Tracer test interpretation

Industry representatives:

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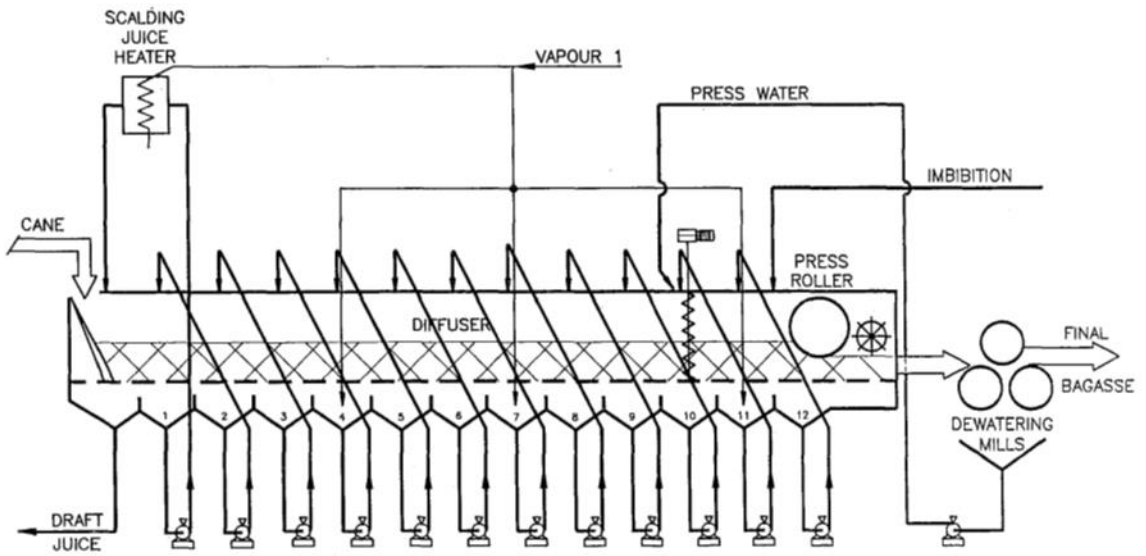
Objective

- Provide a robust method of interpreting tracer test data to guide the adjustment of diffuser sprays to provide optimum cane wetting conditions within a cane bed
  - ie. Use experimental data to determine the distance that sprays must be moved to improve operation
- **Preferably** use a spread sheet to implement method
- Test the validity of the target recycle value used (32%) (additional objective)

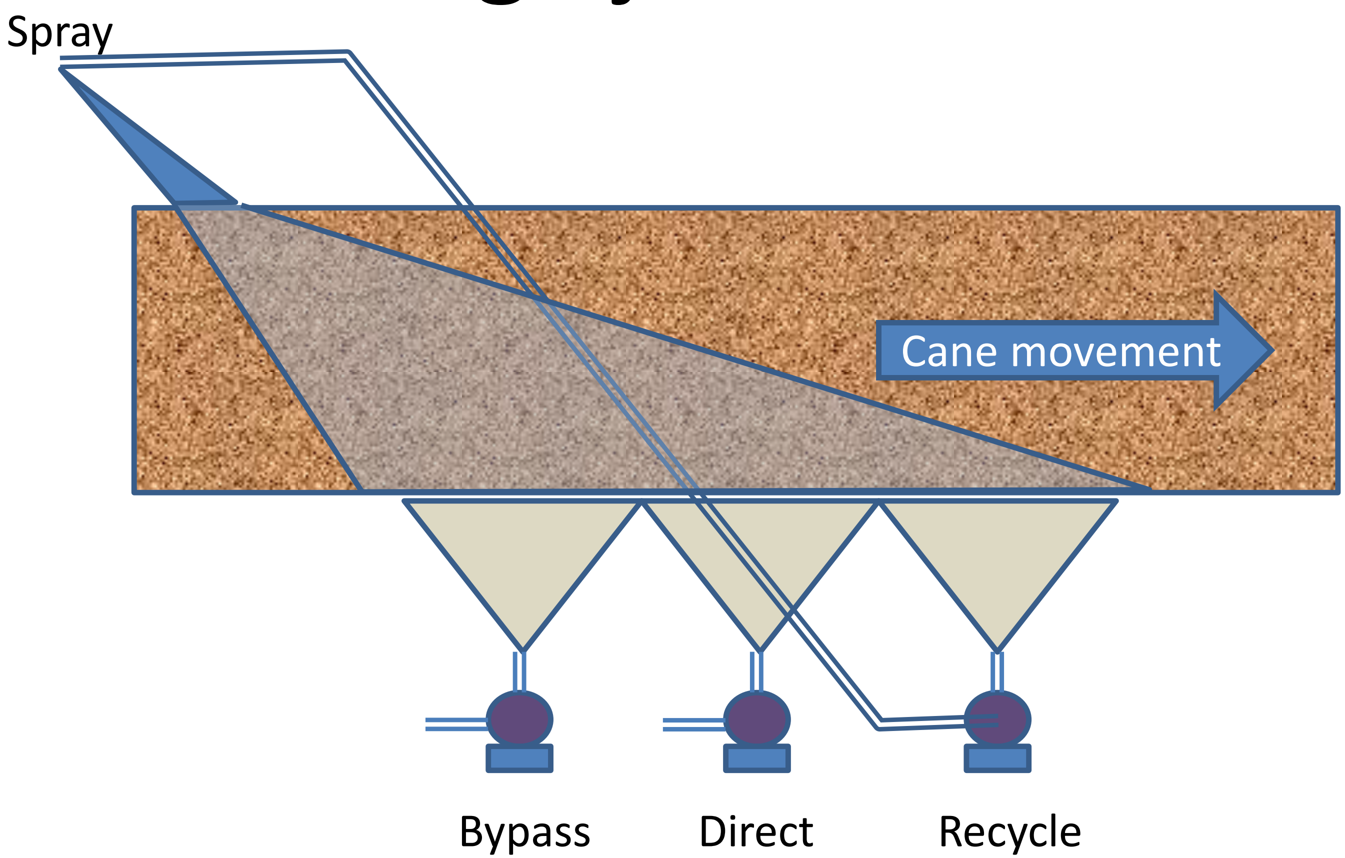
Counter current extraction



Rein 1995, SASTA

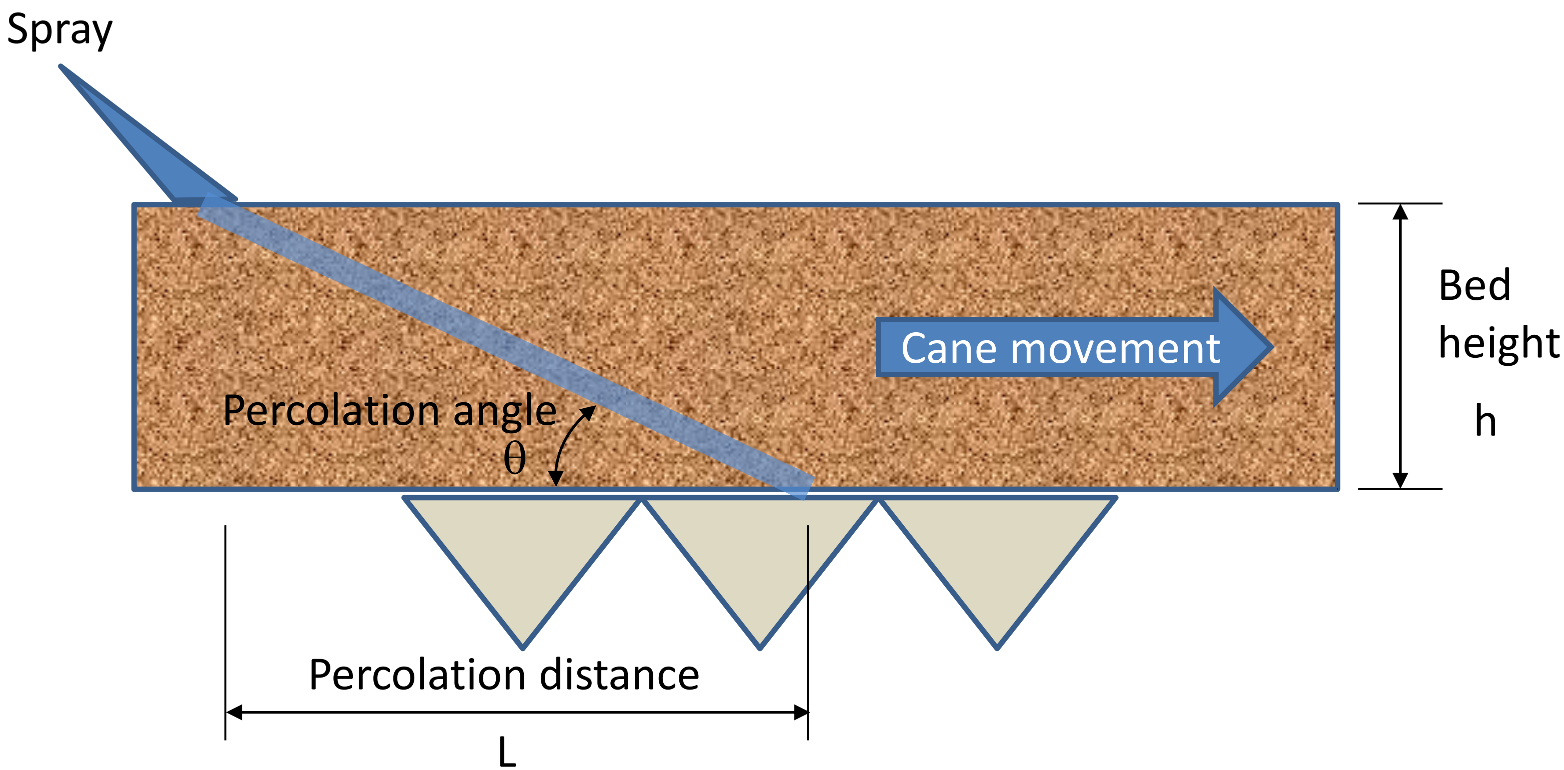
- Sucrose rich shredded cane enters at one end
- A conveyor move cane to other end of diffuser
- Water (imbibition) enters at other
- Water percolates through bed leaching sucrose
- Water is collected and pumped towards the cane entry end of the diffuser
- $\therefore$Cane moves in one direction and water in other direction achieving counter-current arrangement

Stage juice flows



- The intended collection tray is the direct tray
- Juice returning to the source tray is recycled
- Juice exiting past the direct tray bypasses the stage

Terms



Mean residence time $\bar{t}$

Percolation velocity $v = \frac{h}{\bar{t}}$

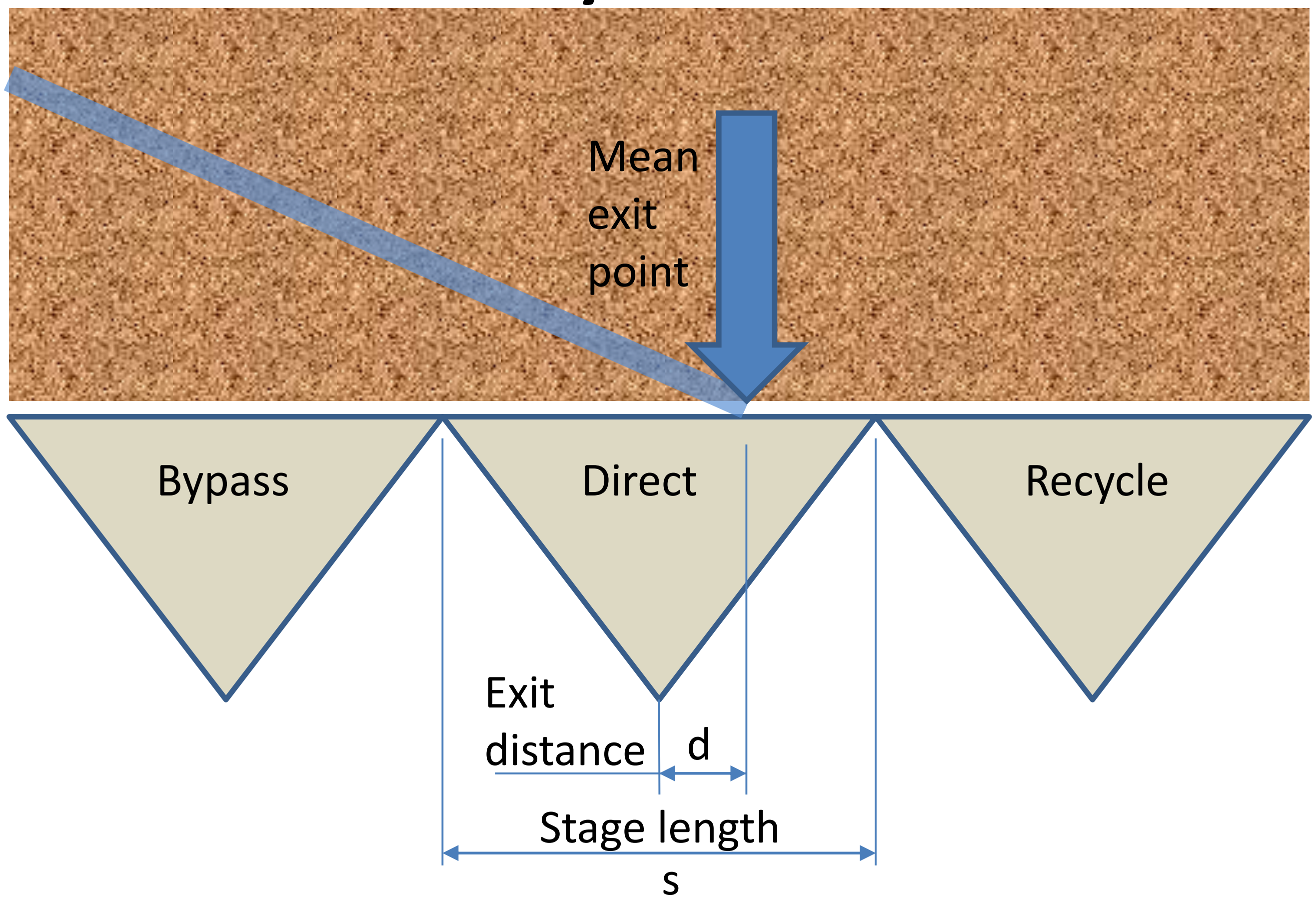
Percolation angle $\theta = \tan^{-1}\left(\frac{h}{L}\right)$

Chain speed $u = \frac{L}{\bar{t}}$

Required recycle

- Extraction require contact between juice flowing in bed and cane
- Bed needs to be nearly saturated for maximum extraction
- Imbibition flow rate insufficient to saturate bed
- Recycle required to increase amount of juice held in bed

Recycle



Recycle : $R = \frac{d}{\frac{1}{2}s}$

If exit point ahead of tray centre d<0
i.e. Bypassing

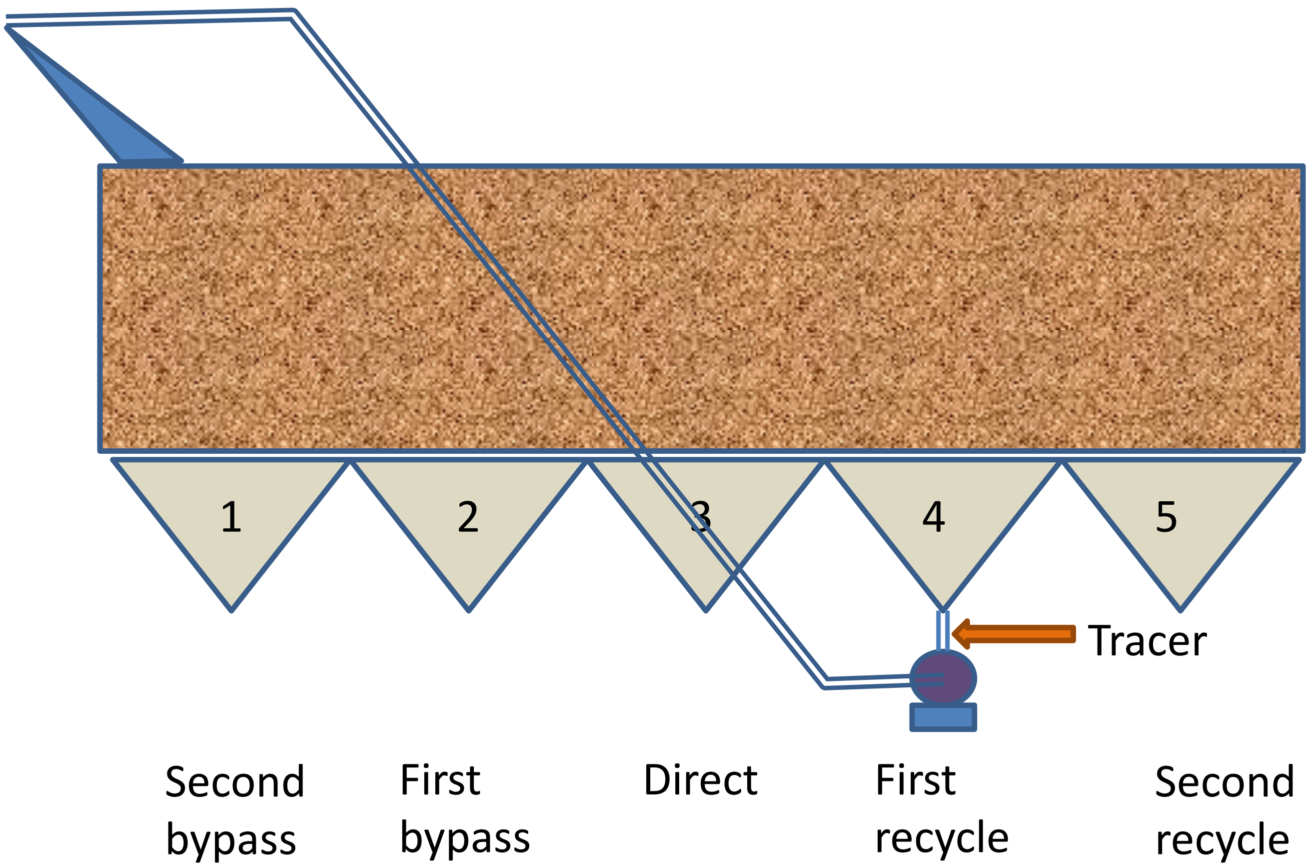
Tracer experiment

Stage pump

Diffuser

Cell and transmitter

Tracer experiment



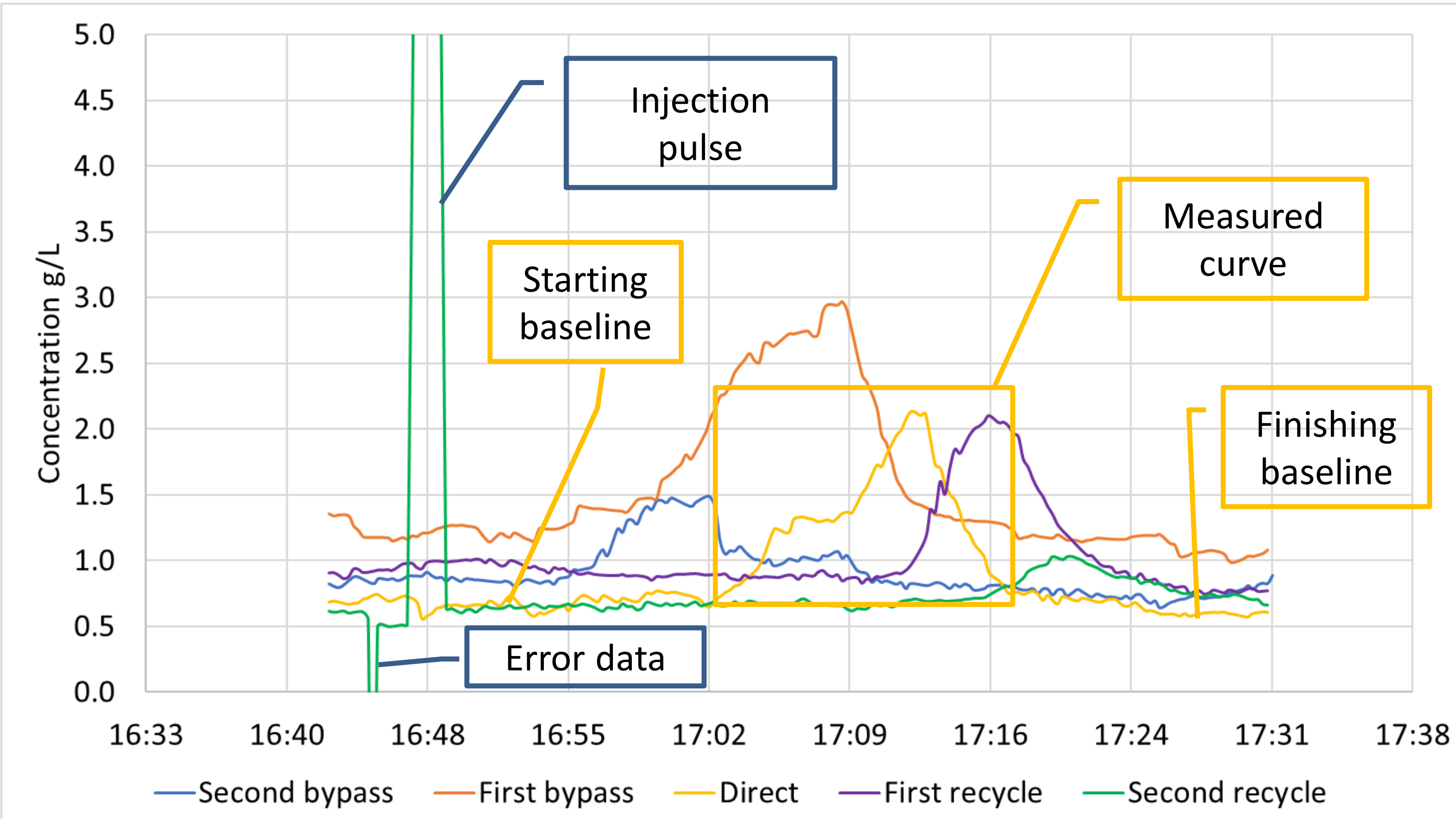
Tracer experiment

- Calibration – for each stage
  - Fill each cell with juice from relevant stage sample point
  - Measure conductivity
  - Add 1 gram/litre NaCl to juice from sample point
  - Measure conductivity
  - Gives 2 point calibration in gram/litre for each stage

Tracer experiment

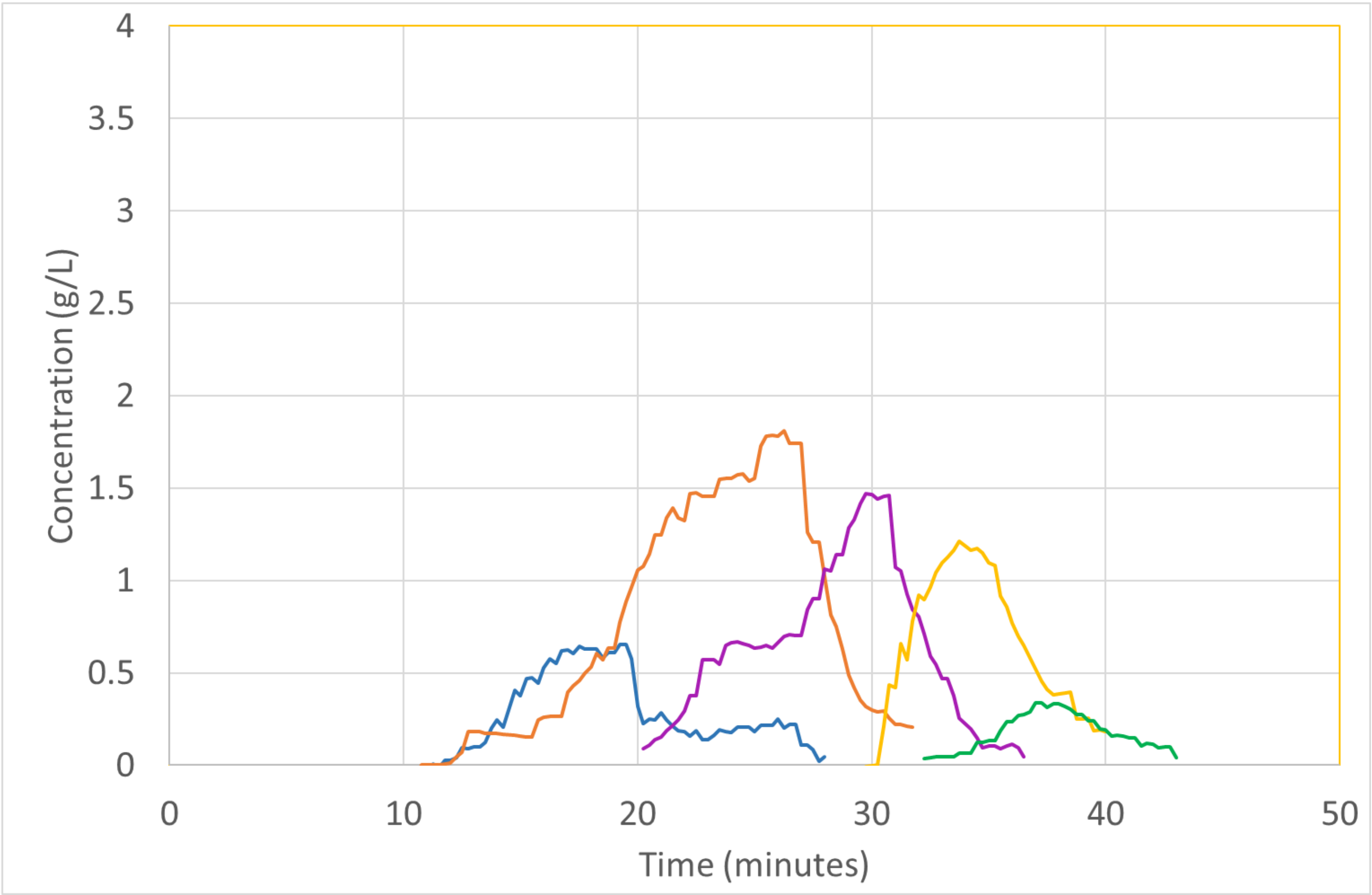
- Five tray data collection
  - Dissolve 50 kg NaCl in hot water/juice
  - Start data logging
  - Pump/gravity feed solution into suction side of stage pump
  - Wait till conductivities have returned to baseline levels
  - Stop logging

Data preparation



Data preparation

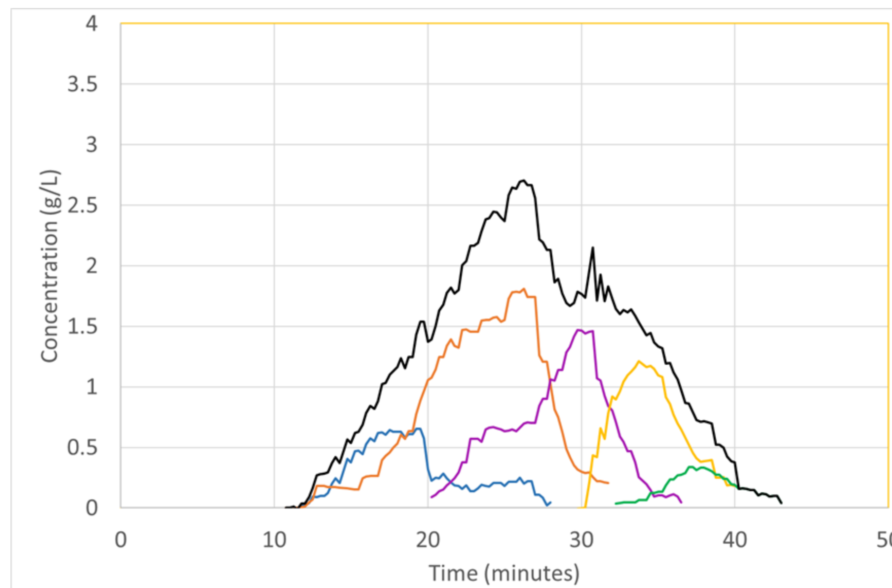
Processed curves



Result interpretation – Current methods

Mean residence time

- Method
  - Represent data as cumulative curve
  - Calculate mean residence time using area-moment approach
  - Calculate exit point and recycle

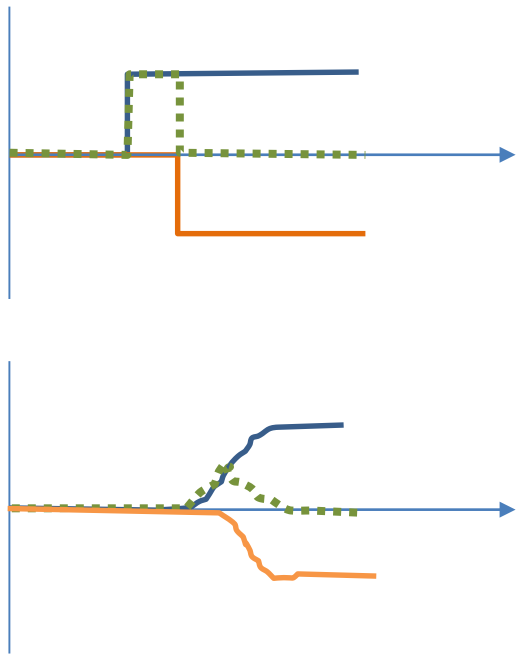


- Comments
  - Sensitive to determining injection point
  - Does not allow for long injection times
  - No noise removal
    - Background variation
    - Mixing
  - Ignores width of spray
  - Spatial information removed

Result interpretation – Current methods

Sum of positive and negative step responses

- Method
  - Approximate injection as sum of positive step and negative step
  - Fit step response model to data
  - Extract dispersion and percolation velocity from model
  - Estimate percolation distance and recycle



- Comments
  - Accommodates long pulses
  - Ignores width of spray
  - Spatial information removed
  - Require estimate of juice entry point

Result interpretation – Current methods

Dispersion model fitting (Love, 1980 ISSCT)

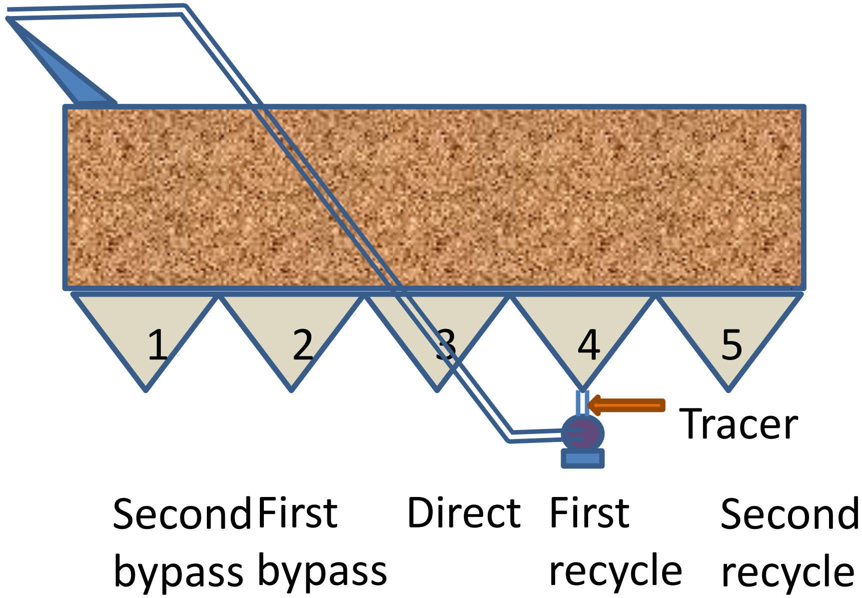
- Method
  - Fit dispersion model solution to data for each stage
  - Extract percolation velocity and dispersion coefficients from curve fit
- Comments
  - Curve fitting involve function which is an integral - complexity
  - Retains spatial information
  - Sometimes has large deviations from data especially when more than three stages used
  - Can be subject to local minima in curve fitting depending on minimisation parameters
  - Can require estimate of entry point
  - Includes spray width
  - Injection time can be accommodate to some extent

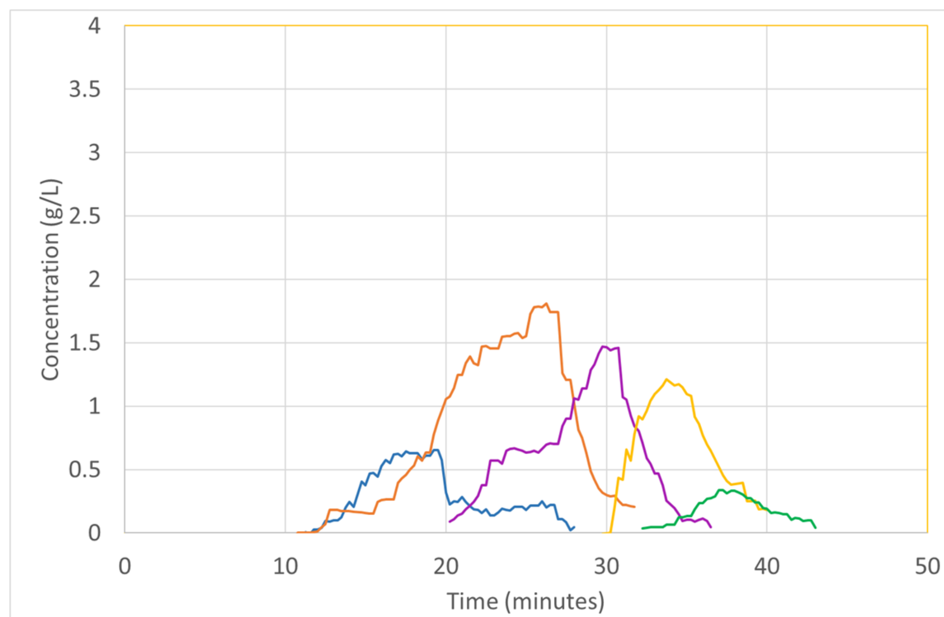
Ideal method

- Gives **change** in position of spray
  - Injection position not required
- Robust in terms of local minima and minimisation starting points

Additional question

- What should the target recycle be to give optimum (say 90%) wetting of the bed?
- Is the value of 32% valid?


1
2
3
4
5
Tracer
Second bypass
First bypass
Direct
First recycle
Second recycle


Concentration (g/L)
Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
10
20
30
40
50