APRIL 2019

WIM #44
CSAH 1, MP 8.1
MANHATTAN BEACH, MN

MONTHLY REPORT

Your Destination...Our Priority

WIM Site Location

WIM #44 is located on CSAH 1 near Manhattan Beach in Crow Wing county.

System Operation

WIM #44 was operational for the entire month of April 2019. Volume was computed using all monthly data.

System Calibration

WIM #44 was most recently calibrated on 2015-08-10. Table 1 summarizes the front axle weights of class 9s by lane [1]. Table 1 indicates that the class 9 front axle weights were all within +/- 9% of baseline calibration values for all lane 2 but not lane 1. Figure 1 shows the distribution of gross vehicle weights (GVW) in Class 9 vehicles at this site for the last 12 months of operation [2]. Figure 2 depicts the average front axle weight as a percent difference from the first full month following calibration.

Summary of Volume Statistics

Total Monthly Volume: 25476 | Passenger Vehicles: 18455 | Heavy Commercial Vehicles: 7021

Monthly Average Daily Traffic (MADT): 849 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 234

See Table 2 for vehicle class breakdown

Passenger Vehicles (PVs) and Heavy Commercial Vehicles (HCVs)

Volume trends. EB vehicles typically reached highest volume levels on Tuesdays, with lowest volumes reported on Sundays. WB vehicles typically reached highest volume levels on Tuesdays, with lowest volumes reported on Sundays (see Figure 3 and 4).

Passenger Vehicles (PVs)

Volume trends. On an average 24-hour day (see Figure 5), EB PVs generally reached peak volume levels between 07 AM and 04 PM. Similarly, WB PVs peaked in volume between 03 PM and 05 PM

Heavy Commercial Vehicles (HCVs)

Volume trends. On an average 24-hour day, HCVs traveling EB typically reached peak volume levels between 07 AM and 04 PM, while volume going WB peaked between 03 PM and 05 PM. See Figure 6. Out of all HCVs, the two highest traffic volumes were generated by Class 5's and Class 8's.

Overweight HCVs

Volume trends. Of a total of 7021 HCVs, 73 of them were overweight [3]. These overweight HCVs contributed to 0.3% of total monthly volume, and 1.1% of total monthly HCV volume. EB overweight vehicles typically reached highest numbers on Tuesdays, with lowest volumes reported on NAs. WB overweight vehicles tended to reach highest volumes on Mondays, with lowest volumes reported on NAs. See Figure 3 .
The top two overweight violators by class were the class 6 and class 10 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 60.3% of all overweight vehicles traveling WB this month (see Figure 7 & 8). Figure 9 shows the number of vehicles exceeding 88,000 pounds that crossed the WIM over the last 12 months. The highest number of 88,000+ vehicles within the last 12 months occurred in January.
WIMs are currently used as a screening tool for weight enforcement, and it is estimated that the WIM scales can measure gross vehicle weights (GVW) within 90-95% of static weight scale measurements. Due to the possibility of measurement error, vehicles exceeding 10% of their legal weight limits (or 1.1 times their legal weight limits) are considered overweight in this report [4].
Using normal load limits ,4 EB vehicles exceeded 88,000 pounds (3 vehicles were Class 10's; 1 vehicles were Class 9's). Of vehicles traveling WB,

5 EB vehicles exceeded 88,000 pounds (3 vehicles were Class 10's; 1 vehicles were Class 9's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from April 2019.

Loaded vs. Unloaded HCVs. Figure 10 shows the GVW distributions of Class 9s and 10s in April 2019. Data suggests that there were greater numbers of fully_loaded Class 9's than empty Class 9's traveling EB, while there were more fully_loaded Class 9's than empty traveling WB. Data also suggests that there were more fully_loaded Class 10's than empty traveling in the EB direction. In the WB direction, there were more fully_loaded class 10 vehicles.

Freight Totals. A total of 10766 tons of freight was recorded to have crossed the WIM. More freight was shipped EB (56.4%) than WB (43.6%). See Table 4 and Figure 11 for more freight information.

Infrastructure Considerations

Bridge. Bridge No. 95425 (a precast pipe arch) is approximately 3.45 miles south west from WIM #44. Bridge No. 95426 (a precast pipe arch) is approximately .08 miles sw of WIM #44. WIM #44 recorded a total of 25476 vehicles with a combined GVW of 179514 kips (1 kip = 1,000 pounds = 0.5 tons) in April 2019. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 787 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 50.3% of all ESALs were recorded EB while 49.7% was observed WB. In particular, 34% of all ESALs were generated by the Class 5's (Class 5's were also responsible for generating 31% of total GVW observed this month). See Table 6

and Figures 14-15 for more information on ESALs (Table 6 also provides flexible ESAL factors for each vehicle class using a terminal serviceability of 2.5 and a structural number of 5).

WIM monthly reports can be found at: http://www.dot.state.mn.us/traffic/data/reports-monthly-wim.html

MnDOT's vehicle classification scheme and vehicle class groupings for traffic forecasting can be found at: http://www.dot.state.mn.us/traffic/data/data-products.html#weight

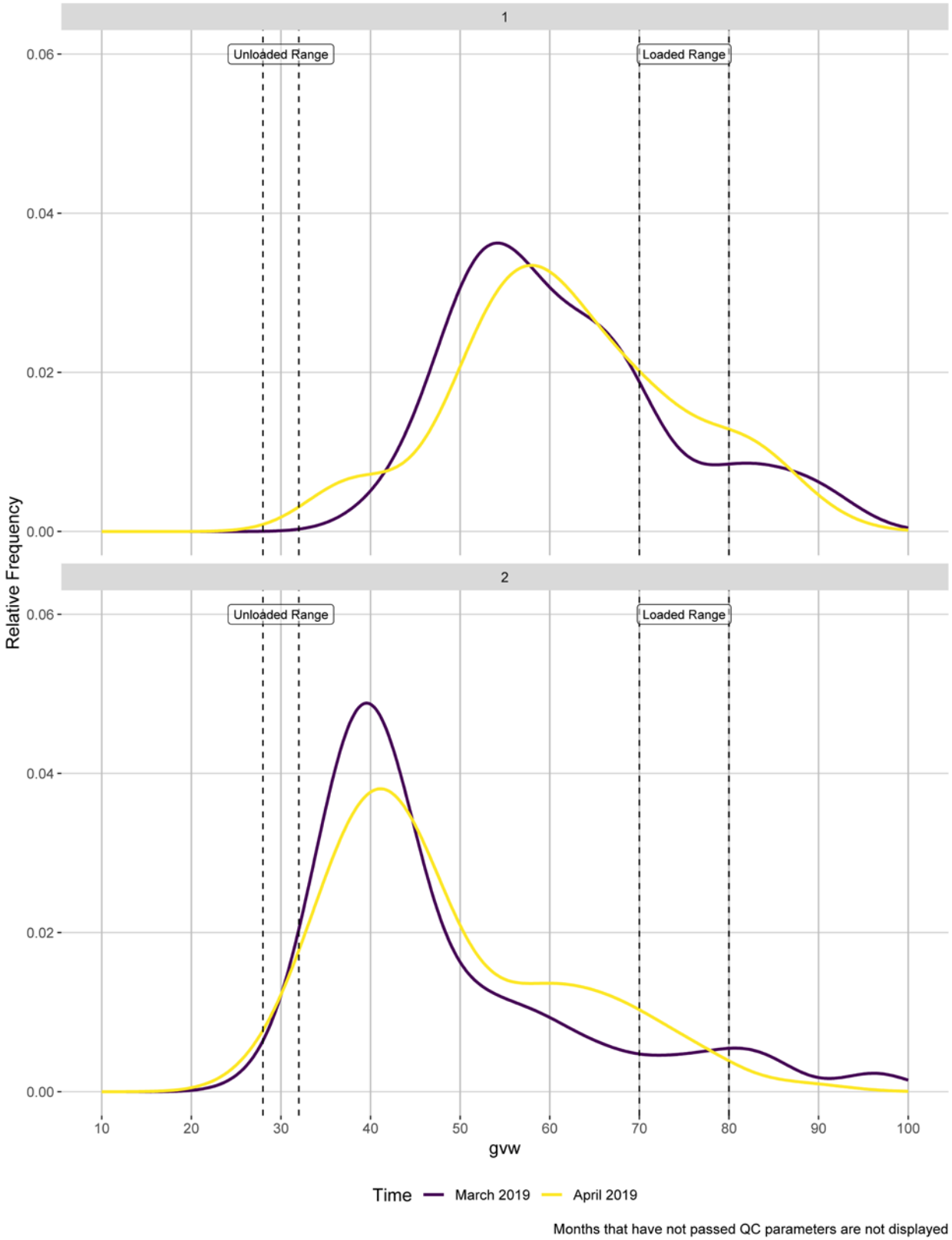
- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

- [2] Previous WIM research indicates that unloaded Class 9s typically weigh 28-32 kips, while loaded Class 9s generally fall in the 70-80 kip range. More recent data from several WIM sites suggests that the unloaded Class 9 range may have moved a little higher over time (due to increased presence of sleeper cabs, etc.), although these ranges are also thought to be site-specific.

- [3] An HCV is considered overweight during normal load limits in this report if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 80,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 20,000 pounds; tandem axles spaced 8' or less = 34,000 pounds; tridem axles spaced 9' or less = 43,000 pounds; quad axles spaced 13' or less = 51,000 pounds). Monthly reports use this standard regardless of the time of year however, the Winter Load Increase (WLI) allows a 10% across the board increase in axle and gross vehicle weights without a permit on US, state routes, and county roads. An HCV is considered overweight during Winter Load Increase(WLI) if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 88,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 22,000 pounds; tandem axles spaced 8' or less = 37,400 pounds; tridem axles spaced 9' or less = 47,300 pounds; quad axles spaced 13' or less = 56,100 pounds). An overweight HCV is only included once in the overweight volume calculations regardless of how many of the aforementioned conditions are violated. For information on MN weight limit dates and statutes: http://www.mrr.dot.state.mn.us/research/seasonal_load_limits/sllindex.asp

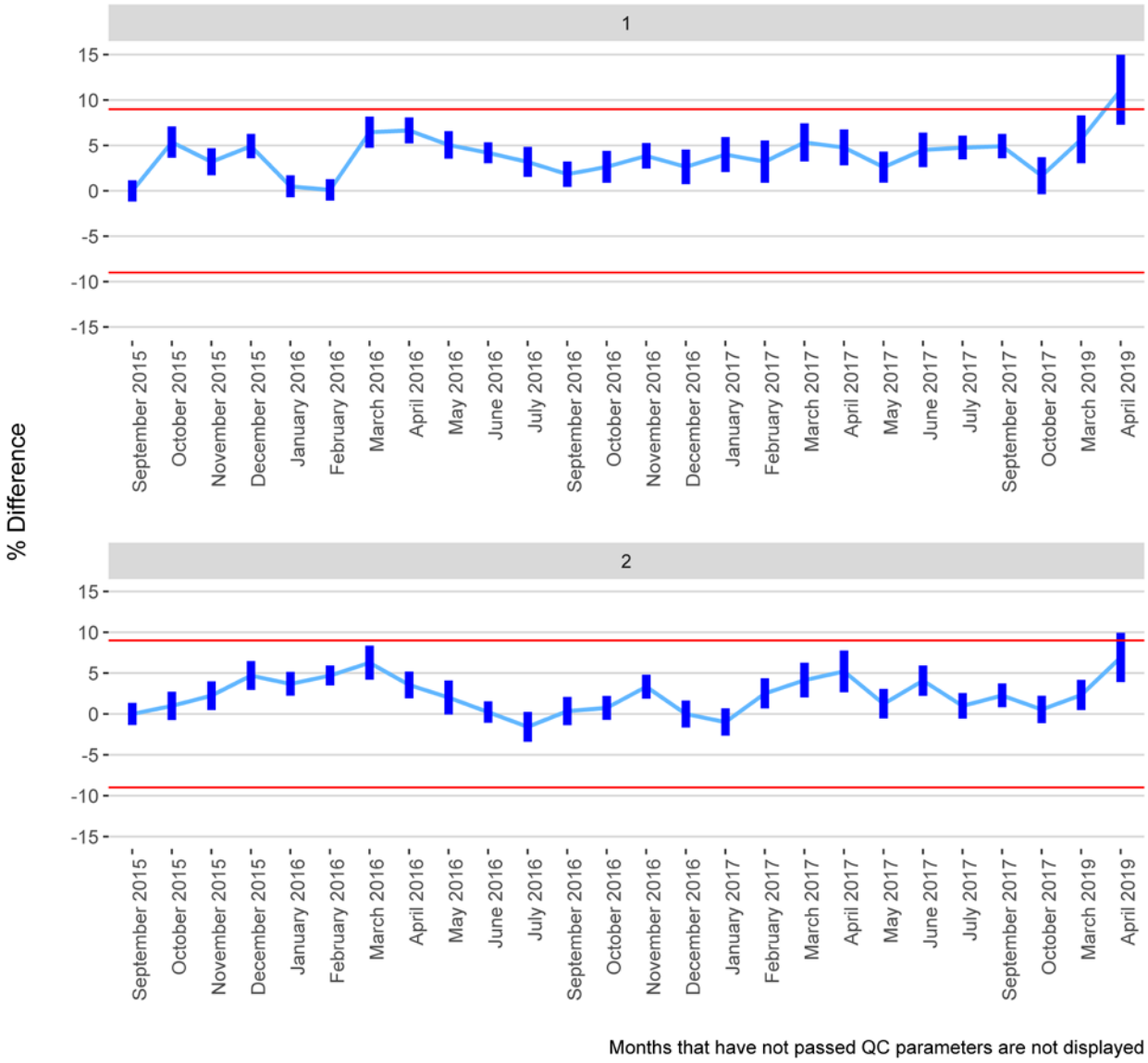
- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened (e.g., 80,000 lbs + 8,000 lbs = 88,000 lbs). Similarly during WLI vehicles weighing 96,800 lbs should be screened.

Figure 1 - Monthly Class 9 GVW Histogram



Months that have not passed QC parameters are not displayed

Figure 2 - Percent Difference of Front Axle Weight from Last Calibration (+/- 95% CI)



Months that have not passed QC parameters are not displayed

Figure 2 - Average Vehicle Volume vs. Day of the Week

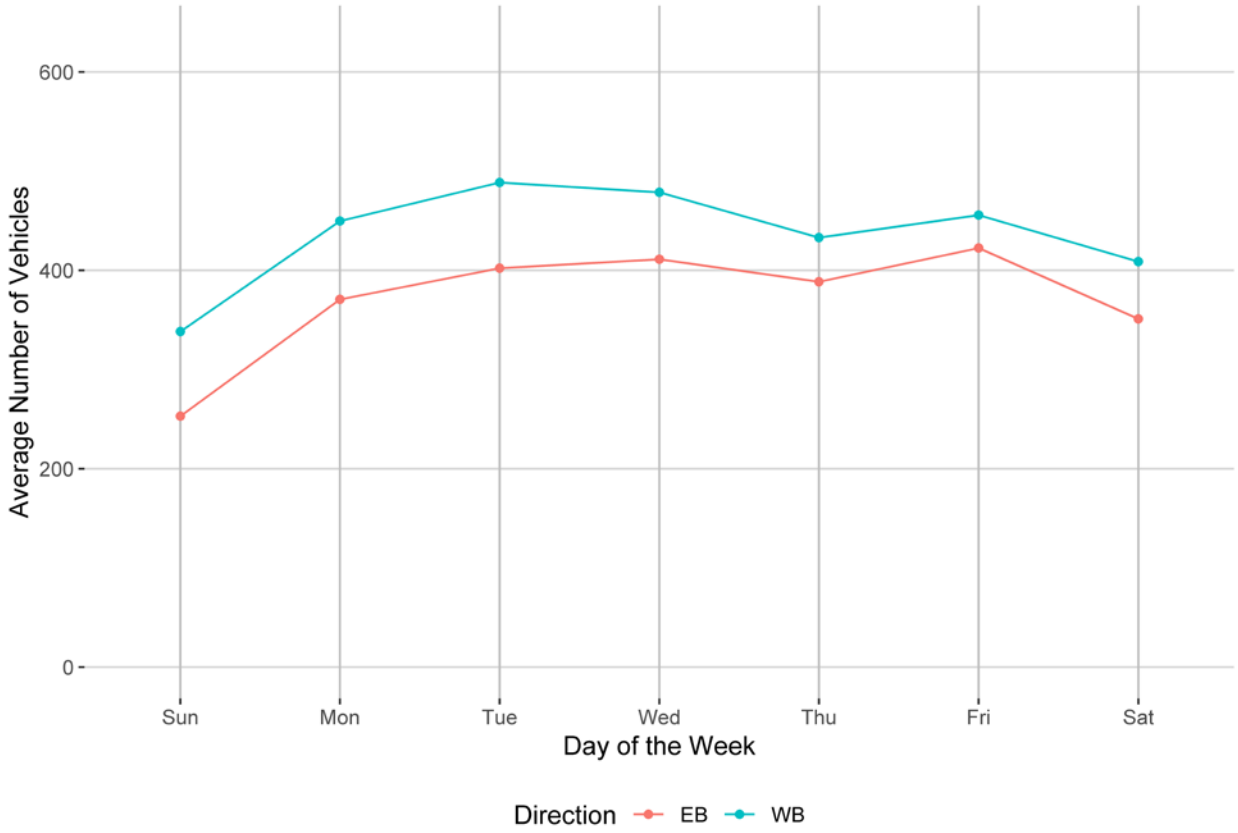


Figure 3 - Average Overweight Vehicle Volume vs. Day of the Week

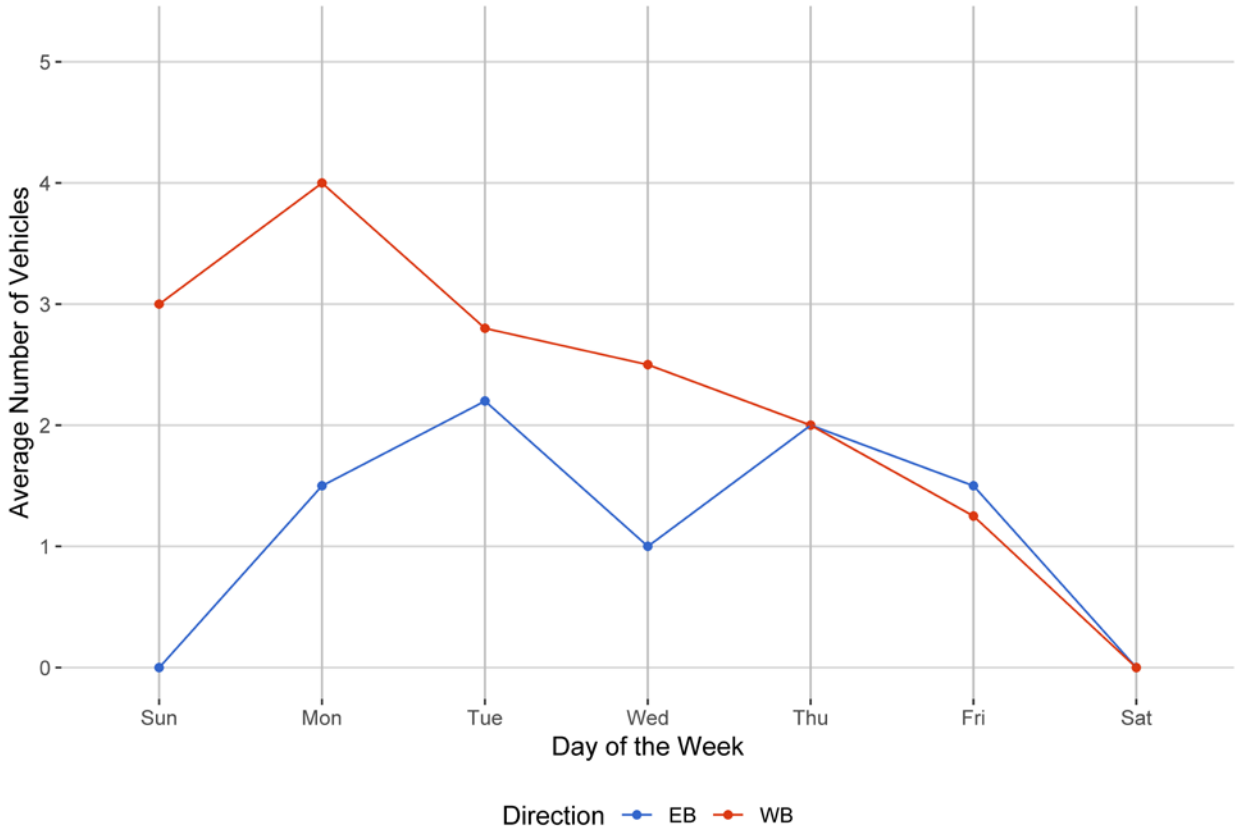


Figure 4 - Passenger Vehicles vs. Hour of the Day

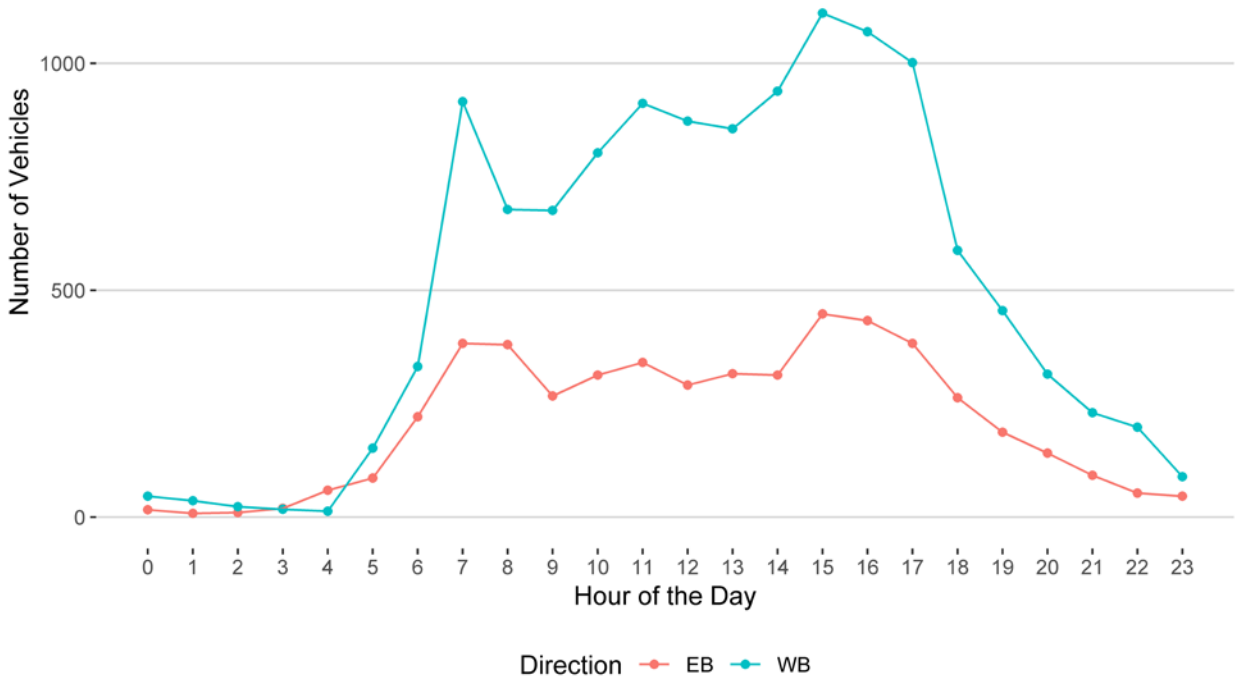


Figure 5 - Heavy Commercial Vehicles vs. Hour of the Day

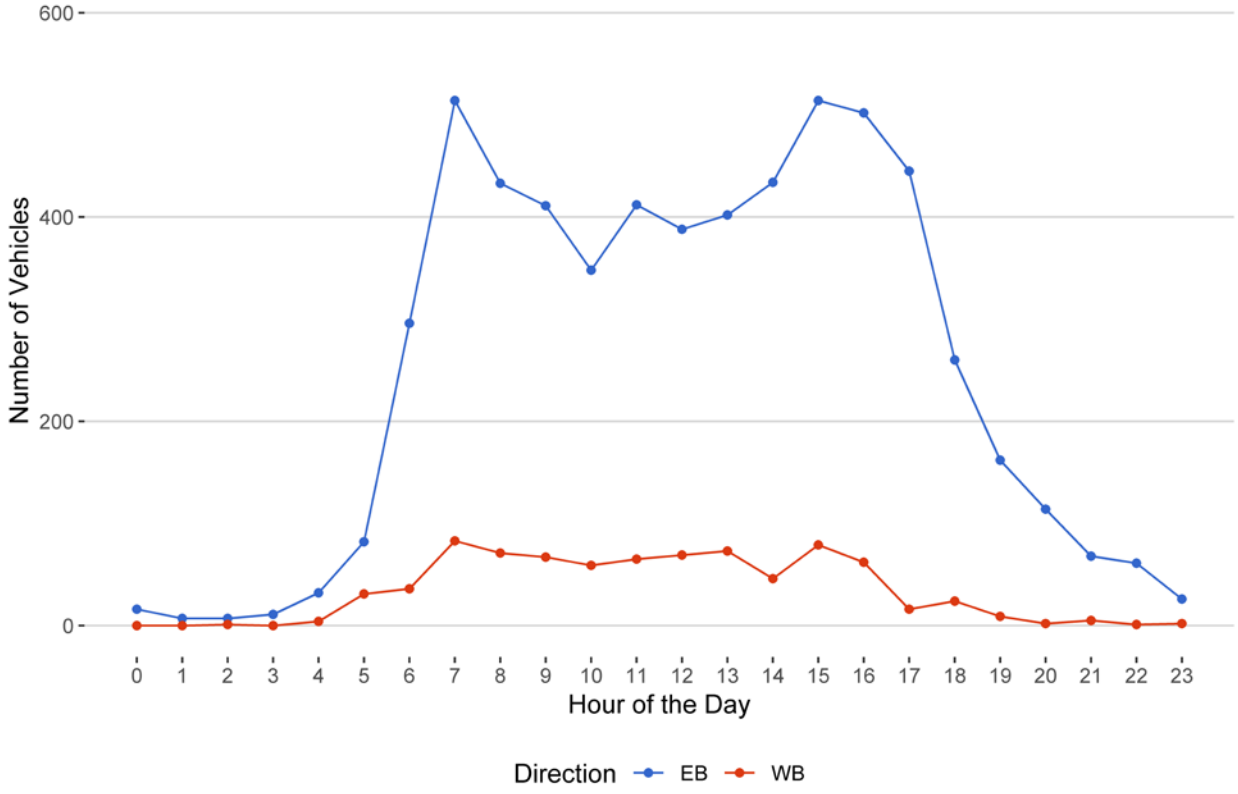


Figure 6 - Overweight Vehicles by Class
vs. Hour of the Day

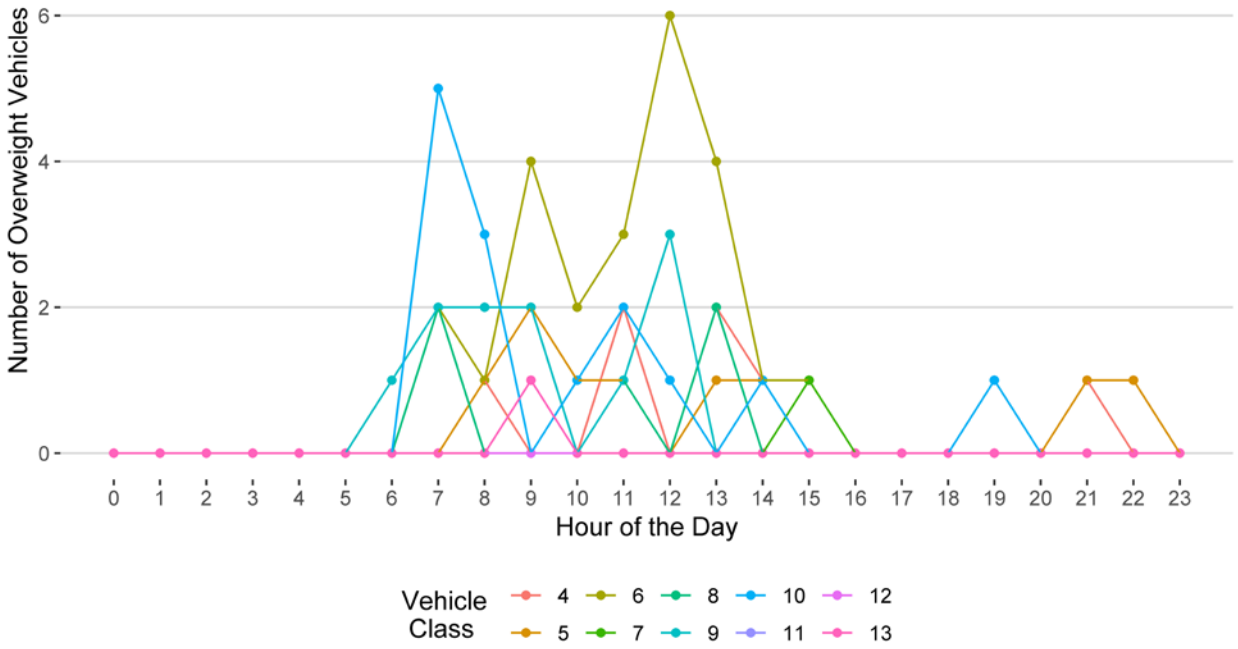


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

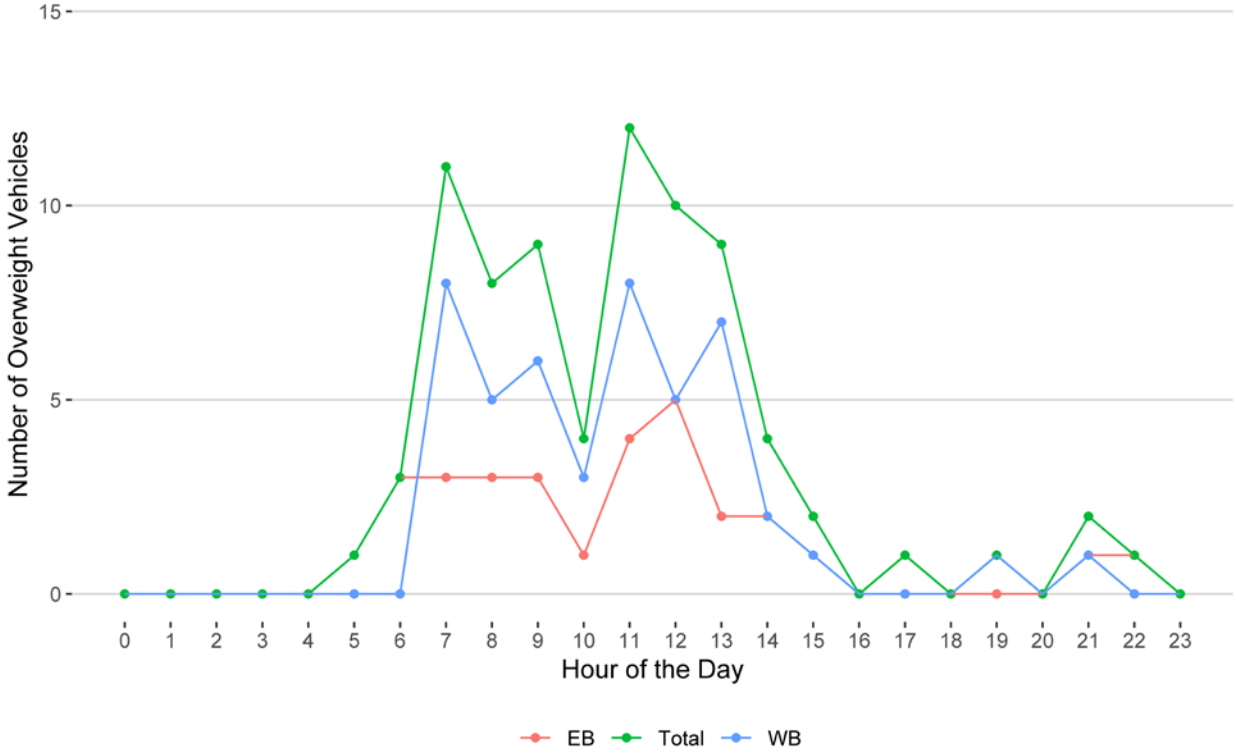
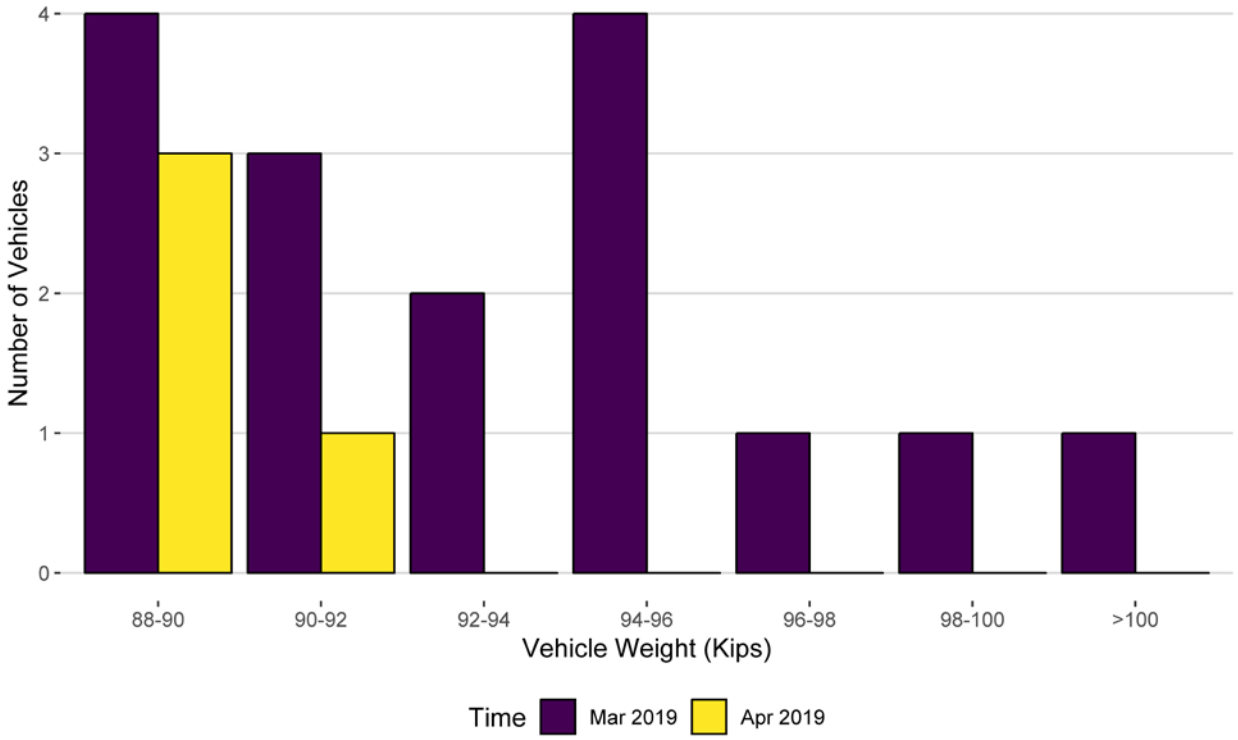
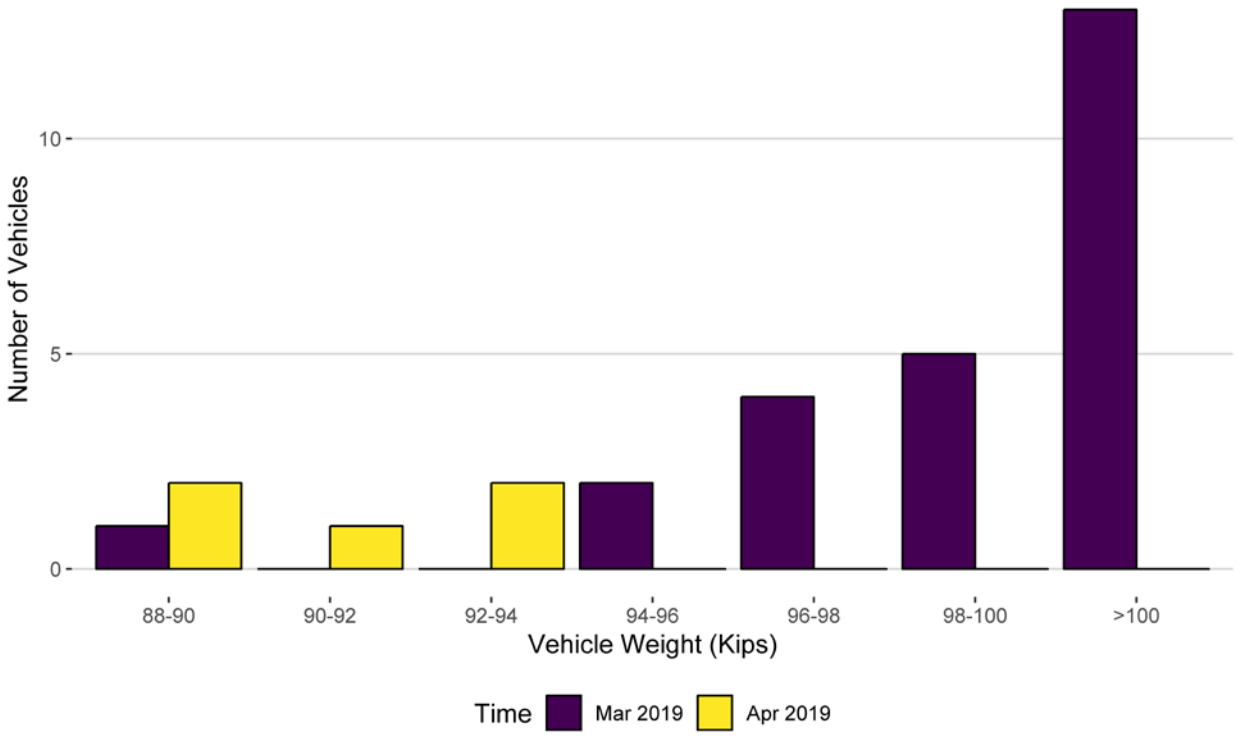


Figure 8 - Histogram of EB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Mar 2019*	*Apr 2019*
88-90	4	3
90-92	3	1
92-94	2	0
94-96	4	0
96-98	1	0
98-100	1	0
>100	1	0
Total	16	4

Figure 8 - Histogram of WB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Mar 2019*	*Apr 2019*
88-90	1	2
90-92	0	1
92-94	0	2
94-96	2	0
96-98	4	0
98-100	5	0
>100	13	0
Total	25	5

Figure 8 - Class 9's and 10's by Direction vs Gross Vehicle Weight

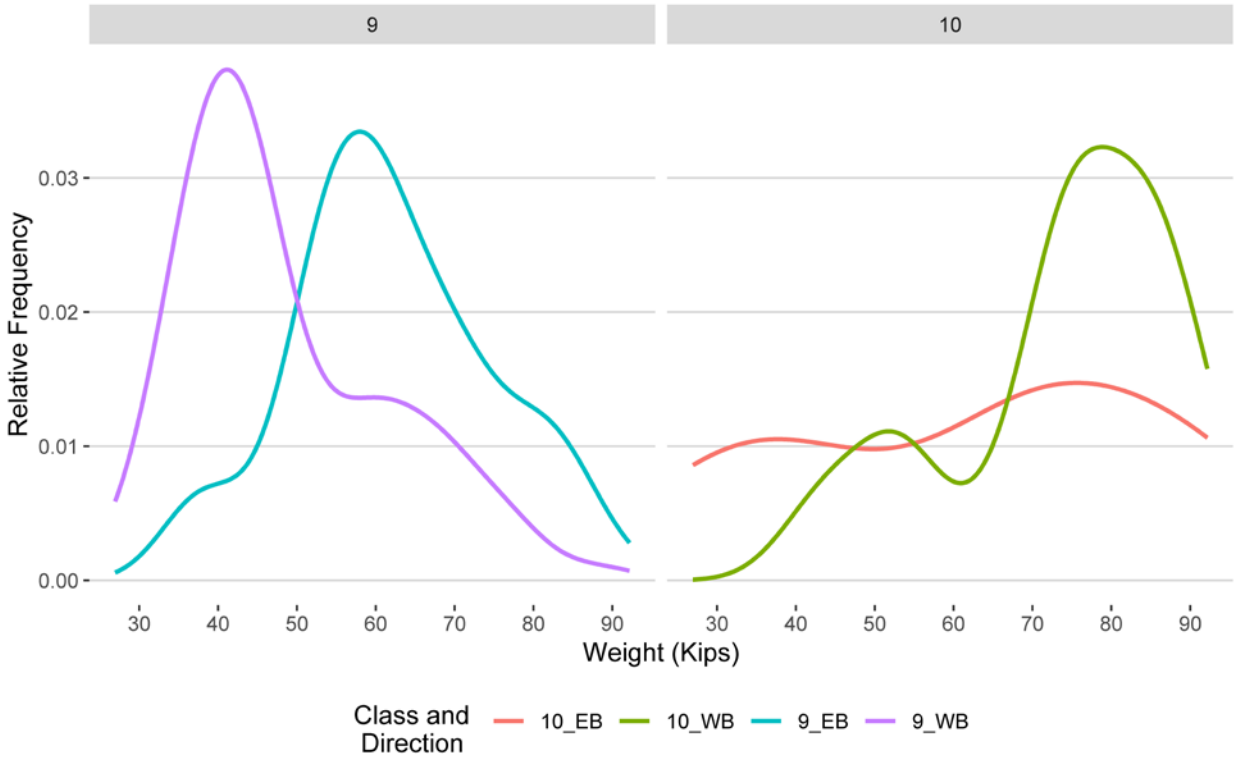


Figure 9 - Freight Percentage by Direction and Class

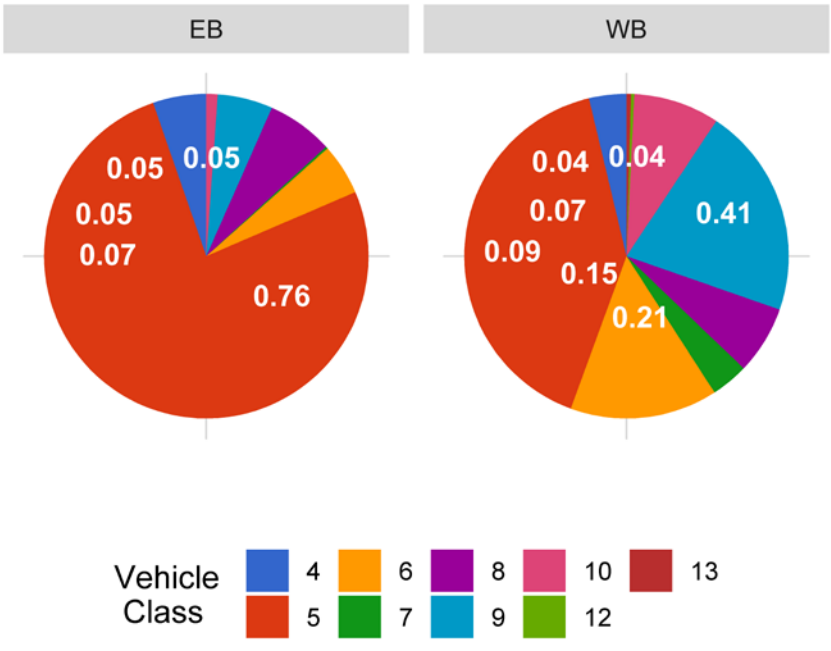


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

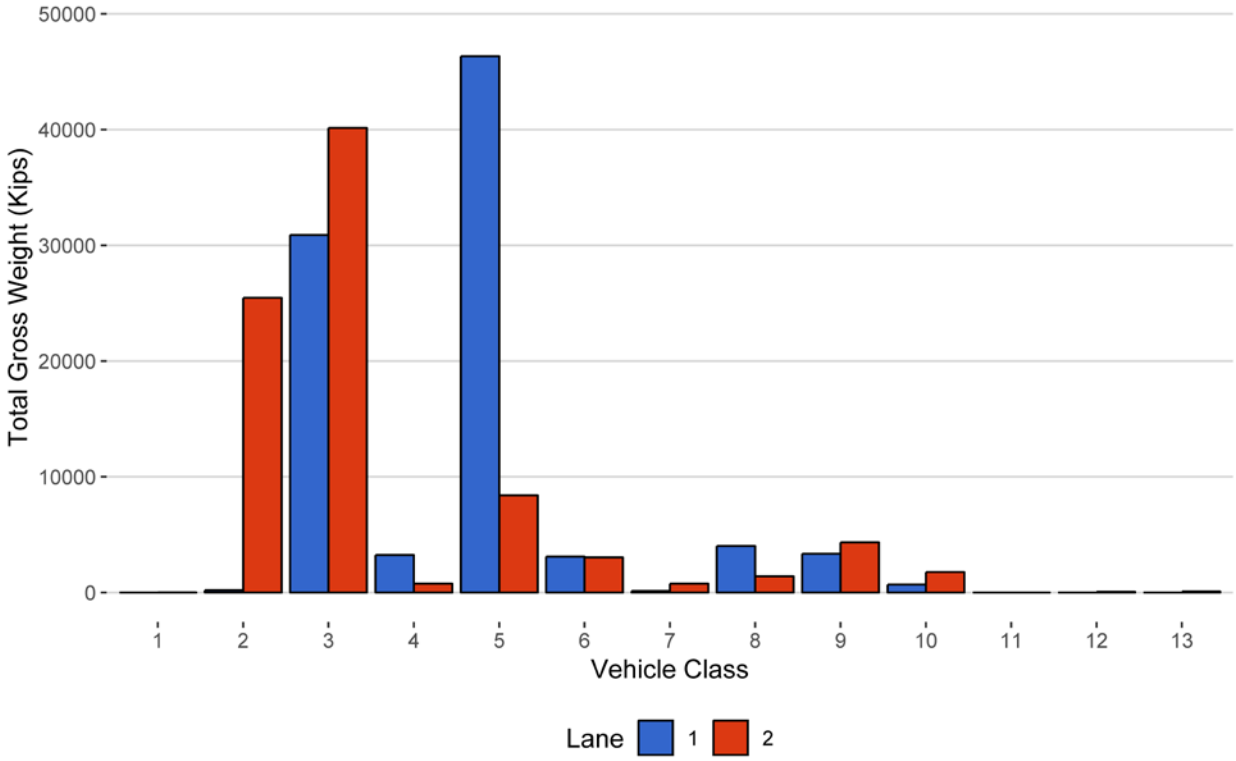


Figure 11 - Total Gross Vehicle Weight b

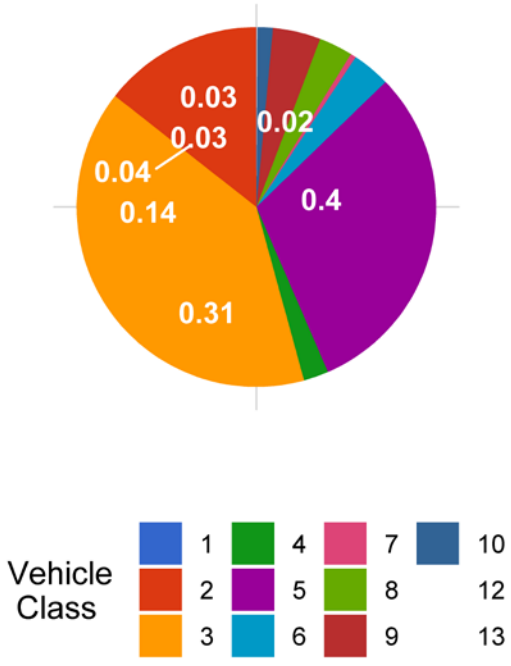


Figure 12 - Total ESALs by Class and Lane

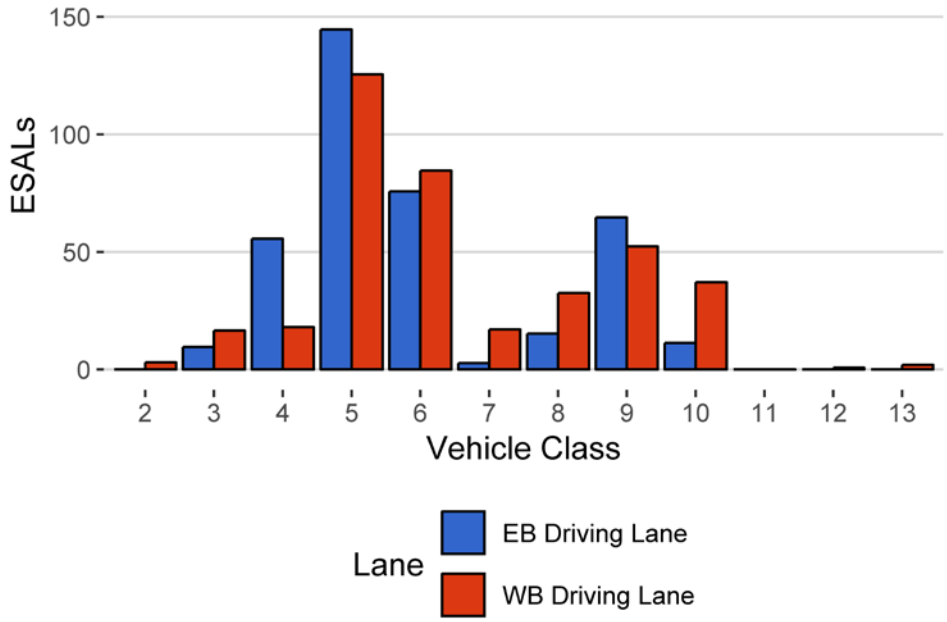


Figure 13 - ESALs by Class

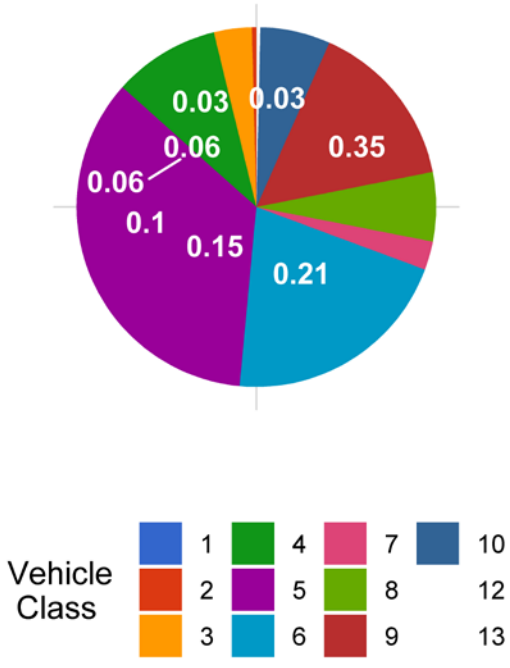


Table 1 Class 9 Front Axle Weight by Lane

Month	*Lane 1 (Kips)*	*Front Axle +/- 9%*	*Lane 2 (Kips)*	*Front Axle +/- 9%*
September 2015	10.51	0.00	10.69	0.00
October 2015	11.07	5.36	10.79	0.99
November 2015	10.85	3.20	10.93	2.24
December 2015	11.03	4.92	11.19	4.71
January 2016	10.56	0.50	11.08	3.69
February 2016	10.52	0.10	11.19	4.71
March 2016	11.19	6.46	11.36	6.28
April 2016	11.21	6.66	11.07	3.55
May 2016	11.04	5.06	10.90	2.02
June 2016	10.95	4.18	10.71	0.24
July 2016	10.84	3.19	10.52	-1.58
September 2016	10.70	1.83	10.72	0.36
October 2016	10.79	2.64	10.77	0.75
November 2016	10.92	3.86	11.04	3.35
December 2016	10.79	2.64	10.69	0.00
January 2017	10.93	4.00	10.58	-0.98
February 2017	10.85	3.21	10.96	2.52
March 2017	11.07	5.33	11.13	4.15
April 2017	11.01	4.78	11.24	5.21
May 2017	10.78	2.61	10.82	1.25
June 2017	10.98	4.51	11.12	4.08
July 2017	11.01	4.77	10.79	0.99
September 2017	11.03	4.93	10.93	2.27
October 2017	10.68	1.65	10.74	0.55
March 2019	11.10	5.66	10.93	2.33
April 2019	11.68	11.13	11.43	6.93

Table 2 Vehicle Classification Data

Vehicle Class	*Monthly Average Daily Volume*	*Monthly Total Volume*	*Monthly Total Volume Percentage*	*Monthly Total Overweight Vehicles*	*Monthly Total Overweight Percentage*
1	0	7	0	0	0
2	229	6880	27	0	0
3	386	11567	45.4	0	0
4	6	170	0.7	7	9.6
5	206	6179	24.3	9	12.3
6	5	160	0.6	24	32.9
7	1	16	0.1	2	2.7
8	10	310	1.2	5	6.8
9	5	149	0.6	11	15.1
10	1	36	0.1	14	19.2
11	0	0	0	0	0
12	0	1	0	0	0
13	0	1	0	1	1.4
TOTAL	**849**	**25476**	**100**	**73**	**100**

Table 3 Top 10 Gross Vehicle Weight, Class 9 and 10

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2019-04-16	Tuesday	13:43:16	10	EB	1	94.71
2019-04-22	Monday	13:55:11	10	EB	1	94.65
2019-04-19	Friday	07:11:17	10	WB	2	92.18
2019-04-15	Monday	08:33:53	10	EB	1	91.43
2019-04-04	Thursday	10:28:01	10	WB	2	90.64
2019-04-30	Tuesday	12:53:44	9	EB	1	89.29
2019-04-23	Tuesday	07:49:17	10	WB	2	89.26
2019-04-23	Tuesday	07:20:09	10	EB	1	88.97
2019-04-10	Wednesday	07:20:40	10	EB	1	88.85
2019-04-16	Tuesday	08:03:48	10	EB	1	88.63

Table 4 Freight Summary

Vehicle Class	*Direction*	*Weight of Empty Vehicle (Kips)*	*Total Number of Vehicles*	*Number of Empty Vehicles*	*Percentage of Empty Vehicles*	*Total Weight of Vehicles with Freight (Kips)*	*Total Weight of Empty Vehicles (Kips)*	*Total Weight of Freight (Tons)*
4	EB	15	137	5	3.6	3187	52	604
5	EB	8	5413	3076	56.8	25873	20466	3589
6	EB	19	77	0	0	3100	0	819
7	EB	11.5	2	0	0	135	0	56
8	EB	31	251	239	95.2	483	3530	56
9	EB	33	54	0	0	3347	0	783
10	EB	33.5	11	2	18.2	628	59	163
TOTAL	****	****	**5945**	**3322**	****	**36753**	****	**6068**
Vehicle Class	Direction	Weight of Empty Vehicle (Kips)	Total Number of Vehicles	Number of Empty Vehicles	Percentage of Empty Vehicles	Total Weight of Vehicles with Freight (Kips)	Total Weight of Empty Vehicles (Kips)	Total Weight of Freight (Tons)
4	WB	15	26	4	15.4	714	53	192
5	WB	8	527	55	10.4	7976	408	2100
6	WB	19	77	0	0	3033	0	785
7	WB	11.5	13	0	0	767	0	309
8	WB	31	47	22	46.8	949	452	87
9	WB	33	89	5	5.6	4171	156	699
10	WB	33.5	24	0	0	1765	0	481
12	WB	36.5	1	0	0	65	0	14
13	WB	31.5	1	0	0	93	0	31
TOTAL	****	****	**805**	**86**	****	**19533**	****	**4698**
GRAND TOTAL	****	****	**6750**	**3408**	**252**	**56287**	**25176**	**10766**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*EB*	*WB*	*Total*	*Percentage*
1	0	8	8	0
2	202	25456	25658	14.4
3	30889	40143	71032	39.9
4	3239	766	4006	2.2
5	46339	8384	54723	30.7
6	3100	3033	6133	3.4
7	135	767	901	0.5
8	4013	1401	5414	3
9	3347	4327	7674	4.3
10	687	1765	2453	1.4
12	0	65	65	0
13	0	93	93	0.1
TOTAL	**91951**	**86209**	**178160**	**100**
GVW/LANE	**51.61**	**48.39**	**100**	**0.06**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*EB*	*WB*	*Total*	*Percentage*	*Flexible ESAL Factor*
1	0	0	0	0	0.125
2	0	3	3	0.4	0.0014
3	10	17	26	3.4	0.0053
4	56	18	74	9.6	0.96
5	145	126	270	35.1	0.1
6	76	85	160	20.8	2.17
7	3	17	20	2.6	2.23
8	15	32	48	6.2	0.36
9	65	52	117	15.2	1.7
10	11	37	48	6.3	2.52
12	0	1	1	0.1	1.04
13	0	2	2	0.3	1.23
TOTAL	**380**	**390**	**769**	**100**	**12**
ESALS/LANE	**49.4**	**50.7**	**100**	**–**	**–**

Table 7 Site Summary: Volume and Vehicle Class

Month	*Total Volume*	*Monthly ADT*	*Monthly HCADT*	*Passenger Vehicles*	*Passenger Vehicles %*	*Heavy Commercial Vehicles*	*Heavy Commercial Vehicles %*
Mar 2019	21799	703	192	15856	72.7	5943	27.3
Apr 2019	25476	849	234	18455	72.4	7021.5	27.6
TOTAL	**47275**	**–**	**–**	**34311**	**–**	**12964**	**–**
AVERAGE	**23638**	**776**	**213**	**17156**	**73**	**6482**	**27**

ESALs

Month	*ESALS EB Driving Lane*	*ESALS WB Driving Lane*	*Total ESALS*	*Pavement Life Decrease Months*
Mar 2019	402	452	854	66.8
Apr 2019	396	391	787	3.5
TOTAL	**798**	**–**	**–**	**–**
AVERAGE	**399**	**422**	**821**	**35**

Gross Vehicle Weight

Month	*GVW EB Driving Lane*	*GVW WB Driving Lane*	*Total GVW Kips*
Mar 2019	81349	75316	156665
Apr 2019	93104	86410	179514
TOTAL	**174453**	**161726**	**336179**
AVERAGE	**87226**	**80863**	**168090**

Overweight Vehicles

Month	*Total Number of Overweight Vehicles*	*Overweight / Total Volume*	*Overweight / Heavy Commercial Volume*	*Number Over 88,000 lbs*	*Number Over 98,000 lbs*
Mar 2019	119	0.6	2	41	20
Apr 2019	78	0.3	1.1	9	0
TOTAL	**197**	**–**	**–**	**50**	**20**
AVERAGE	**98.5**	**0.4**	**1.6**	**25**	**10**

Freight

Month	*EB Freight Tons*	*WB Freight Tons*	*Total Freight*	*EB Freight %*	*WB Freight %*
Mar 2019	5645	4430	10075	56	44
Apr 2019	6068	4698	10766	56.4	43.6
TOTAL	**11713**	**9128**	**20841**	**–**	**–**
AVERAGE	**5856.6**	**4563.9**	**10420.5**	**56.2**	**43.8**