MARCH 2018

WIM #41
CSAH 14,
MP 14.9
CROOKSTON,
MINNESOTA

MONTHLY REPORT

Your Destination...Our Priority

WIM Site Location

WIM #41 is located on CSAH 14 near Crookston in Polk county.

System Operation

WIM #41 was operational for the entire month of March 2018. Volume was computed using all monthly data.

System Calibration

WIM #41 was most recently calibrated on 2015-02-04. 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: 9347 | Passenger Vehicles: 8199 | Heavy Commercial Vehicles: 1148

Monthly Average Daily Traffic (MADT): 302 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 37

See Table 2 for vehicle class breakdown

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

Volume trends. NB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Sundays. SB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Saturdays (see Figure 3 and 4).

Passenger Vehicles (PVs)

Volume trends. On an average 24-hour day (see Figure 5), NB PVs generally reached peak volume levels between 09 AM and 11 AM. Similarly, SB PVs peaked in volume between 07 PM and 09 PM

Heavy Commercial Vehicles (HCVs)

Volume trends. On an average 24-hour day, HCVs traveling NB typically reached peak volume levels between 09 AM and 11 AM, while volume going SB peaked between 07 PM and 09 PM. See Figure 6. Out of all HCVs, the two highest traffic volumes were generated by Class 9's and Class 5's.

Overweight HCVs

Volume trends. Of a total of 1148 HCVs, 297 of them were overweight [3]. These overweight HCVs contributed to 3.3% of total monthly volume, and 26.9% of total monthly HCV volume. NB overweight vehicles typically reached highest numbers on Tuesdays, with lowest volumes reported on NAs. SB overweight vehicles tended to reach highest volumes on Mondays, with lowest volumes reported on Sundays. See Figure 3 .
The top two overweight violators by class were the class 9 and class 10 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 72.8% of all overweight vehicles traveling SB 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 December.
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 ,20 NB vehicles exceeded 88,000 pounds (11 vehicles were Class 10's; 9 vehicles were Class 9's). Of vehicles traveling SB,

108 NB vehicles exceeded 88,000 pounds (78 vehicles were Class 9's; 25 vehicles were Class 10's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from March 2018.

Loaded vs. Unloaded HCVs. Figure 10 shows the GVW distributions of Class 9s and 10s in March 2018. Data suggests that there were greater numbers of empty Class 9's than fully_loaded Class 9's traveling NB, while there were more fully_loaded Class 9's than empty traveling SB. Data also suggests that there were more fully_loaded Class 10's than empty traveling in the NB direction. In the SB direction, there were more fully_loaded class 10 vehicles.

Freight Totals. A total of 9995 tons of freight was recorded to have crossed the WIM. More freight was shipped SB (70%) than NB (30%). See Table 4 and Figure 11 for more freight information.

Infrastructure Considerations

Bridge. Bridge No. 97559 is approximately 0.1 miles north of WIM #41, and Bridge No. 60K60 is 3.2 miles south of WIM #41. WIM #41 recorded a total of 9347 vehicles with a combined GVW of 91752 kips (1 kip = 1,000 pounds = 0.5 tons) in March 2018. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 1857 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 55.6% of all ESALs were recorded NB while 44.4% was observed SB. In particular, 44% of all ESALs were generated by the Class 9's (Class 9'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

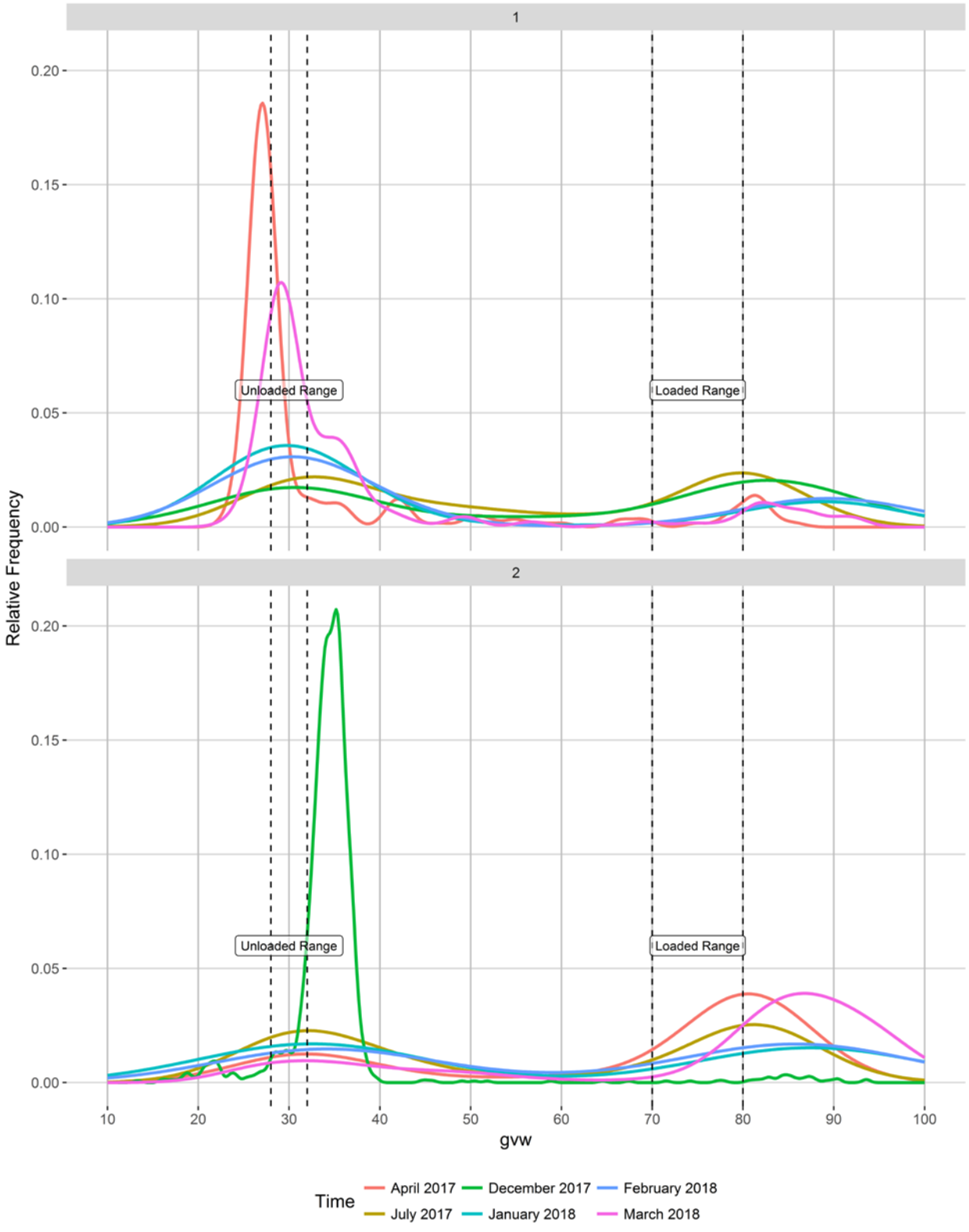
- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

- [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

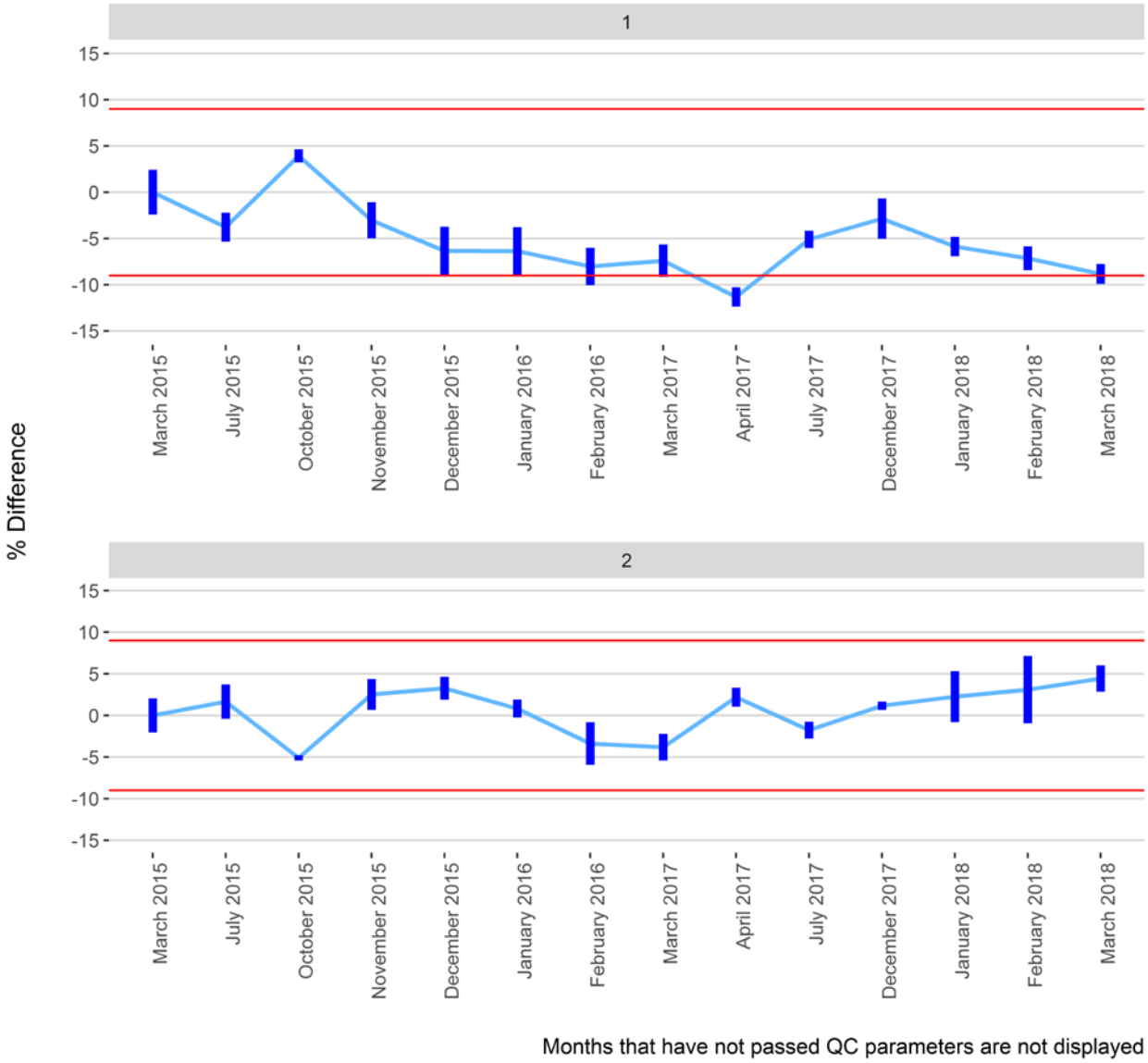
- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened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

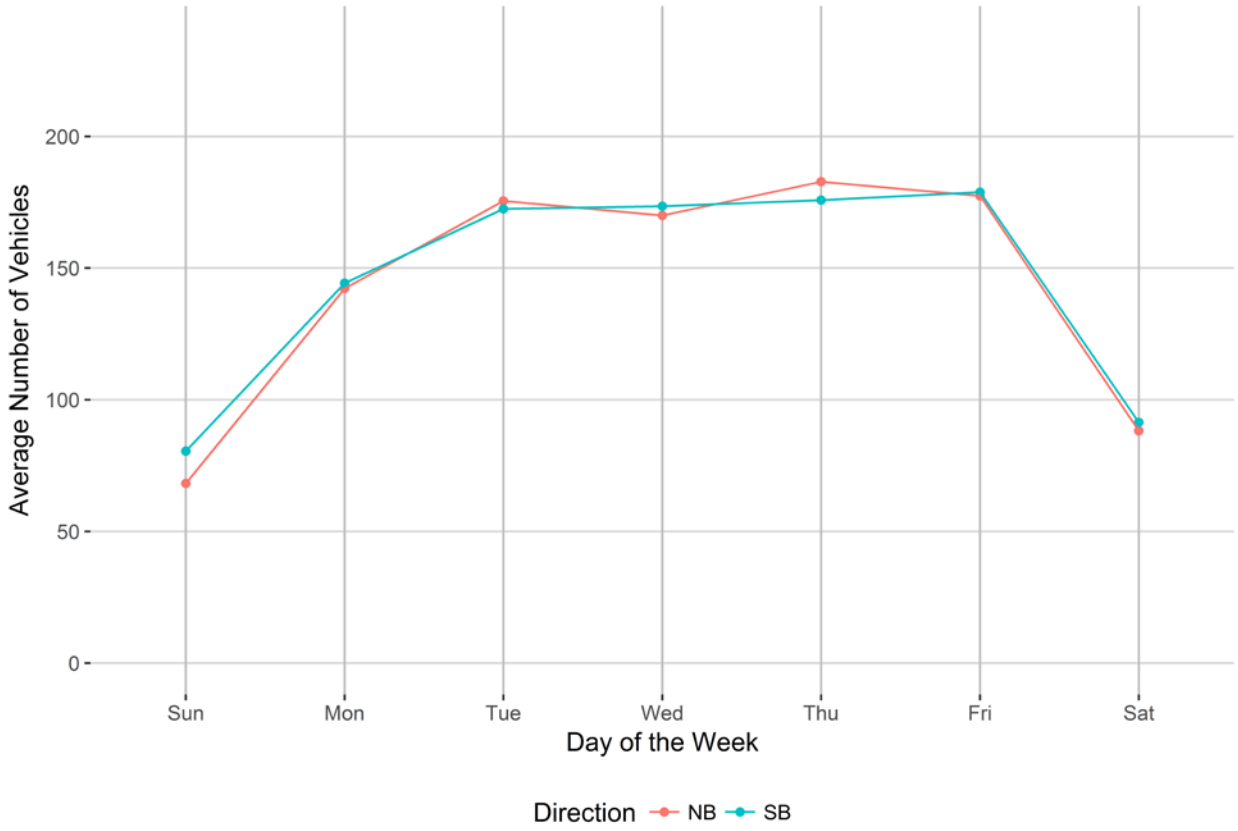


Figure 3 - Average Overweight Vehicle Volume vs. Day of the Week

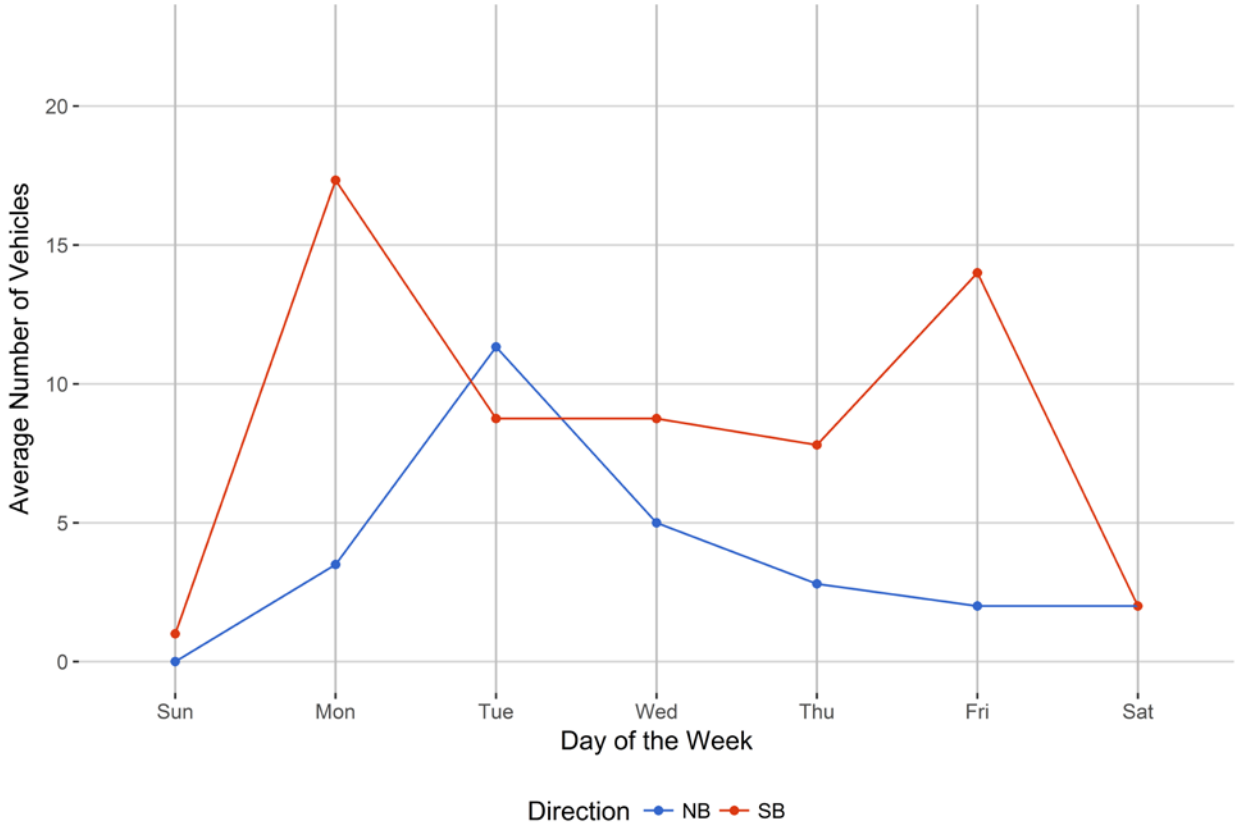


Figure 4 - Passenger Vehicles vs. Hour of the Day

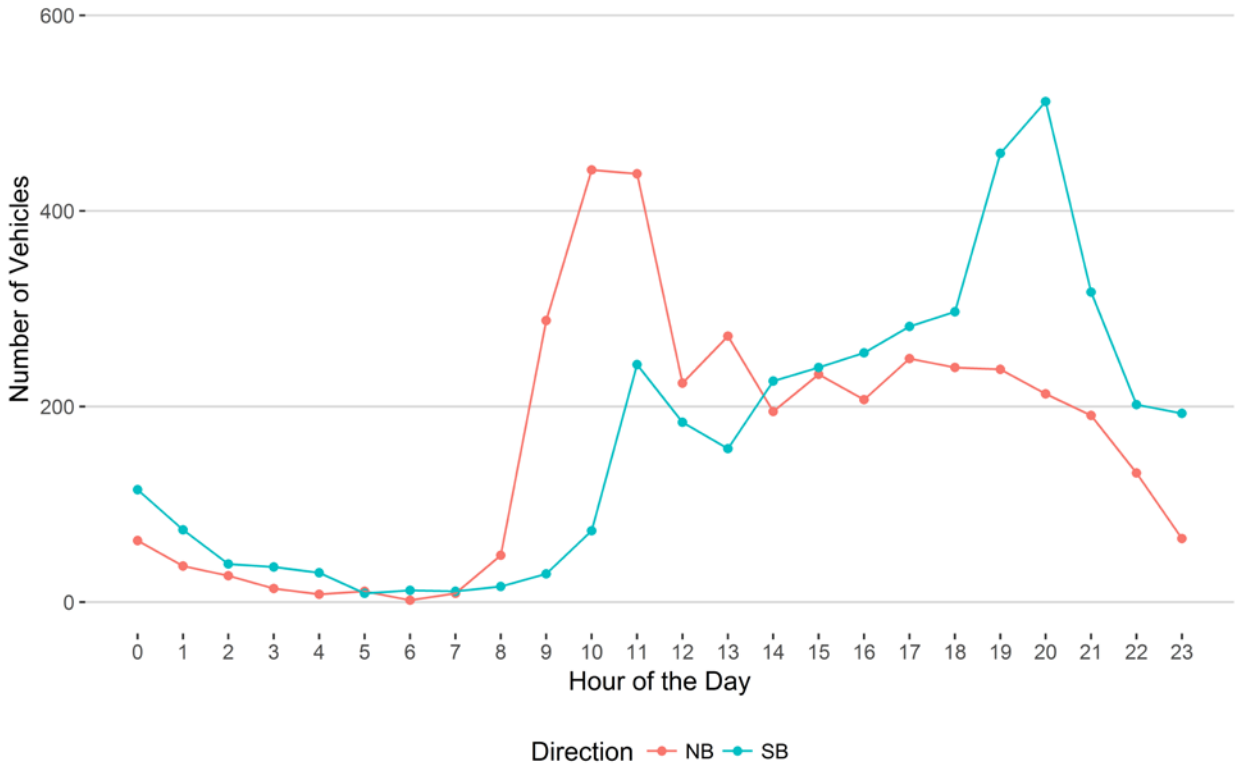


Figure 5 - Heavy Commercial Vehicles vs. Hour of the Day

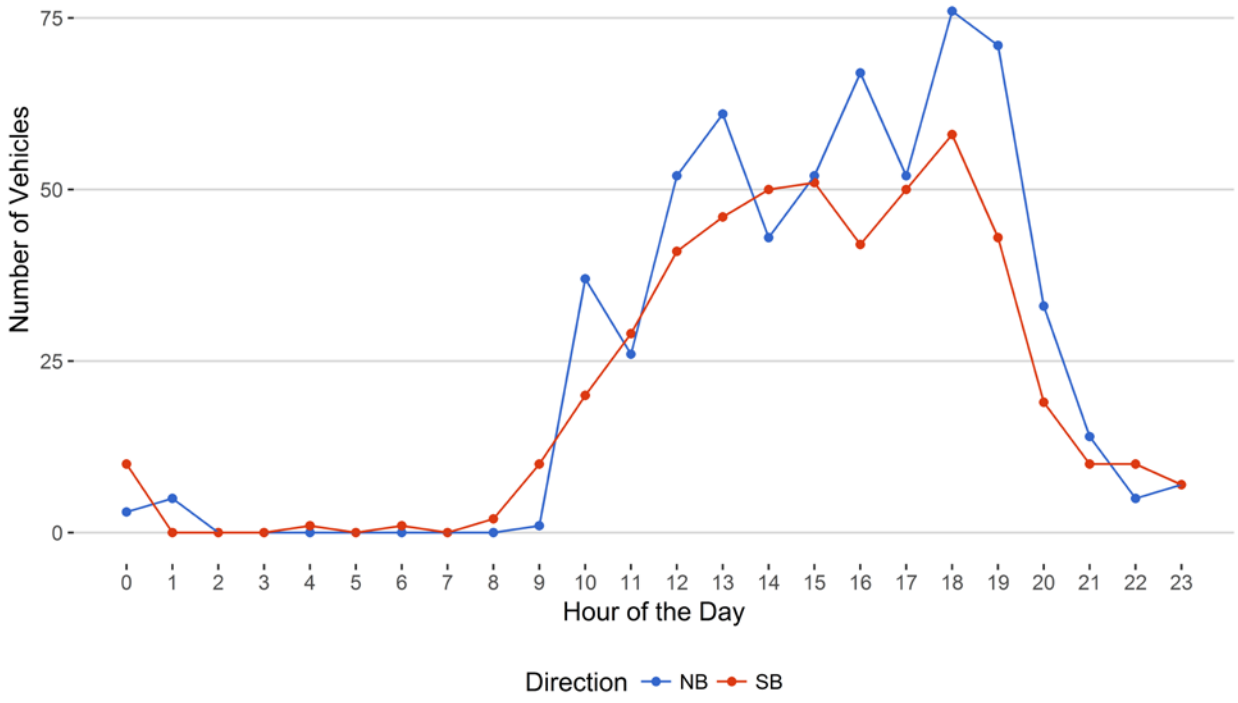


Figure 6 - Overweight Vehicles by Class
vs. Hour of the Day

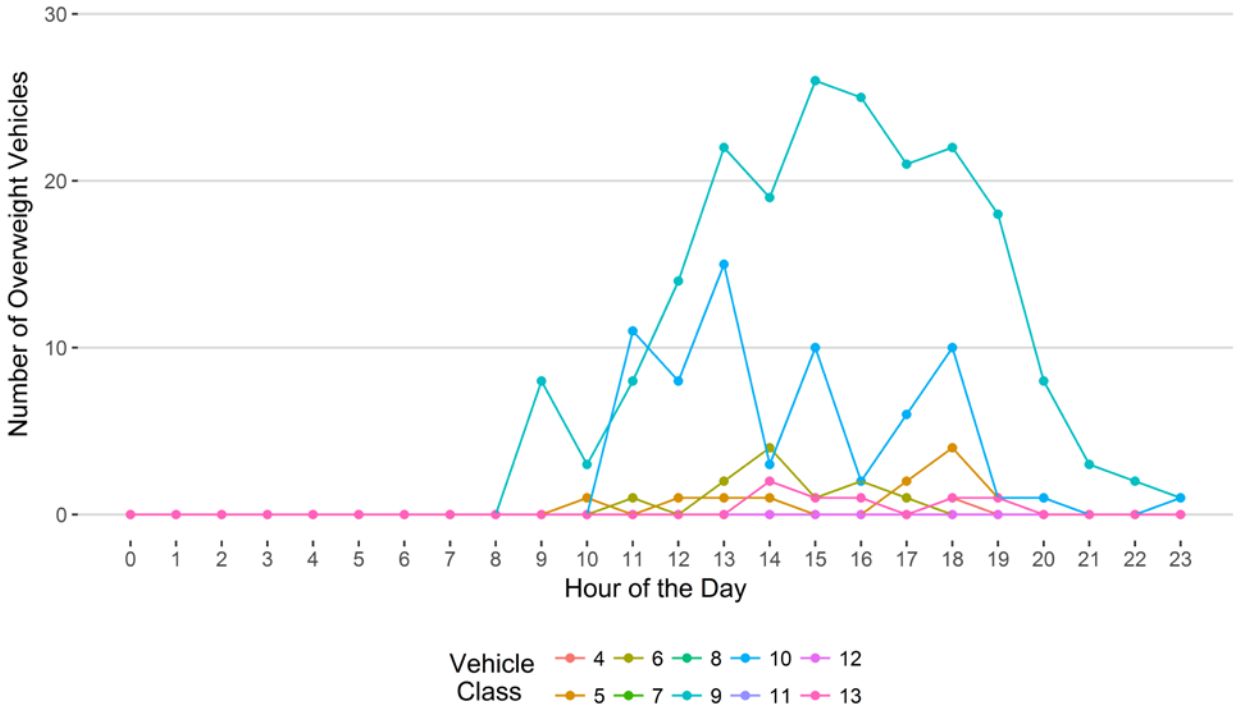


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

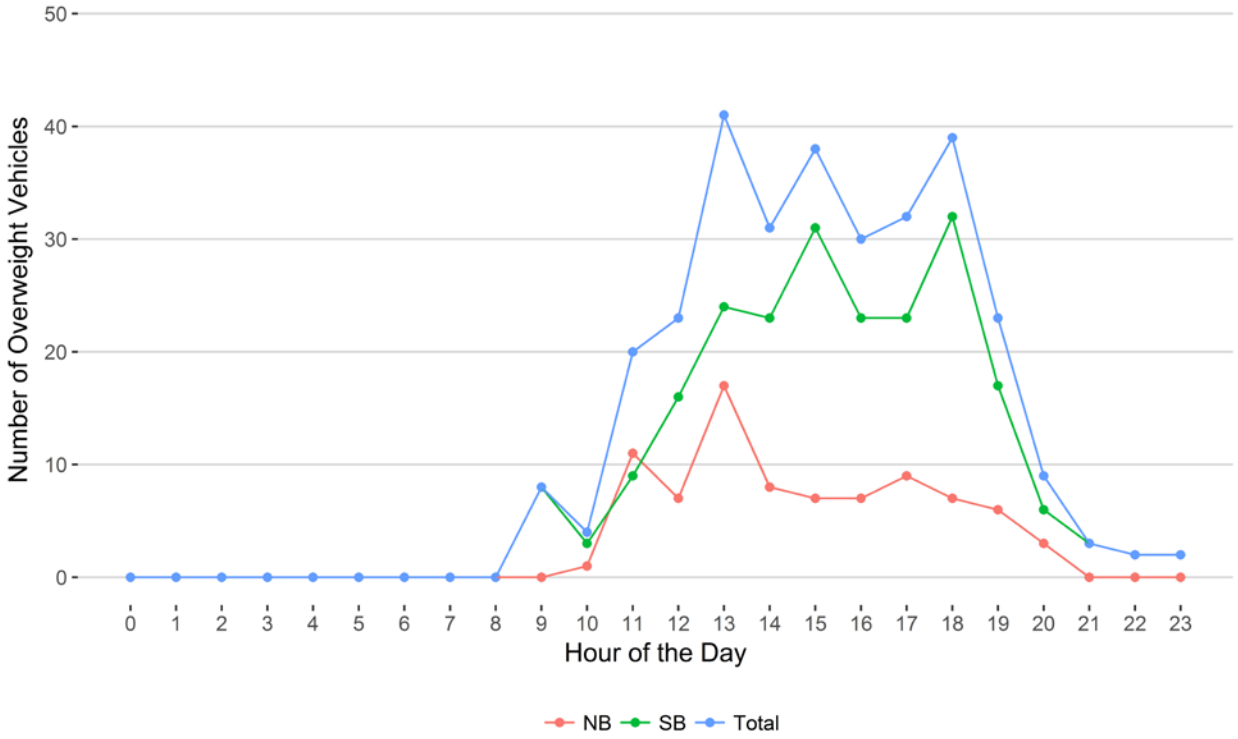
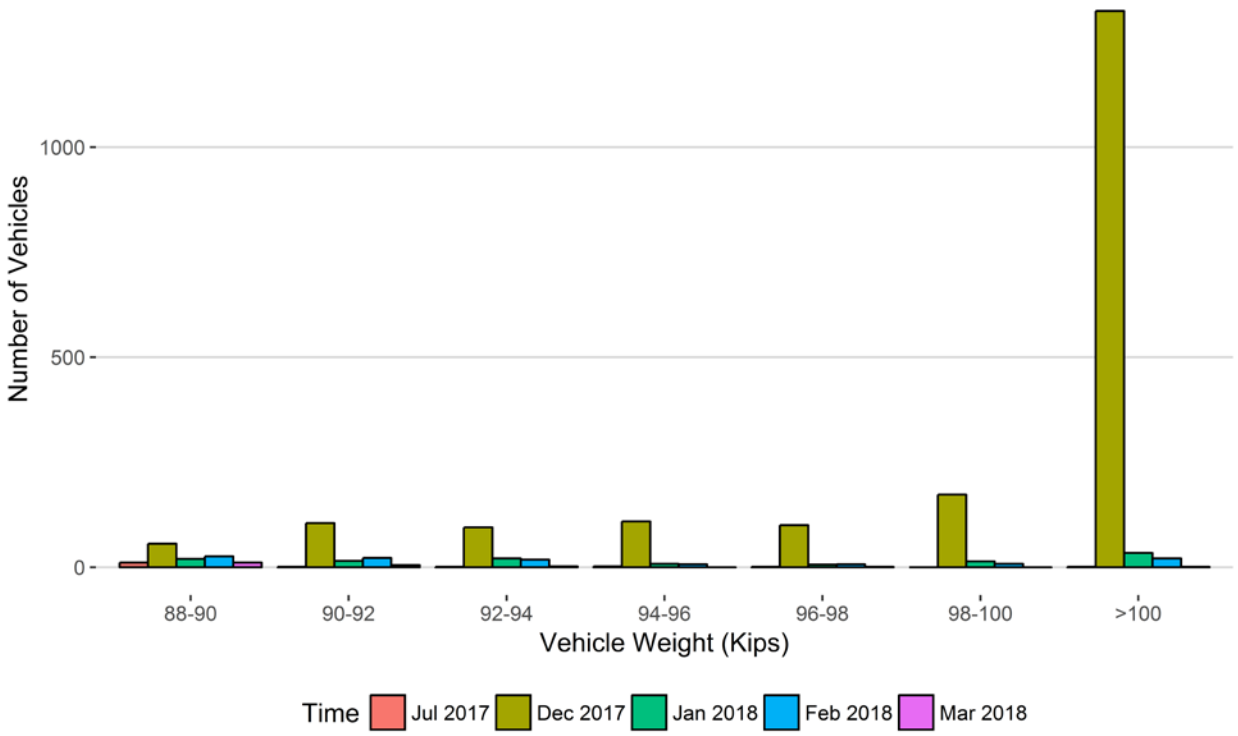
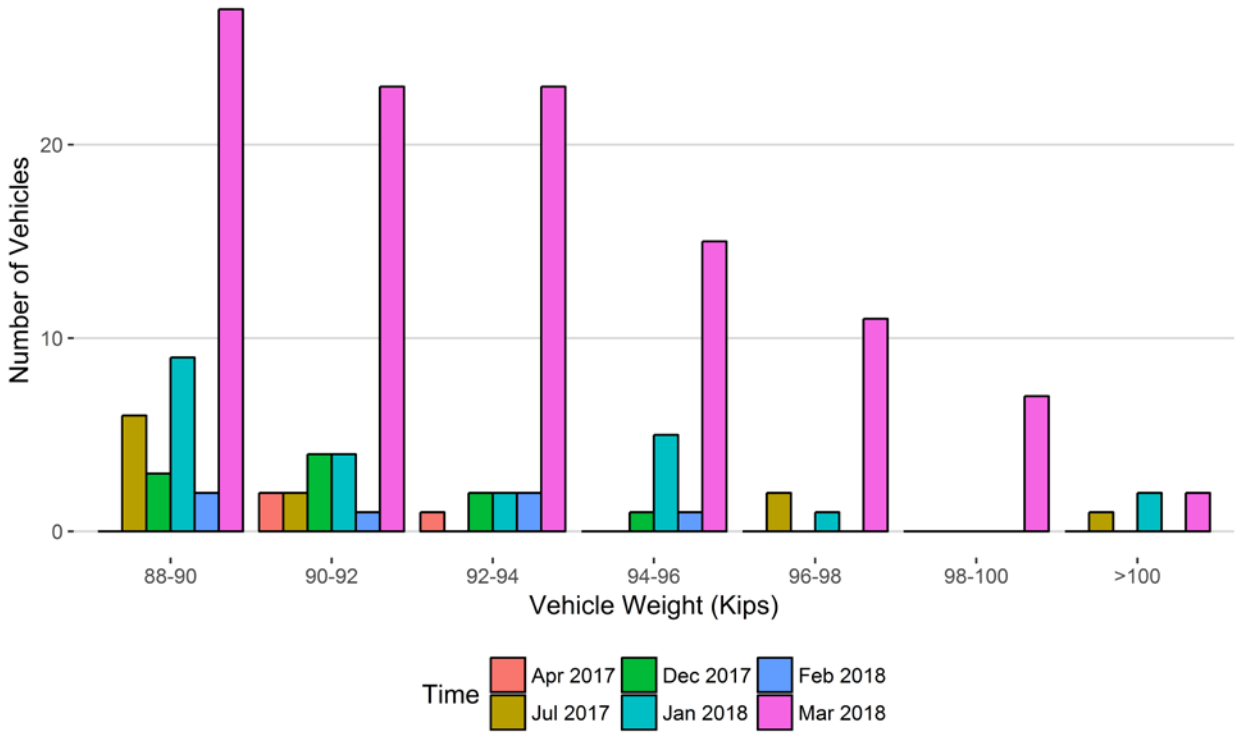


Figure 8 - Histogram of NB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Jul 2017*	*Dec 2017*	*Jan 2018*	*Feb 2018*	*Mar 2018*
88-90	11	56	20	26	11
90-92	1	105	15	22	5
92-94	1	95	21	18	2
94-96	2	109	8	7	0
96-98	1	100	6	7	1
98-100	0	173	14	8	0
>100	1	1324	34	21	1
Total	17	1962	118	109	20

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



Vehicle Weights (Kips)	*Apr 2017*	*Jul 2017*	*Dec 2017*	*Jan 2018*	*Feb 2018*	*Mar 2018*
88-90	0	6	3	9	2	27
90-92	2	2	4	4	1	23
92-94	1	0	2	2	2	23
94-96	0	0	1	5	1	15
96-98	0	2	0	1	0	11
98-100	0	0	0	0	0	7
>100	0	1	0	2	0	2
Total	3	11	10	23	6	108

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

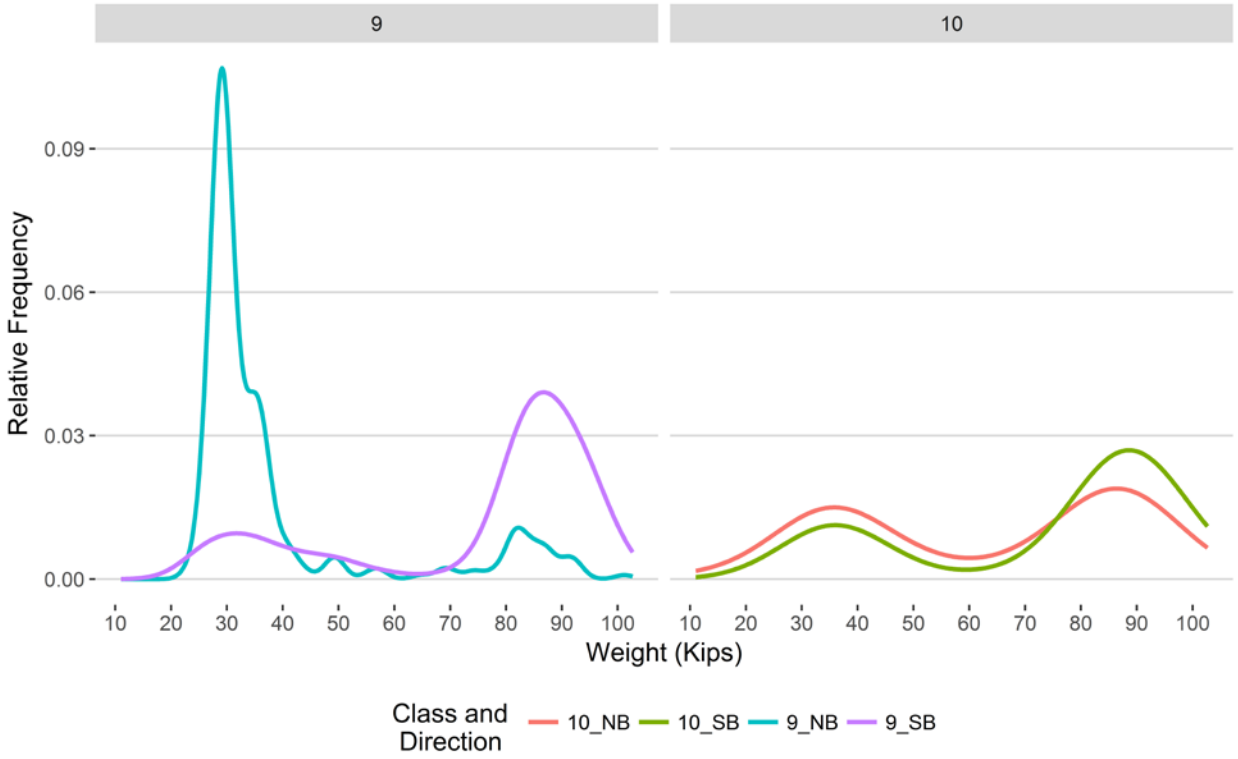


Figure 9 - Freight Percentage by Direction and Class

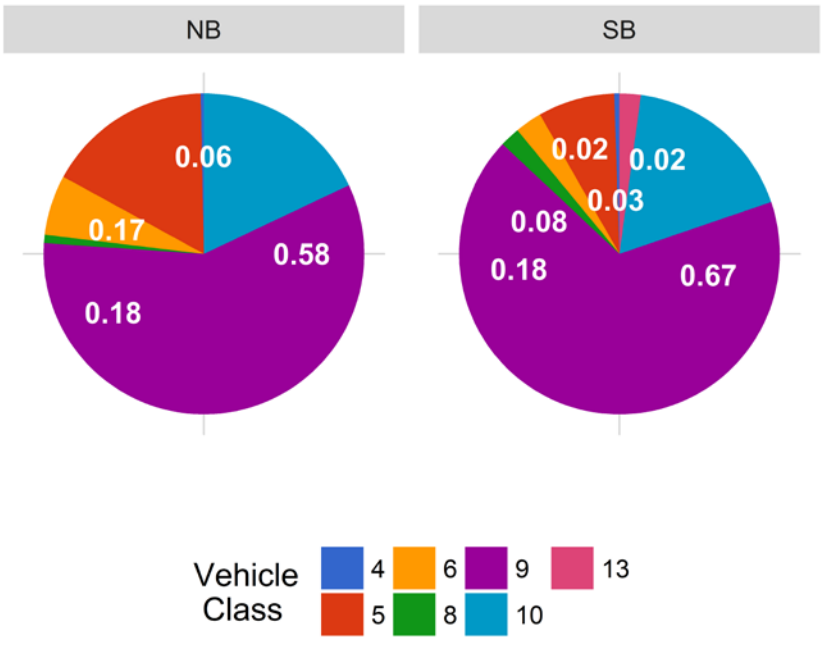


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

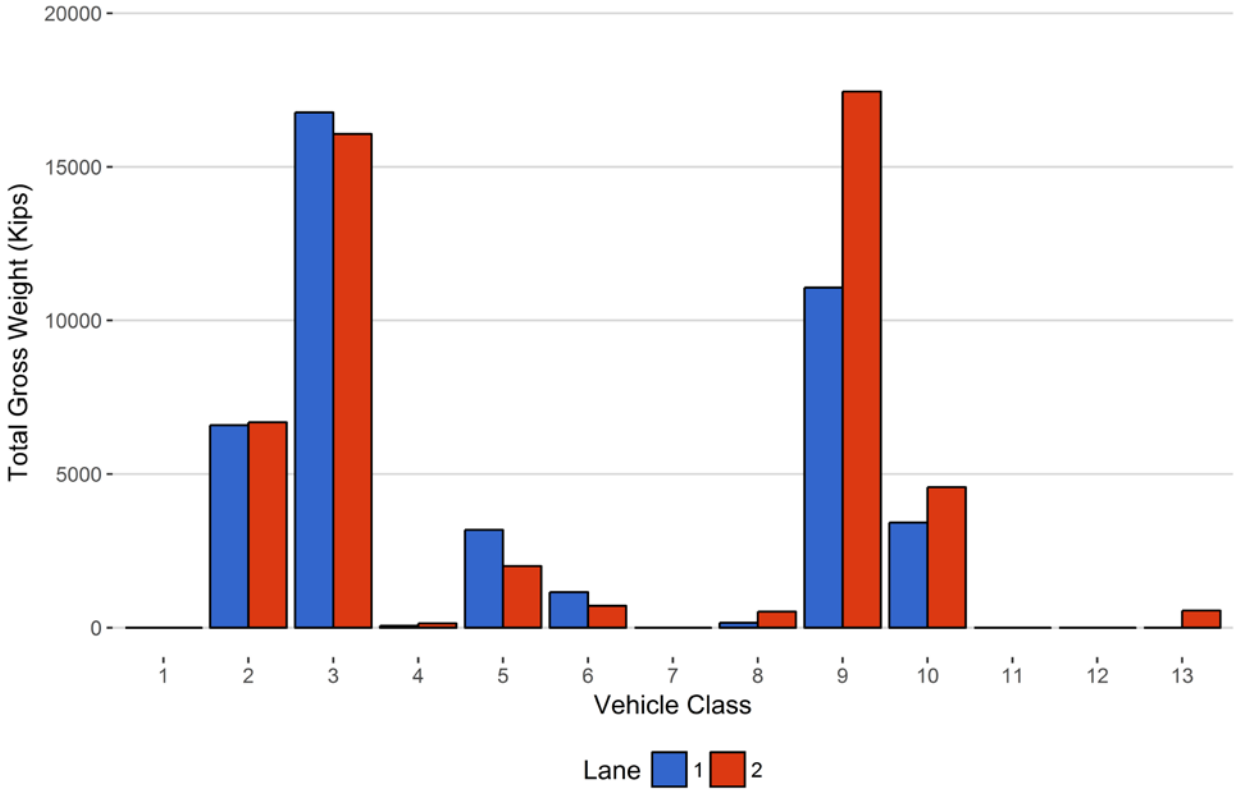


Figure 11 - Total Gross Vehicle Weight by

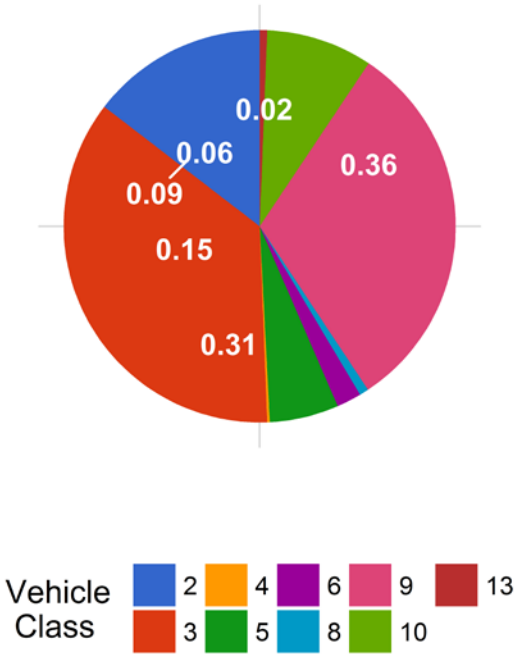


Figure 12 - Total ESALs by Class and Lane

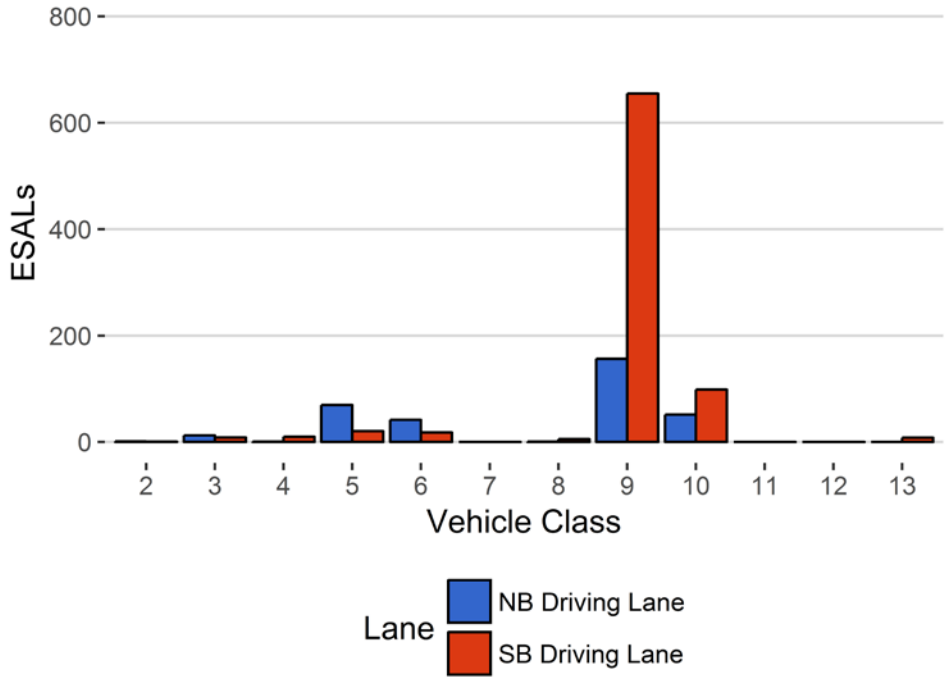


Figure 13 - ESALs by Class

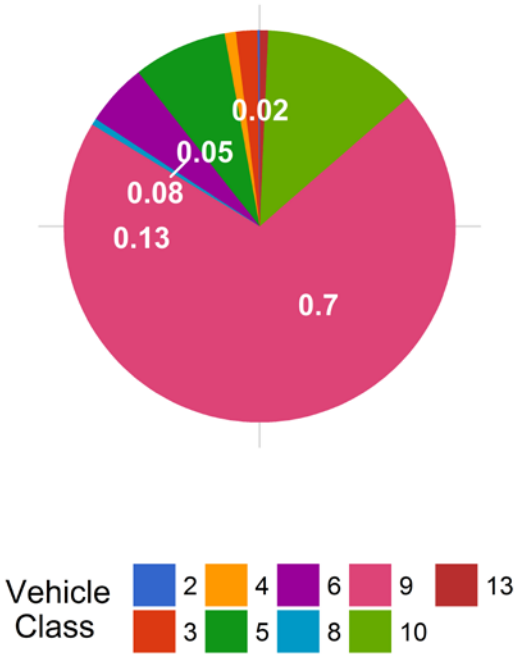


Table 1 Class 9 Front Axle Weight by Lane

Month	*Lane 1 (Kips)*	*Front Axle +/- 9%*	*Lane 2 (Kips)*	*Front Axle +/- 9%*
March 2015	12.00	0.00	11.45	0.00
July 2015	11.54	-3.77	11.64	1.65
October 2015	12.47	3.93	10.87	-5.10
November 2015	11.63	-3.03	11.74	2.52
December 2015	11.24	-6.34	11.83	3.27
January 2016	11.23	-6.36	11.55	0.82
February 2016	11.03	-8.02	11.06	-3.38
March 2017	11.11	-7.40	11.02	-3.81
April 2017	10.64	-11.31	11.70	2.19
July 2017	11.39	-5.09	11.25	-1.76
December 2017	11.65	-2.85	11.58	1.16
January 2018	11.29	-5.87	11.71	2.27
February 2018	11.14	-7.13	11.81	3.09
March 2018	10.94	-8.82	11.96	4.43

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	103	3197	34.2	0	0
3	161	5002	53.5	0	0
4	0	5	0.1	1	0.3
5	13	406	4.3	11	3.7
6	2	51	0.5	11	3.7
7	0	0	0	0	0
8	1	22	0.2	0	0
9	17	537	5.7	200	67.3
10	4	121	1.3	68	22.9
11	0	0	0	0	0
12	0	0	0	0	0
13	0	6	0.1	6	2
TOTAL	**302**	**9347**	**100**	**297**	**100**

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

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2018-03-01	Thursday	10:16:36	9	SB	2	107.71
2018-03-02	Friday	17:53:38	10	SB	2	102.68
2018-03-02	Friday	11:58:22	9	SB	2	101.79
2018-03-02	Friday	20:53:07	9	NB	1	101.16
2018-03-12	Monday	18:08:34	9	SB	2	100.16
2018-03-13	Tuesday	09:50:45	9	SB	2	99.59
2018-03-07	Wednesday	14:10:56	9	SB	2	99.18
2018-03-13	Tuesday	12:56:07	9	SB	2	99.12
2018-03-12	Monday	19:07:45	9	SB	2	98.76
2018-03-16	Friday	13:15:06	10	SB	2	98.32

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	NB	15	3	0	0	61	0	8
5	NB	8	229	11	4.8	3103	79	680
6	NB	19	28	1	3.6	1137	19	312
8	NB	31	6	4	66.7	72	89	5
9	NB	33	285	173	60.7	6040	5028	1172
10	NB	33.5	54	1	1.9	3411	11	818
TOTAL	****	****	**605**	**190**	****	**13823**	****	**2994**
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	SB	15	2	0	0	140	0	55
5	SB	8	162	16	9.9	1887	118	359
6	SB	19	21	1	4.8	689	18	155
8	SB	31	15	4	26.7	439	84	49
9	SB	33	232	22	9.5	16832	621	4951
10	SB	33.5	62	0	0	4573	0	1248
13	SB	31.5	6	0	0	557	0	184
TOTAL	****	****	**500**	**43**	****	**25118**	****	**7001**
GRAND TOTAL	****	****	**1105**	**233**	**189**	**38941**	**6067**	**9995**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*NB*	*SB*	*Total*	*Percentage*
2	6590	6684	13274	14.6
3	16773	16068	32841	36
4	61	140	200	0.2
5	3182	2005	5187	5.7
6	1156	708	1863	2
8	161	524	684	0.8
9	11068	17453	28520	31.3
10	3422	4573	7995	8.8
13	0	557	557	0.6
TOTAL	**42412**	**48711**	**91123**	**100**
GVW/LANE	**46.54**	**53.46**	**100**	**0.11**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*NB*	*SB*	*Total*	*Percentage*	*Flexible ESAL Factor*
2	1	1	2	0.2	0.002
3	12	8	20	1.8	0.0095
4	1	10	11	0.9	2.95
5	70	20	90	7.8	0.49
6	42	18	60	5.1	2.37
8	1	5	6	0.6	0.73
9	156	655	811	70.1	3.23
10	51	98	150	12.9	2.56
13	0	8	8	0.7	1.56
TOTAL	**334**	**824**	**1158**	**100**	**14**
ESALS/LANE	**28.8**	**71.2**	**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 %*
Apr 2017	10885	363	39	9709	89.2	1176.4	10.8
Jul 2017	15408	497	66	13371	86.8	2037.1	13.2
Dec 2017	13625	440	164	8548	62.7	5076.5	37.3
Jan 2018	9334	301	31	8364	89.6	970.2	10.4
Feb 2018	8344	298	26	7623	91.4	721.4	8.6
Mar 2018	9347	302	37	8199	87.7	1148.1	12.3
TOTAL	**66943**	**--**	**--**	**55814**	**--**	**11130**	**--**
AVERAGE	**11157**	**367**	**60**	**9302**	**85**	**1855**	**15**

ESALs

Month	*ESALS NB Driving Lane*	*ESALS SB Driving Lane*	*Total ESALS*	*Pavement Life Decrease Months*
Apr 2017	163	595	757	2.3
Jul 2017	844	812	1656	6.9
Dec 2017	5038	494	5532	9.3
Jan 2018	675	202	877	44.3
Feb 2018	628	248	876	53
Mar 2018	1032	825	1857	22.6
TOTAL	**8380**	**--**	**--**	**--**
AVERAGE	**1397**	**529**	**1926**	**23**

Gross Vehicle Weight

Month	*GVW NB Driving Lane*	*GVW SB Driving Lane*	*Total GVW Kips*
Apr 2017	53516	26950	80466
Jul 2017	46043	18588	64631
Dec 2017	42984	48768	91752
Jan 2018	40432	52112	92544
Feb 2018	81844	70339	152183
Mar 2018	254680	79312	333992
TOTAL	**519498**	**296070**	**815568**
AVERAGE	**86583**	**49345**	**135928**

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*
Apr 2017	179	1.7	15.6	3	0
Jul 2017	411	2.8	20.8	28	2
Dec 2017	2221	19	50.7	1972	1497
Jan 2018	245	2.9	27.8	141	50
Feb 2018	209	2.8	32	115	29
Mar 2018	305	3.4	27.2	128	10
TOTAL	**3570**	**--**	**--**	**2387**	**1588**
AVERAGE	**595**	**5.4**	**29**	**397.8**	**264.7**

Freight

Month	*NB Freight Tons*	*SB Freight Tons*	*Total Freight*	*NB Freight %*	*SB Freight %*
Apr 2017	1899	6229	8128	23.4	76.6
Jul 2017	9795	7956	17750	55.2	44.8
Dec 2017	77434	3362	80796	95.8	4.2
Jan 2018	6853	1794	8647	79.2	20.8
Feb 2018	5819	802	6622	87.9	12.1
Mar 2018	2994	7001	9995	30	70
TOTAL	**104794**	**27145**	**131939**	**--**	**--**
AVERAGE	**17465.6**	**4524.2**	**21989.8**	**61.9**	**38.1**