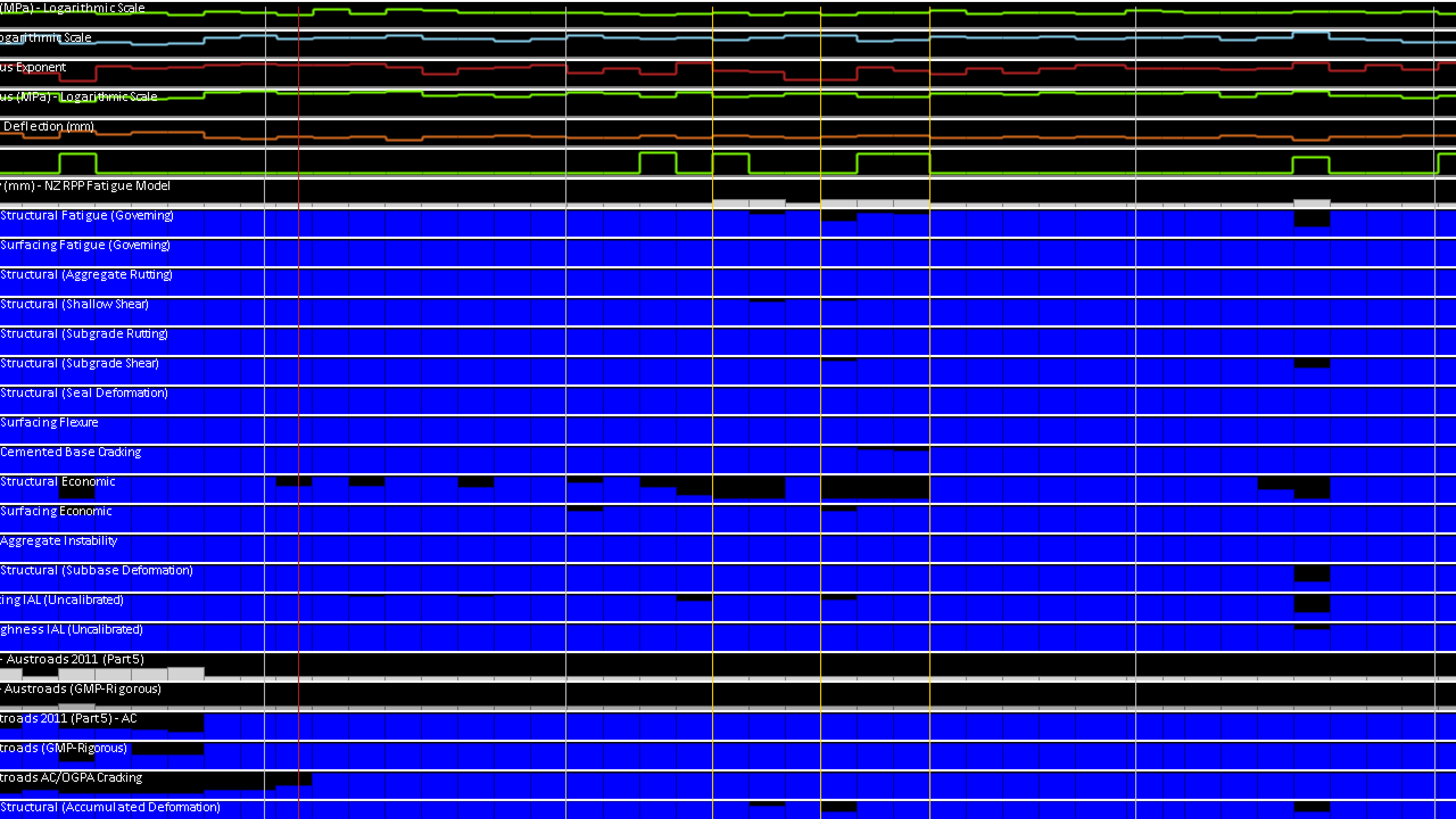
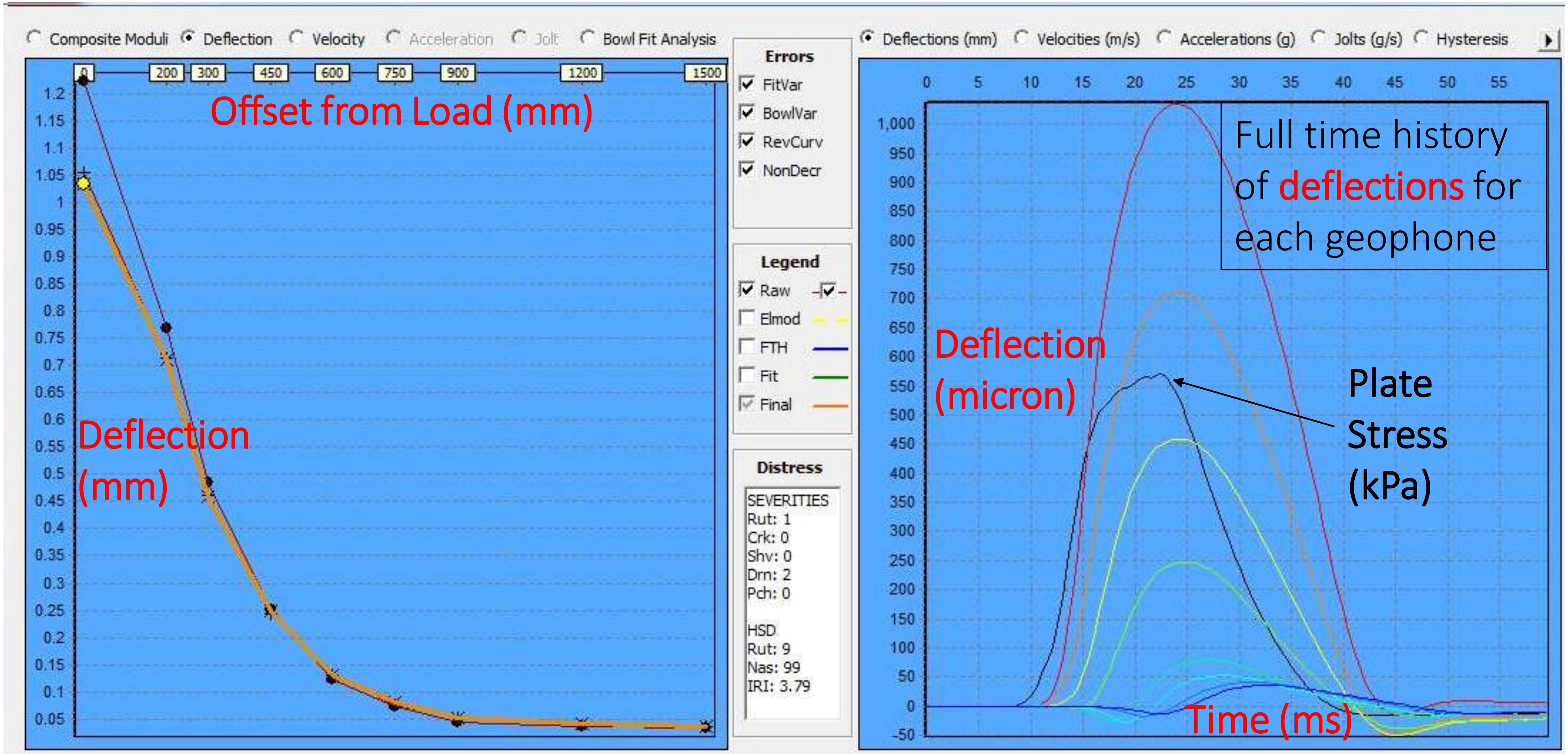
Pavement Life and Forward Works Programme

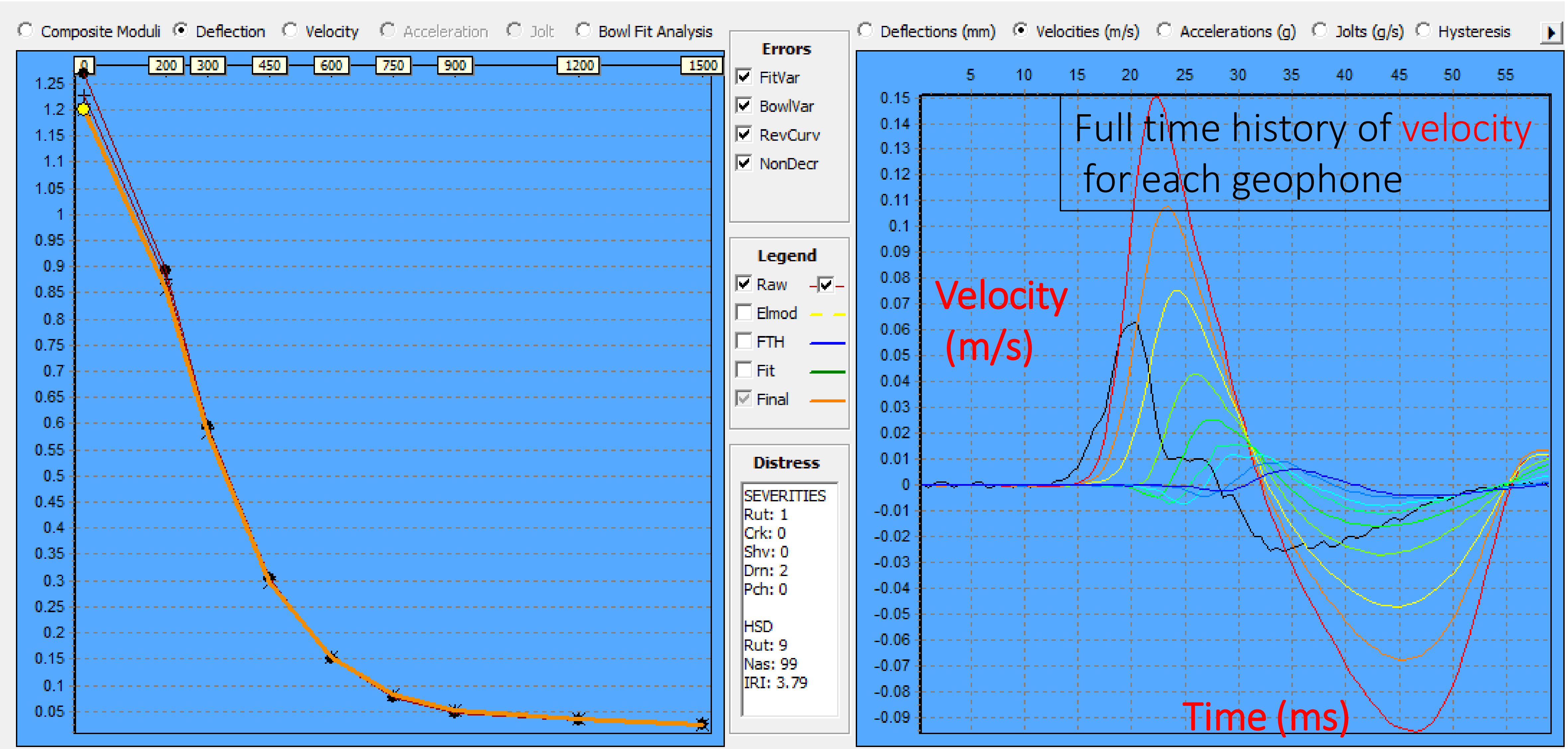
PAVEMENT STRUCTURAL EVALUATIONS FOR ASSET MANAGEMENT


(MPa) - Logarithmic Scale
ogarithmic Scale
us Exponent
us (MPa) - Logarithmic Scale
Deflection (mm)
(mm) - NZ RPP Fatigue Model
Structural Fatigue (Governing)
Surfacing Fatigue (Governing)
Structural (Aggregate Rutting)
Structural (Shallow Shear)
Structural (Subgrade Rutting)
Structural (Subgrade Shear)
Structural (Seal Deformation)
Surfacing Flexure
Cemented Base Cracking
Structural Economic
Surfacing Economic
Aggregate Instability
Structural (Subbase Deformation)
ing IAL (Uncalibrated)
ghness IAL (Uncalibrated)
- Austroads 2011 (Part5)
- Austroads (GMP-Rigorous)
troads 2011 (Part5) - AC
troads (GMP-Rigorous)
troads AC/OGPA Cracking
Structural (Accumulated Deformation)

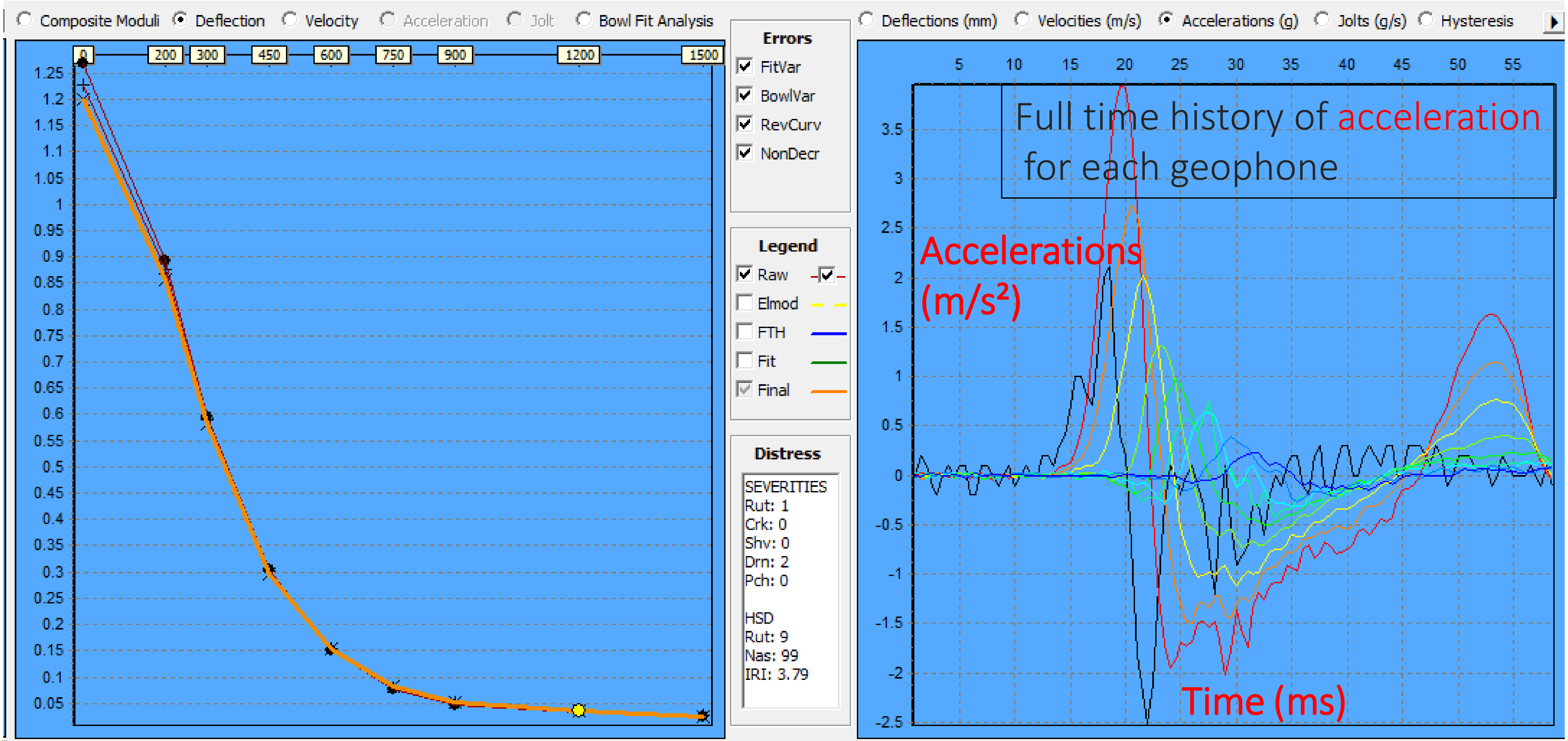
Deflection Evaluation



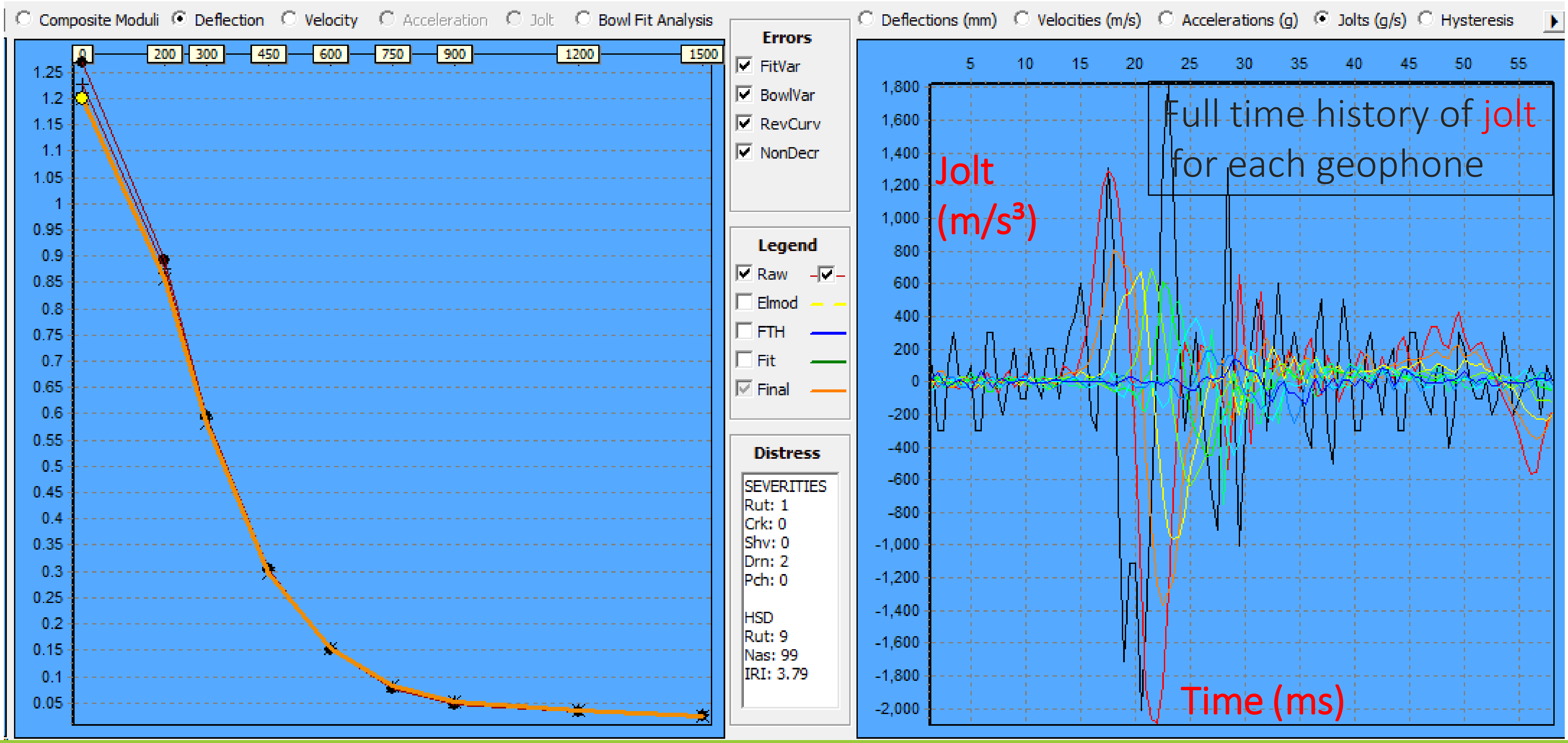
Deflection Evaluation



Deflection Evaluation



Deflection Evaluation



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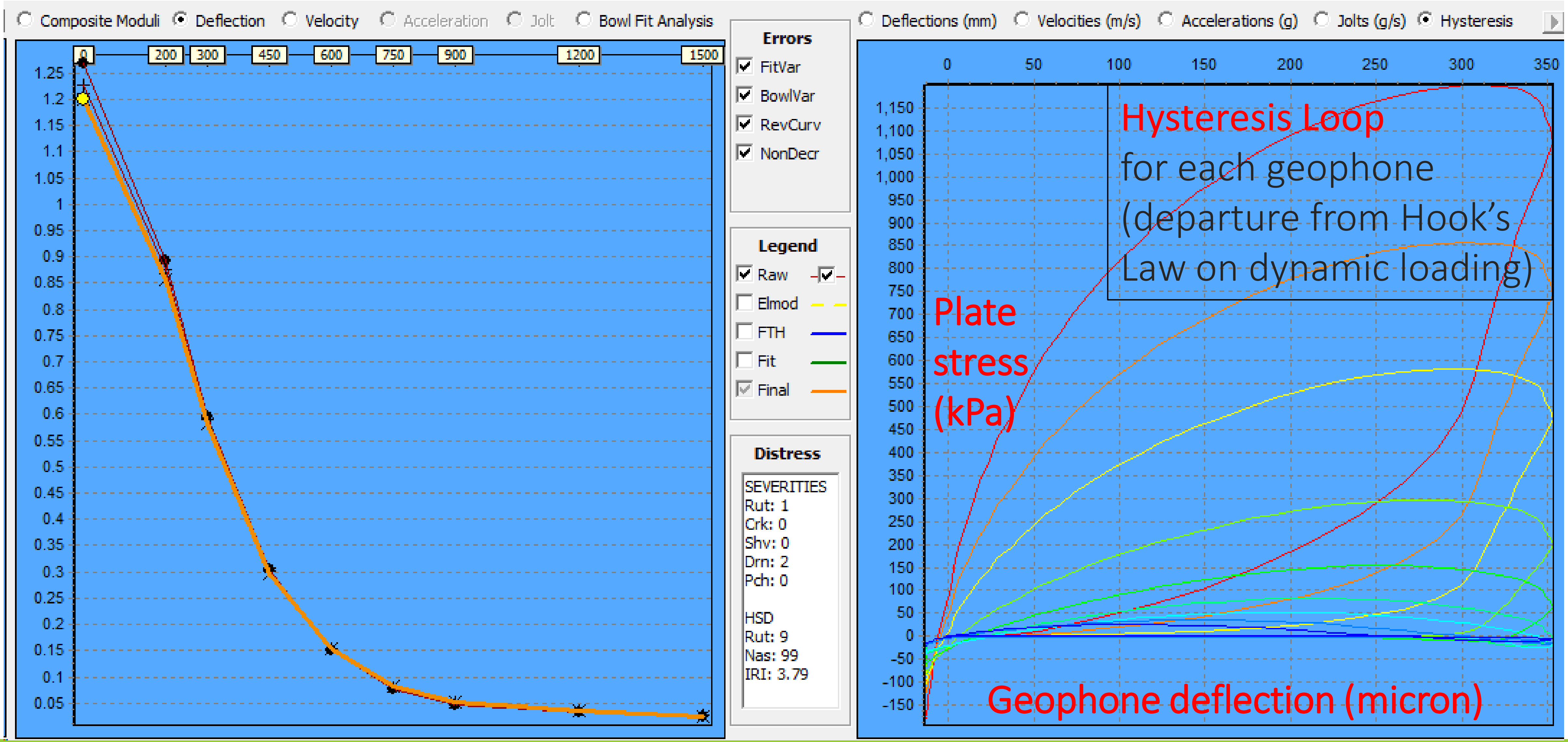
Deflection Evaluation



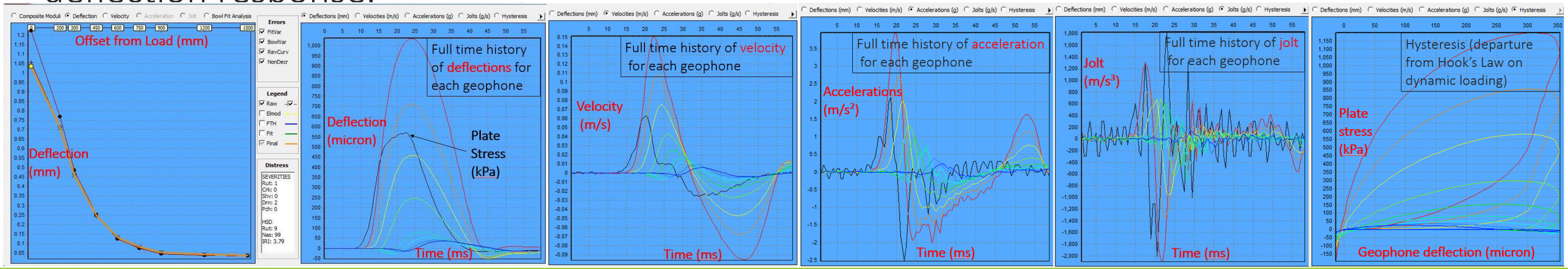
GeoSolve

Deflection Interpretation - Are we adopting the state-of-the-art?

Benkelman Beam (1952)

Structural Number (1962), advanced by World Bank in HDM models in 1987, adopted in NZ in 1999 shortly before being discarded by AASTHO in 2004.

Both approaches (and associated empirical parameters: d0, d200, SCI, SN, SNC, SNP) discard the majority of useful information that relates to the moduli, (and degree of linearity), stresses and strains in the pavement layers, that can be obtained from the full dynamic deflection response.



Deflection Evaluation

Using any of the basic layered elastic models for pavements, corresponding plots can now be readily generated for a wide variety of mechanistic parameters, i.e. stresses, strains or moduli at any time during the test to identify characteristics generated by pavements subject to specific distress modes.

Implementation

The following slides give example pavement structural models for networks.

Correctly identifying the limits of homogeneous intervals of road, ie structural treatment lengths enables efficient management of the network. Often only visual data is available which needs to be supplemented with historic performance information. However, deflection testing and structural analysis provides the most informative approach.

The Structural Treatment Length (STL) file comprises the information illustrated in the pavement models in tabular form. The following are some of the structural treatment lengths with higher priority for renewal, identified in the preliminary study (uncalibrated desktop structural evaluation, i.e. visuals required) for the North Canterbury NOC.

Road ID	File Name	Start (km)	End (km)	Length (km)	Number of Test Points	RPP (Precedent) Life (Years) - User Weight
1831	01S-0332	2.030	3.430	1.400	14	2
625	01S-0311	5.000	5.532	0.532	5	3
610	007-0000-I	10.300	11.900	1.600	7	8

										Drainage Parameters			ructural Treatment (mm) - Subject to Detailed Desig			
Road ID	File Name	Start (km)	End (km)	Length (km)	Number of Test Points	RPP (Precedent) Life (Years) - User Weight	Life (Years) - FWP NZTA Specified	Life (Years) - FWP dTIMS	RPP Distress Mode	Potential for Subsoil Drainag	Priority for Drainage (Greatest Benefi	CBR	Proportion of Length Digouts / Patching	Depth of Reconstruction / Digouts / Patching	Unbound Granular Overlay (RP	RPP Rehab Year
611	007-0016-I	7.720	8.120	0.400	2	-2			Aggregate Instability	High	10.0	31	1.0	390	160	2016
611	007-0016-D	2.020	2.420	0.400	2	-1			Aggregate Instability	High	10.0	64	1.0	460	160	2016
602	01S-0195	1.890	2.390	0.500	5	1			Subbase Deformation	High	0.0	24	1.0	270	50	2017
626	01S-0317	1.936	2.670	0.734	8	1			Accumulated Deformation	High	0.0	16	0.1	770	90	2017
596	01S-0104	6.170	6.370	0.200	2	1			Subbase Deformation	High	0.0	22	1.0	250	50	2017
607	01S-0273	8.360	8.860	0.500	5	1			Subbase Deformation	High	0.0	39	1.0	230	50	2017
1831	01S-0332	4.130	4.730	0.600	6	1			Subbase Deformation	High	0.0	34	1.0	250	50	2017
1831	01S-0332	3.430	4.130	0.700	7	1			Subbase Deformation	High	0.0	32	0.1	290	50	2017
1654	01S-0185	9.750	9.900	0.150	2	1			Subbase Deformation	High	0.0	33	0.5	210	50	2017
602	01S-0195	17.890	19.440	1.550	16	1			Subbase Deformation	High	0.0	35	0.2	290	50	2017
1654	01S-0185	4.650	4.950	0.300	3	1			Aggregate Instability	High	9.5	90	1.0	340	160	2017
1831	01S-0332	2.030	3.430	1.400	14	2			Rutting (IAL)	High	8.1	17	1.0	440	180	2018
596	01S-0104	11.948	13.920	1.972	20	2			Subbase Deformation	High	0.0	36	0.2	250	50	2018
603	01S-0217	6.750	7.057	0.307	3	2			Rutting (IAL)	High	8.8	4	1.0	590	70	2018
603	01S-0217	2.750	3.050	0.300	3	2			Subbase Deformation	High	0.0	18	1.0	270	50	2018
613	007-0044-I	10.220	10.620	0.400	2	2			Aggregate Instability	High	10.0	16	1.0	490	150	2018
1831	01S-0332	8.930	9.270	0.340	3	2			Aggregate Instability	High	7.5	5	0.3	560	180	2018
1831	01S-0332	8.560	8.625	0.065	1	2			Aggregate Instability	High	6.2	33	1.0	370	170	2018
599	01S-0155	3.897	5.915	2.018	20	3			Subbase Deformation	High	0.0	19	0.1	300	50	2019
625	01S-0311	5.000	5.532	0.532	5	3			Aggregate Instability	High	0.0	10	1.0	420	170	2019
611	007-0016-D	8.420	8.820	0.400	2	3			Aggregate Instability	High	9.8	55	1.0	410	160	2019
1831	01S-0332	7.926	8.560	0.634	6	4			Rutting (IAL)	High	0.0	37	0.2	300	50	2020
630	01S-0317_05.26-D	5.370	5.830	0.460	2	4			Accumulated Deformation	High	0.0	18	0.5	640	90	2020
1654	01S-0185	6.050	6.350	0.300	3	4			Accumulated Deformation	High	5.3	19	1.0	550	70	2020
1654	01S-0185	3.350	4.650	1.300	13	4			Rutting (IAL)	High	8.3	86	0.2	510	70	2020
615	007-0078-I	16.140	16.540	0.400	2	4			Aggregate Instability	High	9.9	52	1.0	480	140	2020
595	01S-0090	4.950	5.550	0.600	6	5			Subbase Deformation	High	0.0	20	1.0	280	50	2021
1654	01S-0185	9.550	9.750	0.200	2	5			Subbase Deformation	High	3.6	36	1.0	320	50	2021
613	007-0044-I	3.220	3.620	0.400	2	5			Subbase Deformation	High	9.7	24	1.0	380	150	2021
596	01S-0104	4.370	6.170	1.800	18	5			Rutting (IAL)	High	6.3	22	0.2	310	50	2021
1716	01S-0327-I	0.570	0.988	0.418	3	5			Rutting (IAL)	High	4.1	22	0.3	310	50	2021
612	007-0028-I	13.050	13.313	0.263	1	5			Aggregate Instability	High	7.7	20	1.0	430	160	2021
617	007-0115-D	15.630	15.930	0.300	2	5			Aggregate Instability	High	10.0	24	1.0	580	140	2021
602	01S-0195	1.090	1.890	0.800	8	6			Subbase Deformation	High	9.3	56	0.1	320	50	2022
615	007-0078-I	0.740	1.140	0.400	2	6			Accumulated Deformation	High	6.6	19	1.0	570	50	2022
625	01S-0311	6.220	6.250	0.030	1	6			Aggregate Rutting (RPP)	High	0.0	8	1.0	430	50	2022
602	01S-0195	15.790	16.290	0.500	5	6			Rutting (IAL)	High	5.0	43	1.0	380	50	2022
614	007-0058-I	0.790	1.190	0.400	2	6			Aggregate Instability	High	10.0	60	1.0	440	150	2022
602	01S-0195	2.390	4.290	1.900	19	7			Rutting (IAL)	High	4.4	25	0.2	340	50	2023
607	01S-0273	10.260	10.810	0.550	6	7			Rutting (IAL)	High	5.5	27	0.2	280	50	2023
596	01S-0104	9.977	11.948	1.971	20	7			Rutting (IAL)	High	7.1	16	0.2	430	50	2023
607	01S-0273	9.960	10.260	0.300	3	7			Subbase Deformation	High	5.7	29	1.0	370	50	2023
607	01S-0273	1.893	3.677	1.783	18	7			Rutting (IAL)	High	0.0	19	0.1	270	50	2023
604	01S-0235	0.060	1.993	1.933	20	7			Subbase Deformation	High	3.9	34	0.1	250	50	2023
605	01S-0247	0.240	2.103	1.863	19	7			Accumulated Deformation	High	8.6	24	0.1	450	50	2023
602	01S-0195	4.290	6.090	1.800	18	7			Accumulated Deformation	High	7.1	4	0.2	520	50	2023

Forward Work Programme for Canterbury NZTA Network based on Precedent Performance

Volumetric 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

Distress Mode Weightings

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

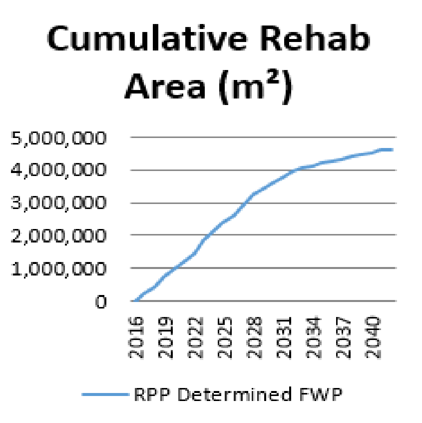
Update

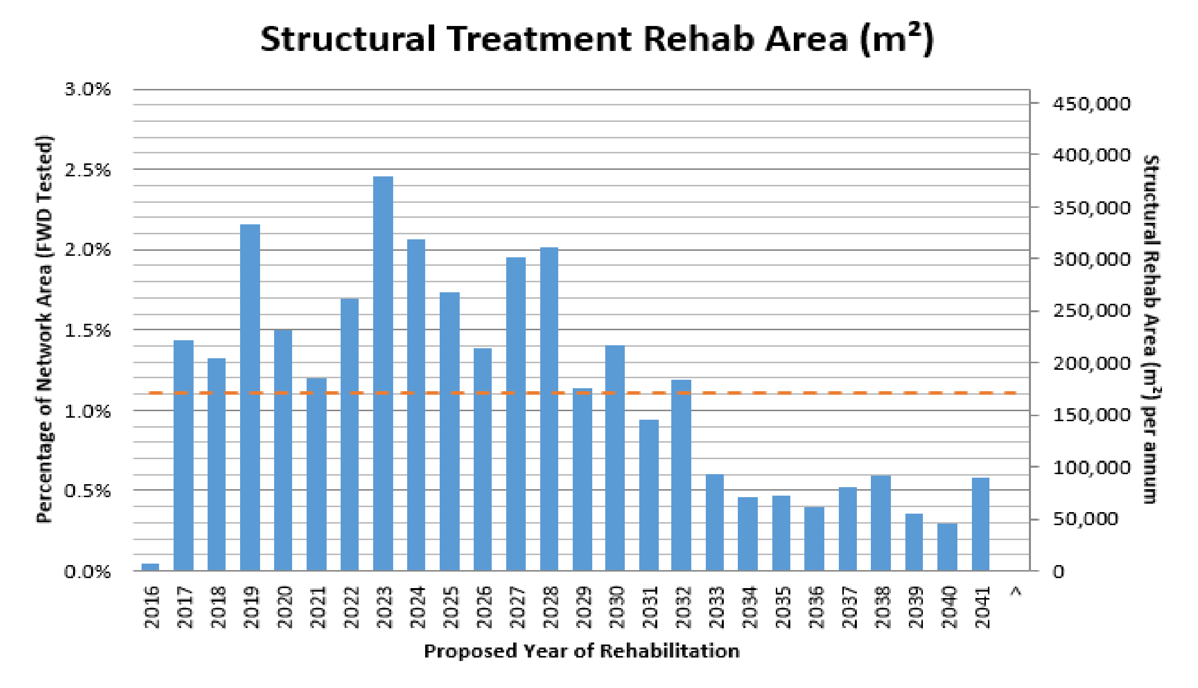
Rehabilitation Priority Weightings

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

STL Terminal Criteria by ONRC Category

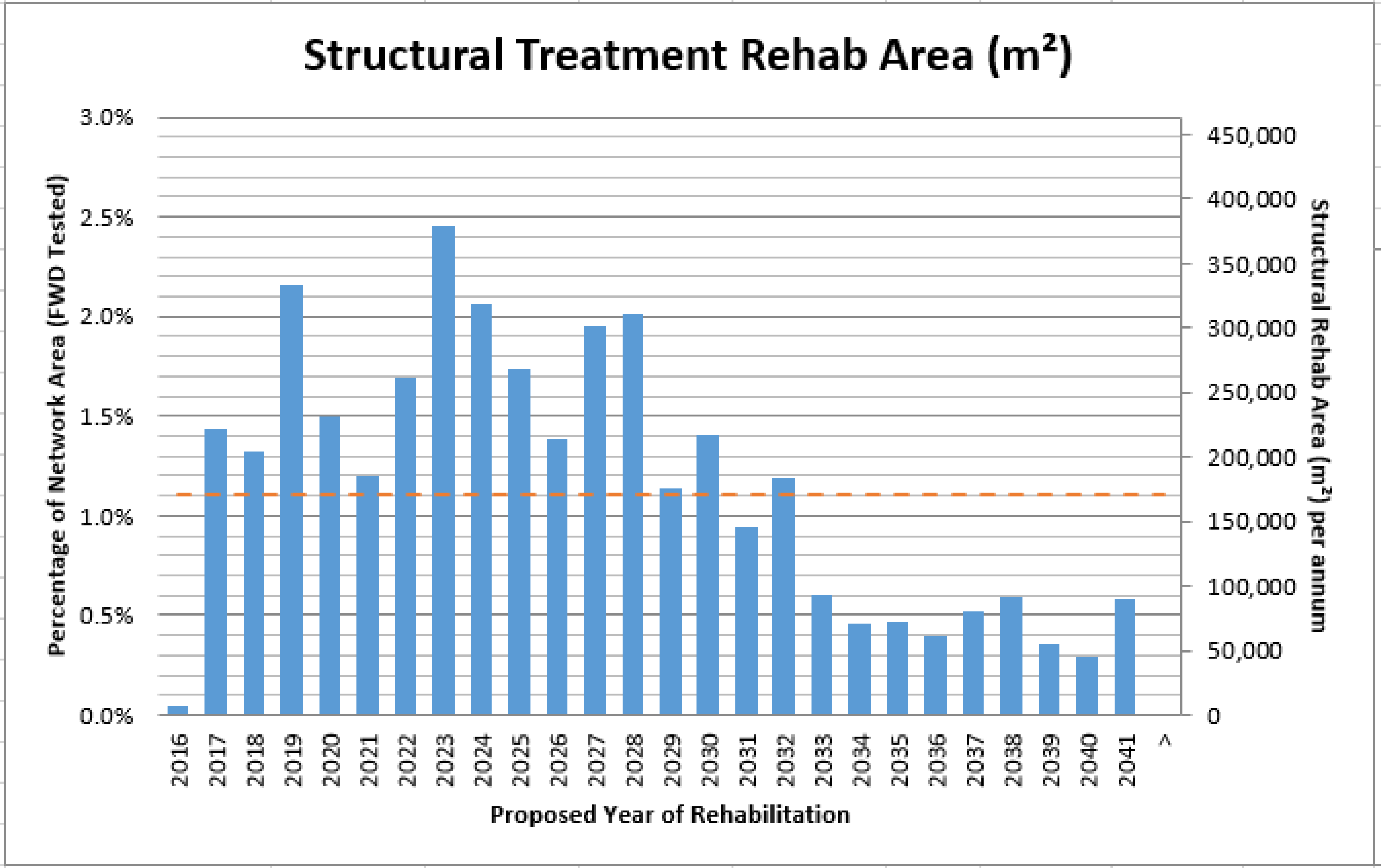
One Network Road Classification (ONRC)	Level of Service (Structural)	Level of Service (Surfacing)	Excessive Maintenance Cost	Urban / Rural Factor
High Volume	10	10	15	0.8
National	10	20	30	0.8
Regional	50	30	40	0.8
Arterial	50	40	60	0.8
Primary Collector	60	50	80	1
Secondary Collector	70	60	90	1
Access	80	80	90	1
Low Volume	90	90	95	1
				0





Implementation Guide | Options | STL | FWP | Graphs | Drainage | Percentages

Forward Work Programme



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Cost of Structural Treatments

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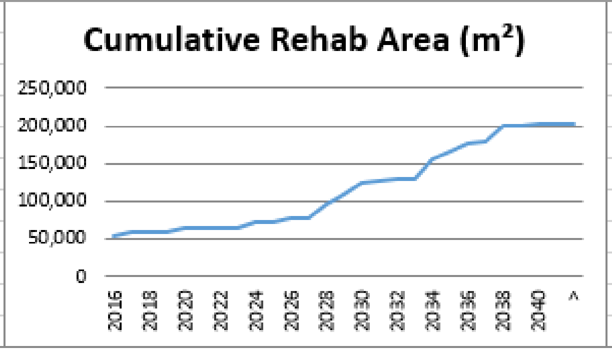

Rehabilitation Priority Weightings

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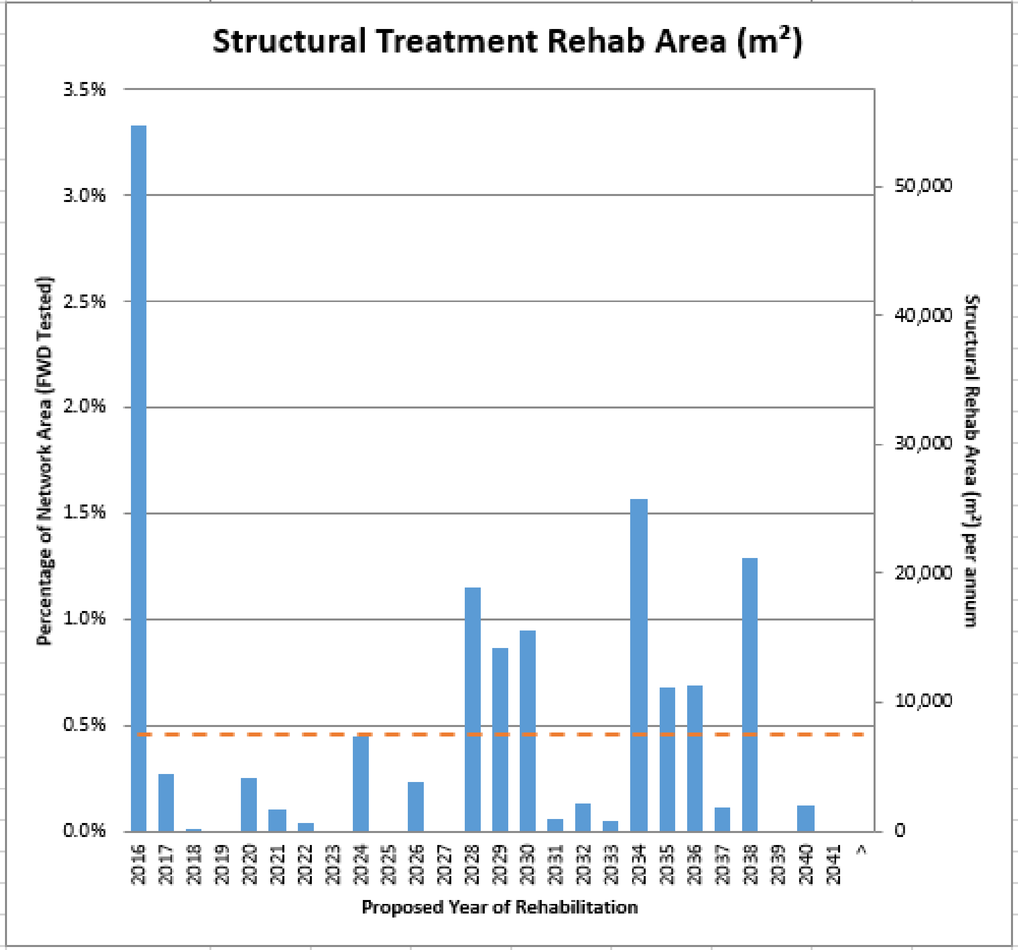
LDO	0	dTIMS Optimal (Unlimited)
LDS	0	RCA Specified
SC	0	RCA Specified Duration (years)
SF	1	Fatigue Calibration

Update

ONRC	R/U Factc	LOS(sur)	LOS(str)	COST			
High Vol	0.8	10	20	50	10	20	50
National	0.8	10	20	50	10	20	50
Regional	0.8	15	20	50	15	20	50
Arterial	1	20	20	50	20	20	50
Primary C	1	25	25	50	25	25	50
Secondar	1	30	30	50	30	30	50
Access	1	35	35	55	35	35	55
Low Volu	1	50	50	70	50	50	70

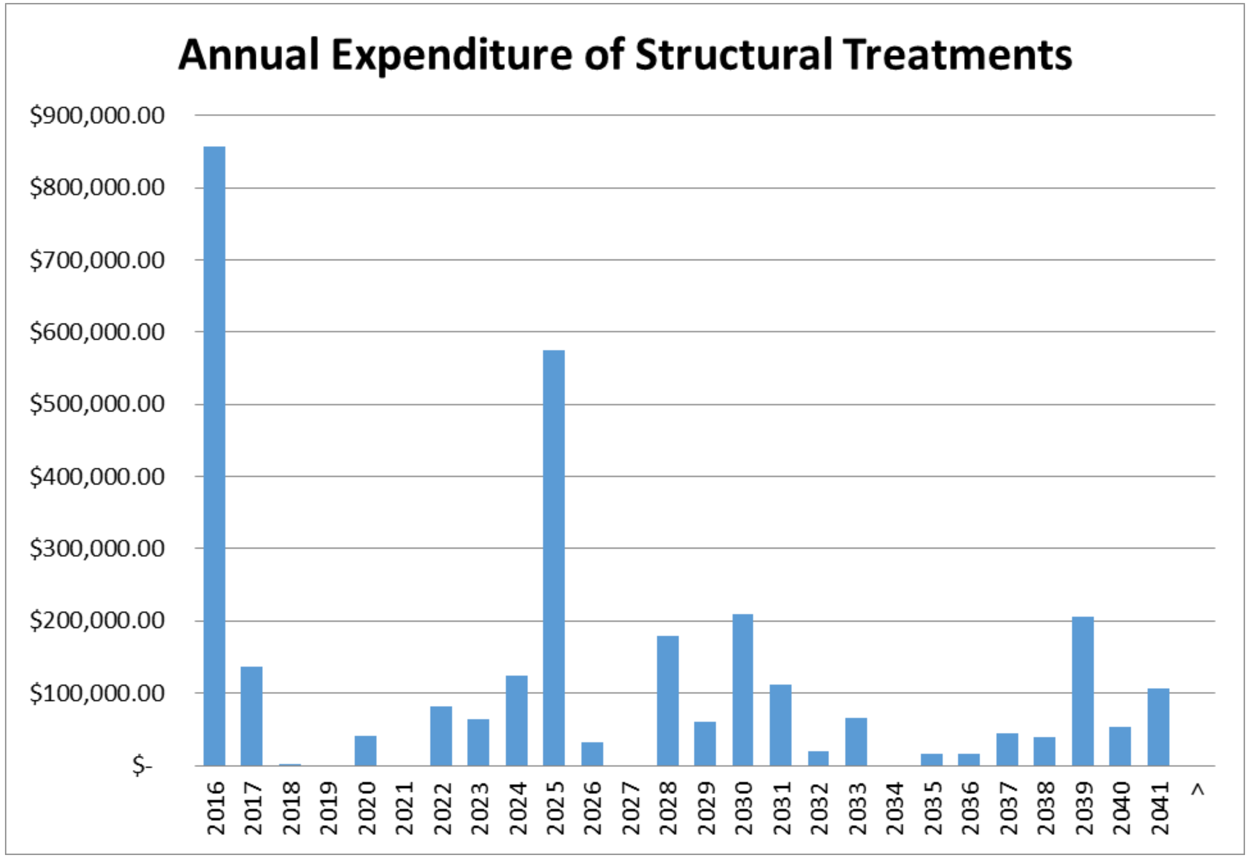
0

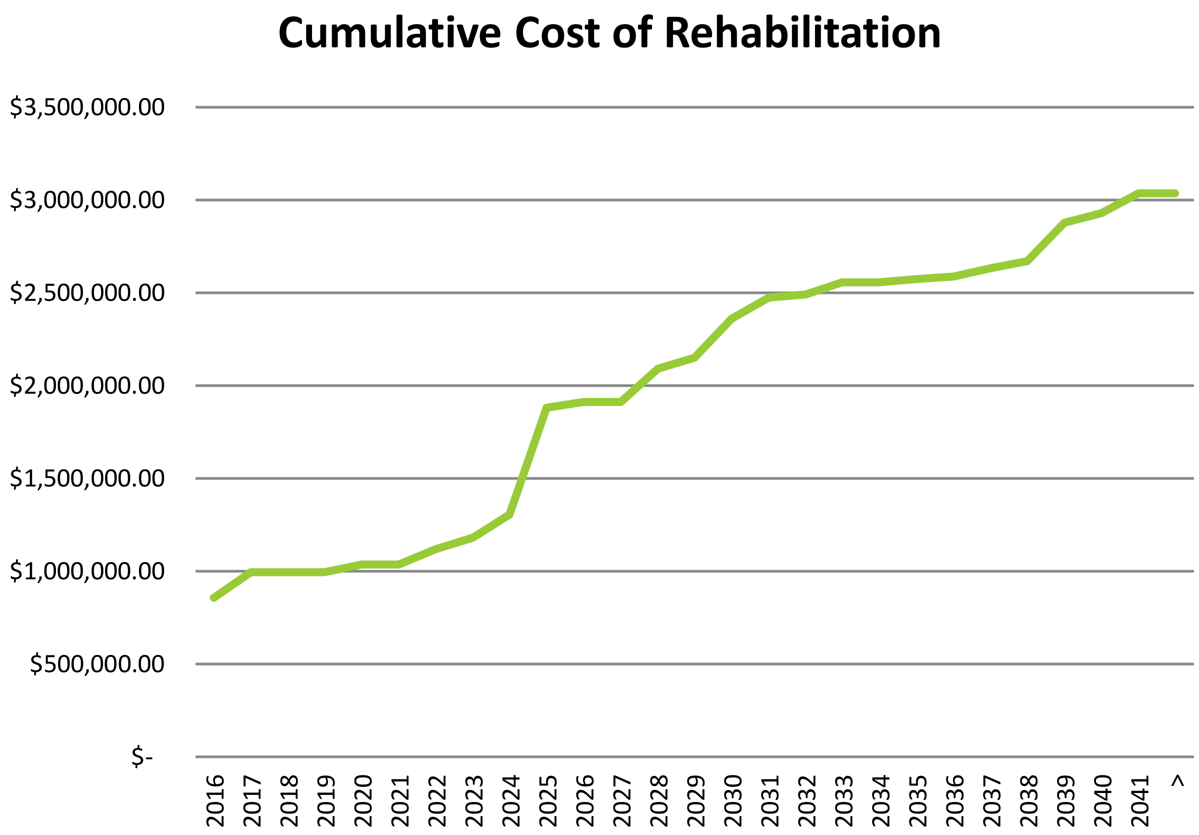


GeoSolve

Summary FWP Presentation

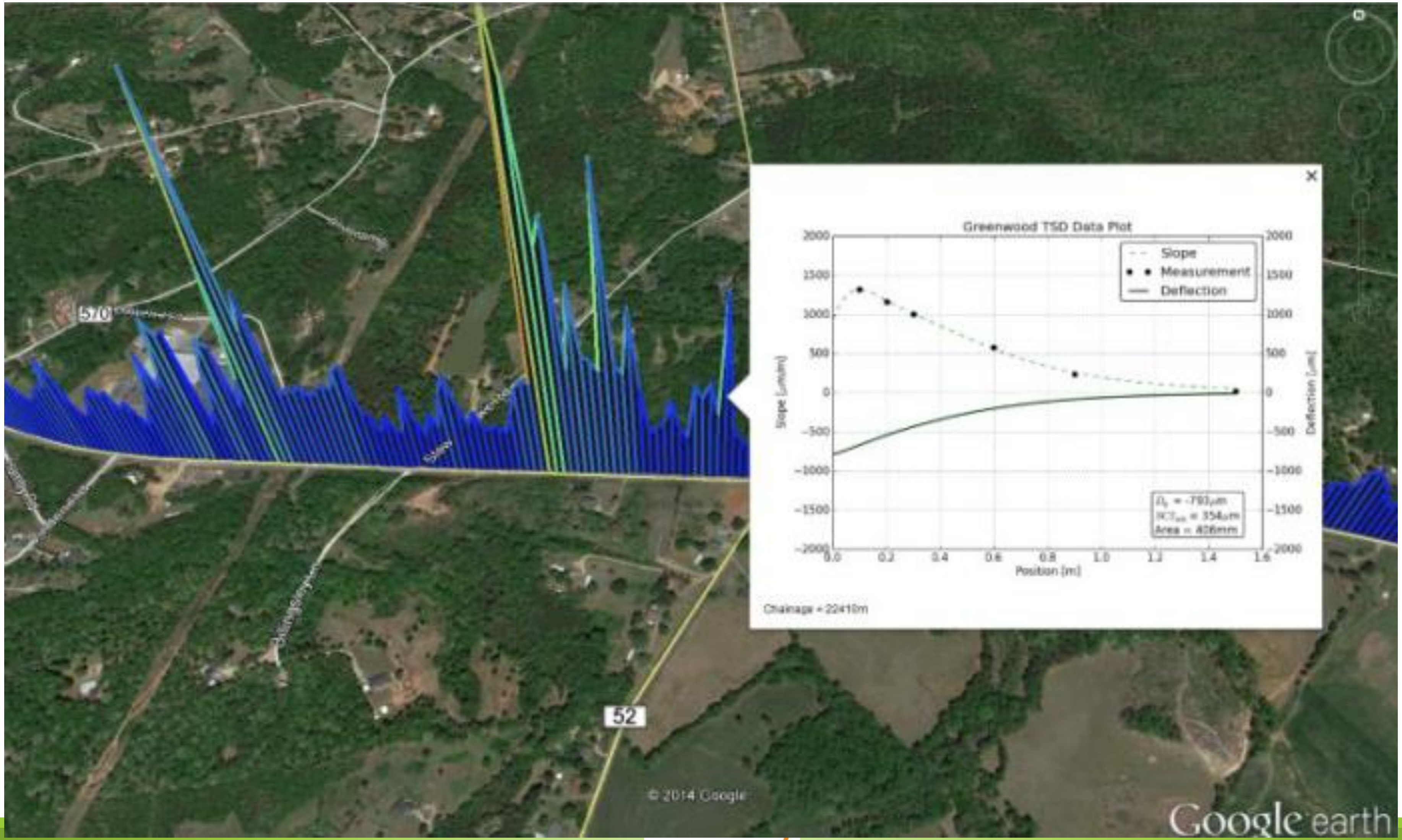
This web based software enables users to readily update or revise the FWP at any future date to adapt to either (i) a required level of service or (ii) a specified budget





Traffic Speed Deflectometer Technology

Google Earth Presentation

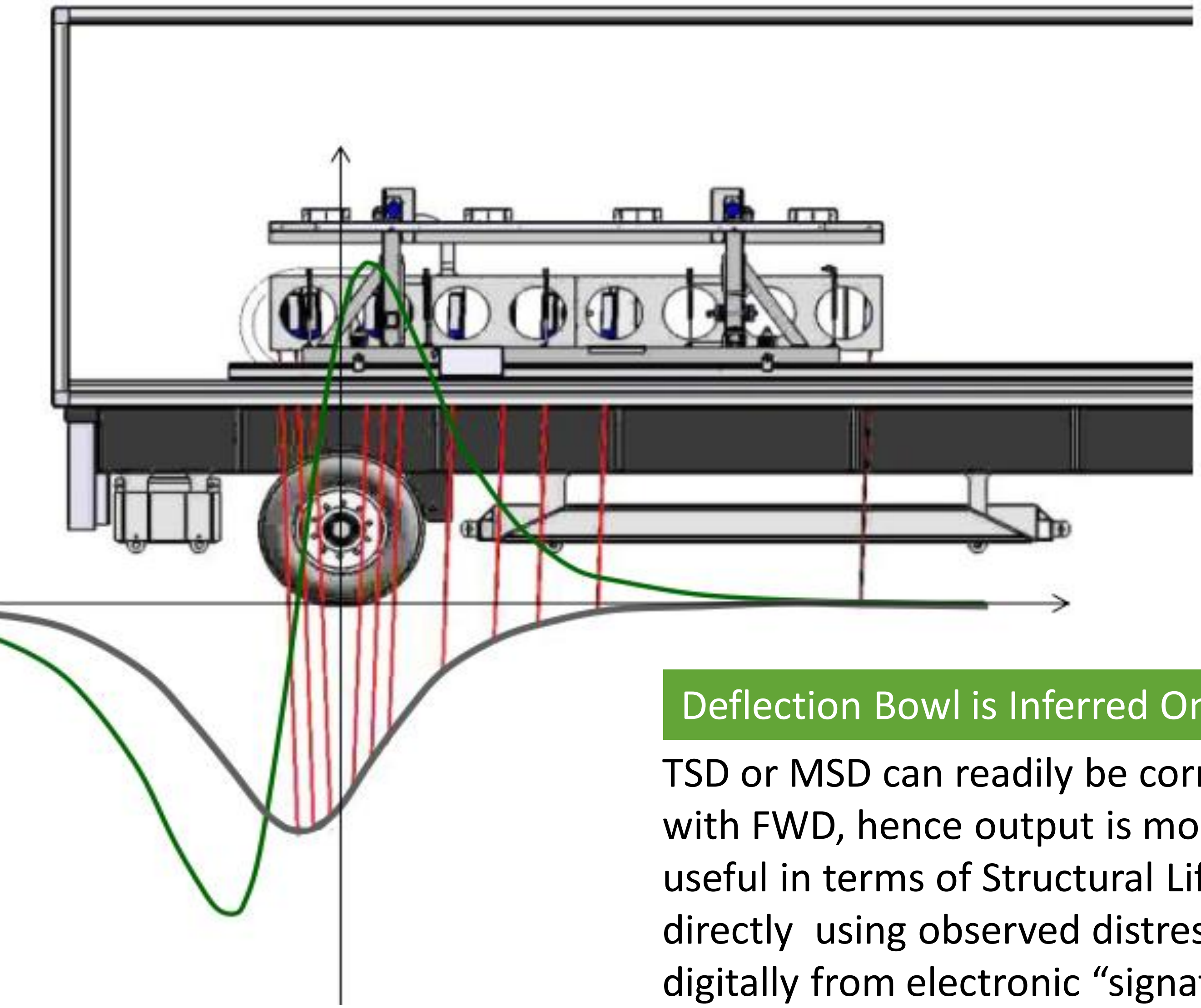


GeoSolve

Traffic Speed Deflectometer (TSD now also MSD)

GREENWOOD ENGINEERING

TSD deflections can be back-calculated



Multi-Speed Deflectometer (MSD) operates at same or wider speed range as TSD, both are screening tools but MSD uses wider frequencies as with a Pavement Analyser.

TSD does not measure deflection directly, hence correlation is made initially to Structural Life (in terms of millions of ESA) then yearly HCV traffic volume is used to generate Remaining Structural Life (years).

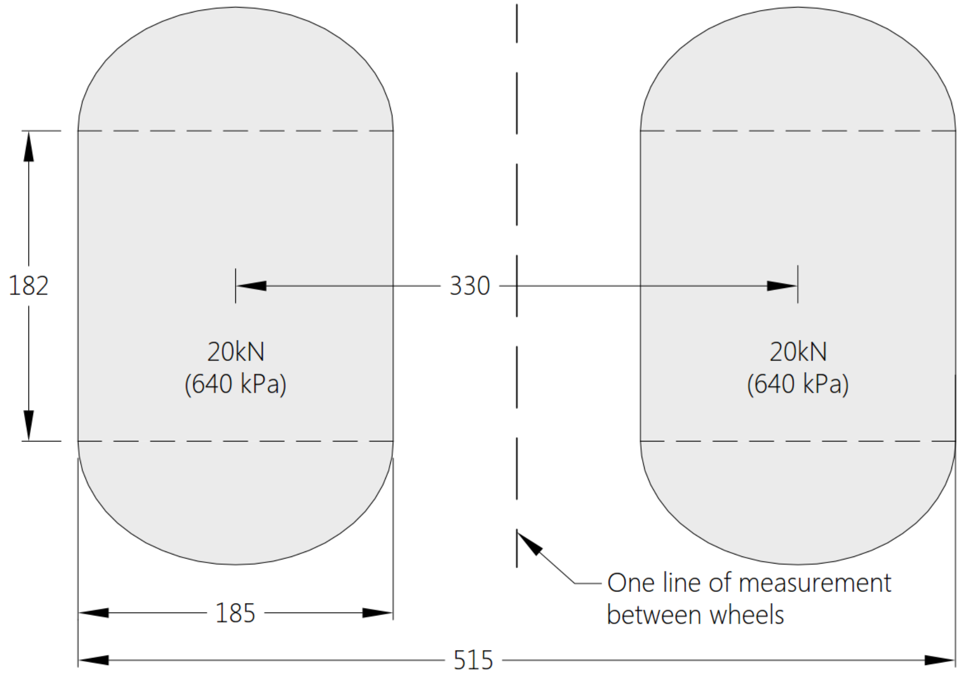
Deflection Bowl is Inferred Only

TSD or MSD can readily be correlated with FWD, hence output is most useful in terms of Structural Life, directly using observed distress or digitally from electronic “signature”

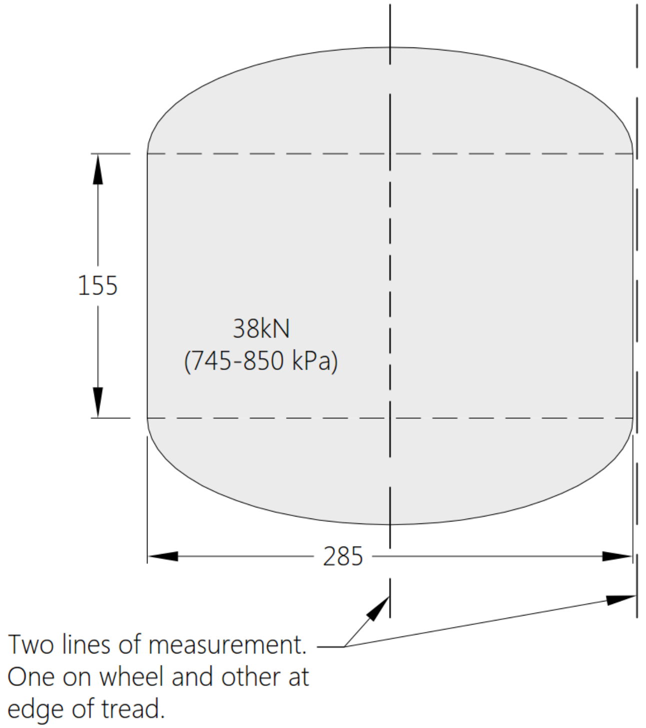
Contact Areas

TSD Twin Tyres — MSD Large Single (or Twin)

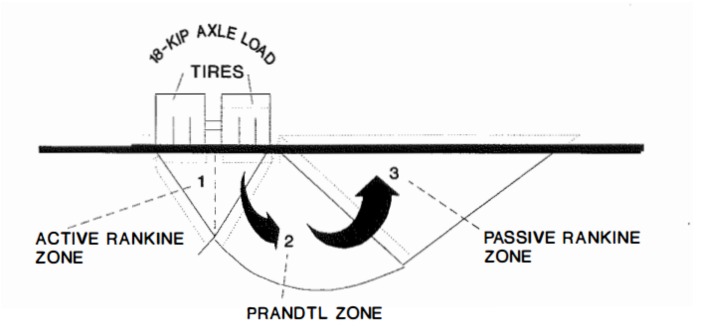
Twin Wheel Contact Area



Large Single Wheel Contact Area



Twin 515 mm
L Single 285 mm



Exponent Comparisons

$2^1 = 2$

$2^4 = 16$

$2^7 = 128$

$2^{10} = 1024$

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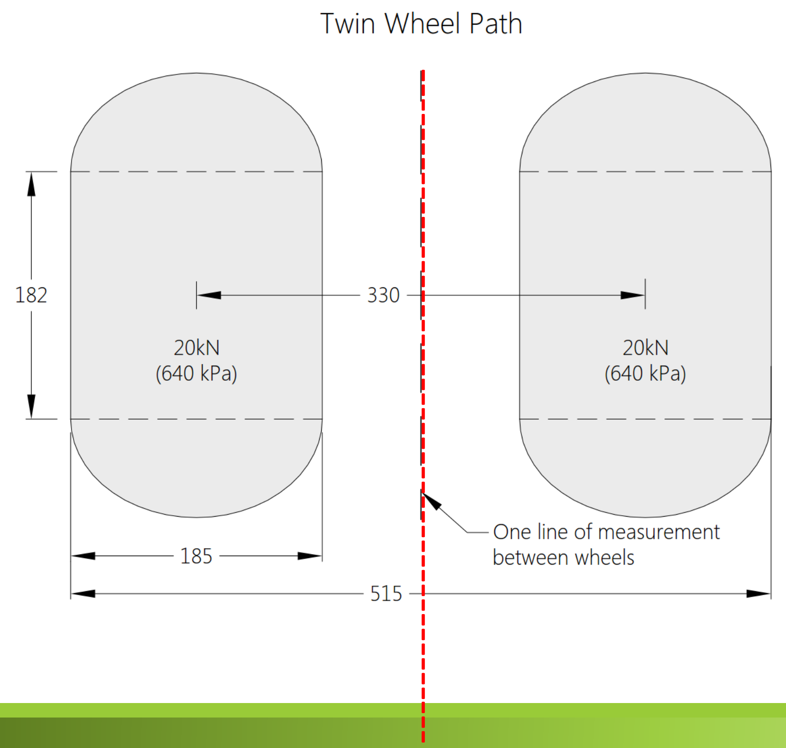
Deflection Bowl Definition

TSD Twin Tyres MSD Large Single (or Twin)

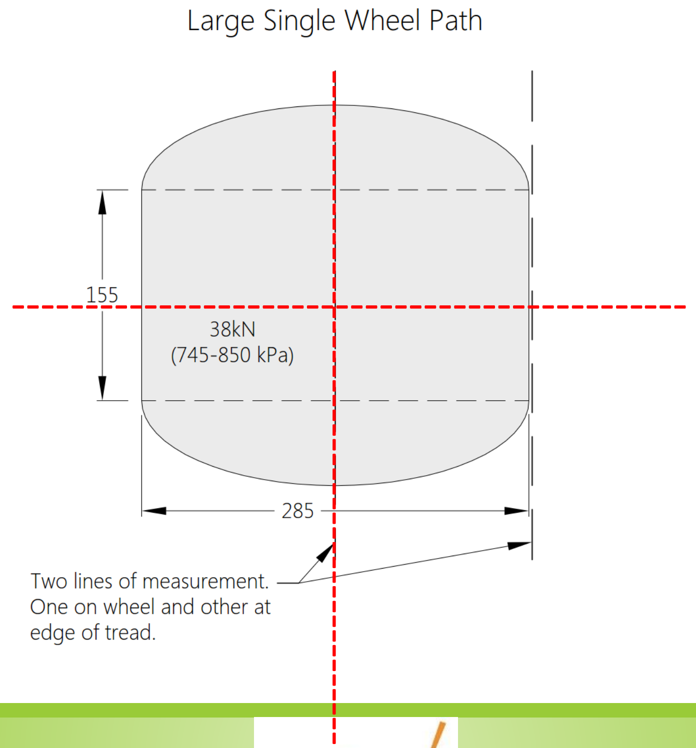
TSD Twin Wheel

2-D Longitudinal Profile Between Wheels



MSD Large Single Wheel or Twin Wheel

3-D Bowl Longitudinal and Transverse Through Wheels



MSD presents several advantages:

(i) Lower capital cost enabling testing of both wheeltracks and multiple units in each country.
(ii) Ideal for untested wheelpath of TSD
(iii) Better definition of top layer moduli for predicting top down cracking of AC and shallow shear life of weak basecourses
(iv) Shorter truck can be used (2 axle) for testing roundabouts, corners, or narrow urban roads with tight turning.
(v) Testing at slow speeds as well as high
(vi) Operates in wet or dry, rough or smooth, not only surfaced but also construction sites and unsurfaced roads
(vii) Year round availability in NZ ! (all seasons)

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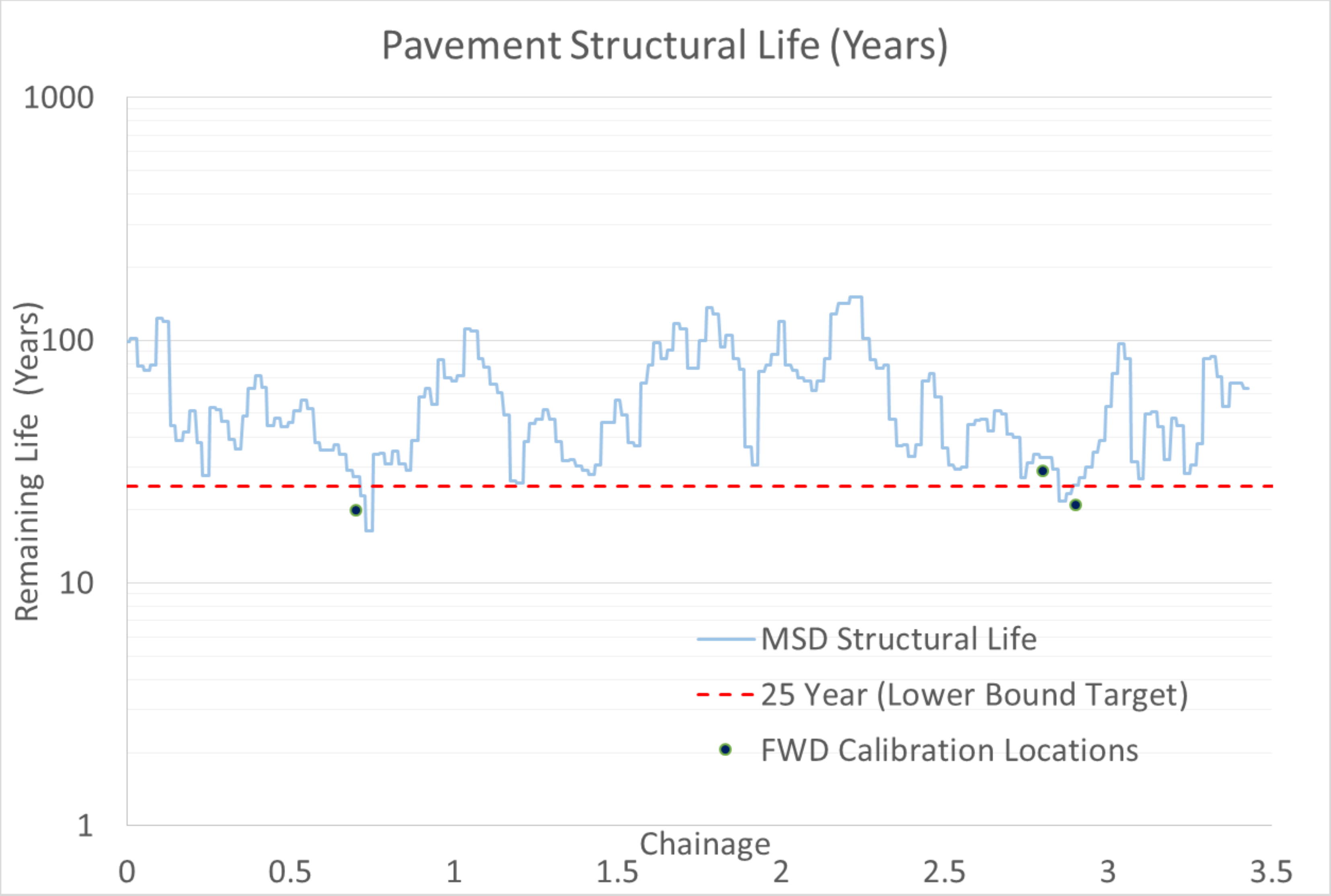
Example use of TSD- MSD - FWD

TSD or MSD data are typically generated at 10 or 20 metre intervals, enabling much more continuous profile of pavement structural life.

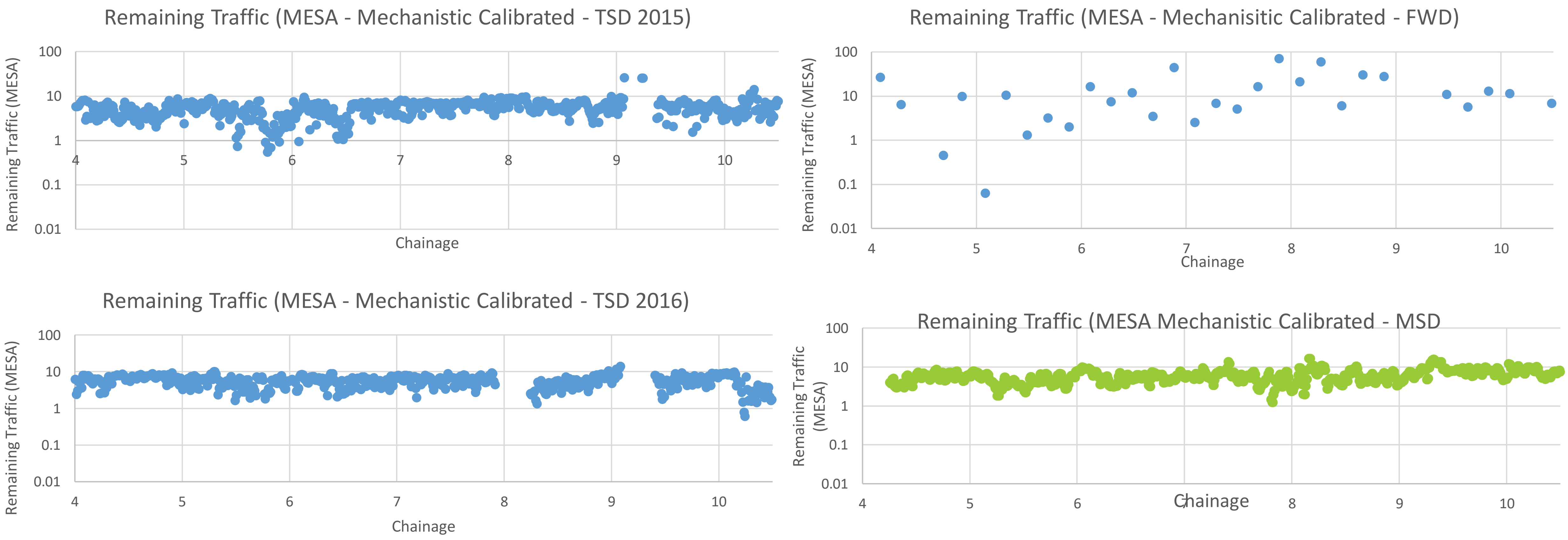
FWD data are not averaged so extremities are more evident. If only the critical (ie lower life) points are calibrated using FWD, a more robust life estimate results at minimal cost. Upper bound life is seldom of interest, as in practice the road performance is governed by the lower 10 percentile.

If the MSD run indicates that the pavement life is consistently good (usually set at above 25 years), further testing may not be warranted, as it will not impact on the Forward Works Programme.



GEOSOLVE

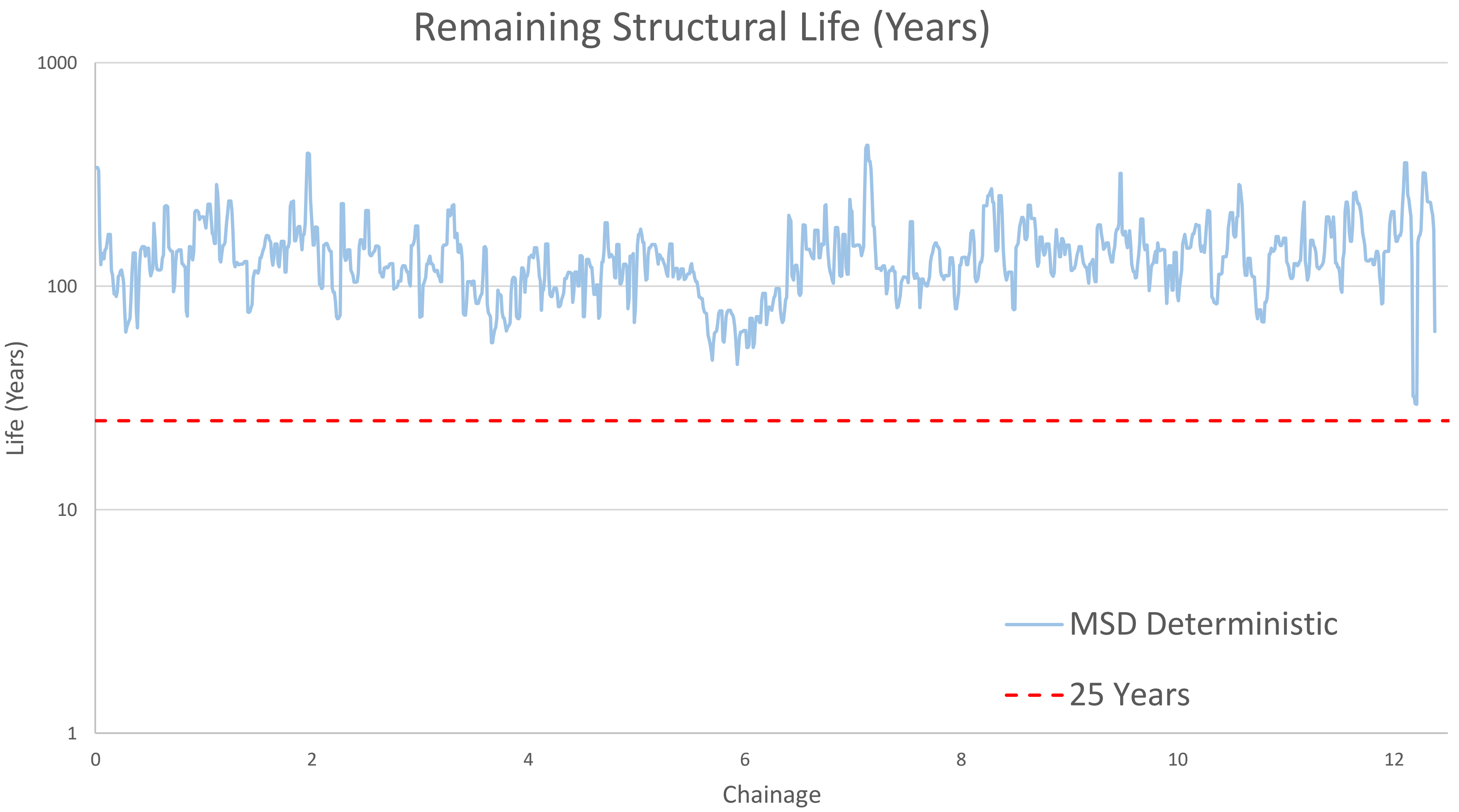
Comparison Between TSD, MSD and FWD



GeoSolve

MSD with Adequately Performing Roads

Many local roads may be conservatively designed and hence need only MSD along one lane to establish that none or only short intervals will affect a 25 year Forward Work Programme.



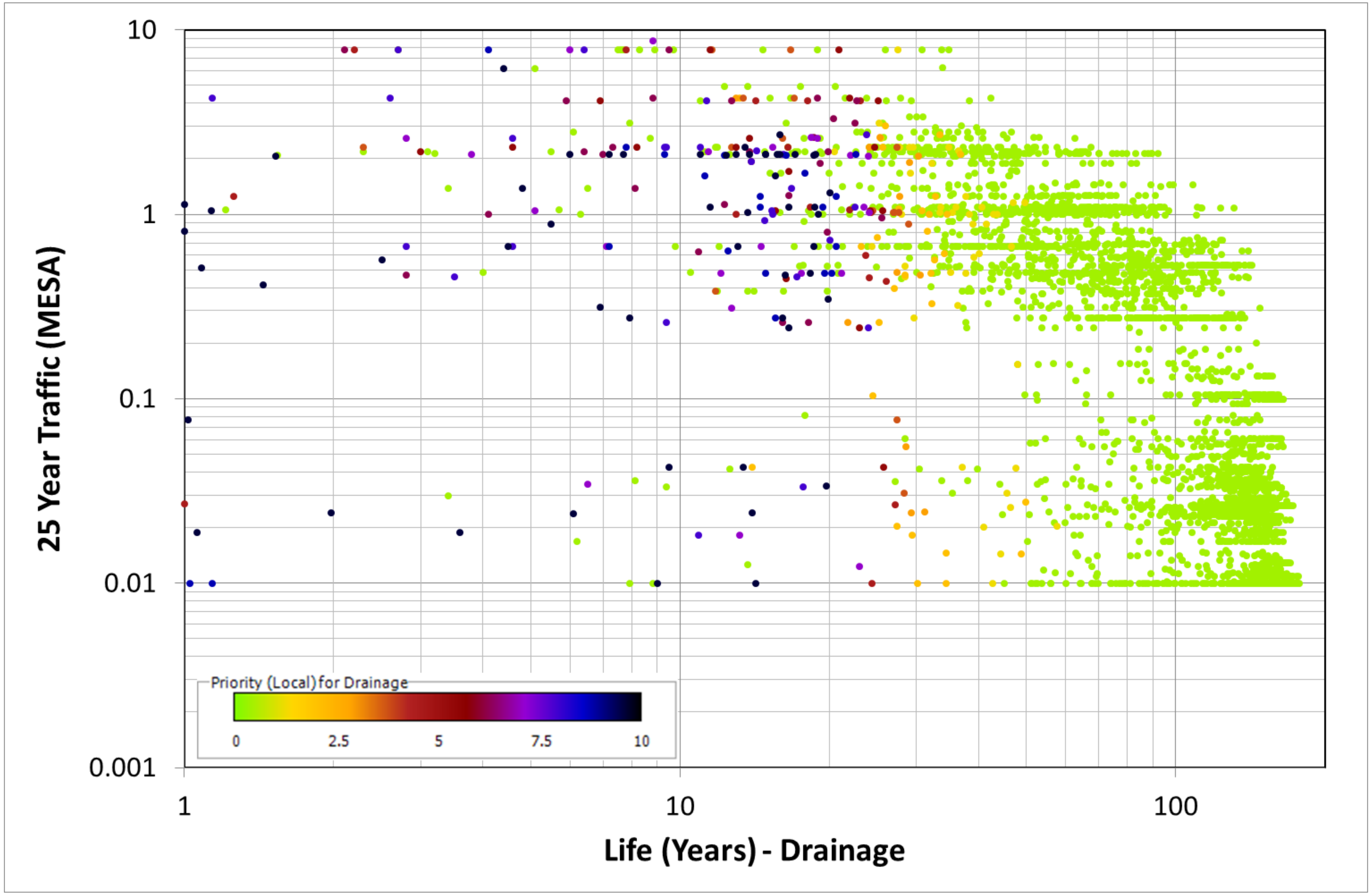
0.6 MESA Design Traffic

Subsurface Drainage – bonus deliverables

A functional spreadsheet is provided and road and chainage identifiers appear on mouseover.

The advantage is that the darker colours show on which road and where, subsurface drainage would have most benefit/cost. (Least pavement life and most likely to respond to subsurface drainage)

Equally importantly, the green points show where subsurface drainage is unlikely to be of any benefit, an aspect that is difficult to judge from surface observation.



Beam Limitations: Static versus Dynamic Test

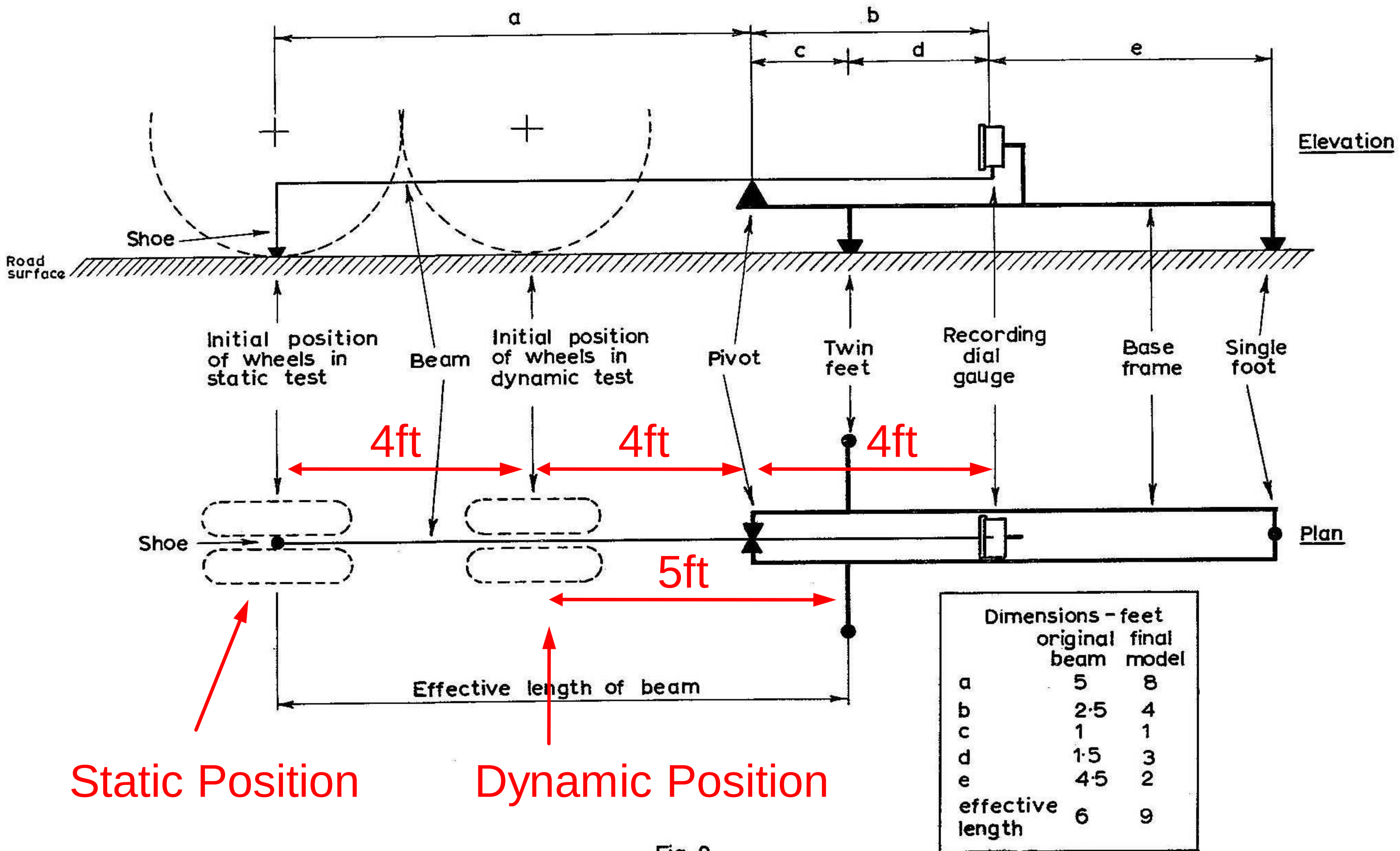
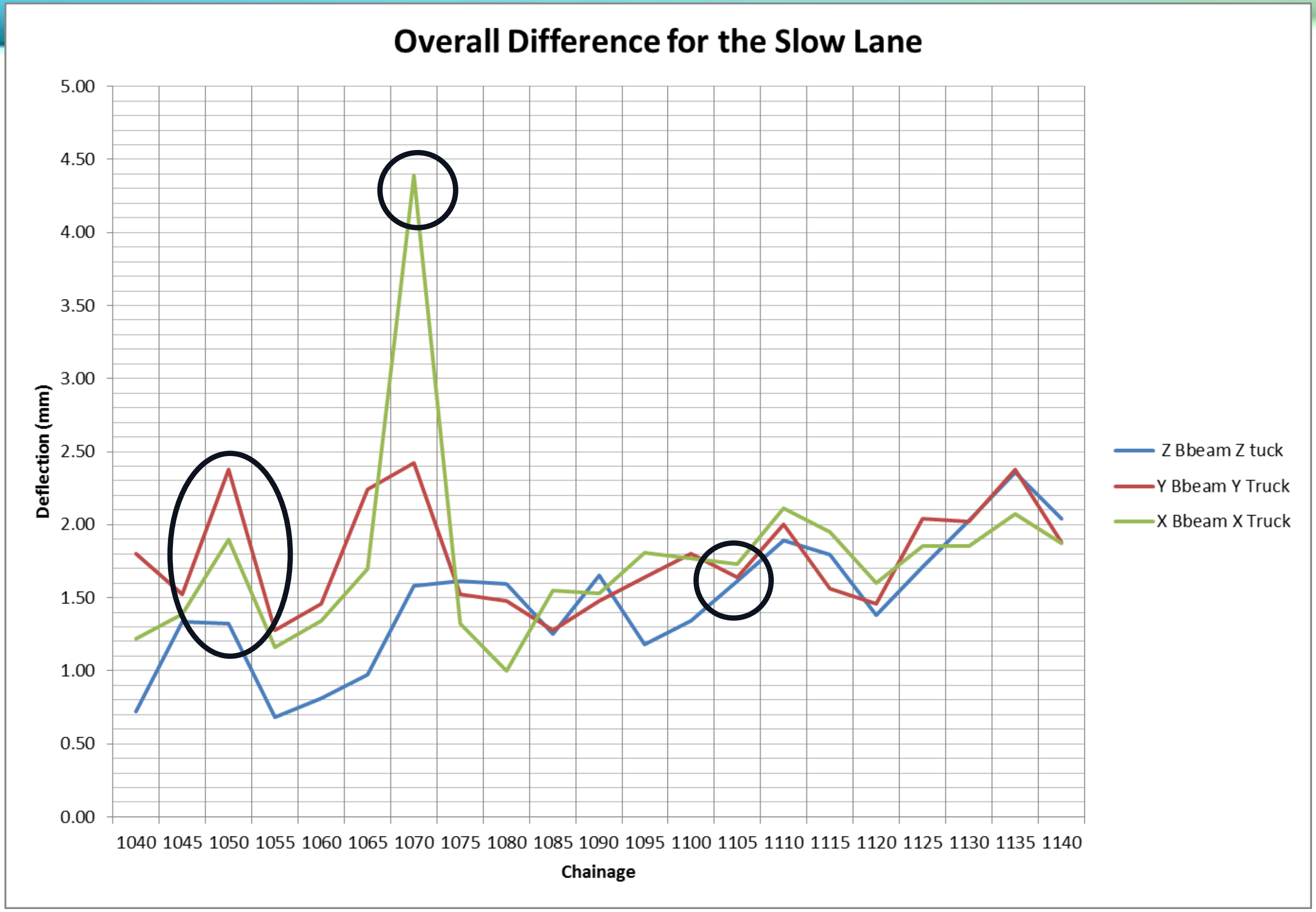


Fig. 2.

DIAGRAMMATIC REPRESENTATION OF THE DEFLECTION BEAM

Beam Limitations: Overall Difference



- Range of Variability between 3% and 30%
- Up to 200% difference in occasional spikes

(Courtesy John Hallett)