NOVEMBER 2018

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 November 2018. 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 lanes. 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: 26981 | Passenger Vehicles: 19445 | Heavy Commercial Vehicles: 7536

Monthly Average Daily Traffic (MADT): 899 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 251

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 Saturdays, with lowest volumes reported on Fridays. WB vehicles typically reached highest volume levels on Fridays, 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 04 PM and 06 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 04 PM and 06 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 7536 HCVs, 328 of them were overweight [3]. These overweight HCVs contributed to 1.4% of total monthly volume, and 4.8% of total monthly HCV volume. EB overweight vehicles typically reached highest numbers on Mondays, with lowest volumes reported on Sundays. WB overweight vehicles tended to reach highest volumes on Fridays, with lowest volumes reported on NAs. See Figure 3 .
The top two overweight violators by class were the class 10 and class 6 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 76.4% of all overweight vehicles traveling EB 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 ,159 EB vehicles exceeded 88,000 pounds (153 vehicles were Class 10's; 5 vehicles were Class 9's). Of vehicles traveling WB,

27 EB vehicles exceeded 88,000 pounds (24 vehicles were Class 10's; 2 vehicles were Class 13's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from November 2018.

Loaded vs. Unloaded HCVs. Figure 10 shows the GVW distributions of Class 9s and 10s in November 2018. 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 19000 tons of freight was recorded to have crossed the WIM. More freight was shipped EB (65.5%) than WB (34.5%). 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 26981 vehicles with a combined GVW of 205285 kips (1 kip = 1,000 pounds = 0.5 tons) in November 2018. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 1645 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 63% of all ESALs were recorded EB while 37% was observed WB. In particular, 35% of all ESALs were generated by the Class 10's (Class 10's were also responsible for generating 10% 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

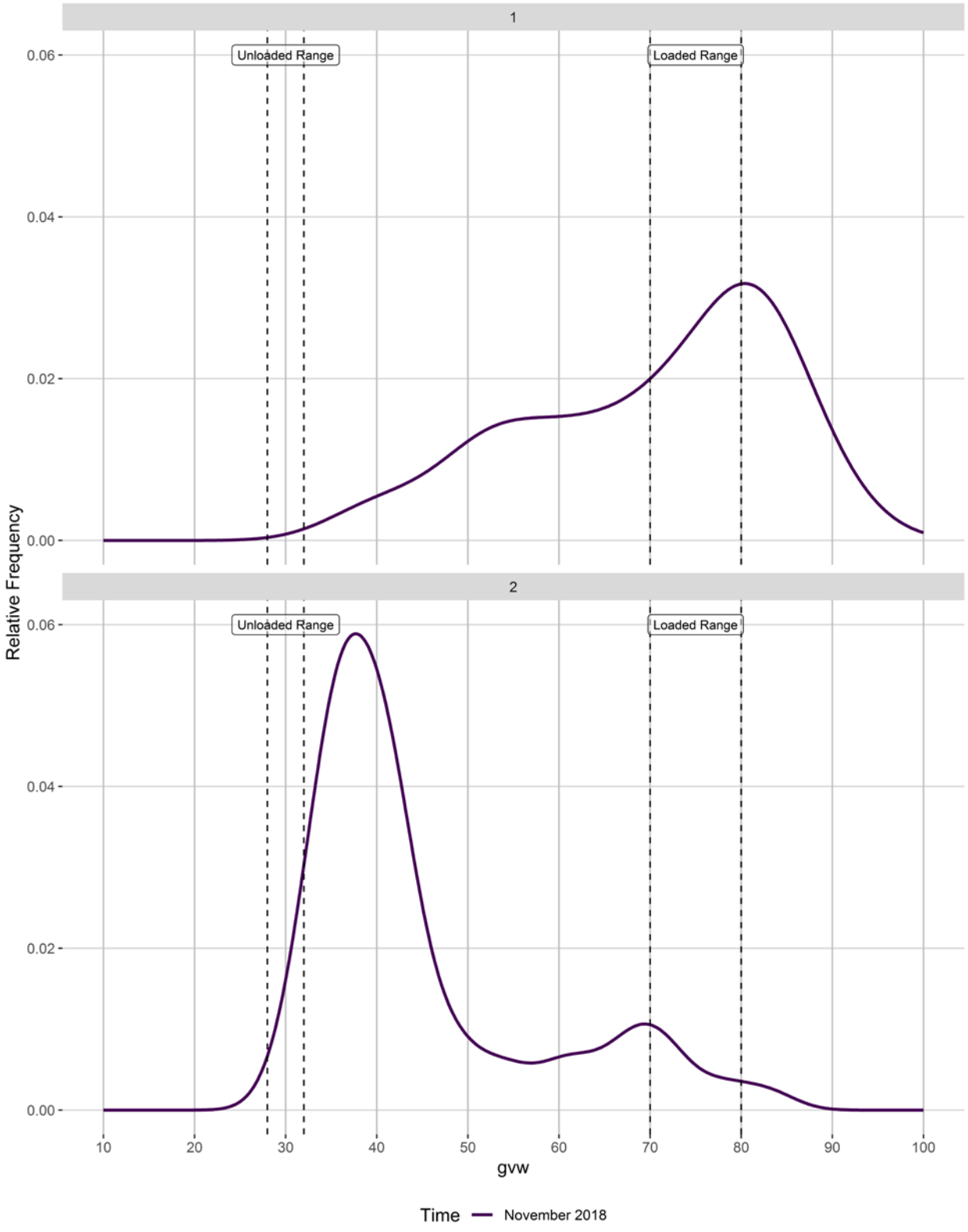
- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

- [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

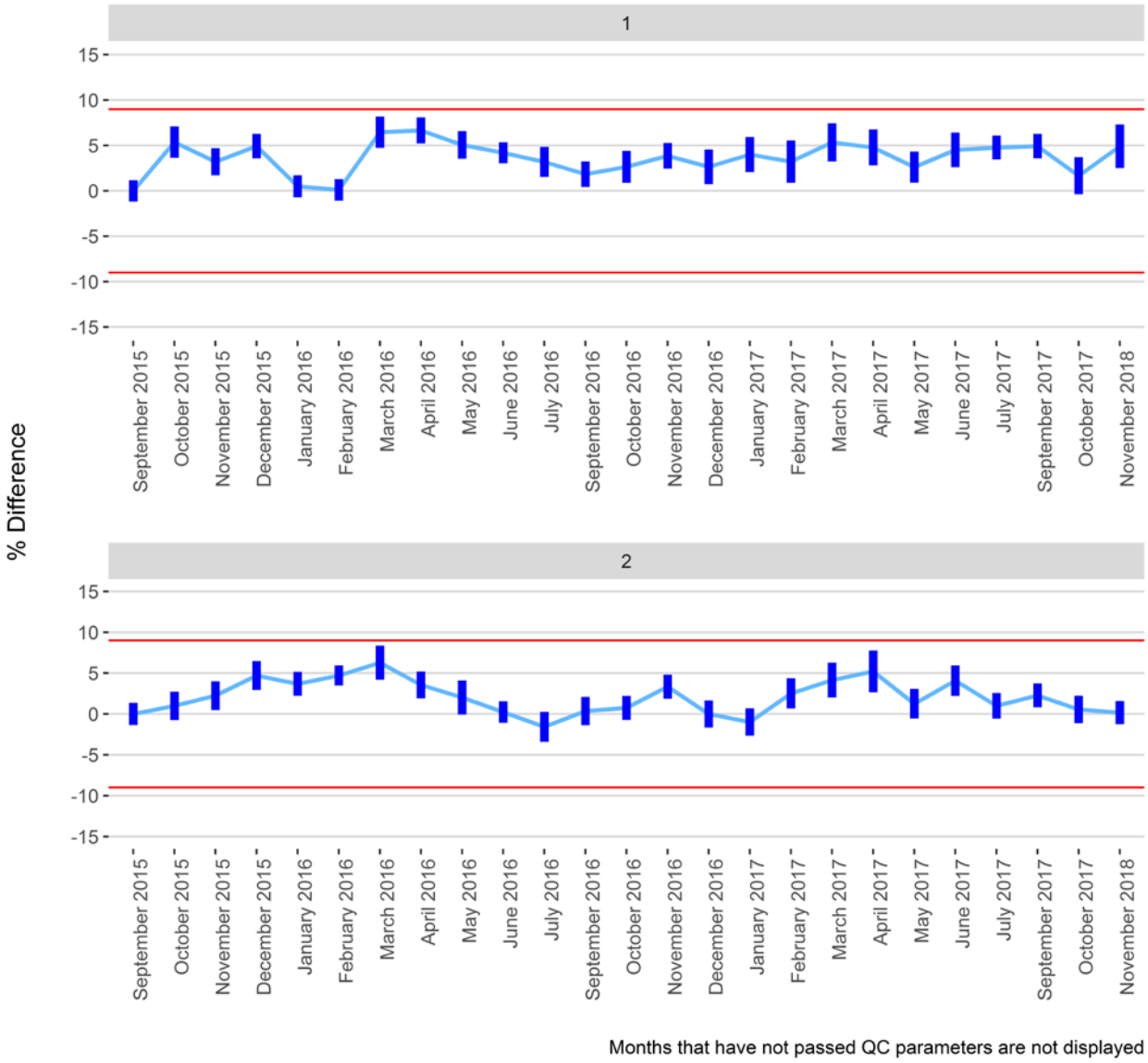
- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened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

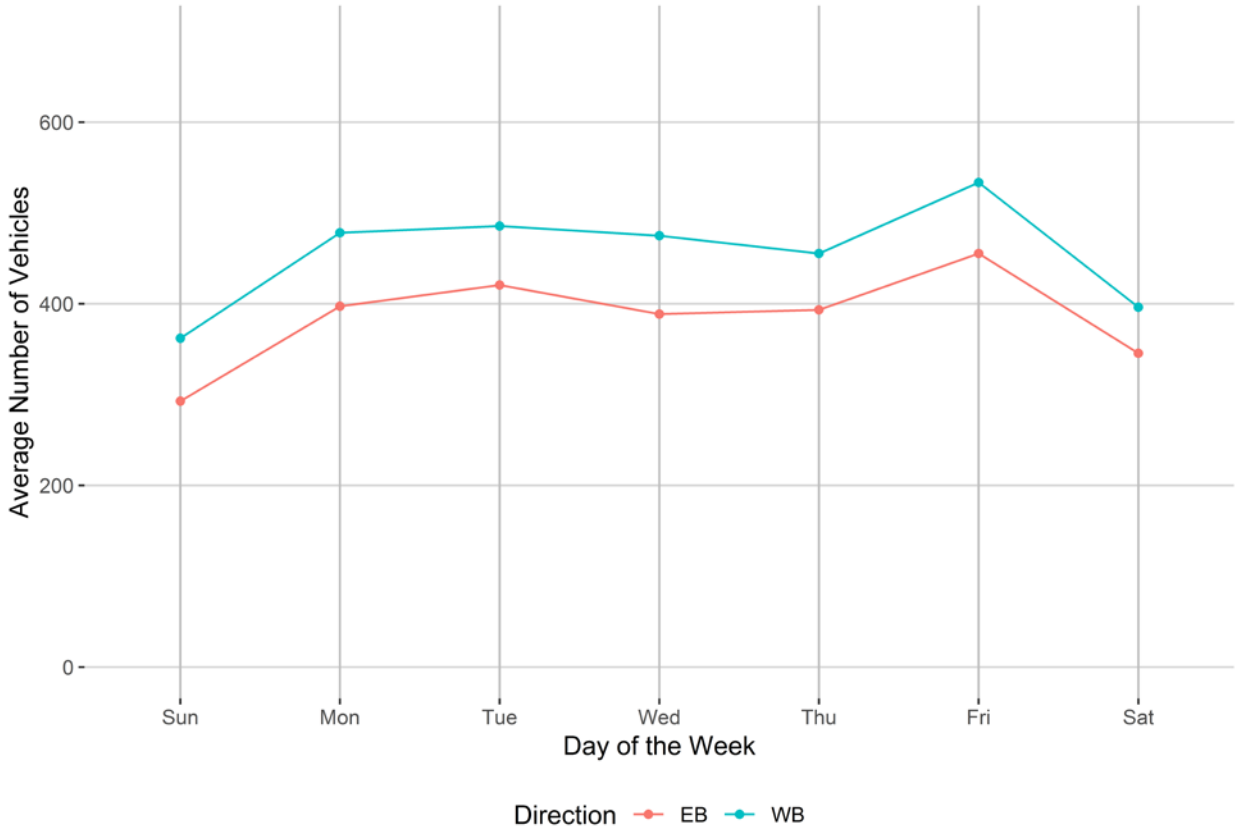


Figure 3 - Average Overweight Vehicle Volume vs. Day of the Week

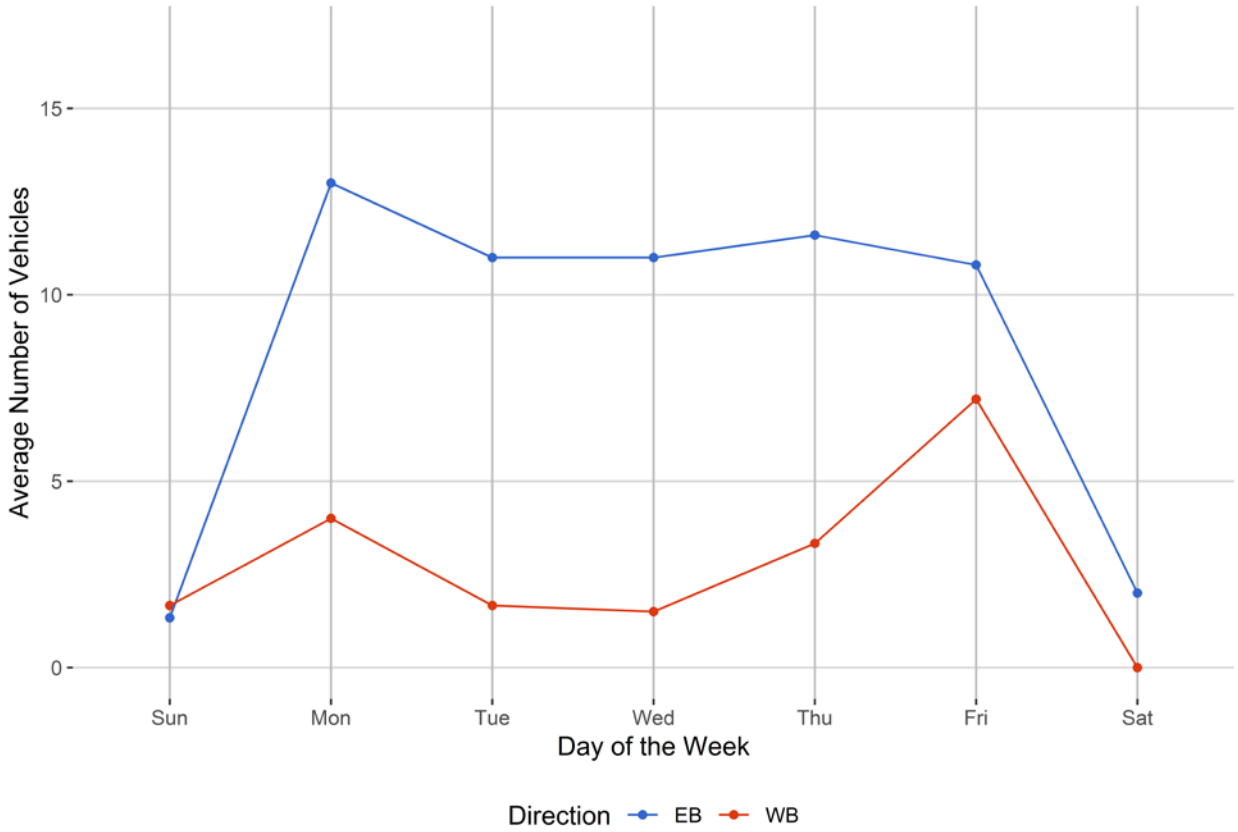


Figure 4 - Passenger Vehicles
vs. Hour of the Day

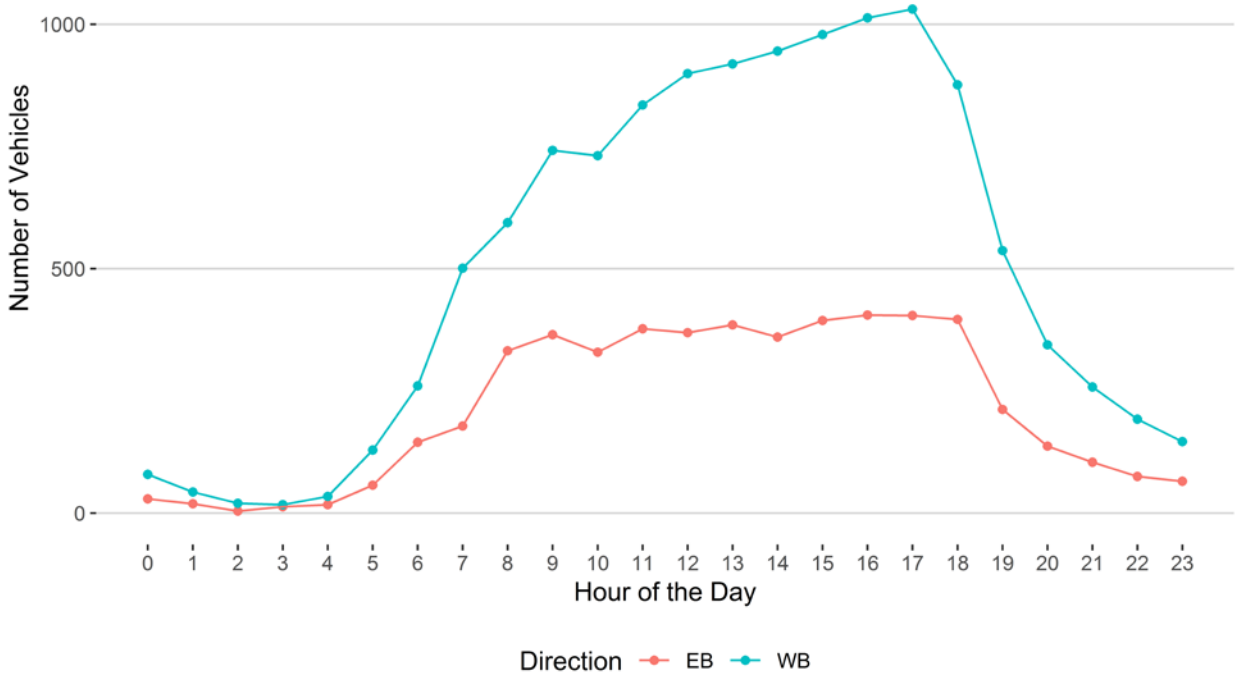


Figure 5 - Heavy Commercial Vehicles
vs. Hour of the Day

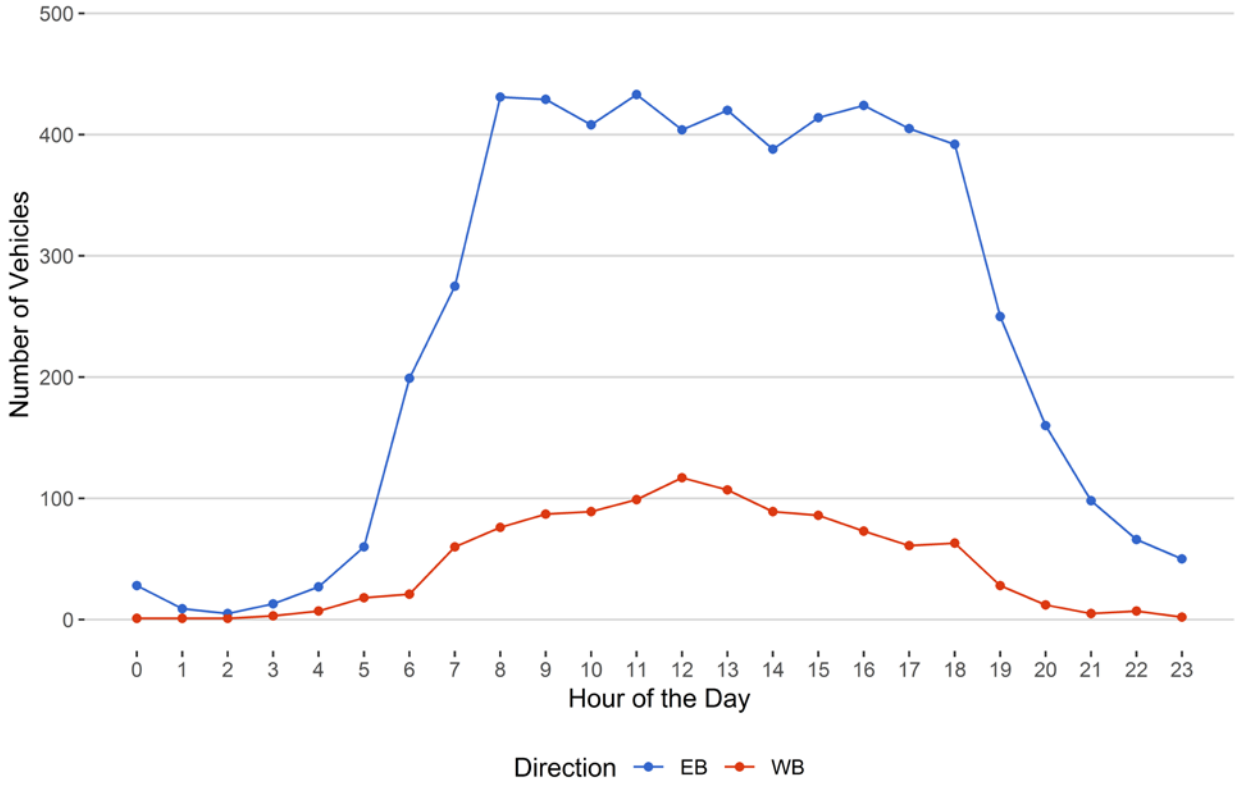


Figure 6 - Overweight Vehicles by Class vs. Hour of the Day

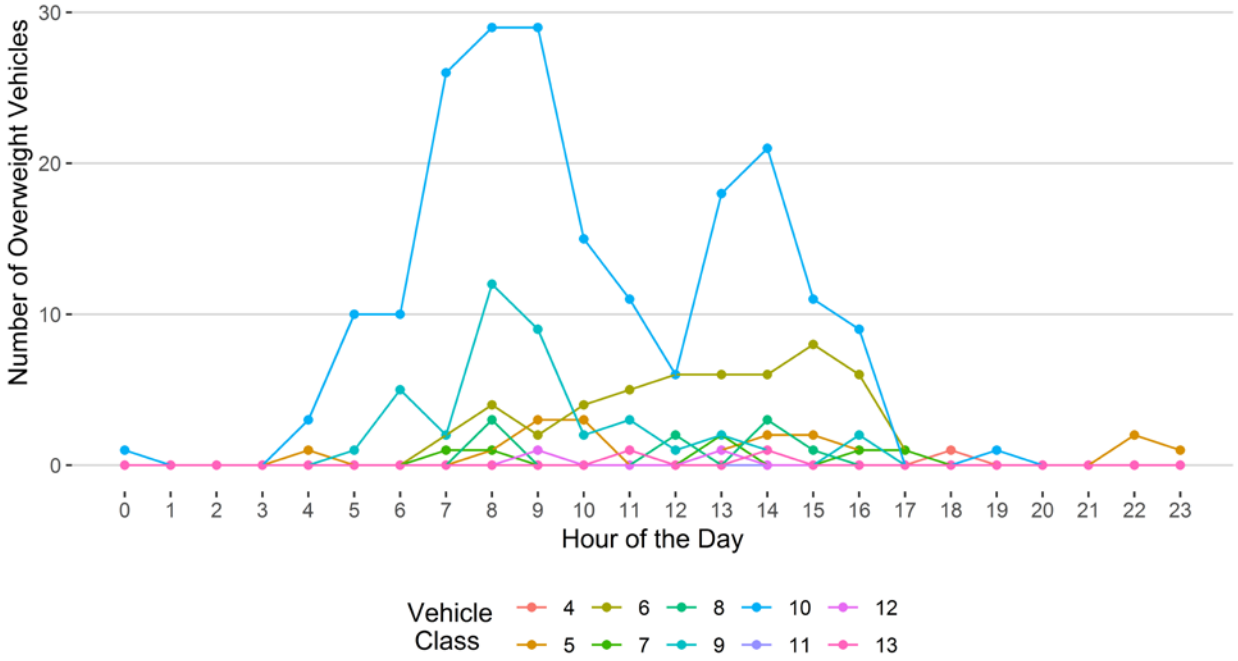


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

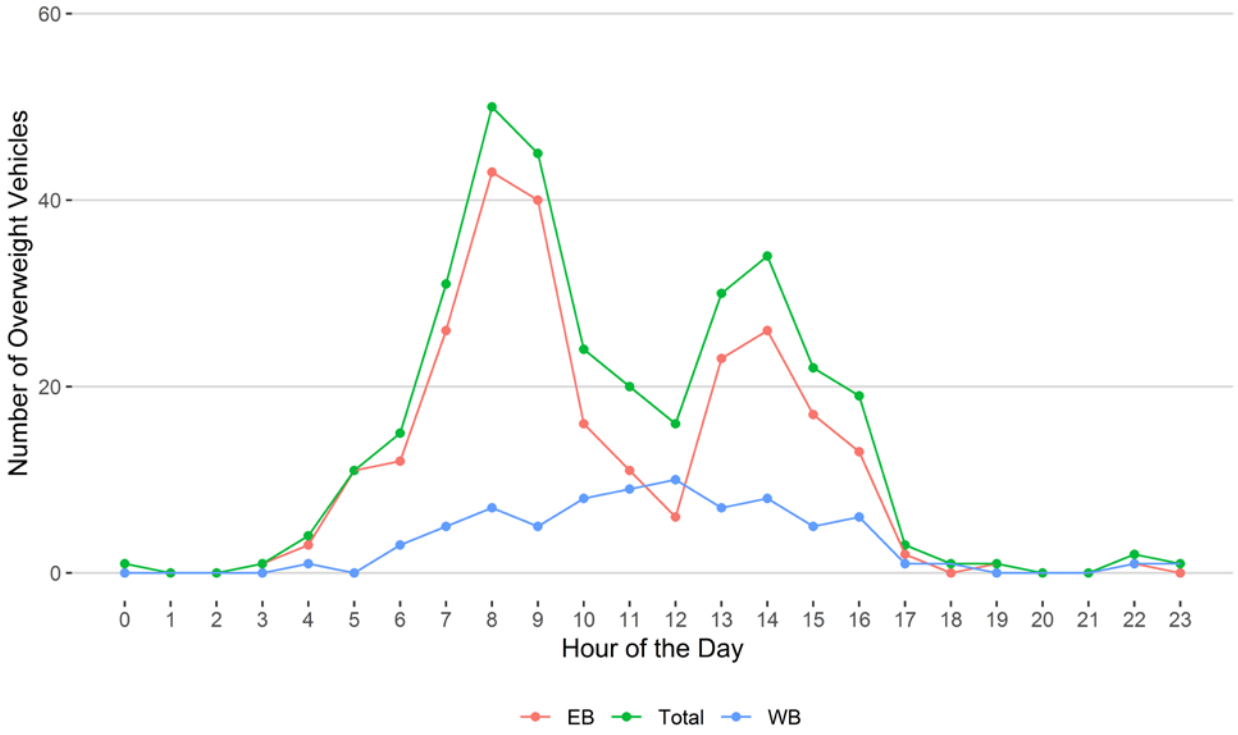
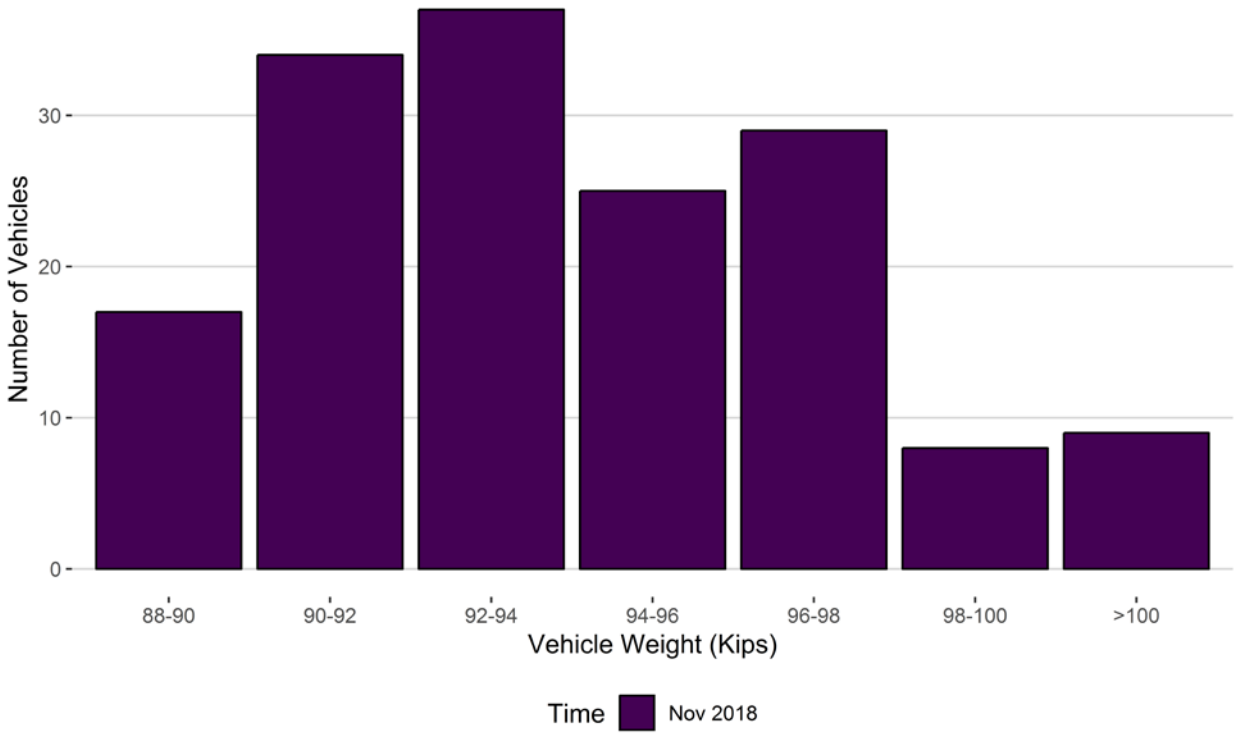
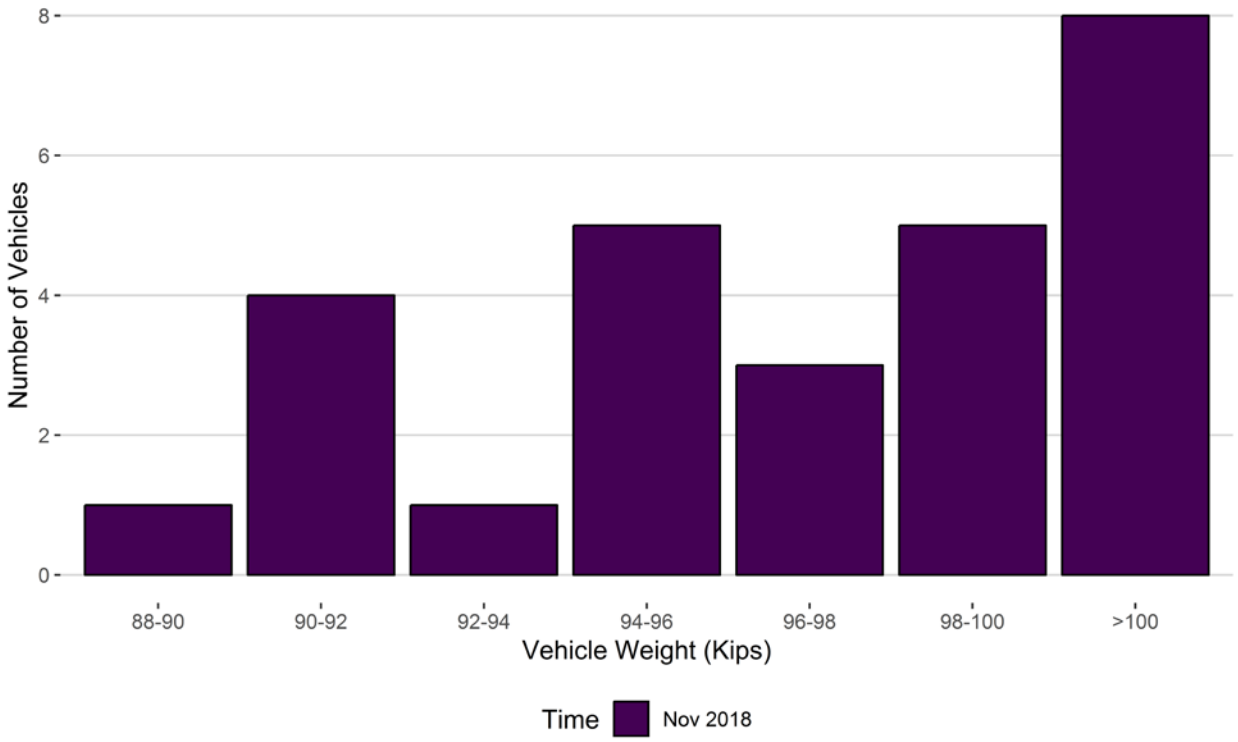


Figure 8 - Histogram of EB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Nov 2018*
88-90	17
90-92	34
92-94	37
94-96	25
96-98	29
98-100	8
>100	9
Total	159

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



Vehicle Weights (Kips)	*Nov 2018*
88-90	1
90-92	4
92-94	1
94-96	5
96-98	3
98-100	5
>100	8
Total	27

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

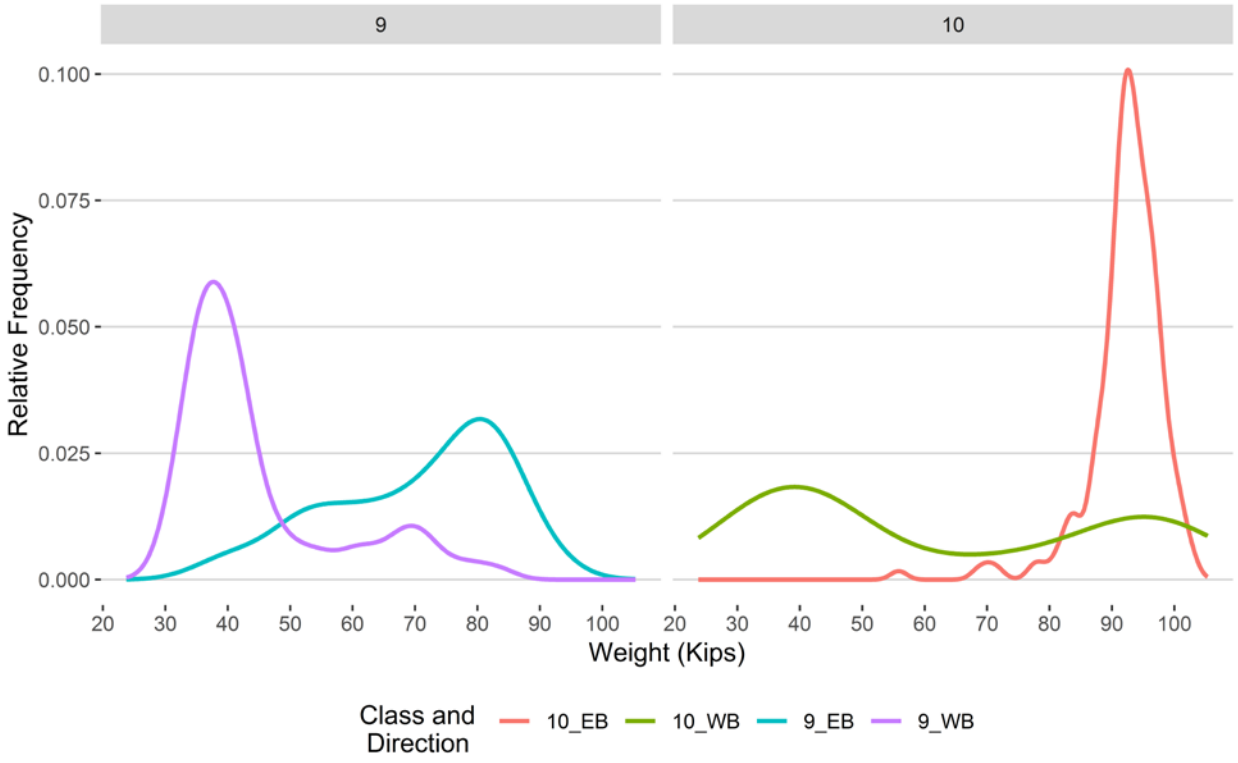


Figure 9 - Freight Percentage by Direction and Class

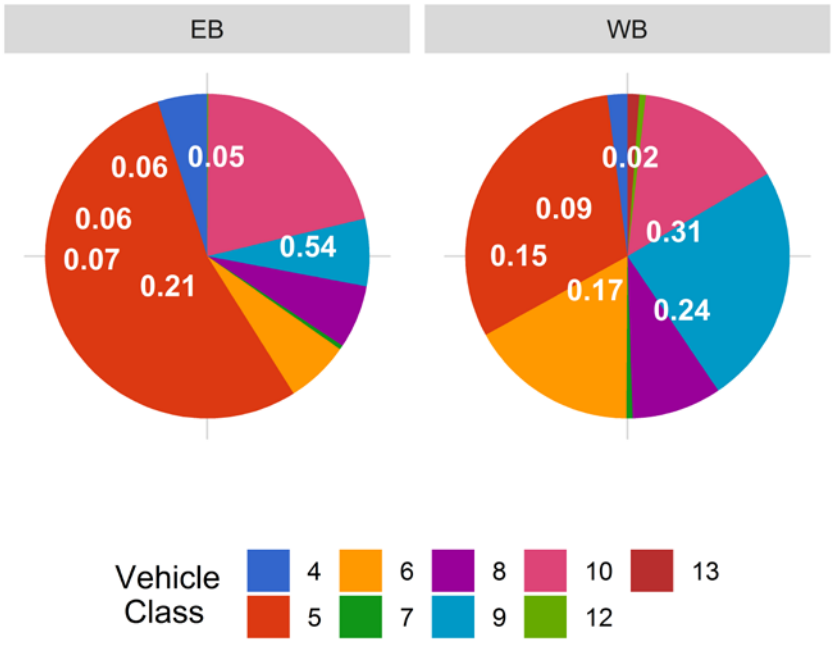


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

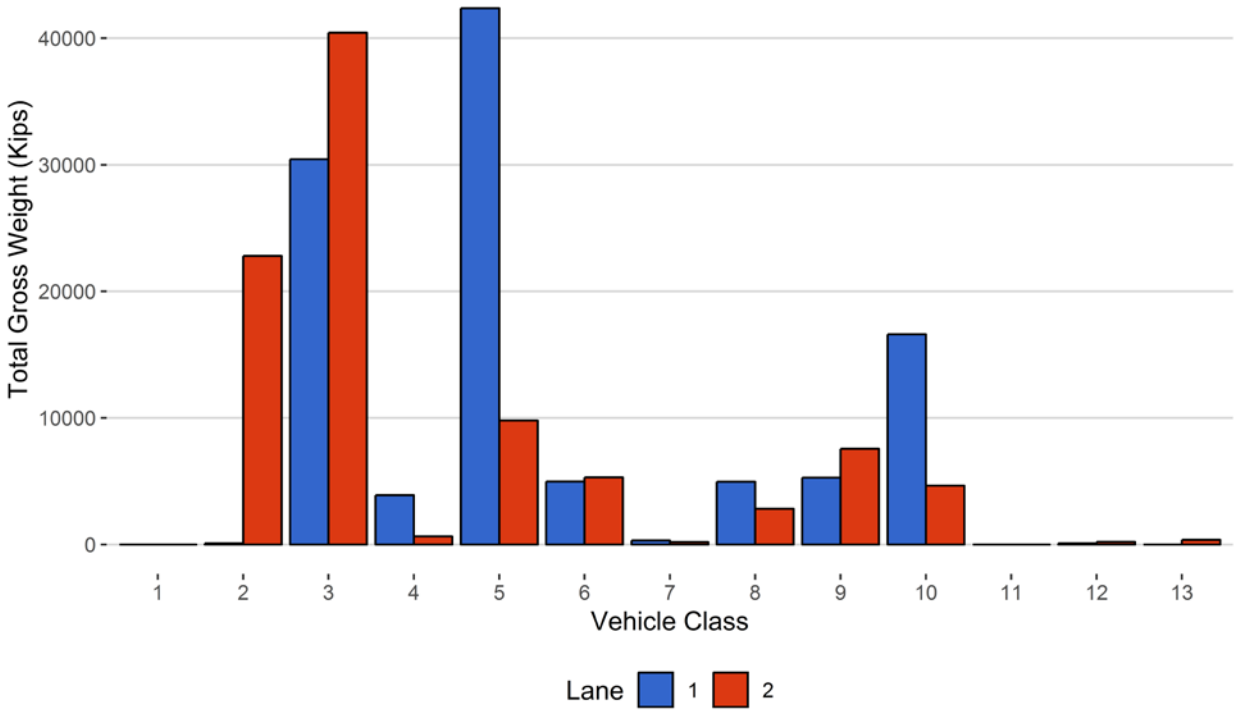


Figure 11 - Total Gross Vehicle Weight b

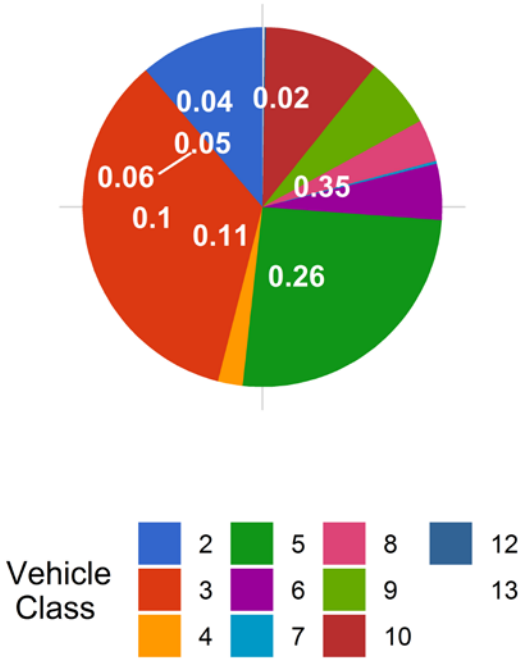


Figure 12 - Total ESALs by Class and Lane

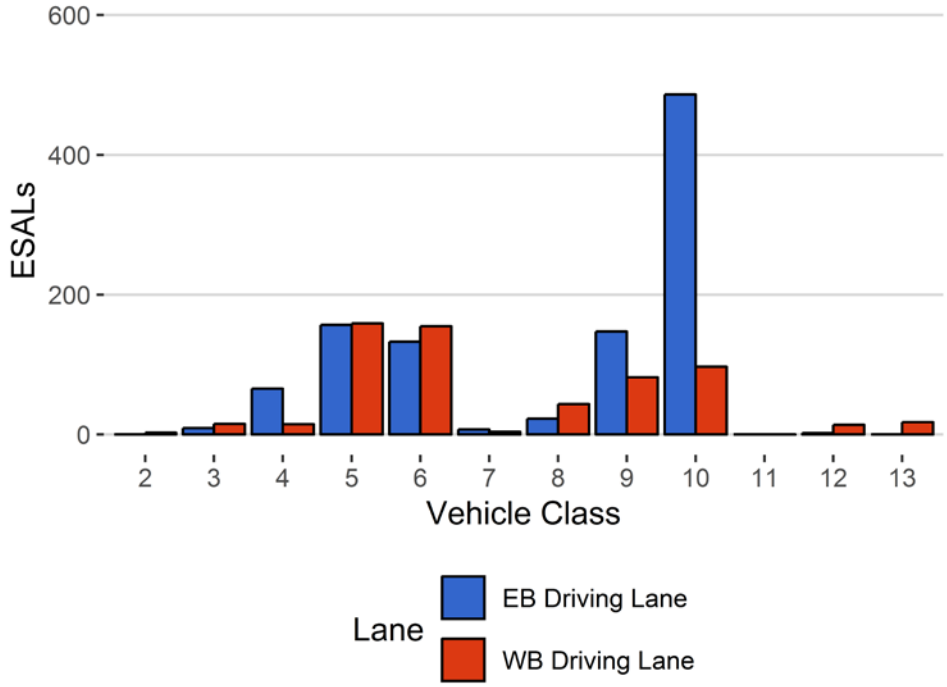


Figure 13 - ESALs by Class

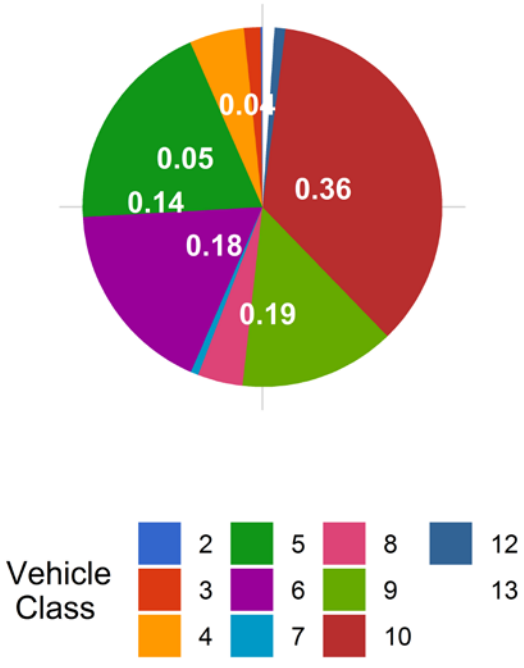


Table 1 Class 9 Front Axle Weight by Lane

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
November 2018	11.03	4.91	10.70	0.17

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	0	0	0	0
2	227	6821	25.3	0	0
3	421	12623	46.8	0	0
4	7	202	0.7	1	0.3
5	202	6064	22.5	18	5.5
6	9	281	1	50	15.2
7	0	10	0	6	1.8
8	14	428	1.6	9	2.7
9	9	266	1	40	12.2
10	9	278	1	200	61
11	0	0	0	0	0
12	0	3	0	2	0.6
13	0	3	0	2	0.6
TOTAL	**899**	**26981**	**100**	**328**	**100**

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

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2018-11-05	Monday	06:13:37	10	WB	2	105.34
2018-11-16	Friday	12:12:38	10	EB	1	102.74
2018-11-30	Friday	13:43:40	10	EB	1	102.67
2018-11-16	Friday	16:04:02	10	WB	2	102.57
2018-11-15	Thursday	12:16:40	10	EB	1	101.54
2018-11-15	Thursday	14:12:22	10	WB	2	101.51
2018-11-23	Friday	07:36:05	10	EB	1	101.31
2018-11-16	Friday	10:13:21	10	WB	2	100.85
2018-11-16	Friday	05:36:04	10	EB	1	100.52
2018-11-15	Thursday	14:11:14	10	WB	2	100.5

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	160	4	2.5	3844	50	752
5	EB	8	4942	3008	60.9	22241	20134	3385
6	EB	19	120	0	0	4970	0	1345
7	EB	11.5	5	0	0	321	0	132
8	EB	31	305	284	93.1	875	4085	112
9	EB	33	75	0	0	5272	0	1398
10	EB	33.5	180	0	0	16609	0	5290
12	EB	36.5	1	0	0	88	0	26
TOTAL	****	****	**5788**	**3296**	****	**54220**	****	**12439**
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	25	6	24	560	72	138
5	WB	8	611	65	10.6	9311	478	2472
6	WB	19	137	2	1.5	5271	35	1353
7	WB	11.5	4	0	0	192	0	73
8	WB	31	87	31	35.6	2221	599	243
9	WB	33	169	12	7.1	7185	377	1002
10	WB	33.5	75	8	10.7	4404	238	1080
12	WB	36.5	2	0	0	202	0	65
13	WB	31.5	3	0	0	369	0	137
TOTAL	****	****	**1113**	**124**	****	**29716**	****	**6561**
GRAND TOTAL	****	****	**6901**	**3420**	**246**	**83936**	**26069**	**19000**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*EB*	*WB*	*Total*	*Percentage*
2	98	22798	22895	11.2
3	30440	40437	70876	34.8
4	3894	632	4526	2.2
5	42375	9790	52165	25.6
6	4970	5305	10275	5
7	321	192	512	0.3
8	4960	2821	7781	3.8
9	5272	7562	12834	6.3
10	16609	4642	21251	10.4
12	88	202	291	0.1
13	0	369	369	0.2
TOTAL	**109027**	**94750**	**203776**	**100**
GVW/LANE	**53.5**	**46.5**	**100**	**0.05**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*EB*	*WB*	*Total*	*Percentage*	*Flexible ESAL Factor*
2	0	3	3	0.2	0.0013
3	9	15	24	1.5	0.0046
4	66	15	80	4.9	0.9
5	157	159	316	19.3	0.12
6	133	155	288	17.6	2.28
7	7	4	11	0.7	1.9
8	23	44	66	4	0.36
9	147	82	229	14	1.9
10	486	97	584	35.7	4.58
12	2	14	16	1	3.01
13	0	18	18	1.1	3.08
TOTAL	**1030**	**605**	**1635**	**100**	**18**
ESALS/LANE	**63**	**37**	**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 %*
Nov 2018	26981	899	251	19445	72.1	7536.5	27.9
TOTAL	**26981**	**–**	**–**	**19445**	**–**	**7536**	**–**
AVERAGE	**26981**	**899**	**251**	**19445**	**72**	**7536**	**28**

ESALs

Month	*ESALS EB Driving Lane*	*ESALS WB Driving Lane*	*Total ESALS*	*Pavement Life Decrease Months*
Nov 2018	1037	608	1645	66.6
TOTAL	**1037**	**–**	**–**	**–**
AVERAGE	**1037**	**608**	**1645**	**67**

Gross Vehicle Weight

Month	*GVW EB Driving Lane*	*GVW WB Driving Lane*	*Total GVW Kips*
Nov 2018	110328	94957	205285
TOTAL	**110328**	**94957**	**205285**
AVERAGE	**110328**	**94957**	**205285**

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*
Nov 2018	331	1.4	4.6	186	30
TOTAL	**331**	**–**	**–**	**186**	**30**
AVERAGE	**331**	**1.4**	**4.6**	**186**	**30**

Freight

Month	*EB Freight Tons*	*WB Freight Tons*	*Total Freight*	*EB Freight %*	*WB Freight %*
Nov 2018	12439	6561	19000	65.5	34.5
TOTAL	**12439**	**6561**	**19000**	**–**	**–**
AVERAGE	**12438.8**	**6561.4**	**19000.3**	**65.5**	**34.5**