

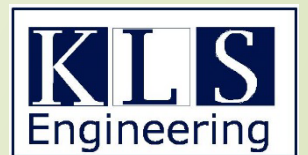
Work Zone Innovations– SMART Only?

Transportation Engineering and Safety Conference
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Prior Speakers

- ▶ Work Zone Data Initiative
- ▶ Work Zone Queues – Impact on Safety
- ▶ How do we ?
 - ▶ Collect Data
 - ▶ Real time/Automated
 - ▶ Accurate/Reliable
 - ▶ Portable
 - ▶ Report Out/Inform (Public, DOT, Others)
 - ▶ Goal
 - ▶ Improve Safety (XX injured or killed today, up XX % over the last 5 years)
 - ▶ Improve Mobility (XX % of non-recurring delay nationwide)

Is Smart Work zones the Answer?

What is a Smart Work Zone?

- ▶ ... provide motorist and workers with “real time” information for improved safety and mobility through the work zone.
- ▶ **Intent of these “Dynamic Systems”**
 - ▶ Supplements existing Static Signs
 - ▶ Automatically identifies less obvious or confusing conditions/hazards
 - ▶ Provides information immediately – appropriate message
 - ▶ Impact Driver Behavior

Many Technologies

- ▶ **Traffic Responsive**
 - ▶ Dynamic Merge (Late/Early)
 - ▶ Queue Warning (Congestion/Stopped Advisory)
 - ▶ Travel Time Information
 - ▶ Ramp Metering
- ▶ **Vehicle Responsive**
 - ▶ Variable Speed Limits
 - ▶ Construction Vehicle Warning
 - ▶ Over Dimensional Warning
 - ▶ Assigned Truck Lanes
 - ▶ Intrusion Warning
 - ▶ Connected Vehicle vs. Automated vs. Autonomous

What Technology is Most Appropriate?

► Well that Depends ...

► Potential problem - Underlying Cause (be Pro-Active or Re-Active)

► Safety

- Back of Queue Crashes
- Construction Vehicles Entering Main Line
- Shoulder deterioration
- Speeding (large speed differential)

► Mobility

- Long Queues
- Excessive Travel Time

► Action Required to Mitigate

► Available Practice/s to Mitigate Action (QW, DL/EM, RM, etc.)

► The Best Is NOT always the Acceptable Practice (e.g., Automated Enforcement, Ramp Metering)

Key Components of a Smart Work Zone?

- ▶ Detect (Radar, Video, etc.)
- ▶ Monitor (including built-in redundancies to eliminate system failure)
- ▶ Communicate
- ▶ Analyze (be clear on the issue you are mitigating – defines the outcome)
- ▶ Manage (database, back up, etc.)
- ▶ Inform (Driver, DOT, Others)
 - ▶ Driven by the desired action you need the driver to take
- ▶ Delivery Means
 - ▶ CMS, Static with Dynamic features, HAR, Media, 511, etc.

Many Technologies

► Traffic Responsive

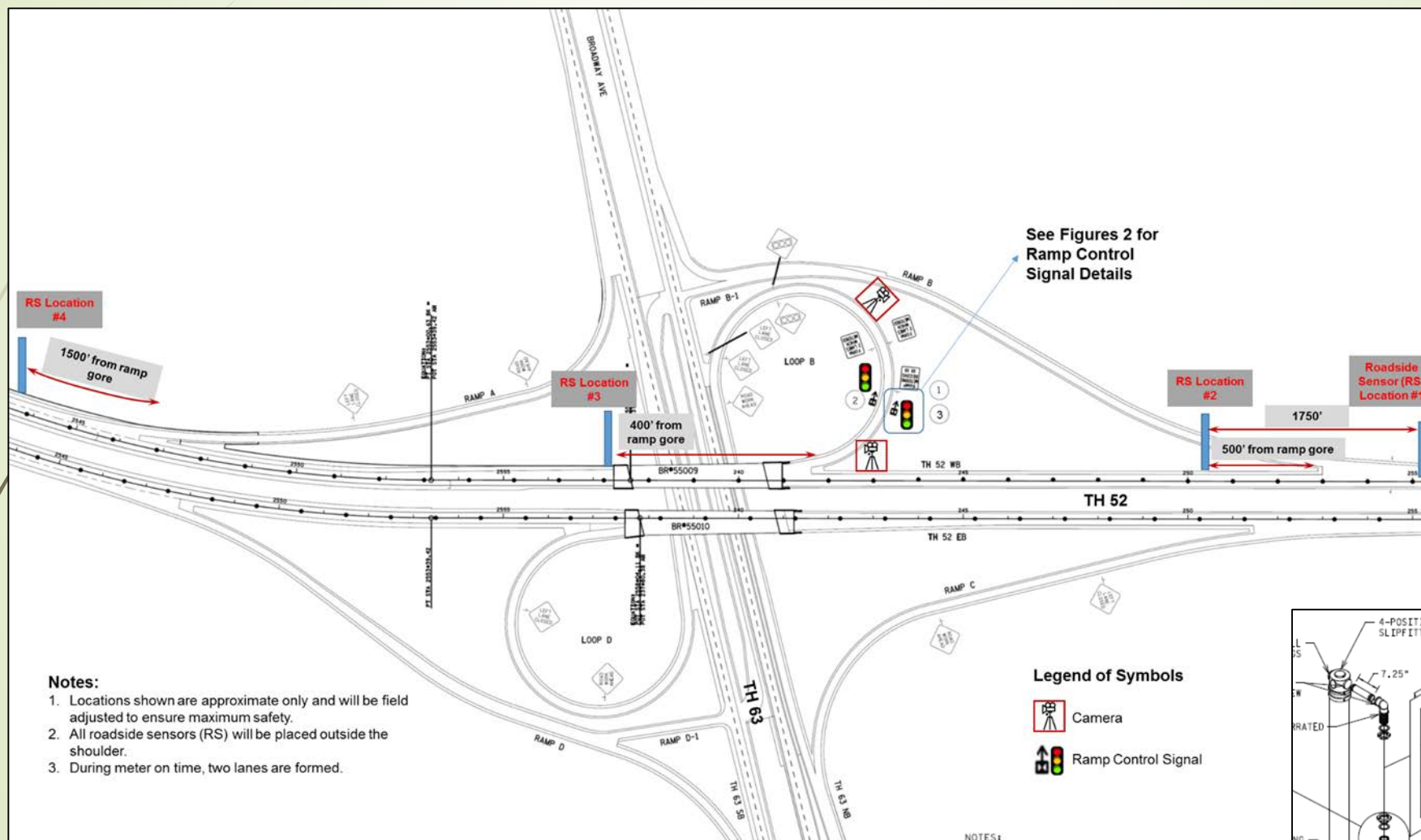
- Dynamic Merge (Late/Early)
- Queue Warning (Congestion/Stopped Advisory)
- Travel Time Information
- **Ramp Metering (Preliminary Data)**

► Vehicle Responsive

- Variable Speed Limits
- Construction Vehicle Warning
- Over Dimensional Warning
- Assigned Truck Lanes **(Preliminary Data)**
- Intrusion Warning
- Connected Vehicle vs. Automated vs. Autonomous

(Discuss briefly the preliminary evaluation for these 2 strategies – Report 2018)

Temp. Ramp Metering (US 52/US 63, MN)

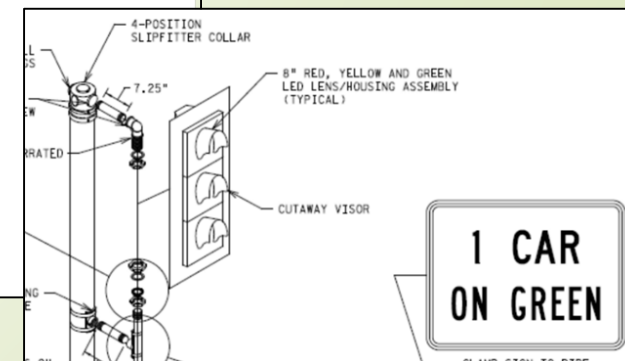


Notes:

1. Locations shown are approximate only and will be field adjusted to ensure maximum safety.
2. All roadside sensors (RS) will be placed outside the shoulder.
3. During meter on time, two lanes are formed.

Legend of Symbols

- Camera
- Ramp Control Signal

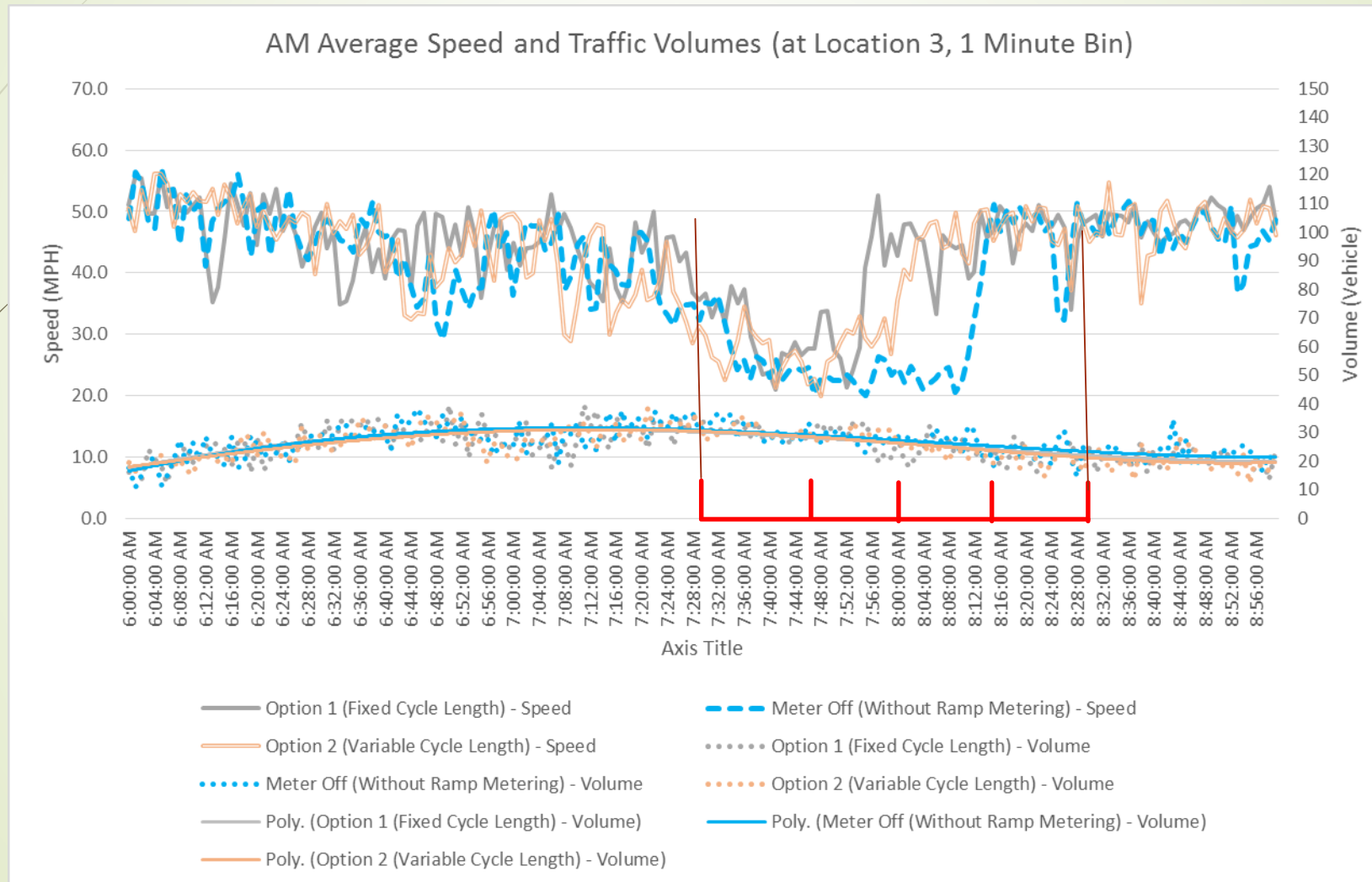


Data Collection (3 weeks each location)

- ▶ Volume
- ▶ Speed
- ▶ Travel Time
- ▶ Classification
- ▶ Headway
- ▶ Compliance
- ▶ Signal Timing Info

(Fixed vs. Variable Time)

Ramp Metering (NCHRP 03 111) – Main Line

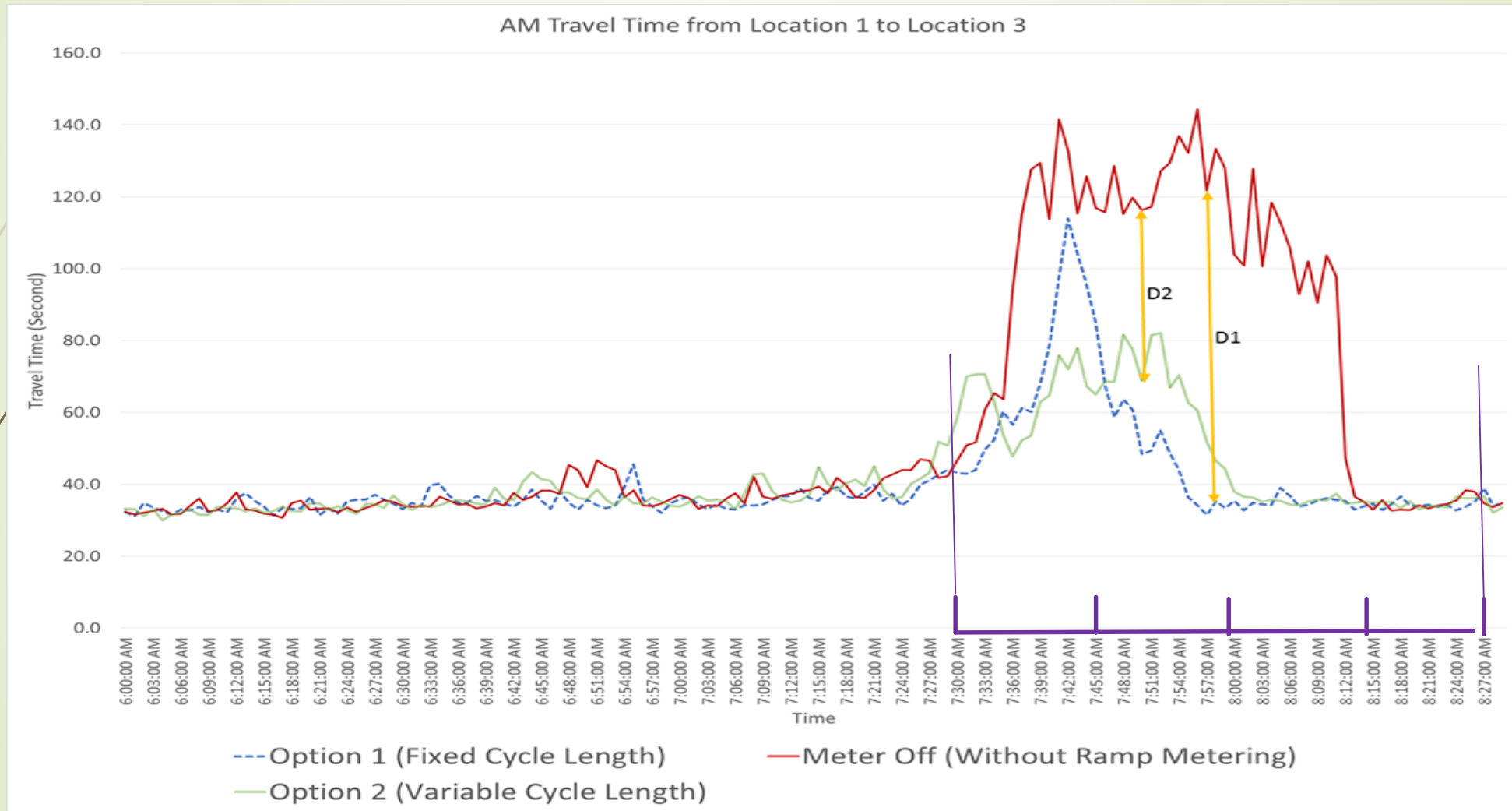


Ramp Metering (NCHRP 03 111) – Speed Comparison

Meter Off (Without Ramp Metering) and Option 1 (Fixed Cycle Length)								
	07:30 to 07:45		07:45 to 08:00		08:00 to 08:15		08:15 to 08:30	
	Meter off	Option 1	Meter off	Option 1	Meter off	Option 1	Meter off	Option 1
Volume (Veh./time period)	450	471	418	436	403	360	342	332
Mean Speed (MPH)	25.61	33.09	22.74	34.31	29.74	45.74	47.28	46.59
85 th Percentile (MPH)	28.17	42.60	26.30	46.04	46.09	50.38	55.20	51.64
SD	6.43	8.38	3.39	10.27	11.44	5.64	8.24	5.82
Mean Speed t_{static}	-5.71		-7.48		-14.63		0.69	

Meter Off (Without Ramp Metering) and Option 2 (Variable Cycle Length)								
	07:30 to 07:45		07:45 to 08:00		08:00 to 08:15		08:15 to 08:30	
	Meter off	Option 1	Meter off	Option 1	Meter off	Option 1	Meter off	Option 1
Volume (Veh./time period)	450	454	418	439	403	367	342	308
Mean Speed (MPH)	25.61	27.20	22.74	26.37	29.74	44.82	47.28	48.52
85 th Percentile (MPH)	28.17	33.87	26.30	31.27	46.09	53.89	55.20	56.05
SD	6.43	6.51	3.39	5.51	11.44	9.47	8.24	7.61
Mean Speed t_{static}	-2.86		-9.20		-16.55		-1.77	

Ramp Metering (NCHRP 03 111) – Main Line

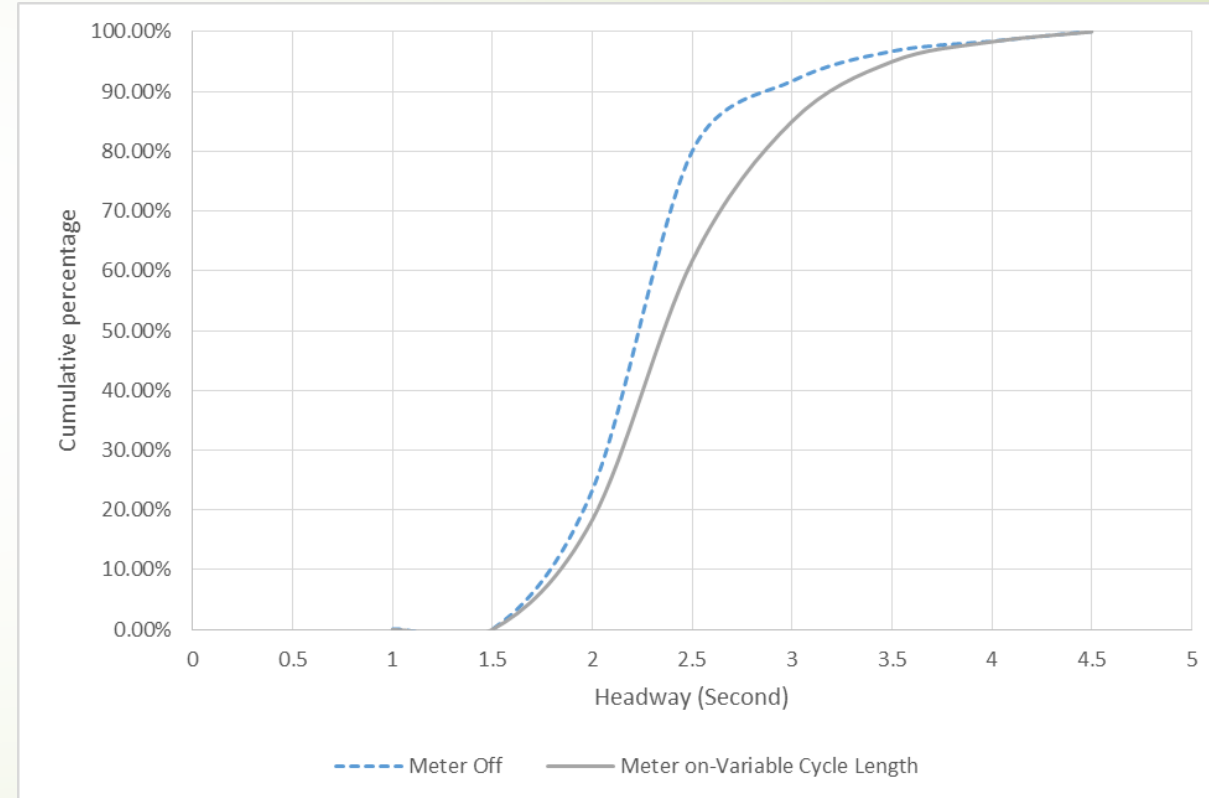
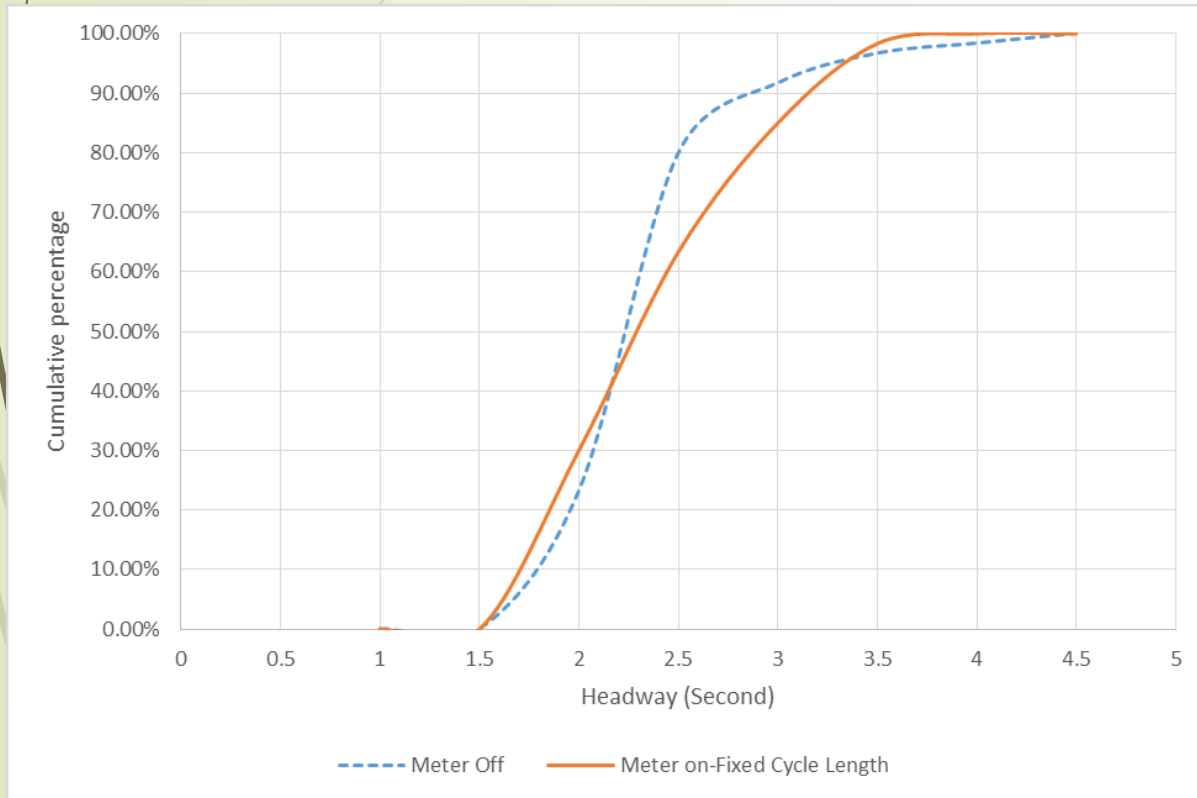


Ramp Metering (NCHRP 03 111)- Travel Time Comparison

Meter off (Without Ramp Metering) and Option 1 (Fixed Cycle Length)								
	07:30 to 07:45		07:45 to 08:00		08:00 to 08:15		08:15 to 08:30	
	Meter off	Option 1	Meter off	Option 1	Meter off	Option 1	Meter off	Option 1
Volume (Veh./Time Period)	450	471	418	436	403	360	342	332
Average Travel Time/Veh. (Second)	95.60	68.62	125.53	50.15	91.73	35.05	34.57	34.60
85 th Percentile Travel Time (Second)	129.29	97.11	133.30	63.36	111.98	36.06	35.66	35.23
SD	34.98	23.74	8.88	15.24	28.63	1.55	1.73	1.51
Mean Speed t_{static}	2.47		16.55		7.66		-0.06	

Meter Off (Without Ramp Metering) and Option 2 (Variable Cycle Length)								
	07:30 to 07:45		07:45 to 08:00		08:00 to 08:15		08:15 to 08:30	
	Meter off	Option 1	Meter off	Option 1	Meter off	Option 1	Meter off	Option 1
Volume (Veh./Time Period)	450	454	418	439	403	367	342	308
Average Travel Time/Veh. (Second)	95.60	64.03	125.53	66.50	91.73	35.62	34.57	34.66
85 th Percentile Travel Time (Second)	129.29	71.90	133.30	81.16	111.98	36.57	35.66	36.11
SD	34.98	9.22	8.88	11.95	28.63	1.05	1.73	1.36
Mean Speed t_{static}	3.38		15.36		7.59		-0.17	

Ramp Metering (NCHRP 03 111)- Headway



Cumulative Headway Distribution Plot – NOT Significant

Driver compliance Rates

- ▶ Fixed cycle length ramp metering—sample size: 445, 63.1 percent compliance
- ▶ Variable cycle length ramp metering—sample size: 376, 76.3 percent compliance

Ramp Metering Conclusion

➤ Conclusion:

- Speeds of vehicles on the mainline increased in both ramp metering scenarios (Significant)
- Travel time became shorter in both ramp metering scenarios (Significant)
- Headways of vehicles on the mainline increased in both ramp metering scenarios (Not statistically significant)
- Driver compliance rate > 60 % (NO enforcement)
- Understand the traffic profile – know when to meter
 - Total Lane Volume < 14-1,600 VPH (Ramp Volume < 400-600 VPH)
 - Examine smaller data bins (< 15 mins)
- Equipment Limitations – Built-in Redundancies

Temp. Truck Lane Restrictions (I 75, MI)

- Reconstruction of 5.6 miles of Interstate-75 (Rehabilitation of three (3) bridges, and replacement of three (3) bridges)



Data Collection (Multiple locations)

- ▶ Volume
- ▶ Speed
- ▶ Classification
- ▶ Headway
- ▶ Compliance

Truck Lane Restrictions (I 75, MI) - Compliance

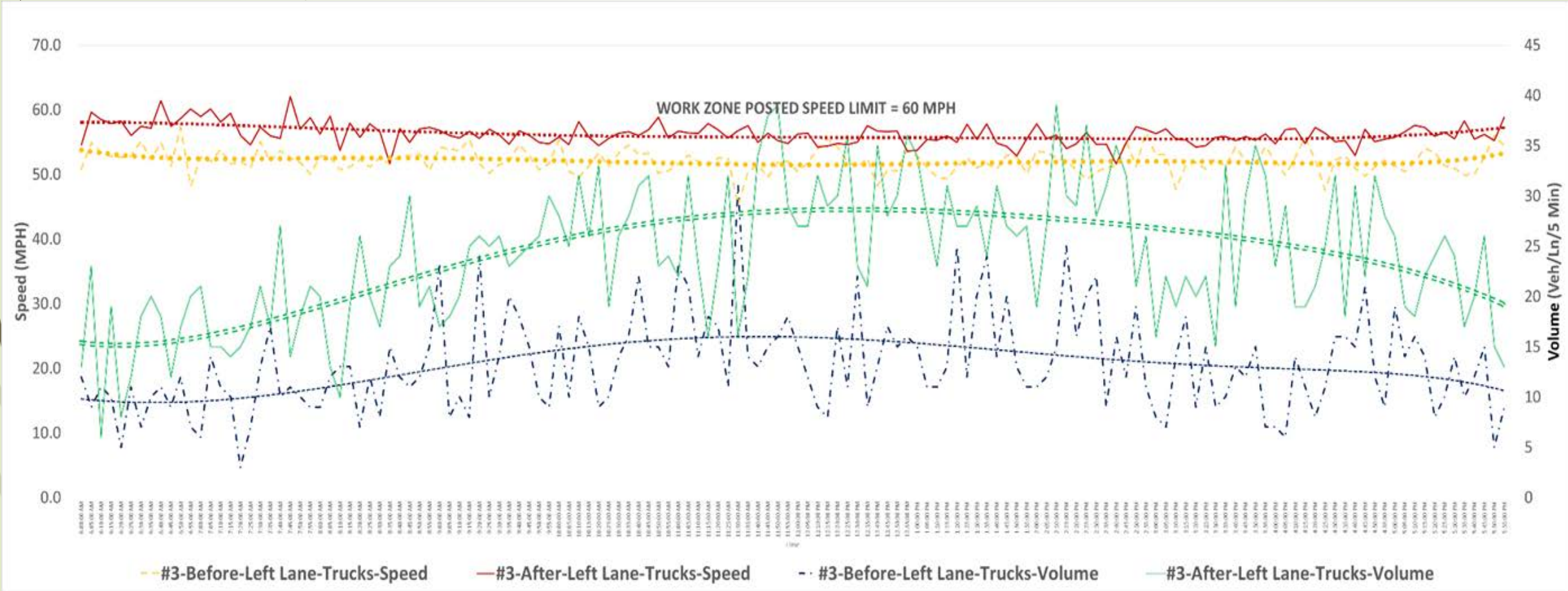
Time	Left Lane – Car Volumes					Left Lane – Truck Volumes				
	Before	After	% Change	Z _{Statistic}	Statistically Significant	Before	After	% Change	Z _{Statistic}	Statistic Significant
0000-0100	200	189	5.5	1.83	Not Significant	193	263	-36.3	-9.59	Significa
0100-0200	140	143	-2.1	1.74	Not Significant	187	246	-31.6	-7.86	Significa
0200-0300	143	144	-0.7	1.19	Not Significant	170	243	-42.9	-9.13	Significa
0300-0400	170	140	17.6	1.56	Not Significant	190	259	-36.3	-7.22	Significa
0400-0500	357	282	21.0	5.95	Significant	226	294	-30.1	-7.52	Significa
0500-0600	545	384	29.5	5.93	Significant	259	405	-56.4	-9.92	Significa
0600-0700	977	755	22.7	7.13	Significant	363	504	-38.8	-9.03	Significa
0700-0800	1125	990	12.0	11.42	Significant	388	620	-59.8	-12.65	Significa
0800-0900	974	818	16.0	8.65	Significant	458	668	-45.9	-12.46	Significa
0900-1000	1017	792	22.1	10.82	Significant	577	844	-46.3	-14.67	Significa
1000-1100	1086	704	35.2	12.07	Significant	546	898	-64.5	-13.79	Significa
1100-1200	1037	654	36.9	12.23	Significant	599	945	-57.8	-15.14	Significa
1200-1300	970	666	31.3	12.05	Significant	532	933	-75.4	-16.83	Significa
1300-1400	965	616	36.2	10.93	Significant	591	850	-43.8	-14.05	Significa
1400-1500	1198	911	24.0	11.16	Significant	554	939	-69.5	-13.93	Significa
1500-1600	1445	1160	19.7	12.02	Significant	432	727	-68.3	-14.82	Significa
1600-1700	1685	1209	28.2	12.45	Significant	480	693	-44.4	-12.62	Significa
1700-1800	1363	1126	17.4	9.19	Significant	421	658	-56.3	-13.48	Significa
1800-1900	554	760	-37.2	8.57	Significant	189	736	-289.4	-14.56	Significa
1900-2000	351	537	-53.0	6.65	Significant	153	647	-322.9	-12.23	Significa
2000-2100	372	402	-8.1	5.09	Significant	240	551	-129.6	-12.20	Significa
2100-2200	551	422	23.4	4.65	Significant	366	488	-33.3	-9.05	Significa
2200-2300	420	448	-6.7	5.85	Significant	215	400	-86.0	-9.59	Significa
2300-2400	381	276	27.6	3.88	Significant	229	417	-82.1	-7.86	Significa
Total	18026	14528				8558	14228			

Truck Lane Restrictions (I 75, MI) – Speed Comparison

Time	Sample Size		Left Lane – Truck Mean Speeds				
	Before	After	Before	After	% Change	T _{Statistic}	Statistically Significant
0000-0300	203	664	53.3	56.9	-6.8	-8.4	Significant
0300-0600	193	425	53.3	56.6	-6.2	-6.2	Significant
0600-0900	752	1340	52.3	57.2	-9.4	-20.2	Significant
0900-1200	1091	1950	52.0	56.0	-7.7	-21.0	Significant
1200-1500	2182	1947	51.9	54.4	-4.8	-17.0	Significant
1500-1800	1952	1522	51.9	55.7	-7.3	-26.3	Significant
1800-2100	1408	1428	52.1	55.9	-7.3	-22.4	Significant
2100-2400	1329	974	52.1	56.5	-8.4	-22.9	Significant

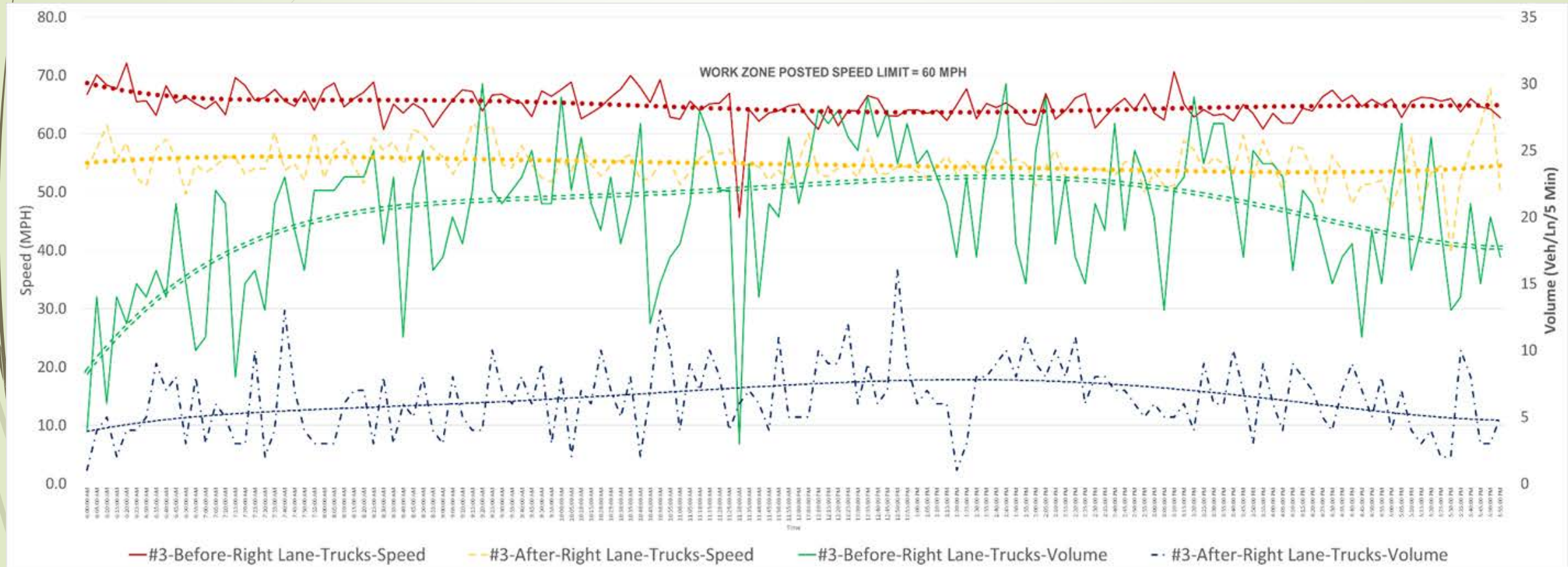
Before-After Truck Mean Speeds—Left Lane

Truck Lane Restrictions (I 75, MI)



Left Lane – Speed & Volume Graph for Trucks with Trend Line, 6.00 AM to 6.00 PM (5 min bin)

Truck Lane Restrictions (I 75, MI)



Right Lane – Speed & Volume Graph for Trucks with Trend Line, 6.00 AM to 6.00 PM (5 min bin)

Truck Lane Restrictions (I 75, MI) – Headway (Left Lane)

Time	C-C & C-T		T-T & T-C	
	Before	After	Before	After
Number of Observations	371	336	199	273
Mean	248.1	271.8	197.5	237.2
Z-score	-2.84094		3.94369	
p-value	.00452		.00008	

Truck Lane Restrictions (I 75, MI)- Conclusion

➤ Conclusion:

- Truck volumes up significantly
- Truck Speeds increased in Left Lane (but below WZ posted Speed Limit)
- Headways for both cars and trucks increased significantly
- Crash data – (being investigated)
- Understand the traffic profile
 - Best when truck traffic is greater than 15-25 % (?) or traffic stream
- Equipment Limitations – Built-in Redundancies
- Need Periodic Enforcement

(Data validation ongoing for other sites)

Lessons Learned?

- ▶ Many Work zone Innovations
- ▶ Understand the Underlying Cause and Action Required to Mitigate
- ▶ Understand the Available Practice/s to Mitigate Action
 - ▶ Build your Knowledge Base (Don't rely on the Contractor)
- ▶ Have a Clear Data Performance Plan
- ▶ Use Feedback Constructively
- ▶ Recognize that No System is Perfect – Build-in Redundancies
- ▶ The Best Is NOT always the Acceptable Practice
- ▶ Document – Share with Others

Thank You

- ▶ Looking for more sites to test
 - ▶ Ramp Metering (XX - PA, I 4 - FL)
 - ▶ Truck Lane Restrictions (2 ongoing)
- ▶ Completed or ongoing evaluation of Smart Work Zones/Technologies please email me

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