FEBRUARY 2019

WIM #48
CSAH 5,
MP 15.05
STORDEN, MN

MONTHLY REPORT

Your Destination...Our Priority

WIM Site Location

WIM #48 is located on CSAH 5 near Storden in Cottonwood county.

System Operation

WIM #48 was operational for the entire month of February 2019. Volume was computed using all monthly data.

System Calibration

WIM #48 was most recently calibrated on 2018-06-12. Table 1 summarizes the front axle weights of class 9s by 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: 7600 | Passenger Vehicles: 6535 | Heavy Commercial Vehicles: 1065

Monthly Average Daily Traffic (MADT): 271 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 38

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 Sundays (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 07 AM and 05 PM. Similarly, SB PVs peaked in volume between 03 PM and 05 PM

Heavy Commercial Vehicles (HCVs)

Volume trends. On an average 24-hour day, HCVs traveling NB typically reached peak volume levels between 07 AM and 05 PM, while volume going SB peaked between 03 PM and 05 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 1065 HCVs, 232 of them were overweight [3]. These overweight HCVs contributed to 3.7% of total monthly volume, and 26.2% of total monthly HCV

volume. NB overweight vehicles typically reached highest numbers on Fridays, with lowest volumes reported on NAs. SB overweight vehicles tended to reach highest volumes on Fridays, with lowest volumes reported on Sundays. See Figure 3 .
The top two overweight violators by class were the class 9 and class 5 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 69.6% 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 September.
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 ,31 NB vehicles exceeded 88,000 pounds (19 vehicles were Class 9's; 7 vehicles were Class 10's). Of vehicles traveling SB,

125 NB vehicles exceeded 88,000 pounds (94 vehicles were Class 9's; 16 vehicles were Class 10's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from February 2019.

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

Freight Totals. A total of 9830 tons of freight was recorded to have crossed the WIM. More freight was shipped SB (66.4%) than NB (33.6%). See Table 4 and Figure 11 for more freight information.

Infrastructure Considerations

Bridge. Bridge No. 97506 (a precast box culvert) is approximately 1.3 miles north of WIM #48. Bridge No. 97666 (a precast box culvert) is approximately .45 miles south of WIM #48. WIM #48 recorded a total of 7600 vehicles with a combined GVW of 72467 kips (1 kip = 1,000 pounds = 0.5 tons) in February 2019. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 1523 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 72% of all ESALs were recorded SB while 28% was observed NB. In particular, 54% of all ESALs were generated by the Class 9's (Class 9's were also responsible for generating 26% 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

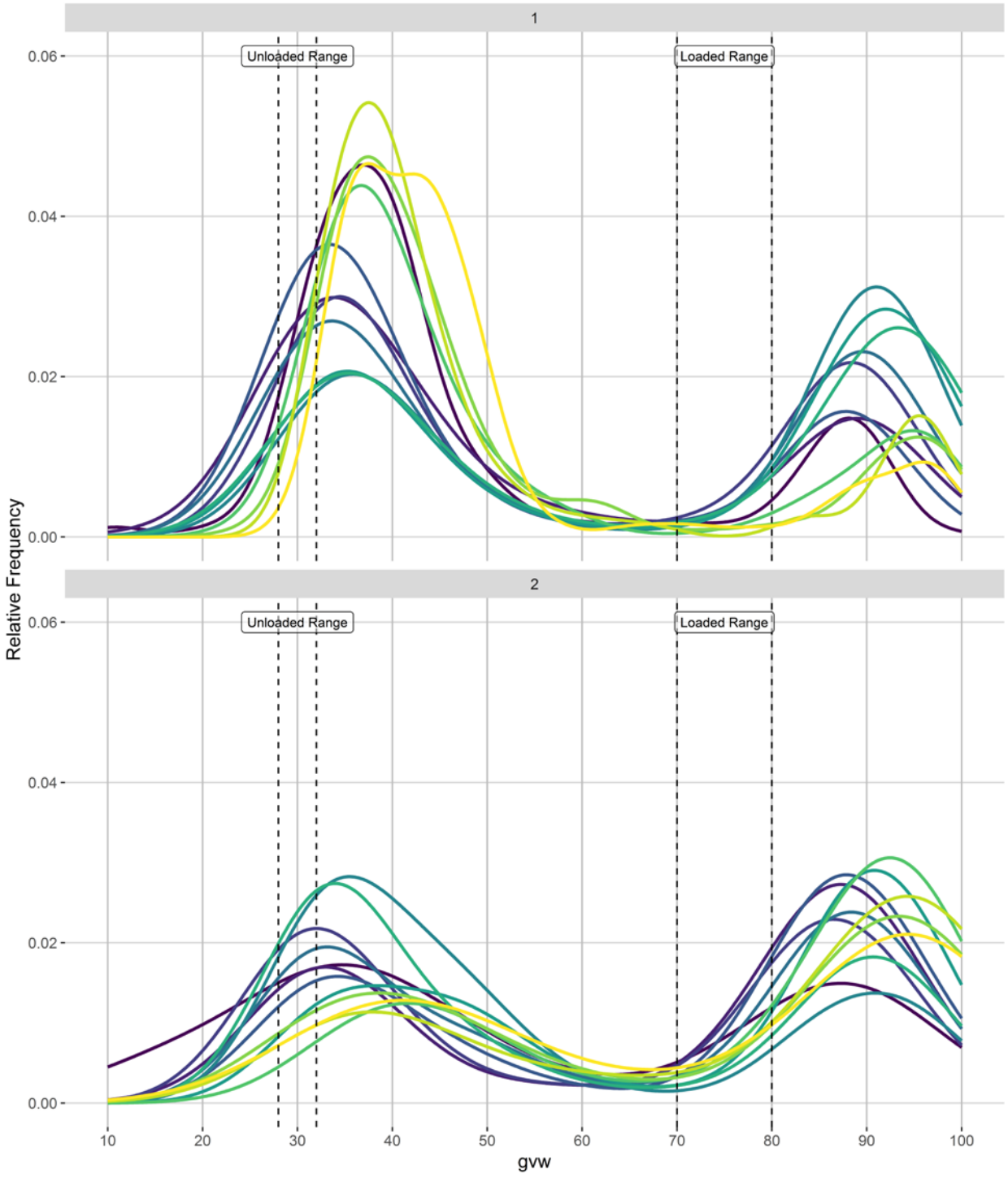
- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

- [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

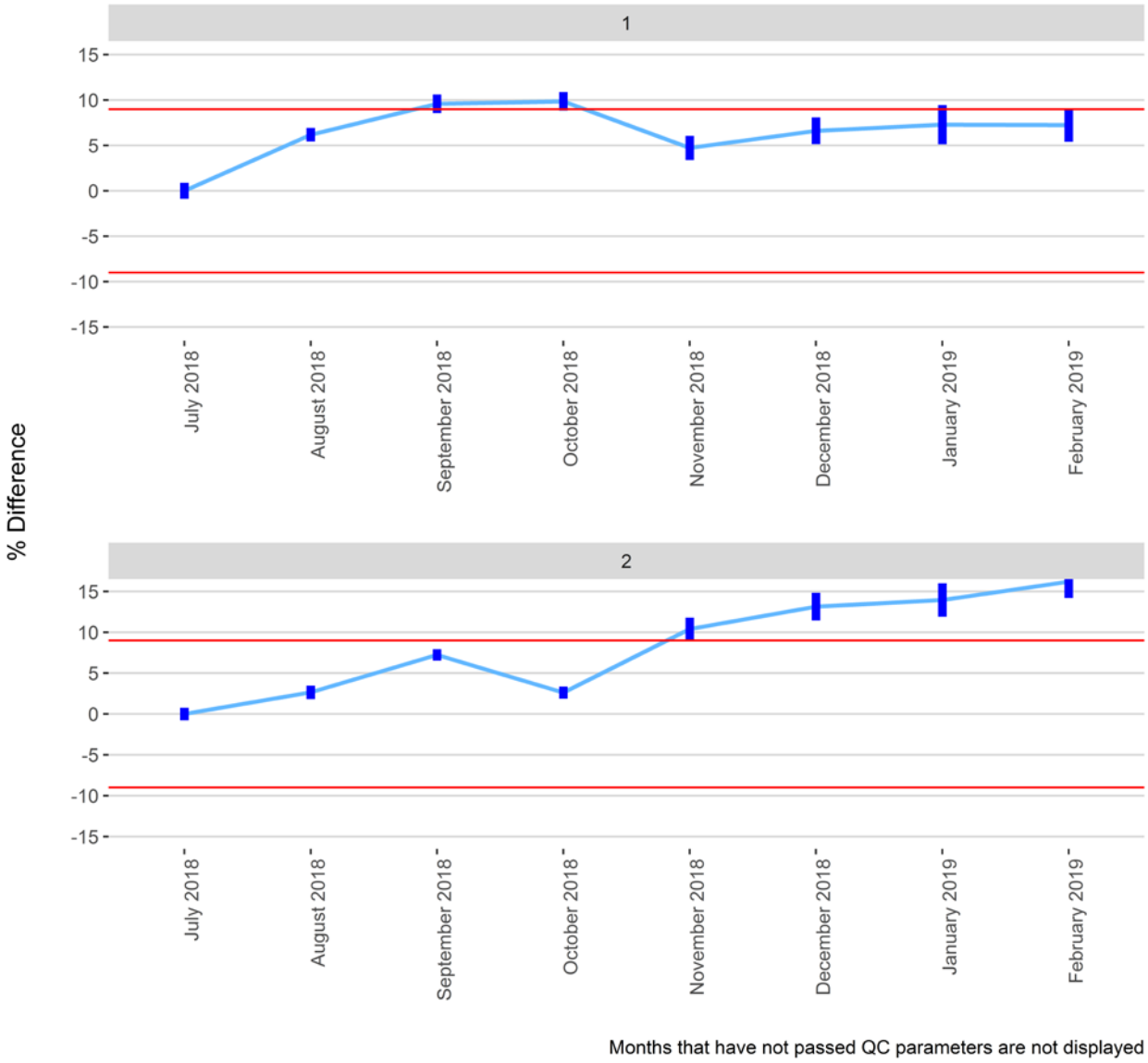
- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened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

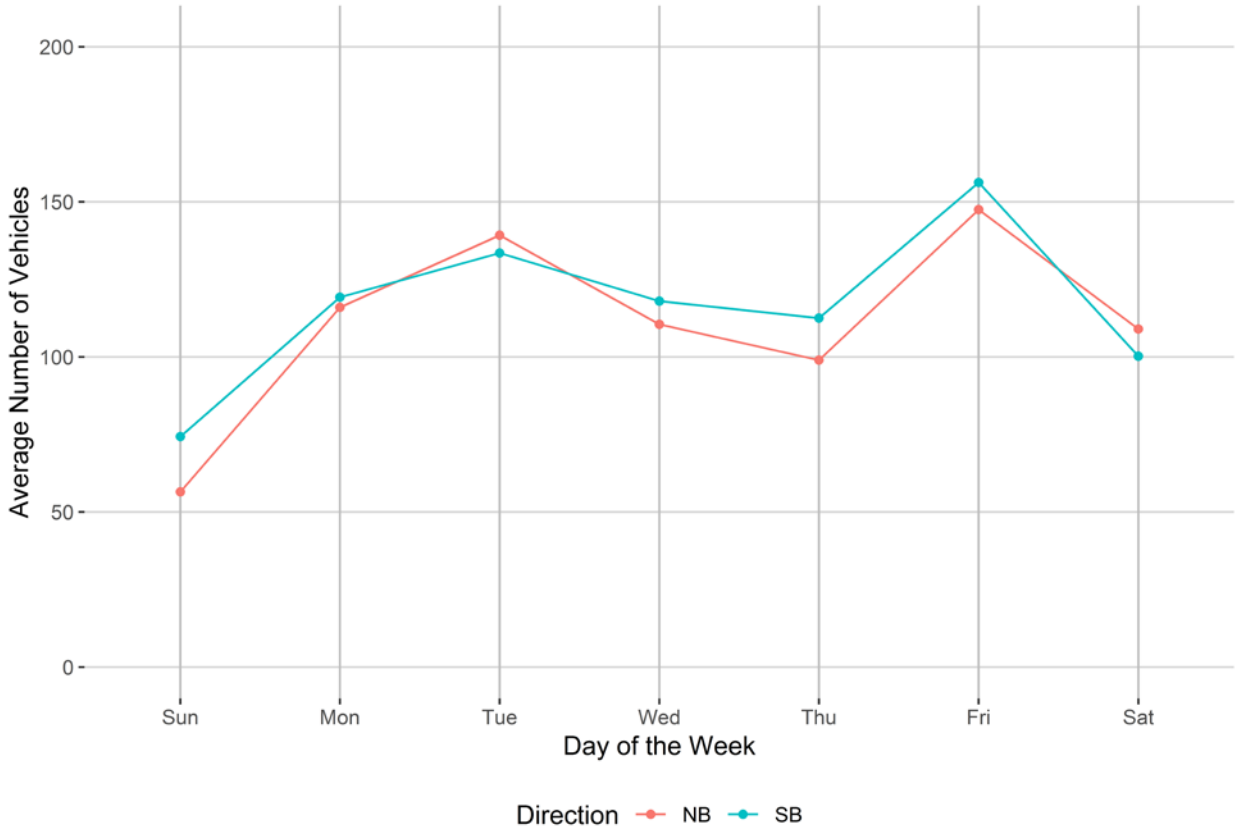


Figure 3 - Average Overweight Vehicle Volume vs. Day of the Week

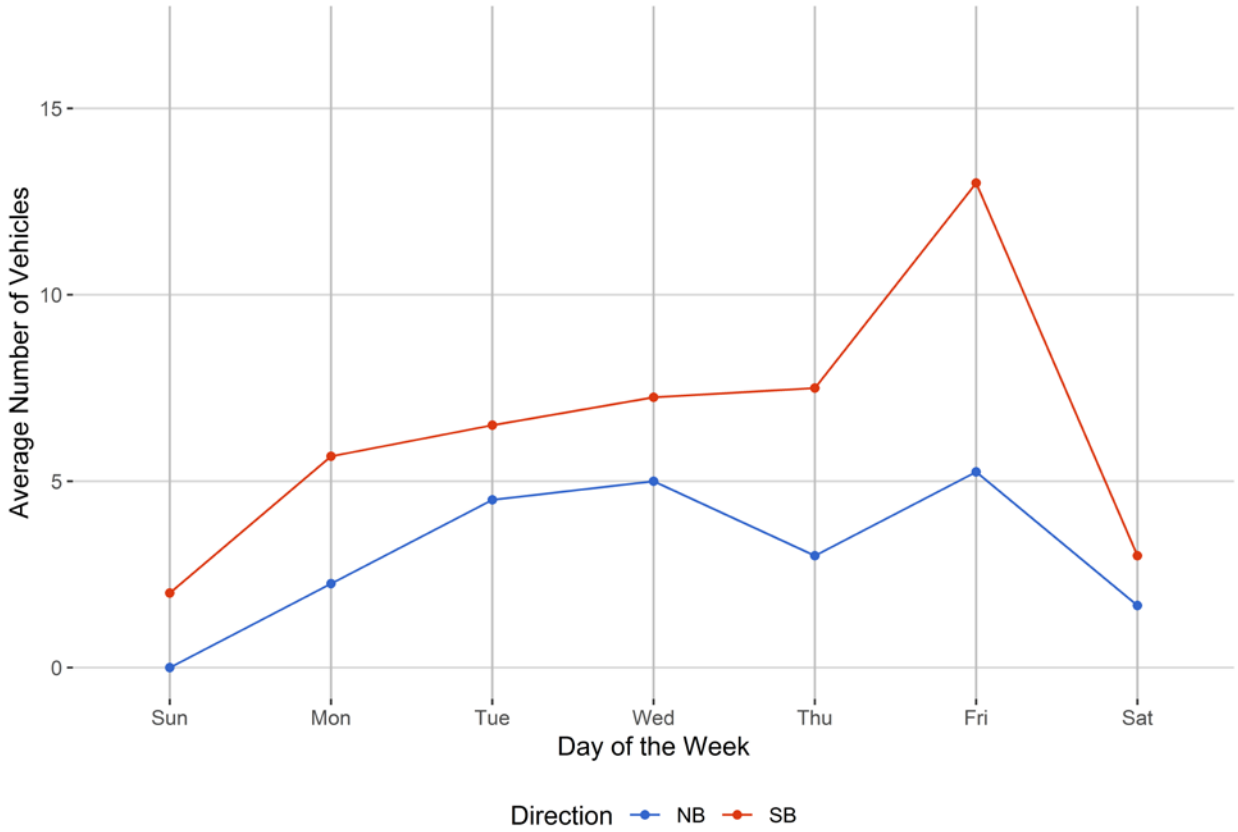


Figure 4 - Passenger Vehicles vs. Hour of the Day

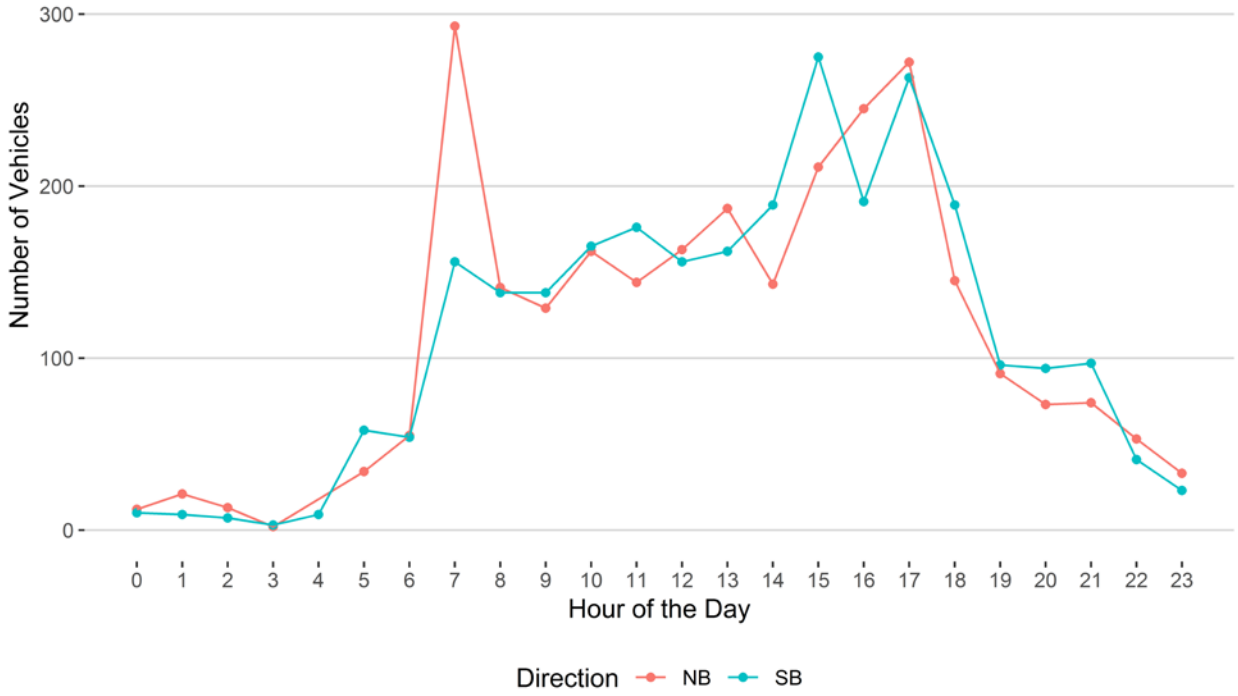


Figure 5 - Heavy Commercial Vehicles vs. Hour of the Day

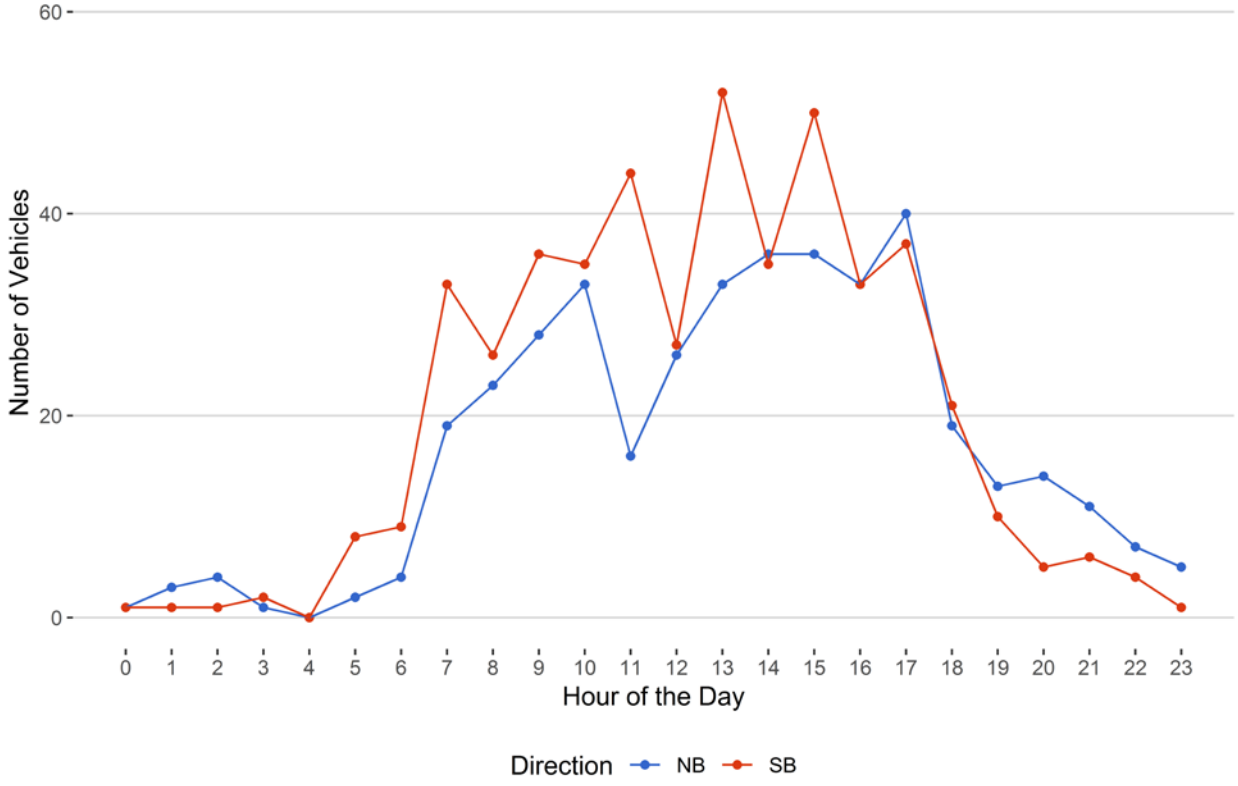


Figure 6 - Overweight Vehicles by Class
vs. Hour of the Day

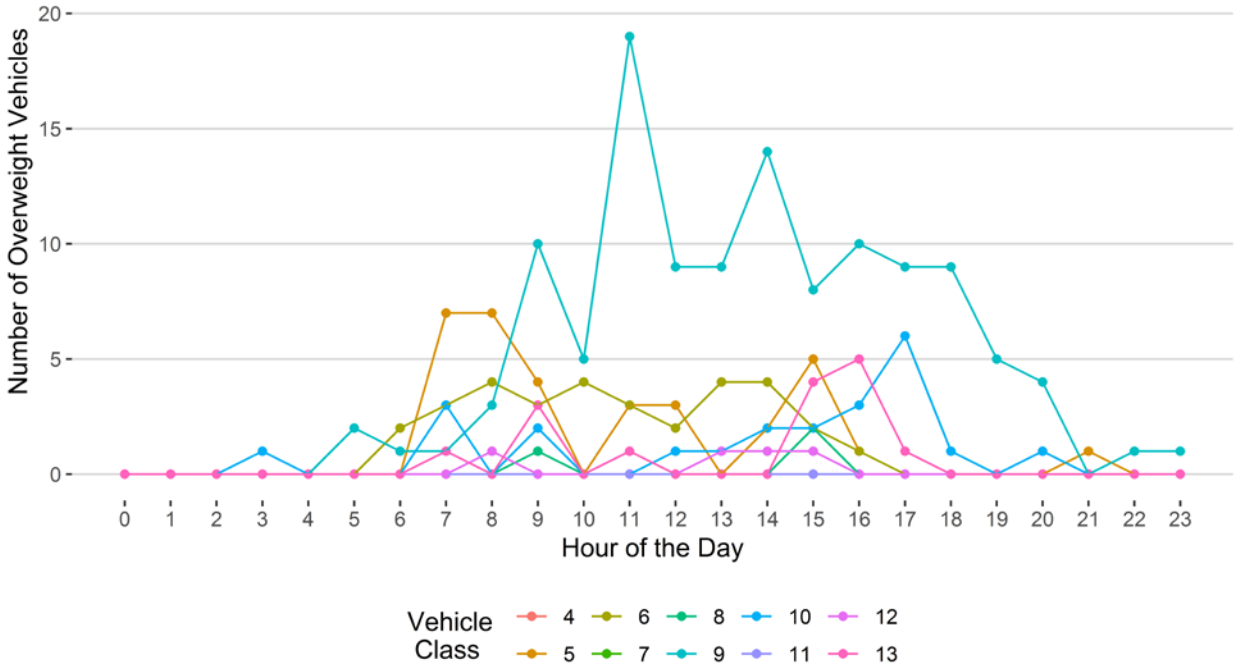


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

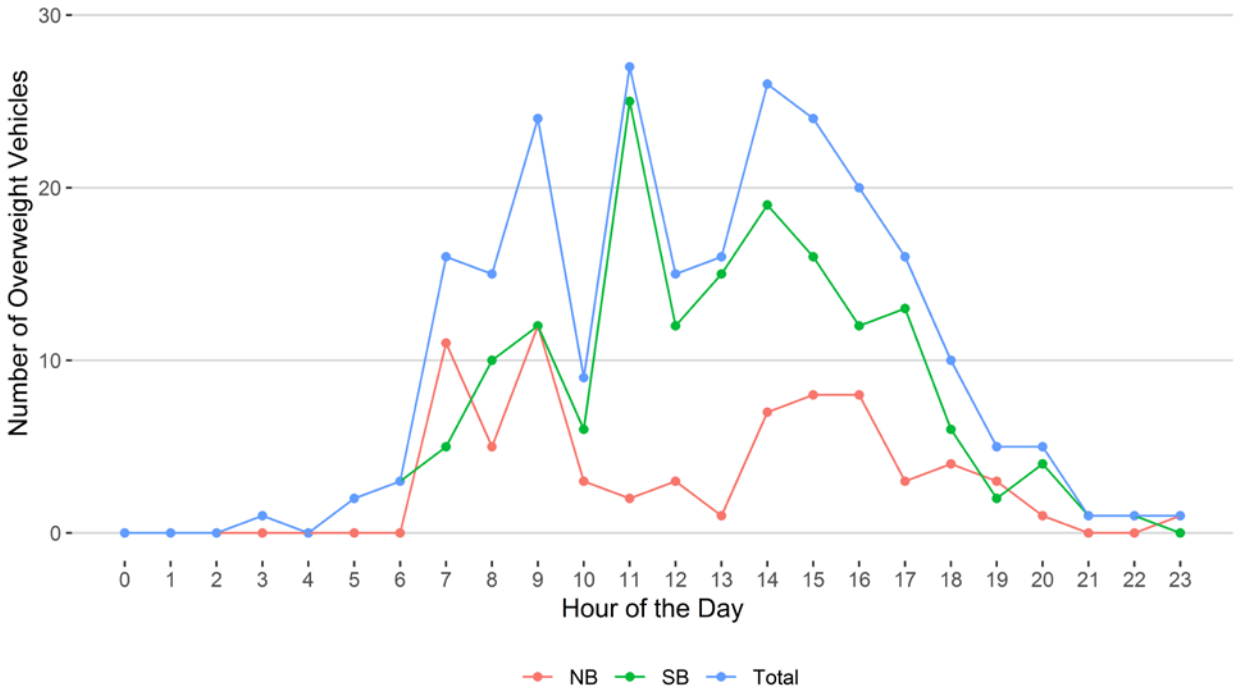
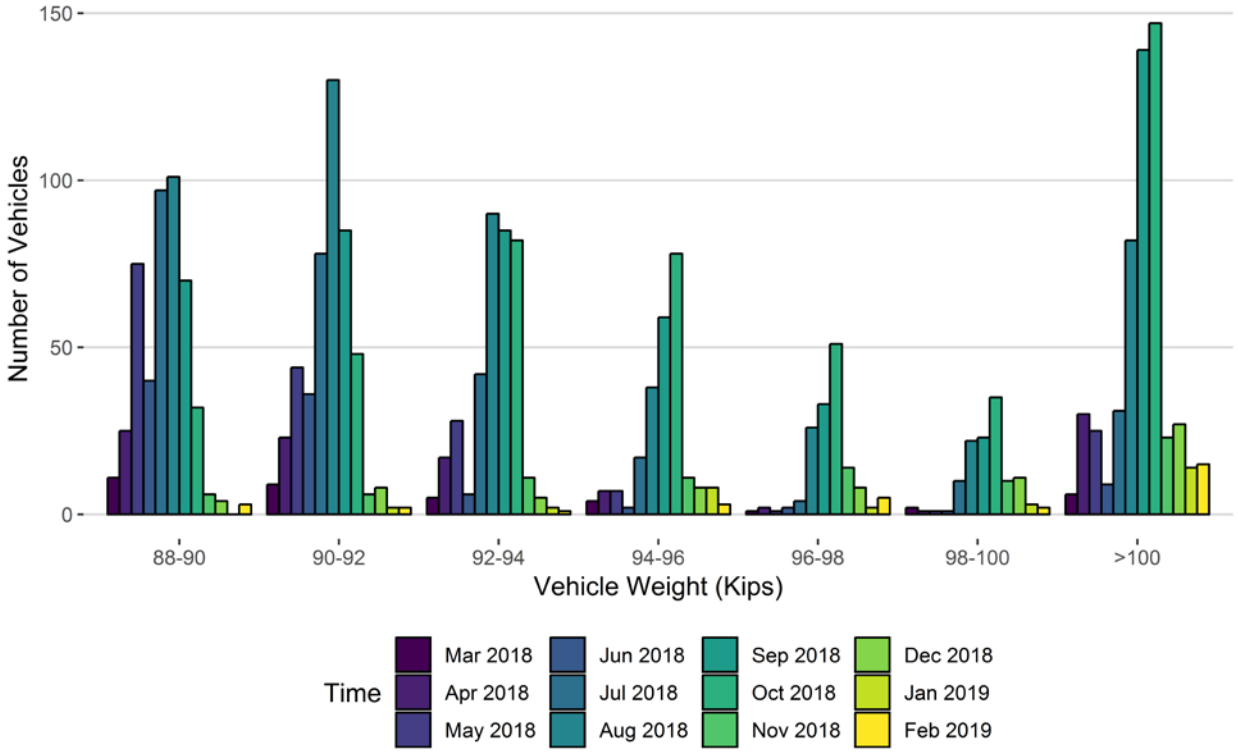
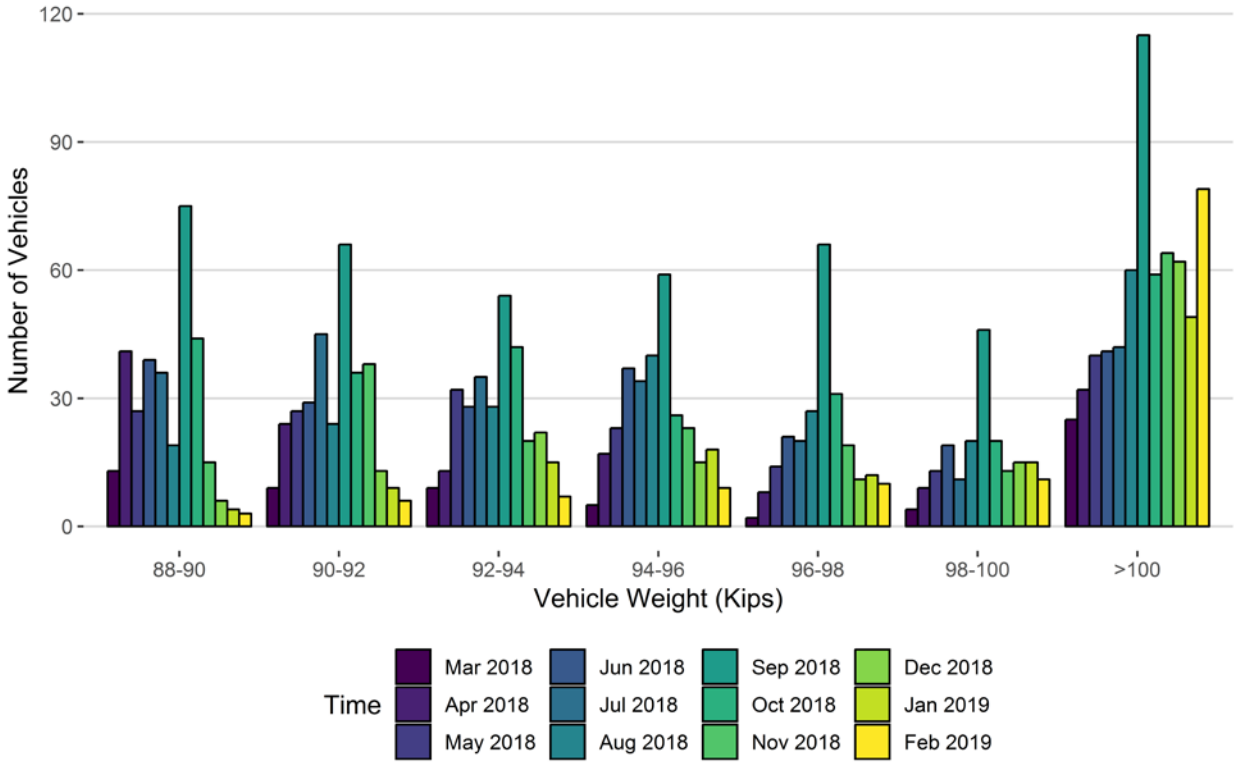


Figure 8 - Histogram of NB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Mar 2018*	*Apr 2018*	*May 2018*	*Jun 2018*	*Jul 2018*	*Aug 2018*	*Sep 2018*	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*
88-90	11	25	75	40	97	101	70	32	6	4	0	3
90-92	9	23	44	36	78	130	85	48	6	8	2	2
92-94	5	17	28	6	42	90	85	82	11	5	2	1
94-96	4	7	7	2	17	38	59	78	11	8	8	3
96-98	1	2	1	2	4	26	33	51	14	8	2	5
98-100	2	1	1	1	10	22	23	35	10	11	3	2
>100	6	30	25	9	31	82	139	147	23	27	14	15
Total	38	105	181	96	279	489	494	473	81	71	31	31

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



Vehicle Weights (Kips)	*Mar 2018*	*Apr 2018*	*May 2018*	*Jun 2018*	*Jul 2018*	*Aug 2018*	*Sep 2018*	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*
88-90	13	41	27	39	36	19	75	44	15	6	4	3
90-92	9	24	27	29	45	24	66	36	38	13	9	6
92-94	9	13	32	28	35	28	54	42	20	22	15	7
94-96	5	17	23	37	34	40	59	26	23	15	18	9
96-98	2	8	14	21	20	27	66	31	19	11	12	10
98-100	4	9	13	19	11	20	46	20	13	15	15	11
>100	25	32	40	41	42	60	115	59	64	62	49	79
Total	67	144	176	214	223	218	481	258	192	144	122	125

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

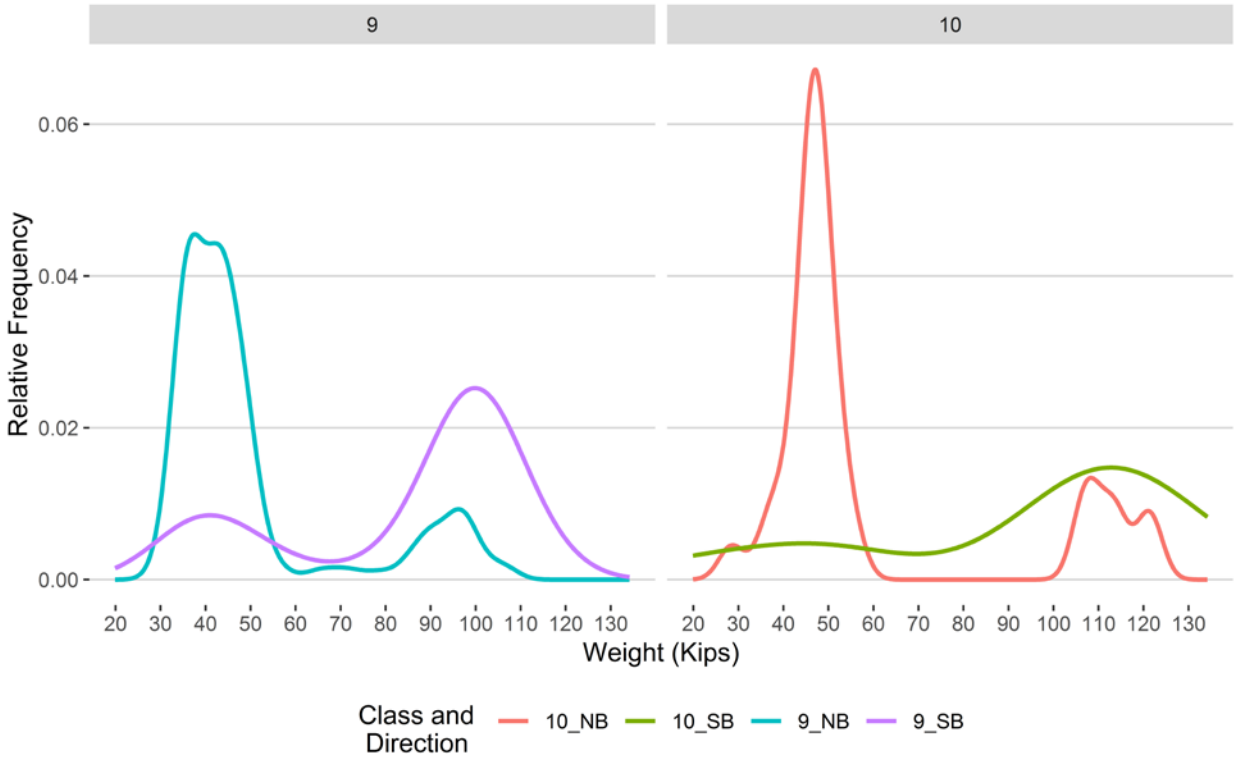


Figure 9 - Freight Percentage by Direction and Class

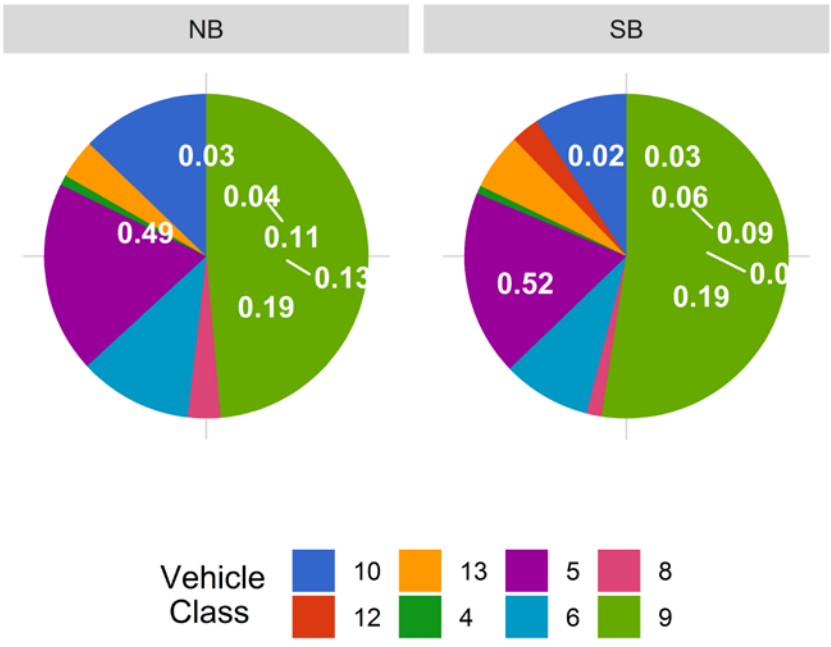


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

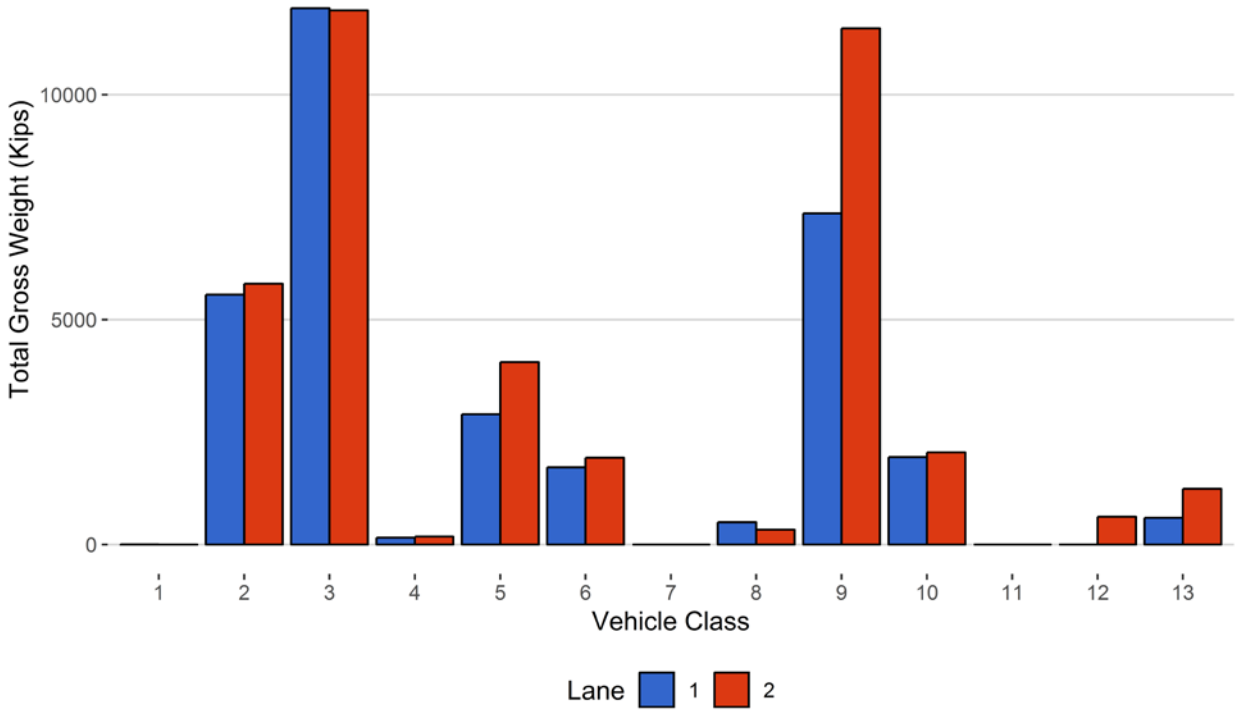


Figure 11 - Total Gross Vehicle Weight b

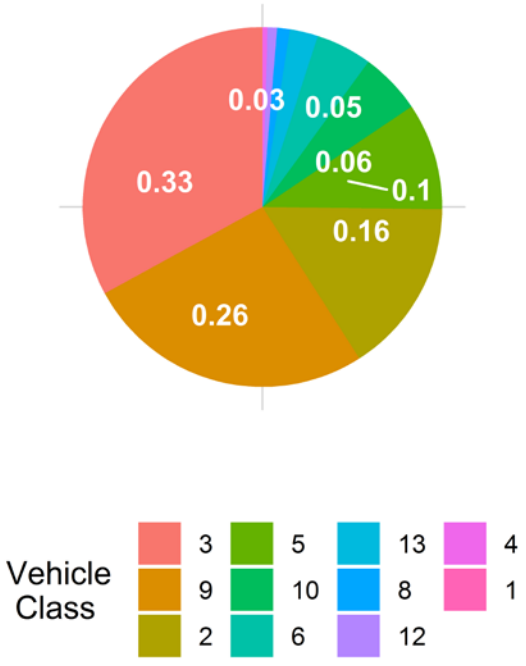


Figure 12 - Total ESALs by Class and Lane

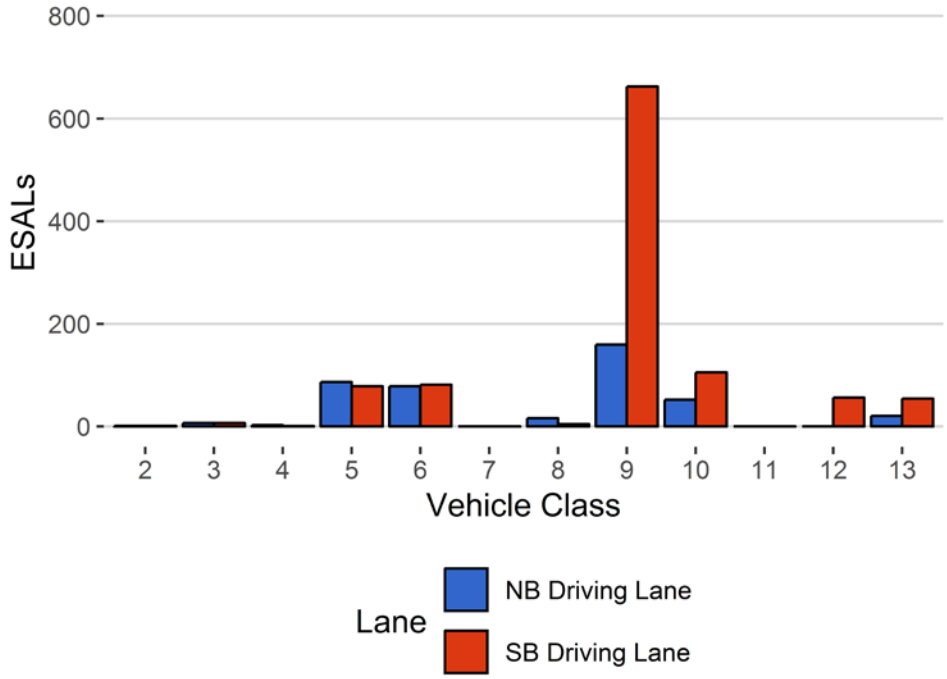


Figure 13 - ESALs by Class

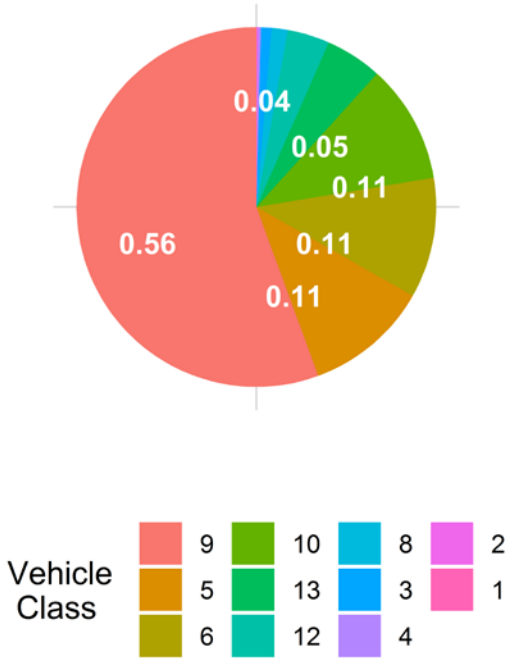


Table 1 Class 9 Front Axle Weight by Lane

Month	*Lane 1 (Kips)*	*Front Axle +/- 9%*	*Lane 2 (Kips)*	*Front Axle +/- 9%*
July 2018	11.77	0.00	11.70	0.00
August 2018	12.50	6.18	12.01	2.65
September 2018	12.90	9.58	12.54	7.23
October 2018	12.93	9.86	12.00	2.62
November 2018	12.33	4.72	12.91	10.39
December 2018	12.55	6.61	13.23	13.13
January 2019	12.63	7.29	13.33	13.95
February 2019	12.62	7.24	13.59	16.20

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	1	0	0	0
2	96	2699	35.5	0	0
3	137	3834	50.5	0	0
4	1	18	0.2	0	0
5	18	495	6.5	33	14.2
6	4	99	1.3	32	13.8
7	0	0	0	0	0
8	1	23	0.3	4	1.7
9	12	341	4.5	120	51.7
10	2	65	0.9	23	9.9
11	0	0	0	0	0
12	0	6	0.1	5	2.2
13	1	18	0.2	15	6.5
TOTAL	**271**	**7600**	**100**	**232**	**100**

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

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2019-02-11	Monday	13:24:00	10	SB	2	134.19
2019-02-13	Wednesday	12:03:59	10	SB	2	123.54
2019-02-01	Friday	15:59:37	10	SB	2	123.22
2019-02-02	Saturday	17:32:32	10	SB	2	122.09
2019-02-06	Wednesday	16:14:29	10	NB	1	121.64
2019-02-13	Wednesday	16:47:30	10	NB	1	121.5
2019-02-15	Friday	17:00:16	10	NB	1	120.9
2019-02-28	Thursday	17:31:22	10	SB	2	118.41
2019-02-19	Tuesday	13:14:00	9	SB	2	118.22
2019-02-01	Friday	14:59:32	9	SB	2	118.01

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	7	2	28.6	129	22	27
5	NB	8	168	0	0	2896	0	776
6	NB	19	38	0	0	1714	0	496
8	NB	31	10	1	10	467	26	94
9	NB	33	147	5	3.4	7202	160	1258
10	NB	33.5	32	1	3.1	1914	28	438
13	NB	31.5	5	0	0	593	0	218
TOTAL	****	****	**407**	**9**	****	**14915**	****	**3307**
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	8	0	0	177	0	29
5	SB	8	243	1	0.4	4048	6	1056
6	SB	19	44	3	6.8	1882	47	551
8	SB	31	9	3	33.3	261	69	37
9	SB	33	136	3	2.2	11390	86	3500
10	SB	33.5	22	2	9.1	2008	41	669
12	SB	36.5	5	0	0	618	0	218
13	SB	31.5	10	0	0	1240	0	462
TOTAL	****	****	**477**	**12**	****	**21623**	****	**6523**
GRAND TOTAL	****	****	**884**	**21**	**97**	**36539**	**484**	**9830**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*NB*	*SB*	*Total*	*Percentage*
1	1	0	1	0
2	5554	5800	11354	15.7
3	11925	11875	23800	33
4	150	177	328	0.5
5	2896	4054	6949	9.6
6	1714	1928	3642	5
8	494	330	823	1.1
9	7361	11476	18838	26.1
10	1943	2049	3992	5.5
12	0	618	618	0.9
13	593	1240	1833	2.5
TOTAL	**32632**	**39546**	**72178**	**100**
GVW/LANE	**45.21**	**54.79**	**100**	**0.14**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*NB*	*SB*	*Total*	*Percentage*	*Flexible ESAL Factor*
1	0	0	0	0	0.5
2	1	1	2	0.2	0.0032
3	7	7	14	0.9	0.01
4	3	1	4	0.2	0.6
5	87	79	166	11.2	0.83
6	78	82	160	10.8	3.83
8	16	5	21	1.4	1.93
9	160	662	822	55.6	5.85
10	52	106	158	10.7	5.26
12	0	56	56	3.8	7.57
13	21	55	75	5.1	6.03
TOTAL	**425**	**1053**	**1479**	**100**	**32**
ESALS/LANE	**28.7**	**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 %*
Mar 2018	9969	322	35	8878	89.1	1091.2	10.9
Apr 2018	10062	335	48	8635	85.8	1427.4	14.2
May 2018	14674	473	73	12414	84.6	2259.8	15.4
Jun 2018	13021	434	67	11020	84.6	2001.1	15.4
Jul 2018	13682	441	78	11271	82.4	2410.8	17.6
Aug 2018	13562	438	85	10928	80.6	2634	19.4
Sep 2018	14017	467	98	11073	79	2944.3	21
Oct 2018	14892	480	116	11303	75.9	3589.5	24.1
Nov 2018	11107	370	47	9686	87.2	1421.5	12.8
Dec 2018	9594	310	39	8393	87.5	1201.4	12.5
Jan 2019	7052	282	28	6187	87.7	864.7	12.3
Feb 2019	7600	271	38	6535	86	1065.2	14
TOTAL	**139232**	**–**	**–**	**116323**	**–**	**22911**	**–**
AVERAGE	**11603**	**385**	**63**	**9694**	**84**	**1909**	**16**

ESALs

Month	*ESALS NB Driving Lane*	*ESALS SB Driving Lane*	*Total ESALS*	*Pavement Life Decrease Months*
Mar 2018	402	520	922	56.5
Apr 2018	724	1023	1747	55.4
May 2018	1396	1406	2801	50.4
Jun 2018	916	1578	2494	67.8
Jul 2018	1730	1722	3452	58.4
Aug 2018	2494	1632	4127	86.4
Sep 2018	2756	3014	5769	85
Oct 2018	2883	1950	4833	100
Nov 2018	707	1320	2027	88.4
Dec 2018	581	1022	1603	97.2
Jan 2019	315	859	1173	100.9
Feb 2019	426	1097	1523	116.2
TOTAL	**15331**	**–**	**–**	**–**
AVERAGE	**1278**	**1428**	**2706**	**80**

Gross Vehicle Weight

Month	*GVW NB Driving Lane*	*GVW SB Driving Lane*	*Total GVW Kips*
Mar 18	43050	42310	85360
Apr 18	54740	56400	111139
May 18	86626	80895	167521
Jun 18	72965	78450	151415
Jul 18	91632	86499	178130
Aug 18	104470	87394	191864
Sep 18	101402	112503	213905
Oct 18	95547	82834	178381
Nov 18	53687	60504	114190
Dec 18	46511	49899	96410
Jan 19	27108	36968	64076
Feb 19	32684	39784	72467
TOTAL	**810419**	**814439**	**1624859**
AVERAGE	**67535**	**67870**	**135405**

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 2018	202	2.2	19.6	105	37
Apr 2018	419	4.4	31.2	249	72
May 2018	669	4.9	31.6	360	82
Jun 2018	607	4.9	31.7	313	73
Jul 2018	828	6.6	36.7	502	94
Aug 2018	907	7.4	37.3	708	185
Sep 2018	1229	10.1	47.7	976	324
Oct 2018	993	10.1	41.6	732	262
Nov 2018	401	3.9	30.1	274	110
Dec 2018	286	3.2	25.2	216	116
Jan 2019	216	3.6	29.4	154	82
Feb 2019	237	3.8	26.4	156	107
TOTAL	**6994**	**–**	**–**	**4745**	**1544**
AVERAGE	**582.8**	**5.4**	**32.4**	**395.4**	**128.7**

Freight

Month	*NB Freight Tons*	*SB Freight Tons*	*Total Freight*	*NB Freight %*	*SB Freight %*
Mar 2018	3533	4672	8204	43.1	56.9
Apr 2018	6268	8863	15130	41.4	58.6
May 2018	11363	11901	23264	48.8	51.2
Jun 2018	8008	12671	20678	38.7	61.3
Jul 2018	14113	13882	27995	50.4	49.6
Aug 2018	19506	13260	32765	59.5	40.5
Sep 2018	19864	22935	42800	46.4	53.6
Oct 2018	19870	14175	34045	58.4	41.6
Nov 2018	5662	9780	15442	36.7	63.3
Dec 2018	4620	7430	12050	38.3	61.7
Jan 2019	2455	5954	8409	29.2	70.8
Feb 2019	3307	6523	9830	33.6	66.4
TOTAL	**118567**	**132046**	**250613**	**–**	**–**
AVERAGE	**9880.6**	**11003.8**	**20884.4**	**43.7**	**56.3**