How to allow for seasonal effects when using skid resistance data

James Mitchell

WDM Limited

ABSTRACT

Wet road skid resistance varies throughout the year, with in the UK and New Zealand, the lowest values occurring towards the end of the summer and the highest values during the winter. To minimise this seasonal effect, testing is limited to the summer months each year but even then there is variation. In New Zealand, the variation over the summer is further minimised by using a number of seasonal control sites that have been set up across the network. These seasonal control sites are tested three times each summer and the measurements used to give a Mean Summer SCRIM Coefficient (MSSC) for each site.

The MSSC provides a datum for controlling within year variations, however it has been noticed that New Zealand, in common with other countries, is experiencing unprecedented year on year variations in weather patterns. This means that although the within year variation has been corrected the between year effects may be affecting the SCRIM results. Because of the size of the NZTA network and the typical weather patterns, it was not practical to implement the Characteristic SCRIM Coefficient (CSC) correction process as used in the UK.

NZTA has overcome this problem by using an Equilibrium SCRIM Coefficient (ESC). A three year rolling average is used for the ESC. The mean of three preceding annual MSSC's is calculated for each area and this mean is used to produce an ESC factor for the current year. The current year area MSSC's are corrected for between year variations by applying the ESC factor.

This paper will describe how the seasonal sites are located throughout New Zealand and split into 14 climatologically similar areas and the checks undertaken on the data each year to ensure there have been no treatments or anything else that may affect the correction factor. It will demonstrate how the approach mitigates the effect of unusual variations on site, giving greater confidence in the SCRIM coefficients calculated and includes approaches that could be used by other highway authorities that use benchmark sites.

1. INTRODUCTION

Wet road skid resistance varies throughout the year. In the UK and New Zealand, this variation has been generally observed to coincide with seasonal change, lowest values in the summer and the highest values during the winter. Environmental factors (particularly rainfall) combined with the inherent aggregate characteristics are thought to be the main contributory factors. The suggested explanation for this variation is that in the summer when the roads are dry most of the detritus is ground to a fine flour that acts like a polishing agent for the road surfacing aggregate under the action of tyres. In the winter when roads are wet for most of the time the fine detritus is leached away leaving the larger gritty material under the action of tyres this grit provides a medium that roughens the stone chips and increases the microtexture and consequently the skid resistance.

The term 'seasonal variation' has traditionally been used to describe this phenomenon, but there are other variations than simply seasonal effect. There is variation associated with more short-term weather effects. Seasonal variation also changes over time due to yearly climate changes. Therefore, to describe this phenomenon correctly, more specific terms are needed [1]:

- Seasonal variation: Variation in skid resistance due to seasonal effect (summer / winter) within a year.
- In-year variation: Variation in skid resistance measurement within a year. This could be due to the seasonal effect, short-term variations (difference in measurement before/after week of rain), as well as repeatability in measurement.
- Year-on-year variation: Changes in seasonal/in-year variations over the years, due to impact of unusual climate experienced over the years.

Various practices have been developed over the years to account for the seasonal variation.

2. SEASONAL CORRECTION

2.1 Mean Summer SCRIM Coefficient (MSSC)

The network is surveyed three times in the same year, in the early, middle and late parts of the testing season. The MSSC is the average of the three consecutive measurements during the testing season, usually the summer when the lowest skid resistance is expected. This is to account for seasonal and in-year variations. Although the MSSC method takes account of some within-season variation, it has been found from experience that the approach is potentially vulnerable to differences between particular years. Particularly hot or wet summers, could give rise to relatively low or high MSSCs compared to the underlying equilibrium value.

[1] AUSTROADS RESEARCH REPORT AP-R444-13. Review of Variability in Skid Resistance Measurement and Data Management.

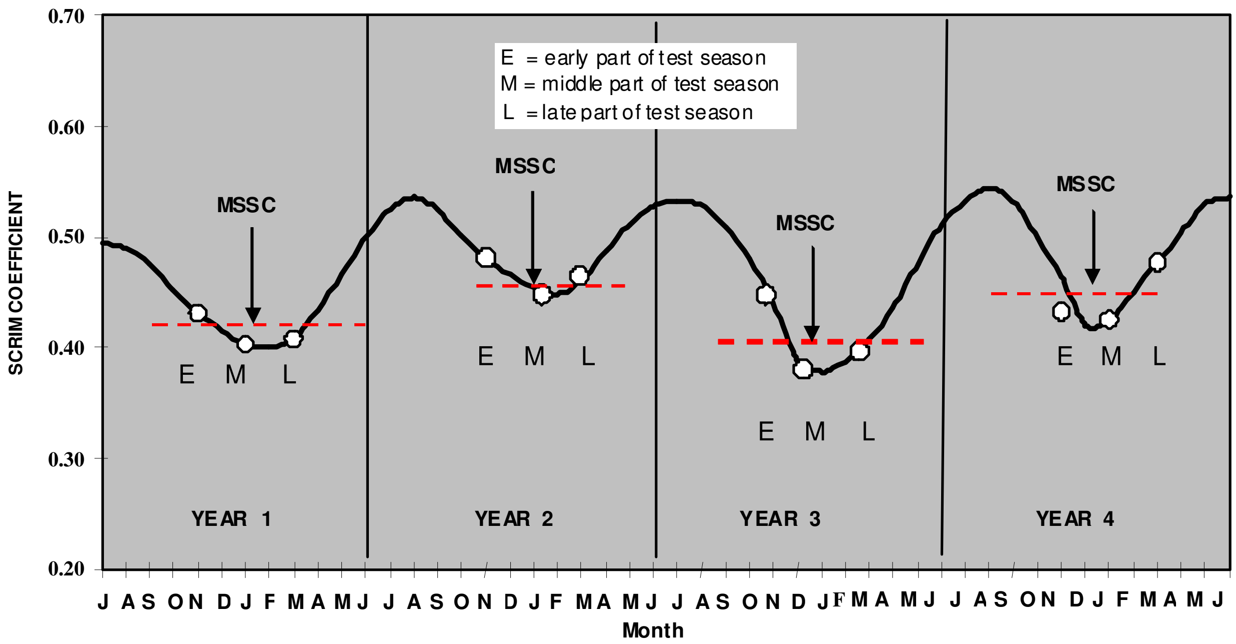

Figure 1: MSSC Seasonal Correction Strategy

2.2 Characteristic SCRIM Coefficient (CSC)

This approach is based on a single annual survey of the network. The method uses measurements from the preceding three years to characterise the long-term skid resistance of the network. This value is used with the mean network skid resistance in the current year, to calculate a correction factor, which is applied to the current year's data to make current values consistent with the long-term average. The whole network is surveyed once during the testing season in each year. Surveys must be planned such that in successive years each road length is tested in the early, mid and late parts of the season [2].

2.3 Equilibrium SCRIM Coefficient (ESC)

The ESC or annual survey with benchmark sites method, is based on the whole of the network being tested once in each year. The overseeing authority will agree a number of benchmark sites (or seasonal correction sites) to cover a relevant geographical area. The benchmark sites are all tested three times in the same year, in the early, middle and late parts of the testing season, to provide MSSC values for each Benchmark Site and an overall average MSSC value for the area. Different parts of the network can be surveyed in different parts of the testing season. Whenever a part of the network is surveyed, all the Benchmark Sites in that area shall be tested at the same time.

[2] HD28/04 SKID RESISTANCE, Volume 7, DESIGN MANUAL FOR ROADS and BRIDGES.

The Mean Summer Correction factor is determined to take account of variation in skid resistance between the time of a particular survey and the average during the testing season, this is the overall average of all of the benchmark sites for the testing season. The average MSSC of all of the benchmark sites in the area for the current testing season, is then compared to the overall average MSSC for all of the benchmark sites over the three years that precede the current testing season.

This method assumes that the average behaviour of the benchmark sites is representative of the area and that the climatic effects leading to seasonal variation between years will have influenced all of the benchmark sites in an area in a similar way. By surveying the benchmark sites three times each season, some account can be taken for the in-year variation. Comparing the sites in successive years allows the effects of year-on-year variation to be reduced.

3. NZTA ESC SEASONAL CORRECTION

NZTA considers that year-on-year and in-year seasonal variations in skid resistance are significant, with between year variations of upto 10%. NZTA operates an annual SCRIM survey across its entire network. The survey covers most lanes, with the SCRIM coefficient (SC) measured in both wheelpaths. Because of the size of the NZTA network and the typical weather patterns, it was not practical to implement the Characteristic SCRIM Coefficient (CSC) correction process as used in the UK. Therefore the ESC method has been adopted in New Zealand.

Originally 70 seasonal sites (or benchmark sites) each 5 km long, were established throughout New Zealand. The country has been split into 14 climatologically zones, zone A to L. In 2007 it was felt that the 70 sites did not give enough coverage in each seasonal zone, so the number of seasonal sites was increased to 114.

Each seasonal site is tested three times throughout the summer, one at the start, one in the middle and one at the end of the summer survey period, to obtain the mean MSSC for each site. Additionally each site is tested as part of the routine network survey in each zone. The reading obtained during the survey is then compared to the mean value to obtain an MSSC correction factor to be applied to the test values within that seasonal zone. The correction factor is also calculated for each month, so that any survey work carried out in a particular seasonal zone can be corrected to the conditions closest to the survey date.

To account for the year-on-year variation, the average MSSC for each seasonal zone for the survey year is calculated and combined with the previous three years average MSSC to get the rolling average ESC value for the seasonal zone. This is then compared to the survey year average MSSC value to obtain an ESC correction factor for each zone. The reported ESC is then calculated by applying the zone MSSC factor nearest to the survey data and the zone ESC factor to each 10 m length of machine measured SC data.

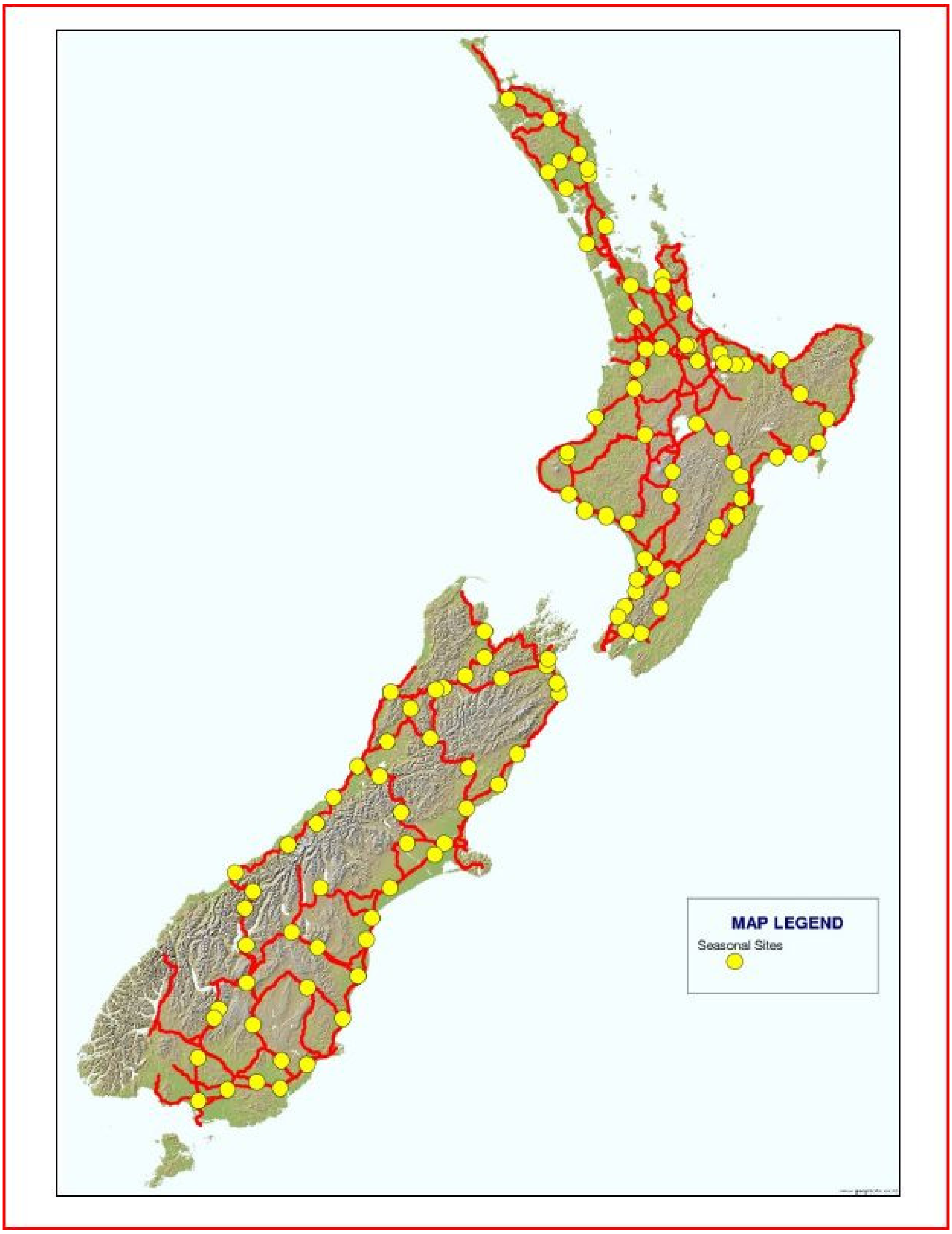

Figure 2: 114 Seasonal Sites throughout New Zealand

The ESC rolling average value for each seasonal zone was originally calculated over four years, the current year and the previous three years. However, it was found that using the current year twice in the ESC calculation, once for determining the long term average and then again in correcting the current year to the long term average was affecting the ESC correction factors. The calculation of the ESC long term average was changed to using the previous three years, as is used in the UK benchmark method.

4. Seasonal Site Verification

The seasonal sites are 5 km in length, but require a minimum 1 km of usable data to qualify for use as a seasonal site. In order to remove external factors other than seasonal variation, plots of MSSC data for within year variation and ESC data for year-on-year variation, along with video from each survey, are inspected to determine areas of maintenance treatment or severe flushing. These lengths are removed from the ESC calculation.

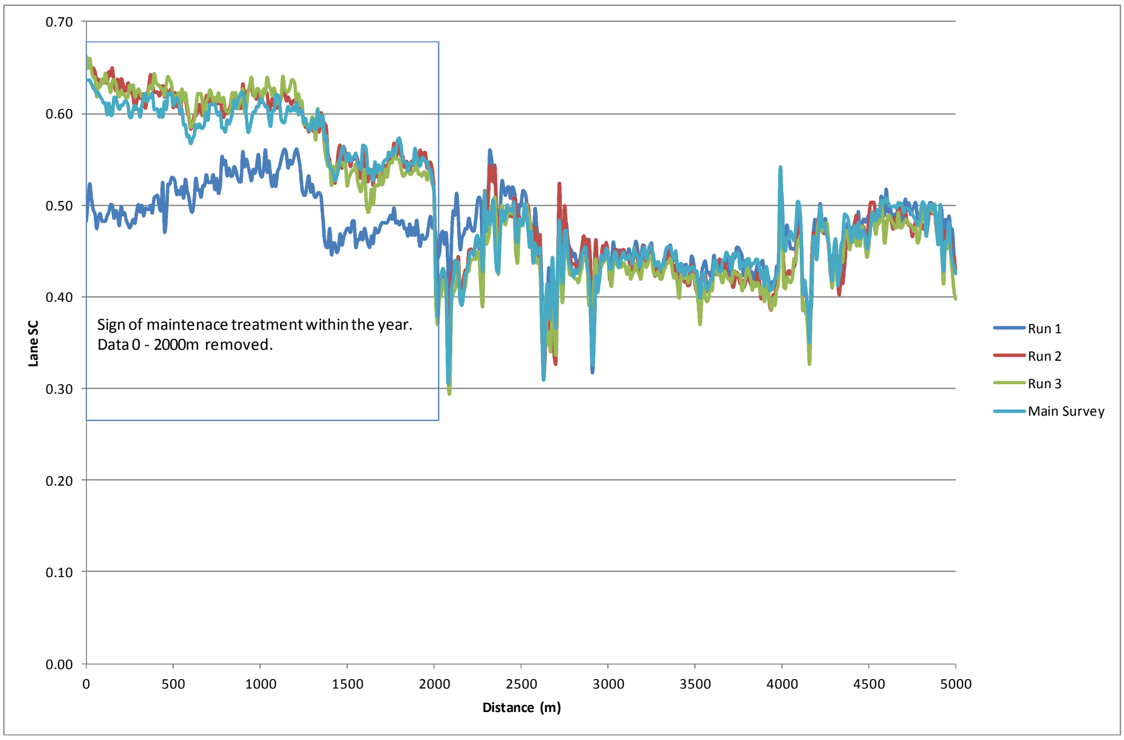

Figure 3: MSSC Seasonal Site Example

Figure 3 shows a plot for one seasonal site, with the SCRIM data from the three MSSC surveys throughout the survey season and the main survey. There is evidence of maintenance treatment after the first MSSC survey between 0 to 2000m. This was confirmed by viewing the videos from each survey and the data between 0 to 2000m removed from the MSSC and ESC calculation.

Figure 4 shows an example ESC plot with four years of MSSC data. There is evidence of treatment in the first km, so data was removed from the ESC calculation for 0 to 1020m. Even with the data removed where there was evidence of treatment in the first km, there is still a variation of 0.06 SC between the four years used in the ESC calculation with the lowest skid values from the 2013 survey.

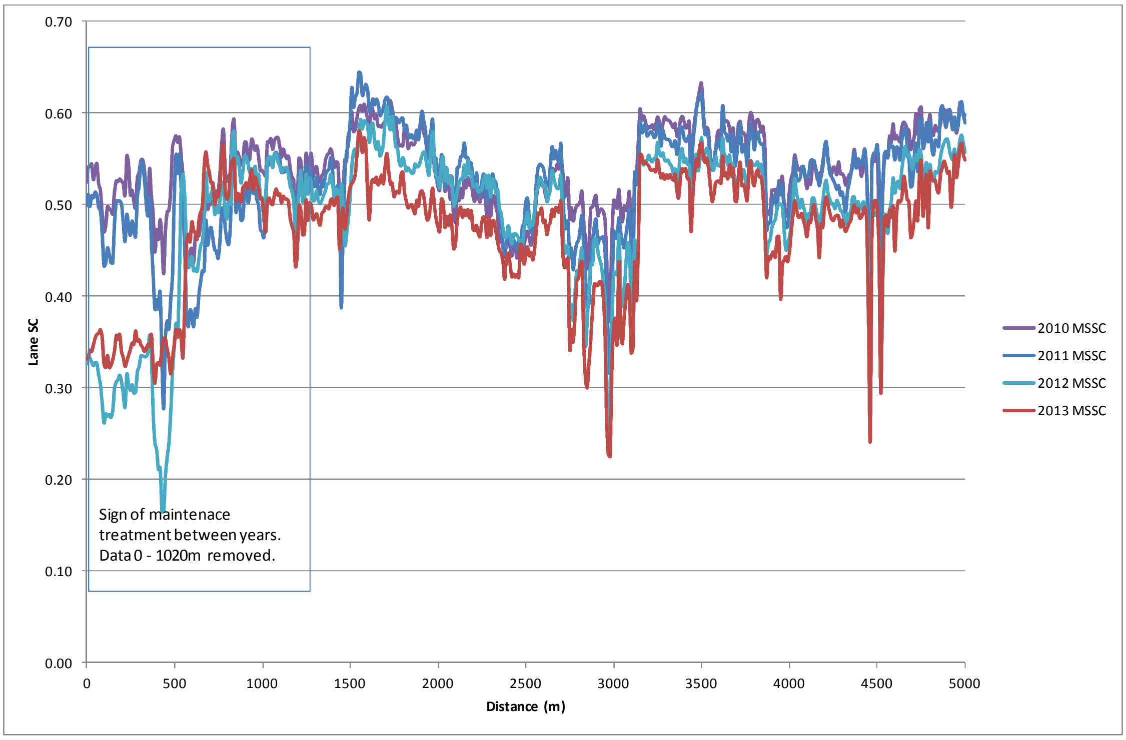

Figure 4: ESC Seasonal Site Example

5. NZTA 2013 Seasonal Correction

The 2012-13 summer in New Zealand was a very sunny summer for most of the country and extremely dry conditions were experienced over most of the North Island. Many North Island regions recorded rainfall totals around half of summer normal. However, parts of Northland, Auckland, Bay of Plenty, Hawkes Bay and Wairarapa received only one third of normal summer rainfall. In contrast, South Taranaki, Wellington, Otago, Southland and Marlborough experienced closer to normal summer rainfall.

Table 1 shows the final 2012/2013 NZTA seasonal correction factors for each zone. There is a correction factor for the months survey work was carried out in each zone. Most of New Zealand experienced mostly dry conditions for the 2012-13 summer with lower than normal rainfall totals. All of the ESC factors for each zone are greater than 1, meaning that the 2013/2013 survey data has to be increased to correct back to the long term average.

Table 1: NZTA 2012/2013 Seasonal Correction Factors

Seasonal Zone	MSSC Correction Factor				ESC Correction Factor	Combined MSSC and ESC Correction Factor			
	Nov	Dec	Jan	Feb		Nov	Dec	Jan	Feb
A			0.993		1.019			**1.011**	
B1	0.967				1.035	**1.001**			
B2		0.986			1.046		**1.031**		
B3	0.907				1.067	**0.968**			
C	0.924				1.070	**0.989**			
D		0.945	1.005		1.062		**1.004**	**1.068**	
E			0.986		1.039			**1.025**	
F		0.927	0.967		1.045		**0.969**	**1.011**	
G		0.974			1.027		**1.000**		
H			0.953		1.034			**0.986**	
J			0.983		1.042			**1.024**	
K1				1.038	1.051				**1.091**
K2				1.007	1.040				**1.047**
L				1.046	1.041				**1.089**

The effect of the very dry summer resulted in 32 of the 114 seasonal correction sites showing a continuing downward trend in the site averaged skid resistance from the three survey runs performed over the summer period October 2012 to March 2013. These downward trending seasonal sites generally occurred in areas experiencing the extremely dry conditions. In addition, 26 out of 114 seasonal correction sites had the site averaged skid resistance value of the second run significantly greater than either the first or third run. It is expected that the second run in the middle of the summer period would have the lowest skid resistance value. This combined effect on 50% of the seasonal sites has resulted in the majority of the MSSC factors (12 out of 16) having a correction factor less than 1.

Combining the average MSSC factors for each zone (mostly less than 1) with the average ESC factors (all greater than 1) resulted in 11 out of 16 of the final combined ESC correction factors having correction factors greater than 1, ranging between 0.968 and 1.091. Therefore zone K1, with the largest combined MSSC and ESC correction factor of 1.091, had the skid survey data seasonally corrected by increasing by 9.1%. A skid reading of 0.5 SC, would be increased to 0.55 SC, an increase of a site category band.

Because of the continuing downward trend in site averaged skid resistance from the three summer surveys over a number of sites, an additional survey was undertaken on some sites to determine if there had been a recovery and the magnitude of the recovery following the breaking of the drought.

Figure 5 shows an example seasonal site from the Bay of Plenty, which was one of the areas that experienced a long dry summer with rainfall totals around half of summer normal. The run 3 survey in March towards the end of the long dry summer, has a significant drop in skid resistance of around 0.15 SC compared to run 1 in October and run 2 in December and the survey in November from the routine testing of the network. The additional fourth survey in May following the end of Summer and break of the drought shows a recovery in the level of skid resistance to that at the start of the summer.

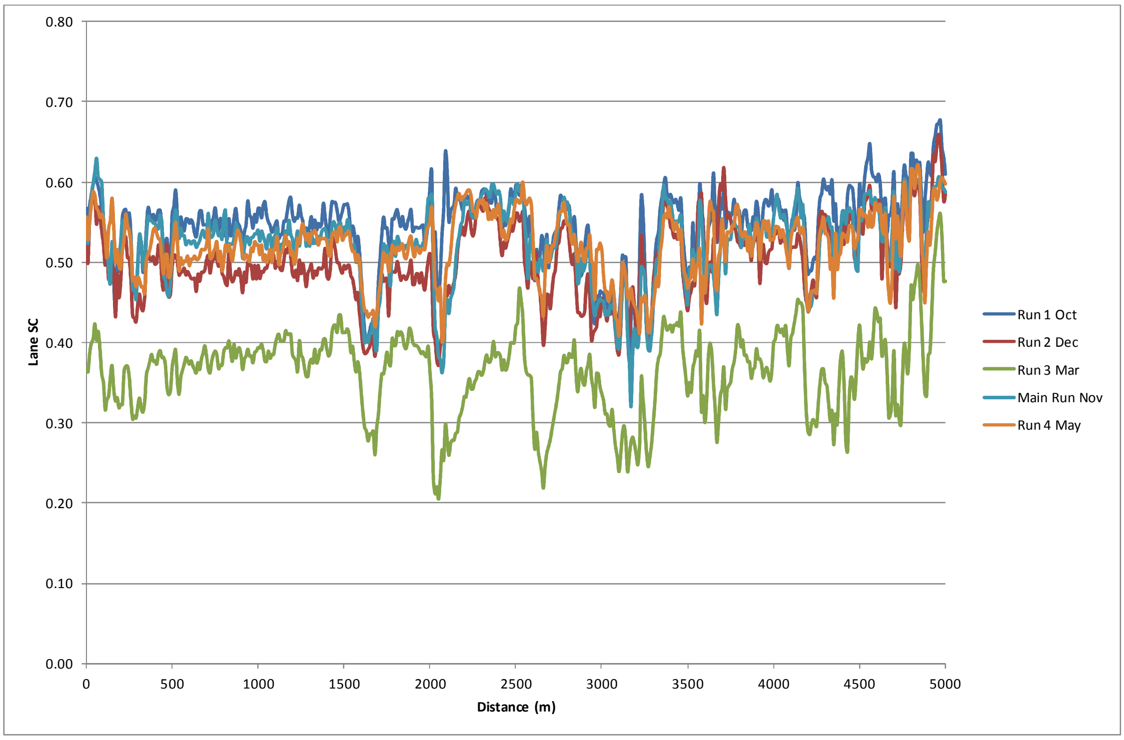

Figure 5: Seasonal Site Example with additional Survey

A drop in the skid resistance of 0.15 SC between runs is extremely unusual and raised concerns during the verification of the seasonal data. There were 11 sites on the North Island, where the third survey in March had a significant decrease in skid resistance of at least 0.1 SC. These sites were predominantly in Napier, East Wanganui and Bay of Plenty, on the East Coast of the North Island in areas that had experienced a long dry summer. The sites were surveyed over several days and not all sites surveyed during that period showed the same pattern. The Lane SC skid resistance is the average of the left and right wheel path data. The low level of skid resistance was present in both the left and right wheel paths, in two independent measuring systems. The sites on the Auckland motorway network, which is predominantly asphaltic concrete, surveyed at the same time as the seasonal sites with the very low run 3 skid resistance, showed almost no seasonal effect. Videos from the surveys with low third run skid resistance were inspected. These sites tended to exhibit a significant amount of flushing, accounting for the significant decrease in skid resistance, Figure 6.

Figure 6: Flushing on Seasonal Site

Therefore there was no justification for excluding these sites with very low third survey skid resistance data from the seasonal site correction process. The extensive flushing present on some sites at the time of the third run survey, was a genuine seasonal effect.

As can be seen from Table 1, zones B3, C and part of F where the network survey was done in December, have the lowest MSSC correction factors. These zones have been influenced by very low third run surveys on some of the sites within the zones. However, the ESC takes into account the lower MSSC average for these sites within the zone when correcting the zone average back to the long term mean and so these zones have higher ESC correction factors.

6. Seasonal Variation in UK

Figure 6 shows the variation in year-on-year skid resistance from a large county in the North of England. Here the CSC method on seasonal correction has not been adopted and the MSSC method is used to correct for within year variation. However, for a large county with over 3000 km of network surveyed each year, only one seasonal control site is used for the MSSC correction. The mean network MSSC values are 0.46, 0.53 and 0.49 for 2010, 2011 and 2012 respectively. Because no year-on-year correction was implemented, this resulted in large variation in the amount of SCRIM deficiency ranging from 41% in 2010, 18% in 2011 to 29% in 2012. 2011 was a very wet summer in the UK, resulting in higher skid resistance values and so less deficiency. Correction for year-on-year variation using either the CSC or ESC methods would reduce the variation in SCRIM deficiency between years.

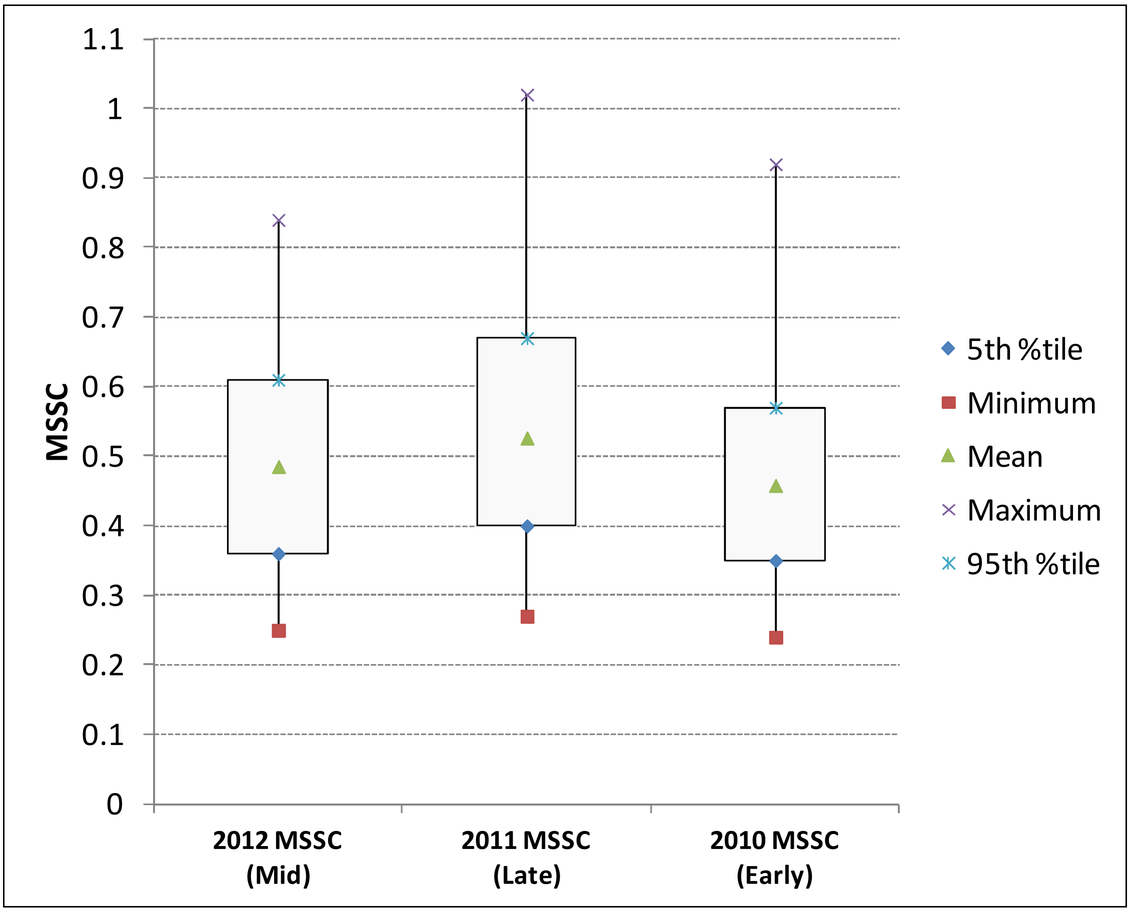

Figure 6: Year-on-Year Variation in Skid Resistance

Another example of the variation in skid resistance correction factors from a county in the south of England, is shown in Table 2 and Figure 7. Here again the MSSC methodology is used to correct for within year variation, based on three surveys of 2 control sites each year, because half of the network is surveyed every other year. Each site is surveyed in both directions. The variation in MSSC correction factors between 2009 to 2012 is shown in Table 2.

Table 2: Variation in MSSC Correction Factors

Year	MSSC Correction Factor
2009	1.073
2010	1.080
2011	1.085
2012	0.966

Figure 7 shows the 2012 average from each survey for the 4 sites. In theory, the pattern should show high readings in the early run, a drop in the mid run, and a recovery in the late run. 2012 experienced strange weather patterns in the UK, and the actual measurements vary significantly. The main survey run in 2012 was an early run, and therefore the correction process is applying a factor of less than 1 to reduce the main run values to the average of the 3 runs. The data from four years surveys can be used to calculate a between years correction factor. If the ESC method is applied to correct for between years variation, the 2012 correction factor would be 1.01, compared to the MSSC correction factor of 0.966.

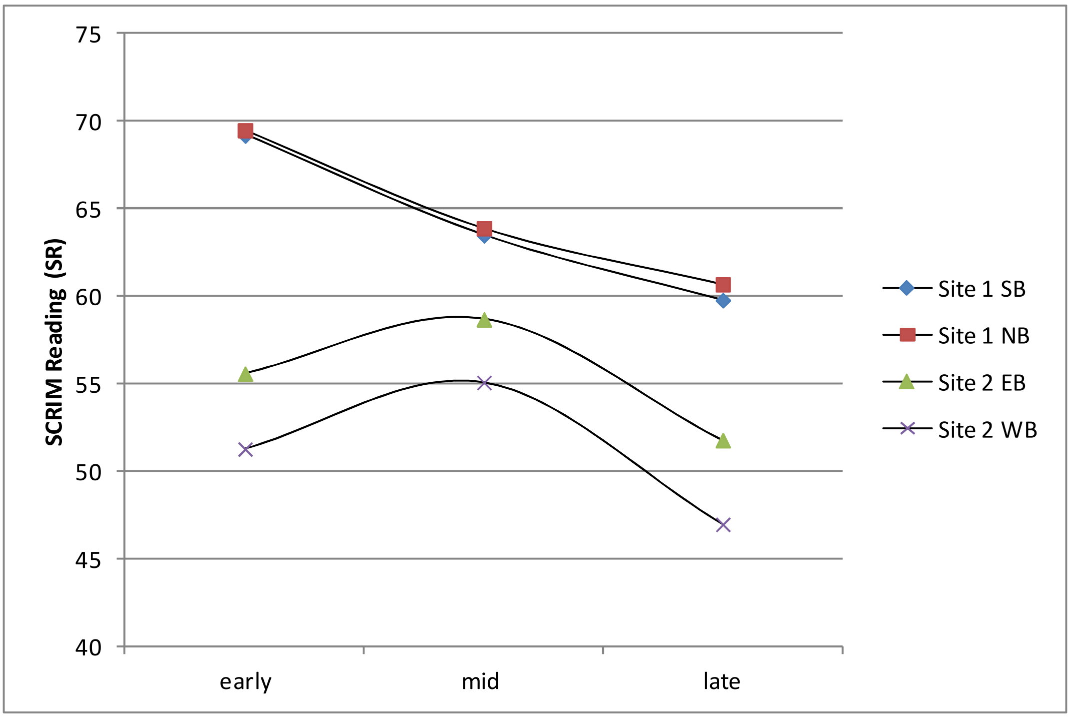

Figure 7: 2012 seasonal data

Figure 7 suggests that there may be other influences on the seasonal correction factor, especially for Site 2. Examination of the 2012 videos suggest the surface condition of Site 1 remained stable; however there is evidence of ‘fatted’ surface dressings on Site 2, Figure 8. It is evident that Site 2 is starting to show significant variations between seasonal runs due to the fatting of the existing surface dressing. This may influence both the ‘in years’ and ‘between year’ seasonal correction factors. Based on the condition evident from the video it is likely that treatment may be required to the road in the near future. On this basis there may be a need to replace the site for seasonal correction purposes, as changes in skid resistance will occur for reasons other than seasonal effects for the period up to the treatment occurring, and for at least 1 year post treatment. The majority of the authority’s network is asphalt surfacing, so flushing / fatting is much more unusual than for the predominantly chip seal surfacings in New Zealand. Therefore, the recommendation is to replace the site for future seasonal correction surveys, where as in New Zealand flushing is a more common occurrence and considered a genuine seasonal effect, so the flushed areas tend not to be removed from the seasonal analysis.

Figure 8: Site 2 2012 ‘fatted’ Surface Dressing

7. Changing Weather Patterns

There are changes to the weather patterns around the world which are having an effect on the long term skid resistance. In theory, the pattern of skid resistance throughout the summer should show high readings in the early period, a drop in the mid period, and a recovery in the late period. It has been recognised that the current late survey period in the UK, from 11th August to 30th September, may not be seeing the recovery at the end of the summer.

Devon County Council use the CSC seasonal correction method, however they still have 10 MSSC benchmark sites throughout the county surveyed each year. In recent years, they have collected additional surveys on these sites, in the middle of April, very early and at the end of October, very late survey periods. Figure 9 shows the 5 surveys for Devon County Council in 2013 for the 10 benchmark sites. It can be seen for most of the 10 sites, the mid survey has the highest values, with the late survey having the lowest. The recovery in the skid resistance values does not happen until the very late survey towards the end of October. Therefore, careful consideration needs to be given to the timing of the skid resistance surveys, so that the low point occurs during the middle period and the recovery in the late period.

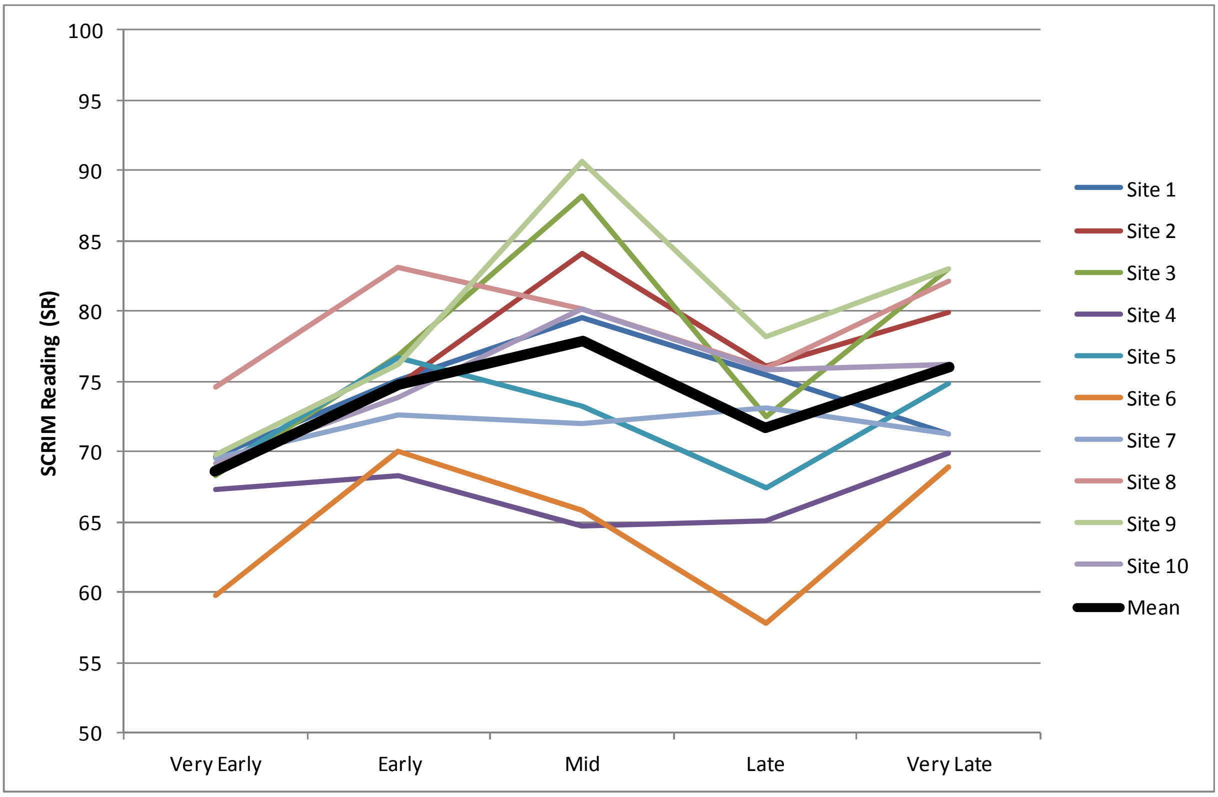

Figure 9: Devon County Council 2013 Seasonal Site Surveys

8. Summary

Year-on-year and in-year seasonal variations in skid resistance can be significant, with year-on-year variations of 10% being experienced in the UK and New Zealand. Not using any seasonal correction, or even using the MSSC correction to adjust for only within year variation can result in large changes in amount of network less than the investigatory level due to year-on-year variation in skid resistance. Therefore, seasonally correcting for long-term changes in skid resistance due to climatic changes can be used to reduce the year-on-year variations due to very wet or long dry summers. The author advocates that the CSC method be used to correct for year-on-year variation as the whole network is surveyed each year and used to calculate the long term average. However, if it is not possible to survey the whole of the network each year, or not practical to rotate the survey between early, mid and late periods, then the benchmark or ESC method should be used. If this method is used, careful consideration needs to be given to the number and location of the benchmark sites as well as their road condition. For large networks, seasonal variations are unlikely to be the same throughout the whole area, so several benchmark sites are likely to be required.

Author Biography

James Mitchell

James Mitchell has 16 years experience in highway engineering with W.D.M. Limited, most recently 6 years as a Consultancy Project Manager after 7 years as Survey Project Manager and before that 3 years working as equipment operator developing first-hand knowledge of operational processes on highway maintenance management projects.

Since joining W.D.M. Limited, he has been responsible for developing software and procedural documents. He has also been Project Manager for a number of different engineering projects involving high speed data collection, including financial modelling and skid deficiency prioritisation. These projects have included surveys on networks operated by NZTA in New Zealand, Department of Energy, Infrastructure and Resources in Tasmania, Highways Agency in England, Transport Scotland and Welsh Assembly, as well as many Local Authorities in the UK.