NEW ZEALAND STATE HIGHWAY - SKID RESISTANCE SUCCESSES

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EXECUTIVE SUMMARY

Transit New Zealand's T/10 specification for skid resistance investigation and treatment selection was first introduced in 1997 with the expectation that it would reduce significantly the exposure of State Highway users to wet road injury crashes. In order to monitor the effectiveness of the T/10 specification, inter-year comparisons of crash rates have been undertaken on a nationwide basis over a 12 year period from 1995-2006. This extended time period spans the introduction of the T/10 specification allowing both its initial and continuing impact on crash rates to be investigated.

Statistics prepared by the Ministry of Transport show that rural crashes are dominated by loss of control incidents whereas urban crashes are dominated by incidents at intersections. Because of the difference in crash mechanisms, rural and urban crashes were separately compared over the 12 year analysis period to establish whether or not the effectiveness of the T/10 specification was influenced by road category.

By comparison to Transit New Zealand, Territorial Local authorities are variable in their management of skid resistance. Where traffic flows are high many implement a skid resistance policy similar to T/10, but none implement this over the whole of their network. Since 2004, it has been a requirement that all roading authorities implement a skid resistance policy in order to receive maintenance funding as part of the National Land Transport Programme.

The relative effectiveness of the different approaches to skid resistance management of road networks adopted by Transit New Zealand and Territorial Local Authorities was therefore established through time-series movements over the 12 year period from 1995 - 2006.
The principal findings from the analysis are summarised below:

1. There has been a significant reduction (between 25% and 50%) in crash rates between 1995 and 1998 for all crash categories investigated, with the reductions being greater for urban roads than for rural roads and for "wet" crashes than for "all" crashes.

2. The fatal and injury crash rate on wet rural State Highways over the period 1998-2006 is trending downwards (reducing 1.1% per annum) whereas the rate of all crashes is largely static for this period. By comparison, both "all" and "wet" crash rates on local authority rural roads are trending upwards, with the "all" crash rate increasing by 1.2% per annum since 1998 and the "wet" crash rate increasing by 0.9% per annum.

3. The "all" and "wet" crash rates for urban roads has remained relatively static for both State Highways and Territorial Local Authorities over the 9 year period, 1998 – 2006.

The above findings confirm that although there has been an annual increase of about 3.2% in the vehicle–kilometres travelled on the State Highway network over the 12 year period 1995-2006, Transit New Zealand's T/10 specification has been effective in bringing about a steady reduction in reported "wet" injury crash rates and maintaining the "all" injury crash rates to 1998 levels on rural sections of the State Highway network.

From the 12 year trend lines, it can be inferred that Transit New Zealand's skid resistance policy, as manifested in the T/10 specification, has reduced the rural State Highway wet road crash rate by about 20%. There are strong indications that it may have also assisted in reducing the rural State Highway dry crash rate by an appreciable amount.

The analysis has also demonstrated that in order to obtain meaningful comparisons between years and between State Highway and local roads, greater attention has to be paid to obtaining accurate traffic exposure figures and a need to incorporate annual rainfall data at a regional level when investigating trends in wet road crash rates.

Improvements in macro and micro texture, as demonstrated by annual measurements, have helped to improve the skid resistance of the state highway network, thereby reducing the risk of loss of control type crashes in wet conditions and consequently contributed to the wet road crash statistics.

1. INTRODUCTION

The TNZ T/10 specification for skid resistance investigation and treatment selection was first introduced in 1997 (Owen and Donbavand, 2005), with the expectation that it would reduce significantly the exposure of State Highway users to wet road injury crashes. In order to monitor the effectiveness of the T/10 specification, inter-year comparisons of crash rates have been undertaken on a nationwide basis over a 12 year period from 1995-2006. This extended time period spans the introduction of the T/10 specification allowing both its initial and continuing impact on crash rates to be investigated.

Statistics prepared by the MoT show that rural crashes are dominated by loss of control incidents whereas urban crashes are dominated by incidents at intersections (refer http://www.mot.govt.nz/annual-statistics-2005/). Because of the difference in crash mechanisms, rural and urban crashes were separately compared over the 12 year analysis period to establish whether or not the effectiveness of the T/10 specification was influenced by road category.

By comparison to TNZ, TLAs are variable in their management of skid resistance. Where traffic flows are high many implement a skid resistance policy similar to T/10, but none implement this over the whole of their network. Since 2004, it has been a requirement that all roading authorities implement a skid resistance policy in order to receive maintenance funding as part of the NLTP, administered by LTNZ. For some TLAs, this may merely involve purchasing aggregates of higher PSV from a selected quarry. Most will use higher PSV aggregates to surface problem curves in rural areas.

The relative effectiveness of the different approaches to skid resistance management of road networks adopted by TNZ and TLAs can be established through time-series movements over the 12 year period from 1995-2006. In addition, local roads can be used for control purposes over the period 1995 to 2003 as most TLAs did not have in place a policy for proactively managing skid resistance at that time. Therefore, crash number and crash rate comparisons were performed between urban and rural roads and SH and local roads to highlight any significant differences over the 12 year analysis period.

In order to carry out these comparisons:

1. Crash data was extracted from LTNZ's CAS database.
2. Traffic exposure data was obtained from the MoT (Cenek, 2006b).
3. Rainfall data for the period 1995-2005 was purchased from the NIWA.

The principal findings of this comparison of crash rate trends along with recommendations for any future similar comparative studies are presented in this report.

2. GENERATION OF DATABASE

2.1 Road Crash Numbers

Road crash numbers were extracted from LTNZ's CAS database by Tiffany Lester, Opus International Consultants, Lower Hutt.

For this study, two groups of crashes were studied: "all" and "wet" (Table 2).

Table 2: Description of Crash Dataset Subsets

Group	Criteria
"all"	All injury and fatal crashes.
"wet"	All injury and fatal crashes with either the road wet field being W (wet) and/or the cause code being 801 (rain) or 901 (heavy rain).

2.2 Exposure Data

Estimates of December 2005 traffic flows were obtained from Stuart Badger of the MoT (Cenek, 2006b). This data was scaled according to the per-annum increases in exposure recorded by the LTNZ (Cenek, 2005a) as recorded in Appendix A2 for the years 1999-2005. Linear equations were fitted to this 1999-2005 exposure data using the least-squares minimisation technique to obtain exposure estimates for the years 1995-1998 (inclusive) and 2006.

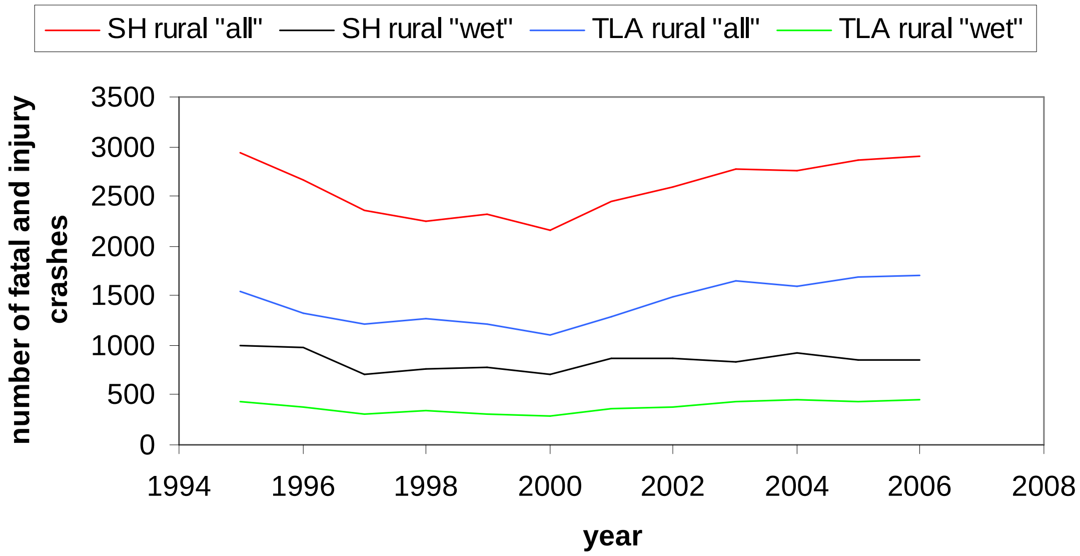
2.3 NIWA Rainfall Data

Based on NIWA data presented by Henderson et al. (2006), SH roads in New Zealand can be assumed wet 25% of the time (i.e. when calculating the "wet" crash rate, the exposure is multiplied by a factor of 0.25).

3. ANALYSIS OF CRASH DATA

3.1 Crash Numbers

Fatal and injury crash numbers are shown in Figures 1 (rural) and 2 (urban). As can be readily seen, the majority of SH crashes occur on rural roads whereas the majority of TLA crashes occur on urban roads.



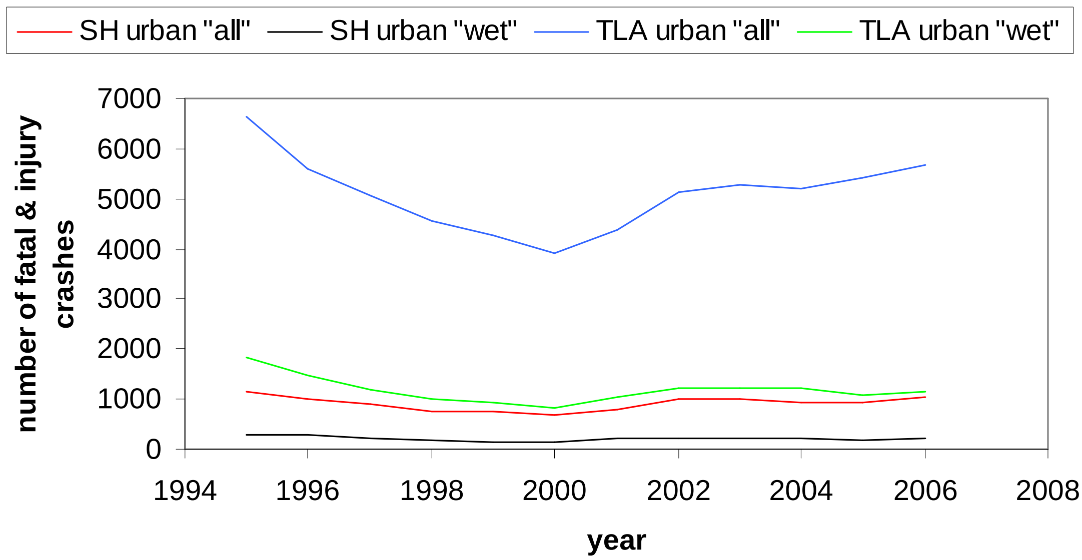


Figure 2: Urban Fatal and Injury Crash Numbers (1995-2006)

3.2 Traffic Exposure Data

Traffic exposure data in terms of vehicle-kilometres travelled is given in Appendix A2. The data indicates that for the period 1995-2006, the average per-annum arithmetic growth in traffic exposure is 3.2% for SHs and 2.2% for TLAs.

3.3 Crash Rates

3.3.1 Rural Crash Rates

For calculating "wet" crash rates, the road surface is assumed to be wet for 25% of the time (Henderson, 2006).

Figure 3 shows that the "wet" crash rate on the rural SH network is trending downward for the period 1998-2006, whereas the "wet" crash rate for the same time period on rural TLA networks is trending upward.

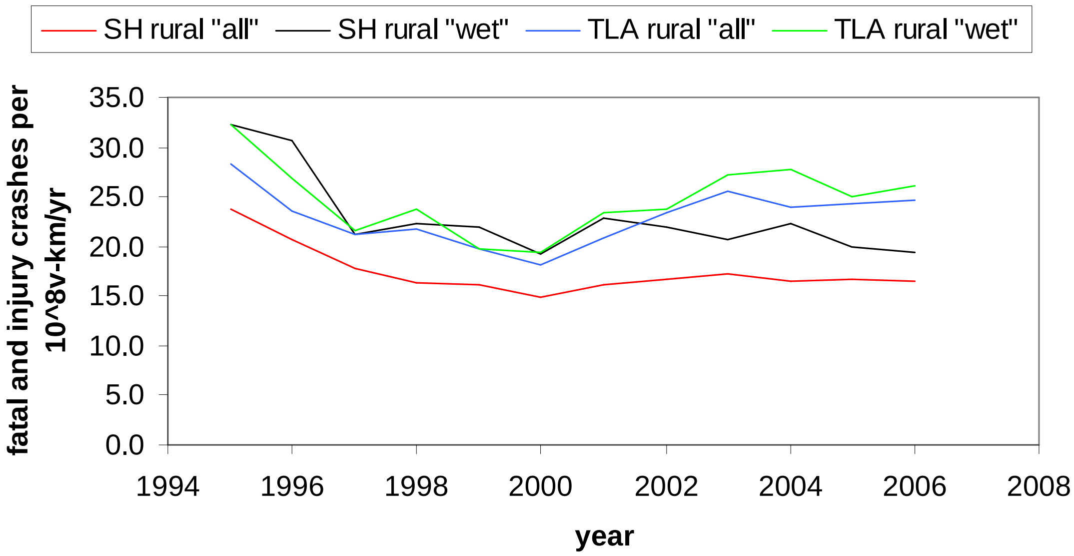


Figure 3: Rural Crash Rates (1995-2006)

The values showing the reduction in rural crash rates (reference year = 1995) over the 4 year period 1995 – 1998 spanning the introduction of the T/10 specification and the 12 year period 1995-2006 are tabulated in Tables 3 and 4 below.

Table 3: Reduction in Rural Crash Rates (1995-1998)

Reduction in Rural Crash Rates between 1995 and 1998							
Expressed as a Percentage				Expressed as Change in Crash Rate (crashes per 10^8 v-km/yr)			
SH (rural)		TLA (rural)		SH (rural)		TLA (rural)	
"all"	"wet"	"all"	"wet"	"all"	"wet"	"all"	"wet"
31.4%	31.3%	22.9%	26.3%	7.5	10.1	6.5	8.5

Table 4: Reduction in Rural Crash Rates (1995-2006)

Reduction in Rural Crash Rates between 1995 and 2006							
Expressed as a Percentage				Expressed as Change in Crash Rate (crashes per 10^8 v-km/yr)			
SH (rural)		TLA (rural)		SH (rural)		TLA (rural)	
"all"	"wet"	"all"	"wet"	"all"	"wet"	"all"	"wet"
30.5%	40.1%	13.0%	19.2%	7.2	13.0	3.7	6.2

With reference to Figure 3 and Tables 3 and 4, the following are points of note:

1. There has been a significant reduction in “all” and “wet” rural crash rates between 1995 and 1998 for both State Highways and TLAs (refer summary data in Table 3.) Note this period spans the initial introduction of the TNZ Specification T/10 for skid resistance investigation and treatment selection.
2. For the following period, 1998 to 2006, SH rural crash rates have either continued to drop (SH “wet” down 12.6%) or risen slightly (SH “all” up 1.2%). By comparison TLA crash rates have both risen by around 10% (“wet” up 9.7% and “all” up 12.8%).
3. Data for the full study period, 1995 to 2006 is contained in Table 4. This shows that the crash rates on the SH network have reduced significantly more than on the TLA network and “wet” rural crash rates have reduced more than “all” rural crash rates.

3.3.2 Urban Crash Rates

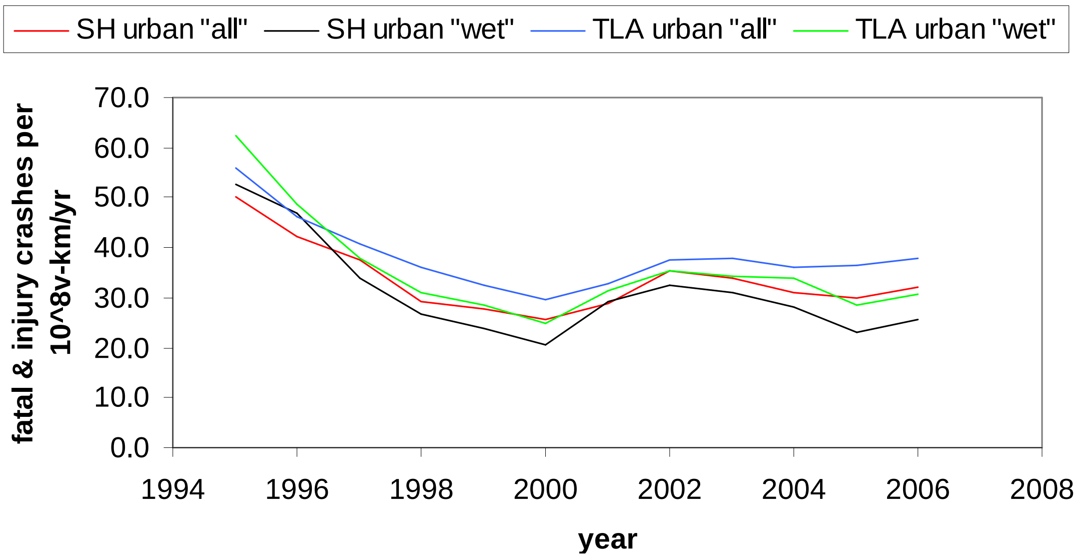


Figure 4 : Urban Crash Rates (1995-2006)

The values showing the reduction in urban crash rates (reference year = 1995) over the 4 year period 1995 – 1998 spanning the introduction of the T/10 specification and the 12 year period 1995-2006 are tabulated in Tables 5 and 6 below.

Table 5: Reduction in Urban Crash Rates (1995-1998)

Reduction in Urban Crash Rates between 1995 and 1998							
Expressed as a Percentage				Expressed as Change in Crash Rate (crashes per 10^8 v-km/yr)			
SH (urban)		TLA (urban)		SH (urban)		TLA (urban)	
"all"	"wet"	"all"	"wet"	"all"	"wet"	"all"	"wet"
41.5%	49.4%	35.8%	50.0%	20.7	26.0	20.1	31.1

Table 6: Reduction in Urban Crash Rates (1995-2006)

Reduction in Urban Crash Rates between 1995 and 1998							
Expressed as a Percentage				Expressed as Change in Crash Rate (crashes per 10^8 v-km/yr)			
SH (urban)		TLA (urban)		SH (urban)		TLA (urban)	
"all"	"wet"	"all"	"wet"	"all"	"wet"	"all"	"wet"
35.8%	51.3%	32.6%	50.7%	17.9	27.0	18.3	31.6

In contrast to rural roads, the SH and TLA crash rates on urban roads and associated trending over the 12 year period from 1995 to 2006 are largely the same (Figure 4). This has been attributed to the different mechanisms of rural and urban crashes (e.g. greater number of conflicts in urban areas) leading to greater "noise" in the urban data. The graphed information is summarised numerically in Table A3 (Appendix A3).

3.4 Factors Affecting Crash Rates

Many initiatives have been undertaken to improve safety on the total NZ roading network. In an attempt to separate out the effect of the TNZ T/10 specification the following factors are significant.

- Davies, R.B., Cenek, P.D. and Henderson, R.J. (2005) showed that, in the range of SCRIM coefficient (SC) 0.35 to 0.65, an increase in SC of 0.1 will reduce the crash rate by 20% in the dry and 35% when the road is wet. This implies that an effective skid resistance policy will reduce the crash rates more in the wet than the dry. By comparison most safety initiatives have a similar effect for both wet and dry roads.

- Jamieson and Cenek (2002), shows a positive correlation between wet and dry coefficients of longitudinal deceleration obtained from locked-wheel emergency braking tests, performed over a range of representative chipseal and asphaltic concrete surfaces i.e. surfaces with higher wet coefficients display higher dry coefficients.

- Overall, TLAs do not invest as heavily in skid resistance improvement of their networks as TNZ does for the SH network (refer section 1). This, when combined with the information above, implies that greater reductions in crash rates should be observed on the SH network than on the TLA network if the TNZ T/10 specification is effective, particularly under wet conditions.

4. DISCUSSION OF RESULTS

The effectiveness of the TNZ T/10 specification can be estimated by considering differences in the percent changes in "all" and "wet" crash rates between SH and TLA road networks over the 12 year analysis period as crash reducing factors other than the introduction of the T/10 specification will be common to both networks. Such factors included the introduction of the Supplementary Road Safety Package (SRSP) in 1995, which was a mainly anti-speeding and alcohol package of road policing and support advertising, and the introduction of the highway patrol in 2002, which was accompanied by reduced tolerance to infringements by the NZ Police. The SRSP is largely credited for the significant reduction in crash rates that took place between 1995 and 1998, as observed in Figures 3 and 4.

Differences in rural and urban crash rates are considered separately below.

4.1 Rural Crash Rates

These have been summarised in Table 7 below for ready reference.

Table 7: Rural Crash Rate Summary 1995-2006

Percent Reduction in Rural Crash Rates			
State Highways		Local Authorities	
"All"	"Wet"	"All"	"Wet"
30.5%	40.1%	13.0%	19.2%

The information in the above table, when combined with the research findings summarised in section 3.4, shows that the TNZ T/10 specification has been effective in reducing the rural SH "wet" road crash rate. It is conservatively estimated that the size of this reduction is around 20% over the 12 year period corresponding to a 1.7% reduction per annum.

There are strong indications that the TNZ T/10 specification has also assisted in reducing the "all" road crash rate on SHs. With reference to Table 7, the reduction attributable to the TNZ T/10 specification is estimated to be 17.5% over the 12 year period corresponding to a 1.45% reduction per annum.

4.2 Urban Crash Rates

These have been summarised in Table 8 below for ready reference.

Table 8: Urban Crash Rate Summary 1995-2006

Percent Reduction in Urban Crash Rates			
State Highways		Local Authorities	
"All"	"Wet"	"All"	"Wet"
35.8%	51.3%	32.6%	50.7%

The data for urban crashes is not as convincing in support of investment in a skid resistance policy. Variability is to be expected, as there are many more traffic conflicts on urban sections of a network compared to rural sections. In addition, there have been a large number of improvements in urban intersection controls over the study period.

It is noted that while the SH urban crash rates have not reduced significantly more than the TLA urban crash rates, the "wet" crash rates have reduced more than the "all" rates for both SH and TLA networks. This indicates that skid resistance is an important factor to control when attempting to reduce crash rates in urban areas.

5. STATE HIGHWAY SKID RESISTANCE

Transit New Zealand has a programme of measuring the skid resistance of the 22,000 lane kilometres of state highway network on an annual basis. These measurements, undertaken by SCRIM in each wheelpath, have demonstrated an improving trend in network skid resistance.

From 1998 to 2007 the proportion of the stet highway network with sections of road below the targeted Threshold Levels for skid resistance, has reduced from 2.12% to 0.66%. This equates to a measure of Good Skid Exposure of 99%, where exposure is measured as vehicle kilometres travelled on an annual basis on network above these Threshold Levels.

Also contributing to improved skid resistance is macrotexture. A further improving trend has been recorded from 1999 when 0.9% of chipsealed surfaces were considered 'flushed" with Mean Profile Depth (MPD) macrotexture level <0.5mm, to only 0.47% of the network in 2007.

Improvements in macro and micro texture have helped to improve the skid resistance of the state highway network, thereby reducing the risk of loss of control type crashes in wet conditions and consequently contributed to the wet road crash statistics.

6. CONCLUSIONS

5.1 Conclusions

Findings from a comparative study of reported fatal and injury crashes on New Zealand roads over the 12 year period from 1995-2006 show that:

1. There has been a significant reduction (between 25% and 50%) in crash rates between 1995 and 1998 for all crash categories investigated, with the reductions being greater for urban roads than for rural roads and for "wet" crashes than for "all" crashes.

2. The fatal and injury crash rate on wet rural State Highways over the period 1998-2006 is trending downwards (reducing 1.1% per annum) whereas the rate of all crashes is largely static for this period. By comparison, both "all" and "wet" crash rates on local authority rural roads are trending upwards, with the "all" crash rate increasing by 1.2% per annum since 1998 and the "wet" crash rate increasing by 0.9% per annum.

3. The "all" and "wet" crash rates for urban roads has remained relatively static for both State Highways and Territorial Local Authorities over the 9 year period, 1998 – 2006.

7. SUMMARY

From the 12 year trend lines, it can be inferred that Transit New Zealand's skid resistance policy, as manifested in the T/10 specification, has reduced the rural State Highway wet road crash rate by about 20%. There are strong indications that it may have also assisted in reducing the rural State Highway dry crash rate by an appreciable amount.

This reduction in wet road crashes, together with the notable improvements to on-road skid resistance over the last ten+ years, demonstrates that Transit New Zealand's targeted policy has proved extremely beneficial in reducing the crash risk to motorists and thereby had a direct result in improving road safety across the state highway network.

8. REFERENCES

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TNZ (2004): Statement of Intent 2004/2005. Transit New Zealand, Wellington. 39 pp.

Appendix A

A1 CAS Crash Data

Table A1.1: CAS Crash Numbers 1995 – 2006

Year	SH				TLA			
	urban		rural		urban		rural	
	"all"	"wet"	"all"	"wet"	"all"	"wet"	"all"	"wet"
1995	1139	300	2931	997	6638	1842	1544	440
1996	1001	278	2658	983	5600	1477	1318	376
1997	915	208	2351	705	5046	1178	1221	309
1998	742	169	2242	764	4572	988	1278	348
1999	737	158	2318	785	4284	937	1207	301
2000	689	138	2166	700	3924	827	1115	298
2001	802	204	2450	865	4397	1053	1289	362
2002	1015	233	2602	862	5151	1219	1488	376
2003	1005	229	2774	832	5293	1203	1652	442
2004	946	214	2761	925	5194	1219	1591	462
2005	946	181	2858	849	5429	1059	1682	431
2006	1036	207	2900	849	5672	1151	1704	451

A2 Exposure Data

Table A2.1: LTNZ Per-annum Exposures (10^8 vkt)

Year	SH		TLA	
	urban	rural	urban	rural
1995	22.8	123.3	118.4	54.6
1996	23.6	128.1	121.2	56.0
1997	24.5	132.8	124.1	57.3
1998	25.4	137.5	127.0	58.6
1999	26.4	143.1	131.9	60.9
2000	26.9	146.1	132.8	61.3
2001	27.9	151.7	134.4	62.0
2002	28.8	156.5	137.3	63.4
2003	29.6	161.0	140.3	64.8
2004	30.6	166.4	143.9	66.4
2005	31.4	170.7	149.5	69.0
2006	32.2	175.5	150.1	69.3

Table A2.2: LTNZ Per-annum Exposure Increase Multipliers (year x vkt = year (x+1) vkt × multipler year (x))

Year	SH	TLA
1999	0.980	0.993
2000	0.963	0.988
2001	0.970	0.979
2002	0.972	0.979
2003	0.968	0.975
2004	0.974	0.963
2005	n/a	n/a

Per-annum exposure increases (1999-2005) based on LTNZ data (Cenek 2006a).

Table A2.3: Linear Exposure Equations (1995-1998 and 2006)

linear fit to 1999-2005 exposure data (10^8 v-km/yr)				
	SH		TLA	
	urban	rural	urban	rural
	"all"	"all"	"all"	"all"
slope	8.61E-01	4.74E+00	2.89E+00	1.33E+00
intercept	-1.69E+03	-9.33E+03	-5.65E+03	-2.60E+03

A3 Crash Rates

Table A3.1: Crash Rates (fatal and injury crashes per 10^8 v-km/y)

Year	SH				TLA			
	urban		rural		urban		rural	
	“all”	“wet”	“all”	“wet”	“all”	“wet”	“all”	“wet”
1995	50.0	52.7	23.8	32.3	56.1	62.3	28.3	32.2
1996	42.4	47.0	20.8	30.7	46.2	48.7	23.5	26.9
1997	37.4	34.0	17.7	21.2	40.6	38.0	21.3	21.6
1998	29.3	26.7	16.3	22.2	36.0	31.1	21.8	23.7
1999	27.9	23.9	16.2	21.9	32.5	28.4	19.8	19.8
2000	25.6	20.5	14.8	19.2	29.5	24.9	18.2	19.4
2001	28.7	29.2	16.2	22.8	32.7	31.3	20.8	23.4
2002	35.2	32.4	16.6	22.0	37.5	35.5	23.5	23.7
2003	34.0	30.9	17.2	20.7	37.7	34.3	25.5	27.3
2004	30.9	28.0	16.6	22.2	36.1	33.9	24.0	27.8
2005	30.1	23.1	16.7	19.9	36.3	28.3	24.4	25.0
2006	32.1	25.7	16.5	19.4	37.8	30.7	24.6	26.0

Note:

The “wet” crash rate assumes that the road is wet for 25% of the time (Henderson, 2006). This is judged to be conservative with respect to “wet” crash rates.

Appendix B

Terminology

The following terms are adopted in this report.

Skid Resistance
The term used to describe the contribution that the road makes to the development of tyre-road friction. It is almost always used in the context of wet road surfaces and is essentially a measurement of the coefficient of friction obtained under standardised conditions in which various variables are controlled so that the effects of the road surface characteristics can be isolated.

SCRIM
SCRIM is the acronym for Sideway-force Coefficient Routine Machine. It is a machine that measures the skid resistance of roads under controlled wet conditions and is capable of testing both wheelpaths of long lengths of road at survey speeds up to 80 km/h.

The raw data from SCRIM is the ratio of the vertical force to the induced side force on the test wheel. The measurement scale is effectively 0.0 to 1.0. The raw SCRIM data is adjusted to account for SCRIM travel speed, temperature, etc. The data is then processed to generate MSSC and then ESC as defined below.

Mean Summer SCRIM Coefficient (MSSC)
This is the mean SCRIM coefficient over the summer period (when skid resistance is generally at its lowest).

Equilibrium SCRIM Coefficient (ESC)
ESC is MSSC data smoothed for year-to-year variations. (The RAMM database from 2002 onwards is populated with ESC data.) ESC values are defined as falling within three ranges:

- High: values of ESC above the IL,
- Medium: values of ESC between the IL and the TL,
- Low: values of ESC below the TL.

The terms IL and TL are defined in the following text.

Investigatory Level (IL) of Skid Resistance
This is the level of skid resistance at or below which a site investigation is to be undertaken, and the information used as a priority indicator for programming treatment.

Threshold Level (TL) of Skid Resistance
The threshold level is currently set at 0.1 below the IL and is the trigger level for determining priority treatment.

Appendix C

Abbreviations

Abbreviation	Transcription
CAS	Crash Analysis System
LTNZ	Land Transport New Zealand
MoT	Ministry of Transport
MPD	Mean Profile Depth
NIWA	National Institute of Water and Atmospherics
NLTP	National Land Transport Programme
PSV	Polished Stone Value
RAMM	Road Assessment and Maintenance Management
SC	SCRIM Coefficient
SCRIM	Sideways force Coefficient Routine Investigation Machine
SH	State Highway
TLA	Territorial Local Authority
TNZ	Transit New Zealand
VKT	Vehicle Kilometres Travelled