EVALUATION OF SPRING LOAD RESTRICTIONS (SLR) EFFECTS ON PAVEMENTS

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Ministère
des Transports

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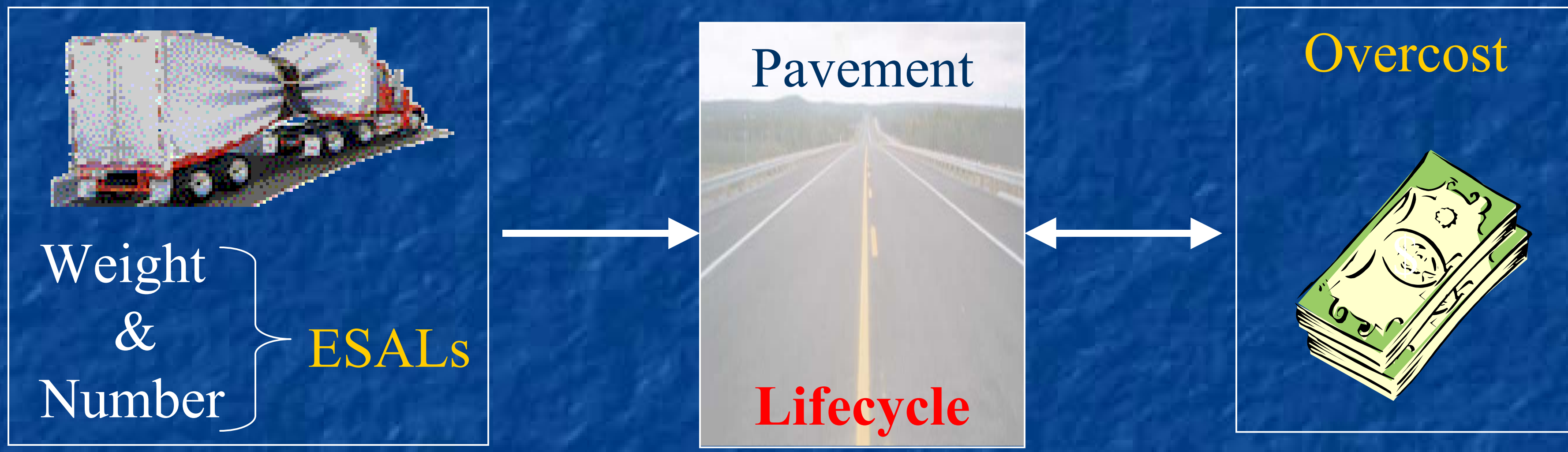
PRESENTATION OUTLINE



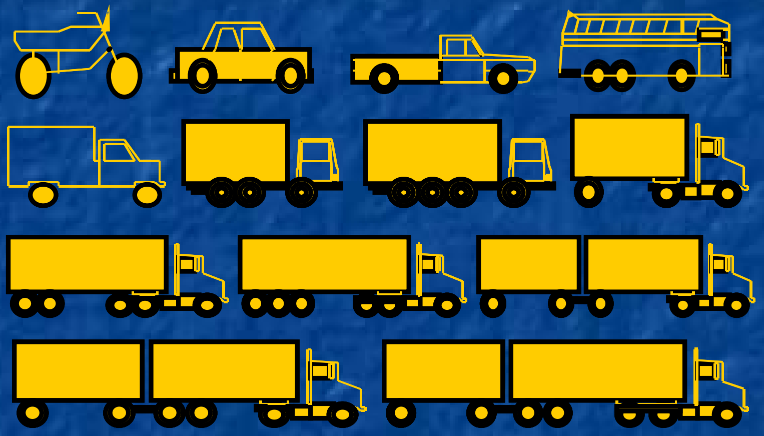
Heavy trucks

$$\text{Truck factor} = \left[\frac{\text{Axle weight}}{\text{Reference axle w.}}\right]^4$$

- ***2* x weight = *16* x damages**

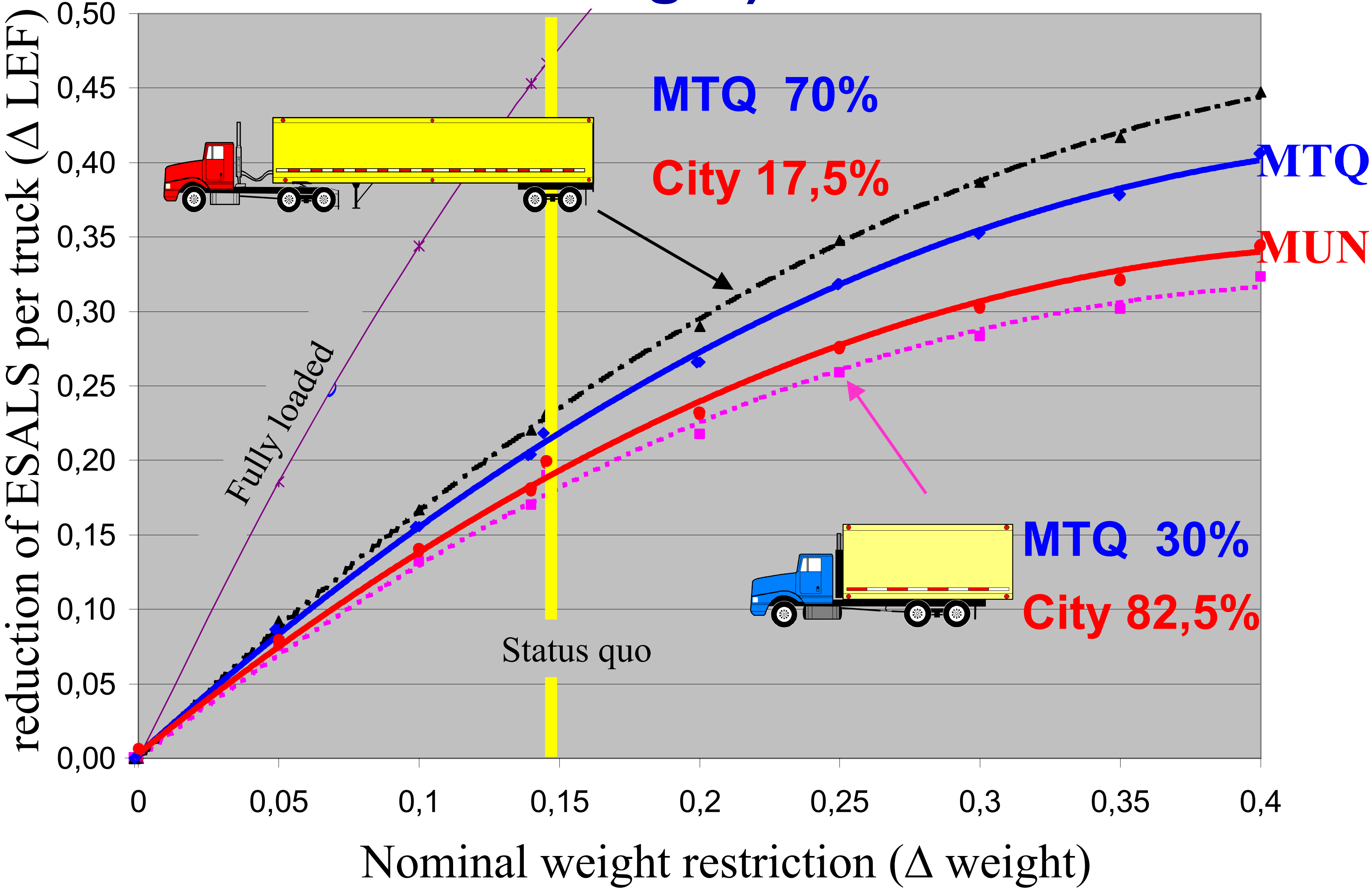
- AASHTO :
  - 1 ESAL = 1 single axle of 8 165 kg
    = 1 tandem axle of 15 200 kg
    = 1 tridem axle of 21 800 kg

Trafic evaluation



- 3,500 counting and classification stations
- 10 Weigh-In-Motion (WIM) scales
- ESALS calculated with ASTM E1318

Load Equivalency Factor : Δ LEF = F(Δ weight)



Heavy Trafic during the spring period

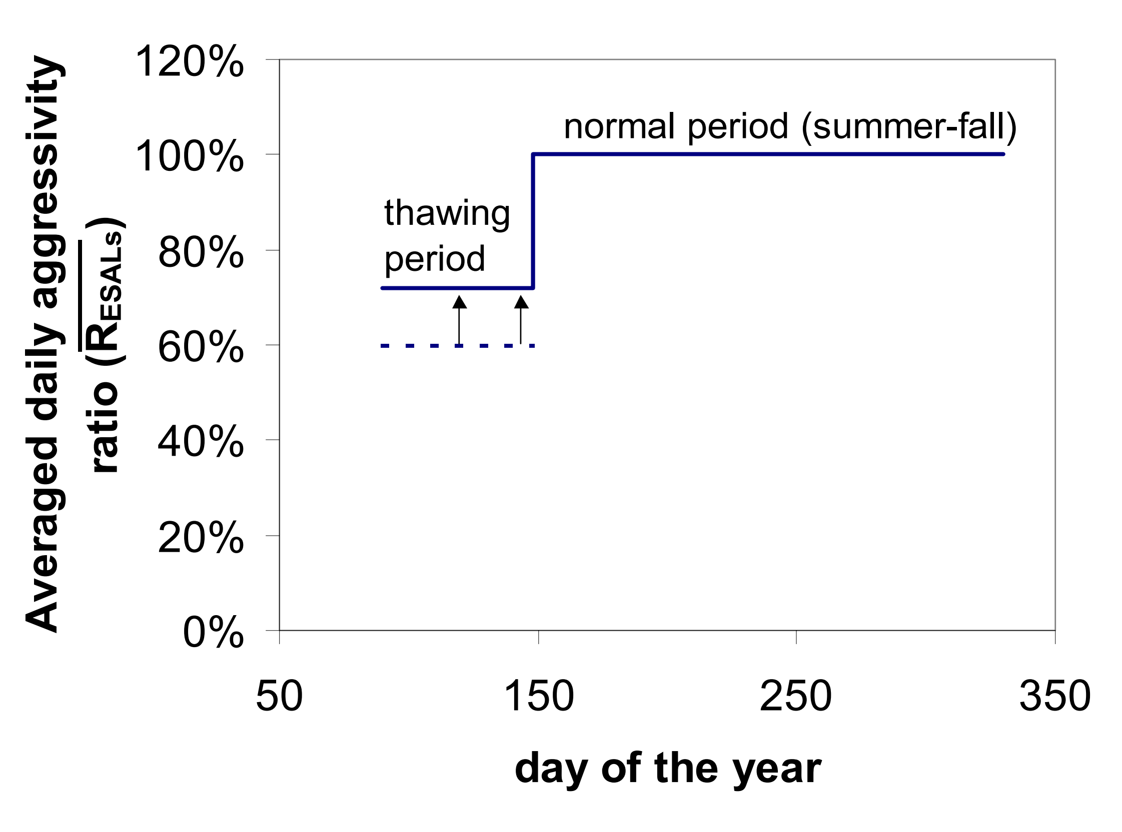
- ESAL per day ≈ 60% of summer
  - Average truck ≈ LEF 20% smaller (SLR of 15%)
  - Shipments needs about ≈ 20% less than normal period

- SLR removal hypothesis
  - Average truck load same as summer
  - ≈ 7% less displacements **=> ECONOMY OF THE INDUSTRY**
  - Shipments needs about ≈ 20% less than normal period

Increase ESALS of 19% (18 % inside cities)

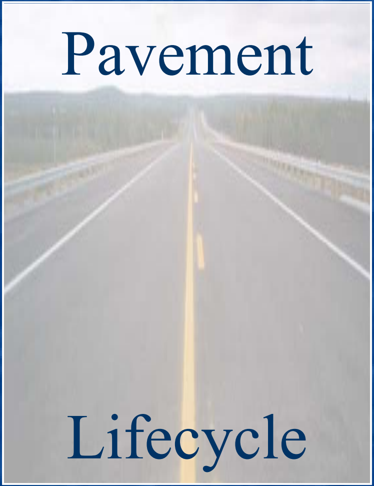
If We Remove Spring Load Restrictions (SLR)

=> 19% more ESALS per day (18% inside cities)



(2) Pavement Damage

19% more ESALS if we remove SLR



Structural Damages
⇒Wheelpath Distresses

Damages During Spring Thaw

- 1a-Literature (example from AASHTO)

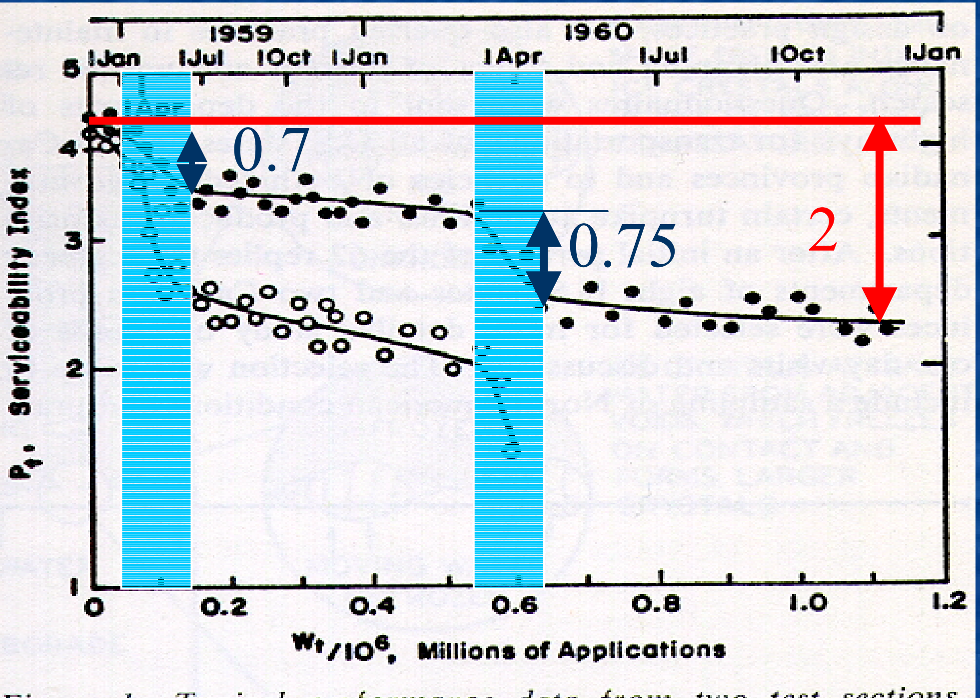


Figure 1. Typical performance data from two test sections, AASHO Road Test (4).

$$Dp = \frac{\Delta PSI_{thaw}}{\Delta PSI_{total}}$$

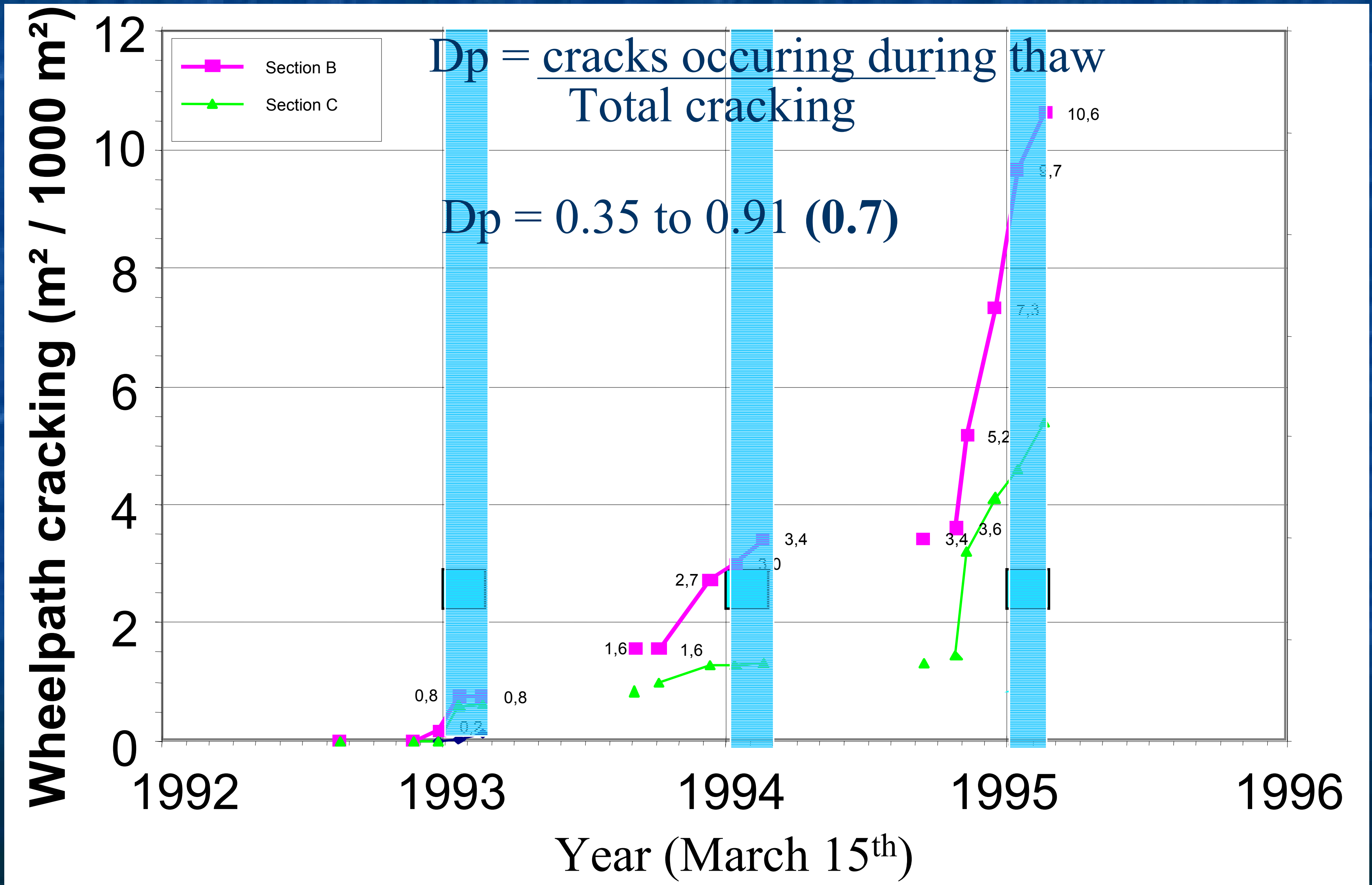
$$Dp_1 \approx 1.45 / 2 = 0.725$$

$$Dp_2 \approx 1.3 / 2.2 = 0.55$$

From all the cases found in literature, spring thaw damages varies from 0.3 to 0.85

Damages During Spring Thaw

- 1b-Performance monitoring (H10, Fleurimont)

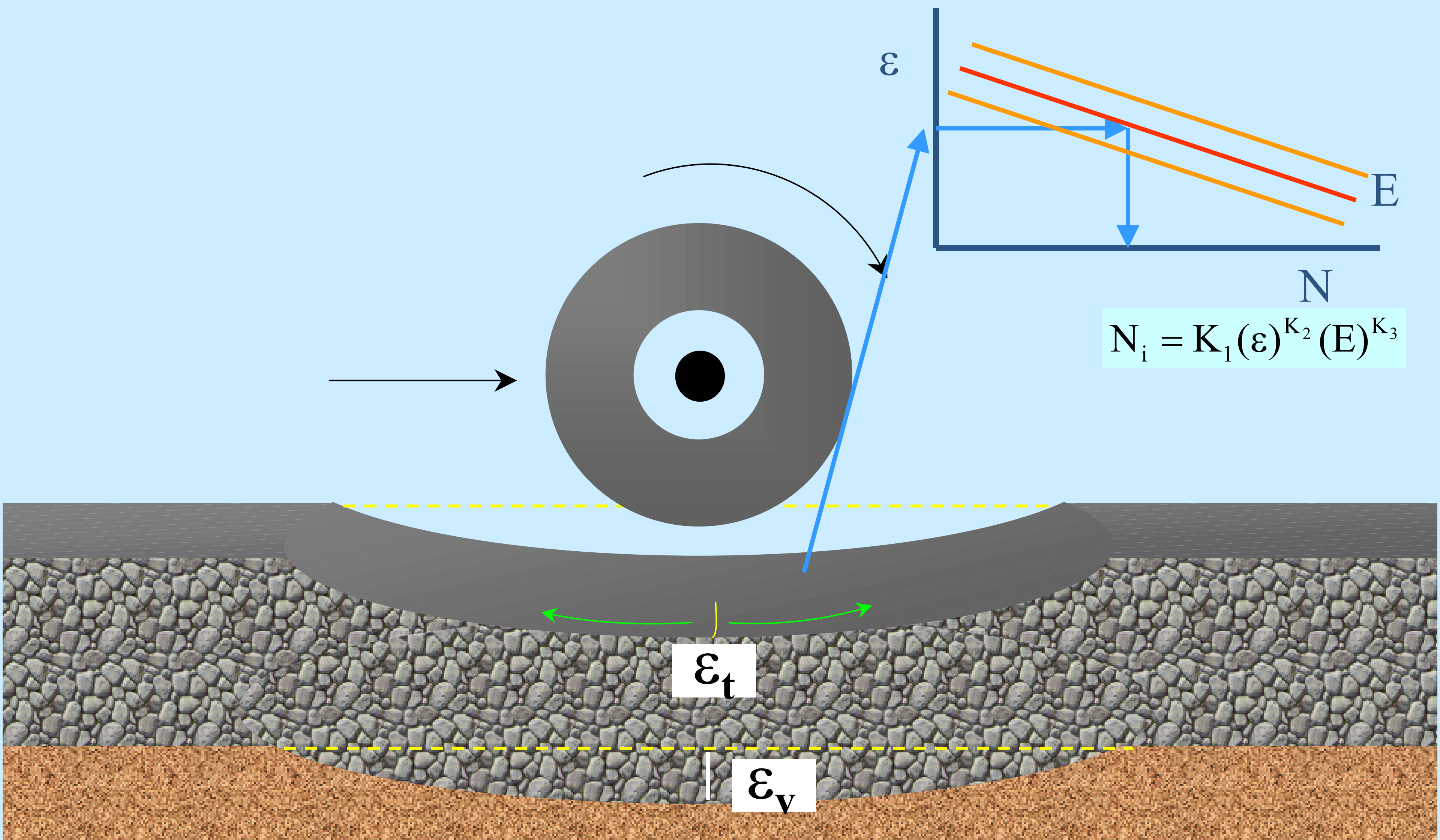


Annotations

- A lot of pavement damaging occurs during winter thawing events
  - Climatic variability between different years
- Ability to raise SLR during each thawing events, including those in winter, would be the ideal of beauty
- Winter Weight Premiums does not appear as a very good feature

Falling Weight Deflectometer FWD

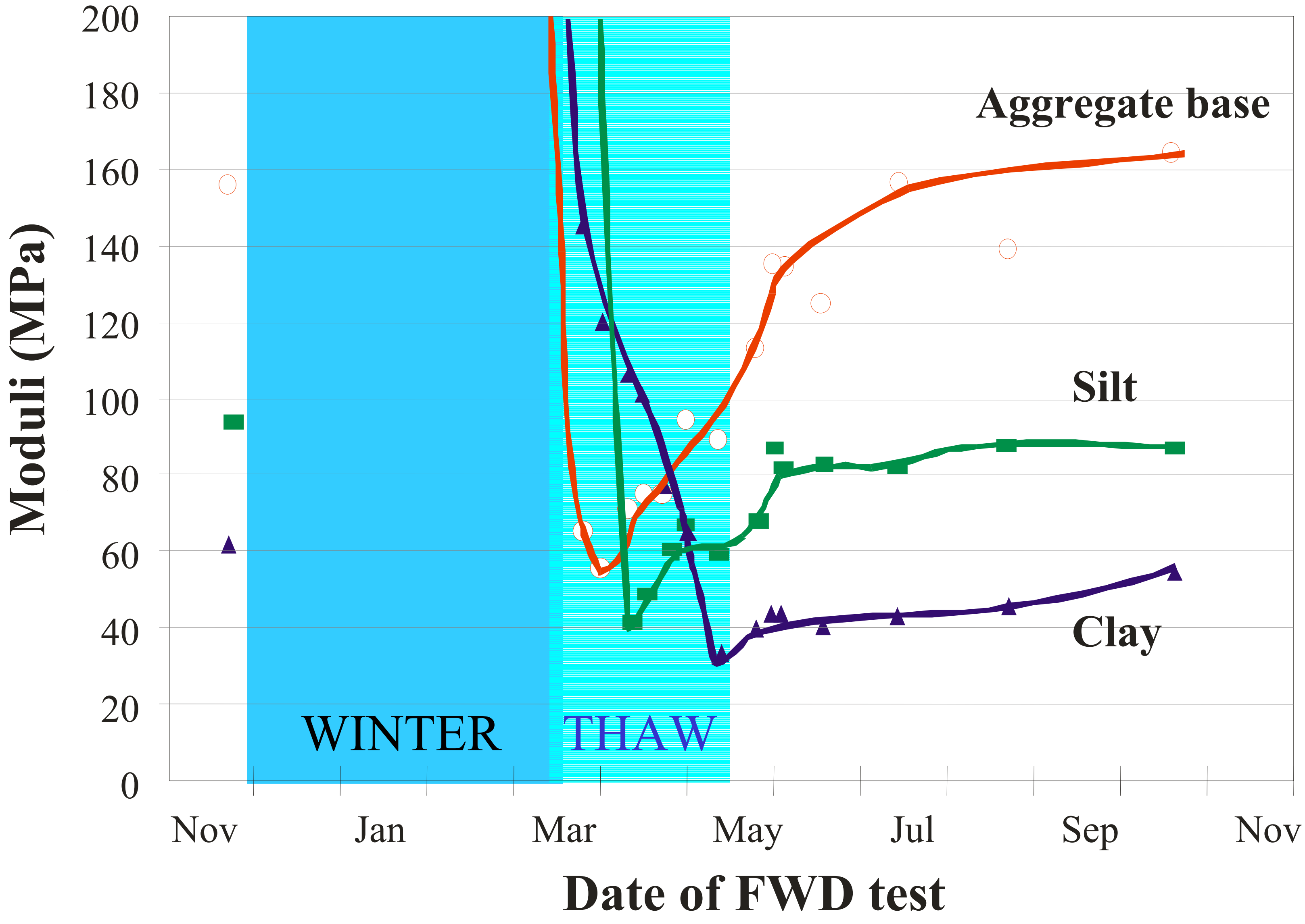
Structural Damaging (1/N)



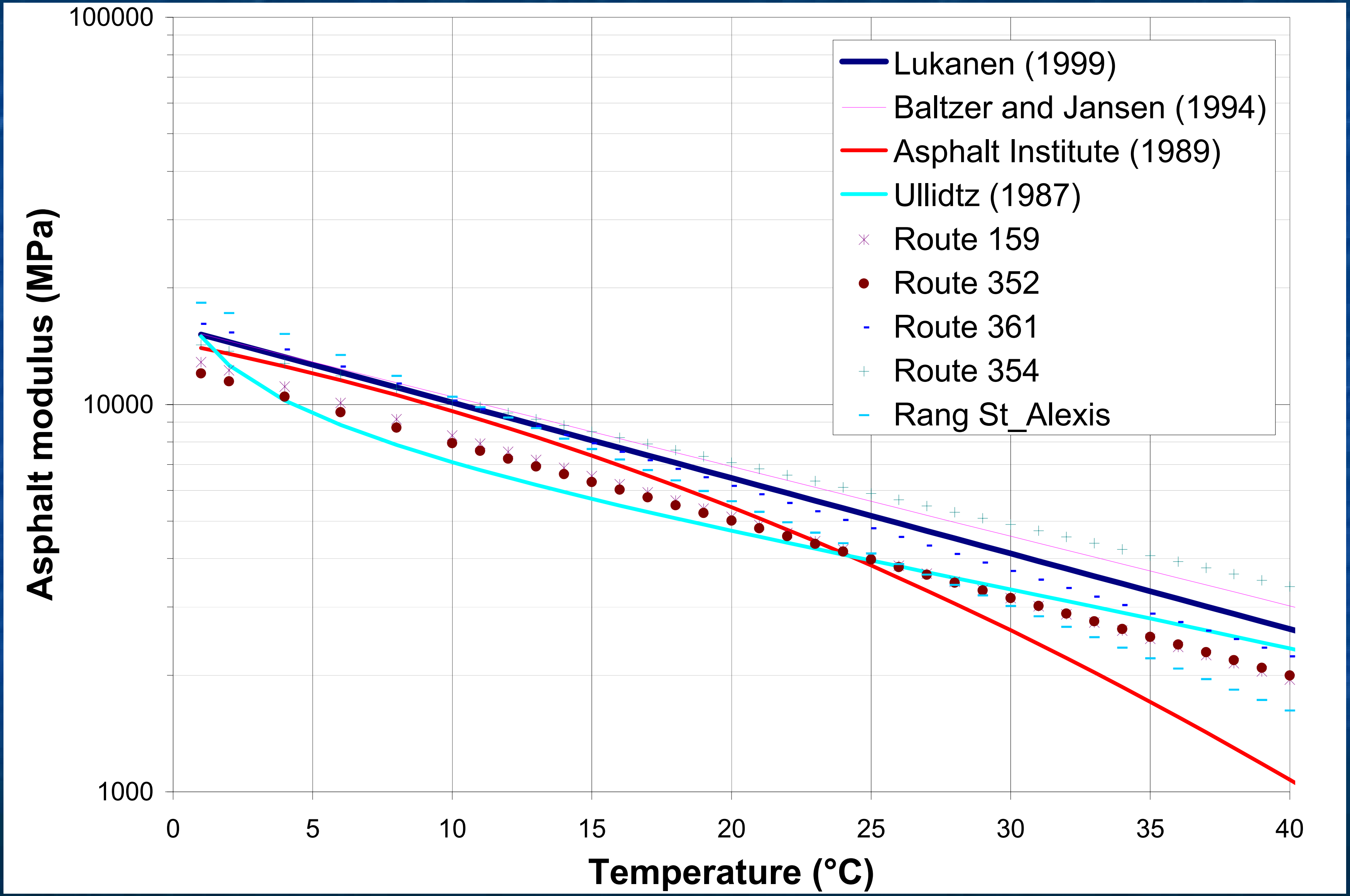
Layered Elastic Analysis Softwares

Unbound Materials Moduli

Rang Saint-Alexis, Saint-Maurice



AC modulus



100000
10000
1000
Asphalt modulus (MPa)
0
5
10
15
20
25
30
35
40
Temperature (°C)
Lukanen (1999)
Baltzer and Jansen (1994)
Asphalt Institute (1989)
Ullidtz (1987)
Route 159
Route 352
Route 361
Route 354
Rang St_Alexis

Structural Indicators

- ε_t: AC elongation (fatigue cracking)
  - Six models from MTQ laboratory
  - Models from Norway, Alaska, Shell, Asphalt Institute
  - Empirical criteria based on $SCI_{20°C}$
- ε_v: rutting by permanent settlements
- PSI: AASHTO-1993 model
    - SN_1 corrected at 20°C

Theoretical Simulation of Structural Damages

Freezing Sensor and Climatic Data

Periodic FWD Testing

Layered Elastic Theory

Fatigue Law

Traffic Data

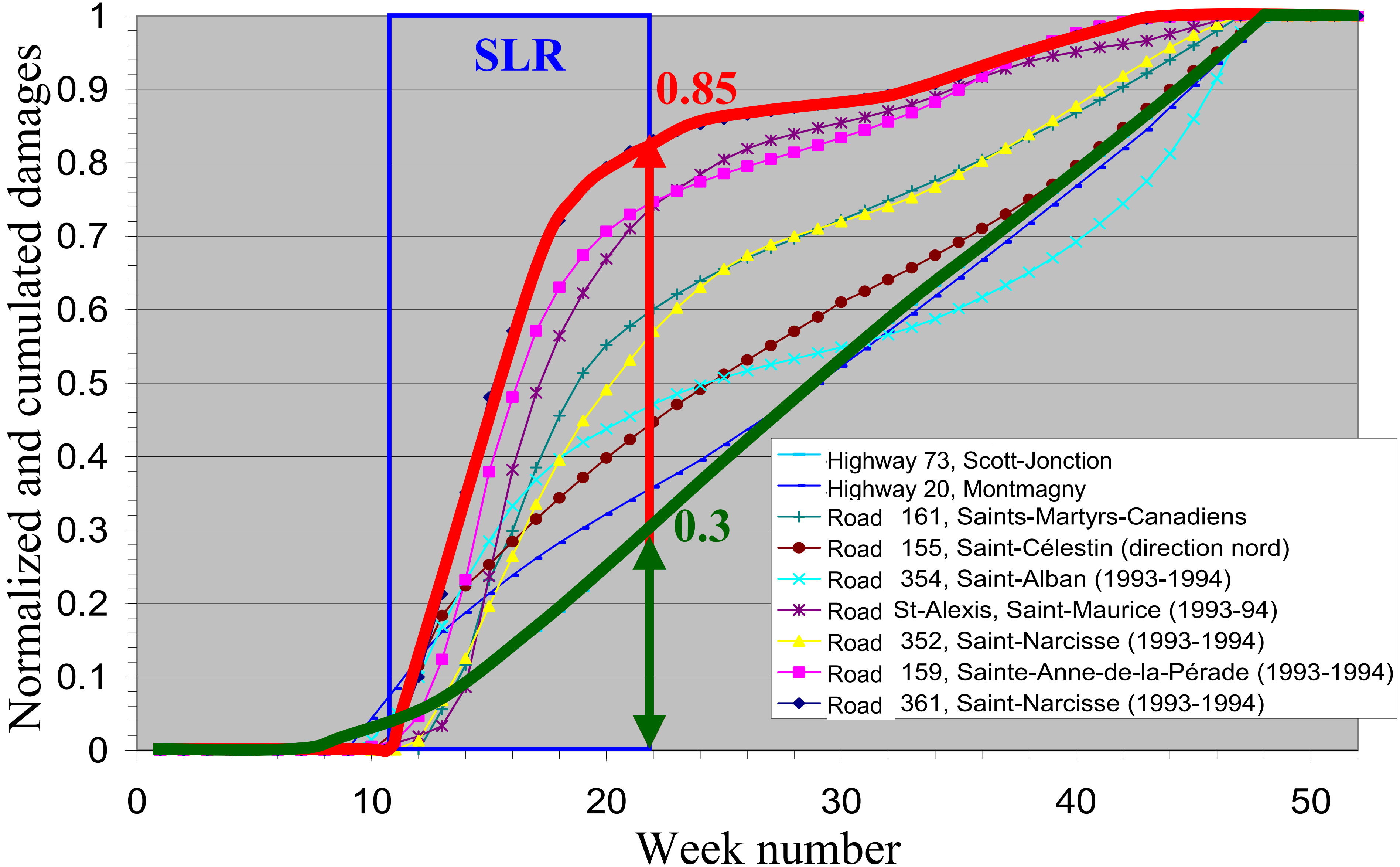
Damage

Time interval	Climatic and other conditions	Properties of the layers of pavement	Pavement deterioration indicator	N	n	D	RDF
Week 1	Temperature, freezing, thawing, (water surface, precipitation, melting snow and ice, state of stress)	Types of materials, thickness, resilient modulus, fatigue strength	Strain, structural number, surface curvature index	$N_i = f$ (indicator)	$n_i =$ ESAL number	Miner's Law: $D_i = n_i / N_i$	$RDF_i = D_i / D_{mean}$
Week 2							
Week 3							
Week i							
Week 52							

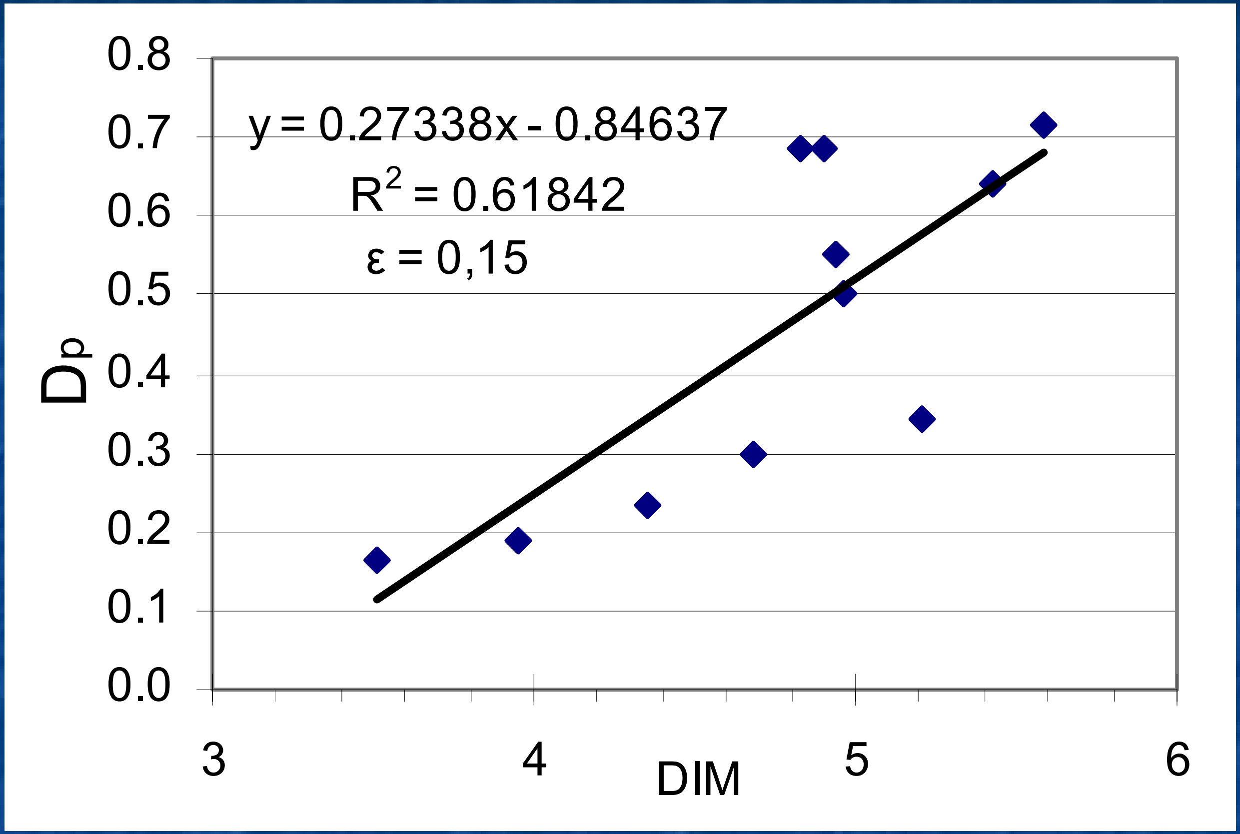
Mean: D_{mean}

Life expectancy: $1/D_{mean}$

Theoretical simulations (damaging)



Spring damages ≈ f (summer deflection)



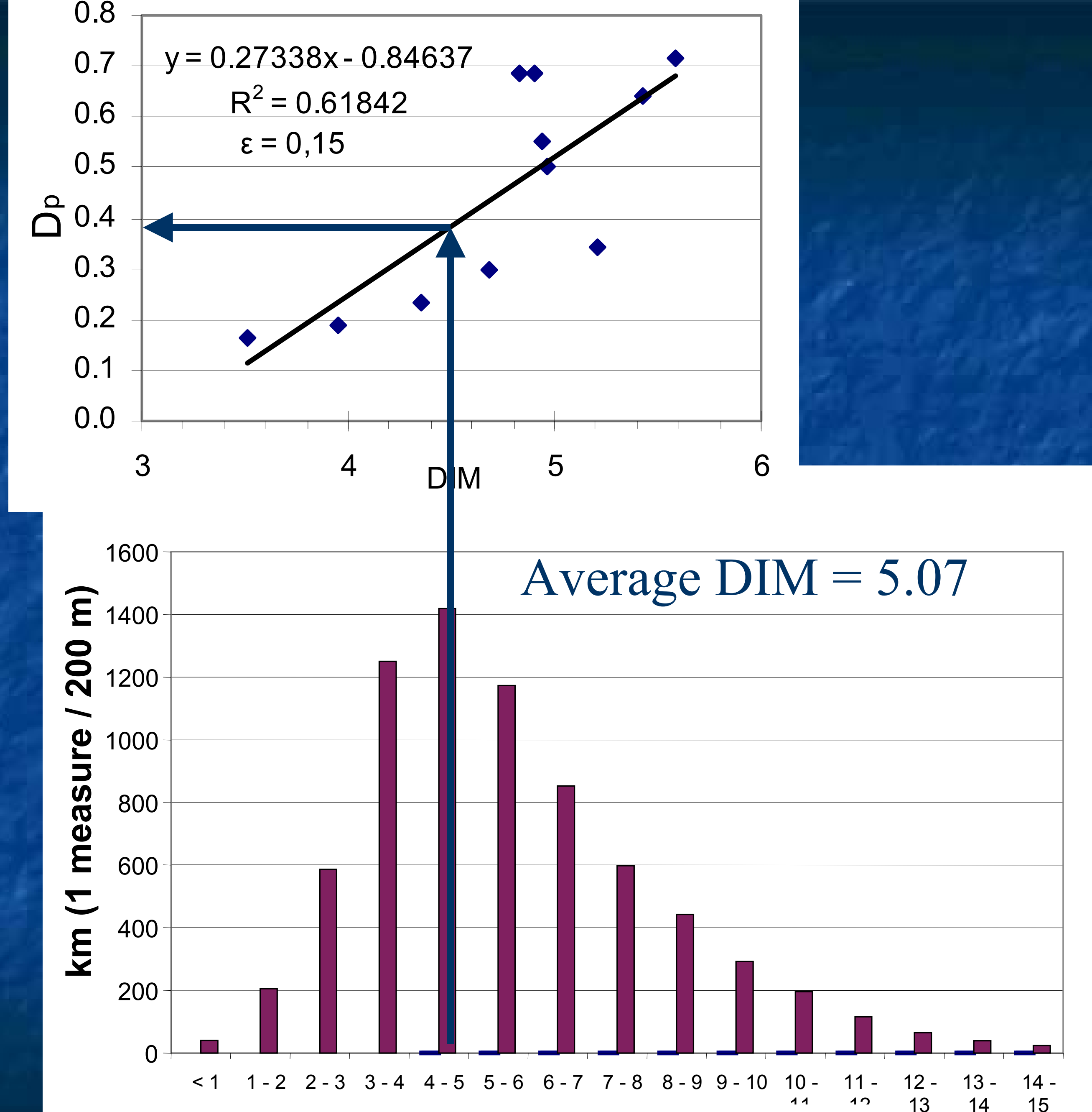
- Allow to use deflection inventory in order to extend conclusions for the whole pavement network

(Adjusted values to account for actual traffic conditions)

1410 km with DIM between 4 à 5

$\Rightarrow$ Dp = 0.38

Weighted average = **0,63**



Dynaflect inventory

ex: national roads

$$\text{DIM} = \sqrt{(0{,}25 \cdot d_{0c} \cdot \text{SCI}_{300c})}$$

If We Remove Spring Load Restrictions (SLR)

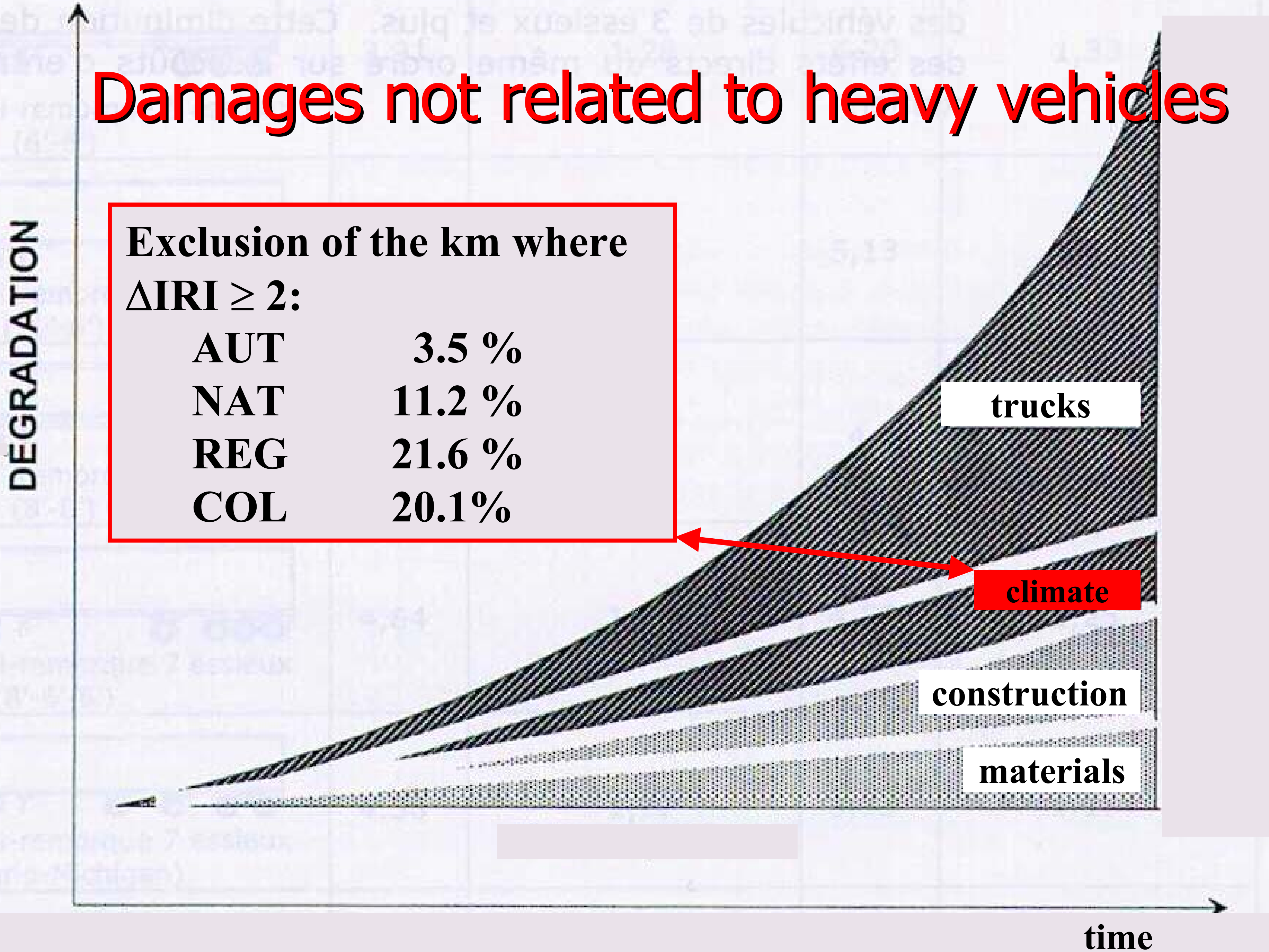
% life reduction = Dp x Δ ESALS

Highways	0.08	(	0.37	x	0.19	)
National roads	0.12	(	0.63	x	0.19	)
Régional roads	0.14	(	0.71	x	0.19	)
Collector roads	0.15	(	0.78	x	0.19	)
Municipal roads	0.14	(	0.74	x	0.18	)

- A typical kilometer of *National Road* cost 10 000$ per year to maintain. The reduced life expectancy of 12% means a minimum annual overcost of 1200 $ per km

Dp = Damages during SLR period

Damages not related to heavy vehicles



Exclusion of the km where $\Delta IRI \geq 2$:

AUT	3.5 %
NAT	11.2 %
REG	21.6 %
COL	20.1%



Actual maintenance cost of the pavement network

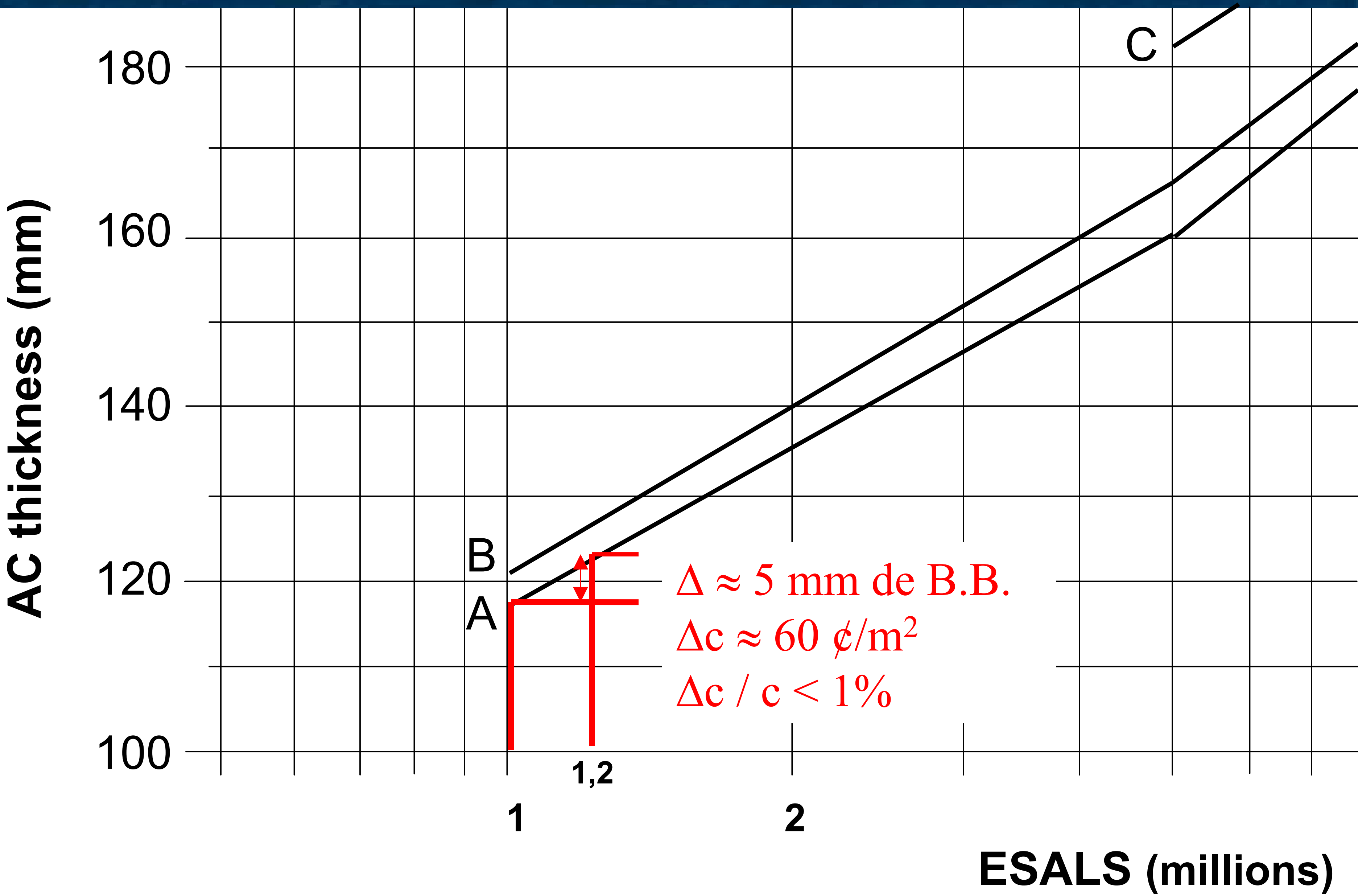
Class of road	Cost (k$ / km / year)	
	LCCA	**PMS**
Highways	14,5 à 18,1	**14,5**
National	9,2 à 11,9	**9,7**
Regional	6,8 à 9,2	**4,4**
Collector	5,6 à 7,6	**5,8**
Municipal	9,5 à 12,8	**5.8**

Network (km)	**Cost (M$ / y)**
3 571	**51.8**
8 843	**85.8**
4 535	**20.0**
6 382	**36.9**
32 859	**190.0**
	384.4

Municipal : **5,8** based upon values on collector roads
PMS (Pavement Management System)

PMS costs from Jocelyn Beaulieu, ing. Service Orientations stratégiques

Design adjustments



If We Remove
Spring Load Restrictions (SLR)

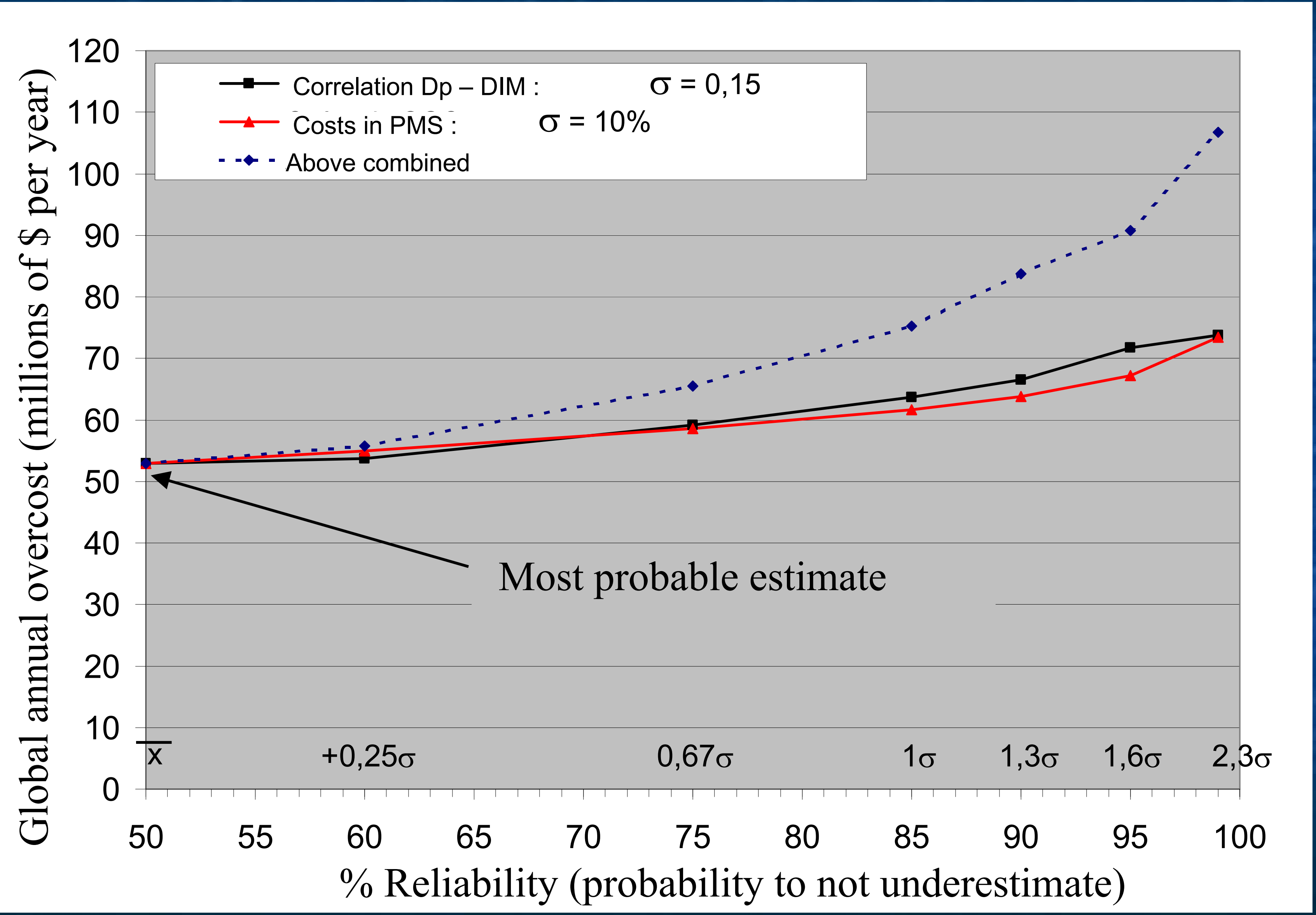
MTQ : 24.4

- Highways : 4.2
- National : 11.5
- Regional : 2.9
- Collector : 5.8

MUNICIPAL : 26.9

TOTAL : 51.3 millions of $

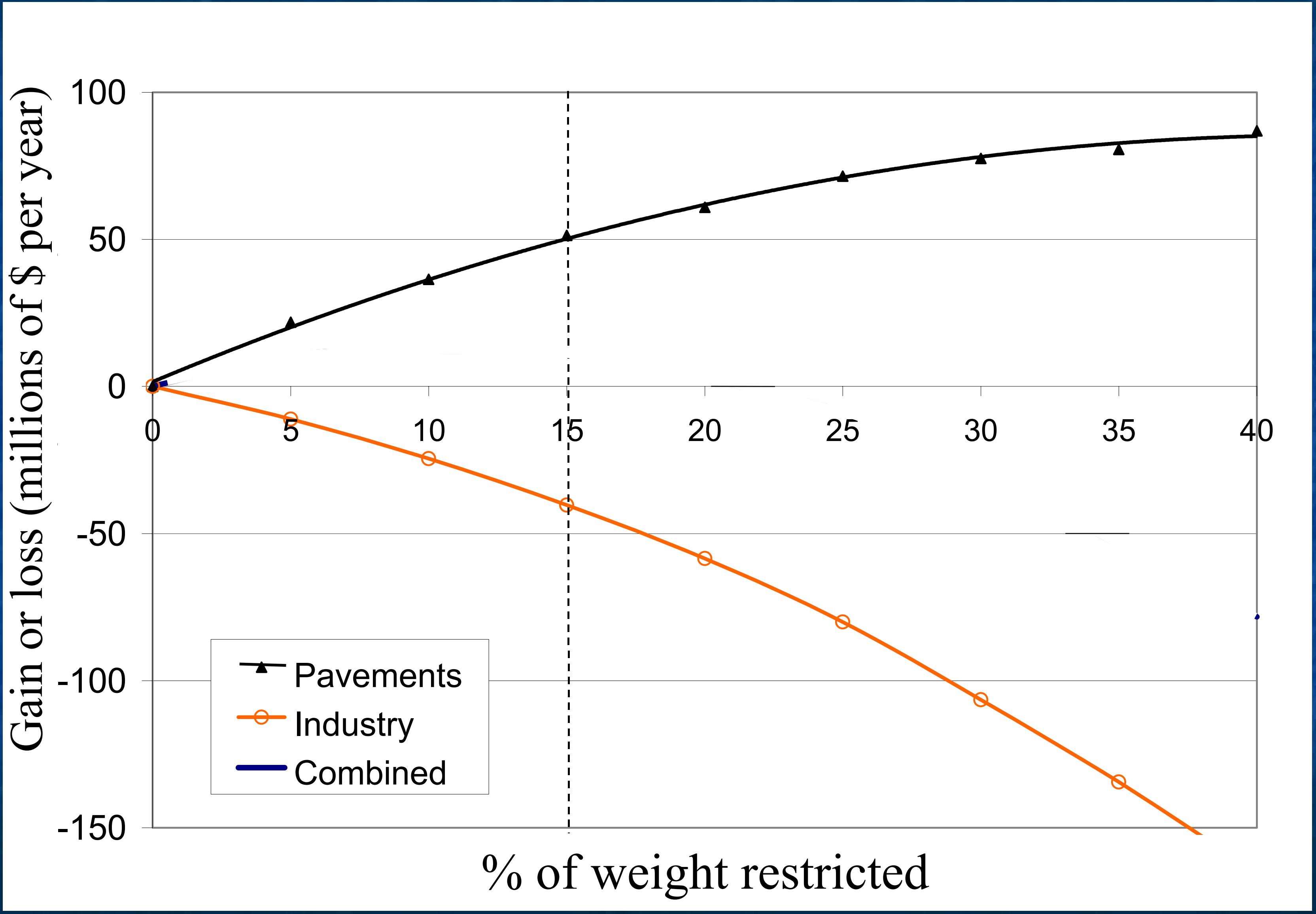
Sensitivity and reliability within standard deviation of data



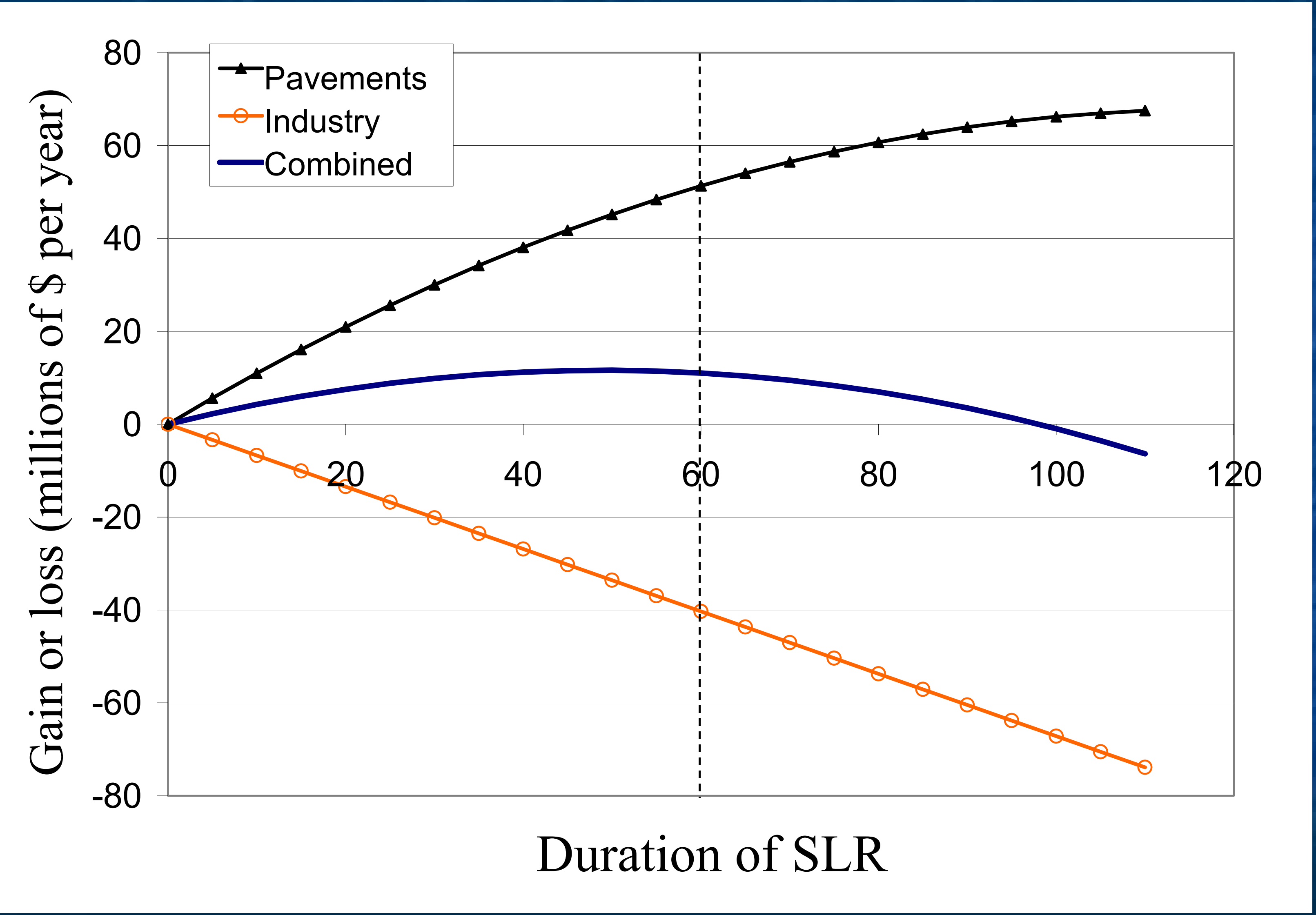
COMPARISON

Québec
Ministère
des Transports

% of weight restricted



Duration restricted



Annotations

- Actual SLR are believed to provides at least about 50 millions of $ per year to the public road administrations (+50 > -40)

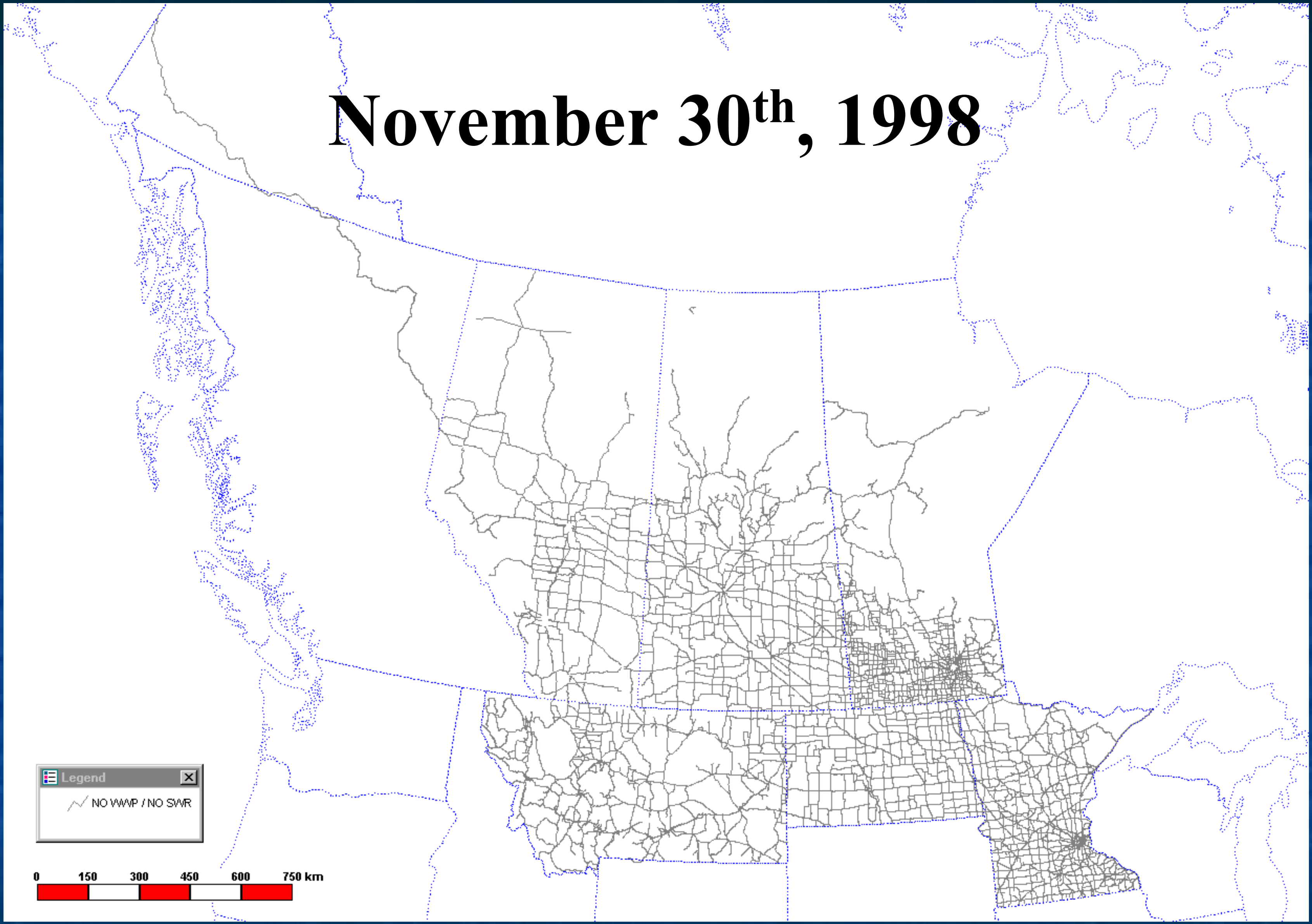
- When comparing with the industry counterpart, the Status quo appear as the optimum homogeneous solution

Heterogeneous approaches

Examples

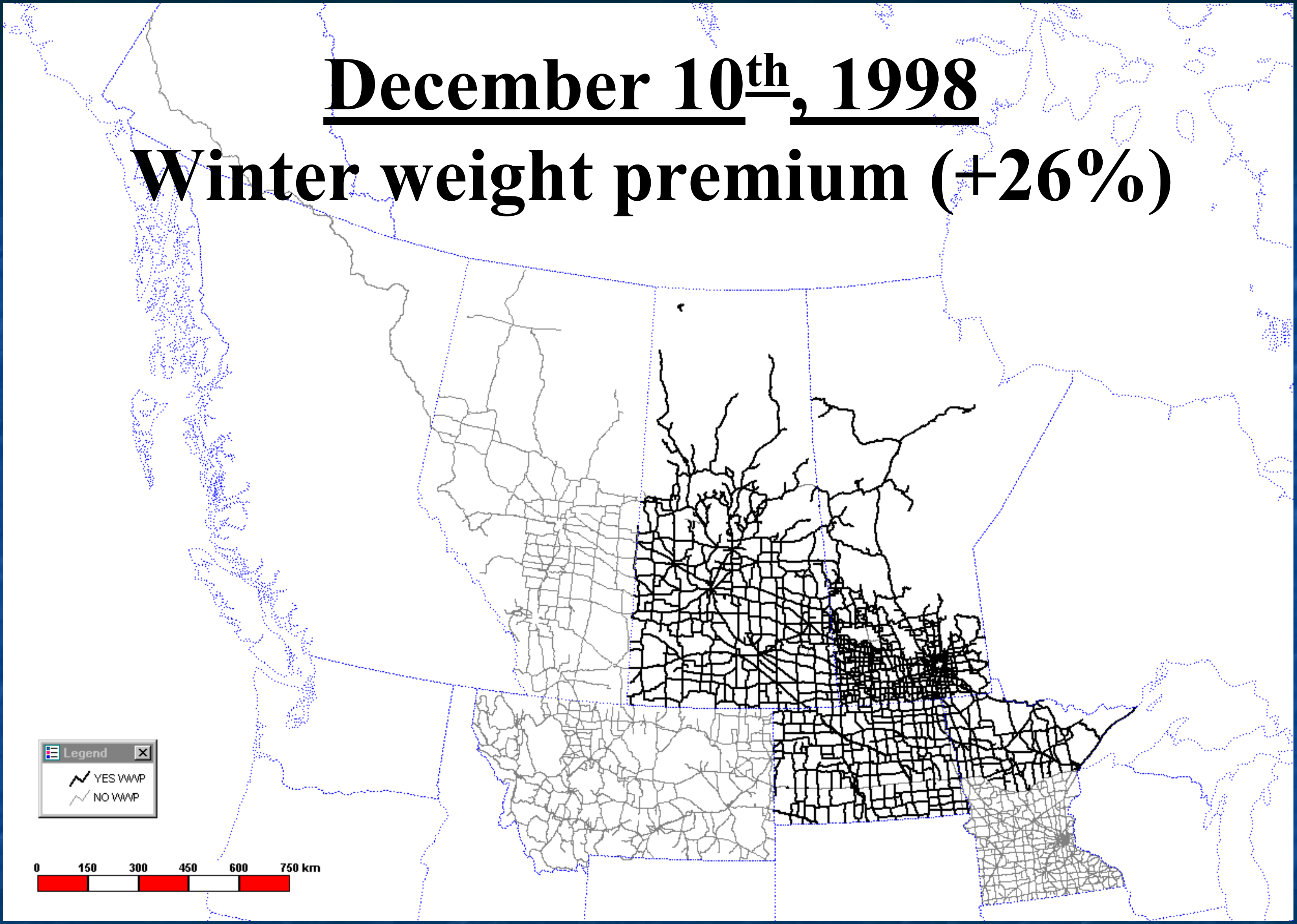
- Norway:
  - SLR : 0 / 12,5 / 25 / 50 % (removed in 1995)
  - Road network divided in three class of permitted loads all year long: 6 / 8 / 10 metric tons
- West of North-America (Canada – USA)
  - One slide per month from November 30th, 1998 to July 1st, 1999.

November 30th, 1998



From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

December 10th, 1998
Winter weight premium (+26%)



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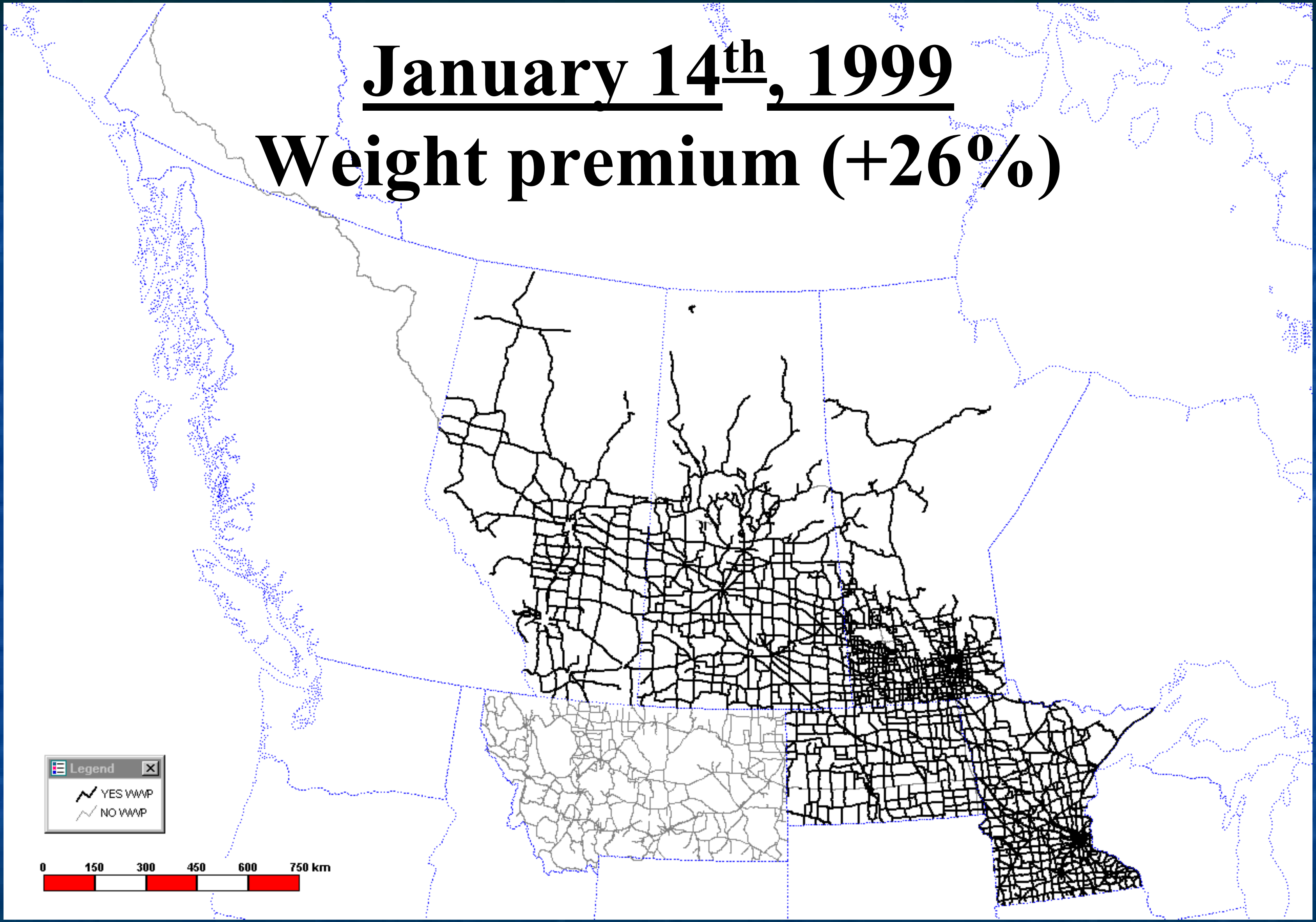
January 14th, 1999
Weight premium (+26%)

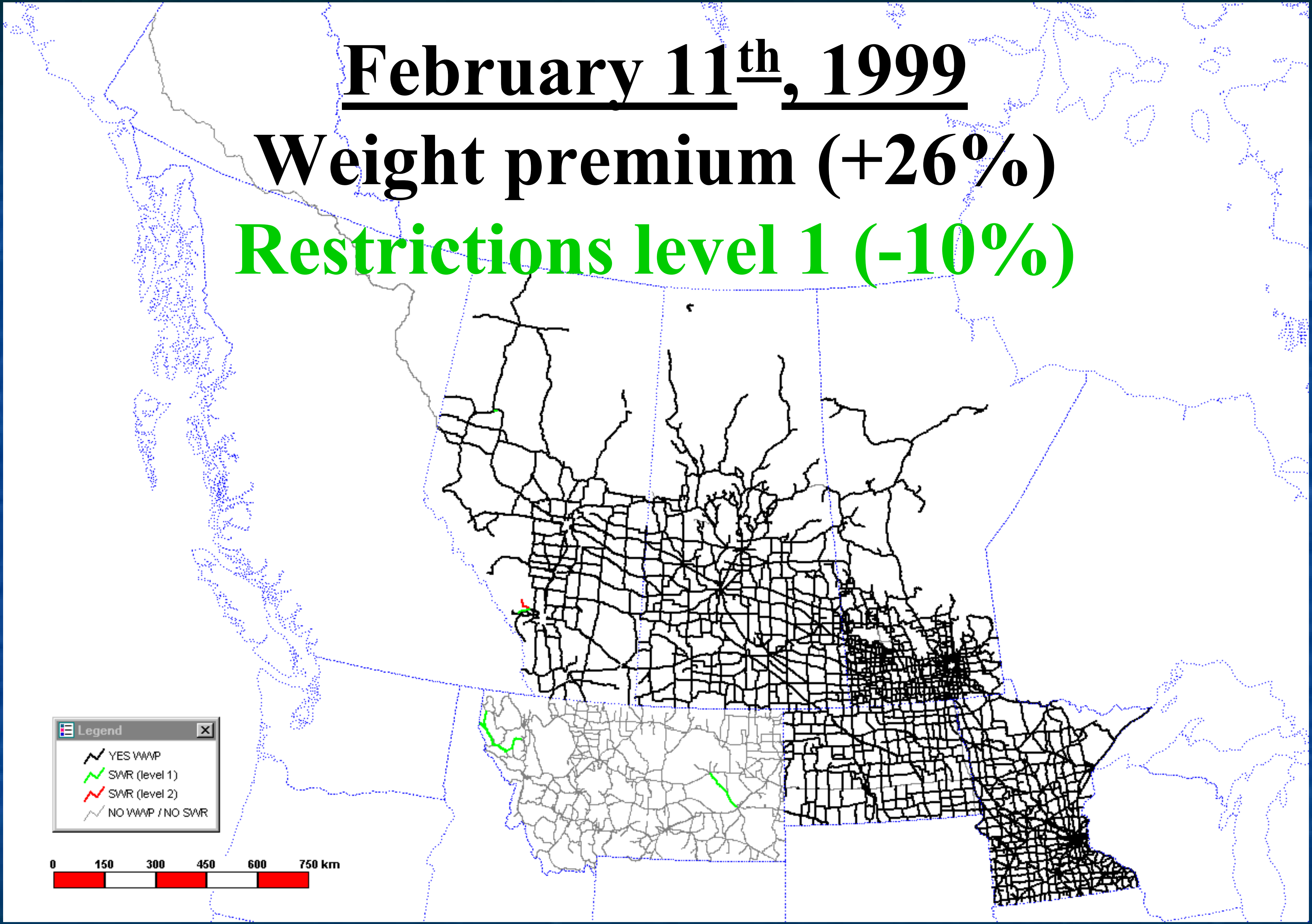


From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

February 11th, 1999

Weight premium (+26%)

Restrictions level 1 (-10%)



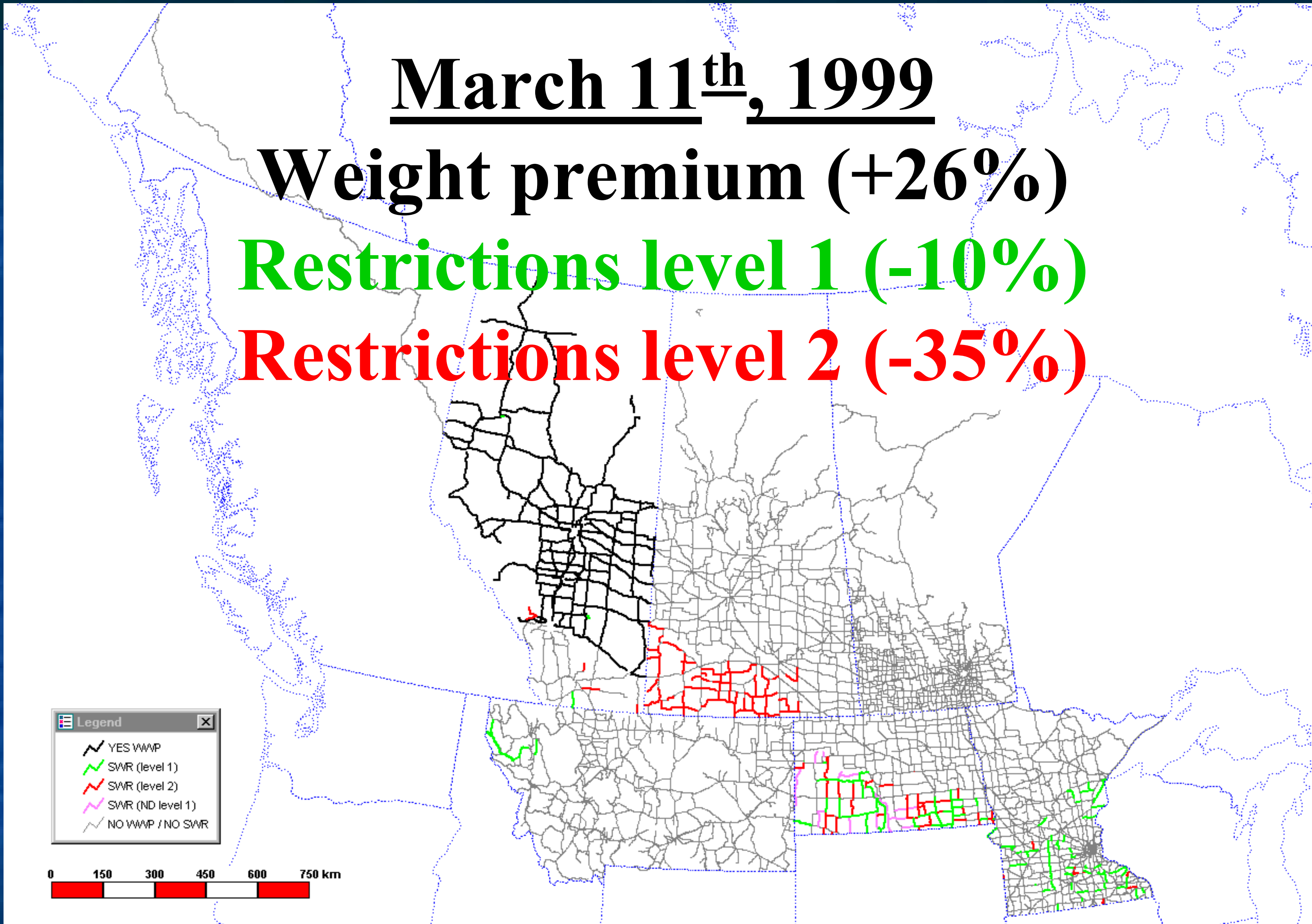
From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

March 11th, 1999

Weight premium (+26%)

Restrictions level 1 (-10%)

Restrictions level 2 (-35%)

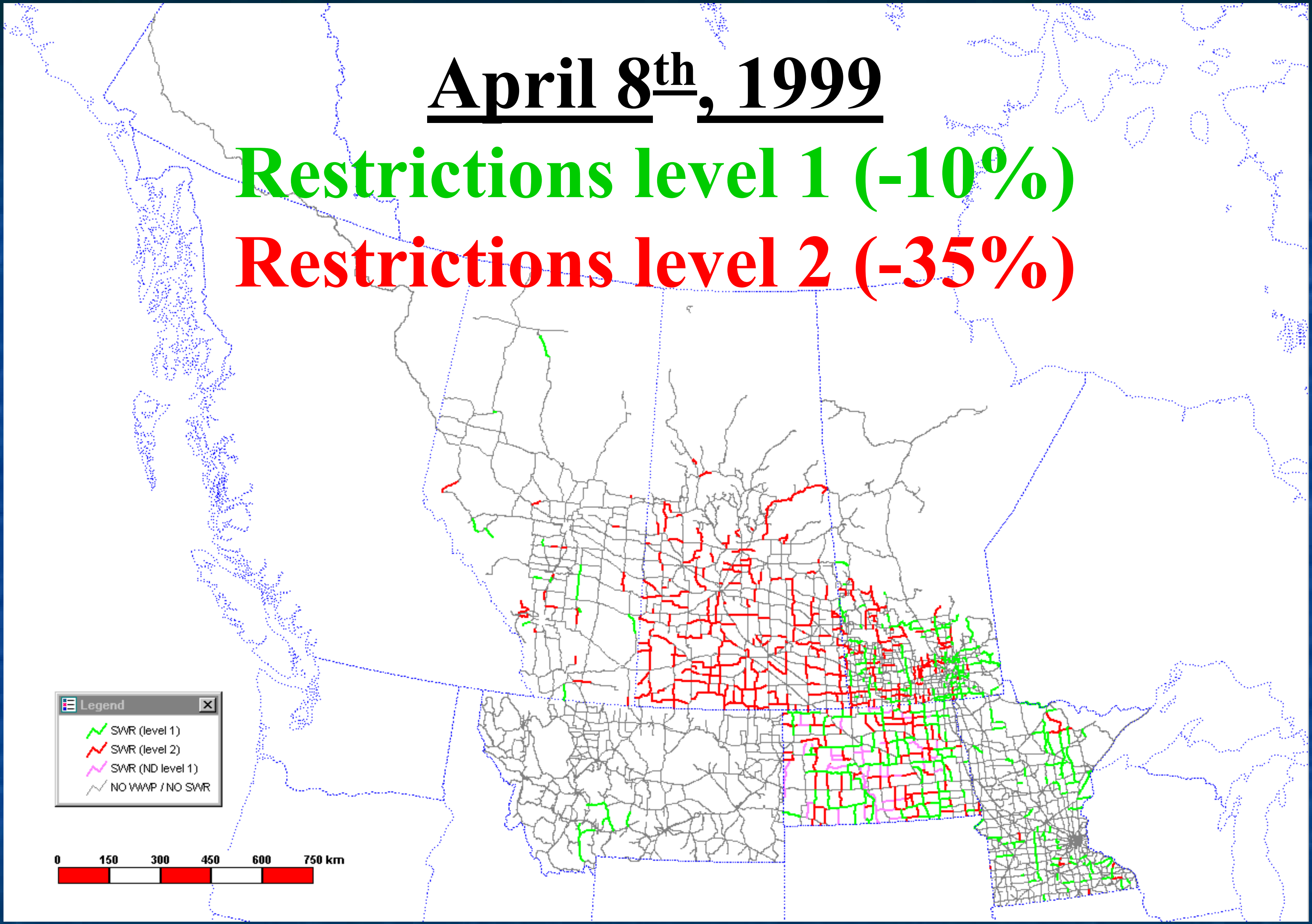


From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

April 8th, 1999

Restrictions level 1 (-10%)

Restrictions level 2 (-35%)

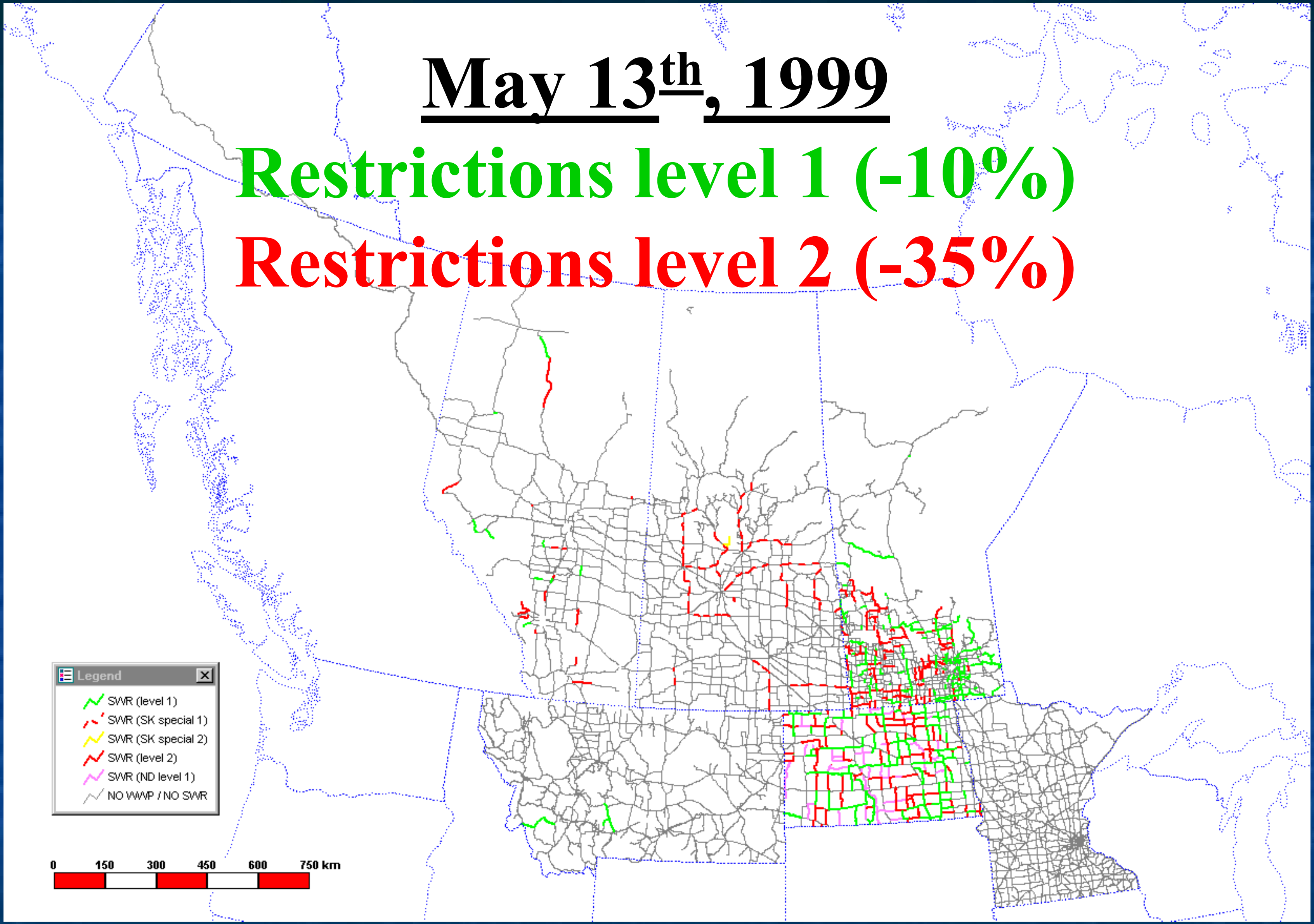


From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

May 13th, 1999

Restrictions level 1 (-10%)

Restrictions level 2 (-35%)

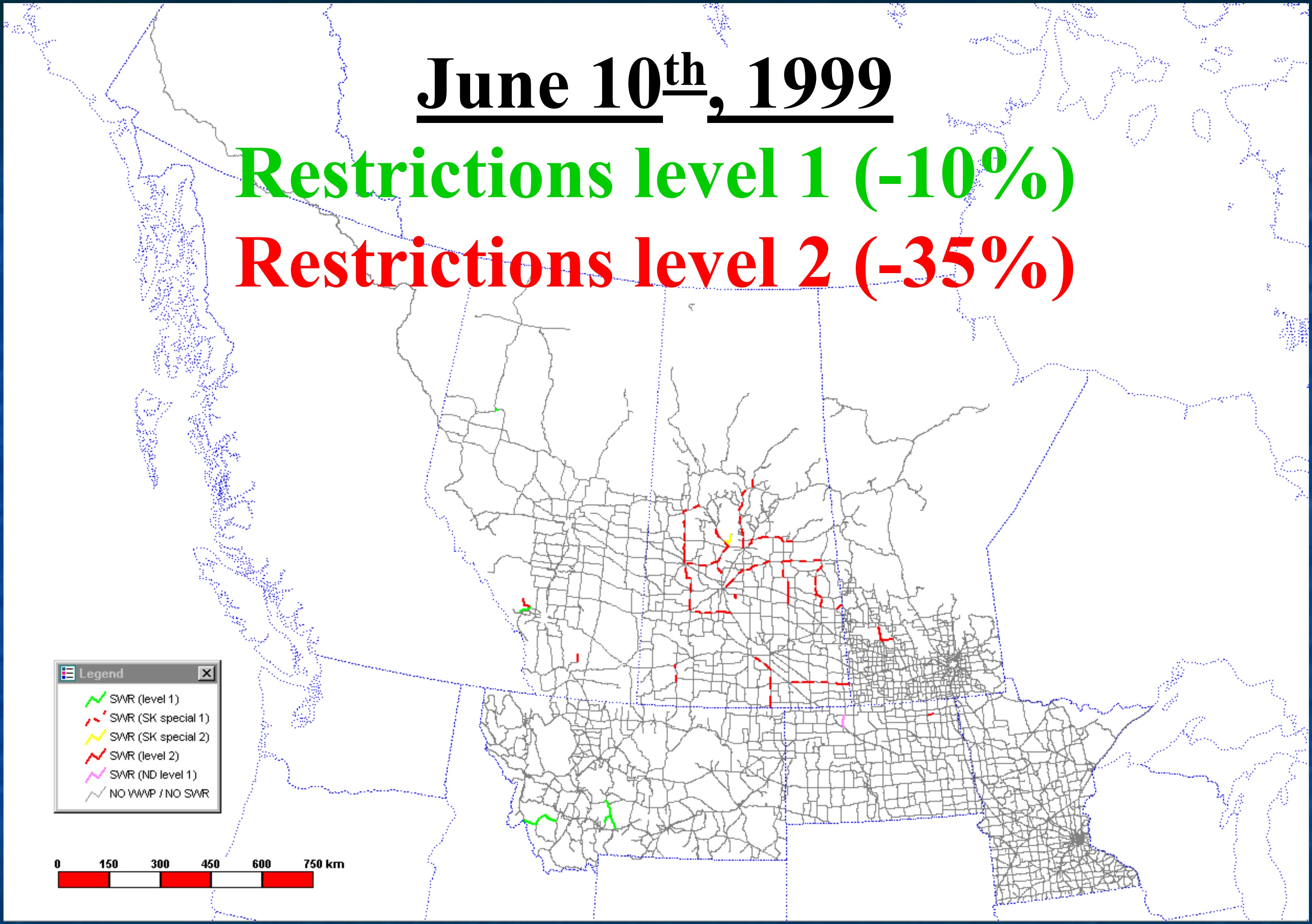


From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

June 10th, 1999

Restrictions level 1 (-10%)

Restrictions level 2 (-35%)



From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

Heterogeneous approaches

- Some problems remains
  - Enforcement
    - Complicated to adequately practice
    - Actual enforcement scales mostly on highways
    - Increased risk of contravening
  - Needs extensive, network level, monitoring of pavement bearing capacity (deflections)
  - Needs harmonisation of a set of predetermined itineraries
    - Each trucks need to use local roads « *before going in* » and « *after going out* » of highways
    - Carefull study needed in order to avoid showing favouritism or being prejudicial to individual interests
  - Increasing restrictions on local roads leads to reduced efficiencies due to unavoidable exceptions (busses, vehicles of public utilities …)

Restrictions hétérogènes

- Problèmes subsistants:
  - Gestion et contrôle des charges
    - Plus complexe à appliquer
    - les stations de pesage sont surtout sur les autoroutes
    - Risques accru de contrevenants
  - Nécéssité d'une auscultation soutenue de la portance sur tout le réseau
  - Nécessité d'harmoniser les principaux itinéraires
    - Les camions doivent utiliser une route secondaire pour entrer et sortir des autoroutes
    - Étude minutieuse requise pour éviter des injustices entre les différents intérêts individuels des entreprises
  - Des restrictions accrues sur les routes locales veraient leur efficacité réduite à cause des exceptions inévitables (autobus, véhicules d'utilités publiques, …)

CONCLUSION

- Homogeneous restrictions are recommended …

  until the developpement of acceptables solutions against the shortcommings of the heterogeneous approach

  - Enforcement more realistic in practice
  - Ensure the same justice for all
  - Status quo appears the optimum homogeneous solution
  - Maintain status quo until further notice
  - Consult all the partners (municipalities and counties, road enforcement services, shippers and industry, other entity concerned).