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Overview of road maintenance, stabilization and dust control practices in BC

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Resource Roads

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Content

- Context and mandate
- Overview of optimum road design features and stabilization and dust control products
- Presentation of some research results
- Observations from BC field visits
- Analysis of cost
- Recommendations and next steps
- Questions

Context - Need

- The BCMFR has spent millions on road upgrade, stabilization and maintenance
- Are current practices cost-effective?
- Are there other products/methods that would be more suitable?

Mandate - Objectives

- Conduct review of current practices
- Field visits to gain a better understanding of road maintenance strategies, methods, products, costs and performance
- Collect data and cost information
- Provide recommendations for improvements

Targeted road networks

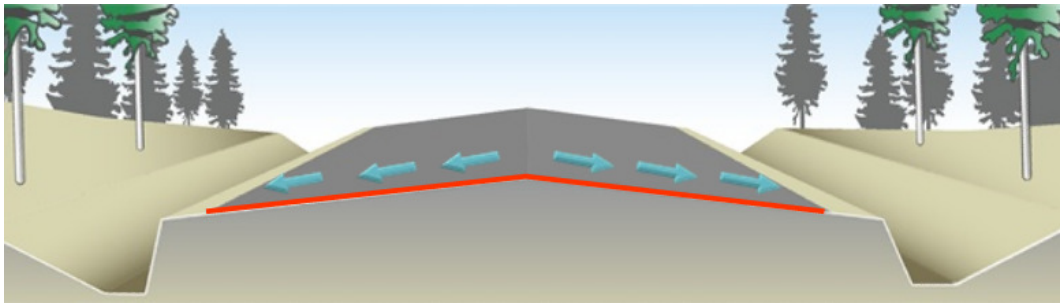
District/Group	FSR	Km stabilized	Visited by FPInnovations	Data collected
Arrow Boundary	Deer Creek	14	-	-
Central Cariboo	Chilcotin South	51	✓	✓
Kamloops	Adams West	41	✓	✓
Okanagan Shuswap	Seymour Main	41	✓	✓
Quesnel	Michelle Baezaeko (3900 Rd)	58	-	✓
Fort St. James	Leo Creek	?	-	-
Mackenzie	Causeway	?	-	-
Nadina	Morice	?	-	-
Vanderhoof	Kluskus 500	27	✓	✓
	Kluskus	100	✓	✓
	Holy Cross	67	✓	✓
Campbell River	Zeballos	0	✓	✓

Optimum road design features

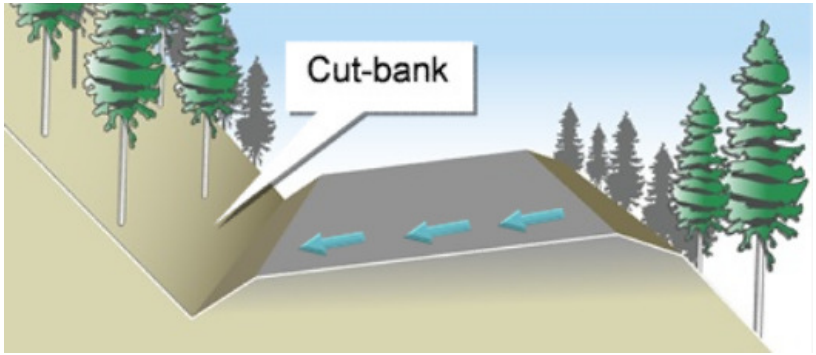
Drainage:

- Aim for a crown of 4 to 6%
- Adequate ditches
- Adequate cross drains

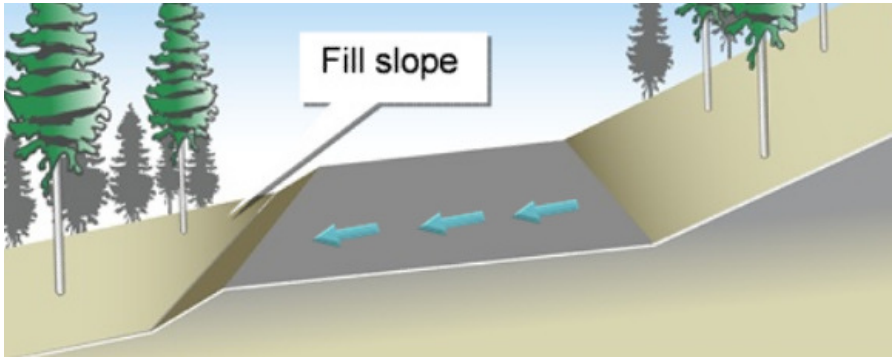
Optimum road design features



Crown



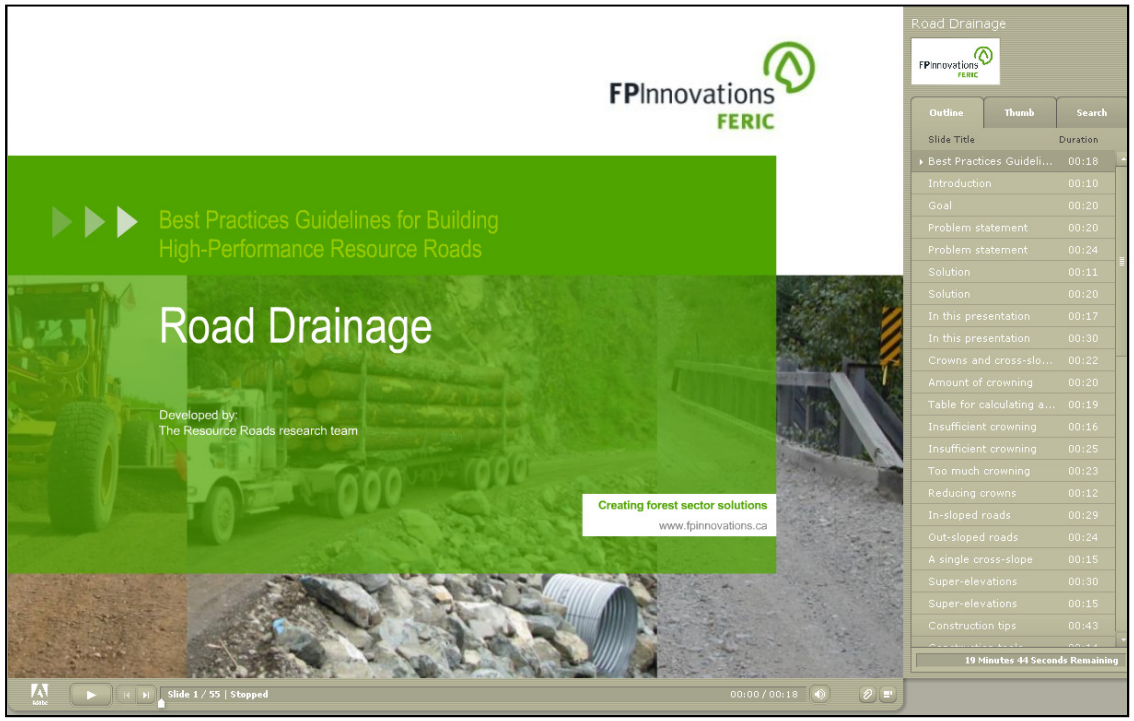
In-sloped



Out-sloped

Optimum road design features

- Flash presentation on road drainage
- Available for free (on-line viewing or download)
- Narrated



FERIC Web site: Solutions/Resource Roads/Guides and Presentations

- ***"Best practices guidelines for building high-performance resource roads: Road Drainage"***

Optimum road design features

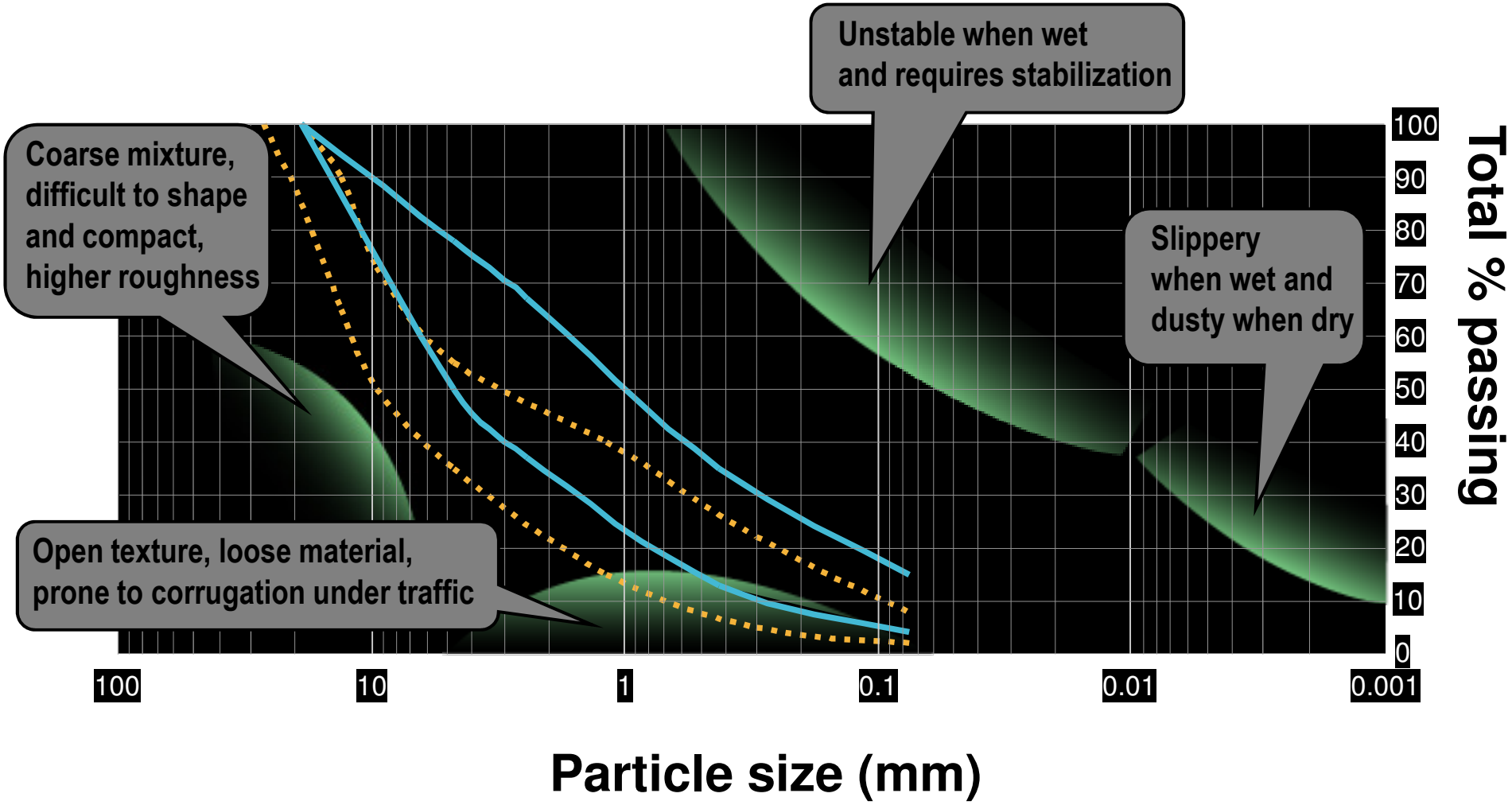
Optimum wearing course materials:

- Use gradation specifications for wearing course applications
- Should have 4 – 15% fines
- Use plastic “clay” fines (Plastic index 4 to 9)

- Good material will reduce surface distress (dust, washboard, loose aggregate, etc.)

Typical gradings

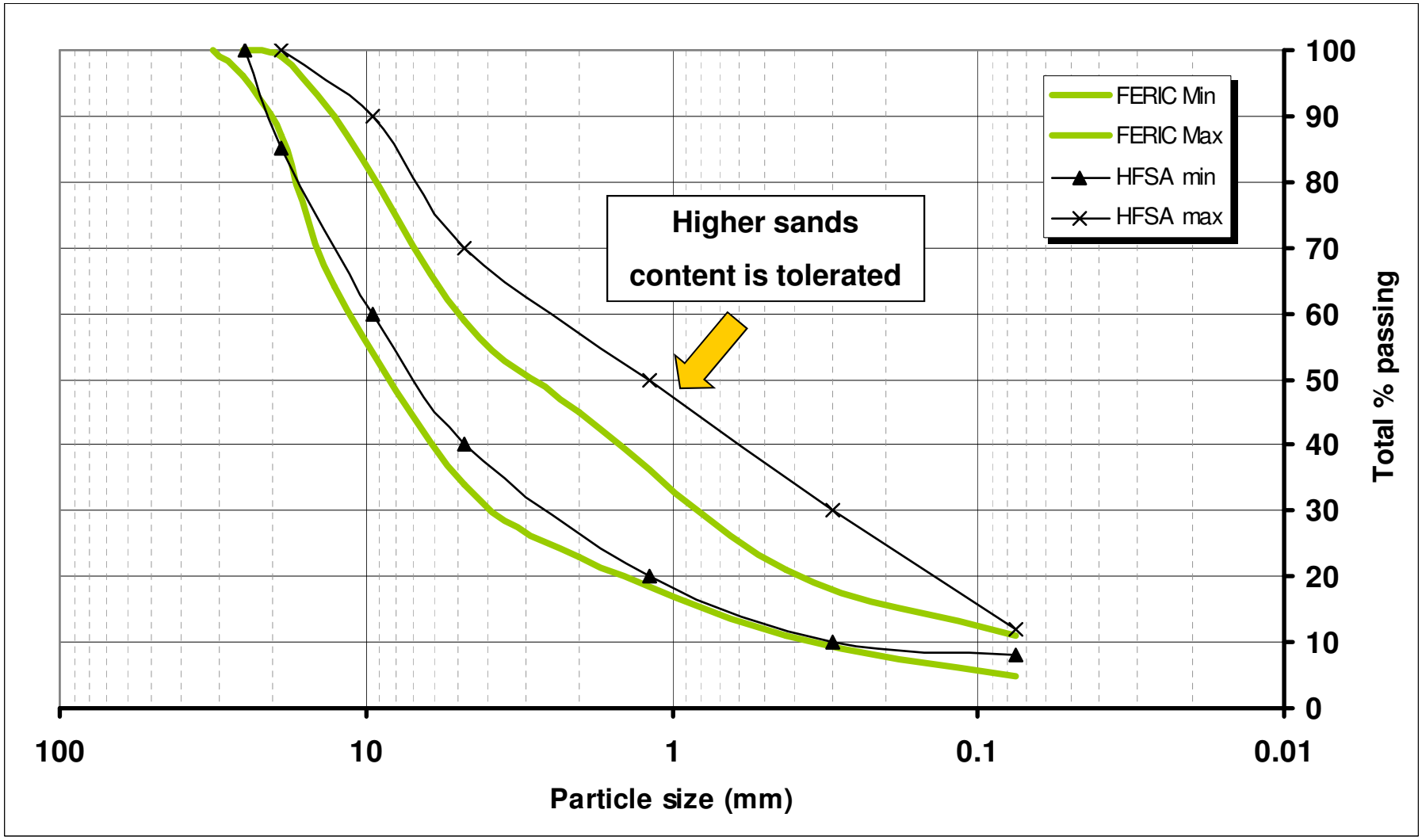
Surface distress problems



Functions of different size materials

Gravel	Sand	Clay
Increases strength, improves traction, reduces surface deterioration (less vulnerable to erosion).	Shares some properties with coarse materials and fines. Helps clay soils drain better and coarse materials retain moisture. Fills gaps in the gravel matrix.	Acts as a binder (cohesion) that holds the aggregates together and aids compaction.

Comparison of HFSA and typical wearing course spec



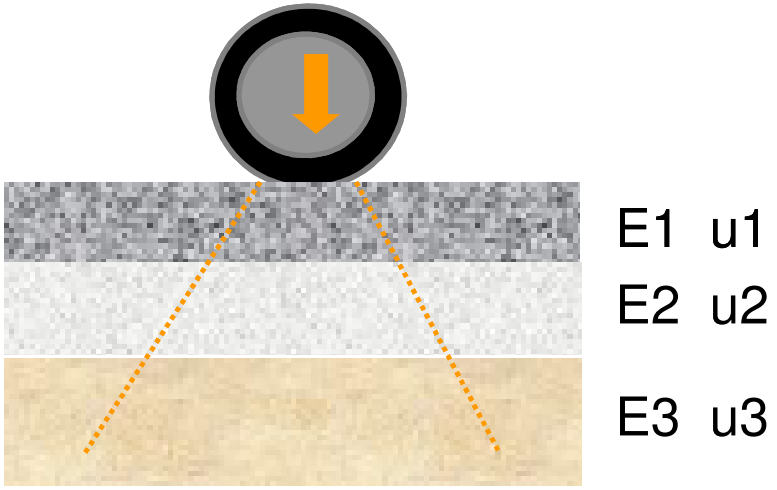
Quality control

- An effective quality control requires grain size distribution analysis during aggregate production
- Meet aggregate spec's

- Stockpiles must be built in successive layers of approx. 1 m thickness to minimize material segregation

Optimum road design features

- Structural design (adequate thickness)
  - Minimize rutting
  - Smoother ride
  - Reduced maintenance
- Based on volume and axle loading



Overview of stabilization and dust control products

- Dust control and stabilization agents are not all equal
- Performance depends on your conditions (material, traffic and climate)
- Cost is also influenced by product availability and supplier proximity

Soil additives

- Additives used for:
  - dust suppression are referred to as Dust Palliatives
  - strength improvement are referred to as Stabilizers
- Both categories can be subdivided into categories of additives available on the market
- More than 400 products are available commercially!

Soil additives

Dust palliatives

- Hygroscopic salts
- Water and wetting agents
- Natural polymers
- Synthetic polymer emulsions
- Modified waxes
- Petroleum resins
- Tars and bitumens
- Other products such as waste products

Stabilizers

- Tars and bitumens
- Synthetic polymer emulsions
- Sulphonated oils
- Lime and cement
- Enzymes and biological agents

Dust control versus Stabilization

	Dust palliatives	Stabilizers
Reduces dust effectively	Yes!	Not all products will
Strength	No mechanical bonds between particles, little to no improvements in strength	Mechanical bonds between particles offers increased strength
Life span	Short (usually one season)	Medium to long, especially full depth reclamation
Cost	Lowest	Highest
Application	Usually easy to apply, often by topical spray	Some products can be applied as topical spray but most require mixing for better results
Quality control	Controlled application rate, moisture, road preparation and compaction is recommended	Most stabilizers require more attention (controlled moisture content, compaction in layers, mixing, etc.)
Rejuvenation	Reapplication or rejuvenation (water) often required during the season depending on traffic and climate	Reapplication or rejuvenation is sometimes required/recommended during the season depending a product
Road maintenance	Most products can be graded without loosing effectiveness	Most will loose effectiveness (on the surface) fallowing grading (bonds are broken)

Product selection criteria

- For Traditional additives, the selection process is well documented, depending on soil type.
- For Non-Traditional additives, application rates, methods, and effectiveness are inconsistent, not all well documented, and sometimes misleading.

"Traditional" products

Products	How they work
Cementitious - Cement - Lime - Fly-Ash	- Cementitious reaction - Used for stabilizing subgrade or base course but not for surfacing application
Hygroscopic products - Calcium chloride - Magnesium chloride - Sodium chloride - Natural brines	- Absorbs moisture from the air - Holds moisture longer in the material - Increases the surface tension between particles - Can be rewetted and reworked
Organic Petroleum Products - Asphalt emulsions - Liquid asphalt - Bitumen	- Seals surface (coat) waterproofing - Particles are coated and asphalt acts as a binder

- For seasonal applications, Lignins and Chlorides have the best proven performance. CaCl and MgCl are widely used across Canada and the USA

“Non traditional” products

Products	How they work
Organic Non-Petroleum Products - Lignosulfonate - Tree resin emulsions - Molasses - Tall oil emulsions - Vegetable oils	- Binds particles together with adhesion - Relatively insensitive to moisture
Electrochemical Products - Enzymes - Ionic products	- Changes the characteristics of clay particles - Relatively insensitive to climate conditions
Synthetic Polymer Products - Polyvinyl acetate - Vinyl acrylic	- Binds particles together with adhesive polymer properties
Clay Additives - Bentonite - Montmorillonite	- Used to *add* PI to the material - Agglomerates with dust

Dust control – What's important?

- Avoid application over poorly-graded material (unstable)
- Perform an effective (reshaping) grading prior to application
- Adequate drainage (proper crown) a key factor of long-term results
- Follow the supplier's recommended application rate and double check with published specs
- After application, AVOID grading during dry periods
- Some products may require a cure period

Dust palliative product selection chart

(adapted from USDA-FS, Bolander)

Dust Palliative	Traffic Volumes, Average Daily Traffic			Surface Material								Climate During Traffic		
				Plasticity Index			Fines (Passing 75µm, No. 200, Sieve)							
	Light < 100	Medium 100 to 250	Heavy > 250 (1)	< 3	3 – 8	> 8	< 5	5–10	10-20	20-30	> 30	Wet and/or Rainy	Damp to dry	Dry (2)
Calcium Chloride	√√	√√	√	X	√	√√	X	√	√√	√	X	X	√√	X
Magnesium Chloride	√√	√√	√	X	√	√√	X	√	√√	√	X	X	√√	√
Petroleum	√	√	√	√√	√	X	√	√	√	X	X	√	√√	√
Lignin	√√	√√	√	X	√	√√	X	√	√√	√√	√	X	√√	√√
Tall Oil	√√	√	X	√√	√	X	X	√	√√	√	X	√	√√	√√
Electro-chemical	√√	√	√	X	√	√√	X	√	√√	√√	√√	√	√	√
Synthetic Polymers	√√	√	X	√√	√	X	X	√√	√√	X	X	√	√√	√√
Clay Additives	√√	√	X	√√	√√	√	√√	√	√	X	X	X	√	√√

Legend: √√ = Good √ = Fair X = Poor

Notes:
1) May require higher or more frequent application rates, especially with high truck volumes.
2) Greater than 20 days with less than 40% relative humidity

Multi-year research project with Université Laval

- Various products tested in the lab as stabilizers
- Stabilizers and dust palliatives tested in the field
- Environmental impact is also part of research

UNIVERSITÉ LAVAL

Field-tested products in collaboration with Université Laval

			Field tested		
Product name	**Category**	**Supplier**	**2007**	**2008**	**2009**
CaCl2	Hygroscopic	DOW Chemical	✓	✓	✓
Solnat 270	Hygroscopic (Natural brine rich in CaCl2 and MgCl2)	Junex (Québec based)	✓	✓	✓
Solnat 340	Hygroscopic (Natural brine rich in CaCl2 and MgCl2)	Junex (Québec based)	✓	✓	✓
Durablend	Hygroscopic with polymer additive	Envirotech Services Inc.			✓
RoadOyl	Natural emulsion (Wood resins)	Midwest Industrial Supply		✓	
Soil Sement	Acrylic polymer (as dust control)	Midwest Industrial Supply	✓	✓	
Soil Sement	Acrylic polymer (as stabilizer)	Midwest Industrial Supply	✓	✓	
X-hesion DC	Plant-based polymer dust control	Envirotech Services Inc.	✓	✓	
X-hesion	Plant-based polymer (as stabilizer)	Envirotech Services Inc.	✓		

Overview of cost and performance

Product name	Cost	Performance as dust control	Performance as a stabilizer	Ease of application
Solnat 270	1.0	+ + +	-	++
Solnat 340	1.1	+ +	-	++
CaCl2	1.3	+ + +	-	++
Soil Sement	2.2	-	+ +	+ *Sticky, equipment cleaning required*
X-hesion	1.8	+ +	+	++
RoadOyl	n.a.	+ +	-	- *Extremely sticky, prompt equipment cleaning required*
Durablend	n.a.	+ + +	+	+ *Viscous, equipment cleaning required*

Field tests

- Treated with CaCl2

- Control section (untreated)

2008 results

2008 results

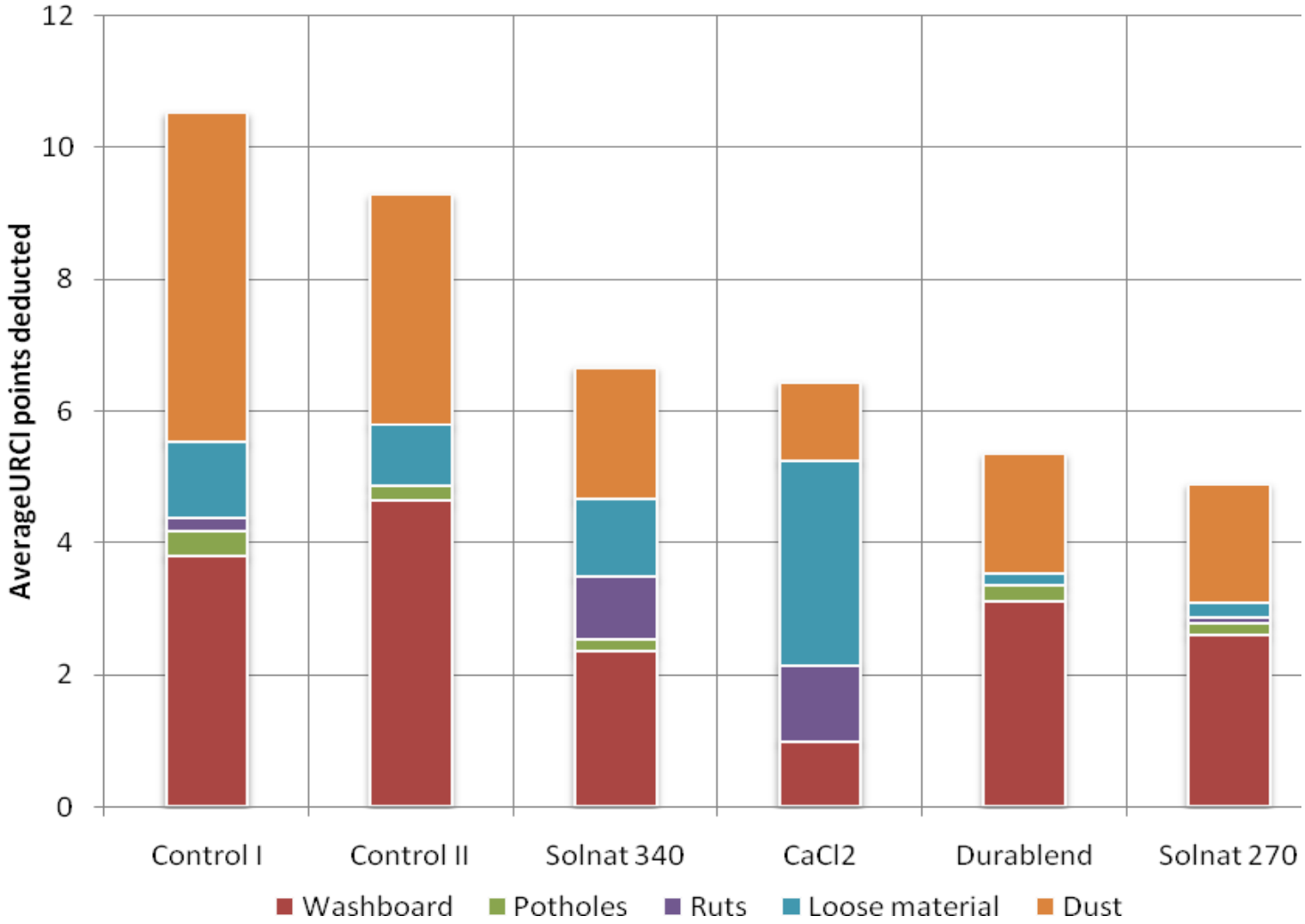
- Relative comparison of dust clouds in different sections

Field visit	Worst → Best								
1	Control	Control S	Soil Sement S	Soil Sement	Road Oyl	Solnat 270	Solnat 340	Xhesion	CaCl2
2	Soil Sement S	Control	Soil Sement	Control S	Xhesion	Road Oyl	Solnat 340	Solnat 270	CaCl2
3	Control	Soil Sement S	Control S	Soil sement	Road Oyl	Xhesion	Solnat 340	Solnat 270	CaCl2
4	Control	Soil Sement S	Control S	Soil sement	Xhesion	Road Oyl	Solnat 270	Solnat 340	CaCl2
5	Control	Control S	Soil Sement S	Soil sement	Solnat 270	Xhesion	Road Oyl	Solnat 340	CaCl2

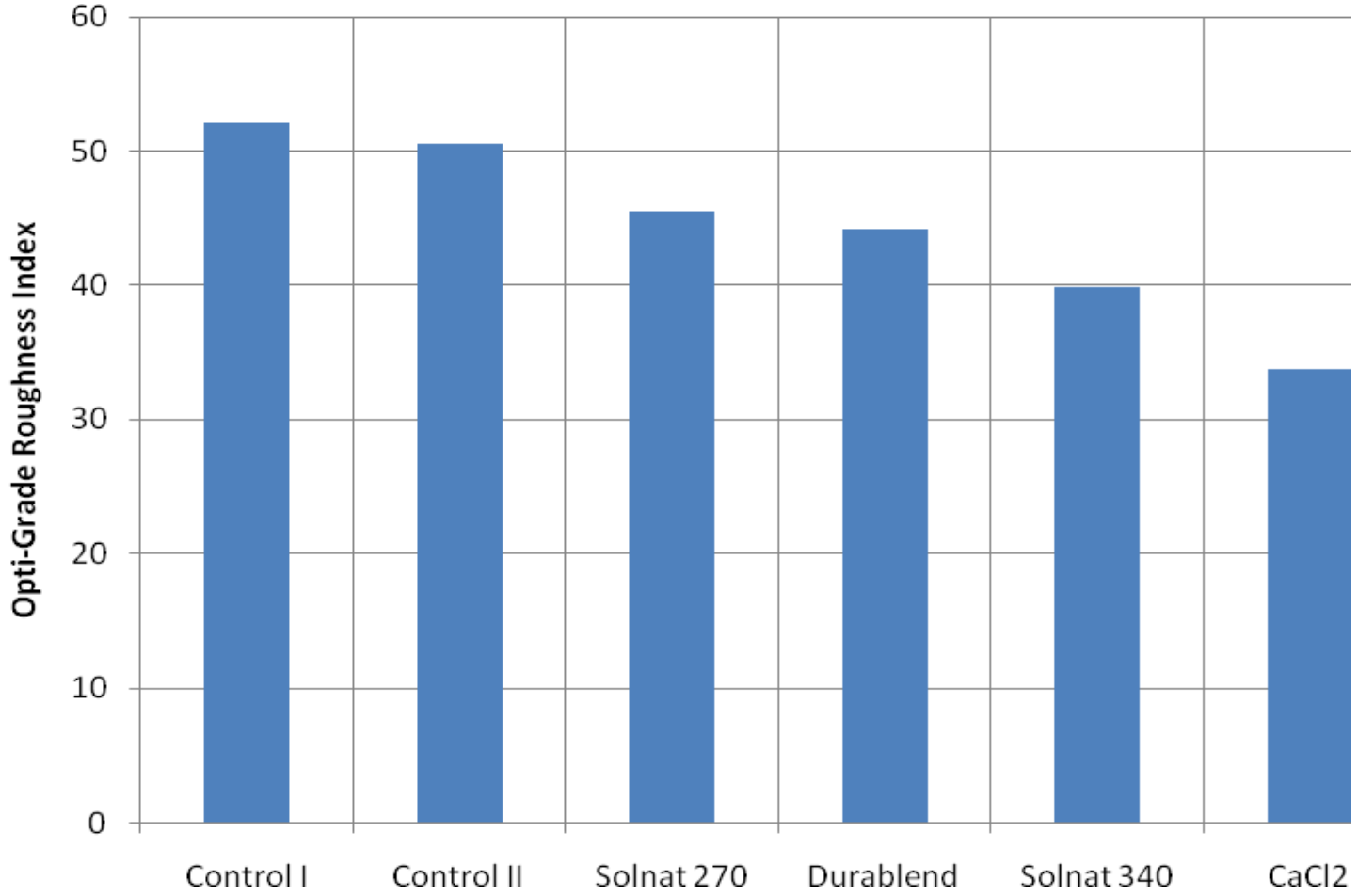
2008 results

- Hygroscopic products (Solnat and CaCl2) and Road Oyl performed best
- Soil-Sement polymer did not perform well as a dust suppressant but as a soil stabilizer, it was able to cut by half road deflections measured with a PFWD
- X-hesion polymer had average results as a dust suppressant, but performed well in previous tests, both for dust control and stabilization

2009 results (Unsurfaced Road Condition Index)



2009 results (OptiGrade roughness values)



2009 results

- Four hygroscopic products (CaCl2, Solnat 270, Solnat 340 and Durablend) were tested
- All products performed well
- Durablend performed best followed by CaCl, Solnat 270 and 340
- In terms of road condition, Solnat 270 presented the best results followed Durablend, CaCl and Solnat 340
- Difference in performance between products was small

BC Field visits

District/Group	FSR	Km stabilized	Date/contact
Vanderhoof	Kluskus 500	27	September 7th Vince Sewell
	Kluskus	100	
	Holy Cross	67	
Central Cariboo	Chilcotin South	51	September 8th James Moe and Jerry Mooney (Tolko)
Okanagan Shuswap	Seymour Main	41	September 9th Brent Case, Barry Markin and Lee
Kamloops	Adams West	41	September 9th Brent Case and Barry Markin
Campbell River	Zeballos	0	September 24th Don Earles and Chris Petersen

Field observations – Kluskus

- AADT: 50 (light), 125 (heavy)
- Treated in two lifts in 2007
- Yearly topical spray is applied by CanFor in May-June
- Light dust towards end of summer
- Subgrade on first 23 km composed of cohesive soils (silts)
  - Some signs of rutting and punchouts
  - Heavy rain prior to visit
- Fairly flat crown could be improved
- Overall, road is in good condition (no berms, washboards or erosion)

Field observations – Kluskus 500

- AADT: 30 (light), 50 (heavy)
- Treated in two lifts in 2007
- Lower traffic than Kluskus
- No rejuvenation has been applied since ’07 upgrade
- Some loose material along shoulders
- Overall in good condition despite low maintenance

Field observations – Holy Cross

- AADT: 50 (light), 100 (heavy)
- Treated in two lifts in 2004
- Annual liquid CaCl rejuvenation
- No rejuvenation since 2008 (West Fraser)
- More washboard and potholes than on Kluskus
- Road is still in good shape

* Fairly steep sideslope near km 31, could be prone to erosion

Field observations – Chilcotin South

- AADT: >50 (light), 100 (heavy)
- Treated in two lifts in 2008
- Rejuvenation in 2009 (flake)
- 2010 rejuvenation conducted by Canfor in Canyon only
  - 18 km in May
  - 12 km in August (lower rate applied down center)
- Semi-arid conditions in valley with some washboard on steep hills
- Four grading interventions on back-end

Field observations – Chilcotin South

- Pit Km 21.5
  - Imported clay
  - Fairly clean aggregate, low angularity and small marbles
- Pit Km 33
  - % fractured faces appeared higher
  - This road section was said to hold-up better
  - Could also be climate difference
- High fractured-face aggregate is recommended for sharp curves and switchbacks

Field observations – Chilcotin South

- Road is in good condition, good ditching, turn-outs, quality material and minimal washboard/potholes
- No signs of structure problems
- Aim for 4% crown
  - Front-end of road was flat
  - Back-end was better but not 4%

Field observations – Seymour Main

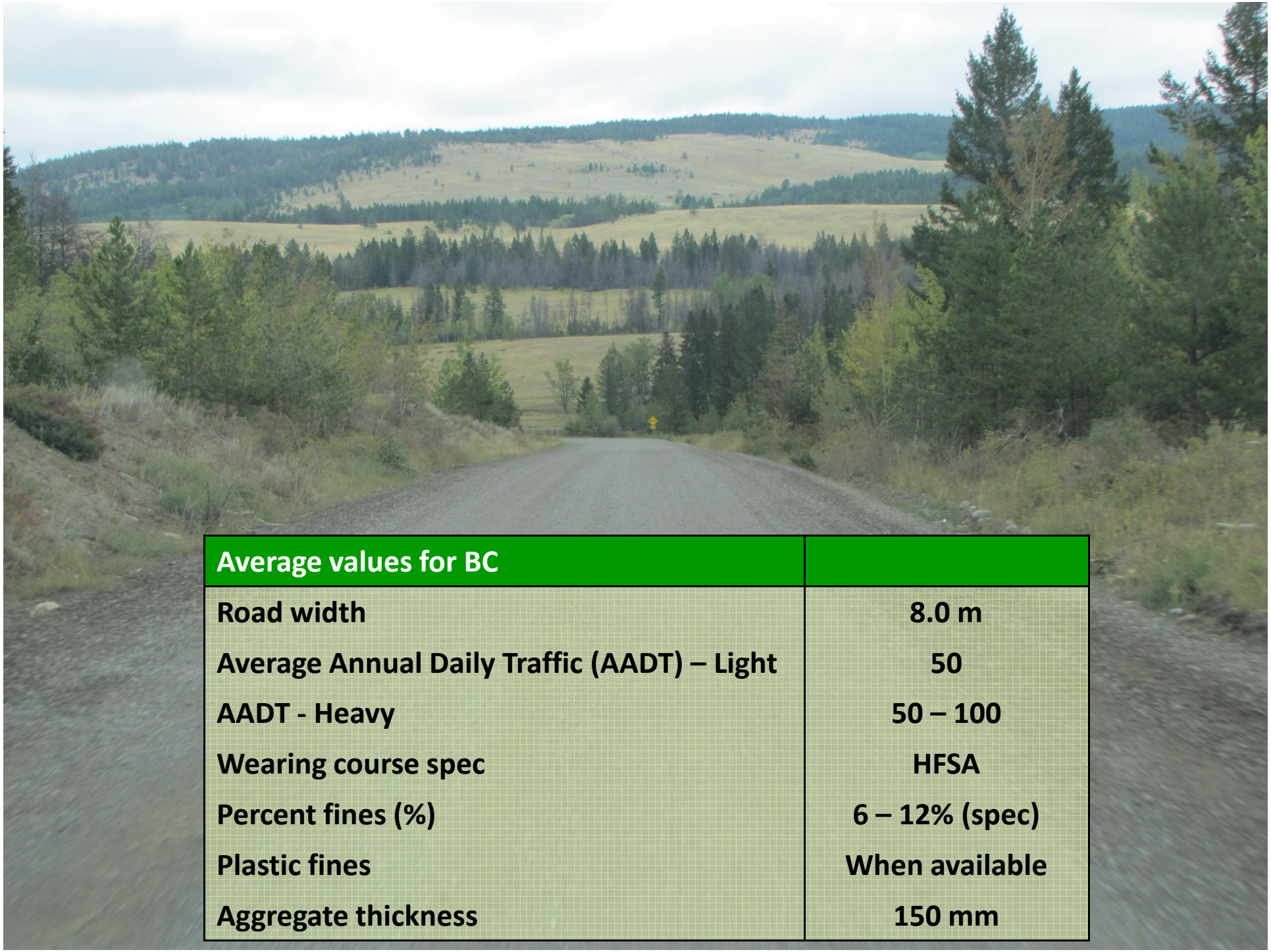
- AADT: 50 (light), 50 (heavy)
- Heavier traffic on back-end (km 27 to 41)
- Treated in two lifts in 2009
- Rejuvenation applied in May 2010 but not re-graded until Sept.
- Flat crown caused by fall grading
- Limited sources of plastic fines
- Dust free
- Potholes, washboard and some loose material throughout because of limited grading

Field observations – Adams West

- AADT: 50 (light), 140 (heavy)
- Treated in two lifts in 2009
- Rejuvenation in May 2010 and only re-graded in fall
- Dust free
- Road surface in good condition
- Some potholes because of limited grading

Field observations – Zeballos

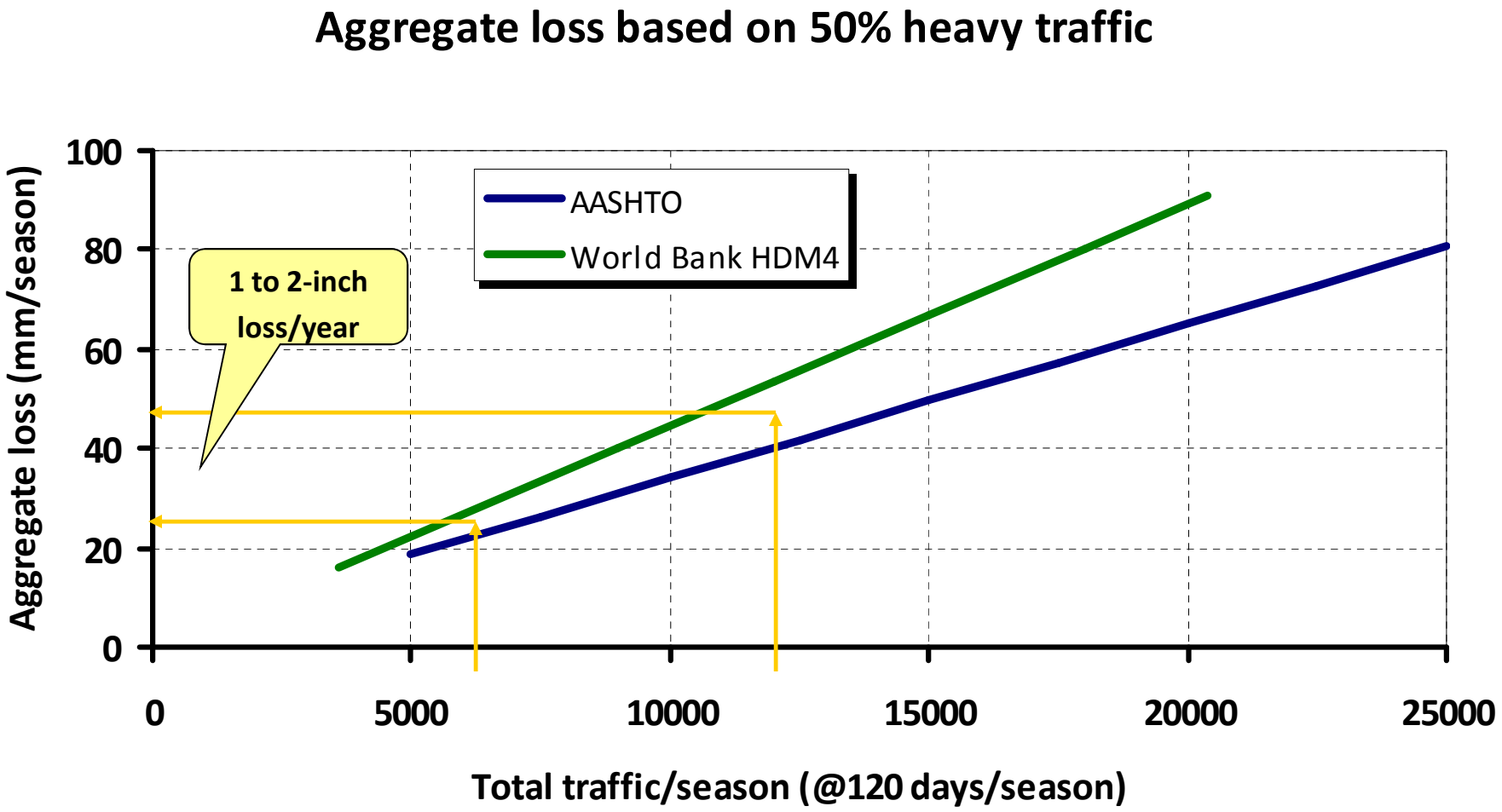
- Road not treated yet and “was” in good condition at time of visit!
- Many potholes and washboard throughout
- No signs of structural problems
- Grading practices need improvement (berms and crown)
- Aggregate has been produced/stockpiled with plastic fines
- Some sections may not require 6-inch layer of aggregate (e.g., km 42 to 24.7)
- Some ditching needed on front-end
- Quote of $44,000/km received for aggregate placement significantly above average



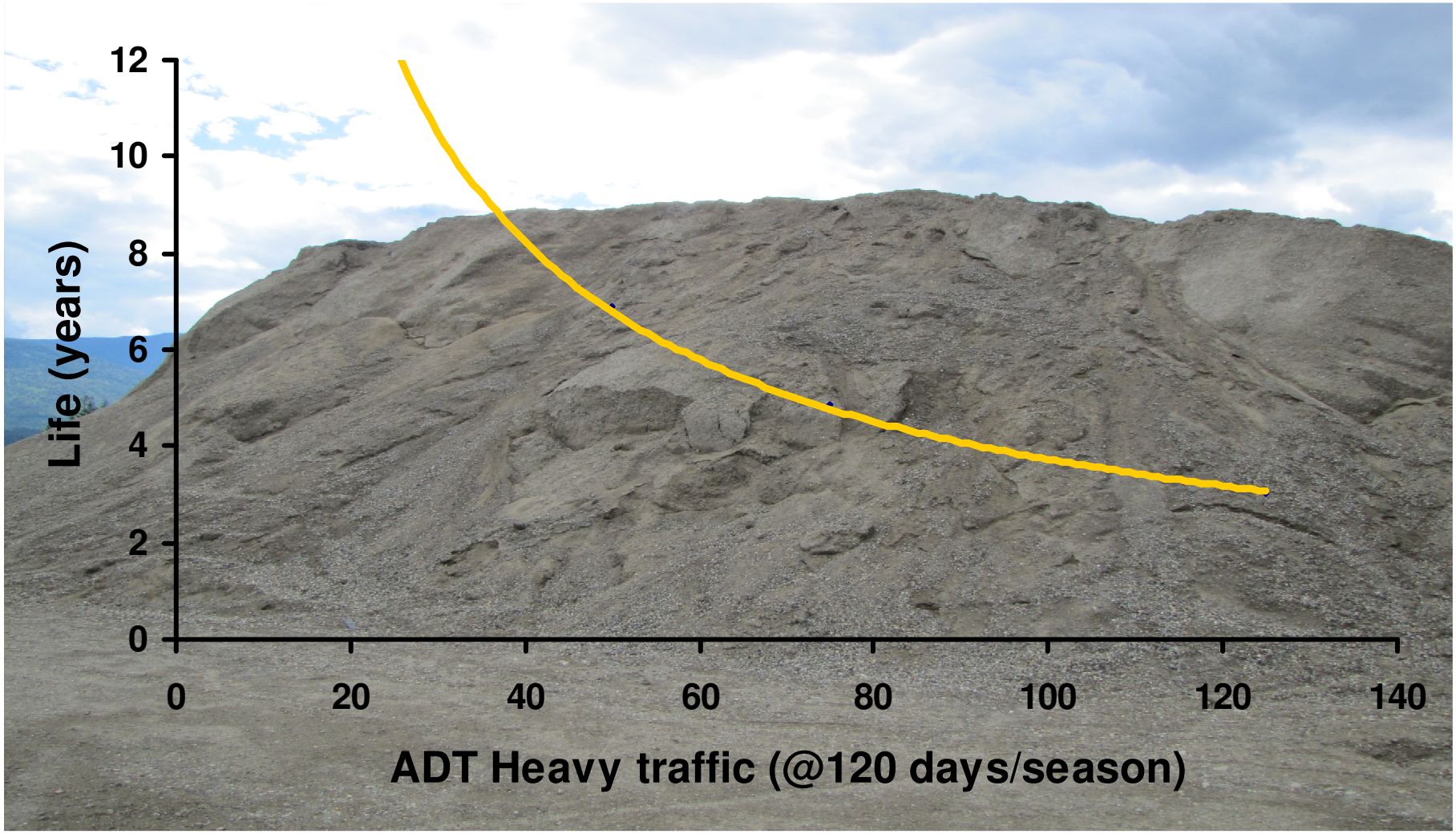
Average values for BC	
Road width	8.0 m
Average Annual Daily Traffic (AADT) – Light	50
AADT - Heavy	50 – 100
Wearing course spec	HFSA
Percent fines (%)	6 – 12% (spec)
Plastic fines	When available
Aggregate thickness	150 mm

Average values for BC	
Aggregate production cost ($/km)	12,000 ($6.50/m³)
Aggregate placement cost ($/km)	13,000
TOTAL aggregate cost ($/km)	**25,000**
Stabilization during aggregate placement	
Application rate	12-13 t/km (1.6 L/m²)
Product cost	$225/t ($0.25/L)
Product cost ($/km)	2700
Product placement cost ($/km)	1400
TOTAL stabilization cost ($/km)	**4100**
Yearly dust control application	
Application rate	7.5 t/km (1.0 L/m²)
Product cost ($/km)	1900
Product placement cost ($/km)	1400
TOTAL dust control cost ($/km)	**3300**
Grading frequency	On-demand, approx. 2 times per season
Grading cost ($/km/year)	**1000-2500**

Aggregate deterioration models



Estimated untreated aggregate life (AASHTO model)

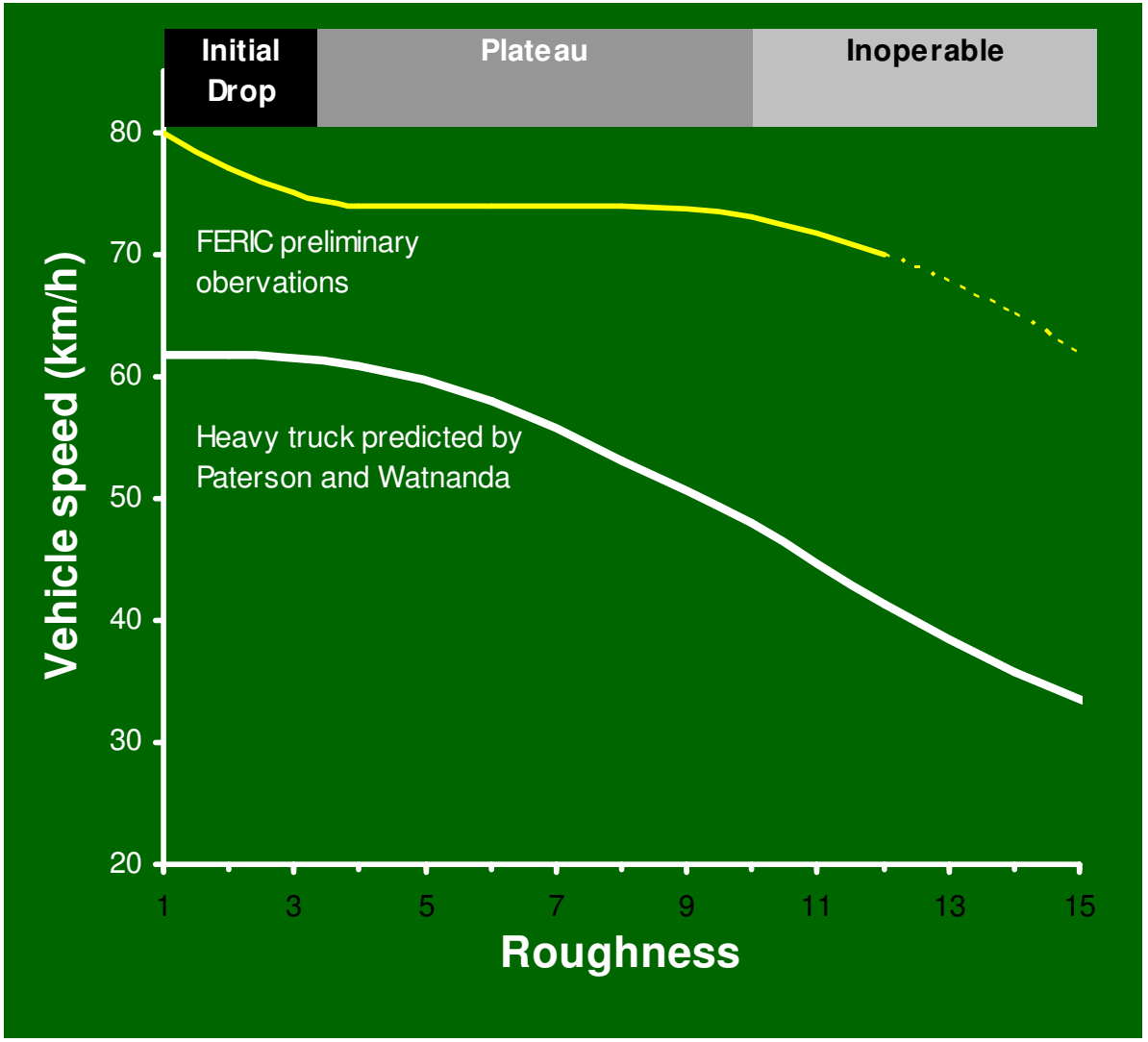


Examples of annual rejuvenation success

- Weyerhaeuser Grande Prairie
- Treated with magnesium hydroxide (MG30) 4 to 5 times per season!
- Approx. $4700/km
- Summer log-truck traffic of 7000 trips
- + Heavy industrial traffic (oil & gas and forestry)
- Payback achieved on:
  - Minimum grading required
  - Revenue from other users $$

Relationship between road roughness and truck speed

- No significant impact on travel speed until roughness is very high
- Road conditions must be very poor before they *influence* the drivers
- Frozen gravel roads appear to have performances similar to sealed roads
- The effect of dust was not evaluated



10-year Life-Cycle Cost Analysis ($/km)

Inputs ($/km)	Baseline	Scenario 1	Scenario 2	Scenario 3
Aggregate initial cost	25,000	25,000	25,000	25,000
Initial stabilization	4100	4100	4100	4100
Annual dust control	3300 (100% of network)	660 (20% of network)	660 (20% of network)	660 (20% of network)
Annual grading cost	1000	2750	2500	2500
Resurfacing @ year 5	0	0	12,000 (50%)	25,000 (100%)
Total cost	73,100	64,200	73,700	88,600
Total Net Present Value @4%	65,000	57,500	65,600	78,000
Total discounted savings	-	-7500	+600	+13,000

Comments on LCCA

- The impact of dust on travel speed is not well documented
- Savings in cycle time doesn't necessarily translate into reduced haul rates
- The total cost of annual rejuvenation is more expensive than using a more traditional approach
- If roads are resurfaced every 5 years, then annual rejuvenation appears to be cost-effective (if surface lasts 10 years)
- This analysis must be done on a case-by-case
- Currently lacking data from licensees (haul rates, cycle time, etc.)

Discussion

- Current HFSA spec is in-line with recommended specs for wearing course applications
- Good practices that should be maintained:
  - Aiming for a fines content of 5 to 12%
  - Adding plastic fines to aggregate
  - Quality control during aggregate production (sampling/sieving)
  - Controlling moisture content during compaction
  - Using mechanical compaction

Discussion

- Good practices that could be relaxed to reduce costs:
  - Systematically using a nuclear moisture-density gauge to monitor and achieve Proctor density
    - Alternative would be to specify a minimum number of compactor passes (function of compactor size)
  - Treating the bottom layer with CaCl
  - Rejuvenating 100% of the road network with CaCl on a yearly-basis (benefit-cost ratio must be assessed)

Discussion

- Current approach is providing good performance and will definitely prolong wearing course aggregate life but at what cost?
- Improved safety must also be considered
  - Less dust = safer in terms of visibility
  - Does less dust mean higher speeds?

General recommendations

- Aim for crown of 4-6%
- When available, crushed aggregate from blasted material will provide better angularity (higher fractured faces) thus better interlock and performance
- Save higher quality aggregate for curves, hills and switchbacks
- Consider using Magnesium Chloride for semi-arid conditions
- Consider using other products (e.g., polymer-based) for wet climate conditions

Next steps - Need

- Guidelines/tools for product selection and maintenance strategies based on:
  - Climate
  - Material type
  - Traffic intensity
  - Level of maintenance
  - Desired performance
  - Cost-effectiveness and Life-Cycle Cost Analysis
- Info-bulletins for product application *(this was suggested by some field personnel)*

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Thanks!

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