Preservation and Quality of Life, Framework and Examples

John Harvey
University of California Pavement Research Center

Overview

- Preliminary framework for quality of life and pavement
- Some examples
  - Tire/pavement noise
  - Heat island
  - Bicycle ride quality

What affects quality of life?

- Already considered in PMS, LCCA:
  - Safety
  - Ability to access essential services
    - Health care
    - Nutrition
    - Education
    - Social access
    - Recreation
  - Cost and comfort of access in motor vehicles

What affects quality of life?

- Not generally considered in current systems:
  - Noise
  - Active transportation
    - Ride quality
    - Safety
  - Thermal comfort
- What else?

- $1.3+ million per mile
- Maintenance problems (graffiti) $100k/yr
- Can not be used everywhere
- Limit future highway expansion
- Not necessarily effective
- Block views

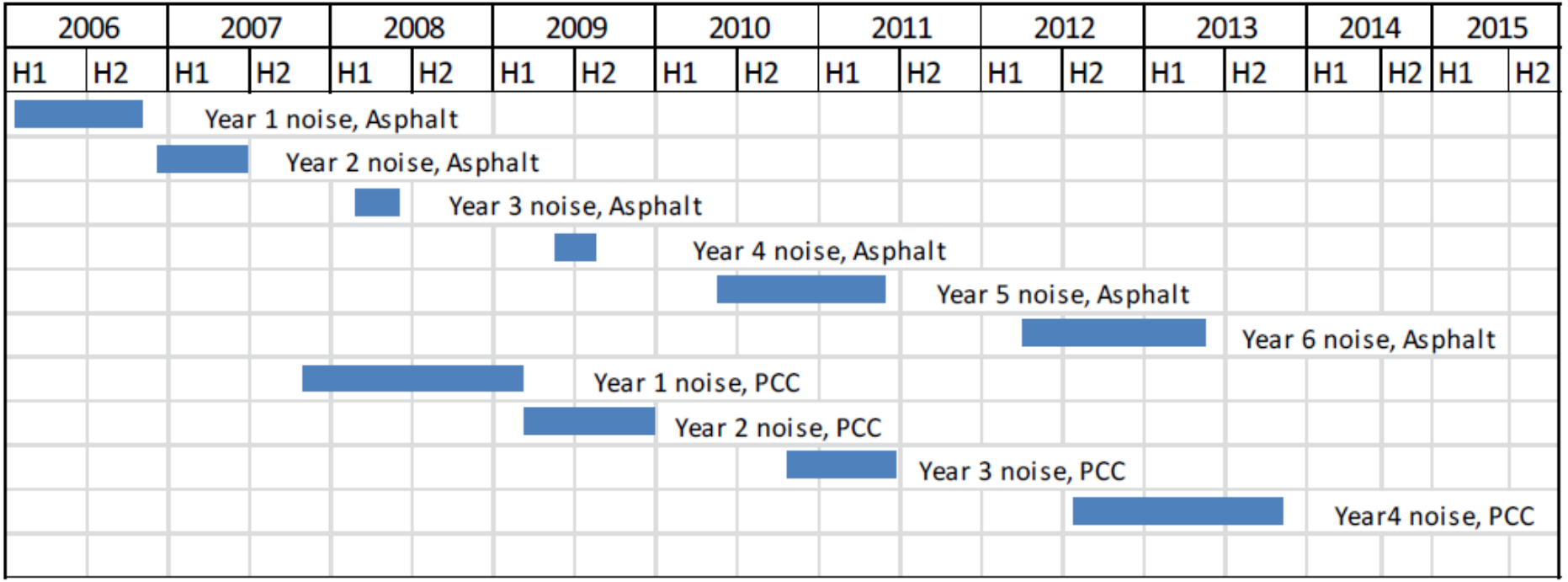
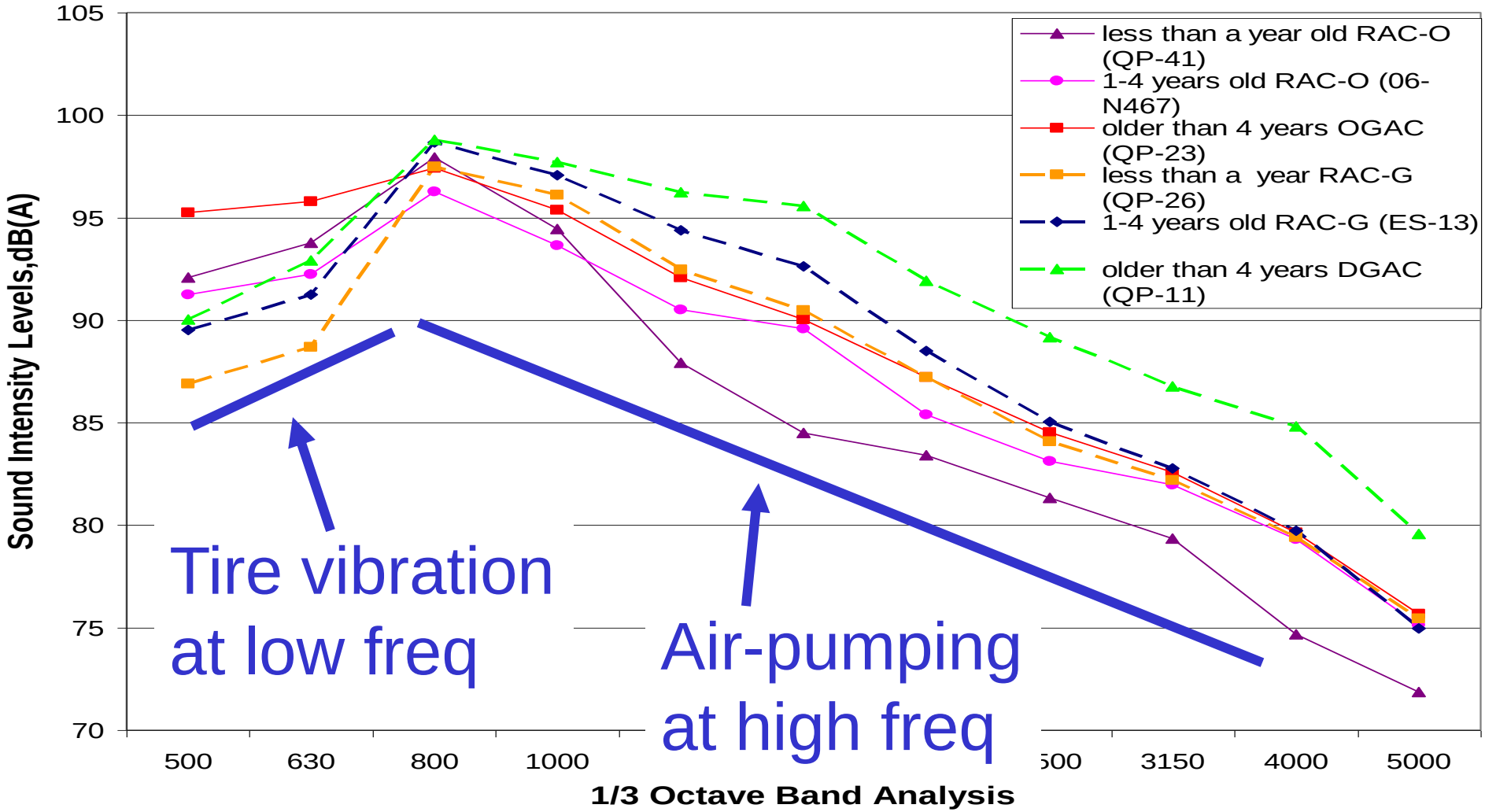
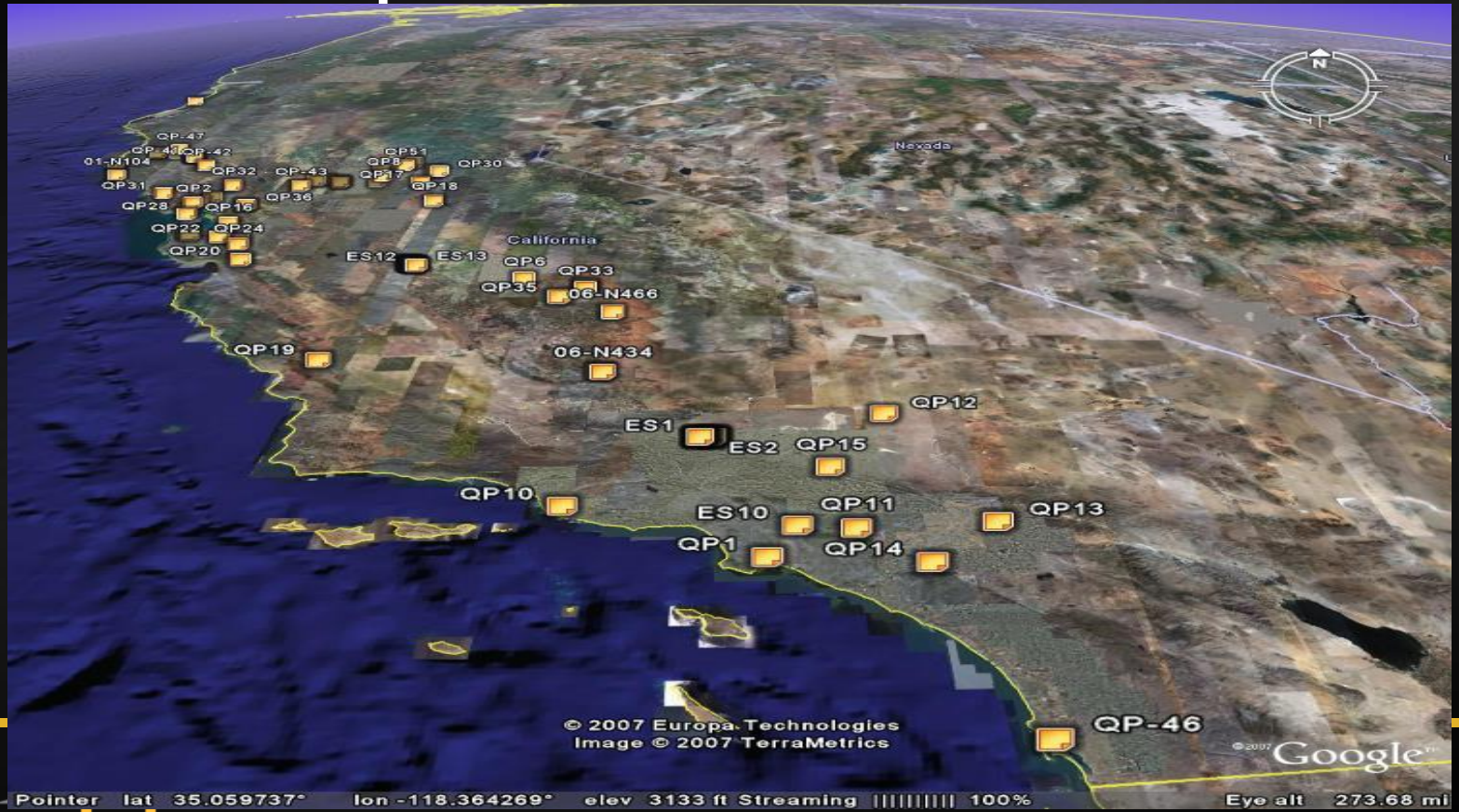


Figure 1.1: Timeline of completed data collection periods for asphalt and concrete pavement noise studies.

Instrumented car measures OBSI, IRI and macro-texture


105
100
95
90
85
80
75
70
Sound Intensity Levels,dB(A)
500
630
800
1000
3150
4000
5000
1/3 Octave Band Analysis
less than a year old RAC-O (QP-41)
1-4 years old RAC-O (06-N467)
older than 4 years OGAC (QP-23)
less than a year RAC-G (QP-26)
1-4 years old RAC-G (ES-13)
older than 4 years DGAC (QP-11)
Tire vibration at low freq
Air-pumping at high freq

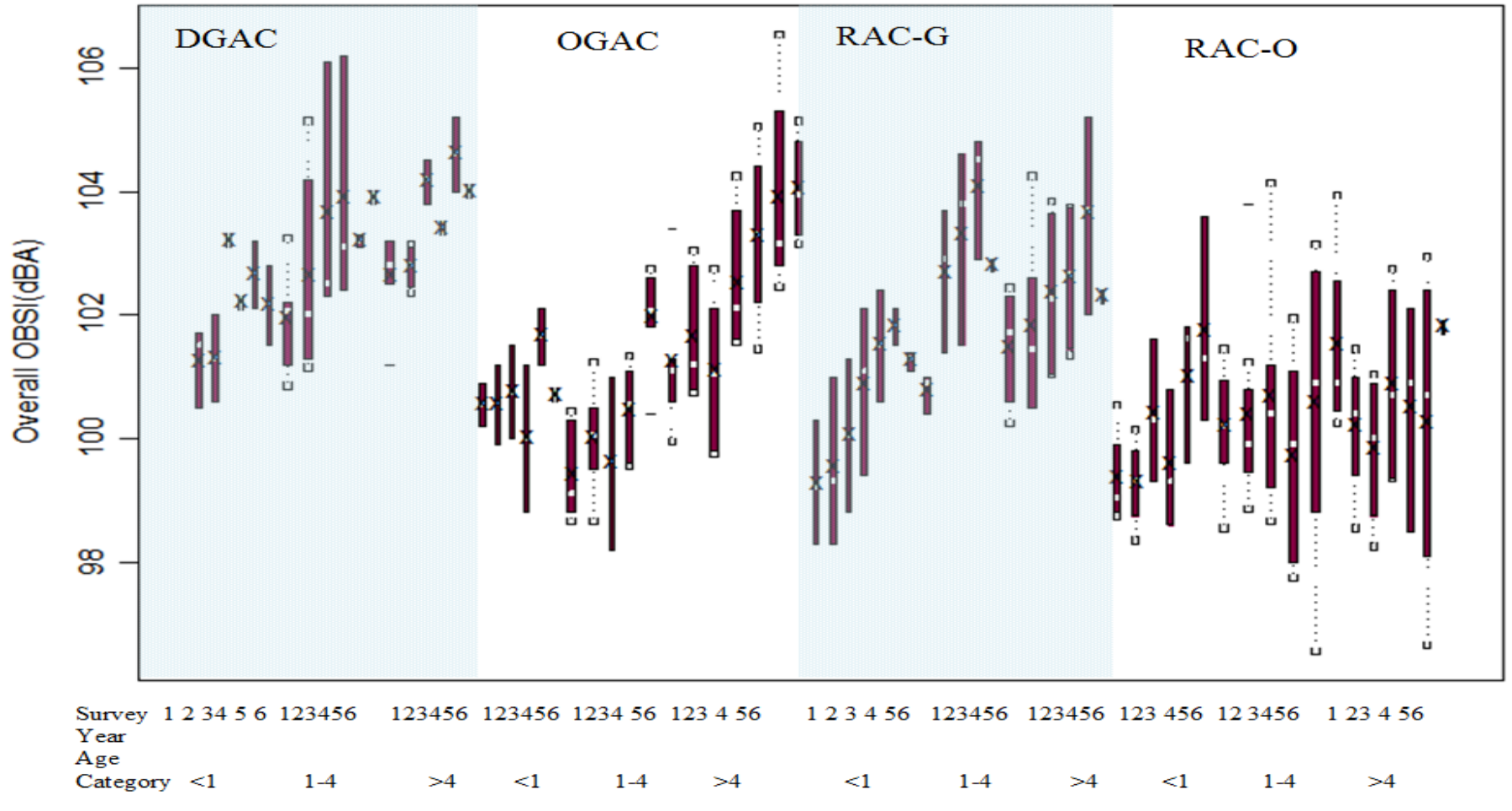
Asphalt test sections:



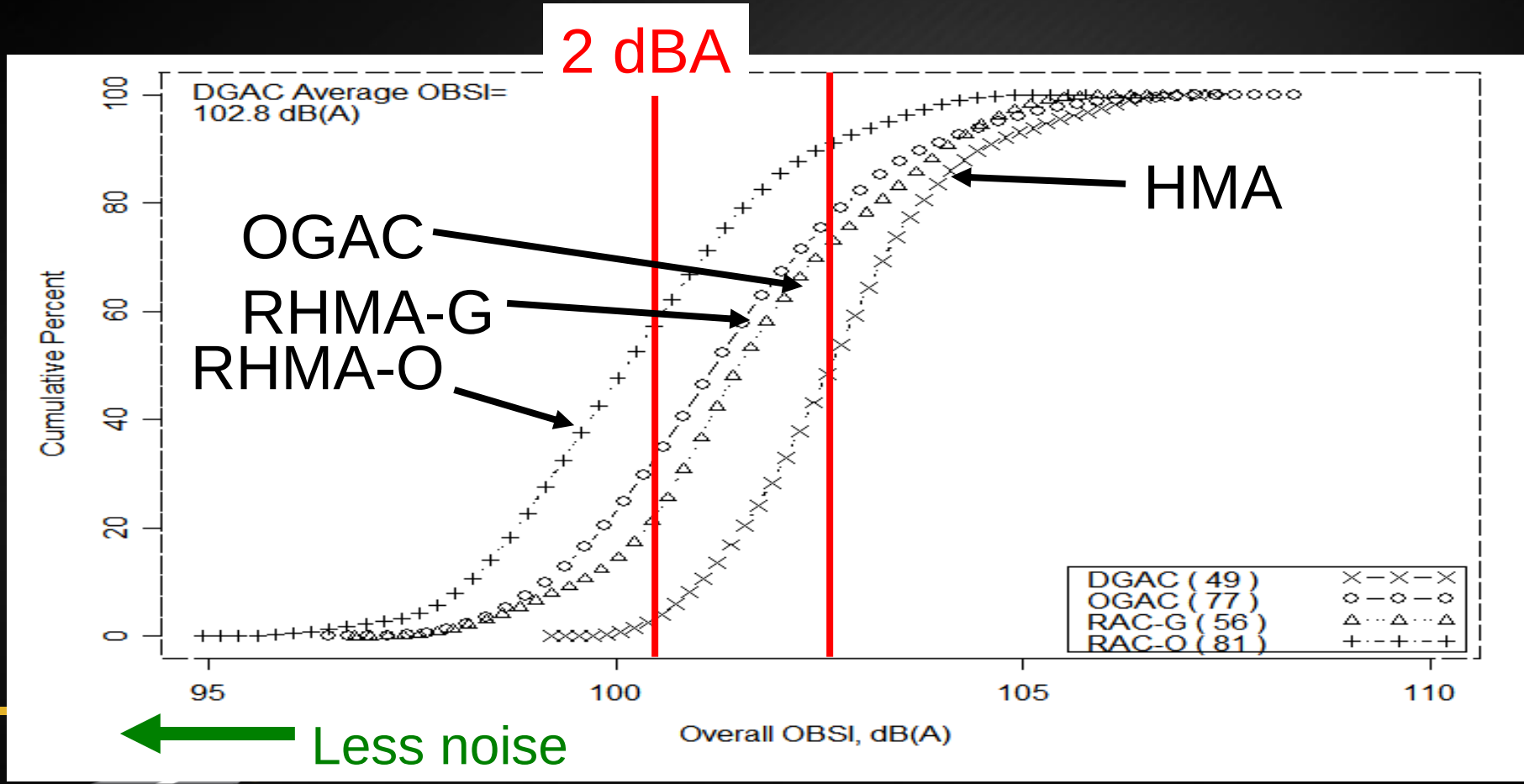
Experiment Design

- Factorial experiment: 54 QP sections
  - Four mix types: dense-graded (DGAC) as control, open-graded (OGAC), rubberized open-graded (RAC-O), rubberized gap-graded (RAC-G)
  - Three age categories: < 1 year; 1-4 years; 4-8 years
  - Two traffic levels (low is < 32,000 ADT)
  - Two rainfall regions (low is < 24 inches/year)
  - Partial factorial for F-mixes, 19 mm open-graded
- Not controlled:
  - Maximum aggregate size (9, 12.5, 19 mm)
  - Polymer vs conventional binders in OGAC

OBSI for each age category over 6 years



Overall distribution of OBSI up to 15 years old



Performance model estimates of time to noise failure (same noise as DGAC)

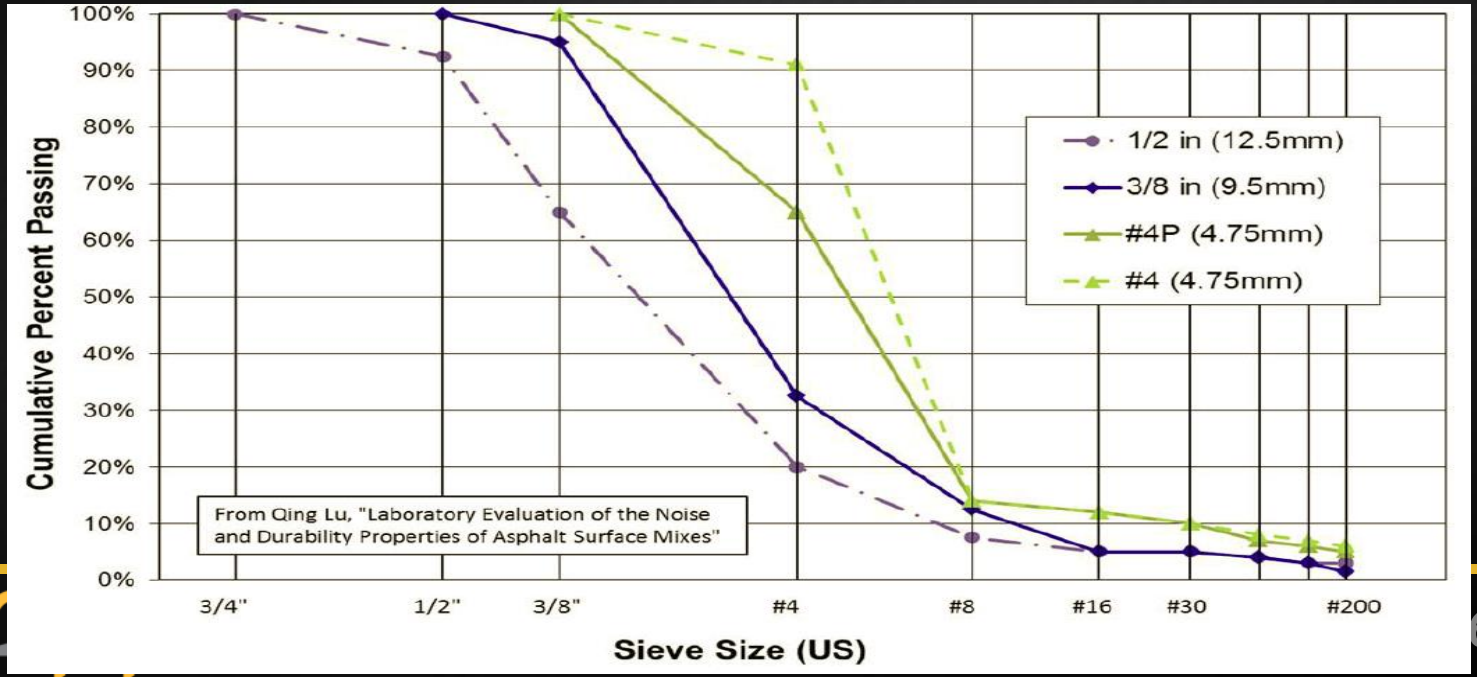
Traffic	Climate	HMA	OGAC	RAC-G	RAC-O
High Traffic (TI=12)	Low Rainfall/ High Temperature	-	9	5	15
	Moderate Rainfall/ Low Temperature	-	9	8	14
	High Rainfall/ Moderate Temperature	-	8	6	14
	Moderate Rainfall/ Moderate Temperature	-	9	6	13
Low Traffic (TI=9)	Low Rainfall/ High Temperature	-	9	6	14
	Moderate Rainfall/ Low Temperature	-	10	9	13
	High Rainfall/ Moderate Temperature	-	11	7	13
	Moderate Rainfall/ Moderate Temperature	-	10	7	14

Performance model estimates of time to IRI failure (2.68 m/km = 160 inches/mile)

Traffic	Climate	HMA	OGAC	RAC-G	RAC-O
High Traffic (TI=12)	Low Rainfall/ High Temperature	15	17	15	18
	Moderate Rainfall/ Low Temperature	9	11	8	16
	High Rainfall/ Moderate Temperature	8	11	11	16
	Moderate Rainfall/ Moderate Temperature	9	12	10	16
Low Traffic (TI=9)	Low Rainfall/ High Temperature	12	17	15	18
	Moderate Rainfall/ Low Temperature	10	12	11	16
	High Rainfall/ Moderate Temperature	11	12	10	15
	Moderate Rainfall/ Moderate Temperature	10	12	11	15

New quieter small stone open-graded asphalt

- Based on field and lab studies
  - Smaller maximum aggregate size, less positive texture
  - Permeability of open-graded mixes



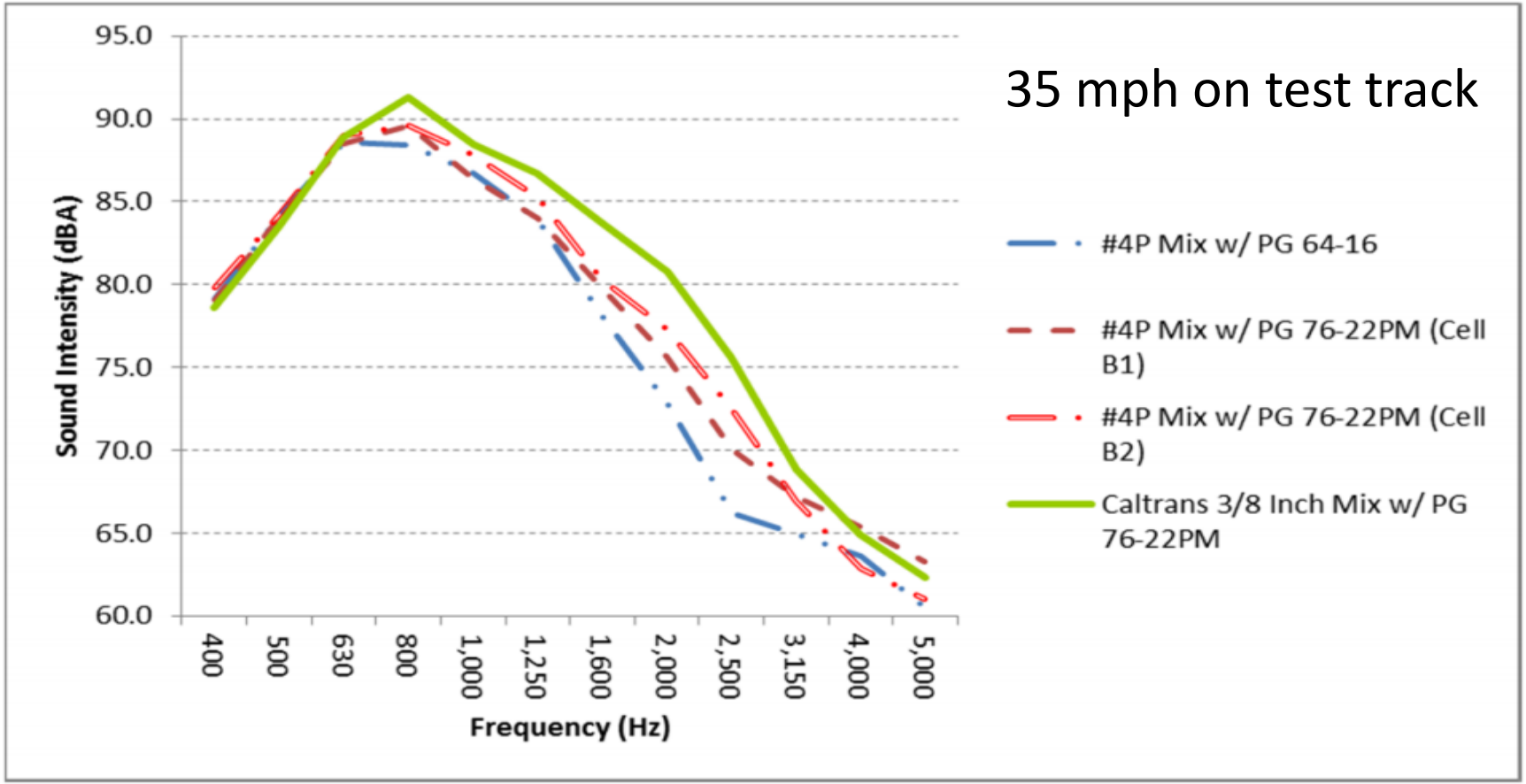


Figure 4.12: 1/3 octave band noise content for the four mixes.

Figure 9.1: Examples of residual specimens after Cantabro testing of the different OGFC mixes. (Note that each original specimen had a diameter of 4 inches [100 mm].)

Comparison with current Caltrans open-graded mix

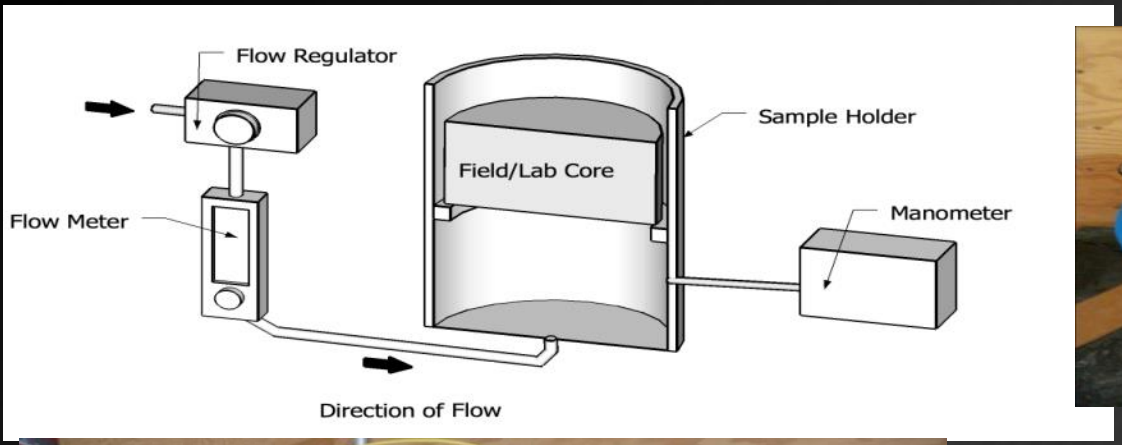
- New smaller stone mixes are
  - More durable (Cantabro)
  - Quieter (35 mph OBSI)
  - Similar or slightly less friction
  - Similar or slightly less permeability

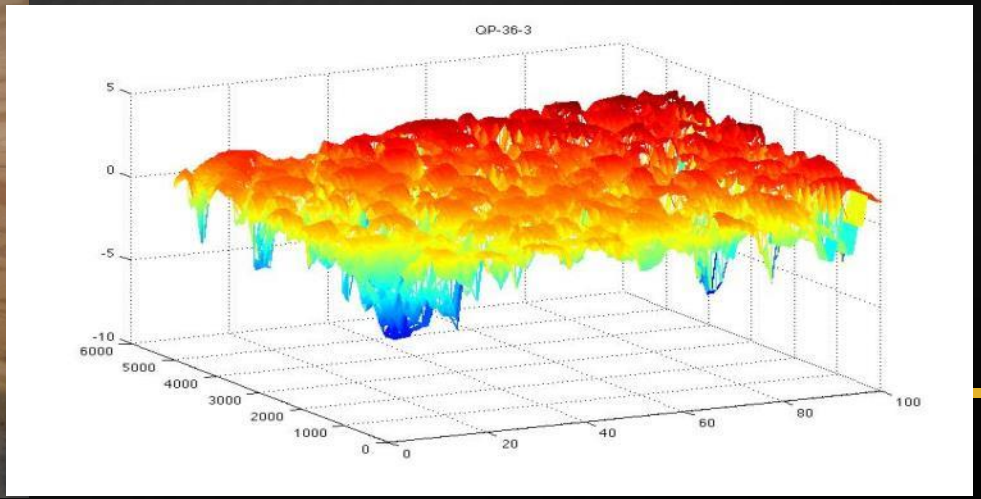
Predicting OGAC noise in the Lab

- Goal:
  - Include prediction of initial noise performance in the laboratory as part of mix design

Lab air permeability

MPD

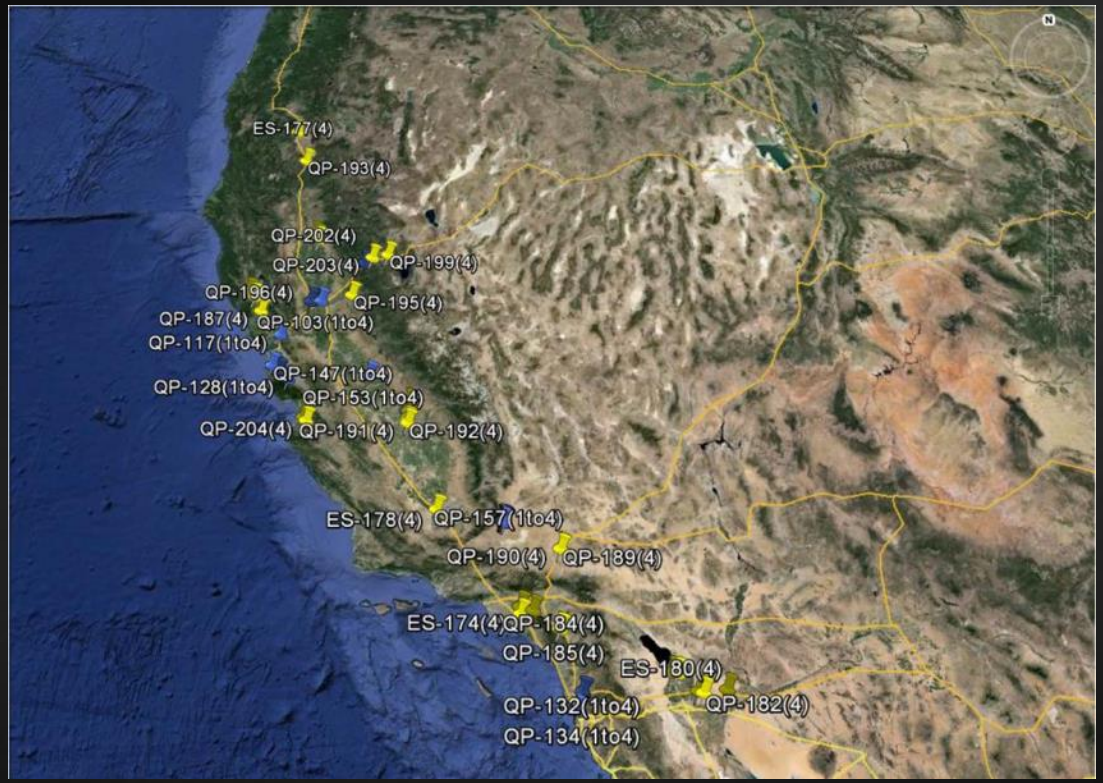




Asphalt Summary

- Use of rubberized open graded recommended
  - Based on long-term noise, smoothness and permeability performance of current mixes
- Method of estimating field noise in the lab developed
- New quieter mixes developed based on findings
  - Need field validation

Concrete test sections:



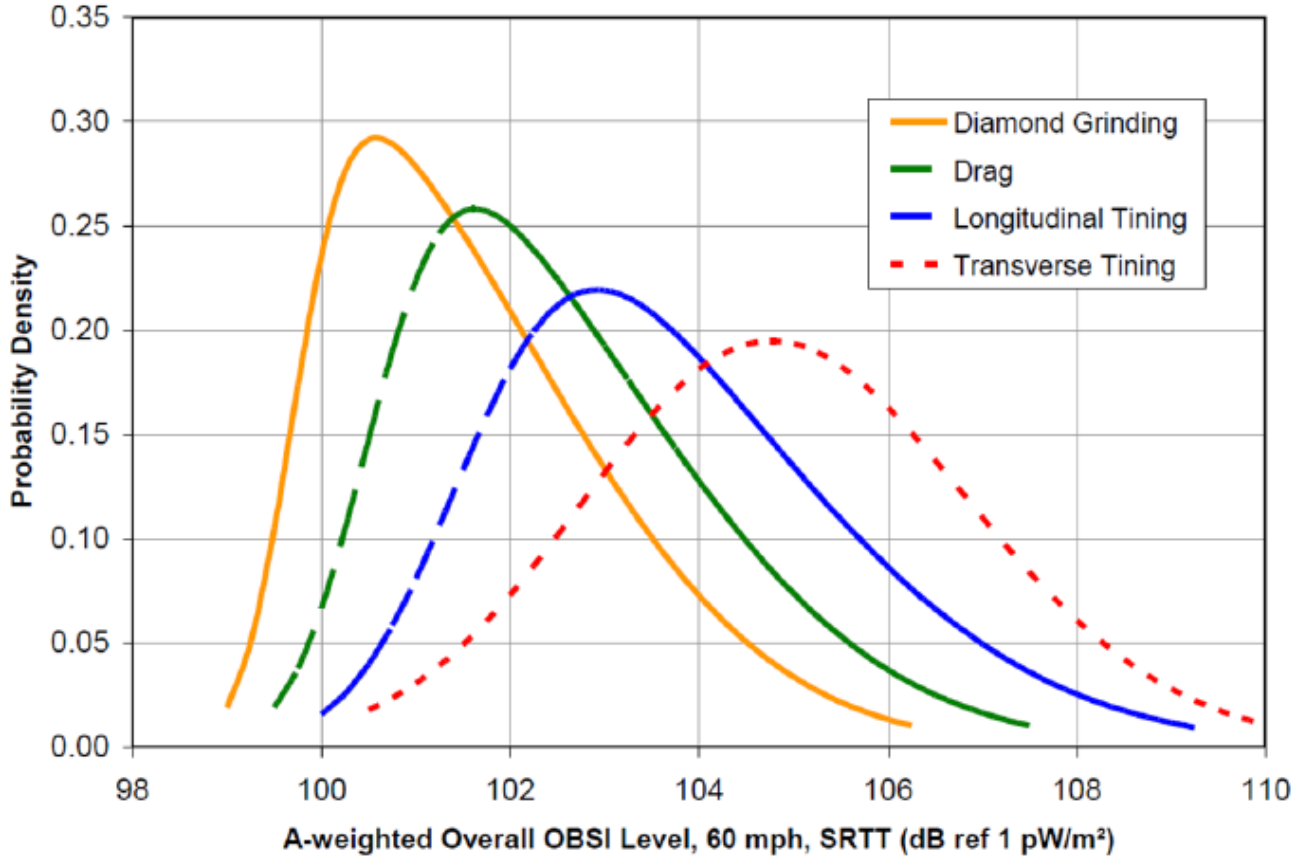
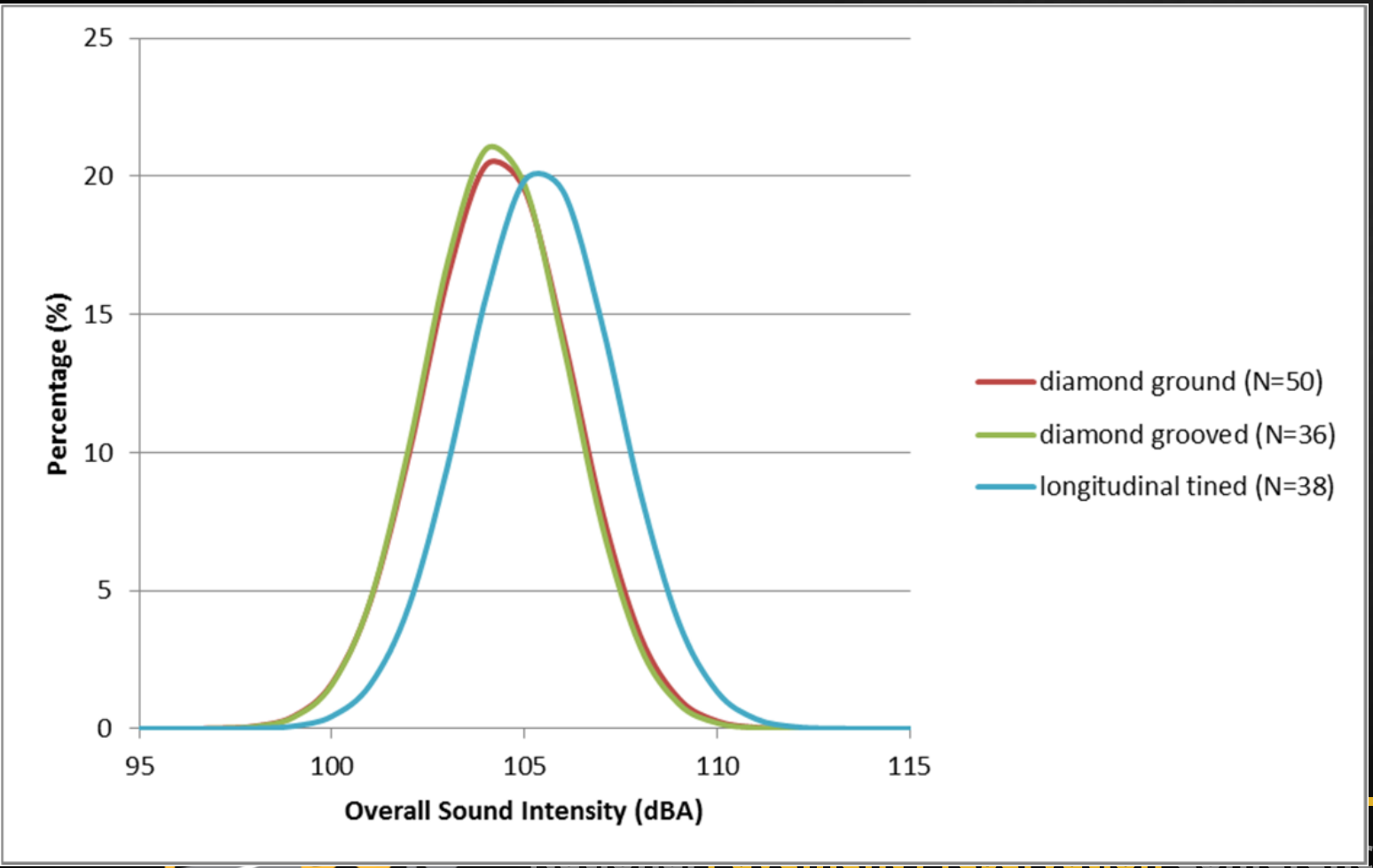


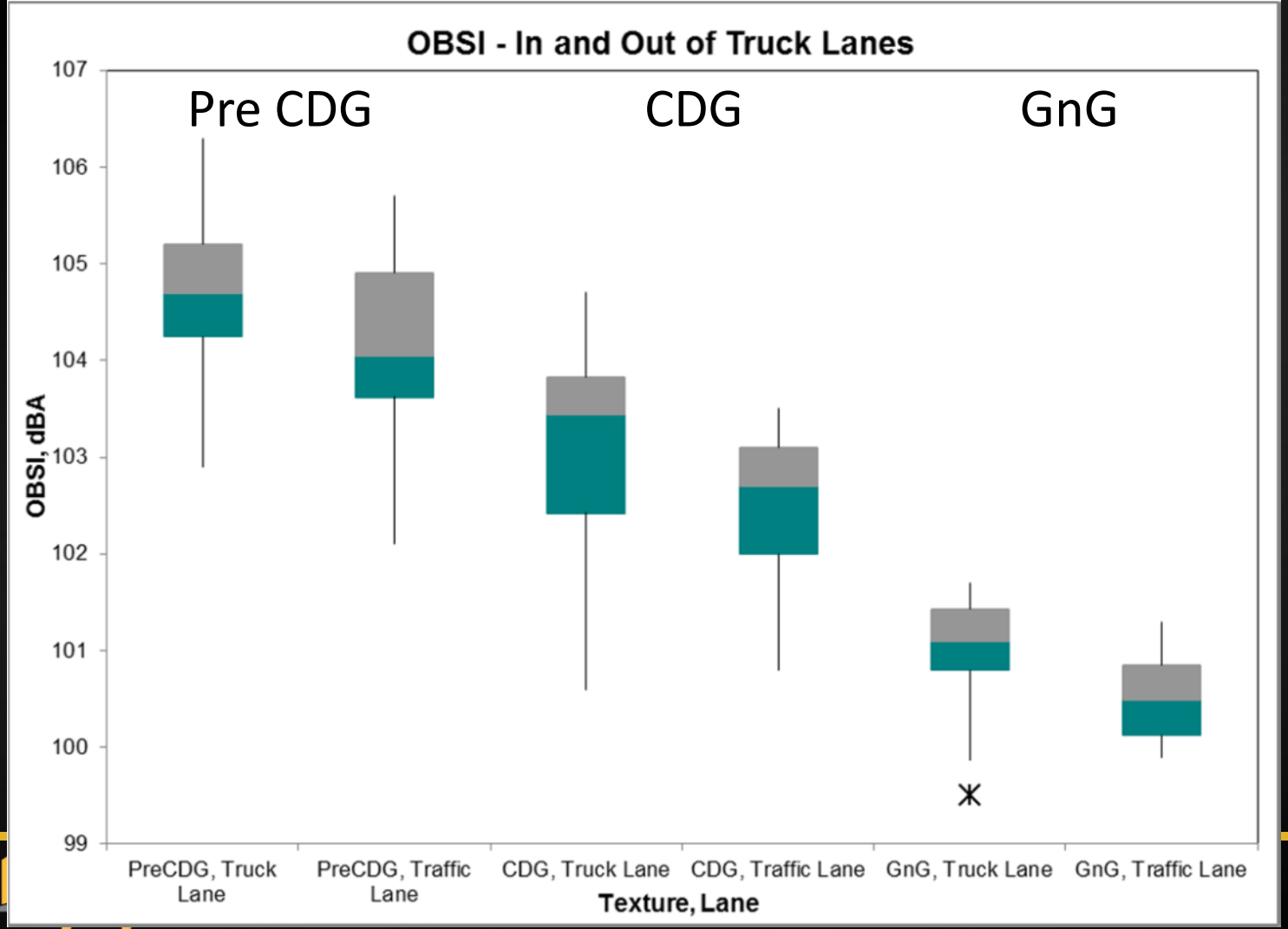
Figure 5.7: Probability distributions of OBSI noise levels for concrete pavement textures as reported by the National Concrete Pavement Technology Center in 2010 (*10*).

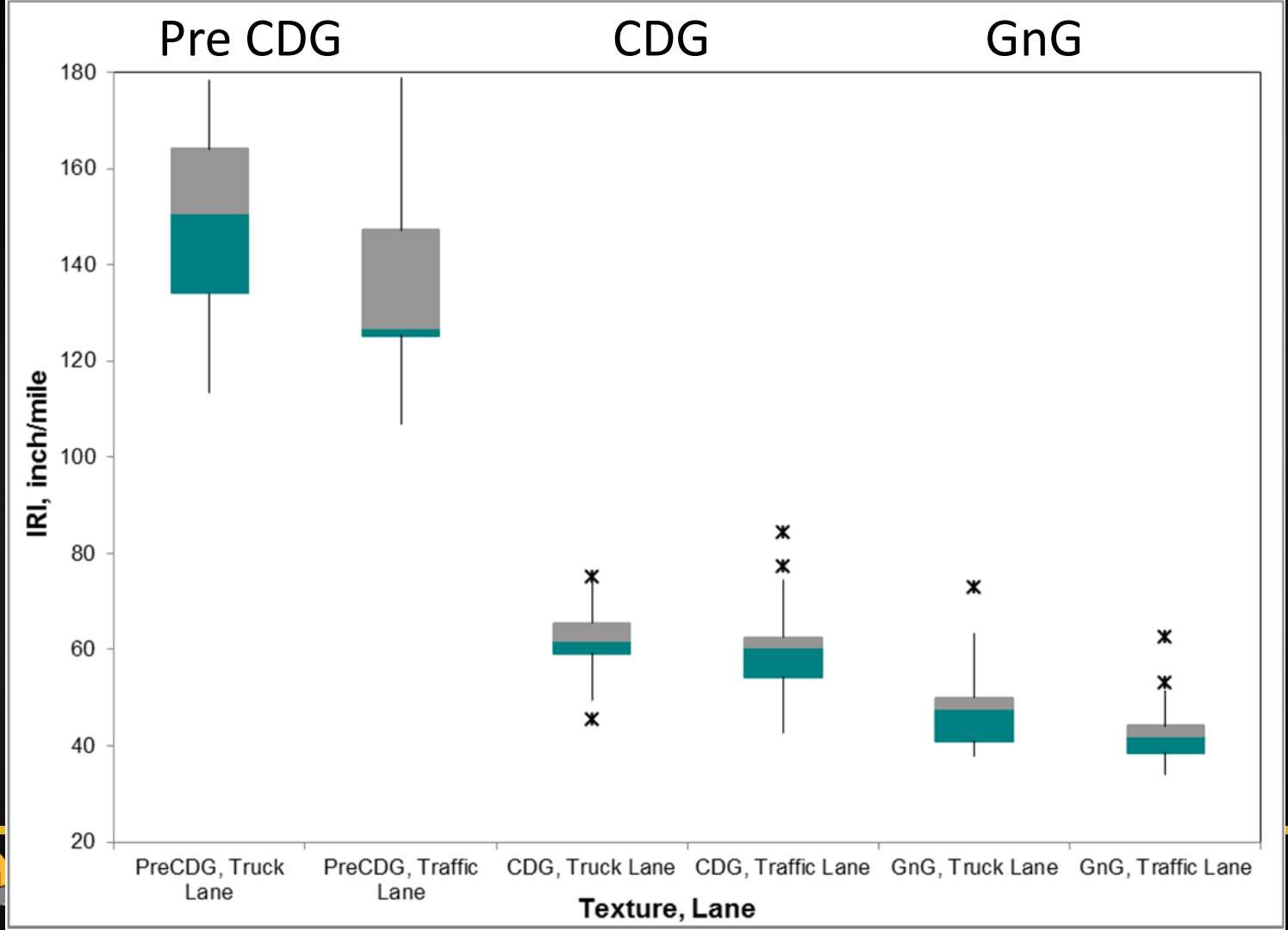
NCPTC Results 2010



UCPRC Results 2013

Grind and groove


OBSI - In and Out of Truck Lanes
Pre CDG
CDG
GnG
OBSI, dBA
107
106
105
104
103
102
101
100
99
PreCDG, Truck Lane
PreCDG, Traffic Lane
CDG, Truck Lane
CDG, Traffic Lane
GnG, Truck Lane
GnG, Traffic Lane
Texture, Lane


Pre CDG
CDG
GnG
180
160
140
120
100
80
60
40
20
IRI, inch/mile
PreCDG, Truck Lane
PreCDG, Traffic Lane
CDG, Truck Lane
CDG, Traffic Lane
GnG, Truck Lane
GnG, Traffic Lane
Texture, Lane

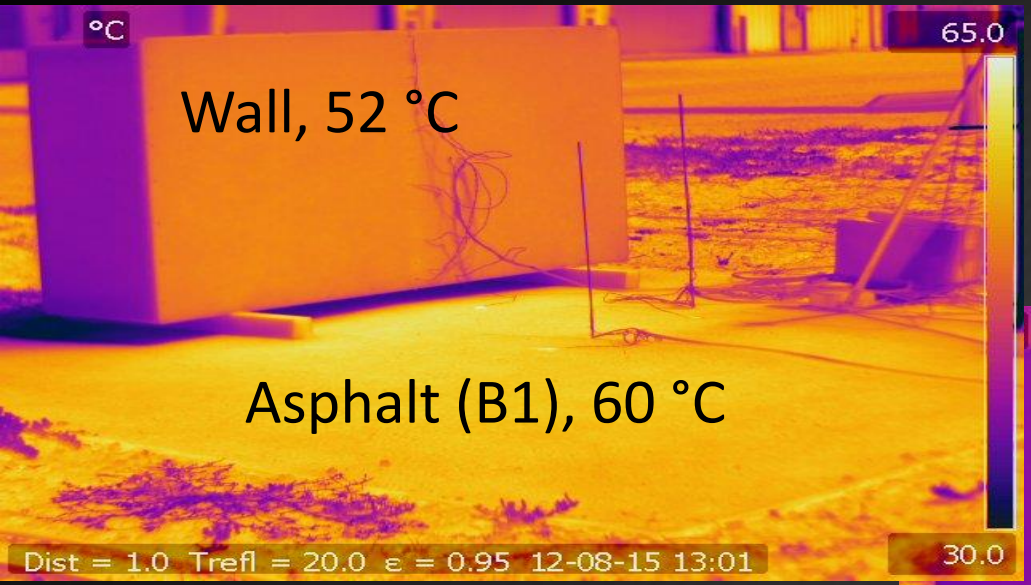
Types of heat island

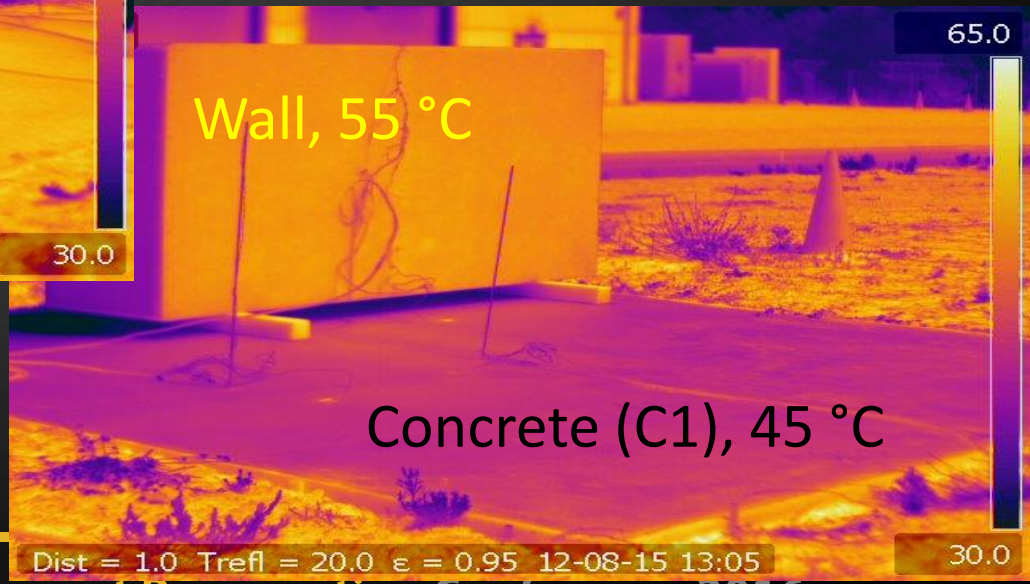
- Urban heat island
  - CARB, Caltrans sponsored study
  - Response to legislation
  - Report and software publish late 2016
- Results of changing HMA/slurries to reflective surfaces
  - Small change in temperature, long time to implement
  - Net effect of change dominated by materials production, generally not beneficial

Types of heat island

- Local heat island
  - Effect on human thermal comfort
  - Balance reflectivity, evapo-transpiration, shade
  - UCPRC, USC and other research

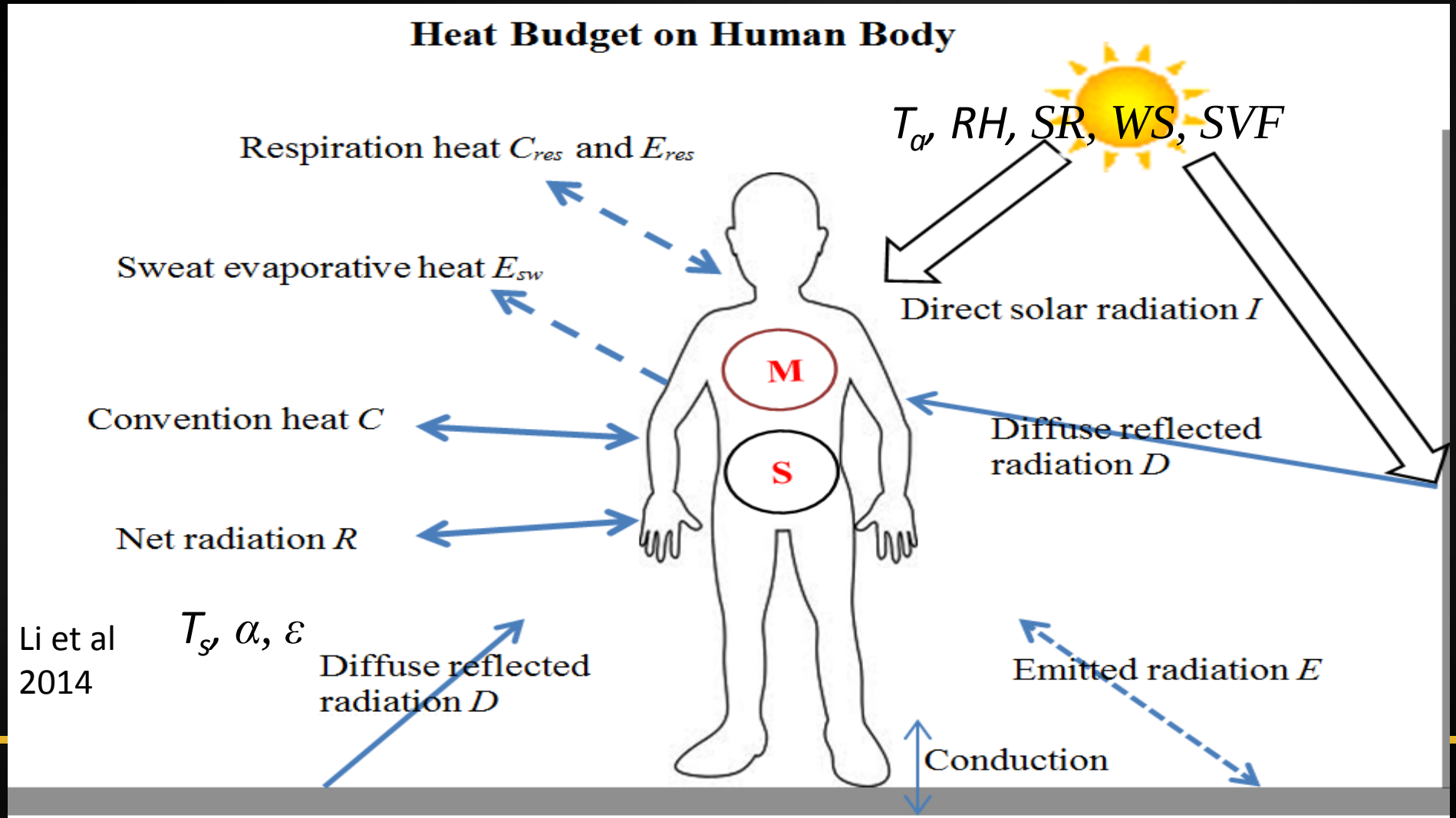
Thermal Impact of Reflection

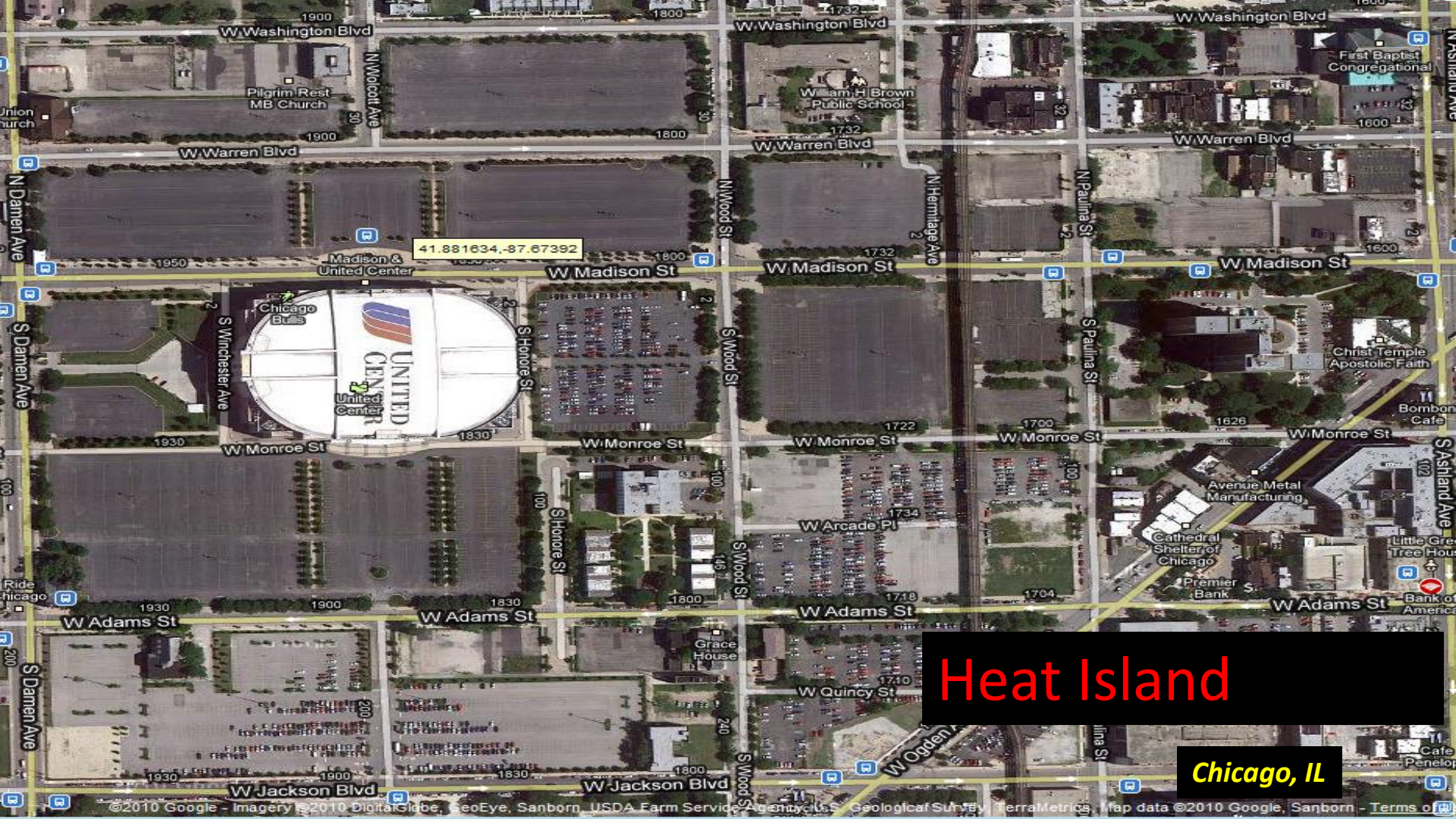




13:00 8/15/2012

Lighter is hotter:
legend range of 30 to 65 °C

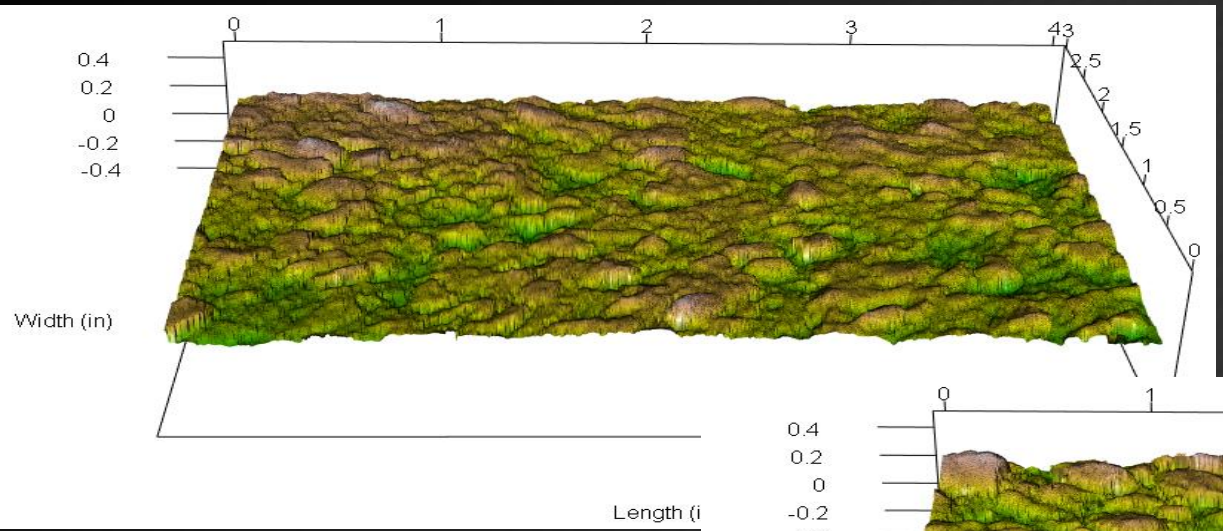

Heat Budget on Human Body
T_a, RH, SR, WS, SVF
Respiration heat C_{res} and E_{res}
Sweat evaporative heat E_{sw}
Direct solar radiation I
M
S
Convention heat C
Diffuse reflected radiation D
Net radiation R
Li et al 2014
T_s, α, ε
Diffuse reflected radiation D
Emitted radiation E
Conduction


Heat Island
Chicago, IL
41.881634,-87.67392
W Washington Blvd
W Warren Blvd
W Madison St
W Monroe St
W Adams St
W Jackson Blvd
N Damen Ave
S Damen Ave
N Wolcott Ave
N Wood St
S Wood St
N Paulina St
S Paulina St
N Hermitage Ave
S Honore St
S Winchester Ave
S Ashland Ave
W Arcade Pl
W Quincy St
Pilgrim Rest MB Church
William H Brown Public School
First Baptist Congregational
United Center
Madison & United Center
Christ Temple Apostolic Faith
Bombon Cafe
Avenue Metal Manufacturing
Cathedral Shelter of Chicago
Premier Bank
Grace House
Ride Chicago
Bank of America
Cafe Penelop
©2010 Google - Imagery ©2010 DigitalGlobe, GeoEye, Sanborn, USDA Farm Service Agency, U.S. Geological Survey, TerraMetrics, Map data ©2010 Google, Sanborn - Terms of

Preservation and Bicycle Riders

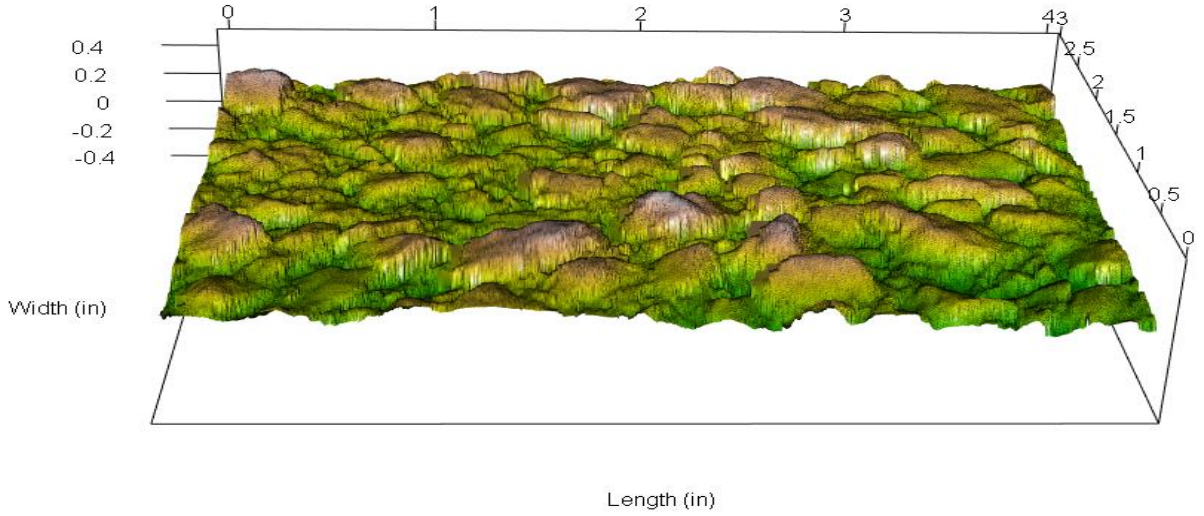
- Develop guidelines for design of preservation treatments suitable for bicycle routes on state highways and local streets in California
- Pavement texture measurements
- Bicycle vibration measurements
- Surveys of bicycle ride quality
  - 6 bicycle clubs
  - General public in Davis, Richmond, Chico, Sacramento, Reno
- Correlations between pavement texture, bicycle vibration and ride quality

Example 3D Macrotexture Images of MPD



Microsurfacing, MPD = 1.1 mm

Coarser 9.5mm chip seal, MPD = 2.3 mm



Conclusions from Bicycle Studies

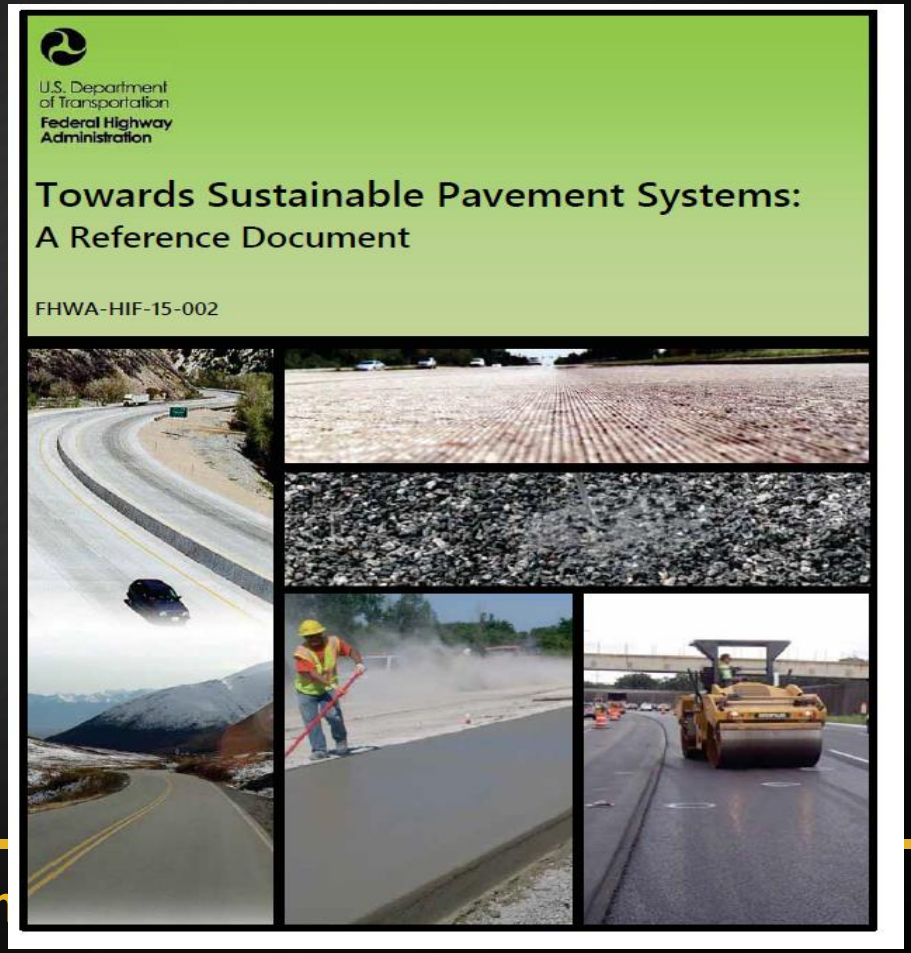
- 80% of riders rate pavements with Mean Profile Depth values 1.8 mm or less as acceptable, limit chip stone size
- Most slurries on city streets produce high acceptability
- Distresses, particularly cracking, reduces ride quality
- Chip seal spec recommendations in Caltrans report
- Can be included in PMS
- Consider “Complete Pavement”

How to consider these preservation criteria?

- Collect the data
- Policy
- Consider in PMS prioritization and treatment identification
- Include in standard project design criteria
- First need to have knowledge and data

FHWA Towards Sustainable Pavements Reference Document

- State of the knowledge
- Search on “FHWA pavement sustainability”
- Also at web site
  - Tech briefs
  - Literature database



Acknowledgements

- Most of this work was sponsored by the California Department of Transportation and California Air Resources Board, whose support is gratefully acknowledged
- These results do not constitute a standard or specification
- The opinions expressed in this presentation are those of the authors only
- This work is a collaboration with colleagues at UCPRC (Davis and Berkeley), LBNL, USC, Oregon State U and Caltrans

Questions:

jtharvey@ucdavis.edu

www.ucprc.ucdavis.edu

- All reports downloadable