

Using Truck GPS Data for Freight Performance Analysis in the Twin Cities Metro Area (TCMA)

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Department of Civil Engineering
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Acknowledgements

- ❑ MnDOT
- ❑ ATRI – Dan Murray & Jeff Short
- ❑ Tara Sasank Sunkara & Dayakar Reddy Singana – Graduate Research Students
- ❑ TAP members
- ❑ MTO, Civil Engineering, UMN



Outline

- Project Progress
 - ✓ TAP Meeting on May 8, 2013
 - ✓ Focus on Task #3 Performance Measures
- Data Summary & Analysis Results
- Performance Measures (Mobility, Delay & Reliability)
- Truck Parking (Location & Duration)
- Ongoing Effort and Next Step
- Q & A

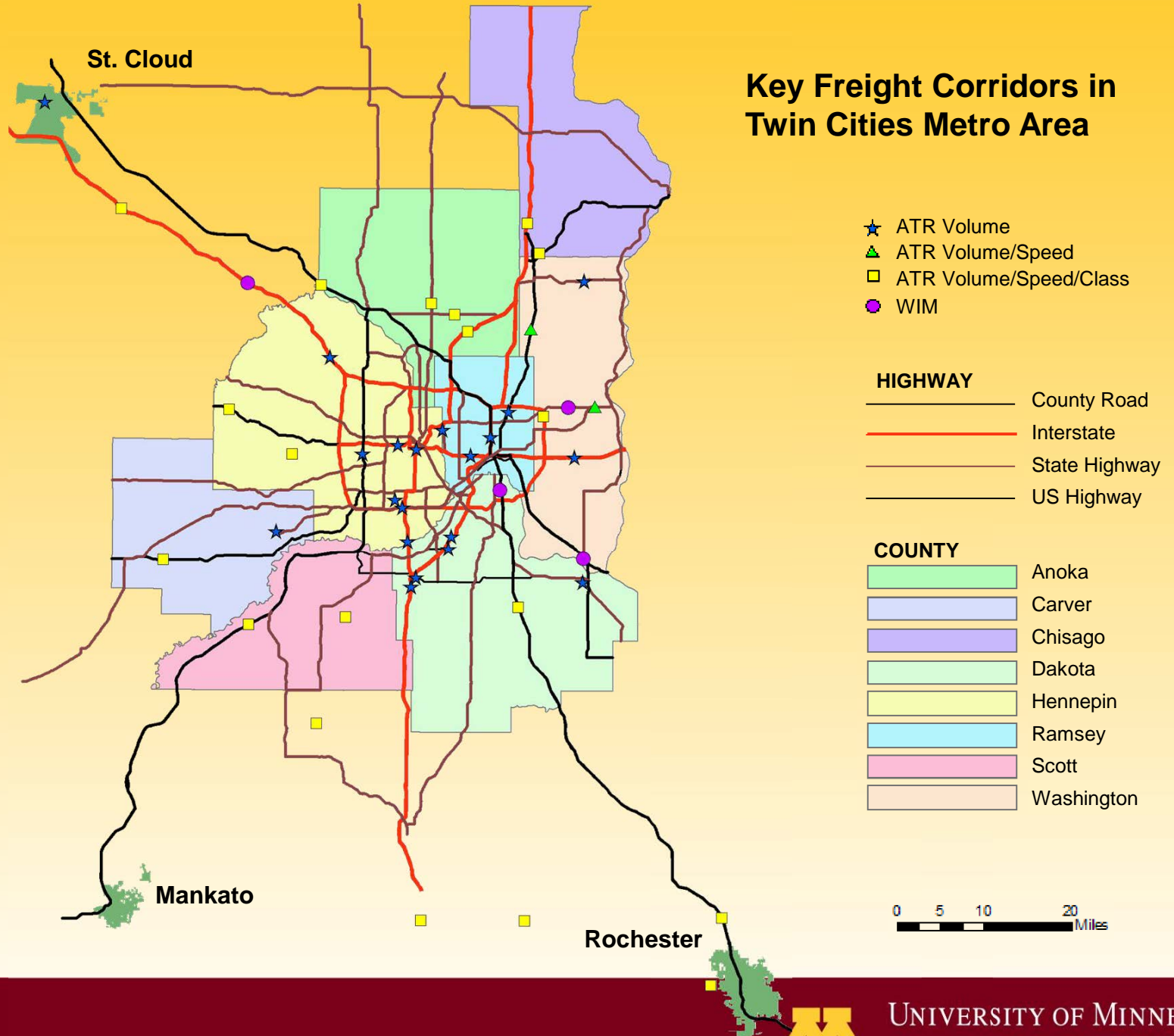


Project Progress

- Literature review (#1) – completed
- Obtain data from ATRI (#2) - completed
- Process data and generate performance measures (#3) - completed
- Process ATR/WIM/loop detector data (#4), due 9/30/13
- Identify freight node, freight significant corridor and congestion (#5), due 12/31/13
- Final report (#6), due 2/28/14



Key Freight Corridors in Twin Cities Metro Area



Truck GPS Data

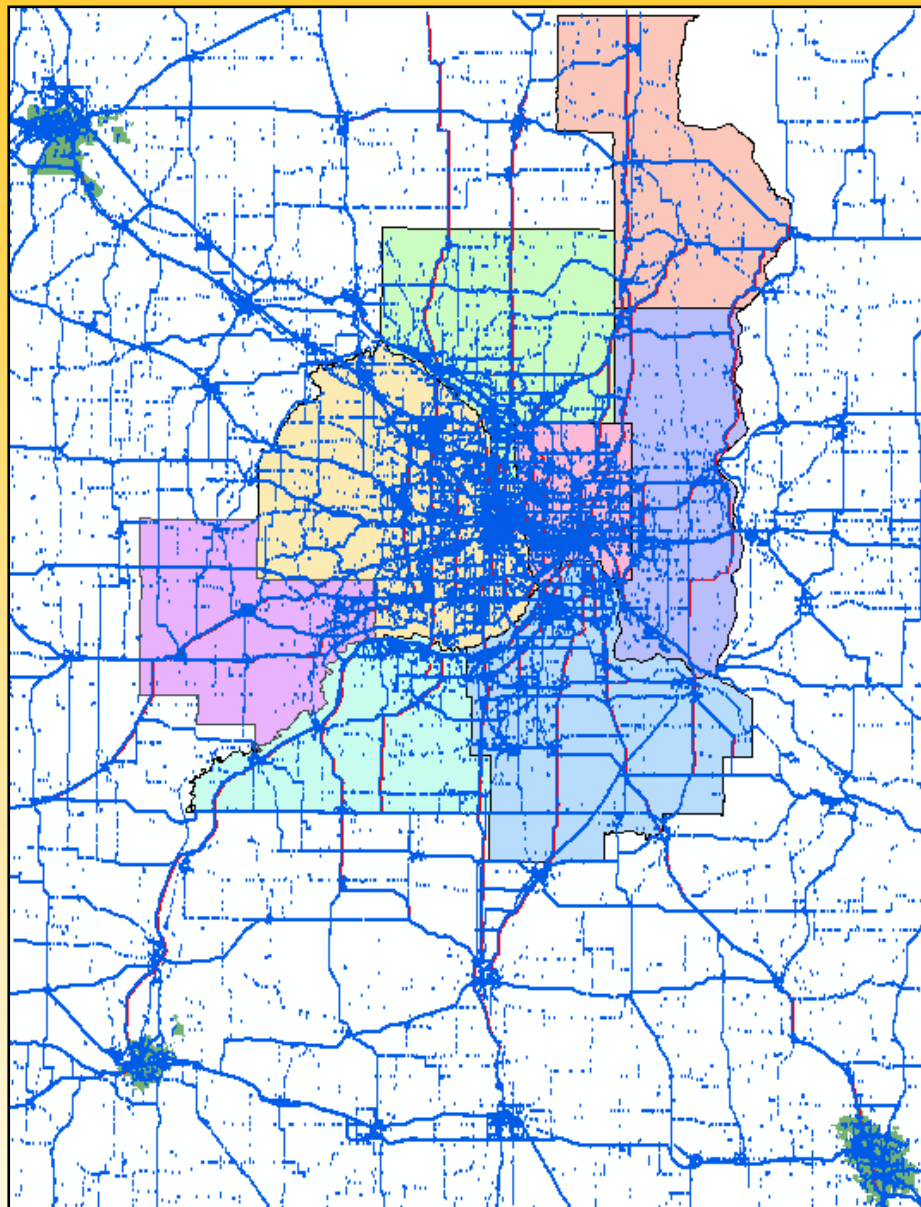
Data Field	DS-A	DS-B	DS-C
Truck ID	✓	✓	✓
Timestamp	✓	✓	✓
Spot Speed	✓	NA	✓
Heading	✓	NA	NA
Latitude	✓	✓	✓
Longitude	✓	✓	✓



GPS Data Summary

Data Set	DS-A	DS-B	DS-C
Time Zone	GMT/UTC	GMT/UTC	GMT/UTC
Spot Speed?	Yes	No	Yes
Static ID?	Yes	Rotate every 15 days	Rotate every 24 hours
Data Accuracy	Within 3 meters	Within 124-134 meters at 90% probability and 129-150 meters at 95% probability.	Within 13-56 meters at 90% probability and 15-58 meters at 95% probability.
Snap Tolerance Used	50 m	150 m	50 m
2012 Number of Truck Trips	29,555	69,063	66,632
2012 Raw Data Size	40,500,081	4,840,339	28,290,687
2012 Snapped	12,287,134	1,246,536	8,593,449
2012 Snapped Percentage	30.3%	25.8%	30.4%
Average (SD) Sampling Time	10 (15) min	22 (28) min	1 (5) min





Snapshot of Truck GPS Point Cloud (Dec. 2012)

WIM Station Summary

WIM ID	36	37	40	42
Route Name	MN 36	I-94	US 52	US 61
County Name	Washington	Wright	Dakota	Washington
Direction	EB	WB	NB	SB
Mile Post	15	200	127	119
City Name	Lake Elmo	Otsego	West St. Paul	Cottage Grove
WIM Location Description	0.7 mi W of CSAH17 Lake Elmo Ave N) in Lake Elmo	1.2 mi NW of CSAH19 (La Beaux Ave) in Otsego	0.5 mi N of CSAH14 in West St. Paul	0.4 mi S of TH95 (Manning Ave S), S of Cottage Grove
WIM Type	Volume / Speed / Class / Weight			
2011 HCAADT	1,100	6,900	4,400	1,750

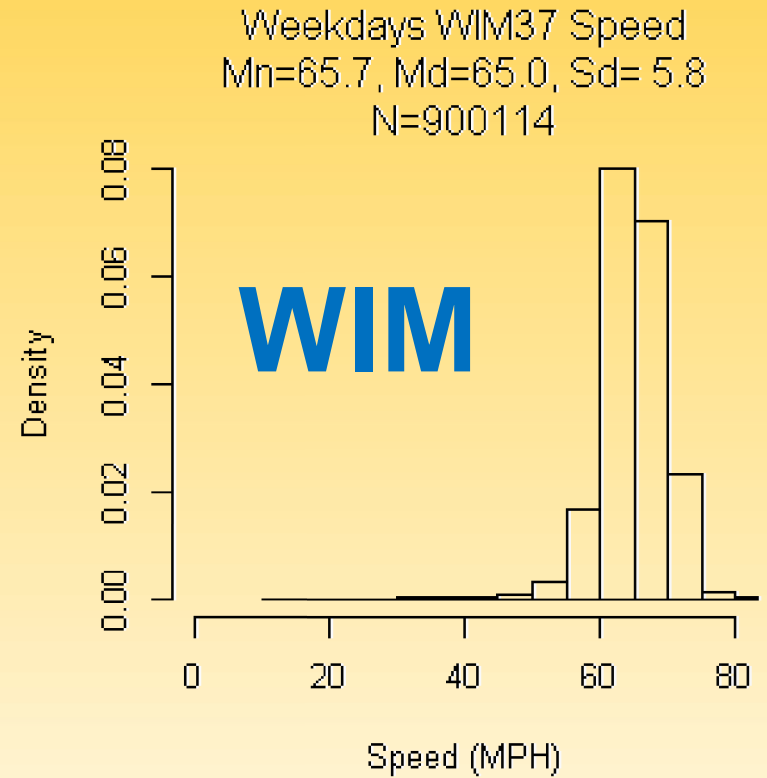
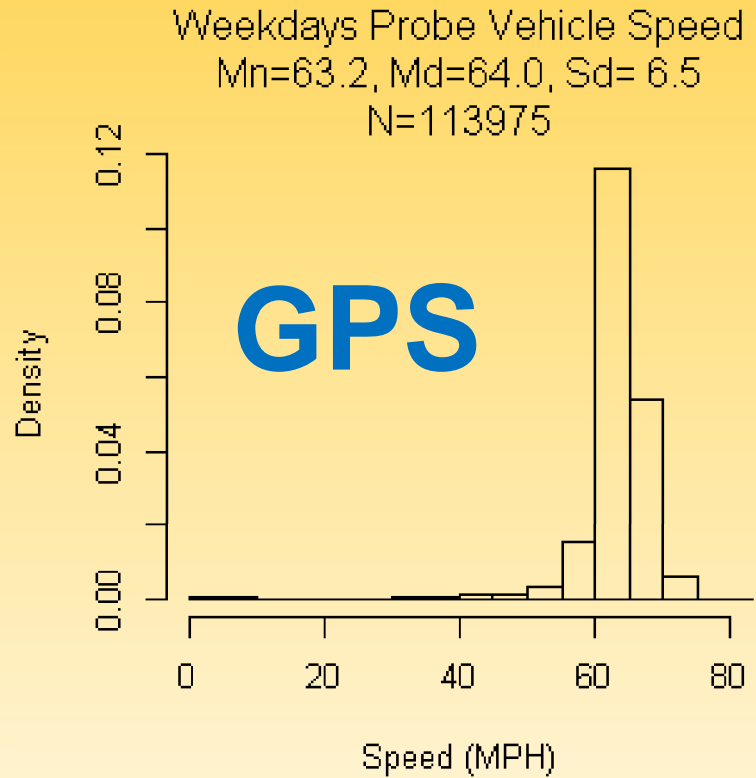




Truck Speed Analysis



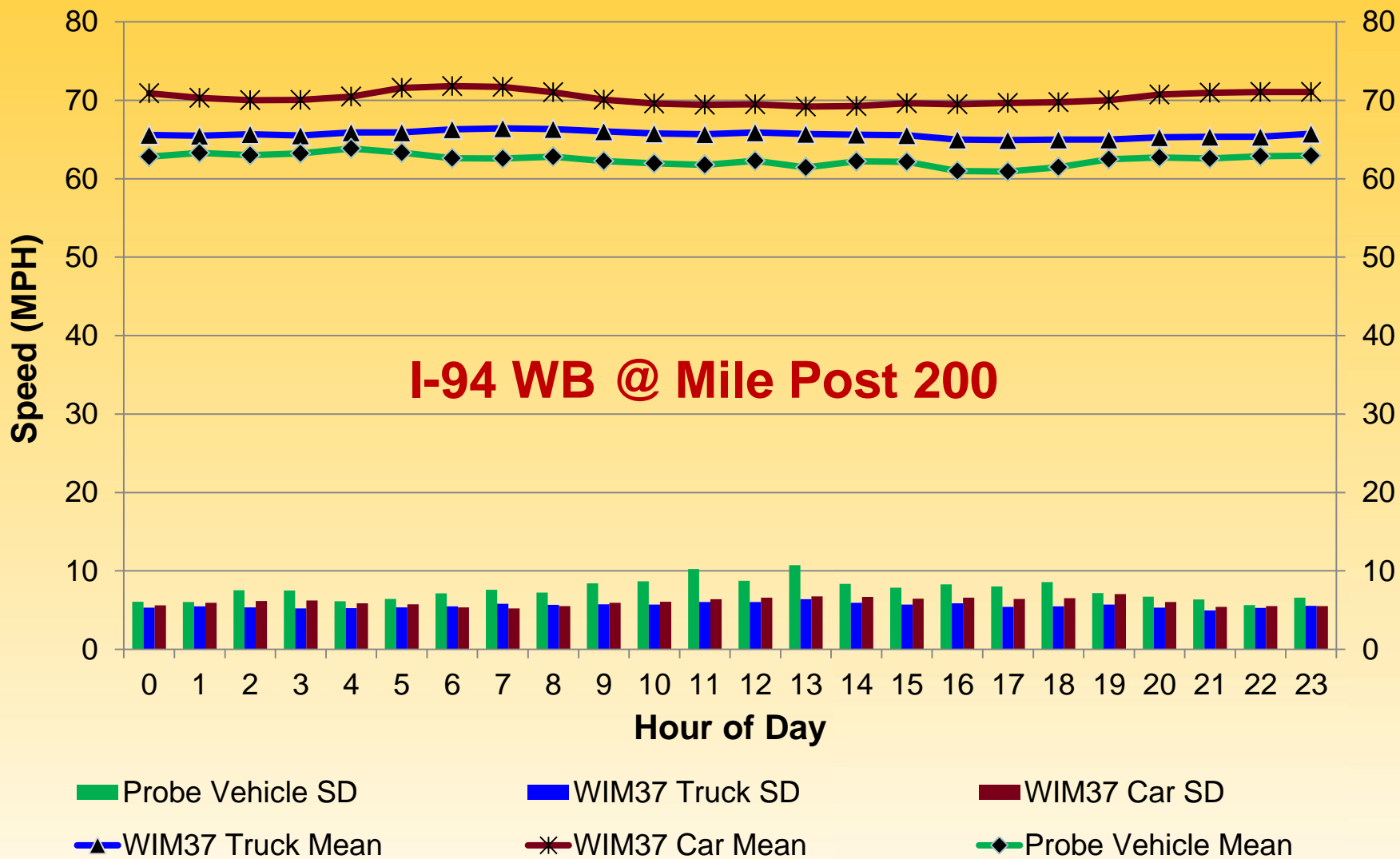
Processed GPS vs. WIM Data



I-94 WB Mile Post 200

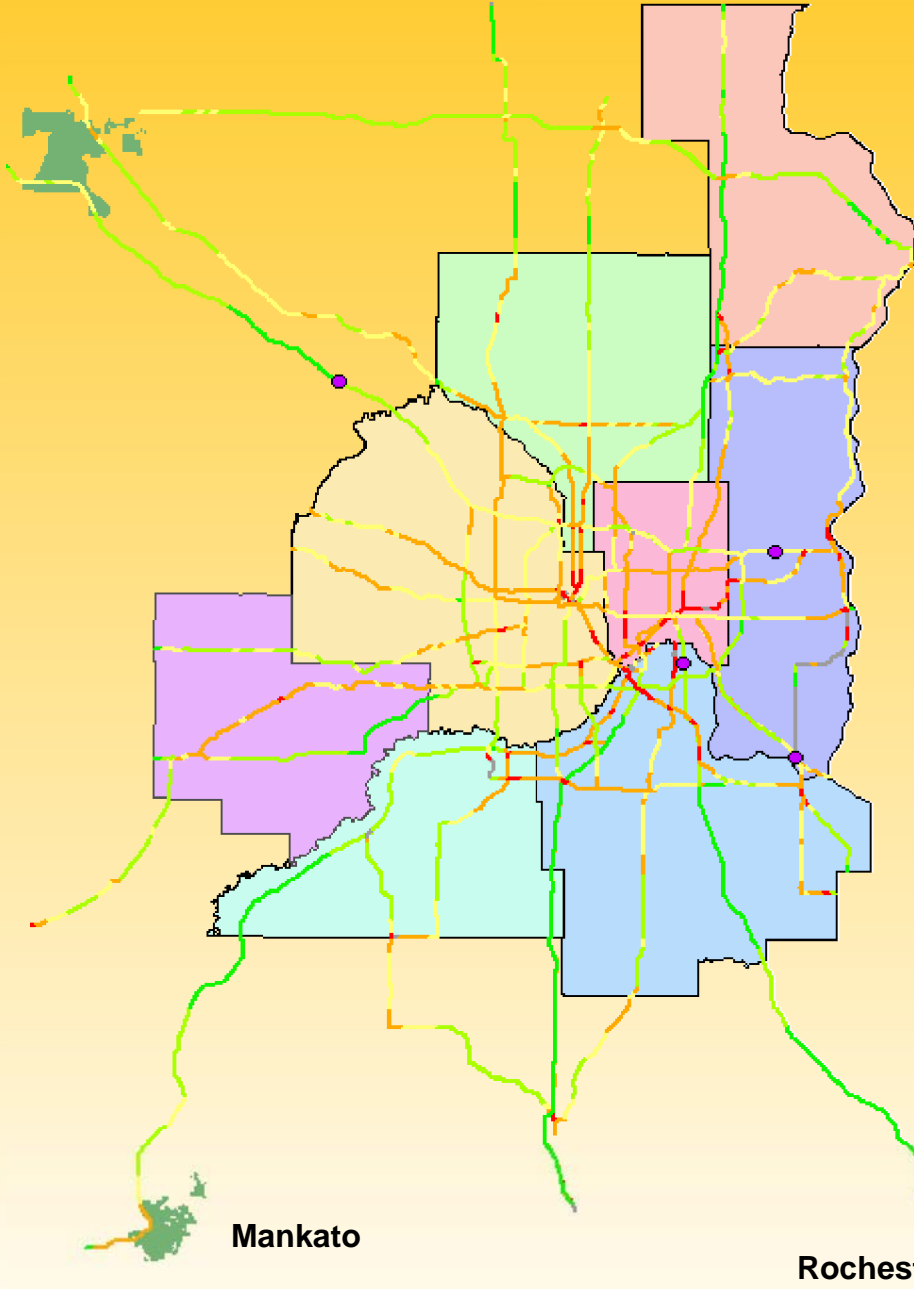


GPS vs. WIM37 Vehicle Speed Comparison



St. Cloud

Weekday Mean Speed Dir = -1 (7AM 2012)

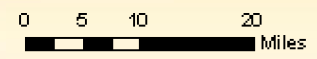


Mean Speed (MPH)

- 0 - 5
- 6 - 15
- 16 - 35
- 36 - 45
- 46 - 55
- 56 - 75

COUNTY

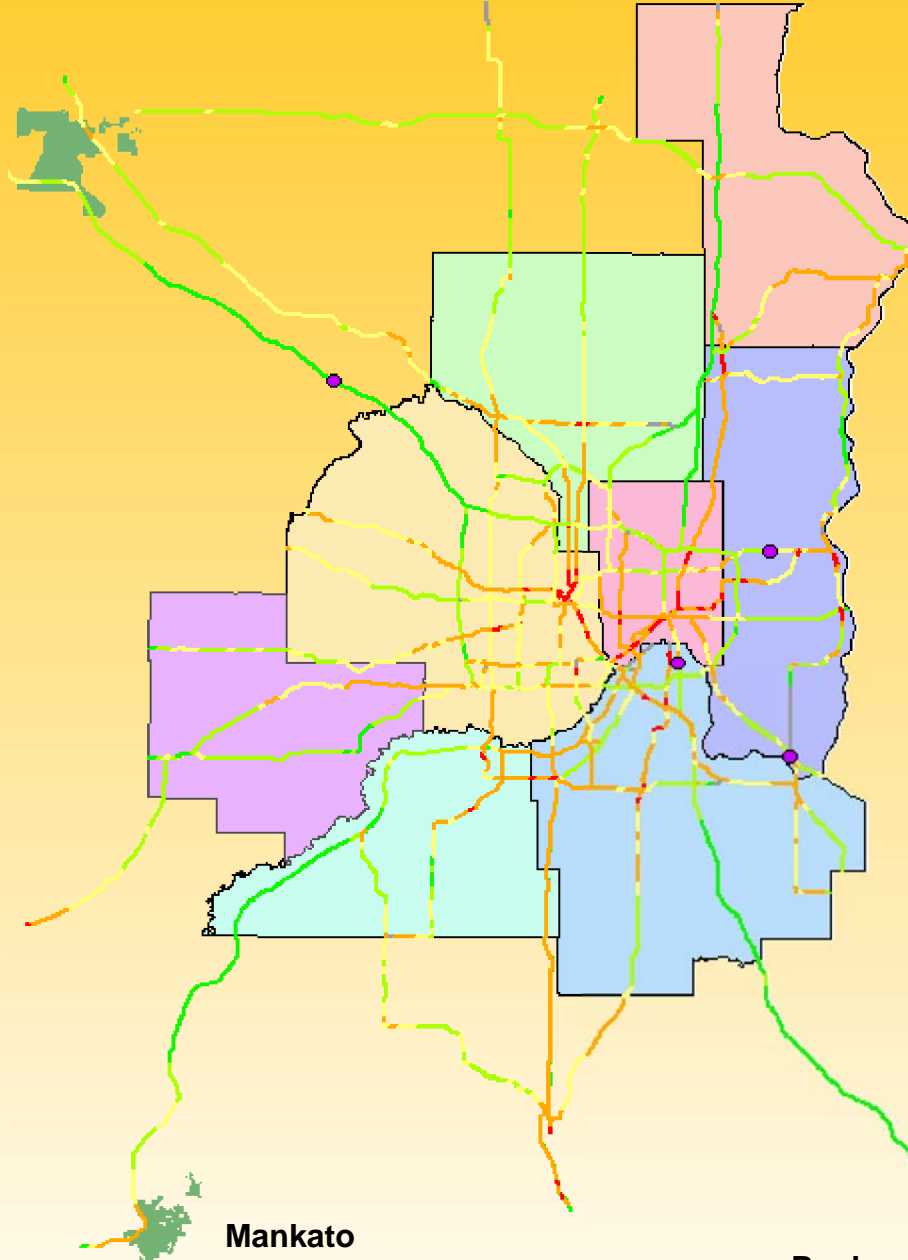
- Anoka
- Carver
- Chisago
- Dakota
- Hennepin
- Ramsey
- Scott
- Washington



Mankato

Rochester

St. Cloud



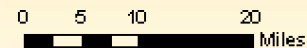
Weekday Mean Speed Dir =1 (7AM 2012)

Mean Speed (MPH)

- 0 - 5
- 6 - 15
- 16 - 35
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Mankato

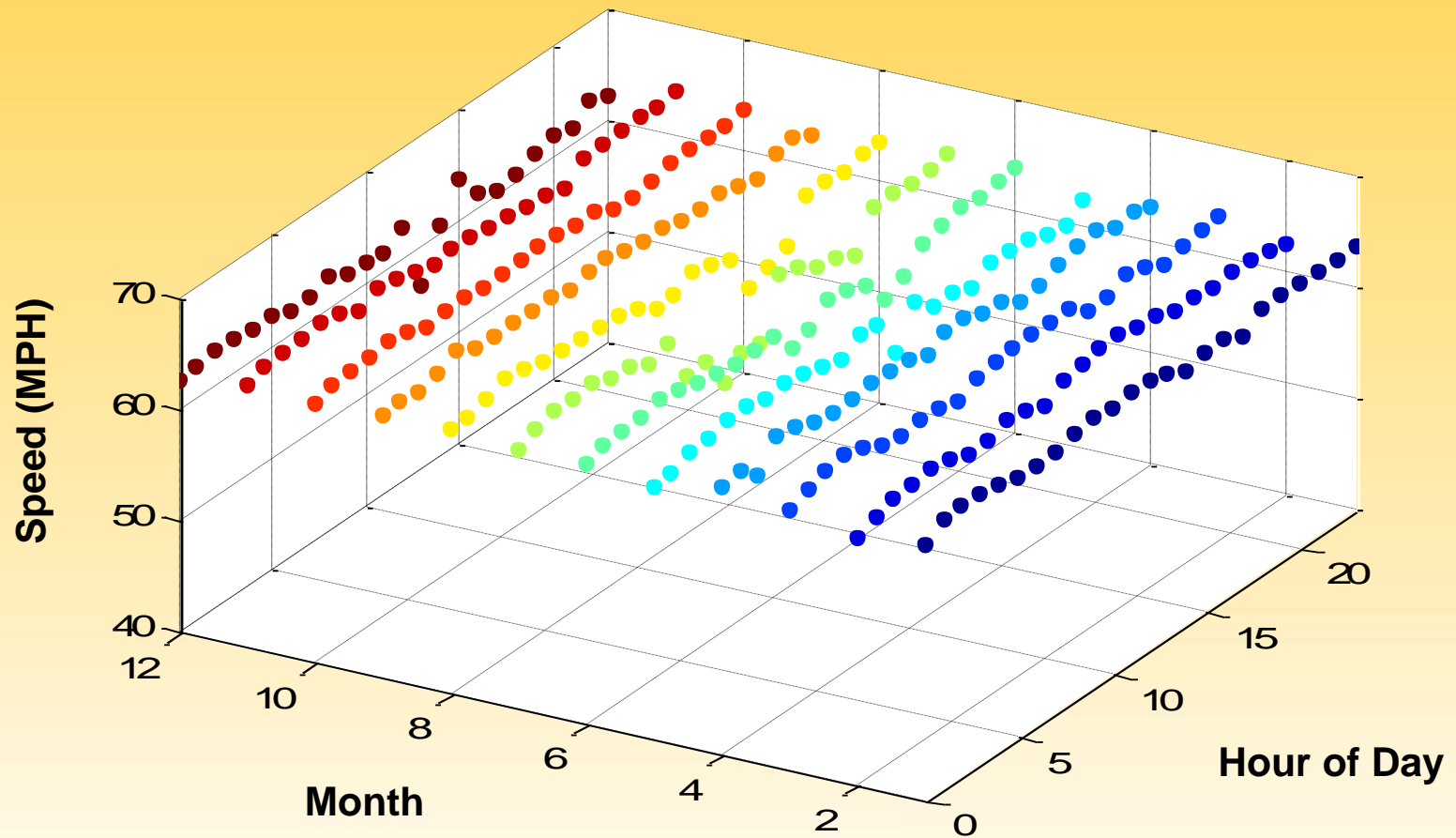
Rochester



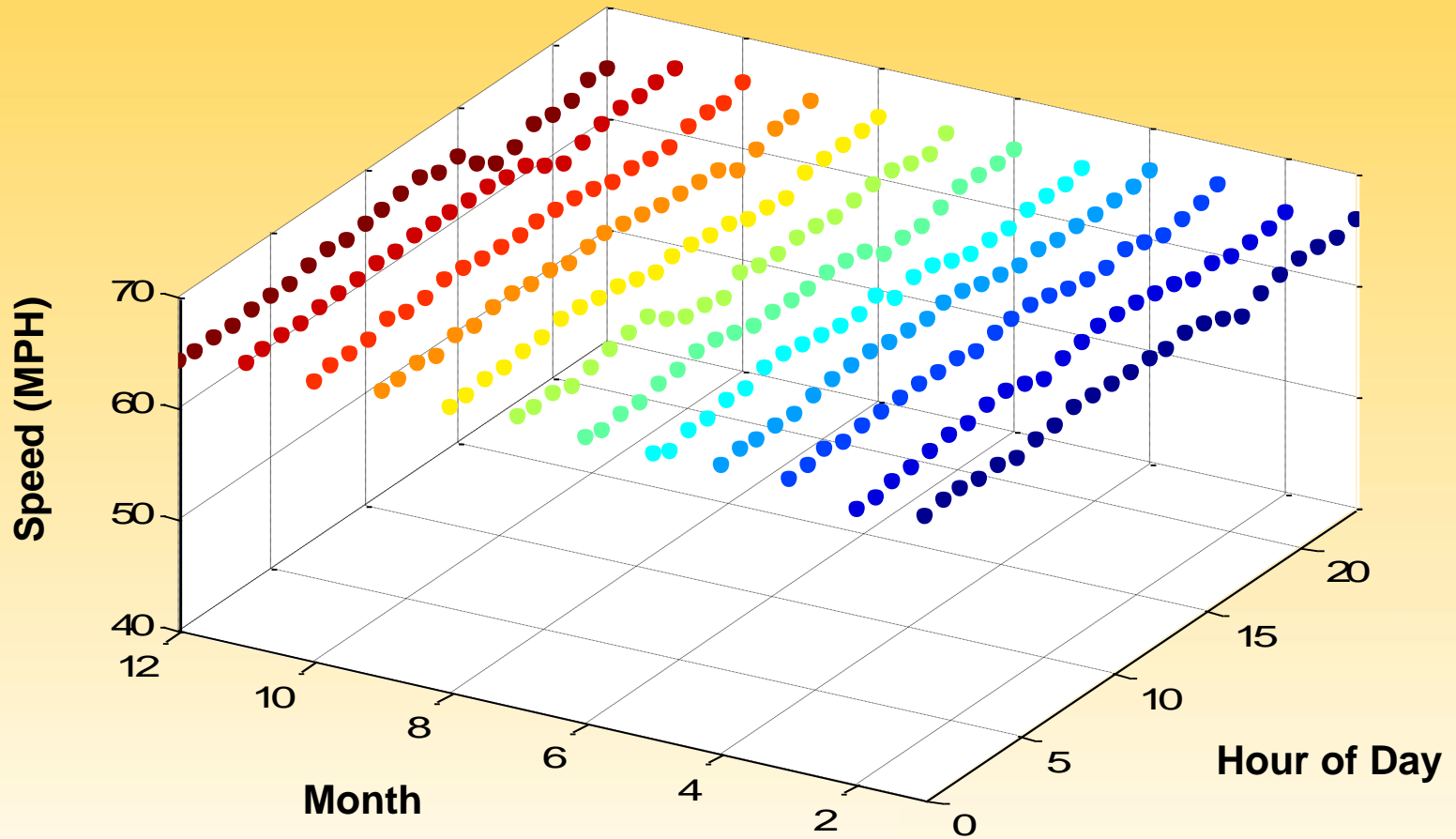
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Probe Vehicle Mean Speed by Month & Hour at I-94 WB Mile Post 200 (WIM37)



Heavy Vehicle Mean Speed by Month & Hour at WIM37 Station





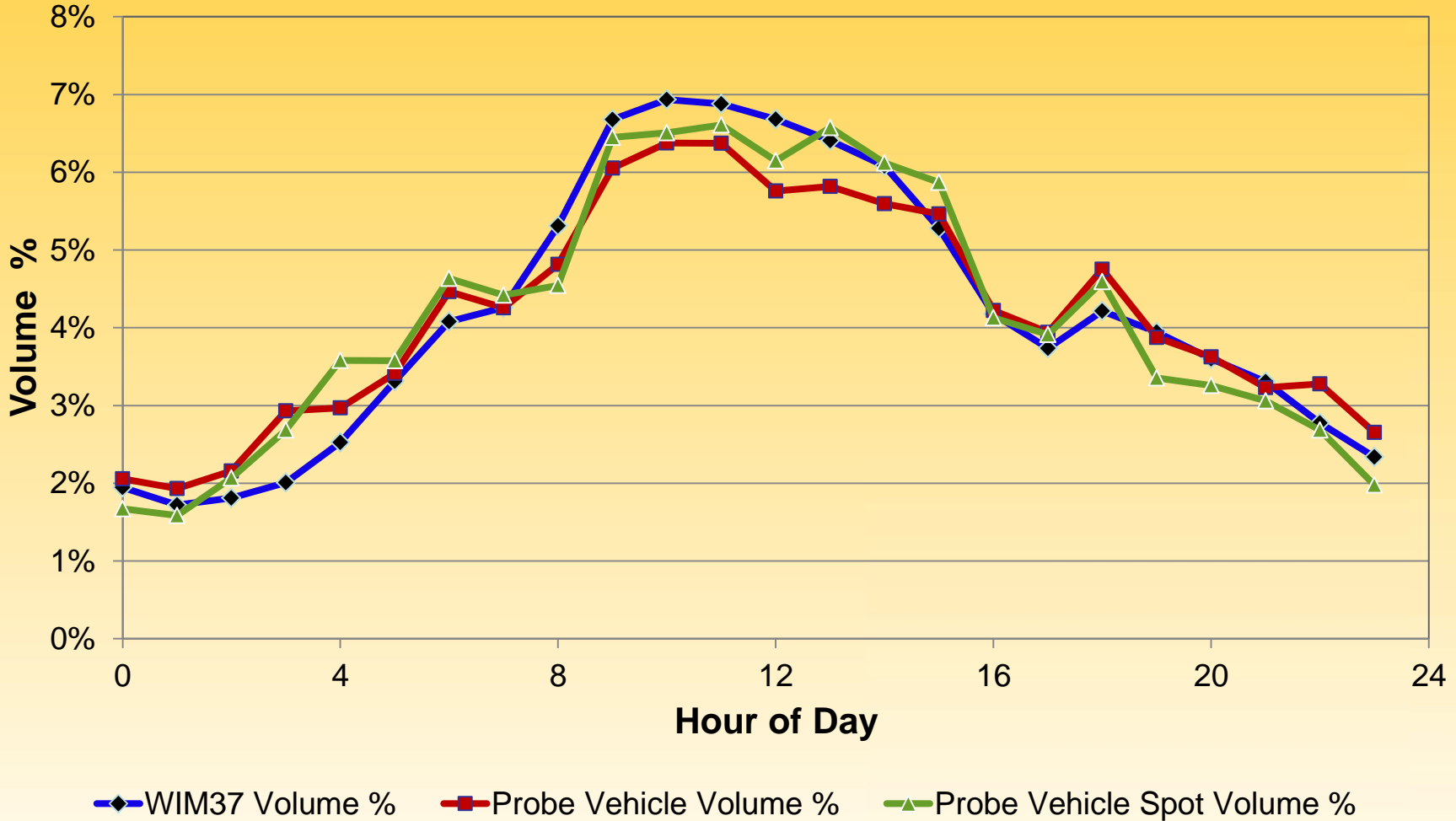
Truck Volume Percentage



Weekday Volume % by Hour

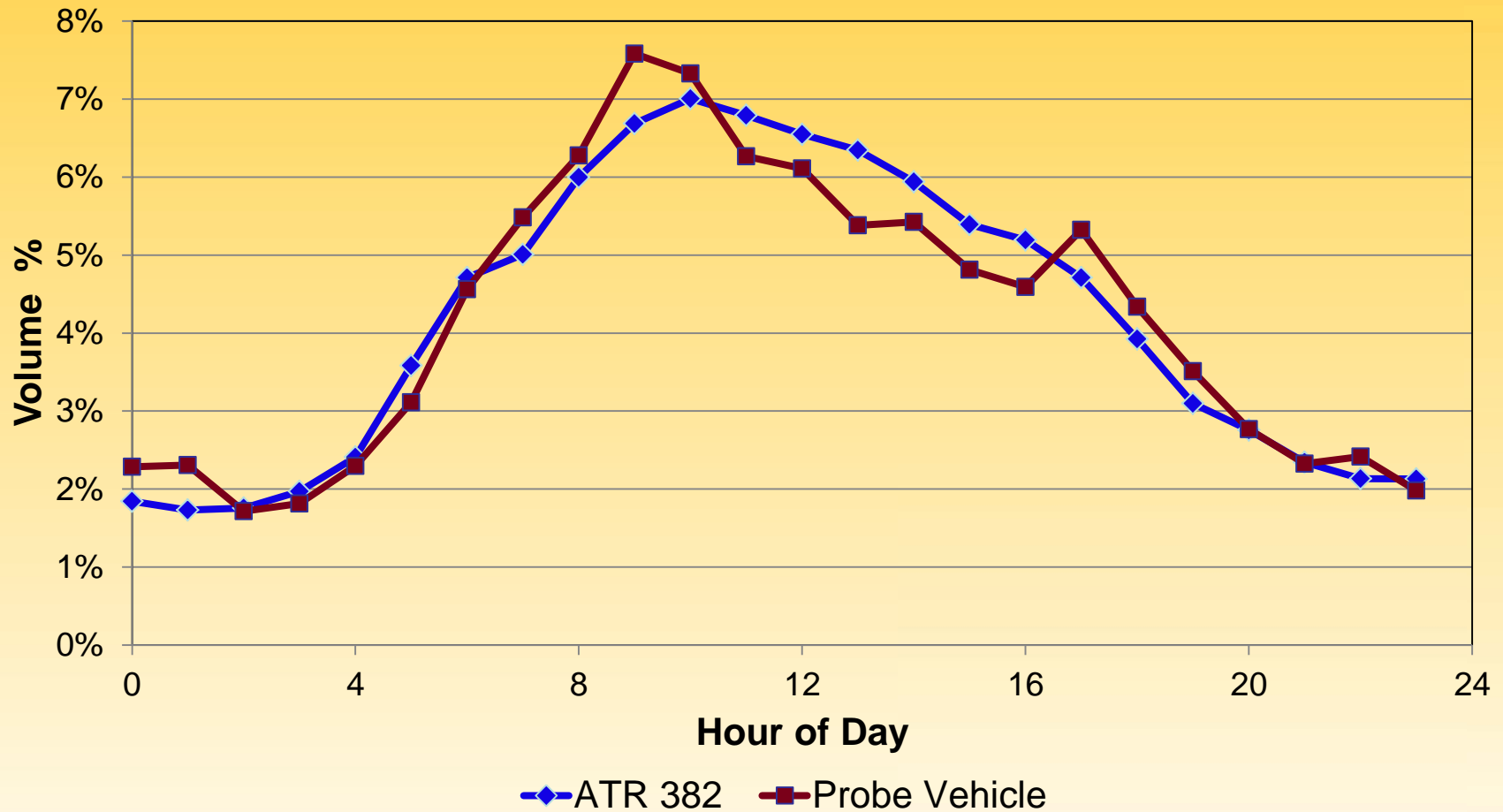
I-94 WB Mile Post 200

($N_{WIM}=900,114$, $N_{Probe}=120,893$)



ATR 382 vs. GPS

Compariosn of Volume Percentage by Hour



ATR 382 - N of 180TH ST E, S of COATES ON US 52



Correlation of GPS vs. ATR Hourly Volume %

ATR Data		Probe Vehicle Data			Correlation Coefficient
ID	HCAADT	Route ID	Segment ID	Count	
188	2,600	29	19	43,199	0.83
191	2,150	33	88	11,961	0.94
200	7,900	24	77	129,595	0.87
335	3,450	34	74	19,741	0.93
341*	5,100	4	18	70,873	0.61
351	1,600	9	15	4,107	0.93
352	1,600	31	55	11,686	0.86
353	1,750	37	49	26,821	0.96
365**	1,700	26	31	4,933	0.51
381	1,350	14	7	22,530	0.99
382	2,700	29	67	42,469	0.97
388	830	25	3	2,576	0.84
400	1,600	9	15	2,841	0.81
422	NA	1	8	433	0.96

* ATR341 - S OF CSAH35 (50TH ST N) IN OAKDALE (I-694)

** ATR365 - S OF CSAH116 (BUNKER LAKE BLVD NE) IN HAM LAKE (State Highway 65)

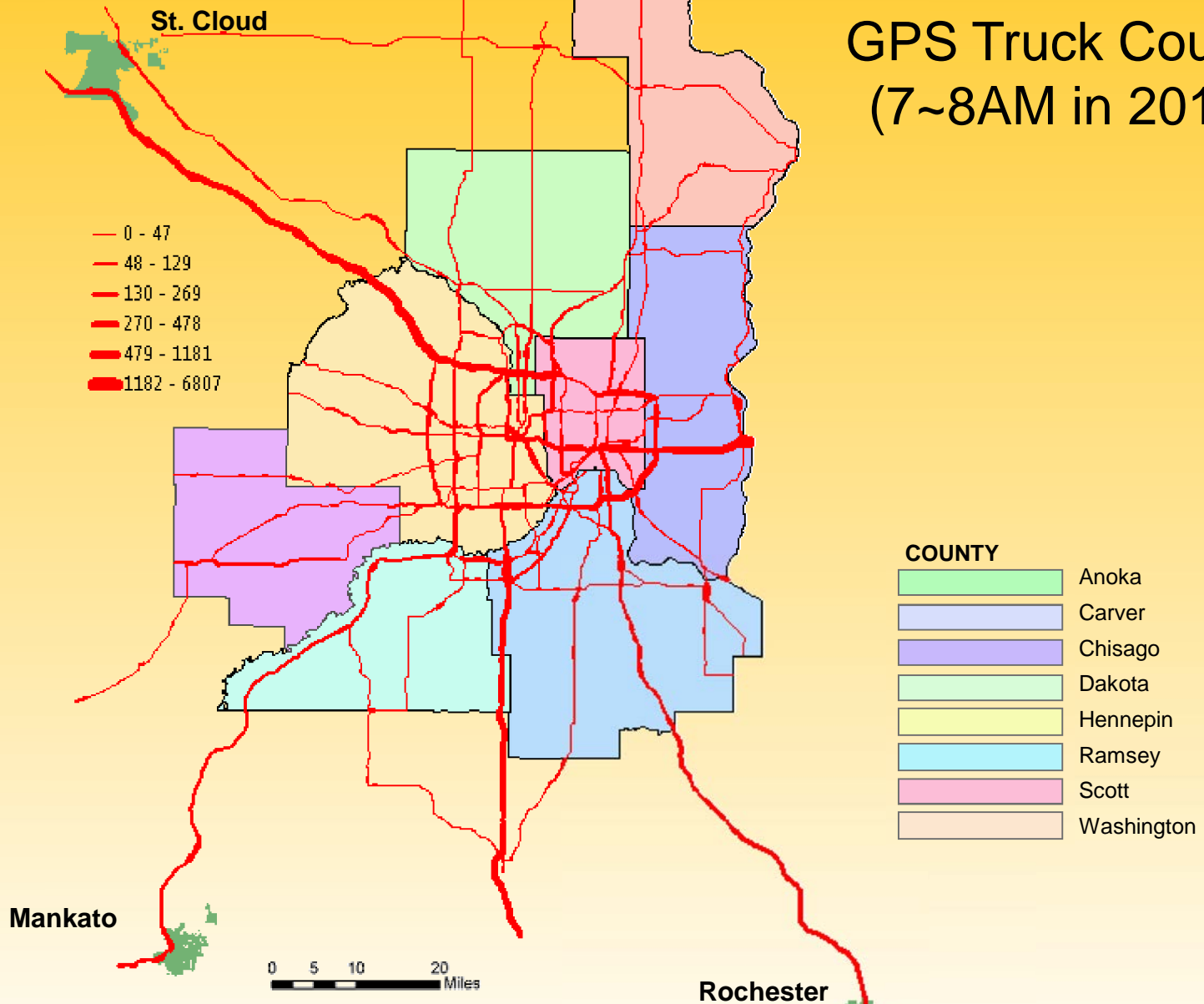


Correlation of GPS vs. WIM Hourly Volume %

WIM Data		Probe Vehicle Data			Correlation Coefficient
ID	HCAADT	Route ID	Segment ID	Count	
36	1,100	5	15	2,023	0.84
37	6,900	24	59	120,839	0.98
40	4,400	29	81	13,386	0.96
41	1,750	27	16	3,764	0.86



GPS Truck Counts (7~8AM in 2012)





Performance Measures



Performance Measures

Truck Mobility

Percent of freight corridor miles in TCMA with average speed < 45 MPH in AM or PM Peak

Truck Daily Delay

$$\sum_{\text{Segment}} \sum_{\text{Hour}} \left(\frac{\text{Segment Length}}{\text{Travel Speed}} - \frac{\text{Segment Length}}{\text{Threshold Speed}} \right) \times HCAADT_{\text{Segment}}$$

Travel Time Reliability Index

$$RI_{80} = \frac{80^{\text{th}} \text{ percentile Travel Time}}{\text{Travel Time at MnDOT Specified Threshold Speed}}$$

Threshold Speed = 45 MPH, Max Throughput Speed

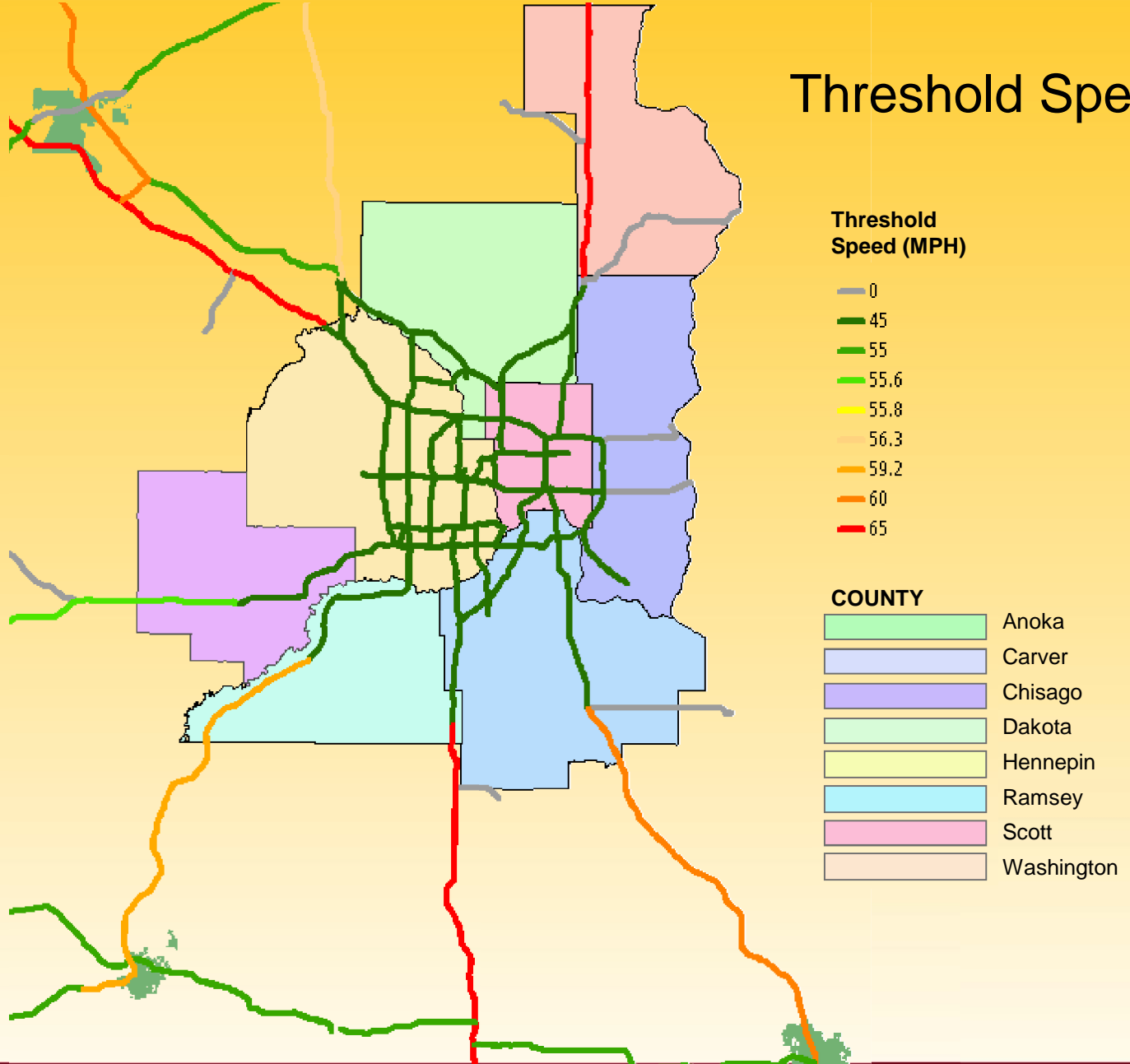


Performance Measures

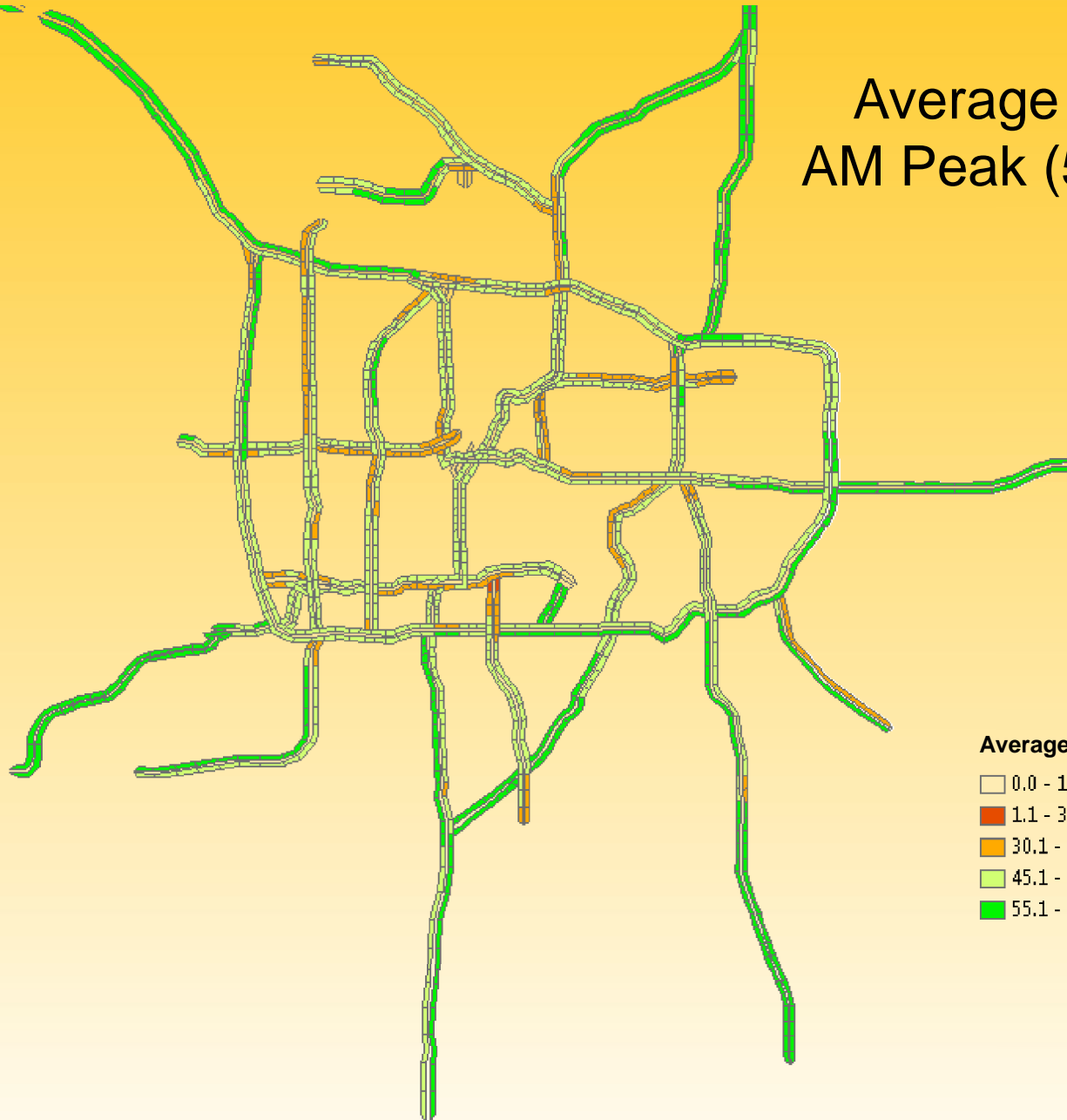
- Annual hours of truck delay in the TCMA
- Truck delay by route & direction
- Average delay in peak & off-peak hours
- Average delay per mile
- Cost of truck delay
 - TTI UMR (2011) **\$88.0** per hour
 - ATRI (2011) **\$68.21** per hour
- Truck reliability index, RI_{80}



Threshold Speed



Average Speed AM Peak (5-10 AM)

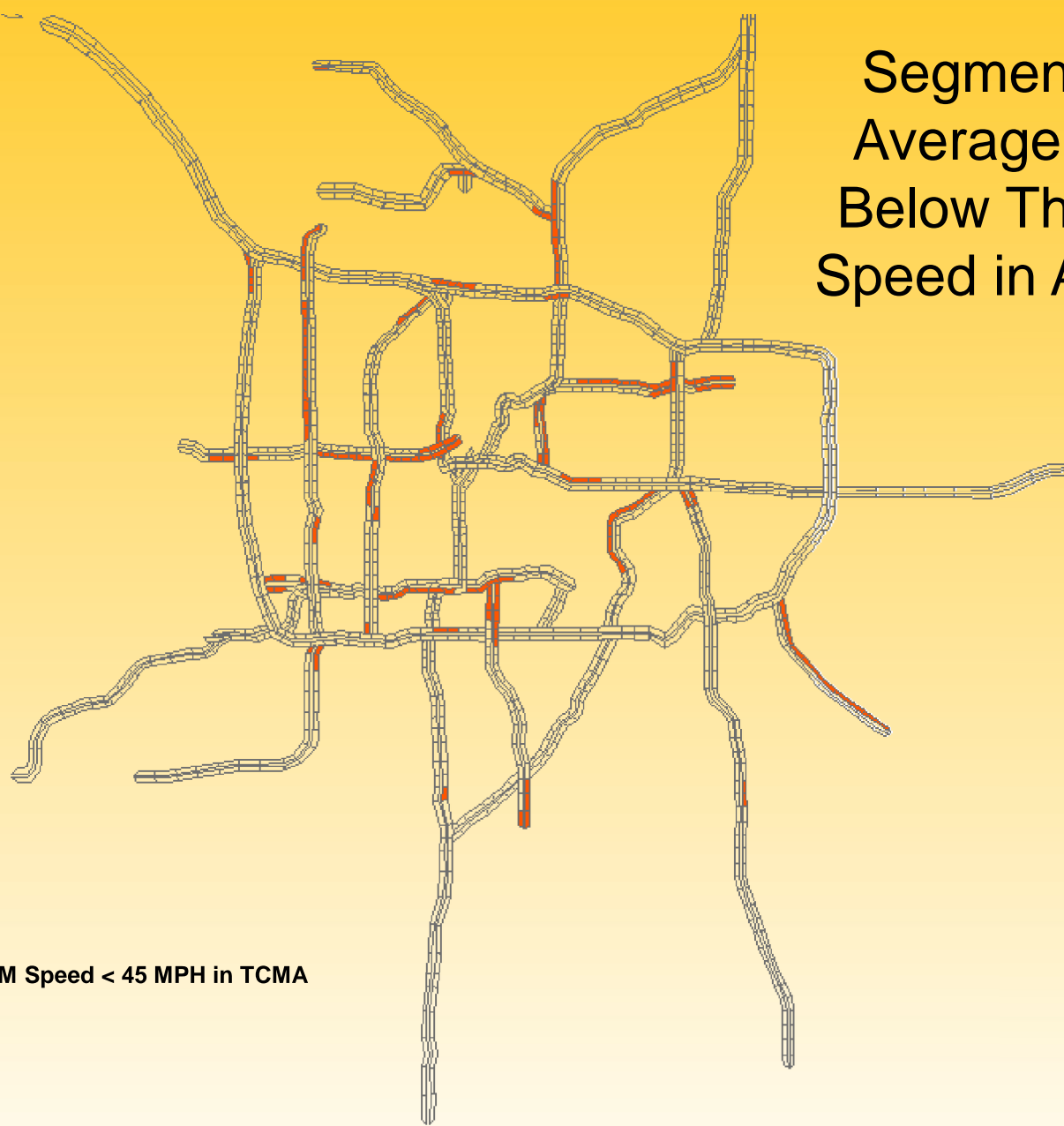


Average Speed

- 0.0 - 1.0
- 1.1 - 30.0
- 30.1 - 45.0
- 45.1 - 55.0
- 55.1 - 65.0



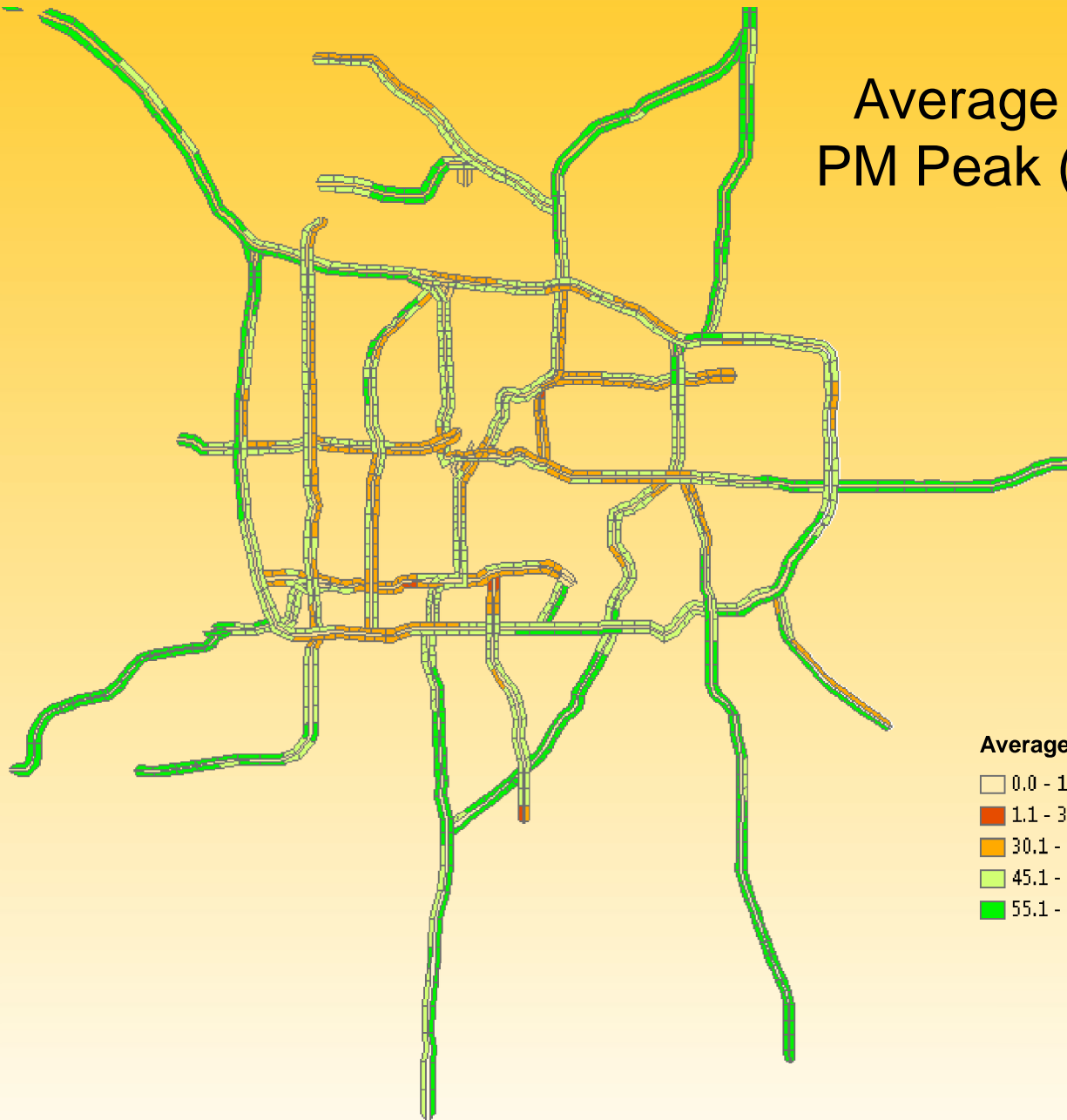
Segments with Average Speed Below Threshold Speed in AM Peak



 Average AM Speed < 45 MPH in TCMA



Average Speed PM Peak (2-7 PM)

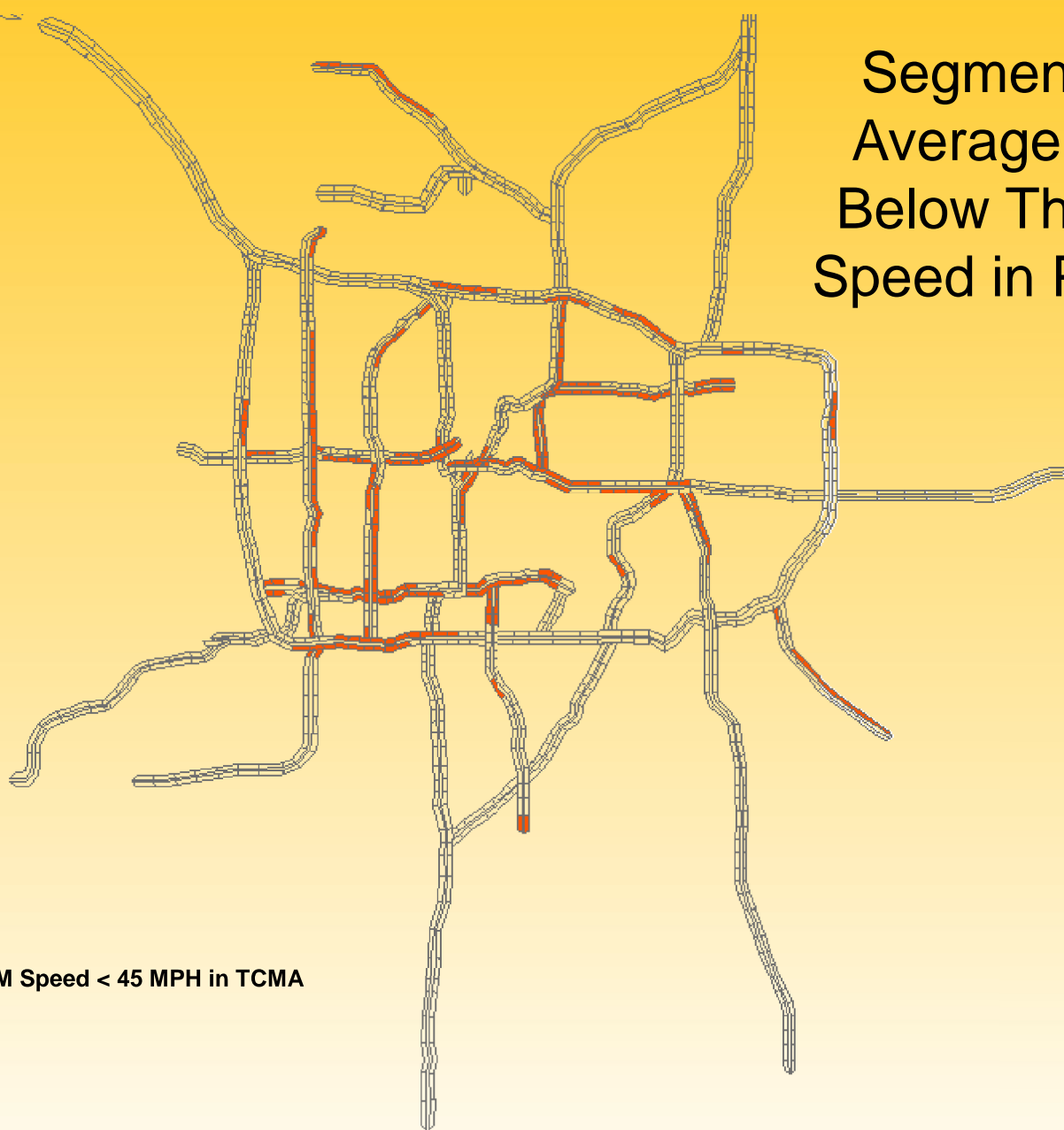


Average Speed

- 0.0 - 1.0
- 1.1 - 30.0
- 30.1 - 45.0
- 45.1 - 55.0
- 55.1 - 65.0



Segments with Average Speed Below Threshold Speed in PM Peak



■ Average PM Speed < 45 MPH in TCMA





Truck Mobility Measure

Time Period (2012 Weekdays TCMA)	AM Peak 5-10 AM	PM Peak 2-7 PM
# of Miles with Average Speed < 45 MPH	96	147
Total Miles of RTMC Stations in TCMA	774	774
Percentage of Miles < 45 MPH	12.4%	19.0%



Truck Delay

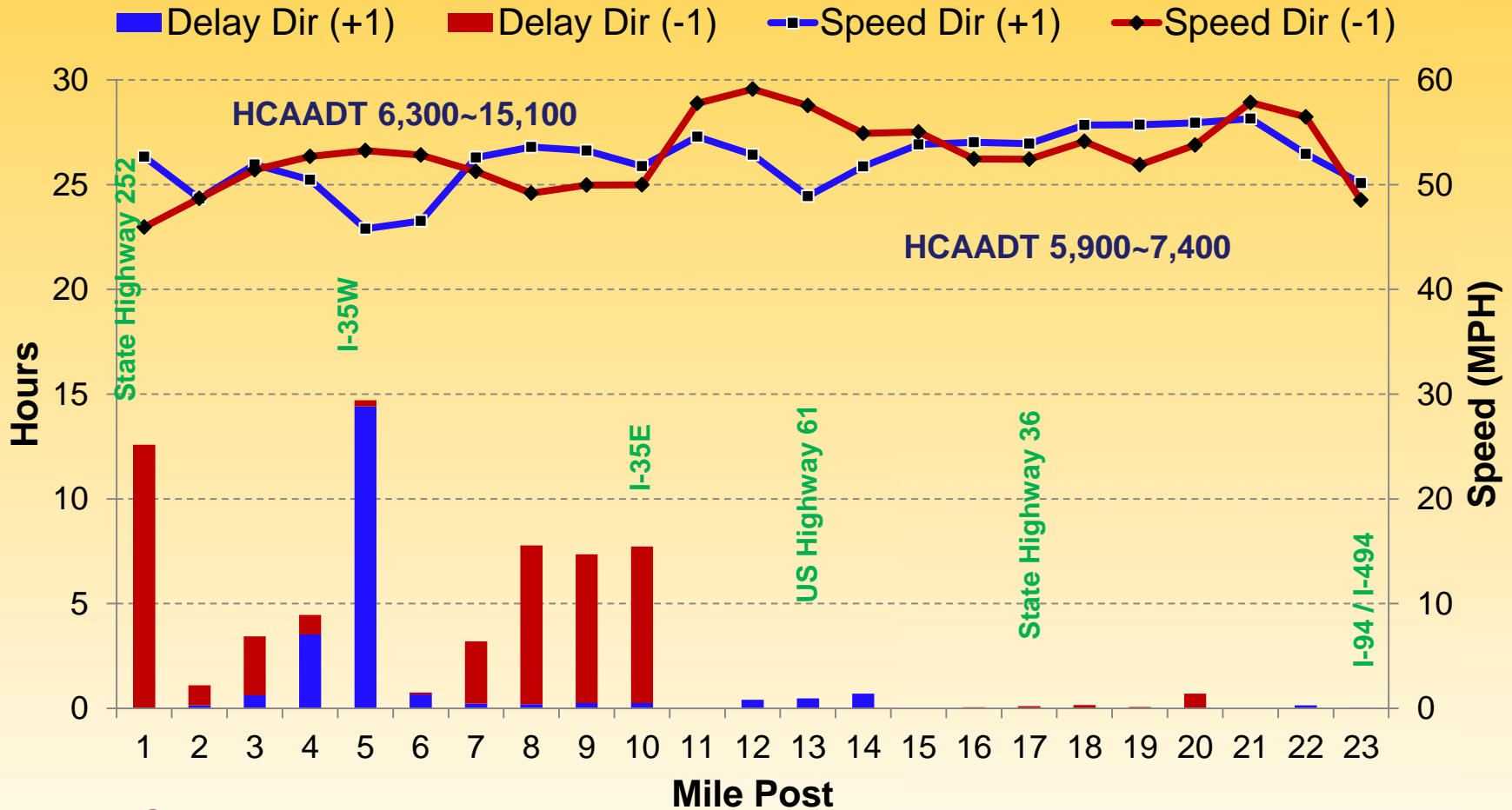
$$\sum_{Segment} \sum_{Hour} \left(\frac{Segment\ Length}{Travel\ Speed} - \frac{Segment\ Length}{Threshold\ Speed} \right) \times HCAADT_{Segment}$$

Threshold Speed = 45 MPH, Max Throughput Speed



I-694

Average Daily Delay and Speed



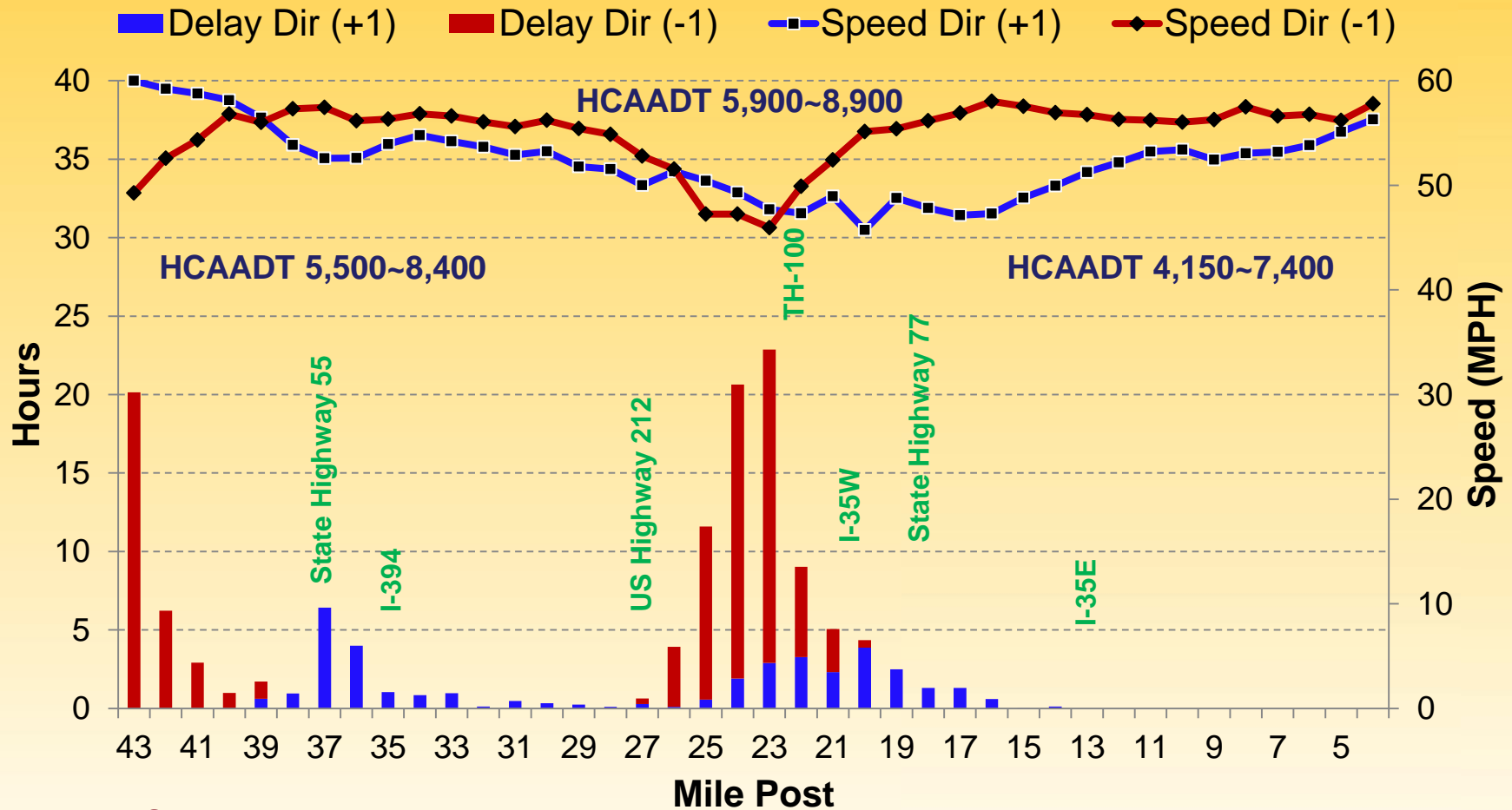
Threshold Speed 45 MPH

Total Truck Delay = 22 (+1) + 44 (-1) = 66 Hours / Day



I-494

Average Daily Delay and Speed

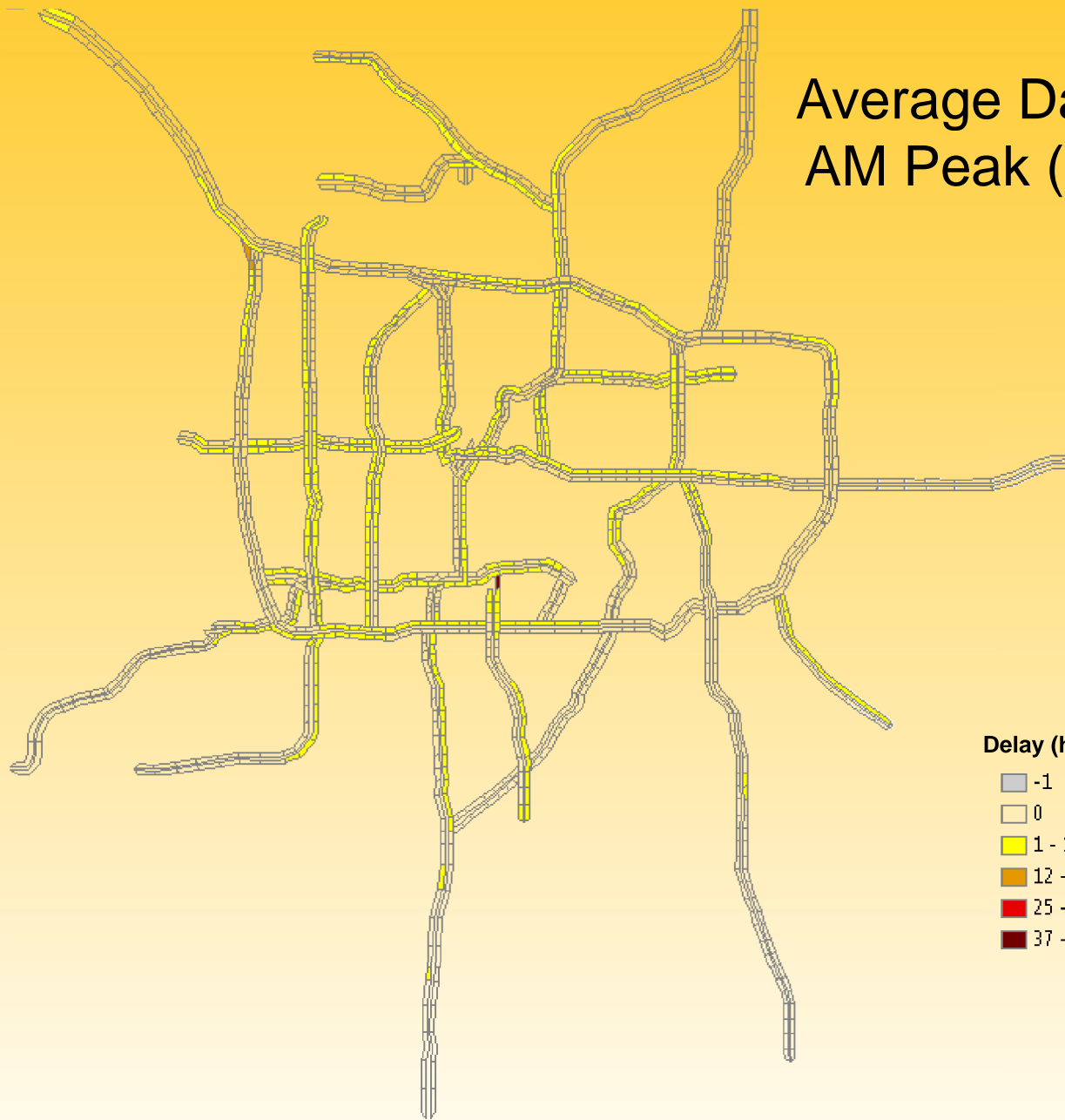


Threshold Speed 45 MPH

Total Truck Delay = 37 (+1) + 95 (-1) = 132 Hours / Day



Average Daily Delay AM Peak (5-10 AM)



Delay (hour)

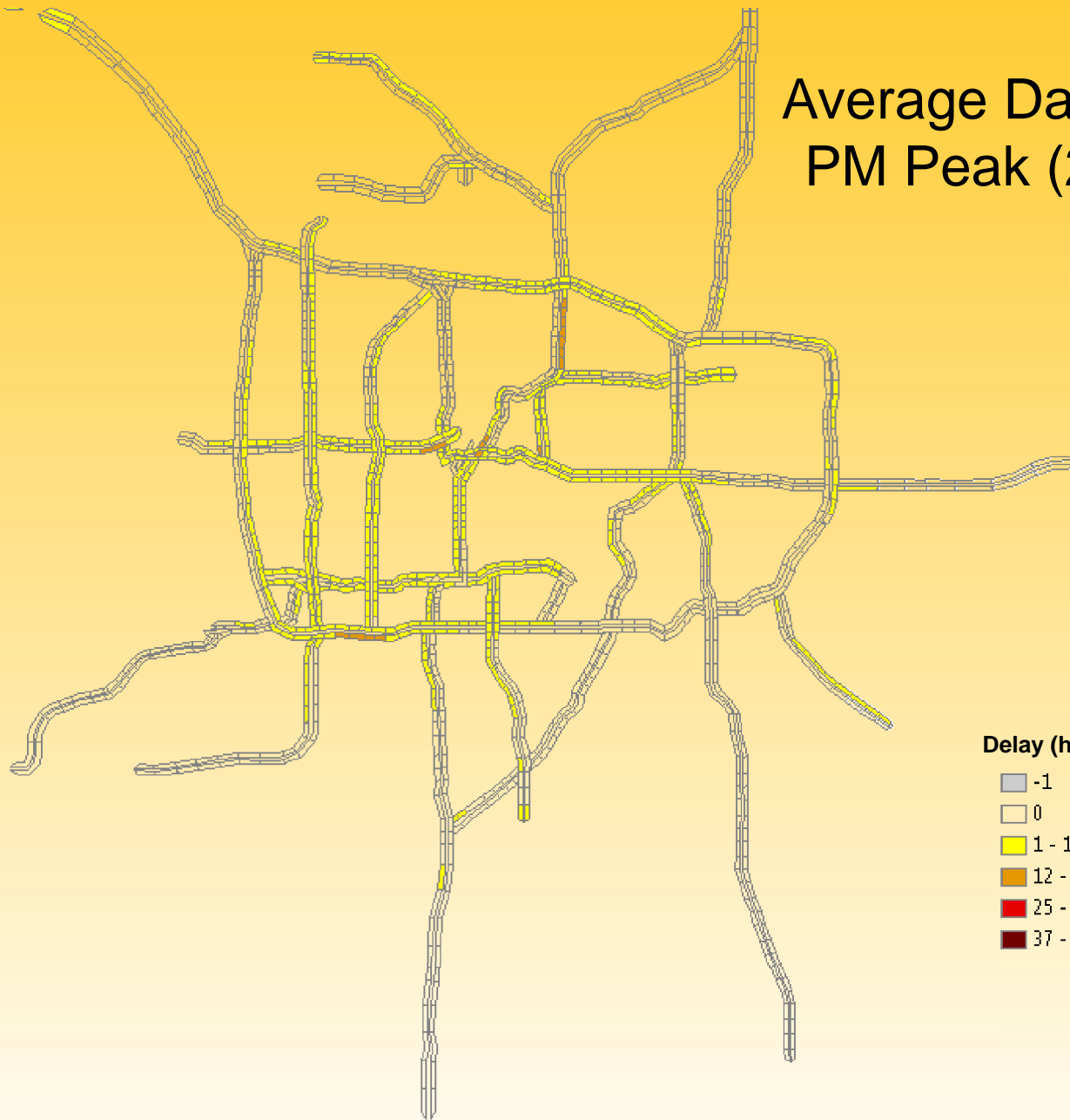
- 1
- 0
- 1 - 11
- 12 - 24
- 25 - 36
- 37 - 57



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Average Daily Delay PM Peak (2-7 PM)



Delay (hour)

- 1
- 0
- 1 - 11
- 12 - 24
- 25 - 36
- 37 - 57



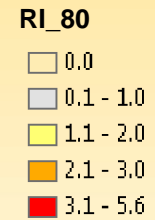
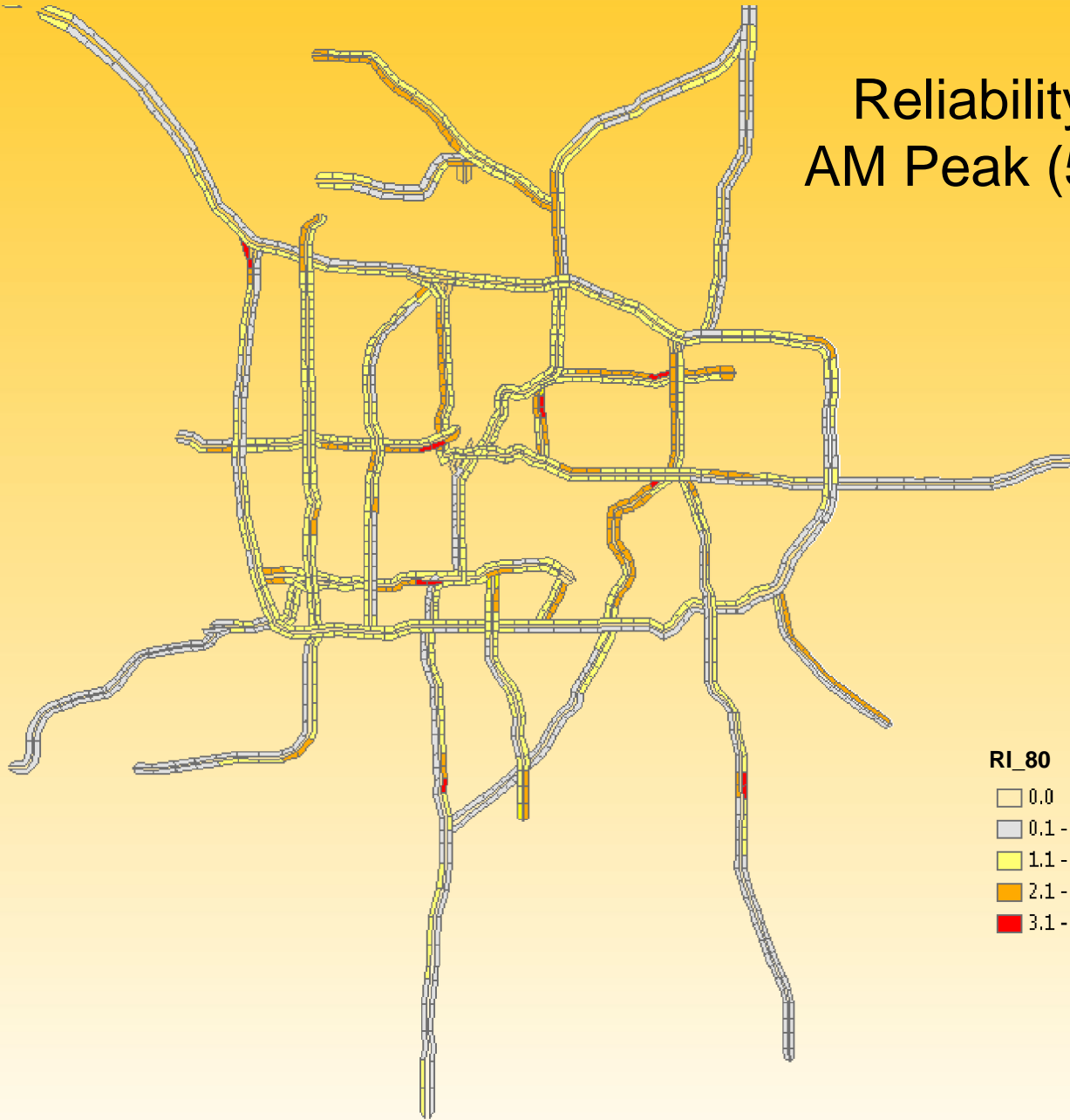
Travel Time Reliability

$$RI_{80} = \frac{80^{th} \text{ percentile Travel Time}}{\text{Travel Time at MnDOT Specified Threshold Speed}}$$

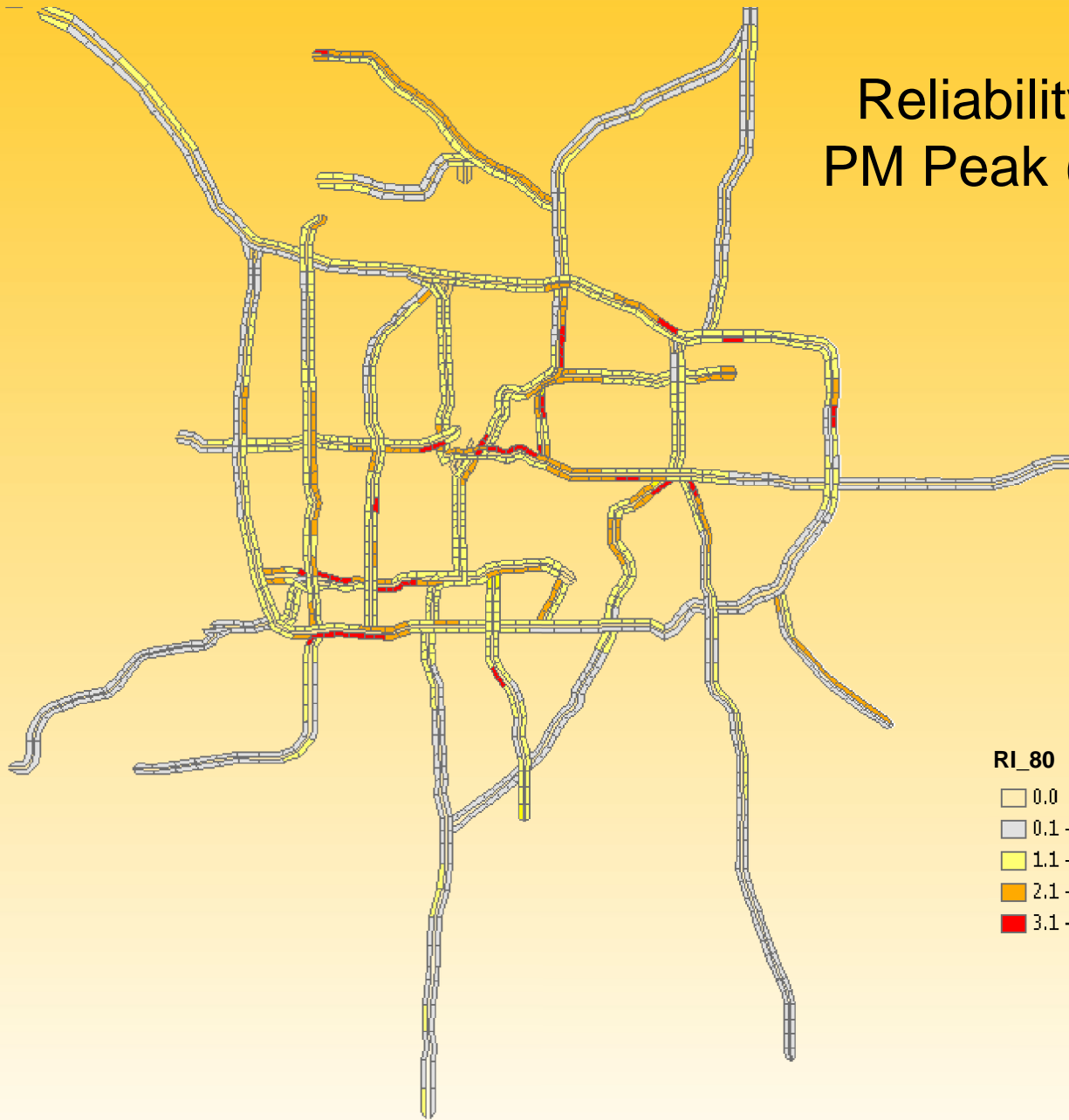
Threshold Speed = 45 MPH, Max Throughput Speed



Reliability Index AM Peak (5-10 AM)



Reliability Index PM Peak (2-7 PM)



RI_80

- 0.0
- 0.1 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 5.6





Truck Stop and Parking



Truck Stops / Parking

Near Roadway

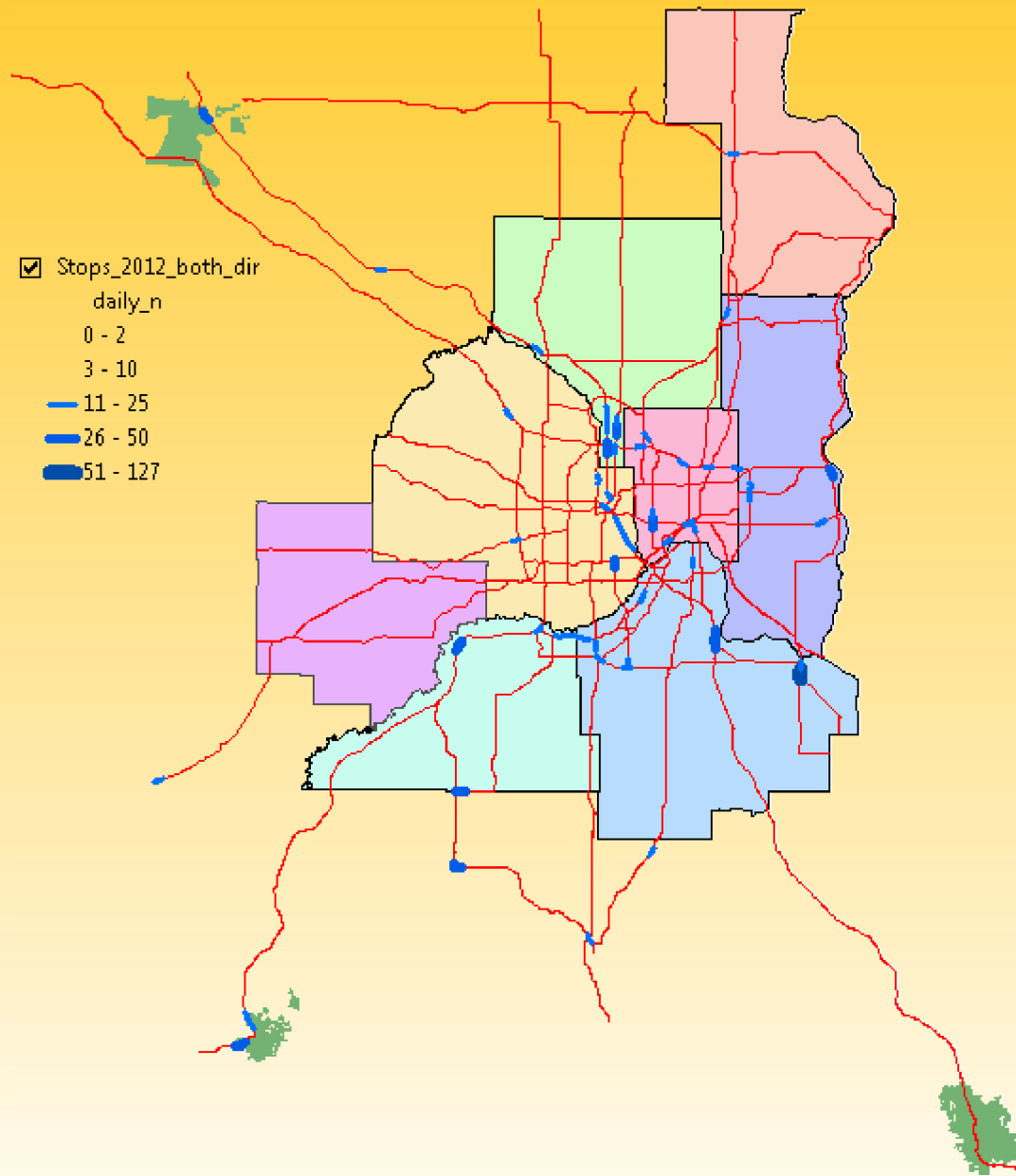
- Spot/Space Speed < 5 MPH
- Stop Duration > 0.5 hour
- Travel Distance < 0.1 mile

Near Rest Area

- Spot Speed = 0 MPH
- Stop Duration > 0.5 hour



- Stops_2012_both_dir
daily_n
- 0 - 2
 - 3 - 10
 - 11 - 25
 - 26 - 50
 - 51 - 127

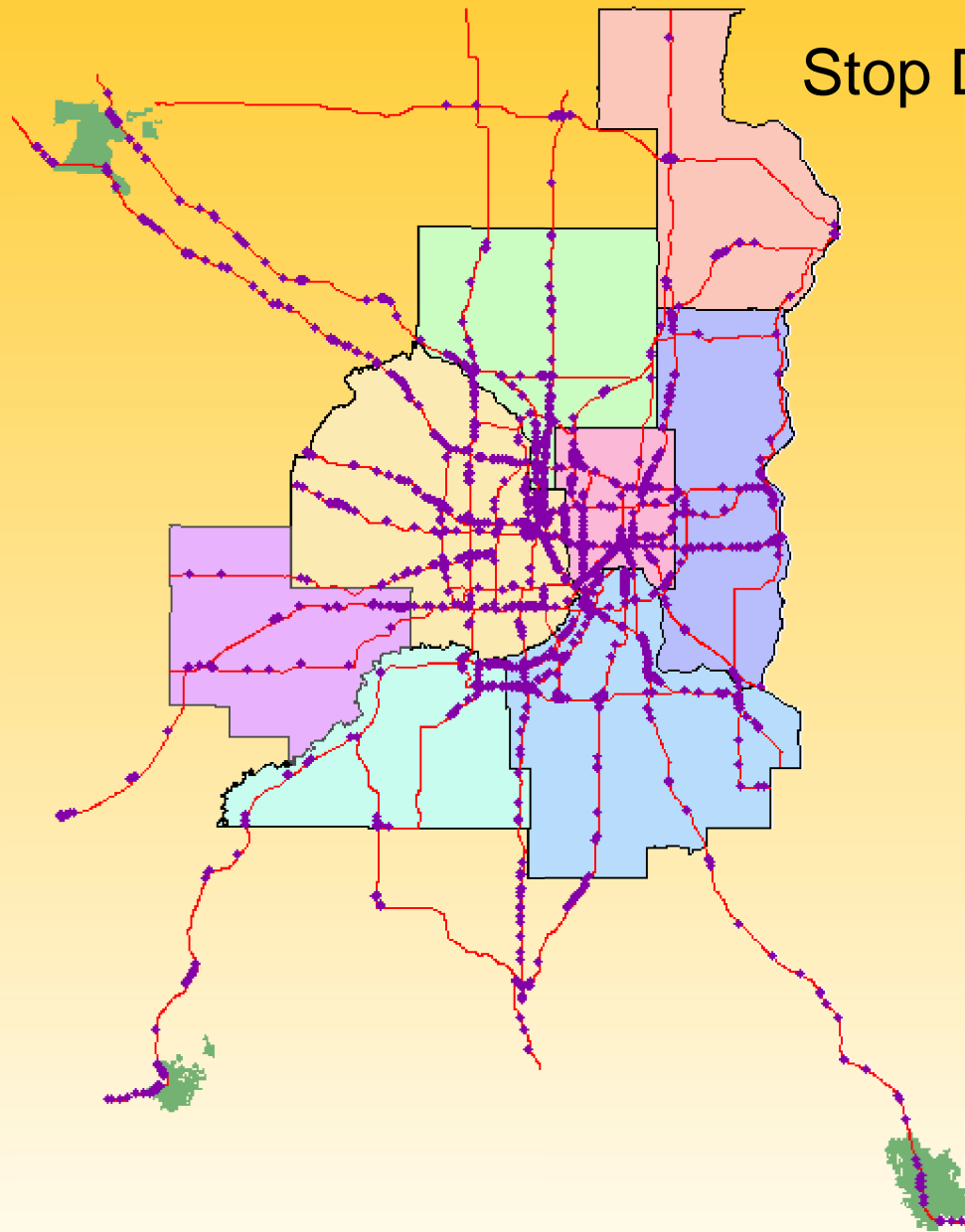


- COUNTY**
- Anoka
 - Carver
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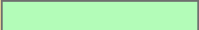


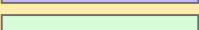
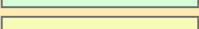
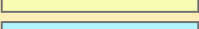
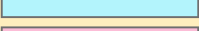

0 5 10 20
Miles



Stop Duration > 0.5 hr



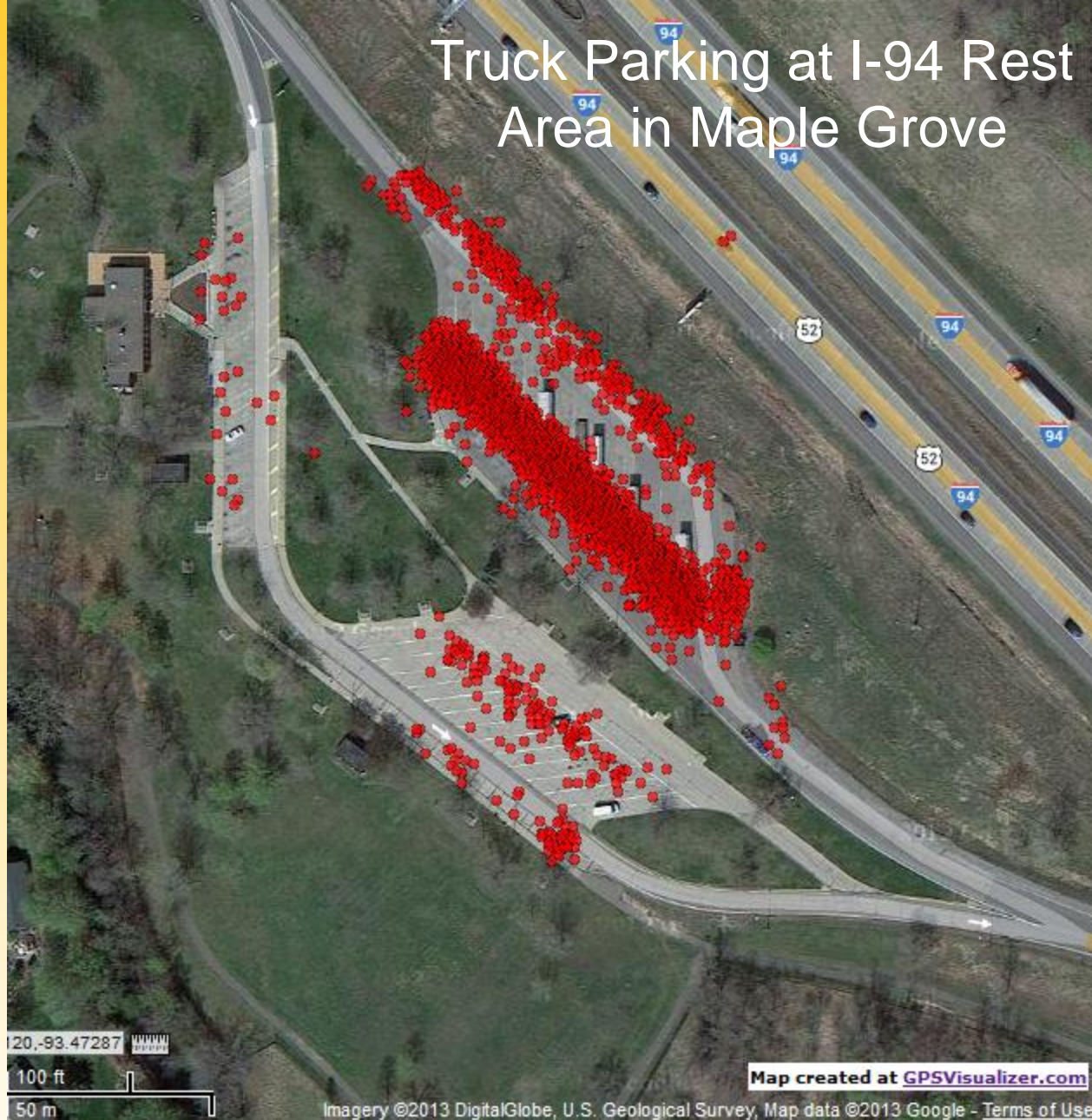
COUNTY

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	Hennepin
	Ramsey
	Scott
	Washington

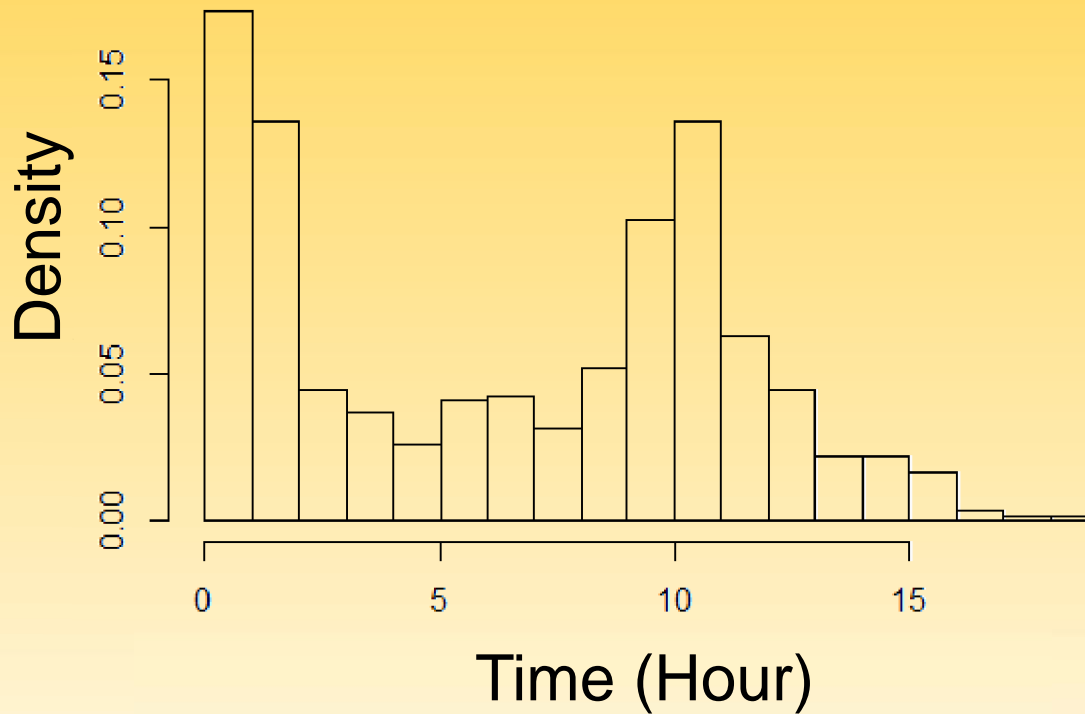
0 5 10 20 Miles



Truck Parking at I-94 Rest Area in Maple Grove

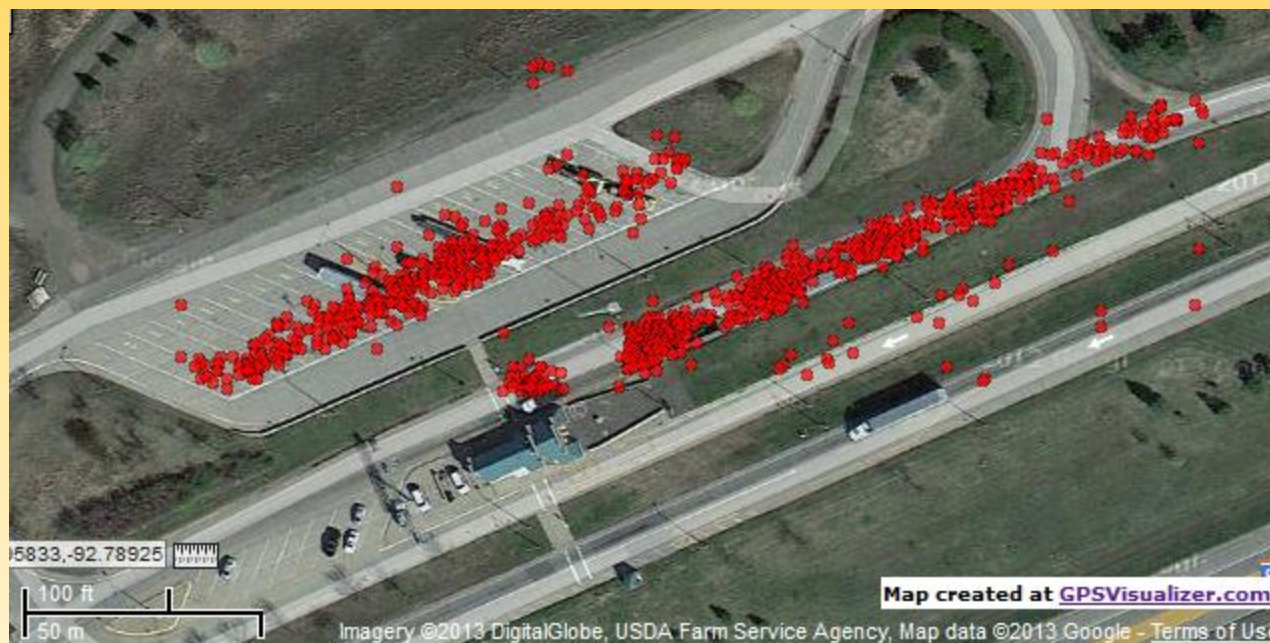


Histogram of Parking Duration at the Rest Area on I-94 in Maple Grove

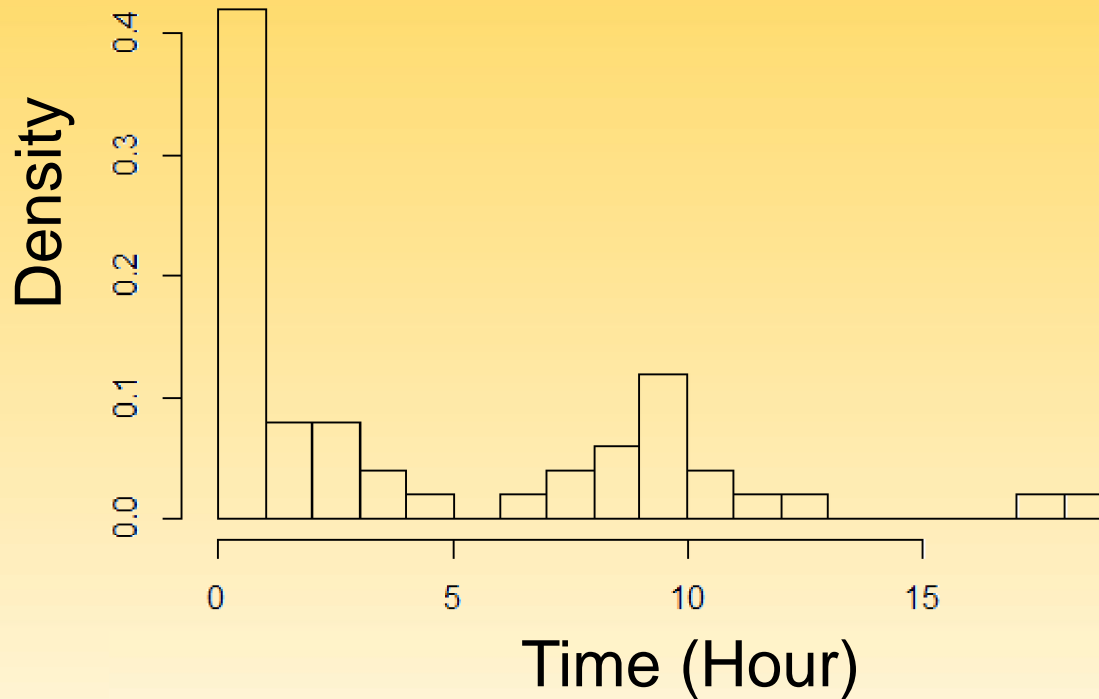


DS-A&C

Truck Parking at I-94 Rest Area in West Lakeland



Histogram of Parking Duration at the Rest Area on I-94 in West Lakeland



DS-A&C

Ongoing Effort & Next Step

- **Truck parking or rest facilities in TCMA**
- Loop detector data (#1222, 1171, 1172, 1157, 1158, 1598)
- ATR Volume/Class/Speed data on stations: 188, 191, 200, 335, 341, 351, 352, 353, 365, 381, 382, 388, 400 & 422
- Identify freight node & bottleneck
- Final report





THANK YOU !

QUESTIONS ?

