Detection of Segregation in Asphalt Pavement Materials using the ARAN Profile System

NORTHEAST ASPHALT USER/PRODUCER GROUP

NEWPORT MARRIOTT, NEWPORT, RHODE ISLAND

OCTOBER 30 & 31, 2002

-by-

Dr. Geoffrey M. Rowe, Dr. Jay Meegoda and

Mr. Andris A. Jumikis

Introduction

- Segregation
  - Segregation in a bituminous mix refers to the uneven distribution of coarse and fine particles along the pavement to another, due to some deficiency in the mixing, transportation, or paving operations
  - Results in dispute between construction-contractors and highway agencies as its presence and severity-level are based on visual observation and judgment

Segregation – the results

- Can lead to deterioration of surface resulting in high maintenance needs
- Surface cracking, crazing and raveling

Segregation

- Pot hole formation results in loss of serviceability

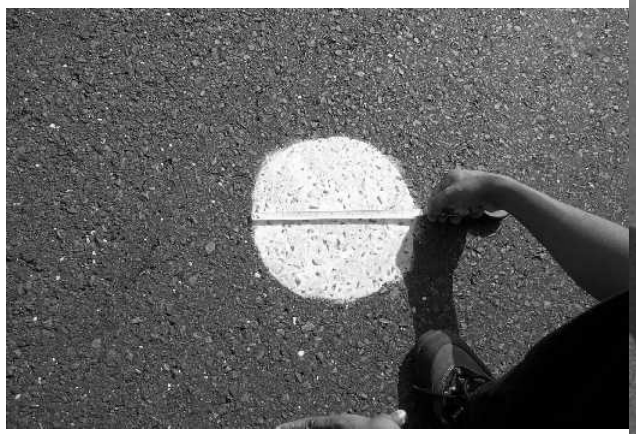
Objectives

- To look at available technology for assessing segregation
- Test methods on a series of sites in New Jersey
- Assess possible implementation of device
- Develop draft implementation protocols

Traditional Methods of Segregation Detection

(1) Visual Identification

(2) Sand Patch Test



New Methods

- **Nuclear Density Gauges**
- **Infrared Thermographs**
- **Laser Measuring Devices**

Technologies

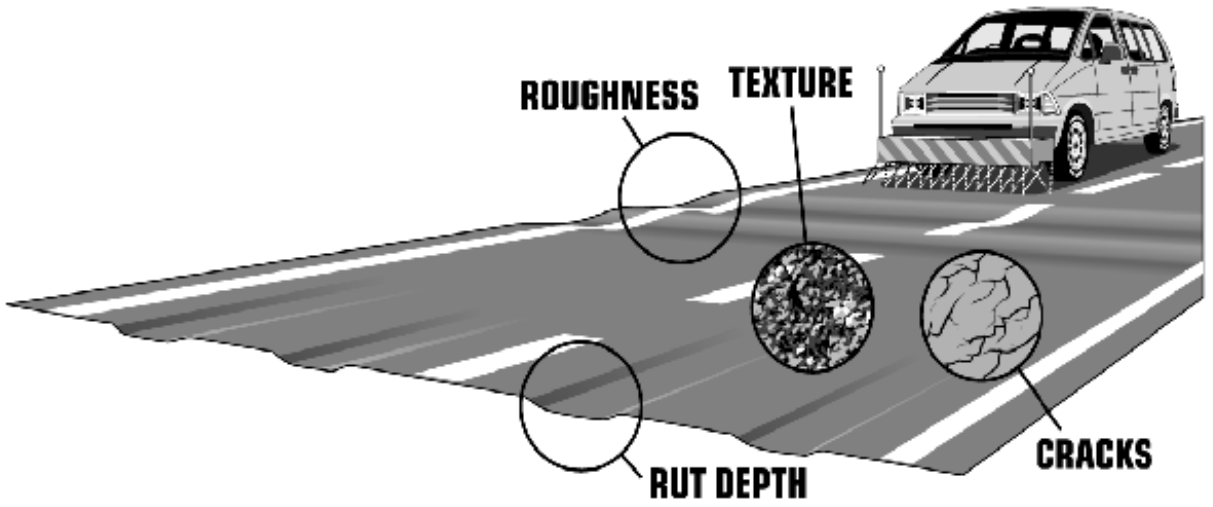
- Laser technology offers best possible method to for implementation

Test Method	Type of Mix			Depth of measurement		
	Fine Gradations	Dense Gradations	SMA	Surface Only	Depth of Lift	Full AC Mat Depth
Visual Observe	Yes	Yes	Yes	Yes	No	No
Sand Patch	Yes	Yes	Yes	Yes	Yes	No
Nuclear Density	Gradation Dependent	Gradation Dependent	Yes	No	Yes	No
Laser	Yes	Yes	Yes	Yes	No	No
GPR	Unknown	Unknown	Unknown	No	Yes	Yes
Infrared	Unknown	Unknown	Unknown	Yes	Thin Lift	Unknown

Laser Measuring Devices

- *Dynatest (*Denmark)
- *Greenwood Engineering (*Denmark)
- *ARAN (Canada)*
- *WDM - HSTM (UK)*
- *ARRB (Australia)*
- *ROSAN (US)*

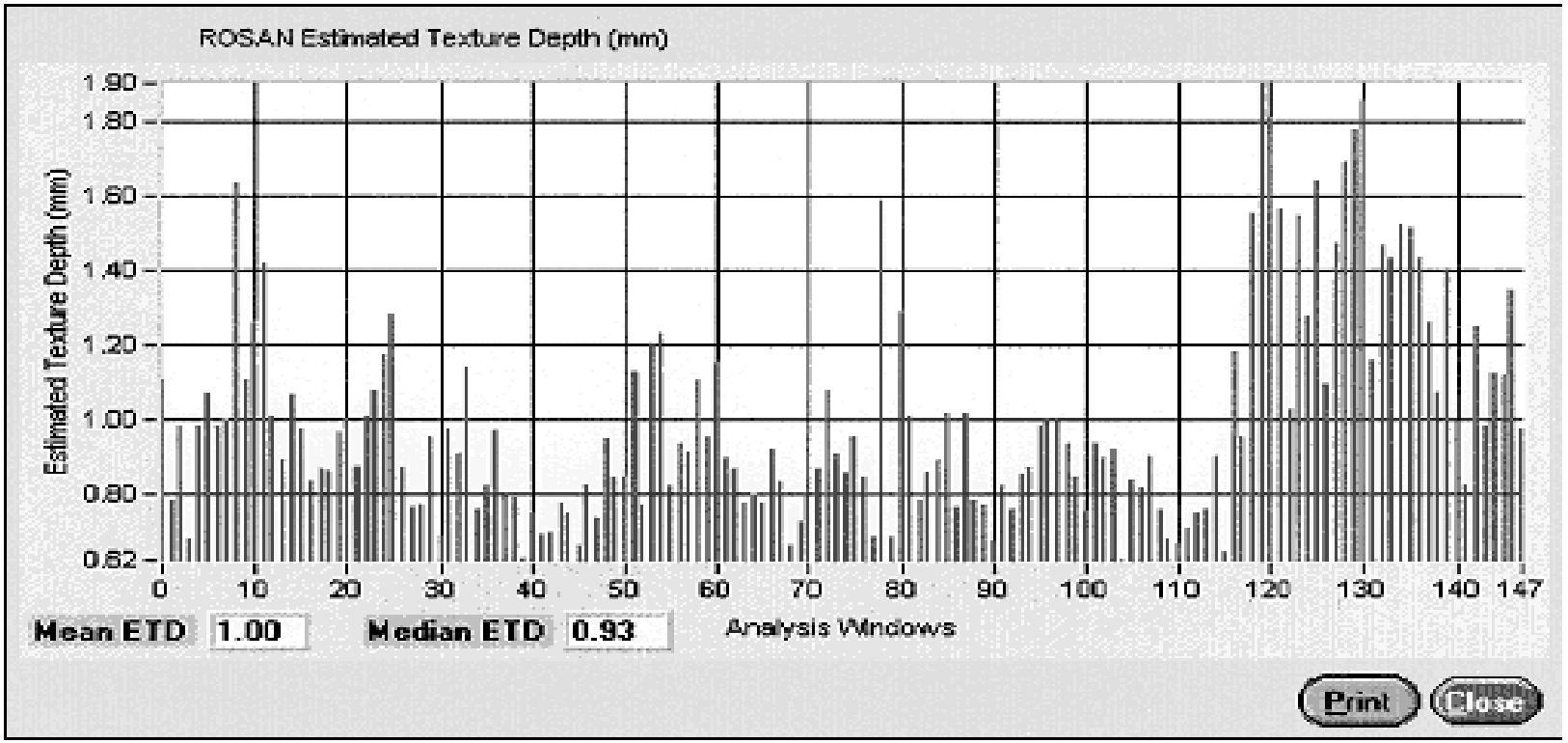
Laser measurements/uses



LMI Selcom
MEASUREMENT & CONTROL

NCHRP Study (NCAT)

NCAT developed the ROSAN$_v$ device, this asphalt pavement and aggregate segregation is illustrated - the graph shows "waves" of about 24-25 meters in length.



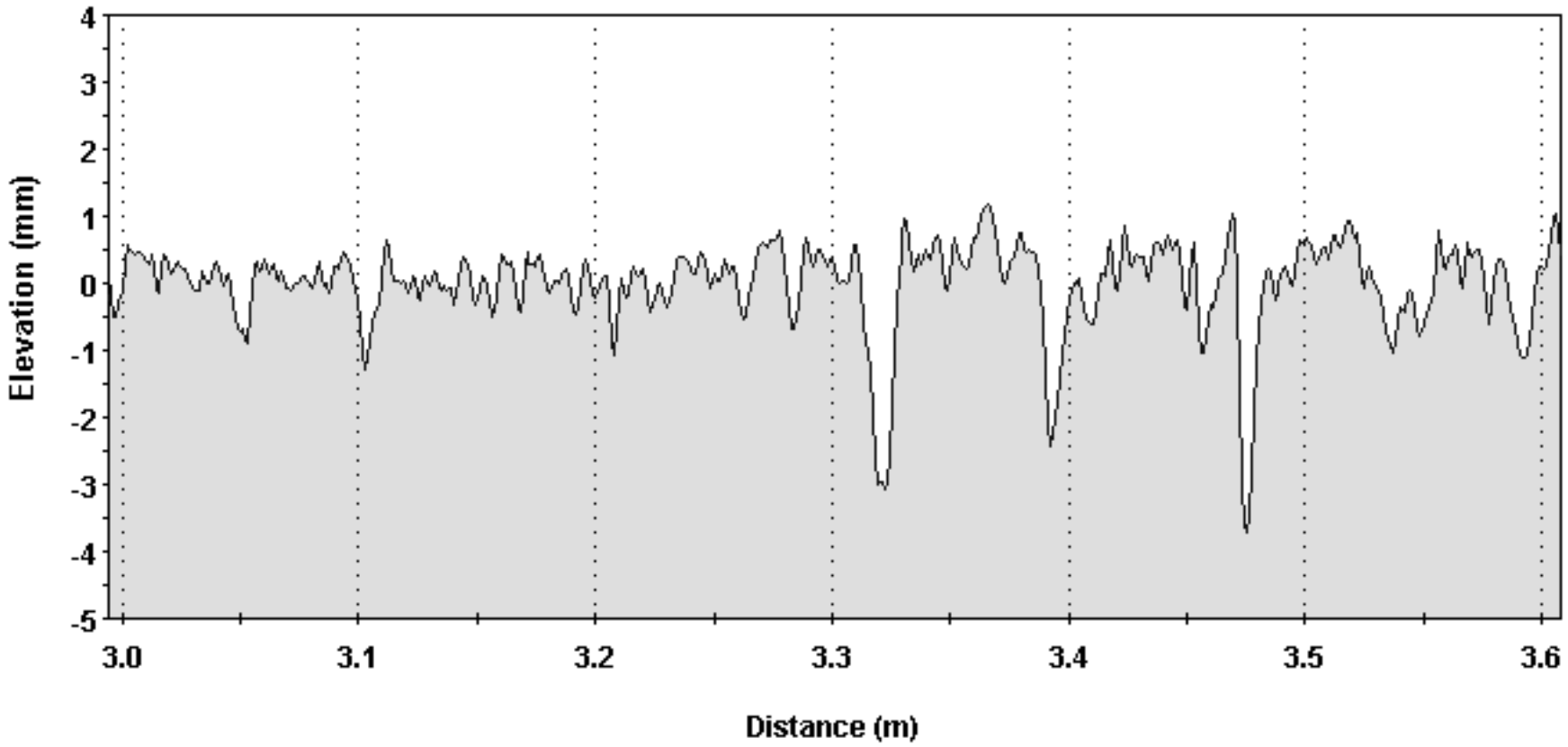
ARAN

4900 - up to 15 subsystems; generally mounted in a *cube* van. A full compliment of sensors provide for automated pavement distress and multi-camera panoramic video-logging.

Equipment selection

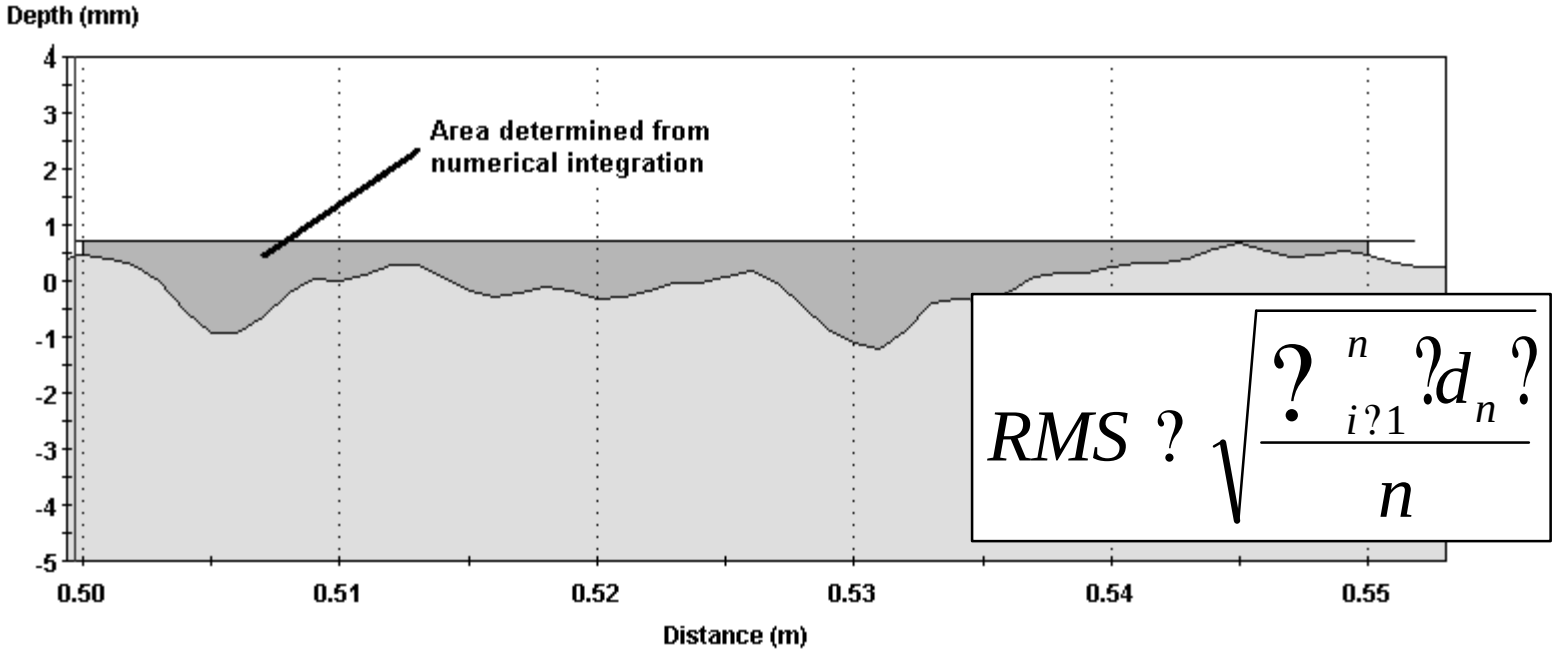
- Since NJDOT operates ARAN – we selected this device for the project
- Drs. Rowe and Meegoda visited facility to obtain first hand understanding of equipment functionality and procedures
- Conducted trial data collection at manufactures facility

Typical ARAN measurements

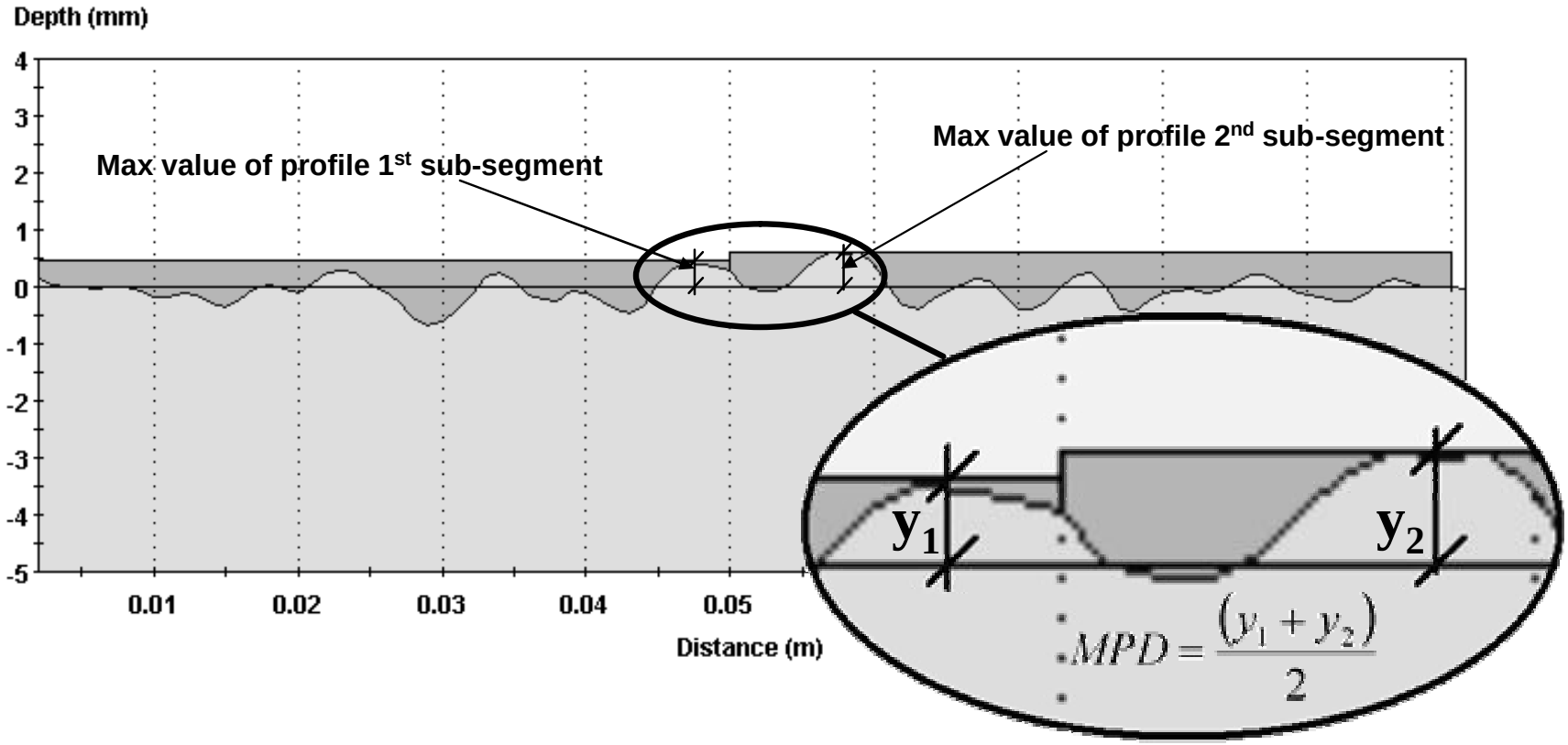


Definitions – ARAN texture

- ARAN uses a numerical integration to compute texture – similar to ASTM E1845



Determination of MPD for a base length



Site evaluations

- Three sites looked at:-
  - Rt. 9 – known segregation
  - Rt. 195 – two areas
    - One segregated
    - One not considered segregated

The Route 9 Site

- The Route 9 site was the first site looked at in detail
- Provided the basis for the analysis
- Site Location:
  - MP 111.5 to 112.0
  - North Bound Fast Line

Field Testing Program

- Texture measurement using ARAN
- Sand Patch Test
- Nuclear Density Measurement
- Coring
- Visual Observations

Field Testing Program

Site Preparation

- 5’ intervals were marked over a length of 1500’
- Three test lines were located 3’, 5.5’ and 8’ from the edge of the road

ARAN

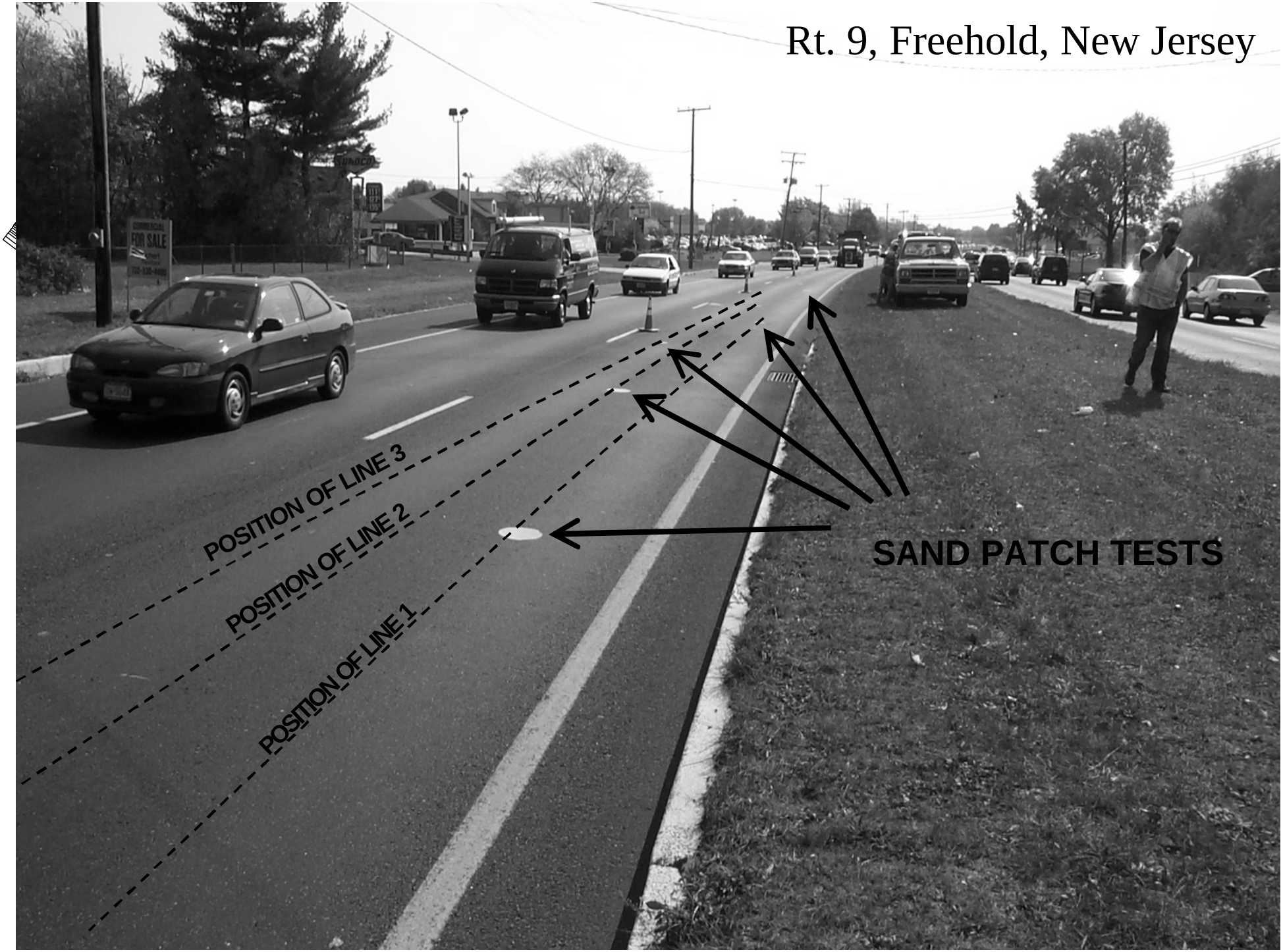
- ARAN was run along each test line at a speed of 40 mph to capture texture profile

Other Tests

- Nuclear Density
  - One test at each Sand Patch location
- Pavement Cores
  - Cores taken from 11 locations to cover the whole site
  - Bulk Specific Gravity
- Visual Observations
  - This was conducted to enable a visual comparison

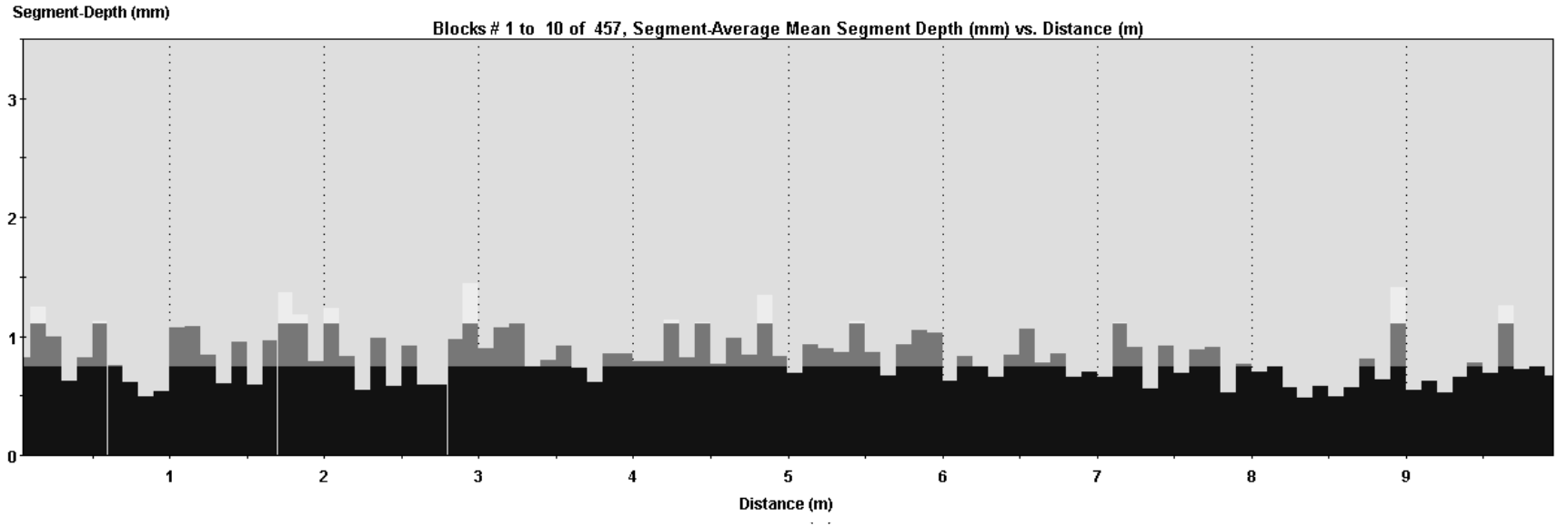
Sand patch testing

Rt. 9, Freehold, New Jersey



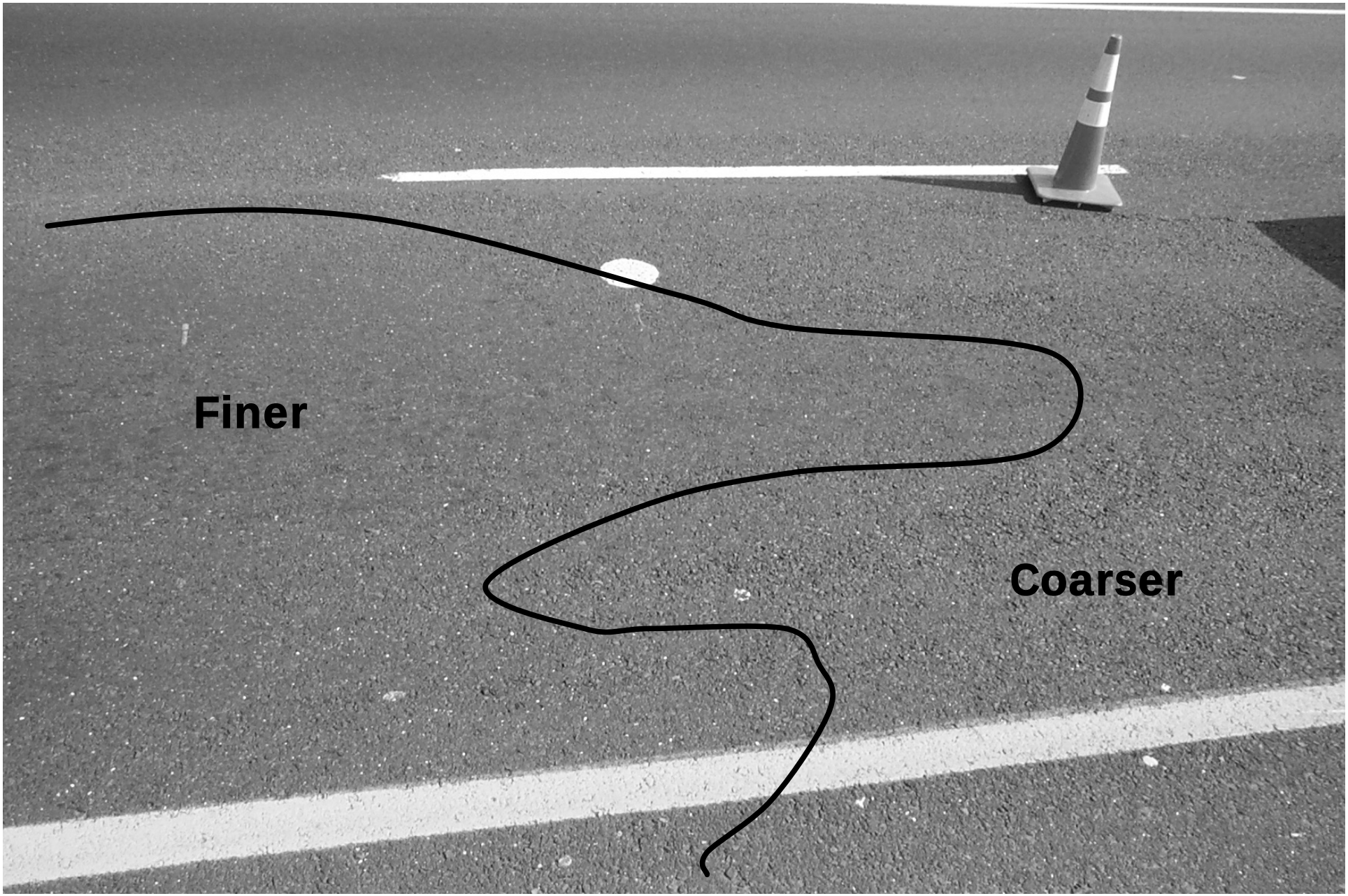
ARAN data

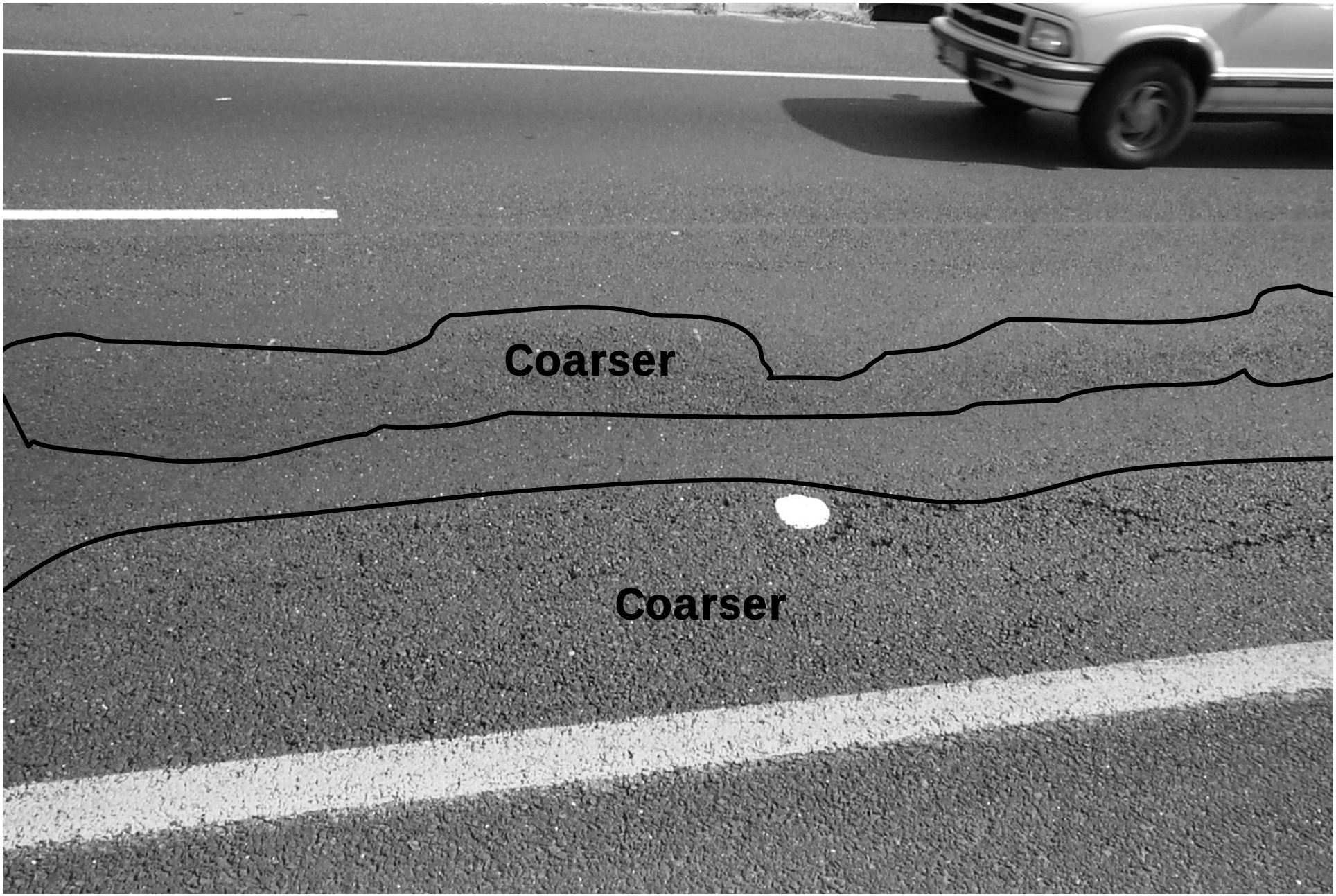
- Three test files – one for each run



Damage to Rt. 9

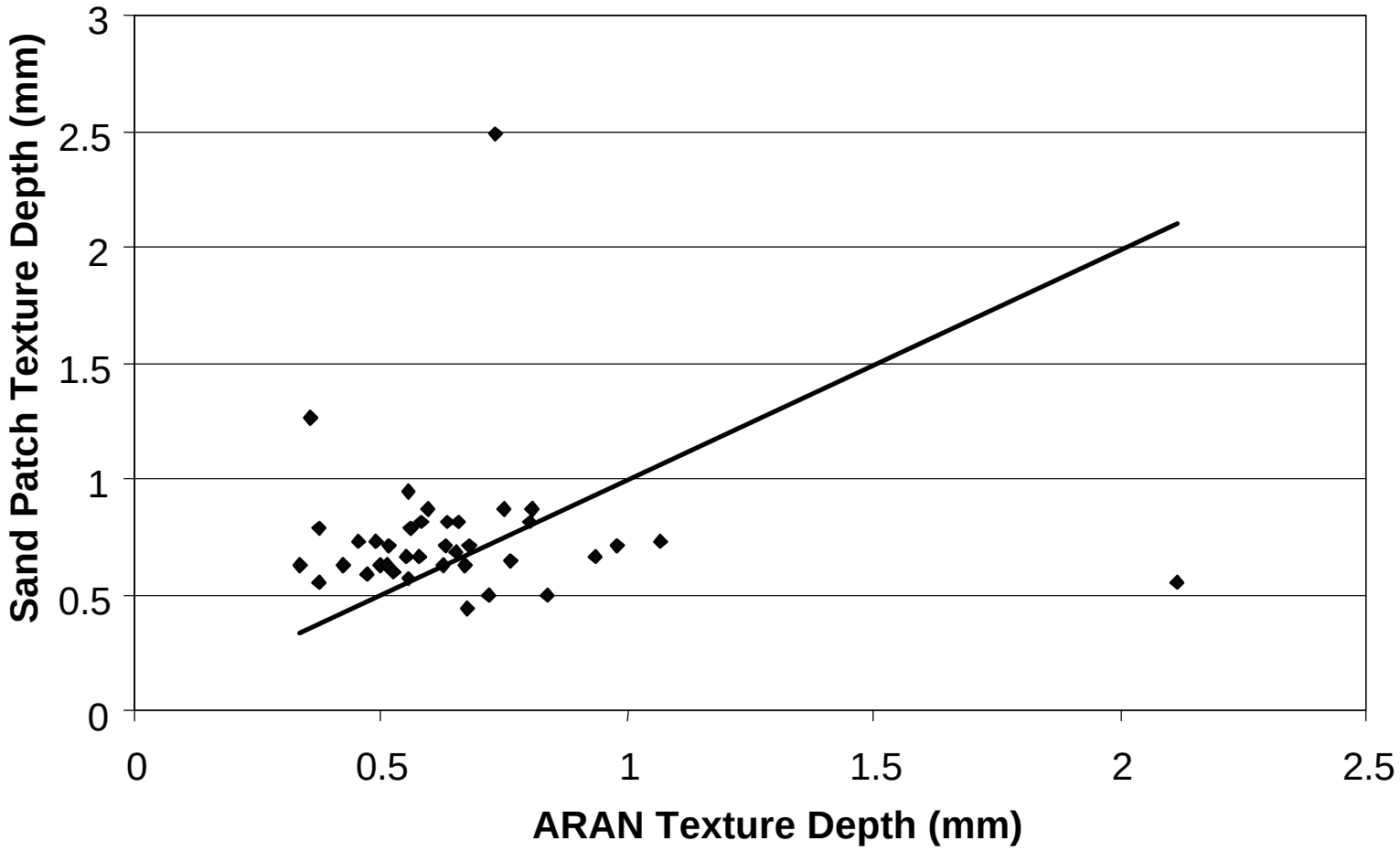
General View. Area of the foreground is patched due to disintegration of materials as a result of segregation


Finer
Coarser

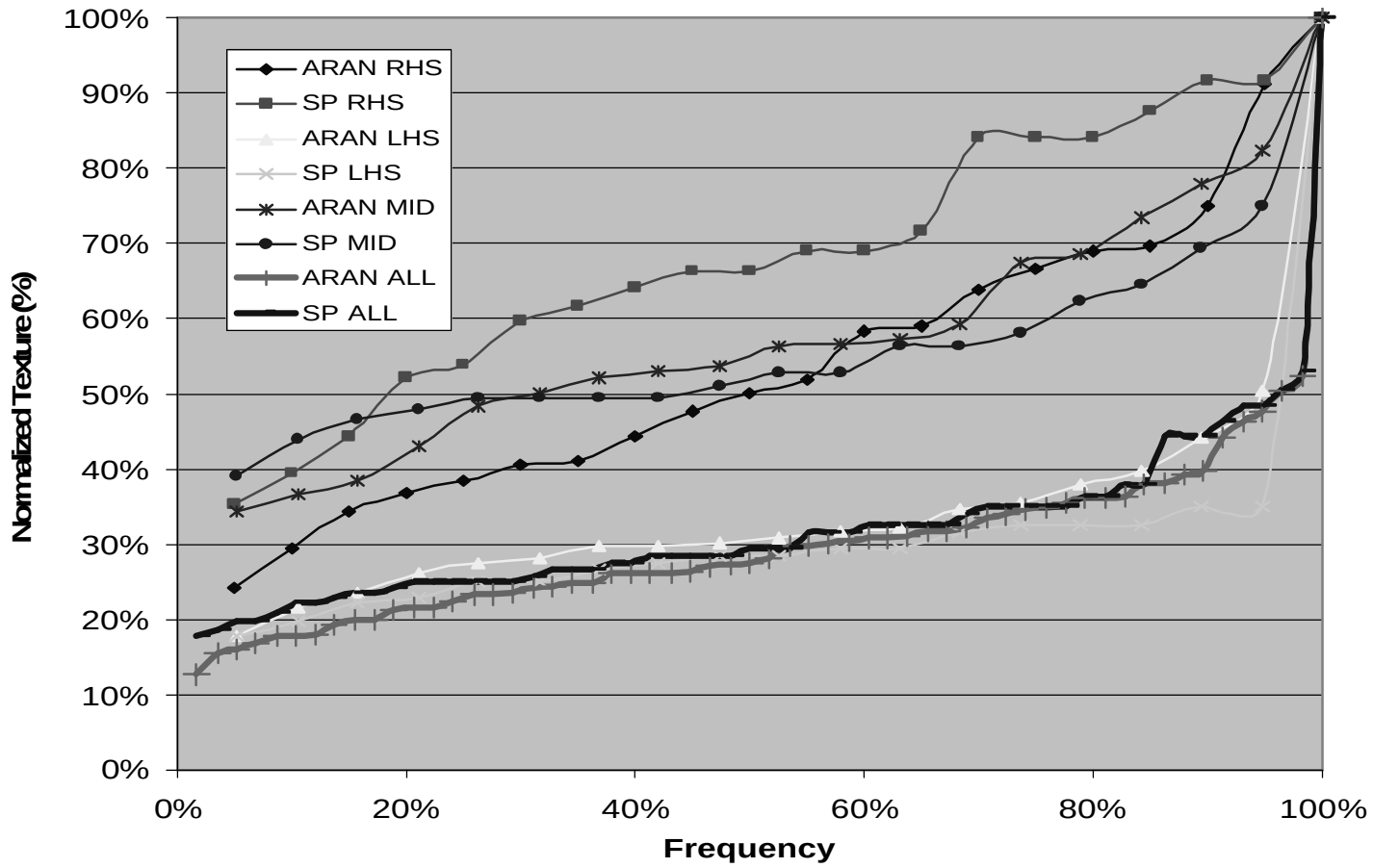

Coarser
Coarser

ARAN testing on Rt. 9

Poor correlation- standard regression



Good Correlation between Sand Patch and ARAN – frequency distribution

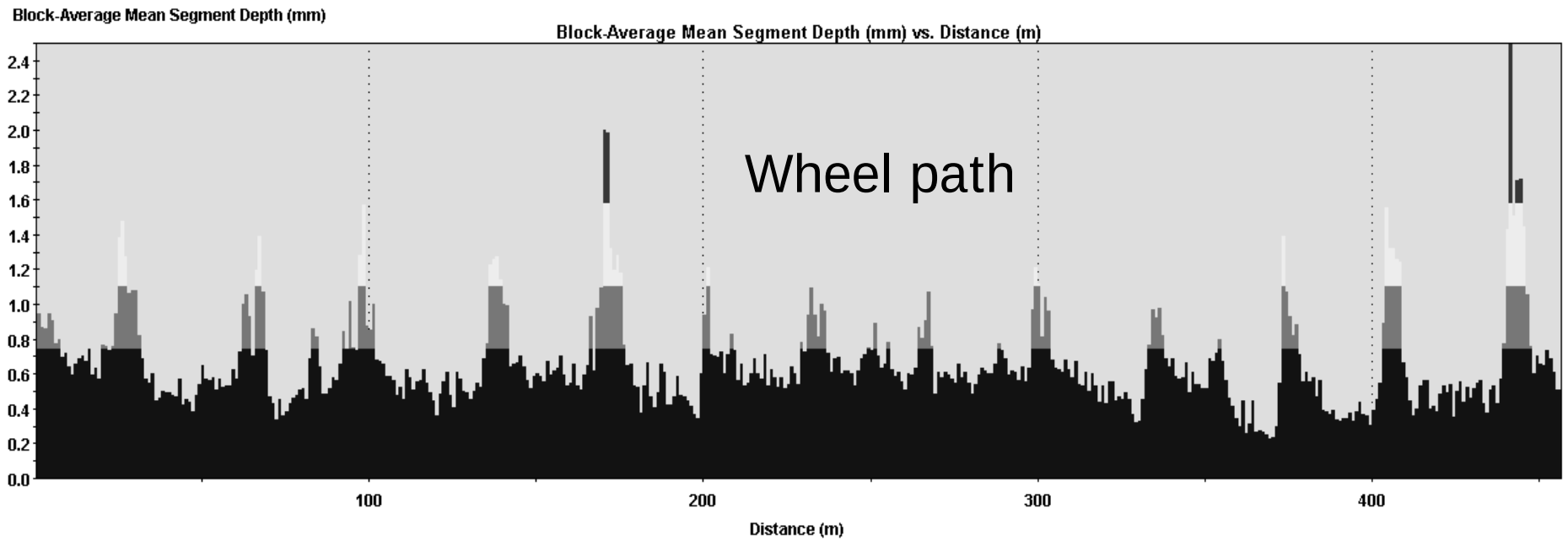


Correlation

- Poor with regression
- Good with frequency distribution
- Conclusion
  - ARAN did not follow same line as intended
  - Data is representative of same population

Segregation detection

Data is consistent with end of truck segregation – peak at approximately 30 yard centers.

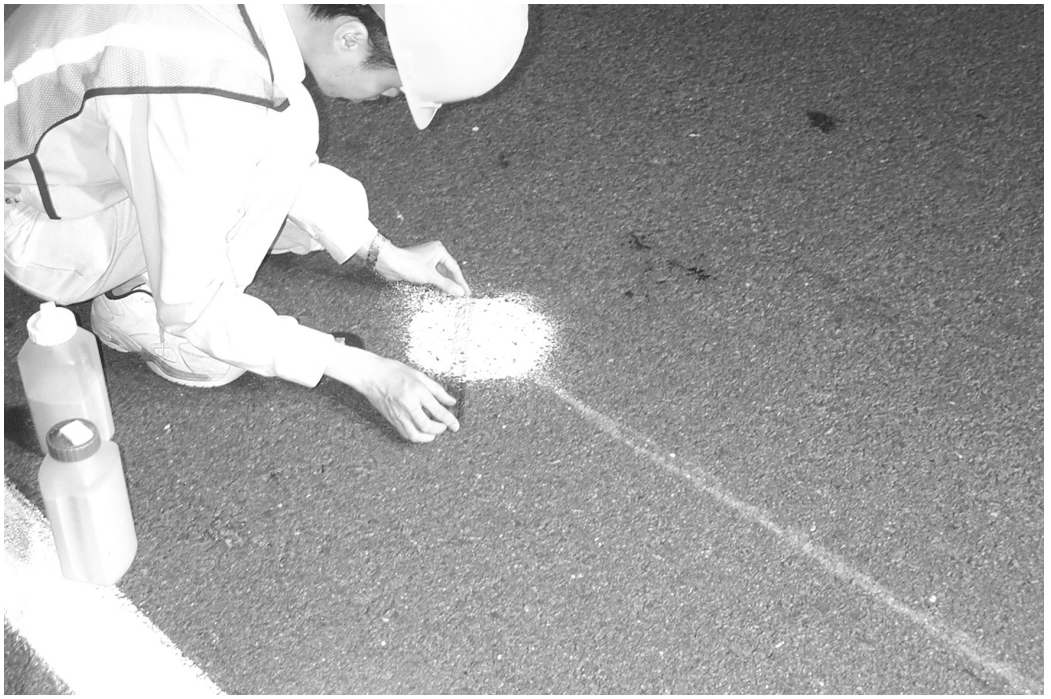


Rt. 195

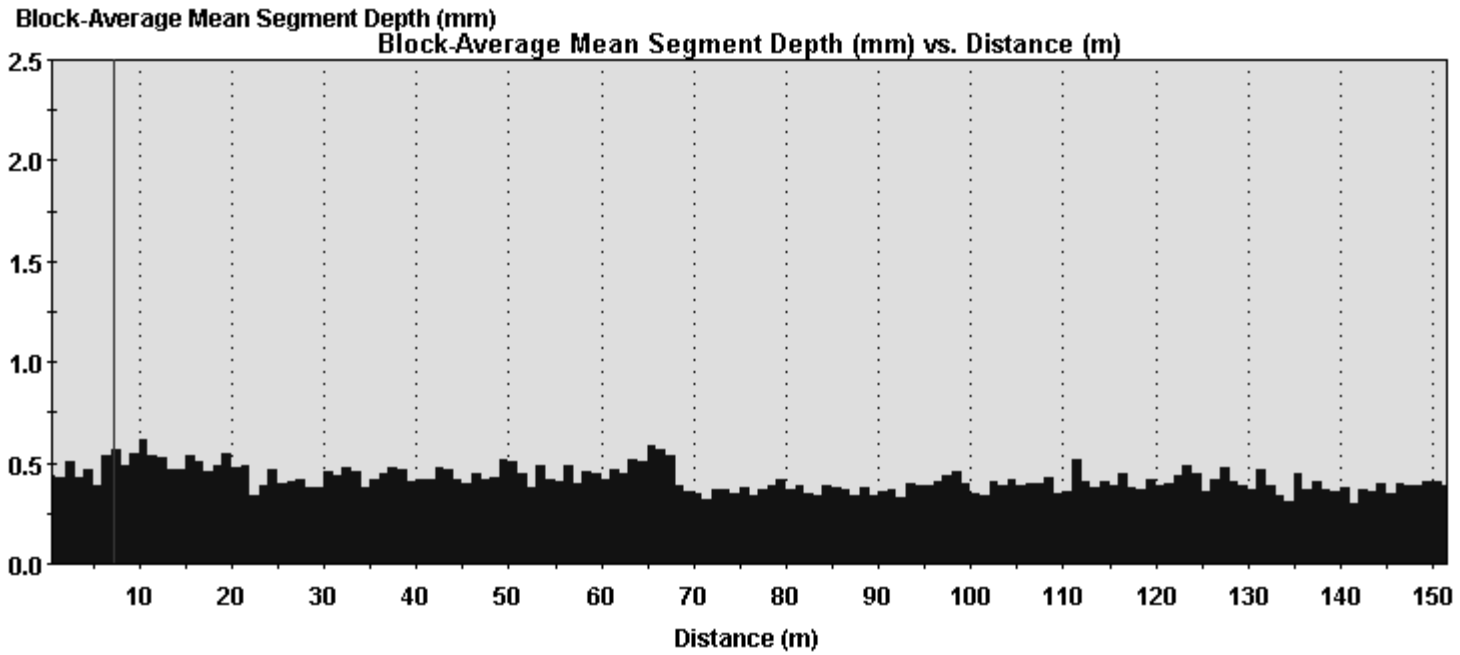
- Project tested at night
- 2 sites/areas on Rt. 195

I-195 testing

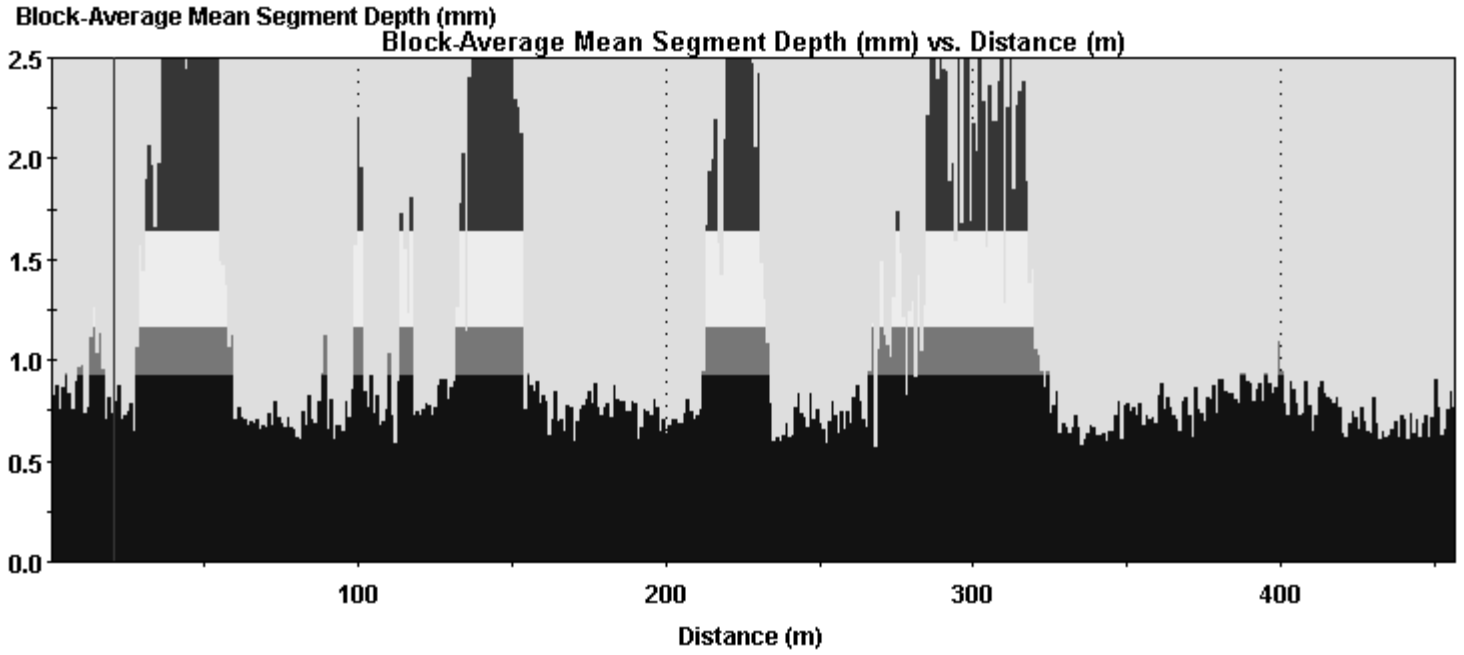
- Testing on I-195 done during a night closure due to traffic considerations
- Paint line used to help locate position of ARAN device



CONTROL



SEGREGATED AREA

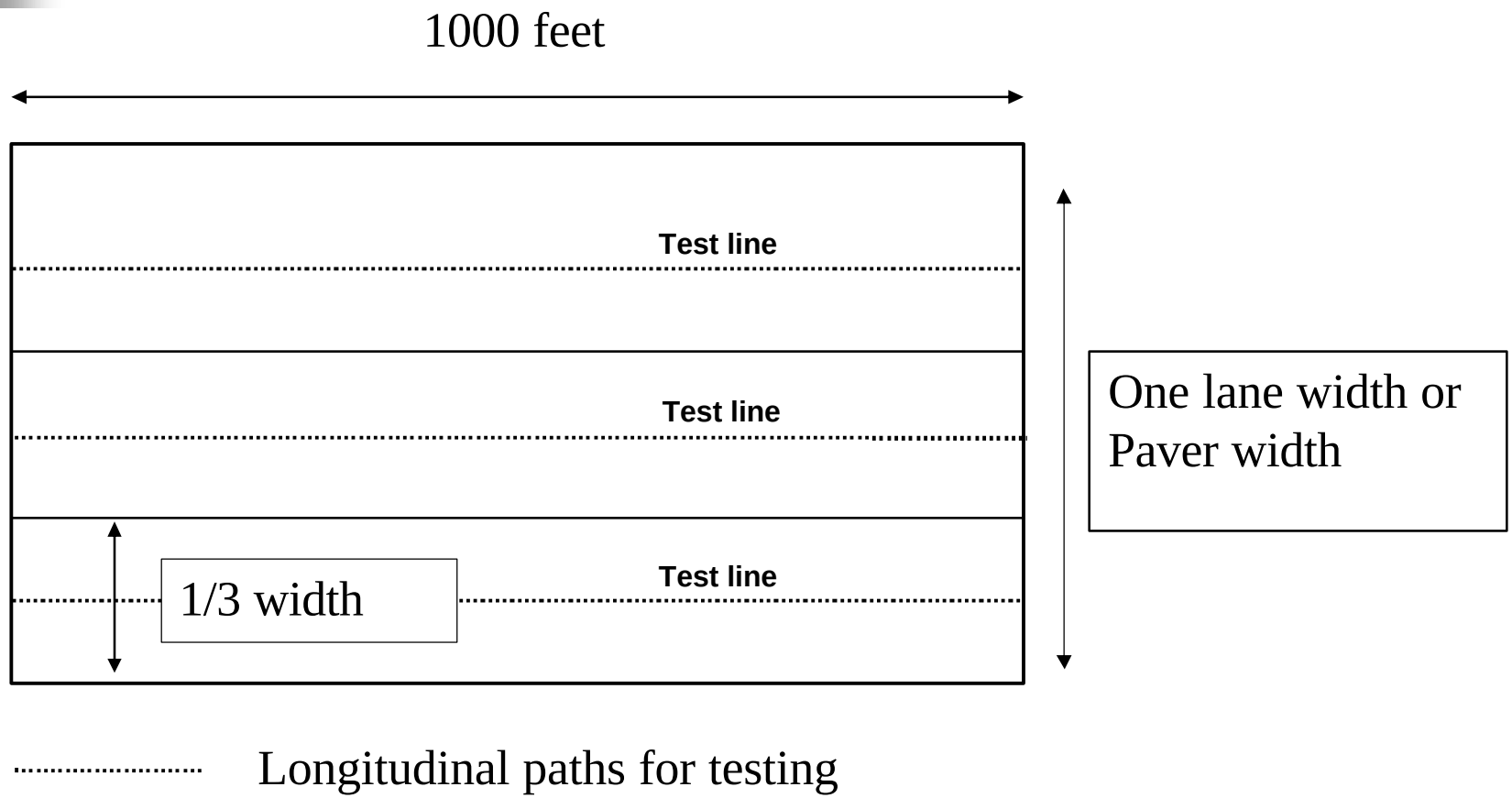


I-195

- Results consistent with visual inspection
- Segregation is different from Rt. 9 in that a regular pattern was not obtained on all runs
- The differences obtained from three runs on the same line suggest that it is very difficult to locate exactly on a line
- The implementation of a specification will need multiple lines tested to produce a fair result for a site

Application of the ARAN in specifications

Definition of % segregation and class



Definition of % segregation

$$A_i = \frac{\sum_{n=1}^{3}\sum_{k=1}^{N} l_{ink}}{A_{Total}} \times \frac{W}{3} \times 100$$

A_i = Percentage area of segregation in each level (i = low, medium or high)

l = Length of a segregated area in meters

W = Width of the test area in meters

A_{total} =Total area of the lot in square meters

n = considered one-third of test area (test line)

k = Segregated area identification number

N = Total number of segregated areas in each test line

Remedial treatments

- Remedial action linked to size of feature and level of segregation

Categorization of extent of the individual segregated areas

Segregation Class	Longitudinal Extent (mm)
1	≤ 200
2	$200 <$ and ≤ 400
3	$400 <$ and ≤ 800
4	$800 <$ and ≤ 1600
5	> 1600

Possible Remedial actions

Remedial actions for segregation

Extent of Individual Segregated Area (mm)	Level of Segregation		
	Low	Medium	High
≤ 200	No Action	No Action	Localized patch
200 < and ≤ 400	No Action	Localized Patch	Remove and replace.
400 < and ≤ 800	Localized Patch	Localized Patch	Remove and replace.
800 < and ≤ 1600	Localized Patch	Remove and replace.	Remove and replace.
1600 ≤	Remove and replace	Remove and replace.	Remove and replace.

AREA Index

- Objective - combine different degrees of segregation into a single quality measure

$$AREA = A_{low} \times 1.0 + A_{medium} \times 1.43 + A_{high} \times 2.5$$

where, A_{low} = Percentage area of low segregation

A_{medium} = Percentage area of medium segregation

A_{high} = Percentage area of high segregation

Pay factors

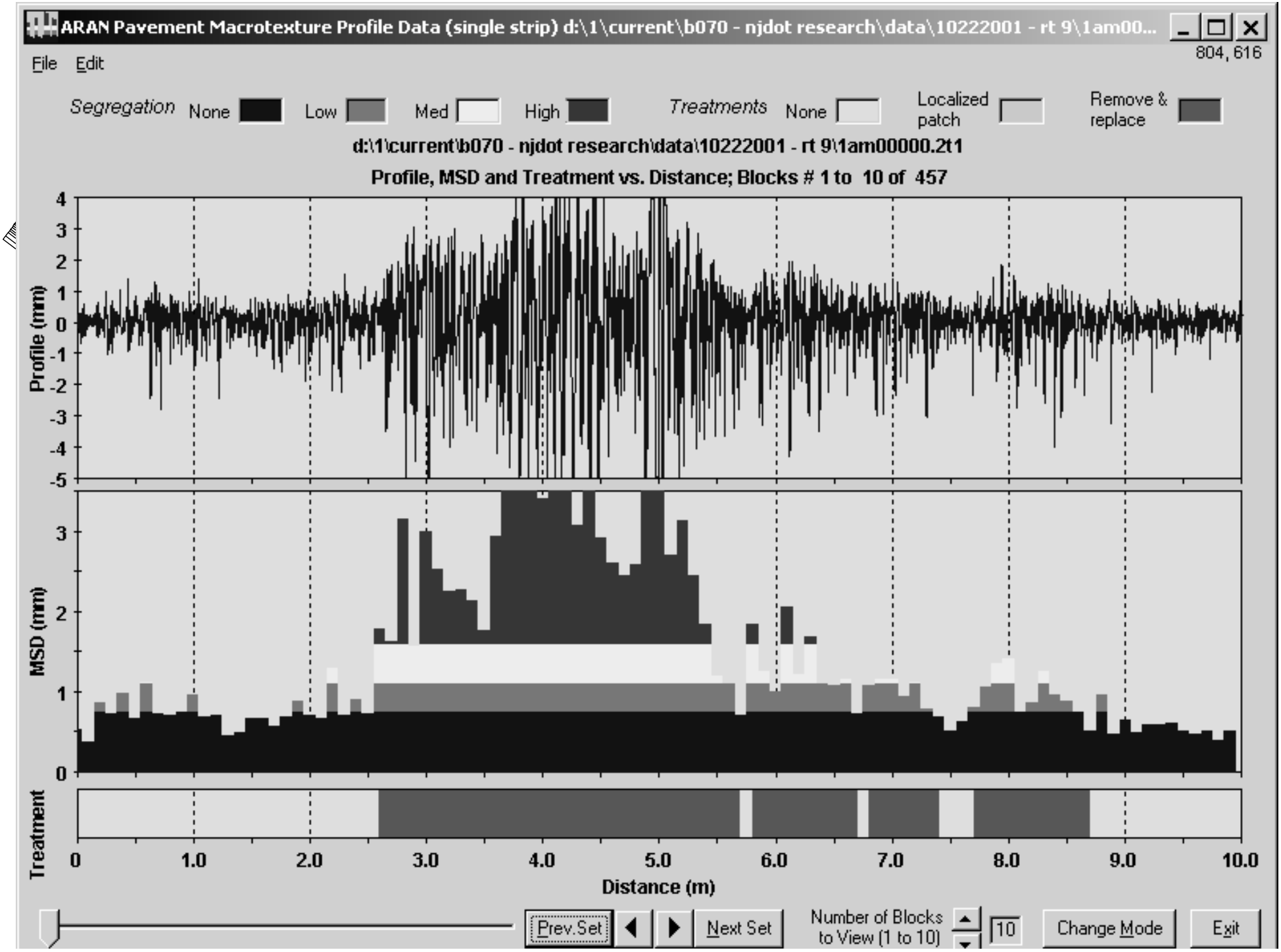
- Pay factors linked to AREA Index

Pay adjustment factors

Range of the AREA Index	Pay Adjustment Factor
0 – 5.0	105
5.0 – 15.0	95
15.0 – 25.0	85
25.0 – 35.0	65
35.0 – 45.0	25

NJTxtr - software for segregation monitoring

- NJTxtr software was developed to detect and monitor segregation based on ARAN
- It uses either user specified asphalt surface course information or texture of non segregated areas to compute Estimated Texture Depth (ETD)
- ETD is used to compute Texture Ratio (TR), which can be used to differentiate different levels of segregation


ARAN Pavement Macrotexture Profile Data (single strip) d:\1\current\b070 - njdot research\data\10222001 - rt 9\1am00...
804, 616
File Edit
Segregation None Low Med High
Treatments None Localized patch Remove & replace
d:\1\current\b070 - njdot research\data\10222001 - rt 9\1am00000.2t1
Profile, MSD and Treatment vs. Distance; Blocks # 1 to 10 of 457
Profile (mm)
MSD (mm)
Treatment
Distance (m)
Prev.Set
Next Set
Number of Blocks to View (1 to 10)
10
Change Mode
Exit

Conclusions (1)

- Several available segregation detection & measuring methods were evaluated to identify the best technology for NJDOT
- Laser texture measuring devices were selected over other technologies since it offers fast data collecting phase without interrupting traffic
- Ratios of texture in segregated areas to that in non-segregated areas were set on the basis for detection and monitoring of different levels of segregation
- AREA index was developed to determine the acceptance or non acceptance of a pavement section

Conclusions (2)

- Based on AREA index, pay adjustment factors are defined to determine the reduction of payment to account for the loss of pavement life due to segregation
- New segregation detecting and monitoring software NJTxtr was developed by combining above developed methodologies
- This software determines a pavement section is acceptable or unacceptable based on the level of segregation present
- A specification was developed for detection and monitoring of segregation based on ARAN collected pavement texture data


Beautiful asphalt highways.
Thank you for your attention.