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Northern Periphery Programme
2007–2013

Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

Impact Analysis Pajala – Svappavaara Road Iron Ore Transportation Options

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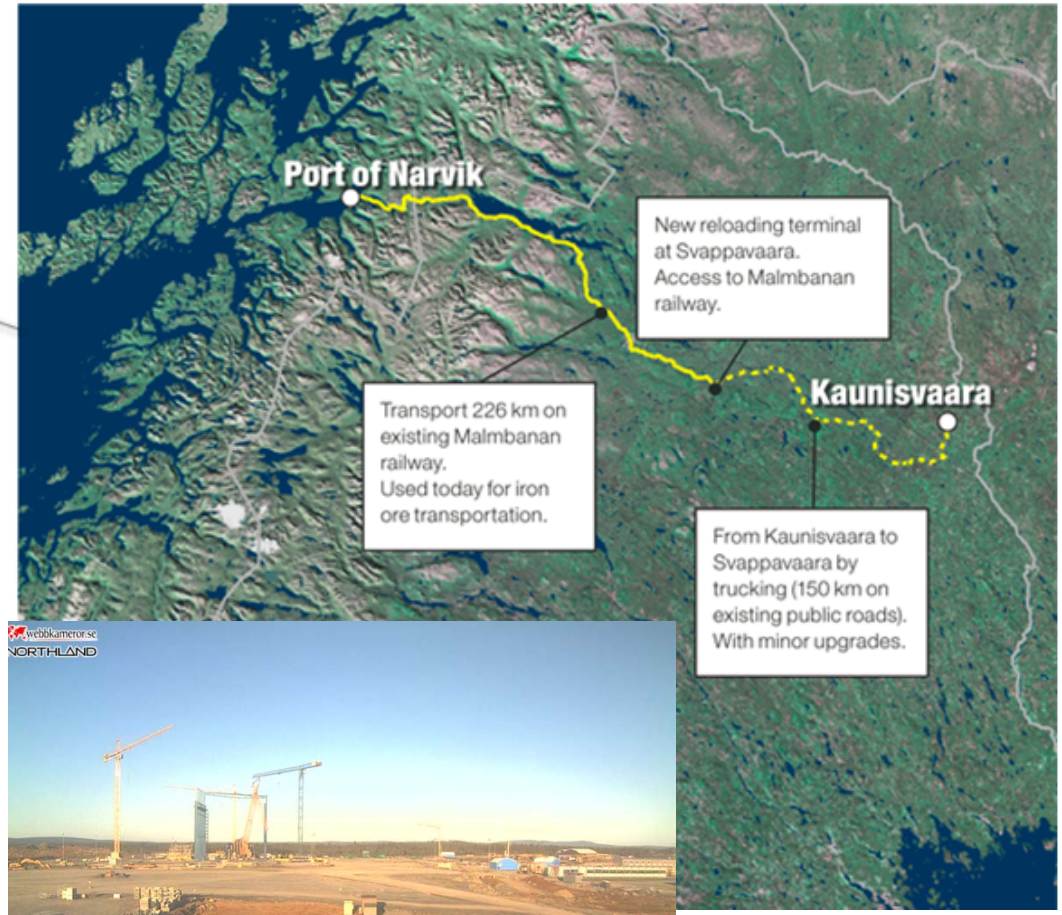
ROADSCANNERS

NORTHLAND

Annual Report 2010

Move



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Impact Analysis and Cost Benefit Analysis of Pajala – Svappavaara Road Iron Ore Transportation Options

GOAL:

a) detailed structural diagnosis and risk analysis for the current road in order to know the immediate strengthening need before the haulage starts

b) perform a cost-benefit analysis for different heavy haulage option in order to propose an optimal socio-economic transportation solution for all the interest parties

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Surveys done (1):

- Profilometer data analysis
- Subgrade evaluation based on geological maps
- Local maintenance expert interview
- GPR surveys (400 MHz + 1,0/2,0 GHz): structures + frost, 3d modelling
- Digital video data collection (3), thermal camera survey
- Pavement distress analysis
- Drainage analysis and design
- Accelometer survey in winter
- GeoVap Quantum 3D Laser Scanner survey winter/summer: frost heave, terrain model

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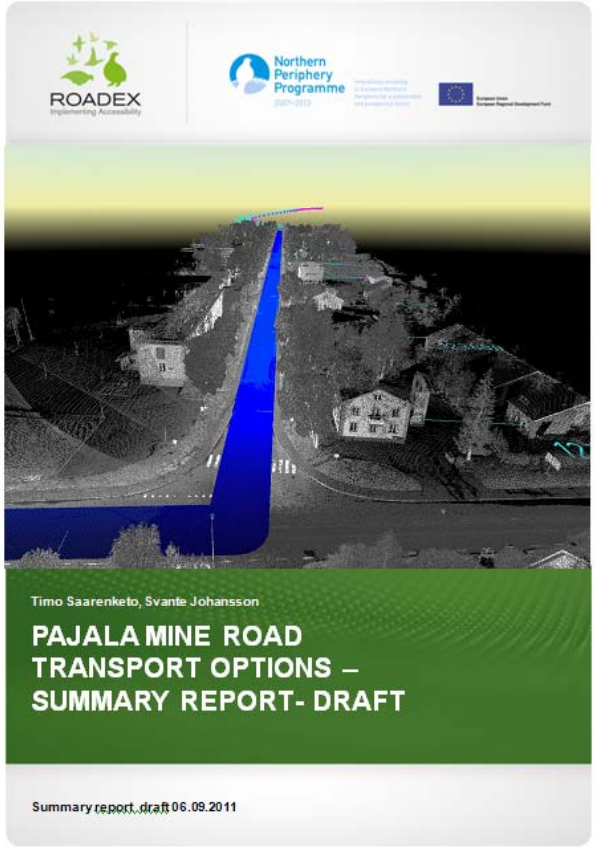
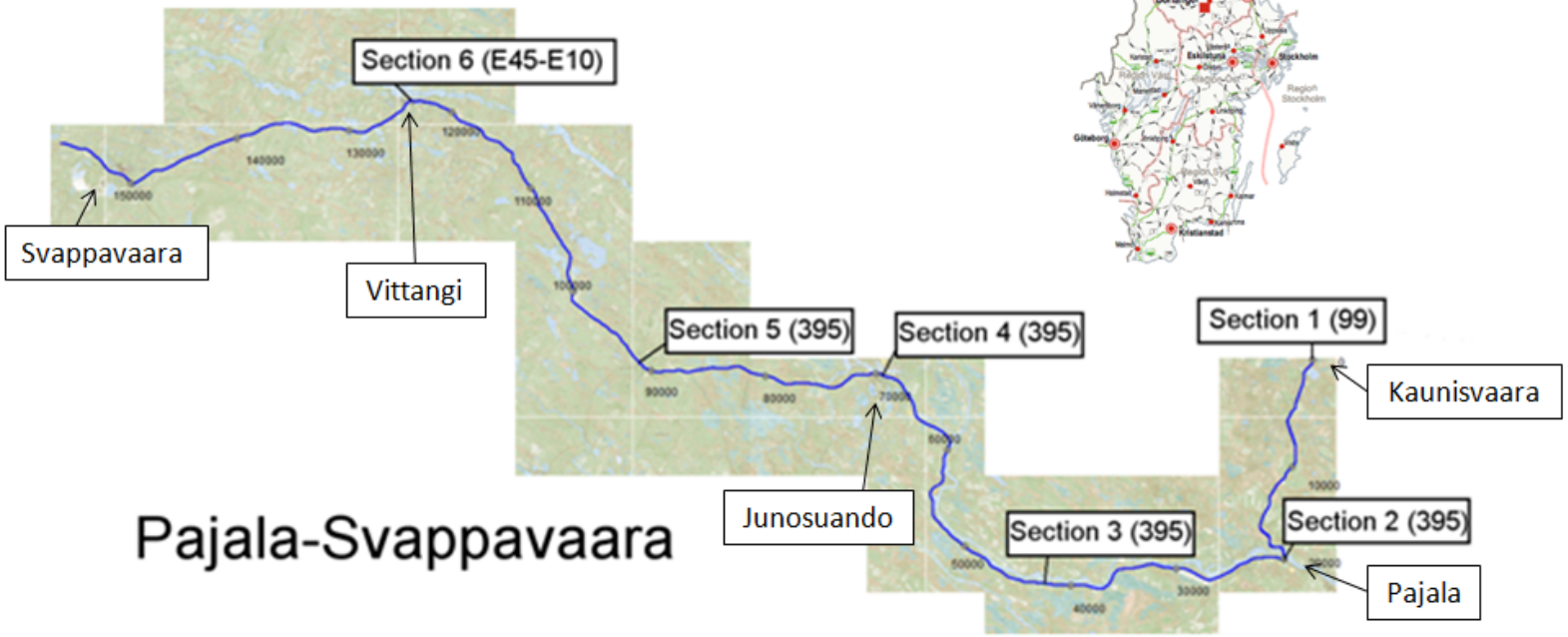
Surveys done (2):

- Drilling (15 drill cores) and sampling (5 TS test samples)
- Laboratory analysis : grading, TS-test, triaxial tests
- HWD data collection and analysis with different load levels
- PMS object calculations for remaining life time
- PMS Object calculations for rehabilitation needed for new 60 tn loading option
- BISAR calculations for different heavy haulage options
- Cost estimates for standard rehabilitations and heavier option
- Final report



Section	Length of section [m]	Point in project [m]	Knot point	Coordinates of knot point		
				X	Y	Z
1	20080	20080	road 395 crossing	855498,49	7482775,71	162,35
2	22168,8	42248,8	road 394 crossing	835069,30	7480779,32	171,64
3	27139,3	69388,1	Road 886 crossing	821279,82	7498604,99	212,05
4	21959,3	91347,4	Naurispalo, Masugnsby	800496,14	7499734,99	322,22
5	32383,3	123730,7	road E45 crossing, Vittangi	781036,88	7522127,18	249,36
6	33599,3	157330	Bergsmanniväg, Svappavaara	751126,24	7518368,19	340,80



Pajala-Svappavaara

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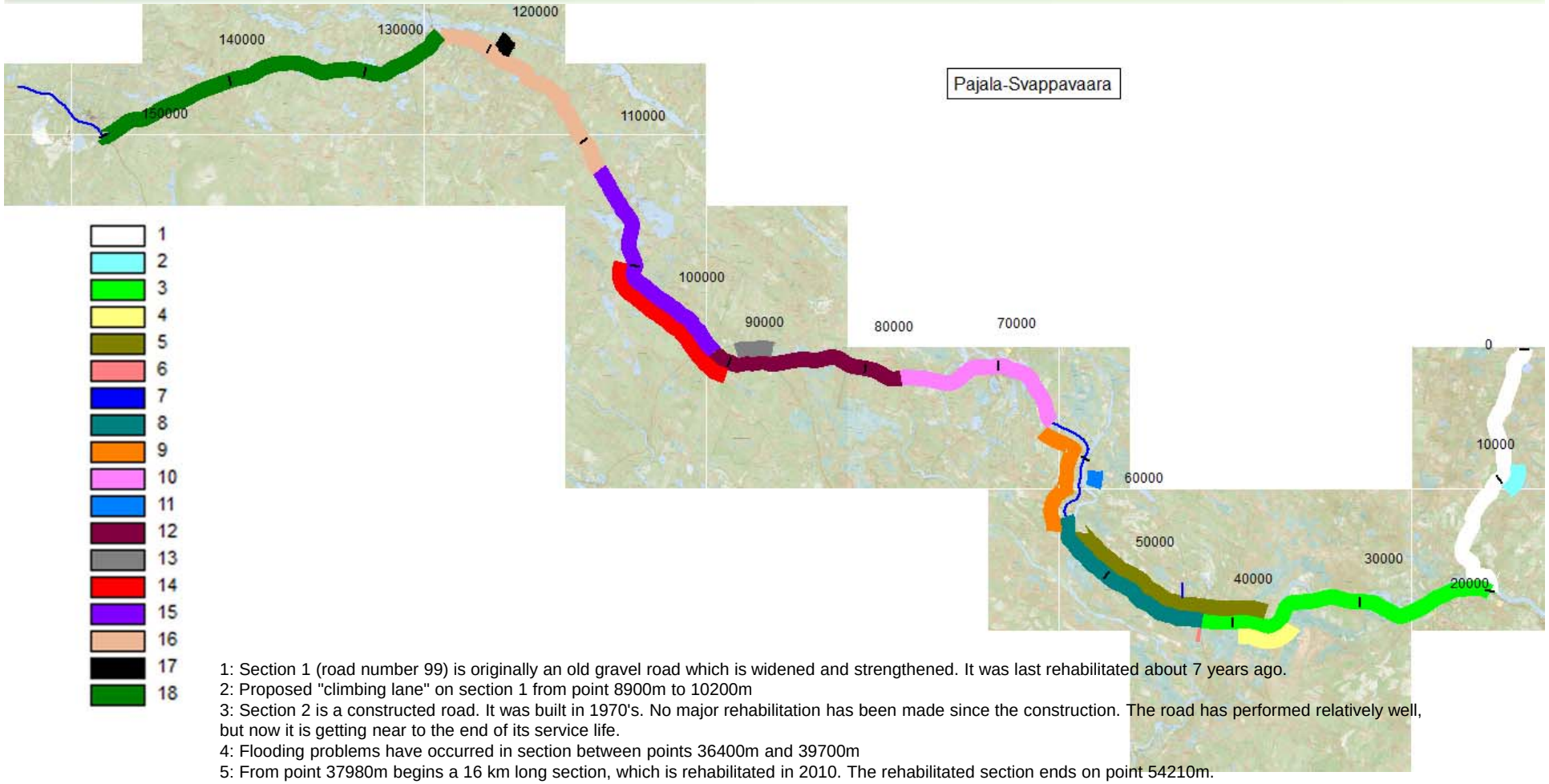

1: Section 1 (road number 99) is originally an old gravel road which is widened and strengthened. It was last rehabilitated about 7 years ago.
2: Proposed "climbing lane" on section 1 from point 8900m to 10200m
3: Section 2 is a constructed road. It was built in 1970's. No major rehabilitation has been made since the construction. The road has performed relatively well, but now it is getting near to the end of its service life.
4: Flooding problems have occurred in section between points 36400m and 39700m
5: From point 37980m begins a 16 km long section, which is rehabilitated in 2010. The rehabilitated section ends on point 54210m.
6: Flooding problems on point 42250m
7: Flooding problems on point 43650m
8: From Anttis to Lovikka the road is not constructed, it is originally an old gravel road.
9: From point 54210m to the end of the section 3 the road is constructed in 1967. It is in quite weak condition until the point 64050m.
10: From point 64050 to point 77390 the road is rehabilitated in 1995.
11: Flooding problems between points 58250m and 59050m
12: From point 77390 to the end of the section 4 the road is rehabilitated in 2002.
13: Proposed "climbing lane" on section 4 from point 86990m to 89090m
14: From point 89890m on, the road is originally an old gravel road until the end of section 5.
15: Section 5 is rehabilitated ten years ago until point 107650m.
16: From point 107650m to the end of the section 5 the road is rehabilitated in 1997. This section is weaker than the previous, ten years ago rehabilitated section.
17: Proposed location where straightening of the road and improvement of road geometry would be beneficial, section 5 from point 118350m to 119750m.
18: The road E45 part of the section 6 is originally built in mid 1970's. It is rehabilitated in two parts (half/half) approximately ten years ago.

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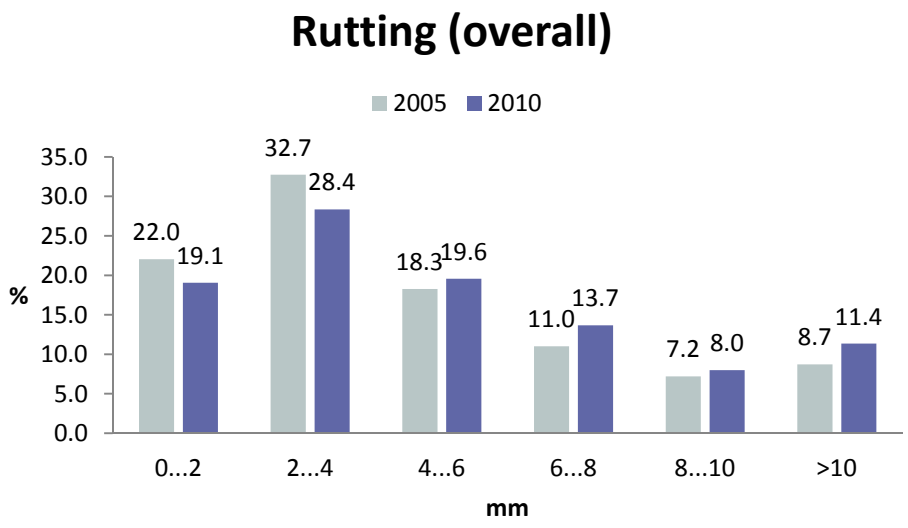
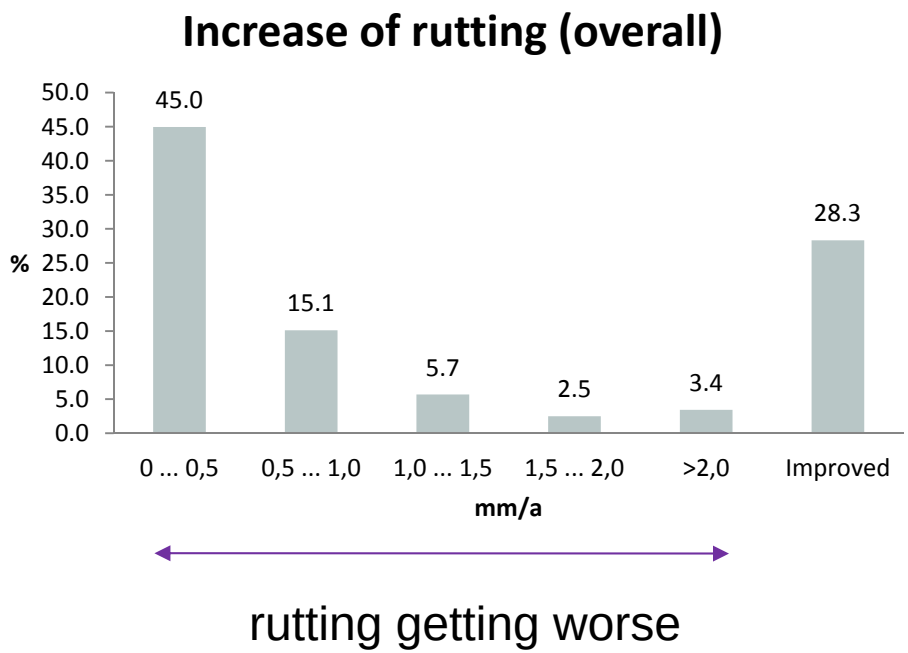
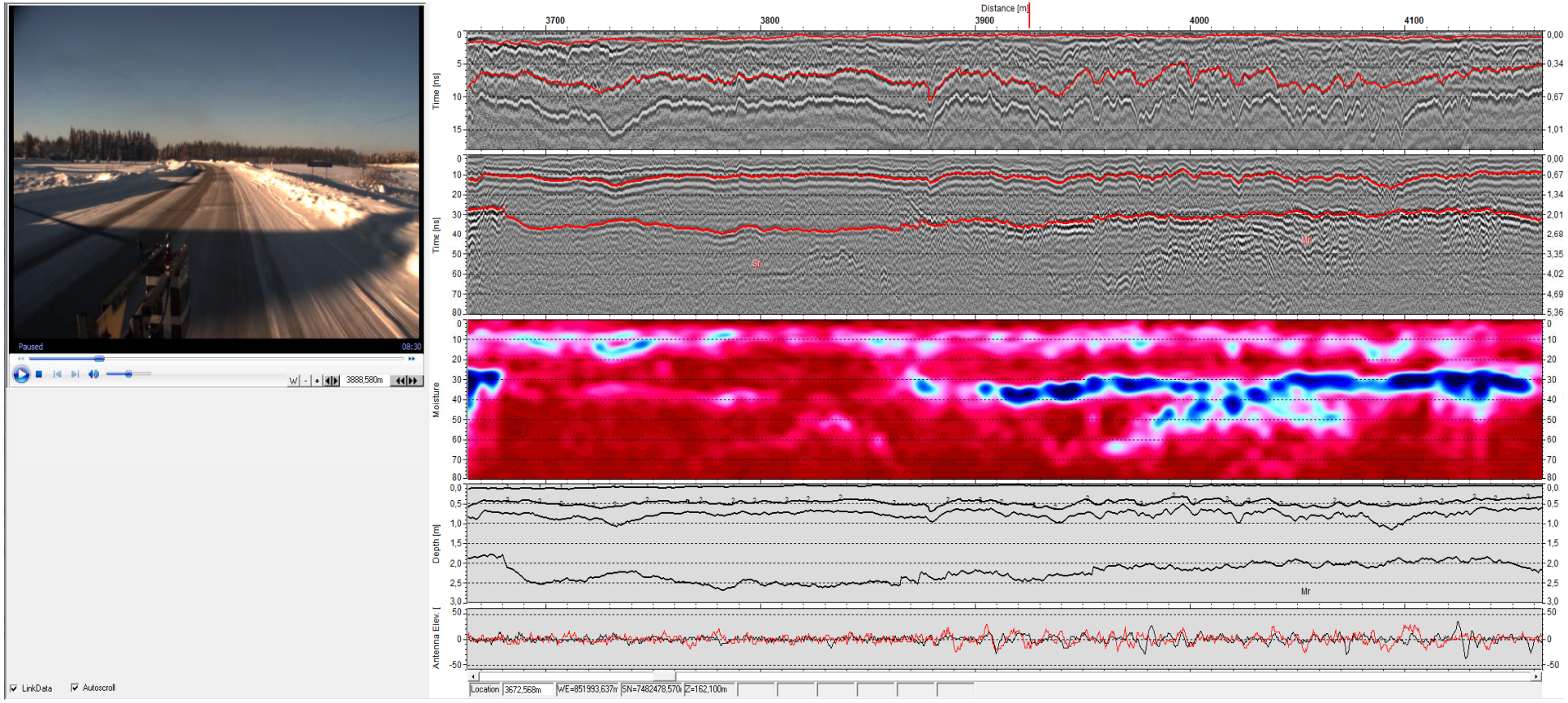
Comparison of the rut depth values of whole Pajala – Svappavaara road in 2005 and 2010





rutting getting worse

GPR frost analysis in winter



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Vibrations – Section 2: 1/1025

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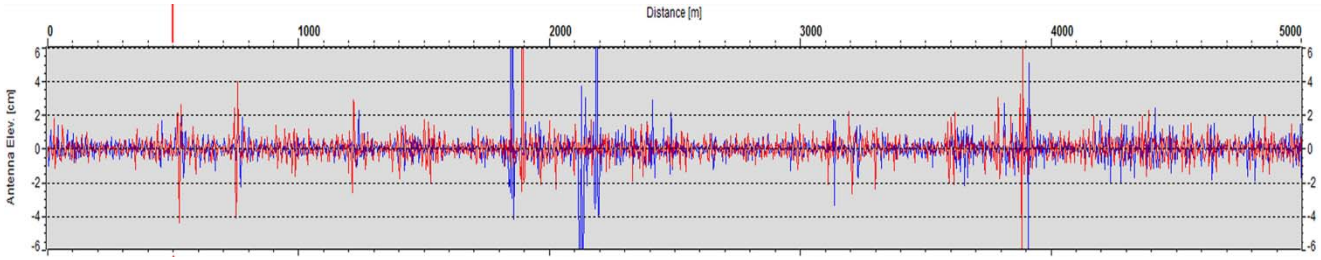
Villages with major roughness problems

- Antinrova village (42550-44200m),
- Lovikka village (54400-55500m, 55950-56600m, 57100-58000m),
- Huhtanen village (59100-60450m),
- Junosuando village (67900-68100m, 68600-71600m),
- Masugnsbyn village (89300-92250m),
- Vittangi village (120150-124450m).



Pavement Distress Mapping

Section 2 (part 1)

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QUANTUM 3D LASER SCANNER MAPPING

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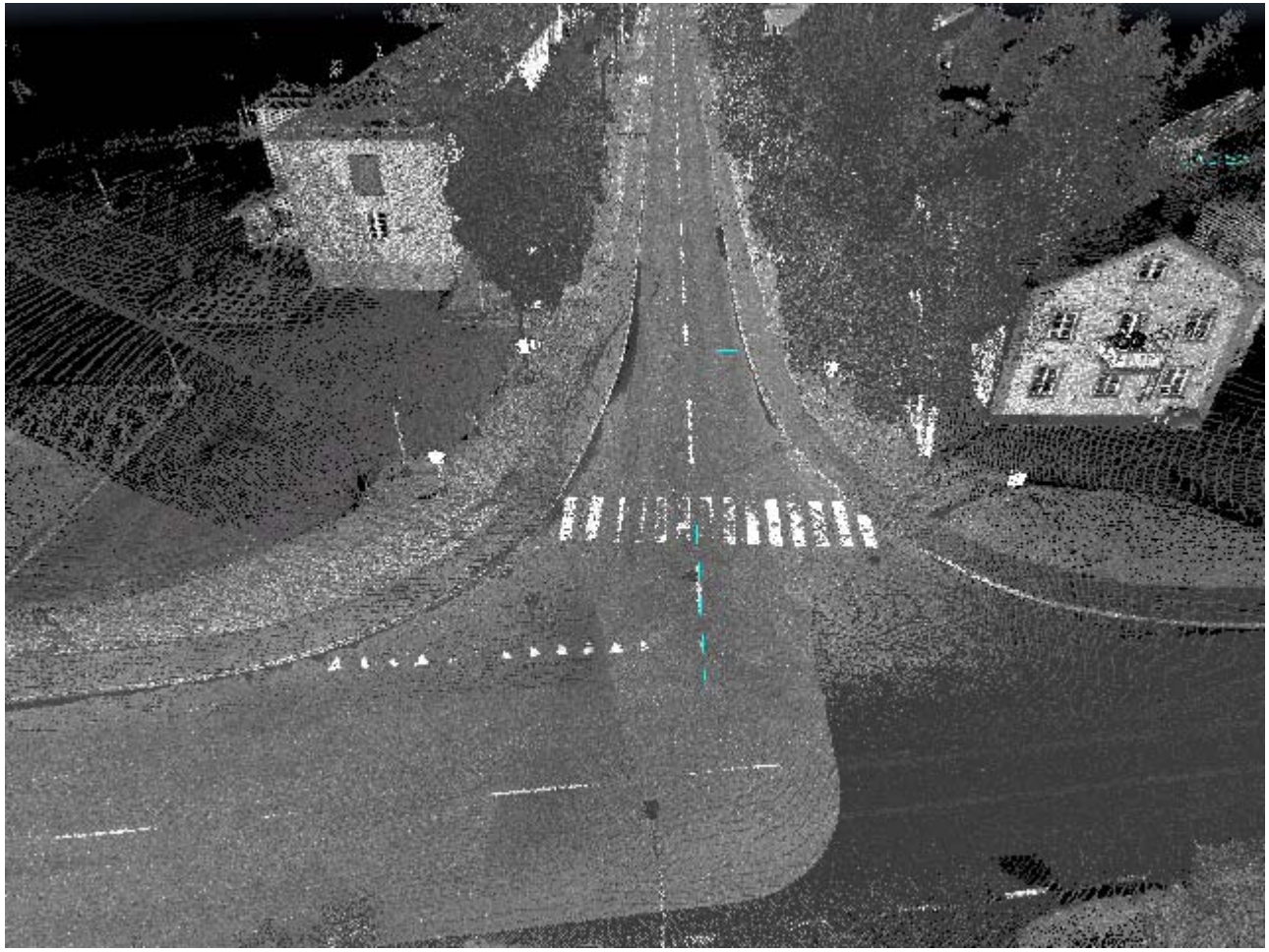
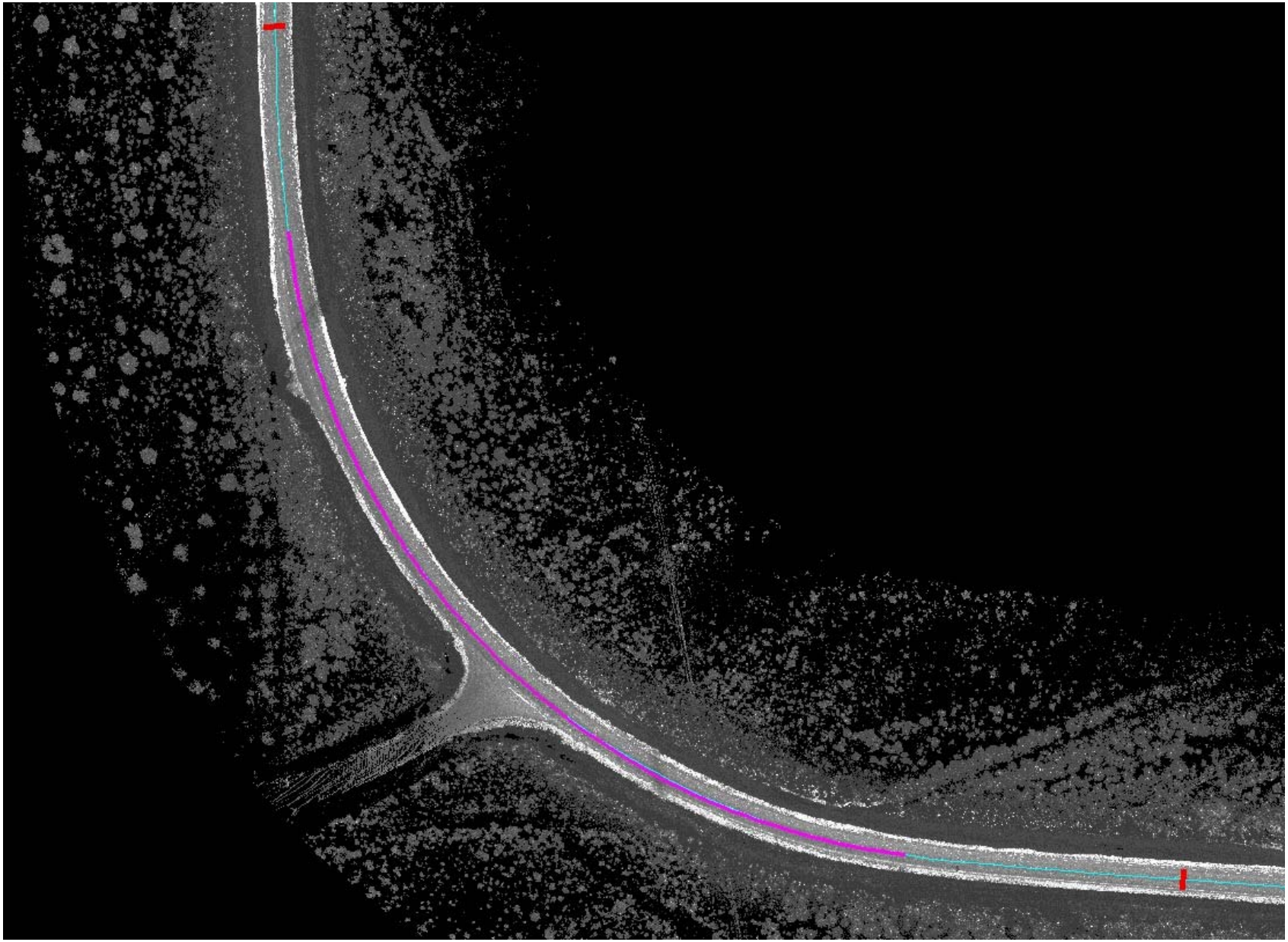
Vittangi – Point Could Model



Section 1, from 17760m to 18160m. Radius 198m.



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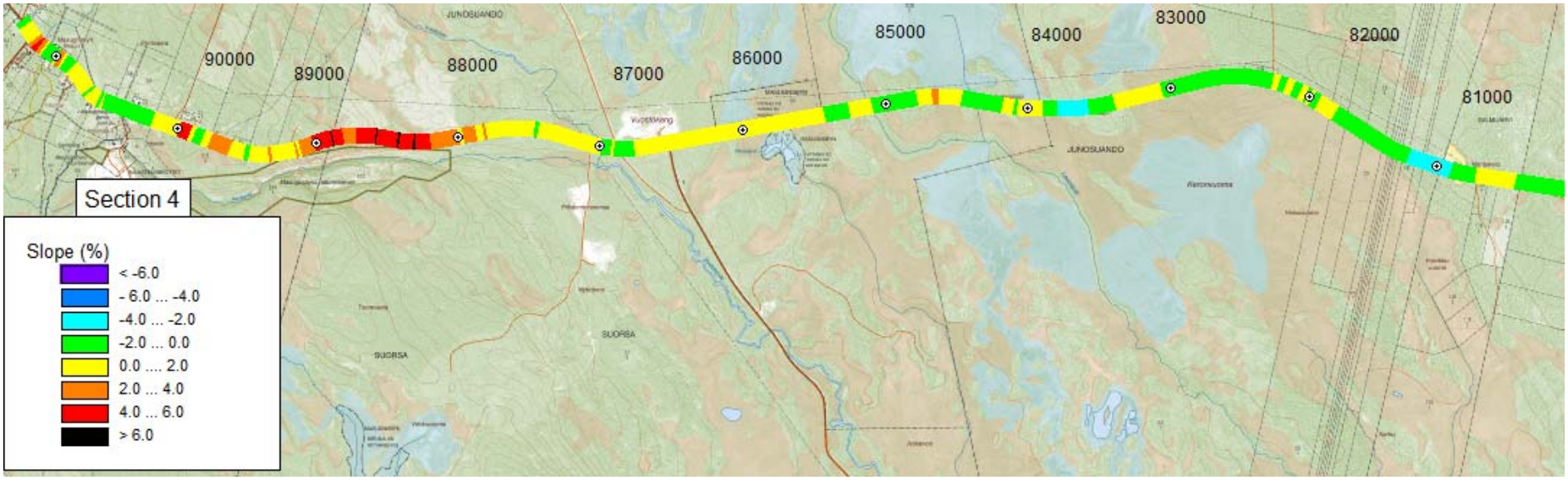
ANALYSIS OF STEEP HILS

Section 4 (part 2)



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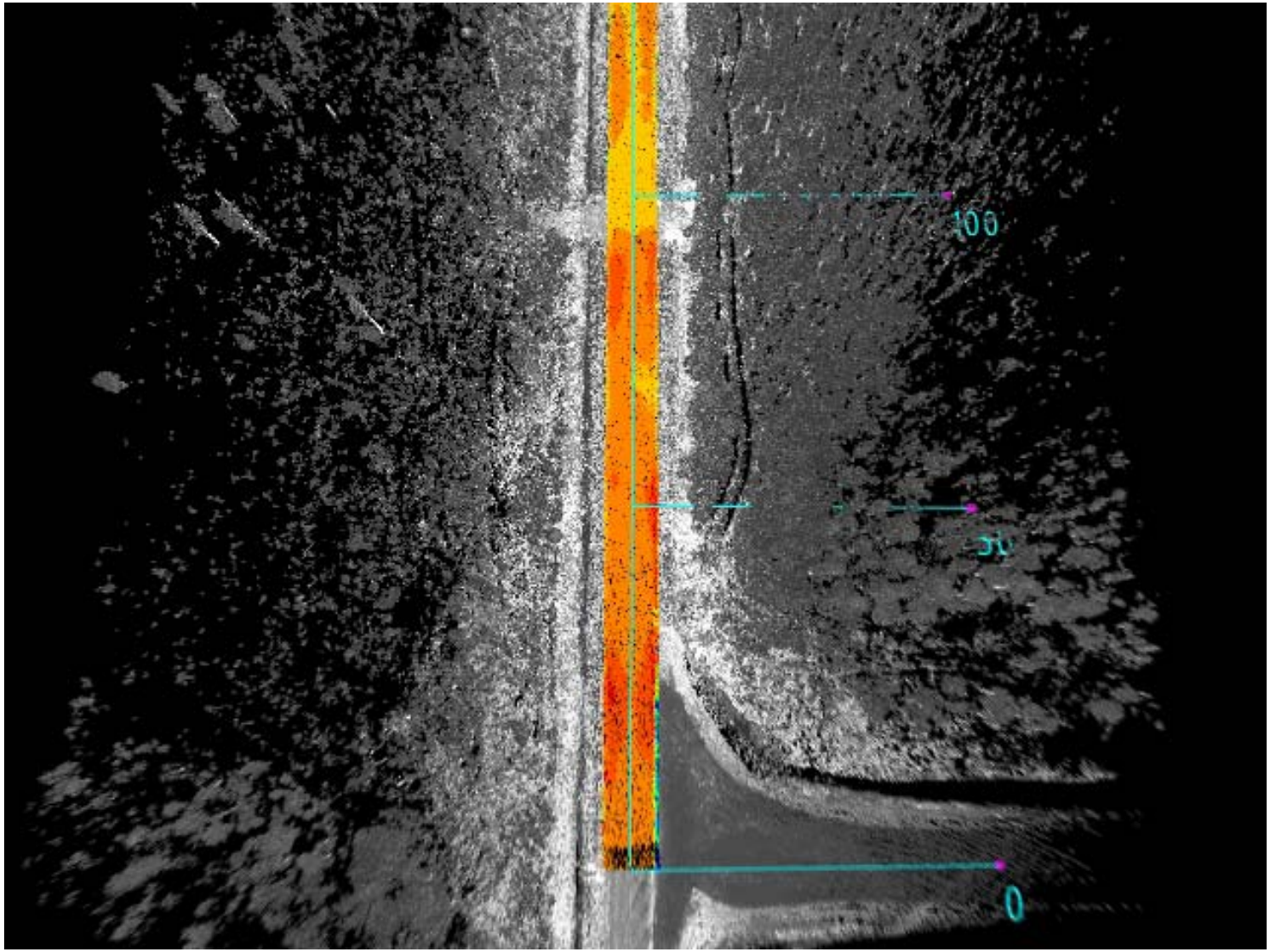
Frost Heave Calculations



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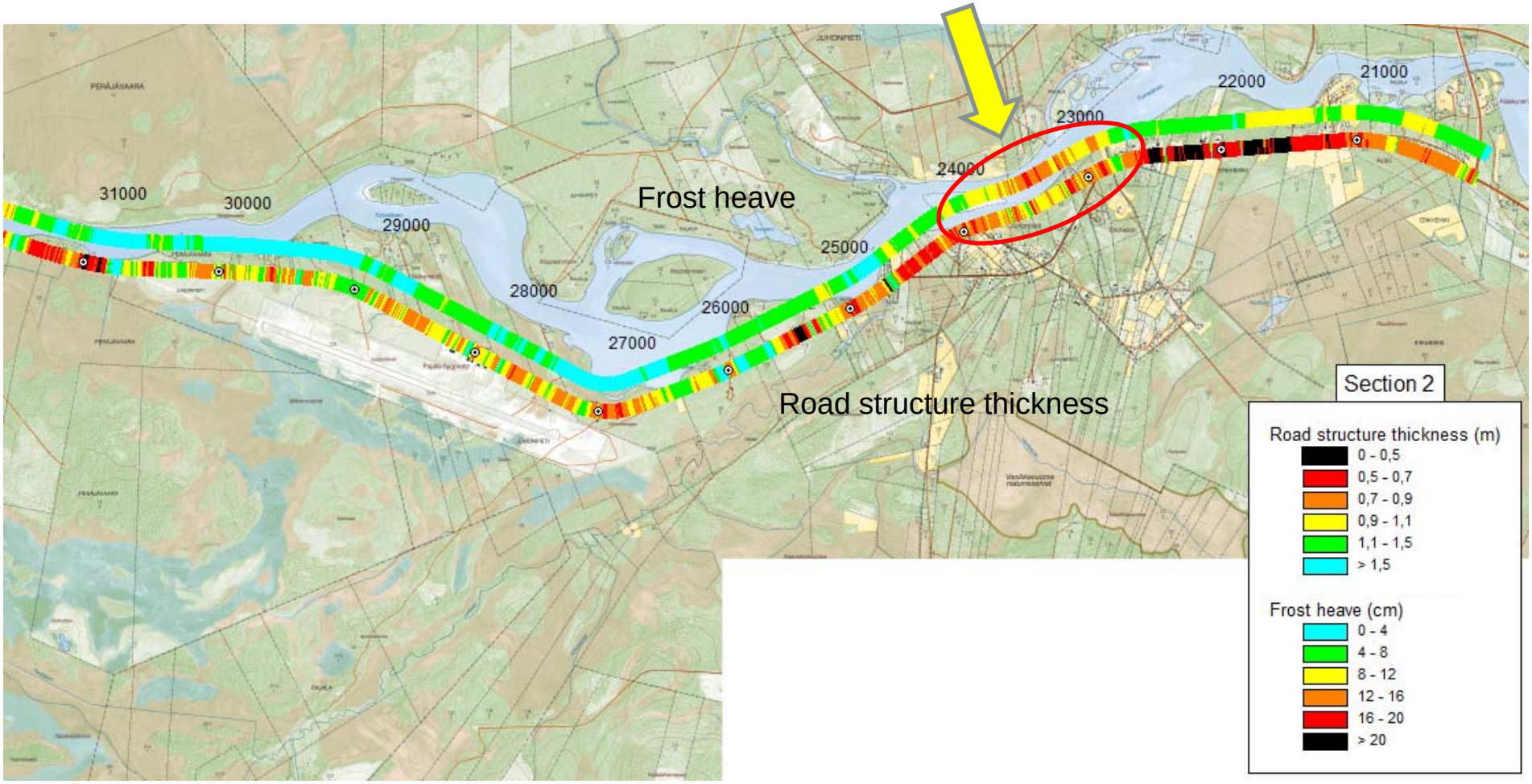
Section 2 (part 1)



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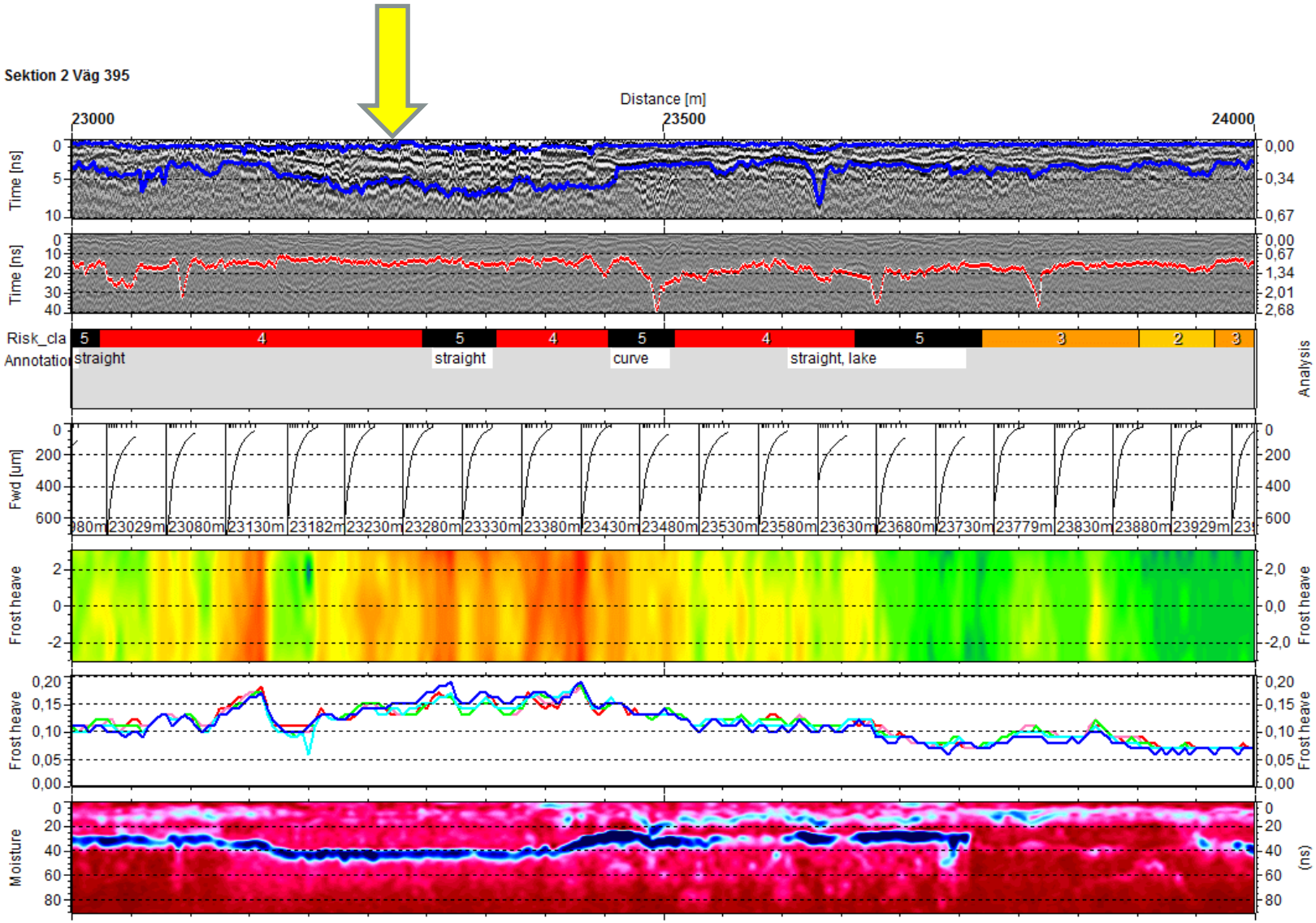

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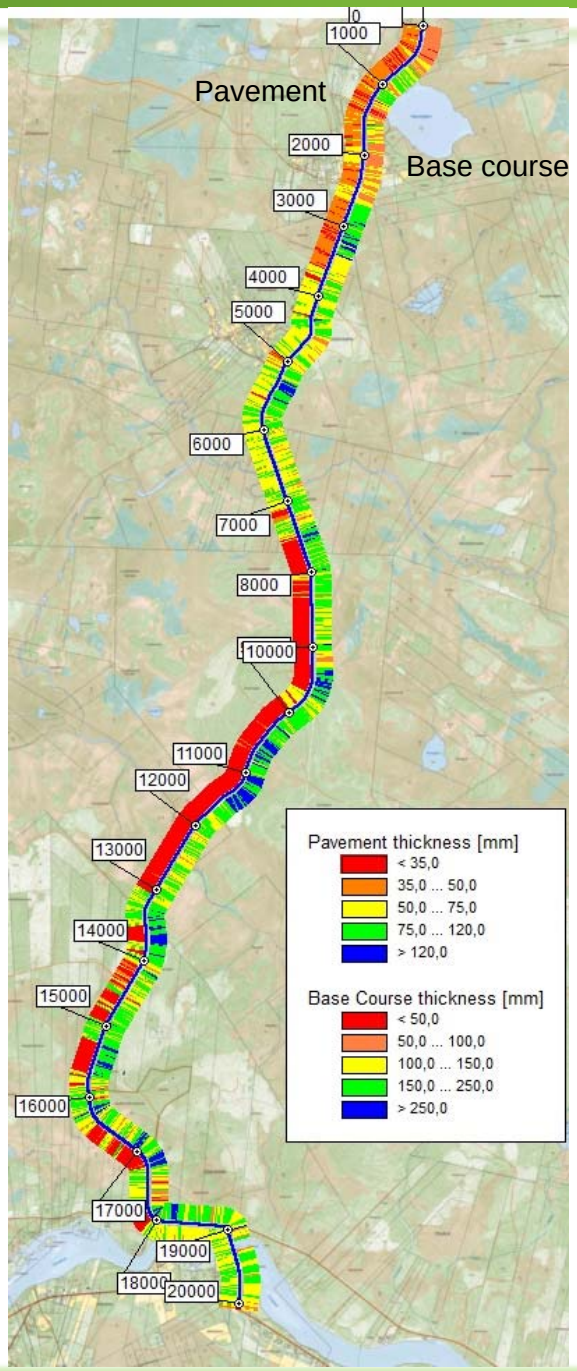
Section 2; 23410m (frost heave ~ 17cm)

GPR ANALYSIS

Section 1

Pavement thickness
Base course thickness



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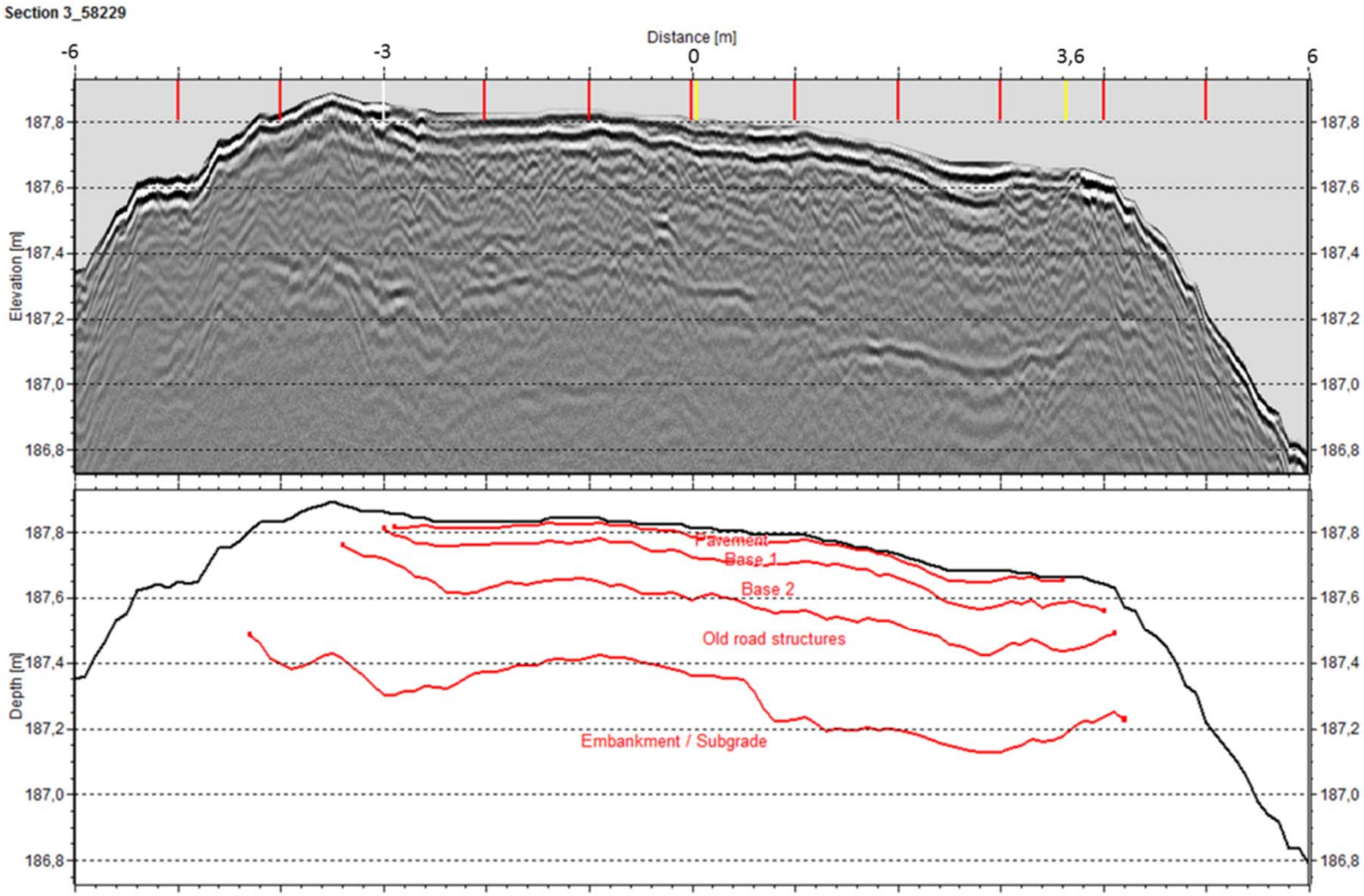
GPR + LASER SCANNER ANALYSIS – CROSS SECTIONS



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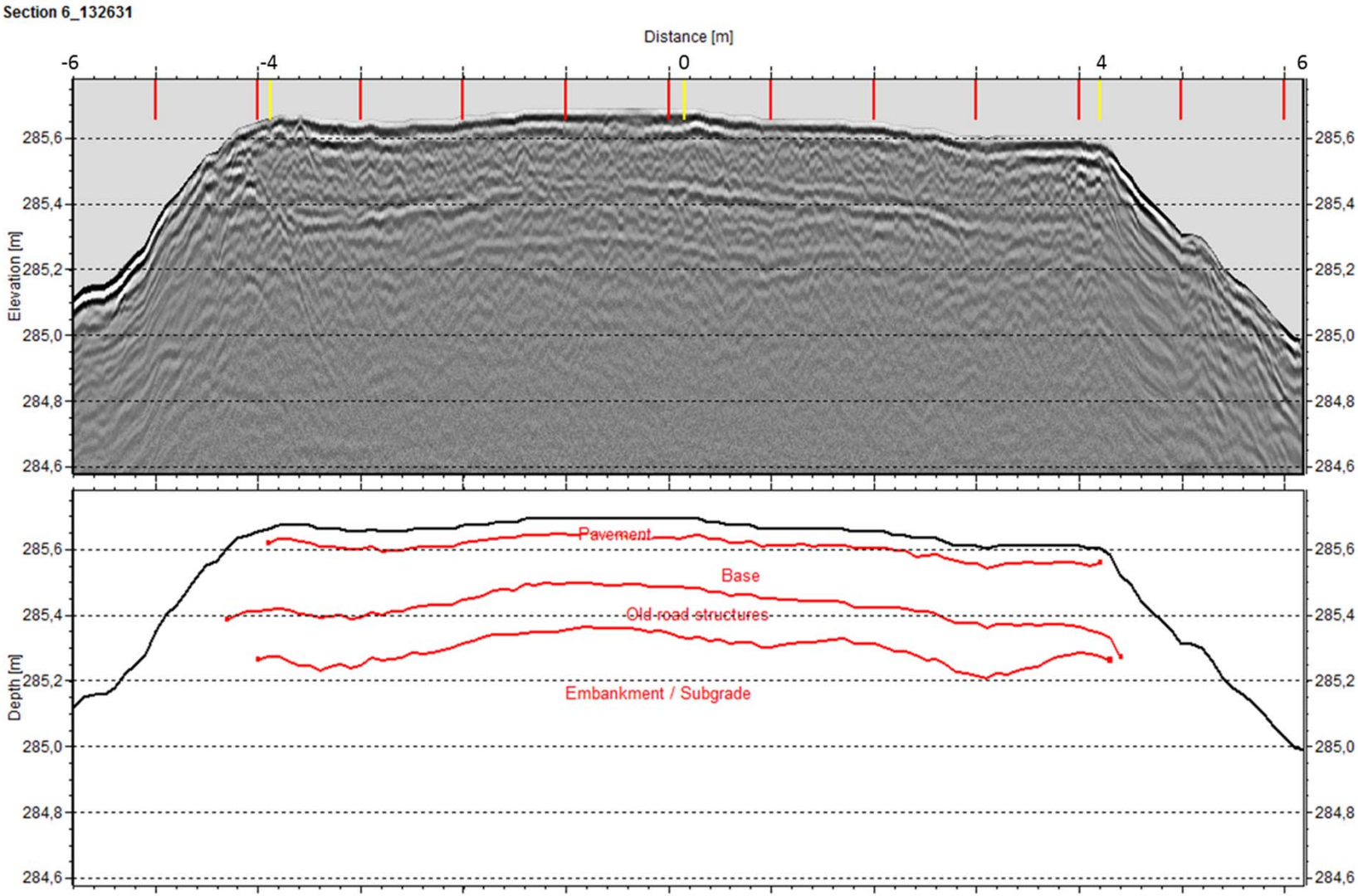
GPR + LASER SCANNER ANALYSIS – CROSS SECTIONS



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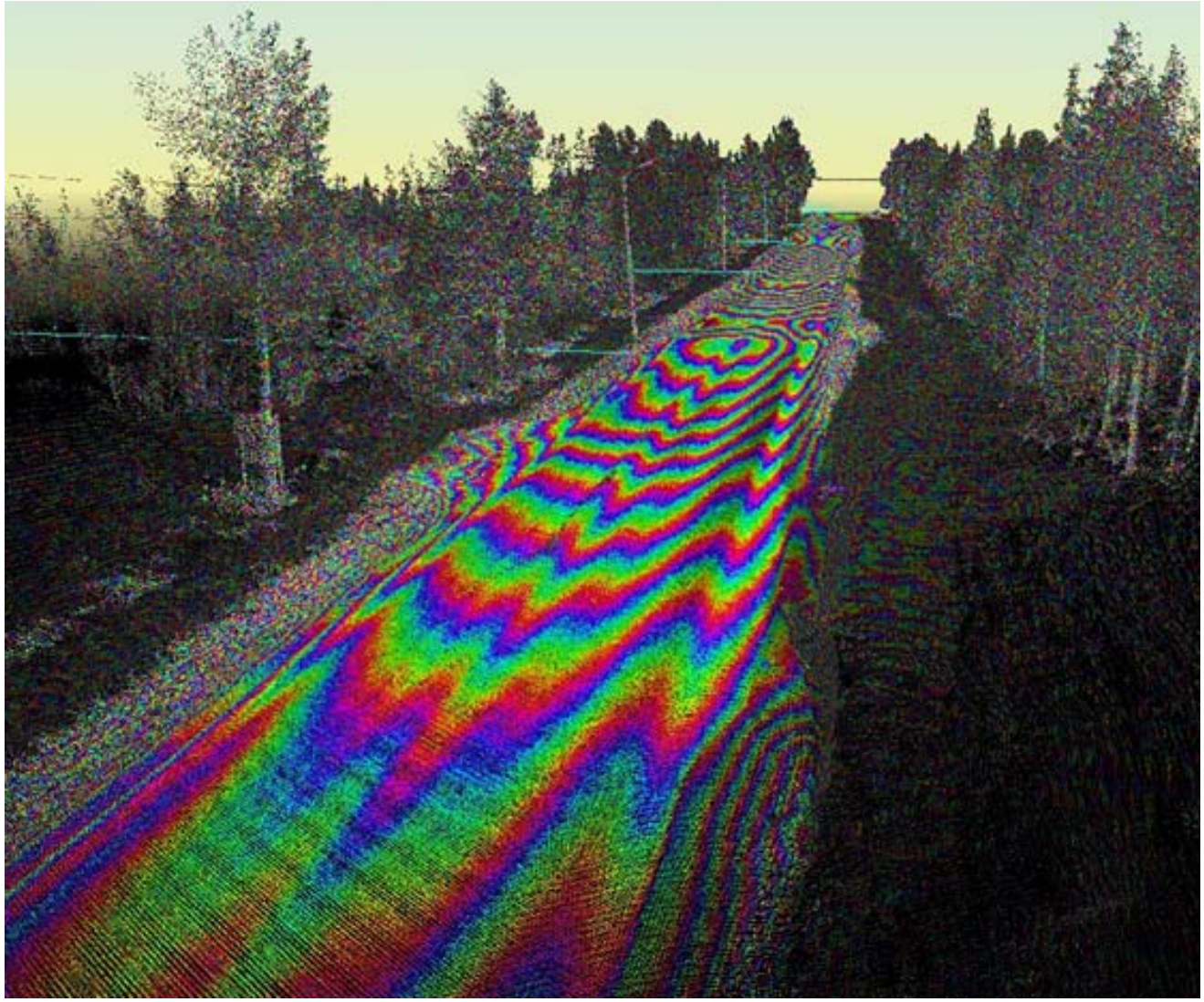
LASER SCANNER ANALYSIS



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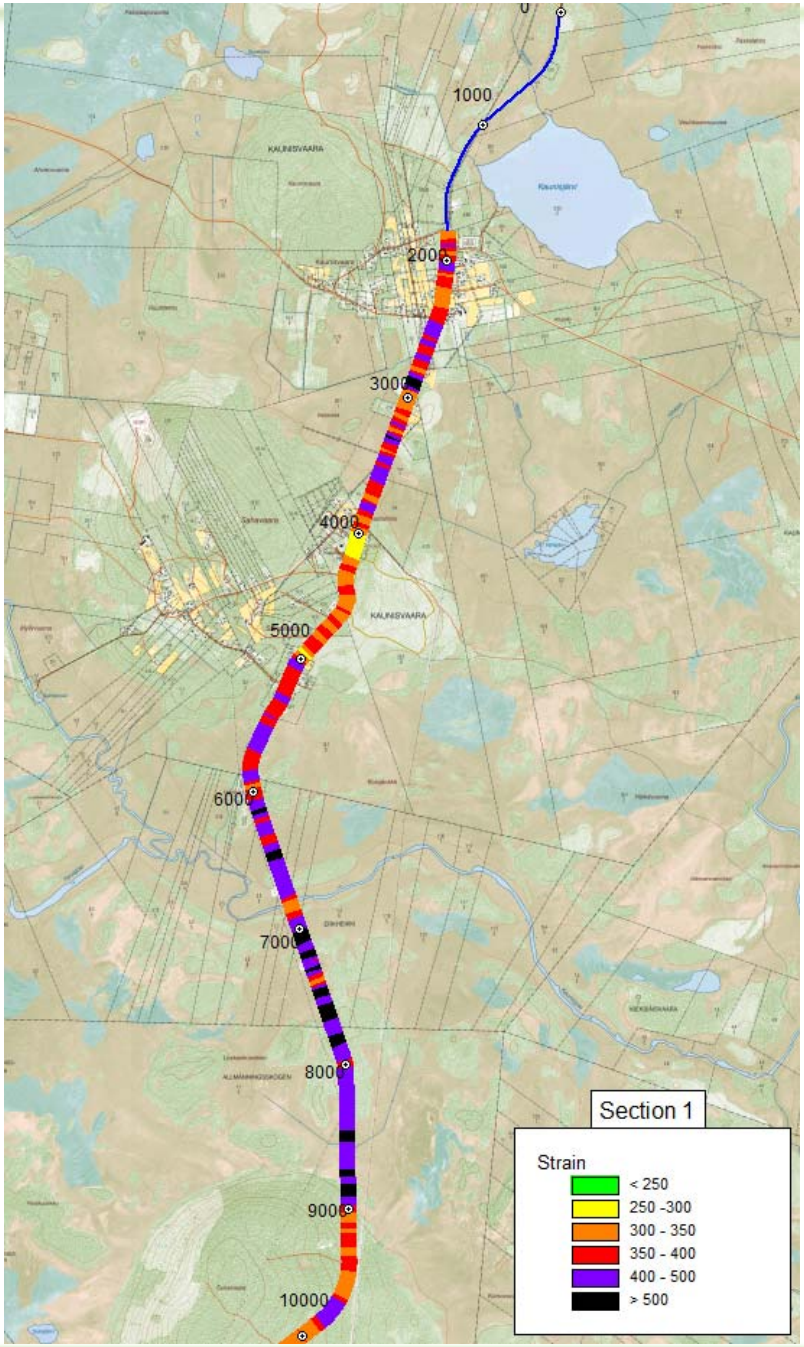
HWD Data Analysis

Strain in pavement bottom
Section 1 (part 1)



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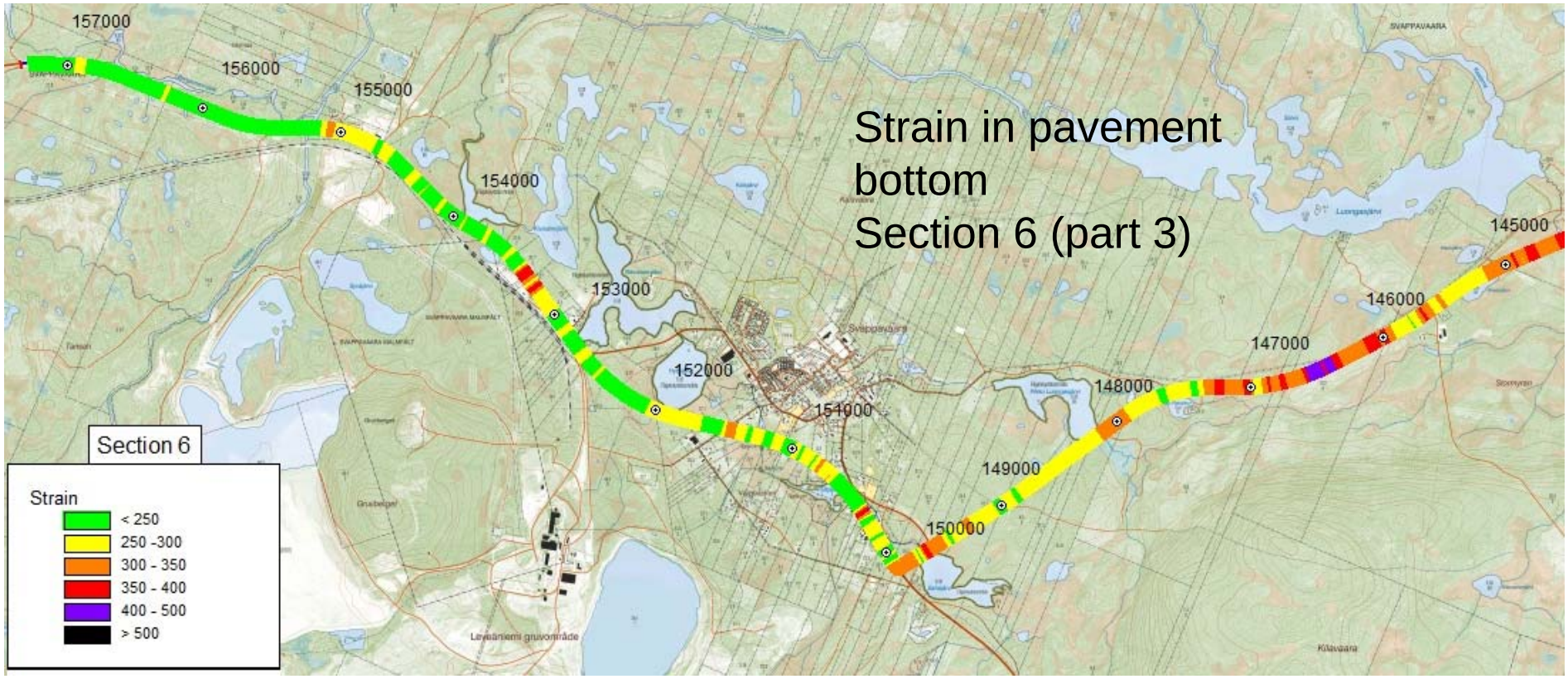
HWD Data Analysis



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Material Surveys:
Tube Suction Test Results of Base Course Samples

	Distance [m]						
Section	From beginning of project	From beginning of section	ATBväg	NB!	Fines content (%)	Max Er-value	Max J-value (mikroS/cm)
1	4050	4050	Väg 99 201/430		6,8	9,66	4
1	8028	8028	Väg 99 197/420		5,5	9,58	22
2	21755	1675	Väg 395 101/959		9,2	12,9	11
3	61548,8	19300	Väg 395 62/184		8,8	9,4	3
4	84888,1	15500	Väg 395 38/856		17,8	10,2	13
4	89128,1	19740	Väg 395 34/886	coal tar	2,4	11,8	17
5	93097,4	1750	Väg 395 30/645		6,2	9,92	7
5	117897,4	26550	Väg 395 5/845	3-10cm	6,8	15,0	31
5	117897,4	26550	Väg 395 5/845	10-18cm	4,4	11,4	32
6	132130,7	8400	E45 398/220	coal tar	3,4	10,3	22
6	137930,7	14200	E45 383/420		8,3	12,1	24

All TS-test dielectric values indicate that base course is frost susceptible

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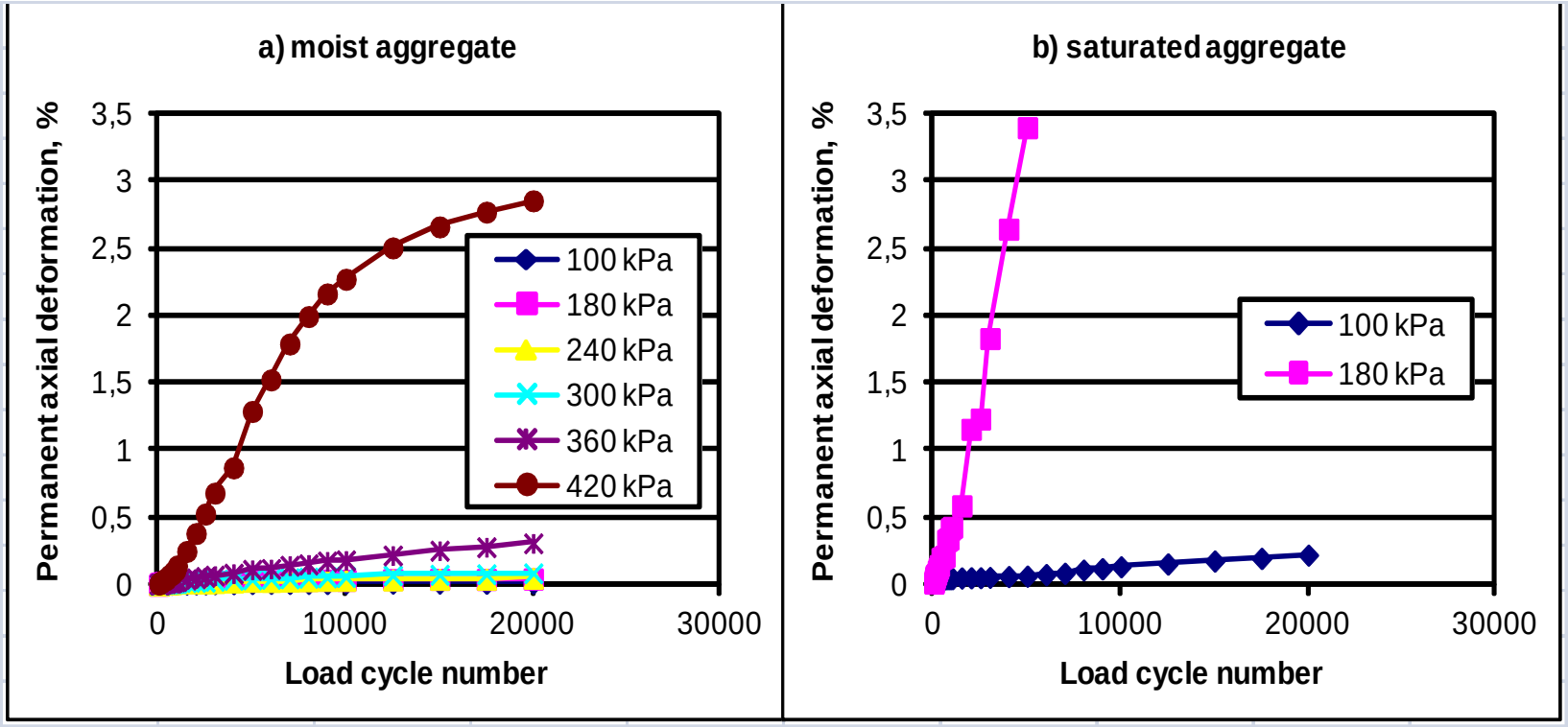
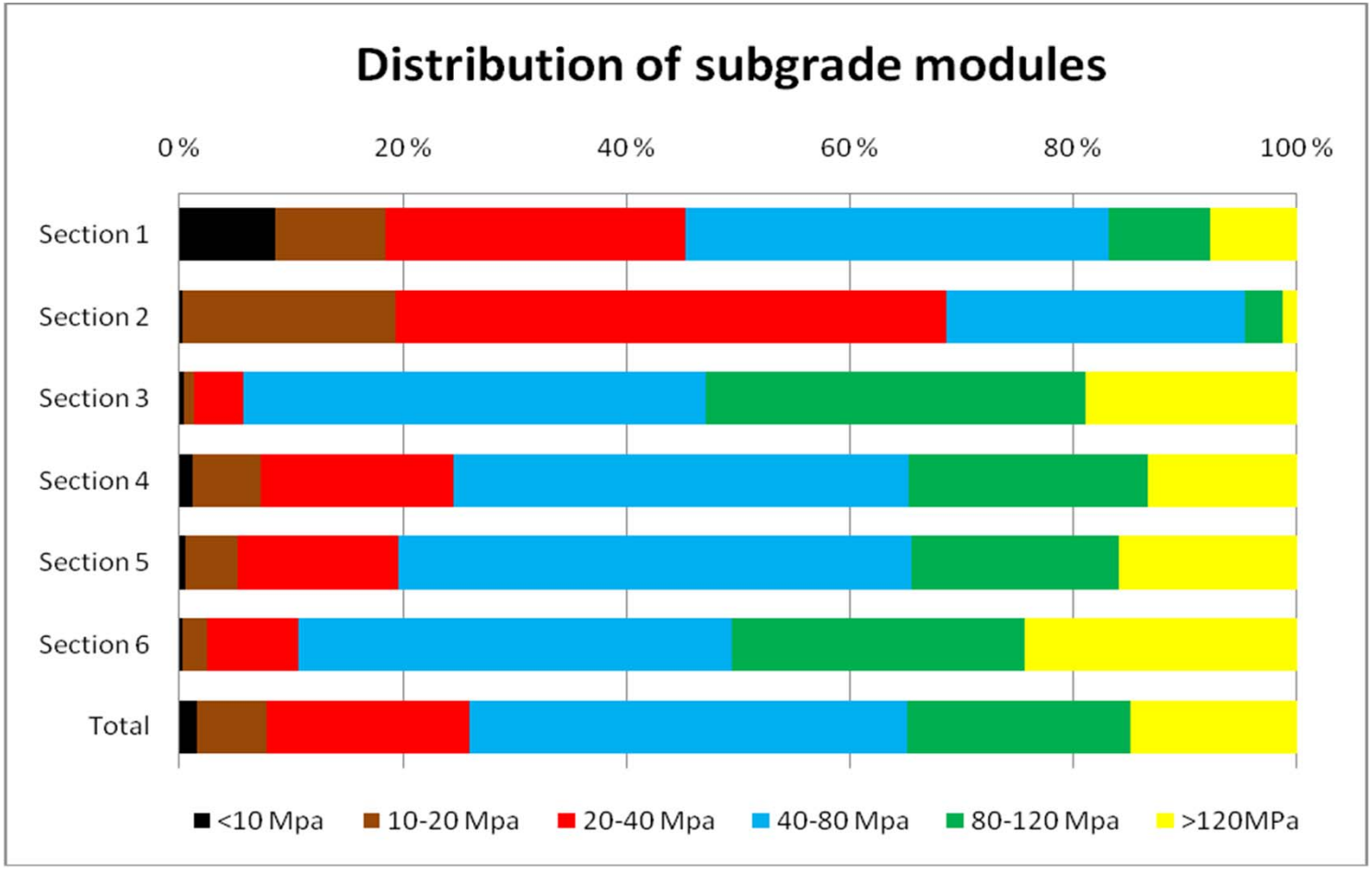
Material Surveys: Base Course Samples are Extremely Sensitive to Permanent Deformation in Spring



HWD Data Analysis – RISK FOR MODE 2 RUTTING



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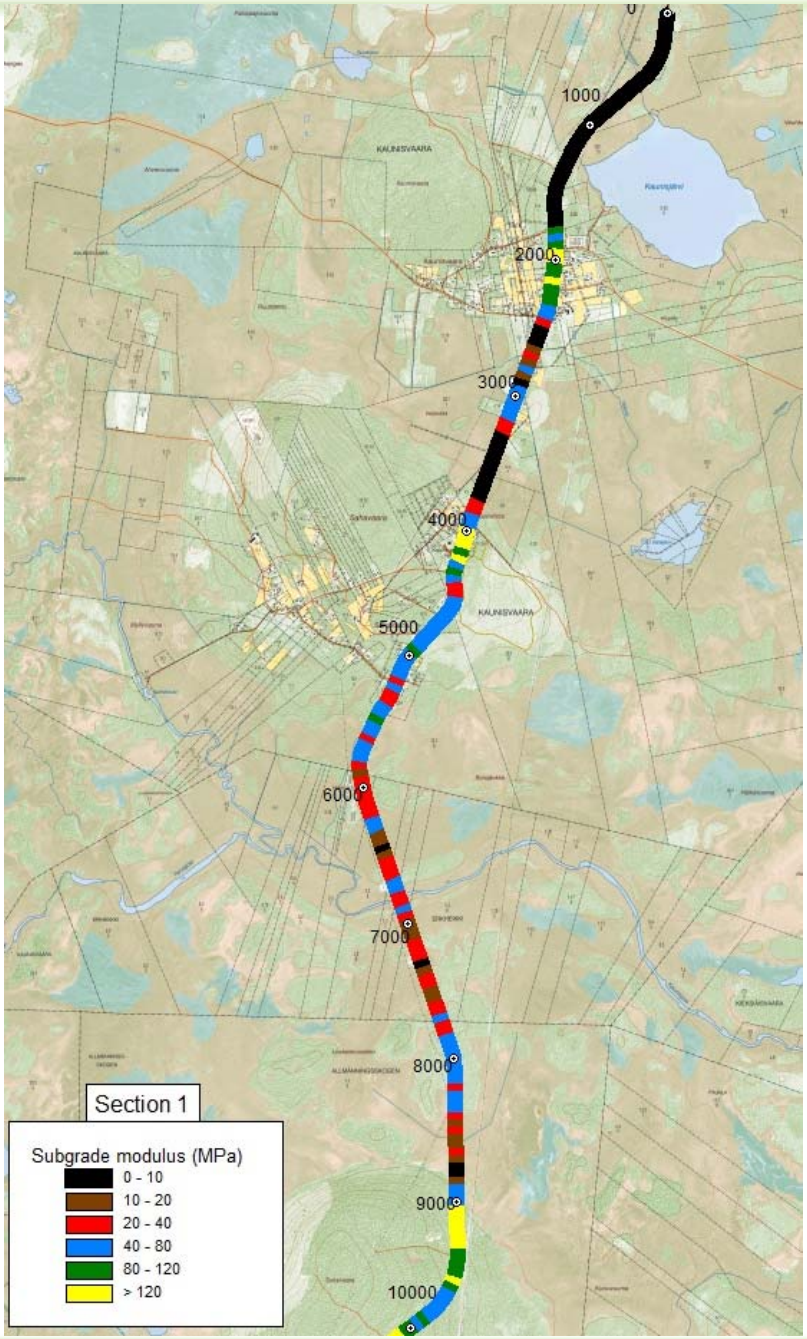
RISK FOR MODE 2 RUTTING

Subgrade modules

Section 1, part 1



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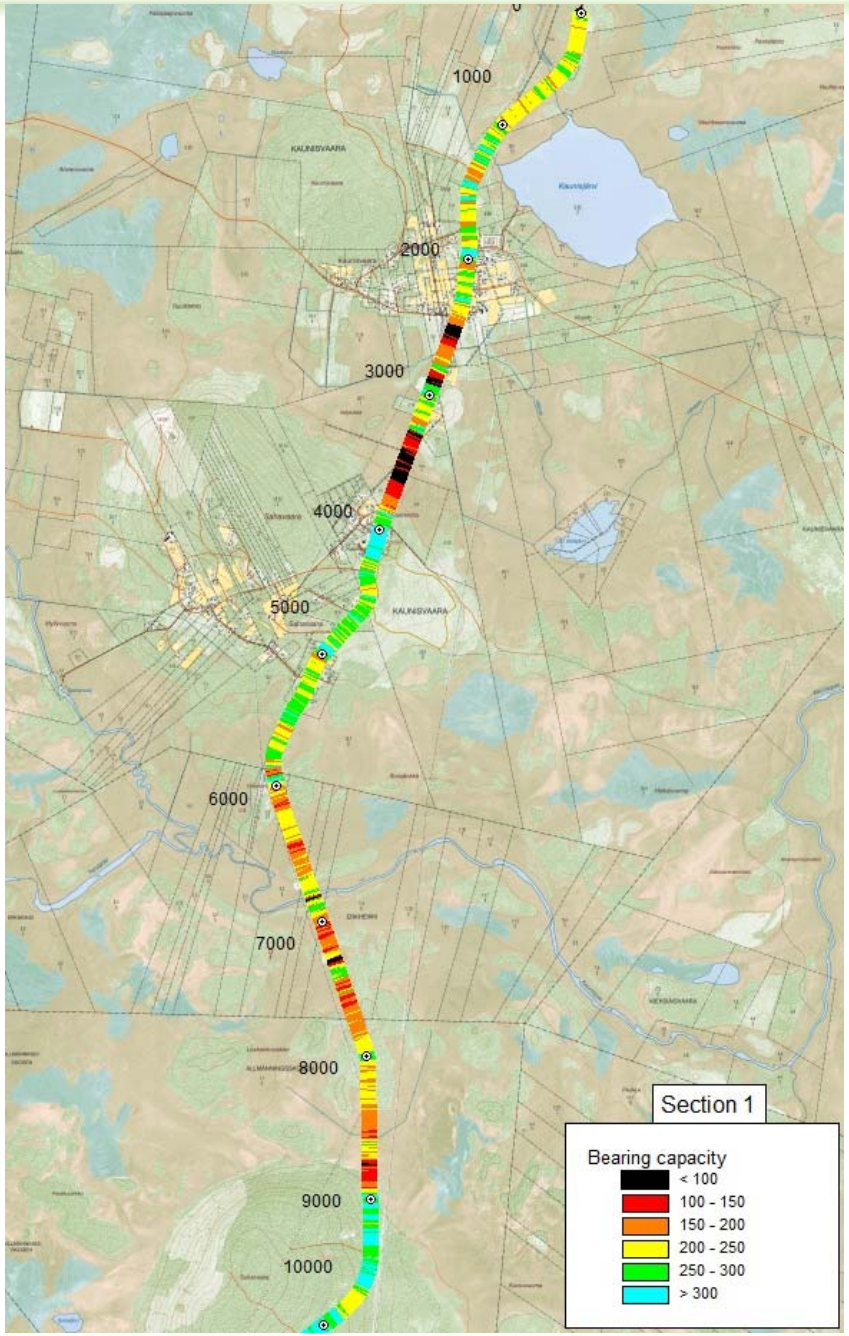
INITIAL BEARING CAPACITY USING ROADEX ODEMARK METHOD

Section 1 (part 1)



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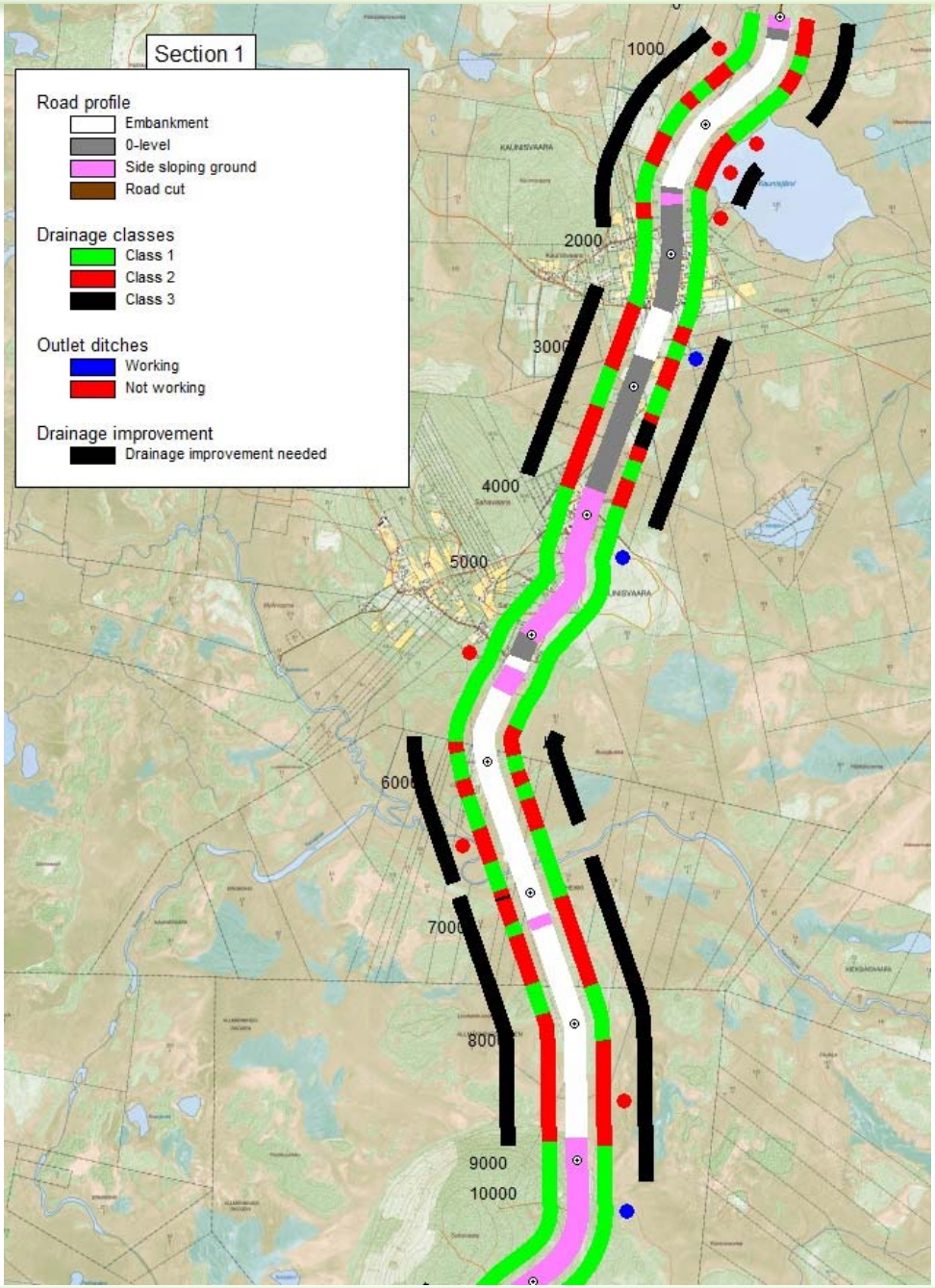
Section 1 (part 1)
Drainage analysis and Improvement need



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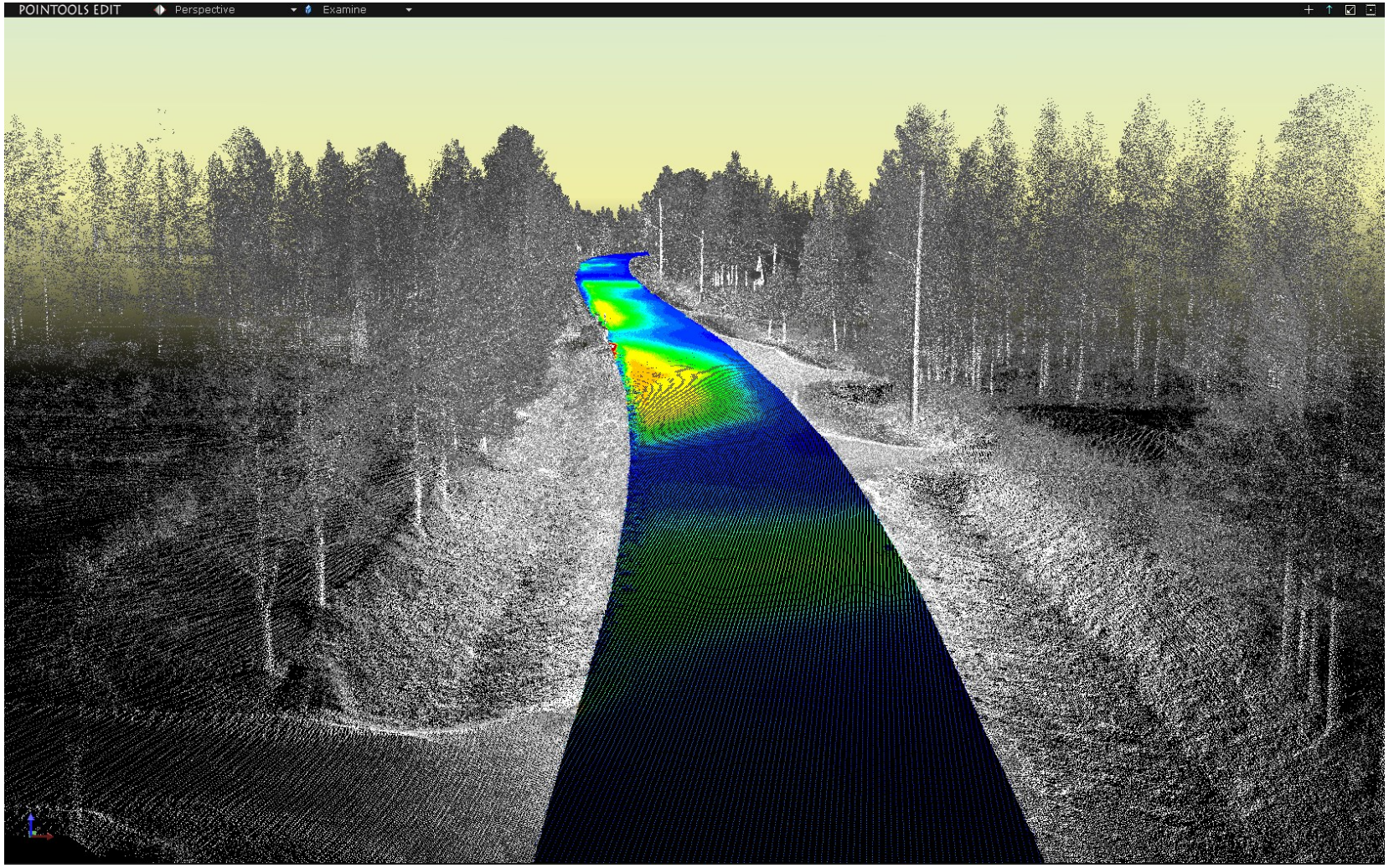
Frost Heave Related to Clogged Exit Road Culvert



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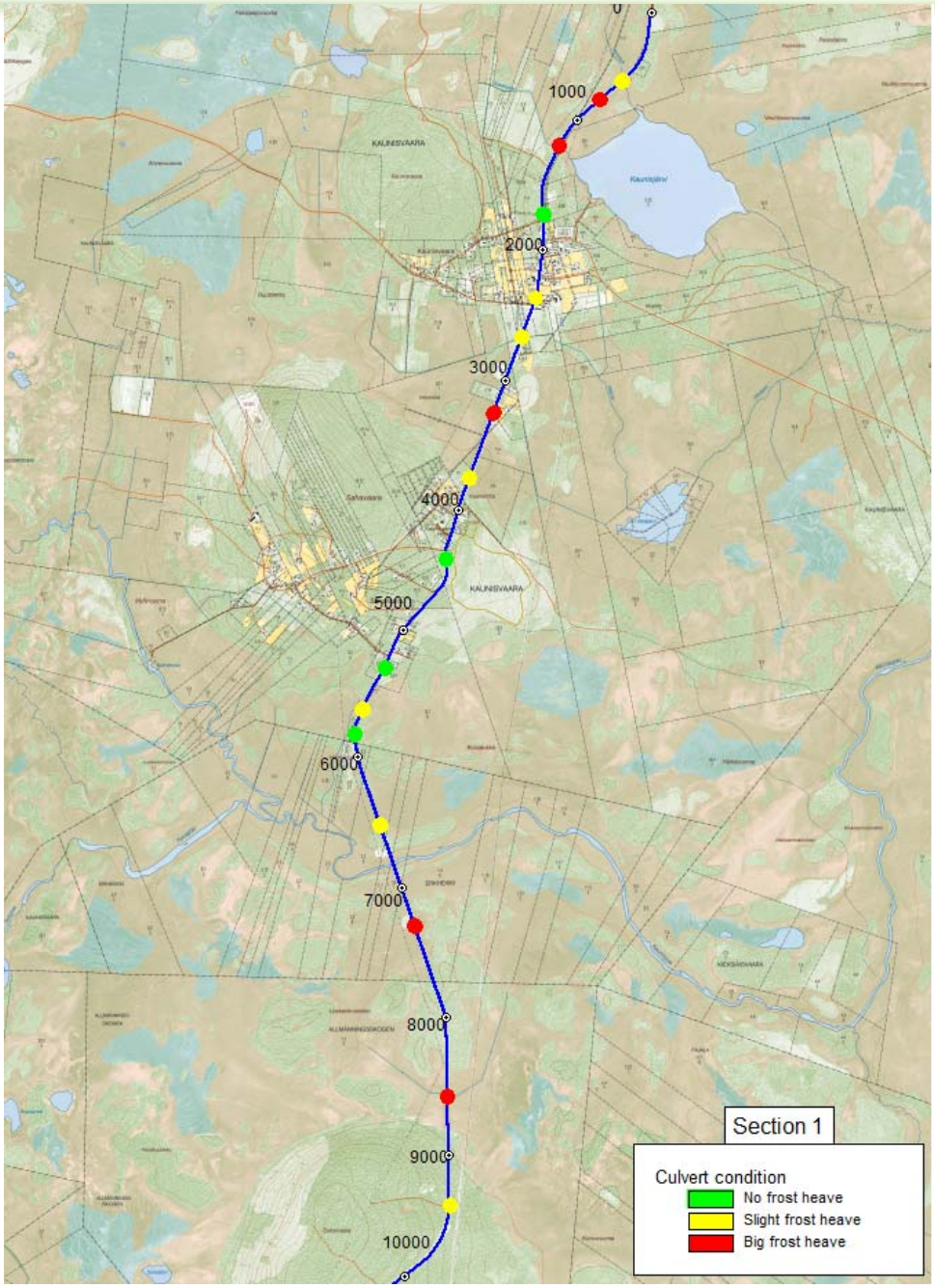
Culvert Inventory

Section 1 (part 1)



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Remaining life time of road, Bound layers and foundation level

Section	Lifetime < 1year
1	100 %
2	100 %
3	100 %
4	71 %
5	100 %
6	100 %
Total	96 %

Risk class	Bound layers [years]	Foundation level [years]
Section 1		
2	0	1
3	0	0
4	0	0
5	0	0
Section 2		
2	0	8
3	0	1
4	0	1
5	0	0
Section 3		
2	0	1
3	0	0
4	0	0
5	0	0
Section 4		
2	1	3
3	0	1
4	0	1
5	0	1
Section 5		
2	0	1
3	0	1
4	0	1
5	0	0
Section 6		
2	0	3
3	0	2
4	0	1
5	0	1

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The needed new structure in order to get 20 years remaining life. Calculations made using PMS Objekt.

Risk class	Pavement [mm]	Bound base [mm]	Unbound base[mm]
Section 1			
2	50	150	150
3	50	150	200
4	50	150	200
5	50	150	325
Section 2			
2	50	150	100
3	50	150	150
4	50	150	150
5	50	150	250
Section 3			
2	50	150	100
3	50	150	150
4	50	150	150
5	50	150	350
Section 4			
2	50	150	150
3	50	150	150
4	50	150	150
5	50	150	200
Section 5			
2	50	150	100
3	50	150	150
4	50	150	150
5	50	150	250
Section 6			
2	50	150	150
3	50	150	150
4	50	150	150
5	50	150	150

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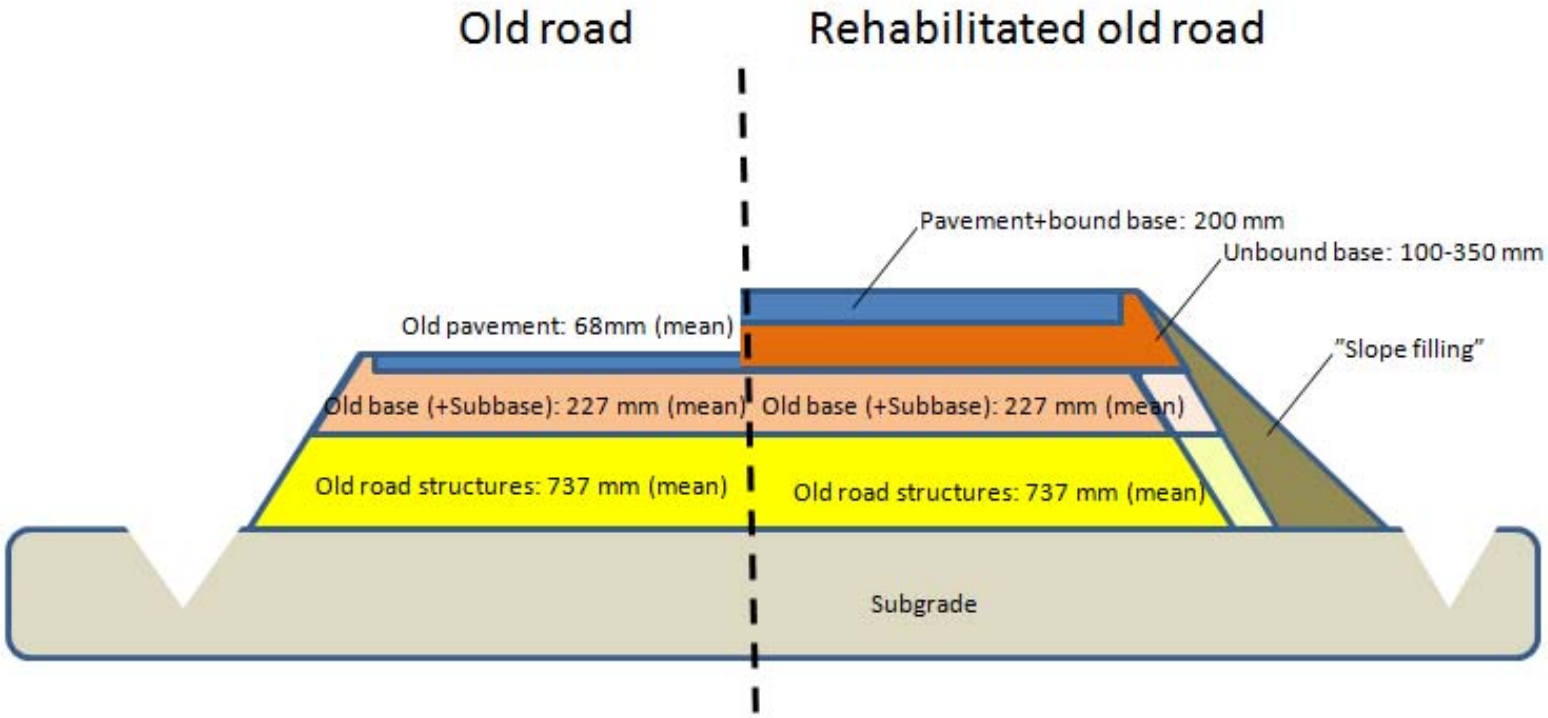
Strenghtening Structures



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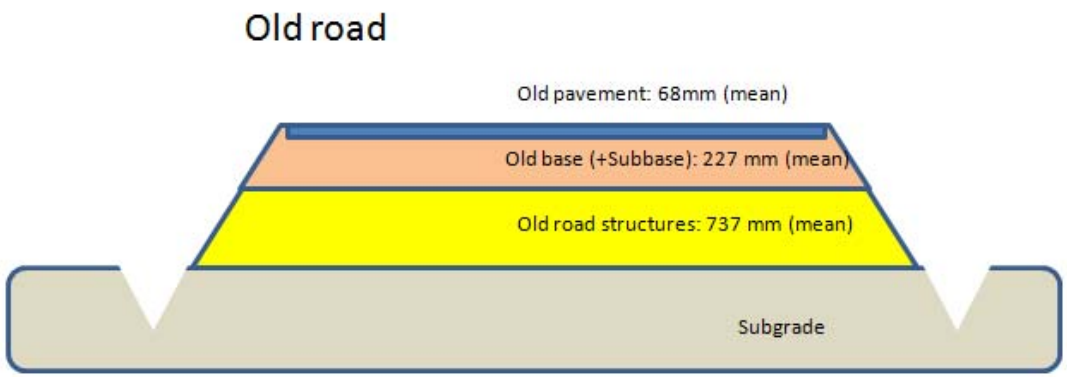
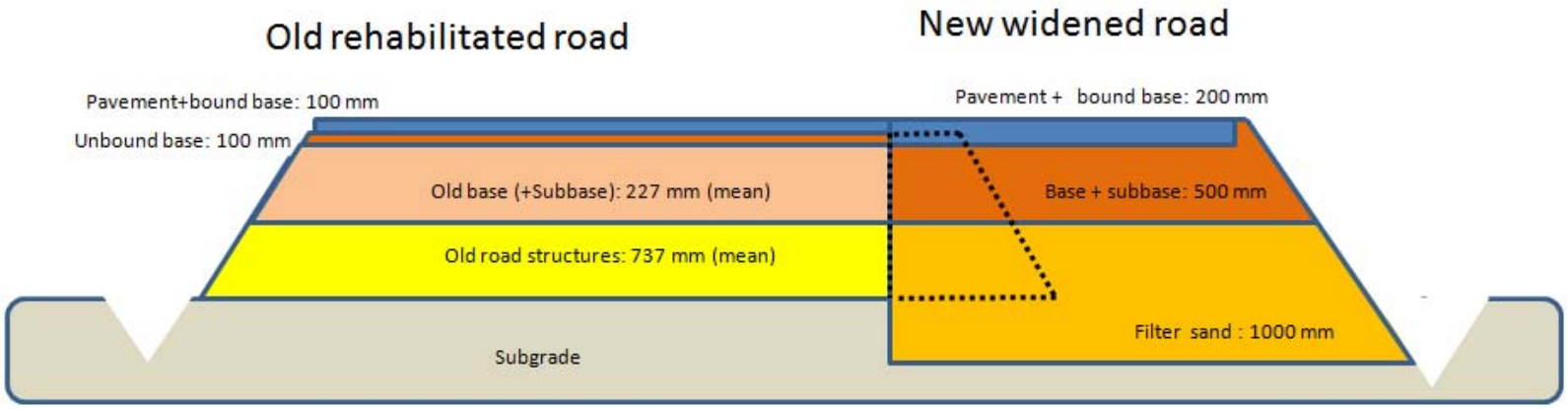
Strenghtening Structures





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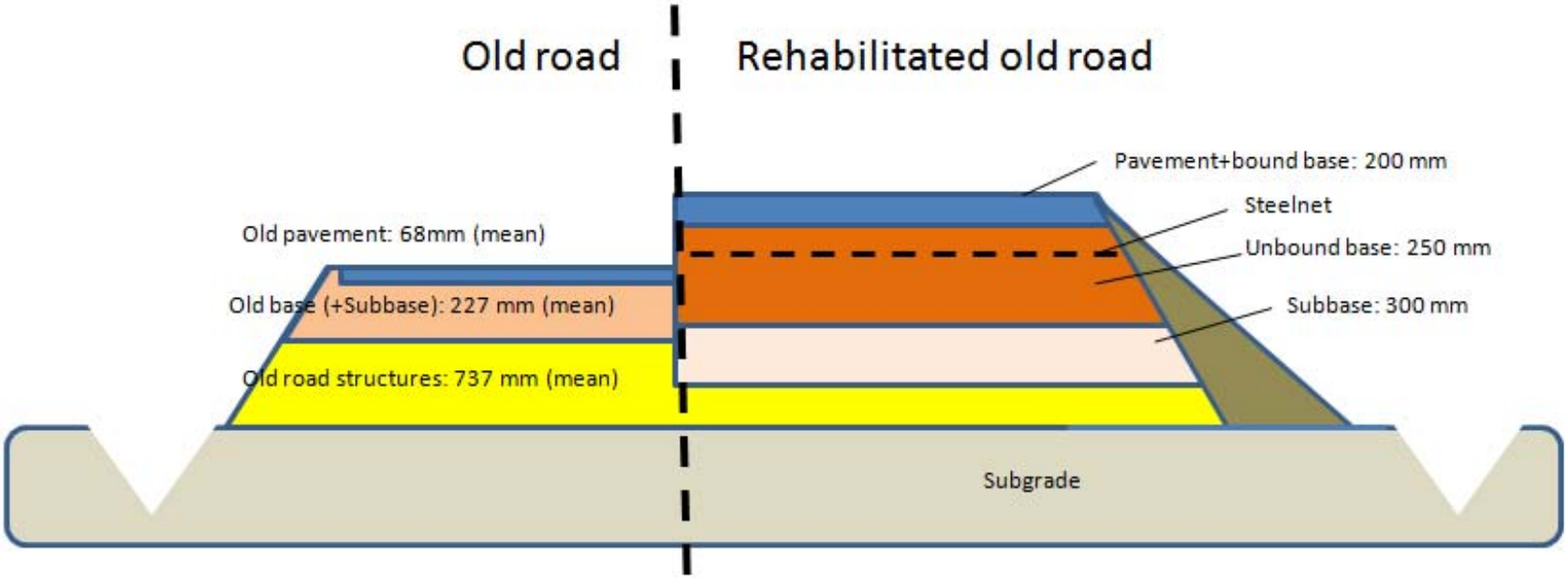
Strenghtening Structures

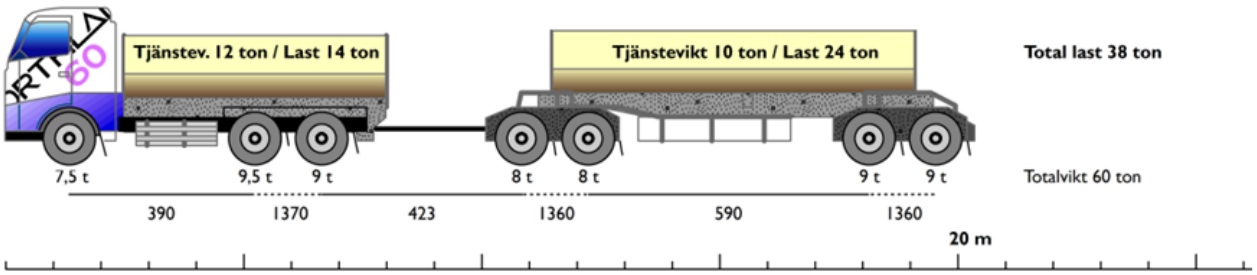


Strenghtening Structures - Standard 60 tn truck

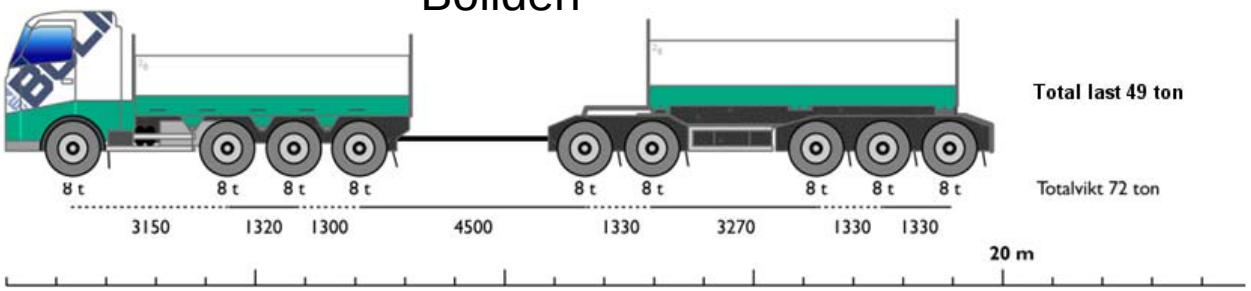
Section	Total price [SEK]
1	53.605.815
2	55.265.680
3	58.702.660
4	54.034.032
5	77.551.451
6	74.055.908
Total	373.215.544

Heavy haulage options

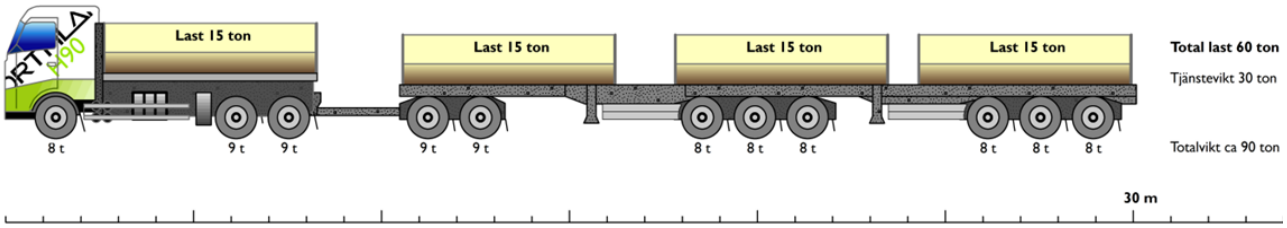
standard



Boliden



En trave till



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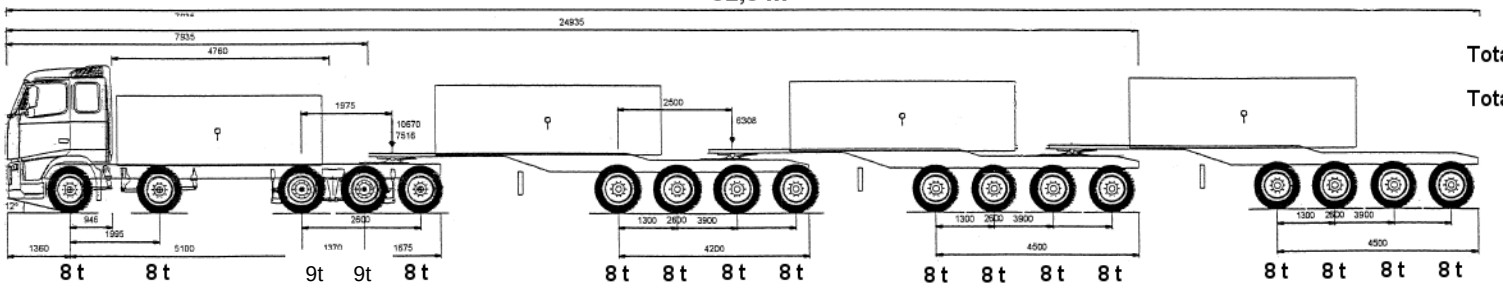
Double Link Options

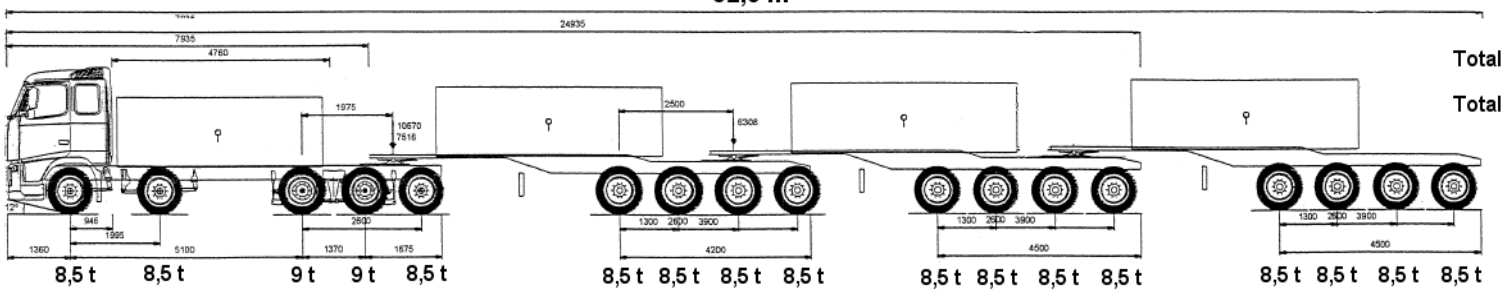
32,5 m



Total last 109 ton

Totalvikt 136 ton

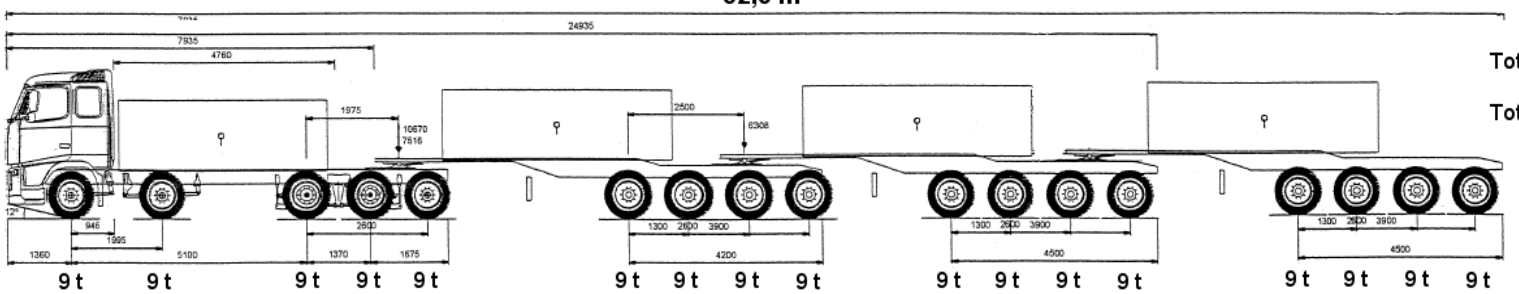
32,5 m



Total last 118,5 ton

Totalvikt 145,5 ton

32,5 m



Total last 126 ton

Totalvikt 153 ton

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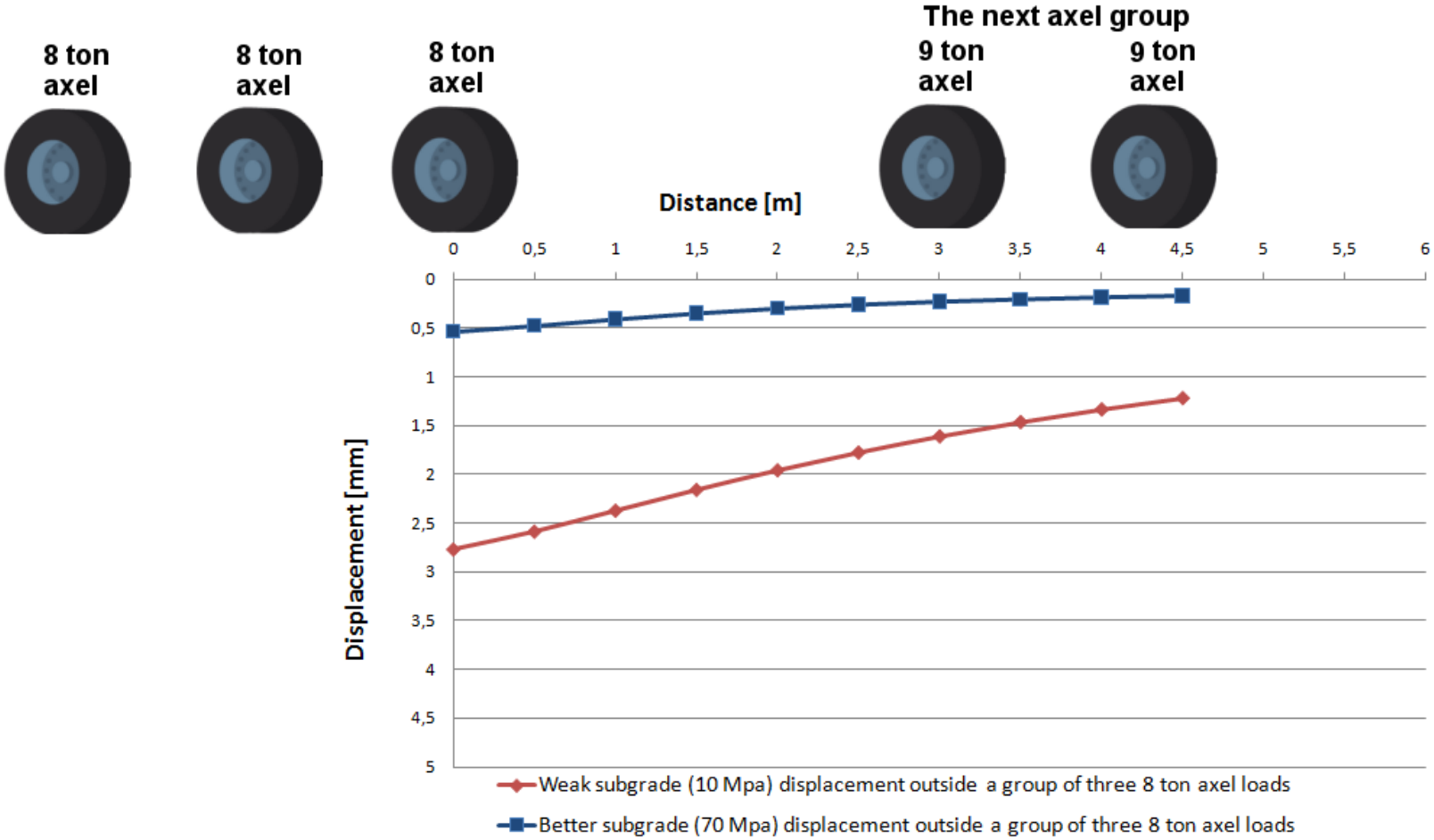
With 200 mm bound structures risks are focus on weak subgrade sections – 8 tn axle



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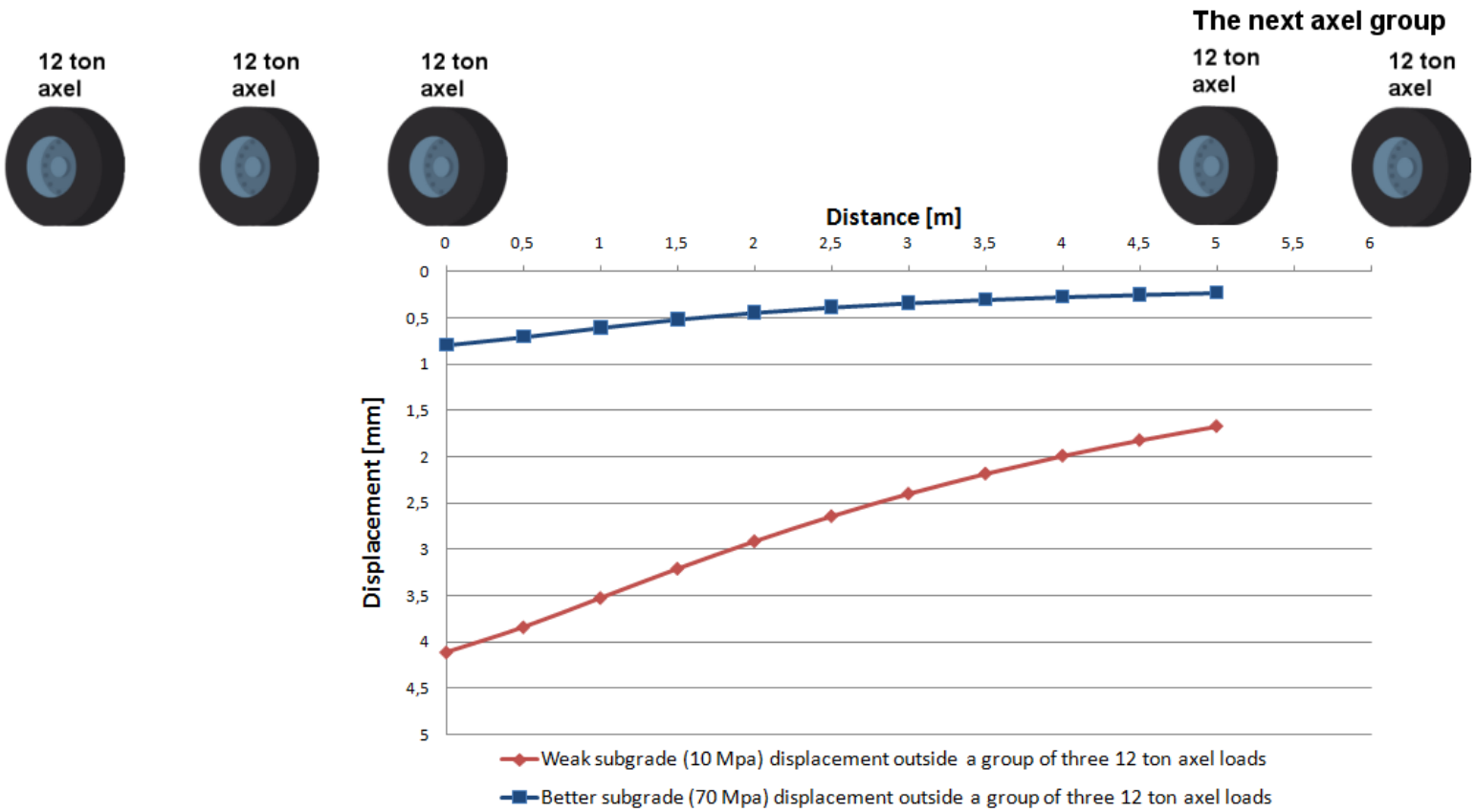
With 200 mm bound structures risks are focus on weak subgrade sections – 12 tn axle



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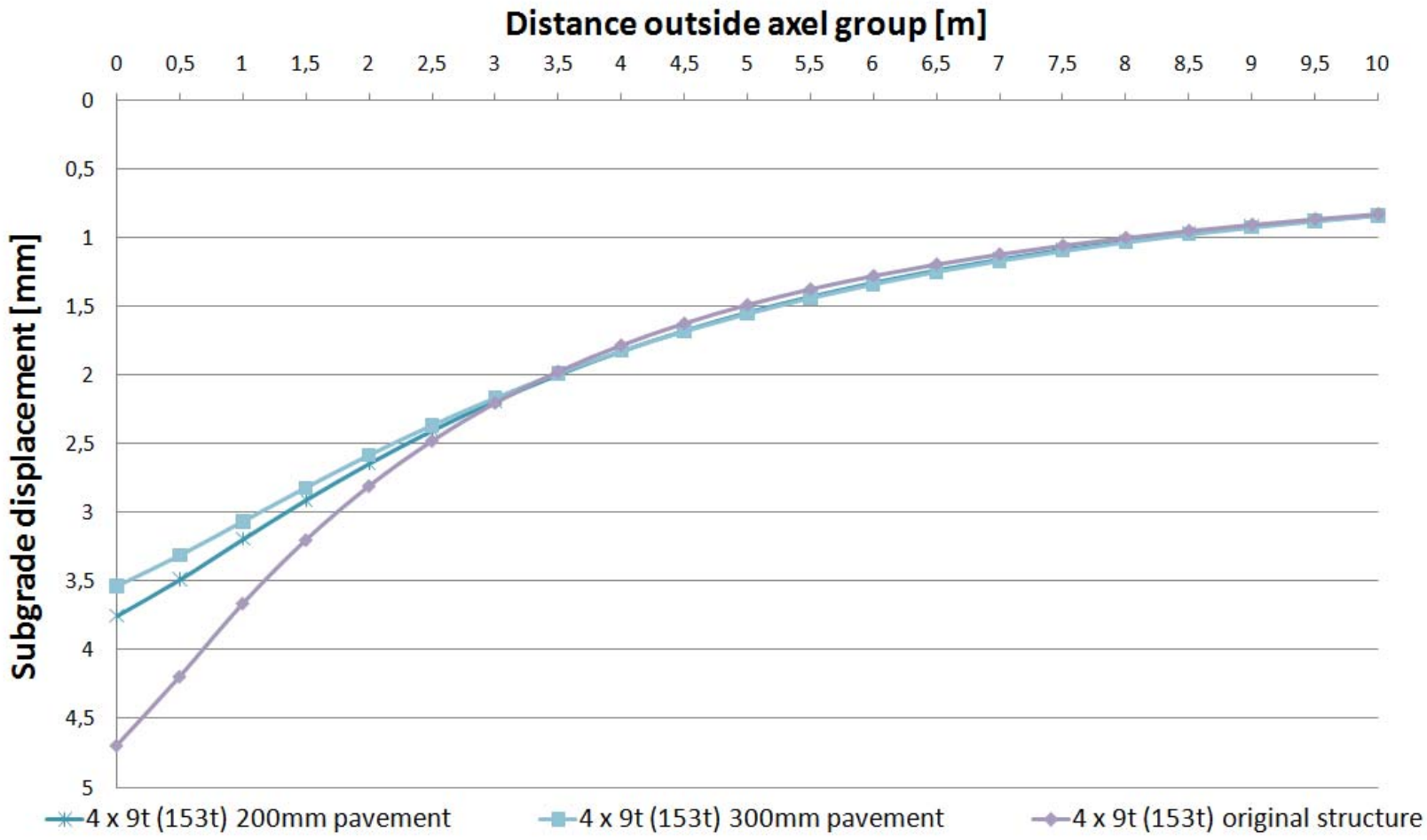
Bisar Calculations – Pavement thickness after 200 mm does not help!



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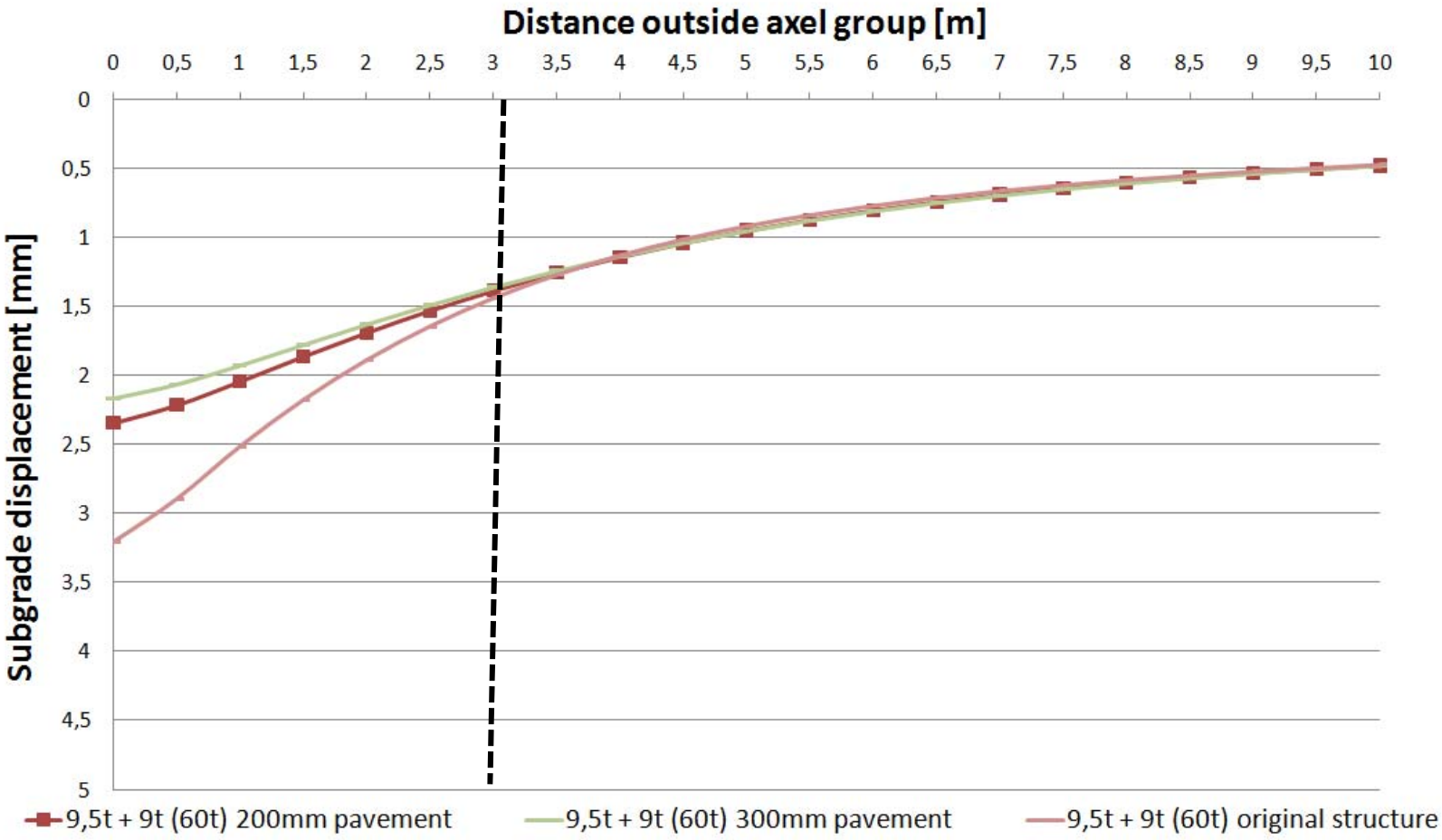
Bisar Calculations – Distance between axles groups



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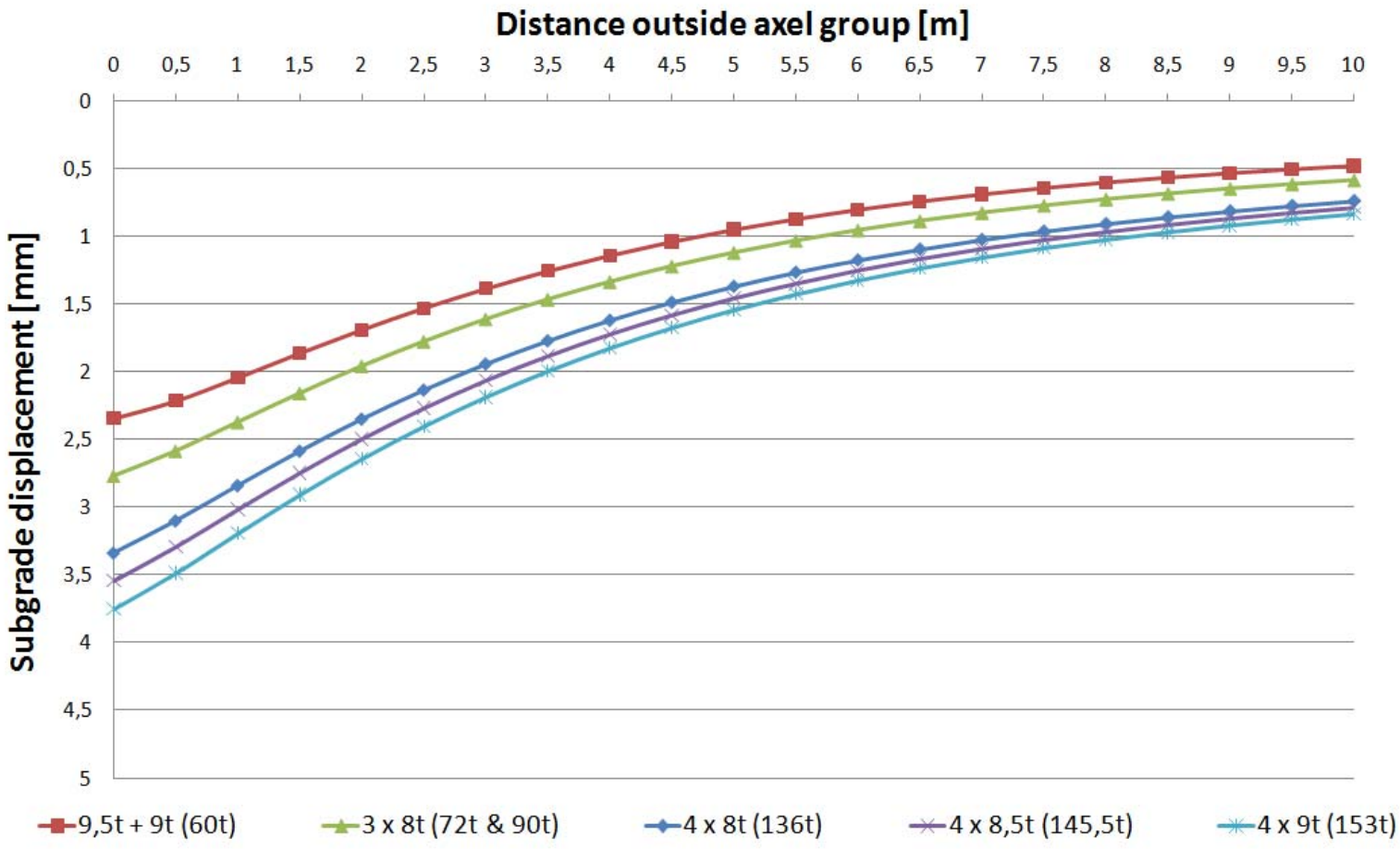
Bisar Calculations



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Fourth Power Rule Calculations

Truck option & total weight	Axel loads					Truck EKV	Net weight	Truck loads	Load effect	Comparison to 60 ton
	7,5 ton	8 ton	8,5 ton	9 ton	9,5 ton		[ton]			
Standard 60 ton	1	2	0	3	1	3,918	38	131579	515581	1
"Boliden" 72 ton	0	9	0	0	0	3,686	49	102041	376163	0,730
"ETT (En trave till)" 90 ton	0	7	0	4	0	5,492	60	83333	457633	0,888
"Double link" 136 ton	0	17	0	0	0	6,963	109	45872	319413	0,620
"Double link" 145,5 ton	0	0	15	2	0	9,142	118,5	42194	385751	0,748
"Double link" 153 ton	0	0	0	17	0	11,154	126	39683	442607	0,858
Annual transportation (ton) =			5000000							
Stress exponent used in calculations =			4							

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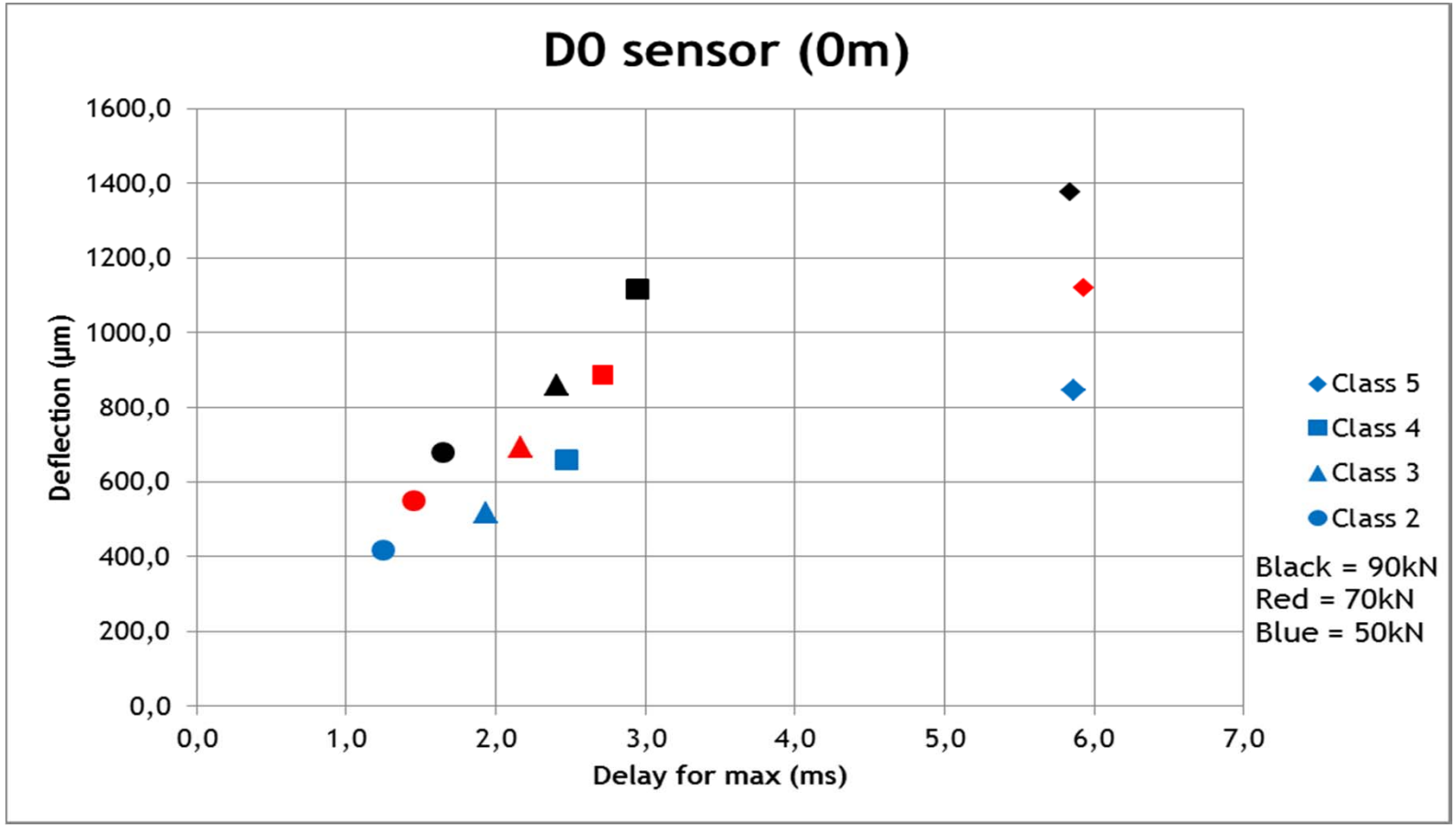
Recovery times:



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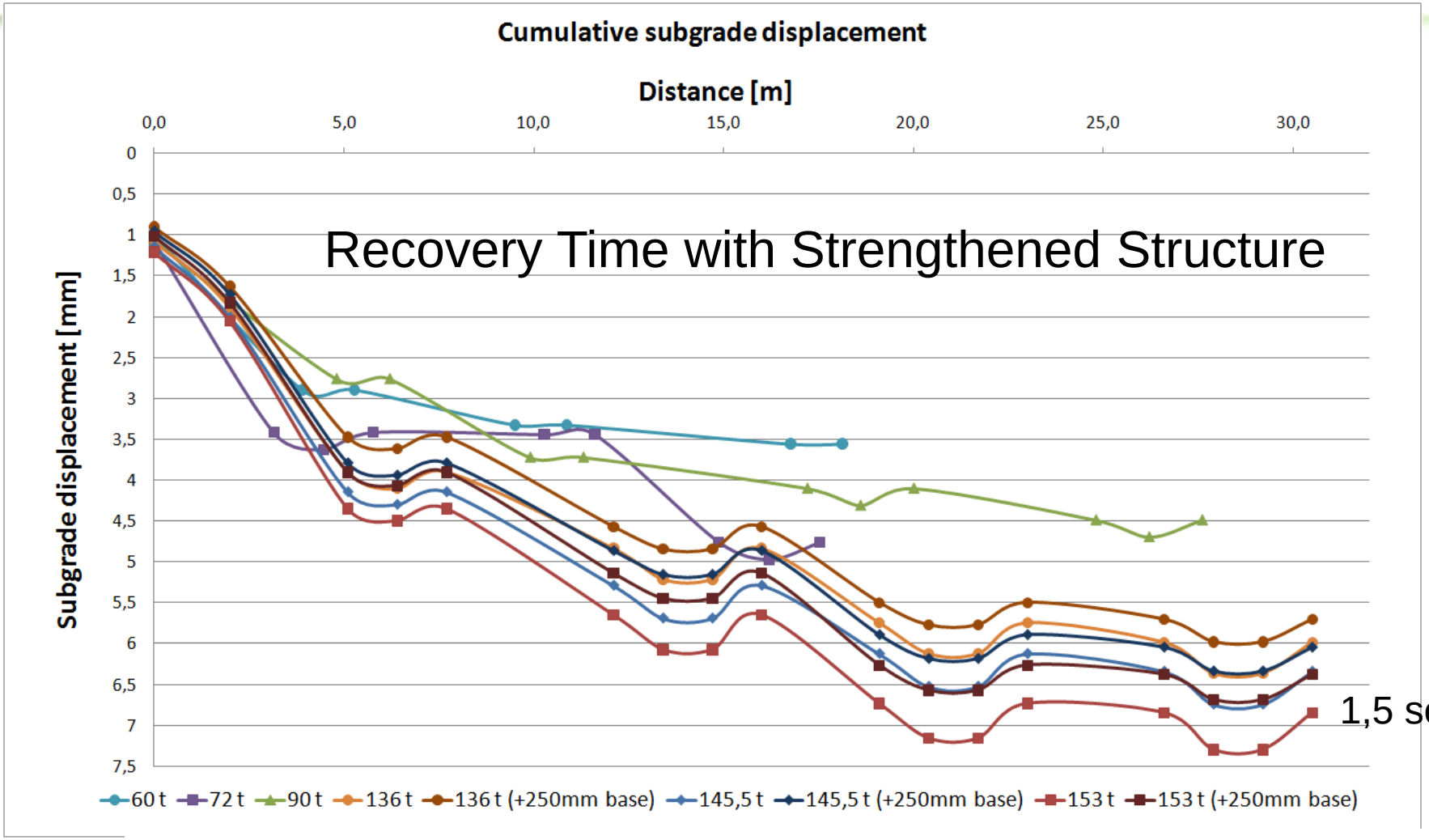
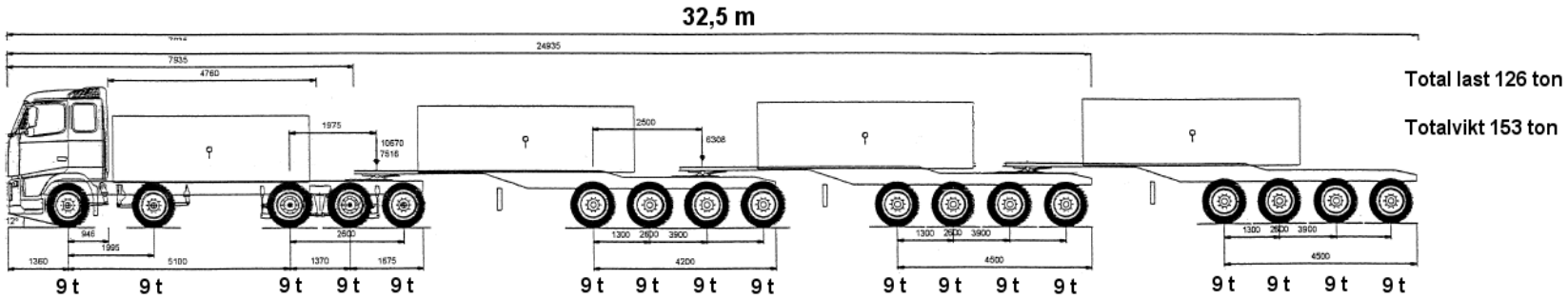


Recovery Time with Strengthened Structure

1,5 sek



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Conclusions (1):

- 96 % of the road lenght will have failures within one year after haulage starts if nothing will be done
- Basic rehabilitation structure for 20 years consists of:
    - 50 mm wearing course
    - 150 mm bound base
    - 100 – 350 mm unbound base
    - new lane for heavier trucks in weakest sections (some sections require soil replacement)
    - climbing lanes for at least two sections (other 2-3 could be considered)
    - one section is calculated in the budget for geometry improvement, others might be considered
- Cost estimate for the work **373 mill SEK + 12 mill SEK for** heavier haulage options

Conclusions (2):

- Drainage is in relatively good shape but could be still improved before rehabilitiation,
    - design for sections with improvement measures have been made
    - culverts with frost problems have been listed (remember that some culverst are on but surrounding structures not)
    - private road road exits cause also problems and should be fixed (may cause vibration problems)
- GPR data showed in most places problems with road shoulders
    - road widening is strongly recommended (not in budget)

Conclusions (3):

- Truck options (more than 30 options were calculated):
  - CTI does not help if 200 mm thick bound layers will be used
  - Most critical are risk class 4 and 5 sections with weak subgrade especially during the spring thaw
  - If heavier trucks will be used subgrade displacement will be 2 times higher – this risk should be acknowledged
  - The best truck option is 136 ton ”double link” (but not for bridges)
  - In winter and in dry summer months it is possible to use higher axle loads and total loads.
  - recovery times caused by more axles will be compensated by longer time between heavier trucks – but **NO CONVOY DRIVING**
  - full scale truck tests are strongly recommended
- Recommendations:
  - monitoring of road structures and loads
  - system for preventative maintenance

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Thank You

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