Western Cape Government

Transport and Public Works

BETTER TOGETHER.

OPTIMISING UNPAVED ROAD PERFORMANCE

INITIATIVES OVER THE PAST 17 YEARS

Roads Pavement Forum: May 2018

Gerrie van Zyl
Richard Hutten
Mervyn Henderson

Introduction

Several initiatives investigated and implemented

- Reintroducing quality management
- Impact of various chemical additives
- Blading optimization
- Optimisation of work methods & Calibration of performance models

Reintroducing quality management

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Improvements implemented

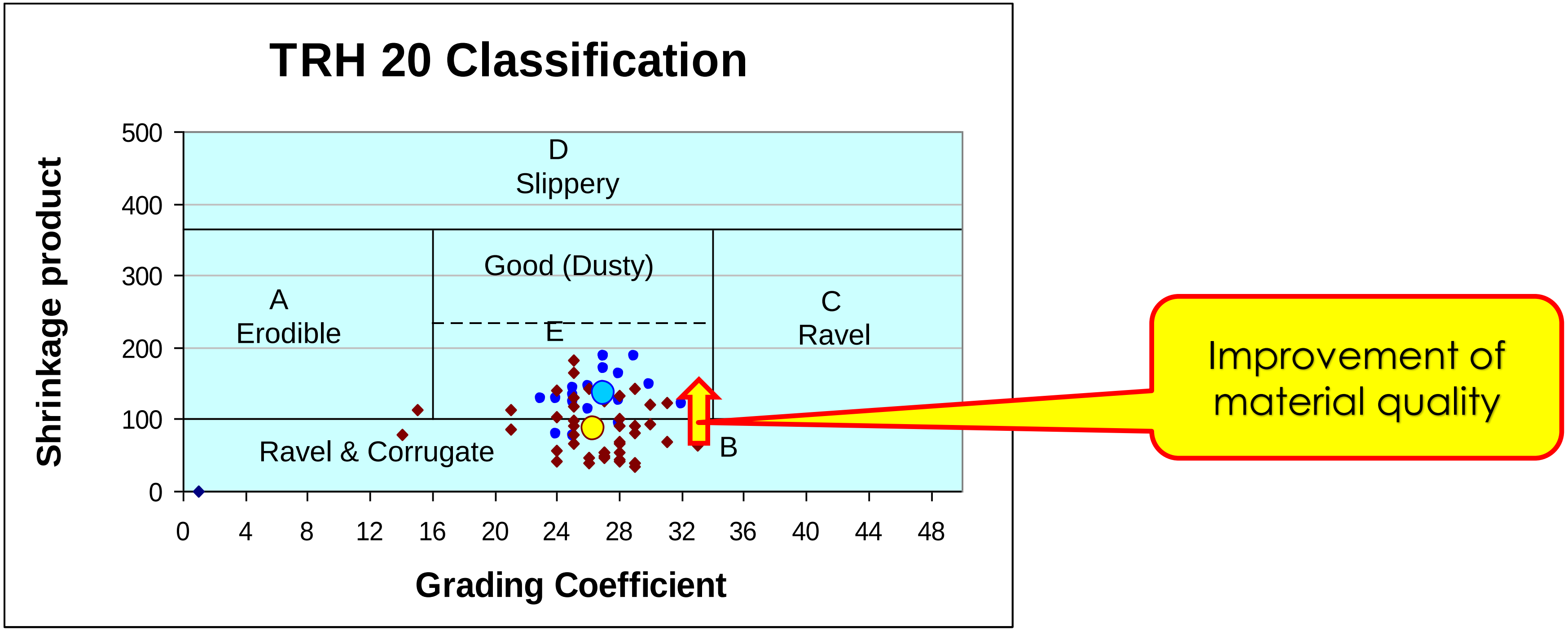
- Investigation, material selection, design, drainage
- Construction processes and training
  - 26 Trial sections
  - Equipment
  - Breaking down oversize
  - Remixing
  - Shape and crossfall
  - Proper compaction
  - Control
- Maintenance processes and strategies documented
- Manuals developed

Selection of materials

Blending

Effect of processing

Software to determine ratios of different materials



Shrinkage product (Sp) = % linear shrinkage x % passing 0,425 mm sieve

Grading coefficient (Gc)
= ([% passing 26,5 mm – % passing 2,0 mm]x % passing 4,75 mm) / 100

Construction Plant & Quality Control

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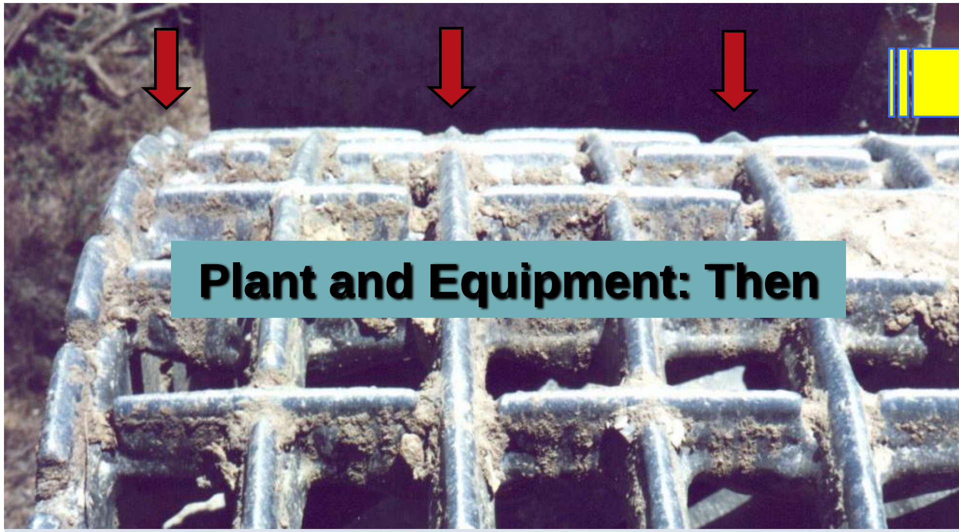

Controlled Construction Processes


Effective Grid rolling


Remove Oversize Manually


Pneumatic Roller Final Compaction


Wet Rolling (Slushing)

Wearing Course Finish

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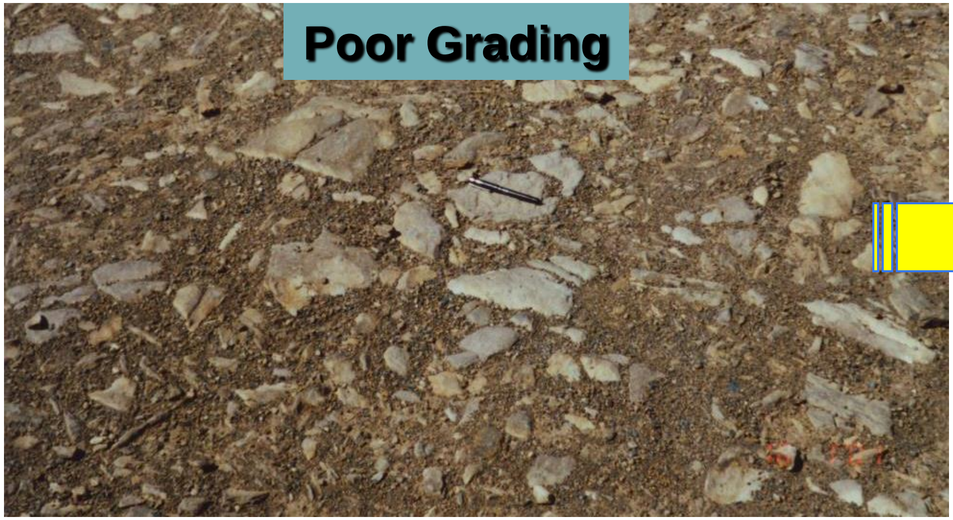
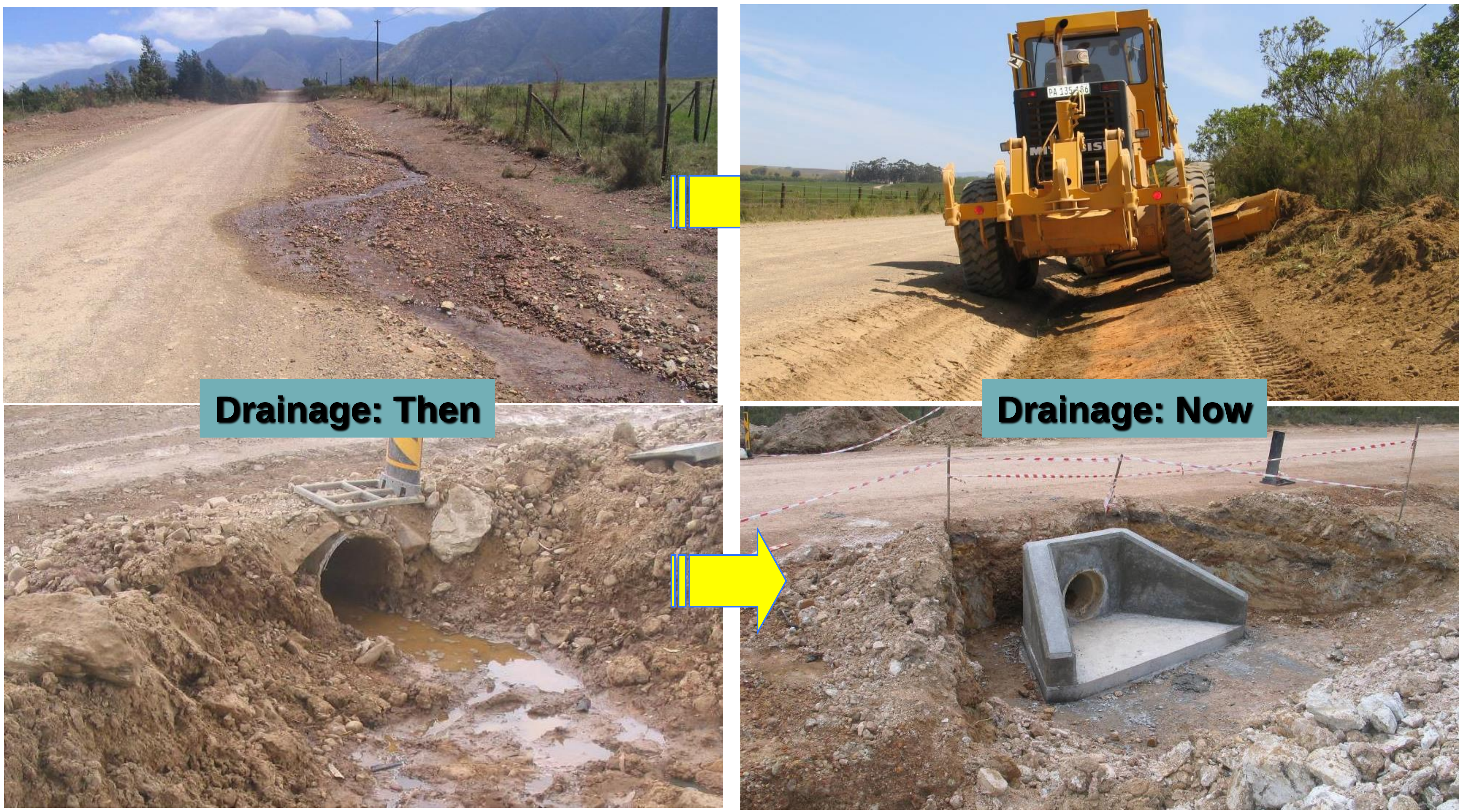

Poor Grading


Improved Grading


Compaction at OMC


Excellent Riding Quality

Drainage



Borrow Pit Development, Mining & Rehabilitation

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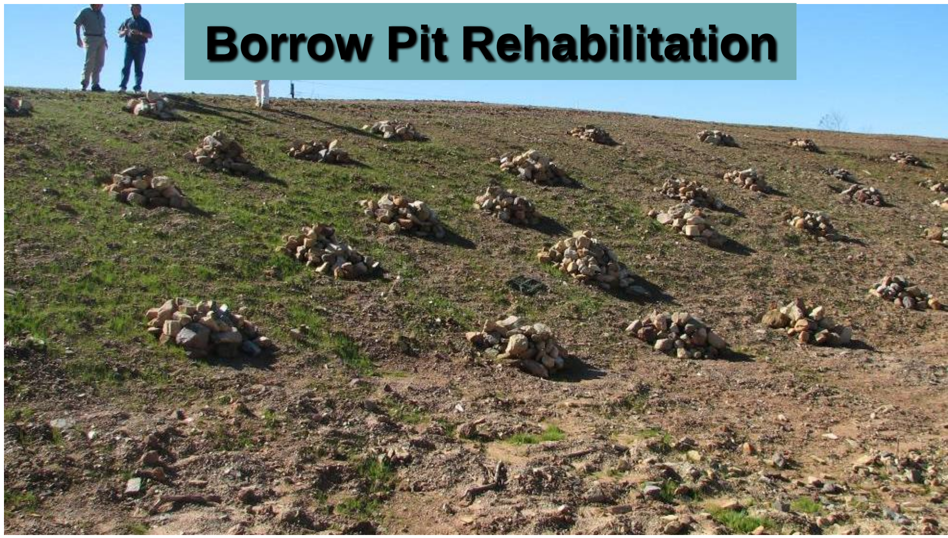
Public Participation


Borrow Pit Rehabilitation


Improved Mining Techniques


Environmentally friendly toilets

Quality management impacts

Study Results

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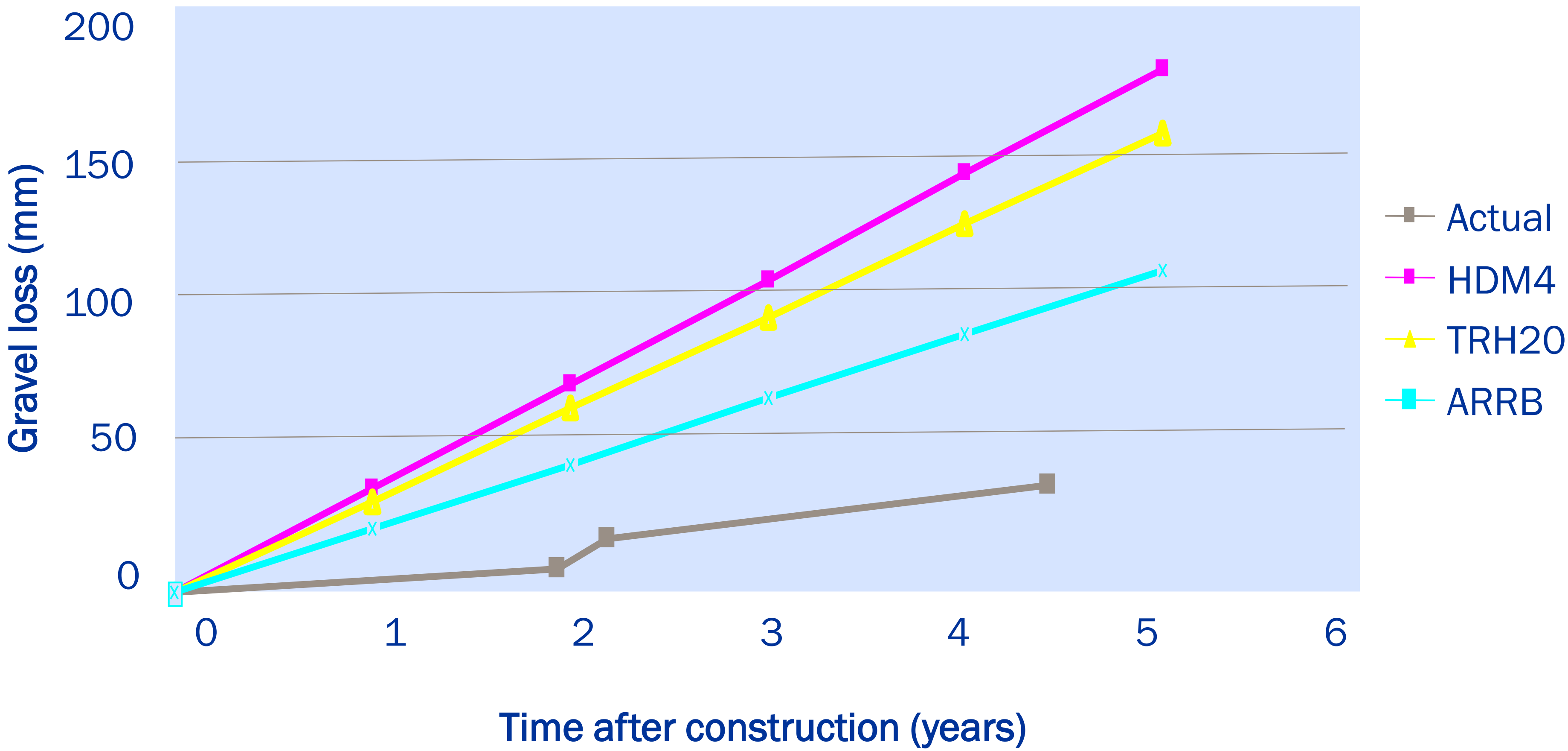
Comparison of Actual vs Predicted Gravel Loss (AADT<350)



Implications "Good practice"

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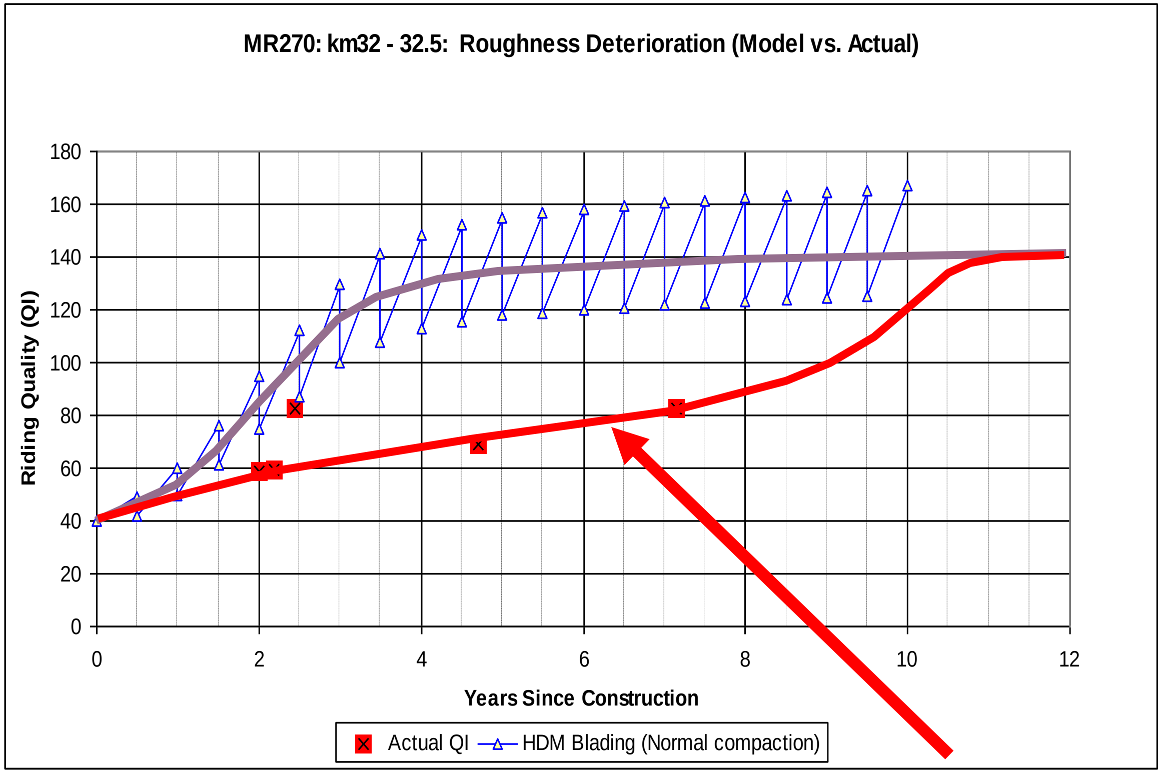
Much slower roughness deterioration than predicted

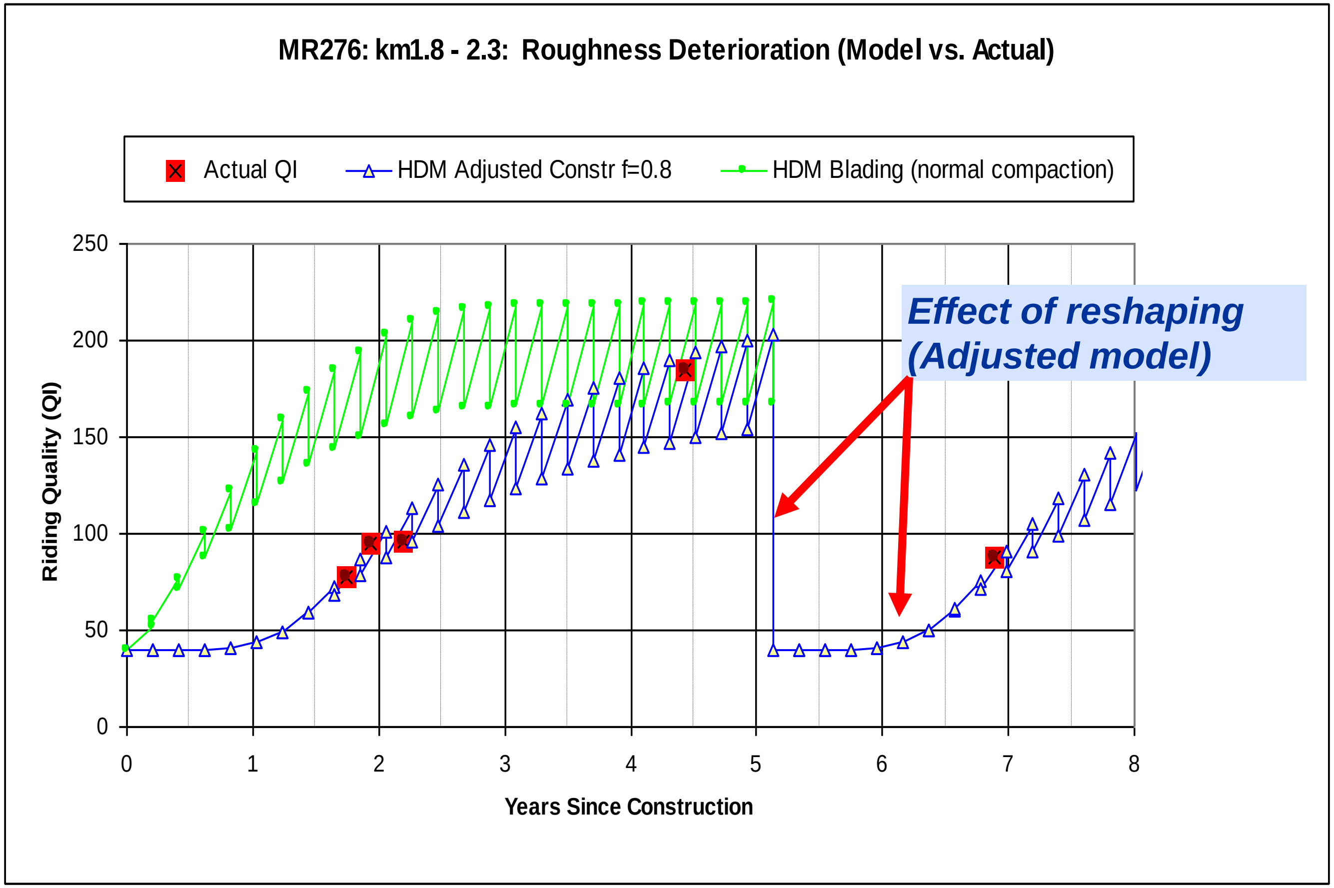


AADT = 66, 17% heavy

Improved performance directly related to savings in VOC

Implications of reshaping

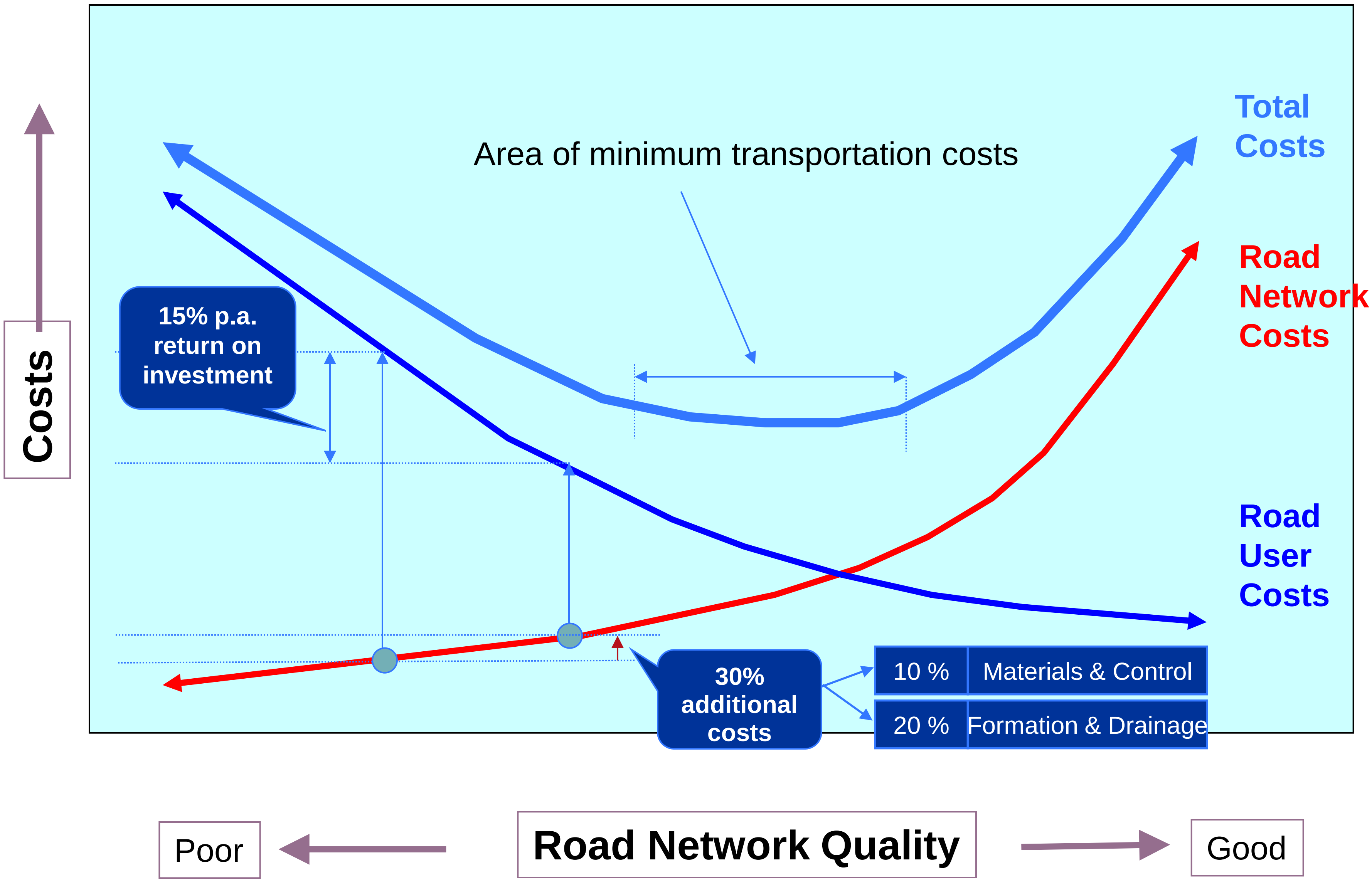
Reshaping more economic than continuous blading at high roughness levels



AADT = 323, 19% heavy (2001)

AADT > 500 (2007)

Impact of quality management



Chemical stabilisation

Impact of chemical additives

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- Several additives on various roads applied and monitored over the past 10 years

Varying effects

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Varying effects

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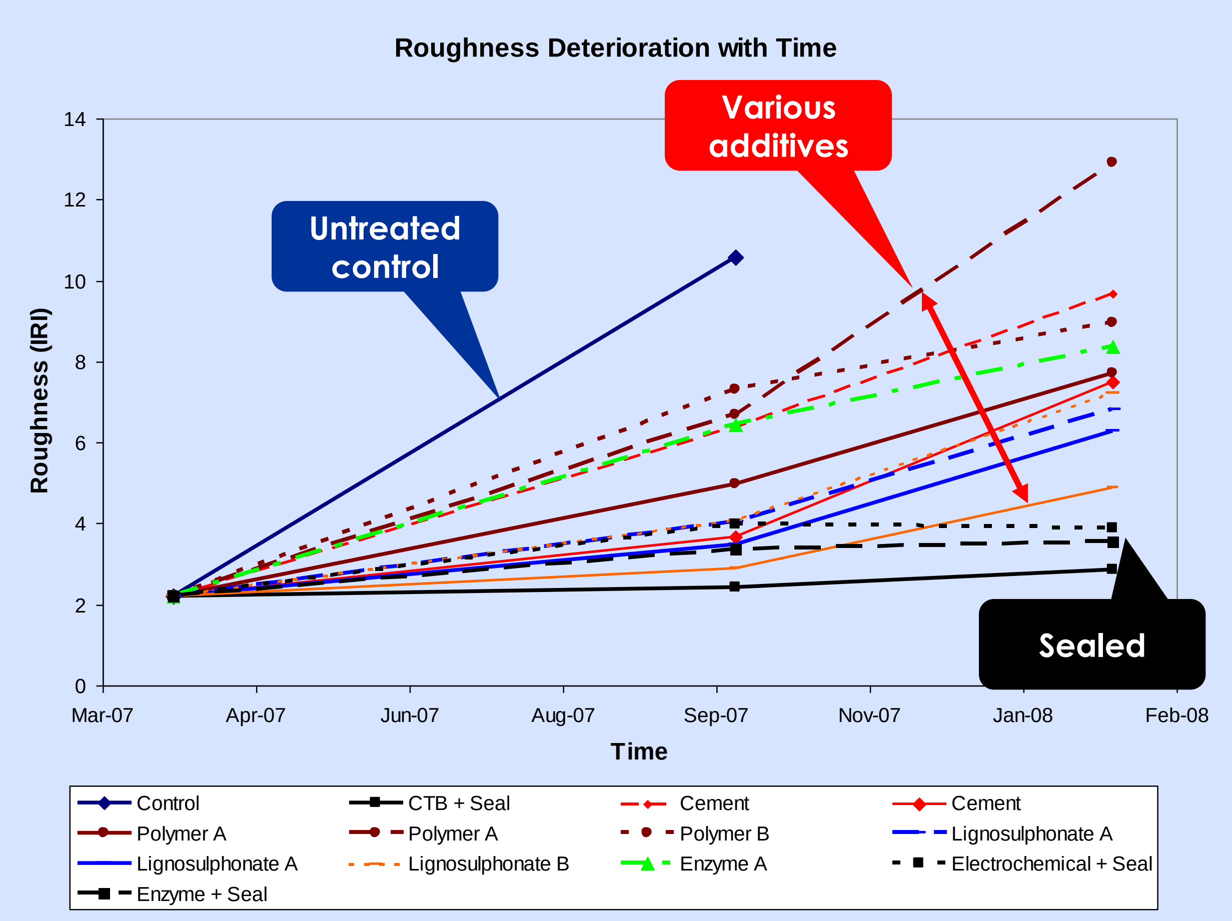
Comparative performance

All additives performed better than untreated control section

No treated section could be maintained for more than 1 year

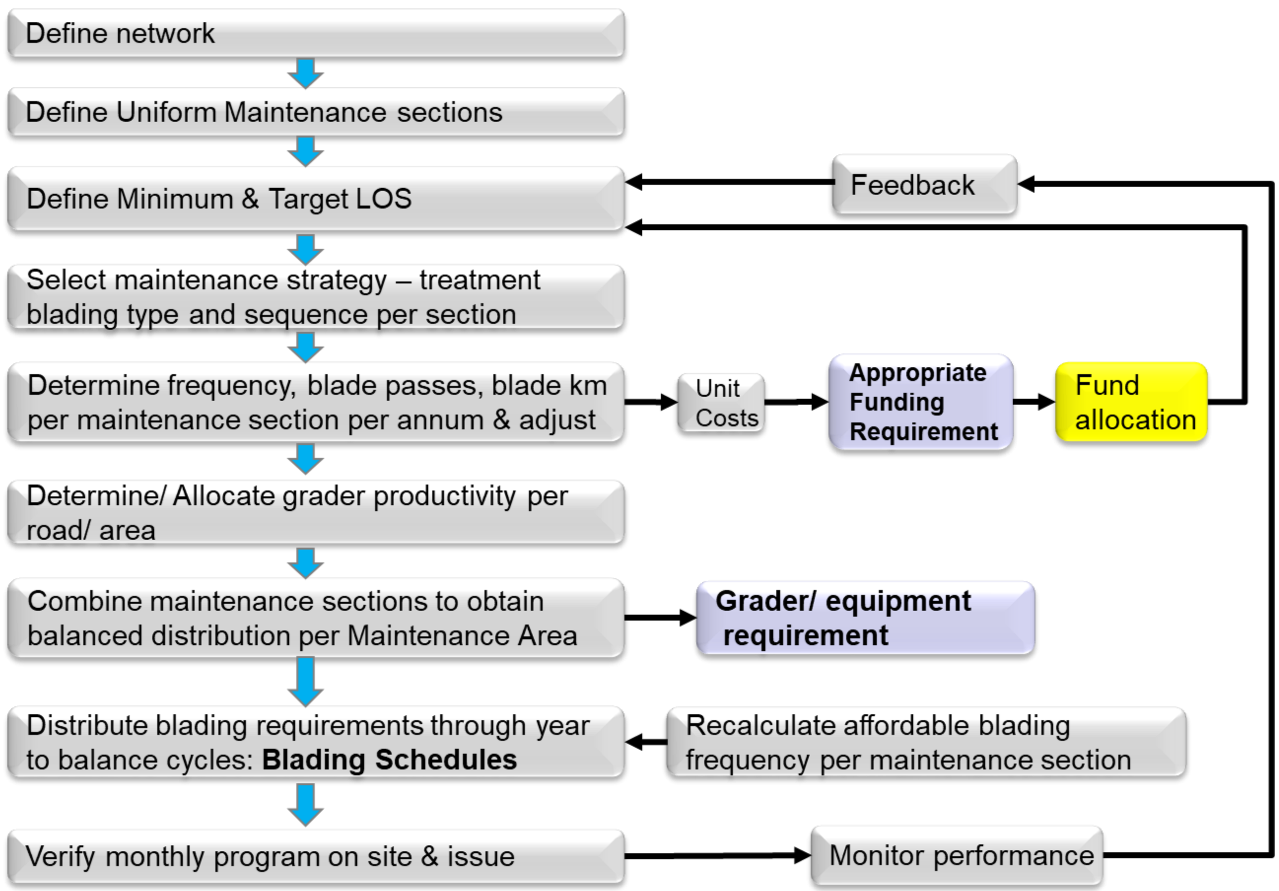
Excellent performance of sealed sections after 3 years



Blading optimisation

Methods investigated

- Theoretical model (Wandering salesman)
- Practical process
  - Best practice
  - In draft TRH20 ??
- FDS developed



Optimisation of work methods & Calibration of performance models

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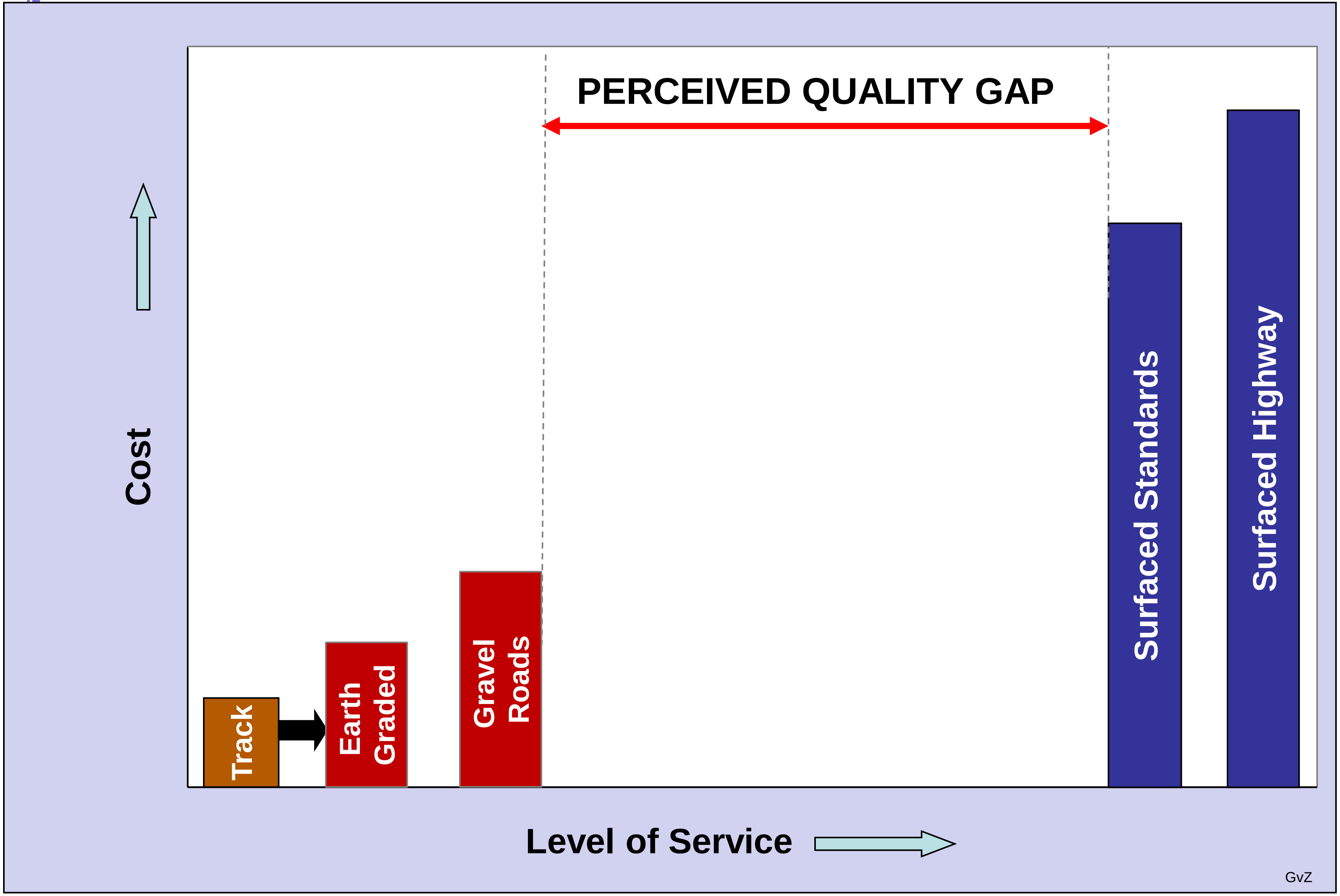
Why ?

- 5% of Vehicle kms travelled on gravel roads
- 35% of maintenance funding on gravel roads
- Gravel road network still deteriorating
  - Average gravel thickness
  - General condition
- Shortage and depletion of suitable materials
- High environmental demands
- Public opinion

Fact: We cannot maintain all unpaved roads at the same level !

Service Delivery



Challenge

- **Traffic volumes too low to warrant high expenditure**
- **Obligation to provide and maintain roads to acceptable standards**
  - ❑ Accessibility
  - ❑ Safety
  - ❑ Mobility

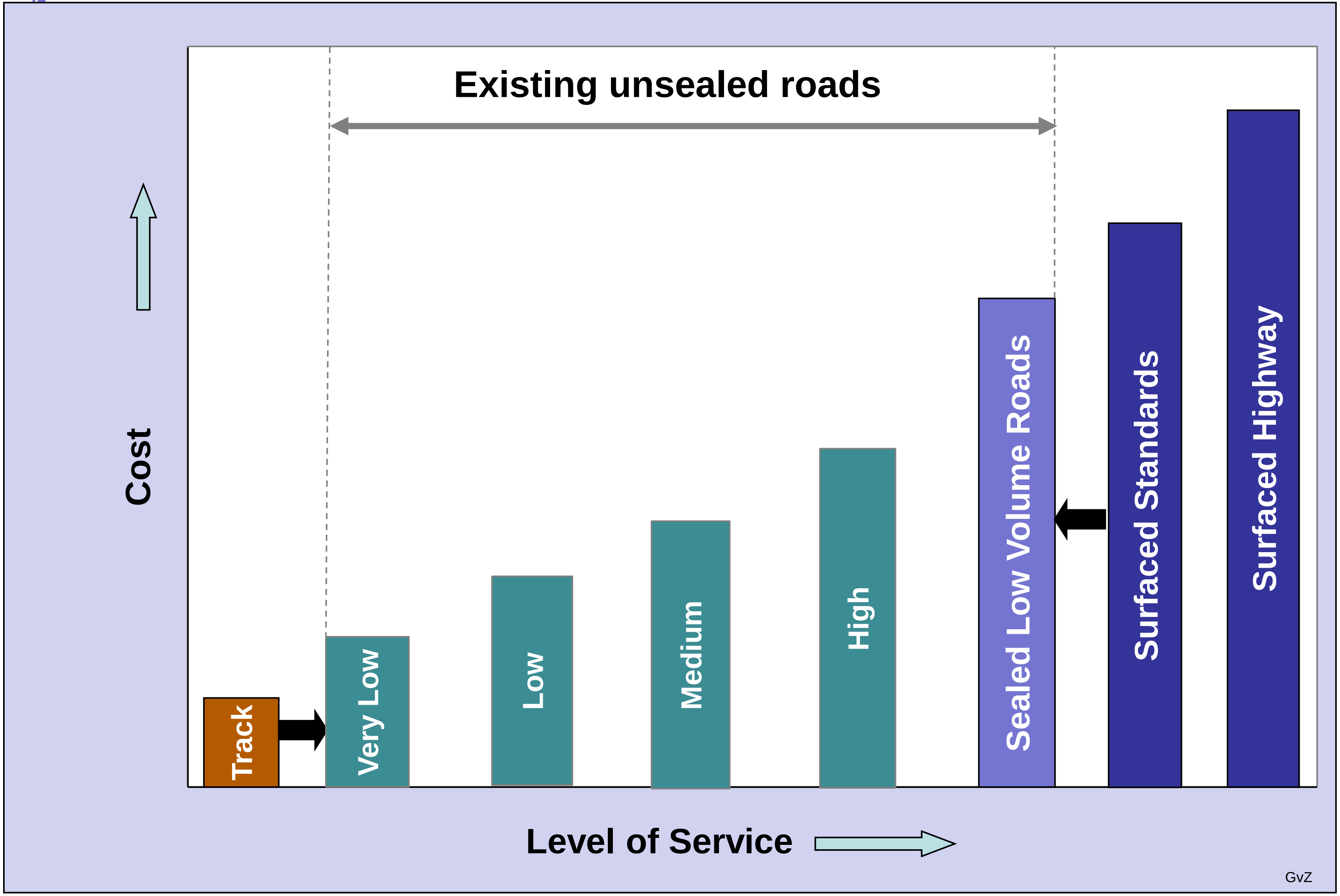
Action

Defining appropriate Levels of Service

- Traffic volume
- Agricultural potential
  - Produce sensitivity
  - Job creation
- Tourism
- Social

Level of service	Mobility			Accessibility[1]		Safety rating in terms of dustiness[2]	Proportion of the unpaved network [km]
	Intervention Roughness [p90 IRI]	Minimum Speed [km/h]	Target[3] Average Roughness				
High	7,5	80	4	99,5%:	≤2 days out of service pa	≤3	2 516,7
Medium	10	60	5	99%:	≤3,5 days out of service pa	≤4	1 760,5
Low	13	40	6	99%:	≤3,5 days out of service pa	≤4	3 013,2
Very low	15	20	6	99%:	≤3,5 days out of service pa	≤5	3 090,4

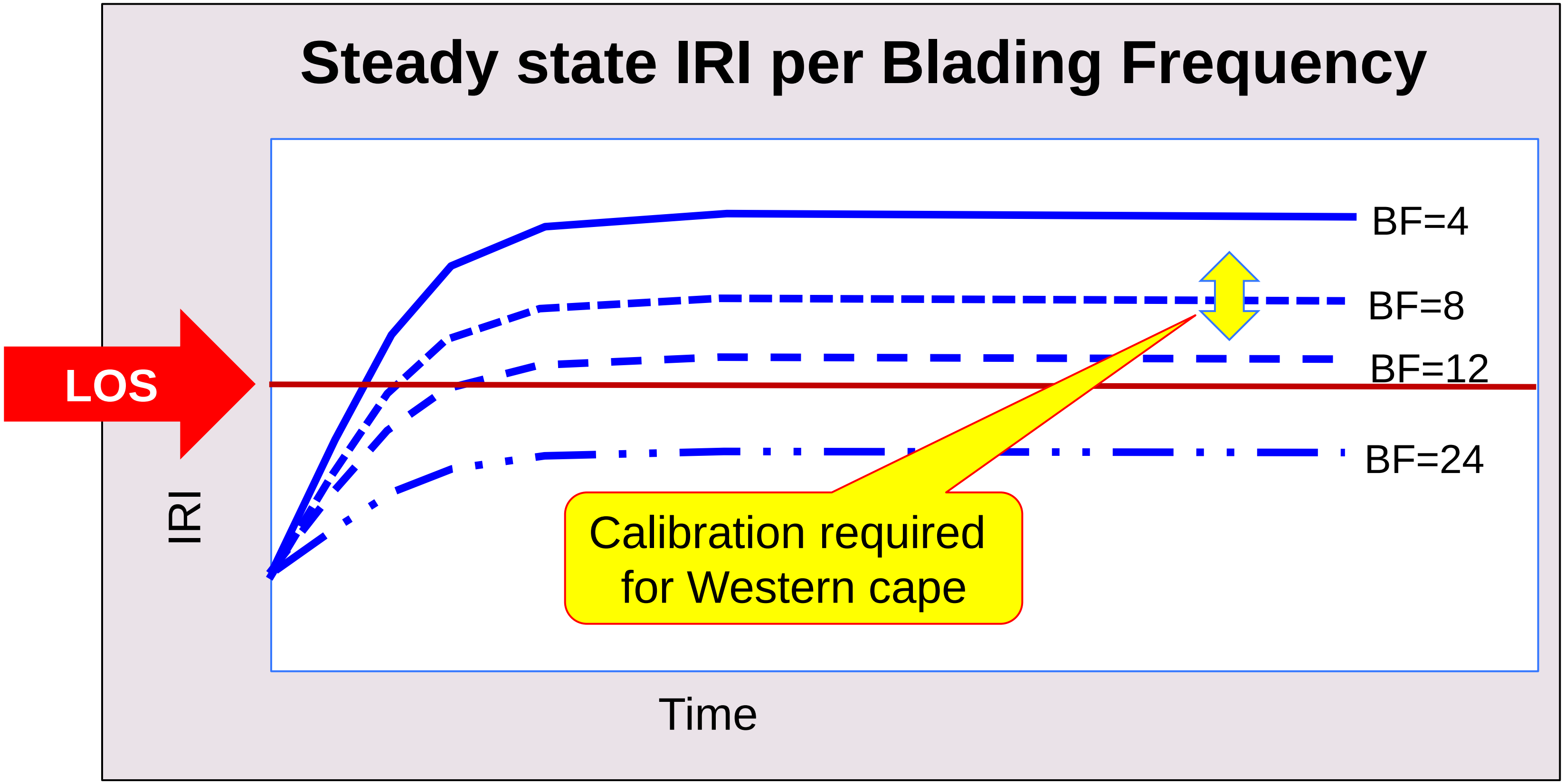
Addressing the Quality Gap



Blading frequency to meet desired LOS ?

HDM4 model - Function of:

- Construction quality
- Traffic, Climate, Material properties, Road geometry
- Maintenance type and frequency



Performance models improvement

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Construction effects

- Previous study
  - Compaction
  - Equipment

Steady state

- Material
- Climate
- Traffic
- Blading Frequency

Calibrate/Adjust HDM4

Material effects

- Previous study
- Crushing/B Pit
- In-line crushing
- -26 versus -37mm
- Additives
  - Clay/ Bentonite
  - Chemical
  - Salt
- Non std materials

Blading type effects

- Light/Heavy/double
- Sand cushioning
- Tyre dragging
- Sandvik
- Blade & Roll

Factorial development

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- **Traffic**
- **Rainfall**
- **Grading**
- **PI**
- **Terrain**

Traffic (AADT)			T1 < 40 vpd			T2 40-100 vpd			T3 >100 vpd		
Grading		MMP	M1 <10mm	M2 20mm	M3 >30mm	M1 <10mm	M2 20mm	M3 >30mm	M1 <10mm	M2 20mm	M3 >30mm
Fine	PI <6	Flat	0	0	0	0	1	2	1	0	2
		Rolling	5	1	7	1	4	16	1	0	7
		Mountainous	2	0	4	0	3	6	0	0	4
	PI 6-10	Flat	4	1	5	3	1	5	6	0	13
		Rolling	7	1	17	5	5	15	5	2	50
		Mountainous	3	2	5	4	2	4	1	0	12
	PI >10	Flat	0	0	0	0	0	0	0	2	0
		Rolling	0	0	2	0	0	6	0	4	3
		Mountainous	0	0	0	0	0	0	0	0	0
Medium	PI <6	Flat	21	20	12	13	15	14	11	19	46
		Rolling	40	14	15	18	29	67	13	21	96
		Mountainous	2	4	2	3	2	17	1	6	20
	PI 6-10	Flat	96	114	81	16	68	73	40	58	100
		Rolling	126	172	166	58	123	215	45	86	313
		Mountainous	13	23	62	15	32	69	3	22	103
	PI >10	Flat	1	0	2	0	0	2	0	2	6
		Rolling	1	0	4	1	1	13	1	6	18
		Mountainous	0	0	0	0	0	3	0	0	8
Coarse	PI <6	Flat	2	0	0	0	2	0	0	0	0
		Rolling	1	0	3	0	2	1	0	0	2
		Mountainous	0	0	1	0	0	2	0	0	1
	PI 6-10	Flat	0	0	0	0	0	0	0	0	3
		Rolling	0	0	0	0	0	4	0	0	3
		Mountainous	0	0	0	0	0	0	0	0	3
	PI >10	Flat	0	0	0	0	0	1	0	0	0
		Rolling	0	0	0	0	0	2	0	0	1
		Mountainous	0	0	0	0	0	0	0	0	1
			324	352	388	137	290	537	128	228	815

67 Road sections selected

Traffic (AADT)			T1 < 40 vpd			T2 40-100 vpd			T3 >100 vpd		
Grading		MMP	M1 <10mm	M2 20mm	M3 >30mm	M1 <10mm	M2 20mm	M3 >30mm	M1 <10mm	M2 20mm	M3 >30mm
Fine	PI <6	Flat	0	0	0	0	0	0	1	0	1
		Rolling	0	1	0	0	1	0	1	0	1
		Mountainous	1	0	0	0	1	0	0	0	1
	PI 6-10	Flat	0	1	0	0	1	0	1	0	1
		Rolling	0	0	0	0	0	1	1	1	1
		Mountainous	0	1	0	0	1	0	1	0	1
	PI >10	Flat	0	0	0	0	0	0	0	1	0
		Rolling	0	0	0	0	0	0	0	1	1
		Mountainous	0	0	0	0	0	0	0	0	0
Medium	PI <6	Flat	0	0	0	0	0	0	1	1	1
		Rolling	0	0	0	0	0	0	1	1	1
		Mountainous	0	0	0	0	0	0	1	1	1
	PI 6-10	Flat	0	0	0	0	0	1	1	2	1
		Rolling	0	0	1	0	0	0	1	2	2
		Mountainous	0	0	0	0	0	0	1	1	1
	PI >10	Flat	1	0	0	0	0	0	0	1	1
		Rolling	0	0	0	0	0	0	1	1	1
		Mountainous	0	0	0	0	0	0	0	0	1
Coarse	PI <6	Flat	1	0	0	0	1	0	0	0	0
		Rolling	1	0	0	0	1	0	0	0	1
		Mountainous	0	0	0	0	0	0	0	0	1
	PI 6-10	Flat	0	0	0	0	0	0	0	0	1
		Rolling	0	0	0	0	0	0	0	0	1
		Mountainous	0	0	0	0	0	0	0	0	2
	PI >10	Flat	0	0	0	0	0	1	0	0	0
		Rolling	0	0	0	0	0	0	0	0	1
		Mountainous	0	0	0	0	0	0	0	0	1

Steady state roughness sites

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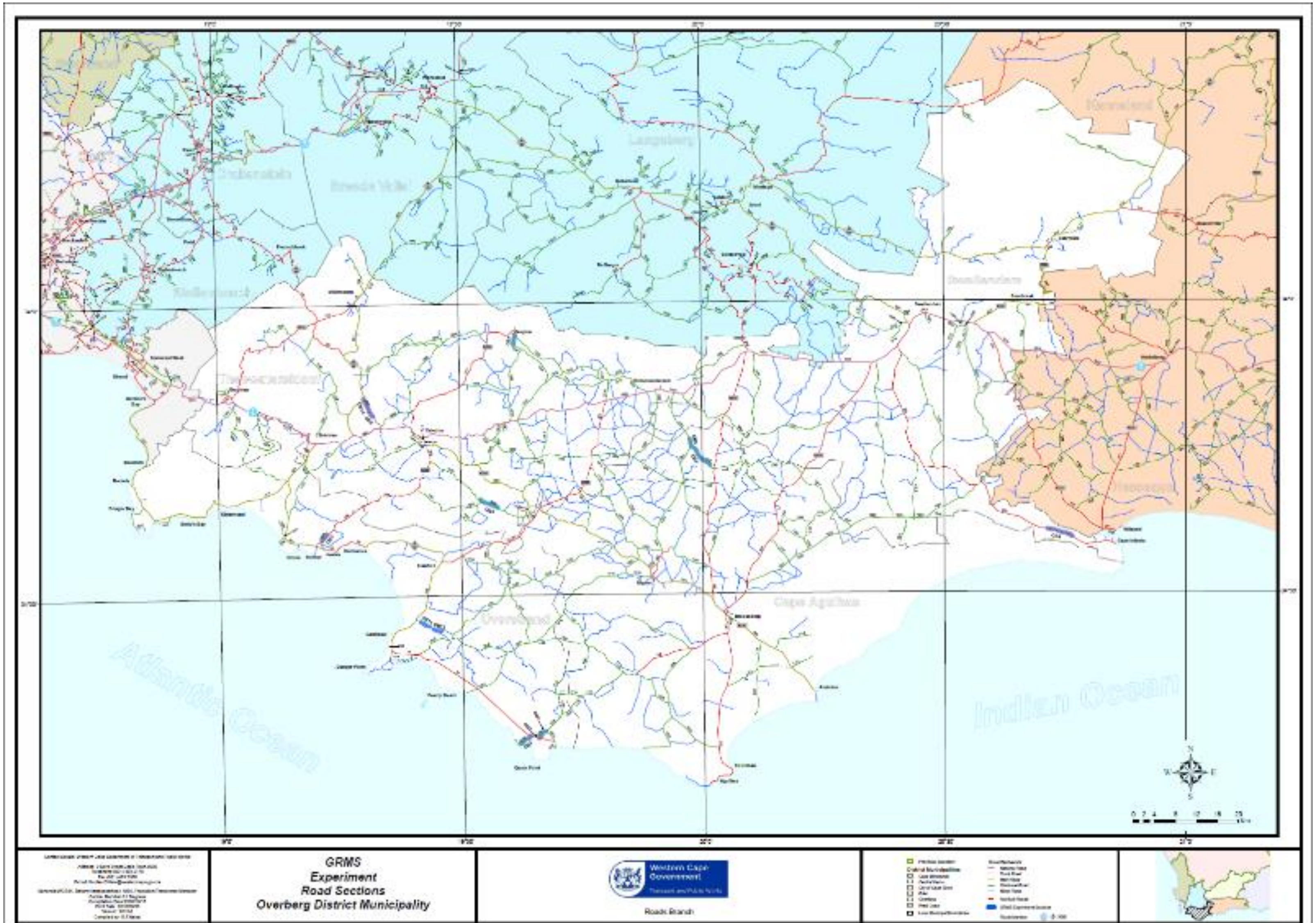

Calibration process

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- **Steady state**
  - ❑ Material
  - ❑ Climate
  - ❑ Traffic
  - ❑ Terrain
  - ❑ Blading frequency

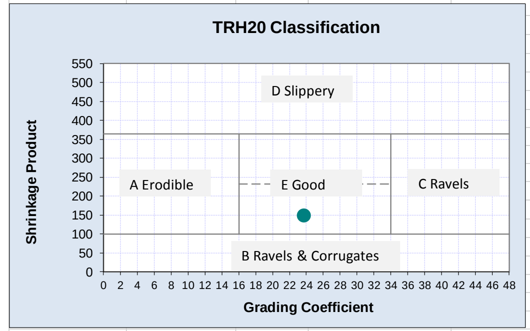
- **Predicted vs Measured roughness**

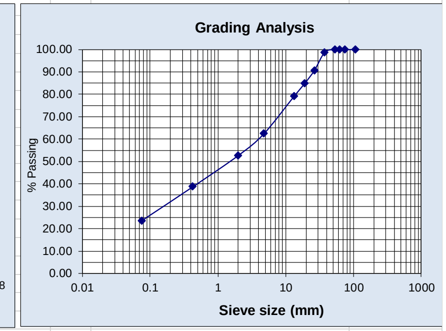
OB9 MR00276 :km 3 - 5.5

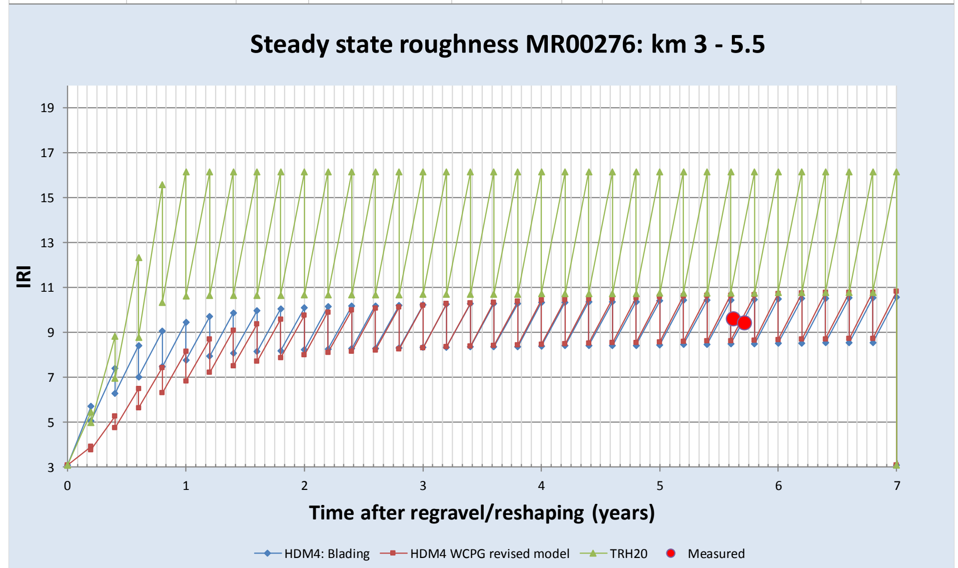
Section Data	
Road No	MR00276
From km	3.00
To km	5.50
Regravel date	15-02-2011
Reshape date	
Ave Blade freq	5
Blade Type	Wet

Traffic	
ADT (No of vehicles)	316
Light	248
Taxi	5
Bus	13
Heavy	50
Traffic Growth (%)	2
Heavies Ratio	0.20

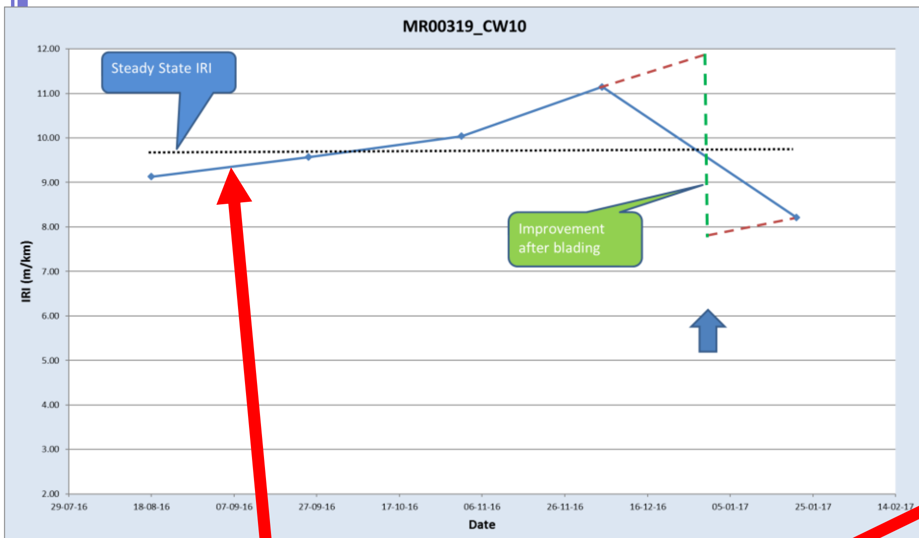
Climate & Geometry	
C (degrees/km)	18
RF (m/km)	26.4
MMP (mm/month)	40
HDM4 vers 2 Calibration Factors	
Mechanical Compaction -COMPGR(t)	0.25
Calibration factor for rough progr Kc	1
Default grading method factor GRAD	0.75
Calibration factor - effect of grading Ka	0.72
WCPG Quality factor	**0.7**

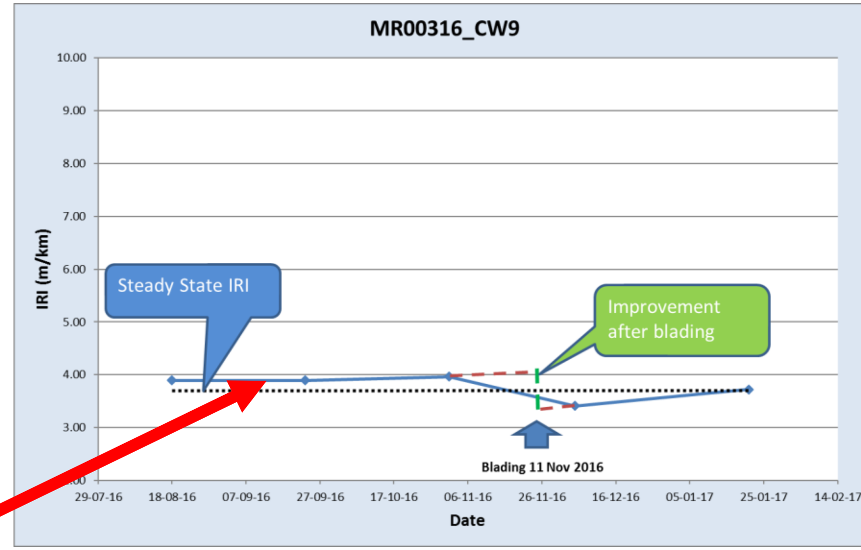






Roughness progression





E3.1.2 Roughness Progression in HDM-4

In version 1 of HDM-4, the HDM-III roughness progression relationship was used. In version 2 the relationship has been amended primarily with the addition of a calibration factor to enable the user to adjust the rate of roughness progression (Morosiuk, 200b).

The HDM-4 roughness progression relationship is given by:

$$RI_{TG2} = RI_{max} - b\,[RI_{max} - RI_{TG1}] \qquad \text{. . . (E3.7)}$$

where

$$RI_{max} = \max\{[21.5 - 32.4(0.5 - MGD)^2 + 0.017(HC) - 0.764(RF)(MMP/1000)],\ 11.5\} \qquad \text{. . . (E3.8)}$$

$$b = \exp\,[c(TG_2 - TG_1)] \qquad \text{where } 0 < b < 1 \qquad \text{. . . (E3.9)}$$

$$c = K_c \min[1,\ COMPGR\ (t)\ \max(1,\ n^{0.33})]\ \{-0.001[0.461 + 0.0174(ADL) + 0.0114(ADH) - 0.0287(ADT)(MMP/1000)]\} \qquad \text{. . . (E3.10)}$$

and

COMPGR = type of compaction used during construction or regravelling
= 1.0 (no mechanical compaction during construction or regravelling)
= 0.25 (mechanical compaction during construction or regravelling)

K_c = calibration factor for roughness progression (default = 1.0)

and the other variables are as defined previously

Kc = Roughness progression Calibration factor

Effect of different blading methods

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- Light blading
- Heavy
- Double heavy
- Blade & Roll
- Sandvik blading
- Towed grader
- Tyre dragging

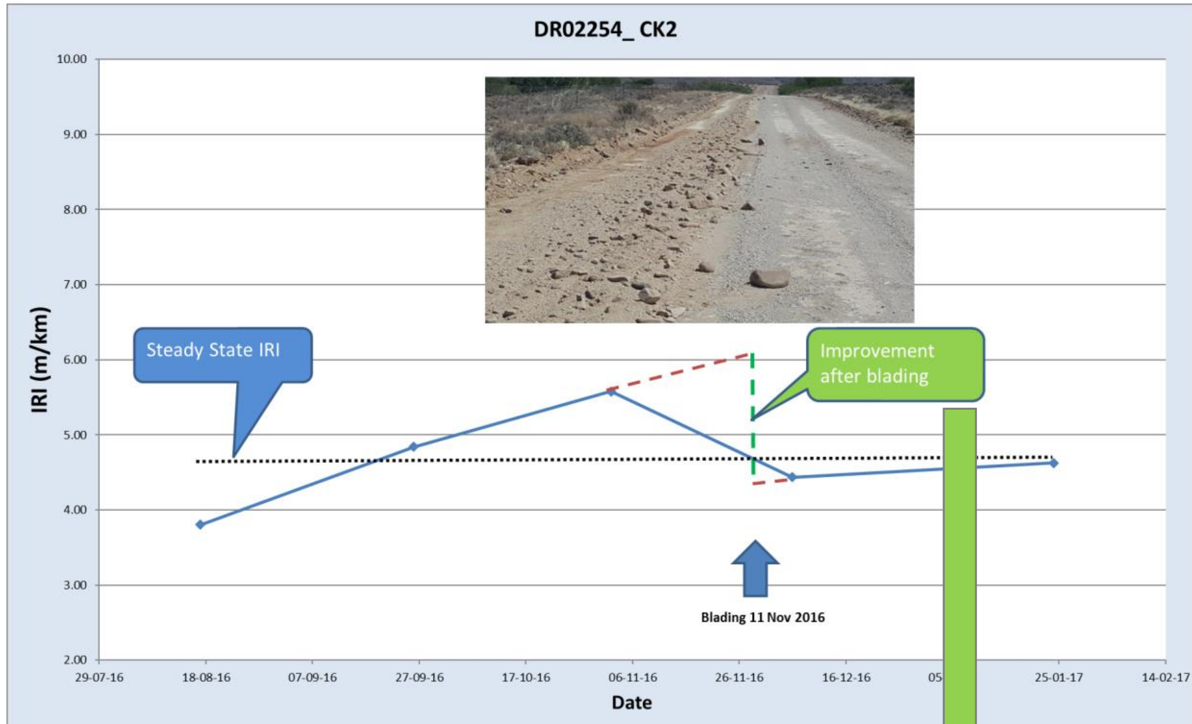

Table E3-1
Default GRAD values for various types of grading

Type of Grading	GRAD
Non-motorised grading, bush or tyre dragging	1.4
Light motorised grading, little or no water, no mechanical compaction	1.0
Heavy motorised grading with water and mechanical compaction	0.75
Full re-processing of wearing course with water and heavy roller compaction	0.2

NB Full re-processing of the wearing course has been observed to produce GRAD values of 0.2. However, as this type of grading is unusual, it has not been included in the default options. Users can obtain lower values of 'a' than the minimum value of 0.5 through the calibration factor K_a.

Model improvement – Mtaerial effects

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Construction effects
- Previous study
    - Compaction
    - Equipment

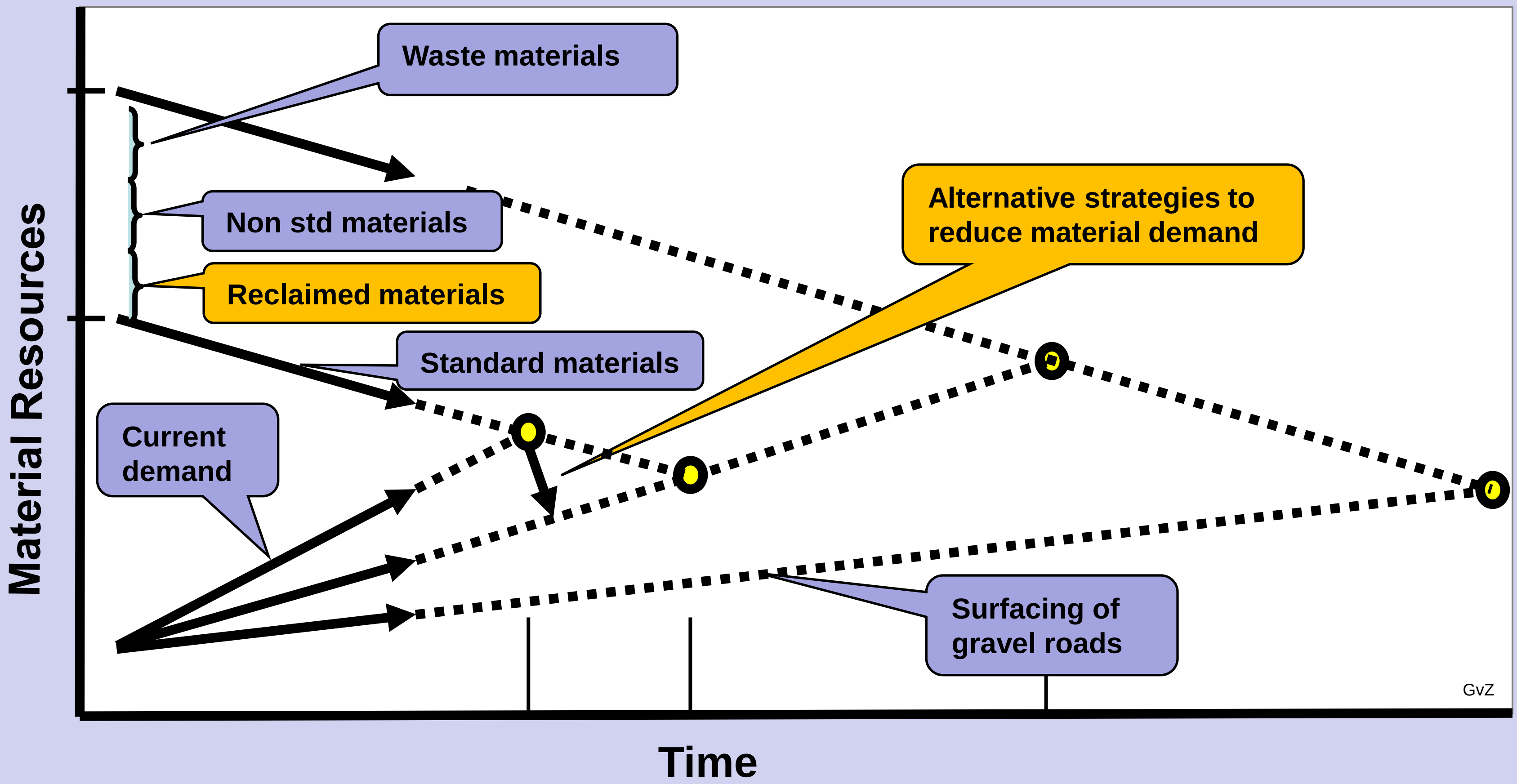
Steady state
- Material
- Climate
- Traffic
- Blading Frequency

Calibrate/Adjust HDM4

Material effects
- Previous study
- Crushing/B Pit
- In-line crushing
- -26 versus -37mm
- Additives
    - Clay/ Bentonite
    - Chemical
    - Salt
- Non std materials

Blading type effects
- Light/Heavy/double
- Sand cushioning
- Tyre dragging
- Sandvik
- Blade & Roll

Optimisation of material



Material effects

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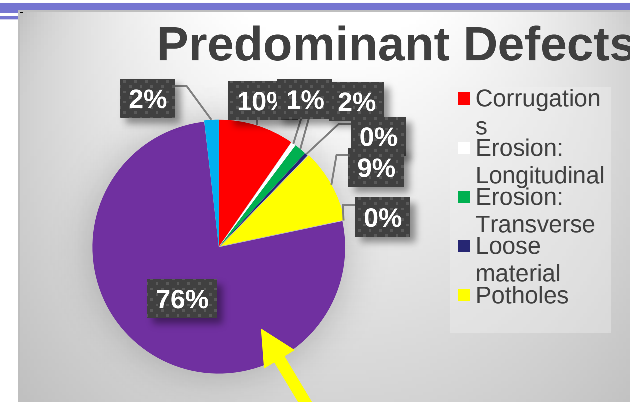
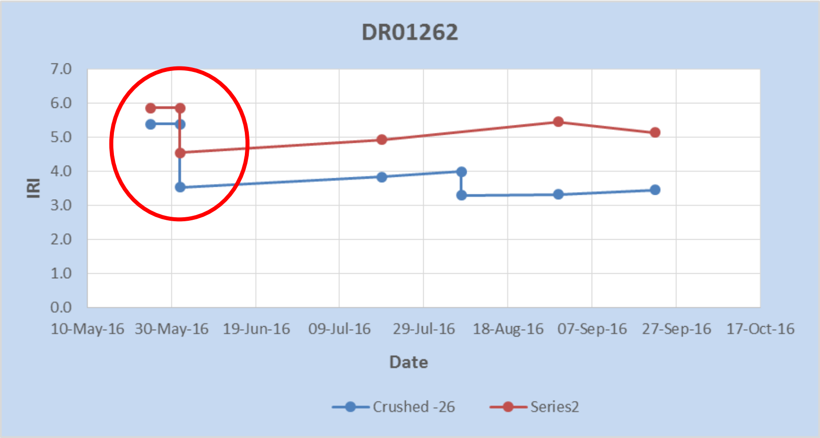
- **Oversize material**

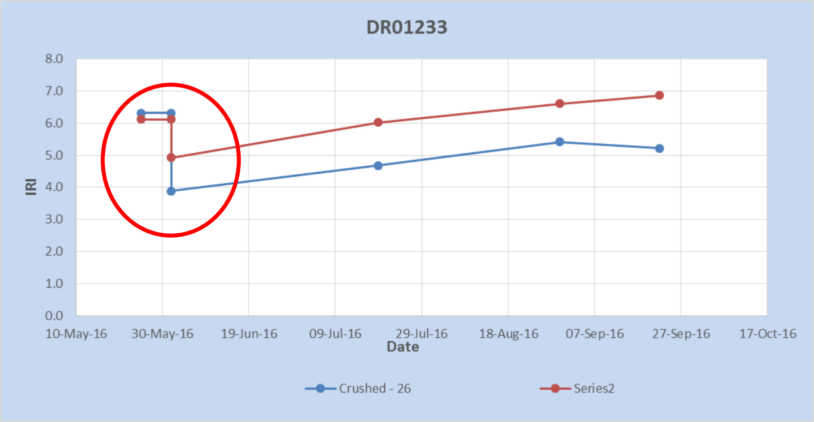


- **Effects of crushing of material**
  - ❑ Crushed material vs BP and Grid rolling
  - ❑ In-line crushing

Crushed (-26mm) vs B Pit & Grid roll

- **Effect of crushed material**
  - ❑ 1 IRI extra improvement after blading
  - ❑ Cost difference
    - 5 blades vs 10 blades





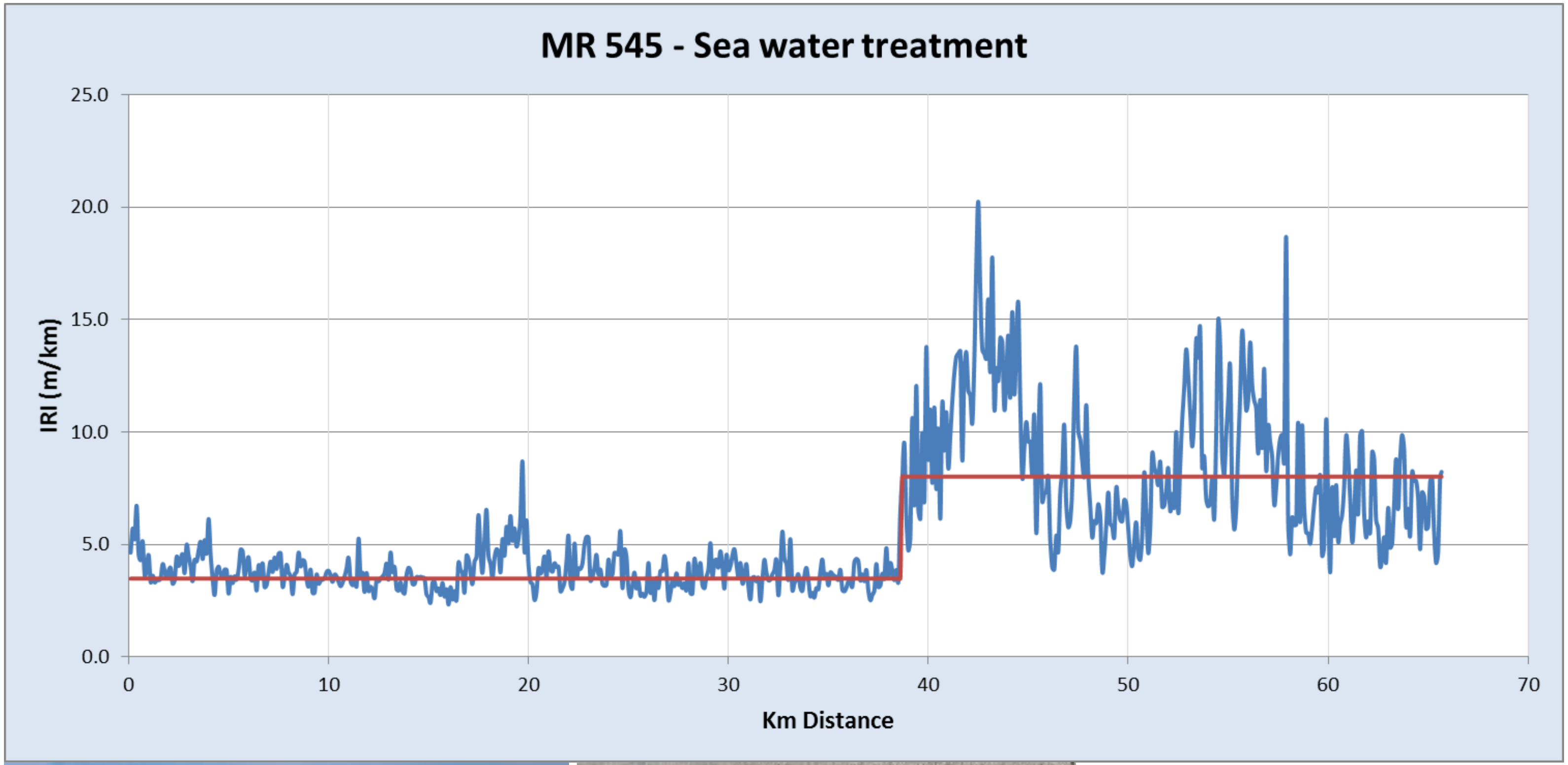
SAVING on DR01233 = R25000/km/y
Agency =R10000, VOC= R15000

Effect of materials

- **Additives**
  - ❑ Previous studies in W Cape
  - ❑ Feedback on Bentonite study (Winelands)
    - Laboratory testing in progress
  - ❑ New promising additives e.g. Zydex
    - Policy – Agrement certification

Sea water treatment

Koekenaap DR2225 - 75 x 7axles HV/day



Sea water treatment

- **Sea water treatment (West Coast)**
  - ❑ Study on environmental impacts (JG Afrika – A Dannhauser)
    - Many benefits
    - Adverse effects
    - Conclusion (Acceptable)
    - Most likely complaint – Vehicle rust
    - Must monitor adverse effects

Model improvement

Construction effects
- Previous study
  - Compaction
  - Equipment

Steady state
- Material
- Climate
- Traffic
- Blading Frequency

Calibrate/Adjust HDM4

Material effects
- Previous study
- Crushing/B Pit
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- -26 versus -37mm
- Additives
  - Clay/ Bentonite
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- Non std materials

Blading type effects
- Light/Heavy/double
- Sand cushioning
- Tyre dragging
- Sandvik
- Blade & Roll

Blade & Roll

- **Purpose**
  - ❑ Quantify effects
  - ❑ Cost-effectiveness ?

Blade & Roll

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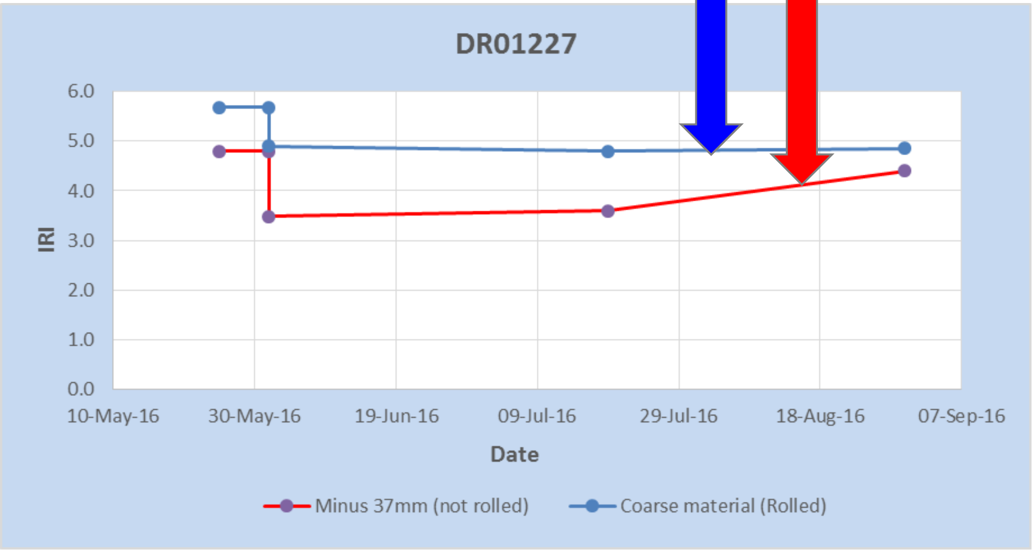
- **Overberg (Effect of heavy PTR) – DR01227**
  - ❑ Rolled Section – No Roughness deterioration in 3 months
  - ❑ Unrolled section – Rapid roughness deterioration after 2 months



Blade & Roll

- **Winelands (DR01380)**
  - 3 Sections, 3 Different materials
  - Each section divided into two
  - Wet blading alone vs Wet blading and **Light PTR roll**
- **Several lessons learnt**
  - Tyre pressure adjust for full coverage
  - Importance of moisture content
  - Effects of rainfall to be taken into account
  - At least 500m sections required

Blade & Roll- Effect on roughness deterioration

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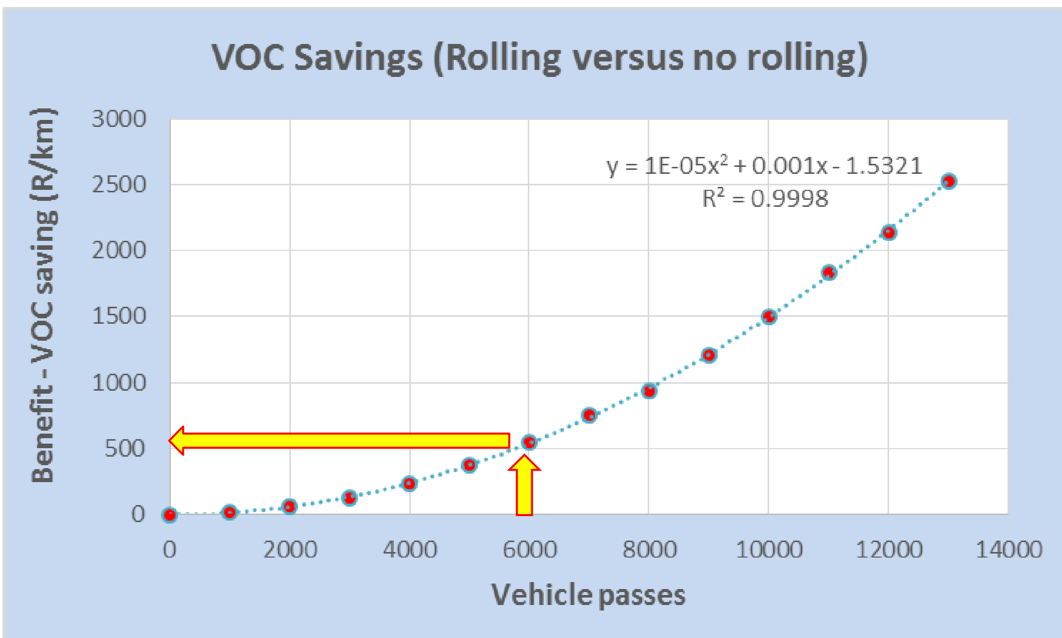
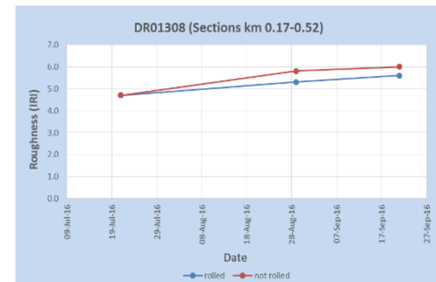
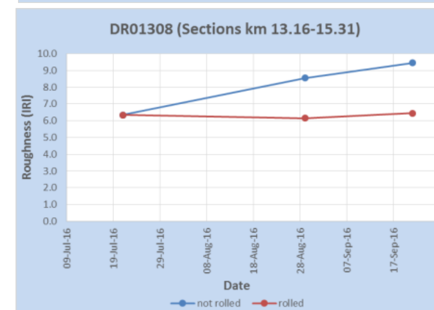
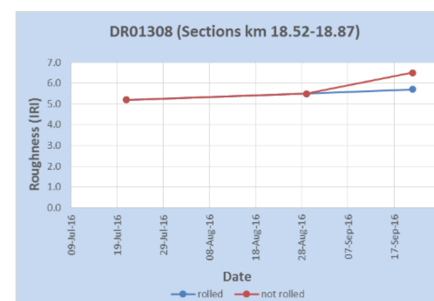
- **Winelands (DR01380) – Effect of Light PTR**
  - ❑ Preliminary results (Roughness)
    - Different materials (All sections positive)
    - Additional cost (rolling) must be < R500/km



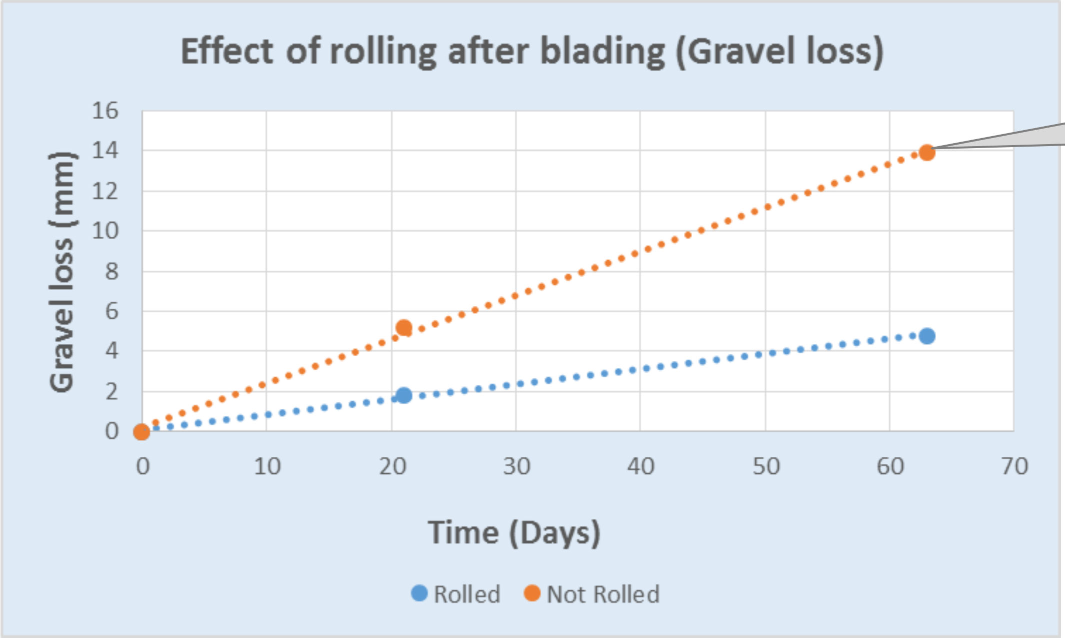






Blade & Roll – Effect on gravel loss

- **Winelands (DR01380) – Effect of Light PTR**
  - ❑ Preliminary results **(Gravel loss)**
    - Effect of material drying out rapidly



20-30mm loose material

Tyre dragging

- **Various configurations**

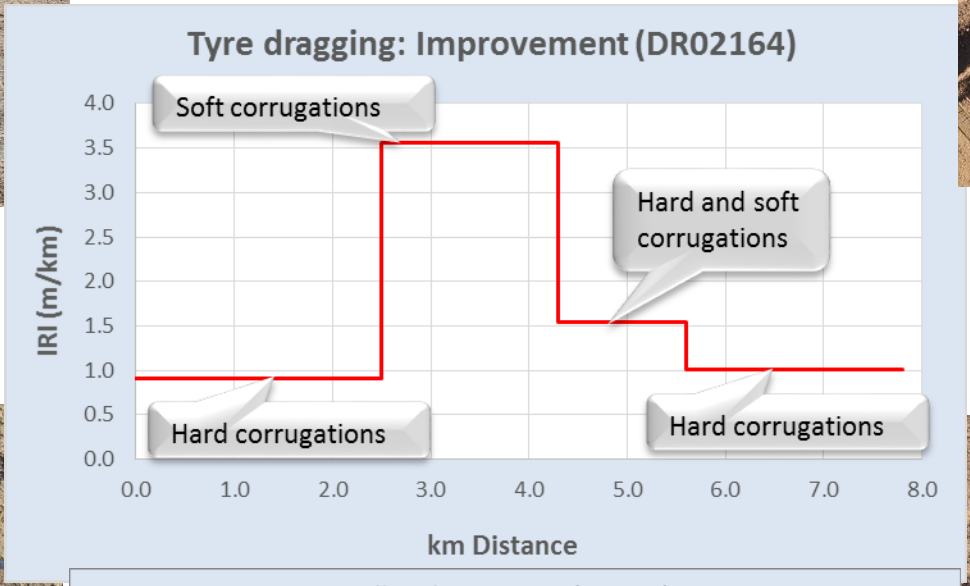
Tyre dragging

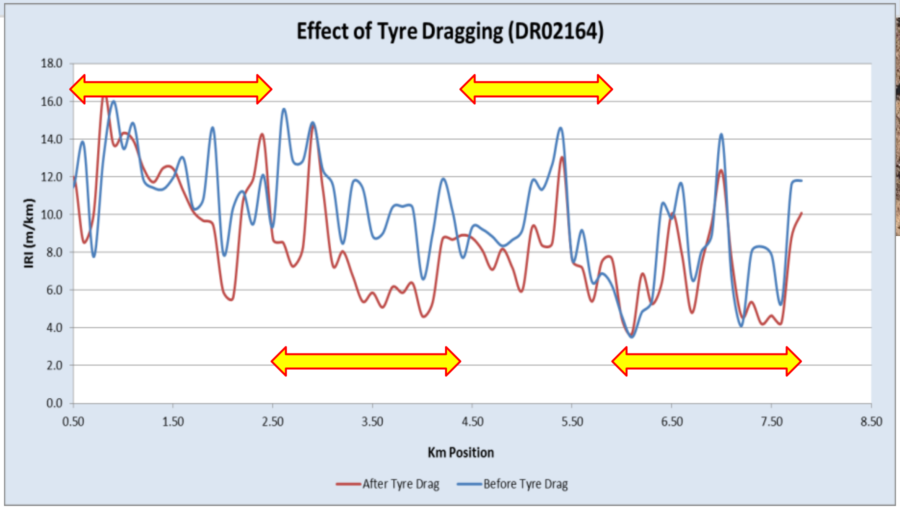
Western Cape Government
Transport and Public Works

- Different
  - ❑ Materials
  - ❑ Sand thickness (20-30mm), (30-60mm).
  - ❑ Moisture conditions
  - ❑ Mass/ configuration

Light Dry Grader blading = R 635.88/km   Tyre drag = < R 300/km

Effects of tyre dragging

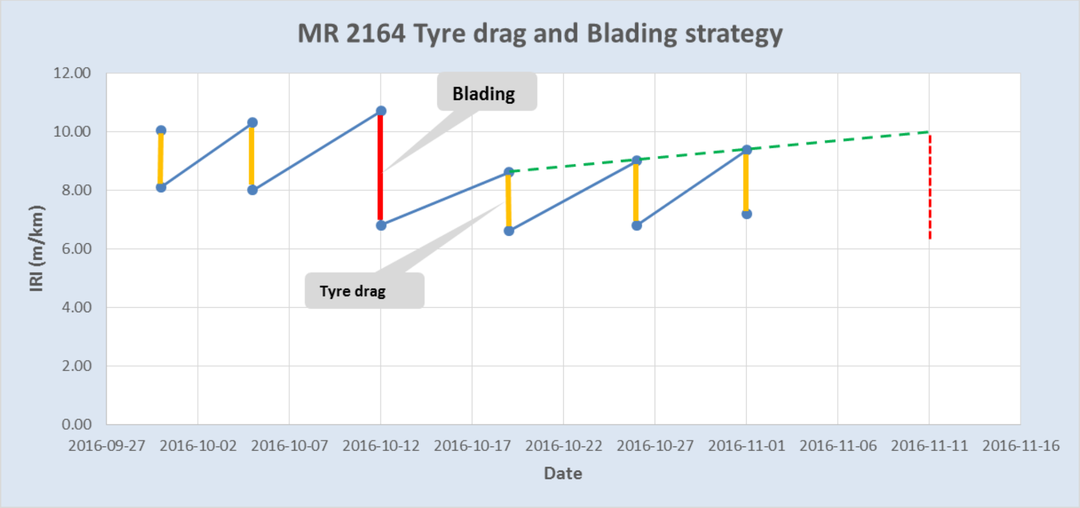




Optimum maintenance strategies

Western Cape Government
Transport and Public Works

- **Influenced by**
  - ❑ Traffic
  - ❑ Sand grading
  - ❑ Thickness
  - ❑ Moisture



- **Combination of maintenance methods required**

Sandvik blading (Serrated blade)

Western Cape Government
Transport and Public Works

PURPOSE

Cost effectiveness for different situations

- Roads identified for testing
- Measures on all roads
  - ❑ 500m Conventional blading
  - ❑ 500m Sandvik blading only
  - ❑ 500m Sandvik blading, water and roll.
- Testing
  - ❑ Roughness
  - ❑ Gravell loss

Tractor-towed grading

Western Cape Government
Transport and Public Works

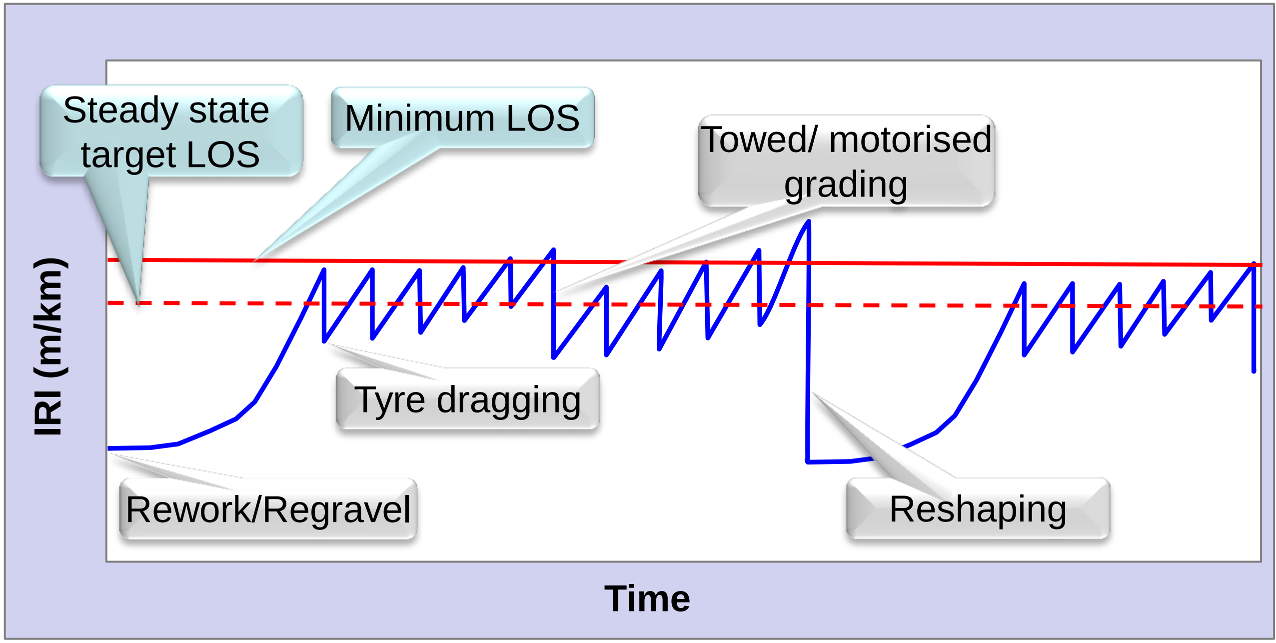
- **Several benefits**
- **Current concerns (Liability)**

Light Dry Grader blading = R 635.88/km   Towed Grader = < R 360/km

Optimum Maintenance Strategies

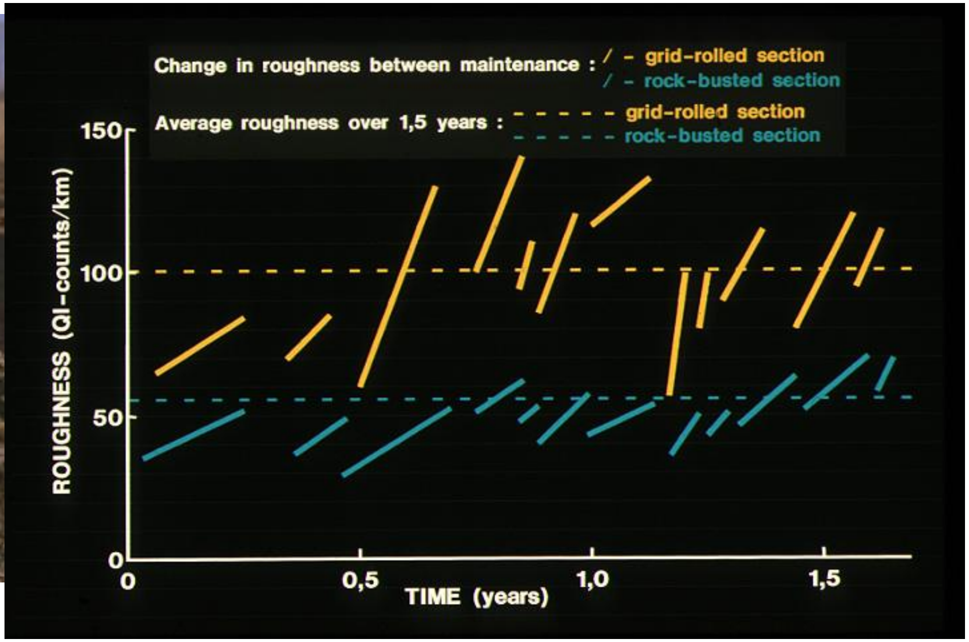
- **Different for different**
  - ❑ Materials
  - ❑ Climatic conditions
  - ❑ Traffic volumes

- **Example**



In-line crushing

- **Need !!!**



Inline crushing

Western Cape Government
Transport and Public Works

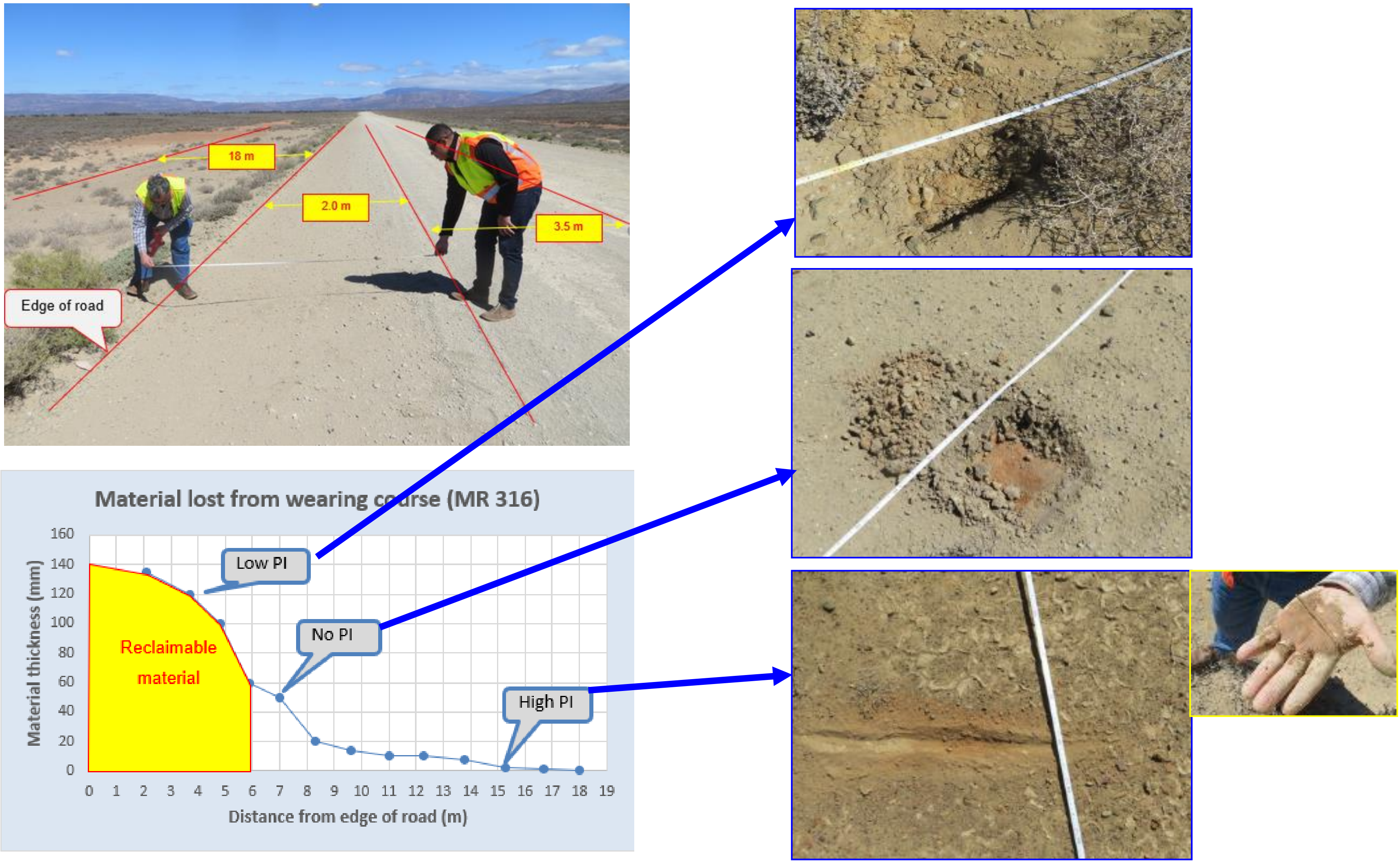
- Several in-line crushers being investigated
- First formal project for testing identified

Reclaiming lost material

- **Where did the gravel go?**
- **Either**
  - ❑ Into the formation
  - ❑ In the side drain/ close to the road edge
  - ❑ Dust blown away

Reclaiming material

Western Cape Government
Transport and Public Works



Reclaiming materials

Western Cape Government
Transport and Public Works

- **Can reclaim 60 – 80% of lost material on roads with a strong formation**

In-line crushing and/or clay addition might be required

Strategies and guidelines must be documented

Conclusions

Western Cape Government
Transport and Public Works

- Initiatives continuing
- Knowledge gained and lessons learnt
- TRH20 ?
- We need momentum
- Be aware of pitfalls and obstacles