ROAD INFRASTRUCTURE MANAGEMENT FORUM

Traffic speed deflection data applied to network asset management

KAIKOURA BYPASS –THE ULTIMATE REALITY CHECK

Acknowledgements to Elke Beca (dTIMS), William Gray, John Hallett, Allen Browne (NPTG), Martin Gribble (NZTA)

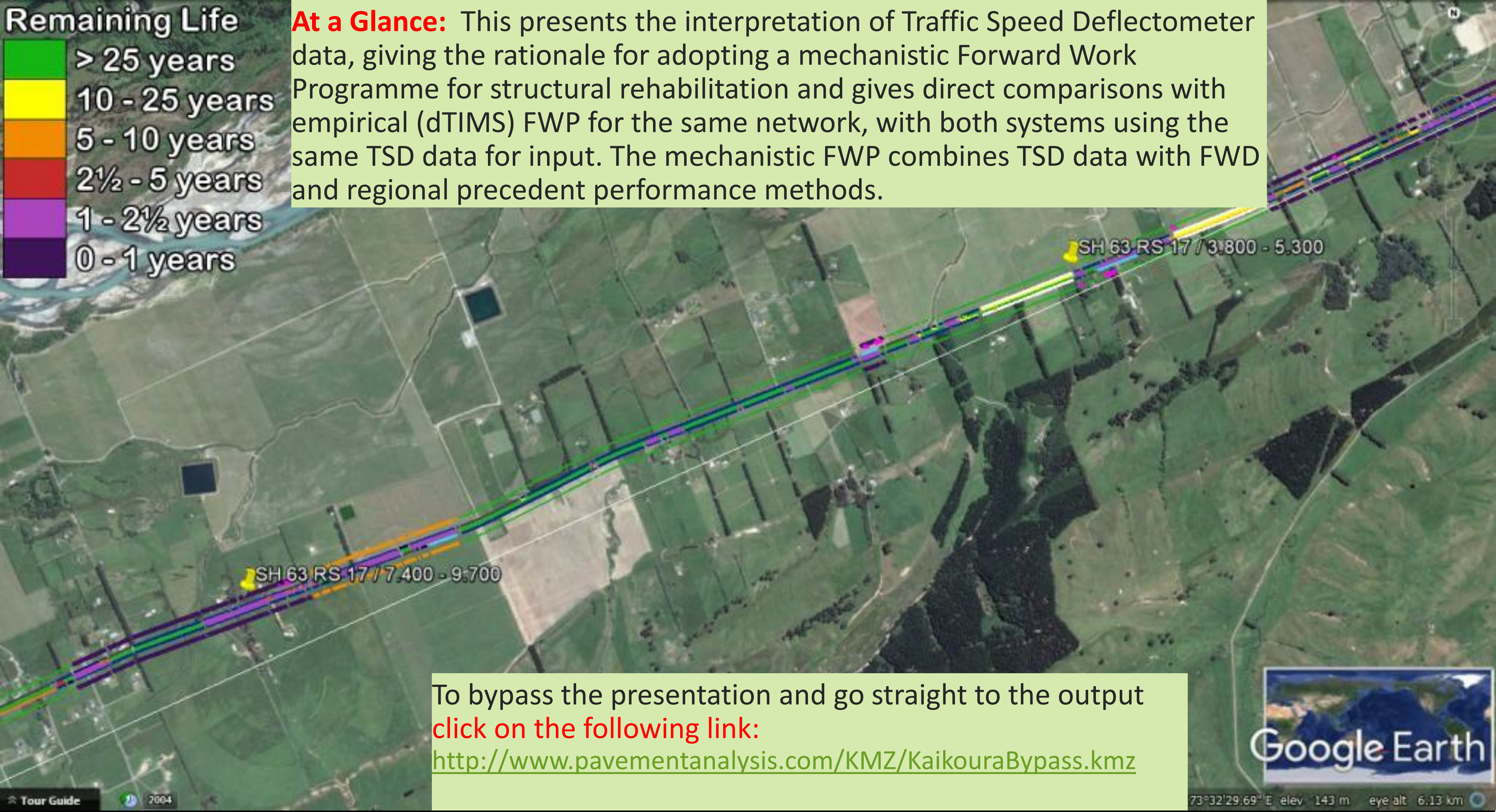
GEOSOLVE

RIMS

IDS

NZ Utilities Advisory Group Inc.

At a Glance: This presents the interpretation of Traffic Speed Deflectometer data, giving the rationale for adopting a mechanistic Forward Work Programme for structural rehabilitation and gives direct comparisons with empirical (dTIMS) FWP for the same network, with both systems using the same TSD data for input. The mechanistic FWP combines TSD data with FWD and regional precedent performance methods.



To bypass the presentation and go straight to the output click on the following link:
http://www.pavementanalysis.com/KMZ/KaikouraBypass.kmz

Introduction

- Traffic Speed Deflection Data:
  - Readings at 1 ms intervals. When averaged, data points at 10 m centres provide good detail. Accurate and repeatable for lasers close to wheel load (highest velocities)
  - Worldwide, no dynamic analysis of TSD bowls is applied in practice, and most (including NZTA) adopt only empirical methods for network FWPs. In this study, TSD bowls are converted to equivalent FWD bowls, in order to utilise existing software and recent innovations for a mechanistic precedent performance model for the network. (Calculating stiffnesses, stresses and strains in each layer at each test point, to determine expected distress modes, combined with extensive examination of terminally distressed sections of pavement throughout the network.)

- 2015 TSD data has been used to produce two Forward Work Programmes (FWP):

(i) traditional empirical model (Elke Beca/William Gray with site specific checks by NZTA)
(ii) using the regionally calibrated mechanistic FWP (for Martin Gribble)

- NZTA's Kaikoura Bypass provides a rare opportunity for a "reality check", of both methods ie accelerated pavement testing on diverse pavements along an 800 lane km "test track" (CAPTIF is 53 m)

Kaikoura Bypass Case History

<u>Background</u>

- Kaikoura earthquake 11/11/2016
- Inundation of parts of SH1
- Needed bypass route
- Original 25-Year Traffic will be experienced by mid next year on northern section (SH 63)
- The ultimate "Reality Check" of life prediction models: <u>Real</u> traffic on <u>real</u> roads with a range of <u>real</u> environments.
- TSD data collected in 2015

→ **Impacts and Distress modes?**

Traditional Empirical Procedure

Functional Evaluation (surface)

RCA Requirements → Functional Levels of Service
Rut, IRI (Skid)

RAMM
High Speed Data
Visual Condition → Data QA,
Historic Evaluation

Preliminary Specified FWP from
Visual Surveys

Traffic Data
Geometry
ONRC
Maintenance Costs
SNP → dTIMS Surface Performance

Coordinated Outputs:
FWP for Resurfacings

Integration of Mechanistic Procedure

RCA Requirements

RAMM
High Speed Data
Visual Condition
FWD & TSD

Traffic Data
Geometry
ONRC
Maintenance Costs
Mechanistic Models

Functional Evaluation (surface)

Functional Levels of Service
Rut, IRI (Skid)

Data QA,
Historic Evaluation

Preliminary Specified FWP from
Visual Surveys

dTIMS Surface Performance +
Subsurface added from
Mechanistic- FWP

Coordinated Outputs:
FWP for Resurfacings &
Validated Specified M-FWP for
Renewals

Feedback loops
to optimise
Structural FWP

Structural Evaluation (sub-surface)

Structural Levels of Service
% Terminal Fatigue, % Excessive cost

Data QA, Validation of Terminal Sites
(RAPT), Regional Precedent
Performance for Fatigue Criteria

Loading (ESA)
Mechanistic Analyses
(Moduli, Stresses & Strains)
Remaining Structural Life

Additional Outputs:
Sub-surface Drainage Priorities
Quantified HPMV Route Impacts

ROAD INFRASTRUCTURE MANAGEMENT FORUM

Traditional Analysis – Distress Modes

- Empirical or traditional mechanistic approaches:
  Consideration of only 1 or 2 criteria for pavement life prediction (e.g. SNP or subgrade strain)

- Mechanistic approach enables more criteria and multiple distress modes to be considered and calibrated to region or sub-region
  (using methodology of the Regional Precedent Performance (RPP) Study recently undertaken for NZTA on 5 of their regional networks).

Multiple Dist

- Andrew Dawson
- International workshop for t development of Mechanisti Methods for Unbound Paver

Rutting

Roughness

Degradation

Flexure

Shear

1	Excess resilience of pavement (see also Mechanisms 6 and 7)
2	Excess rutting from within granular layer due to granular material shear displacement
3	Excess rutting from within granular layer due to compaction by traffic loading
4	Excess rutting from within subgrade layer due to subgrade shear displacement
5	Excess rutting from within subgrade layer due to combined action of subgrade and granular layer(s)- due to complex stress interaction effects
6	Excess rutting from within subgrade layer due to combined action of subgrade and granular layer(s) when subgrade is too resilient
7	Pumping of subgrade into base course
8	Excess longitudinal roughness - uneven-ness
9	Excess longitudinal roughness - potholing
10	Excess longitudinal roughness - corrugations
11	Frost action on susceptible subgrades or granular ma
24	Breakdown of pavement aggregate due to repeated f
25	Softening of the pavement at the time of Spring-thaw
12	Soil heave / shrinkage
13	Wear due to dust loss
14	Wear due to stone displacement by tyre ('gravel loss')
26	Wear due to stone 'loss' into soft subgrade ('gravel loss')
27	Wear due to erosion of surface metalling by water ('gravel loss')
15	Wear due to stone abrasion / attrition
16	Wear due to studded tyre action
17	Seal breakage due to traffic-induced flexure
18	Seal breakage due to environmentally-induced shrinkage (thermal cracking)
19	Seal breakage due to shoving / tearing / shearing
20	Inadequate surface condition- sealed surface too smooth due to aggregate texture loss
21	Inadequate surface condition- sealed surface too smooth due to excess bitumen rising to surface
22	Inadequate surface condition- unsealed surface too slippery due to excess fines on surface (wet weather)
23	Inadequate surface condition- unsealed surface too slippery due to loose gravel on surface

NB Shaded mechanisms largely set aside by workshop - see Section 3.1 and following

Very substantial progress in the last 3 years for New Zealand Unbound Pavements

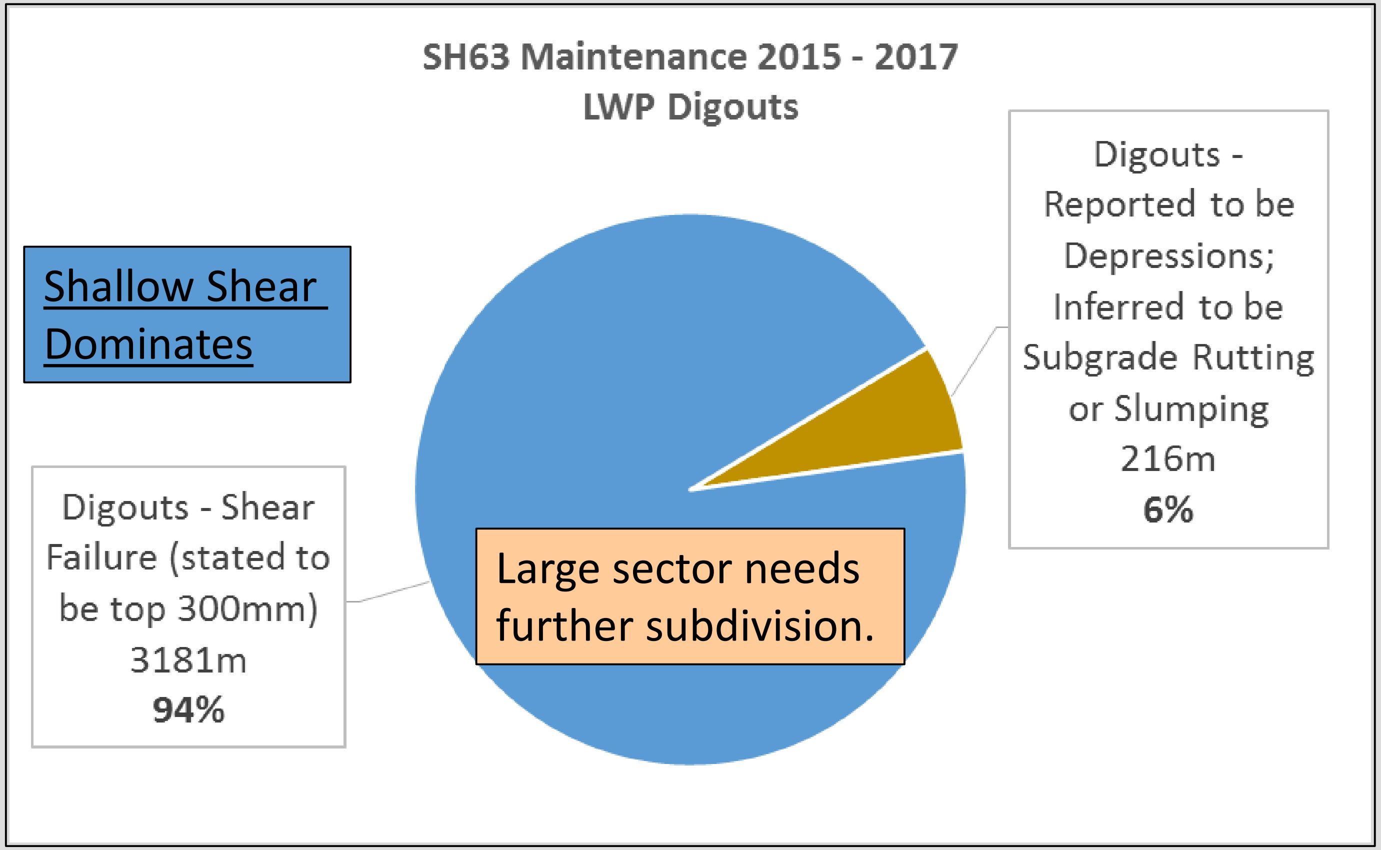
on, 2002

GEOSOLVE

dvisory

Distress Modes

<u>Observed Distress Modes from Kaikoura Bypass Maintenance</u>



Mechanistic Analysis – Distress Modes

Distress Modes from NZ Data Mining

Structural distress modes

1 Shallow Shear – Low Strength (shoving)
2 Shallow Shear – Spreading (strong but inadequate support)
3 Shallow Shear – Heave (in loose or low broken faces BC)
4 Shallow Shear – Hybrid (from above)
5 Aggregate Instability (pumping >75%S, potholing, heave)
6 Aggregate Rutting (VSD in basecourse or subbase)
7* Aggregate Weathering (mineralogical changes in fines)
8 Aggregate Degradation (physical generation of fines)
9 Cracking (conventional, bottom up) of bound layers
10 Flexure (top down cracking) of bound layers
11* Binder Curing/Hardening (aging)
12* Bond loss (cement bound reverting to unbound)
13 Subgrade Rutting (vertical deformation)
14 Subgrade Shear (lateral and vertical deformation)
15 Accumulated Deformation (multiple layers contributing)
16 Slumping/Edge Break (lack of shoulder support)
17 Roughness Progression
18 Shrinkage Cracking (viz FBS with curing/ thermal)

Surfacing distress modes

19 Seal Deformation (more likely as multiple seal layers accumulate)
20 Flexure (top down cracking in seal or thin AC)
21 Reflection Cracking
22* Seal Flushing
23 Scabbing/Ravelling

Economic Triggers

24 Excessive Maintenance costs for the surfacing (seal, thin AC)
25 Excessive Maintenance costs for structural layer(s)

Other characteristics or causes that affect timing of triggers include:

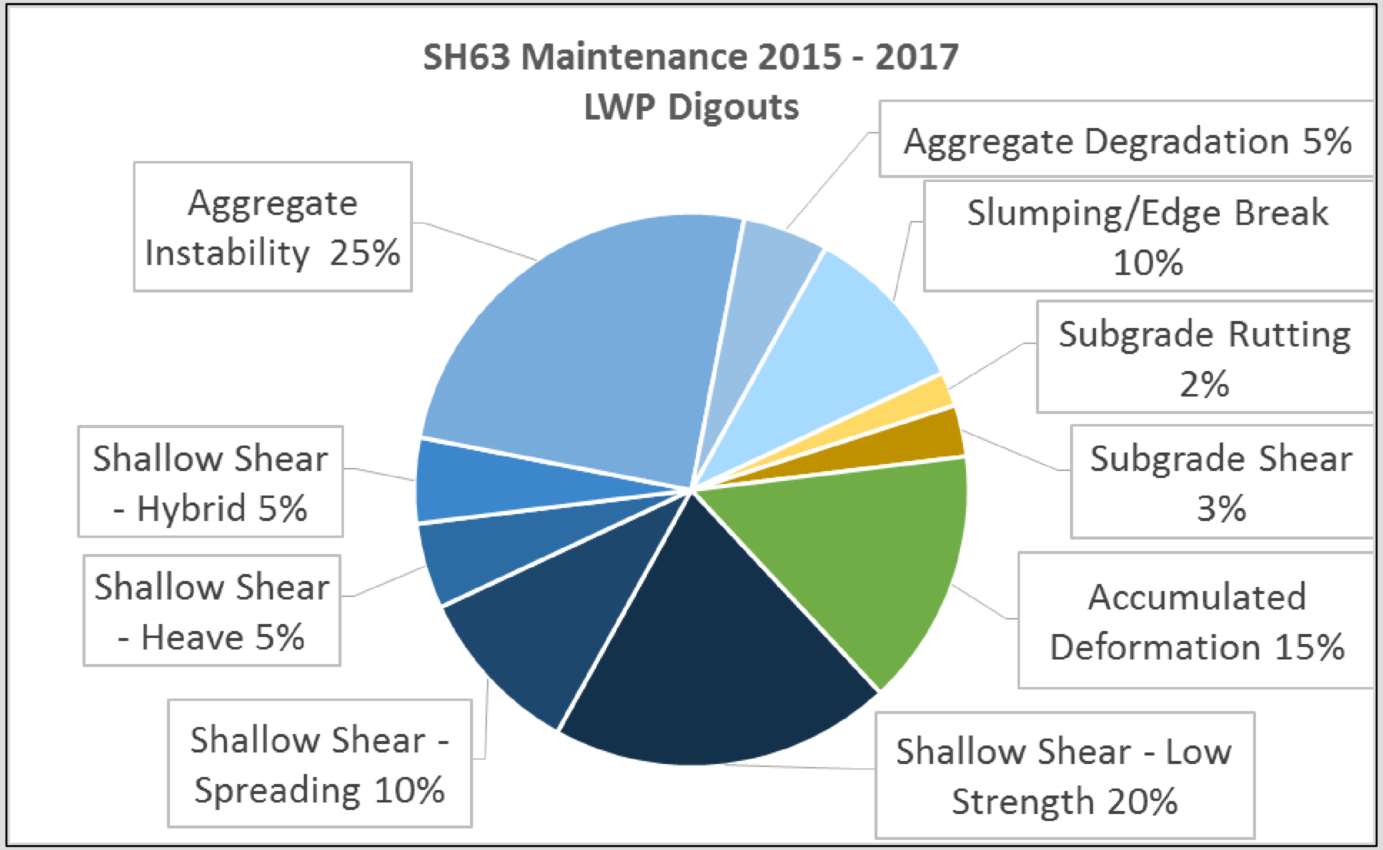
26* Loading frequency effects on inter-particle bonds
27* Cement curing
28* Bitumen embrittlement (environmental ageing)
29* Subgrade –subbase intrusion
30* Frost heave
31* Particle breakdown in freeze-thaw cycles
32 Foundation subsidence (vertical depression)
33 Foundation slumping (lateral deformation)

*7, 11, 12, 22 & 26-31 Not explicitly included in current modelling
Vehicle speed and temperature included for individual modes

ROAD INFRASTRUCTURE MANAGEMENT FORUM

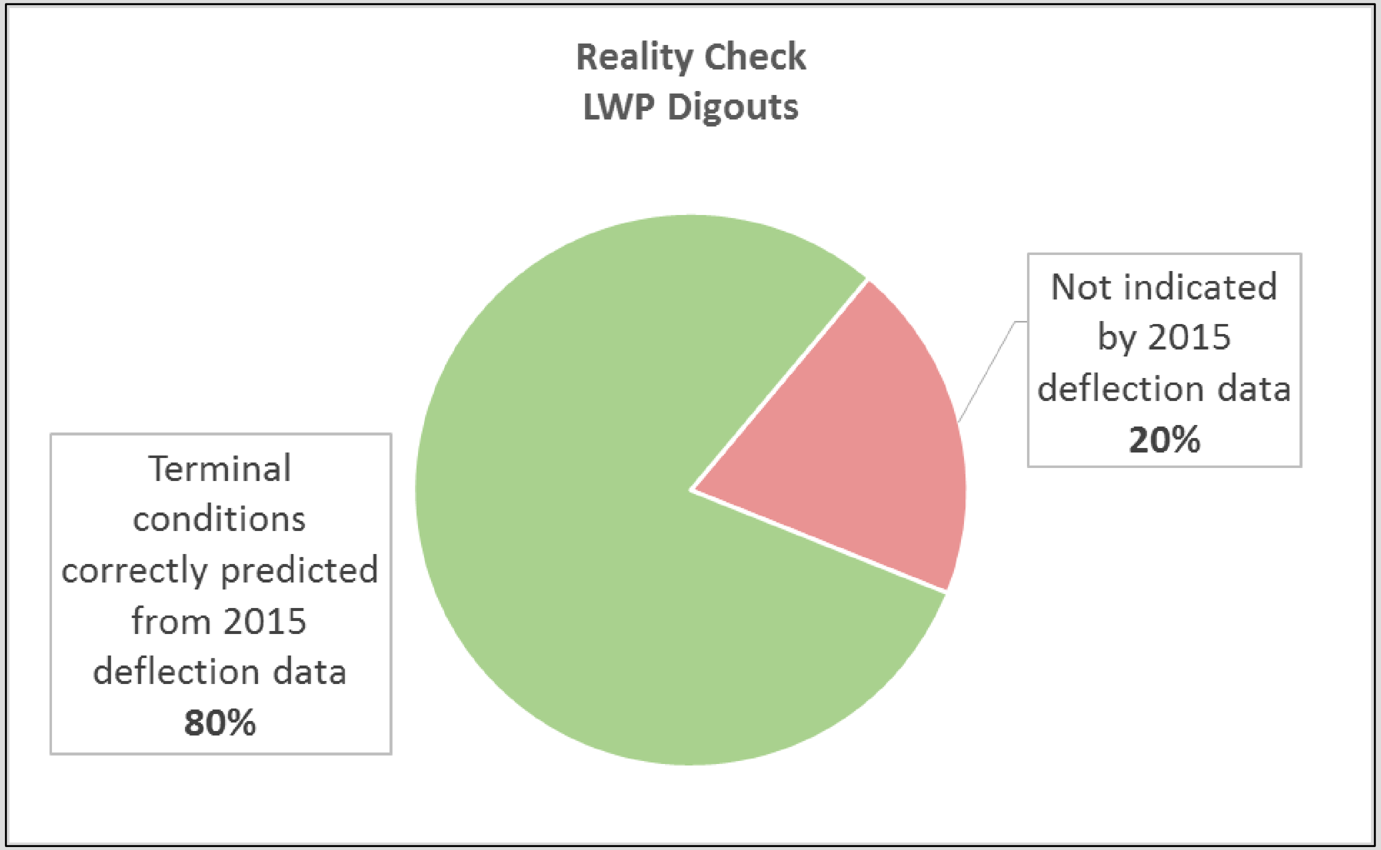
Mechanistic Analysis – Distress Modes

Distress Modes from Kaikoura Bypass Maintenance
Mechanistic Analysis



Mechanistic Analysis – Distress Modes

Kaikoura Bypass Maintenance – Reality Check (Preliminary Calibration)



ROAD INFRASTRUCTURE MANAGEMENT FORUM

Mechanistic Analysis – Distress Modes

Kaikoura Bypass Maintenance – Reality Check (Preliminary Calibration)

Reasons for not predicting distress:

- Only network calibration, not yet site-specific
- TSD testing done only at height of summer
- Shear instability from basecourse saturation is difficult to predict from TSD (Poisson's ratio so far only obtained from FWD with additional sensors, not TSD as yet)
- TSD test data averaged over 10m spacings; shallow shear often initiates for only 1 or 2m length

→ "Dilution" of signal of distressed portion

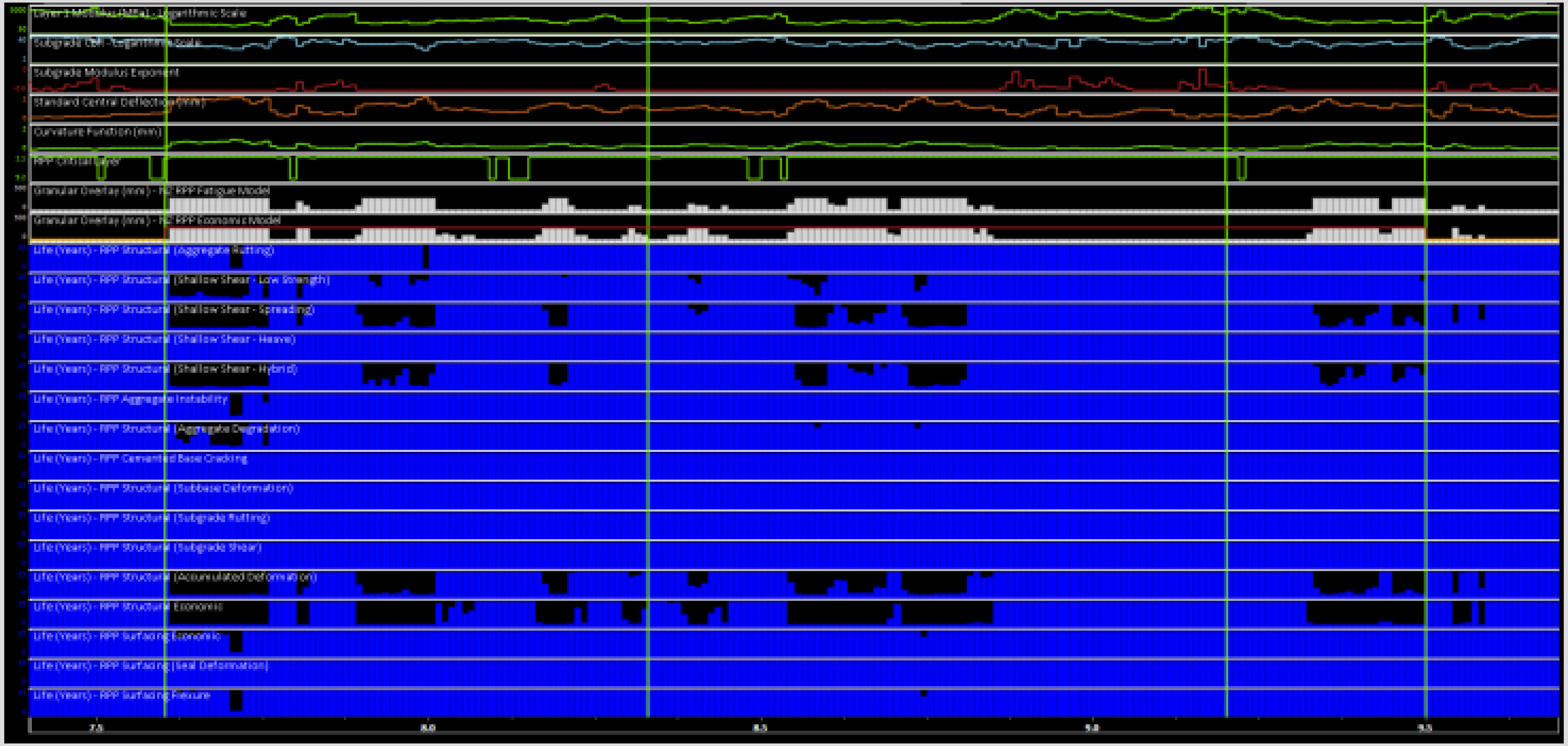
Finer subdivision than 10m is now being explored.

After finer subdivision, reasonable expectations: 90% reliability of predictions

GEOSOLVE RIMS Roading Infrastructure Management Support IDS Infrastructure Decision Support NZ Utilities Advisory Group Inc.

Structural Treatment Length

Pavement Evaluation Output - Overview of pavement life (blue) for alternative distress modes.



GEOSOLVE

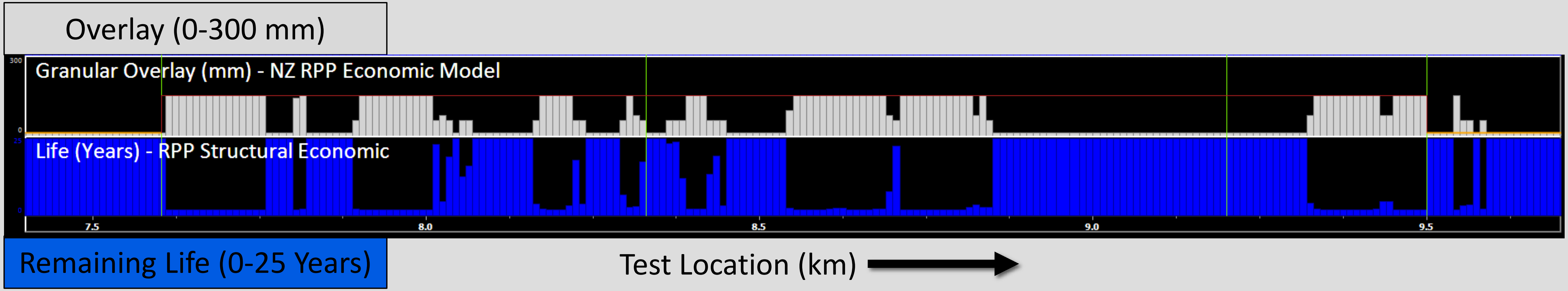
RIMS
Roading Infrastructure Management Support

IDS Infrastructure Decision Support

NZ Utilities Advisory Group Inc.

Structural Treatment Length

Output: the process for methodical structural sub-sectioning to minimise rehabilitation costs.



GEOSOLVE

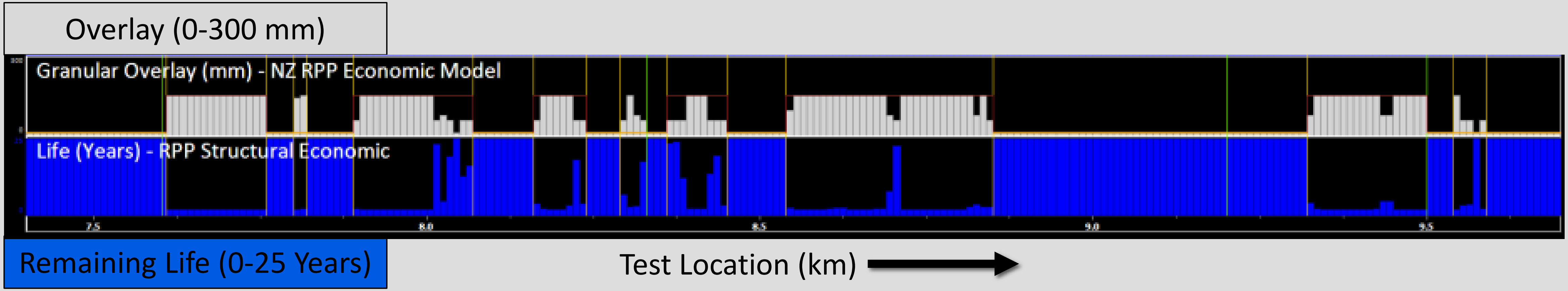
RIMS

IDS Infrastructure Decision Support

NZ Utilities Advisory Group Inc.

Structural Treatment Length

Output



Structural Treatment Length Table

STL file - Ranks all structural treatment lengths in order of priority for rehabilitation

								Rehabilitation Priority, Remaining Life and Governing Distress Mode													
Road ID	File Name	Start (km)	End (km)	Length (km)	Risk of Damage from HPMVs	Life (Years) - RPP Surfacing Fatigue (Governing	Life (Years) - RPP Surfacing Economic	Priority Ranking for Rehab (10th-%ile)	Life (Years) - RPP Structural Economic (50th-%ile)	Life (Years) - RPP Structural Fatigue (Governing, 10th-%ile)	Life (Years) - RPP Aggregate Instability (10th-%ile)	Life (Years) - IAL (Governing, 10th-%ile)	Priority Ranking for Rehab (50th-%ile)	Life (Years) - RPP Structural Economic (90th-%ile)	Life (Years) - RPP Structural Fatigue (Governing, 50th-%ile)	Life (Years) - RPP Aggregate Instability (50th-%ile)	Life (Years) - IAL (Governing, 50th-%ile)	Life (Years) - User Weighted Mechanistic	Life (Years) - FWP Specified	Life (Years) - FWP	RPP Distress Mode
503	063-0017 L1	2.810	3.000	0.190	Medium	32	32	2.2	1	2	46	2	0.5	85	6	87	8	-6	-1	199	Shallow Shear - Spreading
505	063-0046 R1	9.890	10.060	0.170	Medium	171	153	1.2	2	2	76	5	0.2	90	22	137	23	-6	-1	199	Shallow Shear - Spreading
508	063-0074 L1	4.500	4.600	0.100	Medium	3	3	3.5	1	1	17	1	0.3	56	16	126	15	-5	-1	199	Subgrade Rutting
505	063-0046 R1	9.630	9.740	0.110	Medium	99	99	1.0	2	4	82	7	0.2	63	22	106	15	-5	-1	199	Shallow Shear - Spreading
2648	063-0084 L1	0.630	0.760	0.130	Medium	49	49	0.6	5	4	116	11	0.1	86	28	138	25	-5	-1	199	Shallow Shear - Spreading
501	063-0000 L1	6.480	6.699	0.219	Medium	33	33	2.6	1	2	40	3	0.4	60	3	65	22	-5	0	199	Shallow Shear - Spreading
504	063-0029 R1	6.360	6.550	0.190	Medium	23	23	3.1	1	1	3	2	0.2	78	16	87	19	-5	1	199	Shallow Shear - Low Strength
505	063-0046 R1	2.500	2.620	0.120	Medium	44	44	2.7	1	1	58	2	0.4	78	11	99	10	-5	2	199	Shallow Shear - Spreading
508	063-0074 L1	2.460	2.630	0.170	Medium	44	44	2.9	1	1	61	2	0.7	65	3	99	8	-5	199	199	Shallow Shear - Spreading
535	063-0092 L1	7.270	7.500	0.230	Medium	137	100	1.5	1	1	96	2	1.2	56	1	105	3	-5	199	199	Shallow Shear - Subsidiary
501	063-0000 L1	1.140	1.270	0.130	Medium	159	158	0.2	1	1	135	72	0.1	61	12	141	82	-5	199	199	Shallow Shear - Spreading
505	063-0046 R1	11.750	11.880	0.130	Medium	61	61	1.9	2	2	84	3	0.1	67	23	125	44	-5	199	199	Shallow Shear - Spreading
506	063-0059 R1	11.590	11.690	0.100	Medium	77	77	0.6	2	10	101	10	0.2	72	23	141	26	-5	199	199	Shallow Shear - Spreading
503	063-0017 L1	2.670	2.800	0.130	Medium	25	25	2.4	1	1	61	2	1.3	39	2	76	3	-4	-1	199	Shallow Shear - Spreading
508	063-0074 L1	5.260	5.410	0.150	Medium	40	40	3.2	1	1	66	2	1.4	46	2	91	3	-4	-1	199	Shallow Shear - Subsidiary
503	063-0017 R1	3.390	3.550	0.160	Medium	35	35	1.1	1	2	44	6	0.2	44	11	81	24	-4	-1	199	Shallow Shear - Spreading
2648	063-0084 L1	3.720	3.831	0.111	Medium	44	44	2.4	1	1	78	2	0.3	39	11	108	14	-4	-1	199	Shallow Shear - Spreading
508	063-0074 R1	5.080	5.400	0.320	Medium	78	78	2.1	1	2	71	3	0.3	41	15	100	12	-4	-1	199	Shallow Shear - Spreading
506	063-0059 R1	13.440	13.580	0.140	Medium	88	84	0.5	2	10	95	13	0.2	42	24	125	21	-4	-1	199	Shallow Shear - Spreading
503	063-0017 L1	8.340	8.680	0.340	Medium	41	41	2.2	1	1	31	2	0.3	40	3	77	16	-4	0	199	Shallow Shear - Spreading
504	063-0029 R1	14.370	14.510	0.140	Medium	129	129	0.4	1	1	56	28	0.1	37	12	100	41	-4	0	199	Shallow Shear - Low Strength
506	063-0059 R1	3.510	3.700	0.190	Medium	65	63	2.2	1	2	86	3	0.3	43	10	132	20	-4	0	199	Shallow Shear - Spreading
506	063-0059 L1	1.210	1.320	0.110	Medium	159	146	0.7	1	2	73	12	0.1	46	17	110	54	-4	0	199	Shallow Shear - Low Strength
504	063-0029 L1	14.550	14.700	0.150	Medium	117	117	1.3	2	2	66	5	0.2	47	23	92	19	-4	0	199	Shallow Shear - Low Strength
506	063-0059 R1	3.110	3.320	0.210	Medium	49	49	1.8	3	2	57	3	0.2	47	26	110	21	-4	0	199	Shallow Shear - Spreading
504	063-0029 L1	8.690	9.000	0.310	Medium	137	128	3.3	1	1	25	2	0.2	36	7	97	32	-4	2	199	Shallow Shear - Low Strength
504	063-0029 R1	8.110	8.280	0.170	Medium	147	143	2.3	1	1	44	3	0.2	36	12	80	39	-4	2	199	Shallow Shear - Low Strength
505	063-0046 L1	2.490	2.620	0.130	Medium	36	36	2.4	1	2	44	2	0.4	39	12	88	10	-4	2	199	Shallow Shear - Spreading
501	063-0000 R1	0.970	1.131	0.161	Medium	137	137	3.0	1	1	59	2	0.1	47	1	137	51	-4	199	199	Shallow Shear - Spreading
506	063-0059 R1	4.530	4.720	0.190	Medium	9	9	2.8	1	1	55	2	1.7	41	2	62	3	-4	199	199	Shallow Shear - Spreading
505	063-0046 R1	5.790	6.020	0.230	Medium	19	19	2.1	1	2	66	3	0.7	37	4	92	7	-4	199	199	Shallow Shear - Spreading
505	063-0046 R1	7.340	7.630	0.290	Medium	47	47	2.1	1	2	56	3	0.6	45	6	74	8	-4	199	199	Shallow Shear - Spreading
506	063-0059 R1	4.090	4.230	0.140	Medium	161	142	0.9	1	2	61	9	0.2	39	12	86	26	-4	199	199	Shallow Shear - Low Strength
2648	063-0084 R1	5.230	5.410	0.180	Medium	2	2	1.6	1	5	95	2	0.3	48	17	120	15	-4	199	199	Shallow Shear - Spreading
494	006-0000 L1	2.000	2.260	0.260	Medium	131	131	0.9	1	1	146	37	0.4	42	14	159	42	-4	199	199	Shallow Shear - Spreading
508	063-0074 L1	2.360	2.460	0.100	Medium	43	43	2.2	1	2	92	3	0.3	37	17	120	15	-4	199	199	Shallow Shear - Spreading
508	063-0074 R1	7.790	8.140	0.350	Medium	141	140	0.3	1	1	152	34	0.1	37	19	166	55	-4	199	199	Shallow Shear - Spreading
2648	063-0084 L1	7.650	7.750	0.100	Medium	170	150	1.2	2	2	106	7	0.2	40	15	136	22	-4	199	199	Shallow Shear - Spreading
505	063-0046 L1	11.850	12.000	0.150	Medium	53	53	2.2	2	1	77	2	0.2	48	21	122	16	-4	199	199	Shallow Shear - Spreading
501	063-0000 L1	9.140	9.280	0.140	Medium	169	149	0.2	2	8	49	49	0.1	38	22	67	66	-4	199	199	Shallow Shear - Low Strength
501	063-0000 R1	13.740	13.870	0.130	Medium	10	10	0.9	2	3	109	10	0.2	38	23	120	14	-4	199	199	Shallow Shear - Spreading
503	063-0017 R1	1.530	1.691	0.161	Medium	92	92	0.5	2	7	80	11	0.2	38	21	93	18	-4	199	199	Shallow Shear - Spreading
506	063-0059 L1	9.375	9.490	0.115	Medium	172	148	0.2	2	3	41	41	0.1	45	22	61	61	-4	199	199	Shallow Shear - Low Strength

Forward Work Programme

Web software to enable RCA to recalculate a new FWP for alternative Level of Service, or Budget.

Cost of Structural Treatments			
Type	*Rate*	*Unit*	*Description*
OVLA	$ 540	/ m³	Asphaltic concrete overlay
OVLG	$ 133	/ m³	Granular overlay plus chipseal surface
STAB	$ 170	/ m³	Stabilised granular overlay plus chipseal surface
FBS	$ 398	/ m³	Foamed bitumen stabilisation
RCN	$ 133	/ m³	Granular reconstruction
SMRA	$ 648	/ m³	Structural Mill and Replace Asphalt
STR	$ 160	/ m³	Stabilise and Reconstruct
CS	$ 6	/ m²	Spray Seal

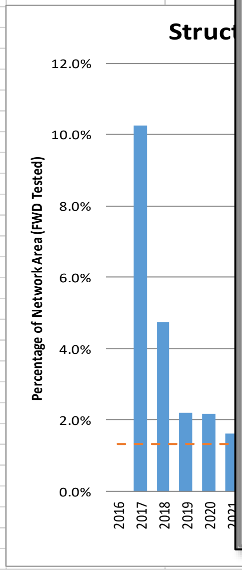
ONRC	R/U Facto
High Volume	0.
National	0.
Regional	0.
Arterial	
Primary Collector	
Secondary Collector	
Access	
Low Volume	

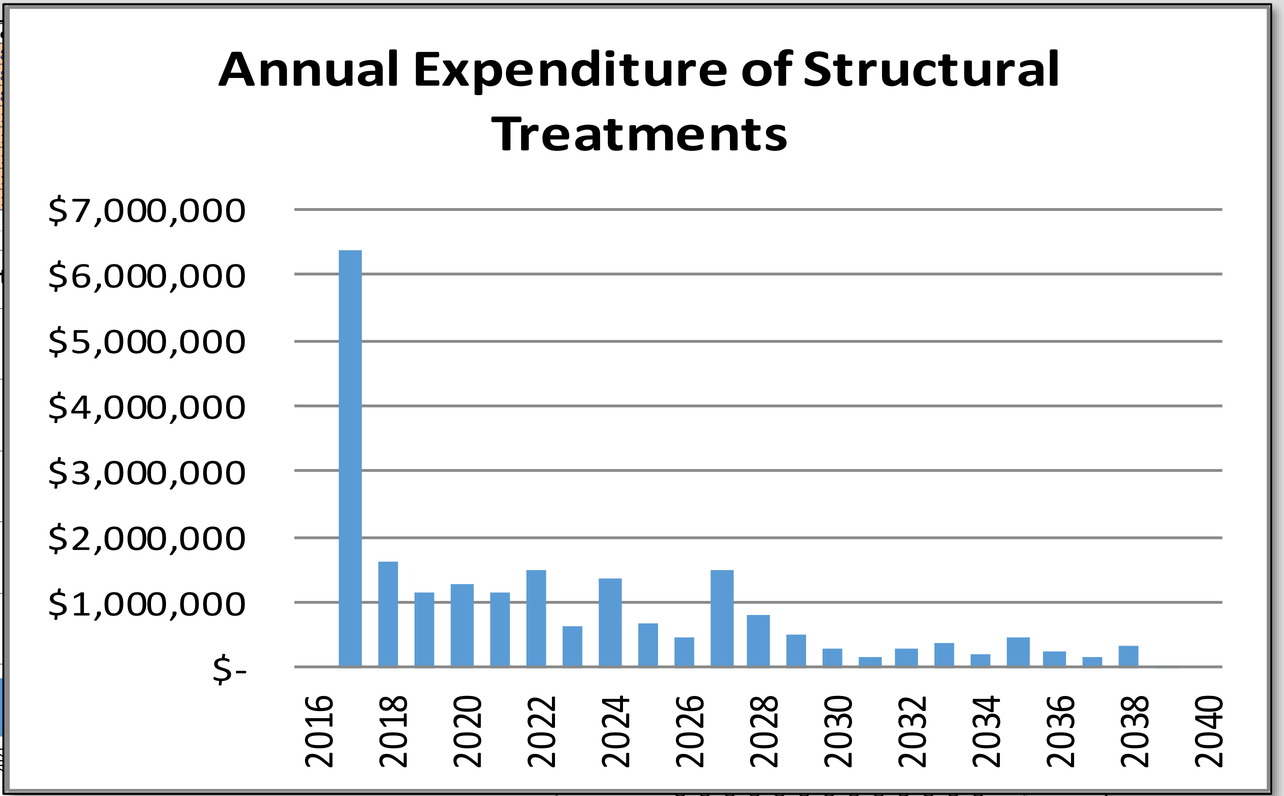
Rehabilitation Priority Weightings		
DF1	1	Negligible
DF2	1.1	Minor
DF3	1.2	Moderate
DF4	1.3	High
DT	1	Design Traffic

Distress Mode Weightings		
LRG	1	Functional Distress
LRE	1	Structural Economic
LRI	1	Aggregate Instability
LSF	0.5	Surfacing Fatigue
LSE	0.5	Surfacing Economic
LDO	0	dTIMS Optimal (Unlimited)
LDS	0	RCA Specified
SC	0	RCA Specified Duration (years)
SF	1	Fatigue Calibration

Update

Export to KML





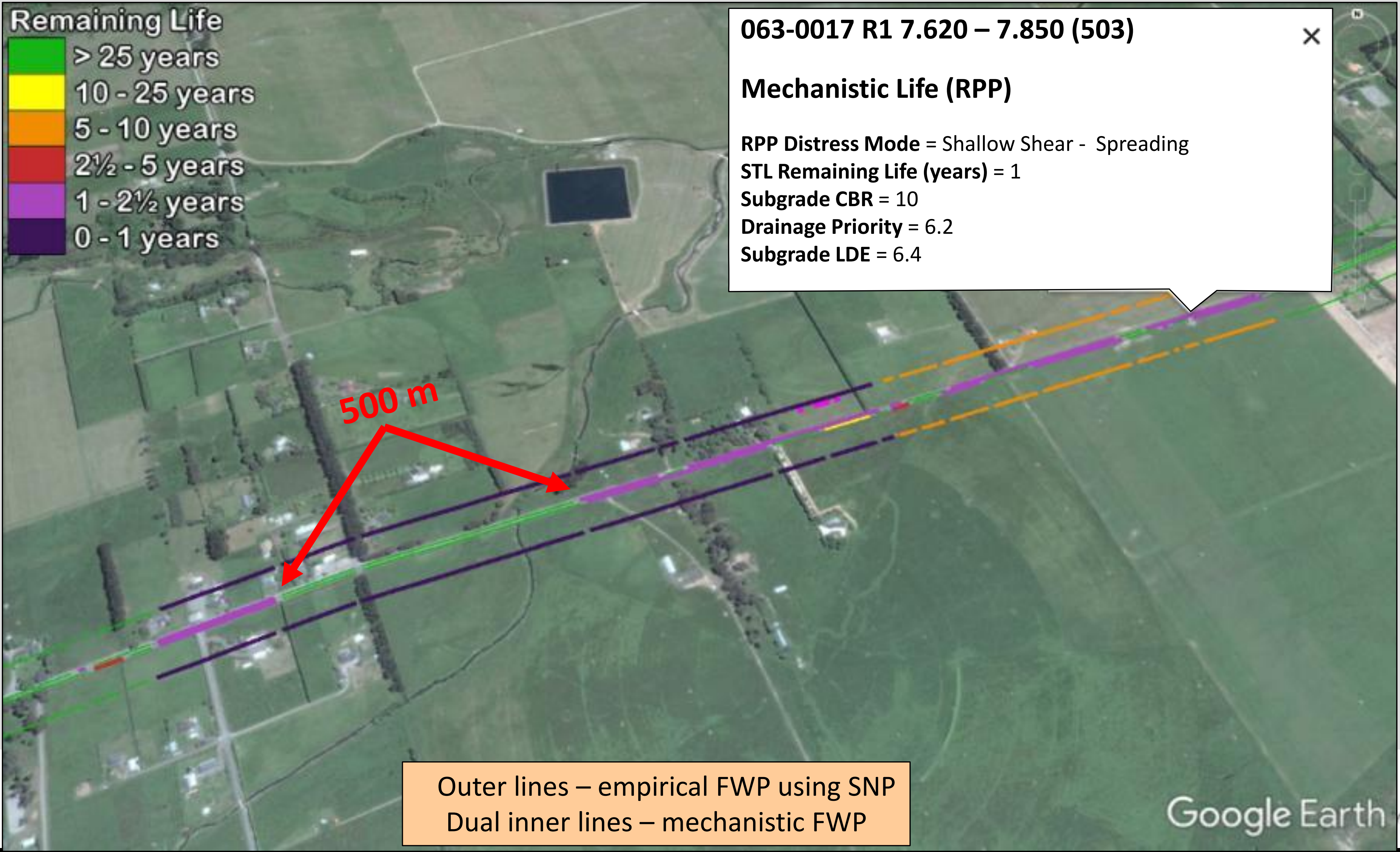
Number of years included in the FWP: 25

GEOSOLVE

RIMS Roading Infrastructure Management Support

IDS Infrastructure Decision Support

NZ Utilities Advisory Group Inc.

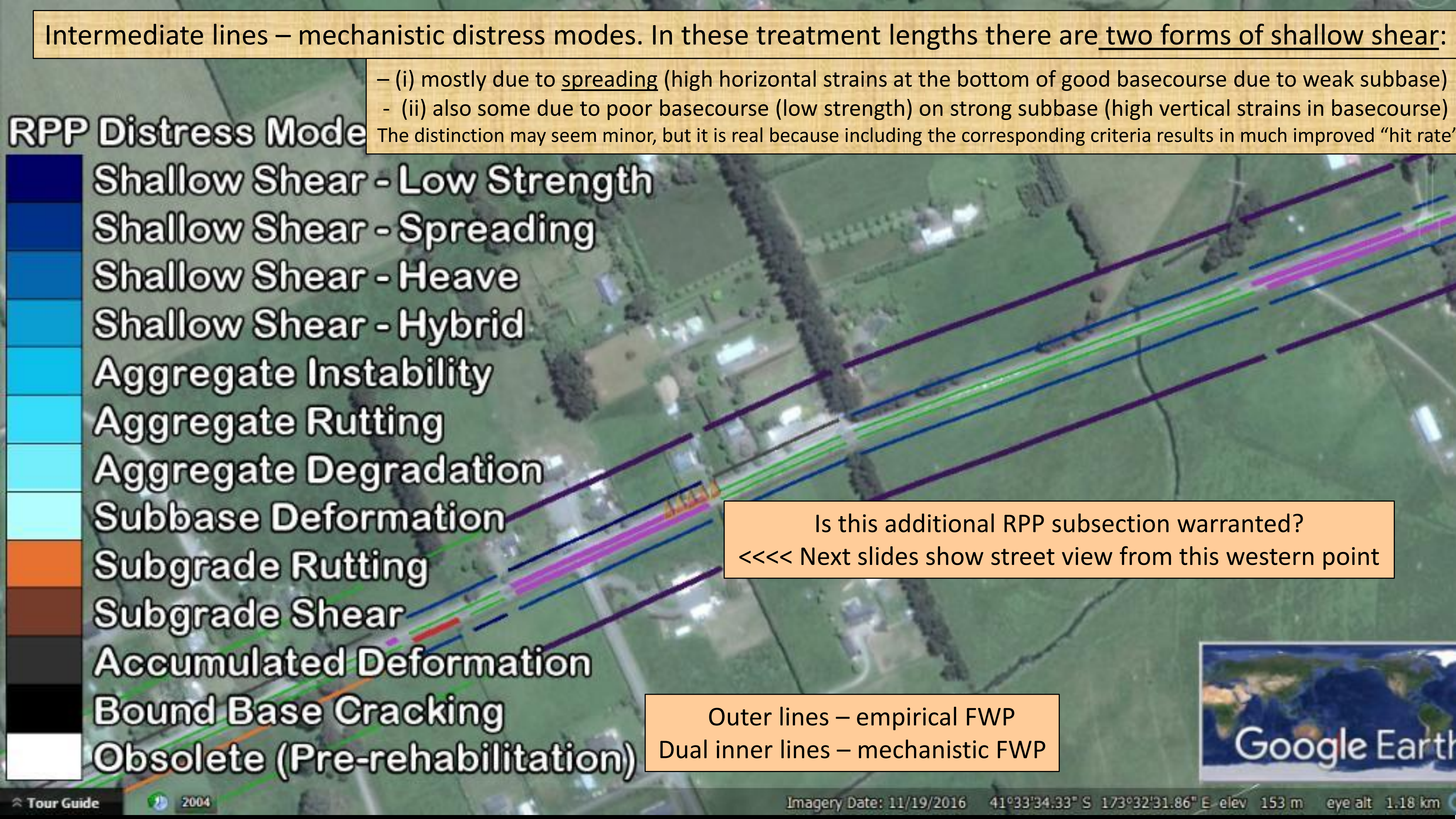

Remaining Life
> 25 years
10 - 25 years
5 - 10 years
2½ - 5 years
1 - 2½ years
0 - 1 years
063-0017 R1 7.620 – 7.850 (503)
Mechanistic Life (RPP)
RPP Distress Mode = Shallow Shear - Spreading
STL Remaining Life (years) = 1
Subgrade CBR = 10
Drainage Priority = 6.2
Subgrade LDE = 6.4
500 m
Outer lines – empirical FWP using SNP
Dual inner lines – mechanistic FWP
Google Earth

Intermediate lines – mechanistic distress modes. In these treatment lengths there are two forms of shallow shear:

– (i) mostly due to spreading (high horizontal strains at the bottom of good basecourse due to weak subbase)

- (ii) also some due to poor basecourse (low strength) on strong subbase (high vertical strains in basecourse)

The distinction may seem minor, but it is real because including the corresponding criteria results in much improved "hit rate"

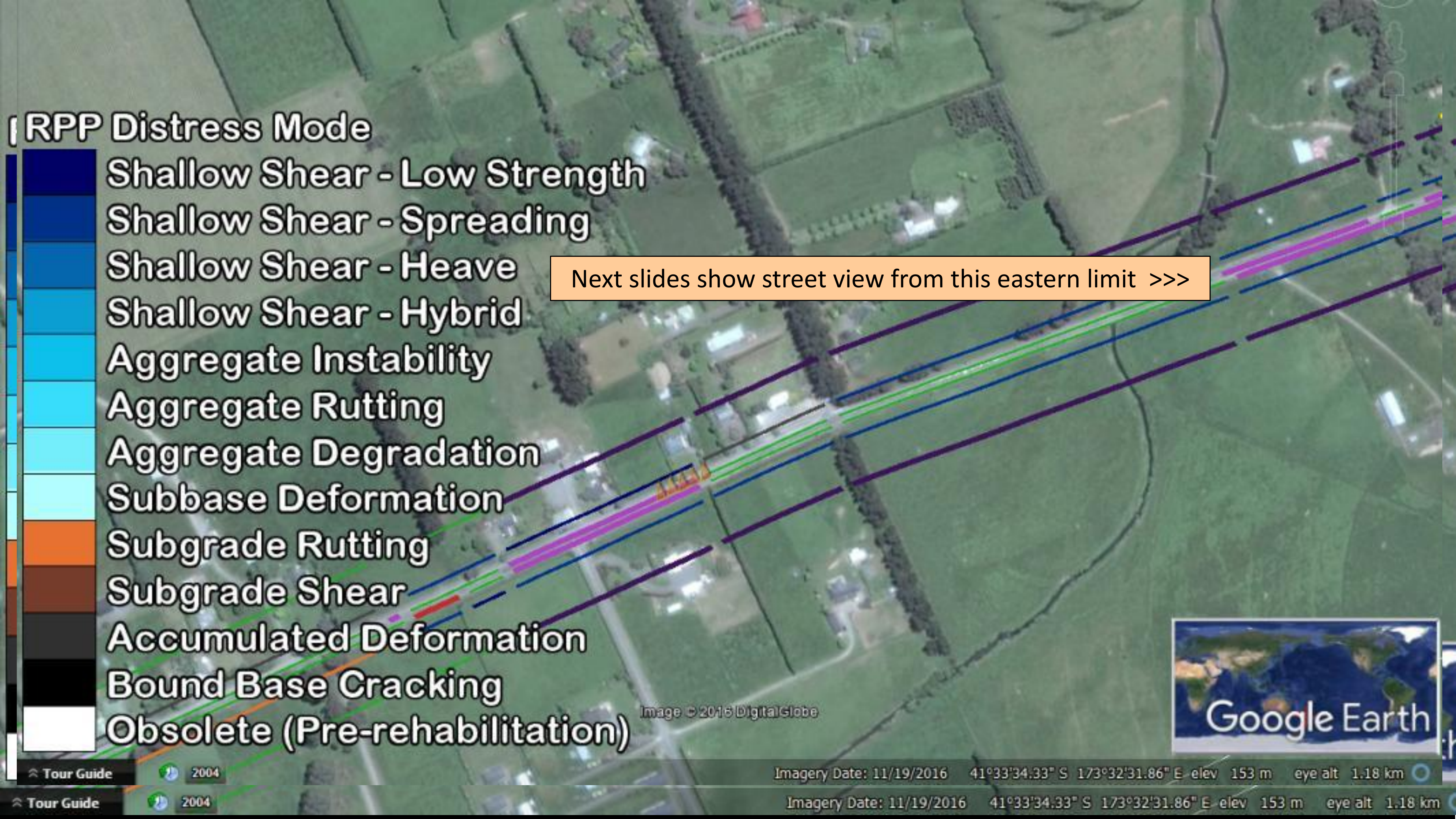


Is this additional RPP subsection warranted?
<<<< Next slides show street view from this western point

Outer lines – empirical FWP
Dual inner lines – mechanistic FWP

View towards the minimal life Structural Treatment Length
From the western RPP sub-section limit.

View in the opposite direction towards the long life Structural Treatment Length (RPP) from the same point at the western RPP sub-section limit, supporting the distinction.

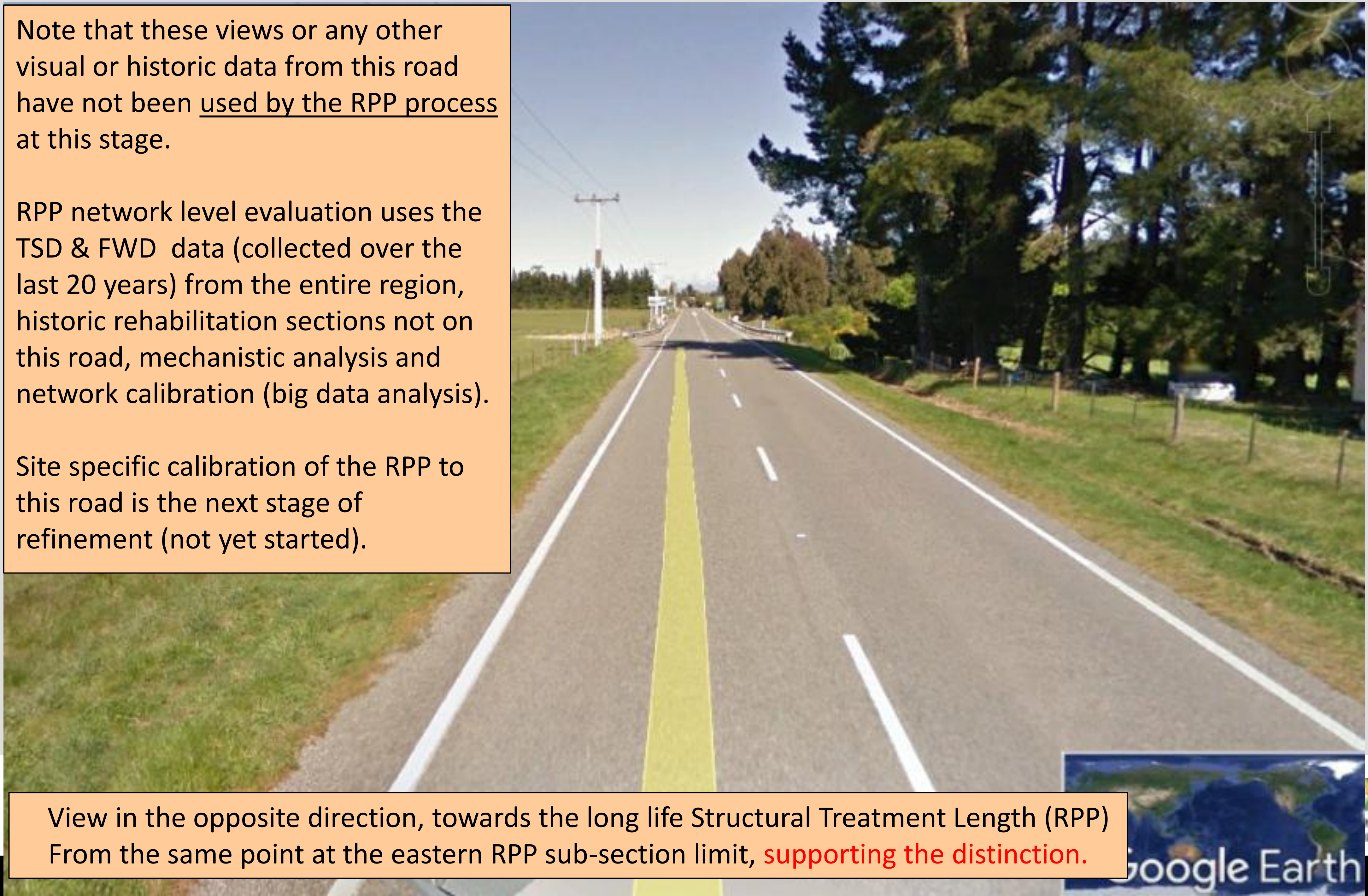

RPP Distress Mode
Shallow Shear - Low Strength
Shallow Shear - Spreading
Shallow Shear - Heave
Shallow Shear - Hybrid
Aggregate Instability
Aggregate Rutting
Aggregate Degradation
Subbase Deformation
Subgrade Rutting
Subgrade Shear
Accumulated Deformation
Bound Base Cracking
Obsolete (Pre-rehabilitation)
Next slides show street view from this eastern limit >>>
Image © 2016 DigitalGlobe
Google Earth
Tour Guide
2004
Imagery Date: 11/19/2016 41°33'34.33" S 173°32'31.86" E elev 153 m eye alt 1.18 km
Tour Guide
2004
Imagery Date: 11/19/2016 41°33'34.33" S 173°32'31.86" E elev 153 m eye alt 1.18 km

View towards the minimal life Structural Treatment Length
From the eastern RPP sub-section limit.

Note that these views or any other visual or historic data from this road have not been <u>used by the RPP process</u> at this stage.

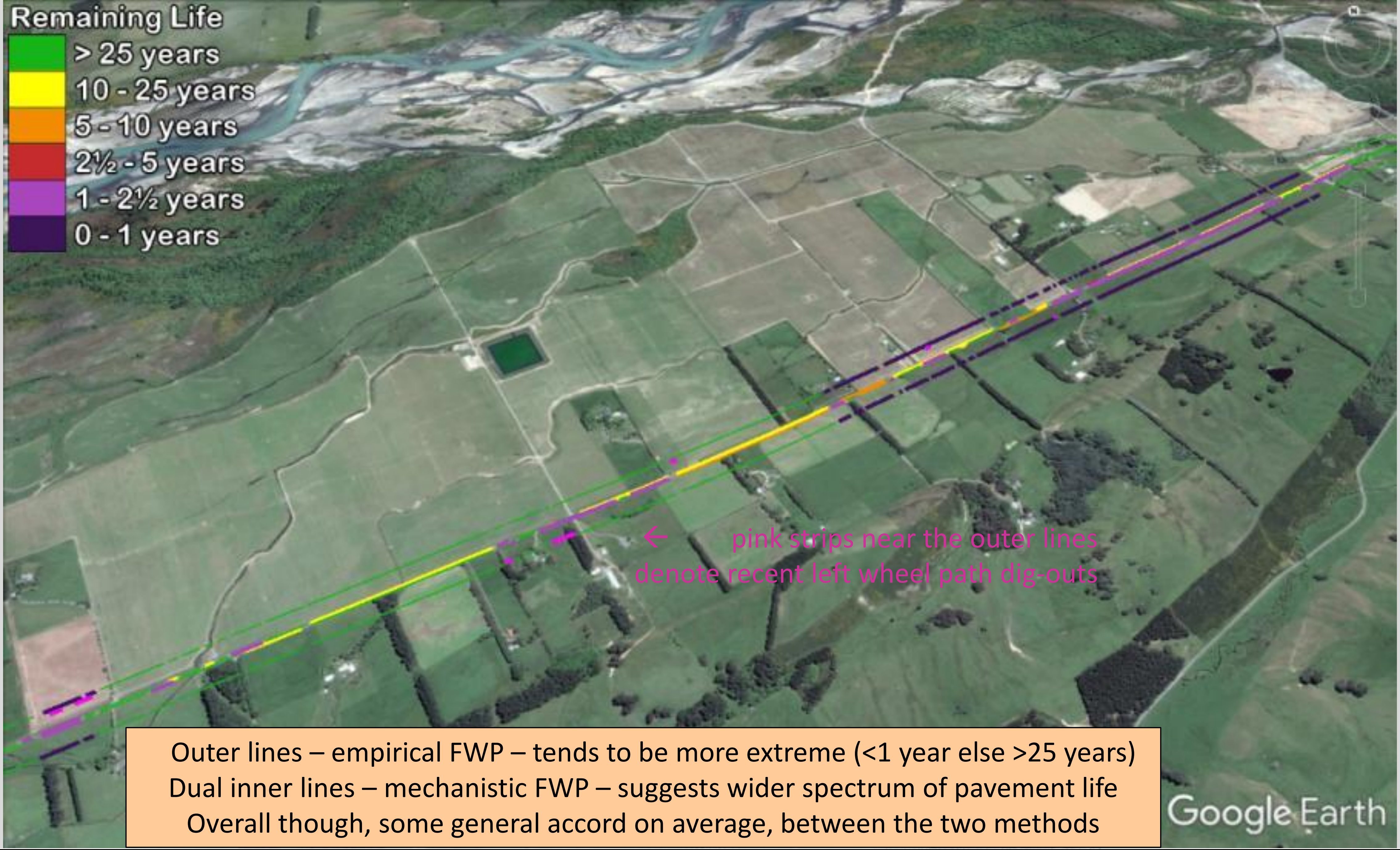
RPP network level evaluation uses the TSD & FWD data (collected over the last 20 years) from the entire region, historic rehabilitation sections not on this road, mechanistic analysis and network calibration (big data analysis).

Site specific calibration of the RPP to this road is the next stage of refinement (not yet started).



View in the opposite direction, towards the long life Structural Treatment Length (RPP)
From the same point at the eastern RPP sub-section limit, supporting the distinction.

Outer lines – empirical FWP –may be too optimistic? (>>25 year life) no lane differentiation
Dual inner lines – mechanistic FWP- more discerning and differentiates between lanes where appropriate



Outer lines – empirical FWP – tends to be more extreme (<1 year else >25 years)
Dual inner lines – mechanistic FWP – suggests wider spectrum of pavement life
Overall though, some general accord on average, between the two methods

Mechanistic vs Traditional Empirical Approach

Mechanistic (Precedent)

Network Regional Calibration

- Subsurface moduli, stresses and strains
- Based on observed network precedent mechanistic performance (collated from regional TSD data and the last 25 years of FWD data) excluding condition data for the current road.
- Outputs remaining structural life, critical layer & terminal distress mode of that layer hence the optimum form of rehabilitation and thickness

Site Specific Calibration

- Visual validation/adaption. (Not yet carried out for Bypass, but should markedly improve the preliminary FWP). Existing distress (shallow shear observed during drive-by) is marked on the Google Earth (.kmz) file.
- Include pavement condition data and address surfacing requirements (or simply input the mechanistic FWP as a Specified Model into Traditional Empirical model)

Traditional Empirical

- Surface analysis and simplified subsurface parameter
- Based on empirical relationships, tends to poorly predict medium or long term life.
- Outputs surfacing requirements and remaining life, but not critical layer or its distress mode
- Site specific validation and adaption of FWP (has been carried out by NZTA for Bypass).

Conclusions-1

- Mechanistic analysis of pavements is now widely favoured internationally as the state-of-the-art (esp Europe, USA, South Africa practices).
- Empirical "one size fits all" structural number approaches such as SNP, the basis of which was officially dismissed (***"Nothing could be more nebulous"***) by its US originators in 2004, are not state-of-the-art. NCHRP (2004). Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures. Final Report. http://www.trb.org/mepdg/guide.htm
- The combination of TSD, FWD, mechanistic analysis and regional precedent performance not only enables much improved pavement life prediction but has another important benefit in that it kindles the interest of innovative pavement designers and asset managers because they can rationalise the performance they observe and make informed decisions. The insight obtained, transforms what tends to be an otherwise mundane role, to one with sufficient challenge to encourage technically inclined engineers and progressive asset managers.
- The reasons this study is so far ahead of TSD interpretation overseas is (i) that NZ highways are not masked by 200 mm of stiff structural AC, so the deeper layer properties can be characterised more reliably, and (ii) the NZ database of FWD for correlations has been maintained and progressively updated over many years using a consistent methodology as set out by Dawson http://www.pavementanalysis.com/images/papers/documents/pavementsworkshop02/briefing.pdf

ROAD INFRASTRUCTURE MANAGEMENT FORUM

Conclusions - 2

- Mechanistic approach promotes a more focussed and optimised Forward Work Programme, and checks for all potential distress modes in all layers over a much longer time frame
- Using structural parameters, more meaningful sub-sectioning translates to much reduced rehabilitation costs while differentiation of each lane allows cost comparison of digouts/local stabilisation with full width treatment with further potential for savings. The claim by Waugh Infrastructure that 25% of roading expenditure is ineffective, may well be countered to a large degree, with these steps.
- Mechanistic FWP (subsurface) is complementary to and readily incorporated into Empirical FWP (mostly surface parameters). The innovative regionally calibrated mechanistic methods have been successfully applied to 5 NZTA Regions, as well as the Kaikoura Bypass
- Preliminary (ie only network level) mechanistic calibration of much of the Bypass has been carried out with highly encouraging results. (TSD data does require thorough scrutiny and sanitising of anomalous readings).
- Site specific mechanistic calibration is now required, preferably now and/or again this winter when more significant distress is expected.

GEOSOLVE RIMS Roading Infrastructure Management Support IDS Infrastructure Decision Support NZ Utilities Advisory Group Inc.

The case for further work: - 1. Kaikoura Bypass presents a rare opportunity for the rapid advancement of predictive modelling for New Zealand unbound pavements

- Comprehensive "baseline data" from pre-quake TSD & FWD
- A lifetime of accelerated trafficking in just over a year on an 800 lane-km "test track"
- The ultimate "Reality Check" for life prediction models: real traffic on diverse real roads in a real environment
- Significant findings already after 3 months accelerated trafficking, even though no site specific calibration as yet.
- Substantial life consumption by end of winter this year (with site specific calibration) for an interim report.
- Equivalent of "25 years" of customary traffic applied by next year will yield conclusions in a practical timeframe
- Ideal database for betterment of existing predictive models of all types (not just dTIMS and RPP but any other contenders)

The case for further work: - 2

- Sound evidence base to establish what features/combinations of alternative models produce the best life predictions
- Well suited to ongoing, long term advancement of all forms of predictive models, (including validation of load damage exponents)
- Joint research proposed by University of Queensland / TMR underway with mutual exchange of TSD data and analyses
- Strong commitment within NPTG for collaborative research on this study - Opus/Beca/Hiways/GeoSolve
- Only other inputs now required are ongoing recordings of date & reason for each digout or AWT (ie identify terminal distress mechanism)
- The Bypass/TSD/FWD/RPP combination is a rare opportunity for applied research with immediate and particularly favourable Benefit/Cost

End

To view and compare empirical and mechanistic FWP's on Google Earth, in closer detail and for the rest of the highway, download this link: http://www.pavementanalysis.com/KMZ/KaikouraBypass.kmz

ROAD INFRASTRUCTURE MANAGEMENT FORUM

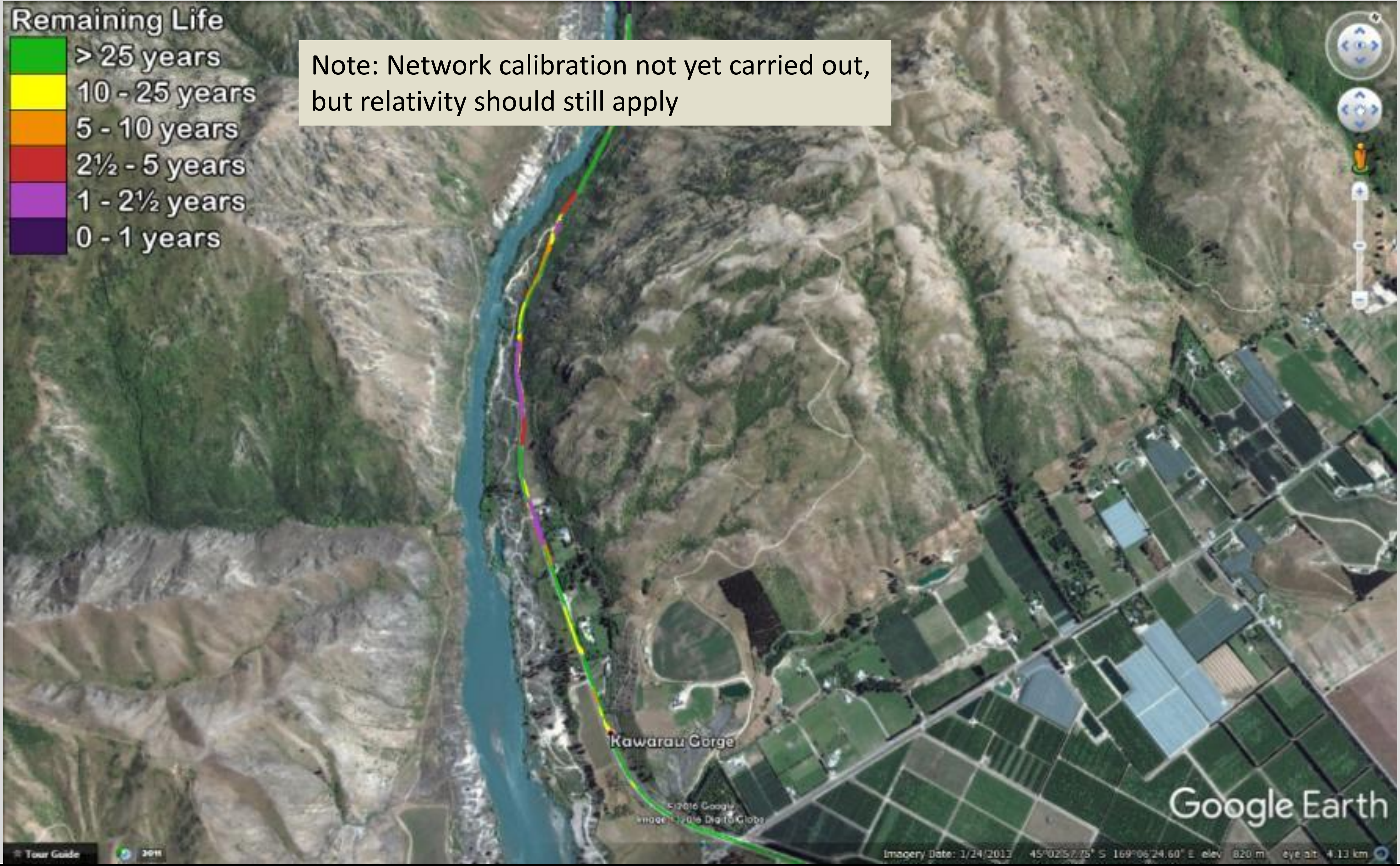
Mechanistic Forward Work Programme

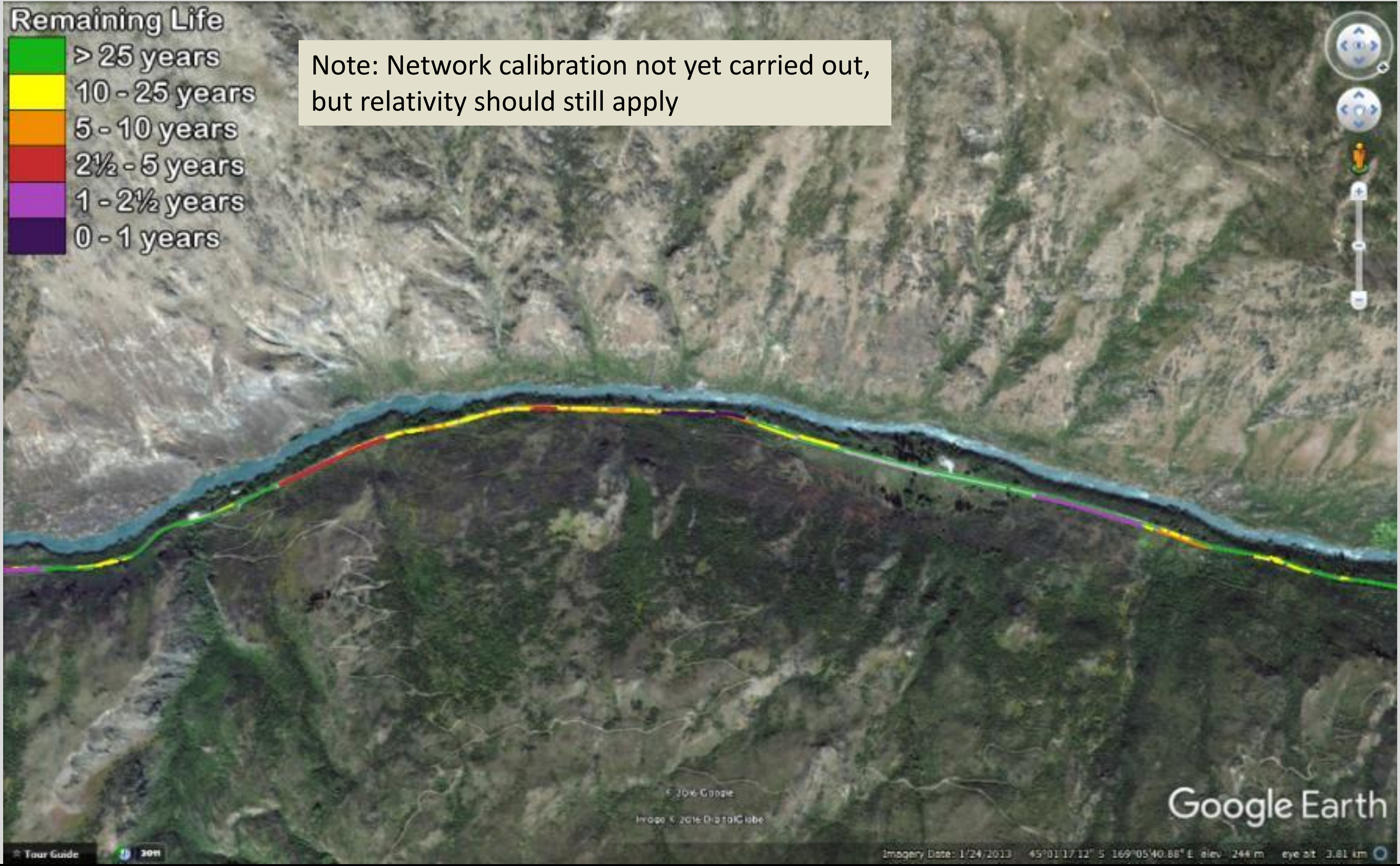
Additional examples of outputs …….. SH6 Kawarau Gorge (Not calibrated for the region. Coastal Otago model has been used so result are likely to be too conservative for the drier climate in Central.)

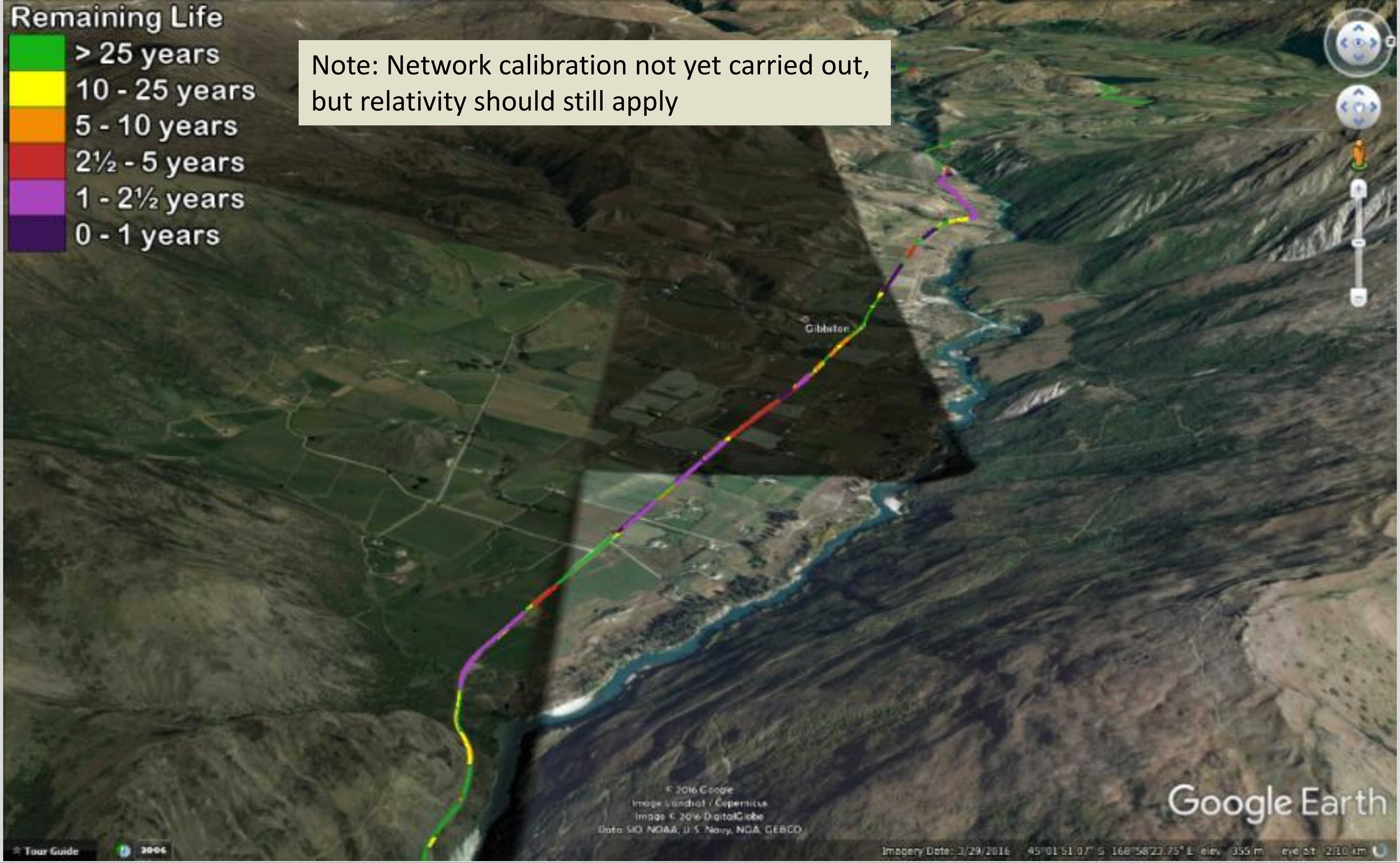
These kmz files (and corresponding spreadsheets) may now be readily output for all structural treatment lengths on the majority of state highways, especially once 2017 TSD becomes available, including generic solutions for each STL quantifying:

- Remaining life
- Critical layer (which layer will govern pavement life
- Distress mode for the critical layer
- Required minimum depth for any digout
- Overlay thickness
- Stabilisation depth
- Subsurface drainage requirements and,
- Susceptibility to HMPV's.

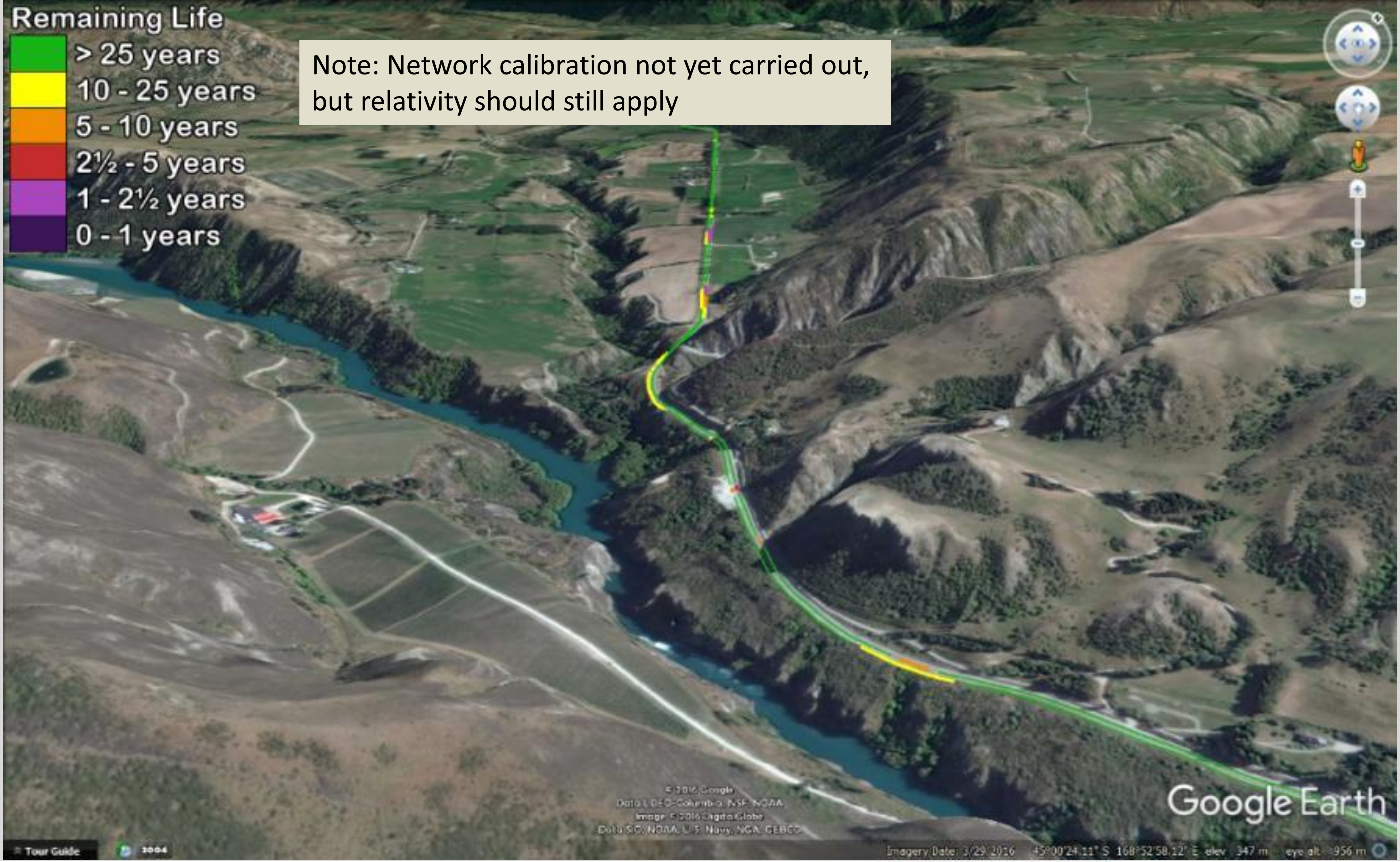
Each lane is differentiated initially for clarity, but lanes and subsections will in many cases be combined where more economic sectioning is carried out for construction. Further improvements once the raw .pt2 files obtained.


Remaining Life
> 25 years
10 - 25 years
5 - 10 years
2½ - 5 years
1 - 2½ years
0 - 1 years
Note: Network calibration not yet carried out,
but relativity should still apply
Kawarau Gorge
Google Earth


Remaining Life
> 25 years
10 - 25 years
5 - 10 years
2½ - 5 years
1 - 2½ years
0 - 1 years
Note: Network calibration not yet carried out, but relativity should still apply
Google Earth


Remaining Life
> 25 years
10 - 25 years
5 - 10 years
2½ - 5 years
1 - 2½ years
0 - 1 years
Note: Network calibration not yet carried out, but relativity should still apply
Gibbston
Google Earth

ROAD INFRASTRUCTURE MANAGEMENT FORUM



ROAD INFRASTRUCTURE MANAGEMENT FORUM