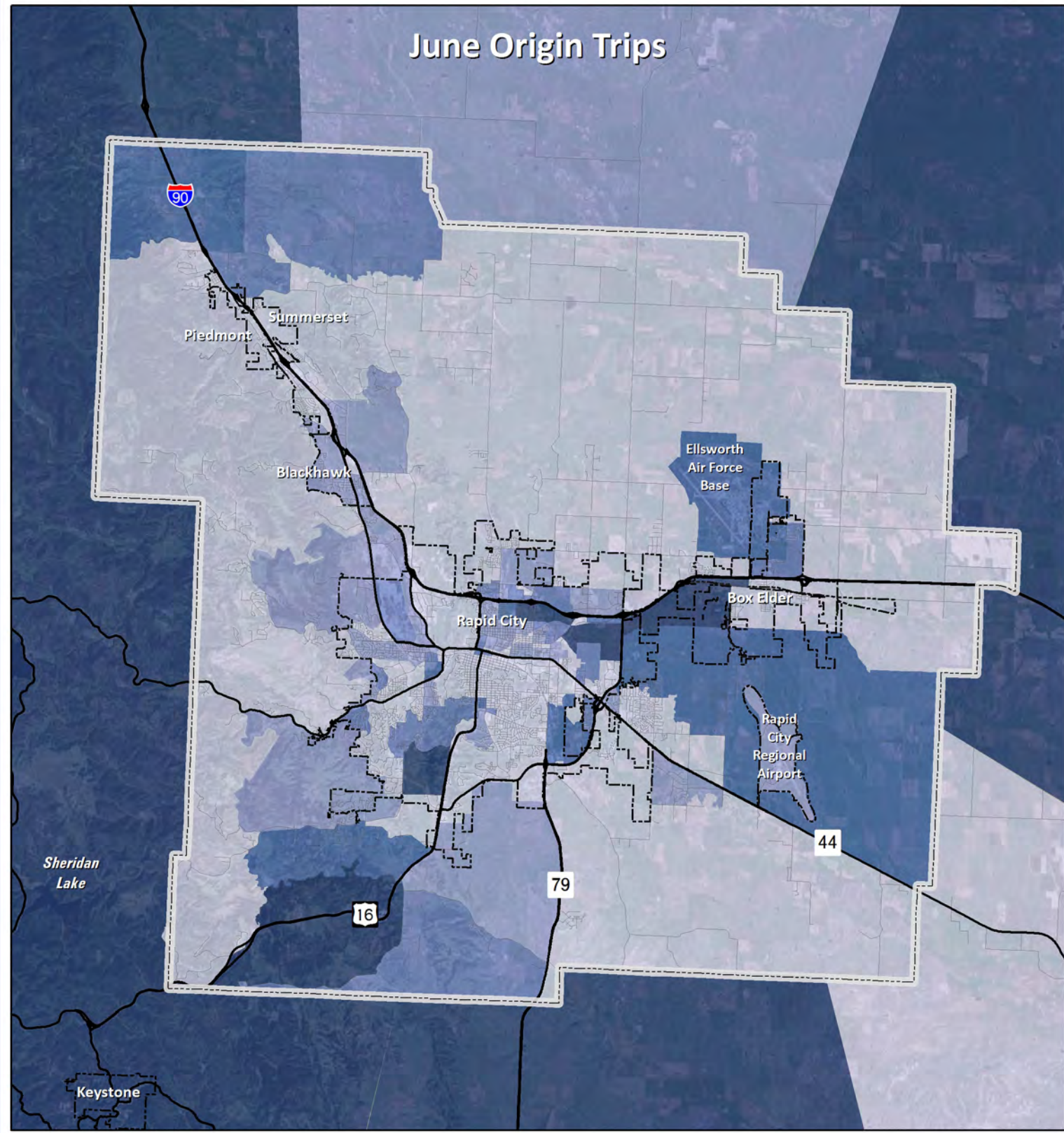


Rapid City Area Origin-Destination Study
April/May Weekday Visitor Trips

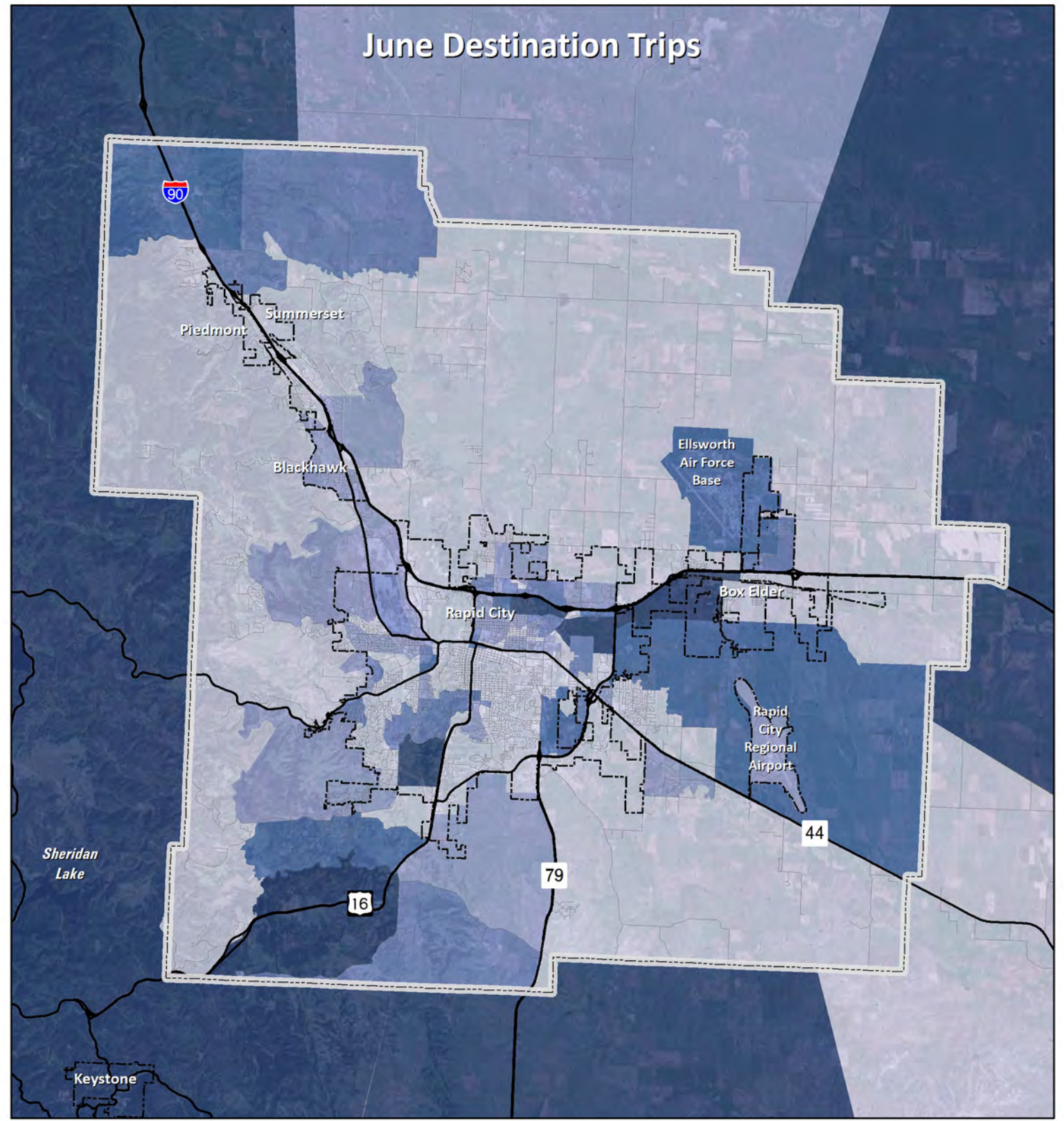


Figure 4

June Origin Trips

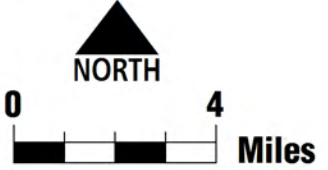


June Destination Trips



Legend

| | | |
|---|------------------------|-------------------------|
| June Origin and Destination Counts | | — State_highways |
| 0 - 100 Trips | 200 - 400 Trips | City & Town Boundaries |
| 100 - 200 Trips | 400 - 800 Trips | Rapid City MPO Boundary |
| | Greater Than 800 Trips | |



Rapid City Area Origin-Destination Study
June Weekday Visitor Trips



Figure 5

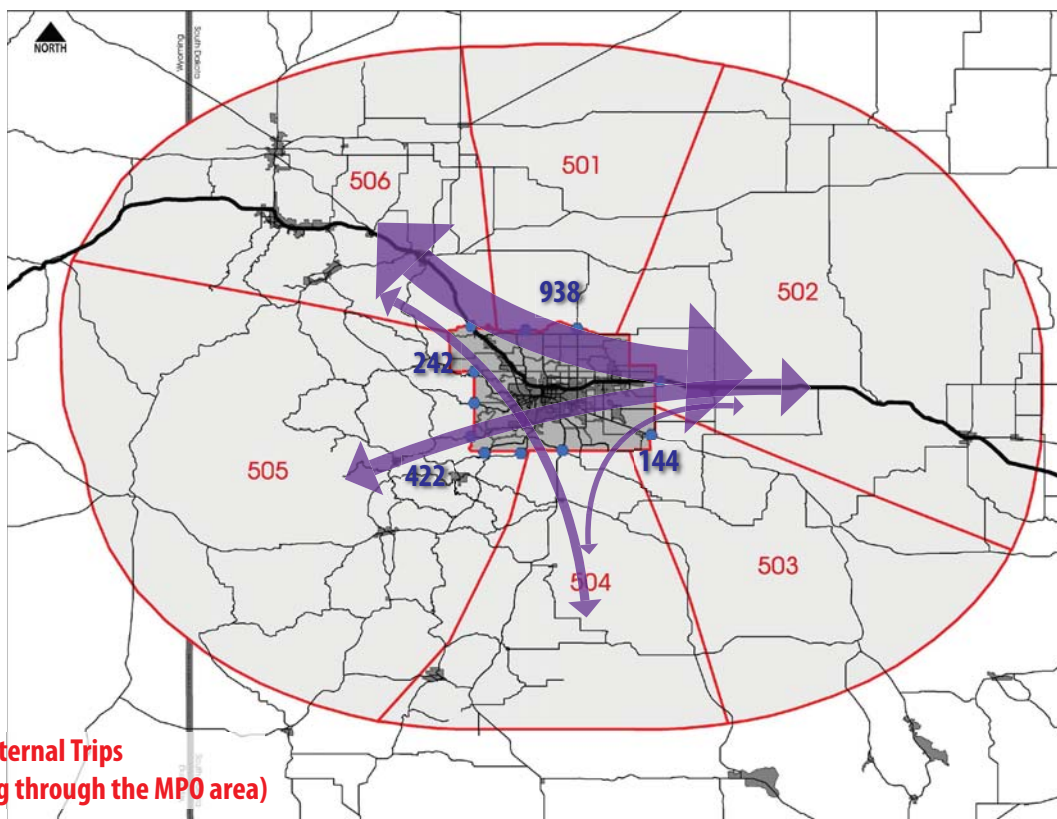
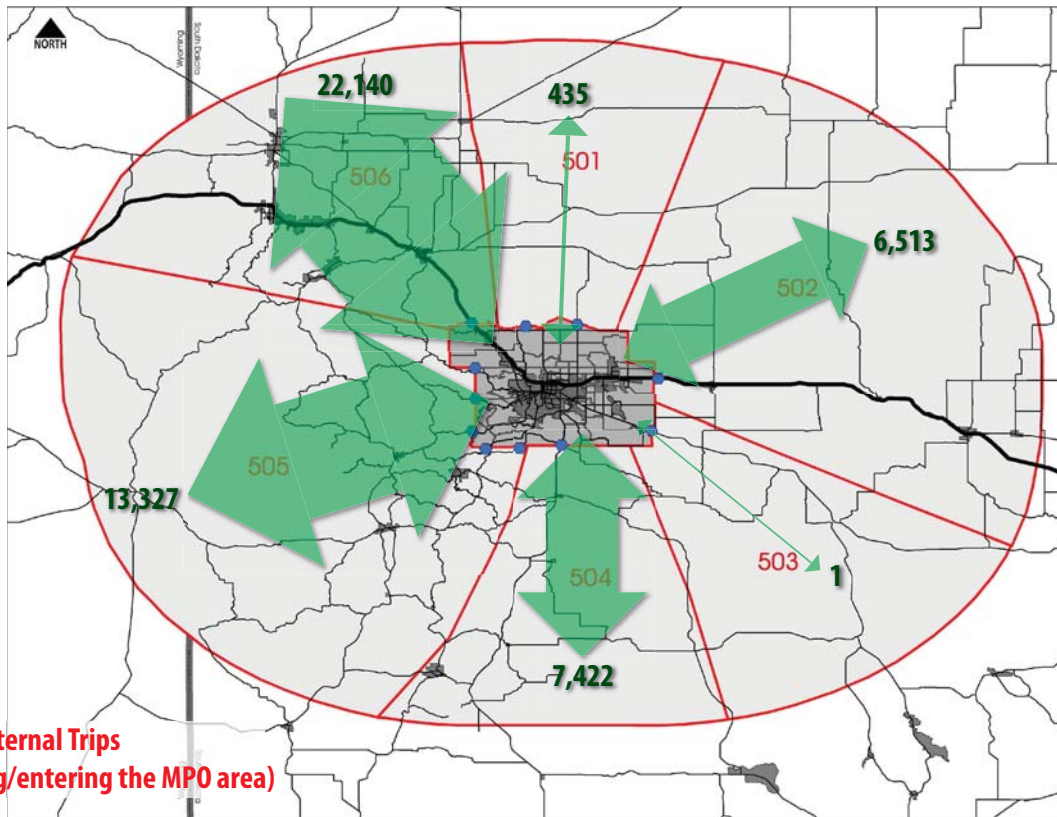


Figure 6
 April - May
 Internal - External and External - External Trips

**APPENDIX A RAPID CITY AREA ORIGIN-DESTINATION STUDY
METHODS AND ASSUMPTIONS DOCUMENT**

**RAPID CITY AREA
ORIGIN-DESTINATION STUDY**

METHODS AND ASSUMPTIONS DOCUMENT

Version 2: March 14, 2014

Original: February 5, 2014

Methods and Assumptions Meeting Dates:

January 27, 2014

March 11, 2014

Prepared for:

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FHU Reference No. 113315-01

The undersigned parties concur with the Methods and Assumptions for the Rapid City Area Origin-Destination Study as presented in this document.

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Date

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INTRODUCTION AND PROJECT DESCRIPTION

The Rapid City Area Metropolitan Planning Organization (RCMPO) maintains the regional travel demand model for areas including the jurisdictions of Rapid City, Box Elder, Summerset, Piedmont, Ellsworth Air Force Base, the unincorporated areas of Black Hawk and Rapid Valley, and the developing areas of Pennington and Meade Counties. The regional travel demand model is a traditional trip-based, four-step model that runs on the TransCAD platform. The existing model has been calibrated and validated against average daily traffic (ADT) counts; vehicle miles traveled (VMT), trip length distributions, and screen line counts. As there is always room for improvement in the calibration and validation process, this Rapid City Area Origin-Destination Study aims to collect data that can be used during the next model update process to more accurately calibrate the regional travel demand model.

For this project, Felsburg Holt and Ullevig will serve as the project manager responsible for coordinating the Methods and Assumption documentation process, coordinating data collection with the provider AirSage, reviewing the provided data for consistency and adherence to the data needs, and documenting the process with a Final Report. The origin-destination data will be purchased from AirSage, a data firm specializing in the procurement and post-processing of mobile device location data. The data collection process uses mobile device location data for select wireless carriers in the study area and relies on data already collected and archived by the wireless carriers.

The study schedule will proceed with the review and acceptance of this Methods and Assumptions Document, followed by notice to proceed for AirSage to develop the requested data (anticipated to take approximately six weeks), and the review of the data and documentation of the process into a final report (anticipated to take approximately three weeks), followed by a final document review process.

The study process will be overseen by the Study Advisory Team, including the following members.

| Name | Organization | Contact Address |
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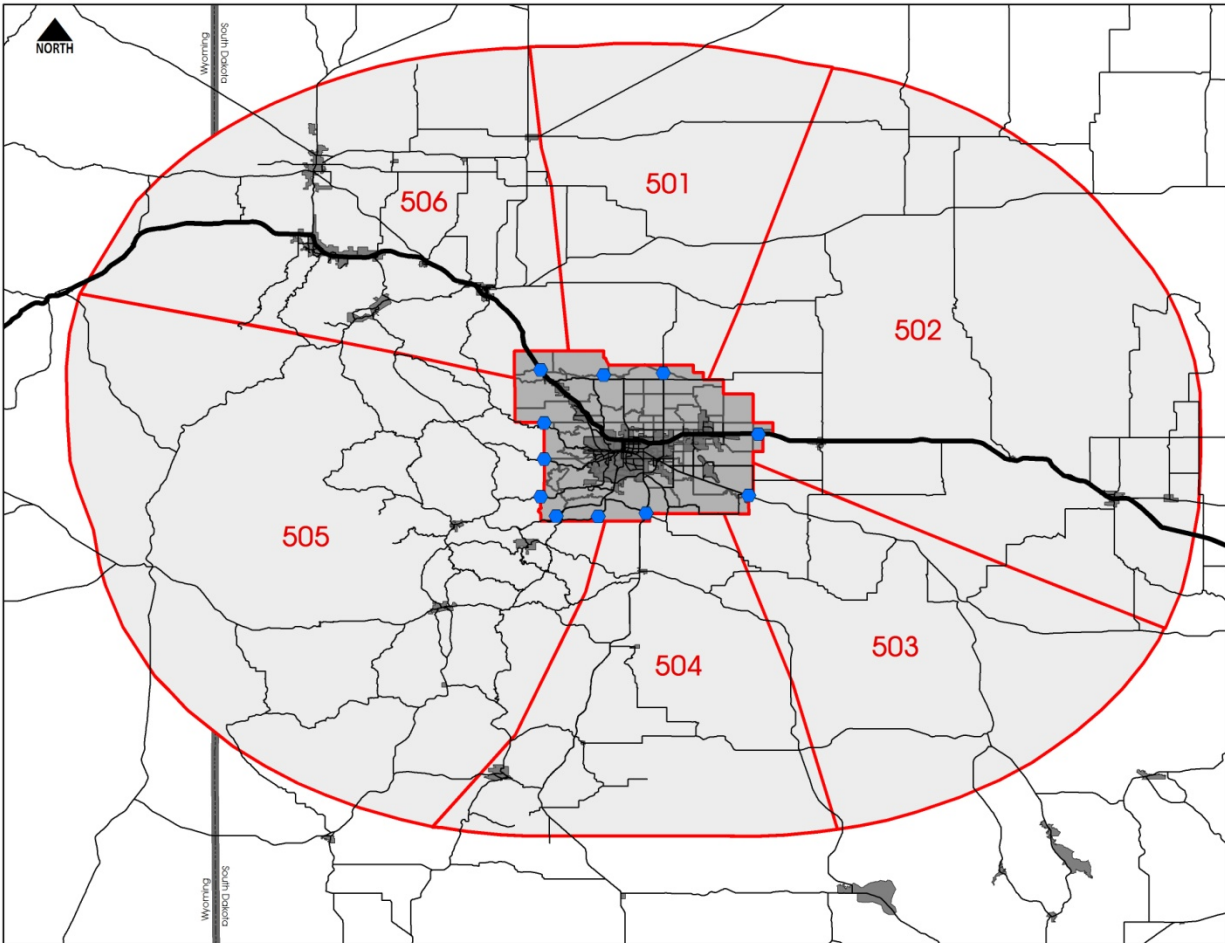
STUDY AREA

Traffic analysis zones defined by the travel demand model serve as the basis for this project's study area. The origin-destination data to be collected for this study will identify trips by the origination and destination zones consistent with the travel demand model zonal structure. The traffic analysis zones defined by the travel demand model must be supplemented to properly capture external trips. These are trips originating or destined for zones outside of the model area and those trips that pass through the model area.

The travel demand model currently defines external zones through a set of eleven external nodes; trips loaded onto the network pass through these zones during the trip assignment process. In order for the AirSage data collection process to account for these trips, external zones have been developed to

convert the point based loading to an area representing the loading point. Per AirSage methodology, this area represents approximately a 45 minute buffer outside the model zone area. Due to the structure of the AirSage process combined with the lack of distinct travel sheds for each node (where one area can be clearly attributed to each node to represent a 45 minute travel time), the model's 11 external zones have been combined into six zones depicted in **Figure 1**. Locations where nodes have been combined primarily focus on the hills west of Rapid City. Also shown are the external zones as blue dots to gain an understanding of where zone combinations have occurred.

Figure 1. Traffic Analysis Zones with External Zones



ANALYSIS YEARS/PERIODS

During the Methods and Assumptions Meeting, the key study parameters were presented for review and discussion, including study area, month of year, day of week, day part aggregations, resident classes, and trip purpose. **Appendix A** contains a short memorandum containing the preliminary recommendations in a tabular format; some of these assumptions changed as a result of the Meeting, the resulting final assumptions follow as **Table 1**.

Table 1. Study Parameters and Assumptions

| Parameter | Description | Final Assumptions |
|-----------------------|--|---|
| Study Area | O-D tables will be developed using a TAZ map corresponding to the travel demand model | Utilize the existing TAZ structure from the RCMPO travel demand model with established external zones (280 TAZ's and 6 defined external zones [from 11 external nodes]) (note: this process will allow development of Internal-Internal, Internal-External, and External-External trip pairs) |
| Month of Year | O-D tables will be developed for a one month period | To capture travel during a typical month (school in session), analyze April 15, 2013 to May 14, 2013 |
| Day of Week | Study will include separate O-D tables for average weekday day and average weekend day | Average Weekday Days: Tues-Thurs Average Weekend Days: Sat & Sun |
| Day Part Aggregations | Determines the periods into which the final O-D matrices are divided (note: must be at least 3 hours long due to data collection accuracy limitations) | Morning: Midnight-6 AM AM Peak Period: 6AM-9AM Midday: 9AM-3PM PM Peak Period: 3PM-6PM Evening: 6PM-Midnight (note: in order to develop data for the peak hour (consistent with the travel demand model), the three hour period will have to be factored manually) |
| Resident Classes | Trip characteristics will be used to characterize users as residents and visitors | Resident/Visitor |
| Trip Purpose | Trip purpose characterizes the originating and destination ends of each trip through the network based on the developed home and work locations for each device. | Trip purposes will be divided into 4 separate classes: <ol style="list-style-type: none"> 1. HBW: Home-based work 2. HBO: Home-based other 3. WBO: Work-based other 4. OBO: Other-based other (note: while the RCMPO travel demand model utilizes a Home-based shopping trip purpose, this category is not available from the data collection process and will be incorporated into the Home-based other category) |

The above study parameters define the assumptions that will be used to develop the principal data set. These resulting origin-destination tables will be used to recalibrate the existing Rapid City MPO travel demand model within the next year.

Additionally, the Study Advisory Team expressed interest in understanding the trip pattern differences between the typical month and peak tourist season. AirSage has agreed to utilize the buffer month data naturally pulled to complete the principal data set to produce generalized trip origin-destination tables for the summer month of June 2013. The secondary trip tables will not provide detailed information such as resident and visitor or distinguish trip purpose. The trip tables will be useful in comparing the general origin-destination trip differences throughout the region giving a high-level picture of trip making during the tourist season.

DATA COLLECTION

The data collection effort will be completed by AirSage, a firm which boasts a new type of data source – mobile signals. AirSage collects and analyzes real-time mobile signals to provide anonymous data of the location and movement of mobile devices. This data set provides insight into where people are located and how they move about over time. AirSage’s WiSE (Wireless Signal Extraction) technology extracts data from wireless carrier networks, as generated by devices in the normal course of operation (e.g., making phone calls, texting, surfing the Web). Mobile devices frequently communicate with the network, both during use and when the mobile is in idle mode. AirSage technology anonymizes the data stream ensuring user privacy, and performs multiple stages of analysis to monitor the location movement of mobile devices, and thus the population of mobile users.

Further details about the AirSage process have been included in **Appendix B**.

TRAFFIC OPERATIONS ANALYSIS

Not applicable.

TRAVEL FORECAST

Not applicable.

SAFETY ISSUES

Not applicable.

SELECTION OF MEASURES OF EFFECTIVENESS (MOE)

The AirSage data collection process relies on cellular data provided by wireless carriers. The cellular carrier information available to AirSage does not represent the entirety of carrier services, and therefore the complete population will not be collected but instead a representative sample. Based on previous work experience and research, this study will aim to collect at least 25% of cellular devices in the Rapid City study area. If any concerns about reaching this threshold come to the consultant team’s attention, immediate notification will be sent to the Study Advisory Team. Since the data available will represent only a sample of devices in the study area, AirSage will utilize statistical methodologies to convert the

data set into a complete population. These adjusted origin-destination tables will be the final deliverable.

FHWA INTERSTATE ACCESS MODIFICATION POLICY POINTS

Not applicable.

DEVIATIONS/JUSTIFICATIONS

Not applicable.

CONCLUSION

This Methods and Assumptions Document describes the parameters that will be utilized to develop the Rapid City Area Origin-Destination Study. Following approval by the Study Advisory Team, these parameters will be utilized by AirSage to complete the data processing effort. Felsburg Holt & Ullevig will receive the completed data set and review for completeness and preliminary data consistency. The final data will be delivered to Rapid City MPO in its original format along with a Final Report.

**APPENDIX A RAPID CITY AREA ORIGIN-DESTINATION STUDY
METHODS AND ASSUMPTIONS MEETING MEMORANDUM,
JANUARY 24, 2014**



January 24, 2014

MEMORANDUM

TO: Kip Harrington
Patsy Horton

FROM: Steven Marfitano
Elliot Sulsky

SUBJECT: Rapid City Area Origin-Destination Study Methods and Assumptions Meeting
FHU Reference No. 13-315-01

This memorandum documents the input parameters needing definition to successfully complete the Rapid City Area Origin-Destination Study. This meeting serves as the preliminary discussion in development of the Methods and Assumptions Document. Once the Methods and Assumptions Document has been reviewed, finalized, and signed, AirSage will utilize these parameters to complete the data collection process and final origin-destination tables will be created. At the completion of the origin-destination table development process FHU will review the origin-destination tables and provide a Final Report and project deliverables to Rapid City MPO.

The following table defines the input parameters that will be used to define the origin-destination table development. Below, each component has been listed along with a recommendation for how to proceed based on known characteristics of the existing Rapid City Area Travel Demand Model. It is anticipated that Rapid City MPO will use the resulting origin-destination tables to recalibrate the existing model within the next year. If known changes to the structure of the travel demand model are known, those changes should be discussed at this meeting and incorporated into these decisions and the resulting Methods and Assumptions Document.

| Parameter | Description | Preliminary Recommendation |
|---------------|--|--|
| Study Area | O-D tables will be developed using a TAZ map corresponding to the travel demand model | Utilize the existing TAZ structure from the RCMPO travel demand model with established external nodes (280 TAZ's and 11 external stations) (note: this process will allow development of Internal-Internal, Internal-External, and External-External trip pairs) |
| Month of Year | O-D tables will be developed for a one month period | To capture travel during a typical month (school in session), recommend analyzing April 2013 |
| Day of Week | Study will include separate O-D tables for average weekday day and average weekend day | Average Weekday Days: Tues-Thurs Average Weekend Days: Sat & Sun |

| | | |
|-----------------------|--|--|
| Day Part Aggregations | Determines the periods into which the final O-D matrices are divided (note: must be at least 3 hours long due to data collection accuracy limitations) | Morning: Midnight-6 AM AM Peak Period: 6AM-9AM Midday: 9AM-4PM PM Peak Period: 4PM-7PM Evening: 7PM-Midnight (note: in order to develop data for the peak hour (consistent with the travel demand model), the three hour period will have to be factored manually) |
| Resident Classes | Trip characteristics will be used to characterize users as residents and visitors | Resident/Visitor |
| Trip Purpose | Trip purpose characterizes the originating and destination ends of each trip through the network based on the developed home and work locations for each device. | Trip purposes will be divided into 4 separate classes: 1. HBW: Home-based work 2. HBO: Home-based other 3. WBO: Work-based other 4. OBO: Other-based other (note: while the RCMPO travel demand model utilizes a Home-based school trip purpose, this category is not available from the data collection process) |

APPENDIX B UNDERSTANDING POPULATION MOVEMENTS, AIRSAGE HAND OUT

Understanding Population Movements

1.0 Introduction

AirSage, an Atlanta based wireless information and data provider, has developed an approach to gathering data about population mobility throughout a region. AirSage analyzes anonymous location and movement of mobile devices, which is derived from wireless signaling data, to provide new insights into where populations, are, were, or will be, and how they move about over time and in response to special events or disruptions to the roadway network.

The purpose of this document is to describe the methodology used by AirSage to gather data and to calculate and categorize trips to produce trip matrices.

2.0 AirSage Technology

AirSage provides historic population location, movement, and traffic information derived from analysis of wireless (and in particular, cellular phone) signaling data. Combining patented and proprietary data collection and analysis technologies with signaling data from wireless carriers, AirSage has developed and deployed a secure data collection and reporting network with over 100 million mobile “sensors” (mobile devices) that provide unprecedented visibility into where groups of people are, where they were, where they are likely to be, and how they move from one area to another.

AirSage’s WiSE (Wireless Signal Extraction) technology extracts data from wireless carrier networks, as generated by devices in the normal course of operation. Mobile devices frequently communicate with the network through control channel messages, both during use and when the device is in idle mode. The frequency and nature of the signaling data varies based on the network equipment used to provide cellular service to the area. The WiSE technology anonymizes the data stream (ensuring user privacy) and performs multiple stages of analysis to monitor the location and movement of the mobile devices (and thus the population of mobile users).

3.0 AirSage Study Methodology

AirSage uses a modular, multi-step methodology to derive useful information and analytics from wireless signaling data provided by its wireless carrier partners. The core components of the data collection, processing, and delivery process is outlined below.

Device Location Processing: Time-stamped locations (latitude/longitude) are generated for each mobile device (e.g. a cellphone), utilizing the network signaling data generated each time a mobile device interacts with the mobile network. Interaction with the network comes in many forms including sending and receiving text messages or receiving updates or streaming data to/from mobile devices. "Processed Sightings" are created using this information in addition to factoring in the quality of the device and removing any static that might occur within the network that has the potential to obscure the data.

Activity Pattern Analysis: All of the "Device Locations" (Home, Work, etc.) for a device are determined over the course of four to six weeks. The data are run through a series of pattern recognition and statistical clustering algorithms to determine repeated and irregular trip patterns and primary activity locations for a device. These patterns and locations are used to classify trip purpose.

Activity Point Generation: Each Device Location is then combined with other recent sightings and known activity locations to further refine the location, determine if the device is moving or stationary, and calculate additional attributes to create individual "Activity Points." At the most basic level, activity points may be classified as being Home, Work, or Other locations. Home locations are those locations where mobile users spend the majority of their nights. Nighttime is defined between 9:01pm and 6:00 am. Work locations are similarly determined by looking at where subscribers spend the majority of their days between 9:00 am and 5:00 pm. These activity points are then combined to create "Trip Legs" which eventually allow for an overall network of travel behaviors to be established.

Population Synthesis: Using the observed sample devices, the movements for a full population is synthesized. There are two main factors that go into the expansion process: penetration rates and device quality. Penetration rates, simply put, is the ratio of number of resident devices observed by Airsage in a given census tract to the 2010 census population. Currently expansion is performed to census tract but will shift to a more detailed census block group level in a future release. Device quality refers to the number of daily sightings observed for each device. This factor feeds a model which adjusts for the probability of missing trips due to limited visibility of some devices.

Trip Analysis: Each trip is analyzed and classified into various interesting categories such as resident class of subscriber, trip purpose, time of day and day of week. Each of these is explained in detail in the next section.

Data Aggregation and Packaging: For each project a unique study area is defined before the data collection process even begins. This area is then further subdivided into analysis zones. The trip ends (Activity Points) are assigned to these zones. All of the trip ends within those zones are also assigned a

purpose and time of day during which they took place. The number of trip ends are totaled to determine the total number of trips that took place within each zone. All of this data is then packaged in the form of an O-D Matrix and distributed to clients so that they may use our results to perform their own internal analysis.

4.0 Optional Features in OD Matrix

Resident Classes (Optional): Typically, subscribers are classified as residents, non-residents and through. Residents have a home location within the study area. The 'through' field is actually identifying the type of subscriber and not the trip itself. These subscribers were only seen on one day during the study period and they just passed through the region. They might have made intermediate stops along those trips which are being identified here. On the other hand, non-residents were seen more than couple of days (likely, visitors staying few days in the region). For modeling purposes, non-resident and through trips can be combined into 'visitor' trips. A much more detailed classification of subscribers is also available upon request.

Subscriber classification can also be grouped into six categories: resident worker, home worker, inbound commuter, outbound commuter, short term visitor and long term visitor. Resident worker lives and works within in the study area. Home worker is one whose day and night time clusters are same and are within the study area. Short-terms visitors are the 'through' travelers whereas long term visitors stay more than couple of days. Outbound commuter means the subscriber has a home location in the study area but work location outside the region. Inbound commuter has home location in the external area of the study region area but work location is in one of the internal zones. It should be noted that inbound commuter is only relevant when an 'external analysis' is performed.

Trip Purpose (Optional): Trip purpose is classified as either 3-class or 9-class categories. These are standard definitions of what is used in the travel demand modeling industry – HBW, HBO and NHB for 3-class and HH, HO, OH, HW,WH,WW,WO,OW and OO for 9-class. H indicates 'Home' end, W indicates 'Work' end and O indicates 'Other' end. HH, WW means a trip from home to home or work to work. Trips are classified this way when it is certain that the subscriber has left the origin and made a short trip but the destination location is not exactly captured (for example, jogging in the neighborhood, visiting a very close grocery store, walk to lunch while at work etc.). For modeling purposes, it is suggested to use HH in HBO and WW in NHB categories.

Time of day (Optional): Each trip is grouped by trip start time by the hour of the day. This is aggregated into custom categories for time of day analysis. Standard time of day groups used internally are: Midnight to 6 AM, 6 AM to 10 AM, 10 Am to 3 PM, 3 Pm to 7 PM and 7 Pm to Midnight.

Day of week (Optional): Each trip is also identified by the day of the week travel was made. This allows for interesting analysis of travel variation by each weekday or weekend day.

External Analysis (Optional): In certain cases, external zones are added to the study area to account for external-internal travel. The size of the external zones required for an accurate analysis depends on

the network coverage and travel sheds (interstate, highway locations). In general, a 30 to 45 minute travel time buffer is created around study area to form the external zones. The first time a device coming into the study area is seen in these external zones, an origin trip end is identified. Subsequent end points are connected to this origin. This helps to identify all External – Internal, Internal-External and External-External travel in the region.

APPENDIX B AIRSAGE SUMMARY REPORTS: APRIL-MAY AND JUNE

RAPID CITY MOBILE DATA ANALYSIS

Mobile Data Date: April 15, 2013 to May 15, 2013

Figure 1 Study Area Map

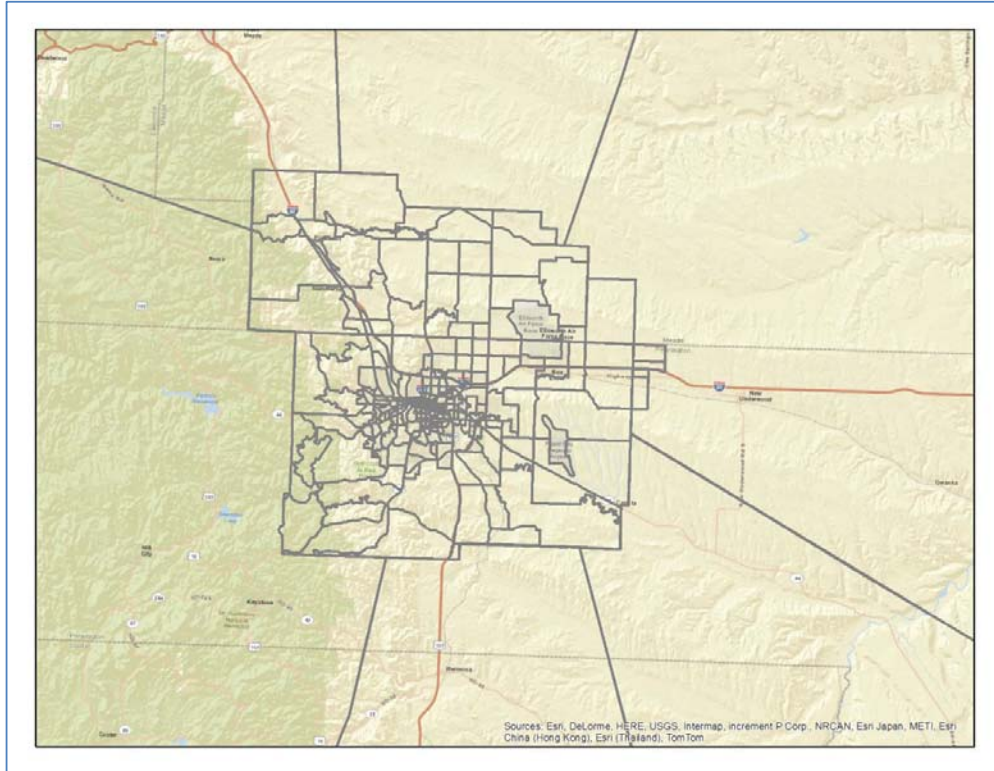
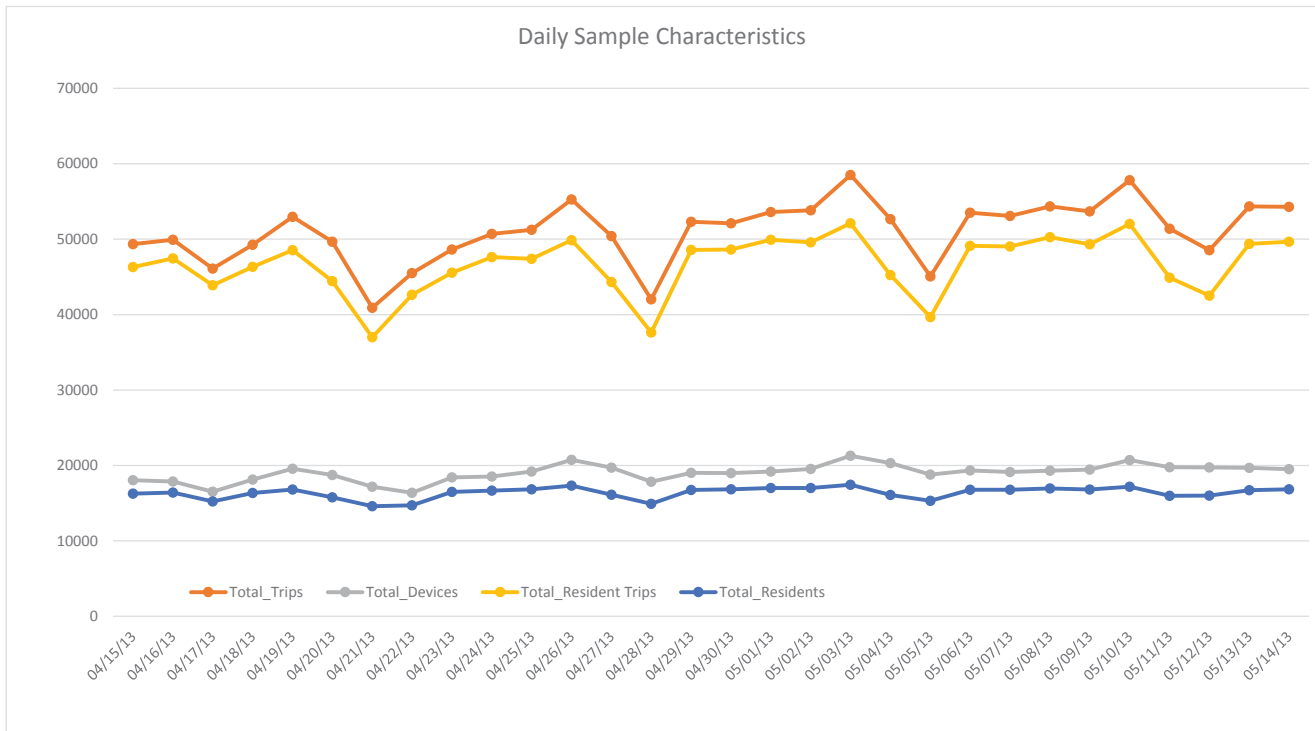


Figure 2 Sample Characteristics



| Table 1 Study Area Demographic Data | | | | |
|--|----------|------------------------|-----------------|---------|
| Study Areas | Coverage | Census Population 2010 | Households 2010 | Pop./HH |
| Rapid City | Total | 104,310 | 46,200 | 2.25 |

| Table 2 Daily Trips by Purpose (Counts) | |
|--|----------------|
| Purposes | Total |
| Home Based Work | 88,260 |
| Home Based Other | 193,164 |
| Non Home Based | 82,242 |
| Trucks Internal | n/a |
| <i>Total</i> | <i>363,666</i> |
| Through non-Trucks | n/a |
| Through Trucks | n/a |

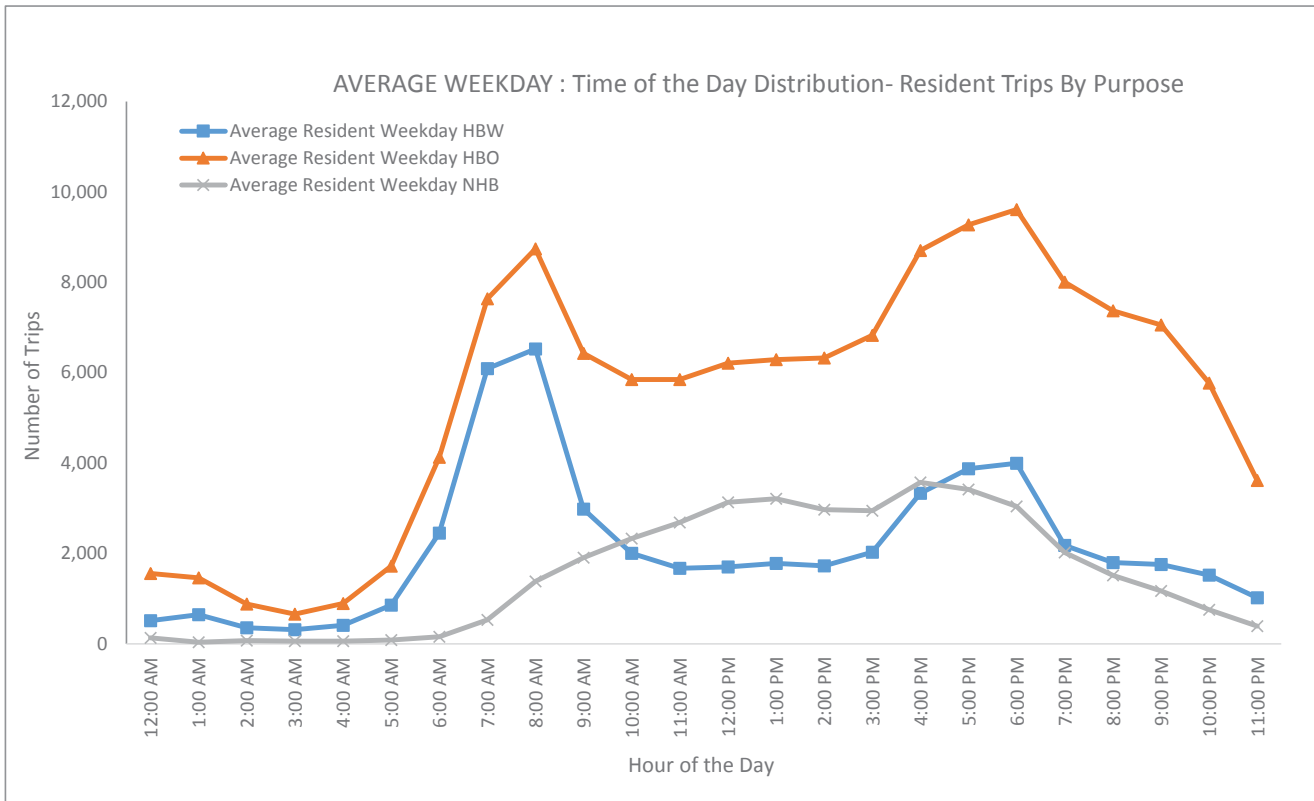
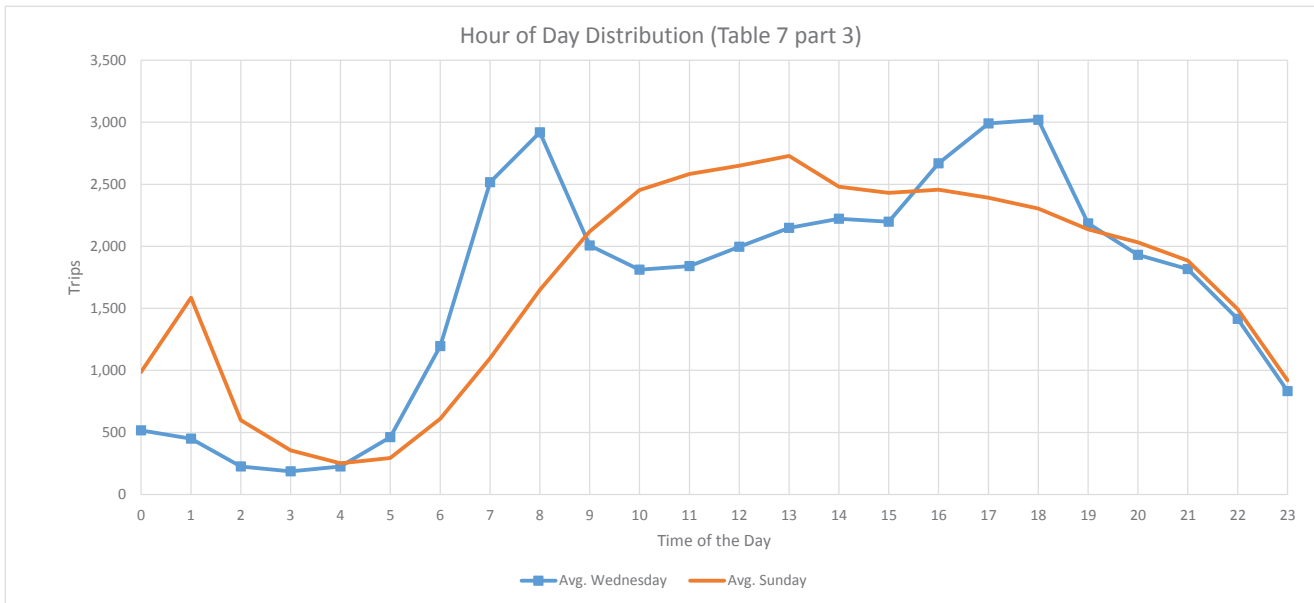
| Table 3 Daily Trips by Purpose (Percentages, only Internal-Internal Trips) | | | | |
|---|----------------|-------------|-------------------|-------------------|
| Number of Person Trips by Purpose | | | | |
| Purpose | I-I | | TDOT ¹ | FDOT ² |
| | Trips | Percent | Percent | Percent |
| HBW | 88,260 | 24.3% | 18% - 27% | 12% - 24% |
| HBO | 193,164 | 53.1% | 47% - 54% | 45% - 60% |
| NHB | 82,242 | 22.6% | 22% - 31% | 20% - 33% |
| <i>Total</i> | <i>363,666</i> | <i>100%</i> | <i>100%</i> | <i>100%</i> |

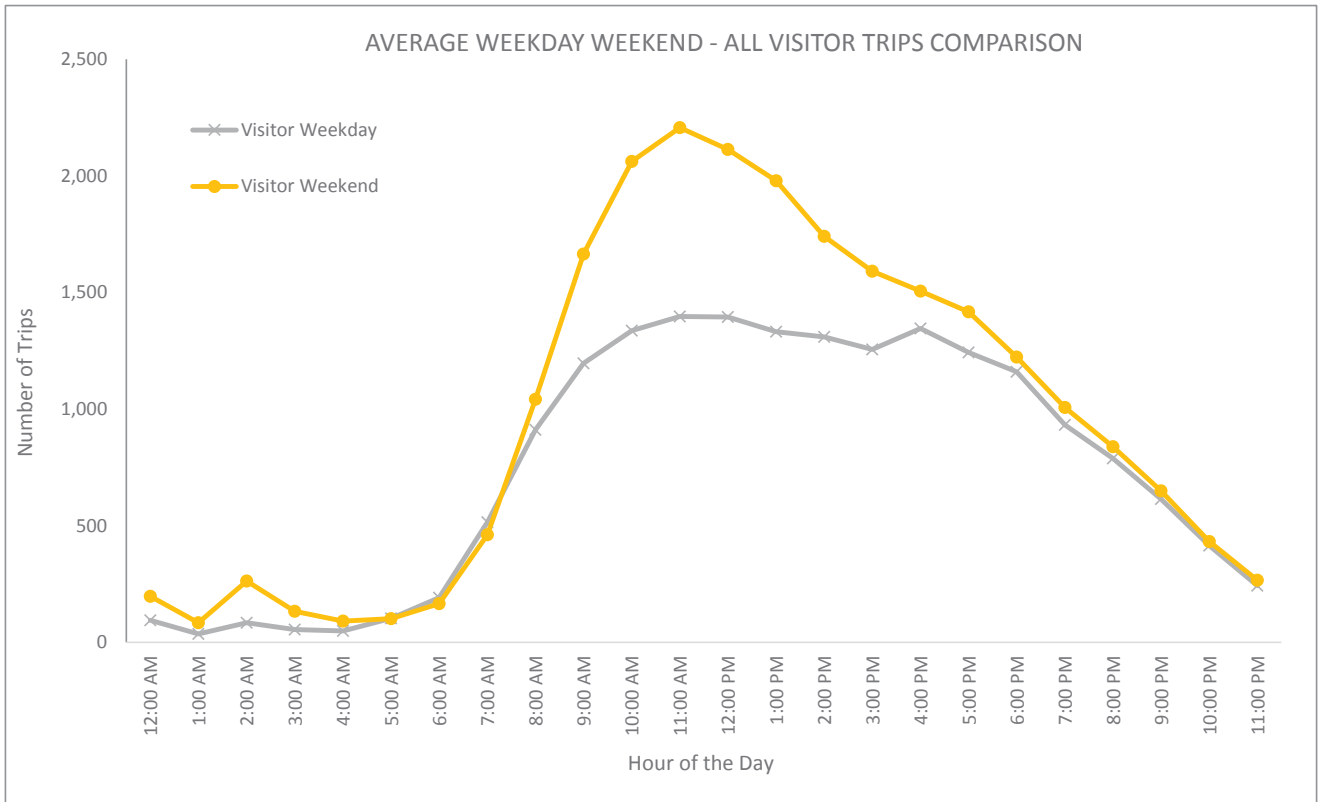
Typical ranges of percent trips by each trip purpose are shown in the following documents:

1. TDOT Standard – Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, 2003, page 5
2. FDOT Standard – FSUTMS-Cube Framework Phase II: Model Calibration and Validation Standards, 2008, page 2-10

| Table 4 Household Person Trip Rates and Population Trip Rates by Purpose | | | | |
|---|--------------|-------------------|-------------------|---------------------------------|
| Household Person Trip Rates by Purpose | | | | Population Trip Rate by Purpose |
| Total | | | | |
| Purpose | AirSage 2013 | TDOT Standard | FDOT Standard | AirSage 2013 |
| HBW | 1.91 | 1.7 - 2.3 | n/a | 0.63 |
| HBO | 4.18 | 3.5 - 4.8 | n/a | 1.47 |
| NHB | 1.78 | 1.7 - 2.9 | n/a | 0.73 |
| <i>Total</i> | <i>7.87</i> | <i>6.9 - 10.0</i> | <i>8.0 - 10.0</i> | <i>2.82</i> |

Figures: Time of Day Distributions





RAPID CITY MOBILE DATA ANALYSIS

Mobile Data Date: June 2013

Figure 1 Study Area Map

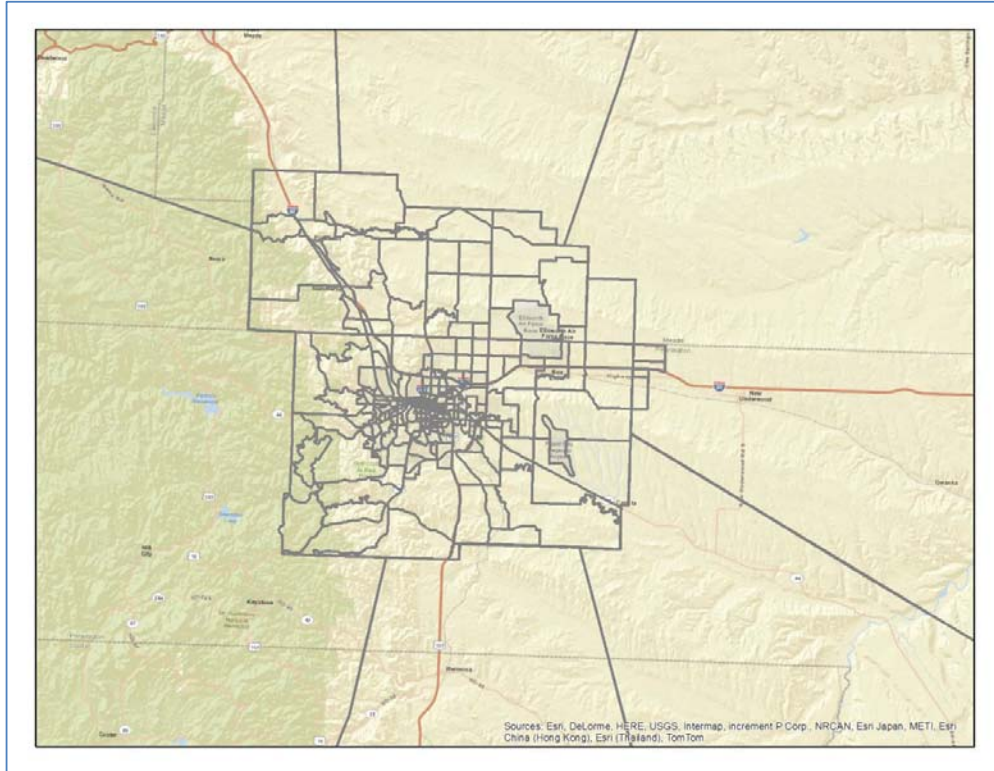


Figure 2 Sample Characteristics

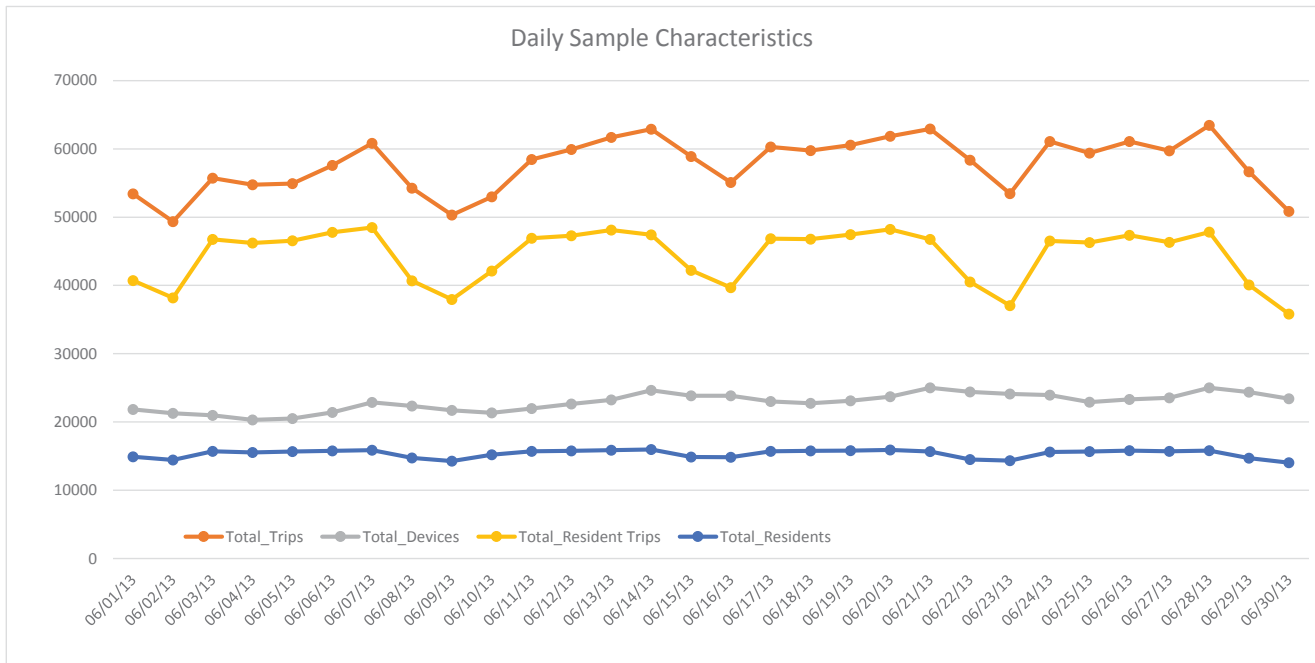


Table 1 Study Area Demographic Data

| Study Areas | Coverage | Census Population 2010 | Households 2010 | Pop./HH |
|-------------|----------|------------------------|-----------------|---------|
| Rapid City | Total | 104,310 | 46,200 | 2.25 |

Table 2 Daily Trips by Purpose (Counts)

| Purposes | Total |
|--------------------|----------------|
| Home Based Work | 79,723 |
| Home Based Other | 195,259 |
| Non Home Based | 118,722 |
| Trucks Internal | n/a |
| <i>Total</i> | <i>393,704</i> |
| Through non-Trucks | n/a |
| Through Trucks | n/a |

Table 3 Daily Trips by Purpose (Percentages, only Internal-Internal Trips)

| Number of Person Trips by Purpose | | | | |
|-----------------------------------|----------------|-------------|-------------------|-------------------|
| Purpose | I-I | | TDOT ¹ | FDOT ² |
| | Trips | Percent | Percent | Percent |
| HBW | 79,723 | 20.2% | 18% - 27% | 12% - 24% |
| HBO | 195,259 | 49.6% | 47% - 54% | 45% - 60% |
| NHB | 118,722 | 30.2% | 22% - 31% | 20% - 33% |
| <i>Total</i> | <i>393,704</i> | <i>100%</i> | <i>100%</i> | <i>100%</i> |

Typical ranges of percent trips by each trip purpose are shown in the following documents:

1. TDOT Standard – Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee, 2003, page 5
2. FDOT Standard – FSUTMS-Cube Framework Phase II: Model Calibration and Validation Standards, 2008, page 2-10

Table 4 Household Person Trip Rates and Population Trip Rates by Purpose

| Household Person Trip Rates by Purpose | | | | | Population Trip Rate by Purpose |
|--|--------------|-------------------|-------------------|--------------|---------------------------------|
| Total | | | | | |
| Purpose | AirSage 2013 | TDOT Standard | FDOT Standard | AirSage 2013 | |
| HBW | 1.73 | 1.7 - 2.3 | n/a | 0.63 | |
| HBO | 4.23 | 3.5 - 4.8 | n/a | 1.47 | |
| NHB | 2.57 | 1.7 - 2.9 | n/a | 0.73 | |
| <i>Total</i> | <i>8.52</i> | <i>6.9 - 10.0</i> | <i>8.0 - 10.0</i> | <i>2.82</i> | |

Figures: Time of Day Distributions

