Watercutting – investigating the lifecycle of watercutter rejuvenation of aggregates

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An important note for the reader

Land Transport New Zealand is a Crown entity established under the Land Transport New Zealand Amendment Act 2004. The objective of Land Transport New Zealand is to allocate resources in a way that contributes to an integrated, safe, responsive and sustainable land transport system. Each year, Land Transport New Zealand invests a portion of its funds on research that contributes to this objective.

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Abbreviations and acronyms

AADT	Annual average daily traffic volume
AC	Asphaltic concrete
AGD	Average greatest dimension
ALD	Average least dimension
AWPT	Area wide pavement treatment
BPN	British pendulum number
BWP	Between the wheelpaths
CVD	Commercial vehicles per day (number of HCV/lane/day $\geq$ 3.5 tonnes)
ERP	Estimated route position
ESC	Equilibrium SCRIM coefficient
GN	Gripnumber from GripTester
HCV	Heavy commercial vehicle
HSD	High-speed data (obtained from the SCRIM+ network testing)
IL	Investigatory level
IWP	Inner wheelpath
LA abrasion	Los Angeles abrasion test
MPD	Mean profile depth (mm)
MSSC	Mean summer SCRIM coefficient
MTM	Minitexture meter
NAASRA	National Association of Australian State Roads Authorities
OGPA	Open graded porous asphalt
OWP	Outer wheelpath
PSV	Polished stone value
RP	Route position
RPM	Raised pavement marker
RS	Route station
SCRIM	Sideways-force coefficient routine investigation machine
SCRIM+	Sideways-force coefficient routine investigation machine specially configured for testing the New Zealand state highway network
SFC	Sideways force coefficient
SMA	Stone mastic asphalt
SMTD	Sensor measured texture depth
Td	Texture depth derived from sand circle diameter.
TL	Threshold level
TNZ or Transit NZ	Transit New Zealand
UHP	Ultra high-pressure (watercutter)

Contents

Executive summary

This research project examined the effect of ultra high-pressure water cutting on chipseal and hot mix asphalt surfacings with polished aggregate. The project monitored sections of the state highway network where polished sections were treated with ultra high-pressure watercutting alongside new surfacing treatments. The microtexture and macrotexture of the watercut and newly constructed sections were compared over a two-year period.

Ten sites were identified for this research project from the 2003 SCRIM+ network survey. These were treated with normal resurfacing techniques apart from a 150–200 metre section on each site that was retexturised using the watercutter. The microtexture and macrotexture of the newly constructed and watercut surfacings were measured for each site at six-monthly intervals over a two-year period to quantify the effect of the treatment and duration of the improvement. Data from the annual SCRIM+ survey was also collected and analysed.

The research showed that watercutting improved both microtexture and macrotexture for all 10 sites. Duration of the improvements varied depending on aggregate properties, site geometry, traffic stresses, climate effects and loss of texture due to flushing and surface contamination. Similarly the performance of the newly constructed surfacings was variable. Within two years of construction the microtexture of the new surfacings on four of the 10 sites had deteriorated to levels measured prior to treatment.

The ultra high-pressure watercutting process has been shown to improve both microtexture and macrotexture. However, where polish-prone aggregates are used the improved microtexture is unlikely to last more than two years. The same short duration improvement occurs when new surfacings are constructed with the same polish-prone aggregates.

A significant advantage with watercutting is its all-weather availability. When sites with poor skid resistance are identified, surfaces can be made safer until the next resurfacing season rather than erecting ‘Slippery When Wet’ signage. In addition, watercutting can be applied to discrete areas of surfacing requiring treatment rather than unnecessarily resurfacing entire sites.

Watercutting is environmentally more sustainable than resurfacing as less non-renewable resources are consumed.

This research project has shown that watercutting is suitable as a short-term (two-year) treatment for high-stress sites with unsafe levels of skid resistance. For sites with normal levels of stress the watercutting process has been shown to double the life of chipseal surfacings on some long-term monitoring sites.

Abstract

There are many techniques for restoring pavement surface microtexture after levels have become deficient. An innovative method, ultra high-pressure (UHP) watercutting is capable of restoring both the microtexture and the macrotexture on polished surfaces as an alternative to traditional resurfacing treatments such as chipsealing.

Preliminary investigations of both laboratory samples and road trial sections have shown that UHP watercutting can restore the microtexture of polished aggregate to a level similar to that of freshly crushed aggregate. The UHP watercutter combines a truck mounted UHP pump, water supply and vacuum recovery system with an independently operated umbilical deckblaster. A rotating spraybar fitted with specialised nozzles directs very fine jets of UHP water at ultrasonic velocity on to the road surface.

This report documents a Land Transport New Zealand Research Project monitoring the performance of UHP watercut surfaces against those of adjacent new surfacings on 10 sites located around New Zealand to compare the rate of loss of the microtexture improvement delivered by the watercutting treatment system compared with the rate of loss of microtexture of new surfacings laid at the same time and location.

1. Introduction

In 1997, Transit New Zealand (Transit NZ) released its T/10 specification, which required sites to be surfaced using aggregate with a polished stone value (PSV) appropriate to the risk associated with the site. The specification was developed on a risk management basis, whereby the level of friction on each 10 m section of the 10,500 km state highway network was determined according to the unique friction demands of each section. In addition, Transit NZ set targets for the required minimum texture depth throughout the network with the increased awareness of the fundamental relationship between road surface macrotexture depth and skid resistance. The relationship between microtexture, macrotexture and skid resistance are explained elsewhere (Roe et al. 1998; Cenek et al. 2000 and 1998c; and Patrick et al. 1998), so are not covered in detail in this report.

After the skid resistance of a surfacing has deteriorated to below an acceptable level there are a number of methods for restoring skid resistance besides resurfacing. Current asset management strategies meet the safety requirements for high-stress high-risk sites; however, this does not take account of the sustainable management of New Zealand's high PSV aggregate resources. The current strategies require resealing, or milling and replacing of the surface when the site fails due to aggregate polishing, wear or unstable flushed chipseal layers. This is an avoidable waste of non-renewable bitumen and high PSV aggregate resources.

Waterblasting at low to medium pressures (up to 20,000 psi) is an established method of bitumen removal and porous asphalt cleansing. In recent times waterjet cutting technology, (employing narrow jets of water under ultra high pressure (UHP) in excess of 35,000 psi) has been applied successfully to the process of bitumen removal.

The waterjet cutting process works by directing fine jets of water at the chipseal surface at 500 m/s. The high velocity impact causes the binder to react as a solid rather than a viscous fluid allowing the waterjet to chip particles of binder and aggregate from the surface. The energy in the fine jets of water travelling at 500 m/s is almost entirely dissipated on first contact with the surface and only the binder, road film and aggregate surface directly in line with the waterjets are abraded. With minimal energy remaining after contact with the surface the water jets cannot disturb the binder underneath the surface aggregate that is holding it in place. The water, aggregate, road grime and detritus are removed by the vacuum recovery system attached by umbilical to the deckblaster trolley.

Another associated benefit from this process is the restoration of the microtexture. Preliminary investigations on laboratory specimens by Fulton Hogan (Pidwerbesky 2002) showed that UHP watercutting could restore the microtexture of aggregate polished on the accelerated polishing apparatus to a level equal to and higher than that of the freshly crushed aggregate. Two-year-old road trials showed that the skid resistance and texture depth of the restored chipseal surface degraded at a similar rate to that of a new chipseal.

Overseas research on sustainable strategies for surfacings is virtually non-existent, though as environmental (and political) pressures come to bear, some work is beginning to appear in the literature. Based on the United Kingdom experience to date, Walsh (2002) concludes that road funding agencies, road authorities and contractors must pro-actively and collaboratively develop and implement sustainable strategies for surfacings. The UHP watercutter technique allows the application of more durable surfacings which could be routinely refreshed using an *in situ* method, effectively reusing the existing aggregates.

Overseas reports document traditional waterblasting treatments as producing only a short-term improvement on the microtexture of polished surfacings and being only suitable for short-term maintenance on polished sites. Mechanical processes that can deliver longer-term microtexture improvement commonly reduce the macrotexture, shortening the life of the treated surfacing. This research was intended to determine whether the UHP watercutting treatment would produce a long-term improvement to the microtexture of polished aggregate (while also improving the macrotexture of the surface) without shortening the life of the treated surfacing.

Currently, high PSV aggregates are used in surfacings in high-stress situations such as intersection approaches, steep hills and short radius bends. Using high PSV aggregate significantly increases the cost of surfacing and the high PSV chips may not have sufficient abrasion resistance to last the surfacing design life. The supply of durable high PSV aggregate is limited so alternatives for the future need to be identified. Therefore, there is a pressing need for a cost-effective solution that uses local aggregates.

This research compared the life-cycle performance and costs of the traditional practice of resurfacing skid deficient sites with high PSV chip, versus the alternative strategy of restoring the microtexture of the polished chip using the UHP watercutting process.

This research, therefore, primarily investigated the rate of loss of the microtexture improvement delivered by the watercutter compared with the rate of loss of microtexture of new surfacings.

1.1 Background

Transit NZ carries out annual surveys of the state highway network using SCRIM+ (sideways force coefficient routine investigation machine). The SCRIM+ measures the wet skidding resistance of the road surface by measuring the sideways force component acting on a free-rotating wheel at an angle to the direction of travel. These measurements of wet skidding resistance are used to identify lengths of road that are at or below the investigatory levels defined for a range of different site categories throughout the state highway network. Lengths of state highway from 10 m upwards are identified and prioritised for investigation and repair if required. SCRIM+ surface friction measurement is the basis of the Transit NZ T/10 specification.

SCRIM+ simultaneously measures the road surface macrotexture using lasers recording the average texture depth for each 10 m length for later analysis. The lengths that do not meet the required levels are identified and prioritised for investigation and remediation if required. The areas identified range in length from as little as 10 m to as long as 10 km.

The PSV required for each specific site is calculated using an equation that incorporates a specific site investigatory level, the minimum skid resistance in terms of sideways force coefficient (SFC), and projected commercial vehicle traffic volumes (CVD) at the end of the surfacing's life. As traffic volumes increase around the country, the requirement for high PSV aggregate is increasing.

In some cases the required PSV is greater than 66. There is no locally available aggregate in New Zealand with a PSV greater than 66; 63 is the highest PSV aggregate available in the South Island, with 66 the highest available in the North Island.

Natural aggregates with a high PSV generally have other less desirable properties (ie, lower strength and durability, and higher abrasion loss) that help to deliver their higher resistance to polishing. Aggregates with high PSV tend to maintain their microtexture by the loss of grains during abrasion; the abrasion resistance of these rocks then depends on the mechanism holding the grains in place. This relationship has led to the use of the aggregate abrasion value test (AAV) in the United Kingdom to ensure the longevity of the surface.

1.2 What are macrotexture and microtexture?

Macrotexture is the larger-scale texture between stone particles in a surfacing, which provides hysteretic (deformation) friction and escape paths for water from under vehicle tyres.

Microtexture is the finer texture on the surface of the aggregate particles, which provides adhesion friction; the sharp points penetrate the water film providing adhesive friction in the wet.

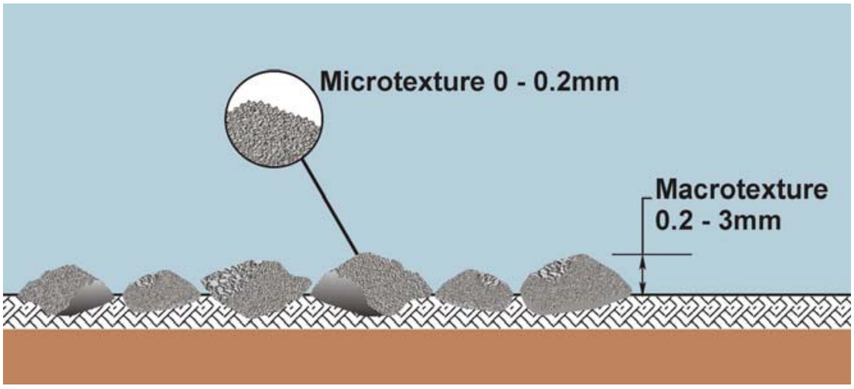

Figure 1.1 Macrotexture and microtexture schematic.

1.3 Project scope

The hypothesis of this research was that UHP watercutting could re-texturise a polished aggregate surface to a microtexture similar to that of freshly crushed aggregate from the same source, and that the re-texturing would significantly extend the life of the surface with respect to microtexture.

Microtexture was measured with the GripTester (described in a later section) and macrotexture was measured with both the minitexture meter and using sand circles immediately before and after watercutting (described in a later section).

1.4 Site selection

Ten sites were selected from sites in the planned state highway resurfacing programme for the 2003/2004 resurfacing season that had a 100 m – 200 m long section for which watercutting could be used in place of the programmed surfacing. The sites were spread geographically around the country to accommodate climatic and aggregate variation. The methodology used to find and select the sites is described in Section 4.

No statistical analysis was carried out on the significance or non-significance of 10 trial sites. Budget constraints and the rarity of sites on the network failing solely because of low microtexture restricted the number of sites selected. Most sites identified for resurfacing on the state highway network failed due to both low macrotexture and low microtexture. The sites selected were varied enough to include various surfacing types, different aggregate types, various climates, a range of traffic stresses and stress types, and different geometric shapes.

1.5 Microtexture testing

Microtexture data analysed for each site included data from SCRIM+ surveys and testing with the GripTester on a six-monthly basis.

SCRIM+ survey data for the sites was included as it is the accepted measure on which Transit NZ calculates compliance with the standards set out in TNZ T/10. The GripTester data is collected for the more specific site testing and monitoring between SCRIM+ surveys.

Seasonal correction of the GripTester results was not required as the GripTester measurements include where possible, the watercut section, new surfacings and lengths of older surfacing to be viewed as control sections.

The British pendulum skid tester was used onsite to verify the optimum forward speed of the watercutter (for maximising microtexture) and to ensure that the exact locations (ie, pre- and post-watercutting) were measured during this verification process.

1.6 Macrotexture testing

The macrotexture of the surfaces of all sites was tested using both sand circle texture measurement (TNZ T/3) and the minitexture meter. The minitexture meter is a portable man-propelled laser texture measuring device developed by WDM for measuring road surface texture depth.

Texture depth data from Transit NZ network surveys on the sites was included for comparison.

1.7 Aggregate testing

Aggregate samples of the new aggregate were taken for testing wherever new surfacing was constructed near or next to the watercutting sites. One site (MacKays Crossing) did not have new surfacing beside it as it was considered unsafe to split the site and have a change of surfacing between the curve tangent points.

Aggregate property tests included PSV (BS812: 1989: Part 114), crushing resistance (NZS4407: 1991: Test 3.10), Los Angeles abrasion (NZS4407: 1991: Test 3.12), particle size distribution (NZS4407: 1991: Test 3.8), particle size and particle shape (NZS4407: 1991: Test 3.13). As samples were taken from the actual aggregate used onsite there was a possibility the samples might not contain sufficient quantities of the appropriate size fraction for some of the testing to be carried out. Some tests required specific size fractions that might not have been included in the sample.

1.8 Timing

The physical works procedure was to get the new surfacing completed, swept and roadmarked before watercutting to minimise the disruption to both the watercut and the new surfacings.

Microtexture testing was successfully carried out with the GripTester on the newly laid surfaces and watercut surface both before and after the watercutting. The griptesting was carried out as soon as the surface had dried after completion of the watercutting. The watercutting and initial surface testing were carried out within eight days of the roadmarking on all sites where resurfacing was carried out.

A malfunction with the GripTester led to the loss of the initial set of data for sites 6, 7 and 8 on State Highway 5 but fortunately WDM was testing State Highway 5 with the SCRIM for research for Transit NZ in the months before the resurfacing and surface rejuvenation. The most recent test was just three weeks before the watercutting so we were able to include the data (uncorrected) from that survey to give some indication of the skid resistance on the sites before the rejuvenation process.

Delays in repairing the GripTester meant the post re-texturing griptesting was not completed until eight weeks after the treatment.

2. Ultra high-pressure watercutter description

2.1 Introduction

The UHP watercutter is a machine that combines both watercutting and road cleaning technologies in a single process to simultaneously remove excess binder and contaminants from pavement surfaces, and retexture aggregate surfaces improving road surface macrotexture and microtexture. The UHP watercutting machine was designed and fabricated in New Zealand by Fulton Hogan Limited.

Large areas of skid deficient road surface have been treated using the UHP watercutter in the past two years and all have shown improved microtexture.

Cenek et al. (1998b) suggest that high-pressure waterblasting ' …removes the road film which clogs microtexture, but probably does not counter stone polishing'. However, subsequent laboratory trials using the PSV test polishing apparatus, British pendulum portable skid tester and the UHP watercutter showed that the watercutter could restore the microtexture of laboratory polished aggregate specimens to a state equal to or higher than the unpolished specimens (Pidwerbesky 2002).

2.2 Watercutter process

The UHP watercutter equipment comprises the truck-mounted UHP pump, water supply, vacuum recovery system and an independently operated umbilical deckblaster (see Figure 2.2) that directs the very high-velocity water jets at the road surface. The watercutter's cutting head has an effective cut width of 560 mm and can restore macrotexture on the road surface (Figure 3.1). As no heat is used in the process, binder is easily collected within the unit's recovered material tank for recycling.

The UHP watercutter operates at a water pressure of 36,000 psi (2500 bar). This high pressure produces energy intensive jets of water applied to the road surface through a rotating spraybar. The optimum design of the spraybar was determined by theoretical design and subsequent field investigations. The quantity of water used is small (15–20 litres of water per minute); it is the very high velocity of the water (about mach 1.5 or 500 m/s) that provides the desired cutting action.

These water jets are energy intensive and very effective at removing the excess binder from the road surface without dislodging the surface aggregate as the energy in the waterjet dissipates very quickly and does not remove the underlying binder that anchors the aggregate in place. No significant aggregate loss has been experienced with this system despite the intense energy involved in the treatment.

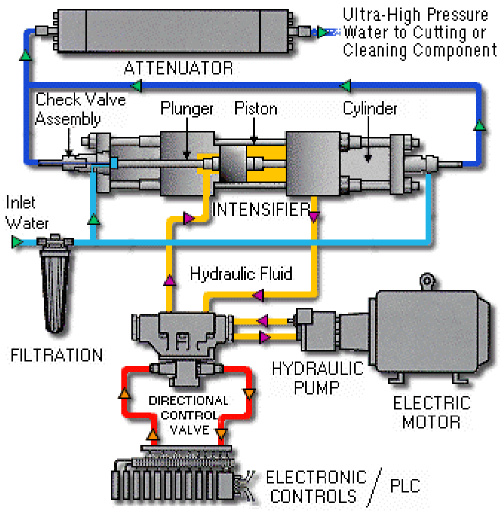

Figure 2.1 Schematic of the pump operation.

2.3 UHP water cutter

UHP refers to pressures exceeding 30,000 psi (2000 bar). The machinery developed to safely and reliably pump water at these pressures is both specialised and expensive.

The latest design (Figure 2.1) uses one engine to meet all the demands of water pumping, deckblaster operation and waste vacuum recovery. This design minimises the fuel used and reduces unnecessary weight.

Optimised axle loads enable a full day's supply of water and a full day's worth of recovered product to be carried. This dramatically improves the efficiency of the whole operation by eliminating the need to travel to and from disposal sites during the day.

Figure 2.2 Water supply and vacuum recovery system.

The recovered product tank on the truck has been designed to cope with the difficult material removed from the road surface. The recovered product contains approximately 20%–30% bitumen-based binder and 20%–30% fine aggregate, which settles in the tank. The tank has been designed as a tipping body with a steep tipping angle and a large hydraulically operated rear door. The door seal was carefully designed to provide a watertight seal even with 8500 litres of water and recovered product on board. The tank is constructed of stainless steel.

Having an operator on the ground with the deckblaster, see Figure 2.2, means that only those areas of the road surface that require treatment can be easily identified and treated. This maximises the useful work achieved, minimises the fuel used and minimises wasted energy. A system mounted entirely on a vehicle cannot deliver this flexibility and efficiency.

3. UHP watercutting procedure

3.1 Introduction

Field observations of surfaces that had been treated with the UHP watercutter indicated that the process was improving the microtexture of the aggregate in the surfacing. Initial laboratory investigation work confirmed that the watercutting process did restore the microtexture of polished aggregate. The initial experiment involved:

- manufacturing PSV test samples
- testing the test sample surface friction with the British pendulum
- polishing the test samples in the polishing apparatus
- retesting the test sample surface friction with the British pendulum
- positioning the specimens in a specially fabricated frame to hold them in place
- watercutting the test samples
- retesting the test sample surface friction with the British pendulum.

The results of this experiment showed the microtexture of the laboratory polished specimen could be restored to levels equal to or indeed greater than the microtexture measured on the sample before it was polished. These results justified further investigation to determine whether the same results were achievable in the field. The microtexture of early watercutting work on the state highway was monitored and the results showed that the microtexture on the watercut surface degraded at rates similar to that of new chipseal constructed in the area. This confirmed that the watercutting process improved both the macrotexture and the microtexture but the rate of deterioration of the restored microtexture was still unknown, and whether the microtexture restoration was applicable to all or only certain types of seals and aggregates remained unproven.

3.2 Process target speed development

The major difference between the microtexture and macrotexture improvement processes is that the macrotexture improvement can be seen and, therefore, the operator can easily control the process by increasing or decreasing speed to produce the required end result. It is, however, impossible to visually measure the effect of the watercutting on the aggregate particle's microtexture so a number of trials were carried out to develop optimum speed targets for the process.

Watercutting was carried out at various operating speeds of the watercutting device on a polished site on State Highway 75 past Tai Tapu, see Figure 3.1. The microtexture of the surface was measured before and after treatment with the British pendulum to identify the appropriate target speed to deliver both optimum retexturing and minimised damage to the chipseal integrity.

Further trials were carried out by re-treating sections already watercut to ascertain if significant further improvement could be attained by watercutting the same area twice; this produced a further small improvement (average 2–3 BPN) to the microtexture of the surface. However, it was not considered cost effective to carry out repeat cutting as part of the process.

As an extra check the results from two different watercutters working side by side on the same section of road were also compared to make sure the process was repeatable between machines.

3.3 Watercutting sites

Resurfacing sites from the 2003/2004 state highway resurfacing programmes that had failed the TNZ T/10 microtexture requirements were chosen for the trials (see Section 4). The trial sites were watercut from edgeline to edgeline to avoid having differential skid resistance across the traffic lane and to avoid having to replace the roadmarkings.

3.4 Aggregate variation

The trial sites were selected from the New Zealand state highway system to encompass a range of surfacing types, PSVs and aggregates.

A large number of permutations had arisen on the sites with regard to the aggregate comparisons. On most sites aggregates with higher PSV than the previous aggregate that had polished were used in the resurfacing; however, on the two Whangamoa sites an aggregate from a similar source was used.

3.5 Checking test results

Care was also taken to check the microtexture test results from before and after watercutting while the machine was on site to ensure the process had been effective. The magnitude of the measured microtexture after the watercutting process was always much greater than that measured immediately before the watercutting.

Figure 3.1 Watercutting during the Tai Tapu trials.

4. Site selection

4.1 Introduction

Transit NZ area managers from around New Zealand were contacted to identify suitable sites for the watercutter research trials. Consultants and contractors were requested by the area managers to furnish details of sites that had reduced skid resistance due to polishing of the surface aggregate, from their 2003–2004 resurfacing programmes.

Once a list of possible sites was identified, a site inspection by the principal researcher was carried out to ensure each site had the appropriate attributes (see Section 4.2). The sites were then prioritised on the basis of both suitability and location.

Ten sites on the Transit NZ state highway network throughout New Zealand were selected (their locations are shown in Figure 4.1) based on the following criteria.

4.2 Site attributes

The purpose of the project was to compare the polishing lifecycle of watercut polished surfaces with that of the polishing lifecycle of new surfaces resulting from traditional resurfacing treatments.

Sites with the following attributes were identified from network skid resistance surveys. These sites:

- required resurfacing because of polishing, not excess bitumen
- had minimum lengths of 150 m and 200 m for watercutting and resurfacing, respectively
- had similar surfacing and traffic-induced stresses for both the watercut and the resurfaced lengths
- had accurate traffic data including classification information (where available)
- had known, durable, good quality aggregate on the surface to be watercut
- had good quality surfacing - that would sustain being watercut and last at least another three years
- had a sound pavement.

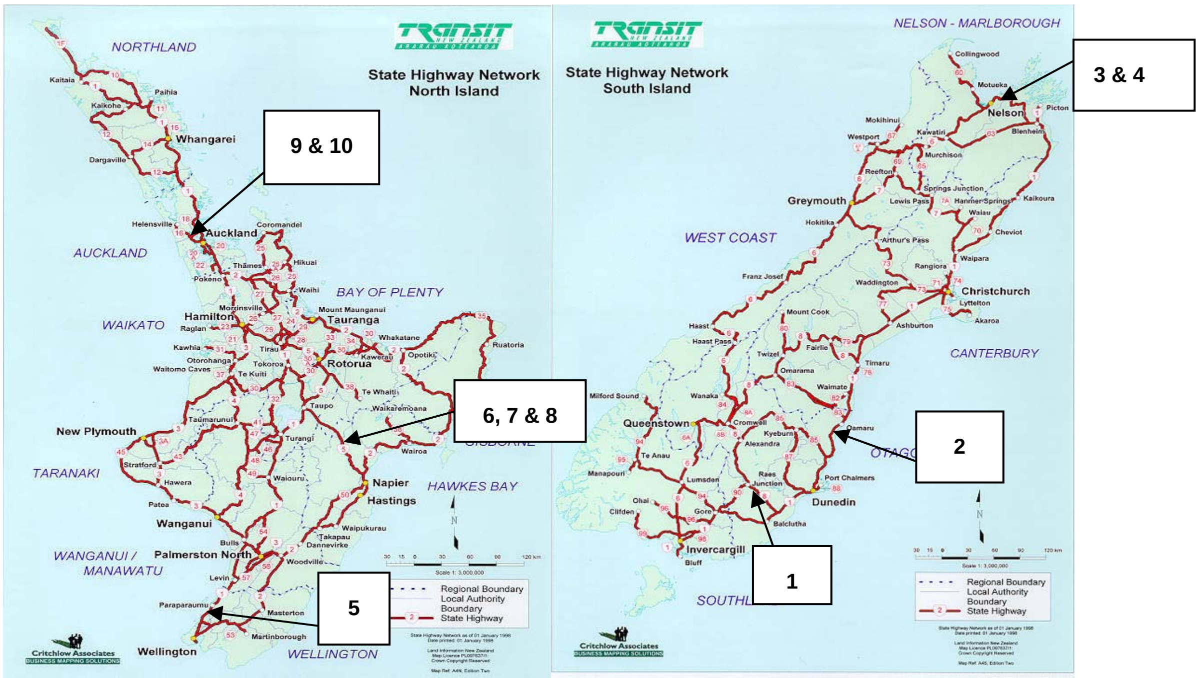

Figure 4.1 North and South Island site location maps.

4.3 Tunnel Hill (Site 1) site description

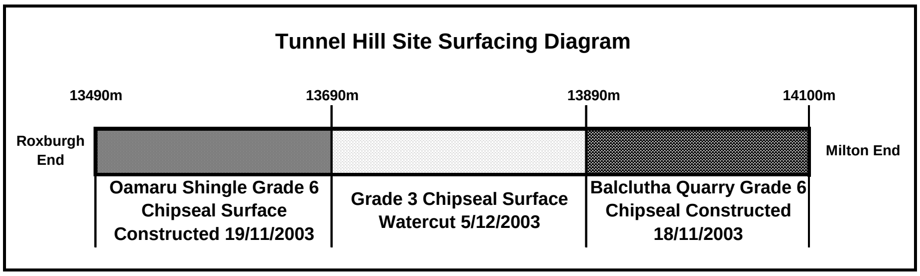

Figure 4.2 Tunnel Hill surfacing diagram.

Figure 4.3 Watercutting at Tunnel Hill.

4.3.1 Location (SH08 RP 401/13.49–14.10)

The Tunnel Hill site is located on State Highway 8 between Milton and Roxburgh in the Otago region of New Zealand; the watercut section was between RP 401/13.65–13.85 with new chipseal at each end.

The site is on the north face on a steep (> 10 %) uphill section with short radius (< 250 m) curves. In the left lane (increasing direction) the site is uphill with a right-hand bend transitioning into a left-hand bend.

4.3.2 Surface description

The existing surfacing on the watercut site was a single coat chip seal using large grade 3 sealing chips (see Table 4.1) from the Fulton Hogan Roxburgh crushing plant. The seal was 12 years old at the time of treatment (it was constructed in October 1991) and had some isolated binder rise in the wheel tracks. The site is not considered an ice gritting area. A small pavement repair located halfway through the watercut section in the right-hand lane was not watercut.

4.3.3 Suitability for project

The chip was well rounded and polished in the wheel tracks due to the traffic stresses on the short radius bends, steep sections, the increased traffic and the length of time in service. The pavement on the watercutting site was sound with only one small digout so waterproofing was not considered an issue. A grade 5 (10 mm) chipseal was constructed at both ends of the watercut section using sealing chips from two different sources. The site had all of the required attributes.

4.3.4 Research overview

This site compared a watercut (4-5/12/03) grade 3 chipseal (sealed October 1991) with two adjacent grade 5 chipseals (see Figure 4.2). One of these used Oamaru Shingle Quarry grade 5 sealing chip (sealed 19/11/03) and the other Balclutha Quarry grade 5 sealing chip (18/11/03).

See Appendix 6 for the Tunnel Hill site data and data analysis.

4.3.5 Treatment selection

The existing surfacing was a grade 3 chipseal constructed in October 1991 using sealing chip sourced from the Roxburgh crushing plant. A recent PSV test was performed on a sample taken from the remnants of chip stockpiles and the result was 56.

The treatment length was programmed for resurfacing because there were numerous 10 m lengths below the investigatory level and some at the threshold level. There had been some minor pavement repairs on some of the bends. There had been two accidents on the site in 2002 but none recorded since then.

As the aggregate on the existing surface was polished it was decided to use Balclutha aggregate, which has a higher PSV of 61 for the chip used on site. The client had a concern regarding the previous performance of the Balclutha sourced sealing chip in a high-stress situation and requested the use of Oamaru Shingle sourced sealing chip, which had the next best PSV (56) in the region, for a performance comparison.

Table 4.1 New Zealand sealing chip grades and sizes.

NZ grade	ALD (mm)	Nominal size (mm)
2	9.5 – 12.0	20
3	7.5 – 10.0	16
4	5.5 – 8.0	12
5	a	10
6	b	7

ALD = Average least dimension (NZS4407: 1991: Test 3.13)

a. Not specified normally by ALD but usually 4.75 – 5.25 mm

b. Not specified normally by ALD but usually 4.00 – 4.50 mm

4.4 Tumai Overbridge (Site 2) site description

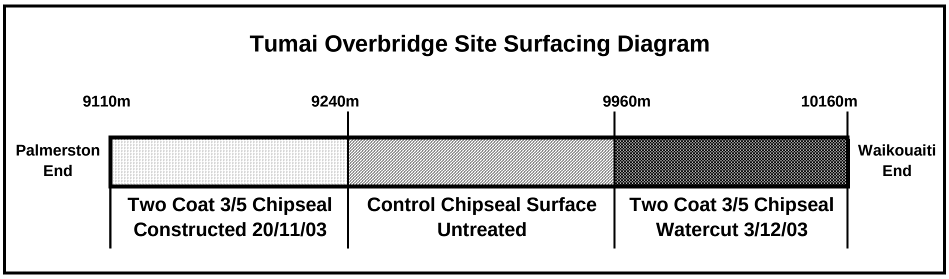

Figure 4.4 Tumai Overbridge surfacing diagram.

4.4.1 Location (SH015 651/8.94-10.25)

The Tumai Overbridge site includes a bridge over the main trunk railway line between Waikouaiti and Palmerston on State Highway 01S in the South Island of New Zealand. The watercut section was between RP 651/10.00–10.25 with a section of new chipseal 1 km north.

The site is on the north face of an uphill section with short radius (< 250 m) bends. In the increasing (RP) direction the site is uphill with a right bend transitioning into a tight left bend across the narrow approaches and the narrow Tumai Overbridge.

Figure 4.5 Griptesting between the wheelpaths at Tumai Overbridge site.

4.4.2 Surface description

The existing surfacing treated by watercutting was a two-coat chipseal constructed 25/11/99 using grades 3 and 5 sealing chips sourced from the Oamaru Shingle Supplies crushing plant. The chipseal surface appeared polished in the wheeltracks on the bends.

There were some areas with binder rise and most of the pavement was in reasonable shape. A section of the right-lane left wheelpath was left uncut where the surface showed evidence of cracking (this was discovered while testing the site). It was not repaired throughout the monitoring period.

The site is not an ice gritting area.

4.4.3 Surfacing

The treatment length was surfaced with a two-coat chip seal using Oamaru Shingle grades 3 and 5 sealing chips in November 1999. The surface friction of the seal was below the threshold level over a short section at the northwestern side of the Tumai Overbridge due to polishing of the aggregate. The left wheel path on the inside of the bend had deteriorated in the two years since the watercutting treatment.

The right-lane pavement on the bend was beginning to fail so only the right wheelpath was treated by watercutting. The section of pavement that was left has not been repaired and has continued to deteriorate.

A new seal was constructed close by the trial site to compare with the watercutting treatment. The seal was constructed on a straight section of road using Oamaru Shingle grades 3 and 5 sealing chips. This seal has shown signs of binder rise in the left lane evidenced by the reduction in texture, but the surface friction on the site remains very good – approximately 0.15 mean summer SCRIM coefficient (MSSC) above the investigatory level.

The control section of untreated chipseal at the south end of the watercutting treatment site had continued to flush and the excess bitumen was removed by watercutting during the monitoring period.

The control section of untreated chipseal north of the watercutting treatment site bled early in the trial causing carryover binder to be deposited on the surface of the freshly treated site.

A realignment project was under construction at the time to straighten the road and avoid future accidents.

4.4.4 Suitability for project

The site was due for realignment in two to three years due to its accident record and the construction was due for completion in 2007. The pavement was generally sound and waterproof. The watercut site could not be split for safety considerations; however, a curve 1 km north which had similar traffic but less traffic stress was programmed for resurfacing. This was included in the monitoring to compare polishing rates. The existing seal adjacent to the north end of the watercut section was performing well and was monitored as a control section.

The site had a history of accidents due to the geometrics and surface. The site had most of the desired attributes so was included in the project.

4.4.5 Research overview

The Tumai Overbridge site compared a watercut (2–3/12/03) 5-year-old grades 3 and 5 chipseal using sealing chip from the Oamaru Shingle Crushing Plant with a new grades 3 and 5 chipseal using Oamaru Shingle Crushing Plant sealing chip (constructed 20/11/03).

See Appendix 7 for the Tumai Overbridge site data and data analysis.

4.4.6 Treatment selection

The site was ideal because it was due for realignment within the next few years. Even if the treatment did not last, the section would become a local road with less traffic and polishing so the microtexture of the surface would increase and not be an issue.

The location of the new chipseal on a lower stress section was not ideal for the research. Even though the traffic would be the same, the polishing stress on such a long radius bend would be much less than that on the watercut section which had a radius of less than 250 m.

The sealing chip chosen for the new chipseal was Oamaru Shingle chip, which performs well on low-stress sites.

4.5 Whangamoa Saddle (Site 3) site description

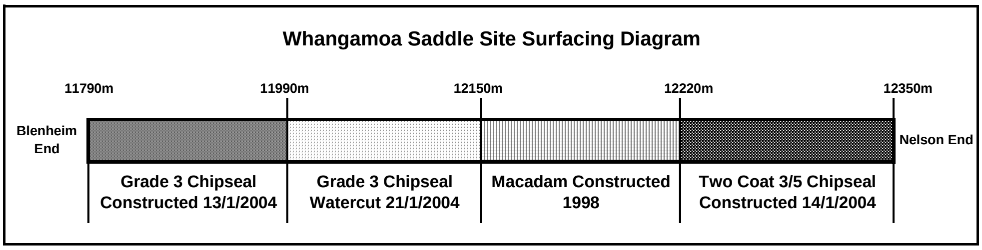

Figure 4.6 Whangamoa Saddle surfacing diagram.

Figure 4.7 Watercutting at Whangamoa Saddle site.

4.5.1 Location (SH06 RP 80/11.46 – 12.44)

The Whangamoa Saddle is located on State Highway 6 between Nelson and Havelock at the northern end of the South Island in New Zealand.

The watercut site was at RP 80/11.99 – 12.14 and was part of a resurfacing site in the 2003/2004 resurfacing programme on the Nelson side of the Whangamoa Saddle.

The site includes steep (> 10%) inclines and short radius curves (< 250 m) with reasonable shape and steep cross-falls on the bends. It is on the south face so is very shaded, damp and is normally ice gritted throughout winter.

4.5.2 Surface description

The existing surfacing was a two-coat chipseal constructed in December 1998 using grades 3 and 5 sealing chips sourced from the Fulton Hogan Appleby Crushing Plant. There was some binder rise and obvious polishing and rounding of aggregates in the wheeltracks.

The stress on the tightest bends on this section of highway had proven too great for traditional treatments so some sections had been resurfaced with a thin asphaltic surfacing designed to withstand the traffic stress and provide appropriate macrotexture and microtexture.

The new surfacing either side of the site was grade 3 chipseal using sealing chips sourced from the Bartlett's Road Quarry and applied on a moderate bend at the Blenheim end of the site. A two-coat grades 3 and 5 chipseal using chips sourced from the Bartlett's Road Quarry was applied on a tight radius bend at the Nelson end of the site.

4.5.3 Suitability for project

The watercut site had polishing in the wheeltracks and a high accident record. New chipseals were programmed at each end in similar environments to compare the polishing rates.

The site fulfilled all of the requirements for inclusion in the project.

4.5.4 Whangamoa Saddle site overview

The Whangamoa Saddle site compared watercut (21/1/04) 5-year-old chipseal constructed with Appleby Quarry grade 3 and grades 3 and 5 sealing chips, with grade 3 and grades 3 and 5 two-coat chipseal constructed 13–14/1/04 using Bartlett's Road Quarry sealing chips. Bartletts Road Quarry has a similar raw material source to the Appleby Quarry. The Macadam, which was manufactured and laid in 1998, used Appleby Quarry sourced aggregate.

See Appendix 8 for the Whangamoa Saddle site data and data analysis.

4.6 Whangamoa Hill (Site 4) site description

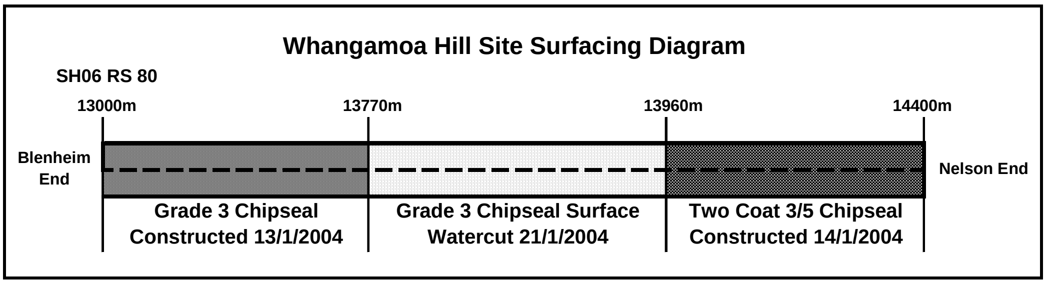

Figure 4.8 Whangamoa Hill surfacing diagram.

4.6.1 Location (SH06 RP 80/12.99 – 14.00)

The Whangamoa Hill Site is located on the Nelson side of the Whangamoa Saddle on State Highway 80 between Nelson and Havelock at the northern end of the South Island of New Zealand. The watercut site was at RP 80/13.74 – 13.93; it was part of a resurfacing site in the 2003/2004 resurfacing programme on the western side of the Whangamoa Saddle.

The site includes steep (> 10%) inclines and short radius curves (< 250 m). Pavement shape was reasonable with steep cross-falls on the bends. A 60 m section in the right-lane left wheeltrack was showing signs of failure so it was not watercut.

The site is on the south face of a hill, so is very shaded, damp and is normally ice gritted throughout winter.

4.6.2 Surface description

The existing surfacing was a polished single-coat chipseal constructed December 1997 using grade 3 sealing chips sourced from the Fulton Hogan Appleby Crushing Plant. There was some binder rise and obvious polishing in the wheeltracks. The stress on the tight bends had proved too great for chipseal and some very high-stress bends had been surfaced with a thin asphaltic surfacing.

The Havelock end of the site was resurfaced with a single-coat grade 3 chipseal using chips sourced from the Bartlett's Road Quarry and the Nelson end was resurfaced with a two-coat grades 3 and 5 seal using chips sourced from the Bartlett's Road Quarry.

4.6.3 Suitability for project

The site was polished, with a high accident frequency, and had new chipseal and Macadam surfaces applied in similar environments to compare with the watercutting. The site fulfilled all the requirements so was included in the project.

4.6.4 Whangamoa Hill overview

The Whangamoa Hill site compared watercut 5-year-old grade 3 and grades 3 and 5 two-coat chipseal constructed with Appleby Quarry chips, with grade 3 and grades 3 and 5 two-coat chipseal constructed 13–14/1/04 using sealing chips sourced from the Bartlett's Road Quarry. The Bartlett's Road Quarry has a similar rock source to the Appleby Quarry.

The site is on the south face of a hill, so is very shaded, damp and is normally ice gritted throughout winter.

See Appendix 9 for the Whangamoa Hill site data and data analysis.

4.7 Mackays Crossing (Site 5) site description

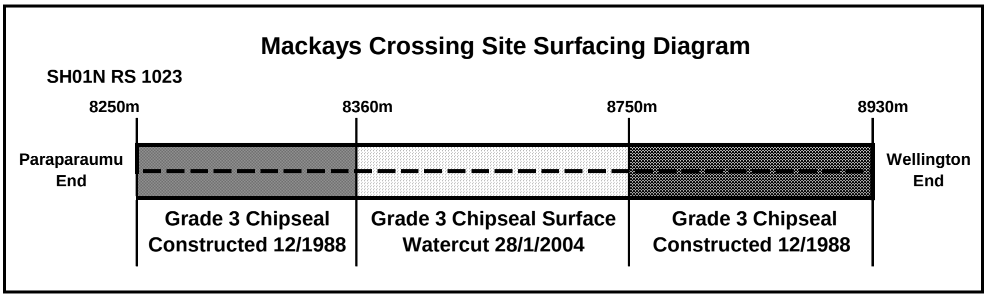

Figure 4.9 Mackays Crossing surfacing diagram.

4.7.1 Location (SH10N 1023/8.36 – 8.75)

The site is located south of the railway crossing at MacKays Crossing on State Highway 01N between Wellington and Paraparaumu at the southern end of the North Island of New Zealand.

The site is shaded during winter and is a high-speed bend to the right travelling south in the increasing direction. The site is a single bend located between two reasonably long straight sections of highway.

Figure 4.10 Mackays Crossing site looking north.

4.7.2 Surface description

The existing surfacing was a single coat chipseal (sealed in 1988) using grade 3 sealing chips sourced from the Winstone's Otaki River Crushing Plant. The chips had polished due to high traffic over an extended period and significant rounding of the chips was evident. The polishing could be easily identified by both visual and manual examination.

The pavement was in reasonable condition with no visible signs of failure apart from some minor flushing.

4.7.3 Suitability for project

The pavement appeared sound and waterproof. The polished aggregate particles were significantly rounded, so this site would be an important indicator of the effectiveness of microtexture restoration.

There were no other resurfacing sites programmed close to this site; however, the chipseal extended into the straights and the SCRIM surveys showed it met most of the requirements.

The site was included in the project without meeting all of the project requirements because we wanted to include a chipsealed site that had very high traffic counts and an older chipseal.

4.7.4 Mackays Crossing overview

This site compared the polishing of a watercut (28/1/04) worn old (sealed December 1988) grade 3 chipseal constructed using sealing chips sourced from the Otaki River Crushing Plant, with the previous and current rates of polishing on the site. The watercut section had both straights and bends to compare with the untreated straight sections of the same seal. The existing chipseal surface was very worn, well rounded and polished.

See Appendix 10 for the Mackays Crossing site data and data analysis.

4.8 Turangakumu Hill (Site 6) site description

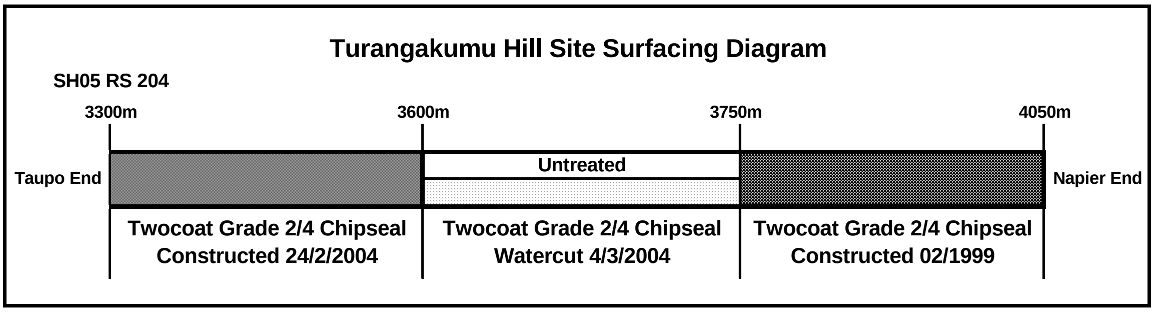

Figure 4.11 Turangakumu Hill surfacing diagram.

4.8.1 Location (SH05 204/3.60 – 3.75)

The Turangakumu Hill site is located on State Highway 05 between Napier and Taupo in the east of the North Island of New Zealand.

Chipsealing was programmed over the length RP 3.45 – 3.75 with a two-coat grades 2 and 4 chipseal using chips sourced from the Poplar Lane Quarry. The watercut section was in the downhill lane on the western side of Turangakumu Hill on a right-hand bend located at 204/3.60-3.75. New chipseal was constructed on the rest of the site from RP 3.45 – 3.60.

The site location is sunny with minimal ice gritting required during winter. There was some polishing on the site.

4.8.2 Surface description

The pavement appeared sound, the existing surfacing was a 4-year-old two-coat chipseal (sealed February 1999) using grades 2 and 4 sealing chips sourced from Winstone's Whitehall Quarry in the Waikato region.

The site had been waterblasted in previous seasons to remove the excess binder on the skid deficient lengths but these still continued to fail SCRIM on subsequent surveys.

The aggregate polishing was easily identified by visual and manual examination as there was significant rounding and a smooth feel to the chips in the wheeltracks when compared with the chips on the shoulders.

4.8.3 Suitability for project

The site fulfilled most of the requirements for the project and even though it was a little shorter than the optimum it was included in the project.

4.8.4 Turangakumu Hill site overview

This compared the polishing of watercut (3–4/3/04) polished two-coat grades 2 and 4 chipseal (sealed February 1999) constructed using Whitehall Quarry sealing chips with an untreated length of the same seal and a two-coat grades 2 and 4 chipseal constructed (24–25/2/04) using sealing chips with a higher PSV sourced from Poplar Lane Quarry. The watercutting treatment was carried out on the left lane only.

See Appendix 11 for the Turangakumu Hill site data and data analysis.

4.9 Wishing Well (Site 7) site description

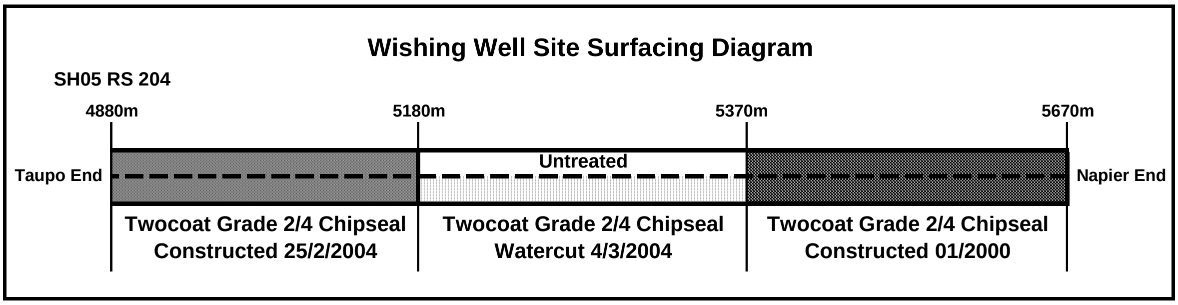

Figure 4.12 Wishing Well site surfacing diagram.

4.9.1 Location SH05 204/4.83 – 5.38D (total site)

The Wishing Well site is located on State Highway 05 between Napier and Taupo in the east of the North Island of New Zealand.

A two-coat chipseal using grades 2 and 4 sealing chips sourced from Poplar Lane Quarry was programmed for the whole seal RP 204/4.83 to 204/5.38. The watercut section was located in the middle of this site in the right lane from the tangent point near the 75 km/h sign at RP

204/5.18 to 204/5.38. The site had a relatively high accident frequency rate. There was an estimated route position (ERP) at 204/5.06 in the middle of the chip-sealing site.

The site is on a sweeping downhill curve leading into a cutting, which has acceptable shape. It is reasonably open, partly shaded at the cutting by trees and is regularly ice gritted during winter.

Figure 4.13 Watercutting on Wishing Well site facing southwest.

4.9.2 Surface description

The existing surfacing was constructed in January 2000. It was a single-coat grade 2 chipseal and the sealing chips were sourced from Winstones Whitehall Quarry in the Waikato region.

The seal had some early chip loss and was fog coated with emulsion soon after sealing. The site had binder rise that was removed by waterblasting after the site was identified by the annual SCRIM survey as having low skid resistance but areas on the site still had low skid resistance on subsequent surveys. There were signs of polishing in the wheeltracks with the surface of the aggregate rounded off with a smooth feel compared with the aggregate surface on the shoulders.

4.9.3 Suitability for project

The site was suitable for the project, as the pavement shape was good with no signs of waterproofing problems. The site would have a new seal constructed after the watercut section limiting the risk of bitumen carryover. There were some areas of binder rise at the Napier end of the watercut section. The site fulfilled most of the requirements for inclusion in the project.

4.9.4 Wishing Well site overview

This site compared the polishing of watercut (3–4/3/04) 4-year-old single coat grade 2 chipseal constructed January 2000 using Whitehall Quarry sealing chips, with a two-coat grades 2 and 4 chipseal constructed (24–25/2/04) using sealing chip sourced from Poplar Lane Quarry. An untreated section of the January 2000 chipseal on a straight section of highway was monitored as a control.

See Appendix 12 for the Wishing Well site data and data analysis.

4.10 Poppellwells Road (Site 8) site description

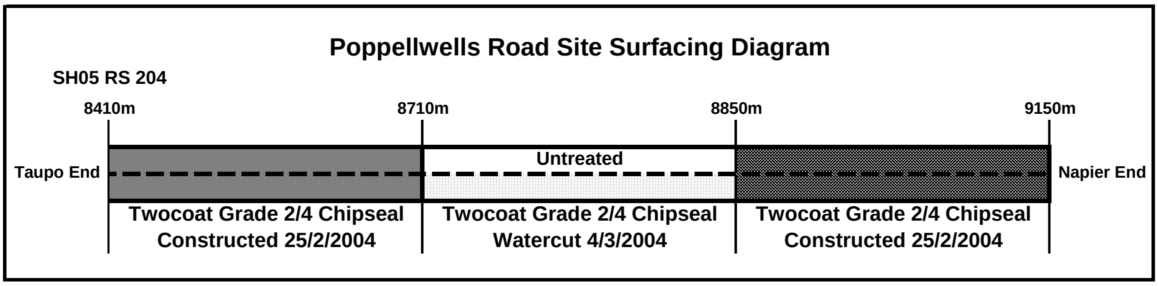

Figure 4.13 Poppellwells Road surfacing diagram.

4.10.1 Location (SH05 204/8.30 – 9.26D (Total site length)

The Poppellwells Road site is located on State Highway 05 between Napier and Taupo in the east of the North Island of New Zealand.

The site is located on an S-bend where the outside lanes of the first (right-hand), second (left-hand) and third (right-hand) bends were identified during the annual SCRIM survey as having skid resistance below the threshold level. The watercutting section chosen was the right lane decreasing on the first right-hand bend from the tangent point near the ERP 204/8.69 from RP 204/8.71 to the seal join at RP 204/8.86.

Both right-hand bends have similar shape and stresses. The bends have radii < 250 m with reasonable cross fall. There is some shading and the site is occasionally ice gritted during winter.

Figure 4.14 Popplewells Road site 17 months after treatment.

4.10.2 Surface description

The existing seal constructed in February 1998 was a coarse textured two-coat chipseal using grades 2 and 4 sealing chips sourced from Winstone's Whitehall Quarry in the Waikato Region. It had good texture throughout but there were signs of flushing and polishing in the wheeltracks. The new seal was a two-coat seal using grades 2 and 4 sealing chips from Poplar Lane Quarry, which had a reported PSV of 59 in 2004.

4.10.3 Suitability for project

The site was considered suitable for the project because it would include a watercut two-coat grades 2 and 4 chipseal between two new two-coat grades 2 and 4 chipseal using different PSV aggregate sourced from the Poplar Lane Quarry in the Bay of Plenty.

4.10.4 Poppellwells Road site overview

This site compared the polishing of watercut (3–4/3/04) polished two-coat grades 2 and 4 chipseal constructed in February 1998 using Whitehall Quarry sealing chips, with a two-coat grades 2 and 4 chipseal constructed (24–25/2/04) at each end of the watercut section using sealing chips sourced from Poplar Lane Quarry.

See Appendix 13 for the Poppellwells Road site data and data analysis.

4.11 Rosebank Road off ramp westbound (Site 9) site description

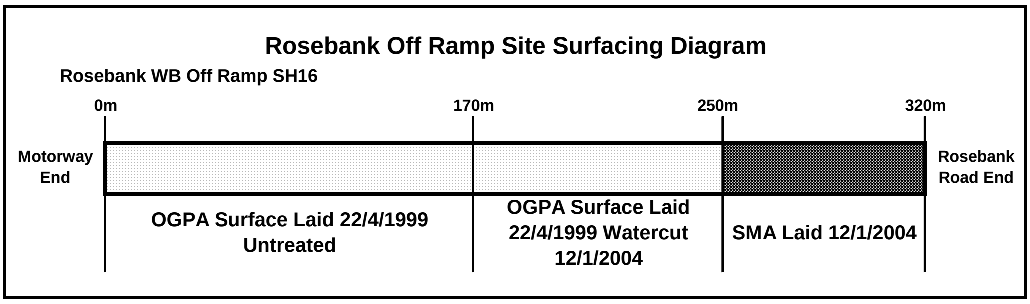

Figure 4.15 Rosebank Road off ramp westbound surfacing diagram.

4.11.1 Location (SH16/0.14 – 0.38)

The site is located on a 300 m off ramp from the State Highway 16 (SH16) motorway. SH16 is located in the Auckland region at the north of the North Island of New Zealand.

The watercut section RP 0.14 – 0.30 started at the concrete bridge joint and finished at the end of the off ramp. The last 80 m from RP 0.30 – 0.38 was resurfaced with 10 mm stone mastic asphalt (SMA).

4.11.2 Surface description

This site was surfaced with 25 mm of open graded porous asphalt (OGPA) in 1999. Some of the mix was starting to show early signs of ravelling with the occasional stone missing from the surface. This was most prevalent from the end of the bridge to the end of the off ramp. The surface had good exposed aggregate and its appearance was more like macadam than that of OGPA.

The new surfacing to be used on half the site was a 10 mm SMA containing coarse aggregate with a PSV greater than 64.

Figure 4.16 Laying SMA on Rosebank site.

4.11.3 Suitability for project

The good aggregate exposure at the surface and stable appearance of the existing mix suggested it should remain undamaged by the watercutting process and last for two or more years.

New surfacing downstream (traffic-wise) from the watercutting meant there should be no wheel tracking of bitumen onto the watercut surface.

The general unsuitability and risks of milling and replacing mix on the bridge deck made watercutting a more suitable treatment than milling and replacing mix.

This was a useful trial site, as extension of the life by a year would deliver an increase of 25% in the life of the existing surfacing. It was the only site that included measuring the effect of watercutting on an open-graded mix.

4.11.4 Rosebank off ramp site overview

This site compared the polishing of a watercut (12–13/1/04) polished OGPA with a SMA surface paved (12–13/1/04) using SMA 11 mm manufactured from a blend of Motouhora Quarry and Reliable Way Quarry aggregate.

See Appendix 14 for the Rosebank off ramp site data and data analysis.

4.12 Te Atatu off ramp eastbound (Site 10) site description

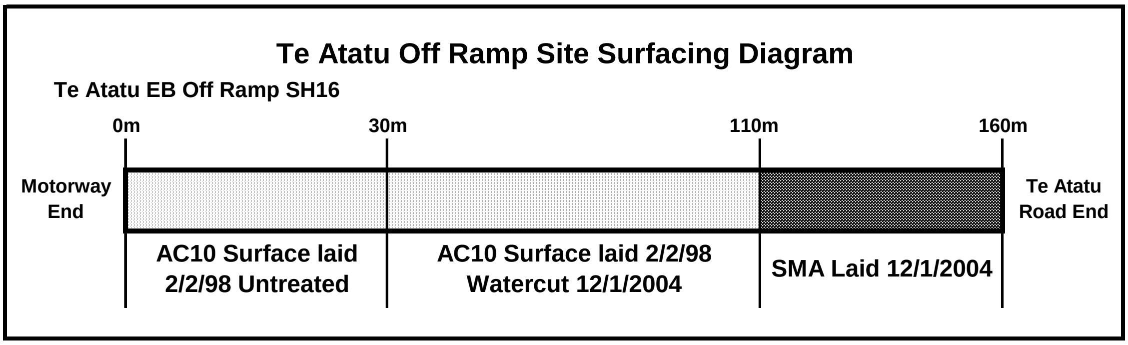

Figure 4.17 Te Atatu off ramp east bound surfacing diagram.

4.12.1 Location SH16 0.00-0.17 (total site)

The site is located on a 170 m off ramp from the State Highway 16 (SH16) motorway. SH16 is located in the Auckland region at the north of the North Island of New Zealand.

The site includes the whole off ramp with watercutting taking place on the first 85 m from RP 0.00 to 0.09 and SMA 10 mm from RP 0.09 to 0.17.

Figure 4.18 Watercutting on Te Atatu off ramp.

4.12.2 Surface description

This site was surfaced with 30 mm of asphaltic concrete 10 mm (AC10 mm) in 1998. The surface had good aggregate exposure with the fines being worn away by the action of the traffic.

One half of the existing AC10 mm was to be watercut and 10 mm SMA containing coarse aggregate with a PSV greater than 61 new surfacing was to replace the AC10 mm on the other half of the site from 220 m to 300 m.

4.12.3 Suitability for project

The good aggregate exposure at the surface and stable appearance of the existing mix suggested it should remain undamaged by the watercutting process and last for two or more years.

New surfacing downstream (traffic-wise) from the watercutting meant there should be little carryover of bitumen onto the watercut surface.

The site was judged a suitable trial site. If the watercutting extended its life by a year or more this would increase the life of the existing surfacing by at least 20%.

This was the only site where the effect of watercutting on an asphaltic concrete surfacing would be evaluated.

4.12.4 Te Atatu off ramp site overview

This site compared the polishing of a watercut (12–13/01/04) 10 mm asphaltic concrete (AC) with a SMA surface paved (12–13/1/04) using SMA 11 mm manufactured with a blend of Moutohora Quarry and Reliable Way Quarry aggregate.

See Appendix 15 for the Te Atatu off ramp site data and data analysis.

5. Site microtexture and macrotexture measurement

5.1 Introduction

The reason for resurfacing on all of the test sites was that the original chip had become polished and all the sites contained lengths that had failed to meet the TNZ T/10 microtexture requirements. An aggregate with a higher PSV was used in the resurfacing on all sites where resurfacing was completed.

The aim of the project was to compare the rate of loss of microtexture on the watercut surface with the rate of loss of microtexture on the new surfacing constructed at the same time as the surface was watercut.

Data from the GripTester and SCRIM+ machine from before and after resurfacing were collected to measure the changes in the microtexture on the surfaces during the 24-month monitoring period.

Macrotexture data from the SCRIM+, minitexture meter (MTM) and sand circles from before and after resurfacing were collected to measure the changes in macrotexture on the surfaces during the 24-month monitoring period.

5.2 Microtexture measurement

The GripTester was used to measure the skid resistance of each site including the watercut section, older surfaces and the resurfaced sections where appropriate. The test lengths were varied to suit the site to include a representative length of each surface type. To ensure some continuity, a further 200 m was measured at each end of the trial site as a control.

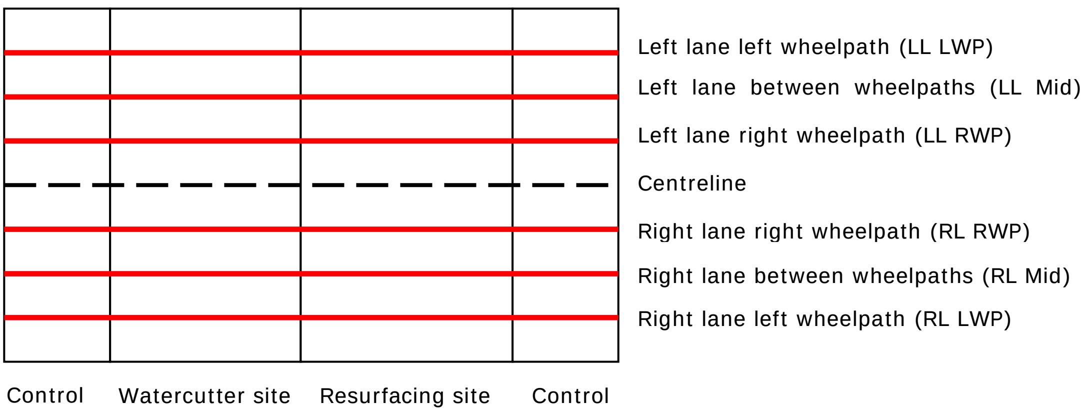

Figure 5.1 Preferred trial site layout.

Microtexture was measured:

- after the resurfacing, and before and after watercutting was carried out on site
- in each wheelpath and between the wheelpaths
- winter – June/July/August
- summer – December/January/February.

Additional measurements recorded while measuring microtexture were:

- temperature of wet and dry pavement surface immediately before and after each run
- air temperature before and after each run
- GripTester tyre temperature before and after each run
- macrotexture using the minitexture meter and sand circles.

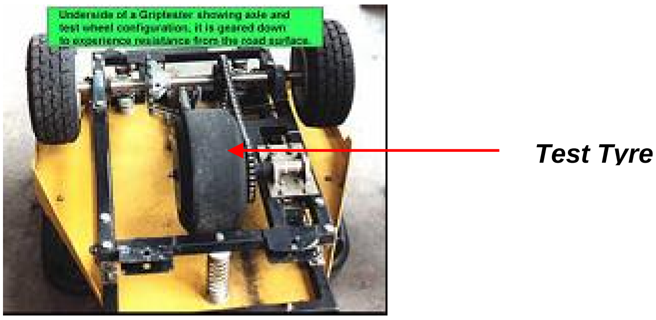

Figure 5.2 Underside of GripTester showing test tyre.

The temperatures were measured for future reference as current research investigating the variation of friction test results suggested that temperature variation contributed to this. However, temperature correction coefficients have still not been established.

5.3 Data gathering process

The main aims of this project were to:

- identify microtexture deficient sites with a range of surfacing types and aggregates
- watercut a section to rejuvenate the surface
- compare the rate of loss of the microtexture improvement to the rate of loss of microtexture of the adjacent new surfaces constructed at the same time.

The trial procedure involved identifying sites on the 2003/2004 state highway resurfacing programme that were being resurfaced on account of insufficient skid resistance as a result of polishing. A representative portion of each site was then selected for watercutting rather than the traditional resurfacing treatments. On most sites the watercut section was adjacent to new surfacing constructed either just before or at the same time as the watercutting treatment was carried out. The sites monitored for skid resistance change included, where possible, a section of older surfacing retained as a control, a new resurfaced section and the watercut section.

To ensure that disturbance of the watercut sites was minimised and to facilitate data collection, the watercutting was carried out at least a week after the adjacent resurfacing. Aggregate samples from the new resurfacings were collected and tested.

The GripTester was used to measure the skid resistance of each site both before and after watercutting. Sand circle tests and the MTM were also used to measure the surface texture before and after watercutting.

SCRIM+ data was sourced from the Transit NZ RAMM database for each of the test sites from surveys carried out before and after the watercutting treatment. The data from these surveys included:

- surface friction data (MSSC) for each wheelpath
- surface texture data (mean profile depth mm (MPD) for each wheelpath and between the wheelpaths
- reduced value calculations (MSSC) for each wheelpath (a measure of the site surface friction compliance with the T/10 specification).

5.4 Griptesting

The GripTester was calibrated according to the manufacturer's instructions before testing was undertaken daily on each test site.

Griptesting was carried out on the site immediately before and immediately after watercutting of the polished surface, then at intervals of approximately six months for two years from the time of watercutting. A minimum of two runs per test line (see Figure 5.1) was carried out to check consistency and repeatability, and these were averaged if considered acceptable. If there were significant variations caused by line deviation, further test runs were carried out until the variation in the surveys was considered acceptable. There was no consistent increase or decrease between surveys that could have been explained by surface washing or rubber contamination from previous runs. The general absence of these phenomena in the testing could be easily explained as the test runs were not a perfect overlap.

Testing only took place if the road was sufficiently dry to ensure that the water film was applied at a constant 0.5 mm film thickness.

A shadow vehicle was used to protect the GripTester with the shadow vehicle driver also monitoring the line driven. The driver towing the GripTester would follow the wheelpaths that the majority of vehicles were taking through the bends and on the straight. The GripTester was set on either the left, centre or right tow ball of the towing vehicle to ensure the measurements were taken safely and accurately in and between the wheelpaths.

Identifying the well-trafficked wheelpaths was relatively simple as the area between the wheelpaths was defined by a coarser texture that was easily visible when driving at 50 km/h. On some sites the new seals were less than a week old but the area between the wheelpaths had gained a visibly different texture in this time.

'Left lane' is used to define the left lane when driving in an increasing direction in relation to the route position markers.

Measurements of the pavement and test tyre temperatures were taken after each test run. As part of the quality plan for this project, griptesting was also carried out on SCRIM calibration sites in the local area remote from the site to act as a control and to further verify the correlation between the GripTester and the SCRIM+ machine.

5.5 Microtexture data

The site surface friction was measured using data from the GripTester for:

- the complete site of the left wheelpath, right wheelpath, and between the wheelpaths from the 'before' and 'after' watercutting
- monitoring testing of the complete site at six-monthly intervals after the watercutting treatment of the left wheelpath, right wheelpath, and between the wheelpaths.

and data from the SCRIM+ annual network surveys for:

- the length of the site of the left wheelpath and right wheelpath from surveys carried out in the 12 to 24 months before the resurfacing treatments and each survey carried out after the resurfacing treatments.

5.5.1 Transverse variation

Griptesting in the three positions across the road showed that there was a difference in the friction measured in the wheeltracks compared with the less trafficked line in between, especially where the traffic was driving a consistent line. It was noticeably more difficult to identify the most used driving line on bends.

GripTester results for the line between the wheelpaths showed that there was significant transverse variation of measured surface friction across the lane (ranging from 0% up to 50%). Deviations from the wheelpath line into the area between the wheelpaths or outside the wheelpath would cause higher surface friction values than would be recorded for the wheelpaths.

Much care was taken by the driver towing the GripTester and the test team to avoid deviations from the chosen line. The driver of the pilot vehicle and the computer operator monitored the line being tested using a television camera focused backwards on the GripTester and a screen in the cab of the towing vehicle. Any test runs that had significant deviations into or out of the wheelpaths were repeated. The damp lines left behind after each test gave the driver an indication for the next run.

Comparisons between GripTester results and SCRIM+ results suggested that a possible reason for some of the anomalies in the SCRIM+ surveys from year to year were due to the different line tested by SCRIM+ from the more trafficked and polished wheeltrack tested by the GripTester in areas with tortuous alignments. The SCRIM+ is commissioned to follow the natural driveline; however, the SCRIM+ is contractually not allowed to cross the edgeline and centreline. This means that the SCRIM+ cannot follow the natural driveline through some alignments where the general traffic is cutting the corners. There could be potentially serious consequences from the SCRIM not measuring the polished wheeltracks, as the reported results could appear to be higher than the site investigatory level requirements, when in fact the results were lower (ie, actual skid resistance was lower than reported).

The significant transverse variation in surface friction measured with the GripTester indicated that there might be significant differential skid hazards on the network that were not being identified by the SCRIM+ as it was only measuring the wheelpaths.

5.5.2 Microtexture data format

Data was compared using the average surface friction for each of treatment lengths. The justification for this was the variations observed between test runs from each 10 m average result and the transverse variations.

GripTester data was reported as a gripnumber for each 10 m length of site tested. Gripnumbers were then averaged for the watercut sections, new surfacing sections and control sections as appropriate to the site.

SCRIM+ data was sourced from the annual network survey for each of the sites from before and after the treatment. MSSC data for each 10 m length of a site was averaged for each of the treatment lengths.

Reduced values from the SCRIM+ surveys, which compared the surface friction result with the required level of friction, were collated. The network manager used these reduced values to identify and prioritise resurfacing work, so they were a real measure of the performance of the watercutting treatment and other treatment lengths on the test sites. The reduced values used in this analysis were based on the MSSC values compared with the required investigatory level value for each 10 m section based on TNZ T/10. The network consultant could vary the investigatory level value for each 10 m section, as it was their responsibility to assign the optimum investigatory level values based on all characteristics of the site for their network.

Reduced values based on the equilibrium SCRIM coefficient (ESC) (calculated by averaging the annual surveys) were not used because comparisons were being made between data from the annual surveys.

5.5.3 Data correction

5.5.3.1 Location

Locating each measurement taken to the correct section of road that it applies to is reasonably straightforward when testing small sections of state highway, as is relating it to the route station (RS) and route position (RP and ERP) markers if the markers are accurate and within the site. The error in the location for the start and end of each section and surfacing joint is less than 10 m. This means the GripTester data for the 10 m lengths at the start and finish of the treatment lengths may be skewed with data from the adjacent surfacings.

The SCRIM+ data is taken from a network survey that is referenced to the RS and interpolated for each 10 m length. This works very well on straight sections of highway but in tortuous alignments becomes more difficult as it depends on the SCRIM+ machine driving exactly the same line each year.

For this project, extracted data from SCRIM+ surveys was shifted to align changes in surfacing with those measured in adjacent years as the RPs of these changes had varied from year to year. This was done to ensure that the data for the surface condition of each of the surfacings was compared with data for the same length.

5.5.3.2 Season corrections

Seasonal corrections were developed to change the measured SCRIM+ surface friction data to a MSSC to enable a direct comparison of the state of the network. The corrected (MSSC) data was used in this analysis for surface friction and reduced value comparisons.

MSSC data was used rather than the ESC data as the averaging of results for the surfaces that had been resurfaced would disguise the change.

Seasonal corrections were not developed or applied for GripTester data for these sites, as they were mostly located in areas with climate and stress factors likely to affect the surface as much as the weather pattern experienced at test time.

5.5.3.3 Diurnal surface and test tyre temperature variations

The air and surface temperatures varied considerably during the monitoring as testing was carried out in the early morning, afternoon and night, during both mid-winter and mid-summer. The temperatures of the road surface and GripTester tyre were measured at the end of each test run. The minimum surface temperature measured while testing was –2.0°C and the minimum test tyre temperature was 12.0°C measured at the same time. The maximum surface temperature measured while testing was 36.0°C and the maximum tyre temperature measured at the same time was 23.0°C representing a spread of 38°C in air temperature compared with an 11.0°C spread in tyre temperature.

The temperature of the water dispensed during testing immediately in front of the test tyre moderated the effect of the road surface temperature on the test tyre temperature. This was evidenced by the lack of a straight-line relationship between test tyre temperature and road surface temperature. The temperature of the water was not measured or controlled.

There were some significant variations in the surface friction measured on the surfaces adjacent to the watercut sections when comparing the before and after data. In general this data was collected early morning (before) and late afternoon (after).

The comparison of the change in surface friction with the change in the tyre temperature and the road surface temperature is shown in the graphs in Appendix 16. There was no significant relationship between the change in the measured surface friction and the road temperature during the testing and likewise between the measured surface friction and the test tyre temperature. The control surfaces were the untreated surfaces adjacent to the watercut sections.

5.6 Macrotexture measurement

Sand circles and MTM testing were carried out before and after watercutting on each site. Sand circle measurements were made in the wheeltracks and between the wheeltracks typically every 20 m on the test site and for the first 40 m onto the adjacent surfacing at each end of the watercut trial section.

A MTM was used to measure the macrotexture of the site before and after watercutting. The MTM was pushed at constant speed (achieved using an additional speedometer accurate at low speed as the device was speed sensitive) in the direction of traffic flow.

The MTM was calibrated each day before testing according to the manufacturer's instructions. After review of the initial repeat testing, it was decided that single tests on each path provided sufficiently representative results and also reduced the time of lane closure required for measurements. Testing was carried out on the watercut section and 20–30 m of the adjacent treatment lengths at each end before watercutting, after watercutting and at intervals of approximately six months afterwards. The results were reported as averages for the watercut section and the adjacent surfaces for each trial site.

The MTM encountered problems associated with the measurement of the texture depth of some of the surfaces during the initial testing. The coarseness, roughness, the presence of loose chips (new seals) and the subsequent mastic rich surface of the new SMA all resulted in high levels of 'dropouts' (lost pulses from the texture laser) during testing.

Testing shaded sites during the winter months with the MTM also proved difficult, as the road surface did not always dry out sufficiently for testing and some dropouts in data measurement occurred. The winter 2004 measurements on the Whangamoa Hill and Saddle sites were affected in this way with no data at all recorded on the Whangamoa Saddle site and no data recorded for the adjacent surfaces on the Whangamoa Hill site.

Sand circles were measured on all sites as a backup for the MTM with consistent results between the two test methods. Where there was a relatively large increase in texture depth (Td) from the sand circles, the MTM data showed a relatively large increase in sensor measured texture depth (SMTD). There has been no attempt to establish a correlation between the two measurements, despite the fact the line measured with the MTM ran through the areas tested with the sand circles.

SCRIM+ macrotexture data for the site and adjacent lengths of the state highway was collected. The SCRIM+ surveys are carried out on an annual cycle testing the entire state highway network. The macrotexture data is recorded as an average for each 10 m length in mean profile depth millimetres (MPD mm) in the outer wheelpath (OWP), between the wheelpaths (BWP) and inner wheelpath (IWP) for each lane.

Minor errors can occur at the start and end of test section data when the ends of the 10 m lengths measured by the SCRIM+ do not coincide with the starts and finishes of the surfacing treatments.

5.7 Calibration

The GripTester and MTM were calibrated according to the manufacturer's instructions.

Further checks on the GripTester were carried out by griptesting the SCRIM+ seasonal correction sites located close to the project test sites. The calibration testing was normally carried out between the before and after testing during initial work and either before or after monitoring testing.

Sand circling was carried out by the same operator to ensure consistency of results from site to site.

6. Analysis and interpretation

6.1 Test conditions – variation of control section surface friction

On most of the test sites the test conditions for the before and after griptesting varied significantly. The before testing (griptesting of the complete site including the control section, the new resurfaced section and the test section **before** it was watercut) was normally carried out in the early morning with the after testing (griptesting of the complete site including the control section, the new resurfaced section and the test section **after** it was watercut) in the late afternoon.

It was considered that measuring the surface as soon as the treatment was completed would ensure that the change in surface friction caused by the watercutting was measured before the surface was trafficked. However, this meant that on some sites the conditions of testing changed where the surface was cooler or hotter than that measured before.

It was for this reason that the other sections – control sections and new surfacing sections – were included in the test data. These sections were tested at the same time as the watercut sections. This helped quantify the changes in surface friction caused by the changes in measuring conditions and show that the watercutting treatment did produce significant increases in surface friction greater than those caused by the changes in test conditions.

The variation in test results from one survey to the next is one of the main issues with surface friction testing around the world as the surface condition is continually changing while measurements are being carried out. Each surface friction test can cause a change to the surface condition as water and rubber are deposited on the surface by the test apparatus so subsequent testing is measuring a different surface.

In this project, the inclusion and comparison of data for the other sections as well as the watercut section helped validate the data and show that the surface friction improvement was a real phenomenon.

Some physical changes to the control sections were noted where hot weather caused bitumen exudation ('bleeding') on old seals, binder carryover on all surfaces and chip rollover on some of the new surfacings.

These changes contributed to variations in the surface friction test results for the site control sections, new surfacing sections and the watercut sections.

The variations in measured surface friction were the result of a combination of condition changes with some contributing to an increase and some to a decrease. No attempt was made to calculate a relationship for any of the condition changes, as the contribution of each to the recorded variation in surface friction measured could not be easily established.

The likely contribution of the various changes to the observed variations in the before and after data on the control sections is discussed later in this section.

6.2 Data check

Checks of each data set were made onsite before leaving to ensure the data looked right, and all data was collected. Unfortunately, after the data check for the initial testing for site numbers 6–8 the computer crashed and the test data was found to be irretrievable. A new computer was sourced but during retesting the GripTester failed and it took another six weeks before a replacement machine was available. This caused a delay of eight weeks before the griptesting was completed.

Fortunately (as discussed in Section 1.8) data from a Transit NZ project using a SCRIM+ on State Highway 5 was made available to fill some of the gaps left by this loss of data.

The SCRIM+ SFC data for the treatment length including sites 6–8 was recalculated into gripnumbers using the accepted relationship from TNZ T/10 notes.

$MSSC_{GN} = 0.42GN + 0.2 \Rightarrow GN_{MSSC} = (MSSC - 0.2)/0.42$

The data was then used as the before data for the three sites.

6.3 Monitoring measurement

The intention was to carry out the monitoring testing at six-monthly intervals on all sites in order to have both midsummer and midwinter measurements. However, the length of intervals between testing varied from five to seven months on some sites.

Sand circling and griptesting were completed on all sites. However, the shading on the Whangamoa Saddle site did not allow the surface to dry properly and MTM data could not be obtained in the June 2004 testing.

6.4 Surface contamination

6.4.1 Bitumen

The new seals on the Turangakumu, Wishing Well, Poppellwells Road and the two Whangamoa sites suffered from both chip rollover and chip loss to varying degrees. Visual inspection of the Poppellwells site showed that there was minor tracking of the exposed bitumen onto the watercut surface after it was cut.

Figure 6.1 Bitumen tracking from below Whangamoa Hill site.

Visual inspection of the Whangamoa Hill and Whangamoa Saddle sites showed that there was binder tracking over the site; however, this did not appear to have a significant effect on the results.

The high temperature (>30°C) on the day that the Tumai site was watercut caused the older adjacent seal at the north end of the site to bleed causing some of the excess binder to track onto the watercut section before and after it was watercut; however, the excess binder had been worn off the watercut section by traffic during the six months before the following set of testing.

6.4.2 Stock effluent

The Turangakumu Hill site has a high incidence of contamination by stock effluent on both sides of the road up and downhill. There were signs of fresh contamination on every visit. Testing had to be postponed on one occasion due to the site being covered with stock effluent and while signs of contamination were present on other occasions it did not appear to have had a significant effect on the measurements.

6.4.3 Construction contamination

Pavement repairs had been carried out 'up road' from both the Turangakumu Hill site and the Whangamoa Hill sites. Fine material detritus from the crushed aggregate used in the repairs was tracked over both the watercut and the resealed surfaces of the test sites. Testing was postponed on the Turangakumu site until the pavement repairs were completed to avoid having to test open construction. This contamination did not appear to have had a significant effect on the measurements.

6.4.4 Slip contamination

A number of slips occurred during June 2004 on the Whangamoa Saddle during periods of heavy rainfall. Clay and other fine material from the slip debris were tracked over both the Whangamoa Hill and Whangamoa Saddle sites.

6.5 Test site performance pummaries

6.5.1 Tunnel Hill site performance

6.5.1.1 Comparison of the performance of the watercut length with adjacent surfaces

The reduced value data showed that the watercut section was refreshed by the treatment but 13 months after treatment it had returned to levels similar to those measured 11 months before the treatment. However, the 2006 survey 25 months after treatment showed that the treatment was still performing well.

An extra comparison on the site was the performance of the Balclutha versus the Oamaru chips. Twenty-five months after the seals were constructed the Oamaru surface had some sections below the investigatory level while the Balclutha surface had none.

SCRIM+ microtexture data in the 2004 survey (19/1/2004) showed an increase for all three sections after resurfacing, including the watercut length. The data also showed that the watercut section had retained some of the improvement 25 months after the treatment.

The new chipseal produced a much higher average microtexture than the watercut polished grade 3 chipseal. The Oamaru chipseal surface showed a greater decrease in average microtexture than the Balclutha chipseal surface 25 months after construction. GripTester data showed a measurable improvement immediately after the watercutting treatment on 4 December 2003. Microtexture increased by an average of 0.22 gripnumber (31% improvement). Griptesting results after seven months showed a 6% improvement and after 12 months the site microtexture had returned to pre-treatment levels.

GripTester data for the trial site showed a progressive reduction over the 24 months due to polishing, and the microtexture of the watercut section at the end of the trial was lower than before the treatment. The microtexture reduced progressively on both new chipseals over the two years of monitoring with the average surface friction of the Balclutha chipseal surface slightly higher than that of the Oamaru Shingle chipseal surface.

The SCRIM+ macrotexture data showed an increase for the watercut site in the 2004 survey and a small decrease from this level in the 2005 survey. The 2004 SCRIM survey showed a decrease in texture following chipsealing on both sites using grade 5 sealing chips from two different quarries and a further decrease was measured in the 2005 survey. The 2006 SCRIM+ texture data confirmed that the texture improvement measured on the watercut section had been retained two years after treatment.
The MTM macrotexture data measured showed a small increase in texture depth after watercutting with a trend to decrease over time. The texture increase on the watercut section was mostly retained with further increases in some locations possibly related to the minor chip loss. Testing has shown decreases in the average macrotexture on the new chipseal sections.

The sand circle data for the watercut section showed that most of the texture depth improvement produced by the watercutting treatment had been retained after 24 months. However, the sand circle data for the two grade 5 chipseal sections showed a decrease in the average macrotexture caused by the application of the small grade 5 chip to the coarser grade 3 surface and then a general decrease over the next two years.

The SCRIM+ roughness data showed that in some sections and lanes there had been an increase and in others a decrease. The watercut section showed an improvement in the roughness (decrease) in the left lane (uphill) and an increase in roughness in the right lane (downhill). The opposite occurred in the Oamaru Shingle chipseal section, while the Balclutha chipseal section showed an improvement in both lanes.

6.5.1.2 Tunnel Hill site discussion

The grade 3 chip seal was an old (sealed October 1991) very worn single-coat grade 3 with very rounded edges. The watercutter could not restore sharp edges onto the polished aggregate particles but it did rough up the surface of the stone improving the microtexture and remove detritus from the chipseal surface increasing the macrotexture. There was some minor chip loss between the wheelpaths in the right lane 25 months after watercutting.

This site was chosen because the existing surface was polished. This meant the existing aggregate was predisposed to polish under the traffic loading it was exposed to at the time of measurement. It was, therefore, not unexpected that the surface polished back to pre-treatment microtexture levels after 13 months. Twenty-five months after the watercutting treatment, 95% of the site measured above the microtexture investigatory level.

The small chip (grade 5) chipseals were constructed using freshly crushed chips with the same or higher PSV than the existing (Roxburgh quarry – PSV=56) chip. The higher PSV and numerous sharp edges on these seals have produced a much improved microtexture result.

The microtexture of the site was adequate when compared with the Transit NZ requirements for the site, but TNZ T/10 specifies that all 10 m lengths with a reduced value < 0 should be programmed for repair and any 10 m length with a reduced value < -0.1 has to be treated as soon as possible.

6.5.2 Tumau Overbridge site performance

6.5.2.1 Comparison of watercut length with new and adjacent surfaces

SCRIM+ MSSC reduced value data for the Tumai Overbridge site showed that watercutting had increased the microtexture of the watercut section but 13 months after treatment it had returned to pre-treatment levels. The new chipseal performed well with no lengths below the investigatory level during the monitoring but as it had lower stress than the watercut section it was expected to perform well. The 10 m lengths below the threshold level were part of a 30 m length of the left-lane left wheelpath that was flushing and a section on the right lane that was not treated.

SCRIM+ data collected in January 2004 (two months after treatment) showed an increase of 0.05 MSSC (11%). The 2005 survey, 14 months after treatment, showed that the site surface friction had returned to pre-treatment levels. However, the 2006 survey showed that the average microtexture was still higher than that measured pre-treatment in three out of four wheelpaths.

The increase in microtexture for the new chipsealed surface was much greater (0.13 MSSC) than that shown on the watercut section (0.05 MSSC). However, the chipseal was on a straight unstressed section of state highway with much less polishing than the high-stressed section that was watercut, so this was not a true comparison for the lifecycle of the treatment.

GripTester microtexture data showed an improvement immediately after treatment, increasing by 0.25 gripnumber (37%). The microtexture data six months after treatment still showed a small improvement of 0.07 gripnumber (7%) and after 12 months the microtexture data showed the site had returned to pre-treatment levels. Data collected 18 months and 24 months after treatment showed that the average microtexture was continuing to decline. The untreated section showed increases of 0.09 gripnumber while at the same time the new chipseal showed an increase of 0.13 gripnumber. High ambient temperatures affected both the untreated sections and the new chipseal surfaces at the time of measurement. Bleeding and chip rollover probably affected the surface friction measurements.

The SCRIM+ macrotexture data showed an increase on the watercut section when measured two months after the treatment which then decreased over the next 24 months but still remained higher than that measured before the treatment.

The average texture increase measured by the SCRIM+ eight weeks after sealing was 0.49 mm MPD and seven weeks after watercutting was 0.33 mm MPD. This increase reduced by 0.12 mm for the reseal and 0.17 mm for the watercut section during the next 12 months. The texture average decrease on the untreated section over the same period was 0.11 mm MPD.

MTM data for the watercut section showed an increase immediately after the watercutting treatment followed by a slow decrease over the next 24 months but the macrotexture still remained higher than that measured before the treatment. Difficulties with the MTM meant that we could not measure the surface immediately after watercutting and had to add sand circling to the testing list in case of further problems.

Sand circle testing showed that the watercutting treatment increased the macrotexture of the surface and 24 months afterwards it had still not returned to the levels measured before the treatment.

Roughness data before and after treatment showed that the roughness improved by 9% in the 24 months after watercutting but the control sections showed no change. However, roughness data at 100 m averages for the site measured before 2005 were not accurate enough for comparison with a 200 m long site. The data at 20 m averages for 2005–2006 surveys showed that the average right-lane roughness increased from 83 to 101 NAASRA in the 12 months between surveys.

6.5.2.2 Site discussion

The data collected for the Tumai Overbridge site showed evidence that the watercutting treatment had produced an increase in both the site surface friction and texture. Twelve months after the treatment there were some 10 m lengths below the threshold level and 24 months after treatment this had not changed.

A 60 m length of the right-lane left wheelpath was not treated by watercutting at the time because it was considered too fragile and this section has since failed, as has the right-lane right wheelpath beside it.

The effect of the watercut treatment on this site was adequate but clouded by the binder rise and some binder carryover from the flushed and bleeding seals at either end. While the new chipseal was exposed to the same traffic levels it was not exposed to the same tyre scrub generated by the tight bend on the watercut section. The bridge and guardrail on the site appeared to cause the traffic to run in a more consistent line on the bend, further intensifying the polishing action on the surface of the wheelpaths.

The aggregate in the existing chipseal surface had previously polished on the high-stress sections; this meant the traffic conditions on site were too severe for the aggregate. As expected, watercutting the stone did refresh the microtexture but did not alter the aggregate's ability to withstand polishing and after 12 months of trafficking the watercut treated surface returned to pre-treatment surface friction levels.

The surface still retained some of the texture improvement 24 months after resurfacing.

6.5.3 Whangamoa Saddle site performance

6.5.3.1 Comparison of watercut length with new and adjacent surfaces

The reduced value data showed that the resurfacing and watercutting improved the microtexture for the short term but two years afterwards all the trial sections had lengths below the threshold value and required treatment.

The SCRIM+ microtexture data showed an increase in microtexture after both the watercutting treatment and chipsealing. The watercut section had a smaller increase than the new chipseals but polishing on the site over the subsequent two years after the resurfacing reduced the microtexture on the watercut surface and the new chipseals to levels similar to that measured before resurfacing.

GripTester data showed an increase in microtexture immediately after treatment; however, 12 months later this had reduced to pre-treatment levels and 24 months after the treatment was less than that measured before the treatment.

The 2004 SCRIM+ survey showed an increase in macrotexture had resulted from the resurfacing and watercutting and 24 months later some of the texture improvement had been retained. The increase on the chipseal section was smaller than the macrotexture increase measured on the chipseal sections.

MTM testing showed that the watercutting had increased the macrotexture but after 18 months this had reduced to pre-treatment levels.

Sand circle data showed that the macrotexture on the watercut section increased after treatment and 24 months after watercutting some of this improvement had been retained.

Roughness data showed a big increase in roughness on the watercut section after 24 months and smaller increases for the other sections.

The data also showed an improvement of surface friction for the untreated macadam. The binder wearing off the surface between surveys may have caused this anomaly, or the exposure to the surface of fresh aggregate as the Macadam asphalt surface continued to fail by unravelling.

The Macadam asphalt surface was showing signs of unravelling with the loss of aggregate from the surface probably causing the increase in texture depth.

6.5.3.2 Site discussion

The new chip seals, constructed just before the watercutting treatment, had problems with chip rollover soon after construction due to tyre scrub on the short radius bends during hot weather. This resulted in some chip loss and binder mobilisation along the length of the site. The chipseals were constructed with aggregate sourced from a different quarry than the one that had polished previously; however, as the actual source rock was similar, it polished again.
The left lane of the watercut site showed signs of binder rise leading to areas with low skid resistance.

The results showed that aggregates sourced from both Bartletts and Appleby Quarries and used to construct coarse chipseals were unsuitable for use on such tortuous alignments with the current traffic loadings.

6.5.4 Whangamoa Hill site performance

6.5.4.1 Comparison of watercut length with new and adjacent surfaces

SCRIM+ reduced values for the Whangamoa Hill site showed that two weeks after the watercutting treatment 6% of the right lane was below the intervention level and 0% below the threshold level. Twelve months later it was 0% below the intervention level.

The SCRIM+ reduced values for the left lane showed that two weeks after watercutting 33% was below the intervention level with 0% below the threshold levels, and 12 months later 83% was below the intervention level with 44% below the threshold level.

The new chipseals constructed at the same time adjacent to the watercut section showed similar performance with some sections failing within two years of construction.

The 2004 SCRIM+ survey tested the site two weeks after watercutting and showed an average increase of 0.08 MSSC compared with the 2003 SCRIM+ survey. The 2005 SCRIM+ survey showed a further improvement on the right lane with a rapid deterioration in the left lane, especially in the right wheelpath.

The survey data showed that the new chipseals had a higher initial microtexture but this subsequently reduced leaving some sections of the new seal at levels similar to those measured before the chipseal was constructed.

GripTester data showed that there was a measurable improvement (0.17 gripnumbers) immediately after the watercutting treatment but the surface friction levels returned to pre-treatment levels within 12 months. The data also showed that the microtexture of the new chipseals decreased over the 22 months of monitoring.

The SCRIM+ macrotexture data showed an increase in macrotexture after the watercutting treatment. Subsequent testing showed that in general the average surface texture decreased in the left lane and increased in the right lane but did not return to the texture levels measured before treatment in either lane. The data also showed considerable increases in average macrotexture after construction of the new chipseals, but two years after construction the macrotexture on some sections on the two-coat chipseal had returned to the levels measured before construction.
MTM testing showed that the macrotexture increased after watercutting and 22 months later was still higher than that measured just before treatment.

Sand circle testing showed that the macrotexture increased after watercutting and 22 months later it was still higher than that measured before the treatment.

The roughness data showed that there had been very little change in the roughness on the watercut section with some larger variations on the new chipseal sections.

The SCRIM+ data reported for the right lane might not be accurate as some data was aborted and other reported results in the right wheelpath either side of these aborted readings were not consistent with the other microtexture data.

6.5.4.2 Site discussion

The first 60 m of the left lane of the watercut section had a pavement repair and was surfaced with a two-coat grades 2 and 4 chipseal. The right wheelpath in the area of the repair was identified as flushed and rutting (see Figure 6.2) during the course of the 'before' testing so it had not been watercut as it was likely to fail.

The new grade 3 chipseal lost chip and was fragile during the first summer. The new grades 3 and 5 chipseal had problems with rollover and Figure 6.1 shows the excess bitumen from the surface being tracked towards the watercut section.

The stripped new seal and the untreated flushed section at the start of the watercut site may have contributed to the low microtexture measured.

The data showed that the watercutting treatment improved the microtexture in the right lane and 12 months later the right lane of the site still complied with the requirements. However, the watercutting treatment of the left lane only provided short-term improvement with the performance affected by flushing and bleeding of untreated sections and the failed chipseals.

The chipseals also performed poorly. The surface friction in the left lane of both chipseals returned to pre-treatment levels 12 months after sealing, with more than 70% of the lengths monitored at levels below the threshold level when tested in February 2005.

The chipseals performed better in the right lane with none of the grade 3 chipseal below the threshold level. The section of the two-coat grade 3 and 5 chipseal below the threshold limit could have been caused by errors in the data.

Figure 6.2 Flushed, rutted wheelpath on Whangamoa Hill site.

6.5.5 Mackays Crossing site performance

6.5.5.1 Comparison of watercut length with new and adjacent surfaces

Reduced value data nine months after the watercutting treatment showed a small improvement on the site; however, there were some sections that were still below threshold level and the 2006 data showed similar results. There was some improvement on the site in 2005 when the watercutter was used to remove some excess binder from the surface. The control sections generally continued to deteriorate during the monitoring period.

The SCRIM+ microtexture survey data nine months after watercutting treatment showed there had been some improvement to the microtexture on the watercut section in most locations, but a small decrease in the LL LWP. Generally the microtexture on the untreated sections continued to reduce during the monitoring period.

The GripTester data showed that most of the microtexture improvement had been retained after six months but at 12 months the surface returned to levels measured prior to the site being watercut. The data for the untreated control sections showed trends similar to those measured on the treated section.

The SCRIM+ data showed small increases in average macrotexture in 2004 and 2005 following watercutting. The 2006 survey showed a small decrease in most locations across the road apart from the LL RWP where there was a small increase, which might have been related to some minor chip loss. The macrotexture on the control sections continued to decrease during the monitoring period.

MTM testing showed very little change in the macrotexture on this site after watercutting. Sand circle testing showed that the watercutting produced a small increase in macrotexture in all locations across the road. Subsequent testing indicated that the texture had decreased by the twenty-third month after the watercutting treatment.

6.5.5.2 Site discussion

This site is in the middle of a planned reconstruction project. It is a highly trafficked section of state highway that had already had a number of repairs on the inside of the bend in the right lane where the traffic cut the corner outside the edgeline.

In 2005, just before the SCRIM+ survey there was some flooding at the northern end of the site. The flood detritus may have been carried over and affected the skid resistance of the length of the left lane of the site.

There had been some minor chip loss from the untrafficked areas between the wheelpaths evident in the sand circle texture data; however, the SCRIM+ and MTM texture data did not show this clearly.

Reduced value data showed that there were some 10 m lengths below the threshold level in the watercut site that should be programmed for investigation as soon as possible.

The problem discussed earlier where the SCRIM+ might not test the most trafficked wheelpaths and thus the most polished areas was highlighted on this site where right-lane traffic cut across the edgeline when driving around the bend. This meant that the most polished wheelpaths were probably not being tested for the right lane by the SCRIM+ due to contractual requirements.

The left-lane traffic could not cut the corner as this would require it to cross the centreline. Consequently most traffic was restricted to running between the edgeline and centreline. The well defined and trafficked wheelpaths were measured by the SCRIM+ survey and showed there was polishing on the site.

6.5.6 Turangakumu Hill site performance

6.5.6.1 Comparison of watercut length with new and adjacent surfaces

Reduced value data showed that the surface was worse after watercutting than it was before the treatment. The data showed an improvement on the section where the new seal was constructed; however, 21 months after treatment both the new seal and the watercut section had large portions below the threshold level and required treatment.

The SCRIM+ microtexture survey data did not show an increase after the site was watercut but it did measure an increase on the new chipseal section. The untreated control section showed a decrease during the first year then increases related to pavement repairs and resurfacing. The watercut section and the new chipseal were both below the investigatory level 21 months after their respective treatments.

GripTester data measured an increase in microtexture for the watercut and chipsealed sections after treatment then a steady decrease over time so that 18 months after watercutting the surface was back to pre-treatment levels and 24 months after resealing the right wheelpath of the new seal was back to levels measured before sealing. The untreated section showed a slow decrease over time then an increase, when tested after 18 months, related to the pavement repairs and new surfacings.

The SCRIM+ data showed that the average macrotexture had increased on both the new chipseal and watercut sections after treatment; however, after 21 months both sections had returned to macrotexture levels measured before treatment. The untreated control section continued to decrease in the wheelpaths for the first year of monitoring then showed an increase after the pavement repairs.

MTM data showed that the left wheelpath and between-the-wheelpath texture remained at levels higher than before treatment but the right wheelpath decreased to levels similar to those before the surface was watercut.

Sand circle data showed that the left wheelpath and between-the-wheelpath texture remained at levels higher than before treatment but the right wheelpath decreased to levels similar to those before the surface was watercut.

There was minimal change in the roughness of the site after watercutting.

A new two-coat grades 2 and 4 chipseal was constructed on the untreated section and the untreated left lane adjacent to the watercut section as these were considered a hazard with 50% below the threshold value when tested in the 2005 SCRIM+ survey. These latest new (2005) two-coat grades 2 and 4 chipseals had higher macrotexture and microtexture than the 12-month-old 'new' (2004) chipseal and watercut section.

Figure 6.3 Turangakumu Hill site looking south.

6.5.6.2 Site discussion

The SCRIM+ data showed that the new chipseal was performing relatively better than the watercut and untreated sections even though the new seal had problems with chip loss and chip rollover for the first six months after construction. Repairs to the new chipseal in the uphill (left) lane caused flushing that contributed to the reduction of the microtexture and macrotexture.

The right wheelpath of the watercut lane (right lane) was affected by the construction and failure of the chip seal on the left lane. See Figure 6.3.

Throughout the monitoring period this site was prone to surface contamination from both stock trucks and scattered construction material. On each visit to the site, effluent from stock trucks was identified on both sides of the road. On one occasion six weeks after watercutting, griptesting had to be delayed by two weeks as the surface was covered with effluent; on another occasion griptesting was delayed because pavement repairs were being carried out on the untreated section adjacent to the watercut section.

The new chipseal constructed the week before the watercutting now has very low surface friction and could fail the next SCRIM+ survey. This is in spite of the use of a higher PSV sealing chip. There are a number of possible explanations for the failure of the higher PSV chip seal which include:

- the surface was contaminated by effluent when tested by the SCRIM+
- the extreme stress on the site was polishing the surface of the aggregate and the site required a higher PSV aggregate
- the failure at the start of the chipseal section caused binder to be carried over and deposited on the surface of the chipseal resulting in a short-term drop in surface friction levels.
- a combination of one or more of the above.

The reduced value data showed there were some 10 m lengths on the watercut section that were below the threshold level and these should be investigated and treated as soon as possible.

There also appeared to be problems with the SCRIM+ data on this site as the 2003 SCRIM+ (16/11/2002) survey showed 100% of the watercut section as being **below** the threshold level but the 2004 SCRIM+ (13/11/2003) survey showed 100% of the watercut section as being **above** the threshold level. However, both of these surveys were carried out before the surface was treated in March 2004. The 2005 SCRIM+ survey (14/11/2004) was carried out eight months after this and showed there was a decrease in surface friction when compared with the 2004 SCRIM+ survey data.

The GripTester data showed that the surface friction measured in the wheelpaths was significantly lower than that measured between the wheelpaths. If the test wheel varied in and out of the wheelpath then this could be an explanation for the discrepancy identified in surveys in this area where surface friction went up and down without any obvious change in the surface and certainly no treatment.

6.5.7 Wishing Well site performance

6.5.7.1 Comparison of watercut length with new and adjacent surfaces

The reduced value data showed a small improvement over most of the site after the watercutting treatment and then slow deterioration during the next 24 months of monitoring. The data showed that the new chipseal section performed better than the watercut section as it was constructed with a new higher PSV aggregate but it still had some sections that required treatment. The untreated section continued to deteriorate and required treatment.

The SCRIM+ microtexture data showed an improvement between the 2003 and 2004 surveys before the watercutting treatment, though some work was carried out to remove excess bitumen from the site during this time. The average microtexture on the watercut surface decreased in the left wheelpath and increased in the right wheelpath during the 24 months after watercutting. The average microtexture on the untreated section continued to decrease during the monitoring period.

The GripTester microtexture data showed an increase after watercutting, but 24 months after watercutting the microtexture was nearly back to pre-treatment levels. The data showed that the new chipseal had maintained the microtexture at higher levels than before construction. The microtexture of the new chipseal remained higher than that of the watercut surface even though the new chipseal failed with chip loss in the wheelpaths soon after construction (see Figure 6.4). The GripTester data showed that, after 24 months of monitoring, the average microtexture for the untreated section was generally unchanged.

The SCRIM+ macrotexture testing showed an increase after the watercutting with most of this increase still evident 24 months after the treatment. The new two-coat grades 2 and 4 chipseal had lower macrotexture than the single-coat grade 2 chipseal surface over which it was constructed and the macrotexture had continued to decrease. The average macrotexture of the untreated control section continued to decrease for the first year of monitoring then increased in the last survey.

MTM macrotexture testing measured an increase after watercutting and most of this was retained over the 21 months of monitoring. The average macrotexture on the new chipseal decreased during the 21 months of monitoring, as did the average macrotexture of the control section.

Sand circle macrotexture testing showed an increase after watercutting that was mostly retained 24 months after treatment. Testing of the new chipseal showed that the average macrotexture decreased over the 21 months of monitoring. Testing showed that the average texture in the wheelpaths decreased but there was an increase between the wheelpaths.

The SCRIM+ roughness data of all three sections increased in the 21 months of monitoring.

The texture data for the new chipseal showed a decrease over the 12 months since construction with further isolated chips loss from the wheelpaths. The texture of the watercut section was reducing at a much slower rate more in line with that of the untreated section. The average microtexture of the untreated section was eventually lower than that of the watercut section.

There were some areas of binder rise after 24 months on the watercut site that may have contributed to the low microtexture.

As both the watercut section and the new chipseal section require treatment, it will be easier to construct the next surfacing over the watercut section.

Figure 6.4 New chipseal on Wishing Well site six months after construction.

6.5.7.2 Site discussion

The existing chipseal on the site had problems with excess binder from the outset when it failed and had some repairs carried out. Low-pressure waterblasting was used to remove the excess binder from the flushed areas in the past.

The new chipseal lost both chip and texture over the 24 months after construction and required some repairs and investigation where it had reached the threshold level. The watercutting treatment of the polished surface did not last and the site required further treatment where it was below the threshold level.

Figure A3 in Appendix 12 shows that the watercutting treatment removed the contamination from the peaks on the sealing chip and most of the chip appears to have been retextured.

6.5.8 Poppellwells Road site performance

6.5.8.1 Comparison of watercut length with new and adjacent surfaces

The SCRIM+ reduced value data showed that watercutting improved the microtexture but only marginally and it returned to pre-treatment levels within 21 months. The data showed that the new chipseal performed well but 21 months after construction there were some sections on the chipseal at the Taupo end of the site that had failed and required treatment.

The SCRIM+ survey data showed an increase after the watercutting and chipsealing but 21 months later the watercut section had returned to pre-treatment levels and the new chipseal sections were performing marginally better.

GripTester data for the site showed that there was an increase in the microtexture after the watercutting treatment, but this returned to pre-treatment levels after 12 months of trafficking. After 24 months the new chipseals had a higher microtexture than that measured before construction.

The SCRIM+ macrotexture data showed an increase on both the watercut and the new chipseal sections apart from the right wheelpath of the new chipseal at the Taupo end of the site. Nine months after the site was resurfaced the average macrotexture of the watercut section was greater than that for either of the chipseals. Twenty-one months after treatment the macrotexture of both new chipseals had returned to pre-reseal levels but the macrotexture of the watercut surface was still higher than before treatment.

The MTM had difficulty in measuring the macrotexture of the new two-coat chipseals because of the roughness and porosity of the surface and the abundance of loose chip on the seal surface, so test results could not be recorded during the first visit to the site. The MTM also had difficulty measuring the texture on the last 40 m of the watercut section at the Napier end throughout the project possibly due to the deep texture and moisture retained in the voids of the chipseal surface (see the right-hand side of Figure A4 in Appendix 13).

Sand circle testing before and after watercutting measured an increase in macrotexture that was mostly retained after 24 months.

The average roughness on the site increased on all three sections after the resurfacing treatments were completed.

6.5.8.2 Site discussions

The watercutting treatment showed an improvement to the surface friction and texture on the Poppellwells Road site; however, this increase reduced over time so that eight months after the treatment 30 m of the 150 m length was below the threshold limit and required investigation and probably treatment as soon as possible.
The monitoring showed that the resurfacing treatments improved the macrotexture and microtexture of the site; however, the microtexture on the new chipseal at the Napier end was significantly better than that of both the watercut section and the new chipseal at the

Taupo end. This may be explained by the difference in stress on the sections. The chipseal portion monitored at the Taupo end was mostly straight compared with the 35 and 40 km/h bends on the other two sections.

The surface friction of the new chipseal at the Taupo end showed significant improvement with 0% lower than the threshold level and 26% less than the intervention level in the 2005 SCRIM+ survey eight months after sealing. However, the new seal at the other end had 0% less than the intervention level because of higher surface friction and lower intervention level targets. While it had better surface friction and texture this seal lost chip in the wheelpaths 20–30 m immediately before the watercut section and may have contributed to some binder carryover causing loss of surface friction on the watercut section.

A comparison can be made between the performance of new chipseal on the straight section (Napier end) with that of new chipseal on a tight bend (Taupo end). Both had similar stresses to the watercut sections but the poorer performance of the Taupo end was a result of the polishing effect on coarse chipseal surfaces by traffic travelling the tortuous alignment on this site.

The Whitehall chip (in the old watercut chipseal) polished relatively quickly when used in coarse aggregate chipseal, as the points of the chip exposed to the tyre wore quickly to rounded points. The watercutting treatment could not sharpen up these rounded points but it did roughen them up as seen in Figure A4.

There have been no reported accidents on the site since it was resurfaced.

6.5.9 Rosebank offramp site performance

6.5.9.1 Comparison of watercut length with new and adjacent surfaces

The reduced value test data showed an increase after watercutting but within 23 months the microtexture had returned to the levels measured before the watercutting treatment. The SMA section showed an increase in microtexture after the resurfacing and 23 months later it was still increasing. The untreated OGPA section has slowly deteriorated.

The SCRIM+ data showed an increase in microtexture after the watercutting treatment, with some of the increase still evident 23 months later. The SMA section showed an increase after the laying of the SMA, which was retained 23 months after resurfacing. The untreated control section continued to decrease over the 23 months of monitoring.

GripTester data recorded immediately before and after watercutting showed an increase in average microtexture for the watercut surface for both the watercut section and the resurfaced SMA section. Twenty-three months later the microtexture was still higher than it had measured before the watercutting treatment. The data for the control section showed that the microtexture on the untreated surface had increased over the 23 months of monitoring.

The SCRIM+ surveys showed that the watercutting treatment produced an increase in macrotexture that was retained for 23 months after the treatment. The SMA produced a decrease in macrotexture compared with the OGPA it replaced and the untreated OGPA showed an increase in macrotexture as it began to lose aggregate from the surface.

MTM testing showed that the watercutting treatment produced an increase in macrotexture that was retained during the 23 months of monitoring; the testing also showed that the macrotexture of the SMA decreased over time.

Sand circle testing showed that the increased macrotexture measured after the watercutting treatment was mostly retained 23 months after the treatment. The testing also showed that the macrotexture of the SMA had decreased.

SCRIM+ roughness data showed negligible change in roughness after the watercutting treatment and an increase in roughness on both the untreated OGPA and SMA sections during the 23 months of monitoring.

The 2005 SCRIM+ texture survey identified a 10 m section with an average MPD < 0.7 mm MPD, below the target of 0.7 mm for urban situations.

6.5.9.2 Site discussion

This site provided an opportunity to observe the increase in surface friction as the SMA mastic binder wore off the surface of the new mix, and also to compare this with the do-nothing option and the watercutting treatment.

While the improvement on the watercut section was not significant the site was still complying with requirements 12 months after treatment.

Unfortunately there were some areas on the SMA that had excess mastic on the surface and the continued macrotexture reduction was probably caused by binder/mastic rise especially in the left wheelpath.

6.5.10 Te Atatu offramp site performance

6.5.10.1 Comparison of watercut length with new and adjacent surfaces

Reduced value data showed that the watercutting treatment increased the microtexture of the surface so that it complied with requirements after the treatment. The SMA section also complied with requirements for 23 months after application. The untreated OGPA section contained some sections that did not meet the requirements during the 23 months of monitoring.

SCRIM+ microtexture data showed an increase after watercutting the AC10, most of which was retained for the next 12 months. The data showed an increase on the SMA after the resurfacing followed by a further increase over the next 12 months. The untreated OGPA section microtexture also increased during the 23 months of monitoring.

GripTester data showed an increase in the microtexture of the AC10 after the watercutting followed by a slow decrease during the 23 months of monitoring. The GripTester data showed that the microtexture of the SMA surface increased over the 23 months of monitoring as the mastic wore off the surface off the aggregate in the mix. The data also showed that the microtexture of the untreated OGPA surface increased over the same time period.

The SCRIM+ data showed that watercutting the AC10 surface substantially increased the average macrotexture and that most of this increase was retained over the next 12 months. The SCRIM+ data also showed that the macrotexture of the SMA had increased during the 23 months of monitoring. The macrotexture of the untreated OGPA increased in the wheelpaths and decreased between them in the same period.

The MTM data for the watercut section showed an increase in macrotexture when tested immediately after the watercutting treatment and this improvement was retained at similar levels for the 23-month monitoring period. The SMA and untreated OGPA showed a decrease in macrotexture during the monitoring period.

The sand circle macrotexture data showed an increase after watercutting and the average macrotexture remained at a similar level over the next 23 months of monitoring. The macrotexture of the SMA and OGPA decreased over the 23 months of monitoring.

The roughness data showed an increase after both the resurfacing treatments were completed; however, there was no evidence of further deterioration of the watercut section and the roughness improved on the SMA section.

6.5.10.2 Site discussion

The watercutting treatment improved both the microtexture and macrotexture of the existing worn 10 mm AC which then complied with the macrotexture and microtexture requirement for the site.

The SMA performed well, with the microtexture 100% above the intervention level and increasing over the monitoring period as the mastic wore off the surface exposing the aggregate surface. However, the macrotexture of the SMA decreased in isolated areas where the surface had filled with excess mastic material.

Some cracks in the 10 mm AC were noticed during the initial site inspection and these slowly deteriorated with some of them showing fines pumping from below.
The texture of the untreated OGPA increased during the trial as it started losing some chip from the surface – an early sign of failure by unravelling.

6.6 Summary of watercut trial peformance

6.6.1 Watercut surface microtexture performance

All watercut sites showed an improvement in the average microtexture after the treatment. The average initial improvement for all sites was 0.17 gripnumbers in the wheelpaths, with the average improvement per site ranging from 0.10 to 0.33 gripnumbers. The average improvement between the wheel paths was 0.14 gripnumbers, with the average improvement per site ranging from 0.08 to 0.34 gripnumbers. Subsequent griptesting during the first 12 months after watercutting treatment showed a reduction in microtexture to varying degrees for all sites.

High-speed data from the annual SCRIM survey and GripTester data averaged for each treatment length on the trial sites showed that after only 12 months of trafficking the microtexture of some wheelpaths on some of the watercut sections and new chipseal sections had returned to levels similar to those before they were treated.

6.6.2 Watercut surface macrotexture performance

The macrotexture on the sites showed a small increase in the wheelpaths. The average SMTD increase for all sites was 0.14 mm with a range from 0 mm to 0.45 mm. The average SMTD improvement between the wheelpaths was 0.15 mm. Relatively small changes to the texture depth were expected as only polished sites without flushing were chosen for the study.

No sites had any indication of flushing or binder rise during the initial inspections; however, some isolated areas of flushing and binder rise were encountered on sites 2, 3, 4, 6, 7 and 8. When constructing the trial sections and watercutting the polished sections, the watercutting process removed the excess binder from these areas. This meant that the measured changes in the macrotexture were the result of a combination (to varying degrees) of the removal of the isolated flushed areas, broken/crushed sealing chip, detritus and/or other road grime from the surfacing interstices.

High-speed data from the annual SCRIM+ survey and data from the sand circling and MTM average for each treatment length on the trial sites showed that in general the macrotexture was improved and remained at the post-treatment levels or similar for the 24 months after the treatment was carried out.

6.6.3 PSV and traffic

An analysis of the performance of the microtexture provided by the new aggregate on the tortuous alignments of most of the trial sites showed a response to the heavy commercial vehicle traffic counts and the amount of traffic stress. Where the site had only a short radius bend then the chip performed as expected but if there were S-bends and/or inclines or declines associated with the bends the chip failed to perform.

This could possibly be explained as follows: the scrubbing/polishing action provided by the combination of multiple events described above was not taken into account by the T/10 PSV formula. T/10 allowed for a higher investigatory level for a combination of events which by calculation then required a higher PSV stone; however, the PSV requirement did not ever get ahead of the investigatory level in this situation as the higher PSV stone had to meet the higher ESC target.

6.7 Cause of microtexture reduction

6.7.1 Aggregate properties

All test sites were selected because they had failed the SCRIM survey due to polishing of the aggregate surface. This meant that the existing surface aggregate was predisposed to polishing under the existing traffic levels and stress at the time of testing. In some locations the traffic levels remained relatively static (see section 6.9.4.3). Thus the aggregates selected for resurfacing on these sites needed to have a PSV higher than that of the previous aggregate. However, on some sites despite the traffic levels decreasing substantially, the polishing still occurred.

As the existing aggregates had polished and the traffic and stress levels had remained the same or reduced, there was an expectation that once watercut the surfaces would polish at a rate similar to that of new aggregate and last as long as the previous surface before polishing. However, the extreme nature of the polishing mechanism on these sites meant that the watercut surfaces mostly polished back to pre-treatment levels within 12 months.

6.7.2 Surfacing treatment

Most sites identified for this project as failing the SCRIM+ surface friction survey by polishing had been surfaced with large chip chipseals. Figure A3 in Appendix 12 shows the points of the large chip being rounded and polished by the traffic. The main issue with this phenomenon is that, depending on tyre pressure and rubber hardness, the measuring tyre will make a very small footprint on the surface of these chipseals. This small footprint will cause less hysteretic friction as there are fewer surface projections in a large chip chipseal to deform the tyre and dissipate heat and energy. The adhesive friction could also be reduced due to the small measuring tyre barely making contact with the surface of a large chip chipseal.

6.7.3 Traffic

Total traffic counts (AADT) for most sites remained relatively static (<3%). Between 2003 and 2005 three sites had variations >3% with a 25.4% increase at Palmerston followed by the 6.1% increase at Raes Junction and a 3.9% decrease on the Rosebank site (see Appendix 5).

There was some variation in heavy commercial vehicle (HCV) traffic with most sites showing a decrease in %HCV. The largest change was at the Te Pohue Telemetry Site (from 22%HCV down to 15%HCV). The %HCV was not available for the Raes Junction and Palmerston traffic counters in 2003.

6.8 Lifecycle analysis of watercutting polished surfaces

6.8.1 Longevity of the treatment

The monitoring results from the watercutting treatment versus the traditional resurfacing treatments showed that the process did increase the microtexture on polished aggregate surfaces. The longevity and magnitude of the increase in microtexture and macrotexture varied for each trial section due to the many variables encountered on each site. Also, the longevity and magnitude of the increase in microtexture and macrotexture provided by the traditional resurfacing treatments varied for each trial site due to the type and success of each treatment.

This made it difficult to calculate the life of the treatment as it depended on many factors. The minimum life for the watercut treatment measured was six months before it returned to the pre-treatment levels and required treatment. There were some sites where after 12 months the levels of microtexture and macrotexture were still at post-treatment levels. Some sites still retained some of the microtexture improvement 24 months after treatment.

6.8.2 Longevity of the treatment

A number of the sites monitored were chipseals in high-traffic, high-stress situations where previously traditional surfacing treatments had only lasted four to five years before polishing and resurfacing with another chipseal added more binder and chip to a multiple chipseal layer.

Some of the resurfacing treatments adjacent to the watercut sections failed after one year and required further treatment. Early resealing as a result of polishing of the chip required a higher binder application than usual to fill the voids in the coarse texture of a recently constructed seal; this increased the binder to stone ratio. Multiple seal coats become unstable when the binder stone ratio rises above 20% (Gray and Hart 2003) and this normally requires recycling or rehabilitation.

The average expected life of the new surfacing treatments on the trial sites could conservatively be set at five years.

6.8.3 Longevity of the treatment

See Table 6.1 for a simple lifecycle cost calculation on a 1 km length X 8.5 m wide two-lane highway. The chipseal treatment costs are compared with the watercutting treatment over 10 years ignoring the discounting factors.

Assumptions

1. The cost of a high PSV chipseal is 1.5 X cost of a local aggregate chipseal
2. High PSV chipseals will fail through wear in tortuous alignments
3. Local aggregate chipseals will fail by polishing on tortuous alignments.

Table 6.1 Lifecycle cost calculation

	High PSV chipseal 100% of treatment length	Watercut treatment length edgeline to edgeline	Watercut polished areas (25% area) 3 times in 5 years
Area treated	8500m²	7000m²	1750m²
Cost	$5.00	$6.00	$6.00
Construction cost	$42,500	$42,000	$31,500
Maintenance costs	$2000	$2000	$2000

6.8.4 Sustainability of treatments

At present the lowest cost treatment (upfront cost) of a polished surface is to resurface it with a new resurfacing material. Currently these resurfacing treatments are carried out over the whole of the treatment length to facilitate asset management. This leads to a high proportion of the treatment length being resurfaced when it still complies with the requirements.

Surface friction testing shows that the polishing is restricted to the wheelpaths; however, resurfacing is carried out over the whole lane width.

Resurfacing sections of state highway that do not need it is unsustainable as it is a waste of non-renewable resources such as the binder and the aggregate.

Watercutting allows the treatment of only the areas that are polished, which is a large saving in binder and aggregate. The watercutting treatment removes rather than adds binder to the surface so can extend the time before resurfacing and recycling is required.

6.8.5 MTM measurement

MTM measurement of the average microtexture of the untreated sections at each end of the watercut section showed the dependence on the instrument for measuring exactly the same line location. The variability of the measurements can be attributed partly to measuring different lines and partly to some pavement repairs and binder removal on the previously untreated sections.

7. Conclusions

- The initial testing of the polished sites before and after the watercutting process confirmed that watercutting a polished surface resulted in an increase in both the macrotexture and the microtexture of the surface.
- The watercutting process is capable of increasing the microtexture of a polished road surface from levels below to levels above the specific site requirements.
- Inspection of the surface after watercutting revealed that, as anticipated, the watercutter did not restore sharp edges on the surfacing aggregate but had roughened up the surface of the sealing chip.
- The freshly watercut surfaces coarse aggregate chipseal may create less hysteretic friction than new chipseals because the traffic-worn individual aggregate particles lack the sharp edges and irregular surfaces predominant on freshly crushed sealing chip.
- Testing after 12 months showed that the increase in surface friction produced by the watercutter had mostly been removed by traffic polishing.
- Aggregates in road surfaces that had polished showed their polishing equilibrium level in the current stress and traffic environment was below the safe level required for the site. Under the same conditions, new aggregates from a similar source polished rapidly to the same microtexture level during this research.
- The rate of microtexture reduction of a watercut surface appeared similar to the rate of microtexture reduction of a new aggregate from the same source.
- There was a difference between the microtexture and macrotexture in the wheelpaths and the less trafficked area between the wheelpaths.
- Another possible cause of the year-on-year variations between successive SCRIM+ surface friction surveys could be the difficulty in locating (transversely) the polished wheelpaths due to the SCRIM+ being contractually required to drive between the edgelines and centreline even where the wheelpaths crossed these lines. Data collected in the wheelpaths and between the wheelpaths showed there were significant transverse variations of both microtexture and macrotexture. This problem was generally restricted to tortuous alignments and tight bends.
- The initial measurements of macrotexture of the trial sites before and after watercutting showed that in general there was an increase in macrotexture. However, as the sites were supposed to be microtexture deficient and not macrotexture deficient it was not expected that there would be a significant increase.
- In general the level of texture produced by the watercutting treatment was retained for the 12 months of monitoring apart from isolated areas of binder rise and flushing.
- In general the new chipseals lost macrotexture at a much faster rate than the watercut surface.

- Watercutting to refresh microtexture deficient surfaces would be considered cost effective if only these sections were treated instead of the traditional sealing of the whole length.
- Watercutting can be used to treat sites with low microtexture at any time of the year while traditional treatments require reasonable conditions for long-term success.
- Watercutting is a sustainable treatment that can be applied to 10 m sections of state highway identified as requiring treatment.
- The results from the SCRIM and GripTester show that the surface friction of new chipseals is considerably higher than that of the watercut surface immediately after the resurfacing.
- On most sites the aggregate had polished because it was not appropriate for the combination of the concentrated traffic and severe polishing stresses encountered on the trial sites. The aggregate used in the new surfacings was based on TNZ T/10 and the assigned investigatory level but in some cases this resulted in an inappropriate aggregate being used and the early loss of microtexture for the new surfacing.
- The aggregate selection process needs to be changed so that high-energy sites with combinations of high traffic, high torsional stresses and high scrubbing need to be surfaced with a high PSV polish-resistant aggregate but only need to achieve the appropriate investigatory level on site. The problem with using investigatory levels to calculate the required PSV is that if the investigatory level is increased because of polishing on site then the aggregate has to produce a higher microtexture surface rather than resist the polishing forces it is exposed to and achieve the standard requirement for a small radius bend.
- The research results showed that the process improved the microtexture on polished sites as expected but that most of the improvement appeared to be lost after 12 months.

8. Recommendations

- The requirement for SCRIM to test only the wheelpaths within the edgeline and centreline should be reviewed to ensure that the driveline with the lowest skid resistance is measured on bends, ensuring that all low surface friction hazards are recognised.
- The selection of large stone chipseals in high-stress situations should be reviewed in light of the polishing phenomena previously described.
- Watercutting should be accepted as a resurfacing treatment to retexturise existing 10 mm AC which is failing to meet the TNZ T/10 microtexture and macrotexture texture requirements.
- Where watercutting is used to treat isolated polished areas rather than resurfacing complete treatment lengths the treated area should be recalculated as lane kilometres of resurfacing.
- Further investigation should be carried out on the contribution to microtexture of small chip surfaces versus large chip surfaces.
- Selecting chipseals as the resurfacing treatment for steep graded tortuous alignments with high tyre scrubbing action in similar situations to the Napier and Whangamoa sites should be re-examined with respect to their expected life in light of the polishing and lifecycle performance documented in this report.
- The poor performance of local aggregates on the Whangamoa Saddle sites provides a case for trialling an imported higher PSV aggregate for chipseals, if chipsealing is the preferred treatment for high-stress sites such as this.
- The SCRIM+ survey should ensure that the most polished wheelpaths are tested.
- The effect of audio-tactile (rumble strip) markings or a similar delineation device for reducing corner cutting on short radius and large declination bends should be examined.
- An investigation into the reasons for the high incidence of contamination by stock effluent should be carried out on the Turangakumu Hill site.
- Further investigation is required into a method that ensures more appropriate polish resistant aggregates are selected on high-energy sites with combinations of skid events.
- The PSV requirement for the chip used on steep graded tortuous sections should be reviewed in line with the accelerated polishing resulting from the extreme tyre scrub on bends as shown by the microtexture test results on the new chip seal.

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Appendix 1: New surfacing aggregate particle size distribution

	Tunnel Hill Stockpile Balclutha Quarry grade 5 chip	Tunnel Hill Stockpile Oamaru Shingle Quarry grade 5 chip	Tumai Overbridge Stockpile Oamaru Shingle Quarry grade 3 chip	Tumai Overbridge Stockpile Oamaru Shingle Quarry grade 5 chip	Whangamoa Saddle Stockpile Bartlett's Quarry grade 3 chip	Whangamoa Saddle 13km Stockpile Bartlett's Quarry grade 3 chip	Whangamoa Saddle 13km Stockpile Bartlett's Quarry grade 5 chip	Wishing Well & Turangakumu Hill Stockpile Poplar Lane grade 2 chip	Wishing Well & Turangakumu Hill Stockpile Poplar Lane grade 4 chip	Poppellwells Stockpile Poplar Lane grade 2 chip	Poppellwells Stockpile Poplar Lane grade 4 chip	Rosebank and Te Atatu off ramps SMA 11 mm aggregate grading
19.0 mm			100		100			100		100		
16.0 mm			100		99	100		83		82		
13.2 mm	100	100	84	100	74	78	100	40	100	37	100	100
9.50 mm	98	100	8	100	1	2	98	1	87	2	86	88
6.70 mm	52	55	1	48	0	0		0	3	1	3	45
4.75 mm	3	3	1	3			5		0	0	0	34
2.36 mm	0	1	0	1			0					29
1.18 mm		0		0								24
0.600 mm												20
0.300 mm												17
0.150 mm												14
0.075 mm												2

Appendix 2: New surface aggregate properties

Sample source	Crushing resistance fines produced	Los Angeles abrasion grading and % loss	Polished stone value	Chip ALD	Chip ratio	% Broken faces
Tunnel Hill Stockpile Balclutha Quarry Grade 5 Chip		C 13%	61	5.03	2.09	100
Tunnel Hill Stockpile Oamaru Shingle Quarry Grade 5 Chip		C 13%	56	4.98	2.07	100
Tumai Overbridge Stockpile Oamaru Shingle Grade 3 Chip	2.4%	B 9%	55	9.27	1.88	100
Tumai Overbridge Stockpile Oamaru Shingle Grade 5 Chip	2.4%	C 12%	55	4.86	2.13	100
Whangamoa Saddle Stockpile Bartlett's Quarry Grade 3 Chip	3.2%	B 12%	56	9.38	2.11	100
Whangamoa Saddle 13km Stockpile Bartlett's Quarry Grade 3 Chip	2.7%	B 11%	56	9.46	2.06	98
Whangamoa Saddle 13km Stockpile Bartlett's Quarry Grade 5 Chip	2.7%	C 15%	56	4.55	2.38	100
Turangakumu Hill and Wishing Well Stockpile Poplar Lane Quarry Grade 2 Chip	2.7%	C 13%	59	10.58	1.97	100
Turangakumu Hill and Wishing Well Stockpile Poplar Lane Quarry Grade 4 Chip	6.1%	C 13%	59	6.64	1.94	100
Poppellwells Stockpile Poplar Lane Quarry Grade 2 Chip	6.3%	C 13%	58	10.99	1.88	100
Poppellwells Stockpile Poplar Lane Quarry Grade 4 Chip	6.3%	C 13%	58	6.72	1.98	100
Te Atatu and Rosebank Off Ramps SMA aggregate 4.75-6.70	5.6%	C 15%	61	4.79	2.07	100
Te Atatu and Rosebank Off Ramps SMA aggregate Moutohora Quarry 6.70–9.50	5.6%	C 15%	61	6.43	1.91	100
Te Atatu and Rosebank Off Ramps SMA aggregate Moutohora Quarry 9.50–13.20	5.6%	C 15%	61	8.58	1.72	100

Note: Tests only carried out where sample gradings contained conforming test sample quantities.

Appendix 3: Site accident history watercut sections

Accidents	Route positions used for accident statistics @ 20m	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Tunnel Hill	SH08 401/13.65–13.85	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0
Tumai Overbridge	SH01S 651/9.96–10.16	1	0	0	0	0	0	0	1	0	0	1	0	2	1	1	4	2
Whangamoa Saddle	SH06 80/11.93–12.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Whangamoa Hill	SH06 80/13.77–13.96	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0
MacKays Crossing	SH01N 1023/8.36–8.75	0	0	1	3	0	2	4	3	4	0	3	2	4	1	1 Bef	1	0
Turangakumu Hill	SH05 204/3.60–3.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wishing Well	SH05 204/5.18–5.37	0	0	0	0	1	0	0	2	0	0	0	0	2	0	0	1	1
Poppellwells Road	SH05 204/8.71–8.85	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Rosebank off ramp WB	Rosebank off ramp WB SH16 0.14–0.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Te Atatu off ramp EB	Te Atatu off ramp EB SH16 0.020–0.17	1	0	0	1	1	4	3	3	1	0	1	1	0	0	0	0	0

Based on data from CAS Database 9 June 2006.

'Bef' means accidents recorded before resurfacing treatment.

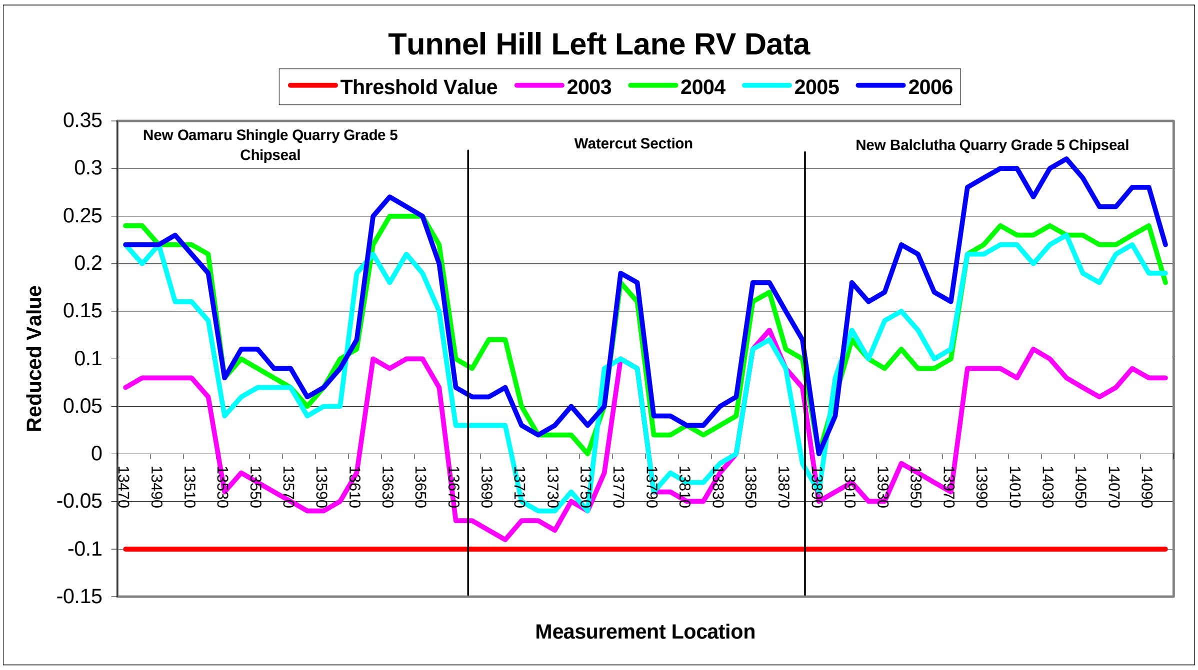
Appendix 4: Surfacing history

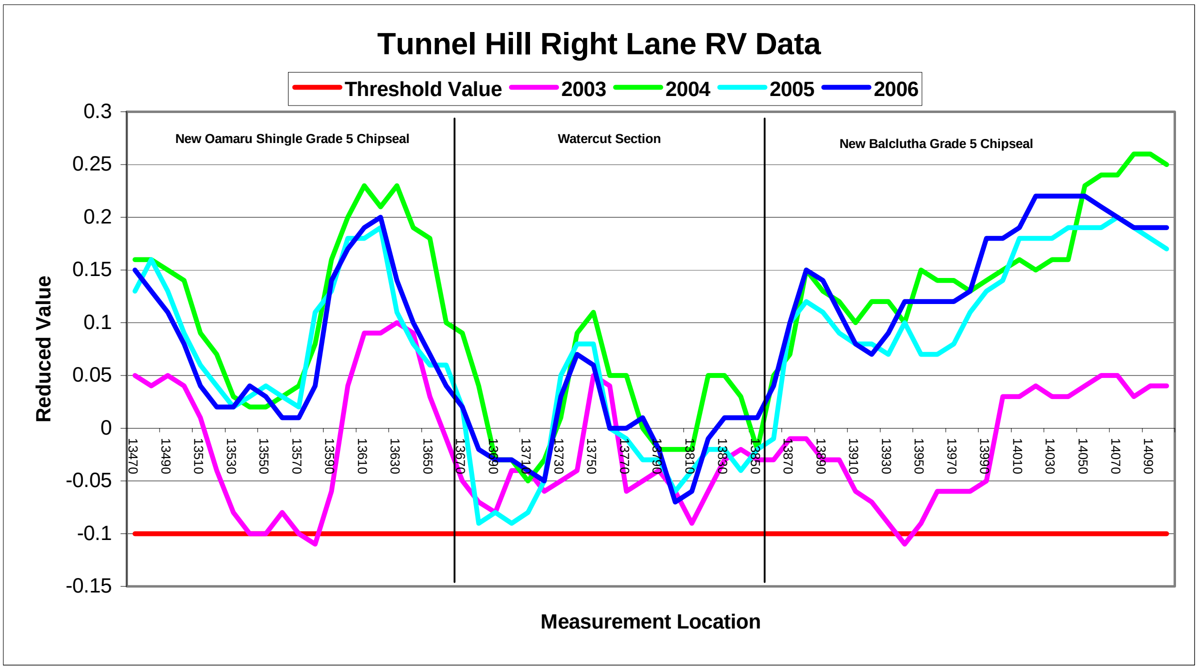
	Route positions used for surfacing	Last surfacing	Surfacing date	Chip source (PSV)
Tunnel Hill	SH08 401/13.65–13.85	Single-coat grade 3 (15 mm) chipseal	16/10/91	Roxburgh
Tumai Overbridge	SH01S 651/9.96–10.16	Two-coat grade 3/5 (15/10 mm) chipseal	25/11/99	Oamaru Shingle
Whangamoa Saddle	SH06 80/11.93–12.09	Two-coat grade 3/5 (15/10 mm) chipseal	12/98	Appleby Quarry
Whangamoa Hill	SH06 80/13.77–13.96	Single-coat grade 3 (15 mm) chipseal	12/97	Appleby Quarry
MacKays Crossing	SH01N 1023/8.36–8.75	Single-coat grade 3 (15 mm) chipseal	1/12/87	Otaki River
Turangakumu Hill	SH05 204/3.60–3.75	Two-coat grade 2/4 (20/12 mm) chipseal	4/2/99	Whitehall
Wishing Well	SH05 204/5.18–5.37	Single-coat grade 2 (20 mm) chipseal	25/1/00	Whitehall
Poppellwells Road	SH05 204/8.71–8.85	Two-coat grade 2/4 (20/12 mm) chipseal	20/2/98	Whitehall
Rosebank off ramp WB	Rosebank off ramp WB SH16 0.14–0.30	25 mm of P/11 OGPA	1999	Unknown
Te Atatu off ramp EB	Te Atatu off ramp EB SH16 0.02–0.17	30 mm of M/10 AC10 mm	1998	Unknown

Appendix 5: Site traffic counts

Site name	Nearest traffic counter	Counter location	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 AADT (%HCV)	2004 AADT (%HCV)	2005 AADT (%HCV)
Tunnel Hill	Raes Junct, East SH90 Craigellachie	SH08 412/0	710	890	1070	1350	1215	1290	1200	1140	1000	1130	1163	1100	1400	1400	1490	1486 (11%)
Tumai Overbridge	Palmerston, Pleasant Valley	SH01S 656/0	4570	3510	3650	4060	4350	4300 (11.8%)	3365 (11%)	4360 (11%)	3750 (11.5%)	3780 (14%)	3499	5310	4370	4620	4570	5796 (21%)
Whangamoa Saddle	Hira Telemetry Site No 36	SH06 100/0	1650	1740	1840	1900	2020	2280 (12.4%)	2310 (11%)	2400 (11%)	2510 (11%)	2650 (11%)	2760 (11.16)	2710 (14%)	3020 (14%)	3170 (16%)	3240 (12%)	3235 (12%)
Whangamoa Hill	Hira Telemetry Site No 36	SH06 100/0	1650	1740	1840	1900	2020	2280 (12.4%)	2310 (11%)	2400 (11%)	2510 (11%)	2650 (11%)	2760 (11.16)	2710 (14%)	3020 (14%)	3170 (16%)	3240 (12%)	3235 (12%)
MacKays Crossing	Paekakariki, South of MacKays Crossing	SH01N 1031/0	18500	20100	20600	19000	19600	19600 (5.8%)	20900 (6%)	21700 (5%)	22400 (8%)	23400 (5%)	23700 (4%)	21840 (4%)	23600 (4%)	24230 (12%)	24130 (6%)	24233 (7%)
Turangakumu Hill	Te Pohue Telemetry Site No 23	SH05 230/0	1710	1760	1810	1900	2020	2280 (12.4%)	2310 (11%)	2400 (11%)	2510 (11%)	2455 (14%)	2500 (15.11%)	2630 (18%)	2830 (18%)	2870 (22%)	2940 (16%)	2892 (15%)
Wishing Well	Te Pohue Telemetry Site No 23	SH05 230/0	1710	1760	1810	1900	2020	2280 (12.4%)	2310 (11%)	2400 (11%)	2510 (11%)	2455 (14%)	2500 (15.11%)	2630 (18%)	2830 (18%)	2870 (22%)	2940 (16%)	2892 (15%)
Poppellwells Road	Te Pohue Telemetry Site No 23	SH05 230/0	1710	1760	1810	1900	2020	2280 (12.4%)	2310 (11%)	2400 (11%)	2510 (11%)	2455 (14%)	2500 (15.11%)	2630 (18%)	2830 (18%)	2870 (22%)	2940 (16%)	2892 (15%)
Rosebank Off Ramp WB	Rosebank Offramp Westbound	SH16 9/0												4840	4790	4880 (6%)	4870 (7%)	4686 (2%)
Te Atatu Off Ramp EB	Te Atatu Offramp Eastbound	SH16 11/0												6460	6280	6360 (5%)	6400 (3%)	6529 (2%)

Appendix 6: Tunnel Hill monitoring data





SCRIM+ reduced value data analysis

The reduced value data represents a calculation comparing the combined measurement of the microtexture in both wheelpaths of the lane with the investigatory level (IL) for each 10 m length of the lane. The threshold level (TL) is set at 0.1 lower than the IL.

Left lane

Oamaru Shingle grade 5 chipseal section

- The 2003 survey carried out 10 months before the chipseal was constructed calculated that 50% of the site was below the IL and 0% of the site was below the TL.
- The 2004 survey carried out two months after the seal was constructed calculated 0% below the IL and 0% below the TL.
- The 2006 survey carried out 26 months after the seal was constructed calculated that 0% of the site was below the IL and 0% was below the TL

Watercut section

- The 2003 survey carried out 11 months before the watercutting calculated that 65% of the site was below the IL and 0% below the threshold level.
- The 2004 survey carried out one month after the site was watercut calculated 0% below the IL and 0% was below the TL.
- The 2005 survey carried out 13 months after the watercutting calculated that 55% of the site was below the IL and 0% was below the threshold value.
- The 2006 survey carried out 25 months after the watercutting calculated that 0% of the site was below the IL.

Balclutha Quarry grade 5 chipseal section

- The 2003 survey carried out 10 months before the chipseal was constructed calculated that 41% of the site was below the IL and 0% was below the threshold level.
- The 2004 survey carried out two months after the seal was constructed calculated 0% below the IL and 0% below the TL.
- The 2006 survey carried out 26 months after the seal was constructed calculated that 0% of the site was below the IL.

Right lane

Oamaru Shingle grade 5 treatment length right lane

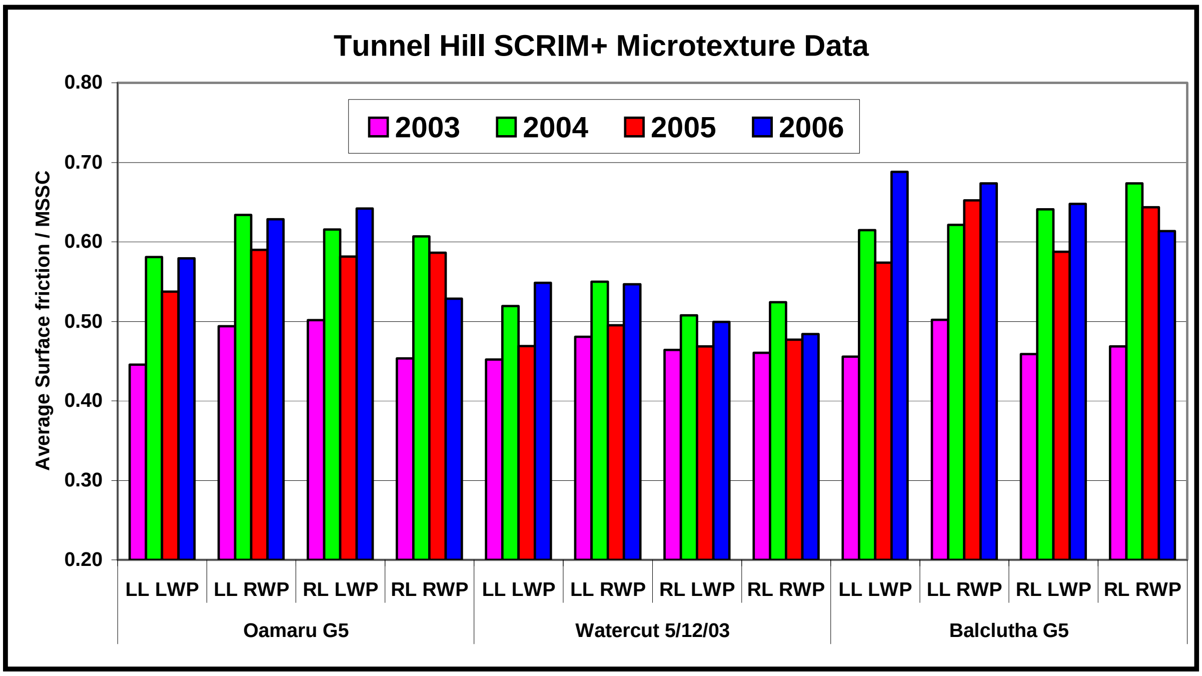
- The 2003 survey carried out 10 months before the seal was constructed showed that 52% of the site was below the IL and 5% of the site was below the threshold level.
- The 2004 survey carried out two months after the seal was constructed calculated that 0% was below the IL.
- The 2005 survey carried out 14 months after the seal was constructed calculated that 5% of the site was below the IL.
- The 2006 survey carried out 26 months after the seal was constructed calculated that 5% of the site was below the IL.

Watercut section

- The 2003 survey carried out 11 months before the watercutting treatment showed that 90% of the site was below the IL and 0% was below the threshold limit.
- The 2004 survey carried out one month after the site was watercut calculated that 38% of the site was below the IL.
- The 2005 survey carried out 13 months after the treatment calculated that 67% of the site was below the IL.
- The 2006 survey carried out 25 months after the treatment calculated that 38% of the site was below the IL.

Balclutha Quarry grade 5 treatment length right lane

- The 2003 survey carried out 10 months before the seal was constructed showed that 48% of the site was below IL and 5% below the threshold level.
- The next three surveys 2004–2006 carried out two, 14 and 26 months after the seal construction respectively calculated that 0% of the site was below the IL and 0% below the TL.



SCRIM+ microtexture data analysis

The SCRIM+ measures the microtexture (MSSC) in each wheelpath and averages it for each 10 m section. The data is then corrected and in this research we used mean summer SCRIM+ corrected data. This data is then averaged for each treatment section for each wheelpath in each lane.

Oamaru Shingle grade 5 section

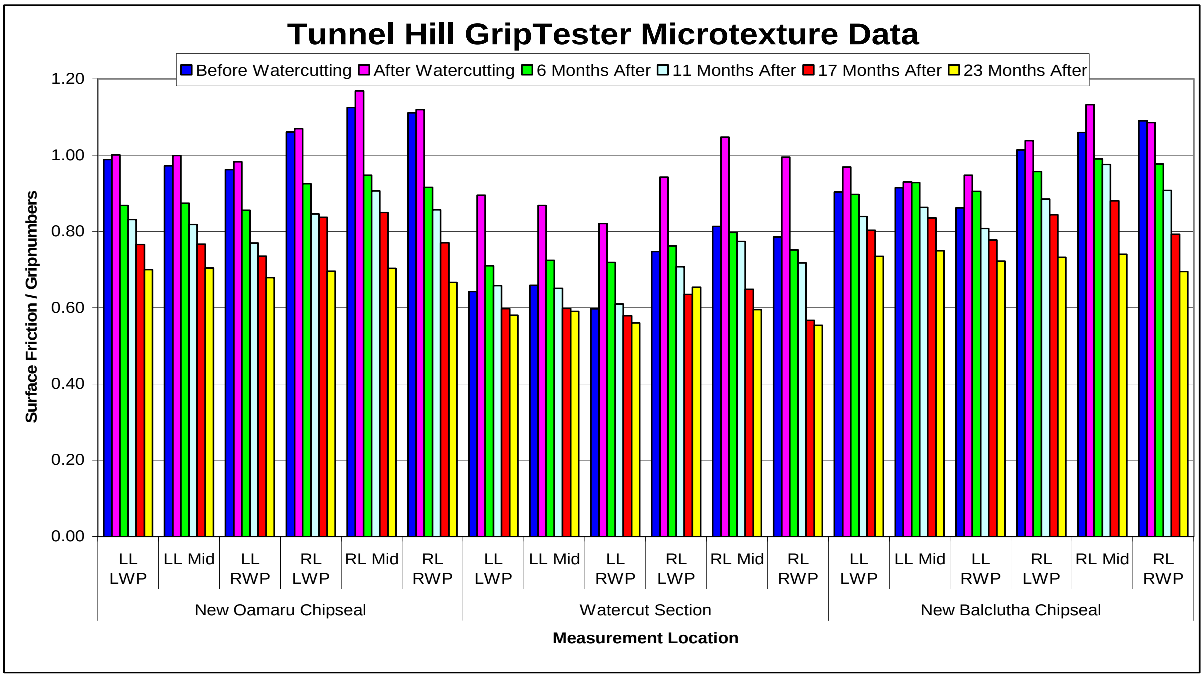
- The average microtexture measured in the wheelpaths in the 2004 SCRIM+ survey two months after the seal was constructed was higher (LL LWP 0.14, LL RWP 0.14, RL LWP 0.11 and RL RWP 0.15) in all wheelpaths than the average microtexture measured in the 2003 survey 10 months before the seal was constructed.
- The 2006 survey 26 months after the seal was constructed showed that the average microtexture had changed (LL LWP 0.00, LL RWP -0.01, RL LWP 0.03 and RL RWP -0.08) from the levels measured two months after the seal was constructed.

Watercut section

- The 2004 SCRIM+ survey a month after the site was watercut showed the average microtexture measured in the wheelpaths was higher (LL LWP 0.07, LL RWP 0.07, RL LWP 0.04 and RL RWP 0.06) in all wheelpaths than the average microtexture measured in the 2003 survey.
- The 2006 survey measured 25 months after the watercutting showed that the average microtexture was still higher (LL LWP 0.10, LL RWP 0.07, RL LWP 0.04 and RL RWP 0.02) than that measured before the treatment.

Balclutha Quarry grade 5 section

- The average microtexture measured in the wheelpaths in the 2004 SCRIM+ survey two months after the seal was constructed was higher (LL LWP 0.16, LL RWP 0.12, RL LWP 0.18 and RL RWP 0.21) in all wheelpaths than the average microtexture measured in the 2003 survey 10 months before the seal was constructed.
- The 2006 survey 26 months after the seal was constructed showed that the average microtexture had changed (LL LWP 0.07, LL RWP 0.05, RL LWP 0.01 and RL RWP -0.06) from the levels measured two months after the seal was constructed.



GripTester microtexture data analysis

Griptesting was carried out immediately before and after the watercutting (5–6/12/2003) – two weeks after the grade 6 chipseals (18–19/11/2003) were constructed. Test runs were carried out along and between the wheelpaths over the entire length of the site. The start and finish of the chipseal and the watercut section were marked in the data during testing for ease of analysis. GripTester data was reported as the average of each 10 m section and the data at each end of the treatment length was contaminated to some extent by data from the adjacent treatment lengths. Once separated into the treatment lengths the data was averaged for each wheelpath and between the wheelpaths.

Oamaru Shingle treatment length

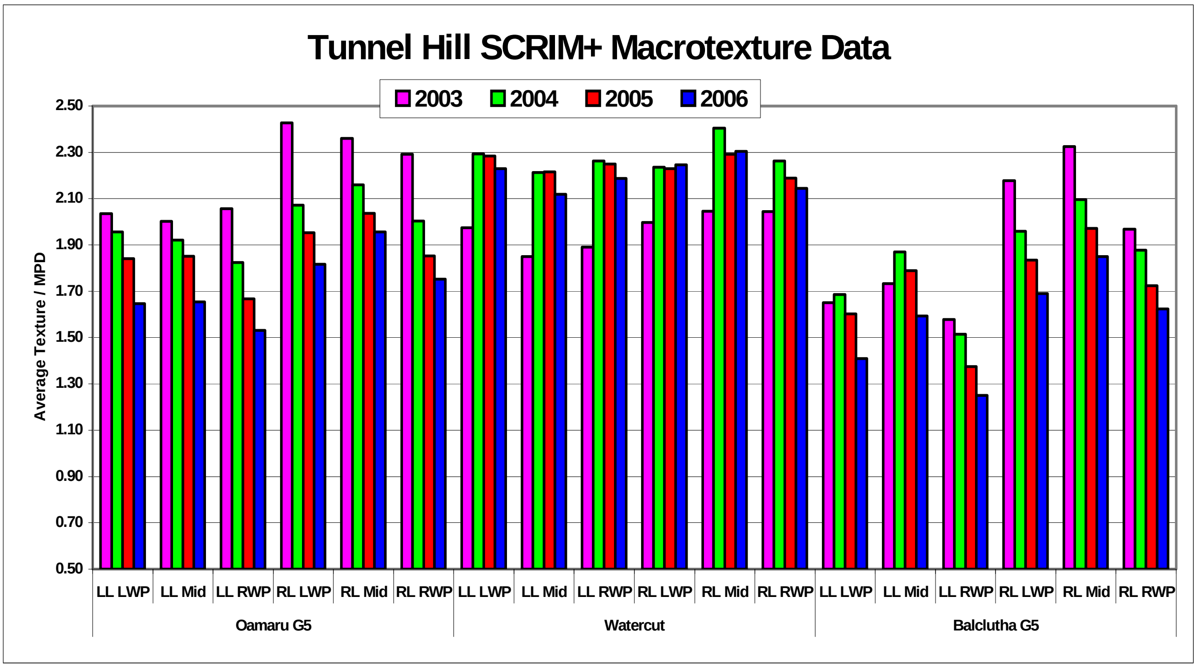
- Griptesting over the two years following the construction of the seal showed that the microtexture of the new chipseal gradually declined from an average 1.04 gripnumbers to an average 0.69 gripnumbers – an average decrease of 0.35 gripnumbers for the new chipseal surface.

Watercut treatment length

- Griptesting after the watercutting treatment measured an increase in the average microtexture in each location across the road.
- Griptesting at approximately six-monthly intervals for the past two years showed a gradual decline so that the average microtexture tested 24 months after watercutting was 0.12 gripnumbers less than that measured before the site was watercut.

Balclutha Quarry grade 6 chipseal treatment length

- Griptesting over the two years after the seal was constructed showed that the microtexture of the new chipseal decreased from an average 0.97 gripnumbers to an average 0.73 gripnumbers – an average decrease of 0.26 gripnumbers for the new chipseal.



SCRIM+ macrotexture data analysis

The SCRIM+ measures the macrotexture in each wheelpath and between the wheelpaths and averages the data for each 10 m section. In this research the data was then averaged for each treatment section for each wheelpath and between the wheelpaths.

Oamaru Shingle grade 5 section

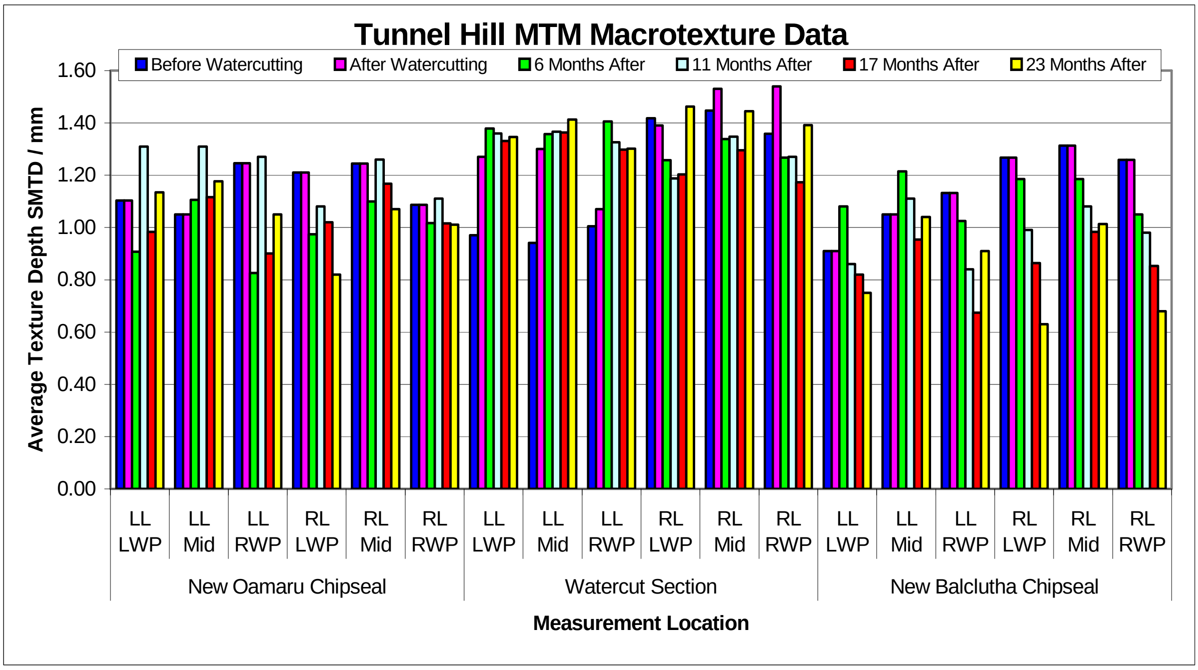
- The 2004 SCRIM+ survey two months after the site was chipsealed reported the average macrotexture for the length as 1.99 mm MPD – a decrease of 0.21 mm MPD when compared with the 2003 SCRIM+ survey data.
- The average macrotexture measured 26 months after the grade 5 seal was constructed (2006 SCRIM+ survey) showed a further reduction to 1.73 mm MPD – a reduction of 0.26 mm MPD.

Watercut treatment length

- The 2004 SCRIM+ survey a month after the section was watercut reported the average macrotexture for the length as 2.28 mm MPD – an increase of 0.31 mm MPD over that measured in the 2003 SCRIM+ survey 11 months before watercutting.
- The average macrotexture of the site measured 26 months after watercutting (2006 SCRIM+ survey) decreased to 2.21 mm MPD.

Balclutha Quarry grade 5 section

- The 2004 SCRIM+ survey two months after the site was chipsealed reported the average macrotexture for the length as 1.83 mm MPD – a decrease of 0.07 mm MPD when compared with the 2003 survey data.
- The average macrotexture measured 26 months after the seal was constructed (2006 survey) showed a further reduction to 1.57 mm MPD – a reduction of 0.34 mm MPD.



MTM macrotexture data analysis

The minitexture meter (MTM) was used to measure the texture of the watercut section before and after resurfacing with the watercutter; 30–40 m lengths of the new seals adjacent to the ends of the watercut section were tested at the same time.

Testing was carried out at approximately six-month intervals during the 24 months after the watercutting following and between the wheelpaths located by the sand circles.

Oamaru Shingle section

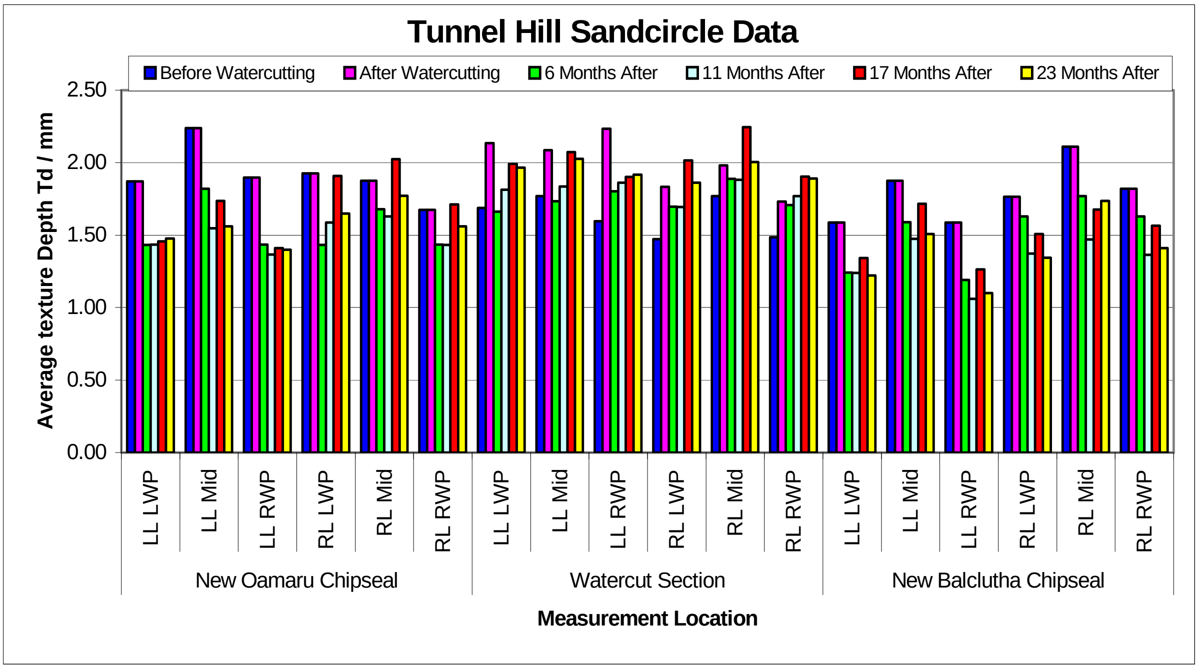
- MTM testing on the new chipseal 24 months after construction showed that the average macrotexture (SMTD) had decreased LL LWP 0.03 mm, LL Mid 0.13 mm, LL RWP -0.20 mm, RL LWP -0.39 mm, RL Mid -0.17 mm, RL RWP -0.08 mm in most locations compared with that measured a month after the seal was constructed

Watercutter treatment section

- MTM testing after watercutting showed an increase in most locations across the road of the average macrotexture (LL LWP 0.30 mm, LL Mid 0.36 mm, LL RWP 0.07 mm, RL LWP -0.03 mm, RL Mid 0.08 mm and RL RWP 0.18 mm) compared with that measured before watercutting.
- MTM testing 24 months after the site was watercut showed that the average macrotexture for most locations across the road was still higher (LL LWP 0.38 mm, LL Mid 0.47 mm, LL RWP 0.30 mm, RL LWP 0.04 mm, RL Mid 0.00 mm, RL RWP 0.03 mm) than that measured immediately before watercutting.

Balclutha Quarry section

- MTM testing on the new chipseal 24 months after construction showed that the average macrotexture had decreased (LL LWP -0.16 mm, LL Mid -0.01 mm, LL RWP -0.22 mm, RL LWP -0.64 mm, RL Mid -0.30 mm, RL RWP -0.58 mm) in all locations compared with that measured a month after the seal was constructed.



Sand circle macrotexture data analysis

Sand circles were measured over the site at intervals of 10–20 m, before and after watercutting and at approximately six-month intervals for the next 24 months. The location of the measurements was kept consistent using RPMs and visual assessment of the surface. Only the 30–40 m of the seals adjacent to each end of the watercut section were tested.

Oamaru Shingle treatment length

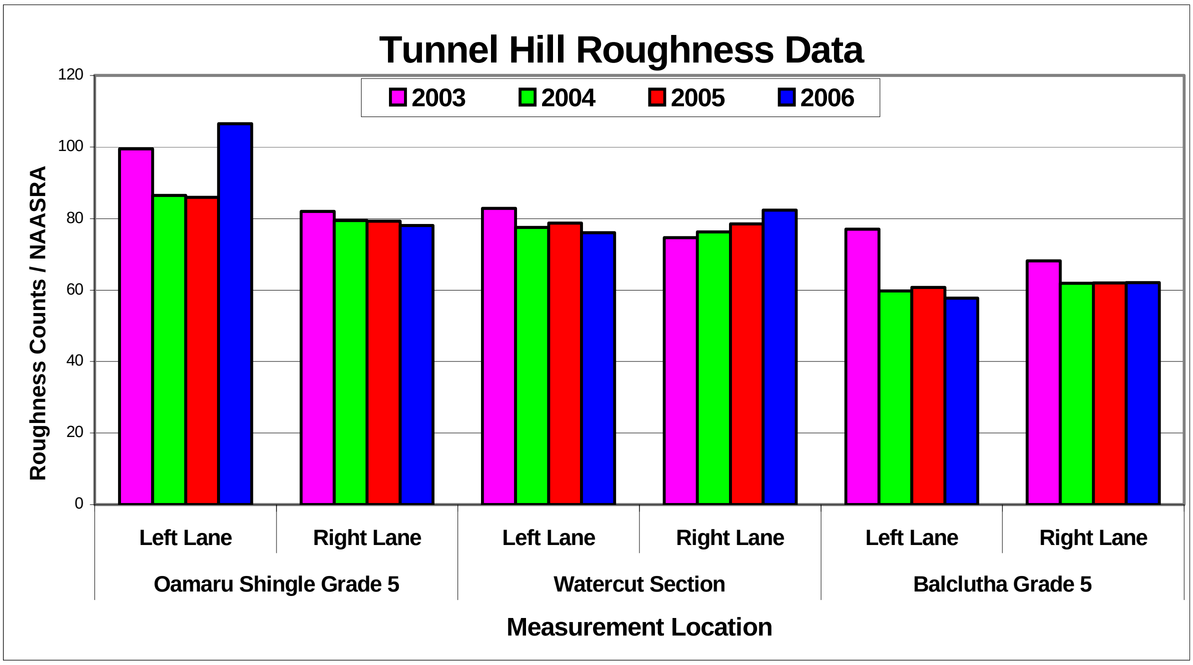
- Sand circling 24 months after seal construction showed a decrease in the average macrotexture (Td) (LL LWP -0.39 mm, LL Mid -0.68 mm, LL RWP -0.50 mm, RL LWP -0.28 mm, RL Mid -0.10 mm and RL RWP -0.11 mm) in all locations compared with that measured a month after the seal was constructed

Watercut treatment length

- Sand circle testing after watercutting showed that the average macrotexture (Td) for the site had increased (LL LWP 0.45 mm, LL Mid 0.32 mm, LL RWP 0.64 mm, RL LWP 0.36 mm, RL Mid 0.21 mm and RL RWP 0.25 mm) compared with that measured immediately before the treatment.
- Testing 23 months after the site was watercut showed that the average macrotexture was still higher (LL LWP 0.28 mm, LL Mid 0.26 mm, LL RWP 0.32 mm, RL LWP 0.39 mm, RL Mid 0.24 mm and RL RWP 0.41 mm) than that measured immediately before the section was watercut.

Balclutha Quarry treatment length

- Sand circling 24 months after seal construction showed a decrease in the average macrotexture (Td) (LL LWP -0.39 mm, LL Mid -0.68 mm, LL RWP -0.50 mm, RL LWP -0.28 mm, RL Mid -0.10 mm and RL RWP -0.11 mm) in all locations compared with that measured a month after the seal was constructed.



Roughness data analysis

The SCRIM+ measures roughness and averages it for each 20 m length in each lane. This data is then averaged for each lane and each treatment section for analysis.

Oamaru Shingle grade 5 treatment length

- The left lane average roughness in 2006 was 7 counts higher than that measured in 2003 before the section was sealed.
- The right lane average roughness in 2006 was -4 counts lower than that measured in 2003 before the section was sealed.

Watercut treatment length

- Left lane testing showed that the average roughness (NAASRA) in 2006 was -7 counts lower than that measured in 2003 before the section was watercut.
- Right lane testing showed that the average roughness in 2006 was 8 counts higher than that measured in 2003 before the section was watercut.

Balclutha Quarry grade 5 treatment length

- The left lane average roughness in 2006 was -19 counts lower than that measured in 2003 before the section was sealed.
- The right lane average roughness in 2006 was -6 counts lower than that measured in 2003 before the section was sealed.

Aggregate polishing

The surface friction allowed the comparison of the rate of polishing the coarse grade 3 chipseal with smaller chipseal surfaces using higher PSV grade 5 chips.

As expected, the surface friction of the new chipseals was higher than that of the refreshed polished grade 3 chipseal.

The high early surface friction of the two new chipseals was achieved by the new sharp edged small aggregate and unpolished microtexture, compared with the worn rounded grade 3 chips with rounded edges and refreshed microtexture.

The macrotexture depths of the two new grade 5 chipseals constructed just before the middle section was watercut showed some variation between lanes and chip sources. The texture depth of the Oamaru Shingle chipseal was on average deeper than the texture of the Balclutha chipseal even though the chip was essentially the same size when tested. Also the uphill texture was less than the downhill texture due to the loading effects of slow-moving heavy commercial vehicles.

Traffic counts

The traffic counts when the grade 3 chipseal was constructed in 1991 were 890 AADT (no % HCV stated). When measured in 2005 they had increased to 1486 with 11% HCV an increase in AADT of 67%.

Accidents

Accident statistics were only collected for the watercut section to monitor the site and make sure that the resurfacing trial did not cause an increase in the accident rate; there have been no recorded accidents on this site since 2002.

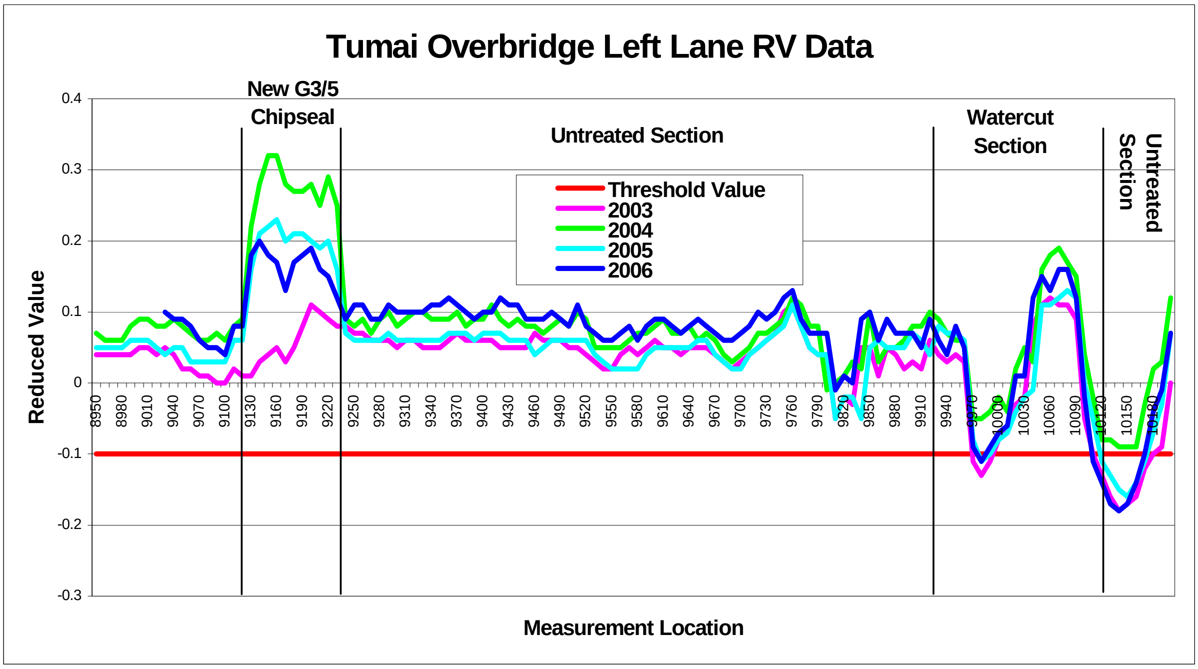
Aggregate testing

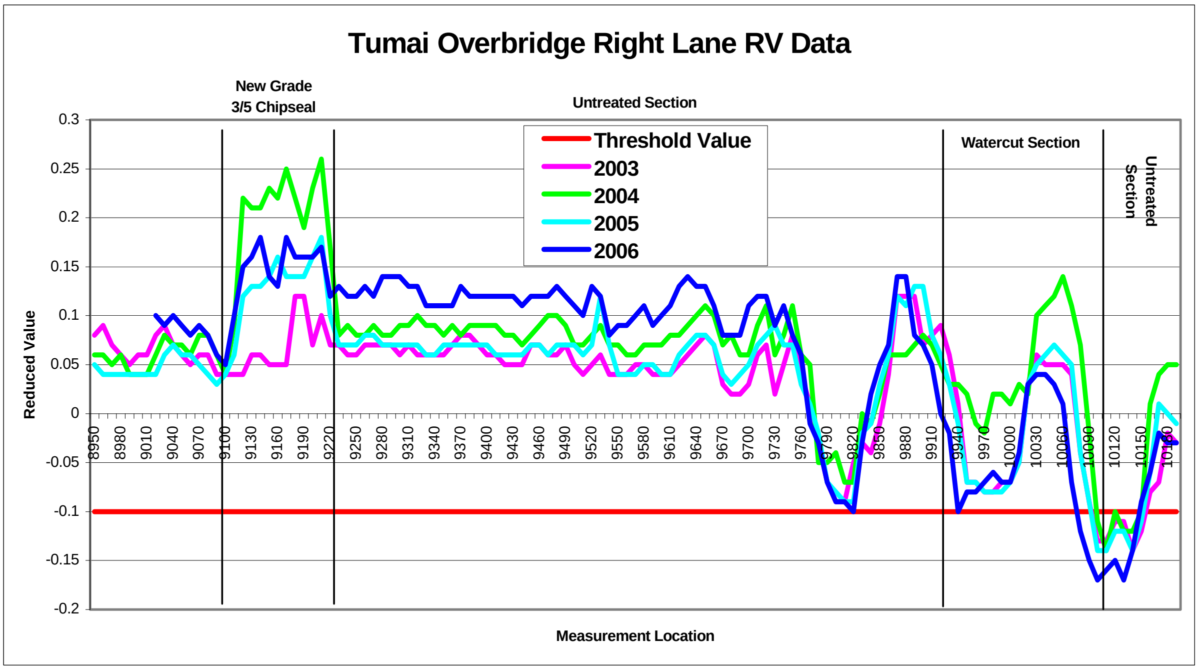
Sieve analysis, and size and shape testing of the two grade 5 sealing chips used in the construction of the seals either side of the watercutting on the site were similar in most respects.

LA abrasion testing of the coarse fraction from the two chips gave the same result.

The PSV of the coarse fraction of the Balclutha grade 5 chip sample was 61 compared with 56 measured on the coarse fraction from the Oamaru Shingle chip sample.

Appendix 7: Site 2 Tumai Overbridge monitoring data





Reduced value data analysis

Left lane

New grade 3/5 chipseal section

- There were no lengths below the TL or IL in this section in the last four SCRIM+ surveys.

Control section – untreated section in between

- There were no lengths below the TL or IL in the last four SCRIM+ surveys.
- 5% of this section was below the IL when measured in the 2003 SCRIM+ survey.

- 2% of this section was below the IL when measured in the 2006 SCRIM+ survey

Watercut section

- 14% of the section was below the TL and 33% was below the IL when measured in the 2003 SCRIM+ survey.
- 0% of the section was below the TL and 24% was below the IL when measured in the 2004 survey a month after the section was watercut.
- 5% of the section was below the TL and 24% was below the IL when measured in the 2006 survey 25 months after the section was watercut.

Right lane

New grade 3 / 5 chipseal section

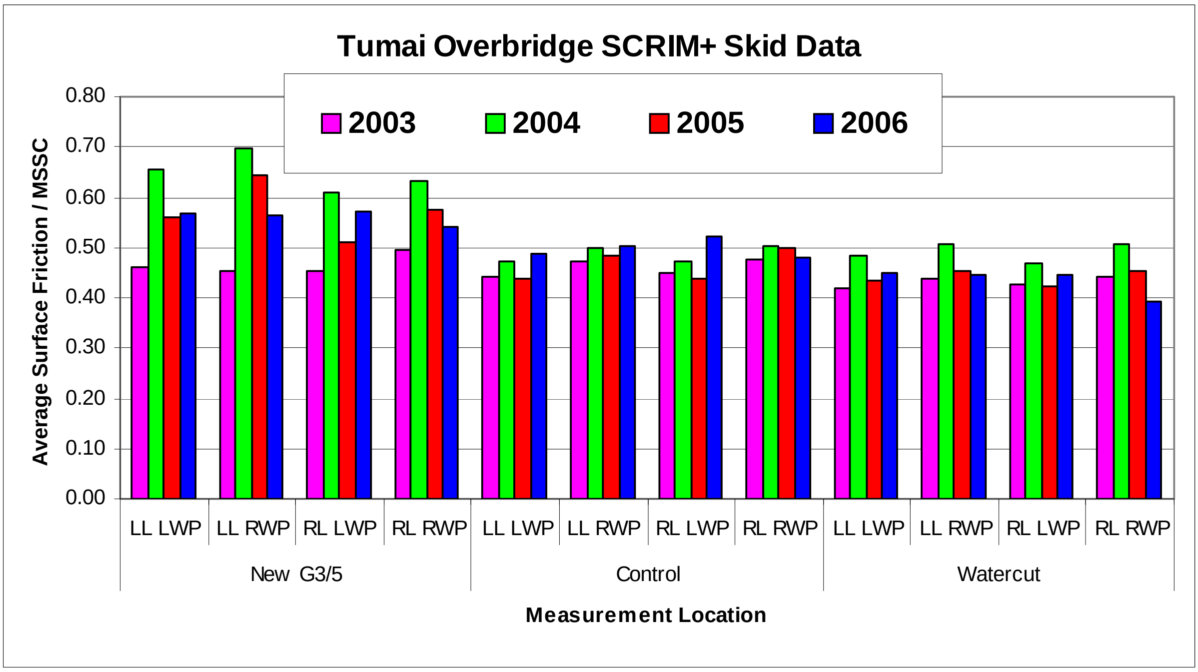
- There were no lengths below the TL or IL in the last four SCRIM+ surveys

Control section – the section between the watercut and new seal

- 0% was below the TL when measured in the 2003, 2004 and 2005 SCRIM+ surveys with one 10 m length measuring below the TL in the 2006 SCRIM+ survey.
- 13% of the section was below the IL when measured in 2003 SCRIM+ survey.
- 9% of the section was below the IL when measured in the 2004 survey with 11% below the IL when measured in both the 2005 and 2006 SCRIM+ surveys.

Watercut section

- 10% was below the TL and 52% was below the IL for this section when measured by the 2003 SCRIM+ survey.
- 10% was below the TL and 24% was below the IL for this section when measured one month after watercutting in the 2004 SCRIM+ survey.
- 10% was below the TL and 57% was below the IL when measured 13 months after watercutting. 24% was below the TL and 67% was below the IL when measured 25 months after watercutting.



SCRIM+ microtexture data analysis

New grade 3/5 chipseal section

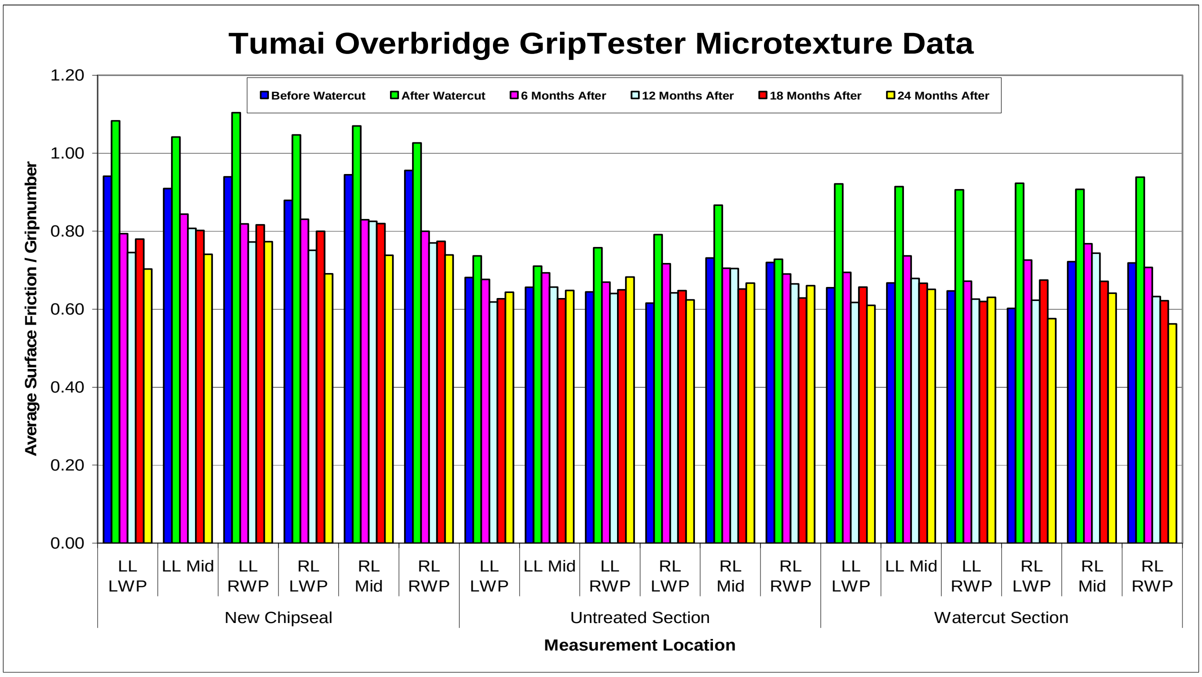
- The average MSSC for the new chipseal surface was 0.18 MSSC higher when measured six weeks after sealing compared with the old surface underneath that had been measured 11 months earlier.
- The average microtexture measured in the 2006 SCRIM+ survey was now only 0.09 MSSC higher than that measured on the old surface before the new seal.

Control section

- The average microtexture for the control section surface when measured in the 2004 SCRIM+ survey was 0.03 MSSC higher than that measured in the 2003 survey.
- The average microtexture measured in the 2005 SCRIM+ survey was similar to that measured in 2003.
- The new seals on pavement repairs in this section contributed to the increase in the MSSC.

Watercut section

- The average microtexture when measured one month after watercutting was 0.06 MSSC higher than that measured 11 months before in the 2003 SCRIM+ survey.
- The average microtexture for the watercut surface when measured 13 months after watercutting had returned to the level measured before it was watercut.
- The average microtexture for the LWP in both lanes and the RWP in the left lane in 2006 was higher than that measured before the watercutting treatment.



GripTester microtexture data analysis

New grade 3/5 chipseal section

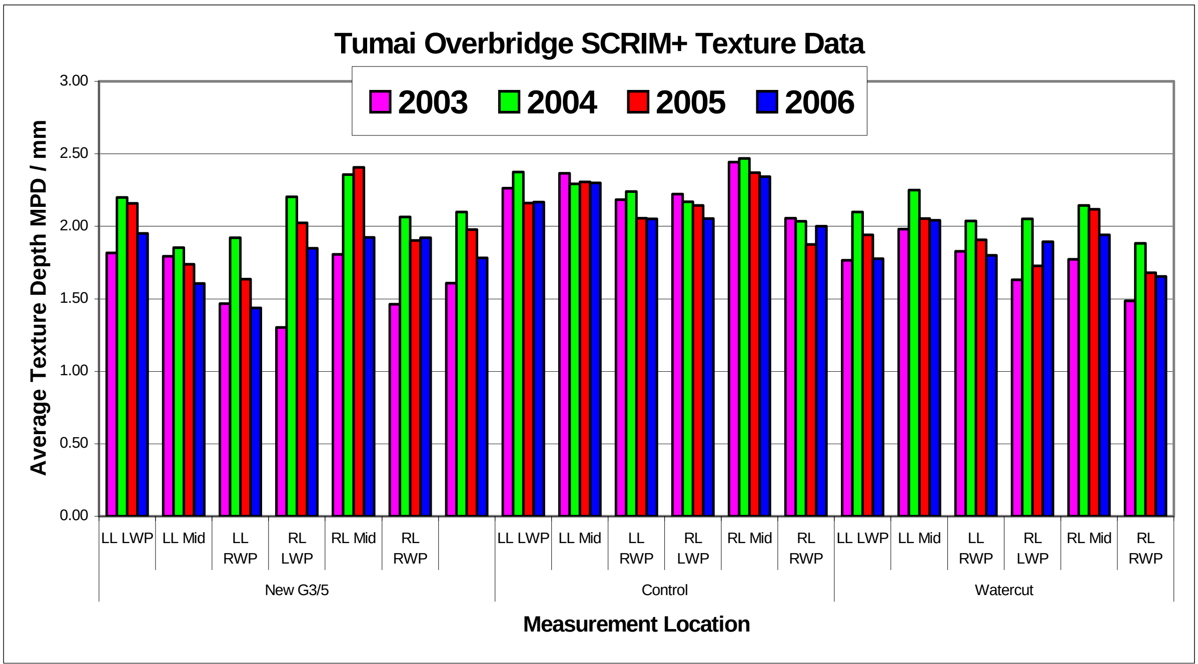
- Average microtexture measurements at the time the watercut section was treated showed an increase of 0.11 gripnumbers over this period.
- Testing of the new seal 24 months later showed that the average microtexture was now 0.20 gripnumbers lower than that measured during the first testing of the site.

Control section (untreated)

- Griptesting showed that the microtexture of the control section had increased by 0.09 gripnumbers between the before and after surveys, probably caused by the initiation of bleeding and flushing by the traffic and high temperature on the day of testing.
- Testing of the untreated section showed that the average microtexture measured 24 months later was now 0.02 lower than that measured at the time of the first testing.

Watercut section

- Average microtexture measurements after the section was watercut were 0.25 gripnumbers higher than that measured on the surface before it was watercut.
- Griptesting six months later showed that the surface microtexture was only 0.05 higher than that measured before watercutting.
- Griptesting 12 months after the section was watercut measured the average microtexture as 0.05 gripnumbers higher than that measured on the surface before watercutting.
- Griptesting 18 months after the site was watercut measured the surface friction at 0.02 gripnumbers lower than that measured before watercutting.



SCRIM+ macrotexture data analysis

New grade 3/5 chipseal section

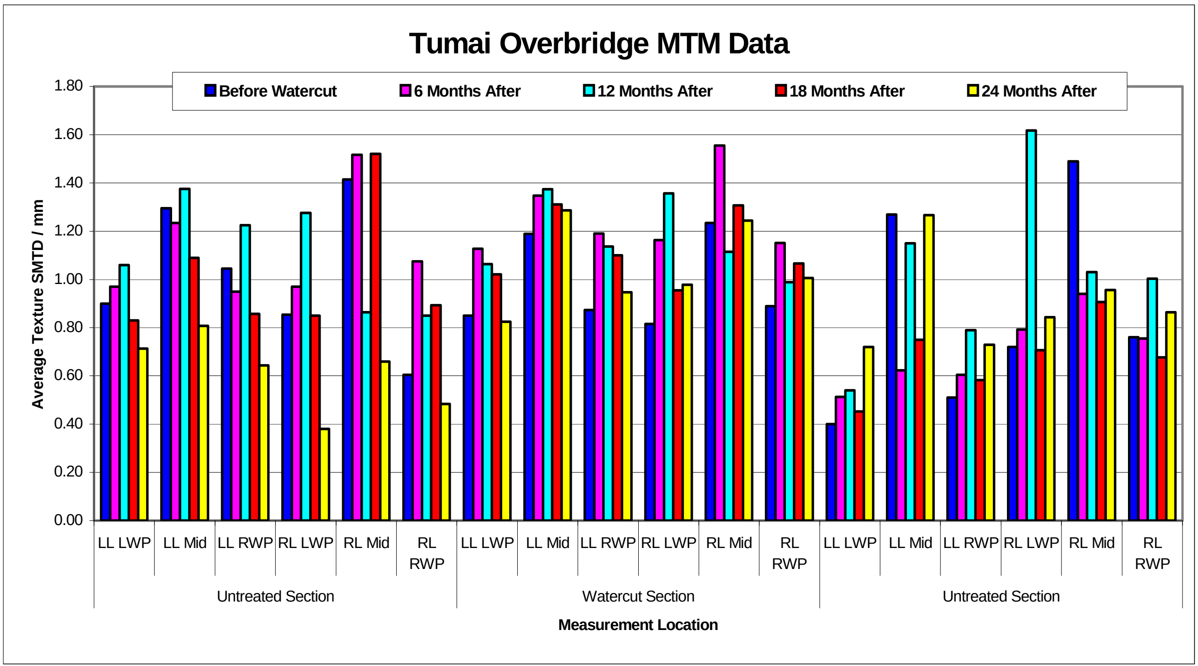
- The average macrotexture for the new grades 3 and 5 chipseal was 2.10 mm MPD when measured six weeks after construction in the 2004 SCRIM+ survey.
- The average macrotexture of the new seal was 1.78 mm MPD when tested 24 months later – a reduction of 0.32 mm MPD (18%).

Control section

- The 2006 survey measured the average macrotexture for the control (untreated section). It was 0.10 mm MPD lower than that measured in the 2003 survey.

Watercut section

- The average macrotexture measured in the 2004 SCRIM+ survey a month after the watercutting showed an increase of 0.33 mm MPD when compared with that measured 12 months previously.
- The 2006 survey showed that the average macrotexture for the watercut section was still 0.11 mm MPD higher than that measured before the section was watercut.



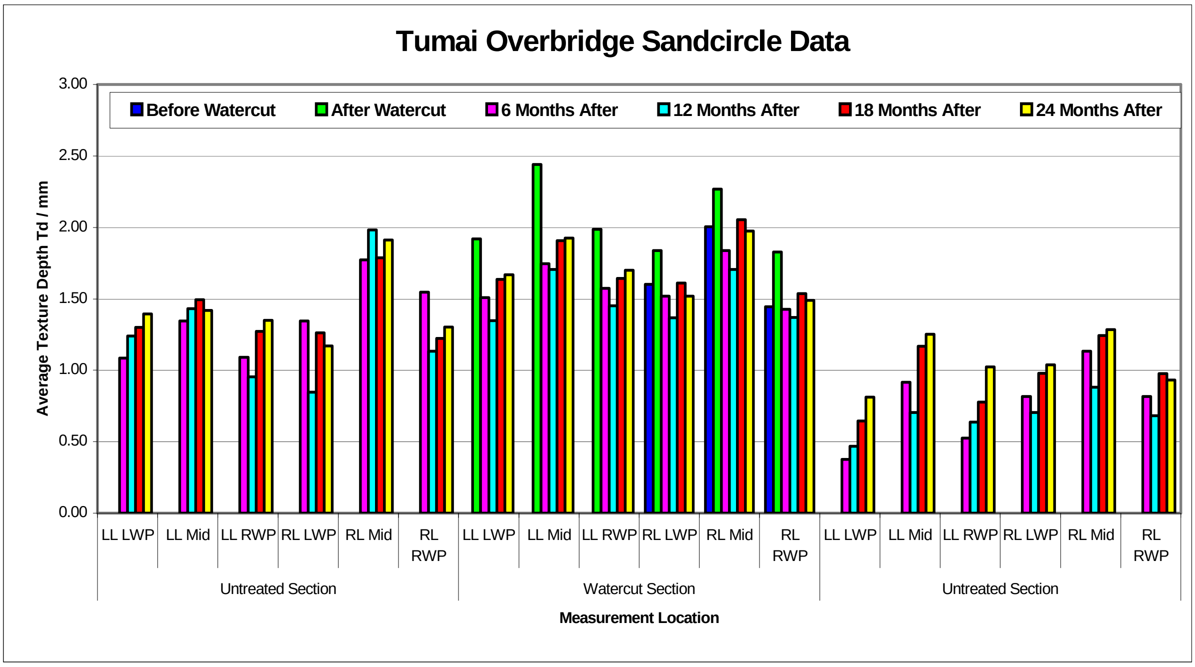
MTM macrotexture data analysis

Watercut section

- MTM measurement of the average macrotexture of the section after watercutting was 0.28 mm SMTD higher than that measured before.
- The average macrotexture 24 months after watercutting was 0.15 mm SMTD higher that that measured before the section was watercut.

Untreated sections

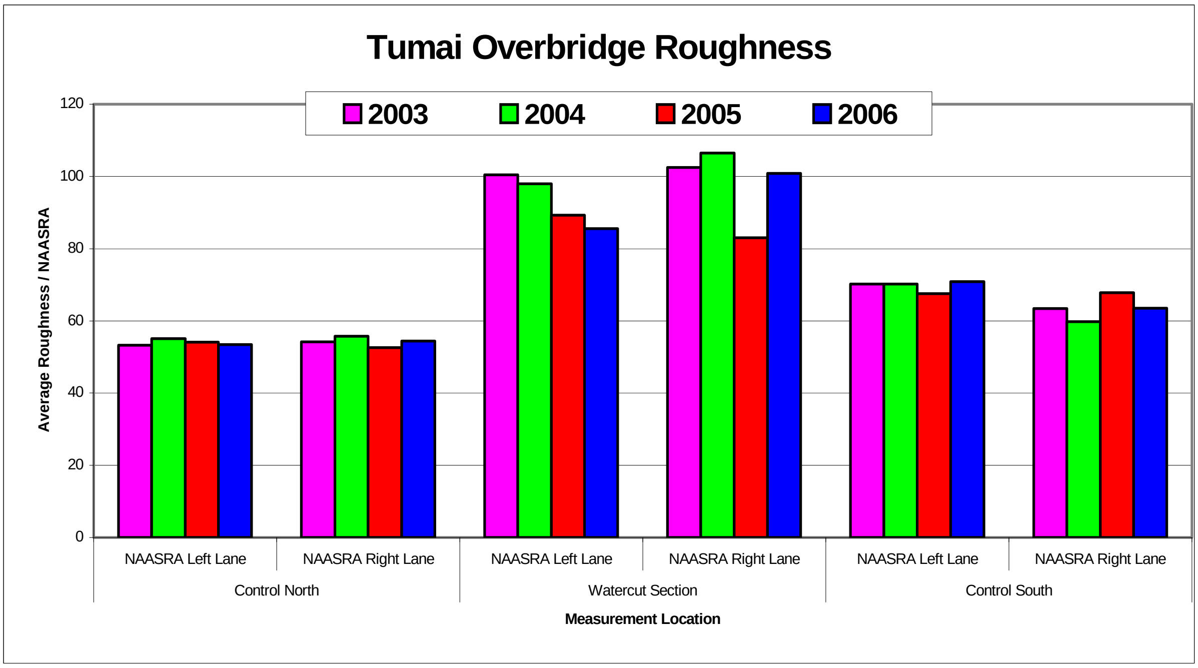
- There was a lot of variance in the results due to the short sections tested and variability of the surface so there was no conclusive data to analyse.



Sand circle data analysis

Watercut section

- Unfortunately some of the sand circle data was missing so a full analysis could not be carried out.
- Sand circle measurement of the watercut section after watercutting showed that the average macrotexture of the watercut section had increased by 0.29 mm Td.
- 24 months later sand circle testing showed that the texture had returned to levels similar to those measured on the watercut section before it was watercut.



Roughness data analysis

Watercut section

- Roughness data collected over the past four surveys showed that the average roughness for the site had reduced from 102 NAASRA before watercutting to 93 NAASRA 25 months after the site was treated.

Control sections (untreated)

- Roughness data for the control sections either side of the watercut section showed that the average roughness for the control north section was the same in 2006 as it was when measured in 2003 in both the left and right lanes.
- Roughness data for control south was one count higher in each lane when measured in the 2006 survey compared with the 2003 survey.

Aggregate polishing

The aggregate on the site had been well rounded and polished by the scrubbing nature of the slow-moving turning traffic. This left very few sharp edges on the existing surface to contribute to the hysteretic component of the surface friction. When the surface was watercut the surface of the stone was refreshed as shown by the increased microtexture.

The PSV requirement calculated using 1999 data was 55; however, the actual traffic in 2005 was higher than estimated and the required PSV for the site has now been calculated at 57. As the PSV of Oamaru Shingle sealing chip was measured at 55–56 it was not suitable for the site and the results have confirmed this. The aggressive traffic scrubbing on the tight bend and the increase in HCVs combined to produce an environment where Oamaru Shingle chip had and would continue to polish readily.

The new seal constructed using Oamaru Shingle chip was on a straight section of road requiring chip with a PSV 51 so Oamaru Shingle chip was appropriate. The new chipseal site had the same traffic but very little turning and scrubbing and the Oamaru Shingle chip performed well in this situation.

Traffic counts

In December 2005 the traffic was estimated at 5796 with 21% HCV. In 1999 when the watercut site was surfaced the traffic was 3780 with 14% HCV – an increase of 130% HCV over the past seven years.

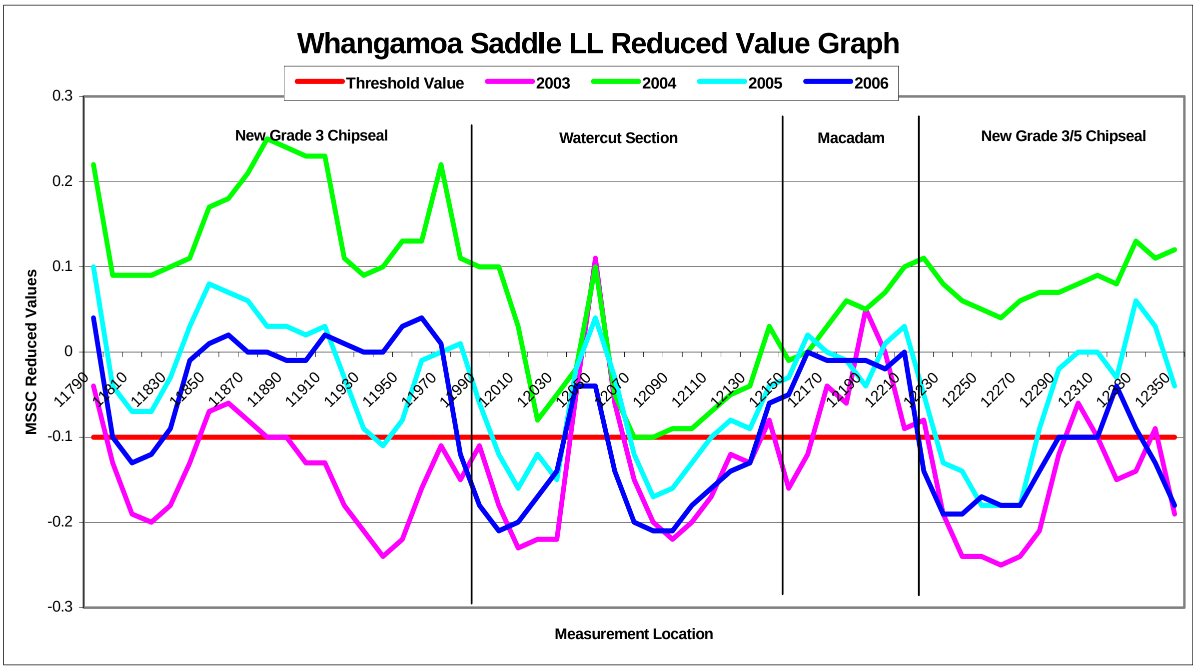
Accidents

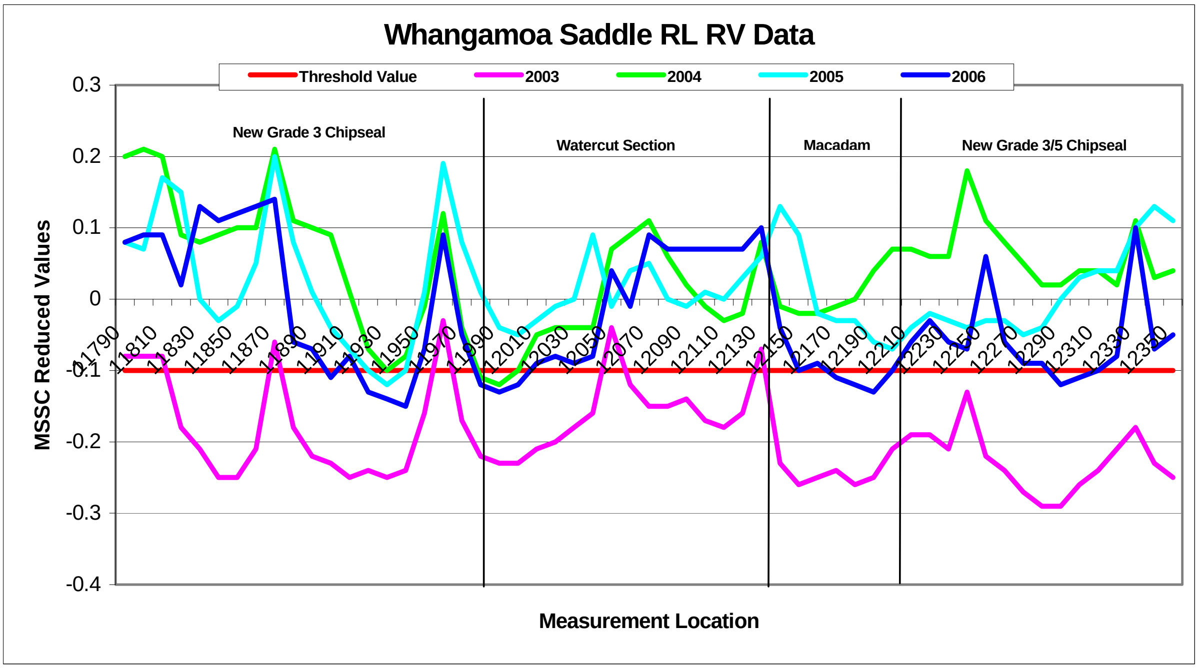
The recorded accidents remained static in 2004 with only one accident recorded for the first year after the treatment. This was the same as the year before.

In 2005 there were four reported accidents; however, two accidents happened on the northbound section where most of the surface had not been watercut due to the condition of the pavement. The other two accident sites were located on the southbound side of the large radius bend in the treated section.

In 2006 there were only two reported accidents on the site.

Appendix 8: Site 3 Whangamoa Saddle monitoring data





Reduced value data analysis

Left lane

New grade 3 chipseal section

- The 2003 SCRIM+ survey 11 months before the section was resealed calculated that 100% of the section was below the IL and 90% was below the TL.
- The 2004 survey three weeks after the seal was constructed calculated that 0% of the section was below the IL and 0% was below the TL.

- The 2005 survey 12 months after the seal was constructed calculated that 48% was below the IL and 5% was below the TL.
- The 2006 survey 24 months after the seal was constructed calculated that 43% was below the IL and 24% was below the TL.

Watercut section

- The 2003 SCRIM+ survey 11 months before the section was watercut calculated that 93% of the section was below the IL and 73% was below the TL.
- The 2004 survey two weeks after the section was watercut calculated that 73% of the section was below the IL and 13% was below the TL.
- The 2005 survey 12 months after the section was watercut calculated that 93% was below the IL and 60% was below the TL.
- The 2006 survey 24 months after the section was watercut calculated that 100% was below the IL and 80% was below the TL.

Macadam section (untreated)

- The 2003 SCRIM+ survey calculated that 75% of the macadam section was below the IL and 25% was below the TL.
- The 2004 survey calculated that 13% of the macadam section was below the IL and 0% was below the TL.
- The 2005 survey calculated that 50% of the macadam section was below the IL and 0% was below the TL.
- The 2006 survey calculated that 75% of the macadam section was below the IL and 13% was below the TL.

New two-coat grades 3 and 5 chipseal section

- The 2003 SCRIM+ survey 11 months before the section was resealed calculated that 100% of the section was below the IL and 85% was below the TL.
- The 2004 survey three weeks after the seal was constructed calculated that 0% of the section was below the IL and 0% was below the TL.
- The 2005 survey 12 months after the seal was constructed calculated that 69% was below the IL and 38% was below the TL.
- The 2006 survey 24 months after the seal was constructed calculated that 100% was below the IL and 85% was below the TL.

Right lane

New grade 3 chipseal

- The 2003 SCRIM+ survey 11 months before the section was resealed calculated that 100% of the section was below the IL and 90% was below the TL.
- The 2004 survey three weeks after the seal was constructed calculated that 33% of the section was below the IL and 14% was below the TL.
- The 2005 survey 12 months after the seal was constructed calculated that 48% was below the IL and 14% was below the TL.
- The 2006 survey 24 months after the seal was constructed calculated that 52% was below the IL and 29% was below the TL.

Watercut section

- The 2003 SCRIM+ survey 11 months before the section was watercut calculated that 100% of the section was below the IL and 87% was below the TL.
- The 2004 survey two weeks after the section was watercut calculated that 60% of the section was below the IL and 7% was below the TL.
- The 2005 survey 12 months after the section was watercut calculated that 33% was below the IL and 0% was below the TL.

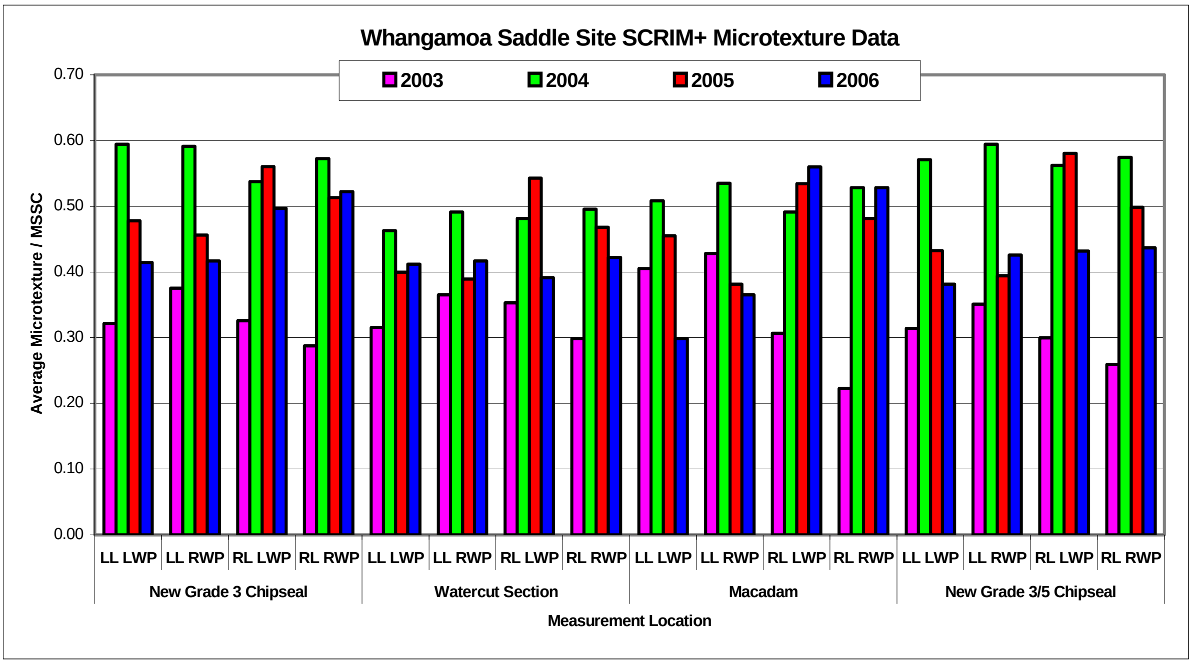
- The 2006 survey 24 months after the section was watercut calculated that 47% was below the IL and 7% was below the TL.

Macadam section (untreated)

- The 2003 SCRIM+ survey calculated that 100% of the macadam section was below the IL and 100% was below the TL.
- The 2004 survey calculated that 43% of the macadam section was below the IL and 0% was below the TL.
- The 2005 survey calculated that 86% of the macadam section was below the IL and 0% was below the TL.
- The 2006 survey calculated that 100% of the macadam section was below the IL and 71% was below the TL.

New two-coat grades 3 and 5 chipseal section

- The 2003 SCRIM+ survey 11 months before the section was resealed calculated that 100% of the section was below the IL and 100% was below the TL.
- The 2004 survey three weeks after the seal was constructed calculated that 0% of the section was below the IL and 0% was below the TL.
- The 2005 survey 12 months after the seal was constructed calculated that 50% was below the IL and 0% was below the TL.
- The 2006 survey 24 months after the seal was constructed calculated that 86% was below the IL and 21% was below the TL.



SCRIM+ microtexture data analysis

New grade 3 chipseal section

- The 2004 SCRIM+ survey two weeks after the section was sealed measured increases in the average microtexture (MSSC) (LL LWP 0.27, LL RWP 0.22, RL LWP 0.21 and RL RWP 0.29) compared with that measured 11 months previously in the 2003 survey.
- The 2006 survey measured decreases (LL LWP -0.18, LL RWP -0.17, RL LWP -0.04 and RL RWP -0.05) in the average microtexture compared with that measured after the chipsealing in 2004.

Watercut section

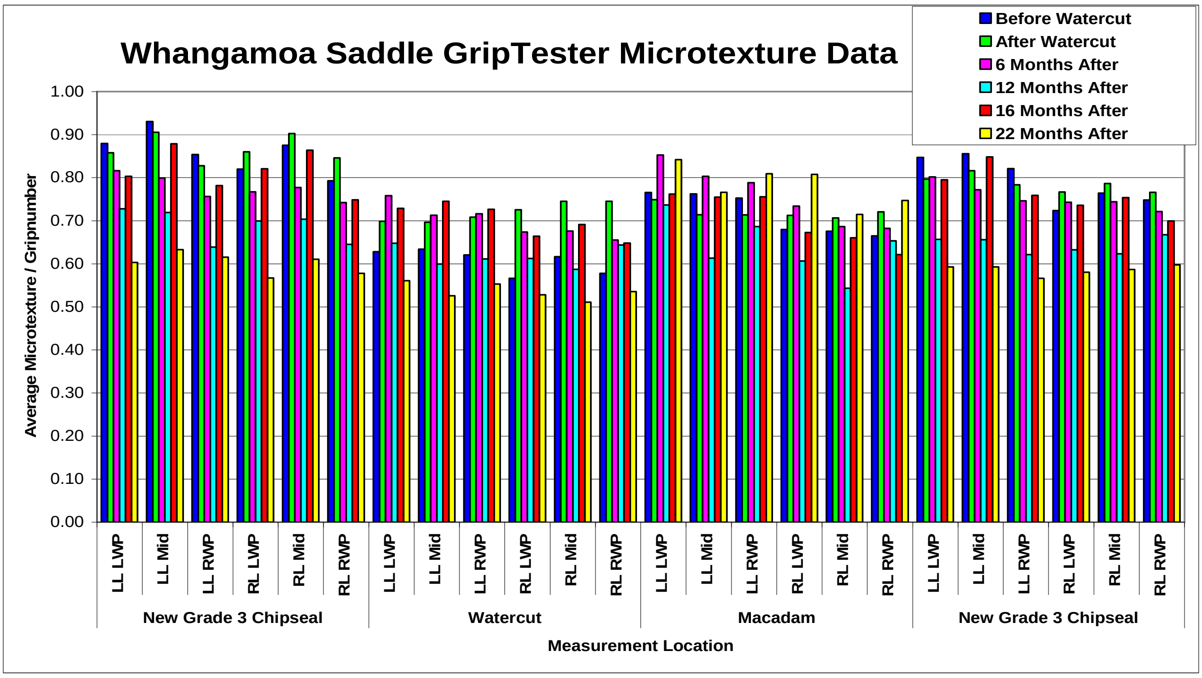
- The 2004 survey three weeks after the surface was watercut measured increases in the average microtexture (LL LWP 0.15, LL RWP 0.13, RL LWP 0.13 and RL RWP 0.20) compared with that measured 11 months before in the 2003 survey.
- The 2006 survey 24 months after the site was watercut showed that some of the microtexture improvement (LL LWP 0.10, LL RWP 0.05, RL LWP 0.04 and RL RWP 0.12) had been retained compared with the 2003 survey measurements 11 months before the section was watercut.

Macadam section

- The 2004 survey measured increases in the average microtexture (LL LWP 0.10, LL RWP 0.11, RL LWP 0.18 and RL RWP 0.31) compared with that measured 11 months before in the 2003 survey.
- The 2006 survey measured decreases (LL LWP 0.11 and, LL RWP -0.06) and increases (RL LWP 0.25 and RL RWP 0.31) in the average microtexture compared with that measured in 2003

New grades 3 and 5 chipseal section

- The 2004 SCRIM+ survey two weeks after the section was sealed measured increases in the average microtexture (MSSC) (LL LWP 0.26, LL RWP 0.24, RL LWP 0.26 and RL RWP 0.32) compared with that measured 11 months before in the 2003 survey.
- The 2006 survey measured decreases (LL LWP -0.19, LL RWP -0.17 RL LWP -0.13 and RL RWP -0.14) in the average microtexture compared with that measured after the chipsealing in 2004.



GripTester microtexture data analysis

New grade 3 chipseal section

- The GripTester survey 24 months after the seal was constructed measured a decrease in the average microtexture (GN) (LL LWP -0.25, LL Mid -0.27, LL RWP -0.21, RL LWP -0.29, RL Mid -0.29 and RL RWP -0.27) compared with that measured three weeks after the seal was constructed.

Watercut section

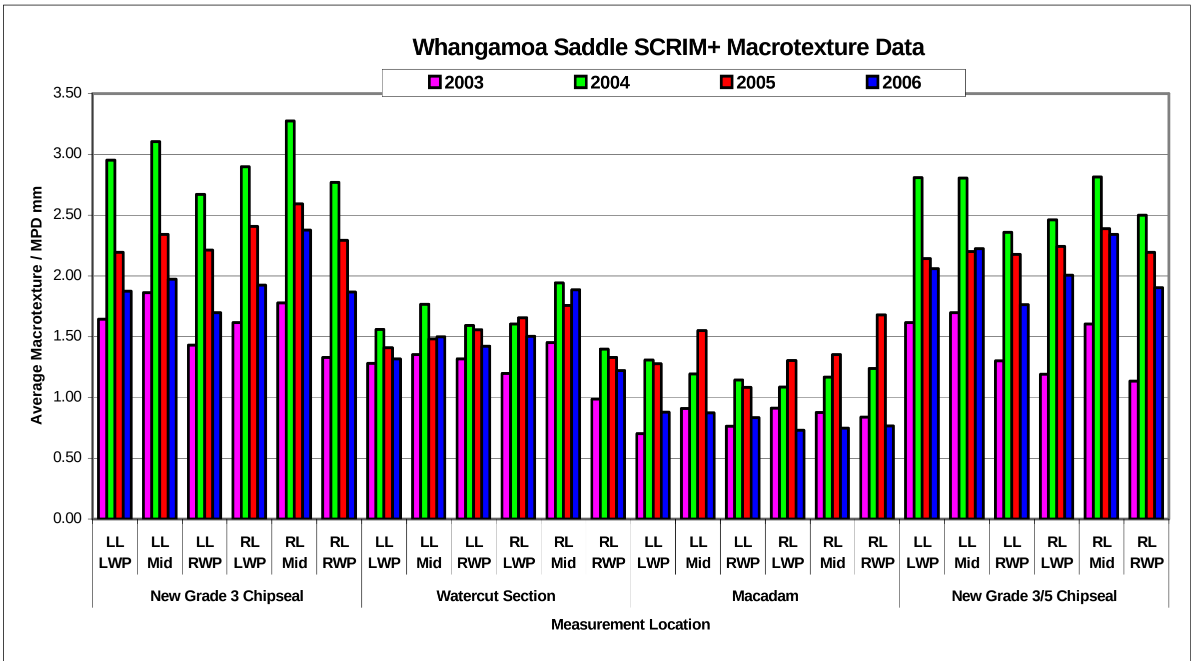
- The GripTester surveys immediately before and after the section was watercut showed an increase in the average microtexture (GN) for each location (LL LWP 0.07, LL Mid 0.06, LL RWP 0.09, RL LWP 0.16, RL Mid 0.13 and RL RWP 0.17).
- The GripTester survey 18 months after watercutting showed that the average microtexture was still higher (LL LWP 0.10, LL Mid 0.11, LL RWP 0.11, RL LWP 0.10, RL Mid 0.07 and RL RWP 0.07) than that measured immediately before the section was watercut.
- The GripTester survey 24 months after watercutting showed that the average microtexture was now less (LL LWP -0.07, LL Mid -0.11, LL RWP -0.07, RL LWP -0.04, RL Mid -0.11 and RL RWP -0.04) than that measured before the section was watercut.

Macadam section

- The GripTester survey carried out after 24 months of monitoring showed that the average microtexture on the macadam had increased (LL LWP 0.08, LL Mid 0.00, LL RWP 0.06, RL LWP 0.13, RL Mid 0.04 and RL RWP 0.08) compared with that measured 24 months earlier.

New grades 3 and 5 section

- The GripTester survey 24 months after the seal was constructed measured a decrease in the average microtexture (GN) (LL LWP -0.25, LL Mid -0.26, LL RWP -0.26, RL LWP -0.14, RL Mid -0.18 and RL RWP -0.15) compared with that measured three weeks after the seal was constructed.



SCRIM+ macrotexture data analysis

New grade 3 chipseal

- The 2004 SCRIM+ macrotexture survey three weeks after the seal was constructed showed an increase in average macrotexture (MPD) (LL LWP 1.31 mm, LL Mid 1.24 mm, LL RWP 1.24 mm, RL LWP 1.28 mm, RL Mid 1.50 mm and RL RWP 1.44 mm) in all locations compared with the 2003 survey 11 months earlier.
- The 2006 survey 24 months after the seal was constructed showed that the average microtexture had reduced in all locations (LL LWP -1.08 mm, LL Mid -1.13 mm, LL RWP -0.97 mm, RL LWP -0.97 mm, RL Mid -0.90 mm and RL RWP -0.90 mm) compared with the 2004 survey.

Watercut section

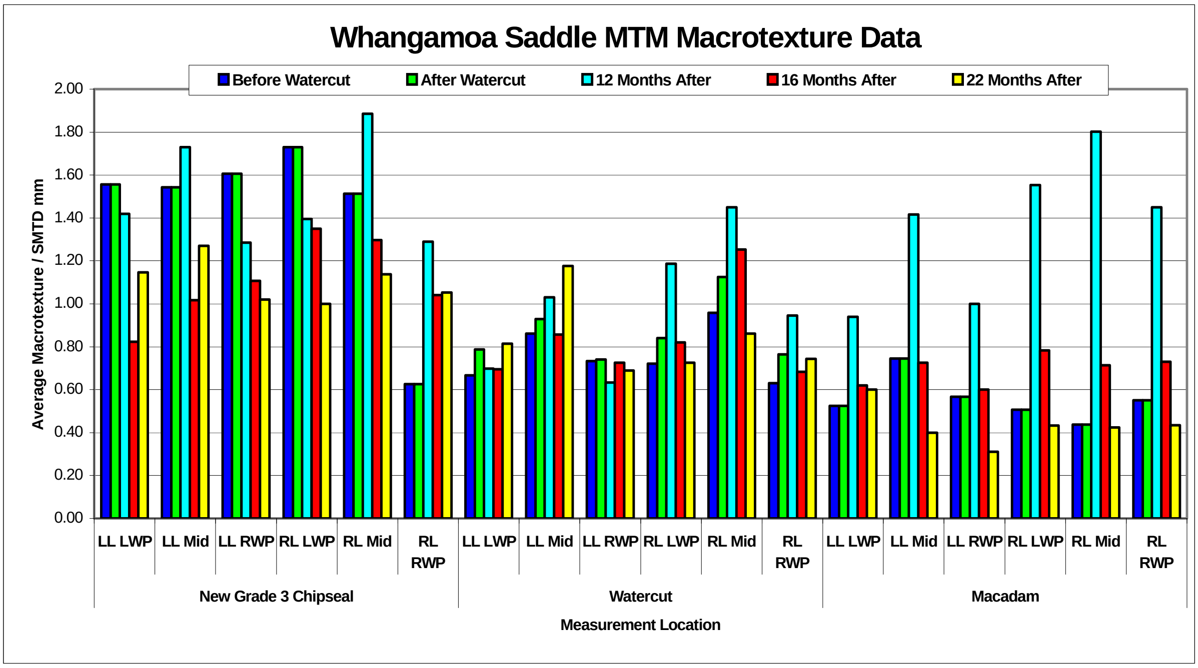
- The 2004 SCRIM+ macrotexture survey two weeks after the section was watercut showed an increase in average macrotexture (MPD) (LL LWP 0.28 mm, LL Mid 0.41 mm, LL RWP 0.28 mm, RL LWP 0.41 mm, RL Mid 0.49 mm and RL RWP 0.41 mm) in all locations compared with the 2003 survey 11 months earlier.
- The 2006 survey 24 months after the seal was constructed showed that the average microtexture had reduced in all locations (LL LWP -0.24 mm, LL Mid -0.27 mm, LL RWP -0.17 mm, RL LWP -0.10 mm, RL Mid -0.06 mm and RL RWP -0.17 mm) compared with the 2004 survey.

Macadam section

- The macrotexture surveys on this section showed some variability of the average macrotexture (MPD) for all locations across the untreated surface. The comparison between the 2006 and 2003 surveys showed a general decrease in most locations (LL LWP 0.18 mm, LL Mid -0.04 mm, LL RWP 0.07 mm, RL LWP -0.18 mm, RL Mid -0.13 mm and RL RWP -0.07 mm).

New grades 3 and 5 chipseal section

- The 2004 SCRIM+ macrotexture survey three weeks after the seal was constructed showed an increase in average macrotexture (MPD) (LL LWP 1.19 mm, LL Mid 1.11 mm, LL RWP 1.06 mm, RL LWP 1.27 mm, RL Mid 1.21 mm and RL RWP 1.36 mm) in all locations compared with the 2003 survey 11 months earlier.
- The 2006 survey 24 months after the seal was constructed showed that the average microtexture had reduced in all locations (LL LWP -0.75 mm, LL Mid -0.58 mm, LL RWP -0.60 mm, RL LWP -0.45 mm, RL Mid -0.47 mm and RL RWP -0.60 mm) compared with the 2004 survey.



MTM macrotexture data analysis

New grade 3 chipseal

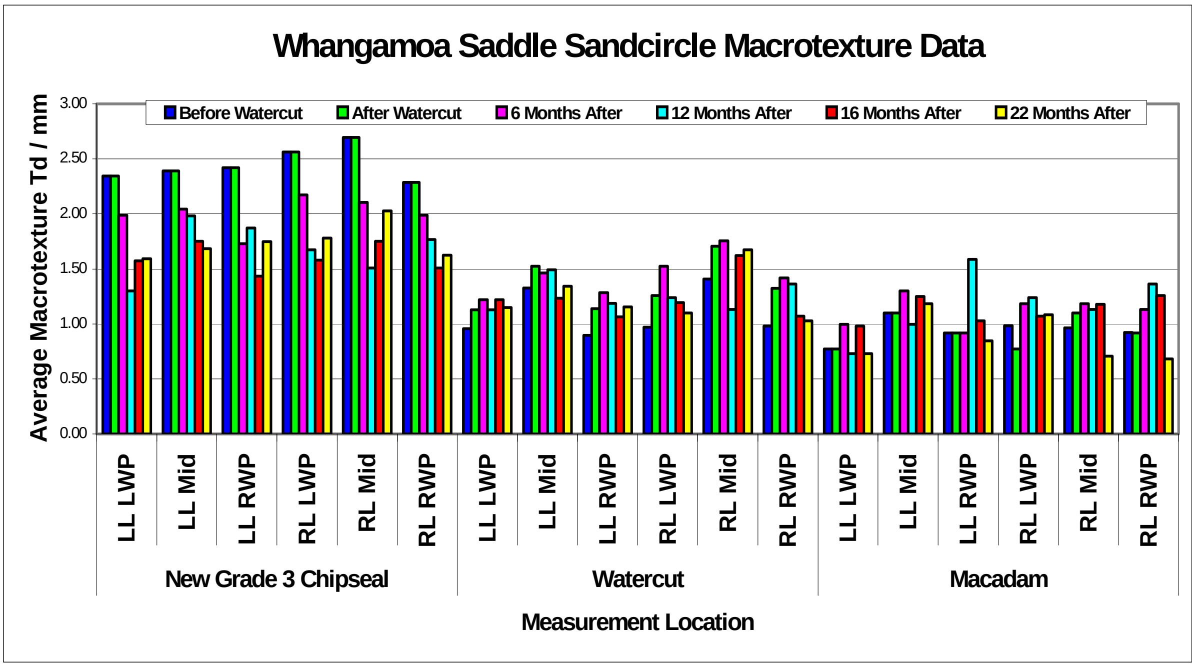
- MTM testing 24 months after seal construction on the short section of new seal adjacent to the watercut section showed that there had been a decrease in the average macrotexture (SMTD) (LL LWP -0.41, LL Mid -0.27, LL RWP -0.59, RL LWP -0.73 and RL Mid -0.38) and an increase (RL RWP 0.43) compared with the measurements taken three weeks after seal construction.

Watercut section

- MTM testing immediately before and after watercutting showed the average macrotexture (SMTD) had increased in all locations (LL LWP 0.12, LL Mid 0.07, LL RWP 0.01, RL LWP 0.12, RL Mid 0.17 and RL RWP 0.13) across the road.
- MTM testing 18 months after watercutting showed that most of the average macrotexture improvement had gone (LL LWP -0.09, LL Mid -0.07, LL RWP -0.01, RL LWP -0.02, RL Mid 0.13 and RL RWP -0.08) when compared with the MTM testing completed after watercutting.

Macadam section

- MTM testing on this section show some variability of the average macrotexture (SMTD) for all locations across the surface without any treatment on the surface. The comparison between the 24 month and initial testing surveys showed an increase (LL LWP 0.08 mm) and a decrease in the other location (LL Mid -0.35 mm, LL RWP -0.26 mm, RL LWP -0.07 mm, RL Mid -0.01 mm and RL RWP -0.12 mm).



Sand circle macrotexture data analysis

New grade 3 chipseal section

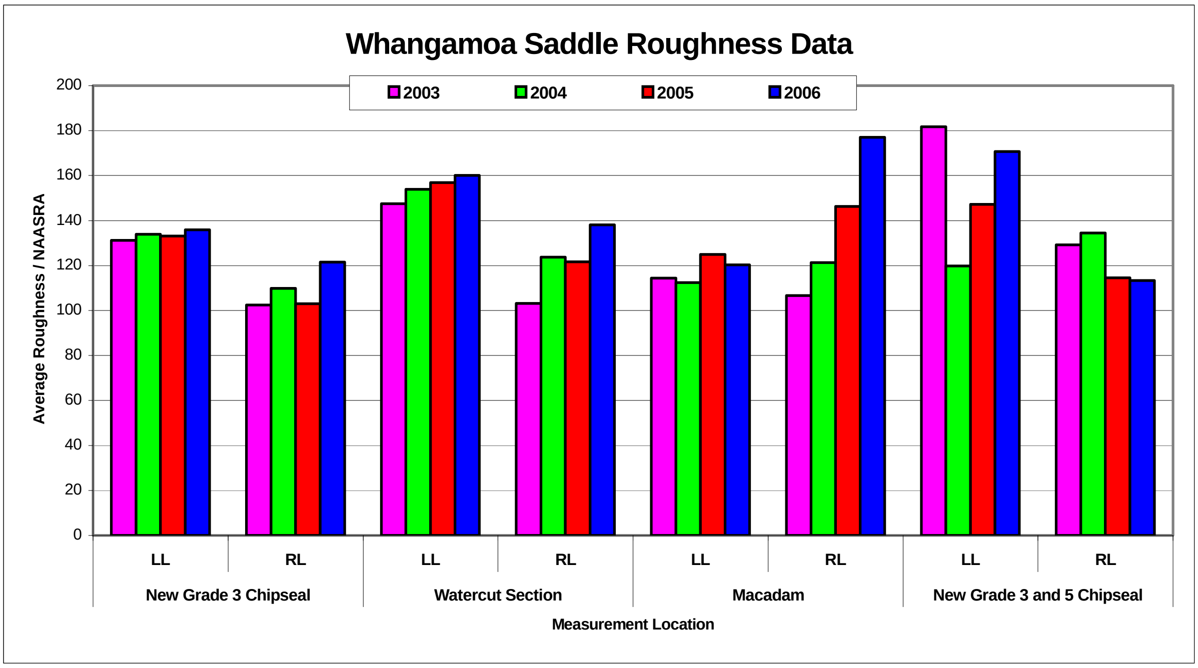
- Sand circles measured over the 24 months of monitoring showed that the average macrotexture (Td) had decreased (LL LWP -0.75 mm, LL Mid -0.71 mm, LL RWP -0.67 mm, RL LWP -0.78 mm, RL Mid -0.67 mm and RL RWP -0.66 mm) when comparing the sand circles 24 months after the seal was constructed with those taken three weeks after construction

Watercut section

- Sand circles measured immediately before and after the watercutting showed a small increase in the average macrotexture (Td) (LL LWP 0.17 mm, LL Mid 0.20 mm, LL RWP 0.24 mm, RL LWP 0.29 mm, RL Mid 0.30 mm and RL RWP 0.35 mm).
- Sand circle monitoring 24 months after the watercutting showed that the average macrotexture had generally decreased (LL LWP 0.02 mm, LL Mid -0.18 mm, LL RWP 0.02 mm, RL LWP -0.16 mm, RL Mid -0.03 mm and RL RWP -0.29 mm) compared with that measured immediately after the watercutting.

Macadam section

- Sand circles measured over the 24 months of monitoring showed that the average macrotexture (Td) had decreased in most locations across the surface (LL LWP -0.04 mm, LL Mid 0.08 mm, LL RWP -0.07 mm, RL LWP 0.31 mm, RL Mid -0.38 mm and RL RWP -0.24 mm) when comparing the sand circles 24 months after the seal was constructed with those taken three weeks after construction.



SCRIM+ roughness data analysis

New grade 3 chipseal section

- The 2006 SCRIM+ roughness survey for both lanes showed an increase (left lane 5 counts, right lane 19 counts) in average roughness (NAASRA) compared with the 2004 survey measured three months before the construction of the new seal.

Watercut section

- The 2006 SCRIM+ roughness both lanes survey showed an increase (left lane 13 counts, right lane 35 counts) in average roughness (NAASRA) compared with the 2004 survey measured three months before the surface was watercut.

Macadam section

- The 2006 SCRIM+ roughness both lanes survey showed an increase (left lane 6 counts, right lane 7 counts) in average roughness (NAASRA) compared with the 2004 survey.

New grades 3 and 5 chipseal section

- The 2006 SCRIM+ roughness both lanes survey showed a decrease (left lane -11 counts, right lane -16 counts) in average roughness (NAASRA) compared to with the 2004 survey.

Aggregate polishing

The fresh crushed aggregate on the new chipseal had higher microtexture than the watercut surface. Most of the difference was probably due to the sharp edges on the fresh chips compared with the rounded edges on the older worn chips. This site had some areas with extreme polishing with small radius bends on slopes greater than 5% and even 10% in places.

The watercut surface had already been polished showing that the aggregate did not have the capability of resisting the polishing mechanism so it was polished again within 12 months. The new chip was from a different quarry but similar source rock and it was unable to resist the polishing mechanism on the tortuous alignment.

Traffic counts

There was very little change in the traffic counts during the period of monitoring; however, the 2005 traffic data showed a 40% increase in HCVs compared with 1998, the year the old surface was constructed.

Accidents

There have been no reported accidents on the watercut section since 1990.

Aggregate testing

The test results showed that the chip complied with the M/6 requirements and was a reasonably strong durable chip; the PSV was 56 similar to previous results for chip from Bartletts Quarry.

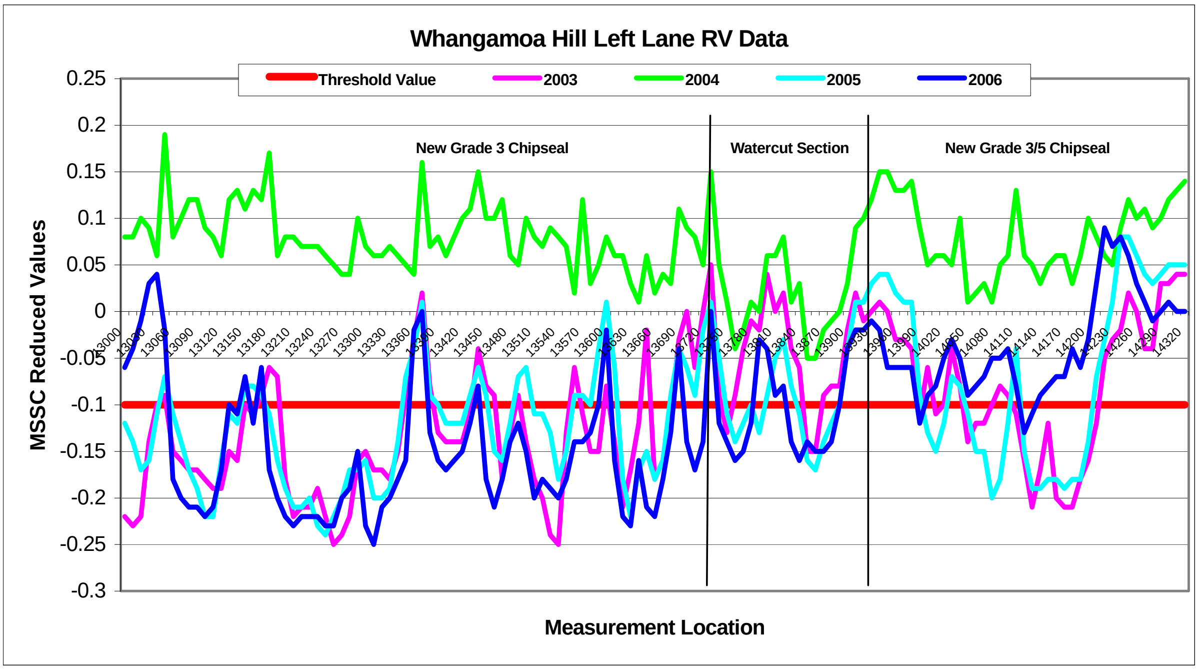
Watercut surface

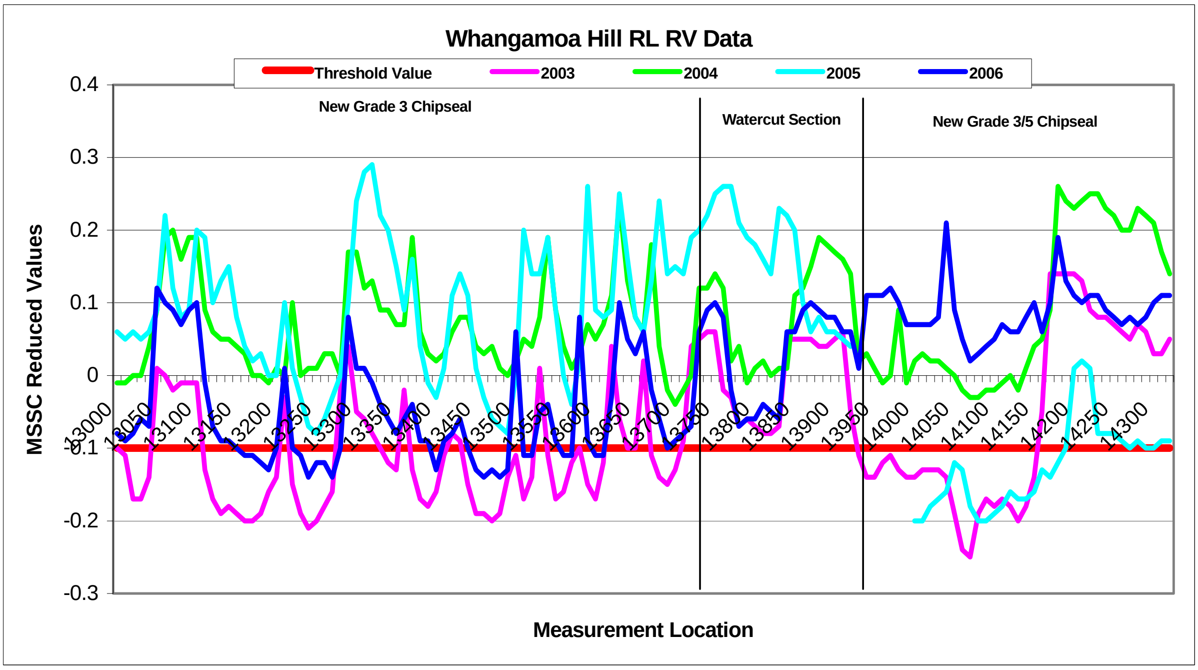
Figure A1. Whangamoa Saddle – surface before and after watercutting.

The surface (above left) before watercutting was dull and full of detritus compared with the freshly watercut surface (above right).

The site had steep banks above and below it, with frequent slips during heavy rainfall all year round. The detritus was tracked up and down the site filling the texture and contributing to the polishing of the aggregate.

Appendix 9: Site 4 Whangamoa Hill monitoring data





Reduced value data analysis

Left lane

New grade 3 chipseal section

- The 2003 survey 11 months before the section was resealed measured 95% below the IL and 71% below the TL.
- The 2004 survey one month after sealing measured 1% below the IL and 0% below the TL.
- The 2006 survey 24 months after sealing measured 95% below the IL and 63% below the TL.

Watercut section

- The 2003 SCRIM+ survey carried out 11 months before the section was watercut measured 65% below the IL and 10% below the TL.
- The 2004 survey carried out two weeks after the section was watercut measured 25% below the IL and 0% below the TL.
- The 2006 survey 25 months after the section was watercut measured 100% below the IL and 45% below the TL.

New two-coat grades 3 and 5 chipseal

- The 2003 survey 11 months before the section was resealed measured 83% below the IL and 50% below the TL.
- The 2004 survey one month after sealing measured 0% below the IL and 0% below the TL.
- The 2006 survey 24 months after sealing measured 69% below the IL and 8% below the TL.

Right lane

New grade 3 chipseal section

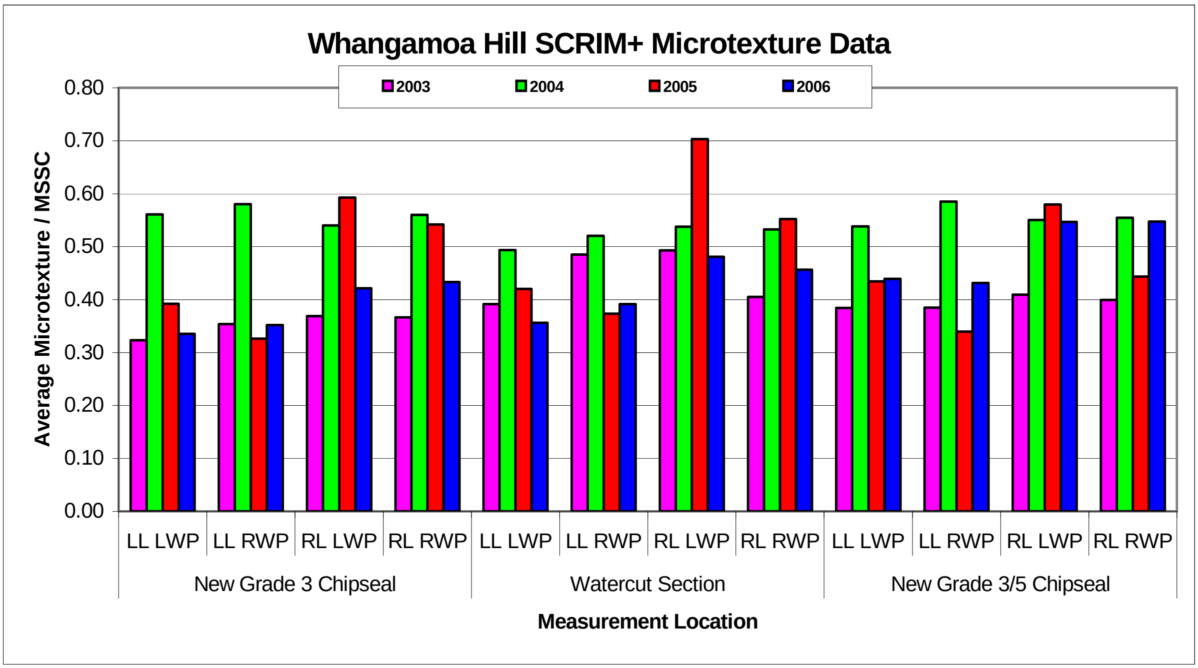
- The 2003 survey 11 months before the section was resealed measured 87% below the IL and 66% below the TL.
- The 2004 survey one month after sealing measured 6% below the IL and 0% below the TL.
- The 2006 survey 24 months after sealing measured 74% below the IL and 35% below the TL.

Watercut section

- The 2003 SCRIM+ survey carried out 11 months before the section was watercut measured 60% below the IL and 25% below the TL.
- The 2004 survey carried out 2 weeks after the section was watercut measured 10% below the IL and 0% below the TL.
- The 2006 survey 25 months after the section was watercut measured 30% below the IL and 0% below the TL.

New two-coat grades 3 and 5 chipseal

- The 2003 survey 11 months before the section was resealed measured 54% below the IL and 51% below the TL.
- The 2004 survey one month after sealing measured 23% below the IL and 0% below the TL.
- The 2006 survey 24 months after sealing measured 0% below the IL and 0% below the TL.



SCRIM+ microtexture data analysis

New grade 3 chipseal section

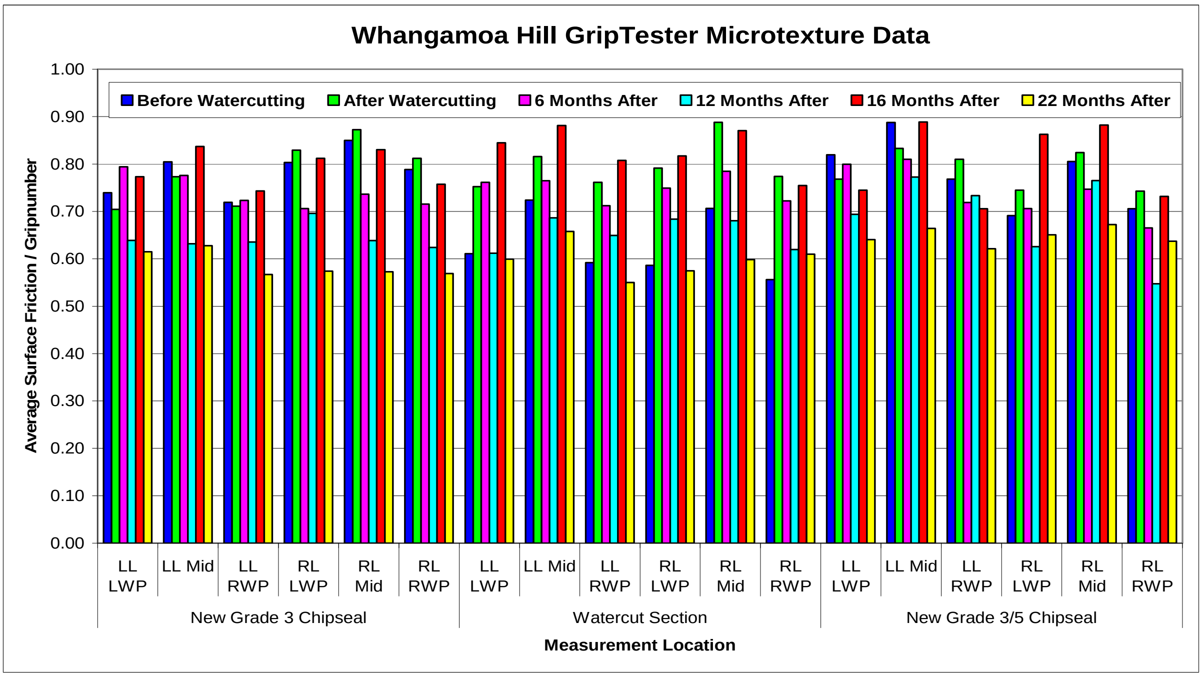
- The 2004 survey carried out one month after sealing showed the microtexture had increased in all wheelpaths compared with the 2003 survey carried out 11 months before sealing.
- The 2005 survey carried out 12 months after sealing showed that the microtexture had returned to pre-sealing levels in the left lane but was still higher in the wheelpaths of the right lane.
- The 2006 survey carried out 24 months after sealing showed that the microtexture in the left lane had returned to pre-sealing construction levels and the microtexture in the right lane was similar or higher compared with the 2003 survey.

Watercut section

- The 2004 survey carried out two weeks after watercutting measured increases in the microtexture for all wheelpaths (LL LWP 0.1 MSSC, LL RWP 0.04 MSSC, RL LWP 0.05 MSSC and RL RWP 0.13 MSSC) compared with the microtexture measured 11 months before watercutting.
- The 2005 survey carried out 12 months after watercutting showed that the microtexture for the site was still higher in the right lane and lower in the left lane than that measured in the 2004 survey.
- The 2006 survey carried out 24 months after watercutting showed that only the RL RWP surface had microtexture higher (0.0.5 MSSC) than that measured before the site was watercut.

New two-coat grades 3 and 5 chipseal section

- The 2004 survey carried out one month after sealing showed that the microtexture had increased in all wheelpaths compared with the 2003 survey carried out 11 months before sealing.
- The 2005 survey carried out 12 months after sealing showed that the microtexture had returned to the levels measured before the sealing in all wheelpaths apart from the RL LWP where it remained higher.
- The 2006 survey showed that the microtexture in all wheelpaths was higher than that measured 11 months before sealing (LL LWP 0.05 MSSC, LL RWP 0.05 MSSC, RL LWP 0.14 MSSC and RL RWP 0.15 MSSC).



GripTester microtexture data analysis

New Grade 3 chipseal

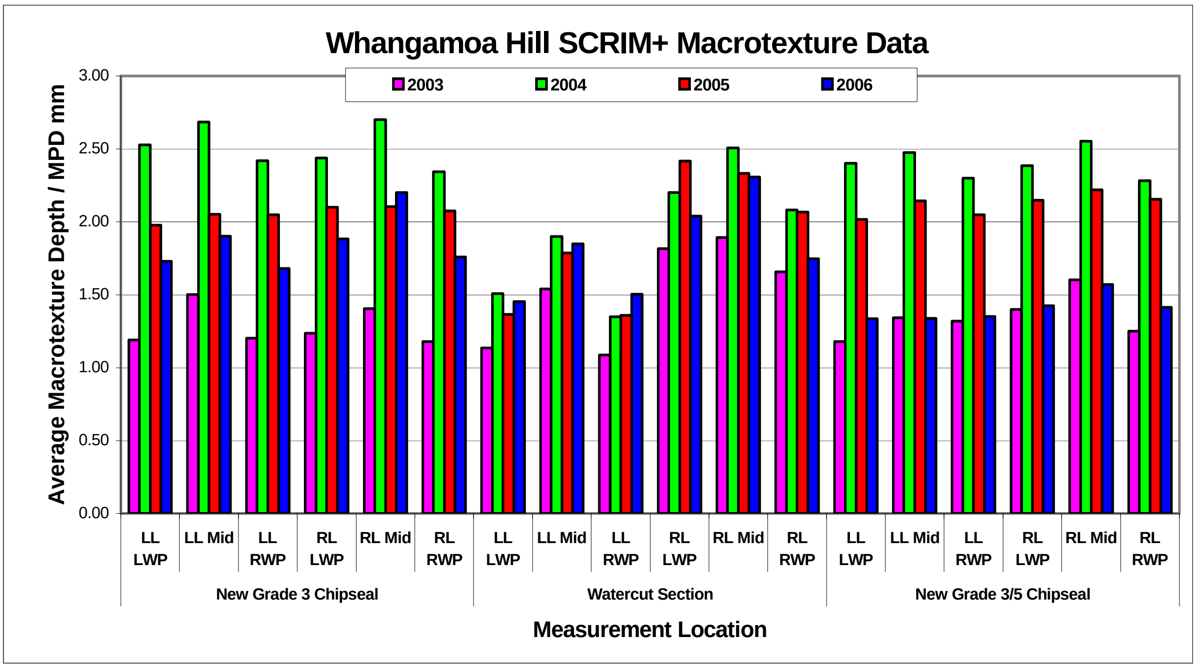
- Griptesting six months after the section was chipsealed showed that the microtexture had decreased in the right lane and increased in the left lane compared with that measured six months previously.
- Griptesting 12 months after the section was chipsealed showed that the microtexture had decreased compared with that measured 12 months before (LL LWP -0.07 gripnumbers, LL Mid -0.14, LL RWP -0.08, RL LWP -0.13, RL Mid -0.23 and RL RWP -0.19).
- Griptesting 22 months after the section was chipsealed showed that the microtexture had further decreased compared with that measured 22 months earlier just after sealing (LL LWP -0.09 gripnumbers, LL Mid -0.15, LL RWP -0.14, RL LWP -0.26, RL Mid -0.30 and RL RWP -0.24).

Watercut section

- Griptesting immediately before and after watercutting showed an increase in microtexture in all measurement locations (LL LWP 0.14 gripnumbers, LL Mid 0.09, LL RWP 0.17, RL LWP 0.21, RL Mid 0.18 and RL RWP 0.22).
- Griptesting six months after watercutting showed that the microtexture had decreased in most locations but was still higher than that measured immediately before watercutting (LL LWP 0.15 gripnumbers, LL Mid 0.04, LL RWP 0.12, RL LWP 0.16, RL Mid 0.08 and RL RWP 0.17).
- Griptesting 12 months after watercutting showed that the microtexture had returned to pre-watercutting levels.
- Griptesting 16 months after watercutting measured return to levels similar to that measured immediately after watercutting.
- Griptesting 22 months after watercutting showed that the microtexture was below that measured just before the section was watercut in all locations apart from the RL RWP.

New two-coat grades 3 and 5 chipseal

- Griptesting showed that the microtexture had increased and decreased in a manner similar to that of the single-coat seal and 22 months after chipsealing the microtexture had decreased (LL LWP -0.13 gripnumbers, LL Mid -0.17, LL RWP -0.19, RL LWP -0.09, RL Mid -0.15 and RL RWP -0.11).



SCRIM+ macrotexture data analysis

New grade 3 chipseal section

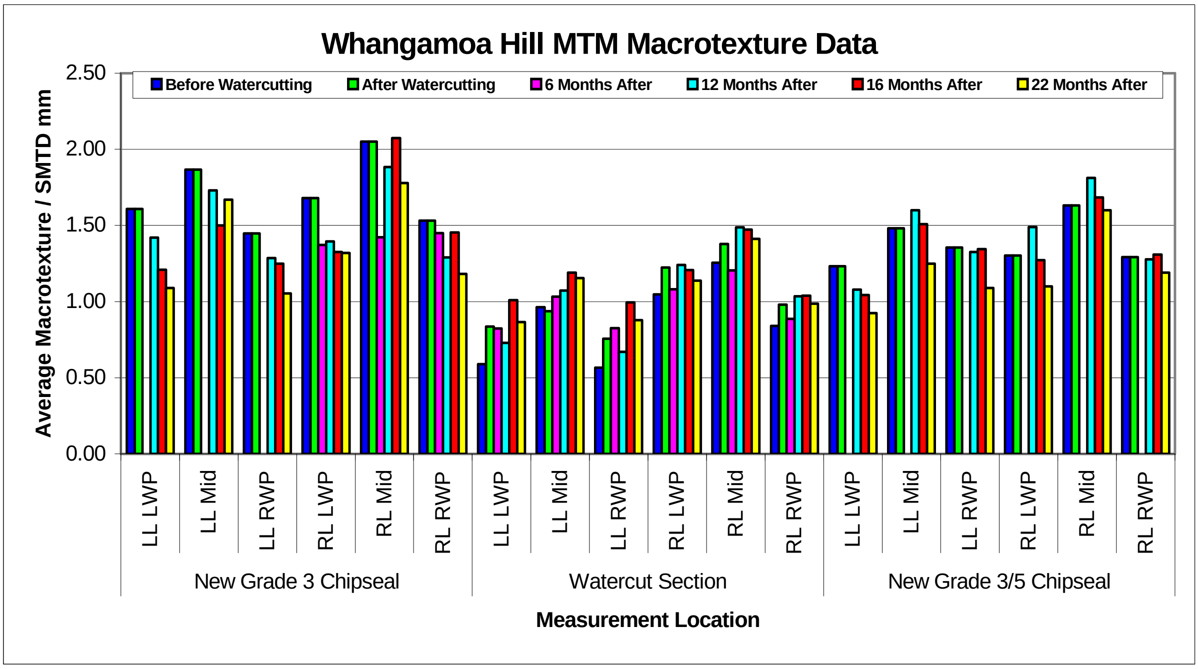
- The 2004 survey measured three weeks after chipsealing showed that the macrotexture had increased compared with that measured on the site 11 months before the resealing.
- The 2005 survey showed that compared with the 2004 survey the macrotexture had decreased (LL LWP -0.55 mm MPD, LL Mid -0.63, LL RWP -0.37, RL LWP -0.34, RL Mid -0.60 and RL RWP -0.27).
- The 2006 survey showed that compared with the 2005 survey the macrotexture had decreased in all locations (LL LWP -0.25 mm MPD, LL Mid -0.15, LL RWP -0.37, RL LWP -0.22 and RL RWP -0.32) apart from the RL Mid that showed a small increase of 0.10 mm MPD.

Watercut section

- The 2004 survey measured two weeks after the site was watercut showed increases in macrotexture (LL LWP 0.37 mm MPD, LL Mid 0.36, LL RWP 0.26, RL LWP 0.39, RL Mid 0.62 and RL RWP 0.42) compared with that measured in the 2003 survey 11 months before the watercutting
- The 2006 survey 22 months after watercutting showed that the macrotexture improvement had been retained in all locations apart from the RL RWP where it had decreased to a 0.09 mm MPD higher than that measured before the watercutting.

New two-coat grades 3 and 5 chipseal section

- The 2004 survey measured three weeks after chipsealing showed large increases in macrotexture (LL LWP 1.22 mm MPD, LL Mid 1.13, LL RWP 0.98, RL LWP 0.99, RL Mid 0.95 and RL RWP 1.03) compared with the 2003 survey measured 11 months before the resealing.
- The 2006 survey measured 24 months after the chipseal construction showed that the macrotexture had returned to levels similar to those measured in 2003 before the section was chipsealed. The comparison between the 2006 survey and 2003 survey was as follows: LL LWP 0.16 mm MPD, LL Mid 0.00, LL RWP 0.03, RL LWP 0.02, RL Mid -0.03 and RL RWP 0.16.



MTM macrotexture data analysis

New grade 3 chipseal section

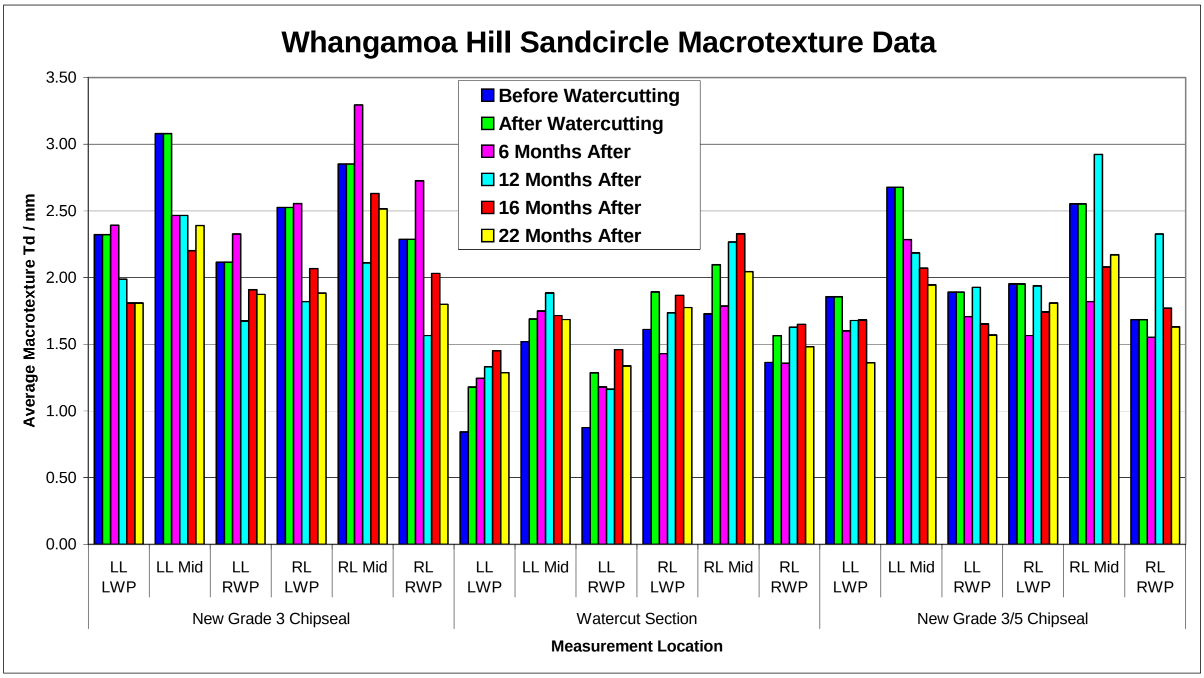
- MTM testing showed incremental decreases in the surface macrotexture over the 22 months of monitoring, so that 22 months after sealing the macrotexture had reduced in all locations across the road (LL LWP -0.52 mm SMTD, LL Mid -0.20, LL RWP -0.39, RL LWP -0.36 RL Mid -0.27 and RL RWP -0.35).

Watercut section

- The MTM measured an increase in macrotexture after watercutting apart from the LL Mid location which measured a small decrease (-0.02 mm SMTD). The increases were as follows: LL LWP 0.25 mm SMTD, LL RWP 0.19, RL LWP 0.18, RL Mid 0.12 and RL RWP 0.14.
- MTM testing 22 months after watercutting showed that the macrotexture was similar to that measured immediately after the treatment. The comparison between the 22 month testing and the after watercutting testing was as follows: LL LWP 0.03 mm SMTD, LL Mid 0.22, LL RWP 0.12, RL LWP -0.09, RL Mid 0.03 and RL RWP 0.00.

New two-coat grades 3 and 5 chipseal section

- MTM testing 22 months after sealing showed that the macrotexture had decreased compared with that measured three weeks after construction (LL LWP -0.31 mm SMTD, LL Mid -0.23, LL RWP -0.27, RL LWP -0.20, RL Mid -0.03 and RL RWP -0.10).



Sand circle data analysis

New grade 3 chipseal section

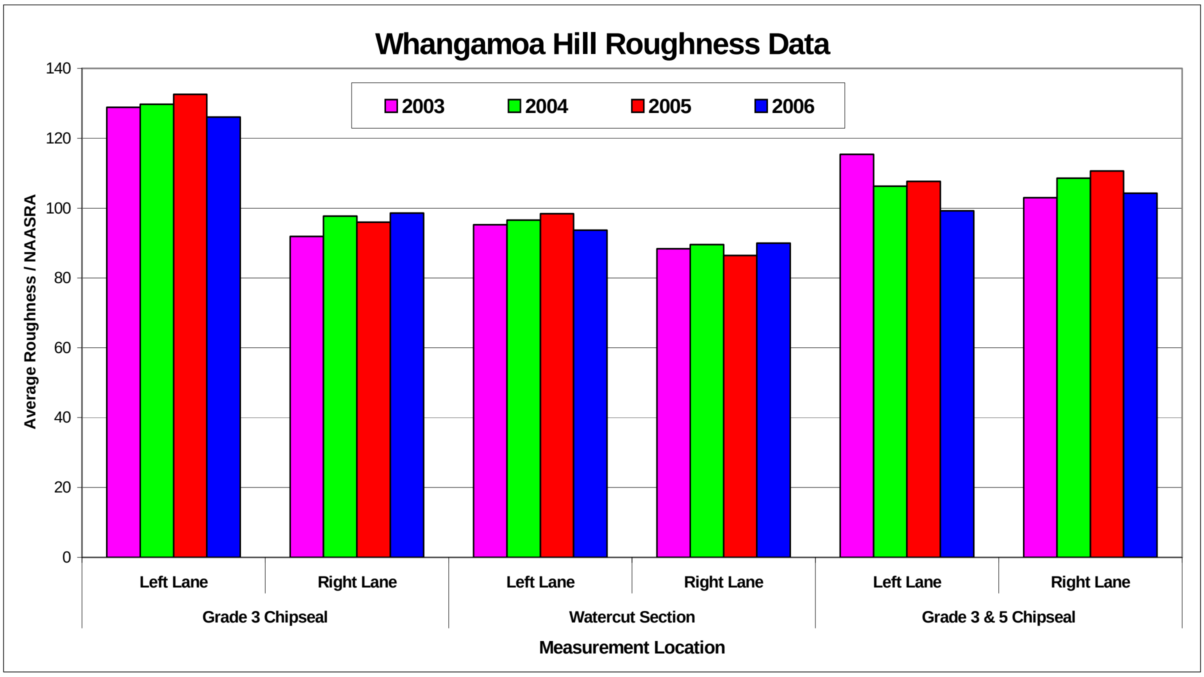
- Sand circling 22 months after the seal was constructed showed that the macrotexture had decreased (LL LWP -0.51 mm Td, LL Mid -0.69, LL RWP -0.24, RL LWP -0.64, RL Mid -0.34 and RL RWP -0.49) compared with that measured three weeks after the chipseal was constructed.

Watercut section

- Sand circle testing immediately before and after the watercutting treatment showed an increase in the macrotexture (LL LWP 0.33 mm Td, LL Mid 0.17, LL RWP 0.41, RL LWP 0.28, RL Mid 0.37 and RL RWP 0.20).
- Sand circling 22 months after the watercutting showed the macrotexture was still higher than that measured before the watercutting treatment (LL LWP 0.44 mm Td, LL Mid 0.17, LL RWP 0.46, RL LWP 0.17, RL Mid 0.32 and RL RWP 0.12).

New two-coat grades 3 and 5 chipseal section

- Sand circling 22 months after the seal was constructed showed that the macrotexture had decreased (LL LWP -0.50 mm Td, LL Mid -0.73, LL RWP -0.32, RL LWP -0.14, RL Mid -0.38 and RL RWP -0.05) compared with that measured three weeks after the chipseal was constructed.



Roughness data analysis

New grade 3 chipseal section

- The 2006 survey showed small changes of –3 NAASRA in the left lane and +7 NAASRA in the right lane compared with the 2003 survey measured 11 months before the seal was constructed.

Watercut section

- The 2006 roughness survey showed that there had been very little change in roughness compared with the 2003 survey.The change in average roughness was as follows: left lane –2 NAASRA and right lane +2 NAASRA.

New two-coat grades 3 and 5 chipseal section

- The 2006 survey showed there had been an improvement (-16 NAASRA) in the left lane and no change (1 NAASRA) compared with the 2003 survey carried out 11 months before the chipseal was constructed.

Aggregate polishing

The fresh crushed aggregate on the new chipseal had higher microtexture than the watercut surface. Most of the difference was probably due to the sharp edges on the fresh chips compared with the rounded edges on the older worn chips. This site had some areas with extreme polishing with small radius bends <250m on slopes greater than 5% and even 10% in places.

The watercut surface had already been polished showing that the aggregate did not have the capability of resisting the polishing mechanism so it was polished again within 12 months.

The new chip was from a different quarry but similar source rock and it was unable to resist the polishing mechanism on the tortuous alignment.

Traffic counts

There was very little change in the traffic counts during the period of monitoring; however, the 2005 traffic data showed a 40% increase in HCVs when compared with 1998, the year the old surface was constructed.

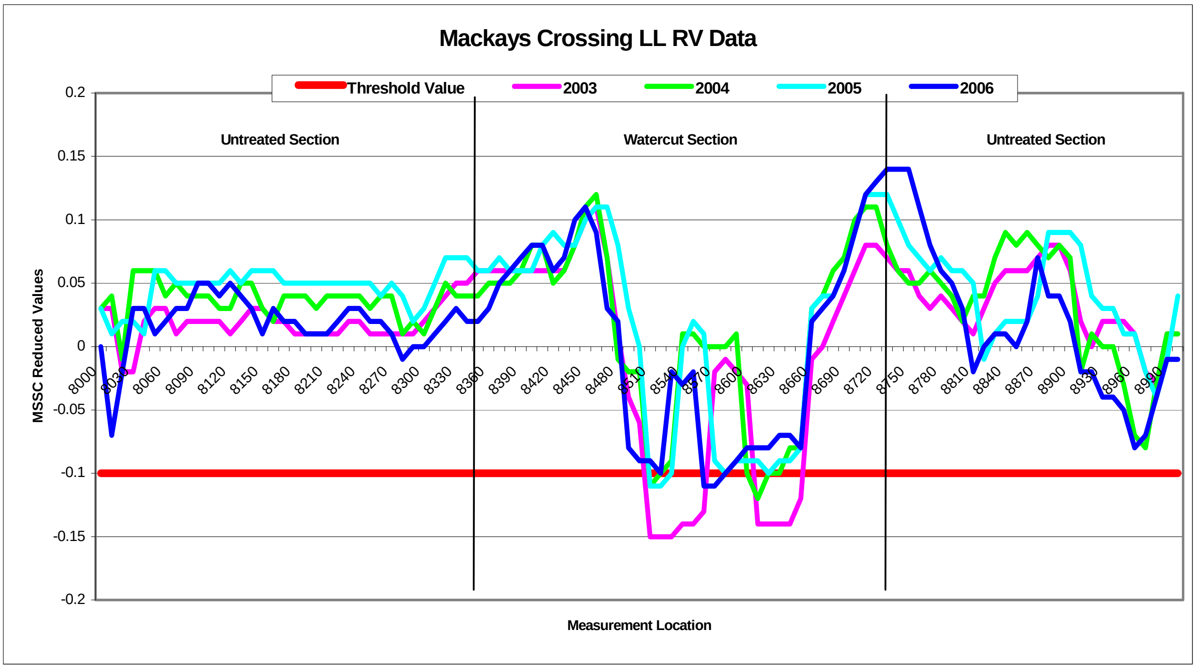
Accidents

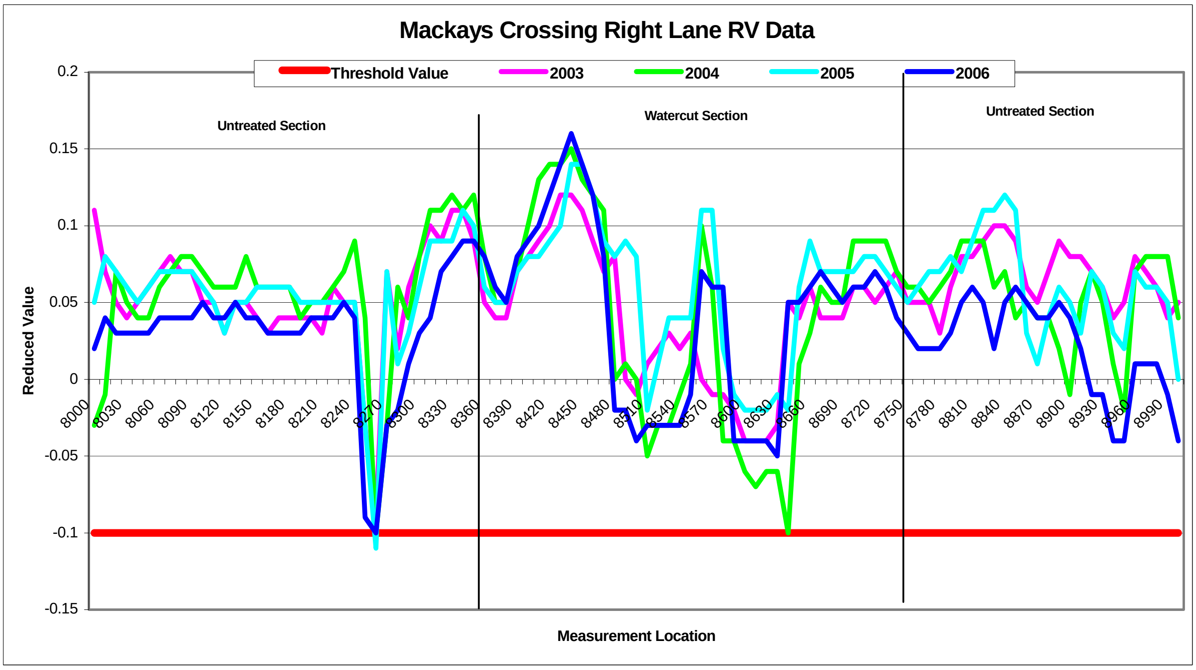
There has been one recorded accident on the Whangamoa Hill site since the watercutting treatment was carried out. This happened in 2005 and there have been no recorded accidents since then.

Aggregate testing

The test results showed that the chip complied with the M/6 requirements and was a reasonably strong durable chip; the PSV was 56 similar to previous results for chips from Bartletts Quarry.

Appendix 10: Site 5 MacKays Crossing monitoring data





Reduced value data analysis

Left lane

Watercut section

- 37% of the site was below the TL when measured in the 2003 SCRIM+ survey.
- 7% of the site was below the TL when measured in the 2004 SCRIM+ survey three months before it was watercut:

- the improvement to the surface was due to watercutting in the 2003 summer to remove excess binder
- 60% of the site was below the IL (2003 SCRIM+ survey) before the first watercut and 40% was below when measured in the 2004 SCRIM+ survey.

- The 2005 SCRIM+ survey carried out nine months after the watercutting measured 7% of the site below the TL and 40% below the IL.
- The 2006 SCRIM+ survey carried out 21 months after the watercutting measured 7% of the site below the TL and 56.7% below the IL.

Control sections

- There were no sections below the TL in the last four SCRIM+ surveys.
- The microtexture on these sites had been slowly deteriorating over the previous four years when measured in the 2006 SCRIM+ survey. The northern control section now has 7% below the IL and the southern control section has 40.7% below the IL compared with 4.7% and 7.4% respectively.

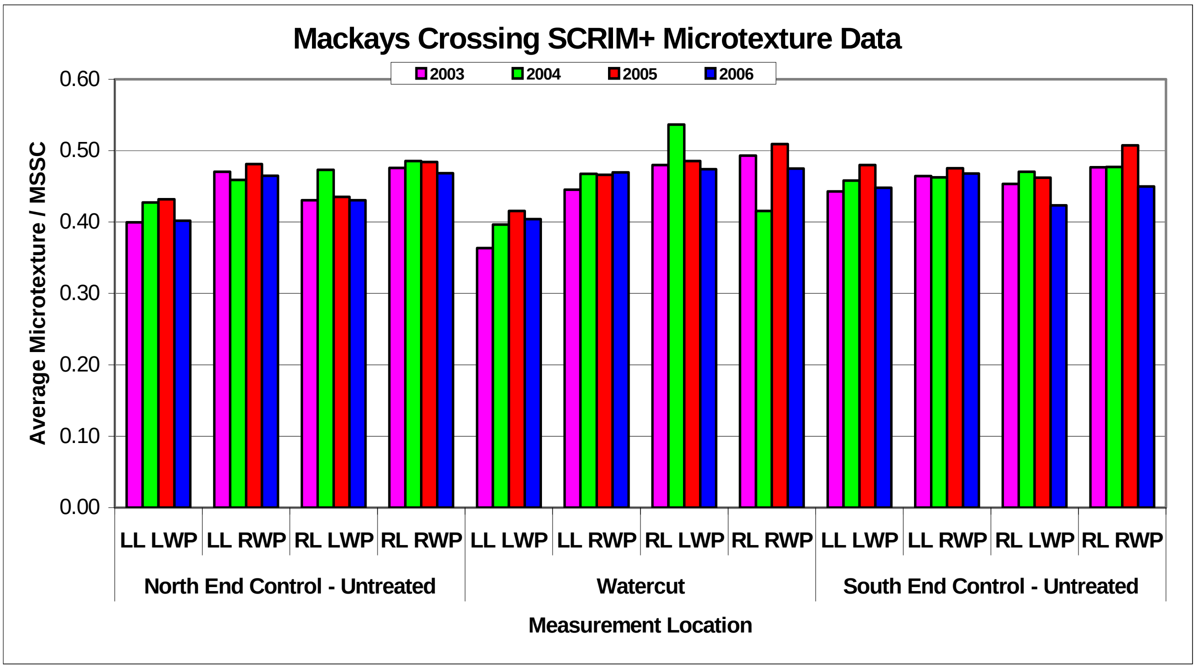
Right lane

Watercut section

- When tested in the 2004 SCRIM+ survey three months before the site was watercut one 10 m length was below the TL and 38% of the site was below the IL.
- When tested in the 2005 SCRIM+ survey nine months after watercutting there was 0% below the TL and 24% below the IL.
- 21 months after watercutting the 2006 SCRIM+ survey measured 0% below the TL and 45% below the IL.

Control sections

- The north control section had remained stable with 3% below the TL and 11% below the IL when measured in the 2004 and 2006 SCRIM+ surveys.
- The south control section had slowly deteriorated from 7% below the IL when tested in 2003 to 22% below the IL when tested in the 2006 survey with 0% 10 m lengths measuring below the TL.



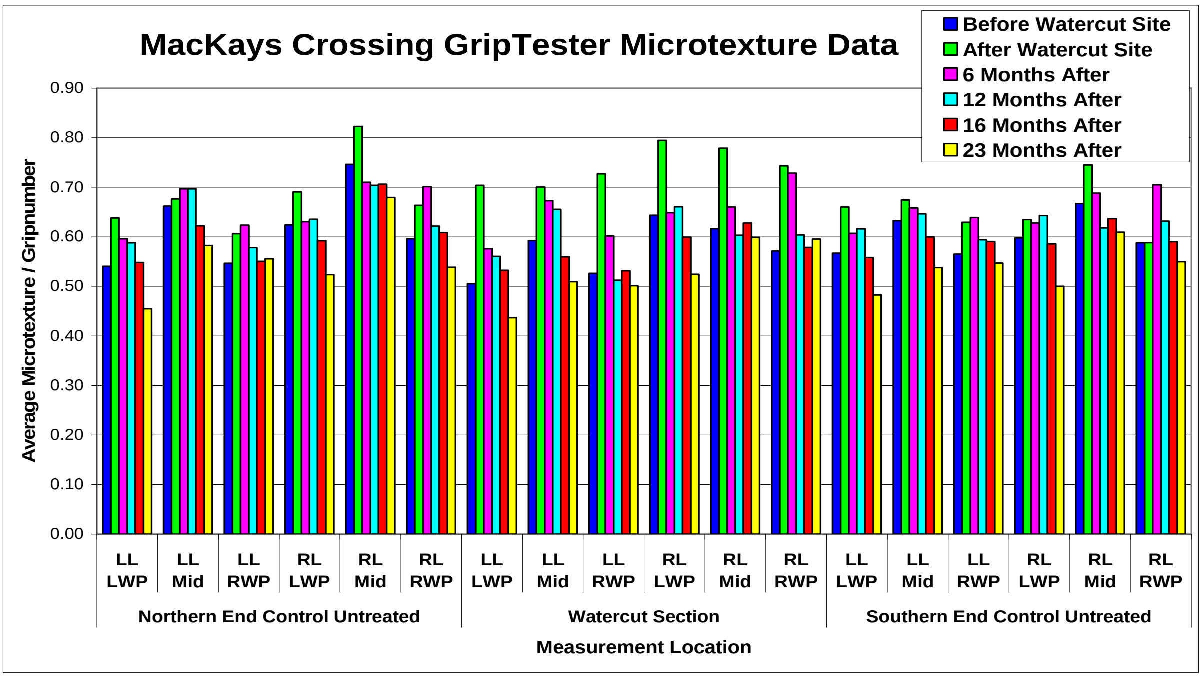
Mackays Crossing SCRIM+ microtexture data analysis

Watercut section

- The microtexture measured in the 2004 SCRIM+ survey showed some improvement on that measured in the 2003 survey:
  - this improvement was due to some binder removal carried out on targeted sections during the 2003 season
- The microtexture measured in the 2005 SCRIM+ survey nine months after the site was watercut for this project showed increases of 0.02 MSSC and 0.09 MSSC in the LL LWP and RL RWP respectively. The microtexture in the LL RWP remained the same and the RL LWP showed a decrease of 0.06 MSSC.
- The 2006 survey showed a further decrease in three wheelpaths with a small increase on the LL RWP when compared with the 2005 survey

Control sections

- The north end control section microtexture had decreased by up to 0.04MSSC between the 2004 and 2006 SCRIM+ surveys. There was no change between the 2003 and 2006 SCRIM+ surveys.
- The south end control section microtexture in the left lane measured in the 2006 SCRIM+ survey remained at similar levels to those in the 2003 and 2004 surveys.
- The south end control section microtexture in the right lane decreased by 0.05MSSC in the LWP and 0.03MSSC in the RWP when comparing the 2006 with the 2004 survey measurements.



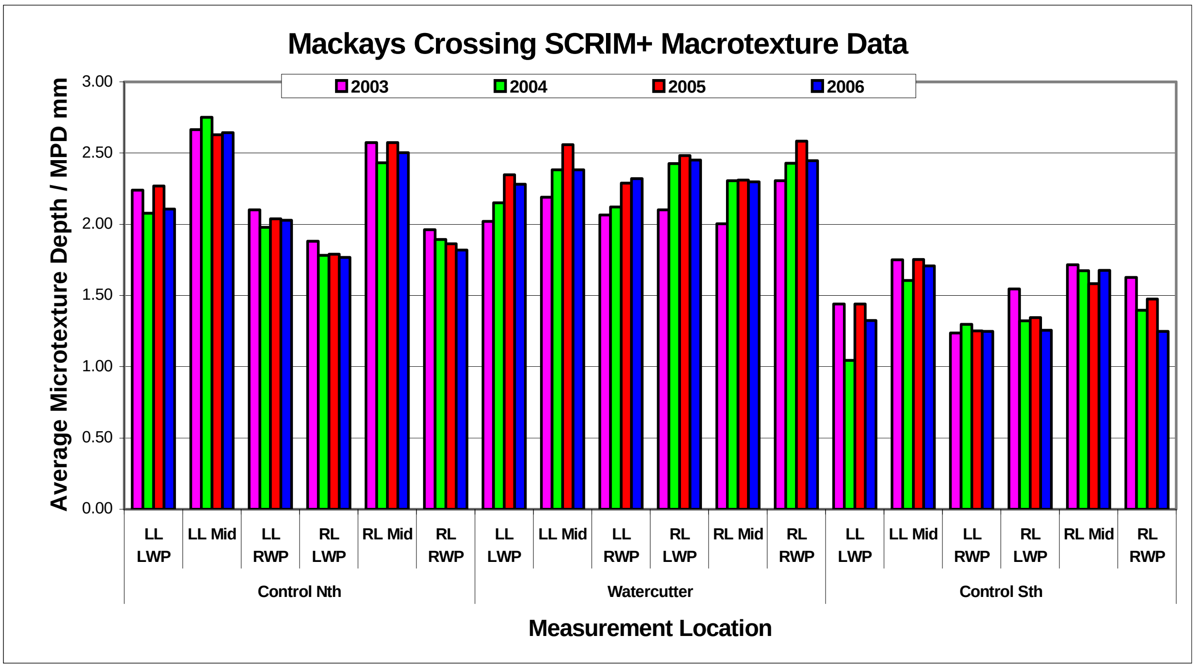
Mackays Crossing GripTester microtexture data analysis

Watercut section

- The test data showed increases in each transverse location when comparing the results from the test immediately before the watercutting of the surface with that measured immediately afterward.
- Testing six months later measured the microtexture as higher than that measured before the site was watercut:
  - the differences calculated (in gripnumbers) were as follows: LL LWP 0.07, LL Mid 0.08, LL RWP 0.08, RL LWP 0.01, RL Mid 0.04, and RL RWP 0.16.
- Testing 12 months later measured the microtexture at levels similar to those measured before the watercutting treatment.

Control sections

- The test data showed a small increase in microtexture for both controls when comparing the before and after test results:
  - the test conditions changed between the before (evening) and after (morning) tests
  - all subsequent testing was carried out between 10.00 pm and 1.00 am.
- Testing six months later showed that the microtexture on the control sections was still higher than that measured six months previously:
  - south end control differences: LL LWP 0.04, LL Mid 0.03, LL RWP 0.07, RL LWP 0.03, RL Mid 0.02 and RL RWP 0.12
  - north end control differences: LL LWP 0.06, LL Mid 0.03, LL RWP 0.08, RL LWP 0.01, RL Mid -0.04 and RL RWP 0.11
  - testing 16 months later showed that the microtexture on the control sections was now similar to or below that measured at the first testing on the site.



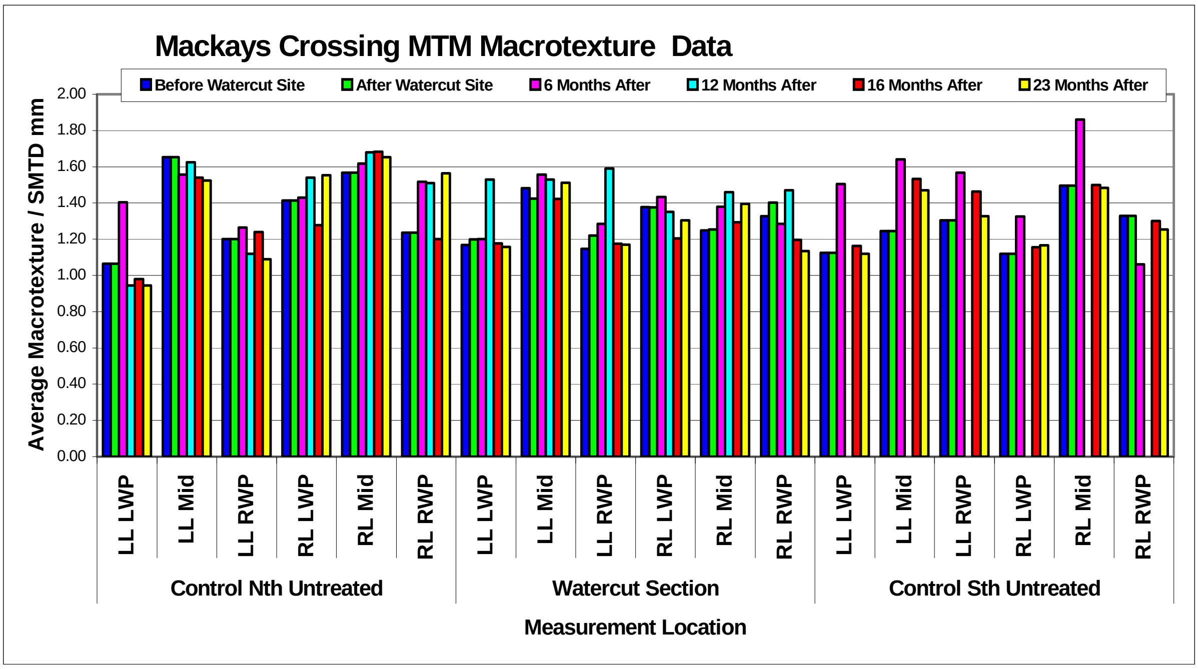
Mackays Crossing SCRIM+ macrotexture data analysis

Watercut section

- The 2004 survey showed an improvement in macrotexture after the binder removal watercutting in 2003.
- The 2005 survey carried out 10 months after the microtexture refreshment watercutting treatment showed further improvement of the macrotexture.
- The 2006 survey measured a decrease in the average macrotexture depth in all locations except the LL RWP where the average macrotexture increased by 0.03 mm MPD.

Control sections

- The macrotexture for both control sections was lower in almost all locations when comparing the 2006 survey with the 2003 survey.



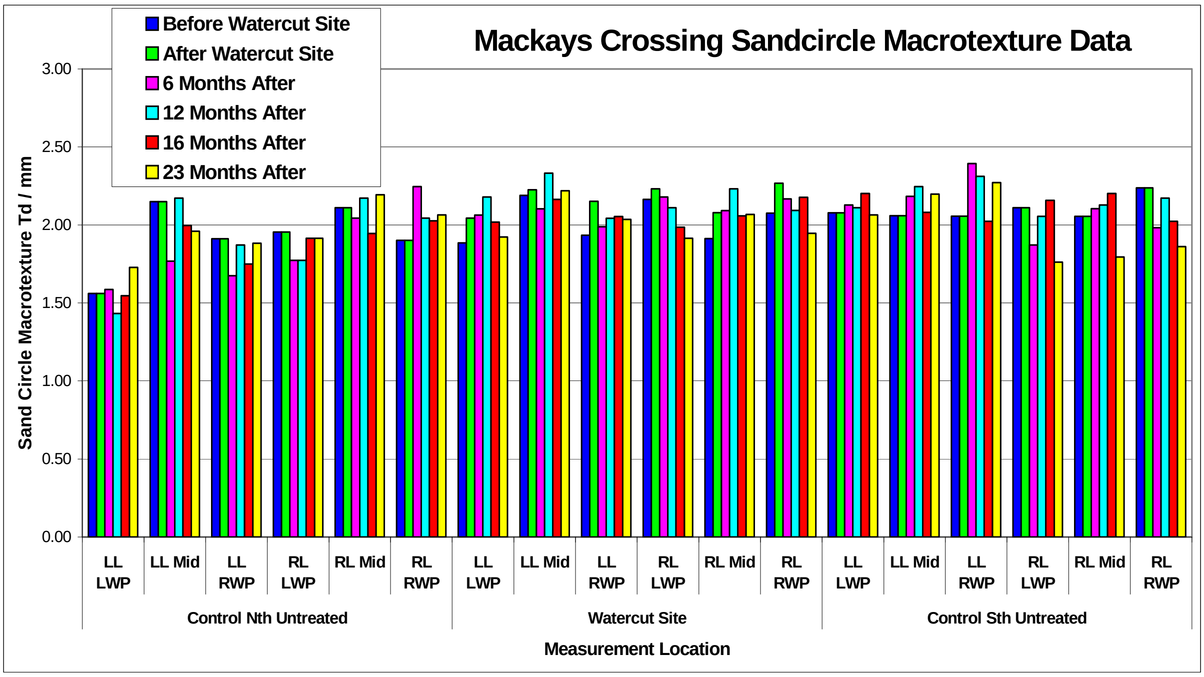
Mackays Crossing MTM macrotexture data analysis

Watercut section

- MTM testing on the surface immediately before and immediately after watercutting showed that there was very little change in the surface macrotexture.
- 24 months after watercutting the macrotexture was lower in all wheelpaths but higher between the wheelpaths.

Control section

- MTM testing on the control surfaces adjacent to the watercut section showed little change over the two years the surface was monitored.



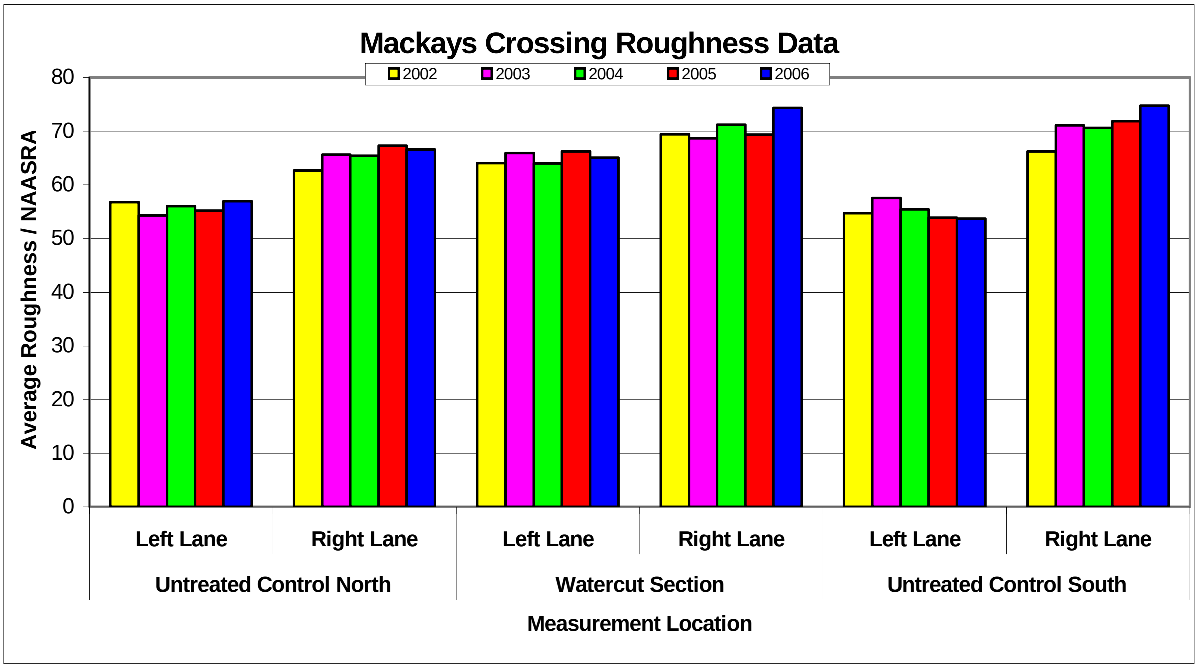
Mackays Crossing sand circle macrotexture data analysis

Watercut section

- Sand circles completed immediately before and after the surface was watercut measured small increases in the surface macrotexture.
- Sand circles 23 months after the watercutting showed that the average macrotexture in the wheelpaths in the left lane had increased by 0.4 and 0.5 mm Td, and decreased in the wheelpaths in the right lane by 0.32 mm Td.

Control sections

- Sand circles on the control sections adjacent to the watercut section 23 months later measured decreases in the macrotexture on the control south right lane and increases in the control north right lane.



Mackays Crossing roughness data analysis

Whole site

- The roughness measured on the left lane of the site remained similar over the last five surveys.
- The roughness measured on the right lane of the site showed a small increase in each of the three sections.

Aggregate polishing

The chipseal was 16 years old when watercut and the grade 3 chip was well worn with a build up of road grime in the voids (see Figure A2). The watercutting removed the grime and sharpened the surface increasing the microtexture. The site was on a short radius curve with high traffic counts that had been steadily increasing over the 16 years of the seal's life.

Otaki sealing chip currently had a PS = 55. The PSV required for the site was calculated using the IL = 0.5 and as Transit's traffic counts had ranged from 56 to 63 above the level of the chip, there was a high likelihood of the chip polishing throughout its life.

Figure A2 Watercut surface left of line and untreated 16-year-old chipseal right.

Traffic counts

Traffic counts were 16,000 AADT in 1987 and 24,233 AADT (with 7% HCV) in 2005, a 50% increase in AADT over the life of the seal to date.

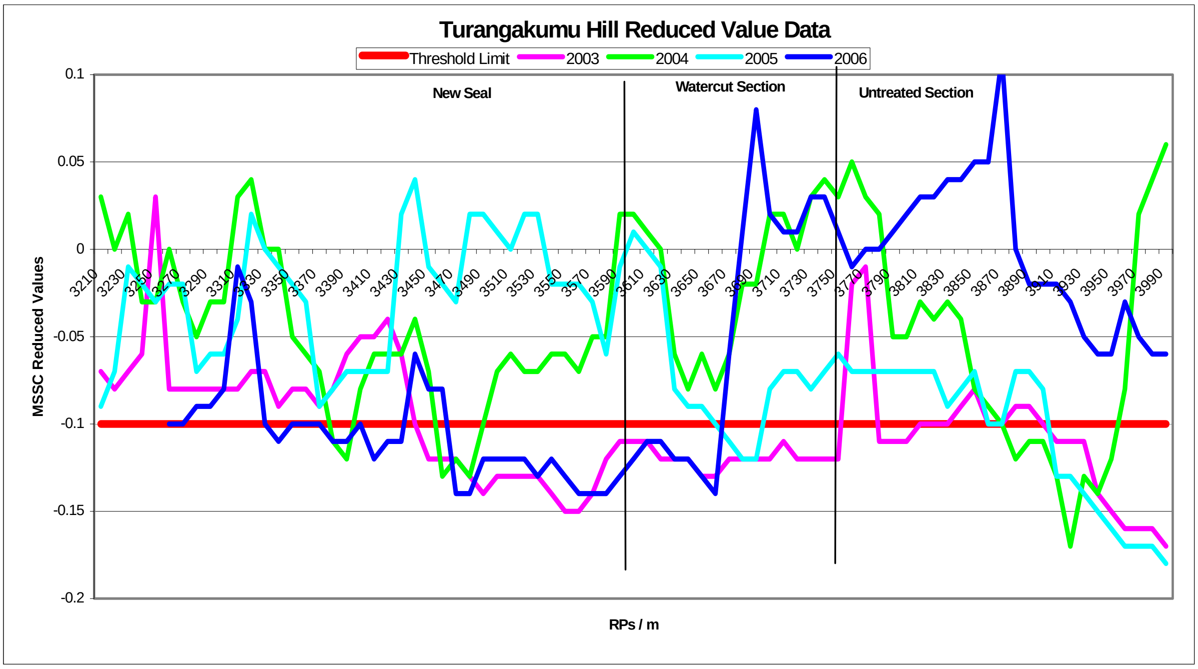
Accidents

There was one reported accident on the site after it was watercut. This occurred in 2005 with no reported accidents in 2006.

Aggregate testing

No new surfacings were constructed for this site so there were no aggregates tested.

Appendix 11: Site 6 Turangakumu Hill monitoring data



Reduced value data analysis

New chipseal section

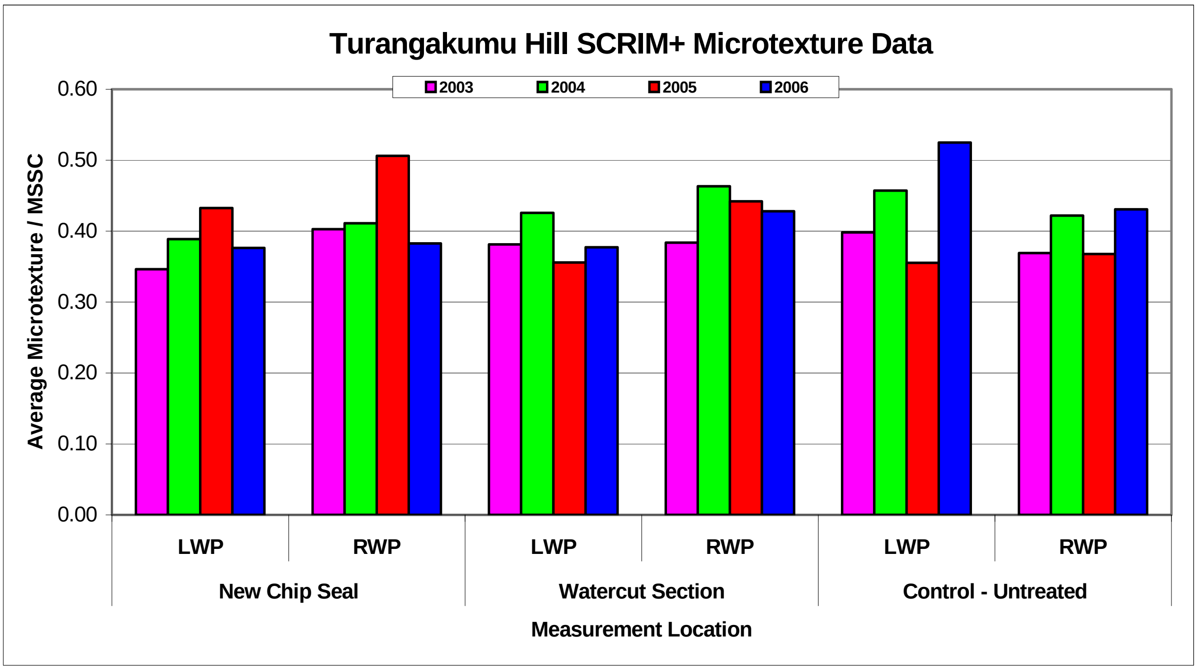
- The 2003 survey measured the new chipseal section 15 months before it was resealed, and found that 100% was below the IL and 39% below the TL.
- The 2004 survey showed that 79% was below the IL and 13% was below the TL. The data showed this measurement was completed three months before the site was resealed.
- The 2005 survey showed that 76% was below the IL and 0% was below the TL nine months after the site was resealed.
- The 2006 survey 21 months after resealing showed that 89% of the section was below the IL and 50% was below the TL.

Watercut section

- The 2003 SCRIM+ survey 15 months before the section was watercut showed 100% below the IL and 100% below the TL.
- The 2004 SCRIM+ survey showed that 44% of the watercut section was below the IL and 0% was below the TL.
- The 2005 SCRIM+ survey nine months after the section was watercut showed that 88% was below the IL and 19% was below the TL.
- The 2006 SCRIM+ survey showed that 50% was below the IL and 44% was below the TL.

Control section (untreated)

- The changes in this section could be related to a small dig out and first-coat seal in the first year of monitoring and then a large area-wide treatment constructed over the whole section before the 2006 survey was carried out.



SCRIM+ microtexture data analysis

New chip seal

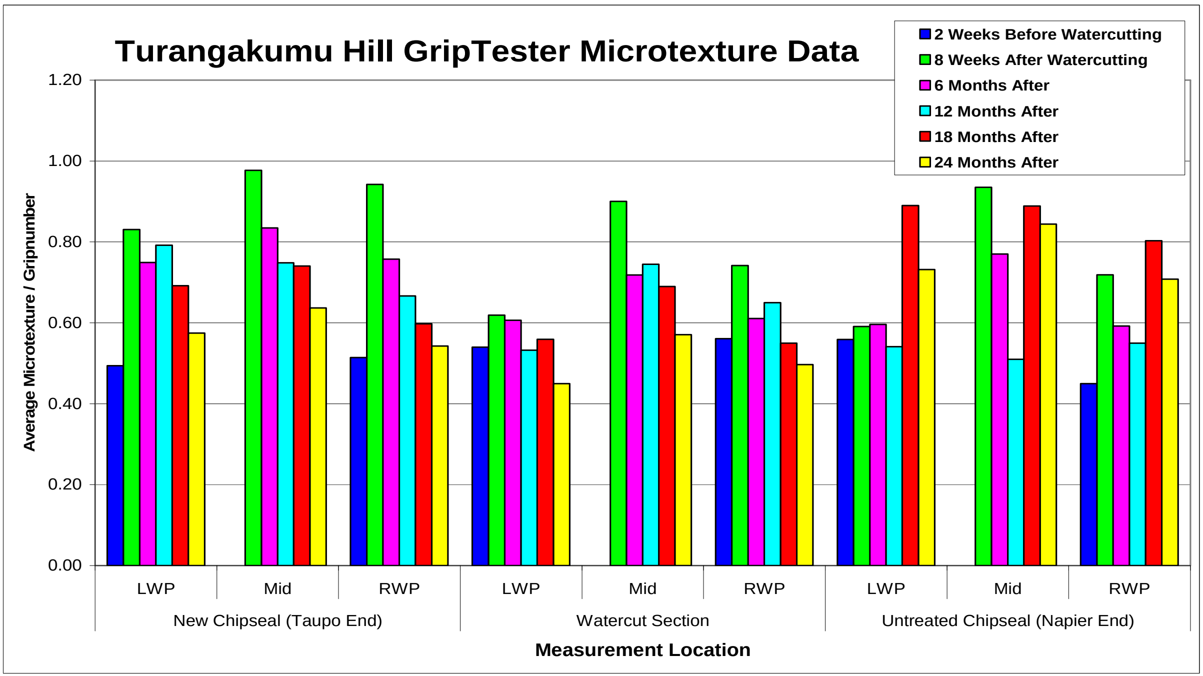
- The 2005 survey nine months after sealing showed an increase in both the LWP (0.04 MSSC) and RWP (0.10 MSSC) compared with the 2004 survey three months before sealing.
- The 2006 survey 21 months after sealing showed a decrease in both the LWP (-0.05MSSC) and RWP (-0.13 MSSC).
- With an average microtexture of 0.38 MSSC in both wheelpaths the new chip seal was below the IL of both the 0.45 and 0.50 that applied on the length of state highway.

Watercut section

- The 2005 survey nine months after the watercutting treatment showed a decrease in both the LWP (-0.07 MSSC) and RWP (-0.02 MSSC) compared with the 2004 survey three months before the treatment.
- The 2006 survey 21 months after treatment showed an increase in the LWP (0.02 MSSC) and a further decrease in the RWP (-0.01 MSSC).
- 21 months after the watercutting treatment the LWP had an average microtexture of 0.38 MSSC and the LWP an average of 0.43 MSSC. Both were below the IL of 0.45 and 0.50 that applied to this treatment length.

Control untreated

- The 2005 survey showed a decrease in both the LWP (-0.10 MSSC) and RWP (-0.05 MSSC) compared with the 2004 survey.
- The 2006 survey 12 months later showed an increase in both the LWP (0.17 MSSC) and RWP (0.06 MSSC) compared with the 2005 survey.



GripTester microtexture data analysis

New chipseal section

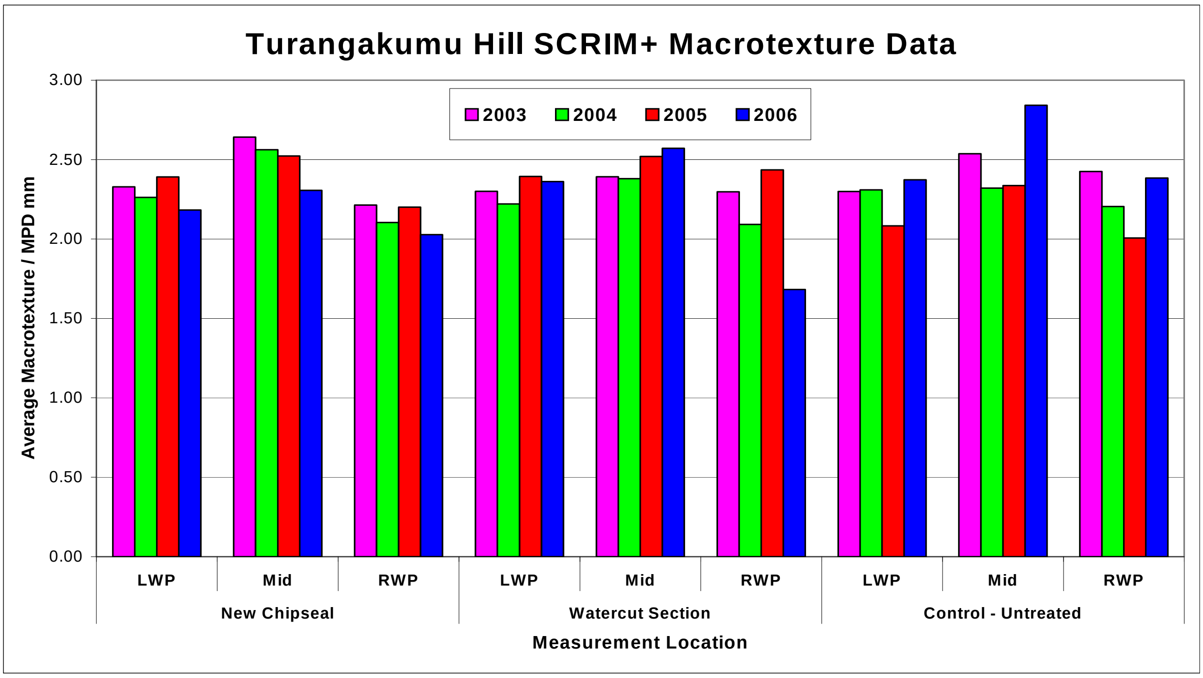
- The GripTester survey nine weeks after sealing showed an increase in both the LWP (0.34 gripnumbers (GN)) and RWP (0.43 GN) compared with the survey carried out the week before sealing.
- Both wheelpaths showed a steady decrease and 24 months after sealing the average microtexture in the LWP was 0.08 GN higher and RWP 0.03 GN higher than that measured the week before sealing.

Watercut section

- The GripTester survey eight weeks after the watercutting treatment showed an increase in both the LWP (0.08 GN) and RWP (0.18 GN) when compared with the survey two weeks before the treatment.
- The GripTester survey 12 months after the treatment showed that the average microtexture in both wheelpaths was decreasing and the LWP was -0.01 GN less and the RWP still 0.08 GN greater, than that measured before the treatment.
- The GripTester survey 18 months after the treatment showed that the average microtexture in both wheelpaths had returned to similar levels to those measured before treatment.

Untreated chipseal section

- GripTester surveys on the untreated LWP showed minimal change over the first 12 months of monitoring, increasing by up to 0.04 GN and finishing -0.02 GN at 12 months. The survey 18 months after the start of monitoring showed a large increase 0.35 GN after the construction of the Area Wide Pavement Treatment (AWPT) and new chipseal surface the microtexture had decreased by -0.16 GN when surveyed six months later.
- The GripTester survey after eight weeks showed that pavement repairs on the untreated RWP had increased the average microtexture by 0.27 GN. This subsequently decreased until the 18 months survey carried out after the AWPT showed another increase of 0.25 GN. This decreased by -0.10 GN six months later.



SCRIM+ macrotexture data analysis

New chipseal section

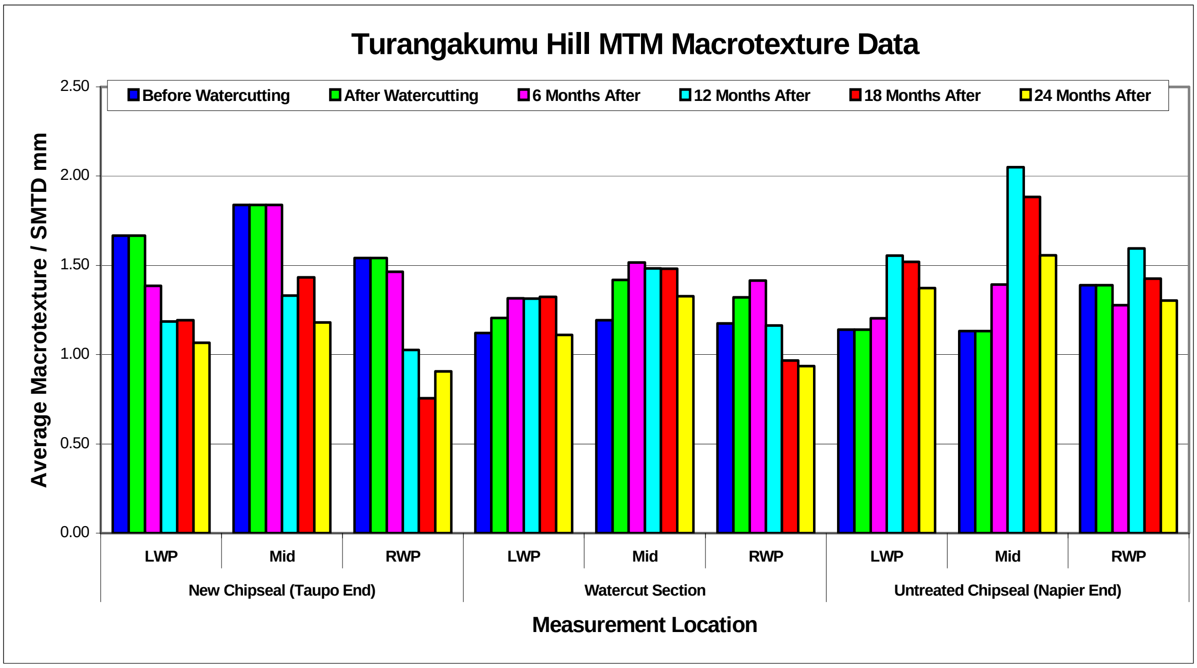
- The 2005 SCRIM+ survey nine months after the chipseal construction showed a small increase in the average macrotexture (MPD) in both LWP (0.13 mm) and RWP (0.10 mm) and a slight decrease between the wheelpaths (Mid) (-0.04 mm) when compared with the 2004 survey measured three months before the seal was constructed.
- The 2006 survey 21 months after the seal was constructed showed that the average macrotexture was lower than that measured before the seal was constructed in all three locations (LWP -0.08 mm, Mid -0.26 mm and RWP -0.08 mm).

Watercut section

- The 2005 survey nine months after the watercutting treatment showed an increase in the average macrotexture in all three locations (LWP 0.17 mm, Mid 0.14 mm and RWP 0.34 mm) compared with the 2004 survey measured three months before the section was treated.
- The 2006 survey 21 months after the watercutting treatment showed that the average macrotexture was still higher in the LWP (0.14 mm) and Mid (0.19 mm) locations than that measured before the treatment but that the RWP (-0.41 mm) texture had decreased significantly.

Control section (untreated)

- The 2005 survey showed that the average macrotexture had decreased in both the LWP (-0.23 mm) and RWP (-0.20 mm) and increased in the Mid (0.02 mm) when compared with the 2004 survey.
- The 2006 survey showed that the average macrotexture had increased (LWP 0.29 mm, Mid 0.50 mm and RWP 0.38 mm) compared with the 2005 survey.



MTM macrotexture data analysis

New chipseal section

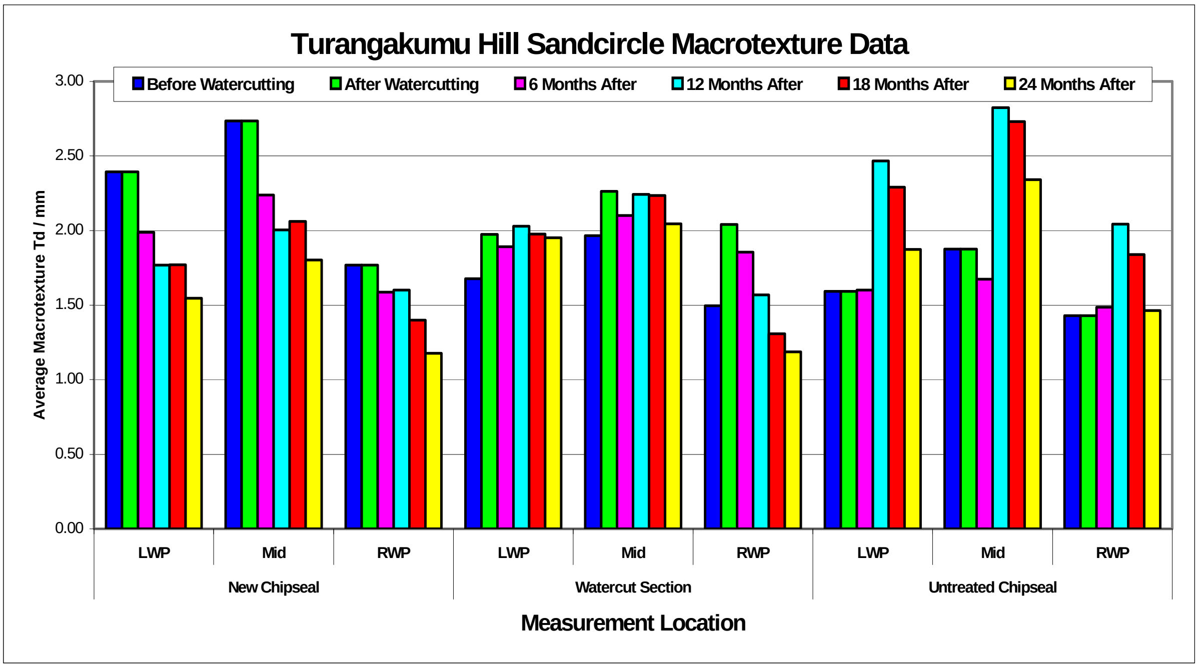
- The average MTM macrotexture (SMTD) measured 24 months after the seal was constructed had decreased (LWP -0.60 mm, Mid -0.66 mm and RWP -0.64 mm) compared with the texture measured two weeks after the seal was constructed.

Watercut section

- The average macrotexture measured immediately after the section was watercut was higher in all locations (LWP 0.08 mm, Mid 0.23 mm and RWP 0.15 mm) than that measured immediately before the treatment.
- The average macrotexture measured six months later showed an increase in each location (LWP 0.20 mm, Mid 0.32 mm and RWP 0.24 mm) compared with that measured immediately after the treatment.
- The average macrotexture measured 24 months after the watercutting treatment was lower in both LWP (-0.01 mm) and RWP (-0.24 mm) and higher Mid (0.13 mm) than that measured immediately before watercutting.

Untreated section (control)

- The average macrotexture measured 12 months after the monitoring started showed an increase (LWP 0.42 mm, Mid 0.92 mm and RWP 0.21 mm) compared with that measured at the start.
- The average macrotexture measured 24 months after the start showed a decrease in each location (LWP -0.18 mm, Mid -0.49 mm and RWP -.29 mm) compared with that measured 12 months earlier.



Sand circle macrotexture data analysis

New chipseal

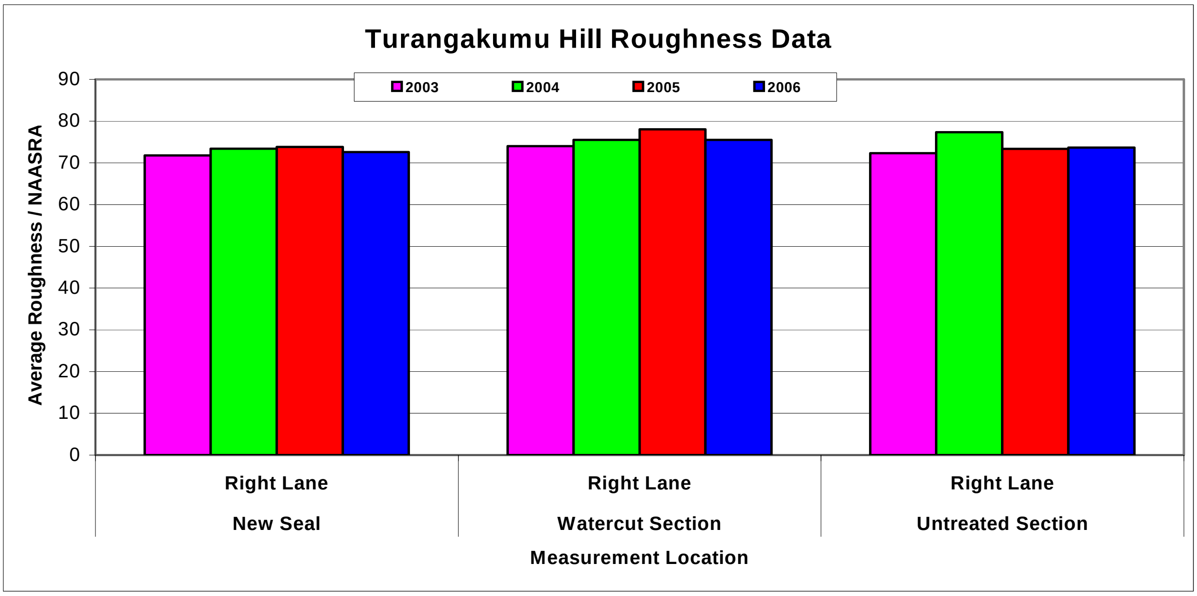
- Average sand circle macrotexture (Td) measurement 24 months after the seal was constructed showed a decrease in each measurement location (LWP -0.85 mm, Mid -0.93 mm and RWP -0.59 mm) compared with the measurements a week after the seal was constructed.

Watercut section

- Sand circle measurements taken before and after the watercutting treatment showed an increase in the average macrotexture (LWP 0.30 mm, Mid 0.30 mm and RWP 0.54 mm).
- The average macrotexture in the LWP remained static and 24 months after watercutting had only decreased by -0.02 mm.
- The average macrotexture in the mid-location decreased slowly over time and 24 months after watercutting had reduced by -0.22 mm compared with that measured immediately after the treatment.
- The average macrotexture in the RWP was decreasing and 24 months after watercutting measured –0.85 mm less than that measured immediately after the treatment.

Control section (untreated)

- The average macrotexture on the untreated section remained static until measurement 12 months after the start of monitoring showed an increase (LWP 0.88 mm, Mid 0.95 mm and RWP 0.61 mm) compared with that measured at the start.
- The average macrotexture was decreasing steadily so that the 24-month monitoring showed a decrease (LWP -0.59 mm, Mid -0.48 mm and RWP -0.58 mm) compared with the 12-month measurements.



SCRIM+ roughness data analysis

New chipseal section

- Very little change in the roughness over the four years surveyed.

Watercut section

- Slow increases from an average roughness 74 NAASRA in 2003 to 78 NAASRA in 2005 followed by a decrease to 76 NAASRA in the 2006 survey.

Untreated section (control)

- The average roughness showed some variability; however, the 2006 survey measured 74 NAASRA compared with 73 NAASRA when measured in 2003.

Aggregate polishing

The watercut section was downhill >10% on a bend with radius < 250m approaching an intersection with a side road. The calculated PSV (using IL = 0.5) required for the actual traffic in 1999 was 54, which was the accepted PSV of the Winstone chip that was applied. However, a growth rate is normally used in the calculation and if 3% (conservative) had been used the PSV requirement would have been 55 and a chip with a higher PSV would have had to be sourced.

The PSV calculation used an IL for the site set at 0.5 for curves with radius < 250m or down gradients >10%. However, as there was a combination of three events – the short radius bend, the down gradient and the approach to a side road intersection – it might have been prudent to adjust the IL for the calculation to ensure an aggregate with more resistance to polishing was used. Increasing the IL to 0.55 would have raised the required PSV to 60. The PSV of the Poplar Lane chip used to construct the new chipseal alongside the watercut site was 59 which was suitable if an IL of 0.5 was used in the calculation (PSV = 55) but not if an IL of 0.55 was used (PSV = 60).

The failure of the chipseal (chip loss and flushing) and regular contamination of the surface from stock trucks would have contributed to the low microtexture test results measured on the test section. The new higher PSV chip might still have sufficient microtexture.

The use of large stone/coarse chipseal increases the scrubbing stress on the surface by lowering the contact area of the vehicle tyres and this would have increased the rate of polishing on the surface. The existing watercut surface was covered with Winstone aggregate, which is a durable, low-wearing chip that tends to round off on its exposed tips.

Traffic counts

Traffic counts in 1999 when the existing seal was constructed were 2455 AADT with 14% HCV (344 HCV). This had increased to 2940 with 16% HCV (470 HCV) in 2004 – a 37% increase in HCV in five years or a growth rate of 6.5% per annum.

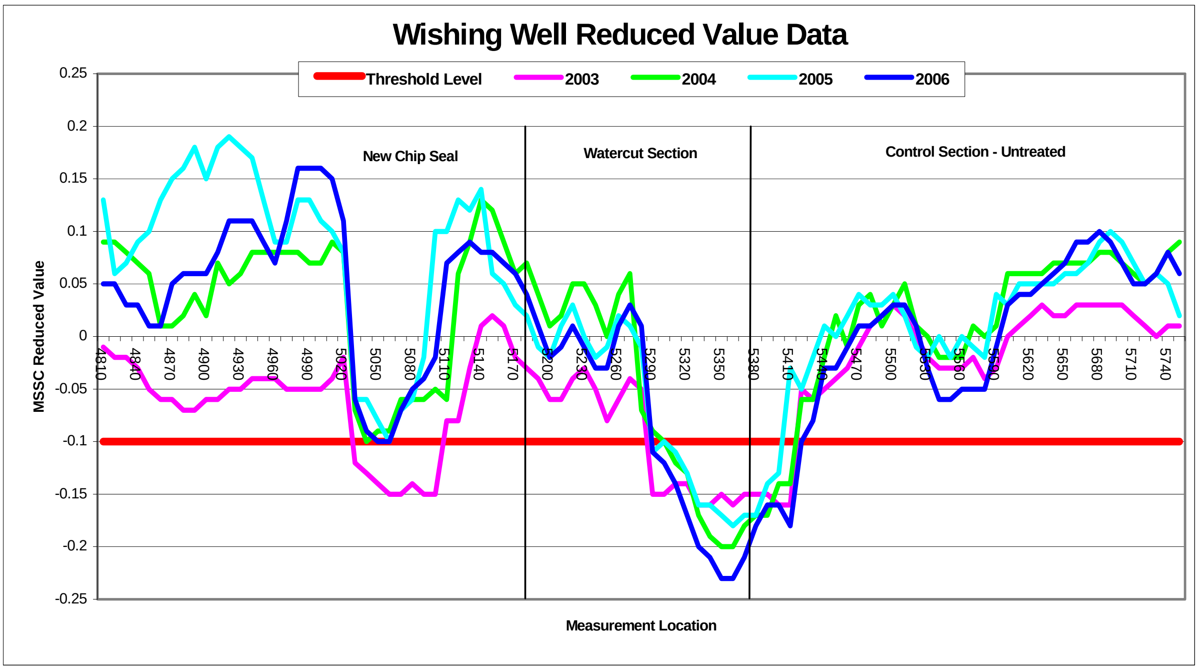
Accidents

There were no recorded accidents on this site from 1990 to 2006.

Aggregate testing

Test results showed that both grades of chip used met the requirements of M/6, and the PSV (59) of the sample was the same as that normally reported for the quarry at that time.

Appendix 12: Site 7 Wishing Well monitoring data



Reduced value data analysis

New chipseal section

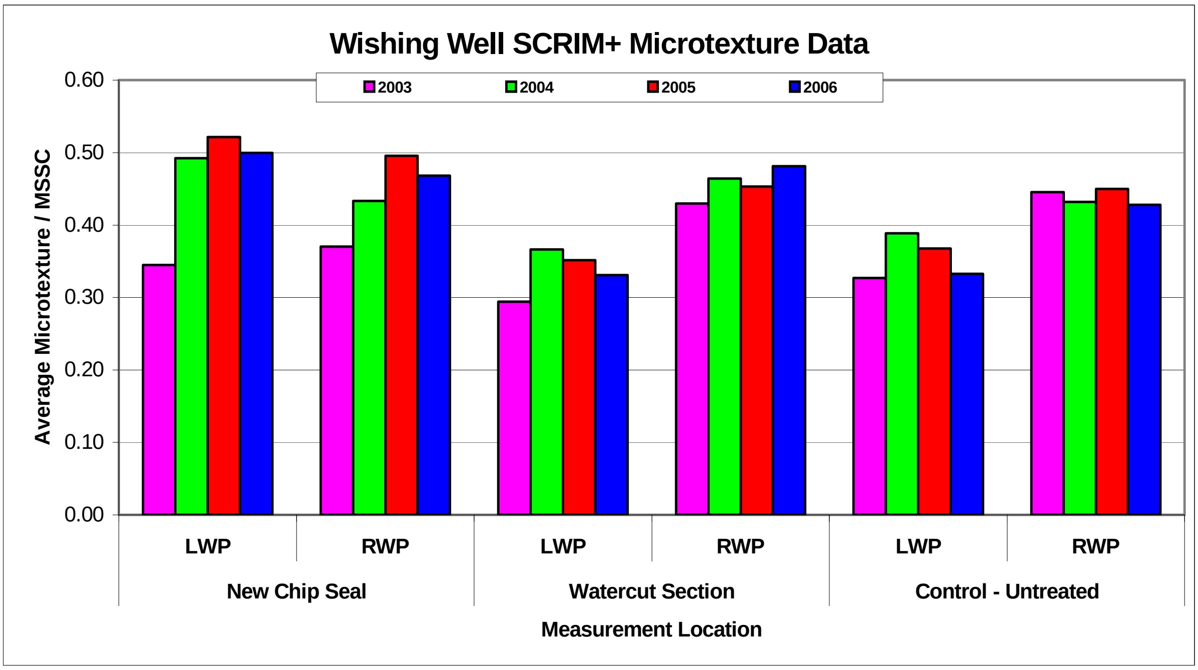
- The 2003 SCRIM+ survey 15 months before the chipseal was constructed showed 100% below the IL and 22% below the TL.
- The 2004 survey three months before the chipseal was constructed showed 27% below the IL and 3% below the TL.
- The 2005 survey nine months after the chipseal was constructed showed 21% below the IL and 3% below the TL.
- The 2006 survey 21 months after the seal was constructed showed 24% below the IL and 6% below the TL.

Watercut section

- The 2003 survey 15 months before the site was watercut measured 86% below the IL and 29% below the TL.
- The 2004 survey three months before the site was watercut measured 43% below the IL and 29% below the TL.
- The 2005 survey nine months after the site was watercut measured 57% below the IL and 29% below the TL.
- The 2006 survey 21 months after the site was watercut measured 52% below the IL and 29% below the TL.

Untreated section (control)

- The 2004 survey measured this section as having 23% below the IL and 7% below the TL.
- The 2006 survey 24 months later measured this section as having 46% below the IL and 20% below the TL.



SCRIM+ microtexture data analysis

New chipseal

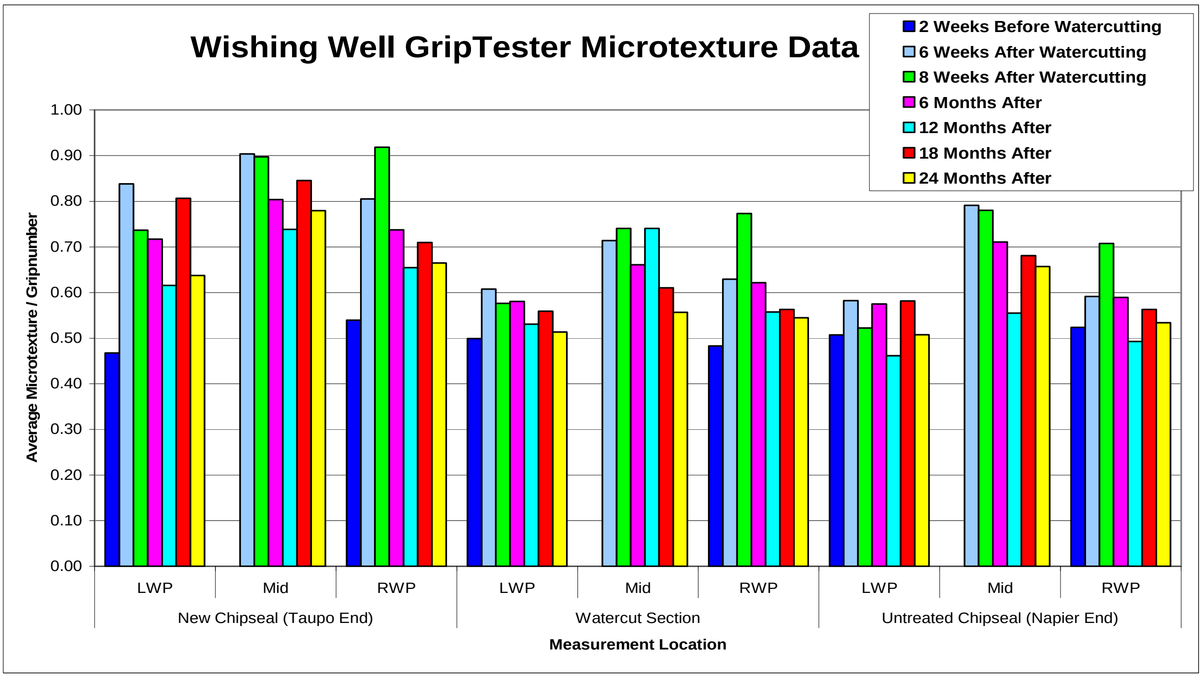
- The 2005 SCRIM+ survey nine months after the chipseal was constructed showed an increase in the average microtexture in both the LWP (0.03 MSSC) and RWP (0.06 MSSC) compared with the 2004 survey measured three months before the seal was constructed.
- The 2006 survey 21 months after the chipseal was constructed showed that the average microtexture was still higher in both LWP (0.01 MSSC) and RWP (0.04 MSSC) than before the chipseal was constructed.

Watercut section

- The 2005 survey nine months after the section was watercut showed a small decrease in both LWP (-0.01 MSSC) and RWP (-0.01 MSSC) compared with the 2004 survey measured three months before the treatment.
- The 2006 survey 24 months after treatment showed a further decrease in the LWP (-0.02 MSSC) and an increase in the RWP (0.03 MSSC) compared with the 2005 survey.

Control section

- The 2005 survey showed a small decrease in the average microtexture of the LWP (-0.02 MSSC) and an increase in RWP (0.02 MSSC) compared with the 2004 survey.
- The 2006 survey showed a small decrease for both LWP (-0.03 MSSC) and RWP (-0.02 MSSC) compared with the 2005 survey.



GripTester microtexture data analysis

New chipseal section

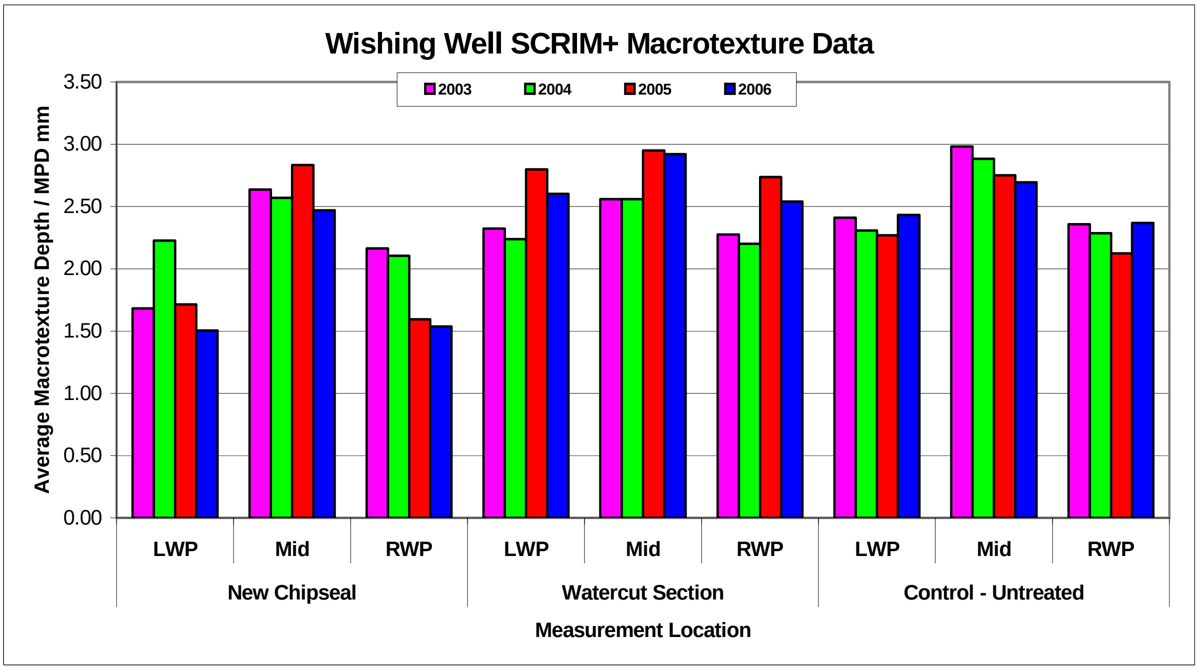
- The GripTester survey seven weeks after the seal was constructed measured an increase in average microtexture in both LWP (0.37 GN) and RWP (0.27 GN) compared with the survey completed one week before seal construction.
- The GripTester survey 24 months after the seal was constructed showed a decrease in the average microtexture in all locations (LWP -0.2 GN, Mid -0.12 GN and RWP -0.14 GN) compared with the survey seven weeks after the seal was constructed.

Watercut section

- The GripTester survey six weeks after the section was watercut showed an increase in average microtexture in both LWP (0.11 GN) and RWP (0.15 GN) compared with the survey completed two weeks before the section was treated.
- The GripTester survey 24 months after the section was watercut showed that the average microtexture for both wheelpaths was still higher: LWP (0.01 GN) and RWP (0.06 GN), than when measured two weeks before the section was watercut.

Untreated (control) section

- The GripTester survey completed six weeks after watercutting measured an increase in the average microtexture for both LWP (0.07 GN) and RWP (0.07 GN) compared with the survey completed two weeks before the site treatment.
- The GripTester survey 24 months after the monitoring began showed that the difference in average microtexture was LWP (0.00 GN) and RWP (0.01 GN), compared with the initial test.



SCRIM+ macrotexture data analysis

New chipseal section

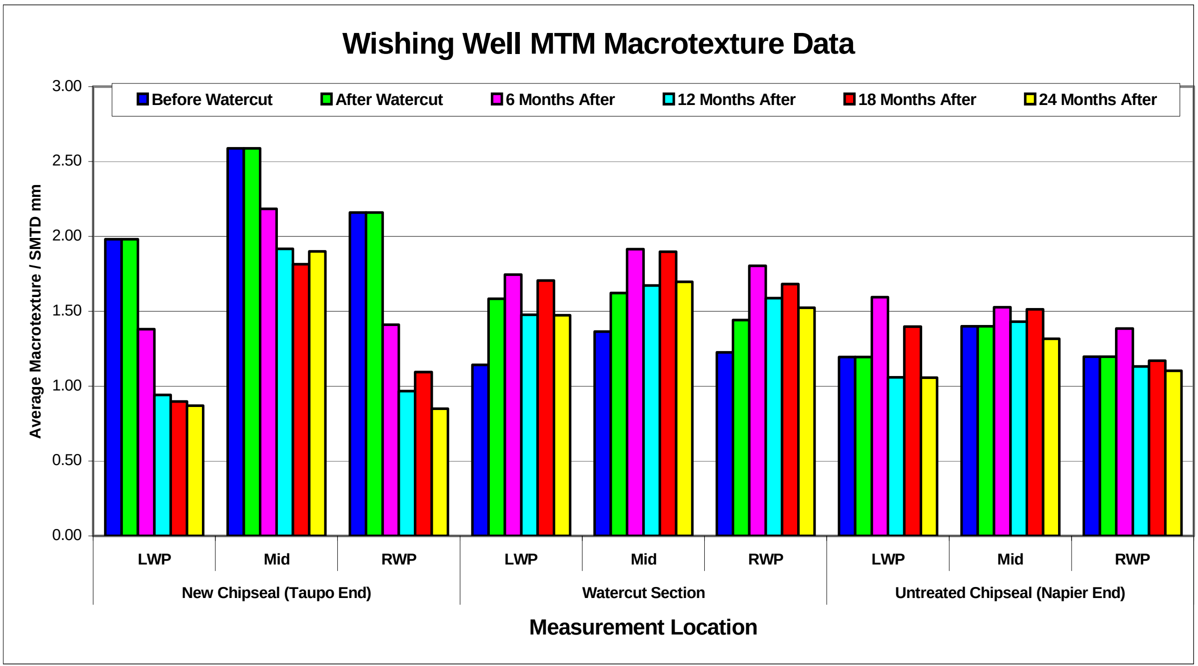
- The 2005 SCRIM+ macrotexture survey completed nine months after the chipseal was constructed measured a decrease in average macrotexture (MPD) in LWP (-0.51 mm) and RWP (-0.51 mm) and an increase Mid (0.26 mm) compared with the 2004 survey completed three months before the chipseal was constructed.
- The 2006 survey completed 21 months after the chipseal was constructed measured a decrease in average macrotexture (LWP -0.21 mm, Mid -0.36 mm and RWP -0.06 mm) compared with the 2005 survey.

Watercut section

- The 2005 survey completed nine months after the surface was watercut measured an increase in the average macrotexture (MPD) in all locations (LWP 0.56 mm, Mid 0.39 mm and RWP 0.53 mm) compared with the 2004 survey completed three months before the treatment.
- The 2006 survey completed 21 months after the surface was watercut measured a decrease compared with the 2005 survey, although the average macrotexture improvement had been maintained at a higher level (LWP 0.36 mm, Mid 0.36 mm and RWP 0.34 mm) than that measured before the surface was watercut.

Control section

- Testing of the control section showed a decrease in the average macrotexture until the 2006 survey, which then showed an increase in LWP (0.16 mm) and RWP (0.24 mm) compared with the 2005 survey.



MTM macrotexture data analysis

New chipseal section

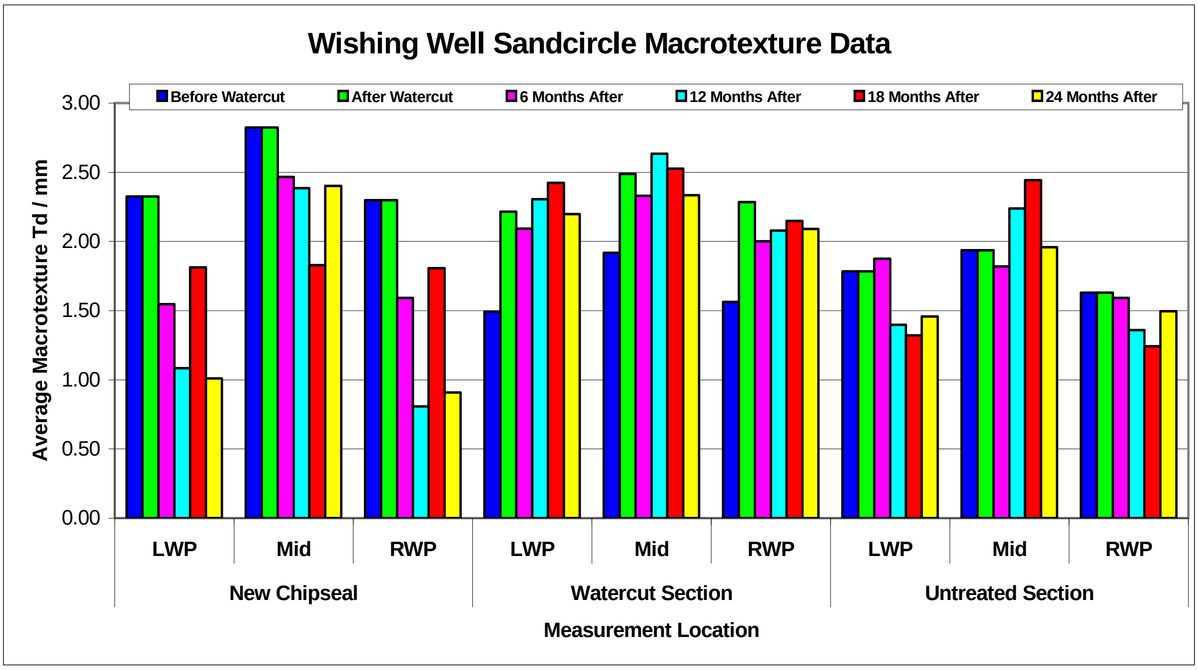
- MTM testing on the short length of new seal adjacent to the watercut section 24 months after seal construction showed that, compared with 24 months earlier, there had been a rapid decrease in the average macrotexture (SMTD) in the LWP (-1.11 mm) and RWP (-1.31 mm) with a smaller decrease between Mid (-0.69 mm).

Watercut section

- MTM testing immediately before and after watercutting measured an increase in the average macrotexture (SMTD) in all locations (LWP 0.44 mm, Mid 0.26 mm and RWP 0.22 mm).
- MTM testing six months after watercutting measured a further increase in the average macrotexture compared with that measured immediately after the watercutting treatment LWP 0.16 mm, Mid 0.29 mm, RWP 0.36 mm).
- MTM testing 24 months after the watercutting treatment showed that the average macrotexture improvement had been retained at a higher level than that measured immediately before the watercutting (LWP (0.33 mm, Mid 0.33 mm and RWP 0.30 mm).

Control section

- MTM testing 24 months after the start of monitoring showed that the average macrotexture (SMTD) had decreased in all three locations (LWP -0.14 mm, Mid -0.08 mm and RWP -0.09 mm) compared with that measured 24 months earlier.



Sand circle macrotexture data analysis

New chipseal

- Sand circle testing 24 months after chipseal construction on the short length adjacent to the watercut section showed that the average macrotexture (Td) had shown a large decrease in the LWP (-1.32 mm) and RWP (-1.39 mm) and a smaller reduction between the wheelpaths Mid (-0.42 mm) compared with the measurements taken two weeks after construction.

Watercut section

- Sand circle testing immediately before and after watercutting measured an increase in the average macrotexture in all locations (LWP 0.72 mm, Mid 0.57 mm and RWP 0.72 mm).
- Testing 24 months after the treatment showed that the macrotexture improvement had been retained and was still higher (LWP 0.71 mm, Mid 0.41 mm and RWP 0.53 mm) in all locations compared with that measured before the treatment.

Untreated section

- Sand circle testing after 24 months of monitoring showed that there had been a decrease in the wheelpaths: LWP (-0.33 mm) and RWP (-0.13 mm) and a slight increase between the wheelpaths Mid (0.02 mm) compared with the results 24 months earlier.

Roughness data analysis

New chipseal

- The 2006 SCRIM+ roughness survey showed a small increase (4 counts) in average roughness (NAASRA) compared with the 2004 survey measured three months before the construction of the new seal.

Watercut section

- The 2006 survey 21 months after the section was watercut showed a small increase (2 counts) in average roughness compared with the 2004 survey measured before the site was watercut.

Control section

- The 2006 survey showed a small increase (3 counts) in average roughness compared with the 2004 survey.

Aggregate polishing

The IL varied for this site from 0.4 with no events on the straight section to 0.5 for the bend with radius <= 250m and some surveys measured a down gradient >5% and <10% on the bend.

Investigation of the polished surface showed that the points and edges of the exposed surfaces of the large chip were rounded and blackened by possibly tyre rubber and bituminous contamination (see Figure A.3 below).

The small contact surface footprint of the test tyre on the road surface caused by the coarse surface of large chip seal had contributed to the accelerated polishing resulting in the low microtexture measured on this site. Figure A.3 shows the rounding and contamination on the tips of the chips, which would only serve to reduce the measured microtexture further.

Figure A3 Wishing Well before (left) and after (right) watercutting.

Traffic counts

Traffic counts in 1999 when the existing seal was constructed were 2455 AADT with 14% HCV (344 HCV). This had increased to 2940 with 16% HCV (470 HCV) in 2004 – a 37% increase in HCV in five years, or a growth rate of 6.5% per annum.

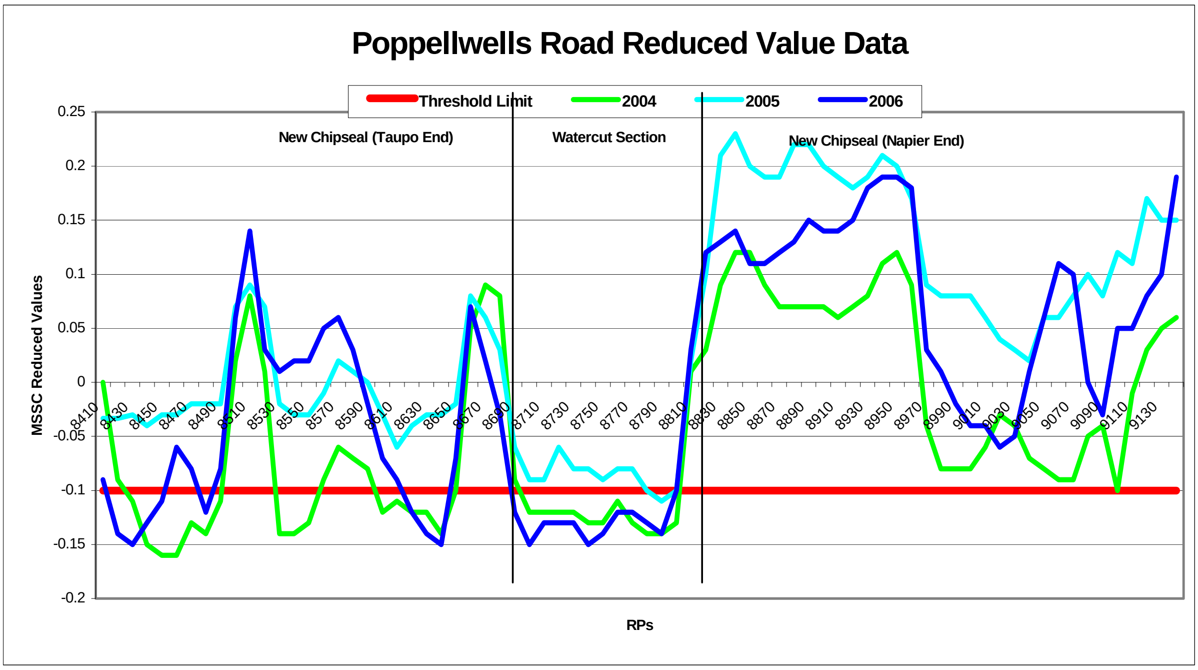
Accidents

There were two reported accidents on the site (one per year) following the watercutting of the site. One accident was in October 2005 and the other in February 2006 and in both cases the surface was wet during a light rain shower.

Aggregate testing

Test results showed that both grades of chip used met the requirements of M/6 and the PSV (59) of the sample was the same as that normally reported for the quarry at that time.

Appendix 13: Site 8 Poppellwells Road monitoring data



Reduced value data analysis

New grades 2 and 4 chipseal (Taupo end)

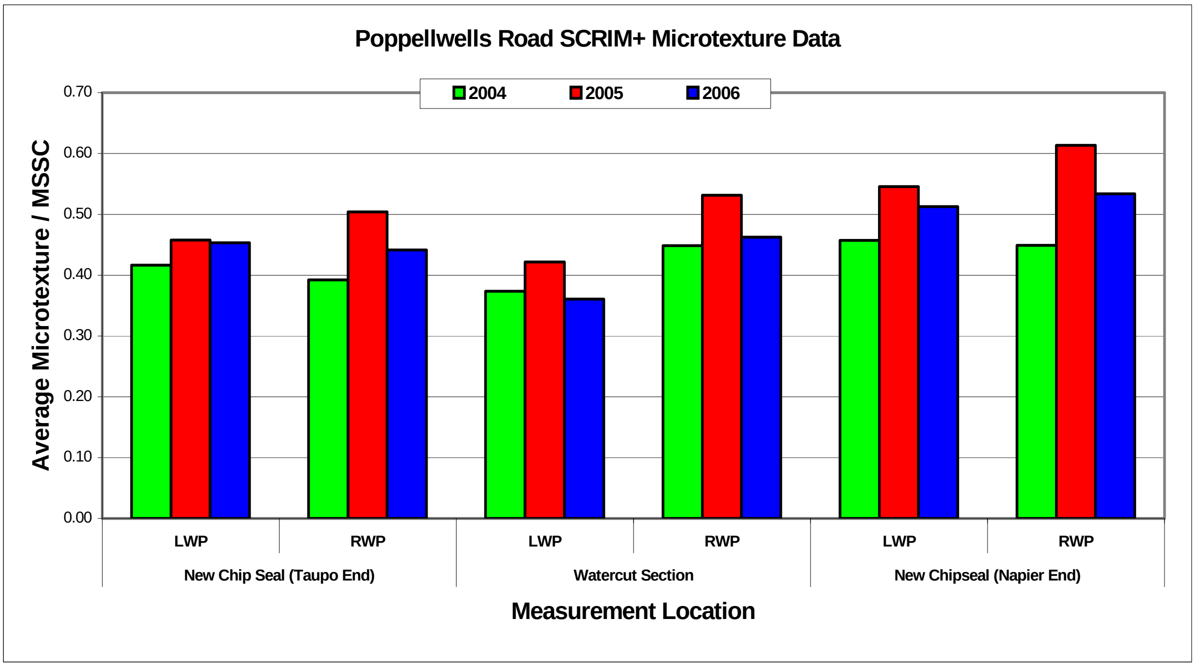
- The 2004 SCRIM+ reduced value measurement three months before the section was resealed showed that 25% of the section was below the TL and 38% was below the IL.
- The 2005 survey nine months after the section was resealed showed that 0% was below the TL and 30% was below the IL.
- The 2006 survey 21 months after the seal was constructed showed that 13% was below the TL and 25% was below the IL.

Watercut section

- The 2004 SCRIM+ reduced value measurement of the watercut section three months before it was watercut showed that 92% was below the TL and 100% was below the IL.
- The 2005 survey nine months after watercutting showed that 25% of the section was below the TL and 100% was below the IL.
- The 2006 survey measured 21 months after the section was watercut showed that 100% of the site was below both the TL and the IL.

New grades 2 and 4 chipseal (Napier end)

- The 2004 SCRIM+ reduced value measurement three months before the section was resealed showed that 3% of the section was below the TL and 45% was below the IL.
- The 2005 survey nine months after the section was resealed showed that 0% was below the TL and 0% was below the IL.
- The 2006 survey 21 months after the seal was constructed showed that 0% was below the TL and 18% was below the IL.



SCRIM+ microtexture data analysis

New chipseal (Taupo end)

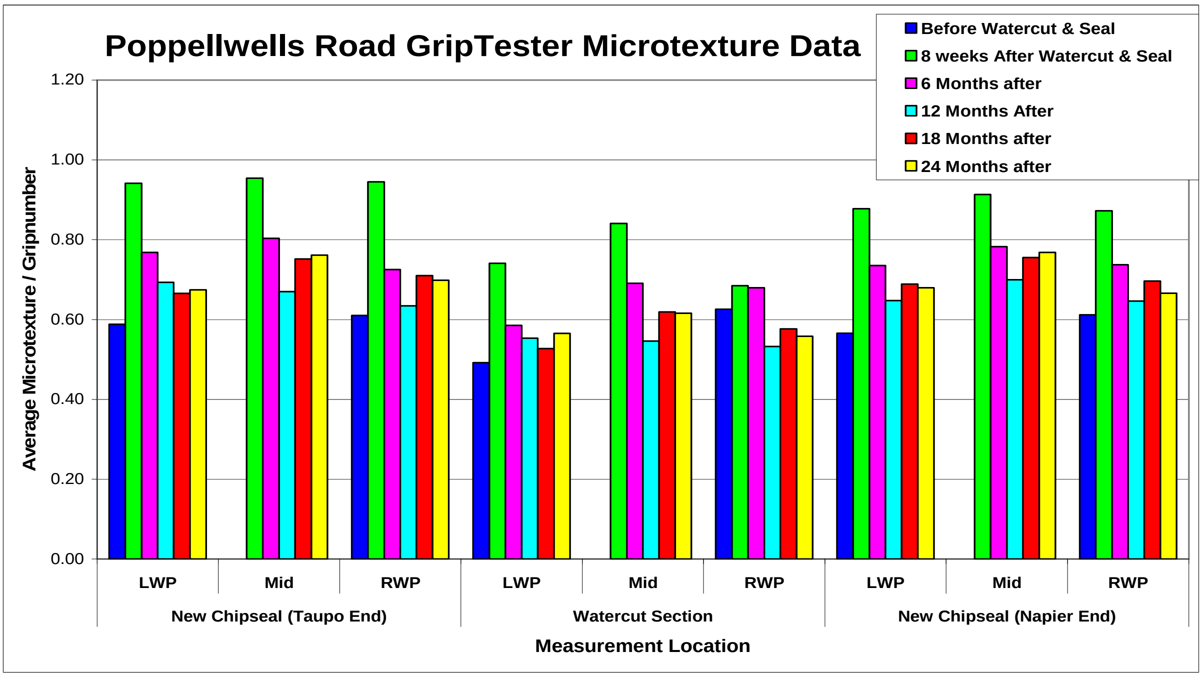
- The 2005 survey nine months after the section was resealed showed that the average microtexture of the new chipseal was 0.08 MSSC higher than that of the old surface that was measured three months before the site was resealed.
- The 2006 survey 21 months after the section was resealed showed that the average microtexture for the chipseal was only 0.04 MSSC higher than that of the surface before the reseal was constructed.

Watercut section

- The 2005 SCRIM+ survey eight months after the section was watercut showed that the average microtexture of the watercut surface was 0.07 MSSC higher than that measured in the 2004 survey four months before the section was watercut.
- The 2006 survey 20 months after the section was watercut showed that the average microtexture of the watercut section had returned to the levels measured before the section was watercut.

New chipseal (Napier end)

- The 2005 survey nine months after the section was resealed showed that the average microtexture of the new chipseal was 0.13 MSSC higher than that of the old surface that was measured three months before the site was resealed.
- The 2006 survey 21 months after the section was resealed showed that the average microtexture for the chipseal was only 0.07 MSSC higher than that of the old surface before the reseal was constructed.



GripTester microtexture data analysis

New chipseal (Taupo end)

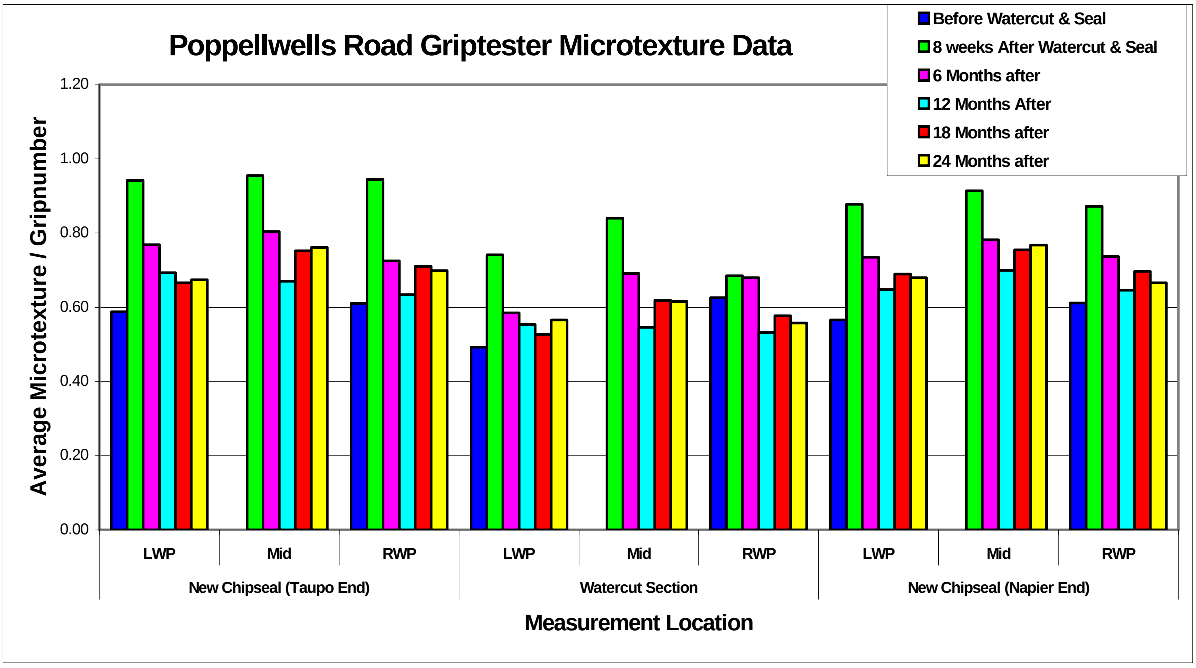
- The average microtexture measured 10 weeks after the construction of the new seal was 0.35 gripnumbers higher than that measured just before the surface was resealed.
- The average microtexture measured 24 months after the construction of the chipseal was 0.11 gripnumbers higher than that measured before the seal was constructed.

Watercut section

- Issues with the GripTester meant the early test results were lost so the first griptesting after the watercutting was eight weeks after the treatment and the before results were calculated from SCRIM+ values.
- The average microtexture measured eight weeks after watercutting was 0.20 gripnumbers higher than that measured just before the section was watercut.
- The average microtexture measured 24 months after watercutting was 0.02 gripnumbers higher than that measured before the surface was watercut.

New chipseal (Napier end)

- The average microtexture measured 10 weeks after the construction of the new seal was 0.30 gripnumbers higher than that measured just before the surface was resealed.
- The average microtexture measured 24 months after the construction of the chipseal was 0.12 gripnumbers higher than that measured before the seal was constructed.



SCRIM+ macrotexture data analysis

New chipseal (Taupo end)

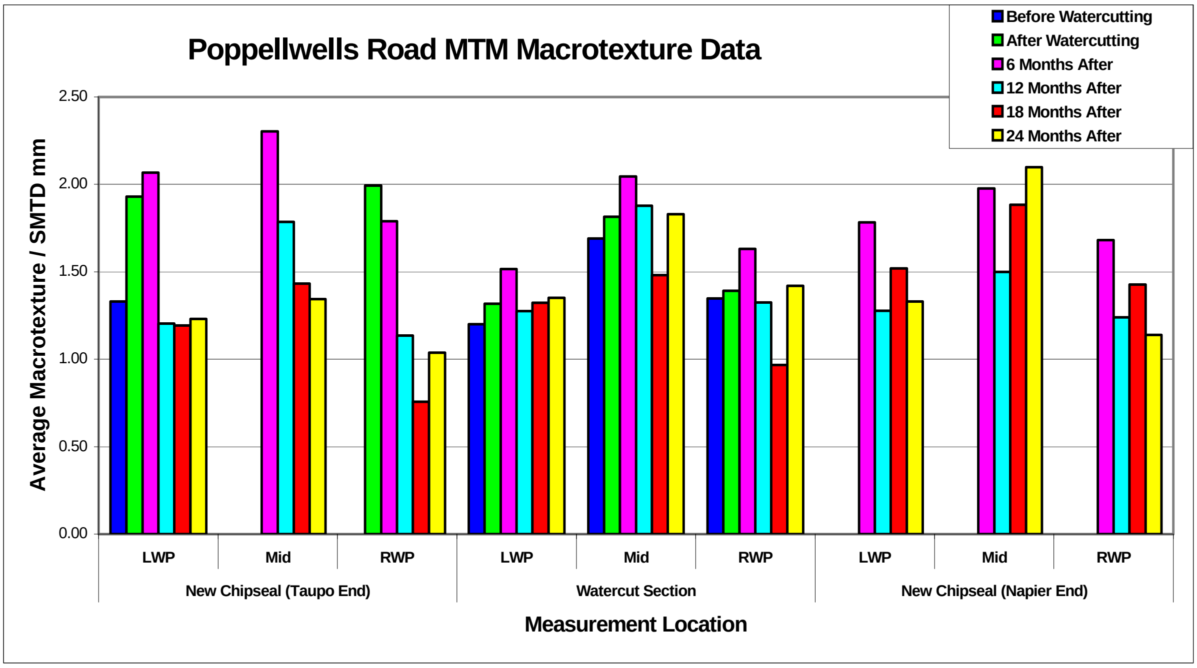
- The 2005 SCRIM+ survey nine months after the section was chipsealed showed that the average macrotexture of the new chipseal surface was 0.08 mm MPD higher than that measured in the 2004 survey three months before the section was chipsealed.
- The 2006 survey 21 months after the section was chipsealed showed that the average macrotexture of the chipseal section was 0.17 mm MPD lower than that measured before the surface was watercut.

Watercut section

- The 2005 SCRIM+ survey nine months after the section was watercut showed that the average macrotexture of the watercut surface was 0.29 mm MPD higher than that measured in the 2004 survey three months before the section was watercut.
- The 2006 survey 21 months after the section was watercut showed that the average macrotexture of the watercut section was still 0.18 mm MPD higher than that measured before the surface was sealed.

New chipseal (Napier end)

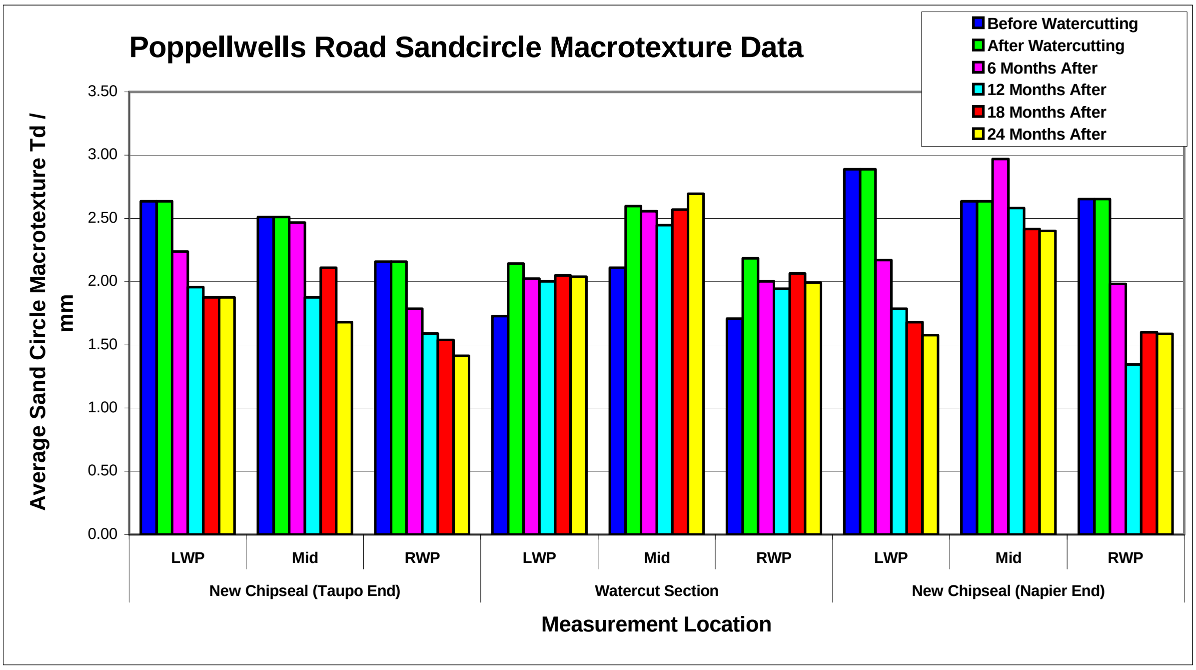
- The 2005 SCRIM+ survey nine months after the section was chipsealed showed that the average macrotexture of the new chipseal surface was 0.34 mm MPD higher than that measured in the 2004 survey four months before the section was chipsealed.
- The 2006 survey 21 months after the section was chipsealed showed that the average macrotexture of the chipseal section was 0.01 mm MPD lower than that measured before the surface was sealed.



MTM macrotexture data analysis

Watercut section

- The average macrotexture of the watercut section increased by 0.10 mm SMTD compared with that measured just before the surface was watercut.
- When measured 24 months later the average macrotexture of the watercut section was still 0.12 mm SMTD higher than that measured before treatment.

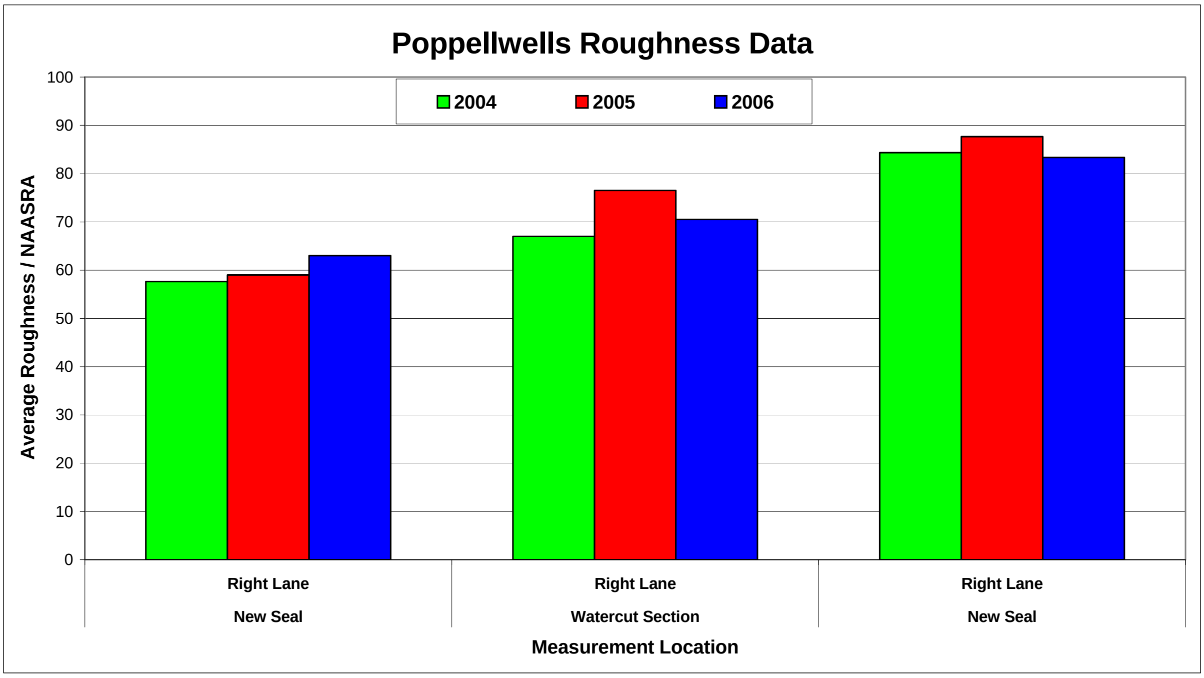


Sand circle macrotexture data analysis

Watercut section

- Average sand circle macrotexture measurements showed an increase of 0.46 mm Td after watercutting the surface.

- Sand circle measurements showed that 24 months after watercutting the average macrotexture of the watercut section was still 0.39 mm Td higher than that measured before the surface was watercut.



SCRIM+ roughness data analysis

New chipseal section (Taupo end)

- Average roughness increased in each of the two surveys following the construction of the chipseal, so that 21 months after construction the section was 5 NAASRA higher than that measured before the new seal was constructed.

Watercut section

- The 2005 survey, nine months after the watercutting, showed the average roughness to have increased (by 10 NAASRA) compared with the 2004 survey which took place three months before the treatment. However, the roughness had decreased (by 6 NAASRA) in the 2006 survey 21 months after treatment.

New chipseal section (Napier end)

- Average roughness increased by 4 NAASRA in the 2005 survey and decreased by 5 NAASRA in the 2006 survey, ending up at similar levels to those measured before the seal was constructed.

Aggregate polishing

Figure A4 below shows that the surface had binder rise into the voids of the seal, and rounding, rubber and binder on the tips of the large chips. Figure A4 also shows that the watercutting removed the excess binder and freshened the surface of the sealing chip.

The data showed that the texture had decreased a little and there were areas in the wheelpaths with some binder rise. The microtexture returned to pre-treatment levels within 12 months and most of this change would be due to polishing.

The surface was constructed using a two-coat chipseal with sealing chips with a PSV of 54. As can be seen from calculations for the Turangakumu and Wishing Well sites, which had similar input data, this was probably not the correct aggregate for the site as it had a combination of events radius <=250m and down gradient >5% and <10% that would have contributed to the polishing of the stone.

Figure A4 Poppellwells Surface before (left) and after (right) watercutting.

Traffic counts

Traffic counts in 1999 when the existing seal was constructed were 2455 AADT with 14% HCV (344 HCV). This had increased to 2940 with 16% HCV (470 HCV) in 2004 – a 37% increase in HCV in five years, or a growth rate of 6.5% per annum.

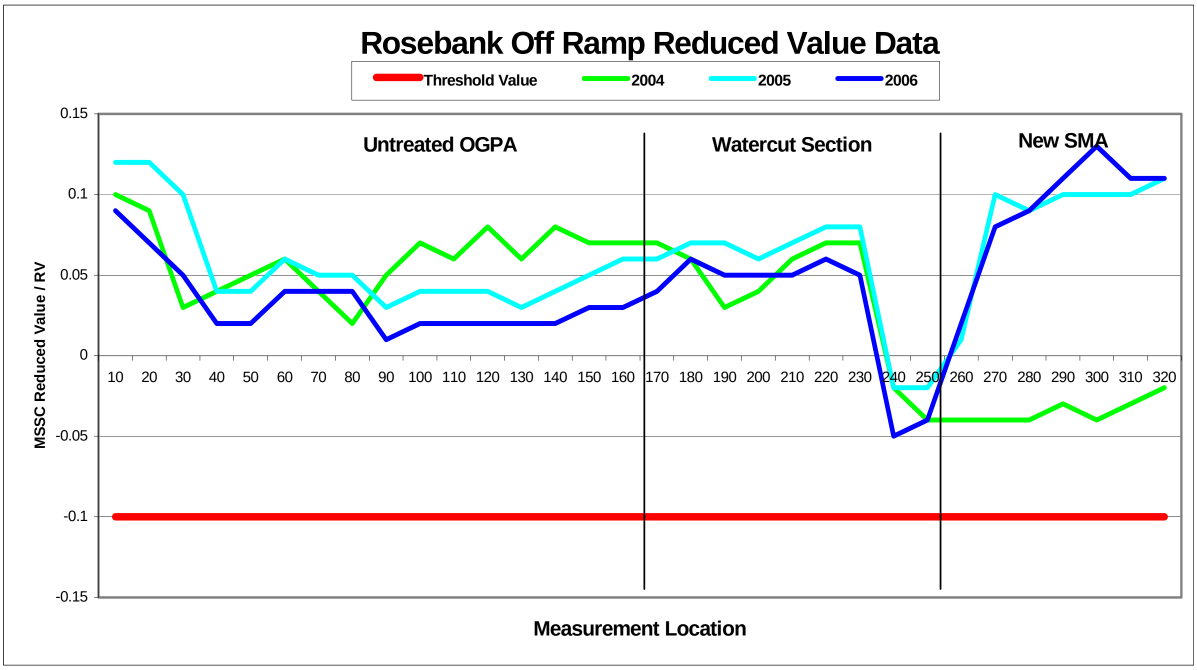
Accidents

The only reported accident on this site since 1990 occurred in 2002 before the site was treated.

Aggregate testing

Test results showed that both grades of chip used met the requirements of M/6 and the PSV (58) of the sample was one lower than that normally reported for the quarry at that time. This was within the ± 2 tolerance on the PSV test.

Appendix 14: Site 9 Rosebank Road monitoring data



Reduced value data analysis

This data represents a calculation comparing the combined measurement of the microtexture in both wheelpaths of a lane with the IL for each 10 m length of the lane.

One of the reasons for the significant changes shown on this graph is the change from year to year of the IL that forms the basis for calculating the reduced value for each 10 m length. An example of this is the 2003 data where the IL was set at 0.45 from 10 m to 220 m then in subsequent surveys (2004, 2005 and 2006) the IL was set at 0.4 for the same length.

Untreated OGPA length

100% of the untreated OGPA length had been above the investigatory level in the 2004, 2005 and 2006 surveys but was slowly deteriorating over time.

Watercut treatment length

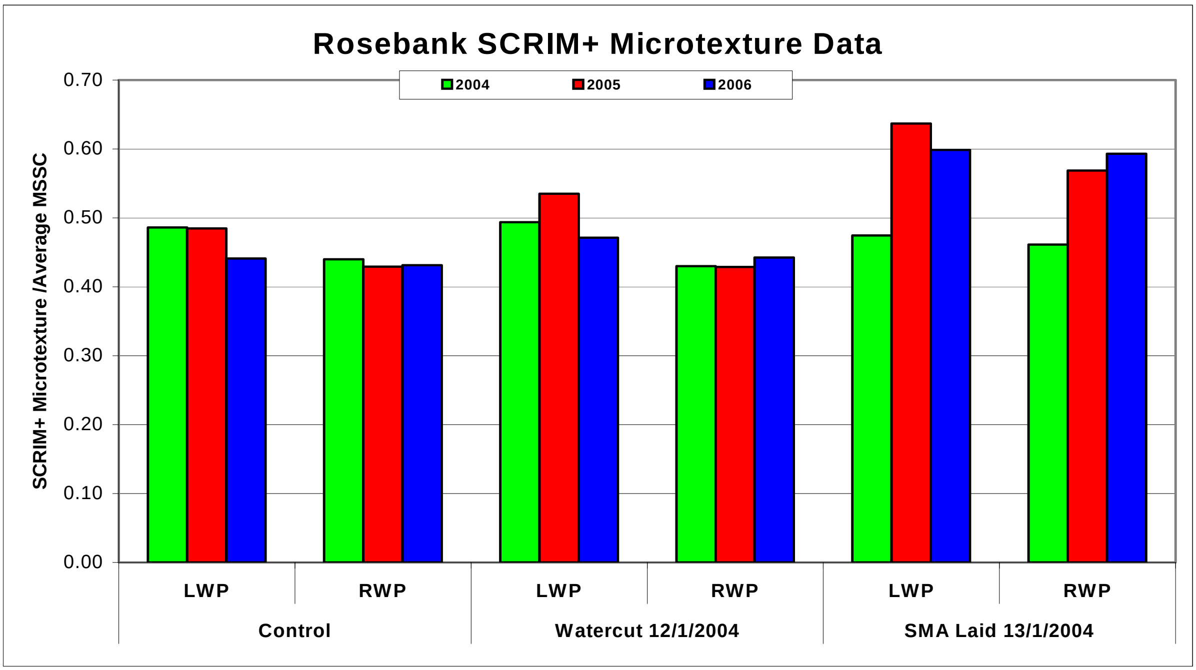
The test data showed a small increase in the 2005 survey, 13 months after the watercutting treatment, over the majority of the site compared with the 2004 survey measured a month before the treatment. However, the 240 m and 250 m sections were both below the IL of 0.5 before and after the watercutting treatment.

The 2006 data showed a small decrease over the whole site compared with the 2005 survey.

SMA treatment length

The 2004 survey carried out a month before the SMA was laid showed that it had 0% below TL and 100% below IL.

The 2005 survey 13 months and the 2006 survey 23 months after the SMA was laid showed that 100% of the site was above the IL.



SCRIM+ microtexture data analysis

Untreated OGPA length

The data from the SCRIM+ surveys shows that the average microtexture in the LWP decreased from 0.49 MSSC (2004) to 0.48 MSSC (2005) to 0.44 MSSC (2006) and in the RWP was reasonably constant at 0.44 MSSC (2004), 0.43 MSSC (2005) and 0.43 MSSC (2006).

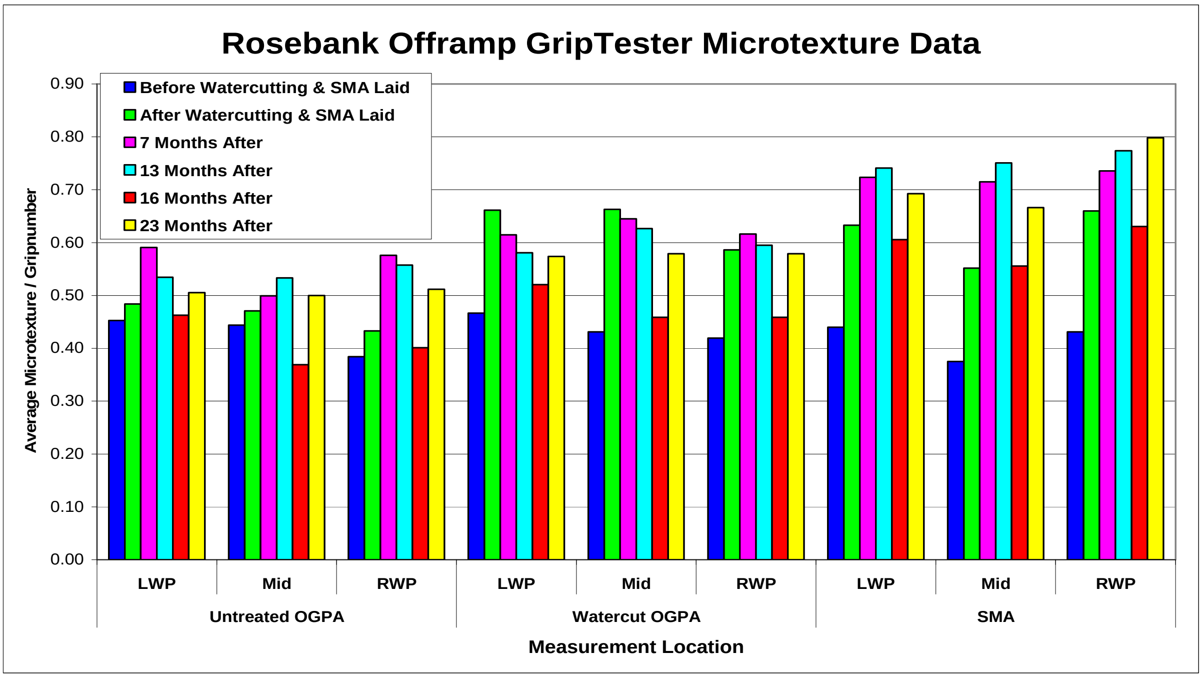
Watercut treatment length

The SCRIM+ microtexture surveys carried out one month before (2004 survey) and 13 months after (2005 survey) the watercutting treatment showed an improvement of 0.49 to 0.54 MSSC in the left wheelpath and no improvement in the right wheelpath. The 2006 survey carried out 23 months after the watercutting treatment showed the microtexture in the left wheelpath dropping back to 0.47 MSSC and increasing in the right wheelpath from 0.43 to 0.44 MSSC.

SMA treatment length

The 2005 survey carried out 13 months after the SMA was laid showed an improvement in the microtexture compared with the 2004 survey measured one month before the SMA was laid. The change in the left wheelpath was from 0.47 to 0.64 MSSC and in the right wheelpath from 0.46 to 0.57 MSSC.

The 2006 survey carried out 23 months after the SMA was laid showed the microtexture in the LWP had decreased to 0.60 MSSC and increased further in the RWP to 0.59 MSSC.



GripTester microtexture data analysis

Untreated OGPA length

Griptesting of the length of untreated OGPA shows that the average gripnumber for the surface varied over time. The LWP data shows the average gripnumber at 0.45 at the start of the monitoring, rising up to 0.59 gripnumber seven months later, and back to 0.51 gripnumbers 23 months after the first test. The Mid data shows the average gripnumber starting at 0.44 gripnumber, up to 0.53 and down to 0.37 gripnumber then back to 0.50 gripnumbers 23 months after the first test. The RWP data shows the average gripnumber starting at 0.38 at the start of monitoring up to 0.58 then back to 0.51 gripnumbers 23 months after the first test.

Watercut treatment length

The griptesting immediately before and after the watercutting treatment showed large increases in average gripnumber for the LWP (0.47 to 0.66), Mid (0.43 to 0.66) and RWP (0.42 to 0.59).

Testing seven months after the treatment showed that the average gripnumber had decreased to 0.62 (LWP) and 0.65 (Mid) and increased to 0.62 (RWP).

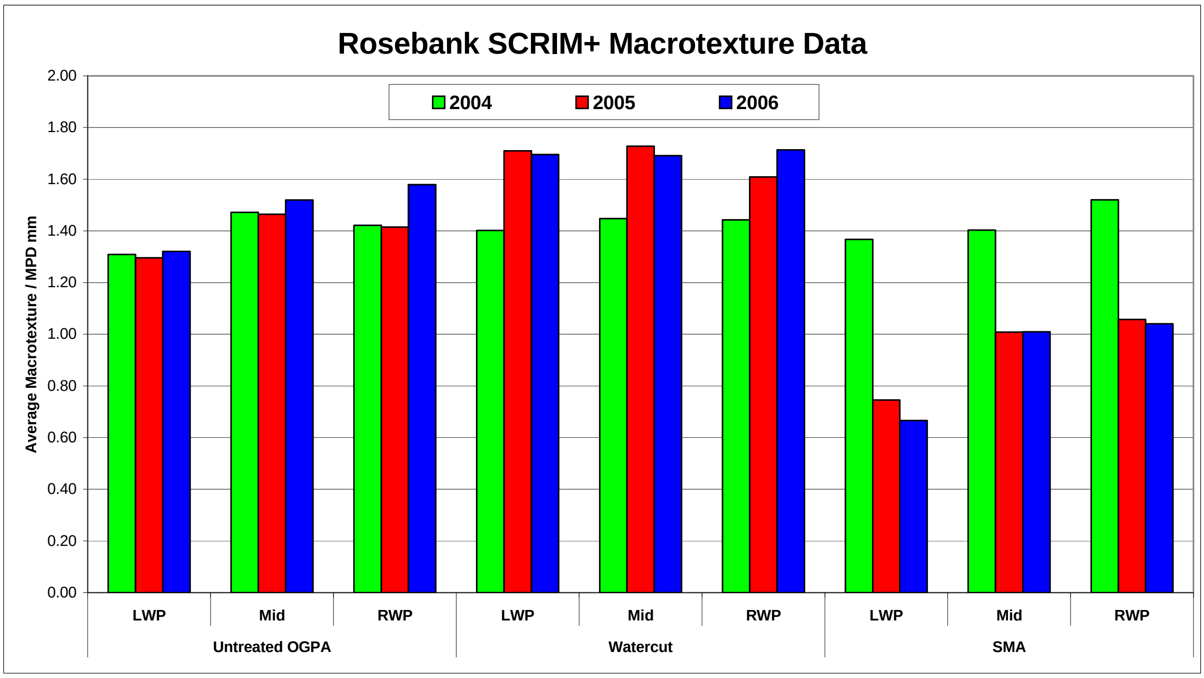
Subsequent testing showed the microtexture had remained constant apart from 16 months after the site was watercut where the result was low. Testing carried out 23 months after the watercutting treatment showed that the microtexture was at 0.57 MSSC (LWP), 0.58 MSSC (Mid) and 0.58 MSSC (RWP) which are 0.10, 0.15 and 0.16 (respectively) gripnumbers higher than that measured immediately before the treatment was completed.

SMA treatment length

The griptesting immediately before and after the SMA was laid showed large increases in the average gripnumber for the LWP (0.44 to 0.63), Mid (0.38 to 0.55) and RWP (0.43 to 0.66).

Subsequent testing showed further improvement to 0.74 (LWP), 0.75 (Mid) and 0.77 (RWP) 13 months after the SMA was laid.

Testing 23 months after the SMA was laid showed that the average gripnumber had decreased in the LWP (to 0.69) and Mid (to 0.67) and shown further improvement in the RWP (to 0.80).



SCRIM+ macrotexture data analysis

Untreated OGPA length

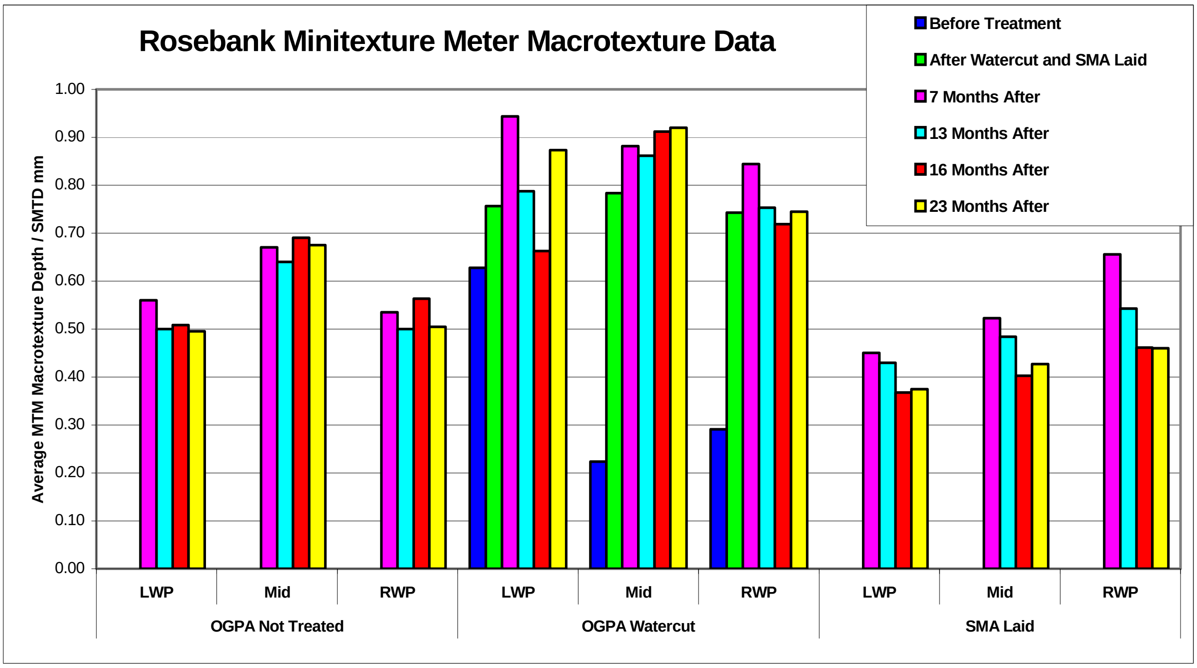
The SCRIM+ macrotexture data shows that the LWP average macrotexture remained relatively unchanged, starting at 1.31 mm a month before the rest of the site was resurfaced and measuring 1.32 mm MPD 23 months later. The average macrotexture at the mid-point has shown a small increase from 1.47 mm MPD a month before and 1.52 mm MPD 23 months later. The average macrotexture of the RWP remained constant at 1.42 mm MPD for the first 13 months then showed an increase to 1.58 mm MPD when surveyed 10 months later in 2006.

Watercut treatment length

The SCRIM+ 2004 survey, measured a month before the watercutting treatment, recorded an average macrotexture (MPD mm) 1.40 (LWP), 1.45 (Mid), and 1.44 (RWP). The 2006 survey, 23 months after the watercutting treatment, measured an average macrotexture 1.70 mm (LWP), 1.69 mm (Mid) and 1.71 mm (RWP).

SMA treatment length

The data shows that the average macrotexture depth (MPD) of the SMA 13 months after laying was 0.75 mm (LWP), 1.01 mm (Mid) and 1.06 mm (RWP). Ten months later the 2006 survey measured the average macrotexture depth (MPD) at 0.67 mm (LWP), 1.01 mm (Mid) and 1.04 mm (RWP).



MTM macrotexture data analysis

Location of the testing was difficult, as the actual wheel paths were hard to see and follow at night using torchlight.

Untreated OGPA length

Difficulties with the MTM and access to the site with traffic management and closures meant that the first macrotexture data for the site was seven months after the first monitoring. The macrotexture data shows the texture remained relatively constant over the four test runs in each of the locations. The difference between the highest and lowest average in each location is 0.06 mm (LWP), 0.05 mm (Mid) and 0.06 mm (RWP).

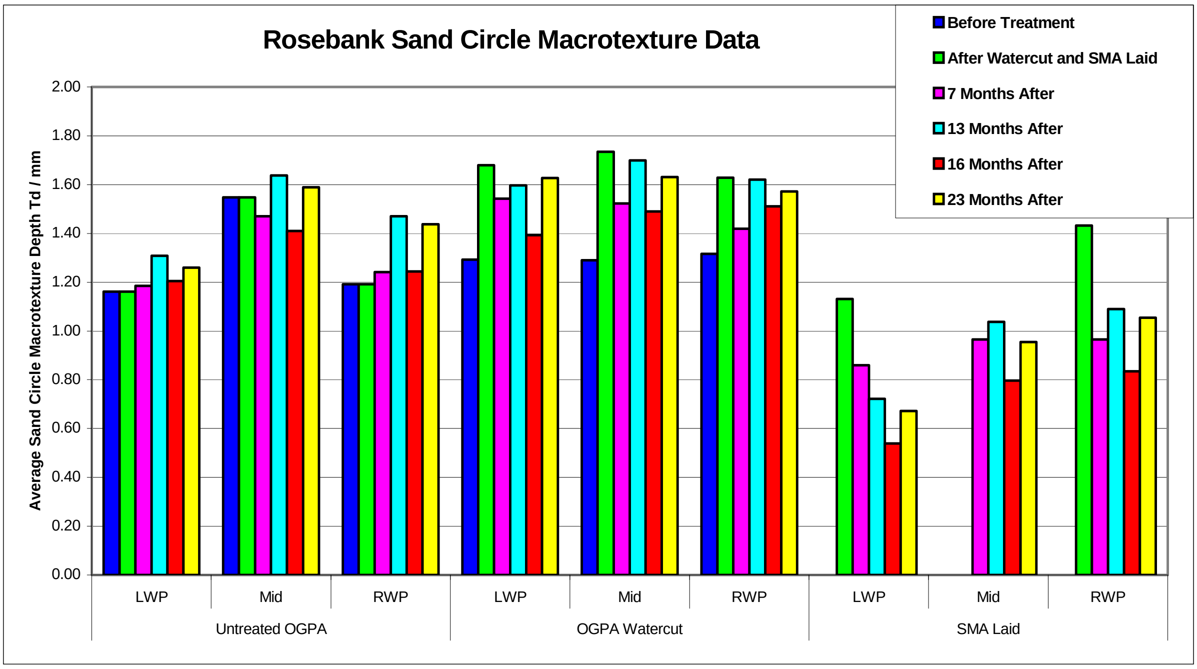
Watercut treatment length

Testing with the MTM immediately before and after the surface was watercut showed good macrotexture (SMTD mm) improvement in the three test lines across the site (LWP 0.63 to 0.76 mm, Mid 0.22 to 0.78 mm, and RWP 0.29 to 0.74 mm). The results varied, however, and 23 months after the treatment the increase was recorded at 0.87 mm (LWP), 0.92 mm (Mid) and 0.75 mm (RWP).

SMA treatment length

The MTM could not measure the macrotexture on the fresh SMA as it was still warm and water from the rollers on the fresh surface affected the readings.

Subsequent testing showed the texture was decreasing in the three locations across the road in the 23 months after the SMA was laid. The macrotexture measured for the locations ranged from LWP (0.45 to 0.37 mm SMTD), Mid (0.52 to 0.43 mm SMTD) and RWP (0.66 to 0.46 mm SMTD) with the first value at seven months after laying and the second value 23 months after laying.



Sand circle macrotexture data analysis

The location of the measurements on this site was difficult without RPMs for delineation and the need to use torches as the monitoring was done at night, so some of the inconsistency may be due to measuring different transverse and longitudinal locations on the surface.

Untreated OGPA length

Sand circle measurement of the macrotexture (Td) was carried out on the last 40 m of the untreated OGPA adjacent to the watercut length for comparison. The data varies due to difficulties relocating to the same site for the monitoring and the small number of data points.

Generally the macrotexture increased over the 23 months since it was first tested (LWP 1.16 to 1.26 mm, Mid 1.55 to 1.59 mm, and RWP 1.19 to 1.44 mm).

Watercut treatment length

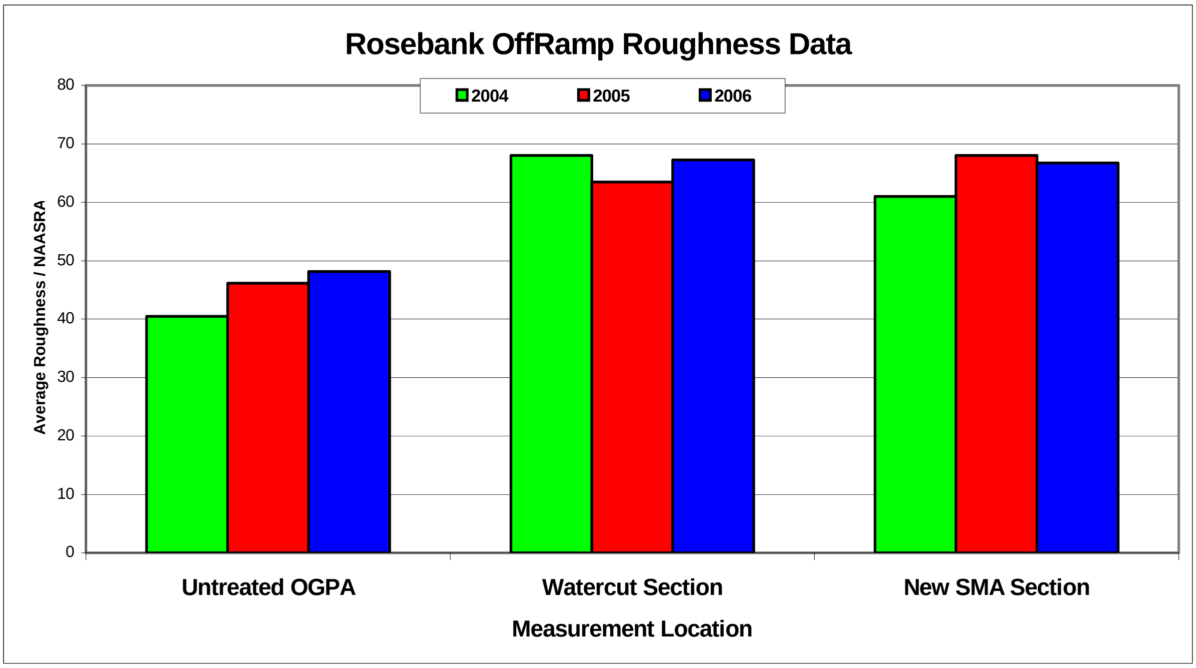
Sand circle measurement of the macrotexture (Td) was carried out immediately before and after the watercutting treatment, with the data showing the following improvements: LWP (1.29 to 1.68 mm), Mid (1.29 to 1.73 mm) and RWP (1.32 to 1.63 mm).

The data varies a little but generally slowly decreased so that 23 months after the watercutting treatment the macrotexture (Td) had reduced to 1.63 mm (LWP), 1.63 mm (Mid) and 1.57 mm (RWP).

SMA treatment length

The sand circle measurements of the SMA showed the macrotexture in the wheelpaths reducing and the macrotexture between the wheelpaths remaining static. The data varied due to the small number of data points and the difficulty in locating the same spot for the retesting.

The data changed over the 23 months of monitoring as follows: 1.13 to 0.67 mm (LWP), 0.97 to 0.96 mm (Mid) and 1.43 to 1.05 mm (RWP).



Roughness data analysis

Untreated OGPA treatment length

The data shows that the roughness increased on this treatment length during the 24 months of monitoring (from 41 to 48 NAASRA).

Watercut treatment length

The roughness data shows very little change from that measured a month before the length was watercut and that measured 23 months later (68 to 67 NAASRA).

SMA treatment length

The data shows that the roughness increased after the SMA was laid from 61 NAASRA one month before to 68 NAASRA 13 months after it was laid. Twenty-three months after the SMA was laid the result was 67 NAASRA.

Aggregate polishing

The OGPA surface comprised exposed aggregate from the mix with detritus filling the interstitial voids. The top surface of the aggregate was worn and rounded with little or no binder coating.

After watercutting the surface was visually cleaner and rougher to touch. Unfortunately all of the work and testing was carried out at night within closures so we did not get any quality before or after photographs of the surface.

In the 2005 traffic counts the PSV calculations produced 53 as the required PSV for the aggregate with an IL of 0.5. The PSV of the aggregate used in the existing OGPA was from Taotaoroa Quarry with a PSV = 54.

The site had an IL = 0.5 due to the bend with radius < 250 m; however, there were other factors such as the long bridge and its off-ramp with braking traffic that could place more demand on the surface than a site with a short radius bend.

The aggregate used in the SMA section on this site had a PSV =61.

Traffic counts

The traffic counts remained static for this off-ramp ranging from 4840 AADT in 2001 down to 4686 AADT with 2% HCV estimated for December 2005.

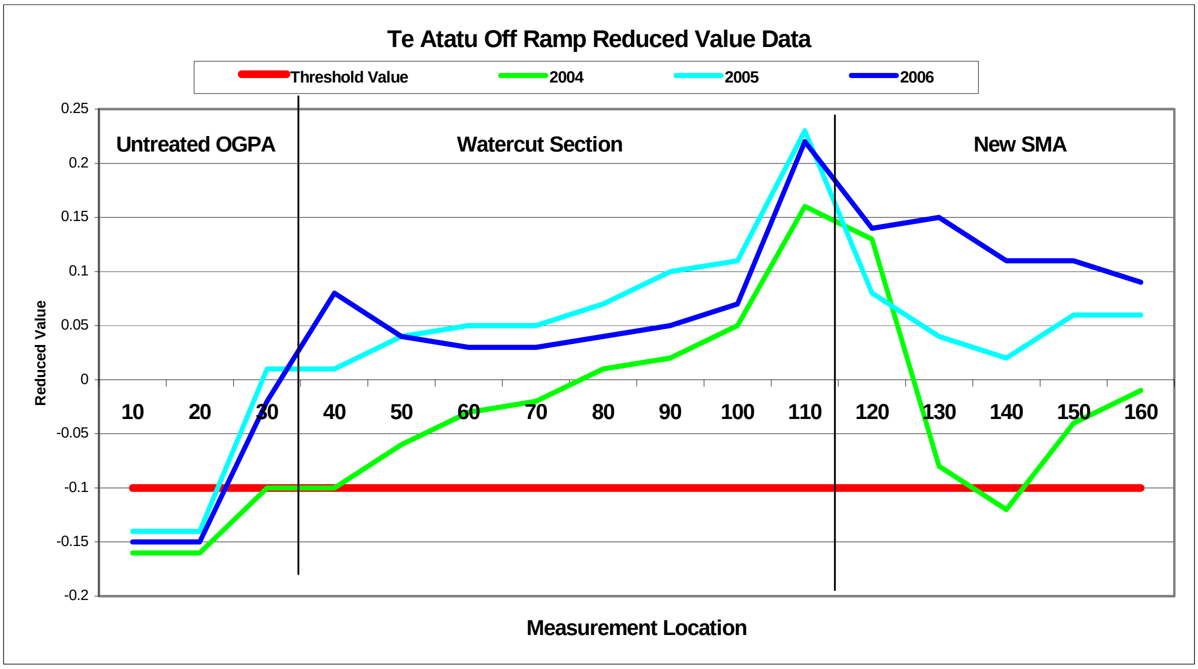
Accidents

There have been no reported accidents on the Rosebank Westbound Offramp since 1999 when it was first surfaced.

Aggregate testing

The test results showed the aggregates complied with the requirements of M/6. The PSV results for each size fraction from Motouhora Quarry were all 61.

Appendix 15: Site 10 Te Atatu monitoring data



Reduced value data analysis

One of the reasons for the significant changes shown in some of the data is the change from year to year of the IL that forms the basis for calculating the reduced value for each 10 m length. An example of this change is the SCRIM site IL for the 90–100 m section, which has changed each year from 0.5 to 0.4 to 0.5 etc since the 2001 survey, probably due to the location of the section close to a tangent point.

Untreated OGPA

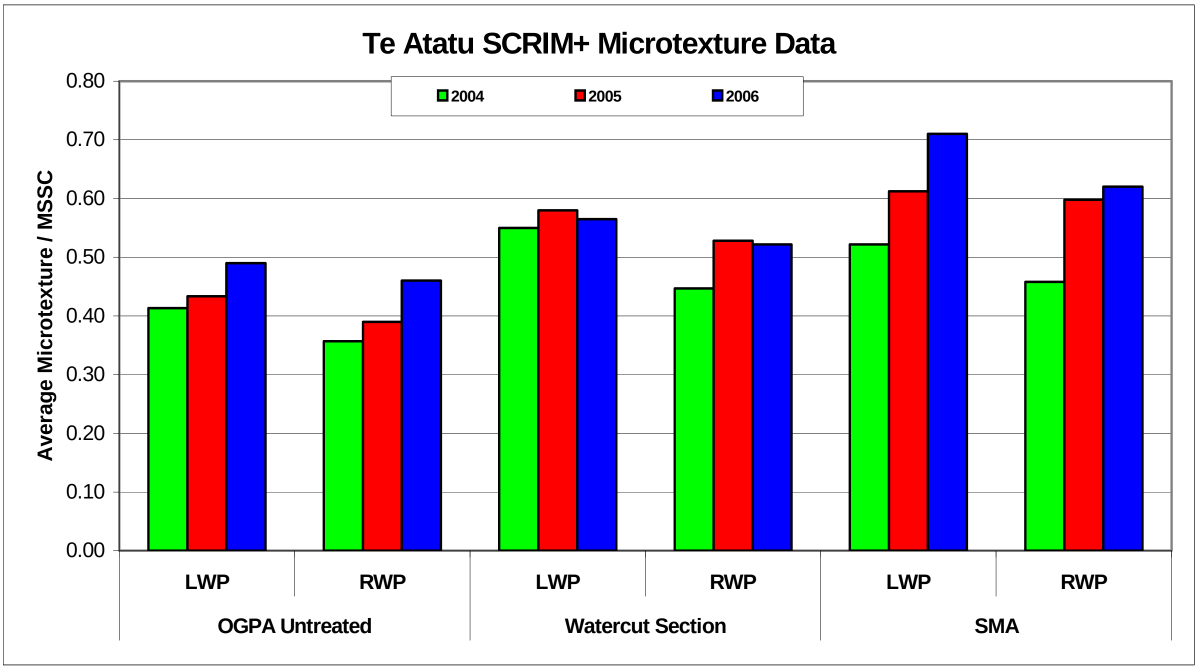
Surveys showed that the microtexture on the first 20 m of the untreated section remained stable and below the TL for the past four years. The change in the third 10 m section was caused by the data for that section including differing proportions of the watercut section.

Watercut section

The 2004 SCRIM+ survey carried out a month before watercutting showed the microtexture had deteriorated from having 25% below the IL in the 2003 SCRIM+ survey to 50% below and one 10 m length at the threshold level. After the site was watercut the 2005 (13 months after watercutting) and 2006 (23 months after watercutting) SCRIM+ surveys showed that there were no 10 m sections below the IL.

SMA section

The 2004 SCRIM+ survey carried out a month before the SMA was laid showed the microtexture had deteriorated from having 40% below the IL in the 2003 survey to 80% below and one 10 m section below the TL. SCRIM+ surveys taken 13 and 23 months after the SMA was laid showed that no 10 m sections were below the IL.



SCRIM+ microtexture data analysis

Untreated OGPA section

Although the average microtexture for this short section was stable but low in the 2004 and 2005 surveys, it showed an increase in 2006. However, the averages were all below 0.5, which was the average IL for the section so the surface was below the IL.

Watercut section

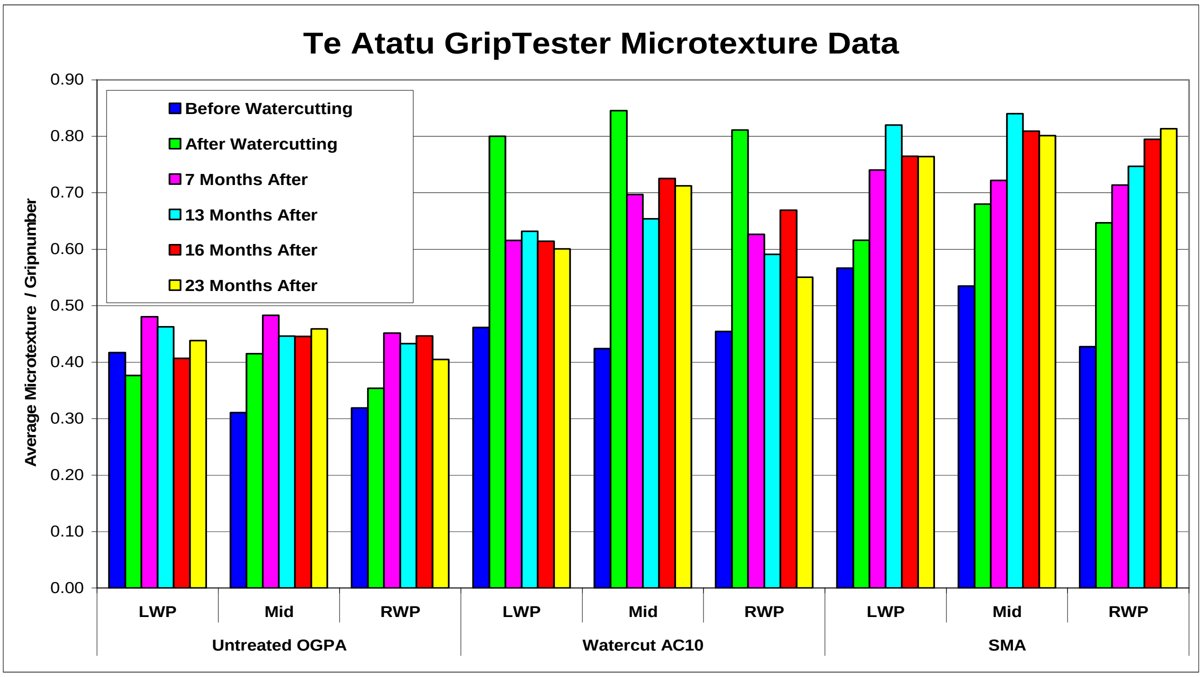
The average microtexture in the left wheelpath of the watercut section measured in the 2005 SCRIM+ survey, 13 months after the watercutting, showed a small increase from 0.55 to 0.58 MSSC. The 2006 survey, 23 months after watercutting, measured 0.57 MSSC for the section showing the improvement had remained.

The average microtexture in the right wheelpath of the watercut section measured in the 2005 SCRIM+ survey, 13 months after the watercutting, showed an increase from 0.45 to 0.53 MSSC. The 2006 survey, 23 months after watercutting, measured 0.52 MSSC showing the improvement had been retained.

SMA section

The average microtexture in the left wheelpath of the watercut section measured in the 2005 SCRIM+ survey, 13 months after the SMA was laid, showed an increase from 0.52 to 0.61 MSSC. The 2006 survey, 23 months after resurfacing, measured 0.71 MSSC showing a further increase as the higher PSV aggregate was exposed by the traffic wearing away the mastic.

The average microtexture in the right wheelpath of the SMA section measured in the 2005 SCRIM+ survey, 13 months after the SMA was laid, showed an increase from 0.46 to 0.60 MSSC. The 2006 survey, 23 months after the resurfacing, measured 0.62 MSSC showing the improvement had remained.



GripTester microtexture data analysis

Untreated OGPA control length

The testing immediately before and after the resurfacing on the other sections showed some variations in the results most likely related to variations in test line location and variations between test conditions.

Subsequent testing showed the microtexture had varied as follows: LWP 0.42 to 0.44, Mid 0.31 to 0.46 and RWP 0.32 to 0.41 in the 23 months since it was first tested. Some of the change may be due to the OGPA beginning to unravel and exposing unpolished aggregate.

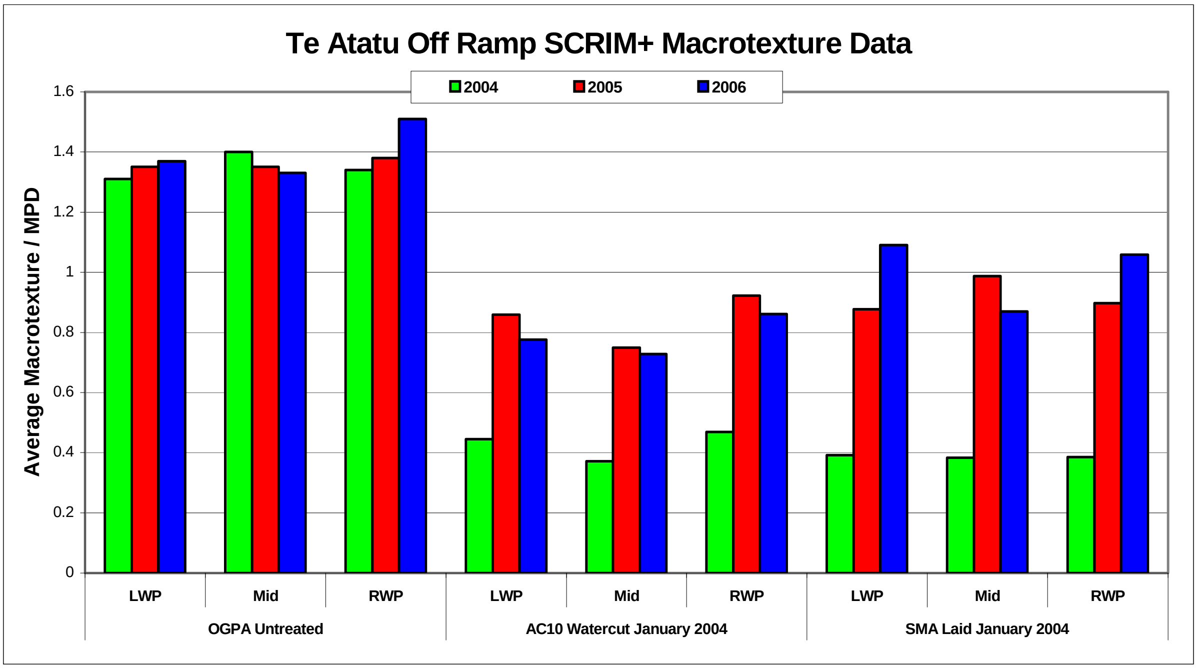
Watercut treatment length

The testing before and after showed large increases in average gripnumber for the LWP (0.46 to 0.80), Mid (0.42 to 0.85) and RWP (0.45 to 0.81). Testing seven months after the watercutting was completed showed the average gripnumber had reduced to 0.62 (LWP), 0.70 (Mid) and 0.63 (RWP). Subsequent testing showed that the watercut section microtexture remained, on average for the last four tests, 0.15 gripnumber higher than that measured before the watercutting in the wheelpaths and 0.27 gripnumber higher between the wheelpaths.

SMA treatment length

The testing immediately before and after showed relatively small increases in average gripnumber for the section length after the application of the SMA for the LWP (0.57 to 0.62), Mid (0.54 to 0.68) and RWP (0.43 to 0.65). This was expected as the surface was still coated with the thick mastic of bitumen, fibres and mineral filler.

Further testing showed that the microtexture on the surface of the SMA increased over the next seven months to 0.74 (LWP), 0.72 (Mid) and 0.71 (RWP), and after 23 months to 0.76 (LWP), 0.80 (Mid) and 0.81 (RWP). It was assumed that the increases were due to the mastic wearing off the surface of the stone exposing the microtexture of the high PSV chip.



SCRIM+ macrotexture data analysis

Untreated OGPA length

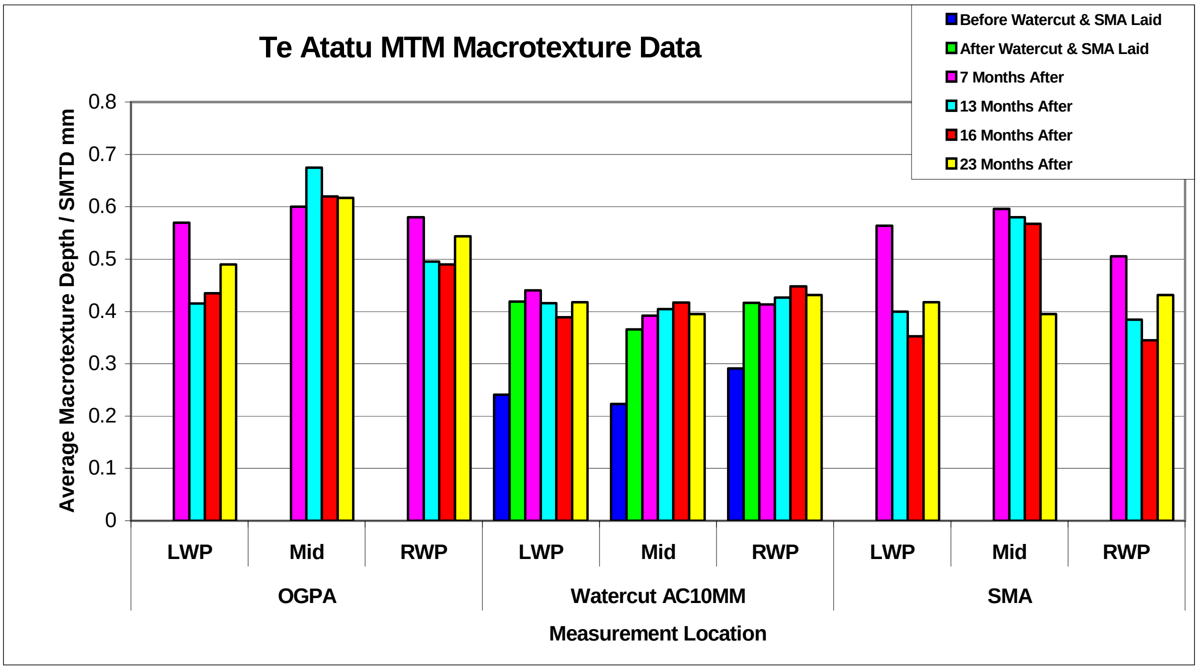
The SCRIM+ surveys (2004-2006) showed the average macrotexture of the OGPA increasing in both wheelpaths LWP (1.31 mm to 1.37 mm) and RWP (1.19 mm to 1.38 mm) most likely due to the OGPA surface beginning to unravel. The macrotexture between the wheelpaths has decreased over the same period from 1.41 mm to 1.33 mm MPD.

Watercut treatment length

The SCRIM+ 2004 survey over the watercut length measured a month before the watercutting showed an average macrotexture (MPD) of 0.45 mm (LWP), 0.37 mm (Mid) and 0.47 mm (RWP). The SCRIM+ 2005 survey measured 13 months after the watercutting showed increases for all three locations to 0.86 mm (LWP), 0.75 mm (Mid) and 0.92 mm (RWP). The SCRIM+ 2006 survey measured 23 months after the watercutting showed that the macrotexture had decreased to 0.78 mm (LWP), 0.73 mm (Mid) and 0.86 mm (RWP).

SMA treatment length

The SCRIM+ 2004 survey over the SMA length measured a month before the SMA was laid measured 0.39 mm (LWP), 0.38 mm (Mid) and 0.39 mm (RWP). The SCRIM+ 2005 survey measured 13 months after the SMA was laid showed it had higher macrotexture at 0.88 mm (LWP), 0.99 mm (Mid), and 0.90 mm (RWP). The 2006 survey showed the SMA macrotexture had increased in the wheelpaths to 1.09 mm (LWP) and 1.06 mm (RWP) as the mastic was worn off the surface by the traffic but it had decreased between the wheelpaths to 0.87 mm (Mid) as the surface voids were filled with detritus.



MTM macrotexture data analysis

Location of the testing was difficult as it had to be done at night by torchlight and the actual wheel paths were hard to identify and follow.

Untreated OGPA length

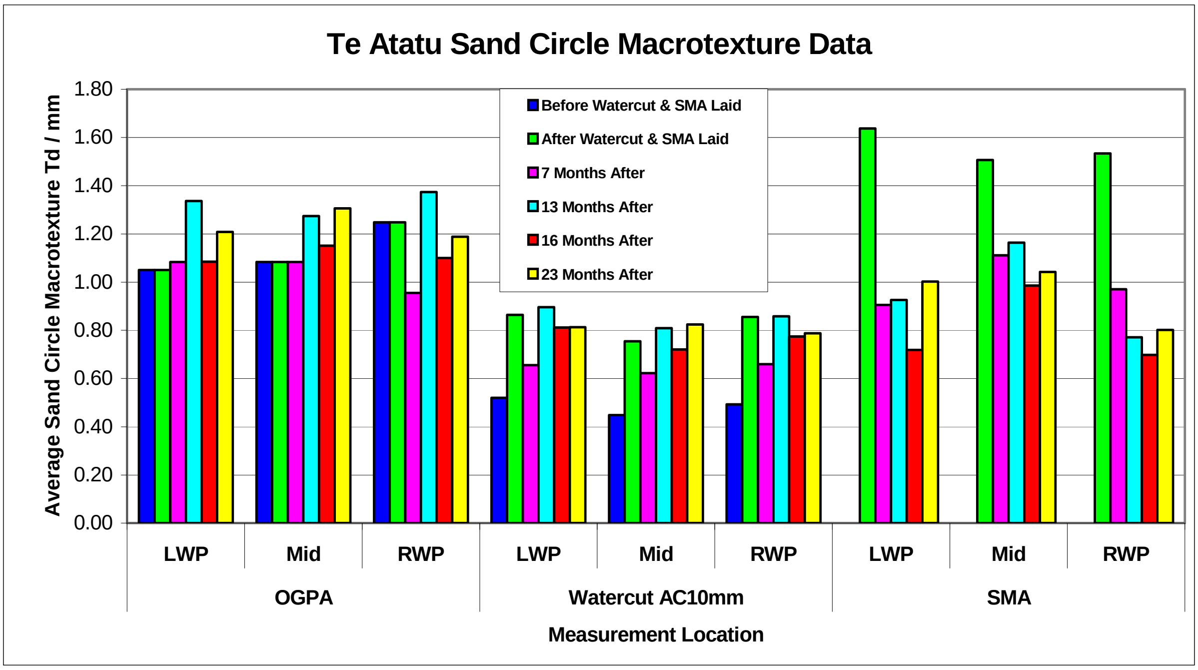
Only a very short section could be tested inside the traffic management closure which restricted the data to 1–2 points. The variations in the data are more likely to be due to variations in the location of the line tested than real changes in the surface.

Watercut treatment length

Test data from before and after watercutting showed an increase in the macrotexture (SMTD) on the AC10 surface from 0.24 mm to 0.42 mm (LWP), 0.22 mm to 0.37 mm (Mid) and 0.29 mm to 0.42 mm (RWP). Subsequent testing over the next 23 months showed the texture had remained at a similar level. The final test results were as follows: 0.42 mm (LWP), 0.40 mm (Mid) and 0.43 mm (RWP) MPD.

SMA treatment length

Test data using the MTM over SMA proved difficult and produced inconsistent results. Readings that were obtained 16 month after resurfacing showed that the macrotexture in both wheelpaths decreased from that measured seven months after resurfacing: 0.56 mm to 0.35 mm (LWP), 0.6 mm to 0.56 mm (Mid) and 0.51 mm to 0.35 mm (RWP). Testing carried out 23 months after resurfacing showed an increase in both wheelpaths to 0.42 mm (LWP) and 0.43 mm (RWP) and further decrease between the wheelpaths to 0.40 mm (Mid).

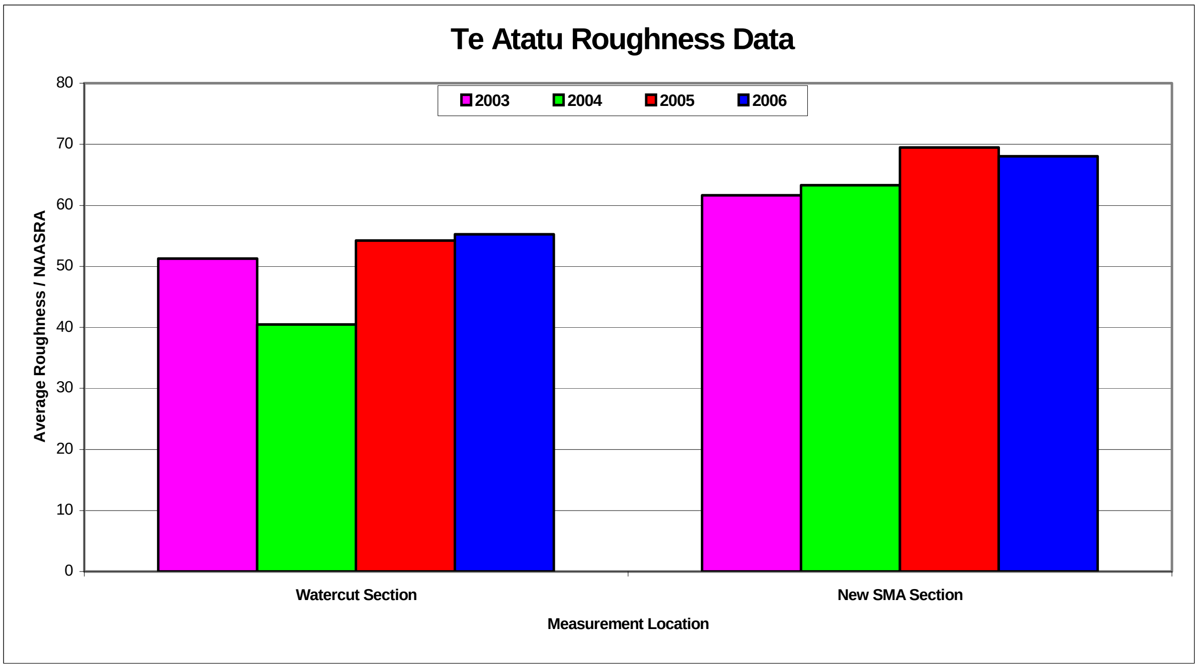


Sand circle macrotexture data analysis

The location of the measurements was difficult as it had to be done at night by torchlight so some of the inconsistency may be due to measuring different transverse and longitudinal locations.

Watercut section

Sand circle measurements of the average macrotexture Td before and after watercutting showed an increase from 0.52 mm to 0.86 mm (LWP), 0.45 mm to 0.75 mm (Mid) and 0.49 mm to 0.85 mm (RWP). Subsequent testing showed the texture had remained at similar levels with a slight decrease in the past 12 months. The results 23 months after watercutting were 0.81 mm (LWP), 0.82 mm (Mid) and 0.79 mm (RWP).



SCRIM+ roughness data analysis

Watercut section

The average roughness of the watercut section increased from 41 before treatment to 54 when measured 13 months after the section was watercut. It measured 55 counts when tested in the 2006 survey 23 months after the treatment.

SMA section

The average roughness of the new SMA section increased from 61 to 69 counts 13 months after treatment; however, the 2006 survey showed a decrease to 58 counts when tested 23 months after treatment.

Aggregate polishing

The watercutting refreshed the microtexture of the exposed chip on the surface and also removed some of the fine asphalt mastic from the surface. The microtexture slowly returned to pre-treatment levels over time and the impact of traffic which suggested it was repolishing.

Most of the site had an IL = 0.5 due to a bend with a radius <= 250 m; one 10 m length had an IL = 0.4 as it had no events; and the last 60 m had an IL=0.55 approaching a Give Way sign. The short radius bend and the approach to an intersection were both features of the last 60 m where the SMA was laid.

The coarse aggregate used in the 10 mm AC was from Moutohora Quarry and had a reported PSV of 58 in 1998 which met the required PSV. The calculation using the IL of 0.55 and 2004 traffic counts with 2% growth rate to calculate the required PSV produced 60, while the PSV of the Moutohora aggregate in 2004 was 65 and the PSV of the aggregate used tested at 61.

At the end of two years monitoring, both surfaces were performing well though the SMA with the newer aggregate with a higher PSV had a higher microtexture even though it was in a higher demand situation.

Traffic counts

There were no traffic counts available for the off ramp before 2001.

Traffic counts at the end of 2005 were similar to those measured in 2001; however, 2003 reported a high proportion of HCVs (5%) decreasing to 3% in 2004 and 2% in 2005. This represented a decrease of 59% HCV from 2003 to 2005.

Accidents

The last reported accident on this site was in 2001, two years before the monitoring started.

Aggregate testing

The test results showed the aggregates used to produce the SMA complied with the requirements of M/6. The PSV results for each size fraction from Motouhora Quarry were all 61.

Appendix 16: Surface friction change compared with tyre and surface temperature change