Analysis of 110 km/hr Speed Limit: Implementation on Saskatchewan Divided Rural Highways

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ABSTRACT

This paper will assess the short-term effects on driver speeds after increasing the posted speed limit on rural four-lane highways in Saskatchewan. On June 1, 2003 the maximum speed limit on select sections of Saskatchewan twinned highways was increased from 100 km/hr to 110 km/hr. Spot speed studies were conducted at representative locations before and after the speed limit increase, during the period from April 2003 to September 2003. While the majority of the data collected was on the four-lane highway system, data was also collected on two-lane highway sections to identify any possible "halo effects" where speed limits were not increased. Data collected at the study sites before the increase indicated that the 100 km/hr speed limit was well below the average driver speed and 85th percentile speed. Data collected after the speed limit increase showed only a minimal increase in average driver speeds, 85th percentile speeds, and pace speeds, while the average increase in speed differential was found to be minimal. The speed limit increase appears to have created a higher driver compliance rate, at least in the short term. The increased compliance rate does not necessarily reflect a change in driver behavior, but may be the result of a change in how compliance is measured. Speed profiles on two-lane highways only showed small changes in vehicle speed characteristics. Overall, raising the posted speed limit has had a lesser effect on driver speeds than anticipated. Due to the short duration of the study, additional studies are recommended to further identify vehicle speed trends and possible changes in collision profiles.

1.0 Introduction

Some aspects of the strong relationships between design speed, operating speed, speed limit, and speed limit compliance are not clearly understood. Speed limits establish the maximum legal travel speed during favorable conditions. They are a balance between travel time, safety, collision risk, and efficiency as well as providing a basis for enforcement. Speed limits have been used for many years in Saskatchewan to influence driver behavior. In general speed limits are necessary to ensure an acceptable level of safety while maintaining efficient travel on Saskatchewan highways.

On June 1, 2003 the maximum speed limit on selected sections of rural twinned Saskatchewan highways was increased from 100 km/hr to 110 km/hr. This increase in speed limit potentially provides a long term opportunity to assess the safety effects of speed, speed limits, enforcement, and perhaps engineering measures to manage speed.

1.1 Methodology

The study consisted of a major effort in collecting various spot speed studies conducted throughout the province. The speeds of approximately 6.2 million vehicles were collected during this study. These observations were then used to estimate the speed distribution of the entire traffic stream at that location, traveling under the conditions prevailing at the time of the study.

While all vehicle speeds were collected, only free-flowing vehicle speeds, defined as vehicles having headways greater than three seconds were used for this analysis. Of the 6.2 million vehicle records collected, approximately 85 percent were free-flowing vehicles.

Free-flowing vehicle operators can determine their own speed based on many factors such as vehicle operating capabilities, driver capability, comfort, roadway conditions, weather, physical characteristics of the road, and posted speed limits. Accordingly, the free-flowing driver is most likely to be influence by a speed limit change, if speed limits do influence driving behavior.

Spot speed studies were conducted at representative locations before and after the speed limit increase during the period from April 2003 to September 2003. The purpose of a spot speed study is to estimate the instantaneous distribution of motor vehicles passing a particular roadway location under conditions prevailing at the time of the study. It is assumed that performing before and after studies at the same locations will eliminate locational differences, and that the "before" conditions would have been repeated in the "after" period if the speed limit increase had not been implemented.

Saskatchewan Highways & Transportation regularly collects traffic information at monitoring stations located throughout the province where speed, vehicle classification, and volume data are collected continuously. For the purposes of this study, spot speed studies were conducted utilizing traffic sensors installed at these monitoring stations and with "light detection and ranging" equipment (often referred to as laser or lidar). The data collected at the traffic

monitoring stations was collected on a continuous basis, while samples collected by laser were typically samples of 185 free flowing vehicles per lane collected during non-peak periods on weekdays with ideal driving conditions. All spot speed study locations were representative of typical conditions present on the highway sections.

Before and after speed studies were conducted at thirty-two different locations within the province. Of these thirty-two locations, twenty-three are located on the four-lane divided highway system. The majority of the data collected was on the four-lane highway system where the speed limit was raised. Data was also collected on four-lane sections and sections of two-lane arterial highways where speed limits were not increased. This was done to identify any possible "halo effects".

1.2 Measurement Error

The speed samples that were collected at traffic monitoring stations used International Road Dynamics IRD-500 series Automated Vehicle Classifiers (AVC), Length Vehicle Classifiers (LVC) and Weigh-In-Motions (WIM) stations. The main sensors used at all sites are permanent inductive loops, and piezoelectric axle sensors.

Information provided by the manufacturer states that vehicle speeds are judged to be precise to a level of 0.11 km/hr to 1.1 km/hr for LVC and AVC equipment. WIM equipment measures vehicle speeds to nearest 1 to 2 km/hr.

Precision is dependant on the raw data collection mode that the unit is operating under, and the type of sensors being utilized in the data collection. Even though data collected was very precise, all speed data collected with the permanent traffic monitoring stations was rounded to the nearest km/hr.

It should be noted that the speed estimates generated by the permanent traffic classifiers are very precise but may not be as accurate. This may be due to calibration errors on site. It is assumed that any differences between measured and actual vehicle speeds are not problematic due to the fact that any errors in the accuracy of the equipment remains consistent for the before and after study periods.

It should also be noted that only vehicles with headways greater than three seconds were used in the analysis. It is possible that situations may have occurred causing a vehicle having a headway greater than three seconds to also have an impeded speed. There is no way of detecting this type of activity with the permanent traffic monitoring stations. This type of occurrence is not expected to be significant.

2.0 Operating Speeds – Sections With Increased Speed Limit

Traffic behavior gives a good indication of an appropriate speed limit that should apply to a particular section of highway. If a maximum posted speed limit is going to be effective, it must be consistent with driver perceptions of what constitutes a safe and proper speed.

Some statistics commonly used to study speeds are:

- Average Speed
- Mode
- 85^{th} Percentile
- 50^{th} Percentile
- 15^{th} Percentile
- Speed Differential
- Pace

2.1 Average Speed & Mode

The majority of the motorist travel speeds did not change significantly over the first four months after the increase of speed limit to 110 km/hr. Analysis indicates that the average speed for all types of vehicles ranged from 109 km/hr to 114 km/hr. The average speed determined from seventeen different sites was 111 km/hr, up from an average of 107 km/hr, resulting in an average increase of 4 km/hr.

The mode is defined as the speed value occurring most frequently. The mode increase varied from 1 to 9 km/hr with an average increase from 5 to 6 km/hr.

Table 1 - Average Speed & Mode

	Ave. Speed			Mode		
Highway Location	**Before**	**After**	**Difference**	**Before**	**After**	**Difference**
C.S. 1-06 (5 km W of Jct No 56)	105	109	+4	108	110	+2
C.S. 1-22 (1.4 km E of Alberta B.)	110	113	+3	109	115	+6
C.S. 11-02 (3 km E of Jct No 54)	106	111	+5	108	112	+4
C.S. 16-25 (3.2 km W of Jct No 340)	106	110	+4	103	109	+6
C.S. 16-29 (0.6 km W of 2-4 Transition)	108	112	+4	108	112	+4
Monitoring Station Averages	***107***	***111***	***+4***	***107***	***112***	***+5***
C.S. 1-10 (7.3 km from Belle Plaine - km 31.58)	106	112	+6	102	110	+8
C.S. 1-10 (West of Kalium @ km 46)	106	110	+4	104	112	+8
C.S. 1-14 (Btw Parkbeg & Secretan @ km 15)	107	109	+2	108	112	+4
C.S. 1-16 (Near Herbert @ km 22)	111	111	-	108	109	+1
C.S. 1-19 (Near Webb @ km 22)	107	110	+3	105	110	+5
C.S. 11-03 (1.2 km N Bethune rest stop km 7.57)	105	110	+5	108	115	+7
C.S. 11-05 (3.7 km N. Hwy Jct 643 @ km 20.94)	106	113	+7	106	114	+8
C.S. 11-07 (N of Hanley @ km 22.71)	110	114	+4	110	113	+3
C.S. 16-25 (Radisson @ km 0)	108	112	+4	111	113	+2
C.S. 16-25 (Maymont @ km 24.72)	108	113	+5	108	110	+2
C.S. 16-25 (E of Denholm @ km 41.3)	108	112	+4	104	113	+9
C.S. 16-29 (Lashburn @ km 22.5)	106	109	+3	102	108	+6
Lidar Studies Average	***107***	***111***	***+4***	***106***	***112***	***+6***

Note: All values shown are in km/hr.

A t-test was used to determine if the difference in the average or mean speed data was significant when comparing before and after speed data. The test determines if the apparent differences in the average speeds are due to chance or because there is a real difference in values.

The t-test analysis revealed that all changes to the average speeds were statistically significant at the 99 percent confidence interval. This low sampling error means very accurate statistical descriptors, so even small changes can be statistically significant. However, changes of 1 km/hr or less are statistically significant but are not practically meaningful due to the fact that individual speed records were rounded to the nearest km/hr and the majority of equipment utilized measures vehicle speeds to be precise to 1.1 km/hr.

2.2 Percentile Distribution

The 85th percentile is defined as the speed at or below which 85 percent of the vehicles are traveling. This percentile serves as a guide when establishing speed limits.

The 50th percentile (also known as the median) is the speed at which half of the vehicles are traveling above, and half below.

The 15th percentile speed is the speed at or below which fifteen percent of the free-flowing traffic travels. It serves as a guide for establishing minimum speed limits. Vehicles traveling below this value tend to obstruct the flow of traffic which can create an accident hazard.

Speed differential is the difference in travel speeds between the various vehicles using the road. It is defined as the difference between the 85th and the 15th percentile speed. It gives the kilometre per hour range in which 70 percent of the vehicles are traveling. As the speed differential increases, the probability of collision increases.

Table 2 summarizes the before and after data for the percentile distributions.

Table 2 – Percentile Analysis

	85th			50th			15th			Differential		
Highway Location	**Before**	**After**	**Difference**	**Before**	**After**	**Difference**	**Before**	**After**	**Difference**	**Before**	**After**	**Difference**
C.S. 1-06 (5 km W of Jct No 56)	112	117	+5	106	109	+3	99	101	+2	13	16	+3
C.S. 1-22 (1.4 km E of Alberta B.)	119	122	+3	109	113	+4	101	104	+3	18	18	-
C.S. 11-02 (3 km E of Jct No 54)	113	118	+5	107	111	+4	99	103	+4	14	15	+1
C.S. 16-25 (3.2 km W of Jct No 340)	115	118	+3	106	109	+3	98	103	+5	17	15	-2
C.S. 16-29 (0.6 km W of 2-4 Transition)	117	121	+4	109	112	+3	100	102	+2	17	19	+2
Monitoring Station Averages	***115***	***119***	***+4***	***107***	***111***	***+4***	***99***	***103***	***+4***	***16***	***17***	***+1***
C.S. 1-10 (7.3 km Belle Plaine - km 31.58)	113	119	+6	106	112	+6	98	105	+7	15	14	-1
C.S. 1-10 (West of Kalium @ km 46)	112	117	+5	106	110	+4	99	101	+2	13	16	+3
C.S. 1-14 (Btw Parkbeg & Secretan @ km 15)	114	117	+3	106	110	+4	100	100	-	14	17	+3
C.S. 1-16 (Near Herbert @ km 22)	113	117	+4	106	110	+4	100	102	+2	13	15	+2
C.S. 1-19 (Near Webb @ km 22)	115	119	+4	107	110	+3	98	100	+2	17	19	+2
C.S. 11-03 (1.2 km N Bethune R.S km 7.57)	112	118	+6	106	111	+5	98	102	+4	14	16	+1
C.S. 11-05 (3.7 km N. Jct 643 @ km 20.94)	113	118	+5	106	111	+5	99	103	+4	14	15	+1
C.S. 11-07 (N of Hanley @ km 22.71)	116	120	+4	110	113	+3	103	106	+3	13	14	+1
C.S. 16-25 (Radisson @ km 0)	115	118	+3	108	112	+4	101	105	+4	14	13	-1
C.S. 16-25 (Maymont @ km 24.72)	115	119	+4	107	112	+5	100	106	+6	15	13	-2
C.S. 16-25 (E of Denholm @ km 41.3)	117	119	+2	108	112	+4	101	105	+4	16	14	-2
C.S. 16-29 (Lashburn @ km 22.5)	113	117	+4	106	109	+3	98	100	+2	15	17	+2
Lidar Studies Averages	***114***	***118***	***+4***	***107***	***111***	***+4***	***100***	***103***	***+3***	***14***	***15***	***+1***

Note: All values shown are in km/hr.

- Based on the free-flowing speed data collected, the posted speed limits were set on average between 14 and 15 km/hr below the 85th percentile speed before the 110 km/hr speed limit implementation. As expected, the posted limits were on average between 8 and 9 km/hr below the 85th percentile speed during the four months after the speed limit increase. This is an average increase of 4 km/hr.

- The 50th percentile had an average increase of 4 km/hr.

- The 15th percentile was on average 99 km/hr to 100 km/hr before the increase and 103 km/hr after the speed limit increase. Individual locations experienced increases from 0 to 7 km/hr.

- On average, speed differential experienced a slight increase. All individual sites (locations) showed only small changes in speed differential. At five locations, the speed differential was slightly decreased. At eleven sites, speed differential increases ranged from 1 to 3 km/hr.

2.3 Pace

Another method to assess travel speed variance is by evaluating the pace speed. The pace speed is the 15 km/hr speed range that contains the highest number of vehicles. The higher the percentage of vehicles in the pace speed, the less variation there is in the travel speeds. Also the 15 km/hr pace is another criteria for selecting a proper speed limit. The speed limit should not be set below the lower limit of the pace.

Table 3 - Pace Analysis

	Pace			% In Pace		
Highway Location	**Before**	**After**	**Difference**	**Before**	**After**	**Difference**
C.S. 1-06 (5 km W of Jct No 56)	99-113	103-117	+4	76	68	-8
C.S. 1-22 (1.4 km E of Alberta B.)	102-116	108-122	+6	67	62	-5
C.S. 11-02 (3 km E of Jct No 54)	99-113	104-118	+5	72	69	-3
C.S. 16-25 (3.2 km W of Jct No 340)	98-112	103-117	+5	69	70	+1
C.S. 16-29 (0.6 km W of 2-4 Transition)	101-115	108-122	+7	63	59	-4
Monitor Station Averages	***100-114***	***105-119***	***+5***	***69***	***66***	***-3***
C.S. 1-10 (7.3 km from Belle Plaine - km 31.58)	100 - 114	106 - 120	+6	71	72	+1
C.S. 1-10 (West of Kalium @ km 46)	100 - 114	102 -116	+2	76	68	-8
C.S. 1-14 (Btw Parkbeg & Secretan @ km 15)	100 - 114	105 -119	+5	75	64	-11
C.S. 1-16 (Near Herbert @ km 22)	99 - 113	104 -118	+5	75	68	-7
C.S. 1-19 (Near Webb @ km 22)	100 - 114	104 - 118	+4	67	63	-4
C.S. 11-03 (1.2 km N Bethune rest stop km 7.57)	100 - 114	104 - 118	+4	72	69	-3
C.S. 11-05 (3.7 km N. Hwy Jct 643 @ km 20.94)	99 - 113	103 - 117	+4	73	70	-3
C.S. 11-07 (N of Hanley @ km 22.71)	101 - 115	106 - 120	+5	75	74	-1
C.S. 16-25 (Radisson @ km 0)	100 - 114	105 - 119	+5	74	72	-2
C.S. 16-25 (Maymont @ km 24.72)	100 - 114	106 - 120	+6	73	75	+2
C.S. 16-25 (E of Denholm @ km 41.3)	99 - 113	105 - 119	+6	69	74	+5
C.S. 16-29 (Lashburn @ km 22.5)	99 - 113	103 - 117	+4	68	76	+8
Lidar Station Averages	***100 - 114***	***104 - 118***	***+4***	***72***	***70***	***-2***

Note: All values shown are in km/hr.

- The 15 km/hr pace speed increased 5 km/hr after the speed limit was increased to 110 km/hr.

- Before the speed limit was increased, on average 71 percent of the drivers were in the 15 km/hr pace. After the increase, this figure dropped to 69 percent. This drop also indicates there was a slight increase in speed variance.

- Individual sites experienced increases in pace from 2 to 7 km/hr. The percentage of vehicles in pace increased as high as 8 percent, and decreased by as much as 11 percent.

2.4 Speed Distributions and Cumulative Frequencies

When raising speed limits, it is a concern that the faster drivers will increase their speeds while the slower drivers' speeds will remain the same. This results in a wider speed distribution. Faster drivers increasing their speeds will cause an extension in the top end of the distribution, while the unchanged slower speeds results in the slow end of the distribution to remain the same. Figure 1 and Figure 2 show that this is not the case on Saskatchewan twinned highways, at least in the short term.

It appears that the percentile distributions for the before and after studies are uniform. The plots show the increased vehicle speeds appear to be relatively uniform throughout the speed distribution.

Figure 1- Speed Distribution (Lidar Only)

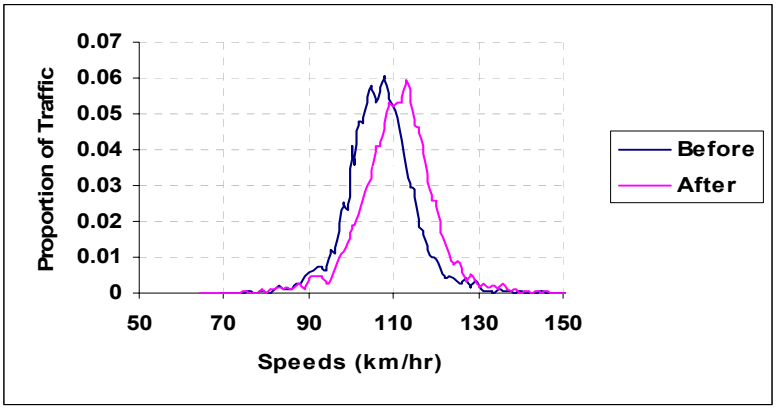
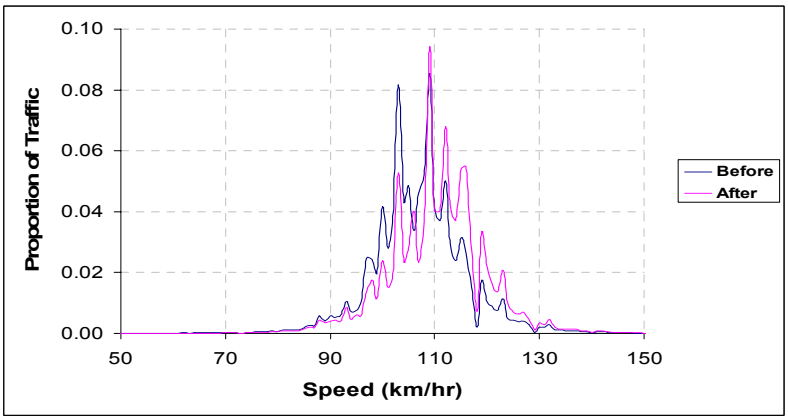


Figure 2 - Speed Distribution (Permanent Stations Only)



The Cumulative Frequency graphs show a reasonably uniform spread and similar slope in the before and after plots. Again, this indicates that there are no major changes in speed differential.

Figure 3 –Cumulative Frequency (Lidar only)

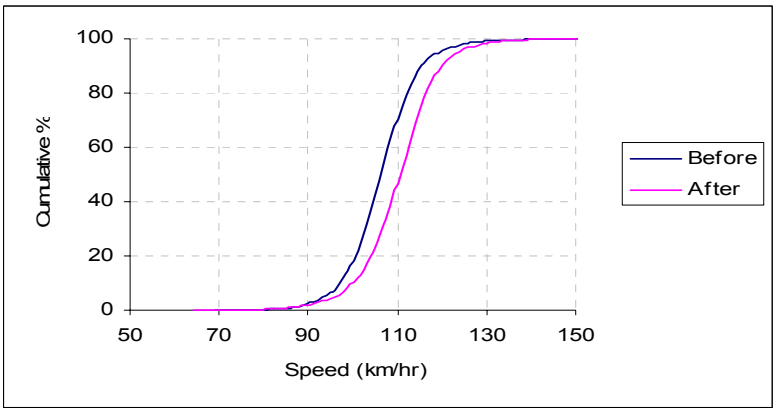
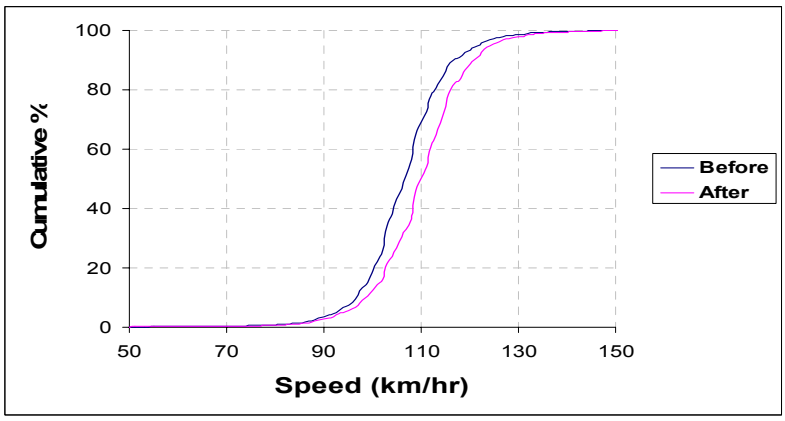
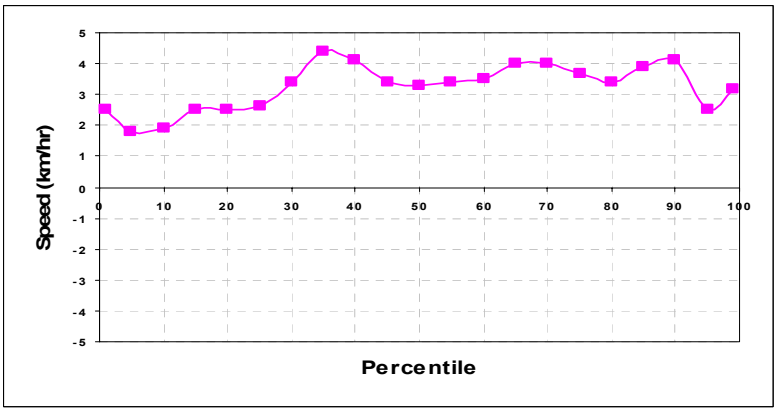


Figure 4 –Cumulative Frequency (Permanent Stations only)



The net changes in percentile speeds from the before and after studies at the permanent traffic stations is shown in Figure 5. Individual speed records from all permanent traffic stations were combined to determine this net change. The permanent traffic stations collected extremely large speed samples resulting in large samples in each percentile speed.

Figure 5 - Before & After Changes in Percentile Speeds (Permanent)



As the figure shows, the percentile increase ranges from 1.9 km/hr to 4.4 km/hr and remains reasonably consistent throughout the percentile distribution.

2.5 Compliance

Driver compliance is the percentage of vehicles operating at or below the posted speed limit. Nearly all highways have a running speed in the range of 5 to 15 km/hr higher than the posted speed limit. It is generally felt that good compliance is achieved if 85 percent of the motorists drive at or below the speed limit (85^{th} percentile is at or below the speed limit).

Motorists operate at speeds according to personal comfort levels and an understanding of tolerance embedded in speed limit enforcement. Thus, while the motorist average speeds on the provincial highway system are above the posted maximum speed limit, drivers are comfortable with both their speed and their risk of being fined for speeding, which creates a "zone" of non-compliance.

Table 4 - Compliance Analysis

	% > 100 km/hr			% > 110 km/hr		
Highway Location	**Before**	**After**	**Difference**	**Before**	**After**	**Difference**
C.S. 1-06 (5 km W of Jct No 56)	79	87	+8	21	44	+23
C.S. 1-22 (1.4 km E of Alberta B.)	88	92	+4	42	65	+23
C.S. 11-02 (3 km E of Jct No 54)	80	89	+9	26	53	+27
C.S. 16-25 (3.2 km W of Jct No 340)	77	85	+8	26	45	+19
C.S. 16-29 (0.6 km W of 2-4 Transition)	83	88	+5	41	58	+17
Monitor Station Averages	***81***	***88***	***+7***	***31***	***53***	***+22***
C.S. 1-10 (7.3 km from Belle Plaine - km 31.58)	82	94	+12	28	64	+36
C.S. 1-10 (West of Kalium @ km 46)	84	89	+5	32	54	+22
C.S. 1-14 (Btw Parkbeg & Secretan @ km 15)	82	86	+4	26	53	+27
C.S. 1-16 (Near Herbert @ km 22)	85	87	+2	29	48	+19
C.S. 1-19 (Near Webb @ km 22)	77	87	+10	32	52	+20
C.S. 11-03 (1.2 km N Bethune rest stop km 7.57)	80	91	+11	26	59	+33
C.S. 11-05 (3.7 km N. Hwy Jct 643 @ km 20.94)	85	91	+6	34	57	+23
C.S. 11-07 (N of Hanley @ km 22.71)	94	98	+4	52	75	+23
C.S. 16-25 (Radisson @ km 0)	90	96	+6	38	64	+26
C.S. 16-25 (Maymont @ km 24.72)	89	100	+11	35	66	+31
C.S. 16-25 (E of Denholm @ km 41.3)	89	97	+8	40	64	+24
C.S. 16-29 (Lashburn @ km 22.5)	82	87	+5	34	47	+13
Lidar Station Averages	**85**	**92**	**+7**	**34**	**59**	**+25**
Total	**84**	**91**	**+7**	**33**	**57**	**+24**

Note: All values shown are in km/hr.

Based on 24-hour free-flow speed data collected at traffic monitoring stations before the speed limit increase, the 100 km/hr posted limit was set on average at the 19th percentile speed. This means that approximately 4 of 5 vehicles on Saskatchewan divided highways were exceeding the posted speed limit.

As expected, the percentage of drivers exceeding the posted speed limit was decreased by approximately 27 percent after the speed increase. However, the number of vehicles exceeding 110 km/hr increased 24 percent. Individual sites experienced increases in percent vehicles exceeding 110 km/hr ranging from 13 percent as high as 36 percent.

The speed limit increase appears to have created a higher driver compliance rate. The increased compliance rate does not necessarily reflect a change in driver behavior, but the result of a change in how compliance is measured. It appears that the increased speed limit has incorporated the preferences of a significantly higher number of drivers.

2.8 Truck Traffic

Permanent traffic monitoring stations collect large volumes of truck traffic. Information was combined from five monitoring stations to determine the effects of the speed limit increase on truck traffic on four-lane divided highways.

Data collection equipment classified vehicles using two different methods; one using total vehicle length (LVC) and one using axle spacing (AVC and WIM). The AVC and WIM systems are more precise units and classify trucks into corresponding FHWA classification bins (5-13). Vehicle length data and axle spacing data was interpreted separately.

Table 5 - Truck Traffic (Permanent Stations)

	LVC			AVC		
	Before	**After**	**Difference**	**Before**	**After**	**Difference**
Ave Speed	103	104	+1	102	104	+2
15th Percentile	96	96	-	95	95	-
50th Percentile	103	104	+1	102	103	+1
85th Percentile	110	112	+2	108	111	+3
Differential	14	16	+2	13	16	+3
Mode	104	104	-	103	103	-
Pace	98-112	99-113	+1	95-109	95-109	-
% in Pace	74	70	-4	80	68	-12
% > 100 km/hr	69	73	+4	55	66	+11
% > 110 km/hr	14	22	+8	8	19	+8

Note: All values shown are in km/hr.

- Trucks on average are driven below the posted speed limit. Average speed for trucks after the speed limit increase was 104 km/hr, 6 km/hr below the posted speed limit. Statistical analysis revealed that all changes in the average speed were statistically significant at the 99 percent confidence interval. Although these small increases in speeds are statically significant, they are not of practical significance.

- 15th percentile remained unchanged for both AVC and LVC data.

- 50th percentile experienced an increase of 1 km/hr for both AVC and LVC data.

- 85th percentile increased 2-3 km/hr.
- The speed differential was increased 3 km/hr to 16 km/hr.
- Mode remained unchanged for both AVC and LVC data.
- The percent of vehicles in pace decreased 8 percent on average to 69 percent.
- Portion of trucks violating the speed limit decreased on average from 62 percent to 21 percent. This is an increase in compliance rate of 41 percent. However, the amount of trucks exceeding 110 km/hr increased on average 10 percent.

As Figures 6 and Figure 7 show that truck traffic at the bottom end of the speed distribution remained relatively unchanged while faster truck traffic increased their speeds slightly. As the cumulative percent increases, before and after trends begin to separate.

Figure 6 - LVC Trucks Cumulative Frequency

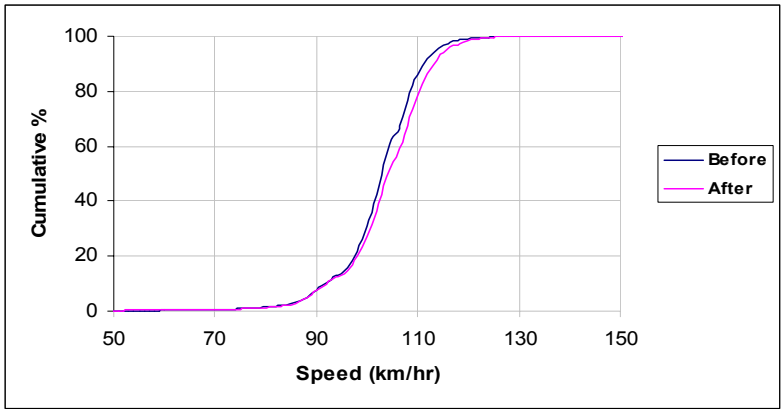
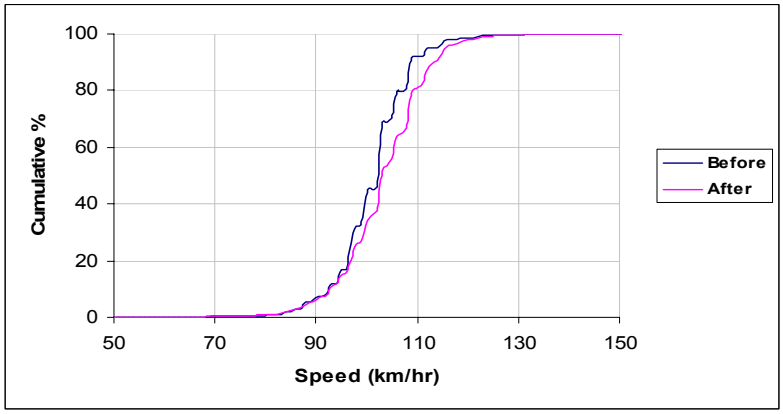


Figure 7 – AVC Trucks Cumulative Frequency



2.9 Trucks vs. Other Vehicles

With the increase in the speed limit, there is the potential to increase the deviation in vehicle speeds between vehicle types. Information was combined from five monitoring stations to compare truck speeds with speeds of all other vehicles.

Table 6 - Trucks & Other Vehicles

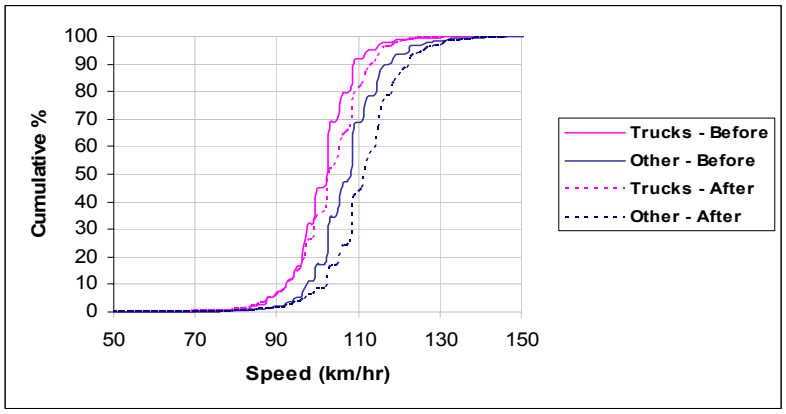
	LVC				AVC			
	Other		Trucks		Other		Trucks	
	Before	After	Before	After	Before	After	Before	After
Ave Speed	109	112	103	104	108	112	102	104
15th Percentile	100	103	96	96	100	103	95	95
50th Percentile	108	112	103	104	108	112	102	103
85th Percentile	116	120	110	112	115	119	108	111
Differential	16	17	14	16	15	16	13	16
Mode	110	112	104	104	109	109	103	103
Pace	101-115	103-117	98-112	99-113	102-116	103-117	95-109	95-109
% in Pace	69	67	74	70	72	69	80	68
% > 100 km/hr	86	92	69	73	83	92	55	66
% > 110 km/hr	38	59	14	22	31	57	8	19

Note: All values shown are in km/hr.

- On average the average speed differential between trucks and passenger cars increased from 6 km/hr to 8 km/hr.

It is clear from the cumulative frequency distribution shown in Figure 8 that larger vehicles travel slower than passenger vehicles on Saskatchewan four-lane highways.

Figure 8 - Cumulative Frequency Distribution



The cumulative frequencies show that the bottom end of the speed distribution for trucks did not increase (slower trucks did not speed up) as stated earlier. However for other vehicles the cumulative frequency indicates that the increase in speed was quite uniform throughout the speed distribution. This creates a slightly increased speed differential between passenger vehicles and trucks. However, with the traffic volumes in Saskatchewan on a twinned facility this is not deemed to be a safety issue.

3.0 Operating Speeds – Unchanged Speed Limit Sections

Throughout the province there are many sections of four-lane highway where the speed limit remained at 100 km/hr. Speed limits of 110 km/hr were not considered advisable in locations with high traffic volumes and significant turning volumes. In addition, short sections of divided highways were not considered for the speed limit increase.

Saskatchewan four-lane highways are designed for a 130 km/hr design speed, which is the Department's highest standard. If halo effect exists, it can lead to increased speeds on roads with lower design standards, where the speed limit was not increased.

Speed data was collected on surrounding two lane highways and sections of twinned highways where the posted speed limit remained 100 km/hr to determine if the speed limit increase on the four-lane highway had an indirect effect on driver behaviour on the two-lane highway system carrying similar traffic.

3.1 Four – Lane Highways

Six individual speed studies were conducted on sections of four-lane highway where the posted speed limit remained at 100 km/hr. There appears to be some individual locations where there is an increase in speeds or possibly faster drivers have increased speeds causing an increase in speed variance.

- On average the speed remained unchanged at 102 km/hr. Individual sites experienced increases as high as 3 km/hr and decrease as low 1 km/hr. It should be noted that highway 1 between White City and Regina had a significant increase in average vehicle speeds. This section of highway is a major commuter route and has a rural cross-section with a 100 km/hr posted speed limit with an average annual daily traffic volume of 14,000 vehicles per day.

- On average the 85th percentile speeds were 11 km/hr above the speed limit after the increase. This is an average increase of 1 km/hr.

- The 50^{th} percentile decreased 1 km/hr.

- The 15^{th} percentile was on average 94 km/hr before the increase and 93 km/hr after the speed limit increase. Individual locations experienced increases that ranged from 2 to -5 km/hr.

- On average the speed differential was increased 2 km/hr. However locations 1-12 and 1-17 experienced increases of 4 and 5 km/hr.

- The 15 km/hr pace speed decreased 1 km/hr. Before the speed limit was increased, 68% of the drivers were in the 15 km/hr pace. After the increase, this figure dropped to 63%. This drop also indicates there was a slight increase in speed variance.

- The percentage of drivers exceeding the speed limit on average was decreased by 2%. However, the number of vehicles exceeding 110 km/hr increased by 4%.

3.2 Surrounding Two-Lane Highways

Selections of sites on surrounding two-lane highways were not random, but were dependant on the location of permanent traffic counter stations on two-lane arterial highways. Speed data was collected on nine two-lane major arterial highways where the posted speed limit remained 100 km/hr. Of these nine locations, analysis was limited to seven locations due to questionable free-flow data at two locations.

Overall there appears to be only minimal changes to drivers' behaviours with the exceptions of C.S. 1-01 and C.S. 11-12. Overall there were minimal driver behaviour changes on surrounding two-lane arterial highways after the speed limit increase.

- On average the speed increased 1 km/hr to 105 km/hr. Individual sites experienced increases as high as 3 km/hr and decreases as low as 1 km/hr. Statistical analysis revealed that all changes to average speeds were significant at the 99 percent confidence interval. Although the small increases such as 1 km/hr in speeds are statically significant, they are not of practical significance.

- On average the 85th percentile speeds were 13 km/hr above the speed limit after the increase. This is an average increase of 1 km/hr.

- The 50^{th} percentile increased 1 km/hr.

- The 15^{th} percentile was on average 97 km/hr before the increase and 98 km/hr after the speed limit increase.

- On average the speed differential was increased 1 km/hr. However five of seven locations experienced no change in speed differential. One location increased substantially by 3 km/hr.

- The 15 km/hr pace speed remained unchanged. Before the speed limit was increased, 73% of the drivers were in the 15 km/hr pace. After the increase, this figure dropped to 71%.

- The percentage of drivers exceeding the speed limit on average was increased by 4%. The number of vehicles exceeding 110 km/hr increased by 5%.

4.0 CONCLUSION

The increase in the posted speed limit has lead to an increase in average speeds. The magnitude of this increase is less than the 10 km/hr increase in the posted speed limit. In general the increased speed limit has lead to a slight increase in vehicle speeds.

It appears that the increased speed limit has incorporated the preferences of a significantly higher number of drivers. However the increased compliance rate does not necessarily reflect a change in driver behaviour, but the result of a change in how compliance is measured.

All of the identifiers in the analysis indicated that the speed differential has been slightly increased with the speed limit increase. Many researchers have concluded or believe that there is a connection between safety and speed differential on highways. The theory is that the wider the speed distribution becomes, there is an increased opportunity for sub-optimal interactions between motorists.

The small increase in speed differential is not expected to have significant consequences due to the high level of service on Saskatchewan twinned four-lane highways. It is anticipated that collision results will be analyzed as they become available in order to test this expectation.

Data analysis summary is as follows:

Table 7 - Summary Results

4-Lane Highways	**Before**	**After**	**Difference**
Average Speed	107 km/hr	111 km/hr	+ 4 km/hr
Mode	107 km/hr	112 km/hr	+ 5 km/hr
85th Percentile	115 km/hr	119 km/hr	+ 4 km/hr
50th Percentile	107 km/hr	111 km/hr	+ 4 km/hr
15th Percentile	100 km/hr	103 km/hr	+ 3 km/hr
Speed Differential	15 km/hr	16 km/hr	+ 1 km/hr
Pace	100-114 km/hr	105-119 km/hr	+ 5 km/hr
% In Pace	69 %	66 %	- 2 %
% > 100 km/hr	81 %	88 %	+ 7 %
% > 110 km/hr	33 %	57 %	+ 24 %

The speed limit change has only been in effect for approximately four months at the conclusion of the data collection. The trends that have been presented in this report show only the initial results of the speed limit increase. More definitive trends may appear as time passes and additional data is collected. These additional trends will be identified in subsequent data sets.

5.0 RECOMMENDATIONS

Further studies need to be conducted to analyze the overall effects of speed limit changes on accidents. In recent years, speed has become one of the quintessential issues in traffic safety. A review of the collision statistics should be completed when data becomes available (estimated 3 years) to examine the relationship between vehicle speed and safety.

Prior to 2003, Saskatchewan Highways and Transportation had not conducted a thorough speed study since 1989. This increase in speed limits provides the Department the opportunity to perform a thorough speed study on Saskatchewan arterial highways and assess the safety effects of speed, speed limits, enforcement, and the possibility of using engineering measures to manage speed. Further analysis is needed to determine any significant impacts that the increased speed limit to 110 km/hr may engender.

The speed limit change has only been in effect for approximately four months at the conclusion of the data collection. The trends that have been presented in this report show only the initial results of the speed limit increase. More definitive trends may appear as timed passes and additional data is collected. These additional trends will be identified in subsequent data sets.

The automated equipment provides an economical means of collecting large samples of continuous, unbiased speed data. It is recommended that speed studies be conducted at the same predetermined locations in the spring and fall for the 2004 calendar year. This data collection includes the use of the automated equipment and spot studies with lidar. Upon completion of an analysis of the additional speed data collected, recommendations for additional data collection may be requested at that time.

6.0 BIBLOGRAPHY

TAC: Geometric Design Guide for Canadian Roads, Sept. 1999, Transportation Association of Canada.

National Highway Traffic Safety Administration: Effects of the 65 mph speed limit through 1990. A report to Congress. USA, 1992. Rept.No. HS-807 840.

Yacoub M. Najjar, Robert W. Stokes, Eugene R. Russell, Hossam E. Ali, Xiaobin "Carol" Zhang: IMPACT OF NEW SPEED LIMITS ON KANSAS HIGHWAYS. Kansas State University , Kansas Department of Transportation. Nov. 2000, Rept No. K-TRAN: KSU-98-3.

Vern Janz: Driver Behavior by Vehicle Type: Travelling Speed and Following Time On a Four-Lane Divided Highway. Alberta Infrastructure. July 2000.

George W. Dougherty, Jr.: Increasing the Speed Limit in Georgia. Have Rural Highways Become More Dangerous? Carl Vinson Institute of Government, The University of Georgia. 2000.

Iowa Highway Safety Management System: Update Report on Speed Limits in Iowa. Feb 2002.

Martin R. Parker, Jr., Huey-Yi Sung, Lori J. Dereniewski (Wade-Trim): Review and Analysis of Posted Speed Limits and Speed Limit Setting Practices in British Columbia. Prepared for British Columbia Ministry of Transportation. 2003. Project Number ZZZ2530.01T.

J. Stuster, Z. Coffman: Synthesis of Safety Research Related to Speed and Speed Management, Publication No. FHWA-RD-98-154, Federal Highway Administration, Washington DC, July 1998.

David L. Cochran (Joint Transportation Research Program): Speed Trends For Indiana Highways, Prepared for Indiana Department of Transportation, Feb 1998, Project: C-36-10C.

Kay Fitzpatrick, Paul Carlson, Marcus A. Brewaer, Mark D. Wooldridge, Shaw-Pin Miaou (Texas Transportation Institute): NCHRP REPORT 504 Design Speed, Operating Speed, and Posted Speed Practices. National Cooperative Highway Research Program prepared for Transportation Research Board. 2003.

Parliament of Victoria, Road Safety Committee, Australia: Inquiry into the revisions of speed limits. Sept. 1994, Australia.

Martin R. Parker & Associates, Inc: Comparison of Speed Zoning Procedures and their Effecticeness. Prepared for Michigan Department of Transportation, Sept 1992.

Parker, M.R., Jr. 1997. Effects of Raising and Lowering Speed Limits on Selected Roadway Sections. Report No. FHWA-RD-92-084. Washington, D.C.: Federal Highway Administration.

John E. Freund, Gary A. Simon. Ninth Edition Modern Elementary Statistics. Prentice Hall, 1997.

Nicholas J. Garber, Lester A. Hoel: Traffic and Highway Engineering. West Publishing Company, 1988.

Institute of Transportation Engineers: 4th Edition Traffic Engineering Handbook. Prentice Hall, 1992.

Nicholas J. Garber, Ravi Gadirau: Factors Affecting Speed variance and Its Influence on Accidents. Transportation Research Record. 1989 (1213) pp64-71.

Guo Xin (Andrew) Liu: A STUDY OF TRAFFIC SAFETY AND VEHICLE TRAVEL SPEED IN SASKATCHEWAN. Prepared for Saskatchewan Highways and Transportation. February, 1996.