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Cost Effectiveness of the Michigan DOT and National Park Service (NPS) Preservation Programs

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applied pavement TECHNOLOGY
providing engineering solutions to improve pavement performance

Presentation Overview

- Cost-Effectiveness of the Michigan DOT Capital Preventive Maintenance (CPM) Program
  - Study objectives and research approach
  - Activities and findings
  - Conclusions
- Performance and Benefits of Surface Treatments on NPS Pavements
  - Study objectives and research approach
  - Activities and findings
  - Conclusions
- Lessons Learned
- Questions

Cost Effectiveness of the Michigan DOT CPM Program

- Sponsor: Michigan DOT
- Contractor: Applied Pavement Technology, Inc. (subcontractor Michigan Tech University)
- Time Period: October 2010 – March 2013
- Background

Study Objectives

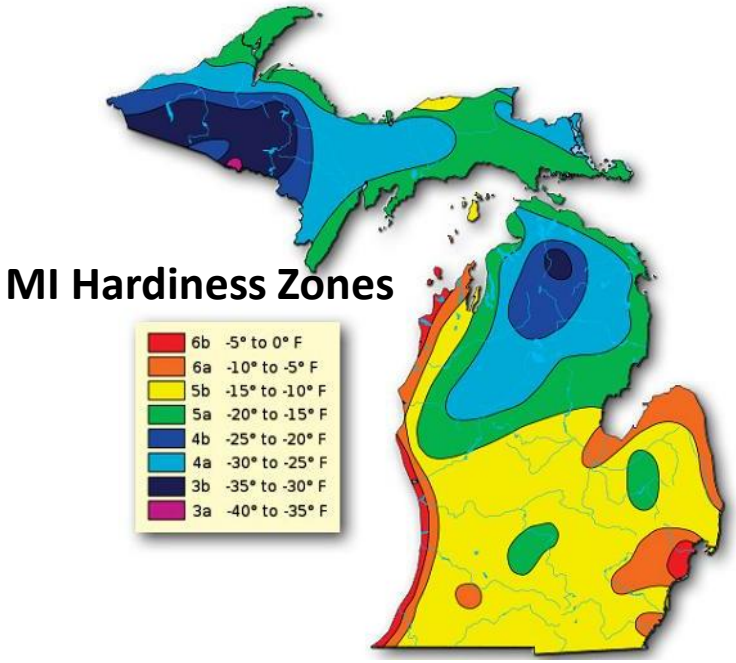
- Determine the costs and benefits of pavement preservation options used by MDOT
- Document the costs and benefits of the MDOT pavement preservation program
- Determine the variability in the costs and benefits of each pavement preservation option
- Establish a relational matrix for the selection of time, location, and preservation option

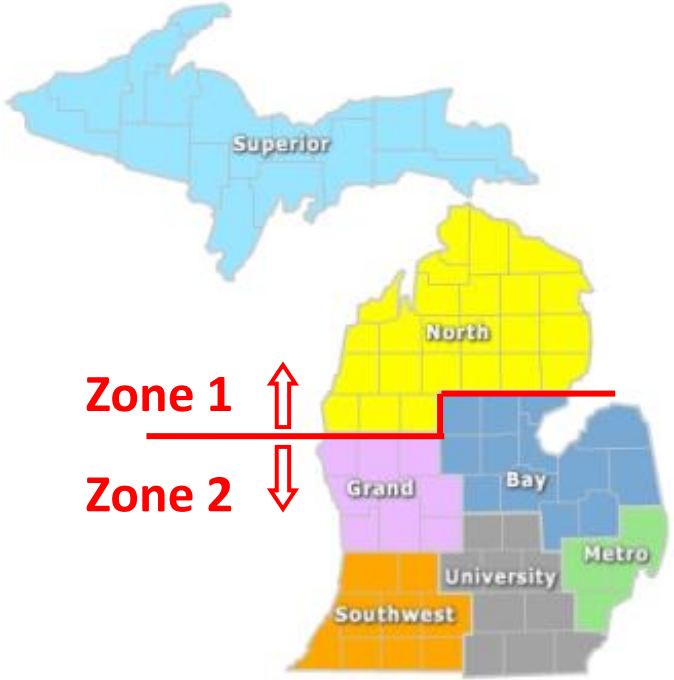
Research Approach

- Data collection and data assembly
- Analyze historical pavement data and develop analysis categories
- Identify gaps/issues with data
- Develop pre- and post-CPM treatment performance models
- Conduct benefit-cost analysis of treatments and MDOT CPM program
- Develop matrix for selection of time, location, and treatment option
- Summarize study findings and recommendations

Data Collection and Assembly

- R&R and CPM projects⇨3,300+ analysis segments
- Pavement type, CPM treatment(s), functional class, traffic level
- Historical Distress Index (DI) data (pre- & post-treatment)
- Climatic zones based on MDOT regions

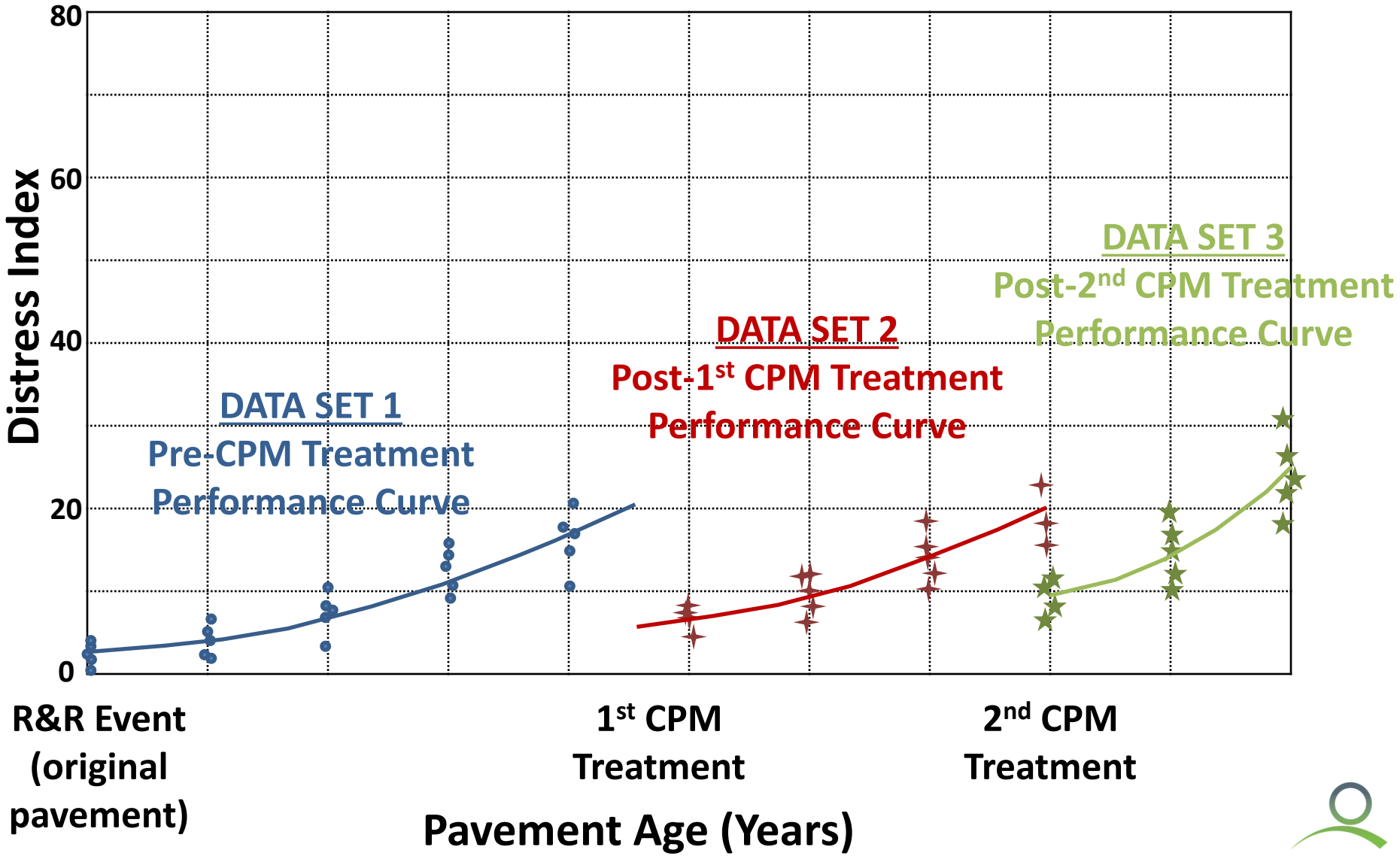




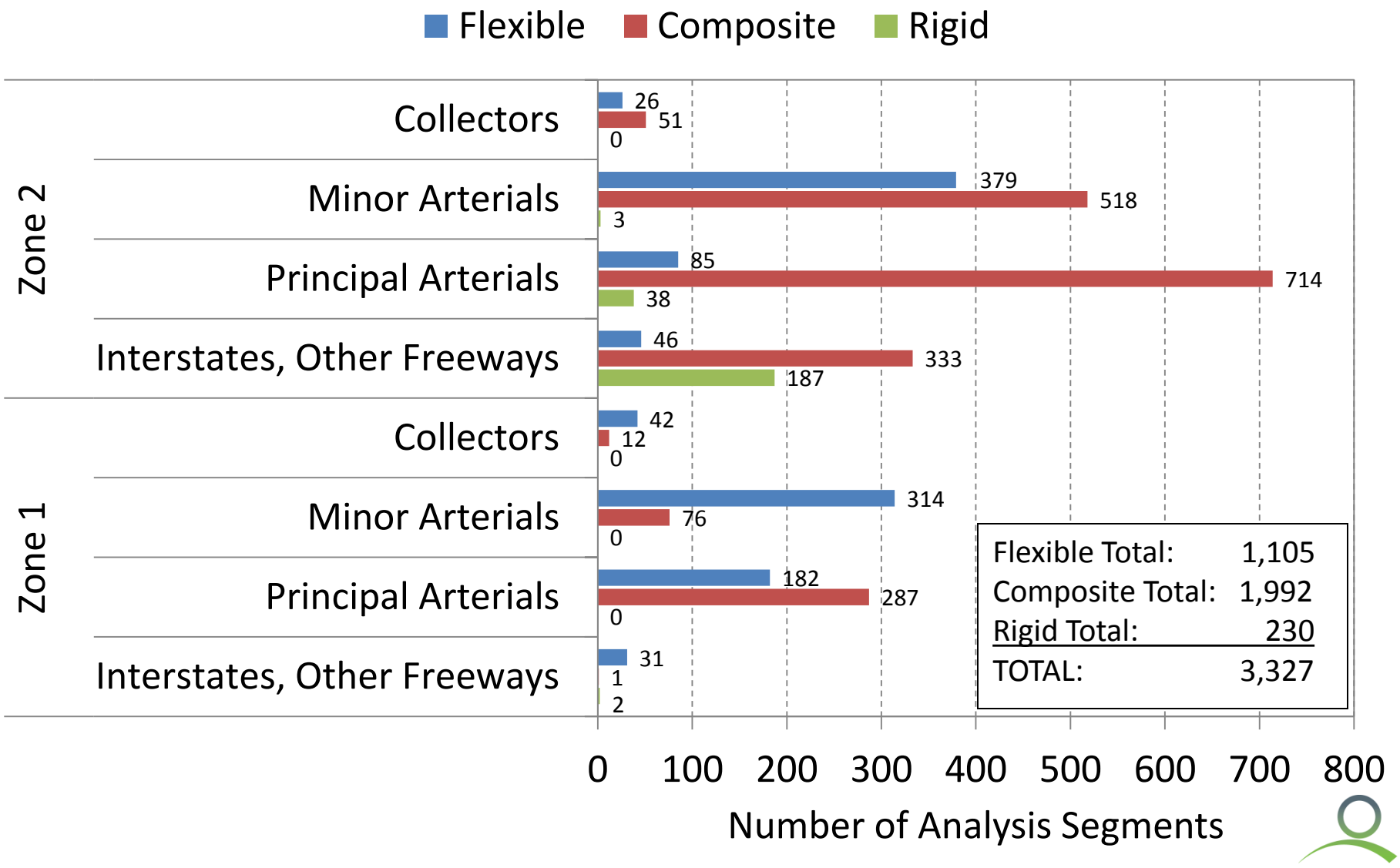
CPM Treatments

CPM Treatment	Number of Projects/Segments
Single Chip Seal	233
Double Chip Seal	87
HMA Crack Seal/Treatment	1,109
HMA Mill and Overlay	743
HMA Overlay	263
Ultra-Thin HMA Overlay	72
Double Microsurfacing	541
Paver Placed Surface Seal	38
PCC Joint and Crack Seal	72
Concrete Pavement Restoration (CPR)	331

Pavement Performance Modeling



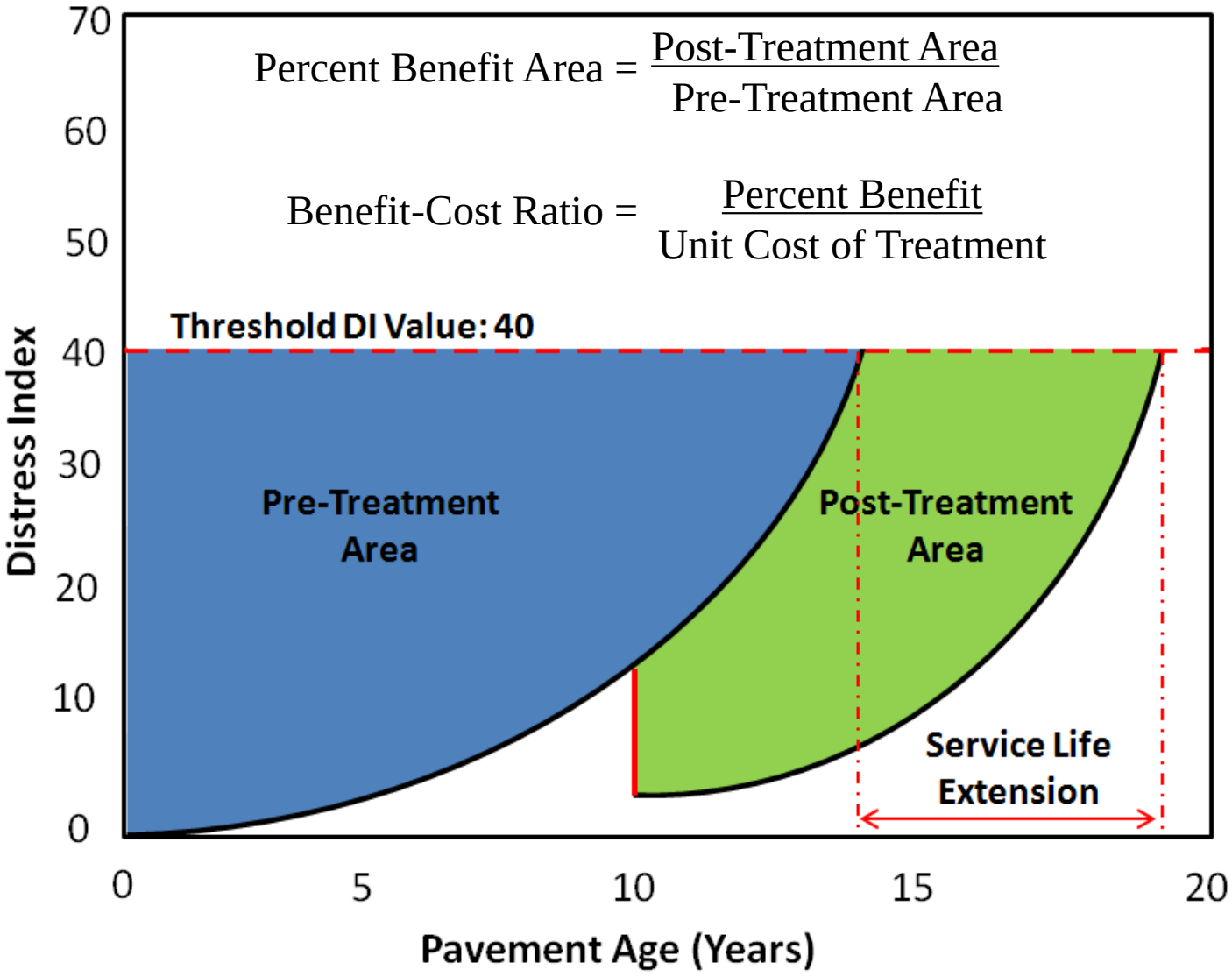
Pre-CPM Treatment Data



Performance Modeling

- Multiple regression models to identify significant factors
  - Dependent variable: DI
  - Independent variables: climatic zone (1 and 2), pavement type (flexible, composite, rigid), pavement age (years since last R&R), functional class, traffic, pre-treatment DI
- Data filtering techniques
- Functional class ⇨ poor models
- Traffic, pre-treatment DI ⇨ not significant factors in many cases
- Focus on “DI vs age”

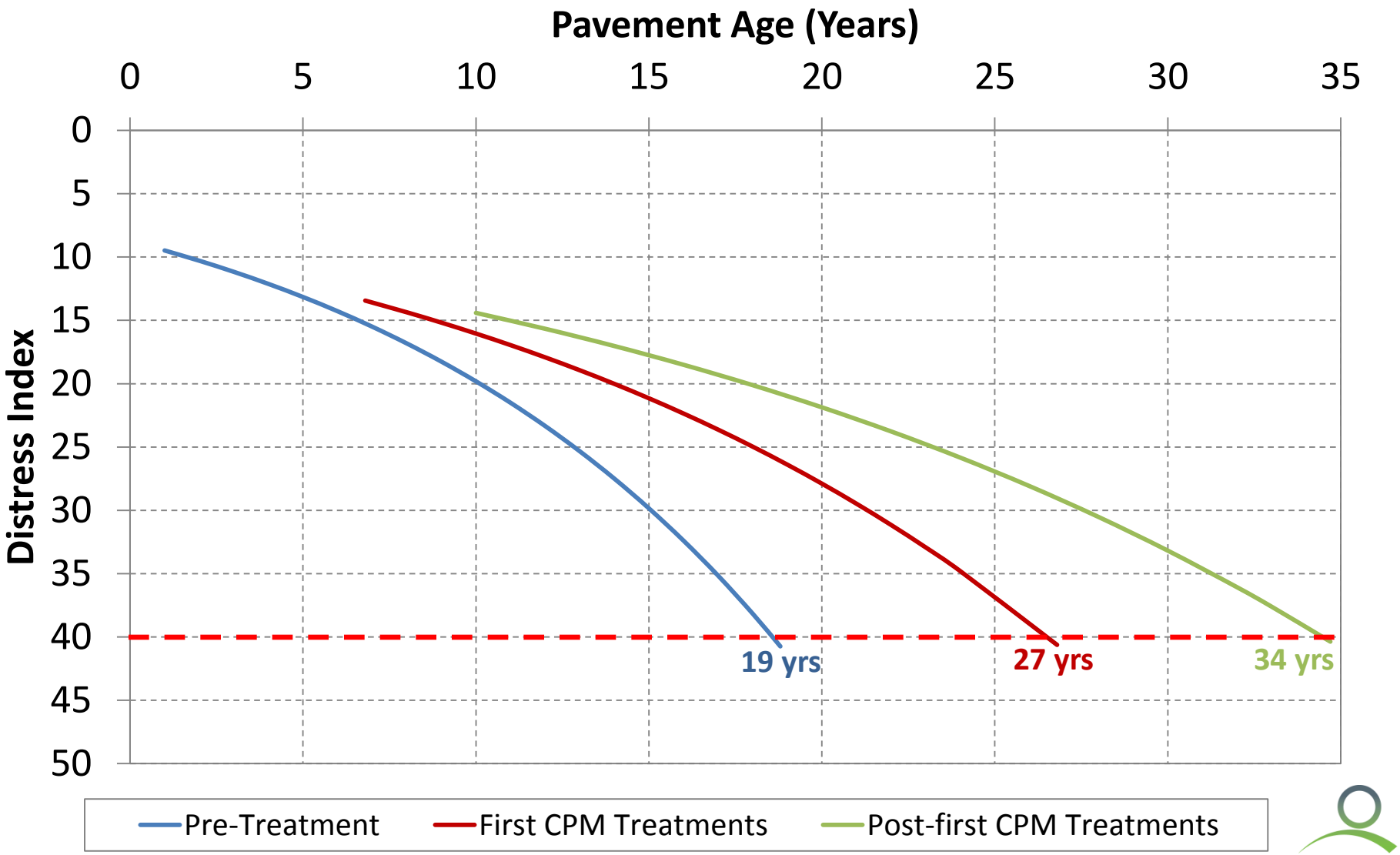
Treatment Performance and Benefit Analysis



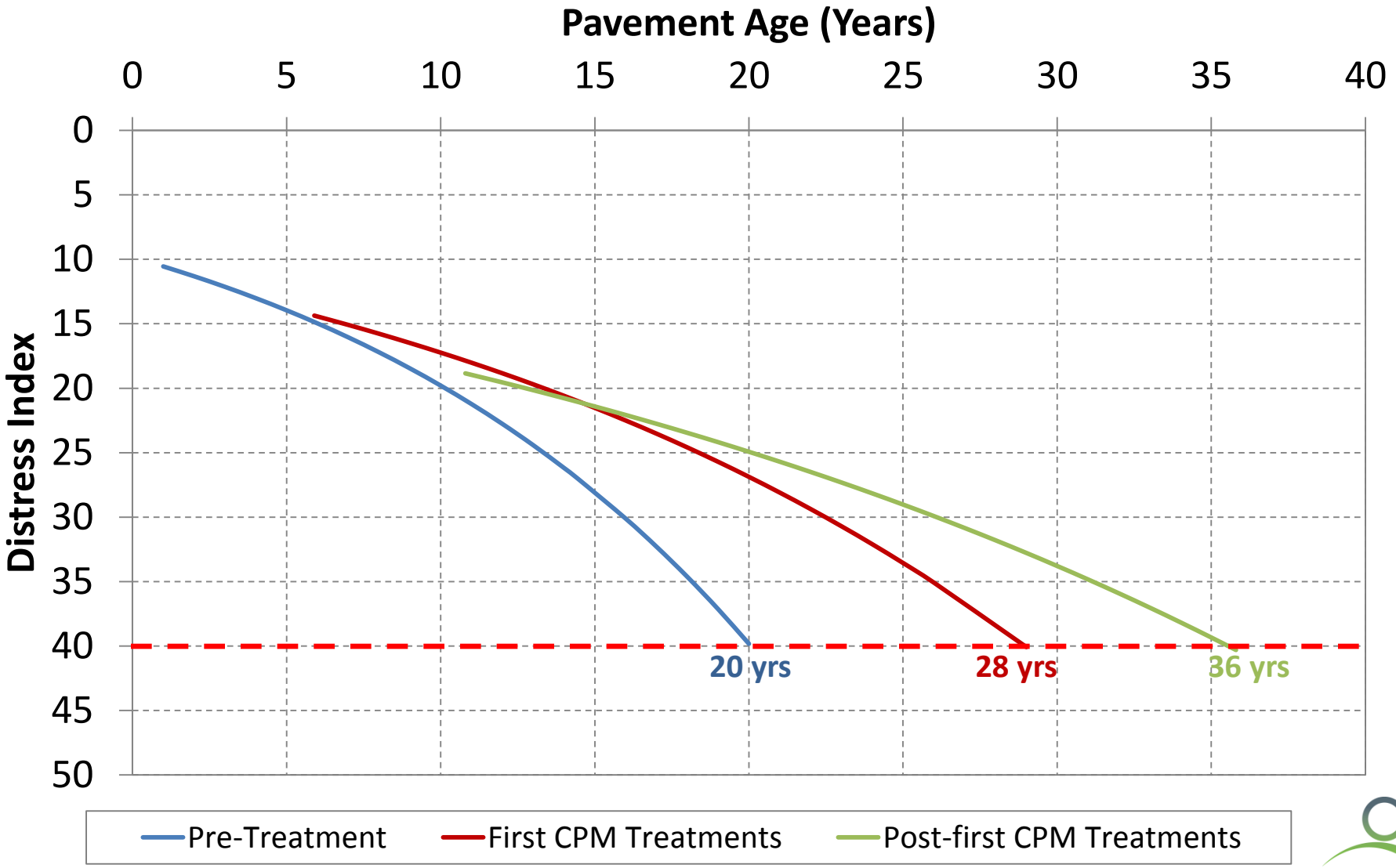
Treatment Performance and Cost Benefit

Treatments	Average Pavement Life Extension (Years)		Percent Benefit over Pre-Treatment Performance		Average Unit Cost (per yd^2)	Benefit-Cost Ratio	
	Flexible Pavements	Composite Pavements	Flexible Pavements	Composite Pavements		Flexible Pavements	Composite Pavements
HMA Overlay (non-structural)	3.6 to 4.0	2.2 to 4.2	35 to 49	12 to 21	$3.59	0.10-0.14	0.03-0.06
HMA Mill and Overlay (non-structural)	7.8 to 7.9	3.6 to 8.5	49 to 79	26 to 68	$4.34	0.11-0.18	0.08-0.16
Ultra- Thin HMA Overlay					$2.29		
Single Chip Seal	2.7 to 6.6		15 to 63		$1.31	0.11-0.48	
Double Chip Seal	6.9	1.9	40	32	$2.27	0.18	0.14
Double Micro-surfacing	1.8 to 7.8	9.8 to 11.6	22 to 61	49 to 56	$2.35	0.10-0.26	0.21-0.24
Paver Placed Surface Seal					$4.70		
HMA Crack Seal/Treatment	0.6 to 2.8	0.9 to 2.1	4 to 12	5 to 21	$0.26	0.15-0.46	0.19-0.80

Flexible Pavement Models



Composite Pavement Models



Study Conclusions

- Flexible and composite pavement CPM treatments effective
  - Service life extensions and benefits vary by treatment, pavement type, and climate
  - Sequential CPM treatments (1st and 2nd combined) provide life extensions of 15-16 years
- MDOT CPM Program certainly helping preserve existing pavements and delaying major R&R activities

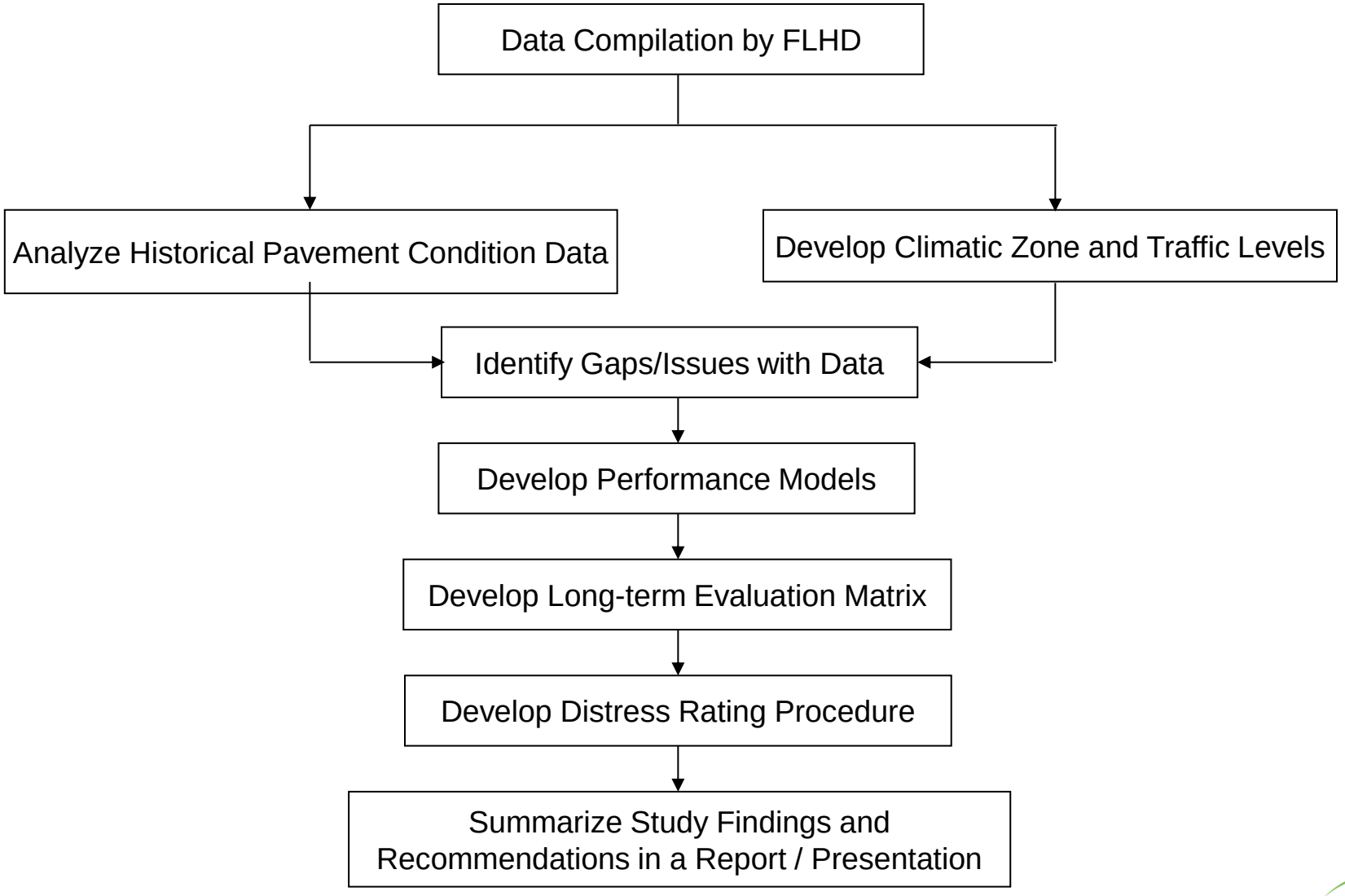
Performance and Benefits of Surface Treatments on NPS Pavements

- Sponsor: FHWA Central Federal Lands Highway Division (CFLHD)
- Contractor: Applied Pavement Technology, Inc. (sub to Yeh and Associates, Inc.)
- Time Period: September 2010 – September 2012
- Background

Study Objectives

- Develop improved performance models addressing use of common surface treatments
  - Shift from generic models involving engineering judgment to objective analytical models that account for factors believed to affect treatment performance
  - Improve ability to identify optimal treatment timings
- Develop treatment monitoring guidelines

Research Approach



Parks Included

Dry Freeze	Dry No-freeze	Wet Freeze	Wet No-freeze
Arches (UT)	Big Bend (TX)	Cuyahoga Valley (OH)	Great Smoky Mountains (TN)
Badlands (SD)	Death Valley (CA)	Lassen Volcanic (CA)	Natchez Trace (MS/TN)
Canyonlands (UT)	Joshua Tree (CA)	Natchez Trace (MS/TN)	Chickasaw (OK)
Lava Beds (CA)		Yosemite (CA)	
Theodore Roosevelt (ND)		Acadia (ME)	
Zion (UT)		Crater Lake (OR)	
Grand Teton (WY)		Kings Canyon (CA)	
John D. Rockefeller Jr. Memorial Parkway (WY)		Shenandoah (VA)	
Rocky Mountain (CO)			

Pavement Facility Types

Principal Pavements (PP): Principal park road, connector park road, urban parkway

Parking Areas (PA):

Other Pavements: Special purpose road, administrative access road, restricted road

NPS Use of Preservation Treatments

Treatment	No. of Projects/Sections[1]
Chip Seal, Type 1 (single-course)	190
Chip Seal, Type 2 (double-course)	53
Fog Seal	5
Microsurfacing	87
Slurry Seal	70
Thin Hot Asphalt Concrete Pavement (HACP) Overlay	9
TOTAL	414

[1] Applied between 1993 - 2010

Treatment Matrix

Environment/ Route Type / Treatment Type	Dry Freeze			Dry No-Freeze			Wet Freeze			Wet No-Freeze		
	PP	PA	Other	PP	PA	Other	PP	PA	Other	PP	PA	Other
Chip Seal, Type 1 (Single Course)	55	16	29	18	10	5	14	29	4	2		8
Chip Seal, Type 2 (Double Course)							14	38	1			
Fog Seal	1	4										
Microsurfacing	1	32	1		33	19	1					
Slurry Seal	1	48	1		6		3	11				
Thin HACP Overlay							3			6		

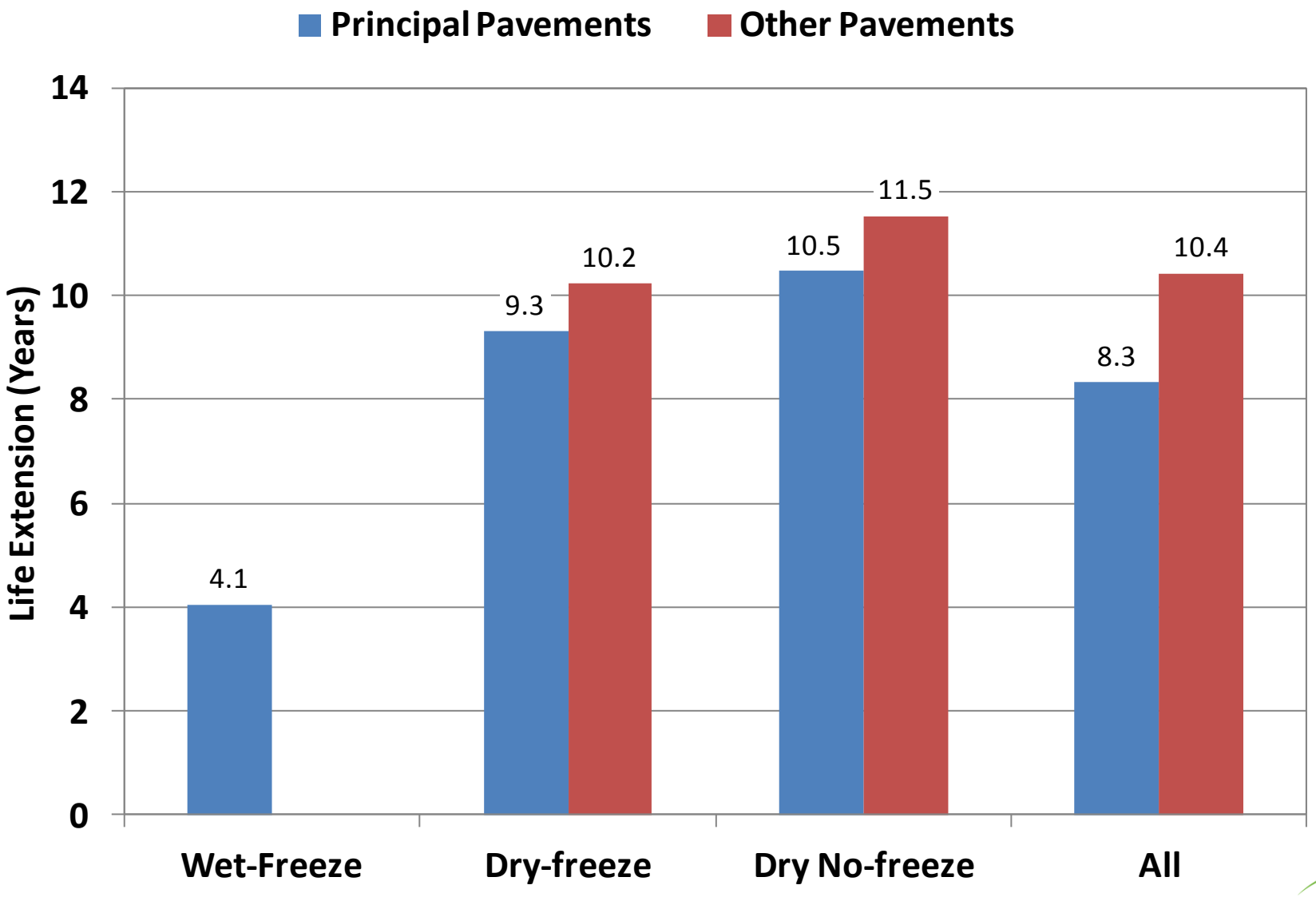
Extensive use (> 8 projects) Moderate use (4 to 8 projects) Limited use (1 to 3 projects)

PP = Principal Pavements PA = Parking Areas Other = Other Pavements

Performance Modeling

- Performance measures (0-to-100 scale)
  - Surface condition rating (SCR) (cracking, rutting, patching deducts)
  - Roughness condition index (RCI) (based on IRI)
  - Pavement condition rating (PCR) (composite of SCR & RCI)
- Pre- and post-treatment models using performance data from 2001-2010
- Realistic pre-treatment models developed for PP in 3 climatic zones, but reliable post-treatment models could not be developed
- Focus on performance jump and life extension (type I chip seals only)

Pavement Life Extension (Type I Chip Seal, SCR)



Study Conclusions

- Original intent to model performance of surface treatments; however multiple problems encountered
  - Data collection equipment/protocol changes
  - Lack of rehabilitation dates
  - Limited performance data
  - Long cycle times leave many unknowns
- Alternate approach applied to Type I chip seals
  - Longer life extensions in dry-freeze vs wet-freeze climates
- Based on limited analysis, FLHD's preventive maintenance program is extending service lives

Lessons Learned

- Target more frequent performance data collection cycle (e.g., 2 years instead of 4)
- If changes in data collection equipment/ protocols occur, establish appropriate methods for linking historical data with new data
- Select good candidate projects for preservation treatments (pavements in fair-good condition only)
- Apply the treatments in optimal conditions

Thank You…Questions??

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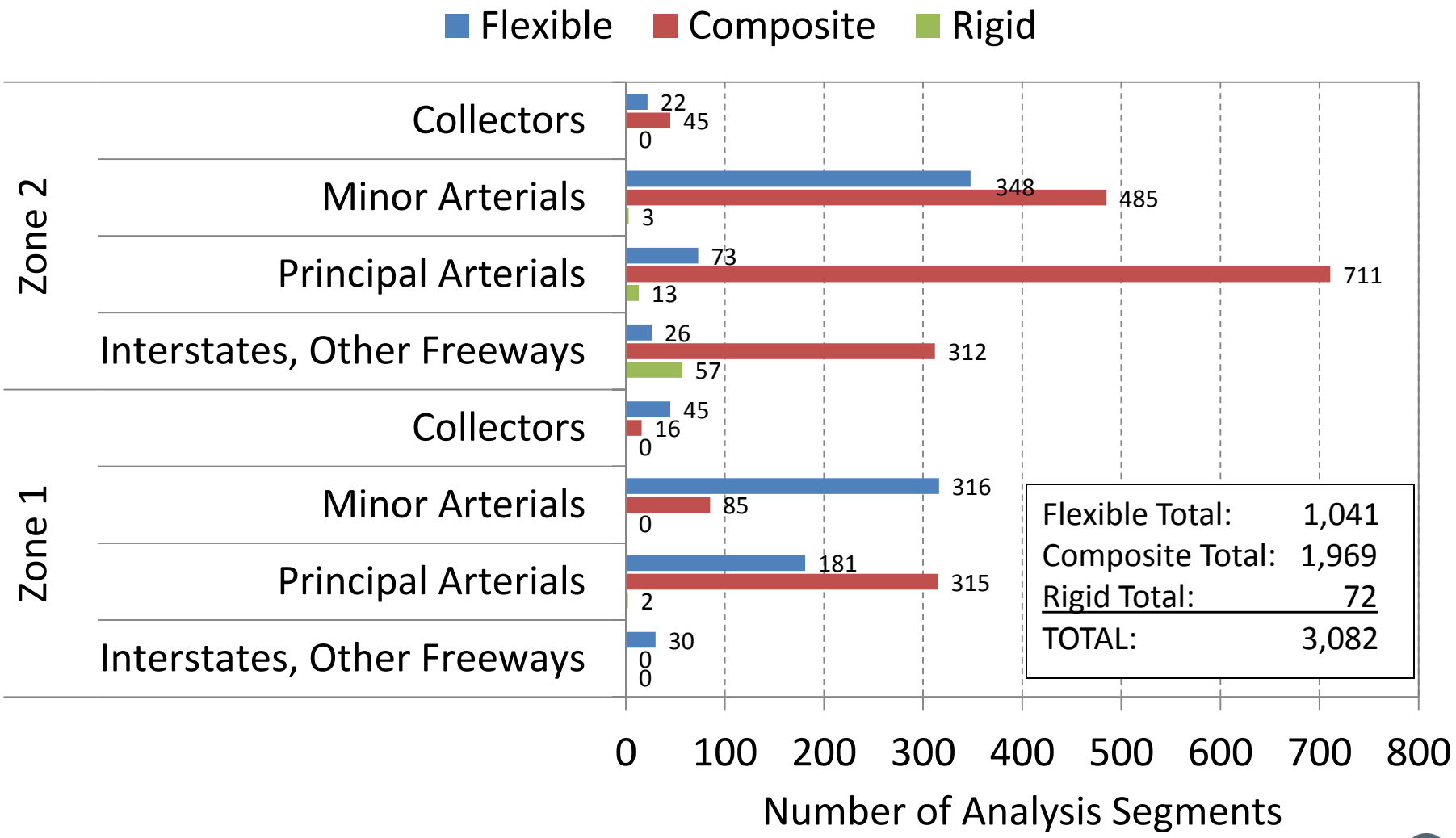
MDOT Report

http://www.trb.org/Finance1/Blurbs/168999.aspx

NPS Data Collection Cycles

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
Year	1994 - 1997	1997 - 2000	2001 - 2004	2005 - 2009	2010 - 2013
Vehicle	ARAN van (paved), Mandli vehicle (unpaved)	ARAN van (large parks), Mandli vehicle (some small parks)	New ARAN van (large parks) Old ARAN van (small parks)	New ARAN van (large parks and some small parks)	PathRunner from Pathway Services, Inc. (small and large parks)
Measures	LC, TC, AC, bleeding, raveling, shoving, patching/potholes, IRI, rutting (no severities)	LC, TC, AC, patching/potholes, IRI, rutting, RCI, SCR	LC, TC, AC, patching/potholes, IRI, Rutting, RCI, SCR	LC, TC, AC, patching/potholes, IRI, rutting, RCI, SCR	LC, TC, AC, patching/potholes, IRI, rutting, RCI, SCR
Comments	Data compromised due to poor collection and processing, many distress ratings done through windshield surveys, deficient matrix, and lack of experience.	Noise in ultrasonic sensors resulted in erroneous rutting measurements, potholes were not filtered unless they exceeded 2 inches in depth, data reduction equations modified resulting in inconsistent measures.	Revised index equations used, resulting in inconsistent measures.	Data from Cycle 3 and Cycle 4 collected using same type of equipment, thereby providing some consistency.	Parking areas surveyed in small parks only, data collected only for principal park, urban parkway, and collector pavements. Data collection vehicle changed in Cycle 5. Data reduction equations modified from Cycle 4.

Post-1st CPM Treatment Data (First App)



Post-2nd CPM Treatment Data (Subsequent App)