



BBIFMAC EEIG Irrigation System Performance – Mackay Dec. 2014

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Irrigation systems dominant in this region

- Travelling gun – soft hose
- Travelling gun – hard hose
- Centre pivots
- Lateral moves
- Surface irrigation – lay-flat fluming
- Drip Systems

Uniformity



Even irrigation water application across the field

Non-uniformity causes yield variation and can lead to poor water use efficiency

Causes of non-uniformity :

Emitter/siphon/nozzle/gate spacing, pressure & configuration

Orifice size & selection misplacement

Nozzle height, angle & wear

Machine movement – travel direction non-uniformity

Flow rate variation from elevation change

Measuring Uniformity



Uniformity is measured by comparing the depth of water applied at various points within a field

Catch cans are used to get a sample for sprinklers

Simulation models of sprinkler patterns, nozzle / emitter / siphon /gate flowrates

Flowrate measurement – bucket & stopwatch comparisons

Testing standards (ISO & ASAE) available

Published Uniformities for CP & LM Machines



| Machine | Can line Spacing | Uniformity | Source |
|-----------------|--------------------------------|-------------|---------------------------------|
| Pivots (two) | Radial 10 ft spacing | 0.87 - 0.91 | Heermann & Hein (1968) |
| Pivots (two) | Radial 6 m | 0.90 - 0.94 | Rapp <i>et al.</i> (1979) |
| Lateral | Perpendicular to machine 0.3 m | 0.75 - 0.89 | Hanson & Wallender (1986) |
| Pivot | Perpendicular 0.3 m | 0.67 - 0.77 | " |
| Pivot | Radial 3 m | 0.77 | " |
| Lateral | Parallel 3 m | 0.73 | " |
| Lateral | 2 spans 0.6 m | 0.59 & 0.76 | " |
| Short Lateral | Field grid | 0.96 | John <i>et al.</i> (1986) |
| Pivots (six) | Radial 5 m | 0.54 - 0.88 | Thooyamani & Norum (1987) |
| Pivots (eight) | Radial 5 m | 0.82 - 0.88 | Thooyamani <i>et al.</i> (1987) |
| | Perpendicular 0.3 m | 0.81 - 0.94 | " |
| Lateral 4 spans | Parallel & perpendicular | 0.94 (mean) | Hills <i>et al.</i> (1988) |
| Short lateral | Parallel 3.6 m | ??? | Bell (1991) |
| Pivots (sixty) | Radial 9.1 m | 0.51 - 0.93 | Heermann <i>et al.</i> (1992) |

Travelling Gun Trial Results

- Uniformity values over 22 trials between 48.5% and 84.5% (Gordon et al. '02)
- Excessive lane spacings common
- Need to use taper nozzles to improve uniformity
- Travel speed variation was lowering uniformity

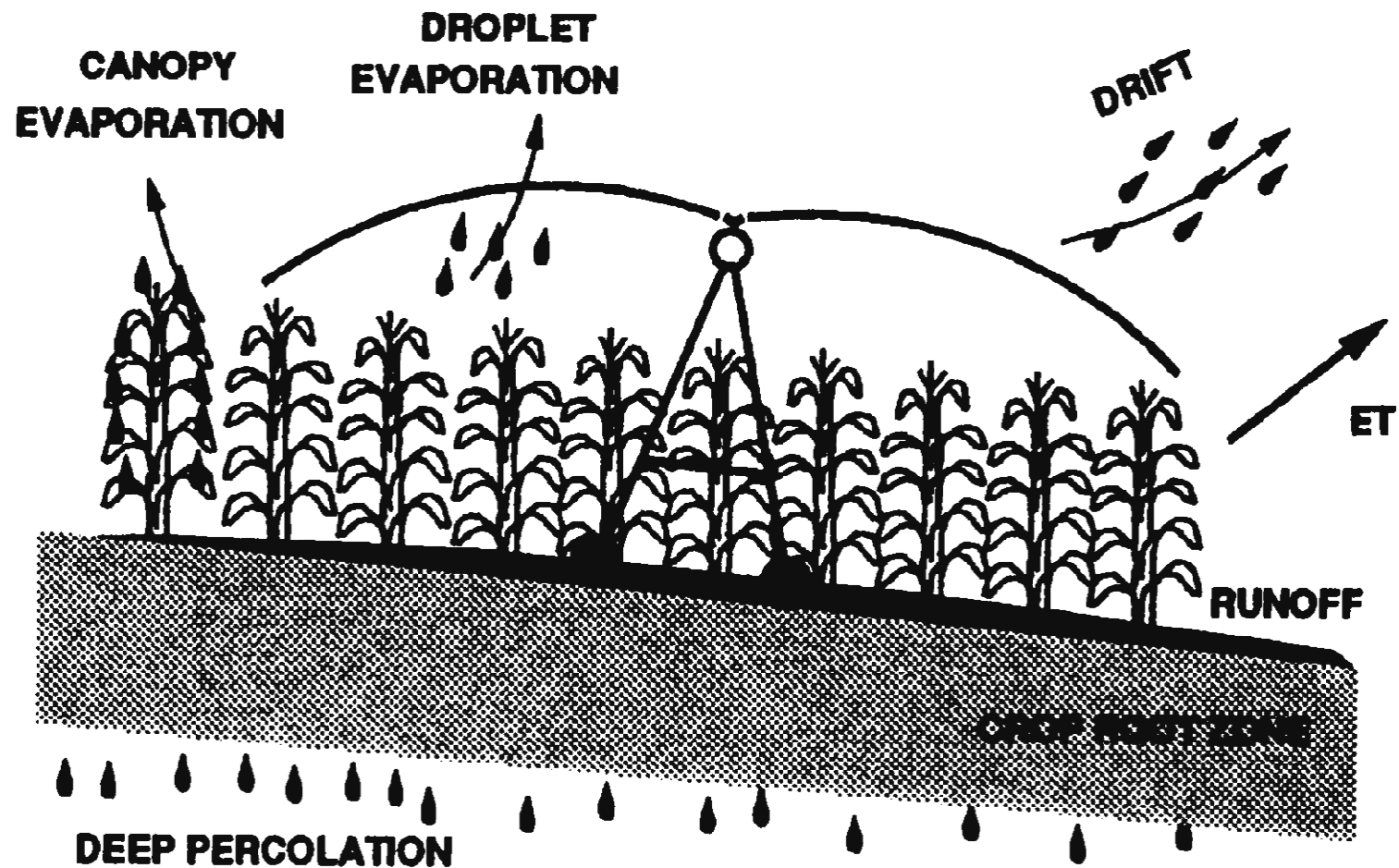
Application Efficiency



At the field scale:

$$\text{Application Efficiency (\%)} = \frac{\text{Volume added to soil moisture store}}{\text{Volume applied to field}} \times 100$$

Application Efficiency



Application Efficiency



- Thompson et al (1997) in TASA 40:(1)
- Full Energy balance of LM irrig field
- Included lysimeters, micromet., sap flow
- Wind speeds from 4 to 8.5 m/s
- Dry Bulb temp. from 16 to 32 °C
- Solar radiation up to 1000 W/m²
- Droplet evap was 0.05 mm in a 25 mm

Published application efficiencies



| Method | Efficiency (%) | Info Source | Comment |
|-----------|----------------|------------------------------|--|
| Bay | 80-90 | Bartells (1979) | Individual irrigations - expt'l bays |
| Bay | 67-84 | Jones (1980) | Irrigation research farm - 3 seasons |
| Furrow | 74-89 | Yule (1984) | Whole season – experimental plots |
| Furrow | 30-50 | Cull <i>et al.</i> (1981) | Single farm - 3 seasons |
| Furrow | 74 | Cull <i>et al.</i> (1984) | Single farm – neutron probe scheduling |
| Furrow | 39-81 | Cock <i>et al.</i> (1986) | Six farms – management not specified |
| Furrow | 14-90 | Raine and Bakker (1996) | Numerous - farmer managed (sugar) |
| Furrow | 17-100 | Smith <i>et al.</i> (2005) | Numerous - farmer managed (cotton) |
| Sprinkler | 39-70 | Cock <i>et al.</i> (1986) | Nine farms – management not specified |
| Sprinkler | 65 | Bell (1991) | Travelling irrigator (1) |
| Sprinkler | 80 | Bell (1991) | Short boom machine (1) |
| Drip | 94 | Cock <i>et al.</i> (1986) | Single farm – management not specified |
| Drip | 30 - 90 | Shannon <i>et al.</i> (1996) | Commercial sugar farms in Bundaberg area |

Application Efficiency & Uniformity



| Trial No. | Nozzle | Gun Pressure (kPa) | Wind Speed (km/h) | Wind Direction | Mean applied depth (mm) <i>flowmeter</i> | Mean applied depth (mm) <i>catch cans</i> | CU (%) 75 m lane spacing | Optimum lane spacing (m) | Application Efficiency |
|-----------|--------|--------------------|-------------------|----------------|--|---|--------------------------|--------------------------|------------------------|
| 1 | 1.2T | 550 | 7.1 | parallel | 60 | 47.3 | 84.2 | 65 | 79% |
| 2 | 1.2T | 550 | 14.3 | cross | 60 | 41.8 | 79.6 | 75 | 70% |
| 3 | 1.2T | 515 | 3.8 | cross | 60 | 35.1 | 77.8 | 85 | 58% |
| 4 | 1.2T | 585 | 15.1 | parallel | 64.8 | 40.7 | 73.1 | 65 | 63% |
| 5 | 1.46R | 550 | 14.1 | parallel | 60 | 38.1 | 48.3 | 55 | 72% |
| 7 | 1.46R | 515 | 12.4 | parallel | 60 | 42.6 | 56.5 | 55 | 71% |
| 8 | 1.46R | 585 | 14.9 | parallel | 68.64 | 54.2 | 69.6 | 65 | 79% |
| 9 | 1.3T | 515 | 4.5 | cross | 68.64 | 59.5 | 80.5 | 55 | 87% |
| 10 | 1.3T | 550 | 8.9 | cross | 70.56 | 47.7 | 84.5 | 75 | 68% |
| 11 | 1.56R | 585 | 9.3 | cross | 72.72 | 54 | 77.2 | 65 | 74% |
| 12 | 1.3T | 550 | 11.6 | cross | 70.56 | 52.9 | 78.6 | 55 | 75% |
| 13 | 1.3T | 515 | 10.6 | parallel | 68.64 | 58.6 | 83.5 | 65 | 85% |
| 14 | 1.2T | 550 | 12.3 | parallel | 60 | 52.7 | 79.1 | 65 | 88% |
| 16 | 1.46R | 550 | 13.8 | parallel | 64.8 | 44.5 | 60.9 | 65 | 80% |
| 17 | 1.2T | 585 | 17 | parallel | 63.12 | 40 | 48.8 | 55 | 68% |
| 18 | 1.2T | 515 | 13 | cross | 58.56 | 32.4 | 67.1 | 55 | 55% |
| 19 | 1.46R | 515 | 14.5 | cross | 61.44 | 37.3 | 66.8 | 55 | 61% |
| 20 | 1.46R | 550 | 13.3 | cross | 64.8 | 49 | 80 | 85 | 76% |
| 21 | 1.46R | 585 | 22.2 | cross | 64.8 | 46.5 | 70.8 | 65 | 72% |
| 22 | 1.2T | 515 | 13.3 | parallel | 57.12 | 54 | 72.3 | 65 | 95% |

Travelling Gun System Characteristics



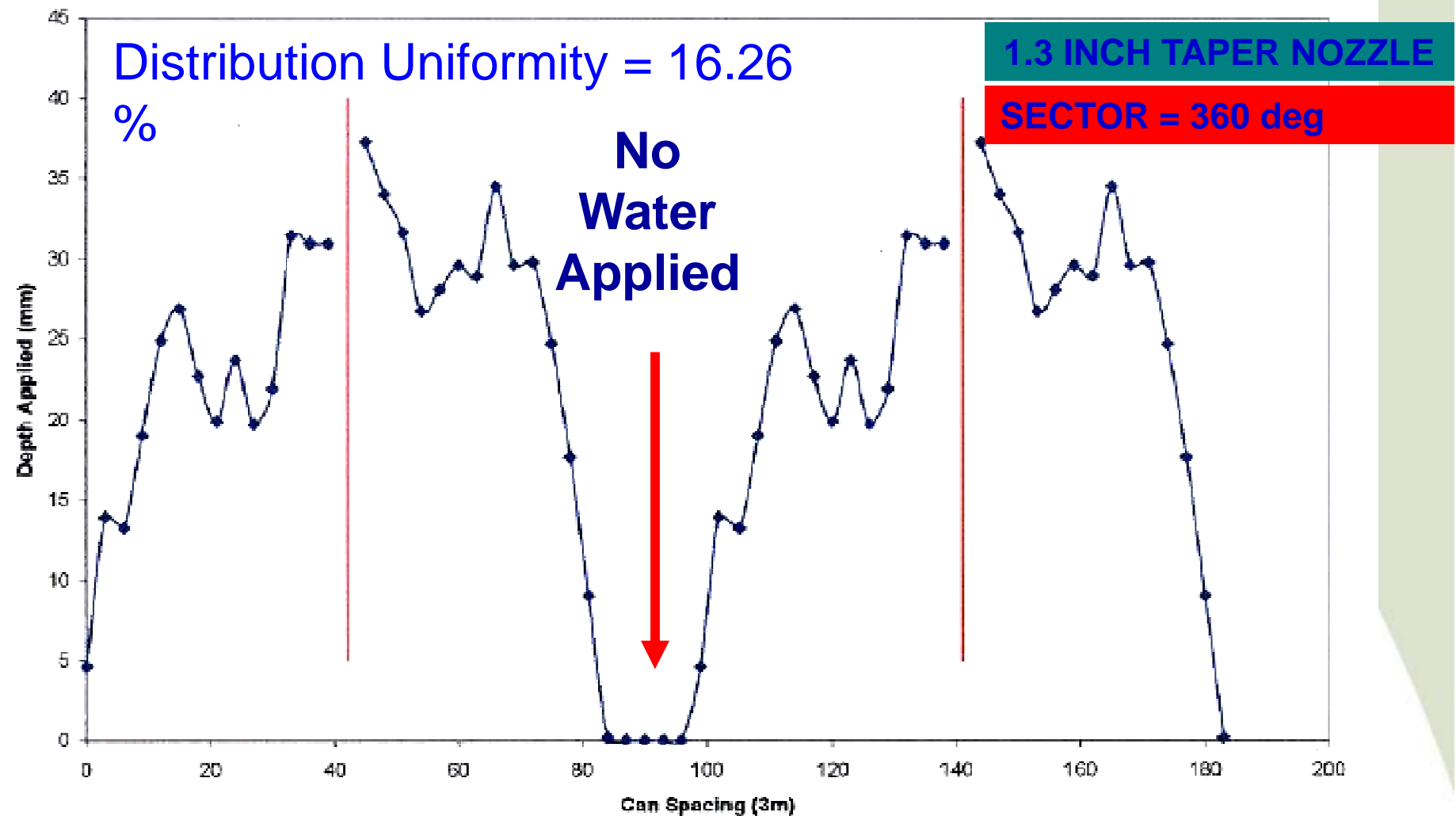
- High pump pressures (up to 90 m head)
- Reasonable pipeline flowrates depending on design
- Comparatively well understood
- Comparatively inexpensive capital costs
- Low average application rates
- High instantaneous application rates
- Wind control over water applied is ????

Excessive Lane Spacing Issue



SOUTHERN CROSS (WITH NELSON P200T GUN)

LANE SPACING = 100 metres



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TRAVGUN V2.3

Travelling Gun Simulation Model

Copyright 2007

Based on the original Travgun
simulation model by Geoff Newell

Theory by Geoff Newell, Rod Smith
and Joseph Foley.

Developed by Malcolm Gillies

gilliesm@usq.edu.au



A computer simulation model for the design of travelling gun irrigation
systems

It includes the calibration of the zero wind profile, wind coefficients and
simulation of the specified layout to determine the application
distribution under measured wind speeds and directions

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National Centre for Engineering in Agriculture (NCEA)
University of Southern Queensland (USQ)



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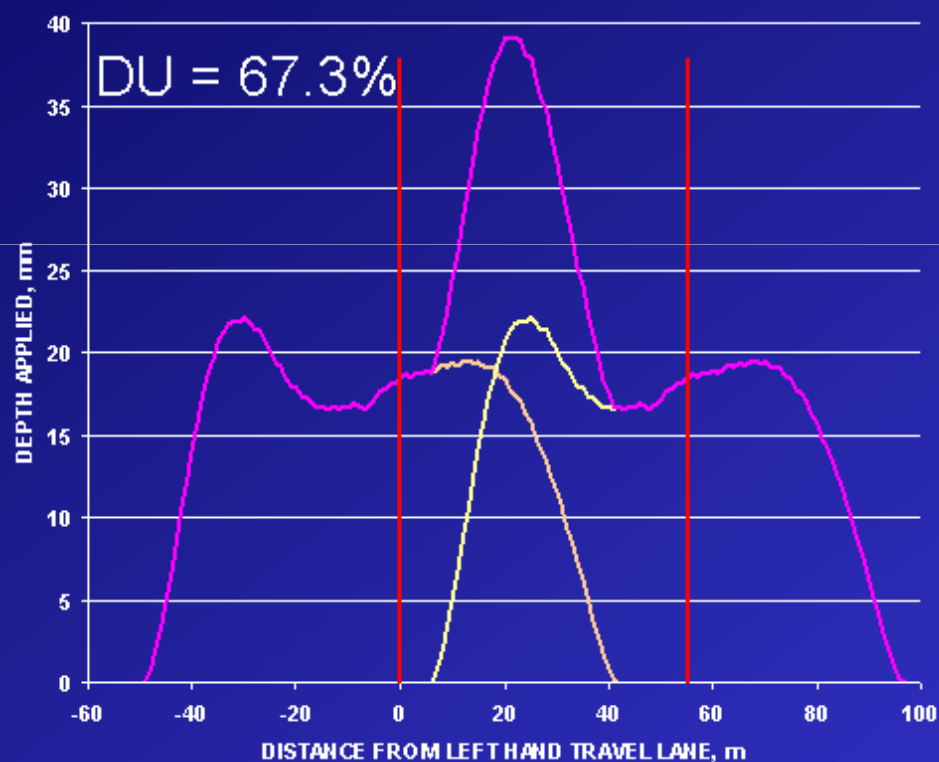
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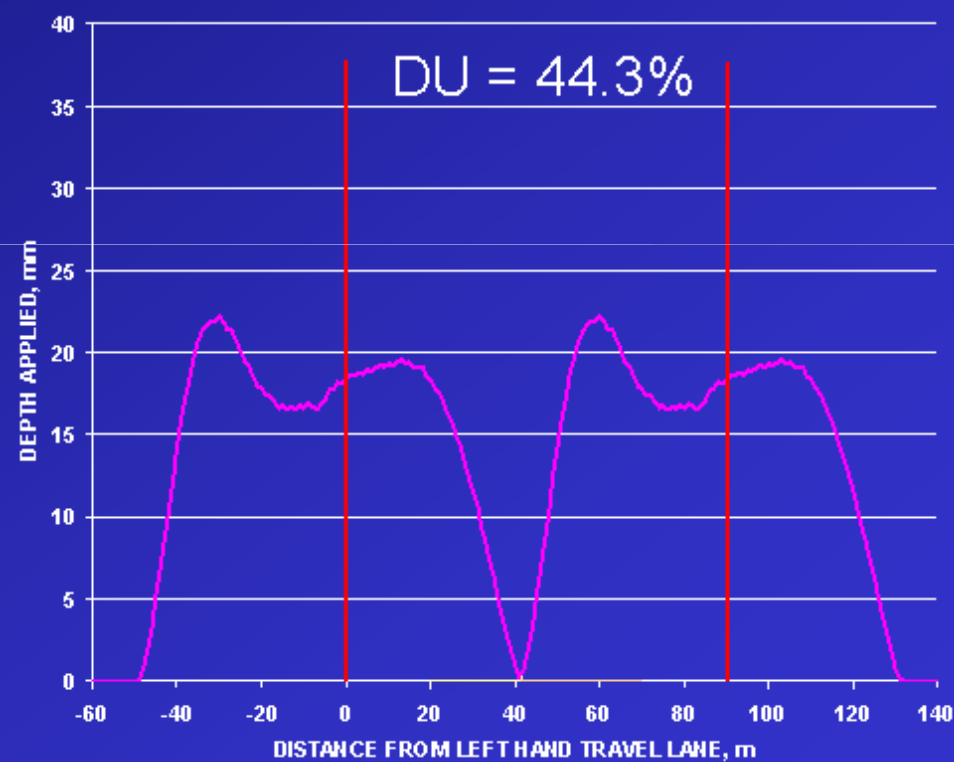
Lane Spacing Problems

Sector Angle = 240° ; Wind Speed = 10 km/h; Wind Direction = 45° from travel direction

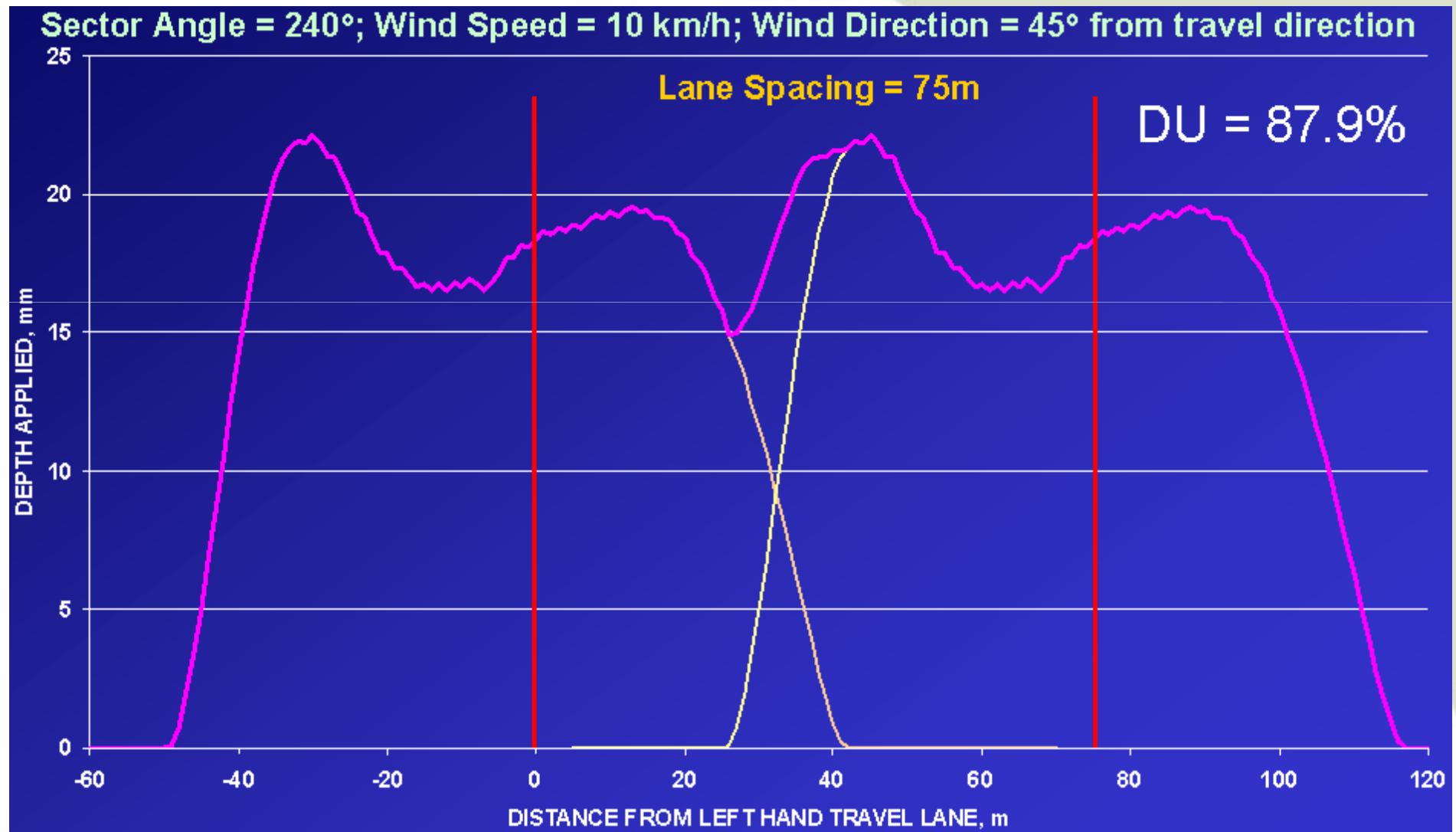
Lane Spacing = 55m



Lane Spacing = 90m



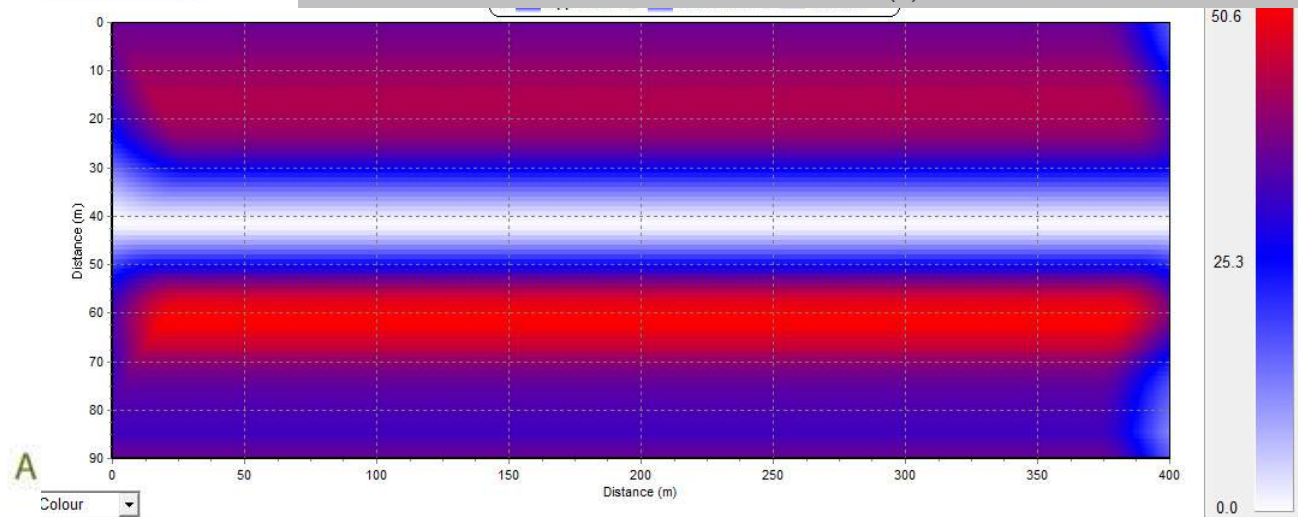
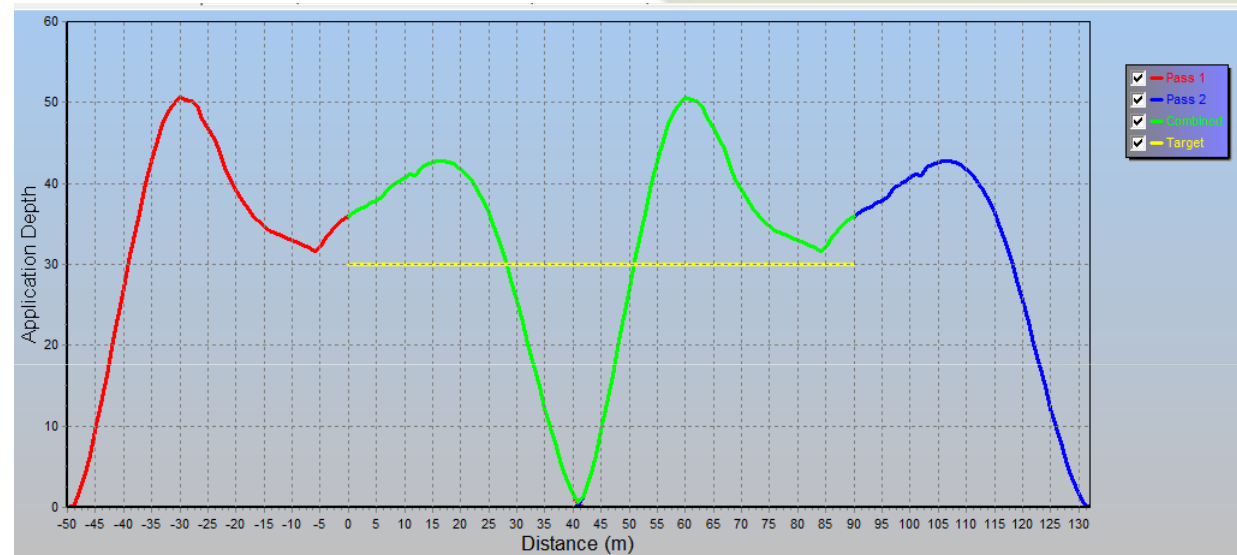
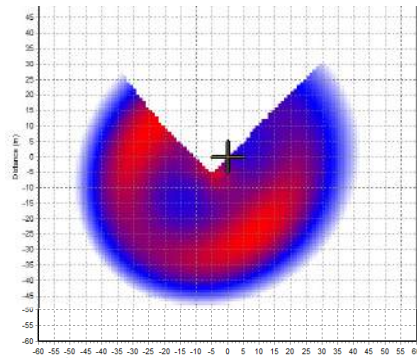
Lane Spacing Adjustment



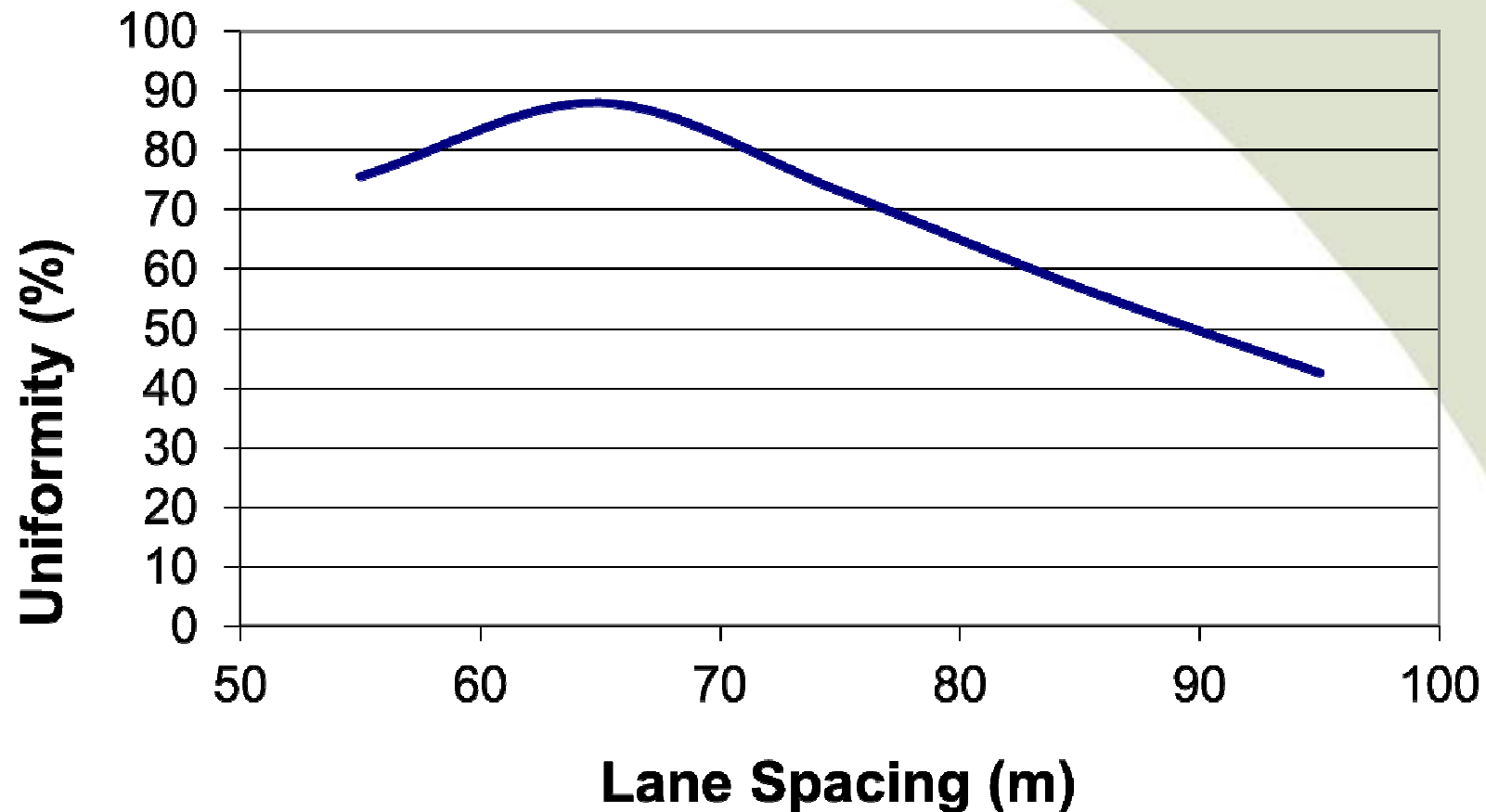
Travelling Gun Example



- Gun operated at 90m lane spacing with wind



Adjusting your Lane Spacing



Lane spacing guidelines

| Wind Speed (m/s) | Lane Spacing (% of wetted dia.) |
|------------------|------------------------------------|
| 0 | 80 |
| < 2.2 | 70 |
| 2.2 to 4.4 | 60 |
| > 4.4 | 50 |

Centre Pivot Machines



of Southern

Lateral Move Machines



Machine Dimensions

- Centre Pivots are usually $\leq 500\text{m}$ long
 - Most commonly in US around 400m
- Lateral Moves are uncommon overseas but when used are usually $\leq 500\text{m}$ long
- Lateral Moves in the Australian cotton industry commonly 800 to 1000 m long
- Manufacturers are reluctant to extend machines past the 800 metre length.

CPs in the Sugar Industry

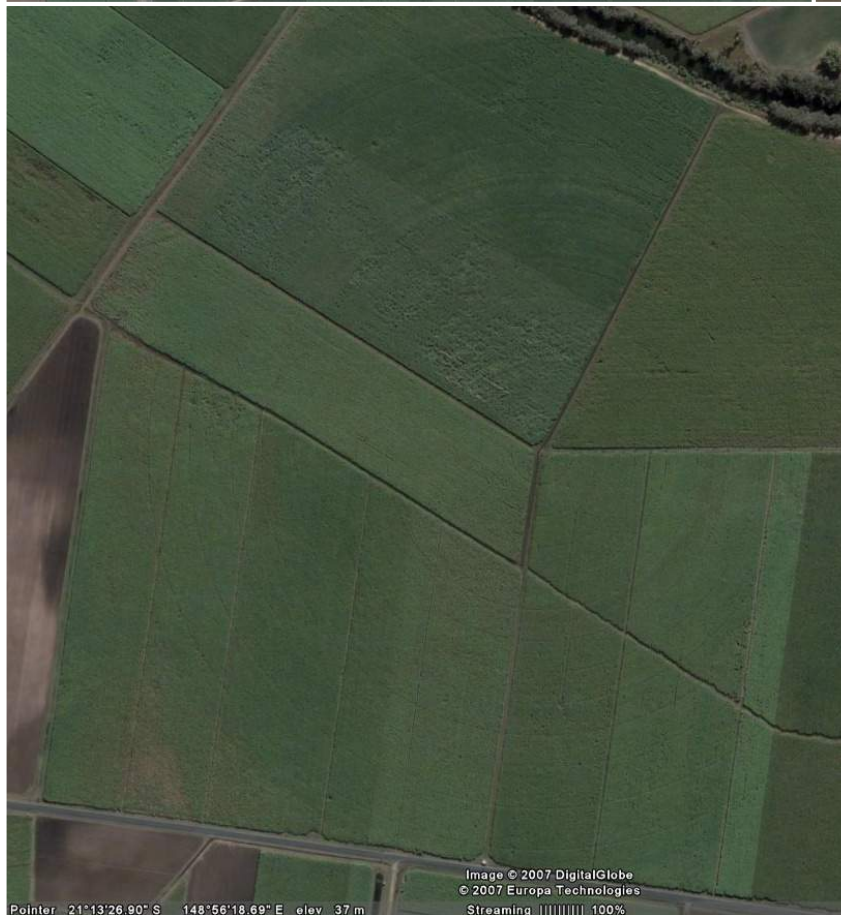


Image © 2007 DigitalGlobe
© 2007 Europa Technologies
Streaming 100%

Pointer 21°13'26.90" S 148°56'18.69" E elev 37 m



Image © 2007 DigitalGlobe
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Pointer 21°12'16.26" S 148°56'56.53" E elev 38 m

Google™

Eye alt 1.92 km

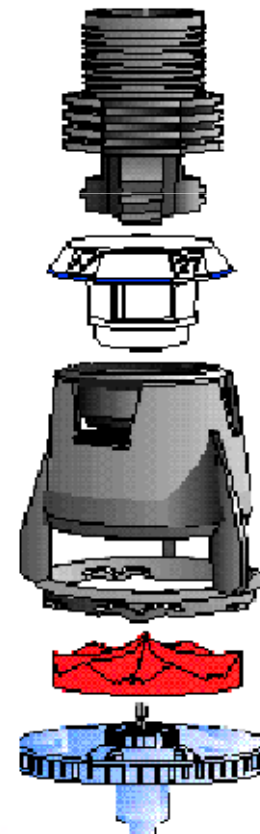
Sprinklers for centre pivot and lateral move machines



Static Plate



Moving Plate



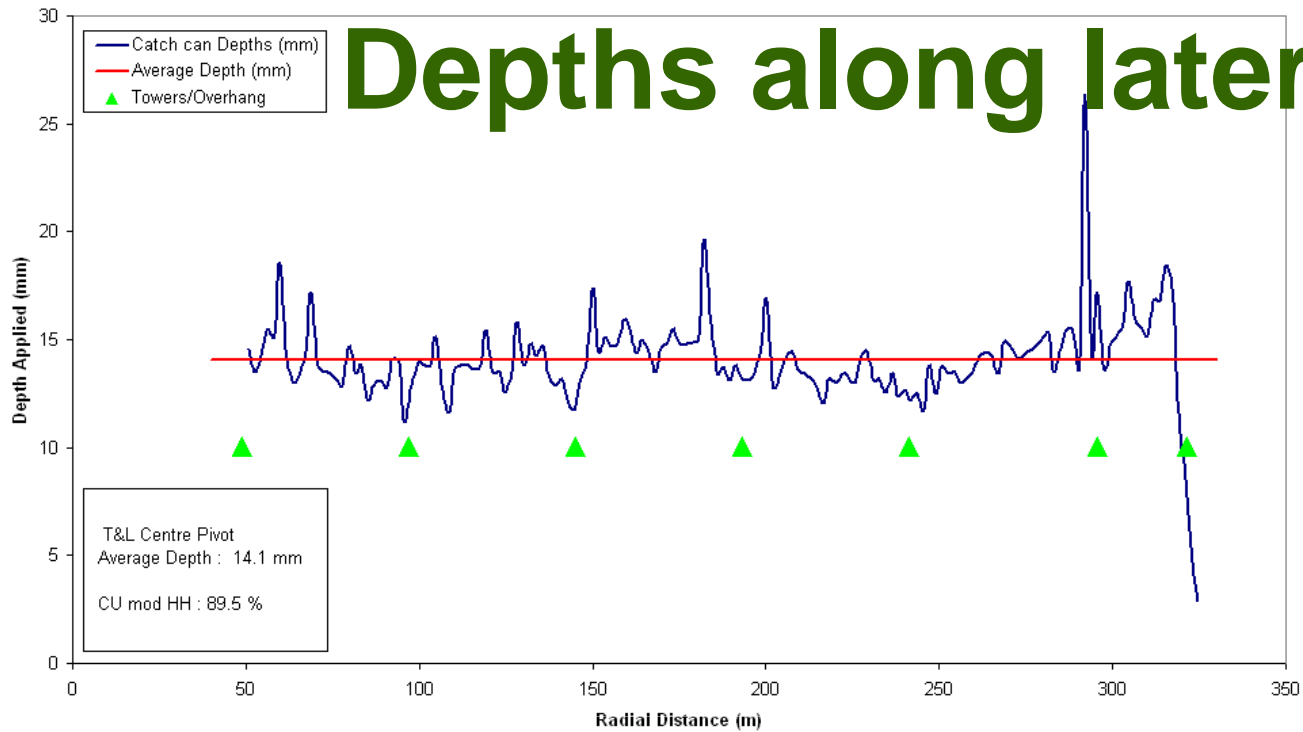
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System Characteristics of CP&LMs

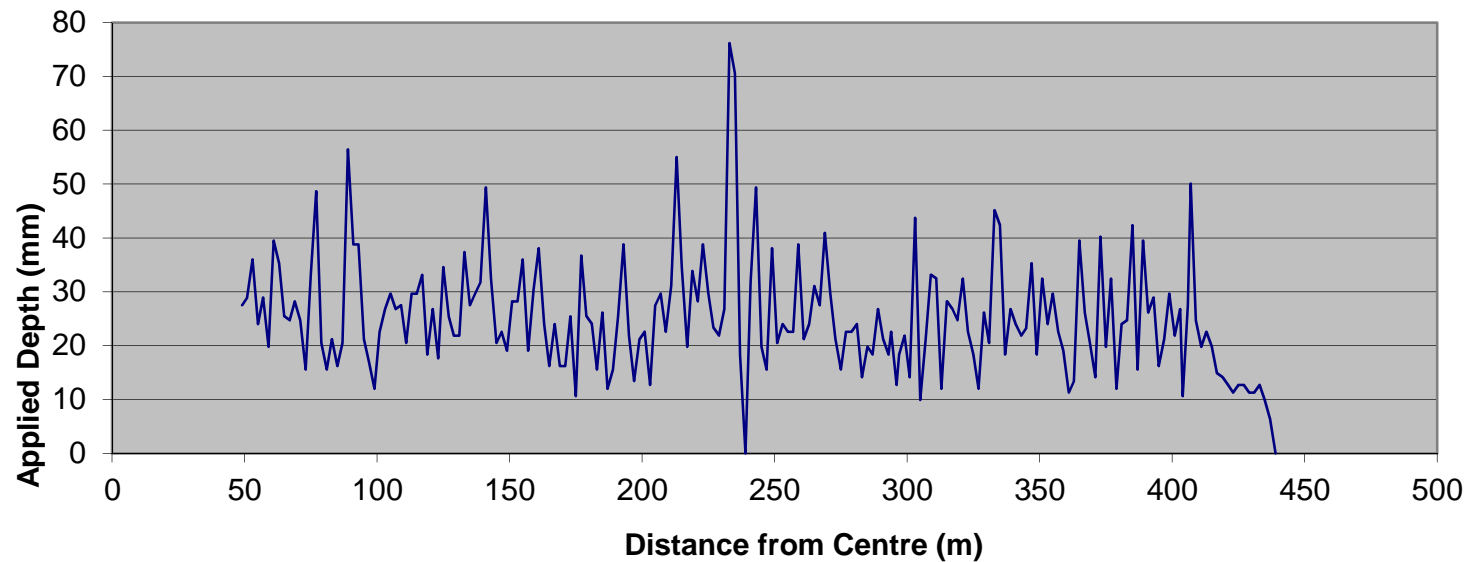


- Low operating pressures
- Very high pipeline flowrates
- Closely spaced nozzles
- High application rates
- High degree of control over water applied – semi-automated
- Higher capital costs, lower op. costs

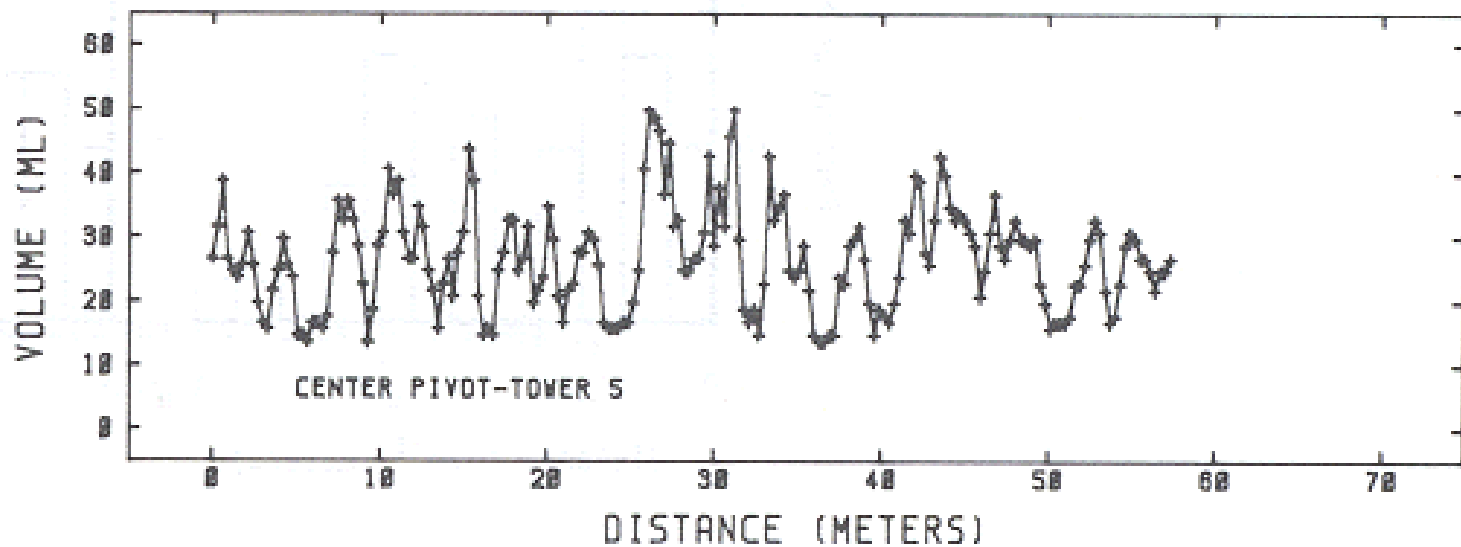
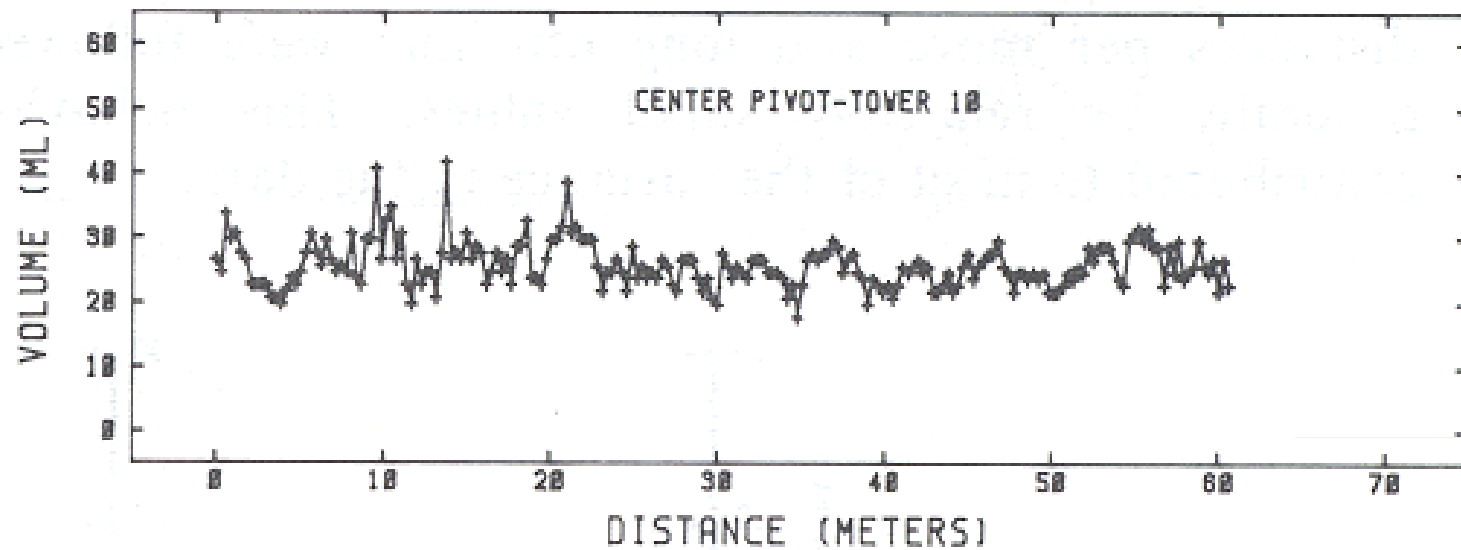
Depths along lateral



Evaluation of Centre Pivot



Depths in direction of travel





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