A Benefit-Cost Approach to Level of Service for Winter Road Maintenance Standards

- **Max Perchanok**
- Research Coordinator
- Ontario Ministry of Transportation
- max.perchanok@ontario.ca

Heather McClintock
Head, Maintenance Standards
Ontario Ministry of Transportation

Tina Greenfield
RWIS Coordinator
Iowa Department of Transportation

Liping Fu, Professor
Civil and Environmental Engineering
University of Waterloo

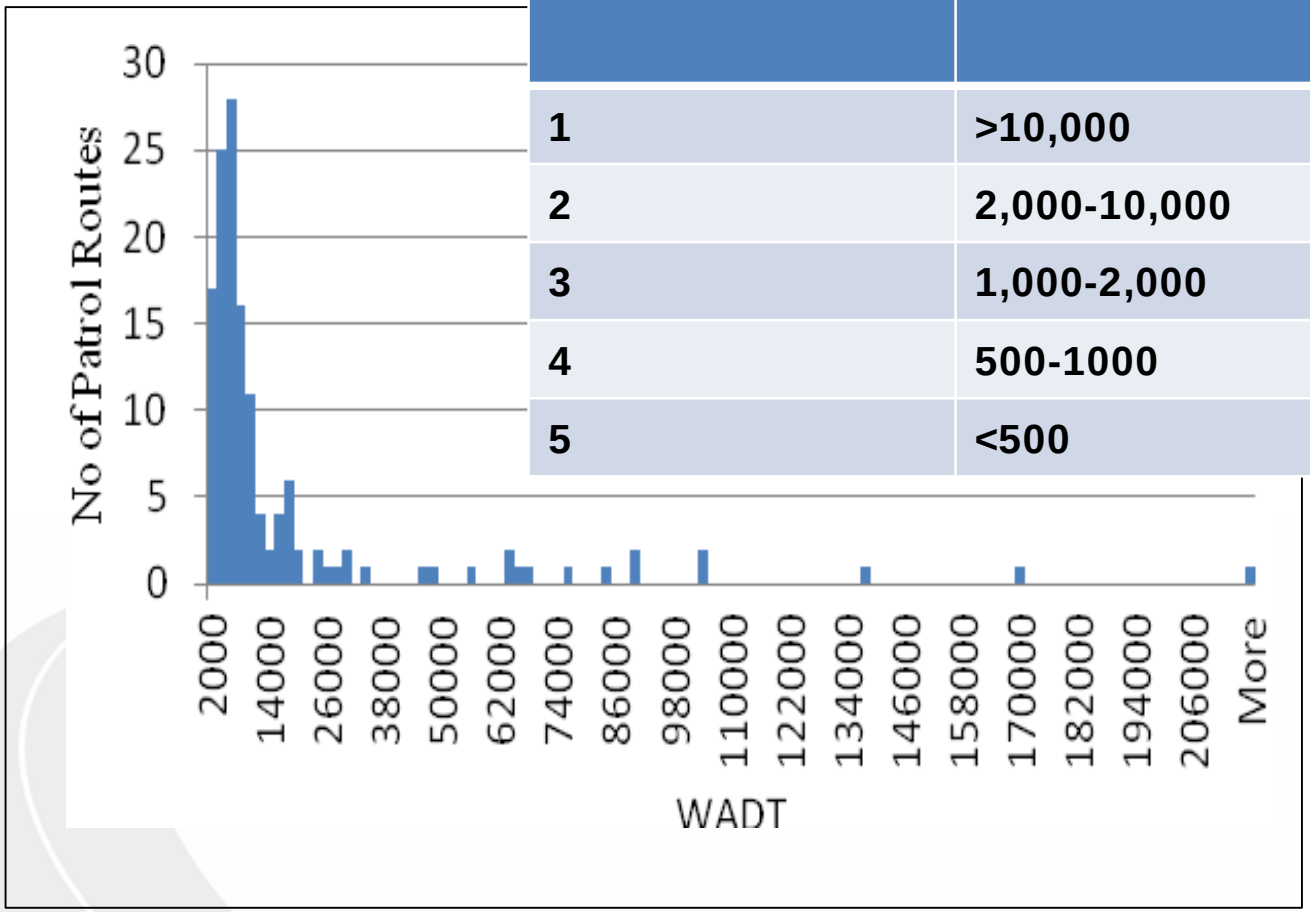
Lalita Thakali, PhD Student
Civil and Environmental Engineering
University of Waterloo

0. CONTENT

1. INTRODUCTION

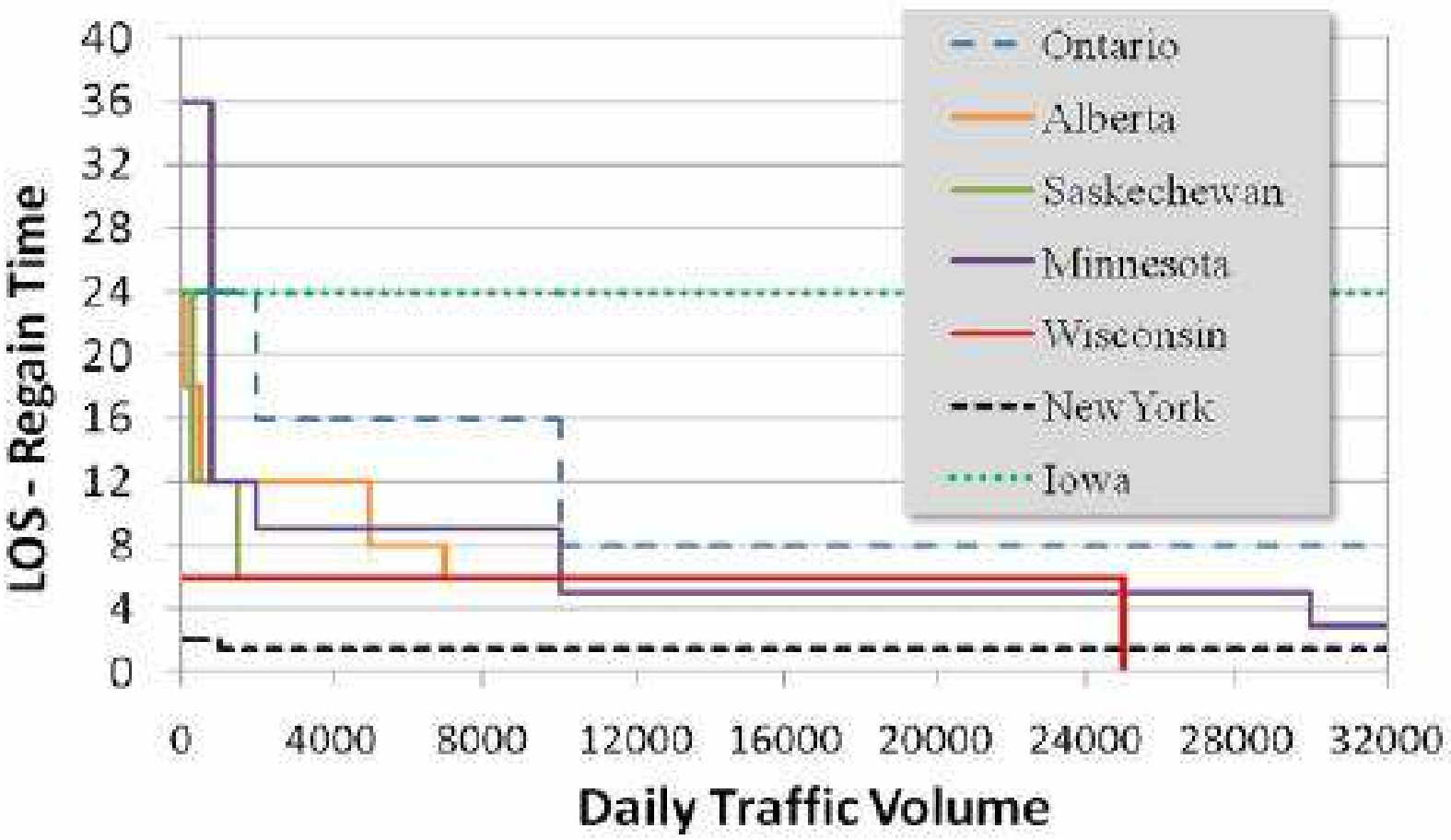
- Highway agency mission
- Constraints to winter maintenance
- Balancing interests of stakeholders

4. Background: Ontario Level of Service Standards



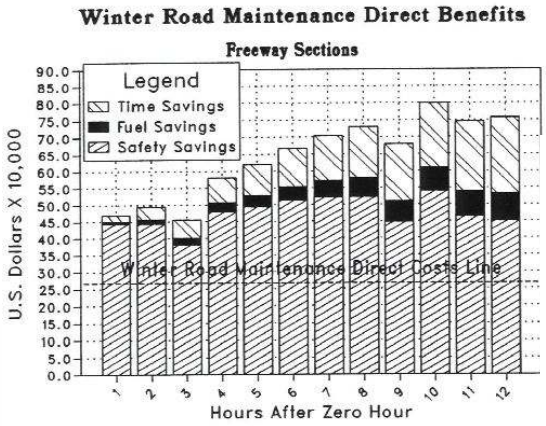
Class	W ADT	M ax. BPRT (hrs)
1	>10,000	8
2	2,000-10,000	16
3	1,000-2,000	24
4	500-1000	24 (centre bare)
5	<500	Snow covered

3. Background: North American Performance-based Standards



5. Background: Benefits and Costs of Winter Maintenance

- Benefit:cost analyses in winter maintenance
  - Indirect costs of accidents, mobility (Kuemmel & Hanbali, 1992 Shahdah and Fu, 2010 ; Fu et al, 2012)
  - Indirect costs of road salt (Environment Canada, 2013)
  - Direct costs equipment, materials, RWIS/MDSS (Veneziano et al, 2010)



Kuemmel & Hanbali, 1992

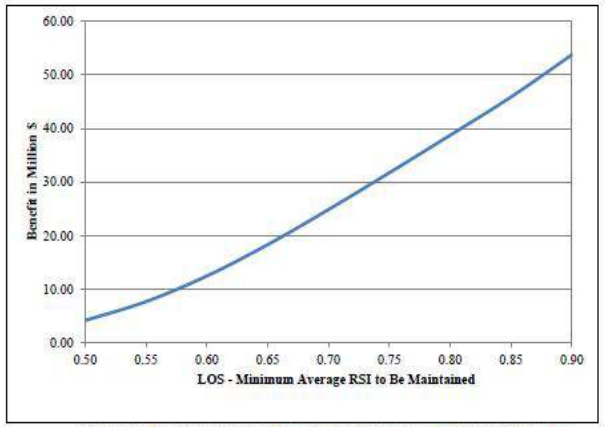


Figure 3: Additional Safety Benefit for Achieving a Given LOS Target

Fu et al, 2012

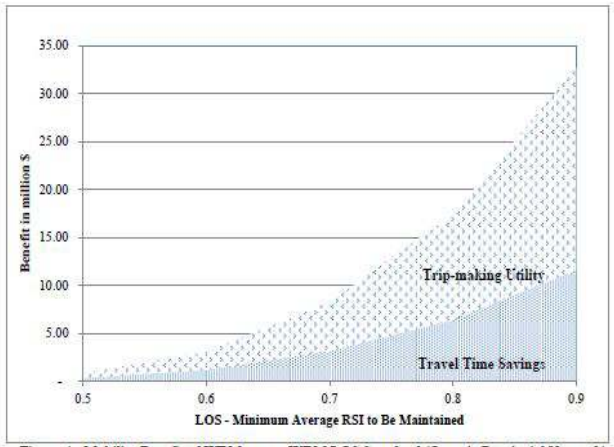
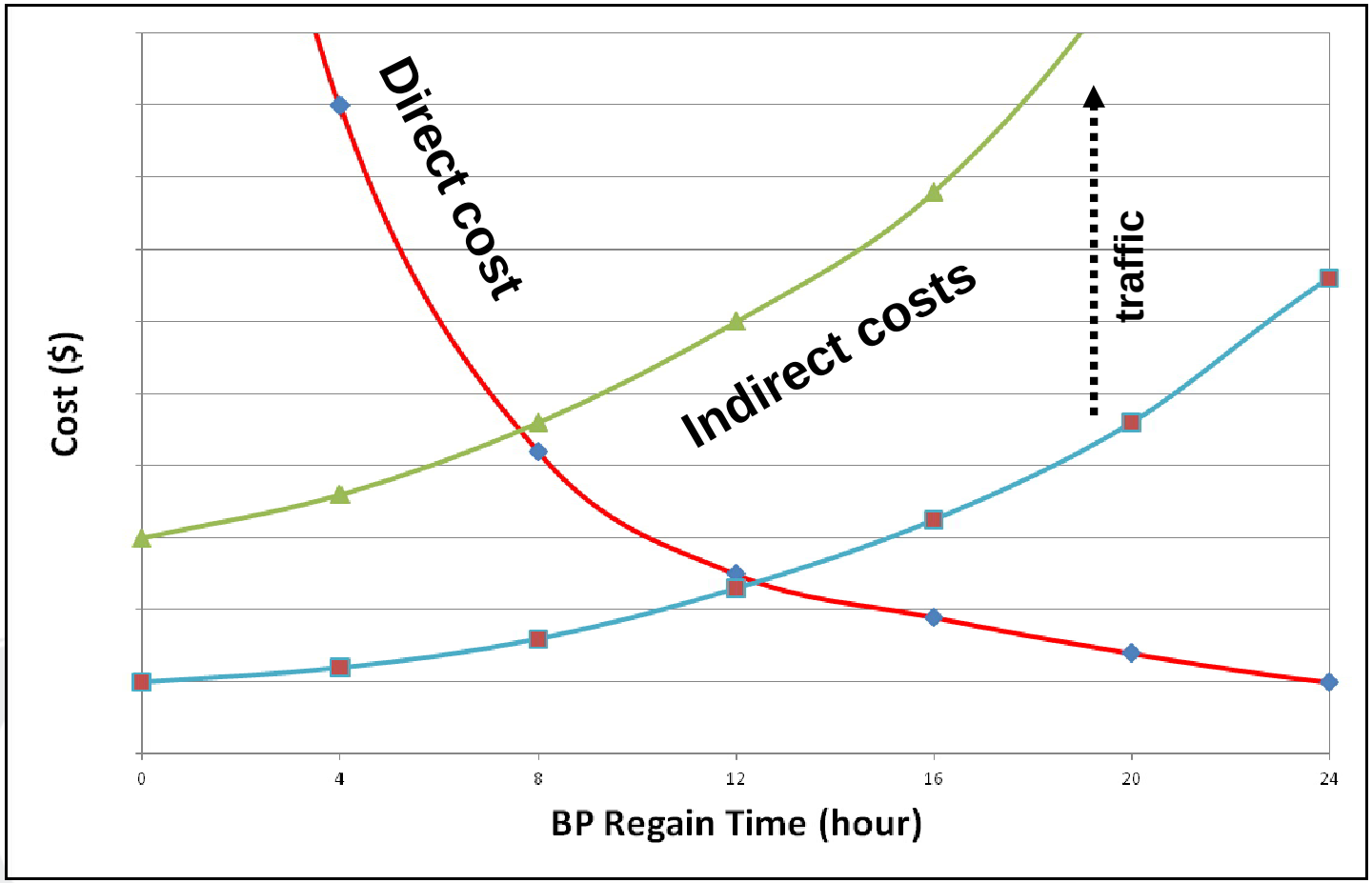


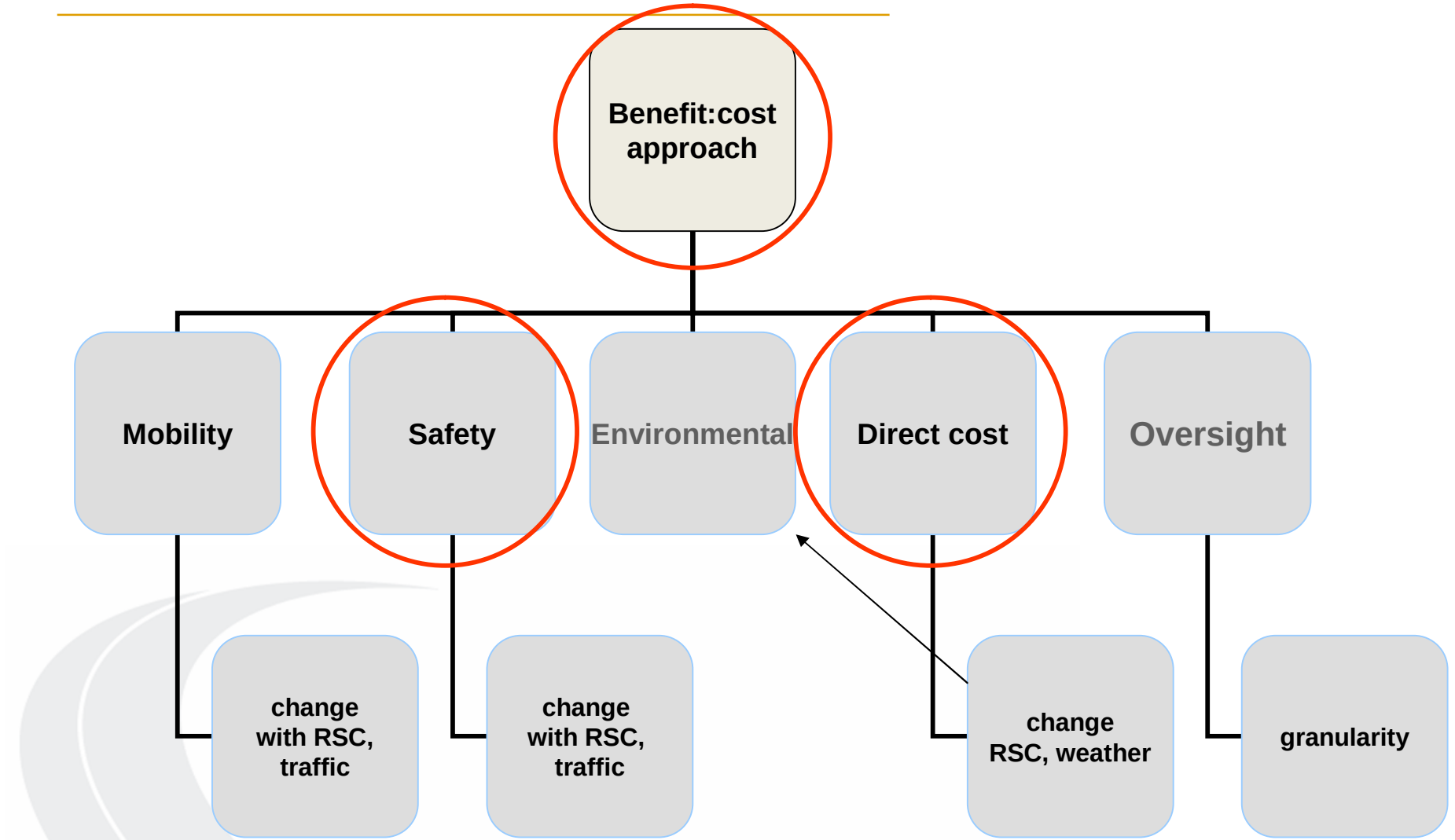
Figure 4: Mobility Benefit of WRM versus WRM LOS Standard (Ontario Provincial Network)

Fu et al, 2012

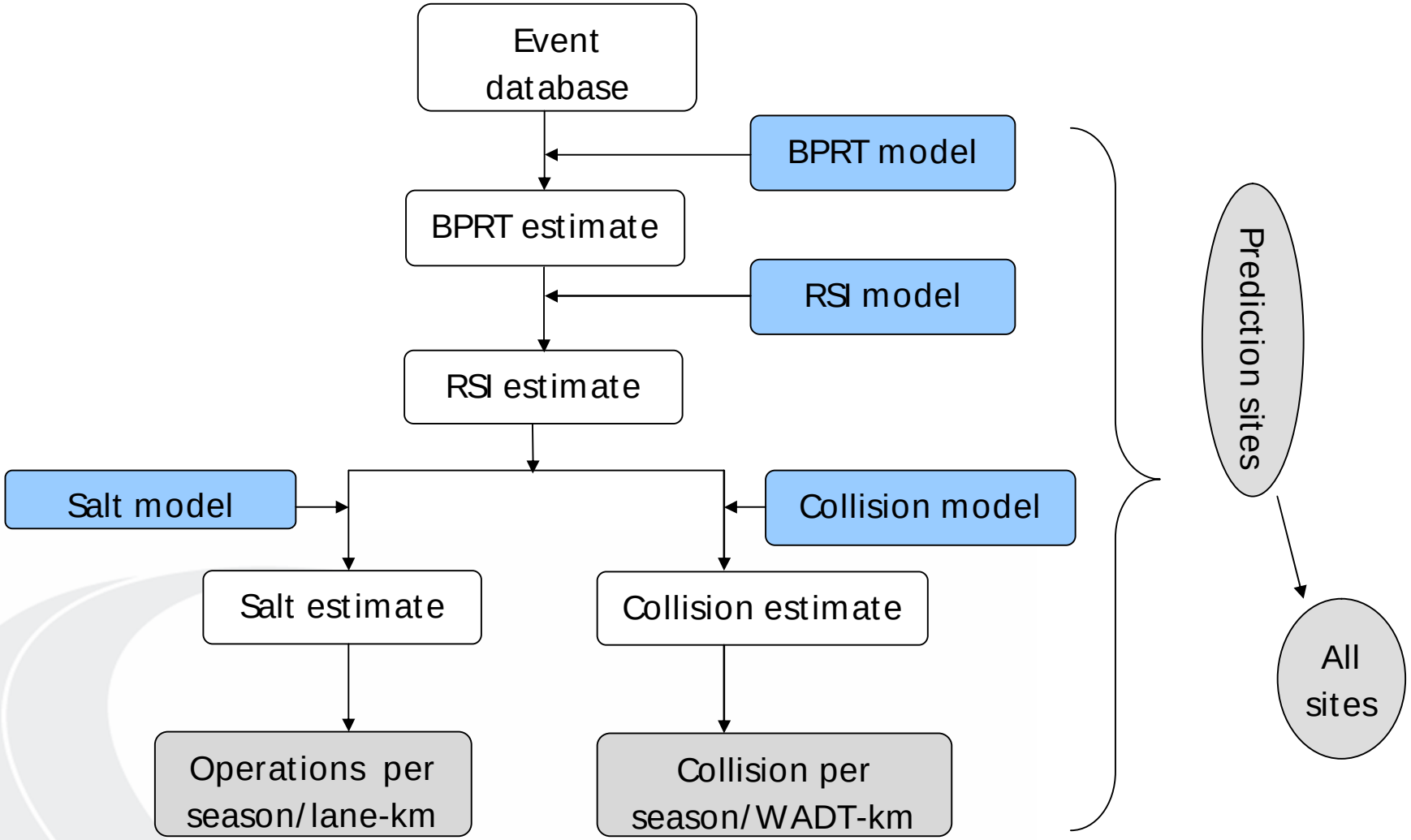
6. Benefit:cost approach to winter maintenance standards



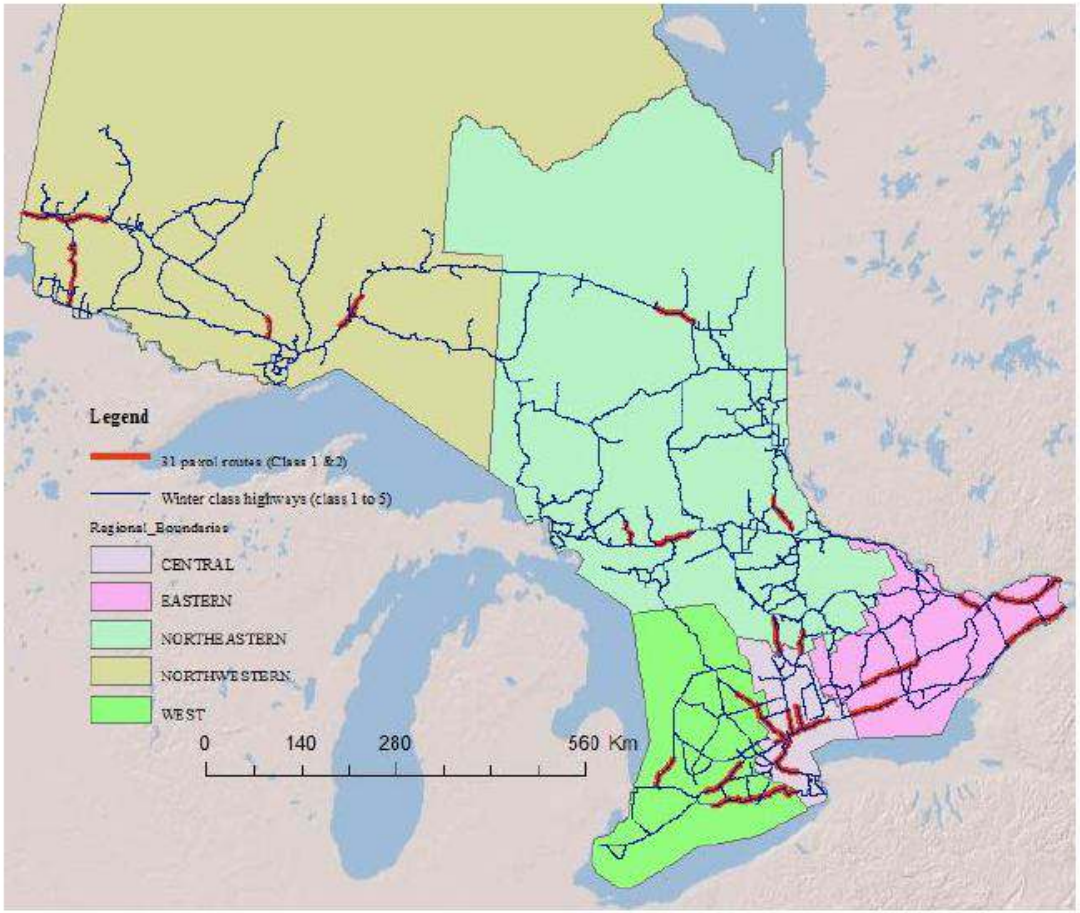
7. Study scope



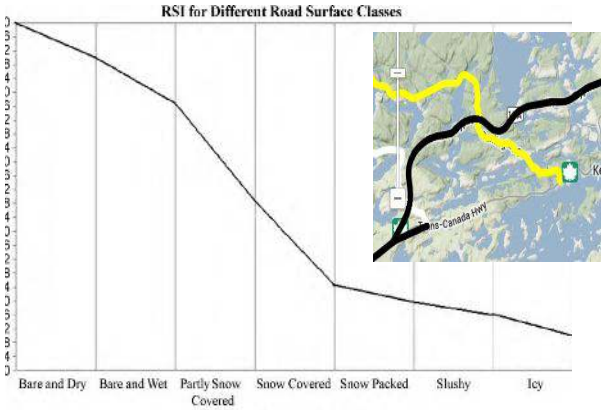
8. Methodology



11. Ontario calibration data



Class 1 and 2 model calibration sites



Hour → storm event

11. Results – model calibrations

Road Surface Index during storm event

$$RSI = 1.96 + 0.01 * T + 0.01WS - 0.03TP - 0.03\ ED + 0.17\ (Road\ Class\ 1)$$

Bare Pavement Regain Time after storm event

$$BPRT = 0.16 - 0.19 * T - 0.01WS + 0.19TP - 0.33\ (Road\ class\ 1)$$

Expected number of collisions during storm event

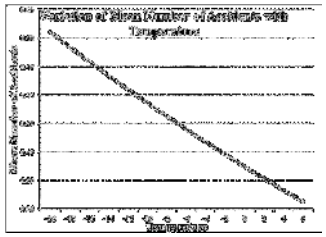
$$\mu = Exp^{0.648} * e^{-3.912 - 0.018T - 0.009WS - 0.044V + 0.014TP - 4.42RSI + M + S}$$

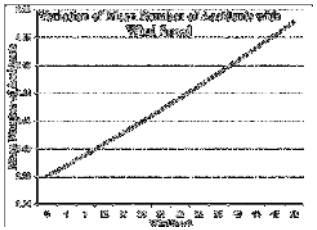
Salt application during storm event

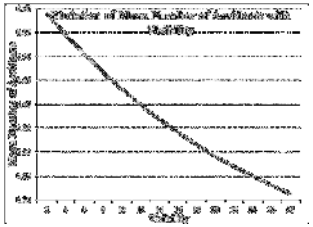
$$Salt = 57.6 - 0.64 * T - 1.36WS + 26.65TP + 50.56\ Road\ Class\ 1 + 8.6ED + 0.01TT$$

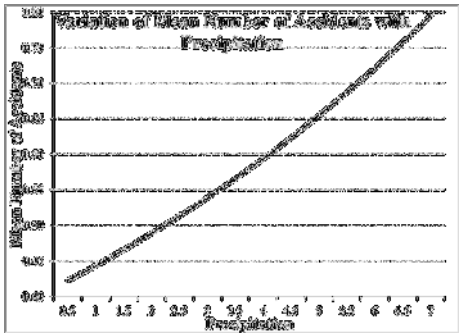
$$+ 32.26(Anti-icing)$$

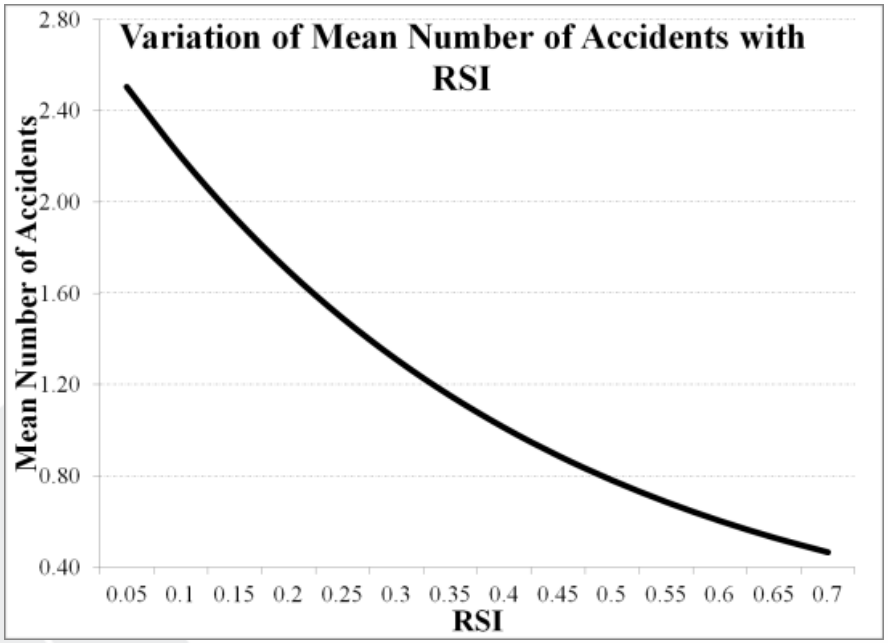
13. Collision model storm event calibrations

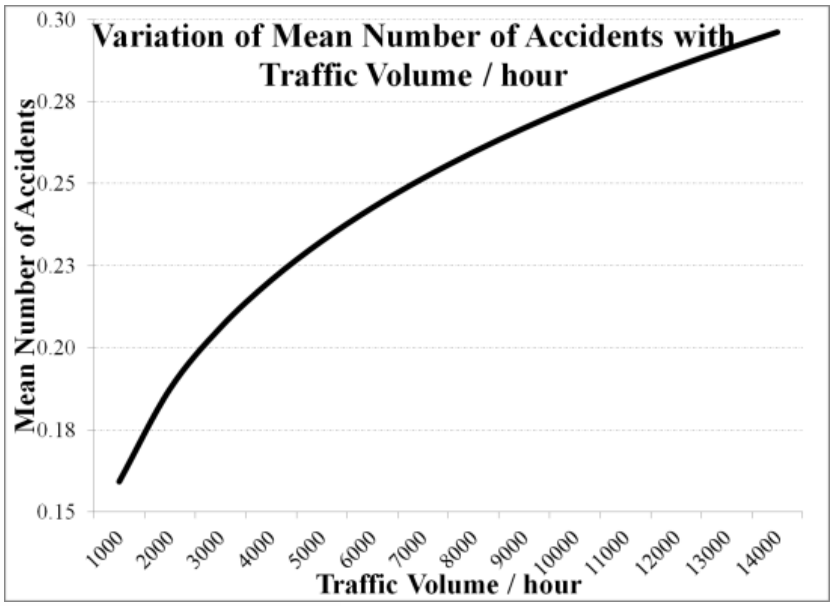




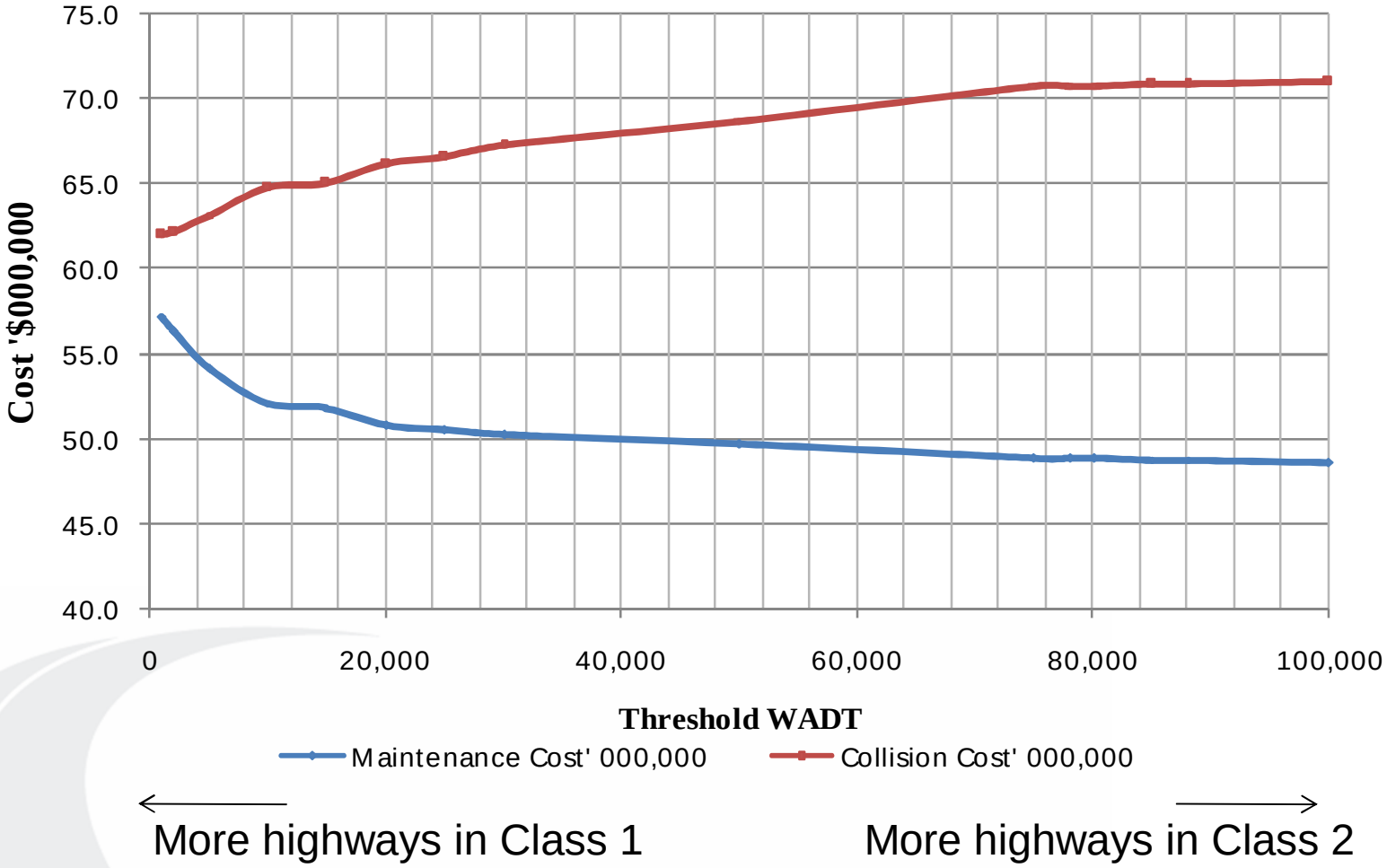




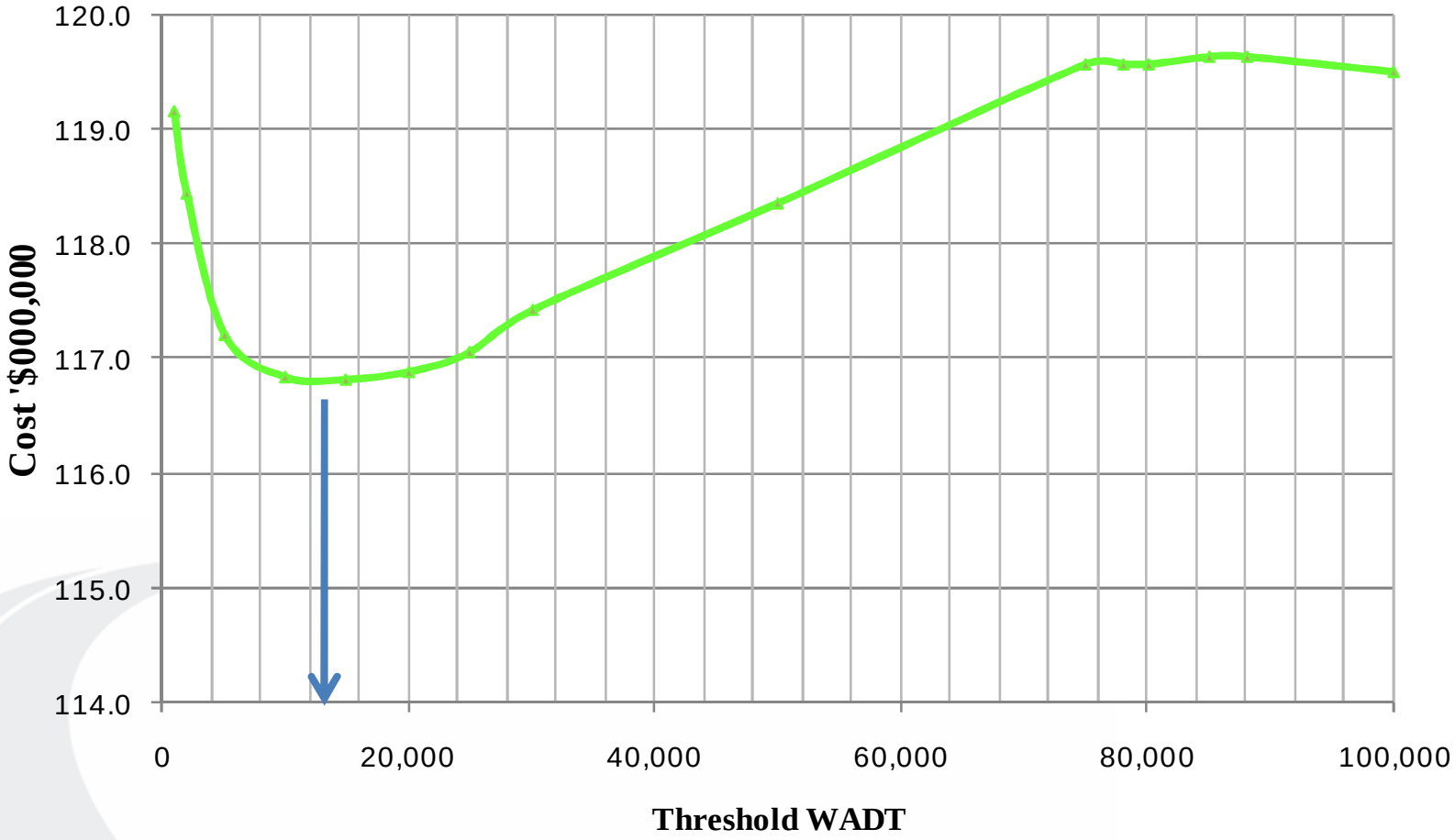




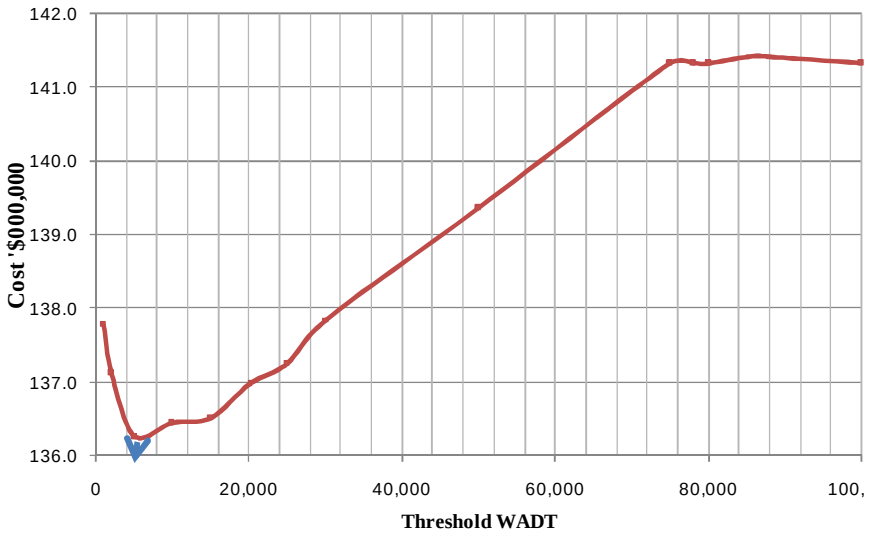
15. Results – variation in direct and collision costs with threshold



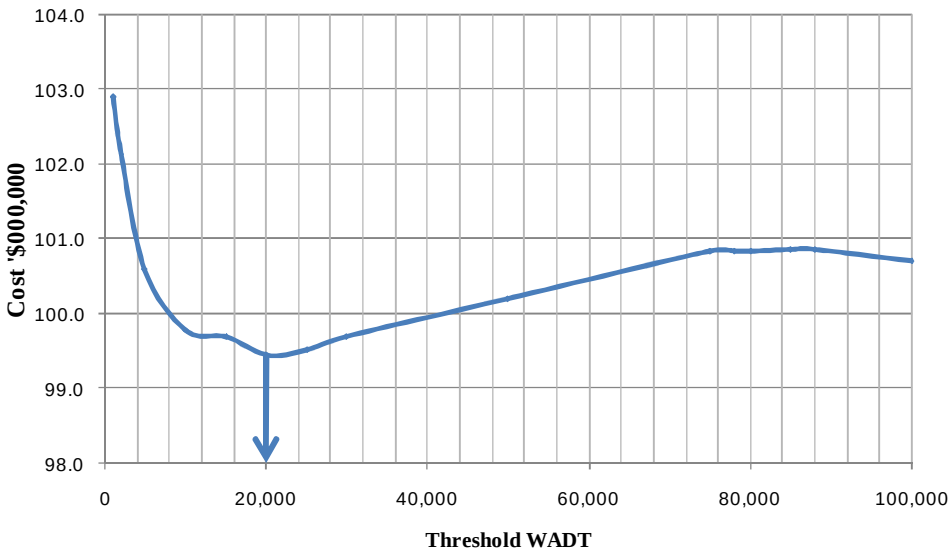
16. Optimization for direct and collision costs



17. Optimizing class thresholds with climate change



20% increase in duration
-more severe storms



20% reduction in duration
- less severe storms

18. Conclusion

- Benefit:cost framework applied to winter standards

- Predictive, storm-event models calibrated:
  - Bare Pavement Regain Time
  - Average Road Surface Index
  - Number of collisions
  - Road salt use

- Applications:
  - Level of service standards
  - Climate change impacts on maintenance
  - New technology, materials

18. *Thank you!*

Dr. Liping Fu, Professor
Dept. of Civil and Environmental Engineering
University of Waterloo
lfu@uwaterloo.ca

Mr. Max Perchanok
Research Coordinator
Ontario Ministry of Transportation
max.perchanok@ontario.ca

Mr. Jason Norville, Chair
Aurora pooled-fund program
janorville@state.pa.us