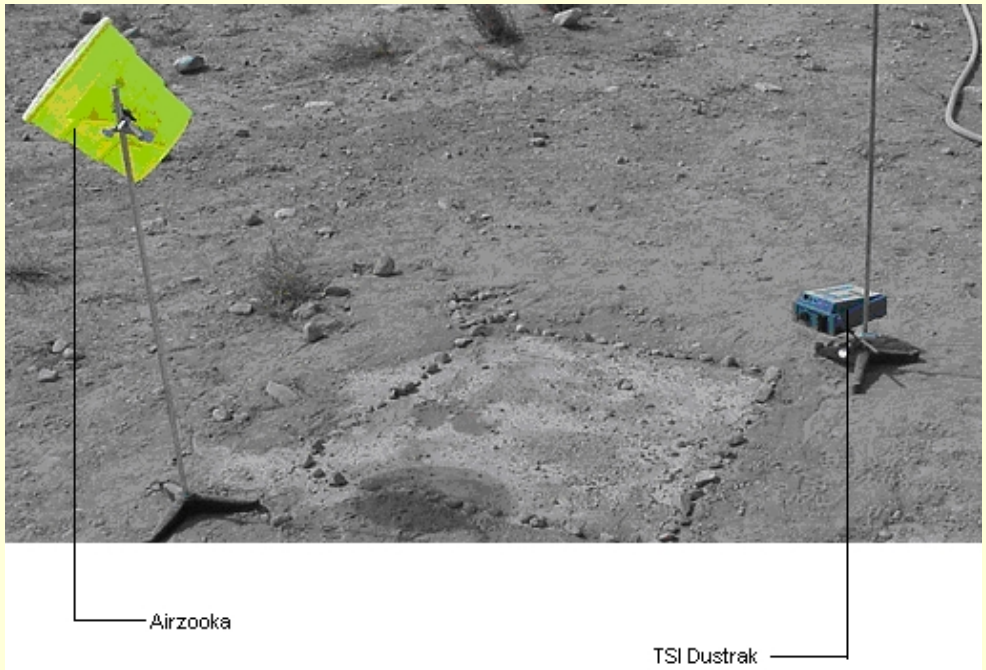
university of nevada, las vegas unlv

Rapid methods for evaluation of effectiveness of water applied on construction sites



David E. James, Thomas C. Piechota, Shibi Paul, Kamakshi Sistla, Kayli Barber, Ayla Kiser

American Water Works Association, February 7, 2006

Project objectives – water effectiveness

- Develop field techniques to evaluate effectiveness of construction water application to control dust

- Industry-friendly recommendations on how to improve construction water application efficiency

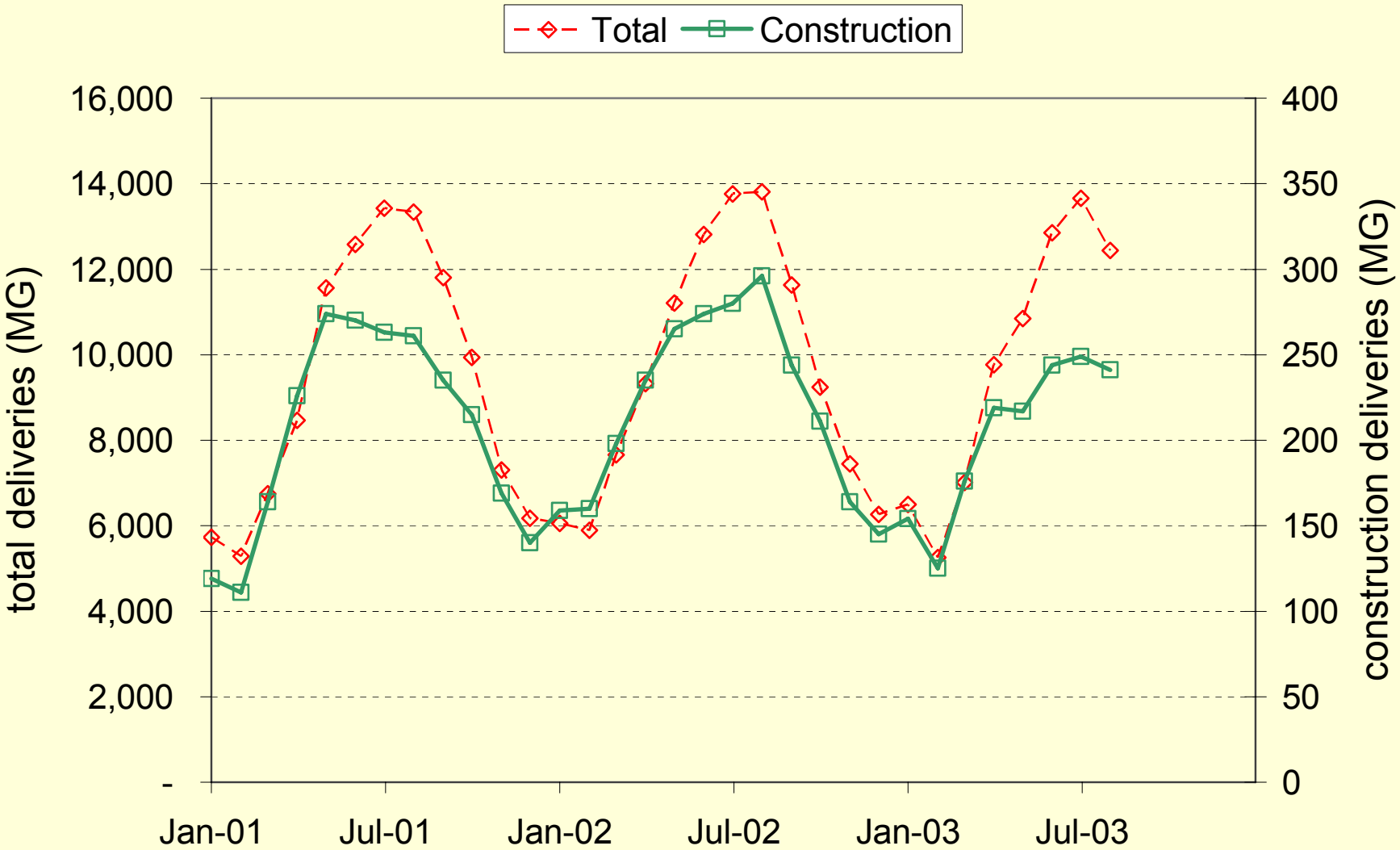
Section 2 Valley wide water use

Utility	Total delivered (MG)	Total construction (MG)	Construction Percentage	monthly ave construction (MG)	Period of record
City of Hend	65,994	1,948	**3.0%**	63	6/01-12/03
LVVWD	305,748	6,703	**2.2%**	210	1/01-8/03
City of NLV*	22,829	2,159	**9.5%**	127	1/02-9/03
Total	**394,572**	**10,810**	**2.7%**	**400**	

*NLV record shorter than others

400 MG/month = 1200 AF/month x 12 mo/yr = 14,400 AF/yr (14,400 homes/yr – 40,000-50,000 people)

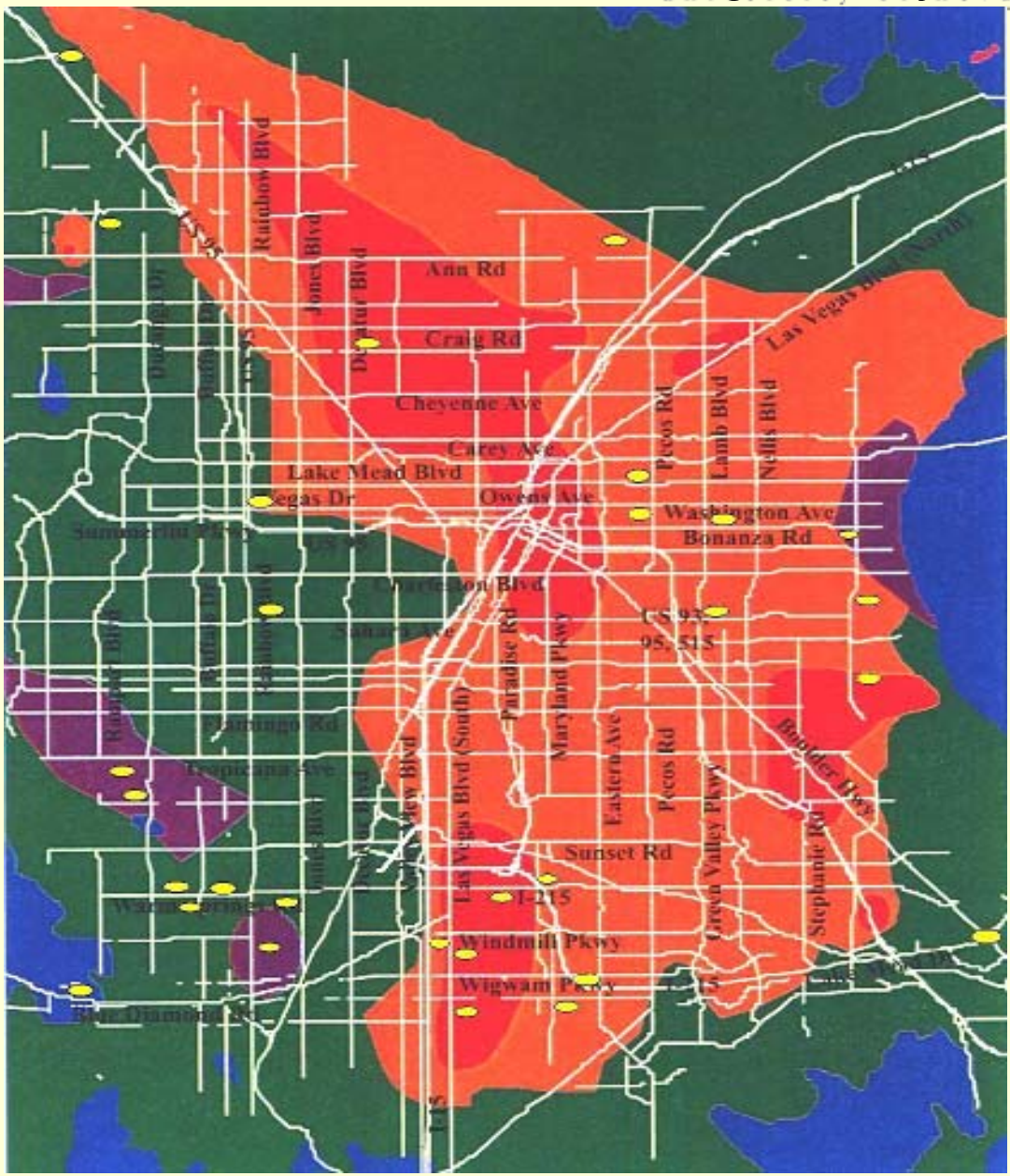
Monthly potable water use
LVVWD potable results - seasonal



Fugitive Dust Control: BMP

- BMP (Best Management Practices, CCDAQM, 2003)
- Site specific dust control measures depending on PEP (Particulate Emission Potential) group
- PEP classifications vary spatially throughout the Las Vegas Valley
- More water usually required for higher PEP categories

PEP Classification on the Las Vegas Valley



Source :Modified from Construction Activities Notebook-II, Clark County Health District, Air Quality Division, version 1.0, January, 2001.


How long does this applied water last for controlling dust?

Project objectives

- Develop simple, industry-compatible tests to measure effectiveness of water
- Apply tests in field to different PEP groups Summer 2004
- Evaluate data

Tests developed

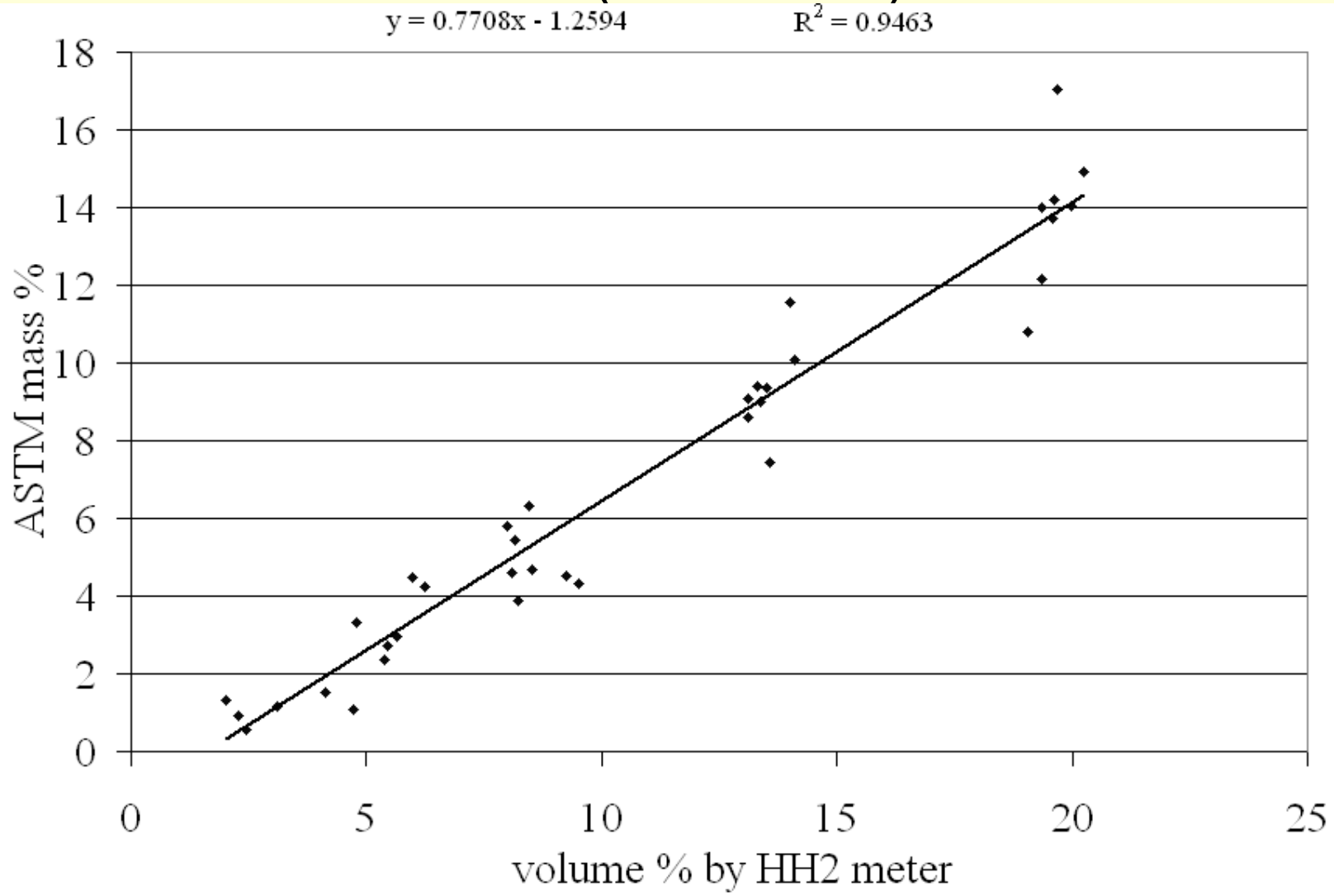
- Rapid mass moisture – water content
- Poof – wind blown PM-10
- Scrape – abraded PM-10
- Bucket – infiltration rate
- Pie pan – crust strength

Tests with HH2 moisture meter- Procedure

- Moisture meter hard to insert into soil
- The soil surface is scooped using a hand shovel
- Soil is made into a hand-compressed pile to cover the probes fully
- Moisture reading noted
- Repeated 5 times on each surface condition

Moisture meter calibration – in lab after field study

- ASTM mass% = 0.77(HH2 vol%) - 1.26 r^2 =0.95



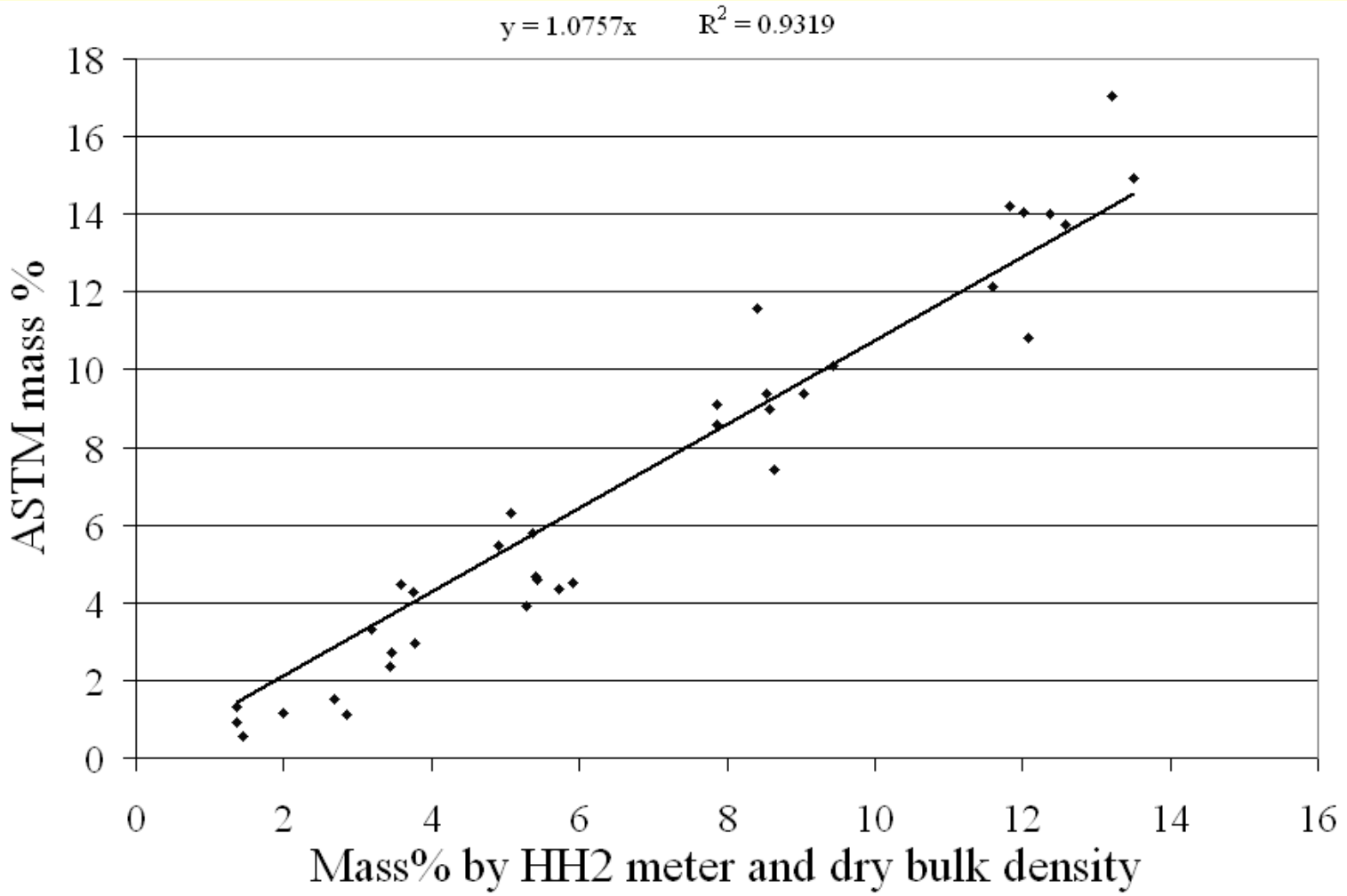
Results-Tests with HH2 moisture meter

Procedure for conversion from Vol% to Mass%:

- Fill a graduated cylinder to known volume(m^3)
- Weigh the cylinder with soil (gm)
- Bulk density(ρ_{soil}) = gm/m^3
- Record Vol% moisture by HH2 Moisture meter
- **Mass% = Vol% *(ρ_{water}/ ρ_{soil})**
- ρ_{water} = $1gm/cm^3$ at room Temp an Pressure

Moisture meter calibration – in lab after field study

- ASTM mass%=1.076(HH2 bulk density mass%) $r^2 = 0.93$



Las Vegas Valley soil classifications

The proposed experiments are conducted on a total of **29 sites** in & around Las Vegas Valley

High - 6
Moderate high - 9
Moderate low - 9
Low - 5

A - 4
B - 17
C - 2
D - 6

PEP	Hydrologic soil groups			
	A	B	C	D
High	-	4	2	-
Mod High	-	7	-	2
Mod Low	2	4	-	3
Low	2	2	-	1

Summary of Moisture contents

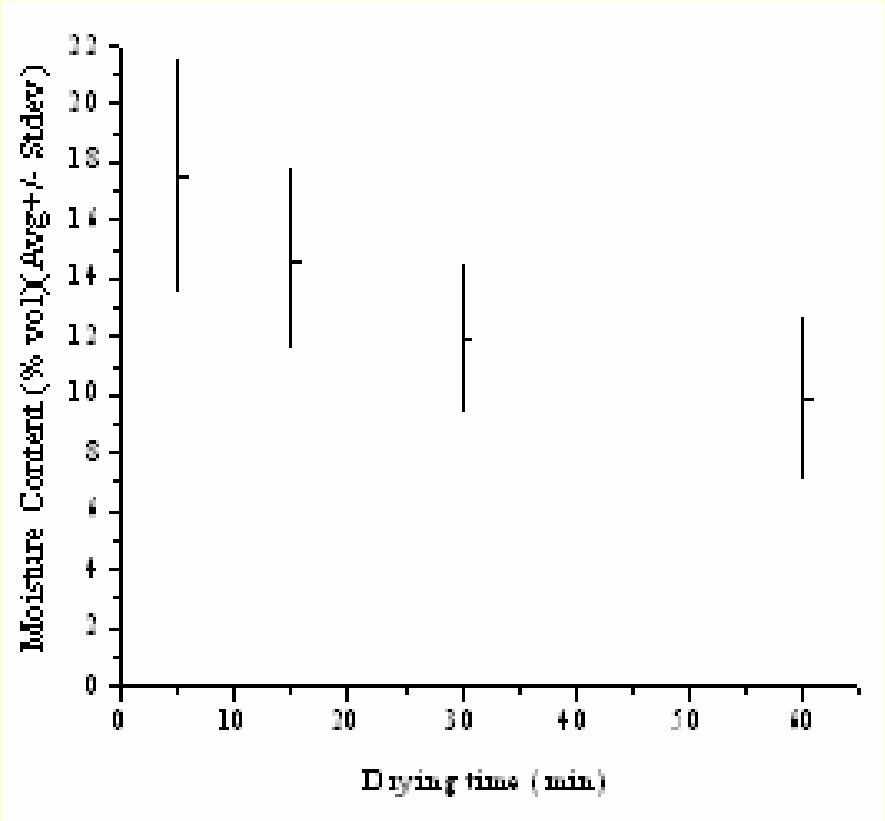
1. Sample summary of Moisture contents (across **PEP groups**)

Surface condition	High	Moderate High	Moderate Low	Low
Dry, stable	2.7	2.6	2.6	4.2
Dry, scrape	2.4	3.4	3.2	4.3
5 min after wetting	**12.8**	**17.9**	**14.5**	**15.2**
15 min after wetting	10.7	14.9	11.6	11.6
30 min after wetting	9.2	12.1	9.4	9.4
60 min after wetting	7.2	10.1	7.5	7.7

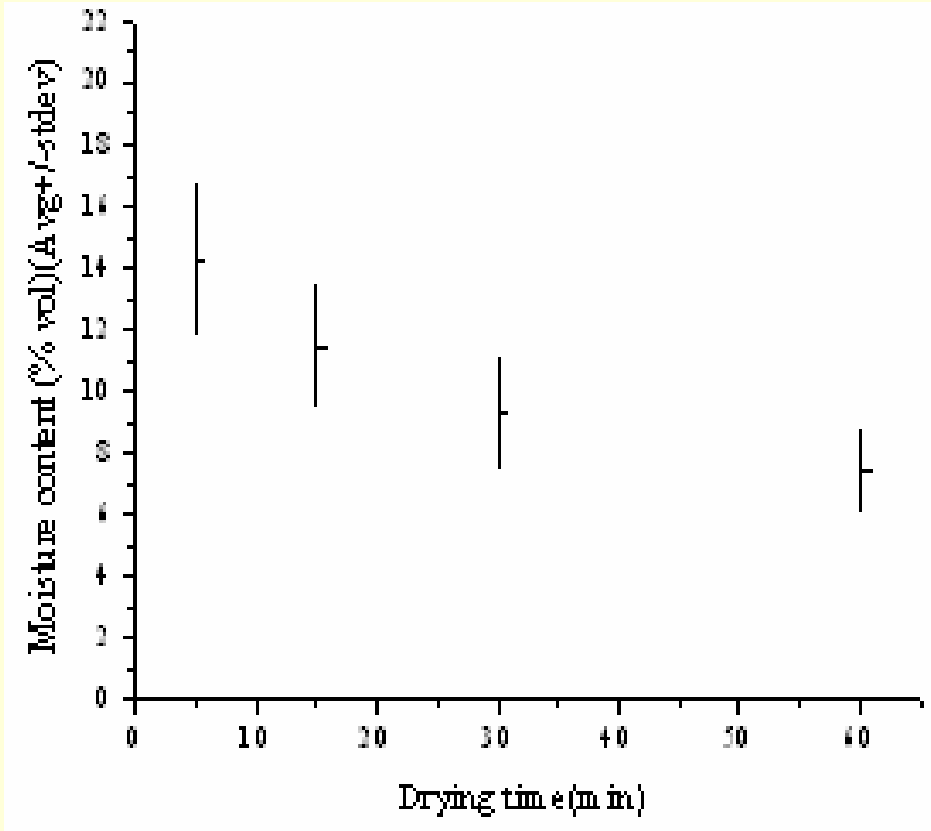
2. Similar table for Moisture contents across Hydrologic soil groups

Summary of Moisture contents (continued..)

Typical summer drying curves for wetted soil



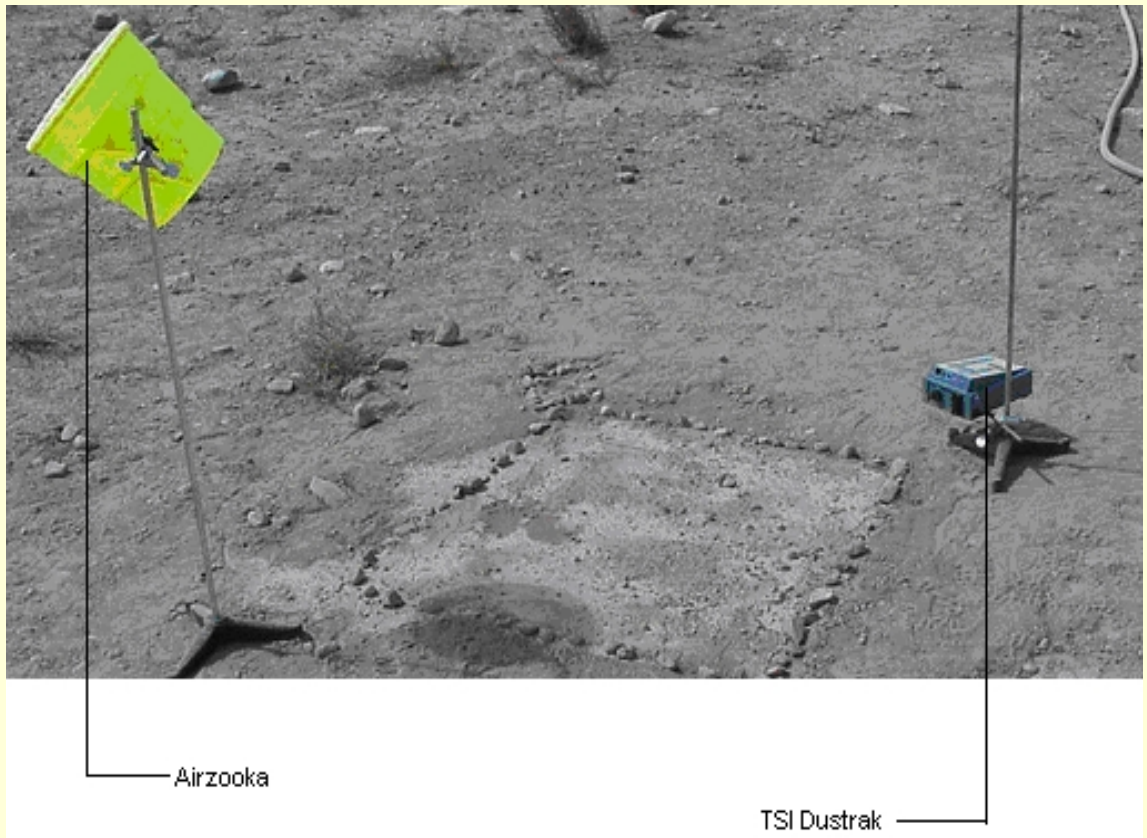
Moderate High PEP



Moderate Low PEP

Poof test Procedure

- Airzooka™ fires 10-12 m/sec pulse every 10 sec
- PM-10 concentration is recorded by Dusttrak™



Scrape test Procedure

- Long handled shovel dragged 5 10-foot runs at 13±4 sec drag time.
- Shovel has 9.07 kg weight spread over 9 inch width.
- PM-10 concentration measured at 7.7” from blade (mg/m^3)
- Experiment is repeated on surface 5 min after wetting

Summary of field test protocols

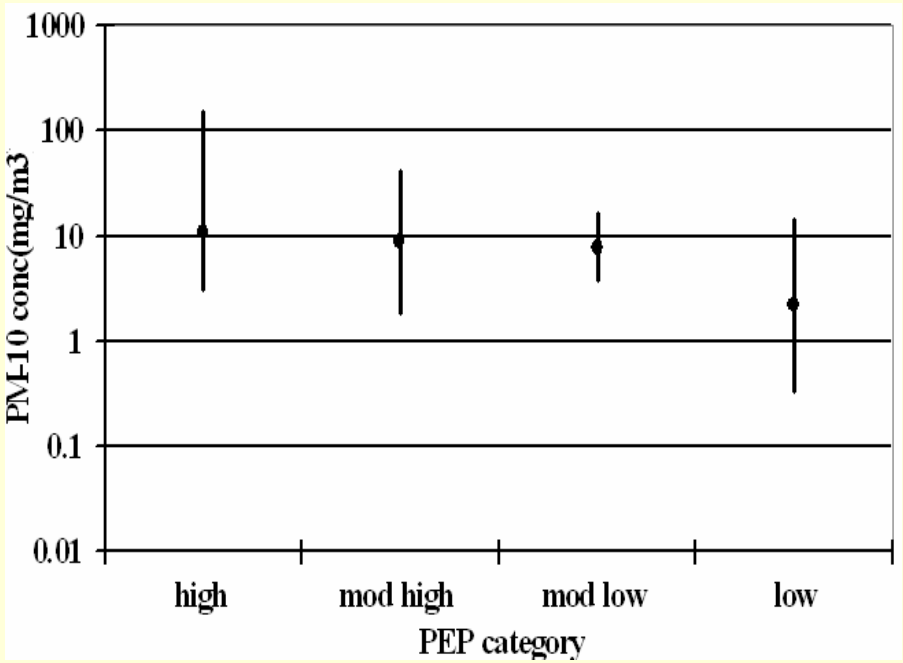
Poof → 10 shots as found → Scrape, repeat test → Apply water Test after 5, 15, 30, 60 min

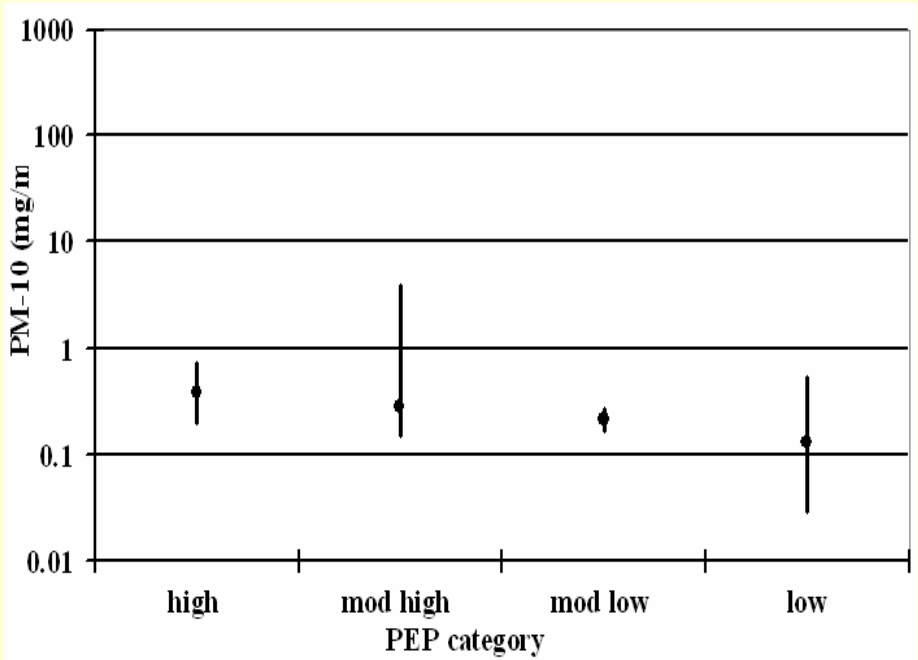
Scrape → 5 runs as found → Apply water, dry for 5 min → Repeat test

Small Wind tunnel → 1 run – 3 velocities 100sec per velocity As found → Scrape, repeat test → Apply water Test after 5, 15, 30, 60 min

Results- Poof test

Effect of wetting on PM-10 Concentration (Poof test)



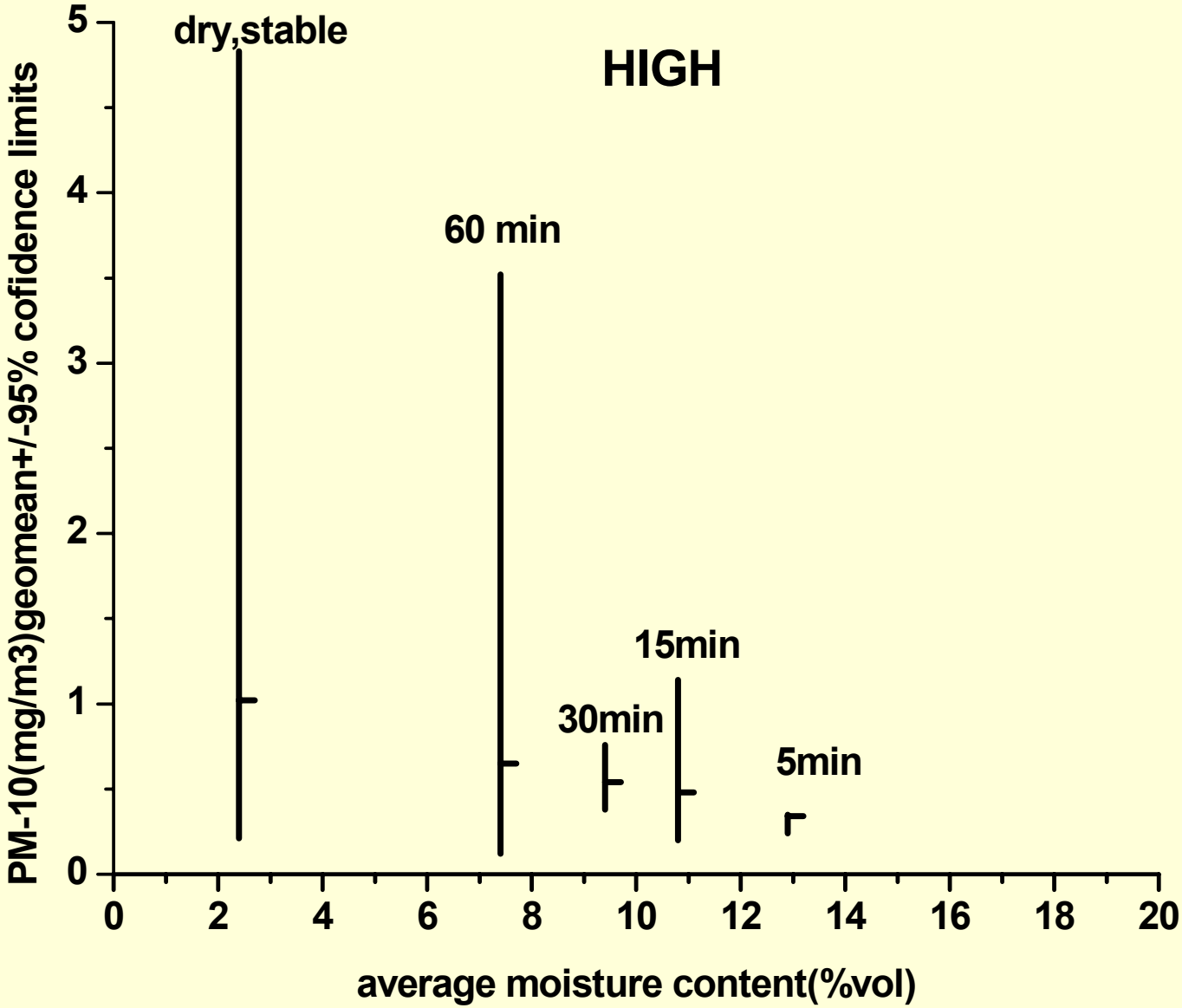


Dry Surface

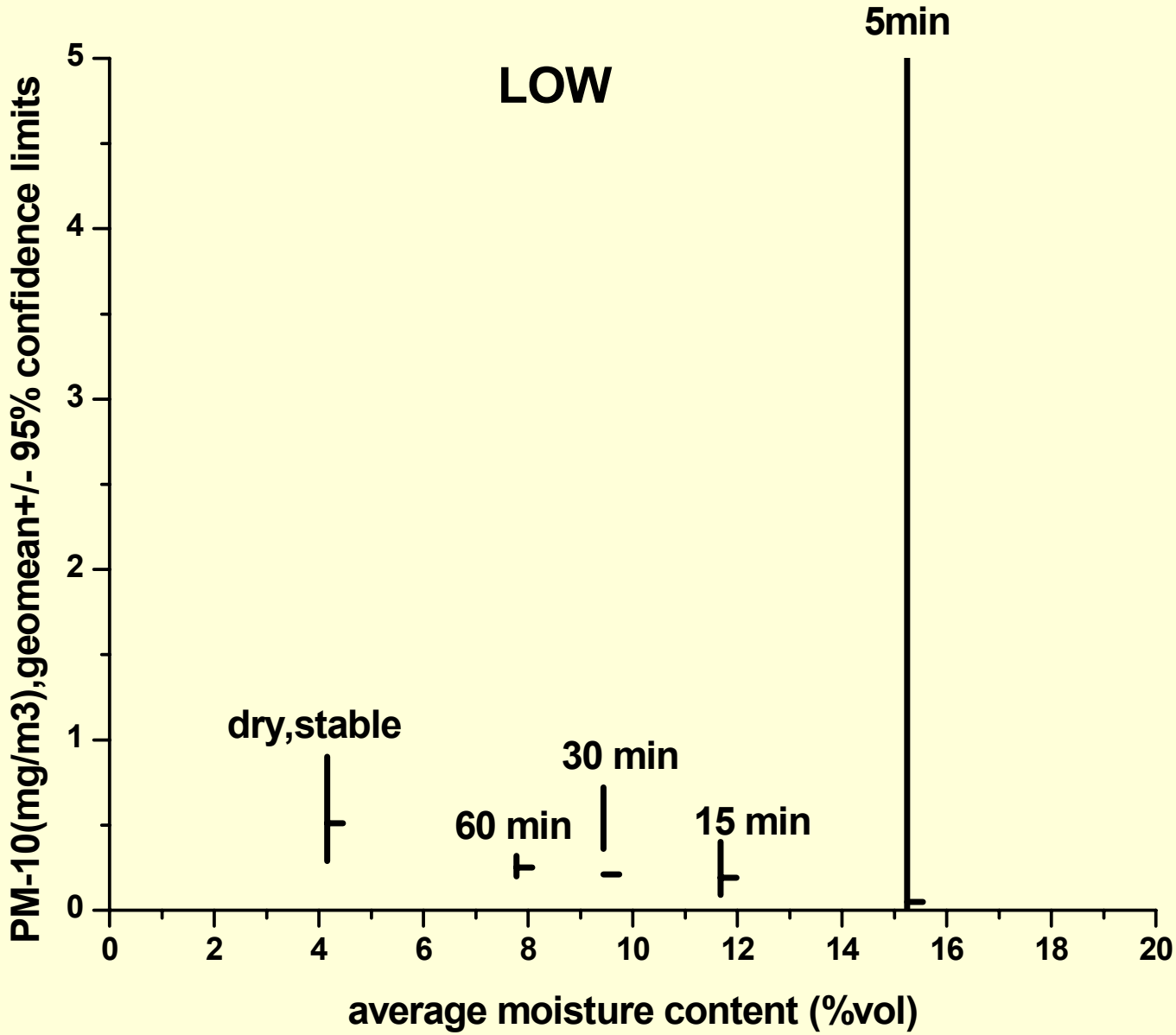
5 min after wetting

PM-10 reduced by a factor of 30 on High PEP soils, and more than 10 on others

Poof Test: in-situ PM-10 vs moisture



Poof Test: in-situ PM-10 vs moisture

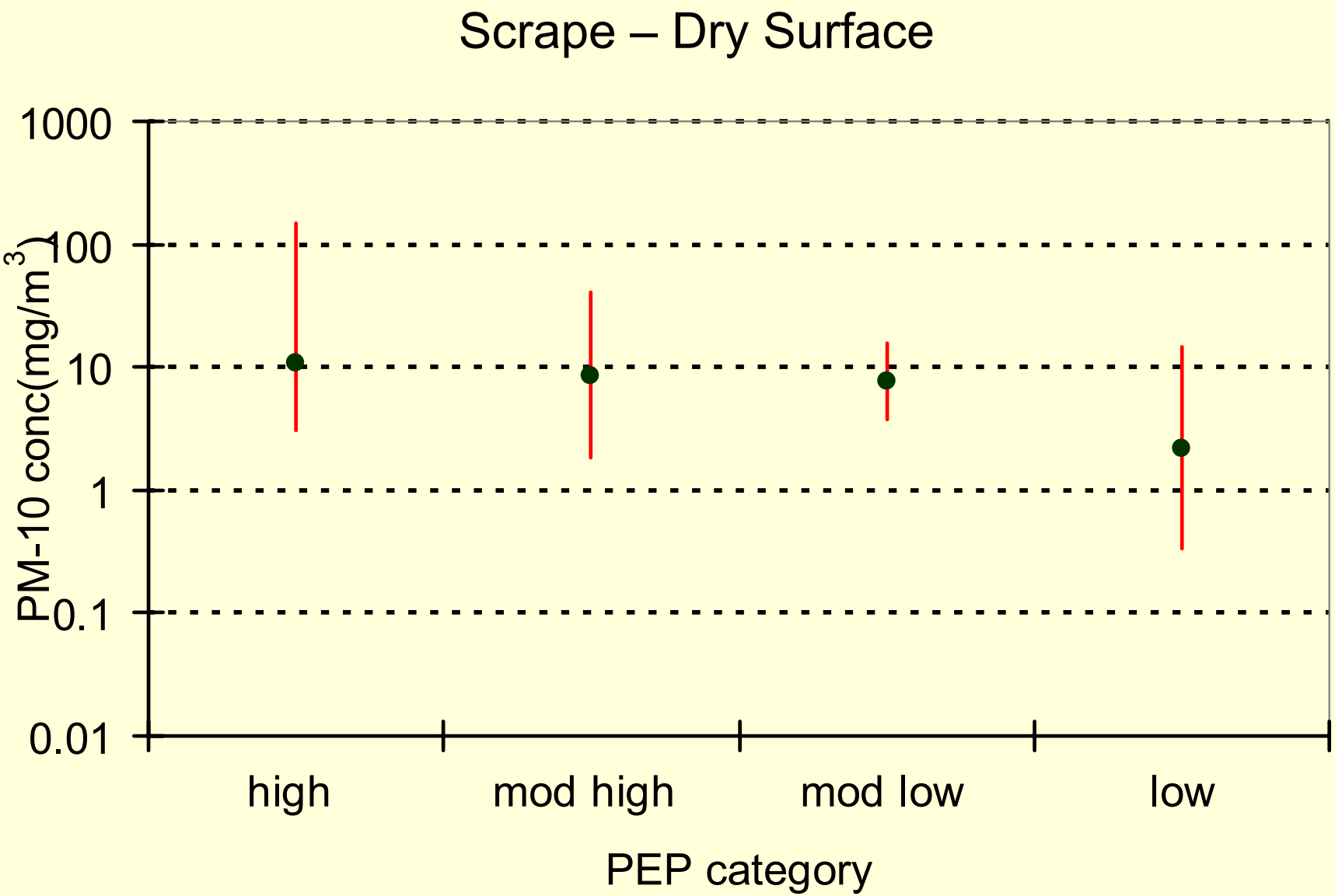


Poof Test Results Summary

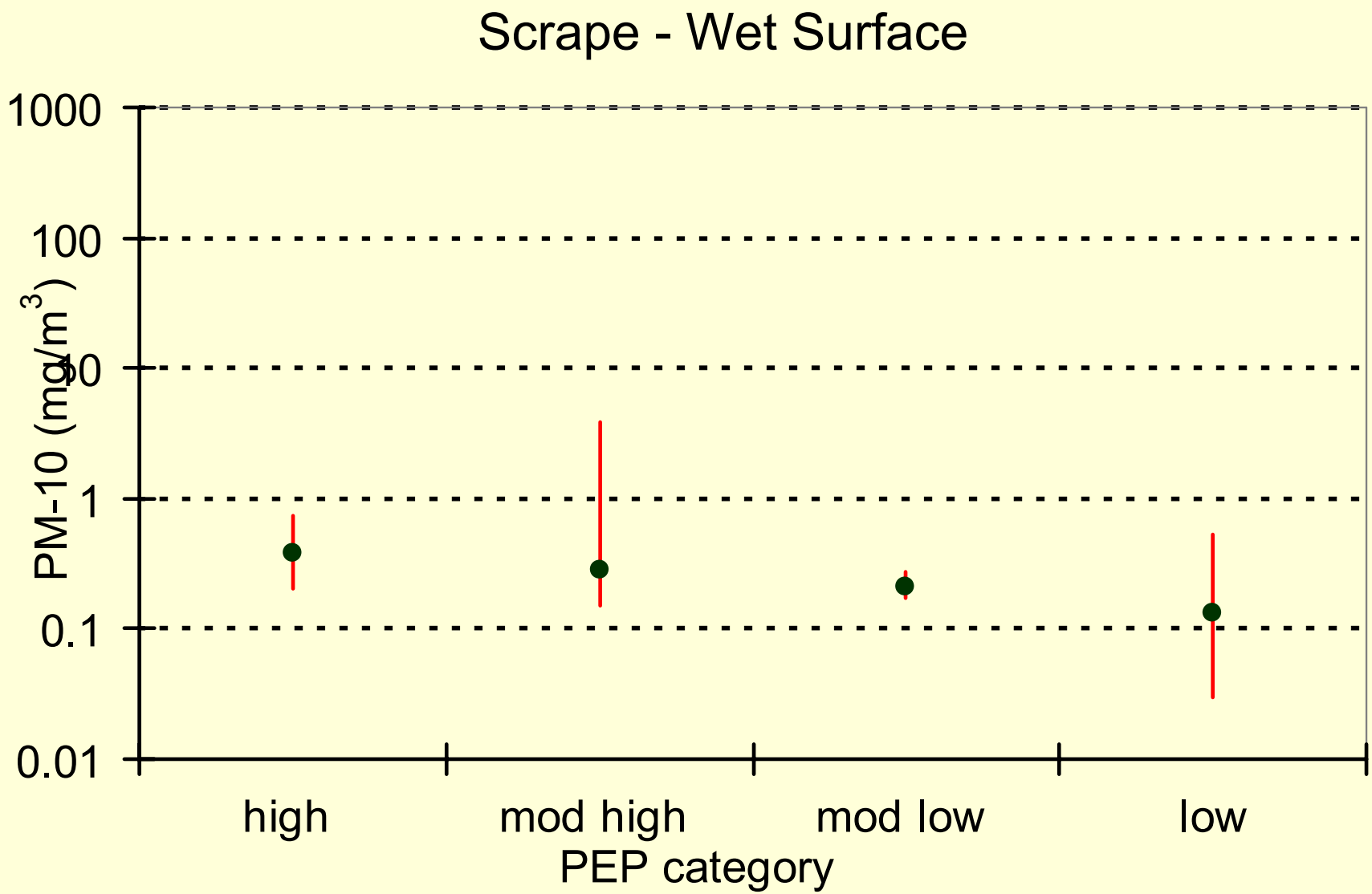
Effect of wetting on average PM-10 emitted

PEP	Dry, Scraped mg/m^3	Wet, after 5 min, mg/m^3	% decrease after 5 min	Wet, after 60 min, mg/m^3	% decrease after 60 min
HIGH	7.74	0.34	96%	0.65	92%
MOD HIGH	2.01	0.27	86%	0.35	82%
MOD LOW	1.46	0.24	83%	0.27	81%
LOW	0.81	0.10	87%	0.25	81%

PM-10 conc. Vs PEP category (geomean ± 95% conf limit)



PM-10 conc. Vs PEP category (geomean ± 95% conf limit)



Scrape Test Results Summary

- Effect of wetting on average PM-10 emitted

PEP category	Dry, Stable	Wet, 5 min after wetting	% decrease in PM-10
HIGH	10.64	0.29	97%
MOD HIGH	8.62	0.28	85%
MOD LOW	7.76	0.19	97%
LOW	2.20	0.13	94%

Infiltration test procedure

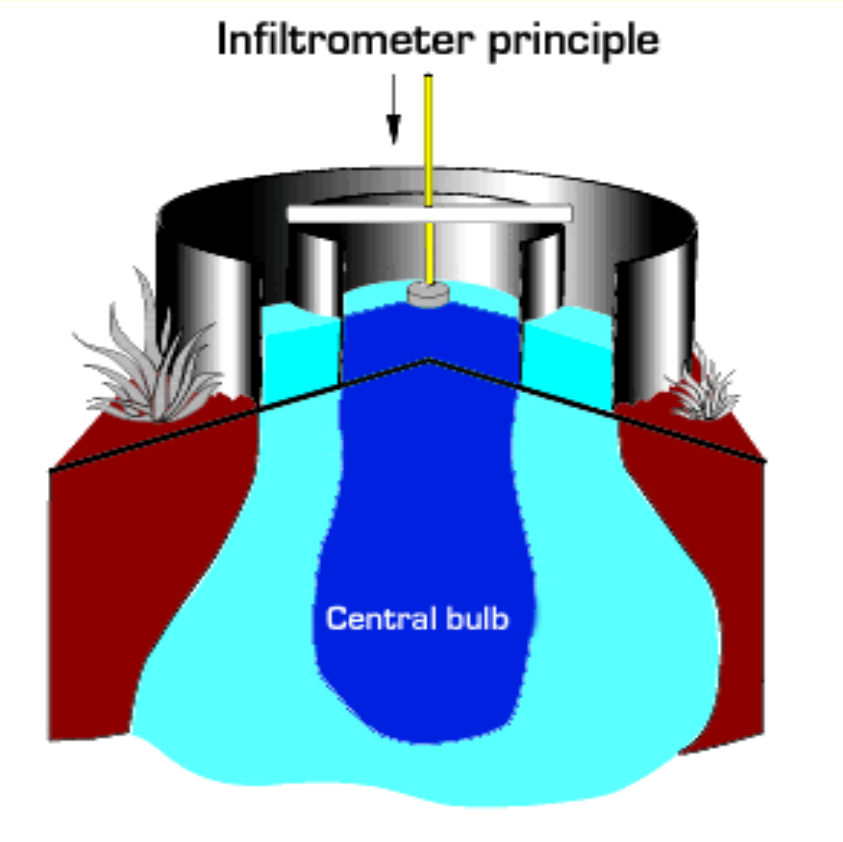
Standard double ring infiltrometer

- 12” Outer Diameter
- 6” Inner Diameter
- Hard to insert into rocky soils
- Soil surface is disturbed
- Ring infiltrometer may be damaged

Infiltration test Procedure

- Two Infiltrometers: Standard Double ring, UNLV Bucket

- The inner and outer rings are filled with water to the brim.
- Water flows straight down in the center bulb
- Set the stopwatch for 15 minutes.
- Difference in water level noted
- Calculate the infiltration rates.



Source:http://www.usyd.edu.au/su/agric/web04/double%20ring%20final.htm
(Included with permission)

Procedure for Infiltration tests

UNLV bucket infiltrometer

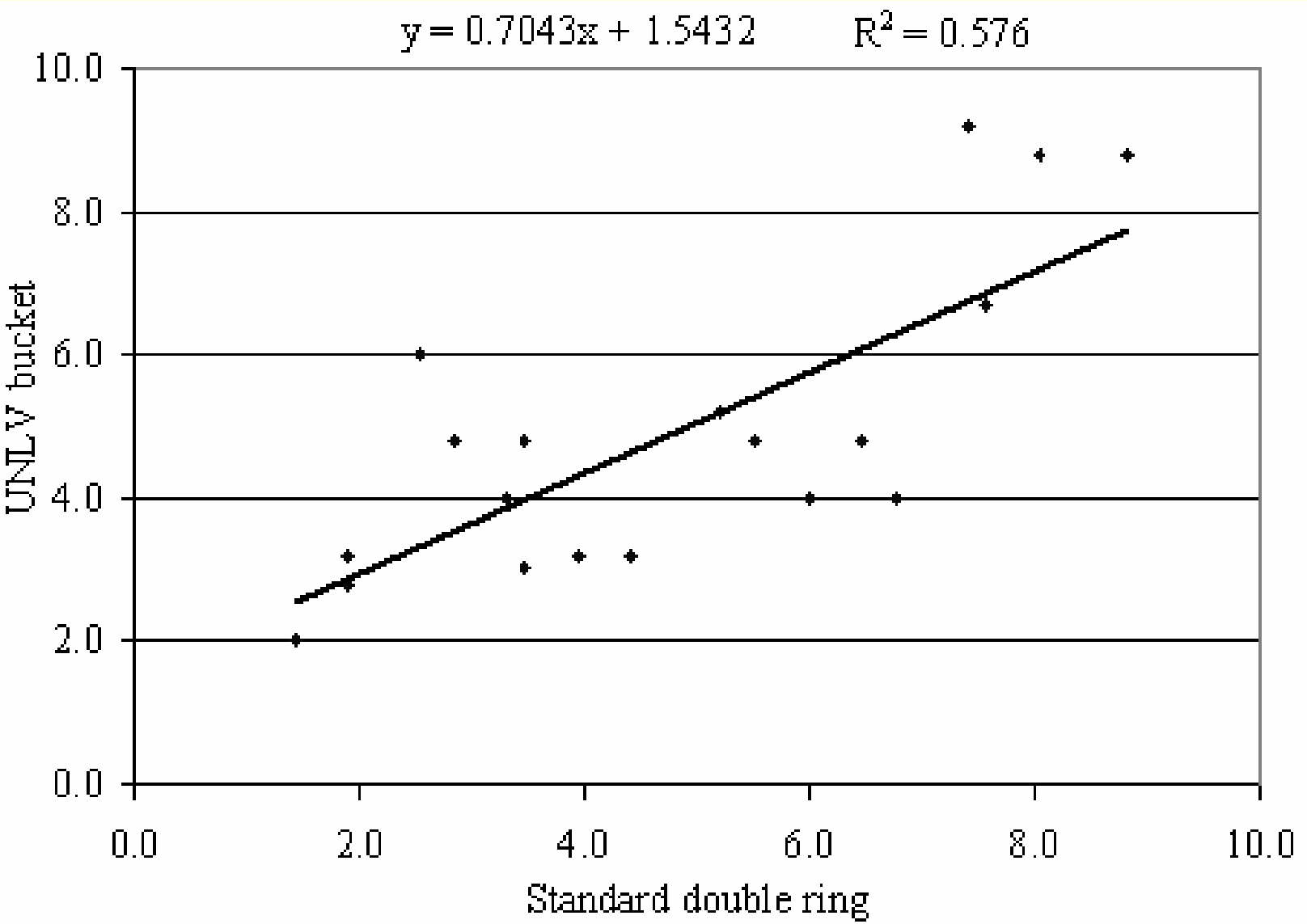
Top view

Bottom View

- 5- gallon plastic bucket
- 1- gallon metal bucket
- Closed Cell Foam

Results- Infiltrometer tests

UNLV Bucket vs. Standard Double ring (Pooled data)



Results - Infiltration Tests

(Average ± 95% confidence limits)
application rate equivalent units: 145 in/hr

Rate on PEP groups (inch/hr)

PEP group	Standard double ring	UNLV bucket
HIGH	**4.4 ±1.1**	**4.5 ±0.9**
MOD HIGH	**6.2 ±2.3**	**5.9 ±2.1**
MOD LOW	**4.9 ±2.2**	**5.4 ±2.8**
LOW	**3.5±2.2**	**3.4±1.2**

Rate on Hydrologic groups (inch/hr)

Hydro-logic group	Standard double ring	UNLV bucket
A	**7.1 ±1.4**	**6.0± 2.8**
B	**5.3± 2.0**	**5.1± 2.1**
C	**4.4± 1.4**	**4.6± 1.6**
D	**2.9± 1.8**	**3.6± 1.0**

Pie pan test Procedure

0.05” 0.10” 0.15” 0.20” 0.30”

low soil

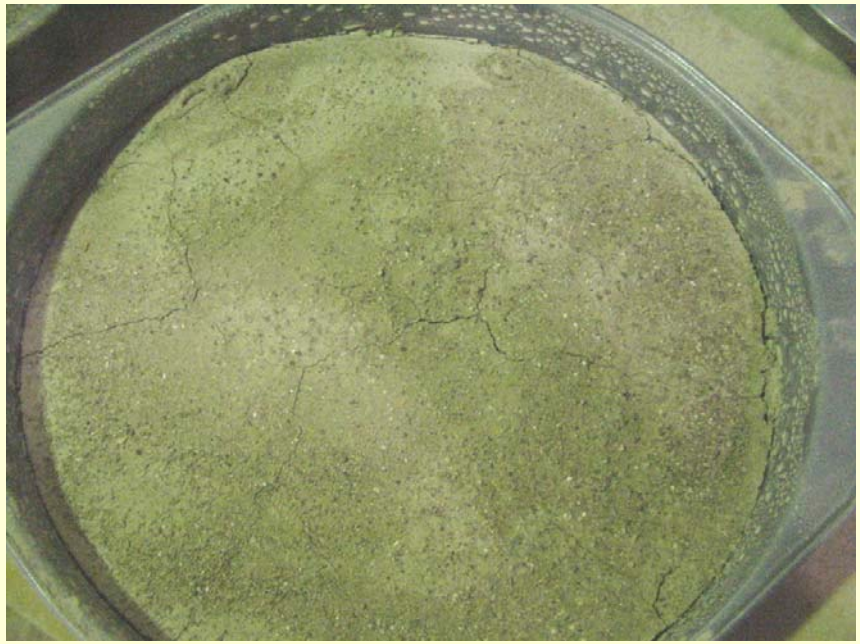
Mod high soil

Most of the soils formed crust at 0.10” of water

0.05” Low PEP 0.010”

partially formed crust

fully formed crust



No dents by ball drop

Mod High PEP

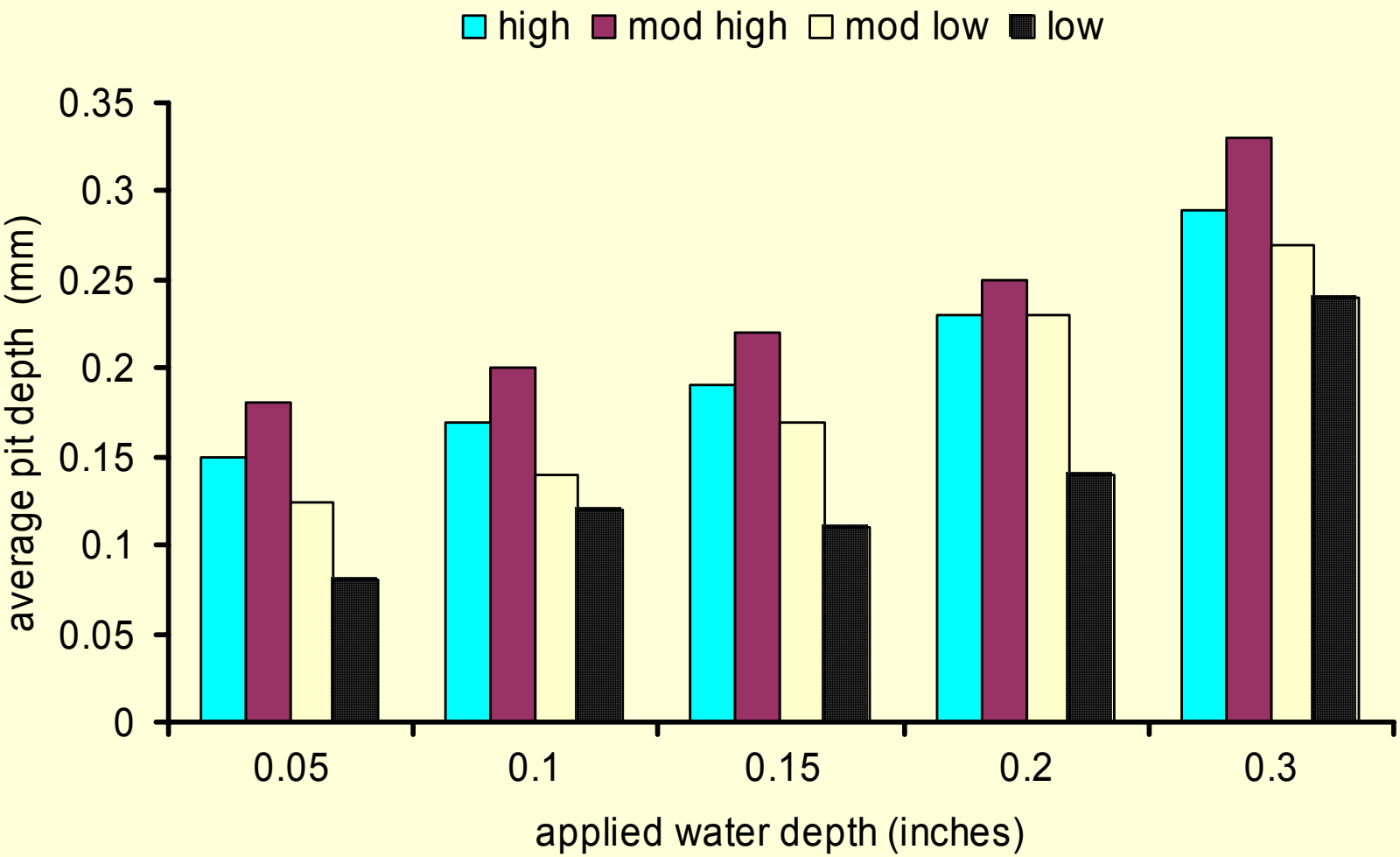
0.05” 0.010”

both crusts fully formed

Easily dented by ball drop

Results –Pie Pan tests

- Crust strength order: Mod High < High < Moderate Low < Low



Summary & Conclusions

- Can rapidly characterize site moisture & effects on fugitive dust generation with Poof and Scrape tests
- 1 hour summer rewatering interval will suppress dust on the High PEP soils
- Soil structure appears to similarly affect crust strength
  - Low > Moderate Low > High > Moderate High
- and infiltration rates
  - Low < High < Moderate Low < Moderate High
- PEP classifications usually indicate potential to emit dust

Recommendations to optimize water use

- Use volumetric TDR meters for rapid in-situ moisture estimates – calibrate for your soil
- Hourly rewetting (at depth of > 1 mm) for High PEP soils in summer
- Temporary reduction in applied water possible after rain events

If we could do follow up research . .

- Evaluate time needed for PM-10 to increase after moisture application for different PEP groups & seasons
- Re-evaluate portable wind tunnel with correct technique
- Measure *in-situ* effectiveness of truck- applied water with field techniques
- Evaluate potential of agricultural surfactants to increase desert soil infiltration rates

Acknowledgments

- Financial support
  - Southern Nevada Water Authority
  - US Bureau of Reclamation
  - UNLV Applied Research Initiative
- In-kind support
  - Aggregate Industries, Gary Robertson
  - Las Vegas Valley Water District, Doug Keene
  - Envirocon, Troy Hildreth
  - Cashman Equipment