FEHRL

Re - Road

Risk Assessment: Waterborne Emissions from RA in Surface Courses

SEVENTH FRAMEWORK PROGRAMME

Introduction

Potential Concern Over Using RA in Road Surfaces

- Potential contaminants closer to the surface
- Increased interaction with environment
- Levels of risk associated with different stages of the process rarely quantified
- Contaminants can be transported by water or air

Waterborne Emissions

Contaminants can come from a number of sources

- Those in the bitumen, additives and aggregates;
- Those which built up on the surface of the road during its previous pavement life/lives;
- Those which build up during the life of the newly laid pavement containing RA.

- Tar: a particular concern (detection issue)
- Focus on PAHs and heavy metals

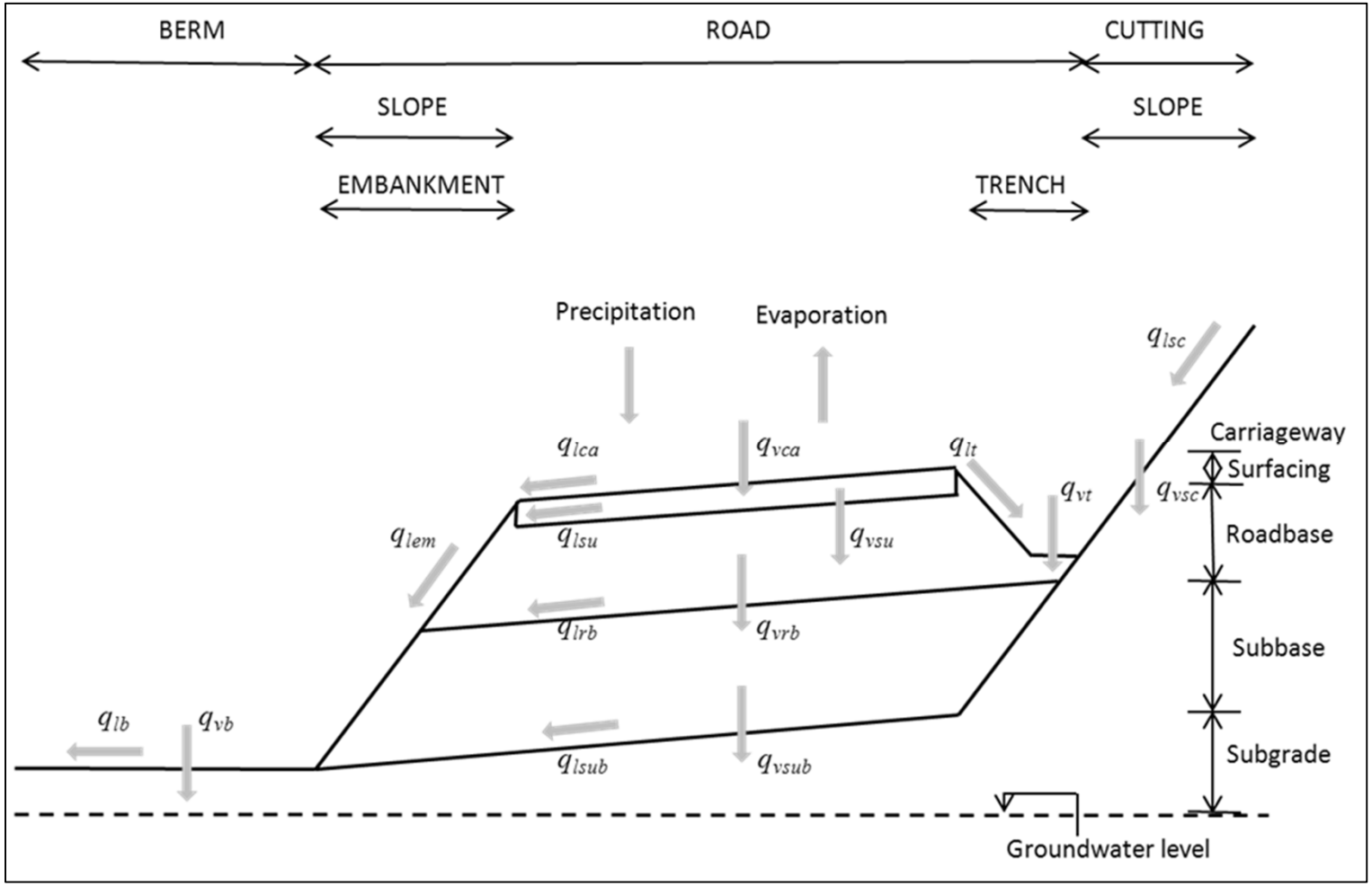
Modelling Approach

- Assumes that leaching associated with infiltrating water is the dominant mechanism
- Is based on a probabilistic Monte Carlo method
- Utilises a standard road construction
  - Road dimensions of 1km in length, 9.5m width
  - 50mm SMA surface course with varying RA content

    <0%, 15% and 30% RA>
  - Other materials used for comparison

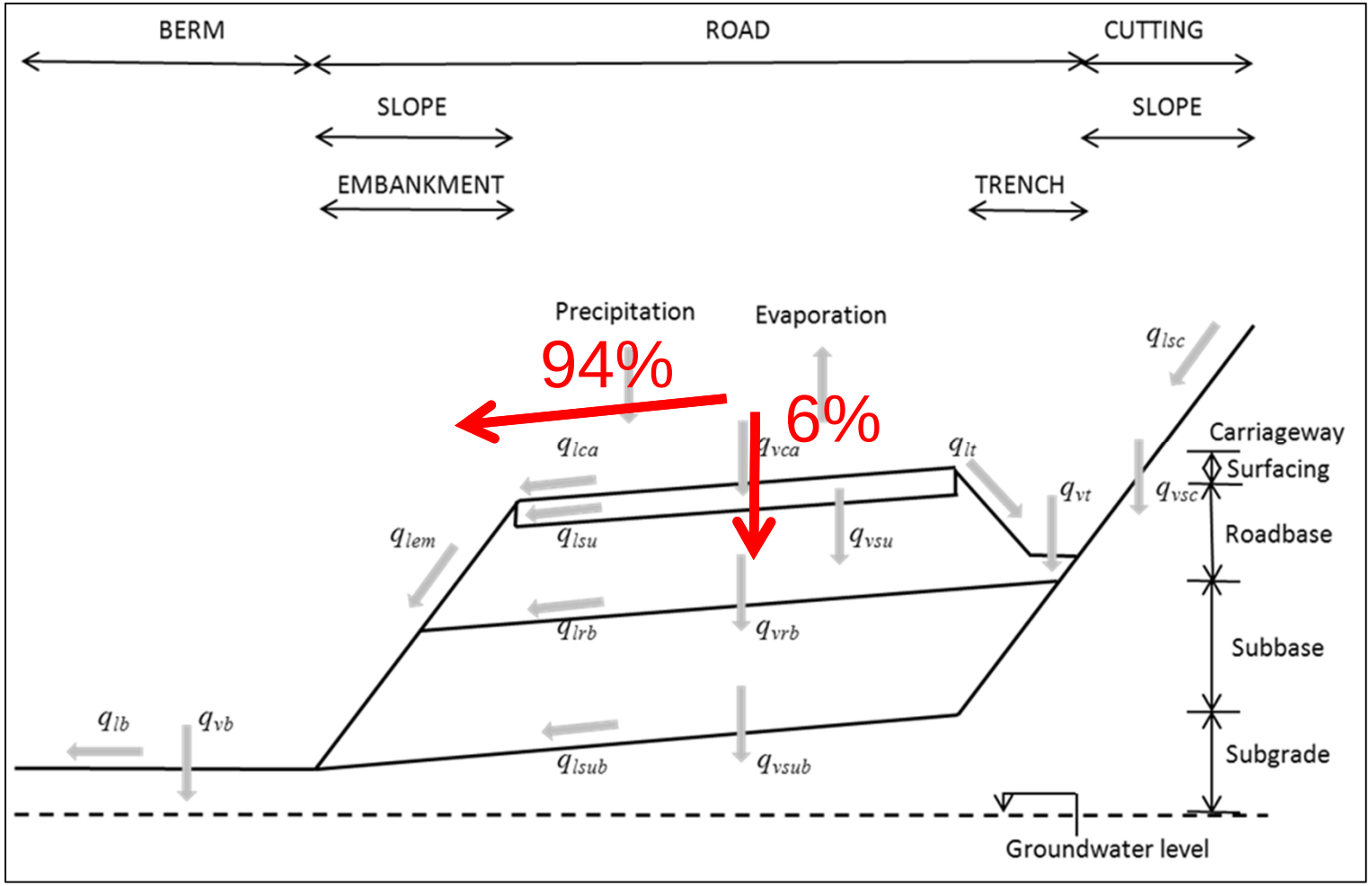
    <Tar containing asphalt, mixed source material, rejuvenated mix with 50% RA>

Modelling Approach



Erlingsson et al 2009

Modelling Approach



Erlingsson et al 2009

Modelling Approach

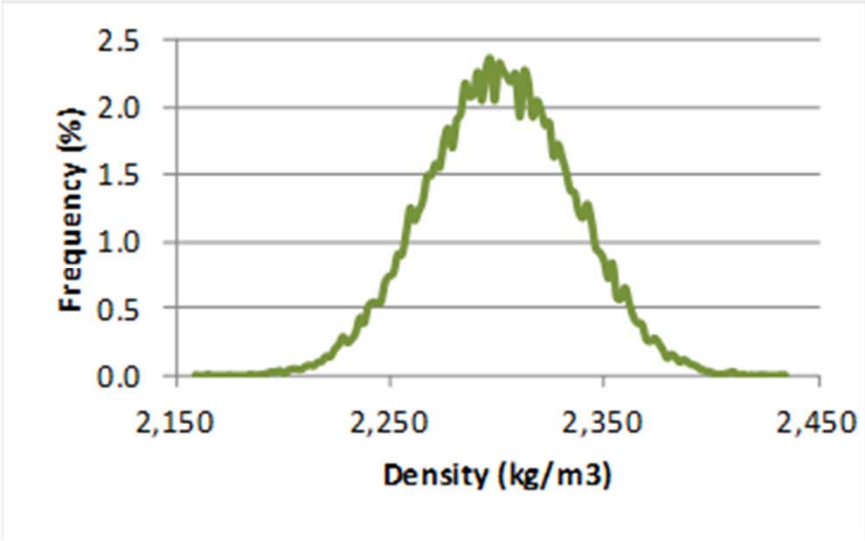
- Assumes that leaching associated with infiltrating water is the dominant mechanism
- Based on a probabilistic Monte Carlo method
  - 20,000 simulations
- Utilises a standard road construction
  - Road dimensions of 1km in length, 9.5m width
  - 50mm SMA surface course with varying RA content
    <0%, 15% and 30% RA>
  - Other materials used for comparison
    <Tar containing asphalt, mixed source material, rejuvenated mix with 50% RA>

Modelling Approach

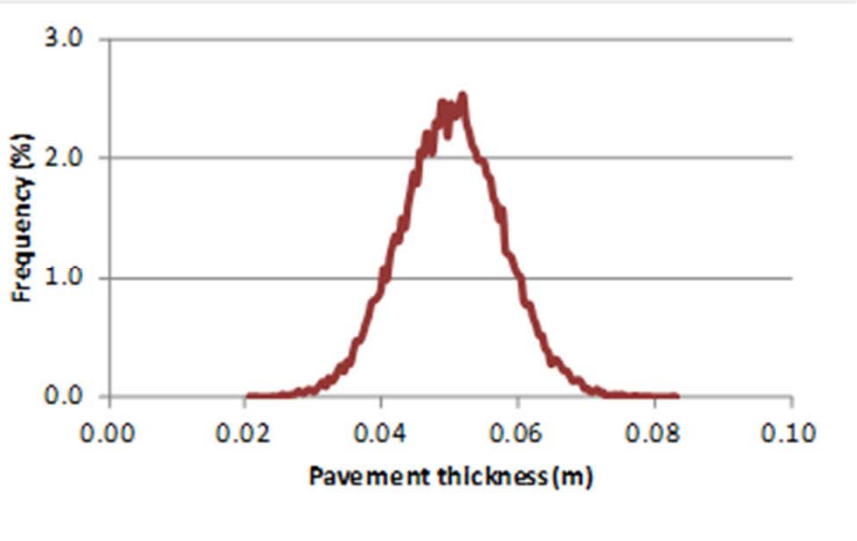
- Statistical distributions applied to key parameters
  - Compaction density <mean = 2300kg/m^3; CoV = 1.5%>
  - Asphalt depth <mean = 50 mm; CoV = 15%>
  - Leaching <11% CoV for PAH-L and PAH-M>
    <30% CoV for PAH-H>
    <30% CoV used for all RA mixes>
- Normal distributions used
  - Truncated to avoid negatives

Modelling Approach

Sample distributions employed



(a) Pavement density

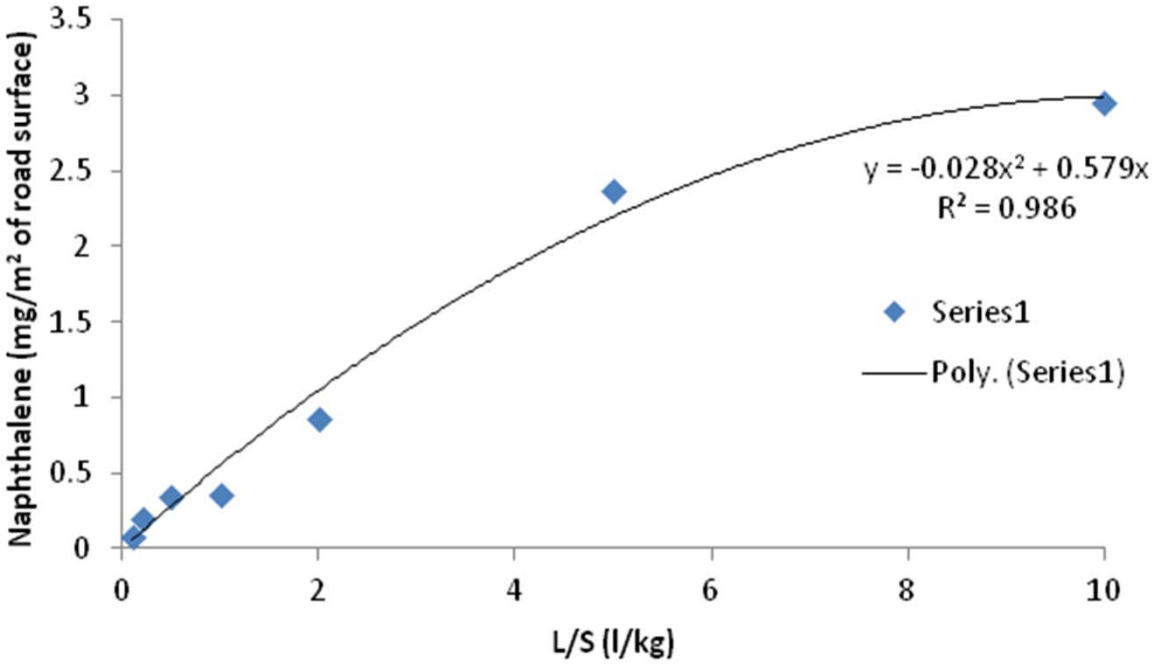


(b) Pavement thickness

Input Data

Leaching behaviour based on real test data:

- Percolation test
  - Characterises leaching behaviour over time (wrt to L/S ratio)
- Batch test
  - Quantifies total amount of contaminants available



Input Data

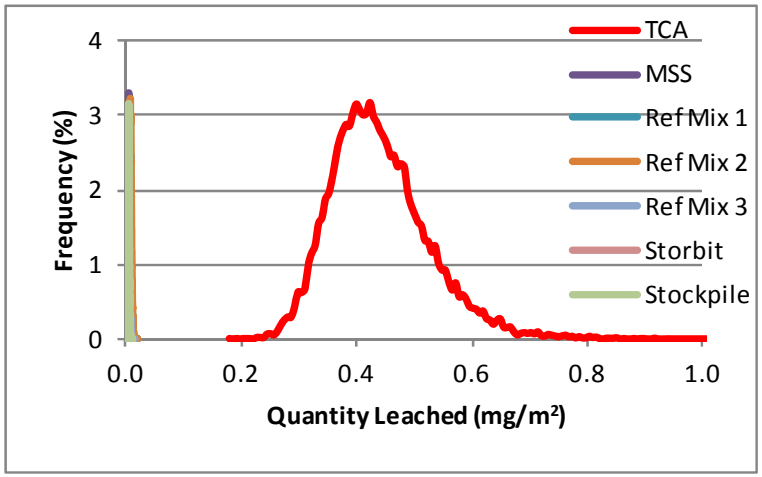
Other test parameters

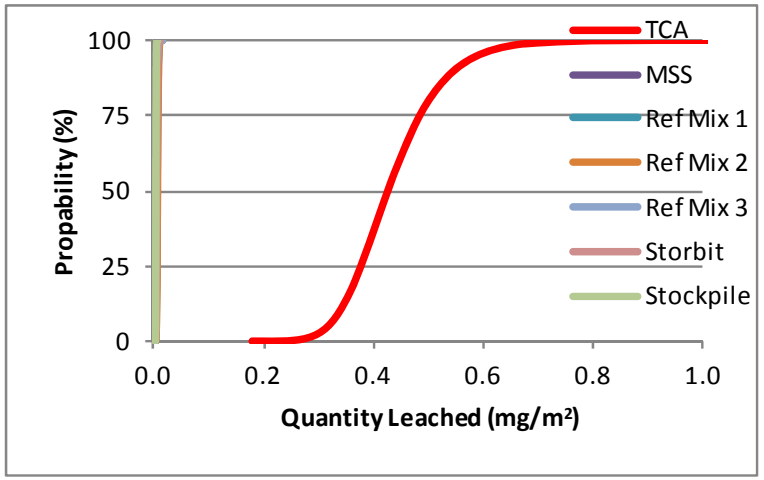
- Pavement subjected to rainfall events based on recorded data (Dublin airport)
- Results compared with groundwater limits
- Calculated for 7 materials
  - SMA mixture containing 0%, 15% and 30% RA
  - Mix containing 50% RA with a rejuvenator <Storbit>
  - Tar containing RA
  - Material from a mixed source stockpile
  - Material from stockpile experiment site

} Material contains no fresh binder – RA not encapsulated in 'new' bitumen

Model Output

Sample Results

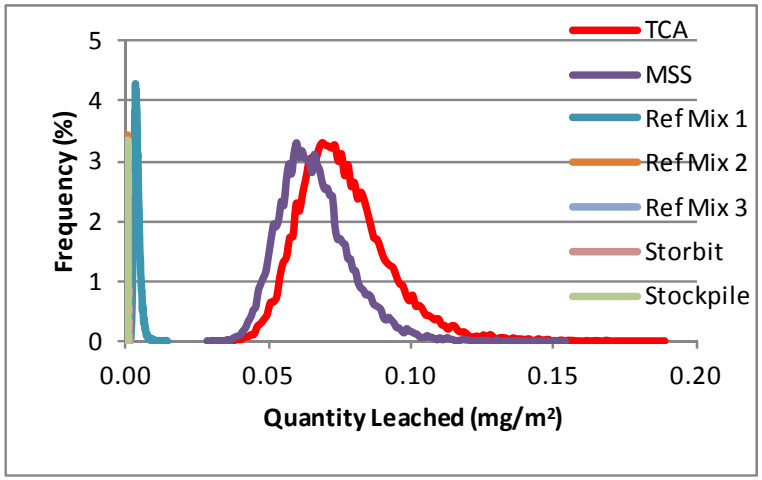


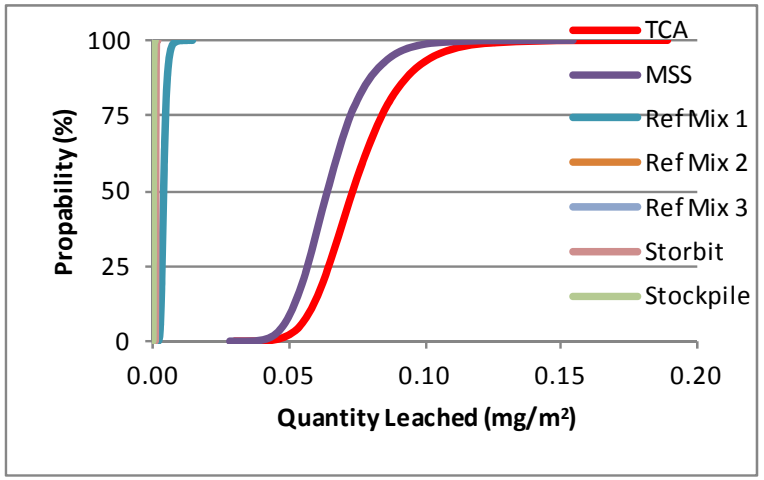


Distribution associated with Naphthalene leaching after 1 years rainfall (pdf and cdf)

Model Output

Sample Results

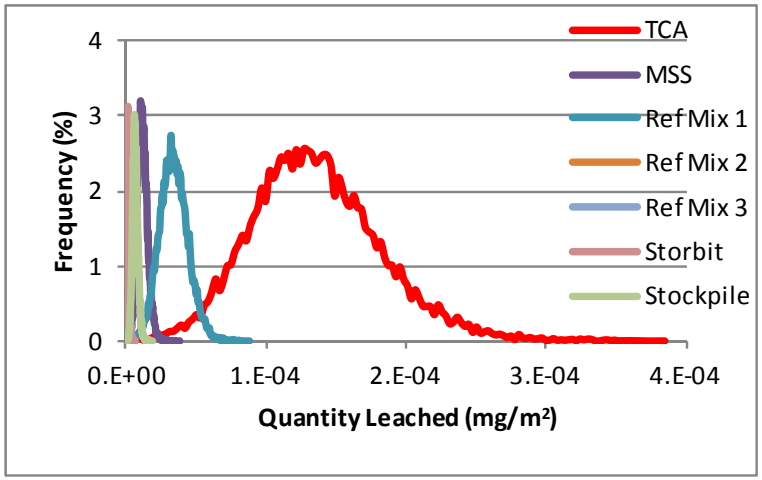


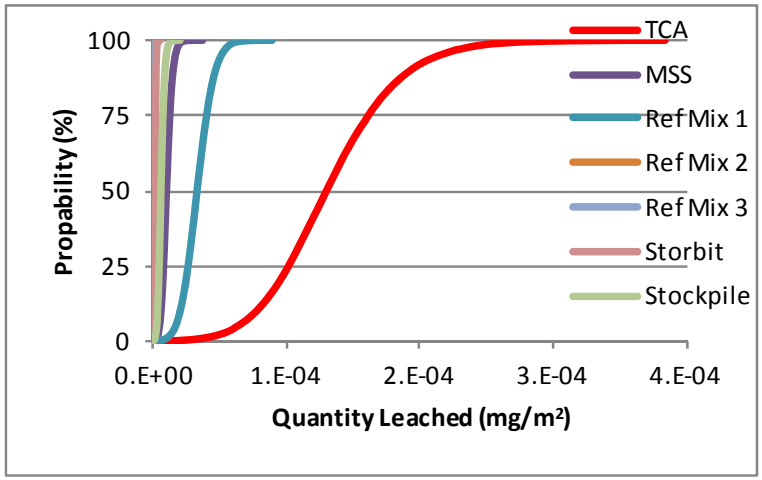


Distribution associated with Fluorene leaching after 1 years rainfall (pdf and cdf)

Model Output

Sample Results

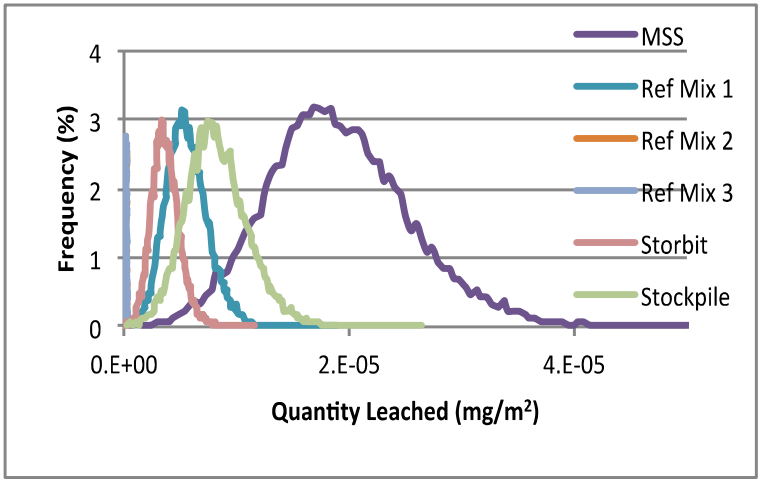


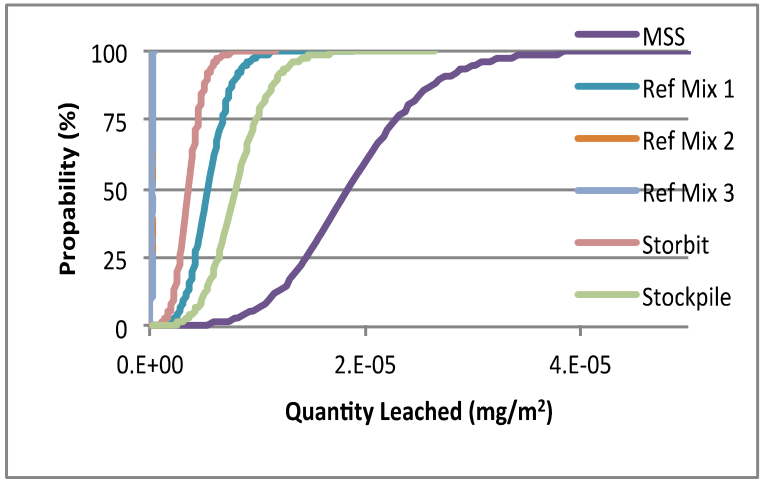


Distribution associated with Dibenz(a,h)anthracene leaching after 1 years rainfall (pdf and cdf)

Model Output

Sample Results





Distribution associated with Benz(a,h)anthracene leaching after 1 years rainfall (pdf and cdf) <excluding TCA>

Groundwater Limits

Comparison with 1 year leaching values

	PAH concentration (µg/l)			
Parameter	TCA	Ref Mix 3	Storbit	EPA Limit
Naphthalene	0.81	0.01	0.01	1.0
Fluoranthene	0.14	0.0003	0.0013	1.0
Benzo(b,k)fluoranthene	5.5E-4	1.6E-6	2.8E-6	0.5
Benzo(a)pyrene	4.7E-4	1.3E-6	2.8E-6	0.01
Indeno(1,2,3-cd)pyrene	3.4E-4	2.4E-6	3.1E-6	0.05
Benzo(g,h,i)perylene	3.4E-4	1.1E-5	2.1E-5	0.05

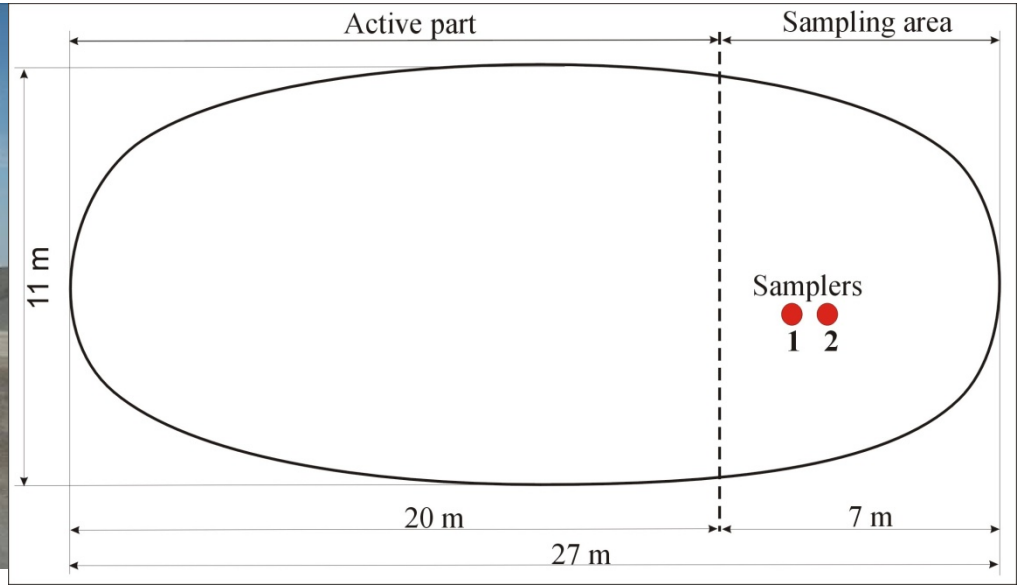
Runoff Comparison

Comparison with 1 year leaching values

	PAH concentration (µg/l)			
Parameter	TCA	Ref Mix 3	Storbit	Runoff (Crabtree et al)
Naphthalene	0.81	0.011	0.010	0.11
Fluorene	0.143	0.0003	0.001	0.03
Acenaphthene	0.115	0.0001	0.001	0.02
Acenaphthylene	0.071	0.0002	0.0005	0.02
Anthracene	0.025	0.0001	0.0004	0.05
Phenanthrene	0.228	0.0002	0.004	0.08
Fluoranthene	0.143	0.0003	0.001	0.16
Pyrene	0.012	0.0001	0.0003	0.16

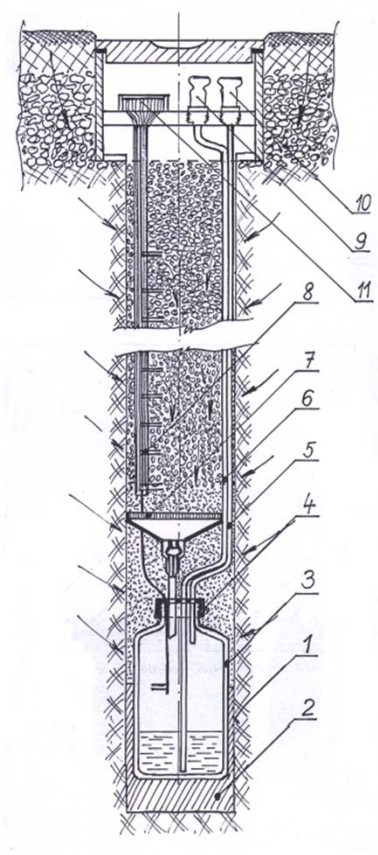
Field Validation

Stockpile Experiment



Field Validation

Water Sampling



Field Validation

Experimental parameters

- Two sampling periods
  - Each approximately 3 months
  - <288mm & 111mm rainfall respectively>
- Analysed for leaching and ecotoxicity effects
- Comparison with laboratory data
  - Differences between laboratory and field data

Field Validation

Comparison with EPA guideline values

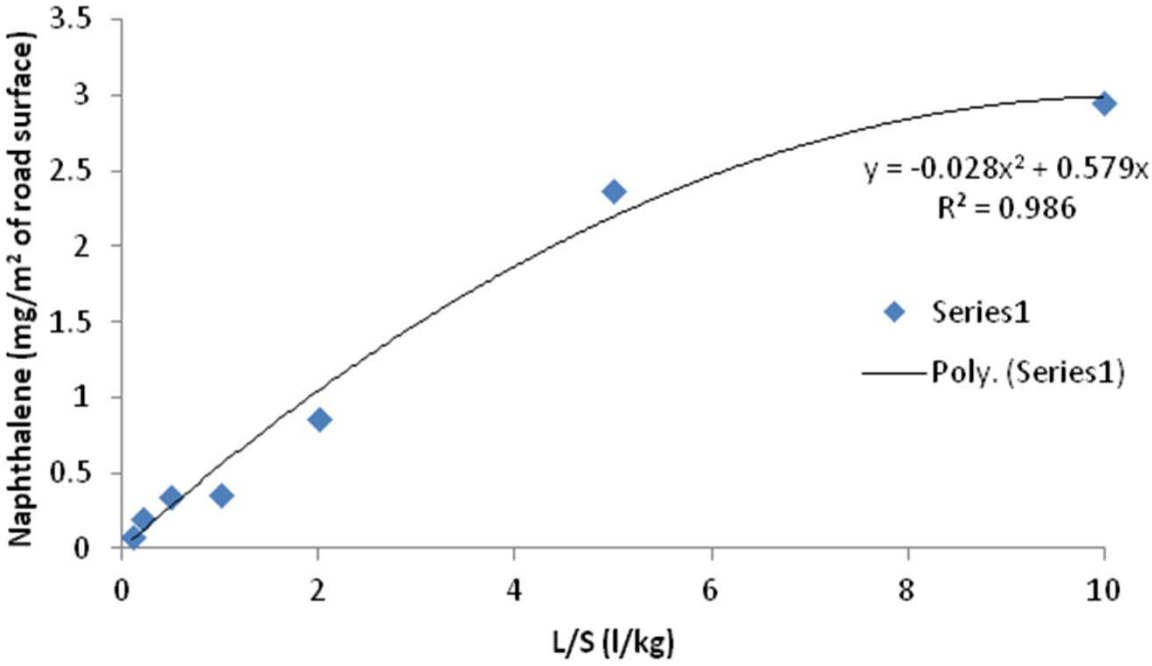
	PAH concentration (µg/l)		
Parameter	1st Sampling Period	2nd Sampling Period	EPA Limit
Naphthalene	0.32	0.13	1.0
Fluoranthene	3.32	0.22	1.0
Benzo(b,k)fluoranthene	1.38	0.58	0.5
Benzo(a)pyrene	0.30	0.29	0.01
Indeno(1,2,3-cd)pyrene	0.33	0.05	0.05
Benzo(g,h,i)perylene	0.64	0.10	0.05

Note: Small quantity of water leached

Field Validation

Outputs

- High concentration of PAH in seeping water
- Stockpile analysis: leaching associated with low L/S ratio
- Potential for more leaching to occur
- Concern over storage of unbound materials



Conclusions

Waterborne Emissions

- Potentially high leaching associated with RA in unbound state
  - Suggests that tar is not always detected
- Significantly reduced leaching observed where RA is used with fresh binder
  - Very little difference between samples containing 0%, 15% and 30% RA and Storbit (50% RA)
  - Leaching associated with mixtures containing RA was observed to be less than that associated with trafficking & subsequent washoff

Conclusions

Waterborne Emissions

- Behaviour changes with PAH
  - Need to consider all 16 PAHs as part of Risk Assessment
  - Need for test methods that better represent pavement materials

    <particle size inappropriate>

    <L/S ratio appropriate>
- Leaching of heavy metals from bound pavements less than that associated with trafficking effects
- Potential concern associated with storage of RA

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