Engineering Analysis and PMS

Washington State Experience

National Pavement Management Conference
Norfolk, Virginia
May 6-9, 2007

Presentation Outline

- Introduction
- HMA life
- PG binders
- Studded tires
- PCC deterioration
- Forensic Studies
- Economic analysis
- Bituminous surface treatments
- Experimental features

Questions

- How is Superpave performing? How does it compare to traditional methods?

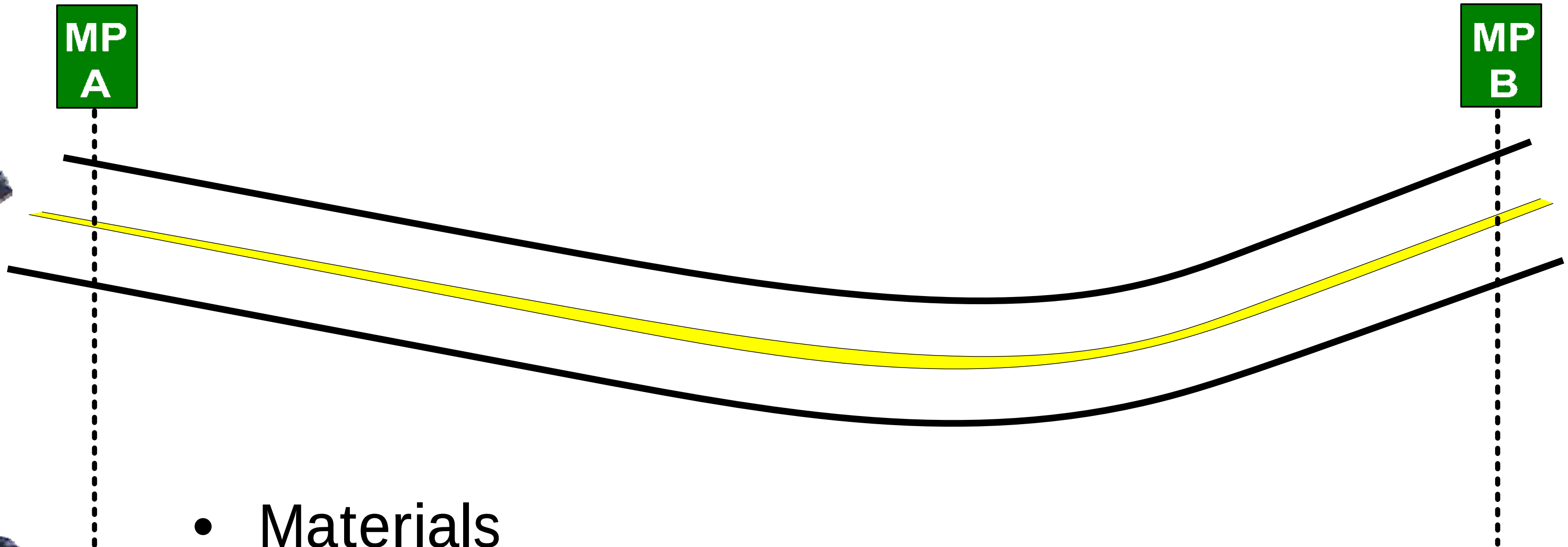
Questions

- What caused the failure of this road? Design? Construction? Materials?

Questions

- What design factors will help ensure a long lasting pavement?

Need a Pavement Management System that will bring together…



- Materials
- Construction quality
- Traffic
- Surface condition / performance
- Rehabilitation / maintenance
- Etc.

Overview of WSPMS

- WSDOT maintains ~ 18,000 lane miles
- Annual pavement condition survey
  - 100 percent of pavement surface in the survey lane (~10,000 lane miles)
  - Rut/wear, IRI, faulting
  - Cracking, patching, raveling, spalling, etc.
    - Pavement Structural Condition (PSC)
- Skid resistance
- Performance equations
  - PSC determined using a best fit curve
  - IRI and rutting, at this time, determined using a straight line regression


HMA Pavement Life

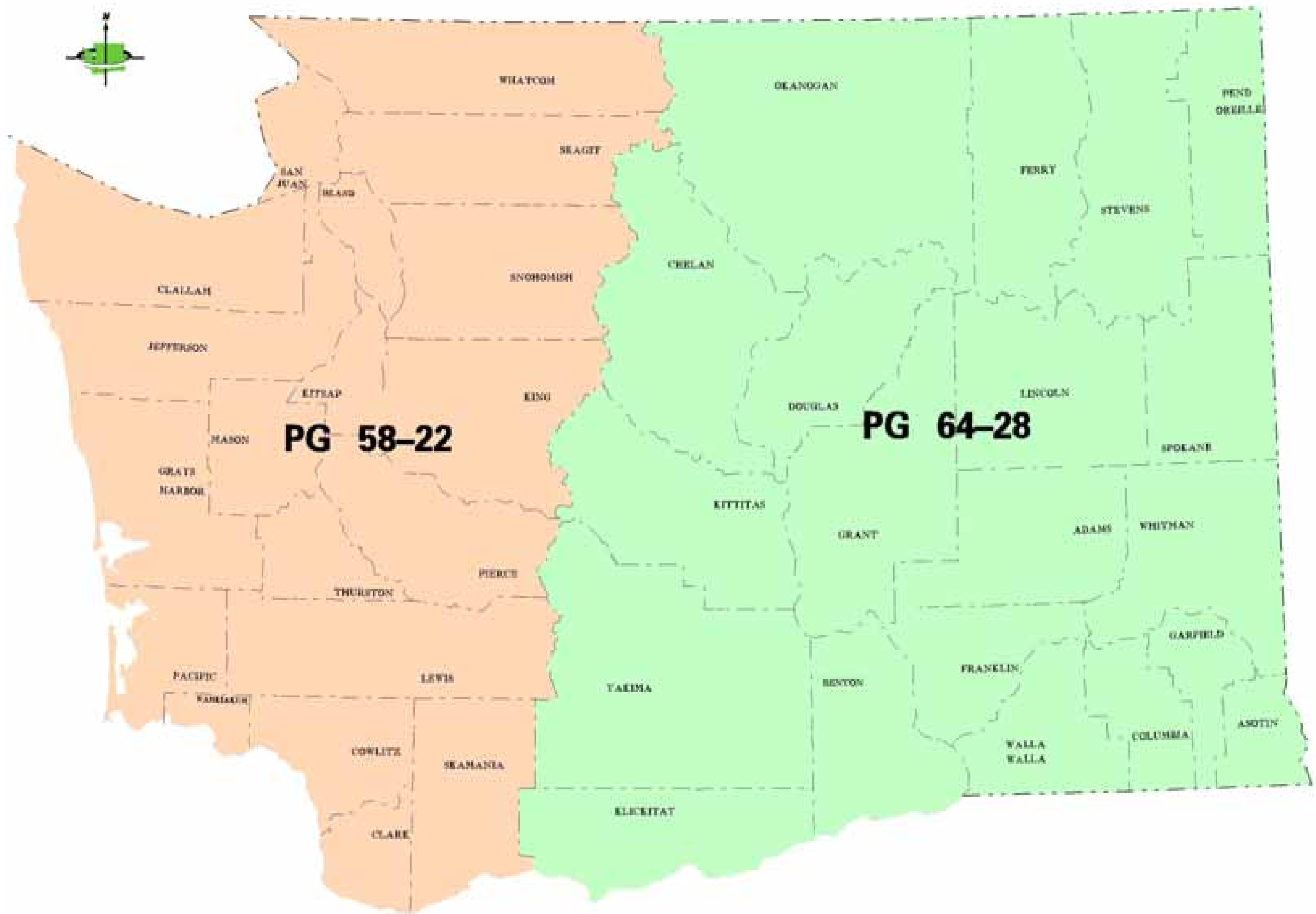
HMA Pavement Life

- Life extension has occurred due to better management of roadways
- However, pavement life is also a function of improvements in:
  - Construction practices
  - Specification changes
  - Material selection process
- Over the last 10 years, pavement life has increased
  - Eastern: 5%
  - Western: 15%
  - Statewide: 16%

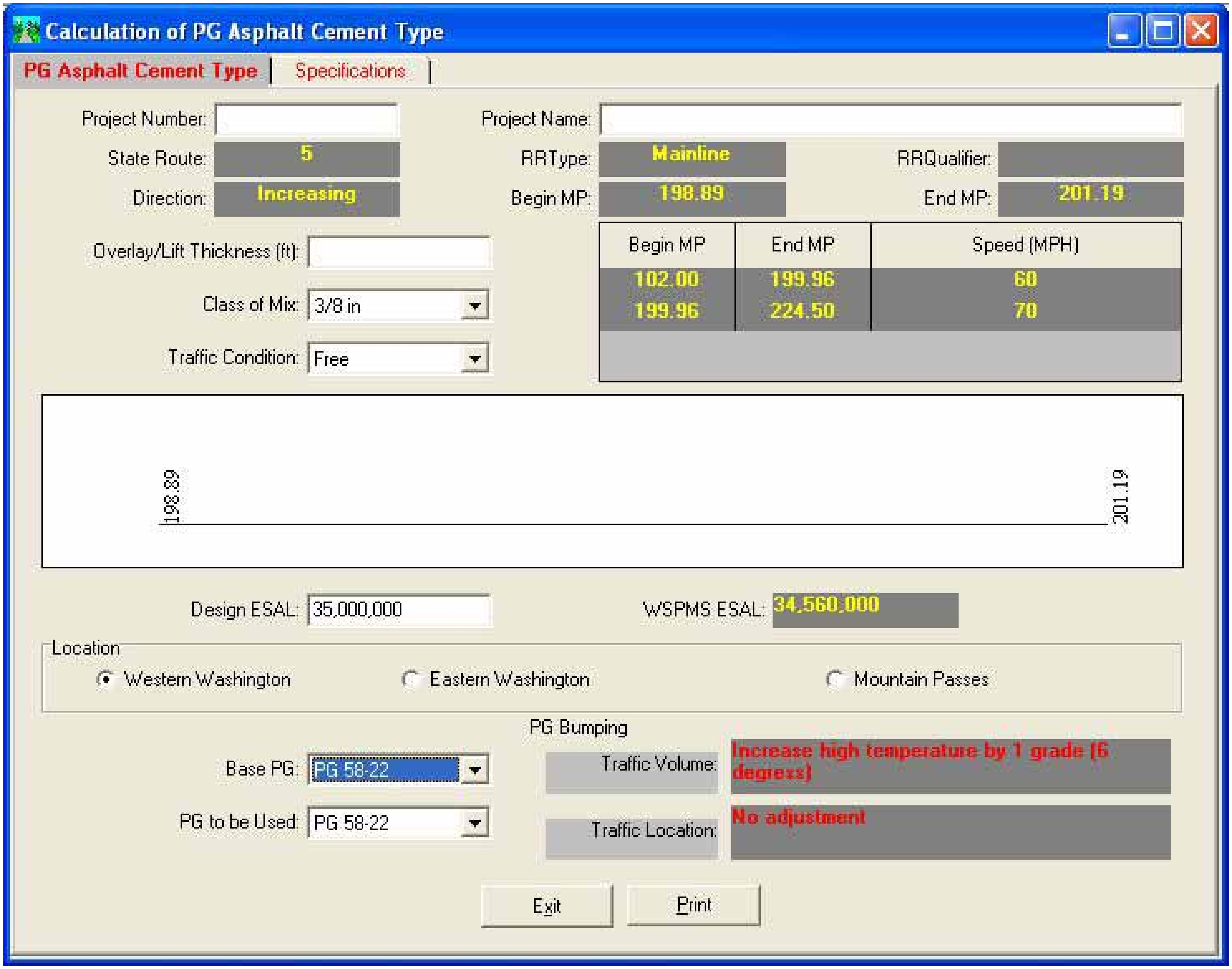
Year	East	West	Statewide
1997	10.7	14.6	12.9
2000	10.8	15.8	14.1
2003	11.3	16.5	14.7
2006	11.2	16.8	14.9


Are Performance Grade
Binders Impacting
Pavement Performance?

Performance Grade Binders

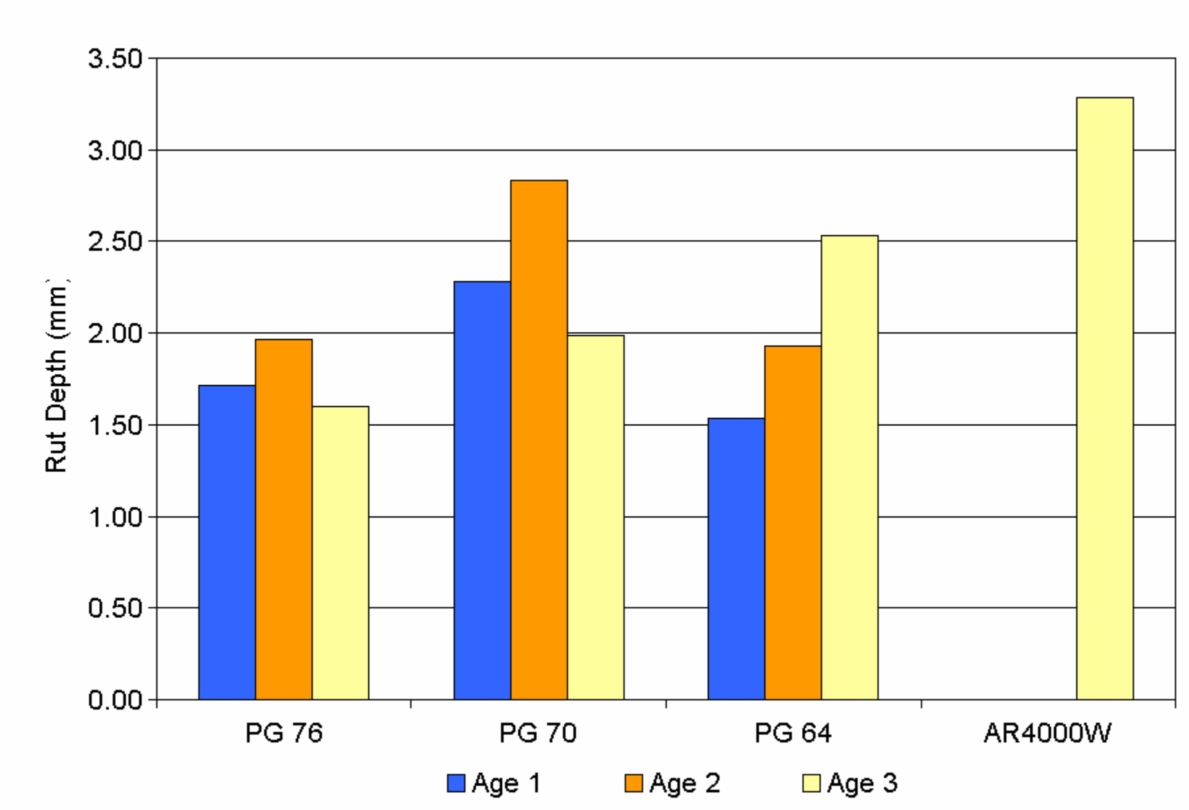


WSPMS Binder Selection



Intersection Rutting

- Eight projects
  - 1 to 7 intersections per project
- Three binder grades
  - PG 76
  - PG 70
  - PG 64



Low Temperature Cracking

- Overlay projects
- High probability that cracks are reflective cracks from underlying HMA
- Low severity
  - Width < 6 mm
- Medium severity
  - Width > 6 mm
- High severity
  - Width > 6 mm and spalled

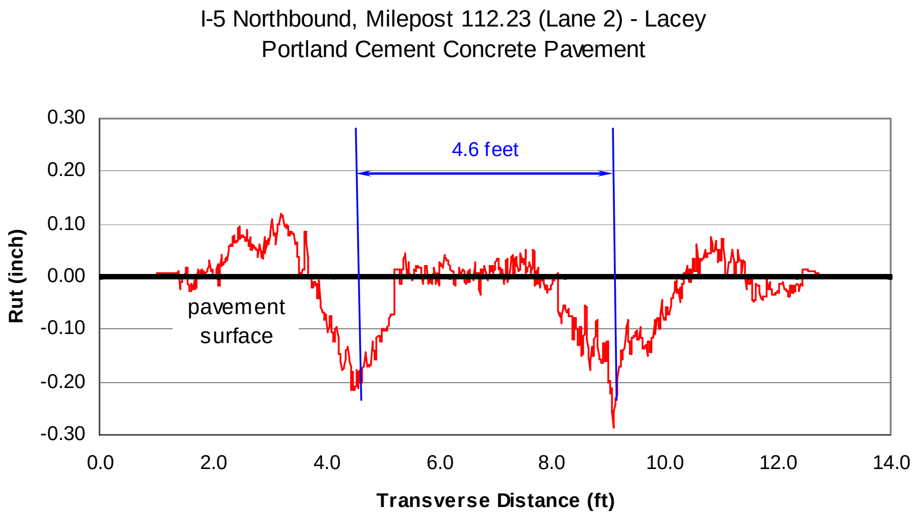
Binder	Low (%)	Medium (%)	High (%)
PG	5.0	4.0	0.0
AR4000W	12.0	12.0	3.0

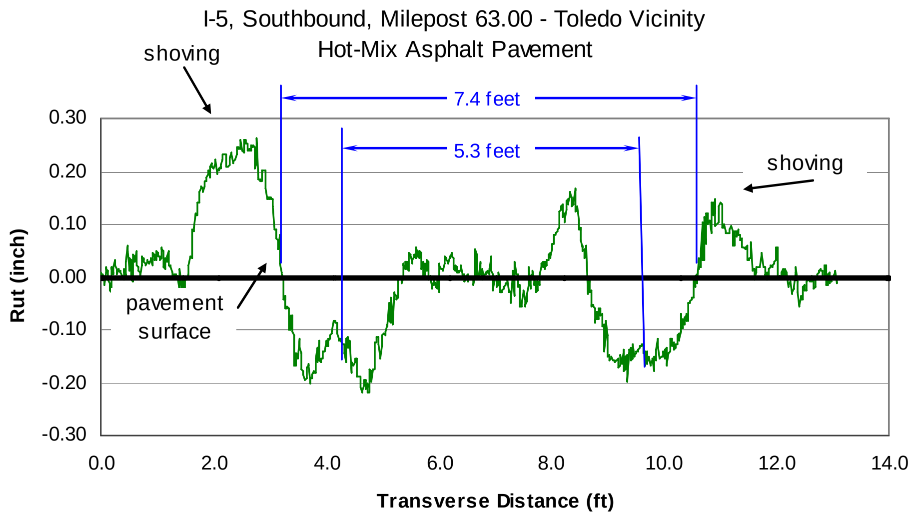
Studded Tire Damage

Studded Tire Damage

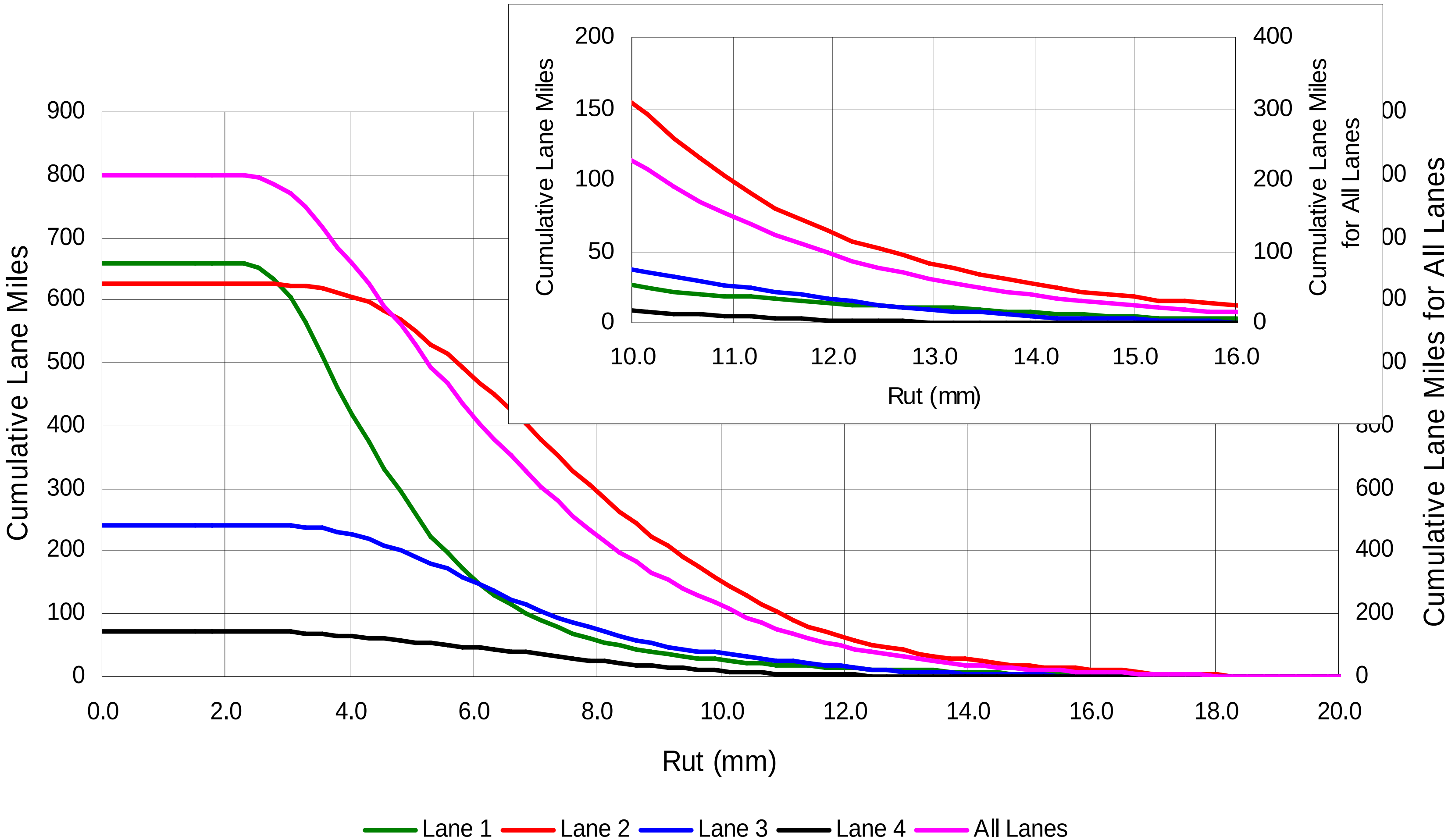
- 1972 Legislation allowed use of studded tires
- November 1 to March 31
- Damage seen primarily on highways with
  - Higher speeds
  - Higher volumes
  - HMA and PCC

Studded Tire Damage





PCCP Wear



Note - Lane 1 is the leftmost lane

Studded Tire Wear on PCC

Rut Depth (mm)	Number of Lane Miles
2 - 4	285
4 - 6	507
6 - 8	374
8 - 10	200
10 - 12	**135**
12 - 14	**60**
14 - 16	**24**
16 - 18	**12**
18 - 20	**3**
Total	1600

234 ln-mi with more than 10 mm of wear

$18.2 million in damage
(estimate for diamond grinding only)


PCC Deterioration

I-5 Deterioration Study

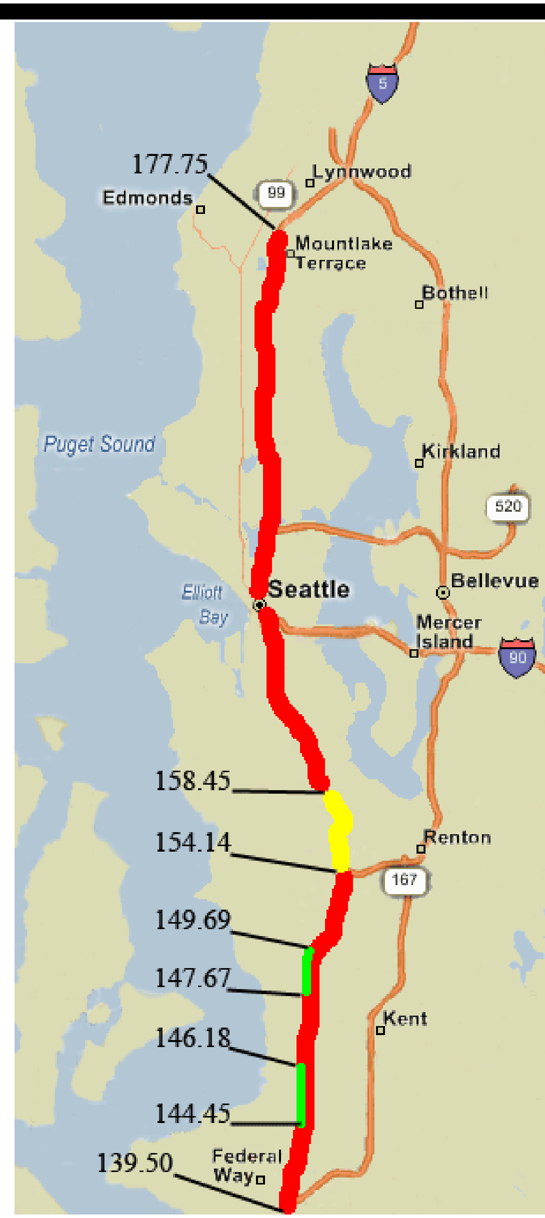
- Scope
  - Understand the condition of PCCP in King County (greater Seattle area)
  - Application to the remainder of state
- Rehabilitated and non-rehabilitated sections
- Varying construction dates
- Performance of different sections

I-5 Deterioration Study

- The data and resources used
  - Construction dates
  - Traffic volumes, percent trucks, ESAL
  - Rehabilitation treatments
  - Pavement structure
    - 9 inch non-doweled slabs on varying base type and thickness
  - Distress summaries
    - Slab cracking, faulting, IRI and wear
  - Video imaging of pavement condition

I-5 Deterioration Study

- Construction occurred from 1962-1970
- Identified three "states"
  - Non-rehabilitated
  - Diamond grinding
  - Dowel bar retrofit and diamond grinding



Non-Rehabilitated PCCP
1999 Diamond Ground PCCP
2001 Diamond Ground and Dowel Bar Retrofited PCCP

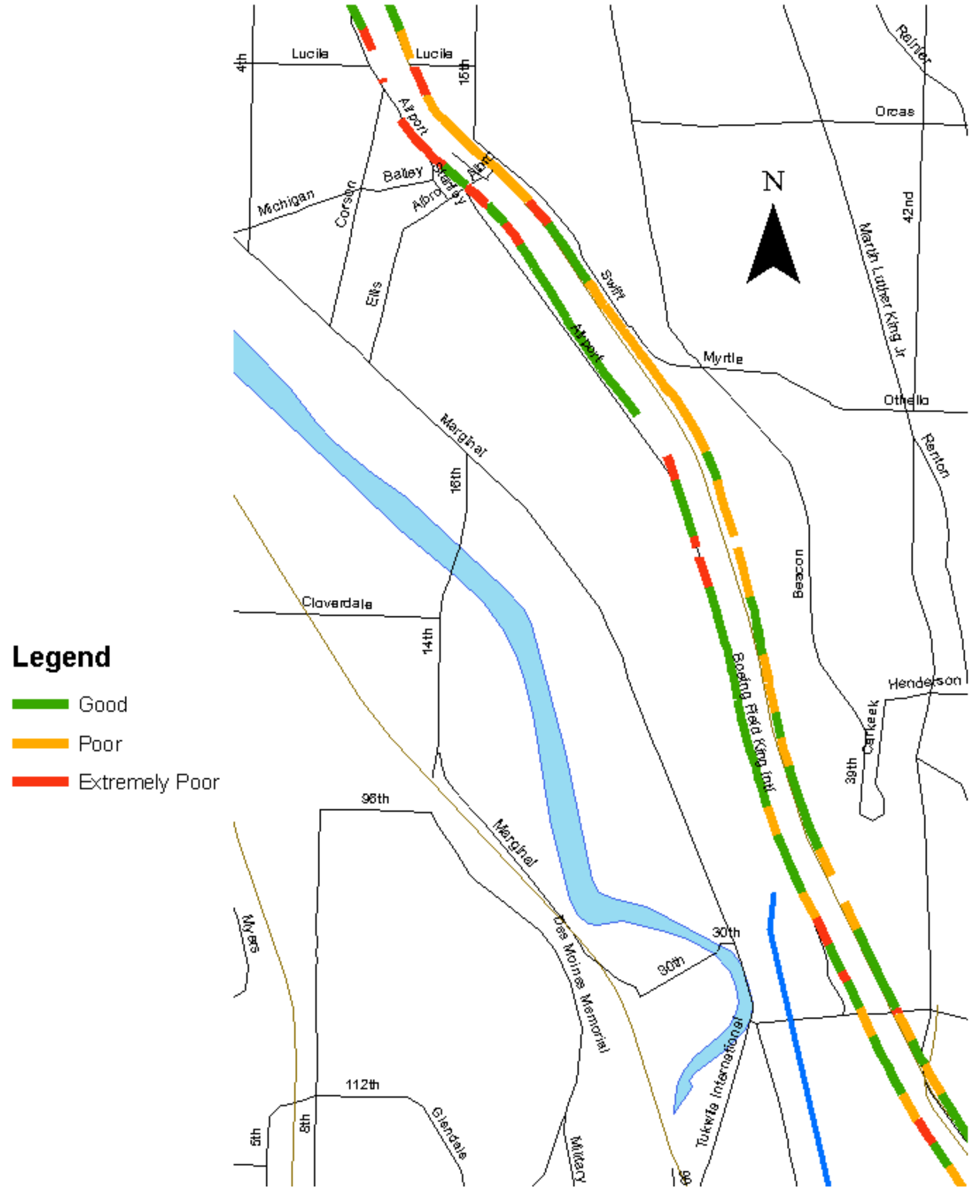
I-5 Deterioration Study

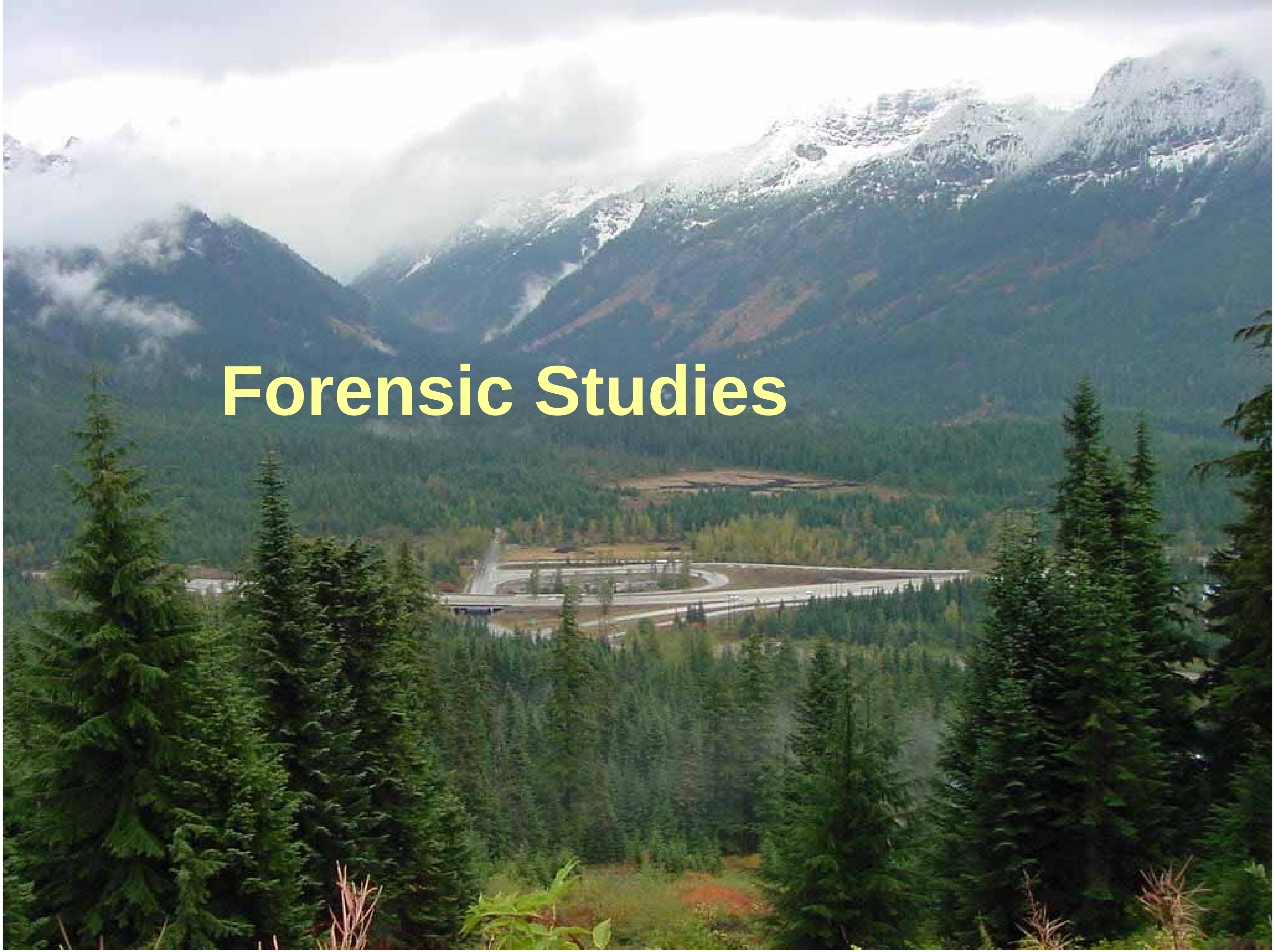
Section	Avg IRI (in/mi)	Wear (inch)	% slabs > ⅛″ faulting	% slabs cracked
Non-rehabilitated	157	0.34	29	14
Diamond Grinding	70	0.18	18	12
DBR and Diamond Grinding	52	0.26	3.4	4.4

I-5 Deterioration Study

Faulting (in)	Cracking	Assigned Value	Color	Pavement Condition
0 - ⅛	0 – 5%	1	green	Good
⅛ – ¼	5% - 10%	2	yellow	Poor
¼ +	10%+	3	red	Extremely Poor

I-5 Deterioration Study




Forensic Studies

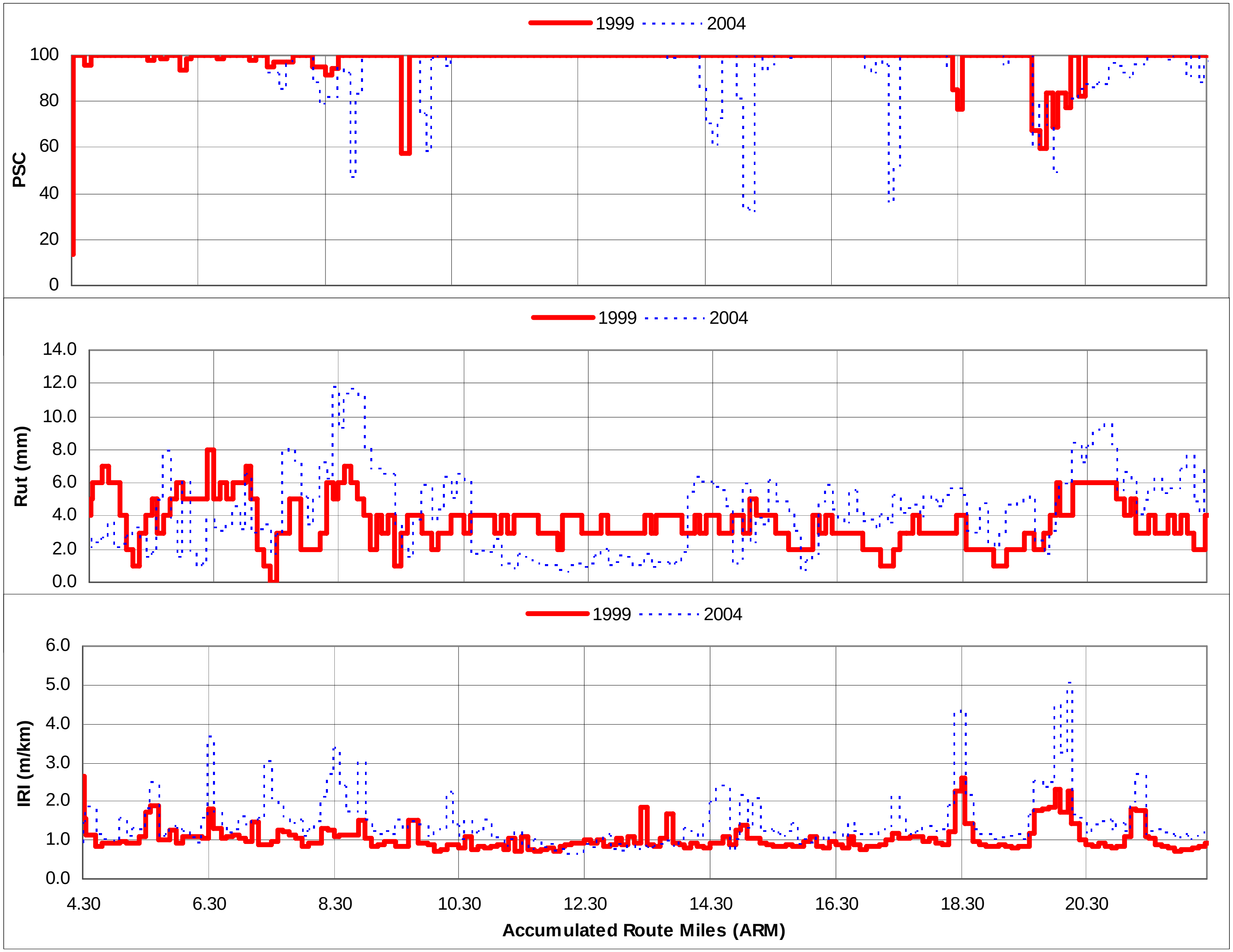
PMS Provides…

- Construction data
  - Construction year
  - Pavement type
  - Pavement thickness
  - QA/QC data
    - Data exists in separate data base
    - Automatic electronic link is still under development
- Condition data
  - PSC
  - Rutting
  - IRI

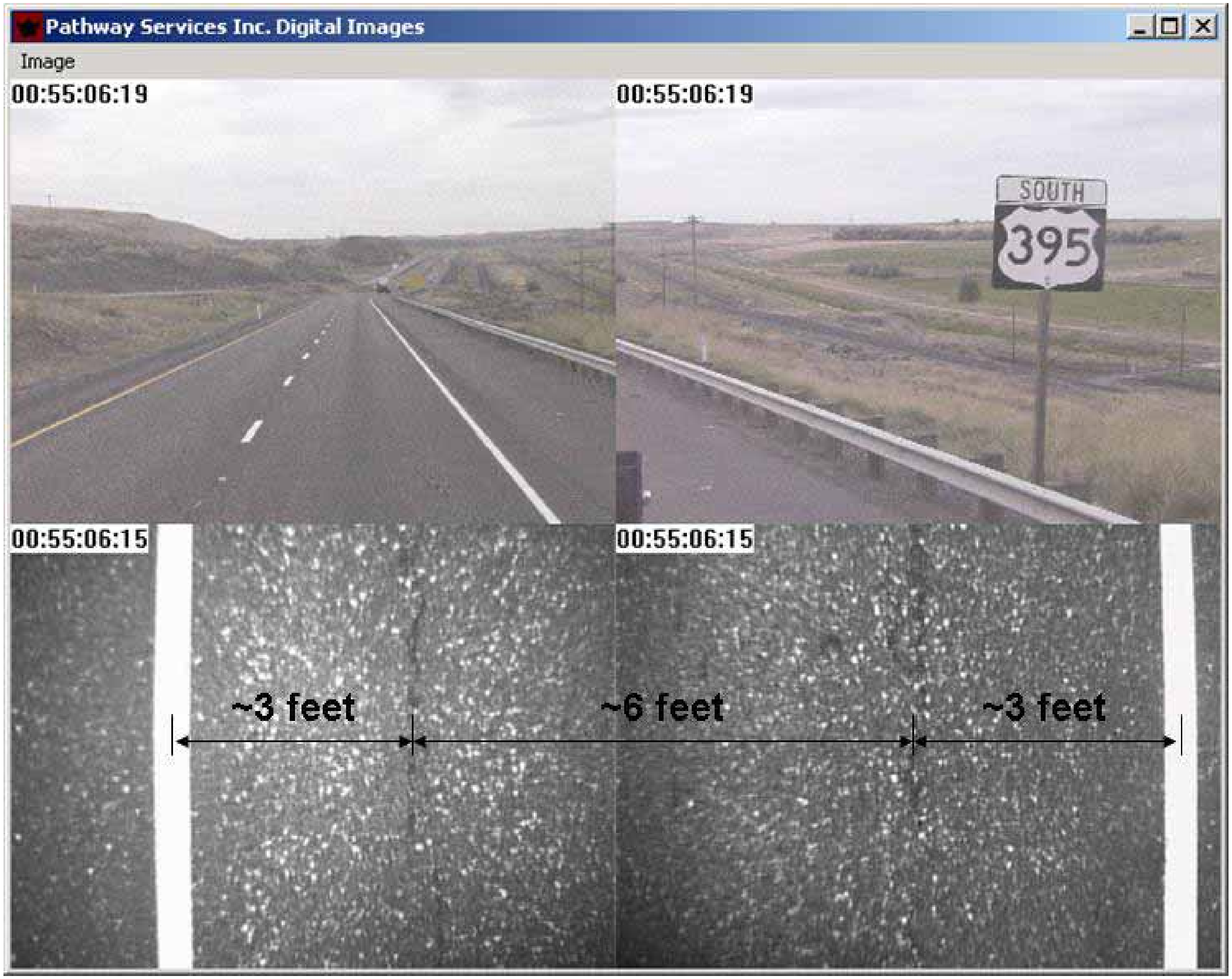
Example of Condition Data

Pavement distresses comparison						
	1999			2004		
Distress	Low	Medium	High	Low	Medium	High
Alligator Cracking	0.0	0.0	0.0	0.4	0.0	0.0
Patching	0.0	0.1	0.0	0.0	1.6	0.0
Raveling	0.0	0.0	0.0	0.0	0.0	0.0
Longitudinal Cracking	0.3	0.0	0.0	1.4	0.0	0.0
Transverse Cracking	0.0	0.0	0.0	0.3	0.1	0.0
Flushing	0.0	0.0	0.0	0.0	0.0	0.0

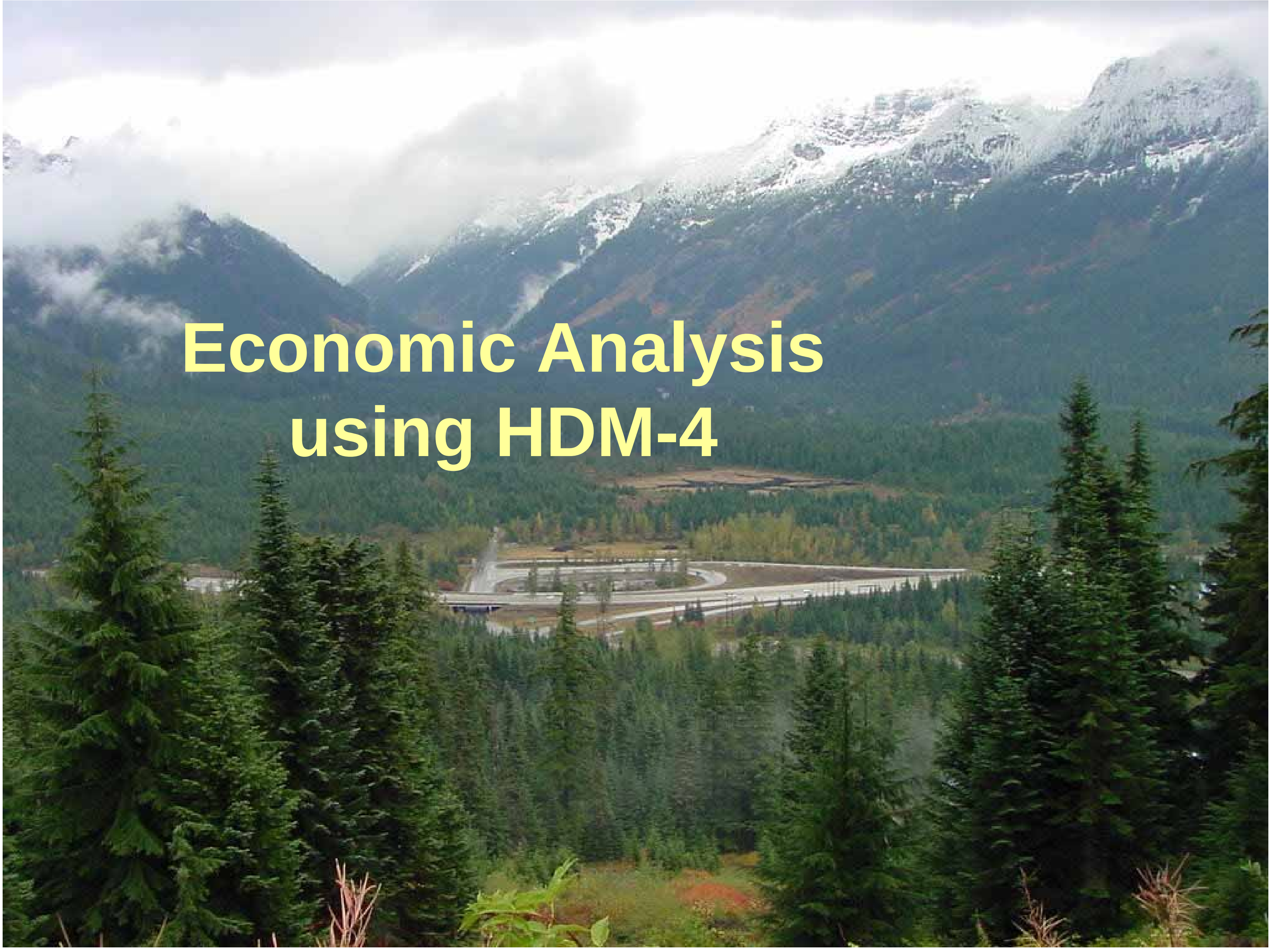
Example of Condition Data



Video Imaging



Economic Analysis using HDM-4



Pavement Management Needs

- WSPMS has ability to determine pavement performance on standard treatments
  - mill and fill, overlay, chip seal, etc.
- Currently lacks the ability to estimate how a funding cut (or increase) effects short and long-term pavement performance
- Potential applications
  - Highway Economic Requirements System (HERS)
  - Highway Development and Management System (HDM-4)

HDM-4 Calibration

- Highway Development and Management System (HDM-4) provides
  - Road performance prediction
  - Road treatment programming
  - Funding estimates
  - Budget allocation
  - Project appraisal
  - Policy impact studies
- Effectiveness is dependant on ability to accurately model and predict pavement performance

HDM-4 Calibration

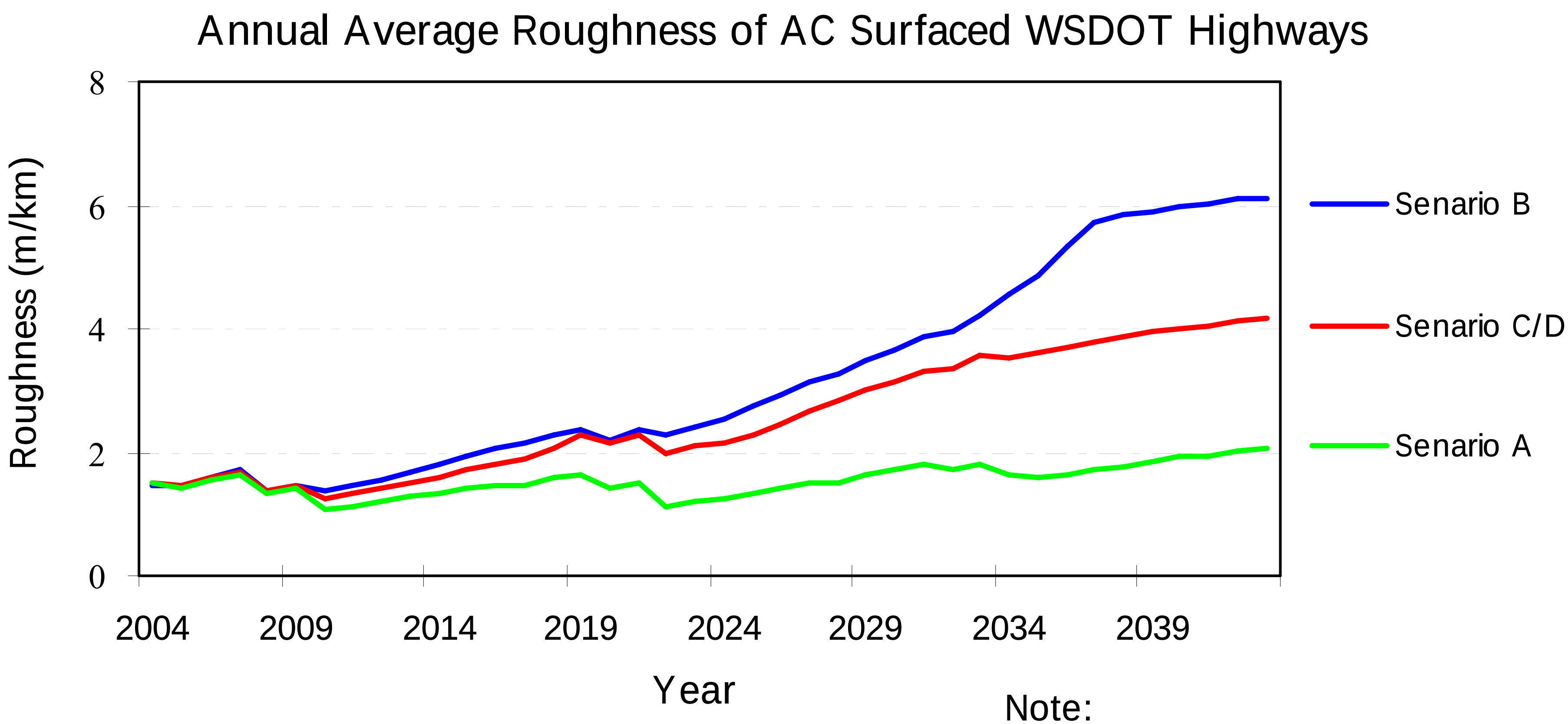
- Effectiveness to model is dependant on
  - Structural design
  - Materials
  - Construction variability
  - Traffic
  - Vehicle operating costs
  - Environmental considerations
  - Maintenance and rehabilitation practices

WSDOT Budget Scenarios for HMA

Scenario	Description	Budget Distribution 2004-2005	Budget Distribution 2006-2015	Budget Distribution 2016-2043
A	Cut $30 M from the current WSDOT HMA budget in FY 2004-2005, then use the unconstrained budget for the last 38 years	$144 ($72/year)	$4,013 ($105.6/year)	
B	Cut $30 M from the current WSDOT HMA budget in FY 2004-2005, then use the current WSDOT budget for the last 38 years	$144 ($72/year)	$870 ($87/year)	$2,438 ($87/year)
C	Cut $30 M from the current WSDOT HMA budget in FY 2004-2005, then bring the network back to the same condition as scenario D in 10 years	$144 ($72 /year)	$1,050 ($105/year)	$2,438 ($87/year)
D	Current WSDOT budget for HMAs	$3,482 ($87/year)		

(All costs are in millions of dollars)

Predicted Roughness



A = cut + unconstrained
B = cut + current WSDOT budget
C = cut + bring back to D condition in 10 years
D = current WSDOT budget

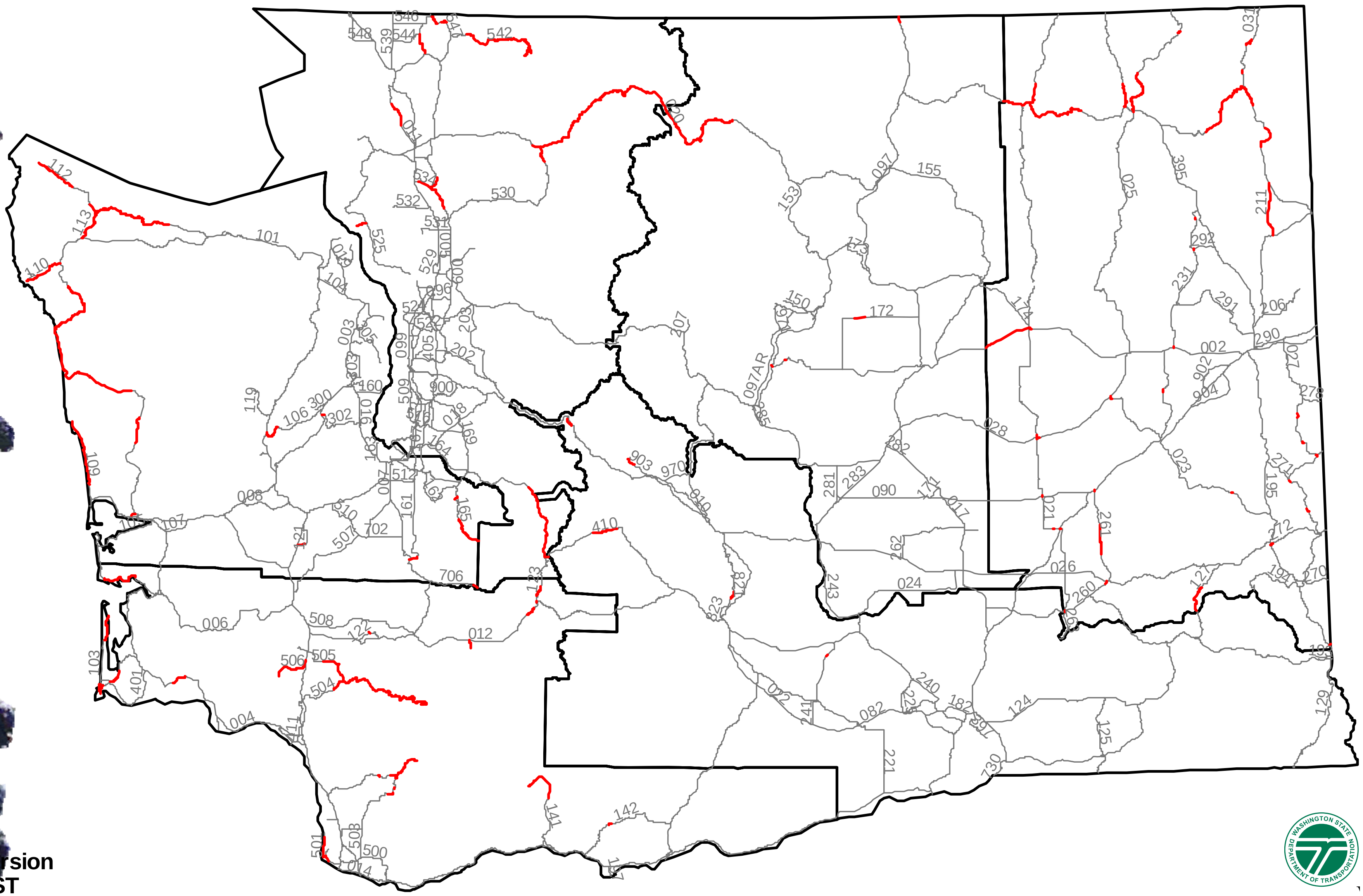
Note:
Scenario C costs $150 million more than scenario D

Bituminous Surface Treatment Analysis

2005-2007 Biennium

- WSPMS staff identified a potential $15 million in savings if current bituminous surface treatment (BST) protocol was implemented
  - ADT < 2000 vehicles
  - ESAL < 50,000 per year
  - HMA through cities and towns
- Legislative direction
  - Reduce pavement preservation program by $10 million for next three biennium's
  - Monies given to Partnership Projects

Potential HMA to BST Routes



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BST Protocol Refinement Study

- University of Washington study
  - What is the appropriate ADT level?
  - Is there a limit for truck volumes?
  - Other factors (noise, speed, grade, etc.)?
  - Are there combinations of BST to HMA cycles to obtain optimal performance?

BST Protocol Refinement Study

- Increasing number of BST surfaces will impact pavement performance
  - How do we quantify this impact?
    - Structural analysis
    - Economic analysis (HDM-4)
      - Performance prediction
      - Impact of rehabilitation cycle on user delay during construction and pavement roughness
    - WSDOT Pavement Management System
      - Traffic
      - Performance

WSDOT Lane Miles

Pavement Type	Lane-miles	% of Total
HMA	10,776	60
BST	4,843	27
PCC	2,262	13
Totals	17,881	100

WSDOT Lane-Miles by ADT

AADT	Lane-miles			
	BST	HMA	Flexible	All Types
0-2,000	3,157	1,834	4,991	4,993
2,000 - 4,000	819	1,645	2,464	2,486
4,000 – 6,000	190	1,423	1,613	1,631
6,000 – 8,000	8	840	848	934
8,000 – 10,000	1	567	568	660
10,000 – 20,000	4	2,094	2,098	2,572
20,000 – 40,000	0	1,610	1,610	2,029
40,000 -80,000	0	1,032	1,032	1,360
80,000 – 160,000	0	436	436	640
>160,000	0	132	132	360

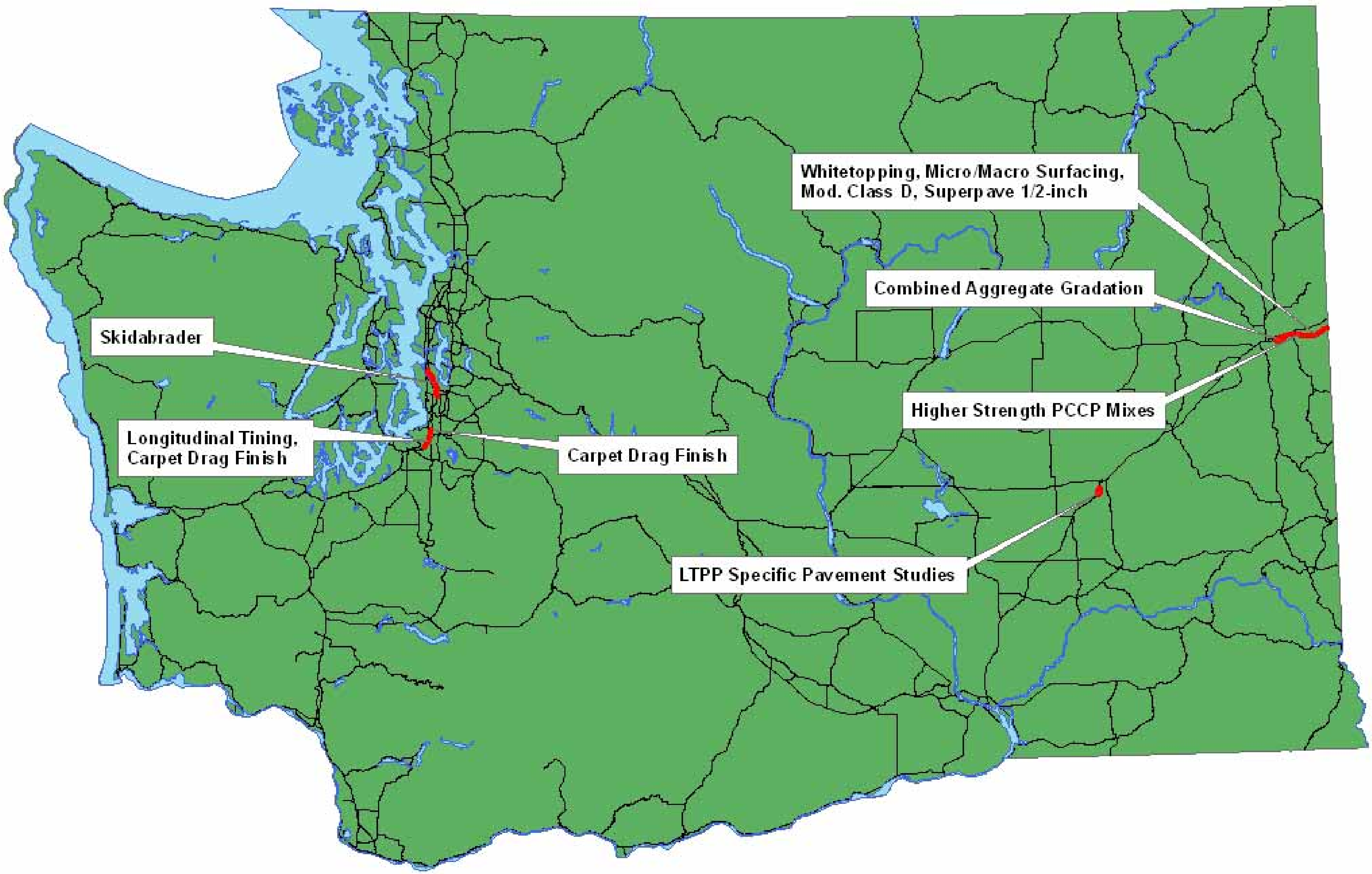
Preliminary Findings

- ADT < 2000
  - Apply BST
  - Exemptions for cities, towns
- ADT 2000 to 4000
  - Combination of BST and HMA
  - Exemptions for cities, towns, difficult traffic conditions, intersections, etc.
- ADT > 4000
  - HMA

Experimental Features

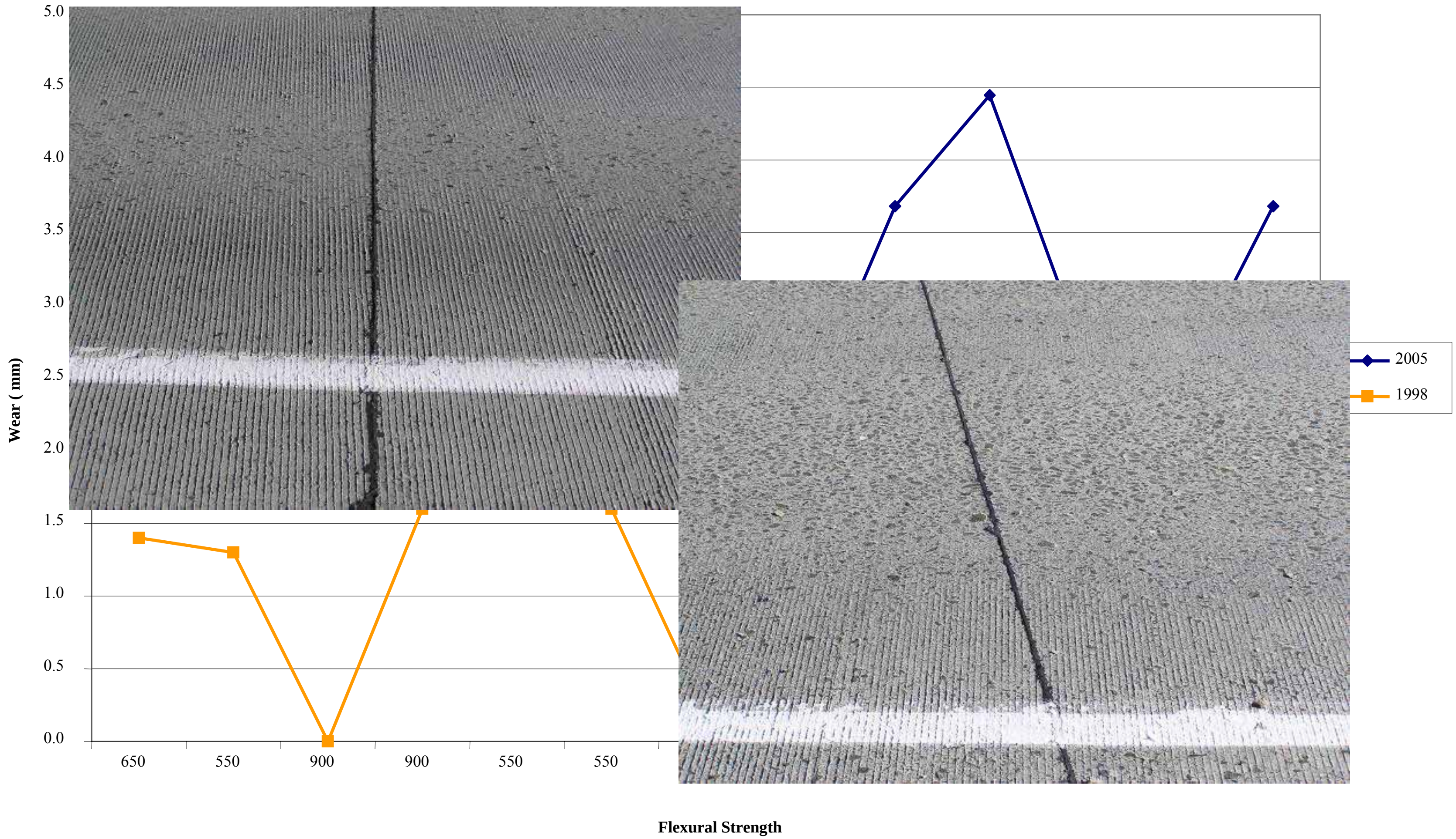
Experimental Features

- New technologies and innovative ideas
- Construction practices
- Specification development
- Pavement performance
  - Ride
  - Pavement condition
  - Rutting/wear
  - Faulting
- Equal or better extension of performance life?



Whitetopping, Micro/Macro Surfacing, Mod. Class D, Superpave 1/2-inch
Combined Aggregate Gradation
Skidabrader
Higher Strength PCCP Mixes
Longitudinal Tining, Carpet Drag Finish
Carpet Drag Finish
LTPP Specific Pavement Studies

SR-395 SPS-2 Pavement Wear




Questions?