Transportation Systems Management and Operations Performance Report

5TH EDITION

APRIL 2021

TSMO

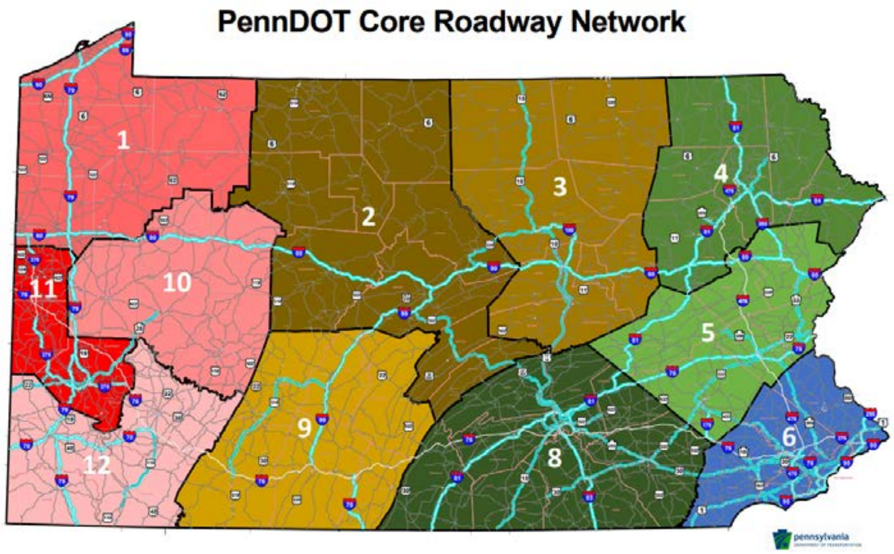




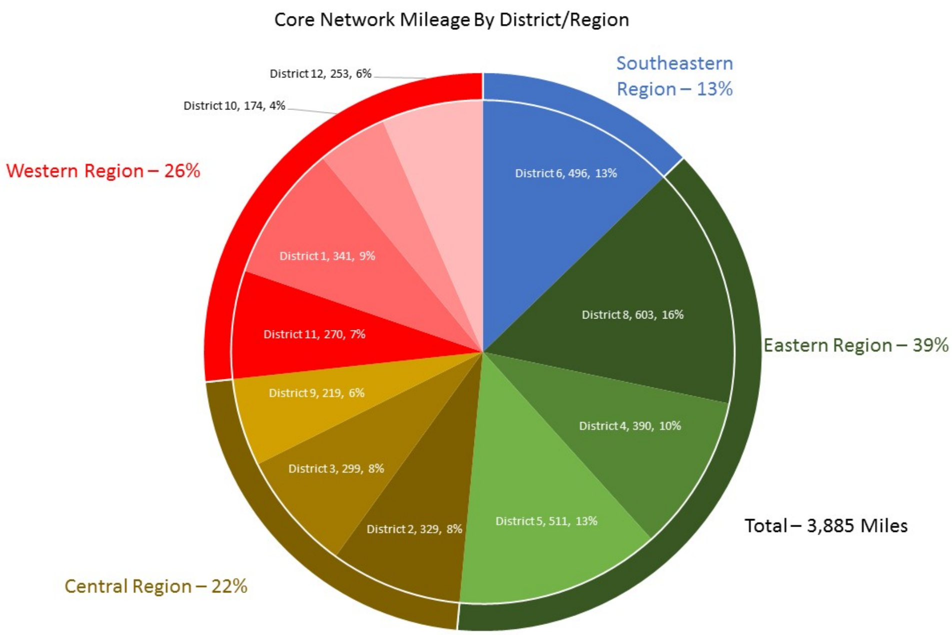
pennsylvania
DEPARTMENT OF TRANSPORTATION

Executive Summary

The TSMO Performance Report exists to provide information to traffic management personnel within PennDOT and partner agencies who impact roadway operations and incident management. This information is gathered to inform responsible parties and assist in making decisions to improve the safety and reliability of the PennDOT Core Roadway Network[1].



The PennDOT Core Roadway Network mileage broken down by District/Region:



[1] Pennsylvania's "Core Roadway Network" was established in 2011 for 511PA, and includes state owned interstates, limited access roads, and other major routes throughout the Commonwealth.

The 5th Edition of the TSMO Performance Report has new information to be considered. The first is the impact of the COVID-19 pandemic on traffic volumes and congestion, as well as exploring Traffic Management Center (TMC) operations in a remote capacity during the pandemic.

The second new focus explores a relationship between hazardous winter conditions and certain crash rates characteristics. Highlights include weather's impact on the duration of road closures during winter conditions and the likelihood of a hazardous weather road closure involving a commercial vehicle.

This edition provides a data update to many measures that have become core to PennDOT's TSMO business; Crashes in existing congestion; Expanded Pennsylvania congestion pie charts and reliability capabilities; TMC situational awareness changes from 2017 to 2019; Incident Clearance Times through 2019.

Below are hyperlinks to respective tables of interest:

New Analysis

COVID-19 Impact on Traffic and TMC Operations

Table 1. RCRS Verified Heavy Congestion Waze Crashes – March 16 to December 31 – 2019 v 2020

- RCRS verification of heavy congestion Waze reported crashes improved by 7.73% during TMC remote operations in 2020 when compared to the same period in 2019.

Impact of Hazardous Weather Conditions on Crash Rates

Table 2. Hazardous Winter Conditions and Impact on Crash Likelihood

Table 3. Core Network Road Closures in Hazardous Winter Conditions - 2017-2019 (Nov to April)

- Commercial Vehicles were involved in at least 55.6% of all incidents that caused full closures during hazardous winter conditions in 2017-2019. CMV involved closures lasted 3 hours longer on average than those with no CMV involved

2019 Update for Reported Measures

Pennsylvania's Congestion Pie Chart - 2019

Congestion Related Crashes on the Core Network – 2019

Table 4. Reportable Crashes by Congestion Type on the Core Roadway Network - 2019

- 6,804 reportable crashes occurred in existing congestion on the core network in 2019. 23% of these crashes were in congestion with no known cause.

Table 5. Injuries Caused by Congestion Related Crashes on the Core Roadway Network - 2019

- Congestion related crashes on the core network caused 23 fatalities and 4,313 injuries (110 of which were serious) in 2019

Secondary Crashes

Table 6. Secondary Crashes by District and Region

- There were 14% more secondary crashes on the core network in 2019 compared to 2017. Primary crashes were verified in RCRS prior to the secondary crash 7% more often than in 2017.

Table 7. Timing of Secondary Crashes Relative to Primary Crash

- Nearly 82% of secondary crashes occurred after more than 15 minutes, and nearly 47% occurred one hour or more after the primary crash in 2019

- Almost 72% of secondary crashes occurred outside of the immediate area of the primary crash (further than .5 miles away) in 2019

Work Zone Congestion-Related Crashes

- Work zone congestion-related crashes decreased by 22% from 2017 to 2019. Work zones related to these crashes were verified in RCRS 4% more often in 2019 compared to 2017.

- 49.8% of work zone congestion related crashes occurred within .5 miles of the work zone in 2019, down from 65% in 2017.

TMC Situational Awareness

- The total number of RCRS verified crashes (reportable and non-reportable) grew by 13.91% from 2017 to 2019

- RCRS verification rates for reportable crashes increased 1% statewide from 2018 to 2019, and are up 3.39% from 2017

- RCRS verification rates for heavy congestion reportable crashes decreased by 2.81% from 2018 to 2019, and are now down 1.55% from 2017.

- The rate of RCRS verification for heavy congestion crashes that occurred more than 2 miles from a camera was virtual unchanged from 2018 to 2019.

Average Incident Clearance Times – 2017 through 2019

New Analysis

COVID-19 Impact on Traffic and TMC Operations

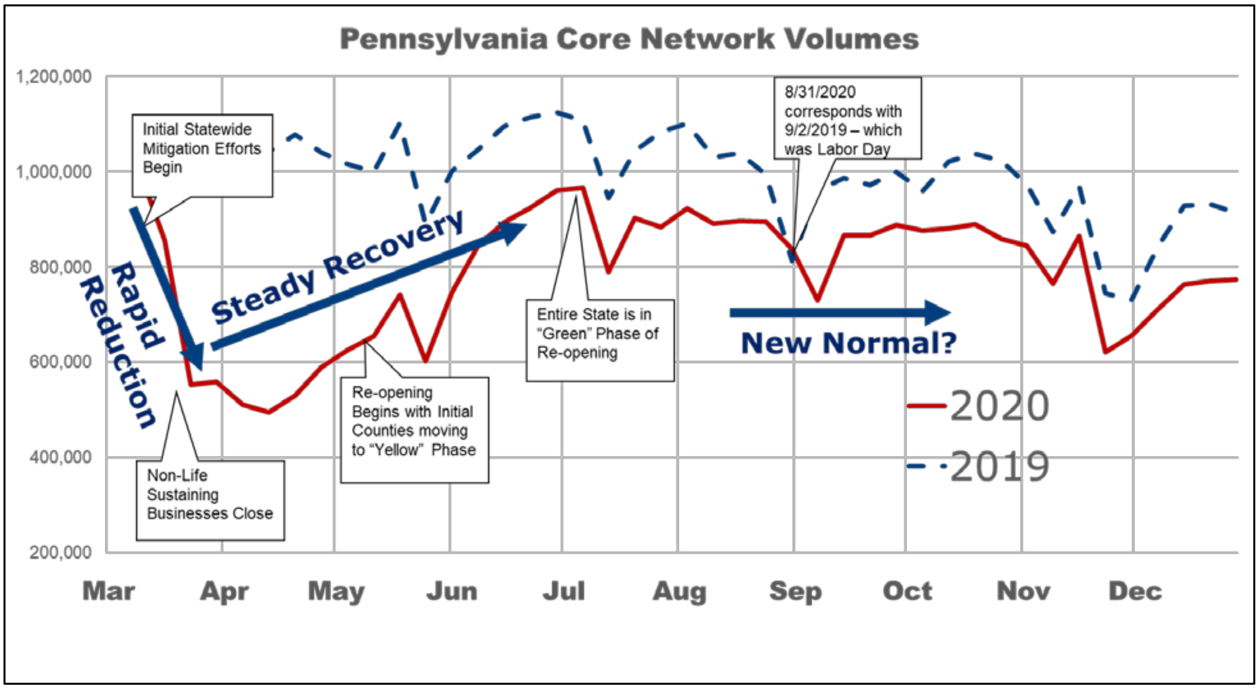
The emergence of the COVID-19 pandemic in late winter/early spring of 2020 had a significant impact on both traffic and traffic operations. When statewide mitigation efforts began in mid-March, there was an immediate and dramatic drop in traffic volumes. Additionally, in response to the pandemic, PennDOT's TMCs transitioned from in-person to remote operations in a matter of days. This section presents data related to the impact of the pandemic on traffic volumes and congestion, as well as looking at how effective TMCs have been in remote operations when compared to previous in-person operations.

COVID-19 Impact on Core Network Traffic Volumes

On March 16th, 2020, the first series of statewide COVID-19 mitigation efforts were announced, to begin the following day. Restaurants were limited to takeout and delivery, and non-essential businesses were recommended to close. These orders were followed by a statewide order to close all non-life sustaining businesses on March 23rd, and then eventually by a statewide state at home order that went into effect on April 1st.

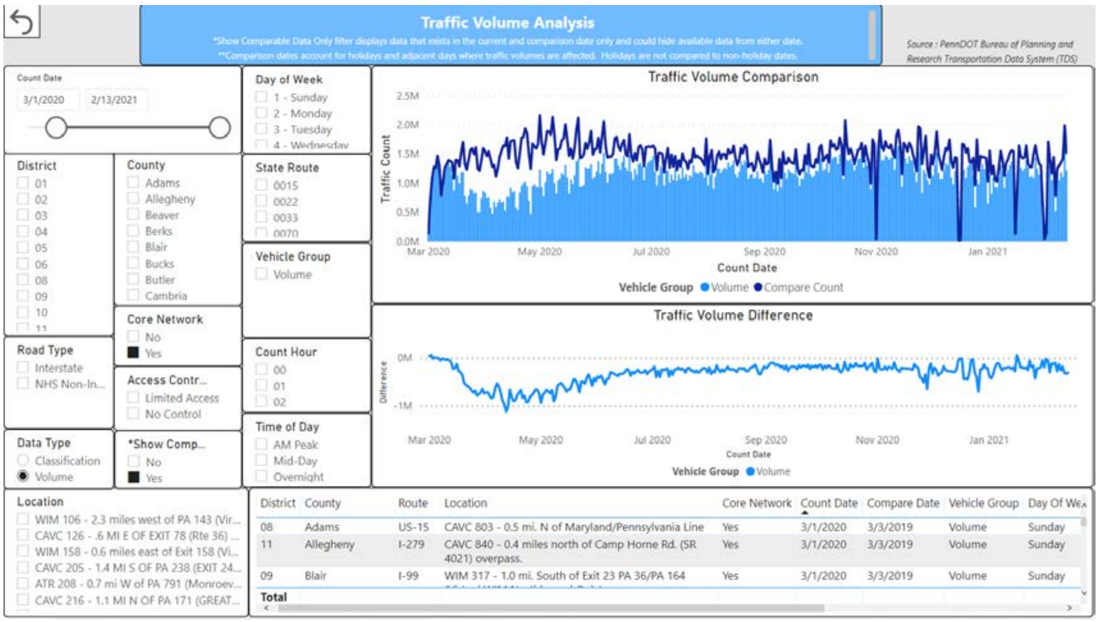
As the chart below shows, the impact on core network traffic volumes was significant. By the middle of April, core network traffic as tracked by PennDOT's permanent count stations was down approximately 50% when compared to the same period in 2019. Traffic volumes recovered steadily from that point through the state's re-opening in June, and continued to increase before plateauing in September and October, at 10-12% below 2019 levels. The resurgence of the virus in fall and winter, along with significantly reduced holiday travel, saw some of those gains reversed in the last 2 months of the year.

Figure 1 – Core Network Traffic Volumes During the COVID Pandemic



There has been significant interest in understanding traffic volume data and trends during the pandemic period. As a result, the Traffic Systems and Performance Unit has been sending out weekly traffic count updates to District Traffic

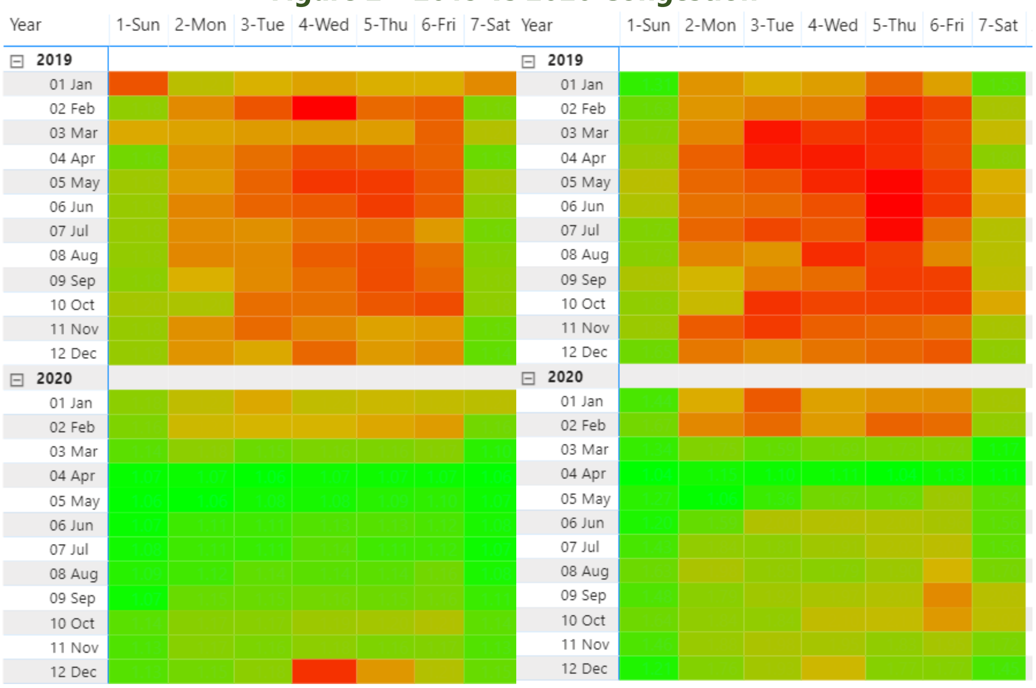
Engineers and executive staff since the spring of 2020. To alleviate the need for this, and to provide Districts with the ability to perform the analysis that they need on their own, a traffic volume dashboard was developed in consultation with the Bureau of Planning and Research, and is available on the Traffic Operations Analytics (TOA) platform. This dashboard provides comparative data from 2019 – 2021 for all of the PennDOT's permanent count stations, offers a variety of filtering and visualizations for quick analysis, and data is automatically updated weekly. The dashboard is pictured below, and can be accessed here. (Note that this report can only be accessed while on PennDOT VPN.)



COVID-19 Impact on Traffic Congestion

The observed drop in traffic volumes caused a significant decrease in congestion on the core roadway network. After the initial statewide mitigation efforts went into effect on March 17th, there was virtually no recurring congestion on the core roadway network, and that trend continued throughout the spring and most of the summer. Average daily vehicle hours of delay on the core roadway network fell from approximately 50K in the weeks prior to the beginning of the pandemic to 11K in the weeks during the pandemic, and only began to approach pre-pandemic norms by the end of summer. When traffic volumes reached their peak levels in late summer and early fall, there was some resumption of recurring congestion. The calendar-like charts below show the contrast between 2019 and 2020 peak planning time index[2] for each day of the week, by month, for the core network as a whole and on a typically highly congestion corridor.

Figure 2 – 2019 vs 2020 Congestion



Entire Core Roadway Network **I-76 in District 6**

[2] Planning time index = ratio of 95th percentile travel time to the freeflow travel time

Effectiveness of Remote TMC Operations

The COVID-19 pandemic dramatically altered the way TMCs operate. By March 18th, only 2 days after the initial statewide COVID-19 mitigation efforts were announced, all PennDOT's TMCs had transitioned to fully remote operations. It has been challenging to measure the effectiveness of TMCs in "real-time" during their remote environment as opposed to when they were in the TMC, because so much of the nature of traffic has been altered by the pandemic. There are fewer cars on the road, and thus less congestion and fewer incidents, independent of anything being done in traffic operations. Additionally, many of our core TMC analyses focused on historical crash data that isn't finalized until the second quarter of the following 2021.

The charts below attempt to quantify how effective remote TMC operations have been when compared with pre-pandemic operations considering Waze's crowd-sourced crashes. Once 2020 crash data has been finalized, that data will be examined as well.

The below table captures the percentage of Waze reported crashes that caused heavy congestion[3] that were verified in RCRS from March 18 to December 31 of 2020, compared with the same period in 2019.

Note: The percentages displayed are preliminary and are likely overstating how many actual crashes are not captured in RCRS. Analysis has determined that for significant congestion causing events, there are often many duplicate Waze events for a single crash. Efforts have been made to filter these out and are ongoing for future analysis.

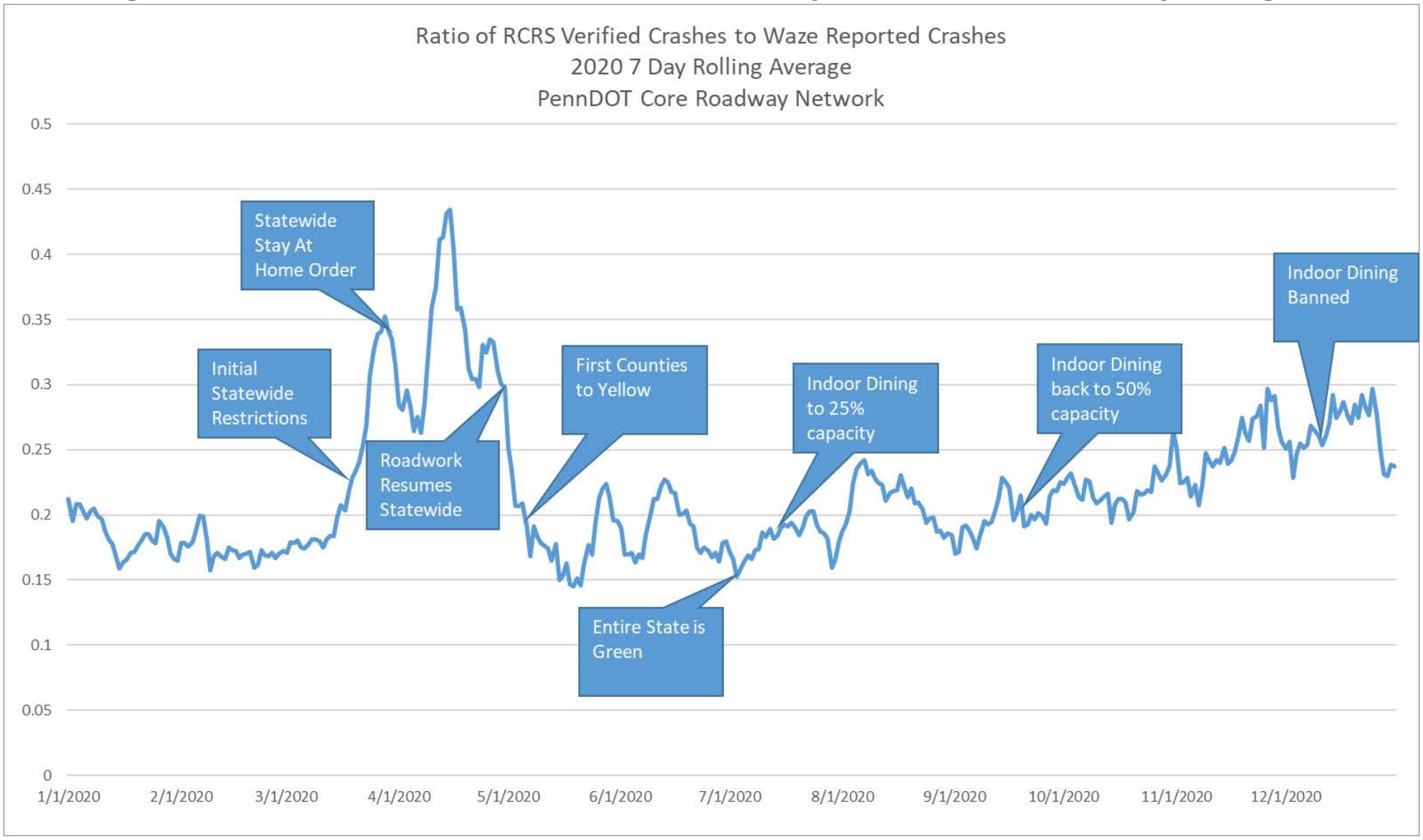
Table 1. RCRS Verified Heavy Congestion Waze Crashes – March 16 to December 31 – 2019 v 2020

Traffic Management Centers (TMC)	2019	2020	Change
Southeastern RTMC (D6)	***20.22%***	***30.03%***	***9.81%***
Eastern RTMC (D8)	***22.32%***	***30.36%***	***8.04%***
District 4 Total	13.17%	0.156716	2.50%
District 4	15.76%	14.43%	-1.33%
District 4 (D8)	9.16%	18.92%	9.76%
District 5 Total	18.12%	23.27%	5.15%
District 5	23.22%	23.50%	0.28%
District 5 (D8)	10.90%	22.83%	11.93%
District 8	29.87%	40.20%	10.33%
Central RTMC (D2)	***22.81%***	***29.29%***	***6.48%***
District 2	27.88%	29.23%	1.35%
District 3	22.09%	23.33%	1.24%
District 9	7.27%	75.00%	67.73%
Western RTMC (D11)	***22.91%***	***25.53%***	***2.62%***
District 1 (Total)	6.34%	10.87%	4.53%
District 1	17.65%	0.00%	-17.65%
District 1 (D11)	4.09%	20.83%	16.74%
District 10	5.68%	18.75%	13.07%
District 11	30.45%	34.04%	3.59%
District 12	15.88%	20.63%	4.75%
Statewide	***21.69%***	***29.42%***	***7.73%***

[3] A heavy congestion event has the scores: (1-Critical >= 10000, 2-Severe 3000 – 9999). Severity score methodology = (Duration of Incident) * (Historical Avg. Speed – Avg. Speed during Incident)

Another way of visualizing remote TMC effectiveness is by comparing the number of Waze crashes verified in RCRS compared to how many crashes were reported by Waze users on the core roadway network, looking at a 7-day rolling average throughout 2020. This is presented to gauge how much is being captured in RCRS relative to how much is occurring on the road.

Figure 3 – Ratio of RCRS Verified Crashes to Waze Reported Crashes (2020 7 day Average)



Key Takeaways

The relative improvement from 2019 to 2020 while in remote operations suggest that TMCs have been able to at least maintain, if not improve, their effectiveness in the remote environment. It merits noting that the number of heavy congestion Waze events declined by 81.5% in this period from 2019 to 2020, so despite the increases in percentage of events being captured, there were significantly fewer total events captured. Further investigation of remote TMC effectiveness will be warranted once 2020 crash data has been finalized.

The ratio of RCRS crashes to Waze crashes spiked significantly at the beginning of the pandemic period, and then fell to pre-pandemic levels after the resumption of roadwork statewide and stayed there throughout much of the summer. It has slowly and steadily risen through the late summer, fall, and early winter. This suggests that TMCs are doing as well or better at capturing crashes on the road in remote operations.

Impact of Hazardous Weather Conditions on Crash Rates

Winter weather provides one of the more pressing challenges for traffic operations. As PennDOT has become more aggressive with implementing speed limit and vehicle restrictions during severe winter weather, the question has arisen, when is the most appropriate time to put those restrictions in place? Weather data from PennDOT's RWIS stations, as well as crash data from the Crash Reporting System have been correlated in order to determine which road condition or combination of road conditions lead to an increased rate of crashes, and possibly be considered as "hazardous" conditions that merit additional attention.

Data below was observed from winter seasons from 2016 - 2019. Crash rates were analyzed at the segment level utilizing the INRIX XD segments that are provided for traffic speed data, based on the RWIS weather conditions that were present in the segment. The conditions (or combination of conditions) below represent the tipping points where crash rates became notably elevated when compared to the crash rates for all other conditions. These conditions and the increased likelihood of crashes that they present is broken down by commercial vehicle vs passenger vehicle.

Table 2. Hazardous Winter Conditions and Impact on Crash Likelihood

Condition	Greater Likelihood of Crash (Times More)	
	Commercial Vehicle	Passenger Vehicle
Low Visibility[4]	2.2 x	3.2 x
High Wind[5]	7.4 x	2.6 x
Freezing Surfaces[6]	2.4 x	1.7 x
Freezing Rain[7]	1.9 x	1.7 x
Slippery Surfaces[8]	1.8 x	1.2 x

[4] Low Visibility is based on a deficient RWIS visibility rating (<5)

[5] High Wind is defined as wind speeds 25 MPH or greater.

[6] Freezing Surfaces include non-dry road surfaces with a surface temperature under 33°.

[7] Freezing Rain includes non-snow precipitation with an air temperature under 33°.

[8] Slippery Surfaces include a deficient RWIS grip level (<65) with an air temperature under 40° and some precipitation in the past three hours.

Incident Duration of Road Closure Crashes In Hazardous Winter Conditions

Anecdotal evidence suggested that commercial vehicle incident timelines during winter storms were significantly longer than passenger vehicle only closures. There had been minimal analysis within PennDOT to determine whether this was the case or not. The below tables show the average and median incident timeline durations of all RCRS verified full road closures on the core roadway network that occurred during hazardous winter conditions. The closures were correlated with the PennDOT Crash Records Database to understand vehicle type involved. 62% of closures were correlated to a reportable crash, offering insight into the amount of full road closures that are a result of disabled vehicles or minor crashes. Additionally, the RCRS description field was examined to identify closures where a commercial vehicle was involved without having been linked to a reportable crash. Data presented below is from an analysis of data from the winter months of 2017 through 2019.

Table 3. Core Network Road Closures in Hazardous Winter Conditions - 2017-2019 (Nov to April)

Commercial Vehicle Involved (101 closures)		
	AVG (HRS)	MEDIAN (HRS)
Duration	3.92	2.00
Incident Influence Time[9]	5.30	3.68
No Commercial Vehicle Involved (43 closures)		
	AVG (HRS)	MEDIAN (HRS)
Duration	0.93	0.50
Incident Influence Time	2.85	2.10
Unknown (37 closures)		
	AVG (HRS)	MEDIAN (HRS)
Duration	1.49	1.00
Incident Influence Time	2.87	2.49

Key Takeaways

This data shows that commercial vehicles were involved in the majority (55.6%) of incidents that caused full road closures during hazardous winter conditions on the Core Roadway Network. Additionally, closures that involved CMV incidents lasted 3 hours longer on average and took more than 2 hours longer for traffic to return to normal (Incident Influence Time) than those where passenger vehicles were only involved. These statistics highlight the importance of being able to safely manage travel during severe winter weather, and how that may factor into PennDOT's ability to manage the roadway network better during emergency operations.

[9] Incident influence time = Time between when the incident occurred and when traffic returned to normal speeds

2019 Update
for
Reported Measures

Pennsylvania's Congestion Pie Chart - 2019

Background

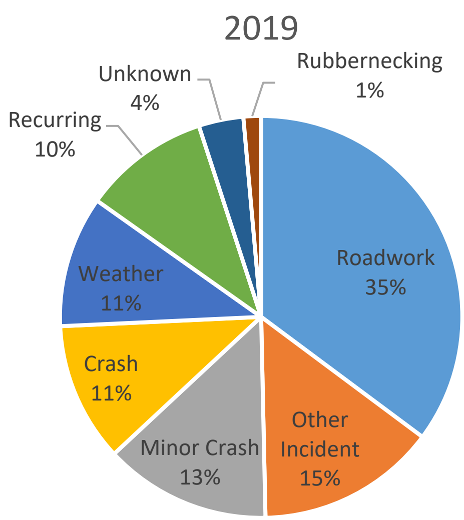
In early 2020, the TSMO Performance Program released a Pennsylvania-specific congestion pie chart using real data for 2018. This effort turned out to be the first in the nation to place comprehensive data behind the measure allowing for the congestion profile to be dynamically scaled to different geography's of interest.

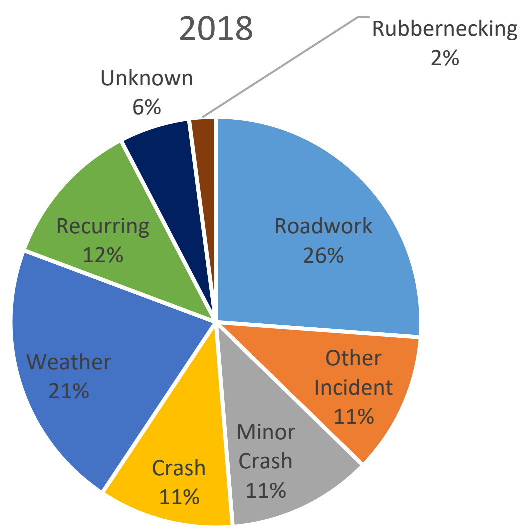
Since the release of the 2018 congestion pie chart, there has been a significant interest in this information from planning and operations personnel, as well as other decision makers within PA. Multiple regions have incorporated their region's pie charts into their Regional Operations Plans (ROPs). The following pages include updated charts for 2019 for the entire core roadway network, as well as for each individual district. In addition, we have provided some examples of the further capabilities of the congestion pie chart tool, by providing some 2019 examples of corridor specific pie charts.

In 2020, the tool was updated to allow for pie charts at the municipality level. The 2019 congestion pie chart is available via the Traffic Operations Analytics (TOA) portal for anyone with a Commonwealth of Pennsylvania account, via this link.

For further information about the methodology used to develop the congestion pie chart, see Appendix 1 – Congestion Pie Chart Methodology.

2019 Congestion Pie Chart vs 2018 – Statewide (Core Roadway Network)





Cause	*Source/Definition*
Roadwork	RCRS Roadwork, Maintenance Database, or Waze Roadwork event
Other Incident	Non-crash traffic hazard from Waze (i.e. disabled/car stopped on shoulder, hazard on roadway)
Minor Crash	Non-reportable crash from RCRS or Waze
Crash	Reportable crash from the Crash Record System (CRS)
Weather	Inclement weather[10] conditions from RWIS or Waze weather event
Recurring	Congestion where speed drop is no more than 10% greater than the historical average speed
Unknown	Cause could not be identified with current data sources
Rubbernecking	Any previously identified congestion pie chart incident cause is linked to one side of the road, and no incident is correlated to the other side of the road in the same area, but still experiences a speed drop above historical norm

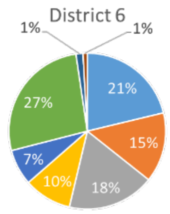
Key Takeaways

The primary change between 2018 and 2019 is a significant decrease in the influence of weather, which led to an increase in a number of other causes. There are likely 2 factors that led to this decrease in weather related congestion. The winter months in 2019 were notably mild compared to 2018, and there was a disruption in the INRIX congestion data in January and February 2019. It is likely some degree of those influences on weather adjusted the overall congestion in 2019. The congestion decrease from 2018 to 2019 was -9.15%.

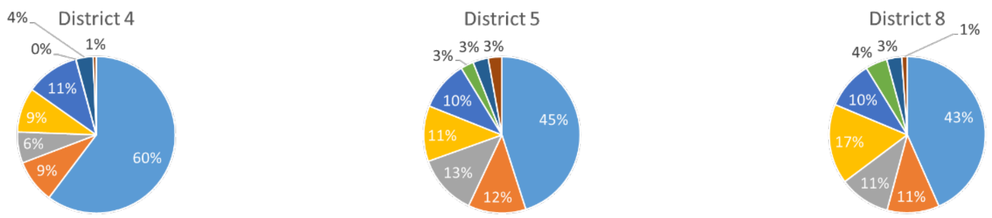
[10] Heavy rain, any kind of snow, and/or snow covered, icy, or wet (with temperature below freezing) roads

2019 Congestion Pie Charts – By District (Core Roadway Network)

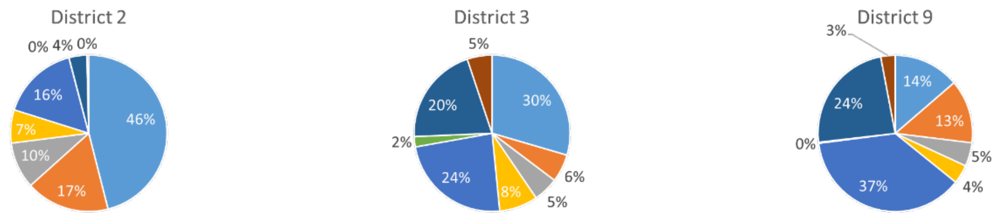
Southeastern Region



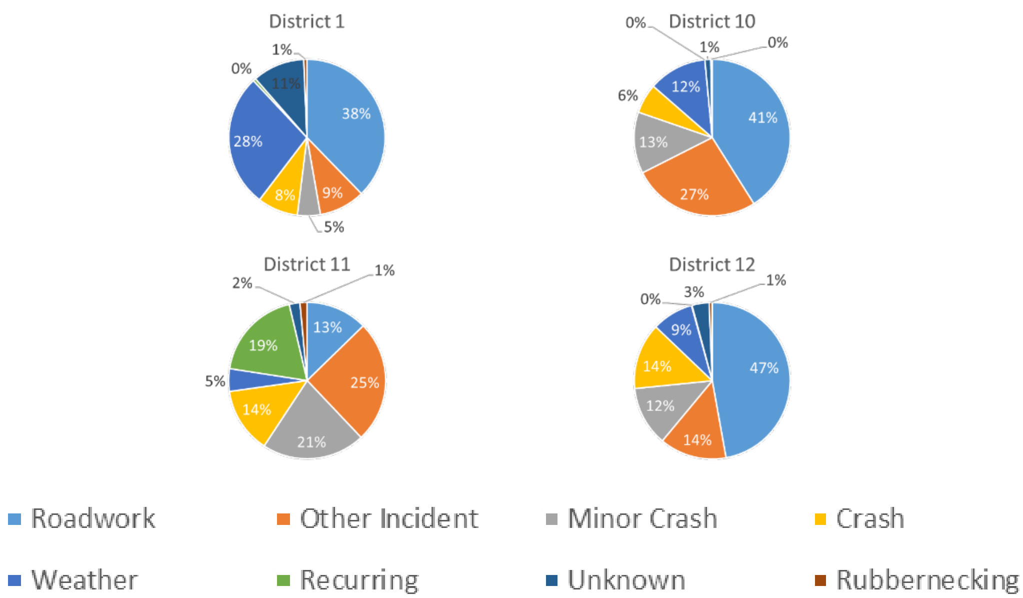
Eastern Region



Central Region



Western Region



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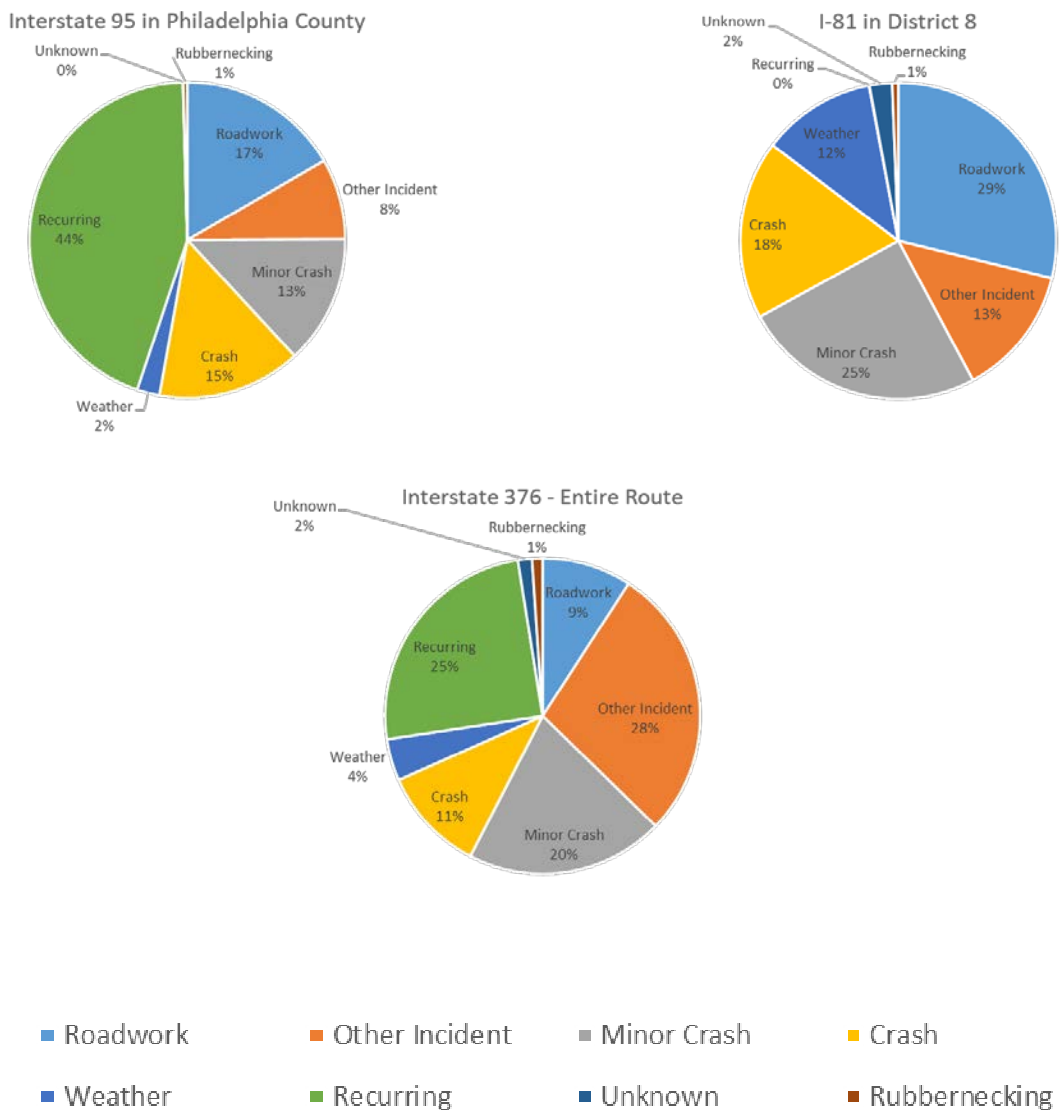
2019 Corridor Specific Pie Chart Examples



Congestion Related Crashes on the Core Network - 2019

The 3rd TSMO Performance Report presented data on crashes that occurred in existing congestion on the core roadway network in 2017. The following information presents an update of that data for 2019. For reference, the numbers under the "Work zone" column represent all crashes that occurred in the congestion behind a verified roadwork event (contractor or PennDOT).

For this update, the analysis utilized Department verified sources, and added crowd-sourced incident data from Waze to get a better picture of what was causing the congestion in several unknown situations. While utilizing Waze data did significantly cut down on the number of unknown events, a large percentage of unknowns remain. These unknowns are heavily weighted towards more minor congestion[11] events. 58% of these crashes were rear end crashes, and an additional 25% were hit fixed object, which is consistent with drivers either running into the back of a queue or swerving off the road to avoid running into the back of a queue.

Table 4. Reportable Crashes by Congestion Type on the Core Roadway Network -2019

District/Region	Crash[12]	Work Zone[13]	Weather[14]	Special Event[15]	Other[16]	Waze Accident	Waze Hazard	Waze Weather	Recurring	Unknown
Southeastern Region (D6)	***455***	***283***	***11***	***2***	***15***	***784***	***447***	***18***	***189***	***576***
Eastern Region	***402***	***414***	***117***	***0***	***11***	***424***	***314***	***14***	***34***	***565***
District 4	75	67	38	0	7	47	37	2	2	68
District 5	172	141	49	0	2	187	137	5	8	189
District 8	155	206	30	0	2	190	140	7	24	308
Central Region	***79***	***55***	***26***	***0***	***0***	***51***	***51***	***2***	***11***	***192***
District 2	32	35	13	0	0	17	18	1	0	51
District 3	12	14	5	0	0	24	16	0	8	96
District 9	35	6	8	0	0	10	17	1	3	45
Western Region	***186***	***172***	***19***	***1***	***5***	***434***	***166***	***5***	***28***	***246***
District 1	19	29	10	0	0	12	12	2	3	53
District 10	15	26	6	0	0	10	5	0	0	23
District 11	118	86	1	0	3	49	32	1	25	41
District 12	34	31	2	1	2	363	117	2	0	129
Statewide	***1122***	***924***	***173***	***3***	***31***	***1693***	***978***	***39***	***262***	***1579***

[11] Events where congestion has a severity score of <1000. Severity Score = (Duration of Incident) * (Historical Avg Speed – Avg Speed during Incident)
[12] A reportable crash or a non-reportable crash that was captured in RCRS
[13] A workzone captured in RCRS or the maintenance database
[14] An RCRS event that is weather related (winter weather, flooding, downed tree/utlity)
[15] A special event that was entered into RCRS
[16] An RCRS event that does not fall into any of the previous categories

These congestion related crashes led to a significant number of injuries and fatalities. The below table indicates the number and type of injuries that resulted from congestion-related crashes on the Core Roadway Network in 2019.

Table 5. Injuries Caused by Congestion Related Crashes on the Core Roadway Network - 2019

District/Region	Fatality	Suspected Serious Injury	Suspected Minor Injury	Possible Injury	Unknown Severity	Unknown If Injured
Southeastern Region (D6)	***6***	***28***	***782***	***427***	***556***	***175***
Eastern Region	***9***	***39***	***680***	***249***	***268***	***108***
District 4	3	3	79	28	70	14
District 5	4	12	266	101	101	54
District 8	2	24	335	120	97	40
Central Region	***4***	***16***	***138***	***43***	***44***	***37***
District 2	0	5	51	18	9	9
District 3	4	7	52	21	23	27
District 9	0	4	35	4	12	1
Western Region	***4***	***27***	***324***	***178***	***142***	***52***
District 1	2	9	34	11	13	10
District 10	1	3	26	8	8	0
District 11	0	8	188	139	105	34
District 12	1	7	76	20	16	8
Statewide	***23***	***110***	***1924***	***897***	***1010***	***372***

Secondary Crashes

For the purposes of this report, a secondary crash is when a subsequent crash occurs in the backlog or queue of a prior crash. Congestion from a primary crash caused[17] 1122 secondary crashes on the Core Network in 2019, or about 6% of all reportable crashes in 2019 caused a secondary crash. Of these, 171 occurred in congestion from unverified heavy congestion crashes, leading to 2 fatalities and 124 total injuries.

The tables below provide a breakdown of these secondary crashes by the District and region, the fatalities and injuries associated with these crashes, and how often the primary crash was in RCRS prior to the secondary crash. The percentage of the time that the primary crash was in RCRS prior to the secondary crash helps Operations staff understand situational awareness of the initial incident. Changeable Message Signs (CMS) continue to be present within 5 miles upstream of the primary crash in over 85% of secondary crash situations

Table 6. 2019 Secondary Crashes by District and Region

	2017			2018			2019			2017 to 2019 Change		
District/Region	Crash Count	Fatality /Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality /Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality/ Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality /Injury Count	Primary Crash in RCRS Prior
Southeastern Region (D6)	385	0/267	39%	500	1/357	48%	455	1/329	45%	70	1/62	6%
Eastern Region	366	3/239	33%	478	3/255	37%	402	2/220	41%	36	-1/-19	8%
District 4	50	0/36	20%	47	0/44	23%	75	0/36	31%	25	0/0	11%
District 5	145	0/93	26%	172	2/77	30%	172	1/99	34%	27	1/6	8%
District 8	171	3/110	42%	259	1/134	45%	155	1/85	53%	-16	-2/-25	11%
Central Region	50	2/38	20%	82	0/40	24%	79	1/40	29%	29	-1/2	9%
District 2	34	2/29	24%	34	0/26	41%	32	0/18	47%	-2	-2/-11	23%
District 3	11	0/5	18%	29	0/9	21%	12	1/6	50%	1	1/1	32%
District 9	5	0/4	0%	19	0/5	0%	35	0/16	6%	30	0/12	6%
Western Region	185	2/135	34%	173	2/98	43%	186	2/126	41%	1	0/-9	7%
District 1	15	1/9	13%	18	0/12	17%	19	2/10	11%	4	1/1	-9%
District 10	17	1/33	18%	11	0/5	9%	15	0/12	20%	-2	-1/-21	2%
District 11	135	0/77	39%	116	2/62	55%	118	0/83	58%	-17	0/6	19%
District 12	18	0/16	28%	28	0/19	21%	34	0/21	6%	16	0/5	-22%
Statewide	986	7/679	35%	1233	6/750	42%	1122	6/715	42%	136	-1/36	7%

[17] Due to data processing limitations, for purposes of this analysis congestion was linked to a crash up to 8 miles behind the crash. Crashes that occurred in congestion further behind the primary crash would not be flagged as a secondary crash.

Table 7 outlines the time and Table 8 the location of the secondary crashes tend to occur relative to the primary crash.

Table 7. Timing of Secondary Crashes Relative to Primary Crash

	2017			2018			2019			2017 to 2019 Change		
Time (Minutes)	Crash Count	Fatality /Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality /Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality/ Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality/ Injury Count	Primary Crash in RCRS Prior
0-15	251	4/191	12%	228	3/154	18%	204	4/162	18%	*-47*	*0/-29*	*6%*
16-30	124	0/72	34%	138	0/93	38%	144	0/88	40%	*20*	*0/16*	*6%*
31-60	210	1/156	49%	269	2/159	46%	249	0/163	49%	*39*	*-1/7*	*0%*
61+	401	2/260	43%	598	1/344	50%	525	2/302	48%	*124*	*0/42*	*5%*
Total	***986***	***7/679***	***35%***	***1233***	***6/750***	***42%***	***1122***	***6/715***	***42%***	***136***	***-1/36***	***7%***

Key Takeaways

In 2019, there were 136 more secondary crashes statewide in 2019 as opposed to 2017, an increase of nearly 14%. Nearly 82% of secondary crashes occurred after more than 15 minutes, and nearly 47% occurred one hour or more after the primary crash. These timeframes are where focus should be placed by TMC's to target better operational response times and highlight the importance of promoting the efforts in FHWA's "Best Practice in TIM" DMS guidance for continuing effective messaging throughout the duration of incident's timeline, congestion, and queue adjustments.

Table 8. Length of Congestion from Primary Crash to a Secondary Crash

	2017			2018			2019			2017 to 2019 Change		
Distance (Miles)	Crash Count	Fatality /Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality /Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality/ Injury Count	Primary Crash in RCRS Prior	Crash Count	Fatality/ Injury Count	Primary Crash in RCRS Prior
<.5	293	3/178	29%	348	2/240	31%	318	3/222	42%	*25*	*0/44*	*13%*
.5 - 2	238	2/164	38%	292	1/158	49%	257	0/144	46%	*19*	*-2/-20*	*8%*
2 to 5	203	1/189	40%	282	3/173	49%	267	1/165	42%	*64*	*0/-24*	*2%*
> 5	191	1/148	37%	311	0/179	40%	280	2/184	38%	*89*	*1/36*	*1%*
Total	***986***	***7/678***	***35%***	***1233***	***6/750***	42%	***1122***	***6/715***	***42%***	***136***	***36***	***7%***

Key Takeaways

The more motorists that can be deterred from driving towards a queue may in-turn positively impact the safety of our congestion-related crashes. The distance information above provides better supporting information for the use of upstream congestion messaging, and can be shared with TIM teams to help mitigating the congestion points more effectively. Regardless of time and distance from the primary crash, there is a CMS close enough to alert approaching motorists of the congestion in over 85% of secondary crashes. Future analysis will focus the effectiveness of CMS messaging in preventing secondary crashes.

For District and Region specific data for the previous two tables, see Appendix 3 – Secondary Crash Numbers by District/Region.

Work Zone Congestion-Related Crashes

Congestion from work zones is another significant factor of crashes. In 2019, there were 924 reportable crashes on the Core Roadway Network in congestion originating from a work zone[18].

The tables below provide a breakdown of work zone congestion-related crashes, fatalities, injuries, and the percentage of work zones that were in RCRS as opposed to just being in the maintenance database. These numbers are then compared to 2017.

Table 9. Breakdown of Work Zone Congestion-Related Crashes by District/Region

	2017			2018			2019			2017 to 2019 Change		
District/Region	Crash Count	Fatality/ Injury Count	Work Zone in RCRS%	Crash Count	Fatality /Injury Count	Work Zone in RCRS%	Crash Count	Fatality/ Injury Count	Work Zone in RCRS%	Crash Count	Fatality/ Injury Count	Work Zone in RCRS%
Southeastern Region (D6)	***406***	***2/316***	***84%***	***318***	***1/246***	***90%***	***283***	***0/247***	***88%***	***-123***	***-2/-69***	***-4%***
Eastern Region	***485***	***6/319***	***94%***	***287***	***2/245***	***94%***	***414***	***3/262***	***97%***	***-71***	***-3/-57***	***3%***
District 4	102	1/78	98%	50	0/48	***92%***	67	1/51	97%	***-35***	***0/-27***	***-1%***
District 5	85	3/57	88%	125	1/114	***96%***	141	1/79	98%	***56***	***-2/22***	***10%***
District 8	298	2/184	94%	112	1/83	***92%***	206	1/132	96%	***-92***	***-1/-52***	***2%***
Central Region	***93***	***1/71***	***88%***	***87***	***0/61***	***97%***	***55***	***0/34***	***96%***	***-38***	***-1/-37***	***8%***
District 2	30	1/22	70%	37	0/18	***92%***	35	0/25	94%	***5***	***-1/13***	***24%***
District 3	41	0/27	98%	16	0/14	***100%***	14	0/6	100%	***-27***	***0/-21***	***2%***
District 9	22	0/22	95%	34	0/29	***100%***	6	0/3	100%	***-16***	***0/-19***	***5%***
Western Region	***197***	***3/110***	***89%***	***217***	***0/150***	***99%***	***172***	***2/114***	***93%***	***-25***	***-1/4***	***4%***
District 1	18	0/9	89%	21	0/12	***95%***	29	0/26	97%	***11***	***0/17***	***8%***
District 10	19	2/17	79%	22	0/10	***100%***	26	1/10	100%	***7***	***-1/-7***	***11%***
District 11	127	0/66	94%	144	0/108	***100%***	86	0/64	90%	***-41***	***0/-2***	***-4%***
District 12	33	1/18	79%	30	0/20	***93%***	31	1/14	94%	***-2***	***0/-4***	***15%***
Statewide	***1181***	***12/816***	***89%***	***909***	***3/702***	***94%***	***924***	***5/657***	***93%***	***-257***	***-7/-159***	***4%***

The following table breakdowns work zone related crashes by their distance from the work zone.

Table 10. Distance of All Work Zone Congestion-Related Crashes from the Work Zone

	2017		2018		2019		2017 to 2019 Change	
Distance (Miles)	Crash Count	Fatality/ Injury Count	Crash Count	Fatality /Injury Count	Crash Count	Fatality/ Injury Count	Crash Count	Fatality/ Injury Count
<.5	778	10/521	452	0/325	460	2/356	*-318*	*-8/-165*
.5 - 2	122	1/96	133	2/107	161	0/125	***39***	***-1/29***
2 to 5	150	1/99	136	1/98	144	2/84	***-6***	***1/-15***
> 5	131	0/100	188	0/172	159	1/92	***28***	***1/-8***
Total	***1181***	**12/816**	***909***	***3/702***	***924***	***5/657***	*-257*	*-7/-159*

[18] Due to data processing limitations, congestion was linked to a work zone up to a maximum of 8 miles behind the work zone. Crashes that occurred in congestion further from the work zone would not be flagged as being caused by the work zone.

Key Takeaways

From 2017 to 2019, there were 257 fewer work zone congestion related crashes, a decrease of almost 22%. This led to a corresponding drop in injuries in these crashes of almost 20%. It is also noteworthy that the percentage of these crashes where the work zone was in RCRS increased from 89% to 93%. The additional 7% of these work zones that were only in the maintenance database does, however, continue to represent an opportunity for improved communications between county maintenance personnel and TMCs.

Additionally, as with secondary crashes, 85% of work zone related crashes had a CMS in proximity to the crash that may have been used to alert motorists that they were approaching the work zone congestion, which is consistent with 2017 data.

Just under half (49.8%) of these crashes occurred within half a mile of the work zone. This represents a substantial decrease from 2017, when 65% of these crashes occurred within half a mile of the work zone. In fact, virtually all of the decrease in work zone congestion crashes relative to 2017 can be traced to the decline in crashes in within half a mile, which suggests that improvements are being made in managing safety in the immediate proximity of the work zone. However, that half of crashes still occur in this area highlights the fact that areas approaching a work zone are at higher risk for crashes, as well as the importance of having situational awareness on work zones, and having an operational response in place for when congestion begins to build in the work zone.

2019 Work Zones with Highest Congestion Related Crash Rates

The below tables highlight the 2019 work zones with the highest rates of reportable crashes that occurred in congestion related to the work zone. Tables are provided for both short term work zones (up to one week in duration) and long-term work zones (longer than one week) with RCRS IDs. Work zones must have more than one related crash to be included. For purposes of this analysis, a crash is linked to a work zone only if it occurred in congestion that was being caused by the work zone[19] – crashes that occur in/near the work zone under non-congested conditions are not considered. Long term work zones are ranked by crashes per day, short term is ranked by crashes per hour. Where possible, these work zones should be investigated to determine any lessons learned/safety improvements that could be made in the future.

Table 11. 2019 Work Zones With Highest Congestion Related Crash Rates (Less than 1 week)

District	RCRS ID	Route	Location	Crashes	Rear End/Hit Fixed Object	Duration (Hours)	Crashes Per Hour
8	477078	I-81 N	Exit 65 to Exit 66	2	2	5.05	0.40
6	442532	I-76 E	Exit 340 to Exit 341	2	2	7.60	0.26
11	484087	I-376 E	Exit 74	2	2	8.02	0.25
6	460554	I-76 E	Exit 345 to Exit 346A	2	2	11.42	0.18
12	456010	I-70 W	Exit 21 to WV Line	2	2	12.13	0.16
6	494654	422 W	Limerick/Linfield to Sanatoga	2	2	17.35	0.12
6	457666	422 E	Armand Hammer Blvd to Sanatoga	2	1	20.08	0.10
6	492134	I-76 E	Exit 344 to Exit 346A	3	3	51.18	0.06
6	495233	I-76 W	Exit 344	2	2	43.25	0.05
6	485711	I-76 E	Exit 345 to Exit 346A	2	0	54.83	0.04

Table 12. 2019 Work Zones With Highest Congestion Related Crash Rates (Longer than 1 week)

District	RCRS ID	Route	Location	Crashes	Rear End/Hit Fixed Object	Duration (Days)	Crashes Per Day
6	473304	I-95 S	Exit 23	33	29	61.67	0.54
8	455288	I-83 N	Exit 40A to Exit 40B	33	32	125.15	0.26
8	449455	US 222 S	PA Turnpike to PA 772	20	19	94.09	0.21
8	492055	US 30 W	Memory Lane to North Hills Road	4	0	18.99	0.21
5	452009	I-380 S	MM 3 to MM 1	4	4	24.50	0.16
6	430519	I-95 S	Exit 6	35	29	238.36	0.15
6	481584	I-95 S	Exit 6	16	14	115.02	0.14
8	461717	I-83 S	MM 7.5 to MD Line	3	2	23.25	0.13
4	461499	I-81 N	Exit 185 to Exit 187	7	7	61.48	0.11
8	455291	I-83 N	MM 3 to MM 5	2	2	19.30	0.10

[19] Due to data processing limitations, congestion was linked to a work zone up to a maximum of 8 miles behind the work zone. Crashes that occurred in congestion further from the work zone would not be flagged as being caused by the work zone.

TMC Situational Awareness

RCRS Verified Crashes – 2017 to 2019

The following tables present trends from 2017 to 2019 on various types of crashes that were verified in RCRS by TMCs, as an examination of progress that is being made in improving situational awareness.

Previous TSMO Performance Reports have primarily focused on the RCRS verification rates for reportable crashes as a measure of TMC situational awareness. However, another potential measure of progress in situational awareness is the total number of crashes (reportable or non-reportable) that have been verified by TMCs and entered into RCRS. These numbers are presented below by Region and District for 2017 through 2019.

Table 13. 2017 through 2019 Total RCRS Verified Crashes – Core Network

District	2017	2018	2019	Change 2018-2019	Change 2017-2019
Southeastern RTMC (D6)	4668	4621	4555	-1.43%	-2.42%
Eastern RTMC (D8)	3672	4302	4536	5.44%	23.53%
District 4	173	341	330	-3.23%	90.75%
District 5	1034	1294	1672	29.21%	61.70%
District 8	2465	2667	2534	-4.99%	2.80%
Central RTMC (D2)	510	655	1124	71.60%	120.39%
District 2	331	433	527	21.71%	59.21%
District 3	138	149	409	174.50%	196.38%
District 9	41	73	188	157.53%	358.54%
Western RTMC (D11)	2053	2119	2205	4.06%	7.40%
District 1	88	97	120	23.71%	36.36%
District 10	60	48	50	4.17%	-16.67%
District 11	1686	1769	1848	4.47%	9.61%
District 12	219	205	187	-8.78%	-14.61%
Statewide	***10903***	***11697***	***12420***	***6.18%***	***13.91%***

The first two TSMO Performance reports issued in 2018 focused on the percentage of core network reportable crashes that were verified by TMC personnel. The table below displays the RCRS verification rate for all reportable crashes on the Core Roadway network from 2017 through 2019. These numbers are provided as insight into how TMCs are progressing in their efforts to improve overall situational awareness.

Table 14. 2017 through 2019 RCRS Verified Crashes – All Reportable Crashes – Core Network

Traffic Management Centers (TMC)	2017 Capture %	2018 Capture %	2019 Reportable Crashes	2019 Reportable Crashes Linked to RCRS	%	Change 2018-2019	Change 2017-2019
Southeastern RTMC (D6)	***40.17%***	***39.65%***	***6741***	***2604***	***38.63%***	***-1.02%***	***-1.54%***
Eastern RTMC (D8)	***30.18%***	***35.63%***	***7346***	***2570***	***34.99%***	***-0.64%***	***4.81%***
District 4 Total	11.13%	19.30%	1128	211	18.71%	***-0.59%***	***7.57%***
District 4	17.50%	23.89%	519	115	22.16%	***-1.73%***	***4.66%***
District 4 (D8)	9.04%	16.27%	609	96	15.76%	***-0.51%***	***6.73%***
District 5 Total	22.91%	28.21%	2810	866	30.82%	***2.61%***	***7.91%***
District 5	30.82%	34.74%	1315	579	44.03%	***9.29%***	***13.21%***
District 5 (D8)	12.84%	19.57%	1496	288	19.25%	***-0.32%***	***6.41%***
District 8	41.74%	46.01%	3408	1493	43.81%	***-2.20%***	***2.07%***
Central RTMC (D2)	***19.16%***	***22.53%***	***1930***	***697***	***36.11%***	***13.58%***	***16.95%***
District 2	34.26%	41.41%	700	342	48.86%	***7.45%***	***14.60%***
District 3	12.19%	13.17%	742	253	34.10%	***20.92%***	***21.91%***
District 9	6.01%	10.83%	488	102	20.90%	***10.07%***	***14.89%***
Western RTMC (D11)	***31.12%***	***31.69%***	***3538***	***1174***	***33.18%***	***1.49%***	***2.06%***
District 1 (Total)	8.90%	8.48%	596	62	10.40%	***1.92%***	***1.50%***
District 1	10.66%	11.60%	154	21	13.64%	***2.04%***	***2.97%***
District 1 (D11)	7.37%	5.92%	442	41	9.28%	***3.35%***	***1.90%***
District 10	12.20%	8.73%	359	36	10.03%	***1.30%***	***-2.17%***
District 11	46.39%	49.25%	1828	956	52.30%	***3.05%***	***5.90%***
District 12	20.40%	17.65%	755	120	15.89%	***-1.75%***	***-4.50%***
Statewide	***32.63%***	***35.02%***	***19555***	***7045***	***36.03%***	***1.00%***	***3.39%***

Major crashes on core network roads can gridlock entire metropolitan areas. These are the instances when effective traffic management strategies are paramount, and most importantly need to be clearly communicated to first responders, and the traveling public to allow for actionable decisions. PennDOT TMCs should aim to have 80% of heavy congestion crashes verified by an RCRS entry for all core roadway network roads. RCRS feeds incident information directly to social media and third-party mapping providers. The table below illustrates the TMC situational awareness of heavy congestion[20] reportable crashes from 2017 through 2019.

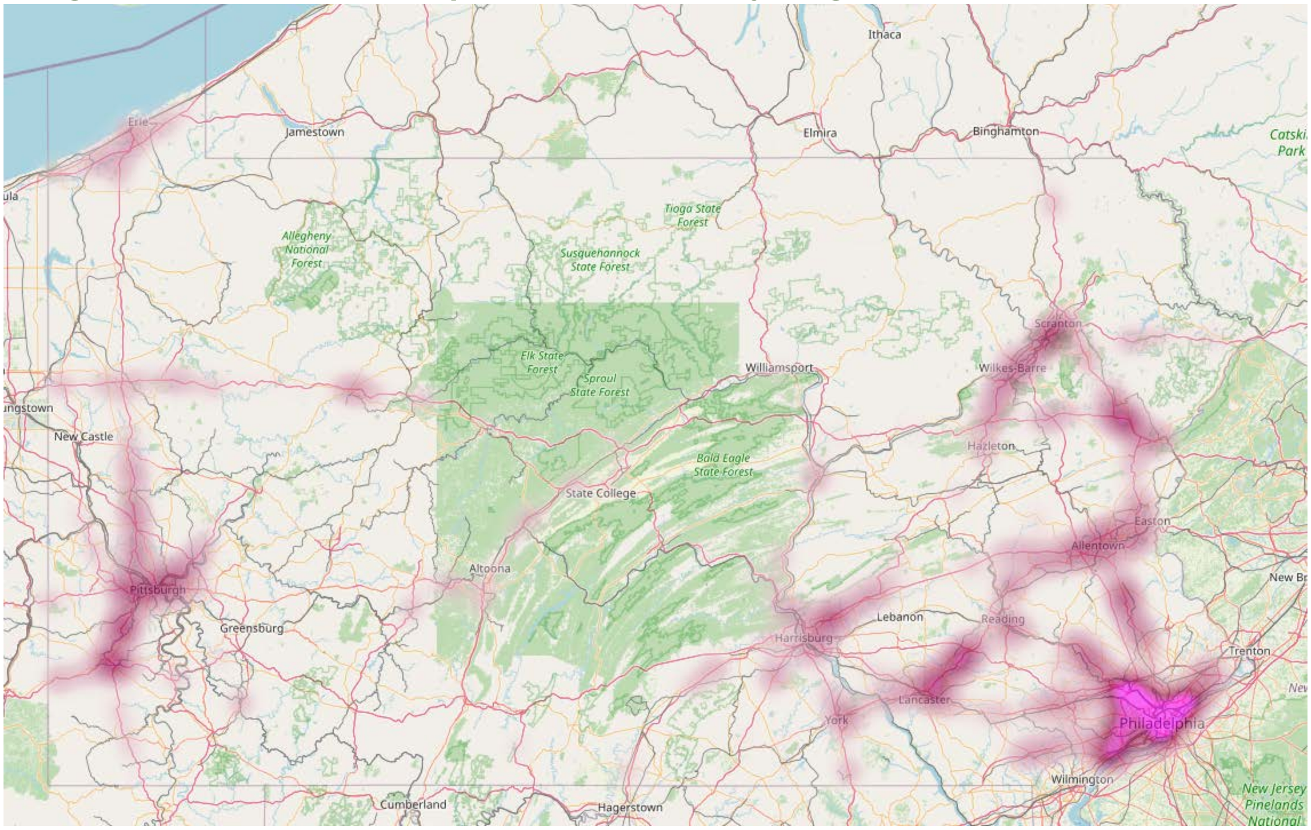
Table 15. 2017 through 2019 RCRS Verified Heavy Congestion Reportable Crashes – Core Network

Traffic Management Centers (TMC)	2017 Capture %	2018 Capture %	2019 Reportable Crashes	2019 Reportable Crashes Linked to RCRS	%	Change 2018-2019	Change 2017 - 2019
Southeastern RTMC (D6)	***70.41%***	***72.10%***	***952***	***619***	***65.02%***	***-7.08%***	***-5.39%***
Eastern RTMC (D8)	***65.39%***	***69.09%***	***1329***	***891***	***67.04%***	***-2.05%***	***1.66%***
D4 Total	38.24%	50.27%	184	96	52.17%	***1.90%***	***13.94%***
District 4	42.11%	52.13%	115	60	52.17%	***0.05%***	***10.07%***
District 4 (D8)	36.28%	48.31%	69	36	52.17%	***3.86%***	***15.89%***
District 5 Total	57.29%	62.94%	472	295	62.50%	***-0.44%***	***5.21%***
District 5	63.07%	64.50%	312	219	70.19%	***5.70%***	***7.12%***
District 5 (D8)	43.62%	59.88%	161	77	47.83%	***-12.06%***	***4.20%***
District 8	78.57%	77.27%	673	500	74.29%	***-2.97%***	***-4.28%***
Central RTMC (D2)	***67.00%***	***62.92%***	***191***	***137***	***71.73%***	***8.81%***	***4.73%***
District 2	83.33%	75.83%	88	75	85.23%	***9.39%***	***1.89%***
District 3	61.25%	64.29%	57	40	70.18%	***5.89%***	***8.93%***
District 9	25.93%	33.33%	46	22	47.83%	***14.49%***	***21.90%***
Western RTMC (D11)	***66.22%***	***63.61%***	***641***	***396***	***61.78%***	***-1.83%***	***-4.44%***
District 1 (Total)	47.69%	41.94%	79	27	34.18%	***-7.76%***	***-13.52%***
District 1	56.52%	63.64%	33	14	42.42%	***-21.21%***	***-14.10%***
District 1 (D11)	42.86%	30.00%	46	13	28.26%	***-1.74%***	***-14.60%***
District 10	43.84%	34.78%	57	20	35.09%	***0.31%***	***-8.75%***
District 11	77.17%	77.56%	375	292	77.87%	***0.31%***	***0.70%***
District 12	54.20%	51.39%	130	57	43.85%	***-7.54%***	***-10.35%***
Statewide	***67.18%***	***68.44%***	***3113***	***2043***	***65.63%***	***-2.81%***	***-1.55%***

[20] A heavy congestion event has the scores: (1-Critical >= 10000, 2-Severe 3000 – 9999). Severity score methodology = (Duration of Incident) * (Historical Avg. Speed – Avg. Speed during Incident)

A statewide map of un-verified heavy congestion crashes is provided below. For District specific maps, please see Appendix 2 – District Specific Heavy Congestion Crash Maps.

Figure 4 – Statewide Heat Map of Un-Verified Heavy Congestion Crashes – Core Network



Key Takeaways

From 2017 to 2019, there has been significant growth almost across the board in terms of the number of crashes being captured and verified on an annual basis. Since there is not a corresponding growth in the number of reportable crashes in these years, it seems likely that these numbers are a result of improved situational awareness. Growth has also been seen statewide in RCRS verification of reportable crashes, with only a few exceptions. However, the same growth has not been seen statewide for the subset of reportable crashes, though particular regions and Districts have seen noteworthy growth in these areas.

It is also worth noting that the Districts and regions that have seen the most growth are those that are utilizing PennDOT's Traffic Alerts system. Further, the significant growth seen across all areas in the Central Region highlights the effectiveness of their efforts to bring County 911 Computer Aided Dispatch (CAD) information directly into the TMC.

Further study is merited to understand why the significant improvement seen in overall situational awareness has not translated into similar growth in awareness of reportable crashes, and in particular reportable crashes that cause heavy congestion

Impact of Traffic Cameras on Situational Awareness

Traffic cameras are one of the most heavily utilized tools for situational awareness and verification. As a result, a preliminary analysis was done to determine the effective radius of cameras of heavy congestion crashes. 2 miles was determined to be a representative breaking point for verified heavy congestion crashes. The numbers provided below are 2019 numbers for heavy congestion[21] crashes more than 2 miles from a camera, with the comparative 2018 counts. The percentages of these events that were reported by Waze is shown for reference and to demonstrate the ability of Waze to provide situational awareness in areas where traditional methods such as cameras do not reach.

Table 16. Crash Capture Rates for RCRS/Waze – Heavy Congestion Crashes > 2 miles from Camera

Traffic Management Centers (TMC)	2018			2019		
	Crashes	RCRS %	Waze %	Crashes	RCRS %	Waze %
Southeastern RTMC (D6)	***154***	***50.00%***	***77.27%***	***152***	***45.39%***	***82.24%***
Eastern RTMC (D8)	***528***	***58.71%***	***78.60%***	***451***	***54.55%***	***81.15%***
District 4	36	52.78%	72.22%	42	52.38%	71.43%
District 4 (D8)	36	36.11%	75.00%	18	33.33%	66.67%
District 5	118	55.08%	78.81%	101	63.37%	82.18%
District 5 (D8)	66	57.58%	56.06%	63	34.92%	87.30%
District 8	272	64.34%	85.29%	227	58.15%	81.94%
Central RTMC (D2)	***184***	***61.41%***	***63.59%***	***133***	***75.19%***	***75.94%***
District 2	69	73.91%	59.42%	52	88.46%	76.92%
District 3	80	63.75%	71.25%	51	68.63%	82.35%
District 9	35	31.43%	54.29%	30	63.33%	63.33%
Western RTMC (D11)	***232***	***39.22%***	***76.29%***	***189***	***44.44%***	***70.37%***
District 1	19	63.16%	73.68%	27	48.15%	51.85%
District 1 (D11)	35	20.00%	68.57%	30	40.00%	60.00%
District 10	62	38.71%	70.97%	51	39.22%	70.59%
District 11	48	27.08%	81.25%	18	50.00%	88.89%
District 12	68	51.47%	82.35%	63	47.62%	77.78%
Statewide	***1098***	***53.83%***	***75.41%***	***925***	***53.95%***	***78.38%***

[21] A heavy congestion event has the scores: (1-Critical >= 10000, 2-Severe 3000 – 9999). Severity score methodology = (Duration of Incident) * (Historical Avg. Speed – Avg. Speed during Incident)

Average Incident Clearance Times – 2017 through 2019

The first TSMO Performance Report issued in February 2018 presented a breakdown of average incident clearance times by District and County for all routes on the Core Roadway Network. The 4th report added data for 2018, while also adding a table that presented data for incident clearance times by interstate and county.[22] The following are updates to those tables that includes 2019 data.

Table 17. Incident Clearance Times by District/County – 2017 through 2019

District/County	Incident Clearance Time			Number of Incidents	Incident Clearance Time Change		District/County	Incident Clearance Time			Number of Incidents	Incident Clearance Time Change	
	2017	2018	2019	2019	2018 to 2019	2017 to 2019		2017	2018	2019	2019	2018 to 2019	2017 to 2019
District 1	***197***	***127***	***139***	***120***	***12***	***-58***	***District 2***	***135***	***111***	***117***	***526***	***6***	***-18***
CRAWFORD	292	156	281	4	*125*	*-11*	CENTRE	150	104	101	201	*-3*	*-49*
ERIE	180	112	123	61	*11*	*-57*	CLEARFIELD	116	111	117	138	*6*	*1*
MERCER	156	146	154	39	*8*	*-2*	CLINTON	172	145	162	100	*17*	*-10*
VENANGO	348	123	127	16	*4*	*-221*	JUNIATA	70	122	117	18	*-5*	*47*
							MIFFLIN	77	88	101	69	*13*	*24*
District 3	***178***	***159***	***103***	***410***	***-56***	***-75***	***District 4***	***124***	***149***	***125***	***331***	***-24***	***1***
COLUMBIA	173	192	91	53	*-101*	*-82*	LACKAWANNA	99	114	103	104	*-11*	*4*
LYCOMING	157	132	81	147	*-51*	*-76*	LUZERNE	129	109	112	149	*3*	*-17*
MONTOUR	260	203	102	24	*-101*	*-158*	PIKE	139	157	142	24	*-15*	*3*
NORTHUMBERLAND	200	169	142	48	*-27*	*-58*	SUSQUEHANNA	114	152	201	50	*49*	*87*
SNYDER	119	157	92	43	*-65*	*-27*	WAYNE	248	199	141	4	*-58*	*-107*
TIOGA	118	177	93	45	*-84*	*-25*							
UNION	214	148	162	50	*14*	*-52*							
District 5	***88***	***96***	***75***	***1670***	***-21***	***-13***	***District 6***	***59***	***63***	***68***	***4548***	***5***	***9***
BERKS	129	127	83	443	*-44*	*-46*	BUCKS*	57	65	76	341	*11*	*19*
CARBON	172	286	133	26	*-153*	*-39*	CHESTER*	61	64	61	463	*-3*	*0*
LEHIGH	64	68	68	634	*0*	*4*	DELAWARE*	63	78	65	596	*-13*	*2*
MONROE	109	138	90	166	*-48*	*-19*	MONTGOMERY*	63	69	71	819	*2*	*8*
NORTHAMPTON	72	80	63	342	*-17*	*-9*	PHILADELPHIA*	56	57	67	2329	*10*	*11*
SCHUYLKILL	244	166	97	59	*-69*	*-147*							
District 8	***80***	***92***	***81***	***2537***	***-11***	***1***	***District 9***	***137***	***122***	***140***	***188***	***18***	***3***
ADAMS	117	125	69	16	*-56*	*-48*	BEDFORD	45	61	76	8	*15*	*31*
CUMBERLAND*	81	84	76	522	*-8*	*-5*	BLAIR	93	115	77	61	*-38*	*-16*
DAUPHIN*	75	89	79	886	*-10*	*4*	CAMBRIA	82	123	84	67	*-39*	*2*
FRANKLIN	96	96	90	98	*-6*	*-6*	FULTON	283	175	496	28	*321*	*213*
LANCASTER	83	113	87	351	*-26*	*4*	SOMERSET	101	109	61	24	*-48*	*-40*
LEBANON*	123	116	112	122	*-4*	*-11*							
PERRY	98	128	95	36	*-33*	*-3*							
YORK	74	76	79	506	*3*	*5*							
District 10	***350***	***197***	***198***	***50***	***1***	***-152***	***District 11***	***66***	***66***	***66***	***1846***	***0***	***0***
BUTLER*	495	124	113	15	*-11*	*-382*	ALLEGHENY*	66	66	66	1834	*0*	*0*
CLARION	301	210	127	14	*-83*	*-174*	BEAVER*	68	117	121	8	*4*	*53*
JEFFERSON*	241	257	306	21	*49*	*65*	LAWRENCE*	147	313	164	4	*-149*	*17*
District 12	***134***	***110***	***113***	***187***	***3***	***-21***							
FAYETTE*	143	199	184	8	*-15*	*41*							
GREENE*	195	94	127	16	*33*	*-68*							
WASHINGTON*	152	115	121	109	*6*	*-31*							
WESTMORELAND	108	104	83	54	*-21*	*-25*							

*- County that has an active Traffic Incident Management (TIM) Team

[22] 2017 numbers will differ from those originally reported in the February 2018 report, as a result of fixing the error regarding which incidents were classified as being on the core roadway network.

Table 18. Incident Clearance Times by Interstate/County – 2017 to 2019

Route/County	Incident Clearance Time			Number of Incidents	Incident Clearance Time Change		Route/County	Incident Clearance Time			Number of Incidents	Incident Clearance Time Change	
	2017	2018	2019	2019	2018 to 2019	2017 to 2019		2017	2018	2019	2019	2018 to 2019	2017 to 2019
I-90	171	124	129	52	5	-42	I-86	273	N/A	N/A	0	#N/A	#N/A
ERIE	171	124	129	52	5	-42	ERIE	273	N/A	N/A	0	#N/A	#N/A
I-376	62	61	61	1036	0	-1	I-70	164	123	193	130	70	-94
ALLEGHENY*	62	60	60	1024	0	-2	BEDFORD	45	17	140	1	123	78
BEAVER*	68	117	121	8	4	53	FULTON	283	175	496	28	321	38
LAWRENCE*	147	313	204	3	-109	57	WASHINGTON*	192	117	122	63	5	-187
MERCER	51	148	80	1	-68	29	WESTMORELAND	108	127	88	38	-39	-146
I-79	122	86	96	361	10	-26	I-80	174	139	136	669	-3	-177
ALLEGHENY*	85	81	85	278	4	0	BUTLER*	N/A	244	N/A	0	#N/A	#N/A
BUTLER*	511	115	114	7	-1	-397	CARBON	172	271	133	26	-138	-310
CRAWFORD	292	156	281	4	125	-11	CENTRE	175	114	139	65	25	-150
ERIE	142	66	87	9	22	-55	CLARION	301	210	127	14	-83	-384
GREENE*	195	94	127	16	33	-68	CLEARFIELD	116	111	117	138	6	-110
LAWRENCE	N/A	N/A	45	1	#N/A	#N/A	CLINTON	202	172	204	69	32	-170
MERCER	114	81	280	5	200	166	COLUMBIA	173	192	91	53	-101	-274
WASHINGTON*	106	109	118	41	9	12	JEFFERSON	241	257	306	21	49	-192
I-279	66	78	68	241	-10	2	LUZERNE	171	136	226	23	90	-81
ALLEGHENY*	66	78	68	241	-10	2	MERCER	172	159	137	33	-22	-195
I-579	53	52	57	16	5	4	MONROE	109	107	86	145	-21	-130
ALLEGHENY*	53	52	57	16	5	4	MONTOUR	260	203	102	24	-101	-361
I-99	120	90	80	132	-10	-40	NORTHUMBERLAND	244	153	197	22	44	-199
BEDFORD	N/A	61	67	7	6	#N/A	UNION	331	162	222	20	60	-271
BLAIR	96	117	79	51	-38	-17	VENANGO	348	123	127	16	4	-344
CENTRE	136	73	82	74	9	-54	I-180	143	122	61	41	-61	-204
I-81	101	109	99	984	-10	-2	LYCOMING	131	123	61	40	-62	-193
CUMBERLAND*	89	97	79	239	-18	-10	NORTHUMBERLAND	187	119	54	1	-65	-252
DAUPHIN*	81	101	95	249	-6	14	I-283	68	88	74	69	-14	-82
FRANKLIN	96	96	90	98	-6	-6	DAUPHIN*	68	88	74	69	-14	-82
LACKAWANNA	98	113	105	78	-8	7	I-83	74	75	73	859	-2	-76
LEBANON*	132	121	121	94	0	-11	CUMBERLAND*	74	72	72	110	0	-74
LUZERNE	114	98	93	117	-5	-21	DAUPHIN*	69	73	67	365	-6	-75
SCHUYLKILL	244	166	97	59	-69	-147	YORK	79	77	79	384	2	-76
SUSQUEHANNA	114	152	201	50	49	87	I-176	316	161	95	13	-66	-382
I-78	88	108	87	436	-21	-1	BERKS	316	161	95	13	-66	-382
BERKS	113	139	105	138	-34	-8	I-380	76	219	117	14	-102	-178
LEBANON*	77	96	79	18	-17	2	LACKAWANNA	65	181	106	8	-75	-140
LEHIGH	77	83	83	175	0	6	MONROE	79	239	132	6	-107	-185
NORTHAMPTON	85	108	71	105	-37	-14	I-84	161	139	129	40	-10	-171
I-76	56	56	58	927	2	2	LACKAWANNA	108	99	100	12	1	-107
MONTGOMERY*	59	62	63	354	1	4	PIKE	139	157	142	24	-15	-155
PHILADELPHIA*	54	51	55	573	4	1	WAYNE	248	199	141	4	-58	-306
I-476	72	79	81	202	2	9	I-676	50	50	65	410	15	-35
DELAWARE*	63	68	67	133	-1	4	PHILADELPHIA*	50	50	65	410	15	-35
MONTGOMERY*	88	101	109	69	8	21							
I-95	60	67	74	1627	7	14							
BUCKS*	58	67	97	111	30	39							
DELAWARE*	61	79	64	417	-15	3							
PHILADELPHIA*	60	63	76	1099	13	16							

*- County that has an active Traffic Incident Management (TIM) Team

Key Takeaways

Both tables are presented to provide insight into areas and locations where incident response and management can be improved. TMC TIM Team involvement needs to be consistently increased on a statewide level.

The Traffic Operations Analytics tool provides an Incident Timeline module which can be used to analyze and better understand incident clearance times at the region, district, route, county, and even municipality level. This is a tool that can be utilized to aid TIM teams in better understanding the timeliness and effectiveness of their incident responses. In addition to incident clearance times, the module calculates the incident influence time, which is defined as the time between when the incident occurs and when traffic returns to normal. This metric provides a better picture of the overall impact of an incident on a route.

Appendix 1 – Congestion Pie Chart Methodology

Methodology

PennDOT's congestion pie chart was developed by utilizing traffic speed data provided by INRIX's flow incident API. While INRIX's exact methodology for conditions that produce a flow incident is proprietary, the general guidelines they issue are traffic speeds that drop below 65% of reference (freeflow) speed for at least 2 minutes, and that a flow incident ends when speeds have returned to greater than 70% of reference speed.

PennDOT's congestion pie chart tool was developed starting with 2018 data and it is limited to routes on PennDOT's Core Roadway Network. All INRIX flow incidents on the Core Roadway Network were brought into the database and correlated to a variety of Department data sources to uncover DOT known "causes":

Data Source	Data Type
Road Condition Reporting System (RCRS)	Traffic Incidents, Roadwork
Maintenance Database	Roadwork
Crash Reporting System (CRS)	Reportable Crashes[23]
Roadway Weather Information System (RWIS)	Inclement Weather

The table below provides the distance and time buffers that were utilized to correlate the causes from various data sources to flow incidents.

Data Type	Distance	Time
Crashes (RCRS + CRS)	2 miles	30 minutes
Weather (RWIS)	15 miles	15 minutes
Work Zone (RCRS)	3 miles	Within start/end time of work zone
Work Zone (Maintenance Database)	3 miles	30 minutes
All Waze Alerts	1 mile	30 minutes

In some cases, multiple potential causes were identified for a single congestion incident. At this time, no special analysis was done to determine a primary cause, or to assign percentages of congestion across the multiple causes. For purposes of this analysis, congestion that correlated to multiple causes, DOT data or crowd-sourced, were classified using the following priority: 1. Crash, 2. Roadwork, 3. Weather

To generate the pie chart, all congestion events were assigned an impact score[24]. The congestion pie charts as presented represent a breakdown of the total impact score by cause.

Known Limitations and Clarifications

- The Core Roadway Network is predominantly limited access, though there are limited signalized areas. There was no effort made to quantify the impact of signals at this time.
- Any recurring congestion due to poor signal timing would fall under recurring congestion for purposes of this tool
- Due to an INRIX data issue, congestion data does not include much of January and February – this, coupled with a milder winter, is the likely cause in the significant reduction in the weather portion of the pie chart from 2018 to 2019
- The original FHWA congestion pie chart was calculated based on vehicle hours of delay
- PennDOT's congestion pie chart tool currently does not take volume into account, although this is planned for a future enhancement

[23] A reportable crash is one in which an injury or a fatality occurs, or if at least one of the vehicles involved required towing from the scene.

[24] The impact score of a congestion event = (event duration) x (length of queue) x (speed drop).

Appendix 2 – District Specific Heavy Congestion Crash Maps

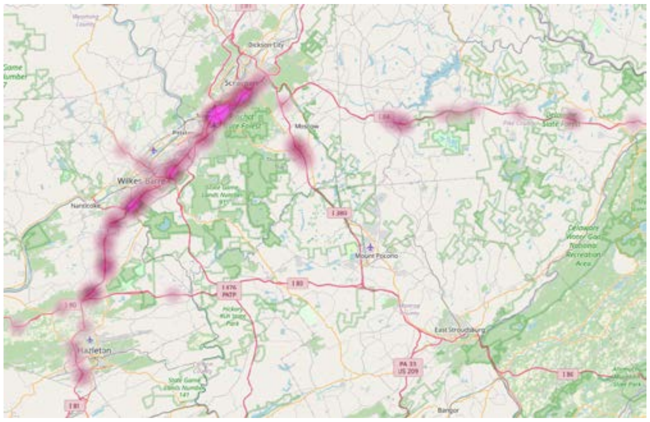
The heat maps provided below are District-specific versions of the statewide map provided in the main body of the report. They illustrate heavy congestion crashes that were not verified in RCRS.

Southeastern Region

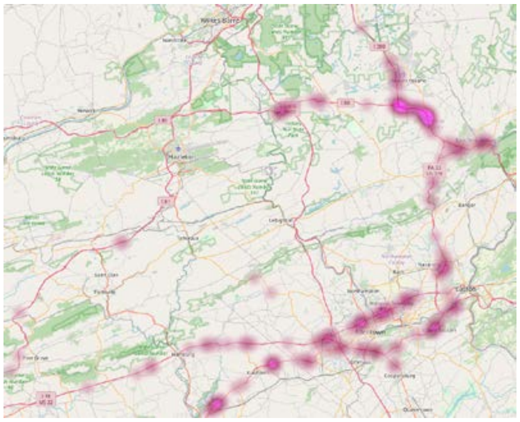
District 6

Eastern Region

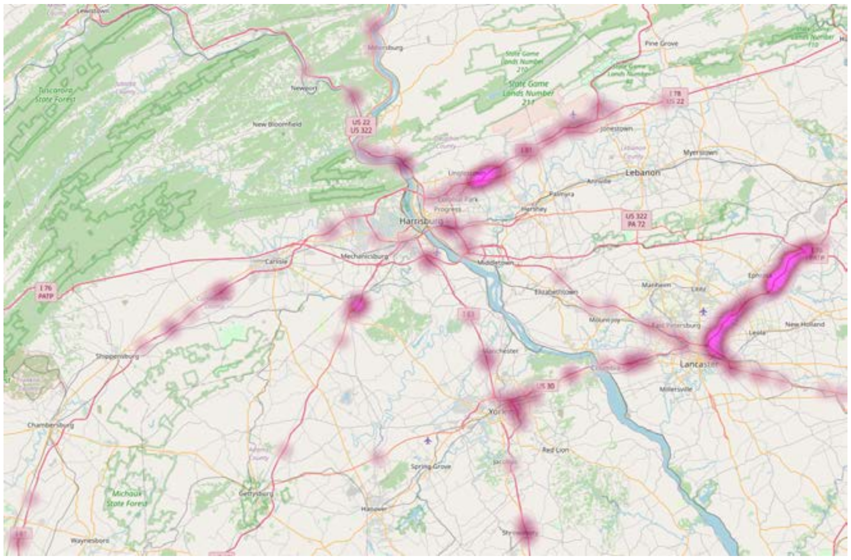
District 4



District 5

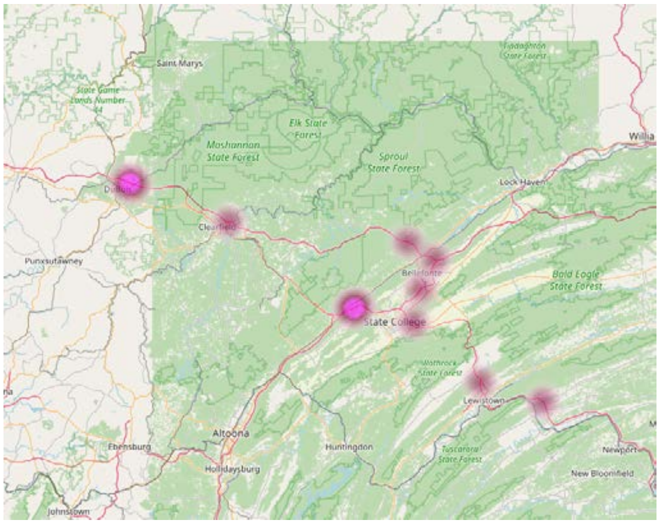


District 8

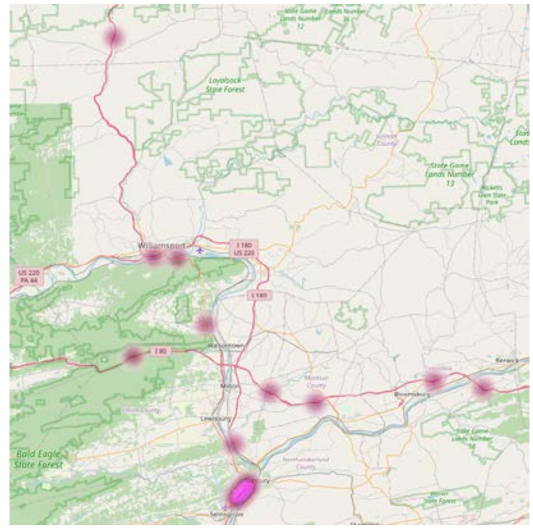


Central Region

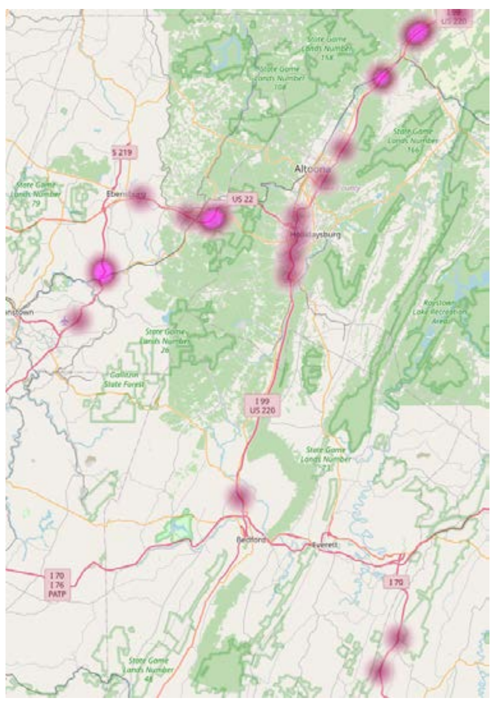
District 2



District 3

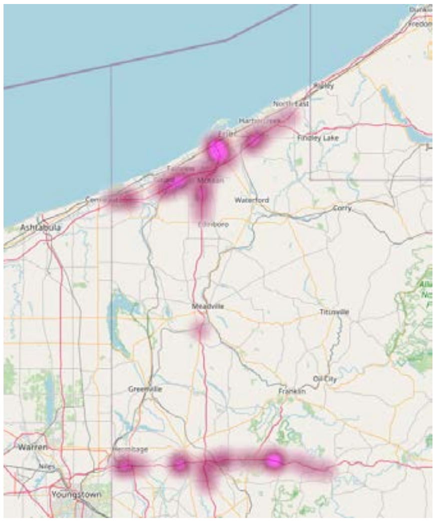


District 9

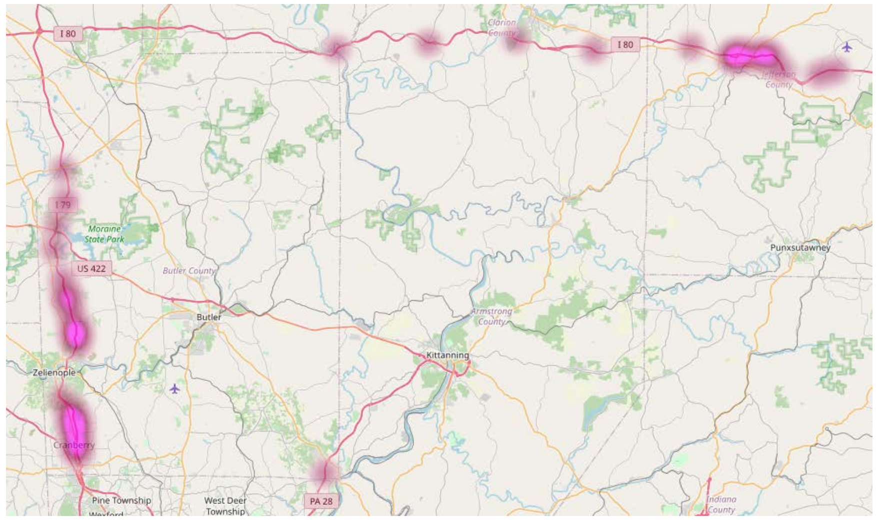


Western Region

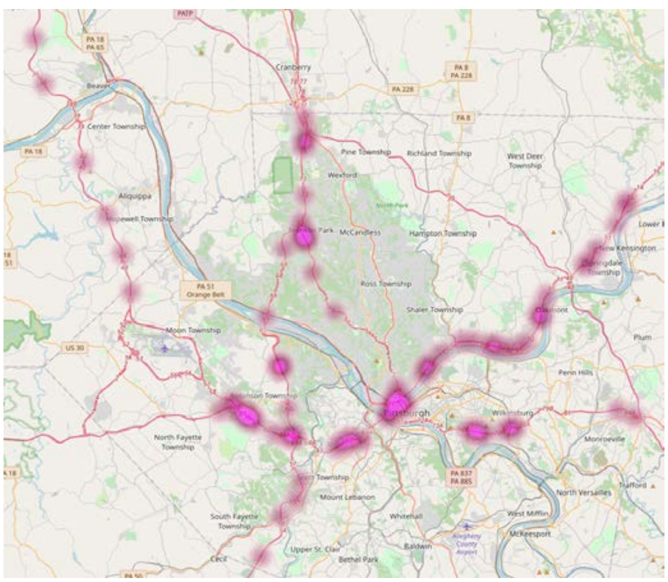
District 1



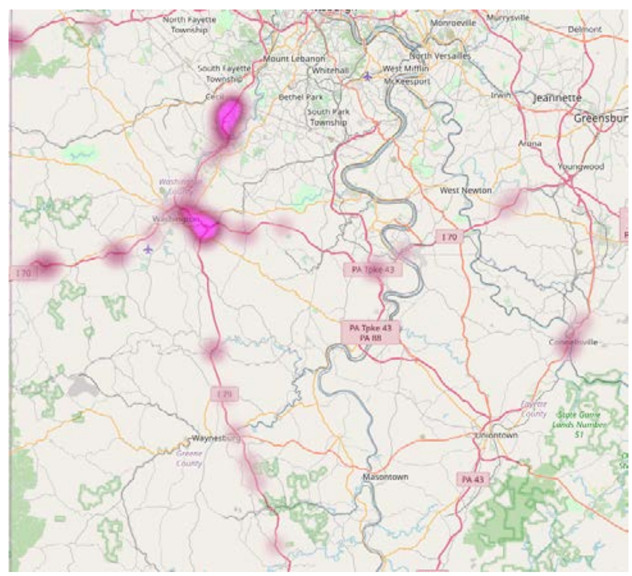
District 10



District 11



District 12



Appendix 3 – Secondary Crash Numbers by District/Region

Southeastern Region

Entire Region

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	72 (16%)	19	26.39%
16-30	50 (11%)	25	50.00%
31-60	103 (23%)	45	43.69%
61+	230 (50%)	117	50.87%
Total	***455***	***206***	***45.27%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	107 (24%)	54	50.47%
.5 to 2	102 (22%)	52	50.98%
2 to 5	102 (22%)	46	45.10%
> 5	144 (32%)	54	37.50%
Total	***455***	***206***	***45.27%***

Eastern Region

Entire Region

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	78 (19%)	15	19.23%
16-30	54 (13%)	17	31.48%
31-60	96 (24%)	50	52.08%
61+	174 (43%)	81	46.55%
Total	***402***	***163***	***40.55%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	119 (30%)	48	40.34%
.5 to 2	101 (25%)	46	45.54%
2 to 5	92 (23%)	38	41.30%
> 5	90 (22%)	31	34.44%
Total	***402***	***163***	***40.55%***

District 4

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	13 (17%)	0	0.00%
16-30	13 (17%)	1	7.69%
31-60	16 (21%)	7	43.75%
61+	33 (44%)	15	45.45%
Total	***75***	***23***	***30.67%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	17 (23%)	4	23.53%
.5 to 2	18 (24%)	9	50.00%
2 to 5	23 (30%)	4	17.39%
> 5	17 (23%)	6	35.29%
Total	***75***	***23***	***30.67%***

District 5

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	27 (16%)	5	18.52%
16-30	22 (13%)	4	18.18%
31-60	45 (26%)	19	42.22%
61+	78 (45%)	30	38.46%
Total	***172***	***58***	***33.72%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	53 (31%)	17	32.08%
.5 to 2	39 (23%)	15	38.46%
2 to 5	37 (21%)	14	37.84%
> 5	43 (25%)	12	27.91%
Total	***172***	***58***	***33.72%***

District 8

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	38 (24%)	10	26.32%
16-30	19 (12%)	12	63.16%
31-60	35 (23%)	24	68.57%
61+	63 (41%)	36	57.14%
Total	***155***	***82***	***52.90%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	49 (32%)	27	55.10%
.5 to 2	44 (28%)	22	50.00%
2 to 5	32 (21%)	20	62.50%
> 5	30 (19%)	13	43.33%
Total	***155***	***82***	***52.90%***

Central Region

Entire Region

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	105 (16%)	24	22.86%
16-30	82 (12%)	29	35.37%
31-60	156 (24%)	64	41.03%
61+	319 (48%)	149	46.71%
Total	***662***	***266***	***40.18%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	181 (27%)	73	40.33%
.5 to 2	147 (22%)	67	45.58%
2 to 5	145 (22%)	60	41.38%
> 5	189 (29%)	66	34.92%
Total	***662***	***266***	***40.18%***

District 2

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	8 (25%)	1	12.50%
16-30	7 (22%)	2	28.57%
31-60	3 (9%)	2	66.67%
61+	14 (44%)	10	71.43%
Total	***32***	***15***	***46.88%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	10 (31%)	4	40.00%
.5 to 2	5 (16%)	3	60.00%
2 to 5	9 (28%)	3	33.33%
> 5	8 (25%)	5	62.50%
Total	***32***	***15***	***46.88%***

District 3

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	1 (8%)	0	0.00%
16-30	3 (25%)	3	100.00%
31-60	2 (17%)	0	0.00%
61+	6 (50%)	3	50.00%
Total	***12***	***6***	***50.00%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	2 (17%)	1	50.00%
.5 to 2	3 (25%)	2	66.67%
2 to 5	5 (41%)	3	60.00%
> 5	2 (17%)	0	0.00%
Total	***12***	***6***	***50.00%***

District 9

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	6 (17%)	0	0.00%
16-30	10 (29%)	0	0.00%
31-60	8 (23%)	0	0.00%
61+	11 (31%)	2	18.18%
Total	***35***	***2***	***5.71%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	21 (60%)	2	9.52%
.5 to 2	6 (17%)	0	0.00%
2 to 5	6 (17%)	0	0.00%
> 5	2 (6%)	0	0.00%
Total	***35***	***2***	***5.71%***

Western Region

Entire Region

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	39 (21%)	2	5.13%
16-30	20 (11%)	10	50.00%
31-60	37 (20%)	26	70.27%
61+	90 (48%)	38	42.22%
Total	***186***	***76***	***40.86%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	59 (32%)	24	40.68%
.5 to 2	40 (22%)	15	37.50%
2 to 5	53 (28%)	22	41.51%
> 5	34 (18%)	15	44.12%
Total	***186***	***76***	***40.86%***

District 1

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	12 (63%)	0	0.00%
16-30	0 (0%)	0	N/A
31-60	1 (5%)	1	100.00%
61+	6 (32%)	1	16.67%
Total	***19***	***2***	***10.53%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	8 (42%)	1	12.50%
.5 to 2	6 (32%)	1	16.67%
2 to 5	4 (21%)	0	0.00%
> 5	1 (5%)	0	0.00%
Total	***19***	***2***	***10.53%***

District 10

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	3 (20%)	0	0.00%
16-30	3 (20%)	1	33.33%
31-60	3 (20%)	1	33.33%
61+	6 (40%)	1	16.67%
Total	***15***	***3***	***20.00%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	6 (40%)	2	33.33%
.5 to 2	3 (20%	0	0.00%
2 to 5	3 (20%)	0	0.00%
> 5	3 (20%)	1	33.33%
Total	***15***	***3***	***20.00%***

District 11

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	22 (19%)	2	9.09%
16-30	11 (9%)	9	81.82%
31-60	28 (24%)	24	85.71%
61+	57 (48%)	34	59.65%
Total	***118***	***69***	***58.47%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	34 (29%)	20	58.82%
.5 to 2	24 (20%)	14	58.33%
2 to 5	36 (31%)	21	58.33%
> 5	24 (20%)	14	58.33%
Total	***118***	***69***	***58.47%***

District 12

Time after Primary Crash			
Time (Minutes)	Total Crashes	Primary Crash in RCRS Prior	%
0-15	2 (6%)	0	0.00%
16-30	6 (17%)	0	0.00%
31-60	5 (15%)	0	0.00%
61+	21 (62%)	2	9.52%
Total	***34***	***2***	***5.88%***

Distance From Primary Crash			
Distance (Miles)	Total Crashes	Primary Crash in RCRS Prior	%
<.5	11 (32%)	1	9.09%
.5 to 2	7 (21%)	0	0.00%
2 to 5	10 (29%)	1	10.00%
> 5	6 (18%)	0	0.00%
Total	***34***	***2***	***5.88%***