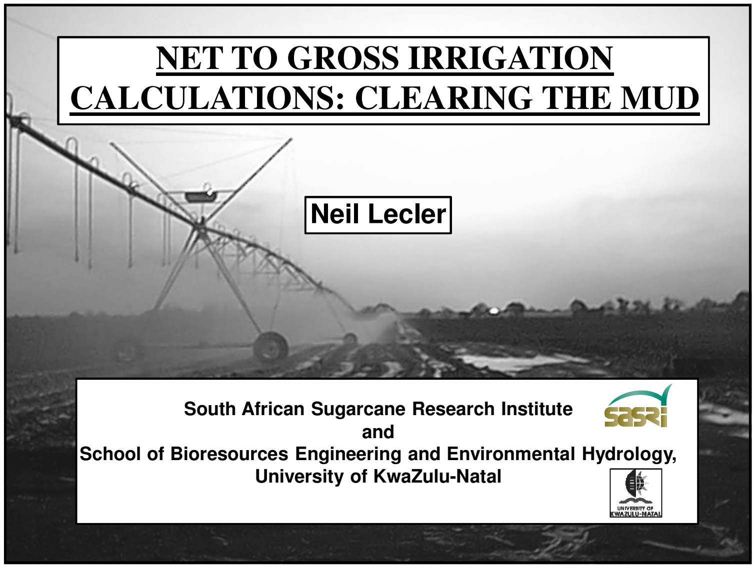


NET TO GROSS IRRIGATION CALCULATIONS: CLEARING THE MUD

Neil Lecler

South African Sugarcane Research Institute
and
School of Bioresources Engineering and Environmental Hydrology,
University of KwaZulu-Natal

Introduction

- Planners and designers,
  - selection of emitter flow-rates
  - the size and cost of system hardware
- Irrigation managers
  - how much water they apply to replenish a certain soil water deficit,
  - water, energy and money used to grow a crop
- Assumptions used in net to gross calculations?

CONTENT

- Understanding net to gross calculations, in SA and Internationally
- Test the assumptions – conceptually and experimentally
- Suggest recommendations to improve

ARC IAE "Design Manual"

Application Efficiency (η_a) % = Ds.100/De

Distribution Efficiency (η_d) % = De.100/Dd

System Efficiency (η_s) % = $\eta_a \times \eta_d$
= Ds.100/Dd

Where
Ds = depth applied to soil surface (for area y)
De = depth exiting emitters (for area y)
Dd = depth withdrawn at farm boundary (for area y)

$$GIR = \frac{NIR.100}{\eta_s}$$

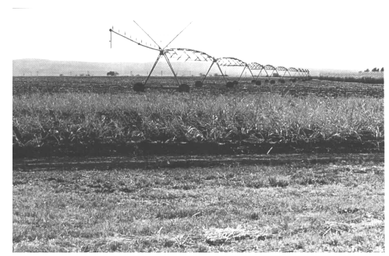
Where
GIR = gross irrigation requirement
NIR = net irrigation requirement

ARC IAE "Design Manual"

Default 'System Efficiencies' ηs

Drip	**95%**
Micro	**90%**
Permanent	**80%**
Mobile	**80%**
Portable	**75%**
Travelling Gun	**70%**
Flood (pipe supply)	**80%**
Flood (earth supply)	**60%**

ARC IAE "Design Manual"



$$GIR = \frac{NIR.100}{\eta s}$$

$\eta s = \eta d \times \eta a$

Mobile Sprinkler
ηs = 80 % (Default),
ηd = 100%, therefore,
ηa = 80%

Implies 20 % non-beneficial spray evaporation and wind-drift loss

ARC IAE "Design Manual"

$$GIR = \frac{NIR.100}{\eta s}$$

$\eta s = \eta d \times \eta a$

Flood (pipe supply)
ηs = 80 % (Default),
ηd = 100%, therefore,
ηa = 80%

Level Basin	GIR = NIR / DU_{lq}
Border	GIR = NIR / ηs
Furrow	GIR = NIR / ηs

Where are the losses between emitter and soil for flood??

Implementation guidelines for WCDM (DWAF, 2000)

$$\text{Total Irr Req'd} = \frac{\text{Area.(Eto .Kc – Reff) x Lfrac. 100 /}(\eta s \ DU_{lq})}{(1 - \text{Conveyance losses})}$$

"DU_{lq} is a factor applied where an increase in irrigation application is necessary to allow for the variance in irrigation distribution and soil characteristics"

SAPWAT

"Divides system efficiency, ηs, into 'spray loss' and a 'distribution uniformity factor' "

SA Scene - Summary

- Inconsistencies between definitions and application of η_a to surface irrigation systems (ARC Design Manual)
- Unexplained introduction of distribution uniformity, DU_{lq}, in some net to gross calculations
  - in place of η_s (Level Basin - ARC Design Manual)
  - in addition to η_s (DWAF WCDM Guidelines)
- Double accounting of on-farm conveyance losses (DWAF WCDM Guidelines)
- Queries of whether or not to account for DU_{lq} in SAPWAT?

International scene ASCE (Burt and Styles, 2007)

Application Efficiency (AE) – single irrigation event

$$\frac{\text{Average depth of irrigation water that contributes to target}}{\text{Average depth of irrigation water applied}} \times 100\ (\%)$$

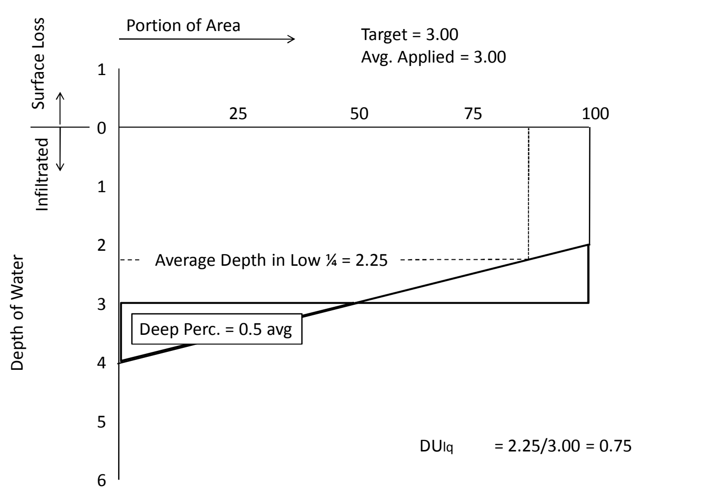
Low Quarter Distribution Uniformity (DUlq)

$$\frac{\text{Average low quarter depth of water}}{\text{Average depth of water in all elements}}$$

Net to Gross (ensure average in low ¼ = target)

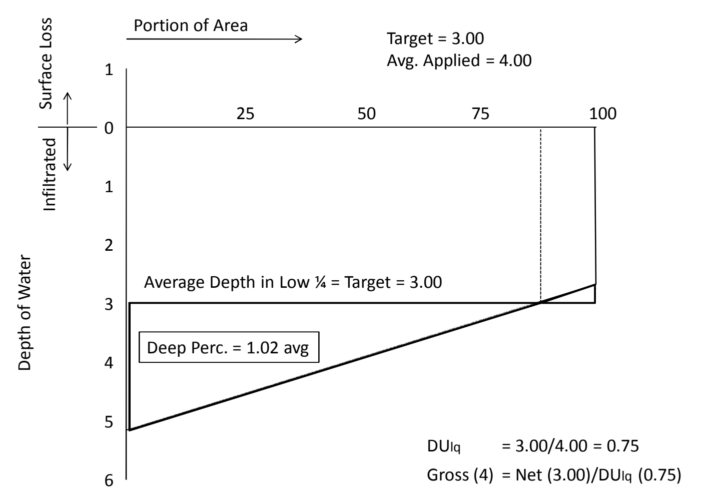
Gross to Apply = (SMD or "Target")/DU_{lq}

WATER DESTINATION DIAGRAM

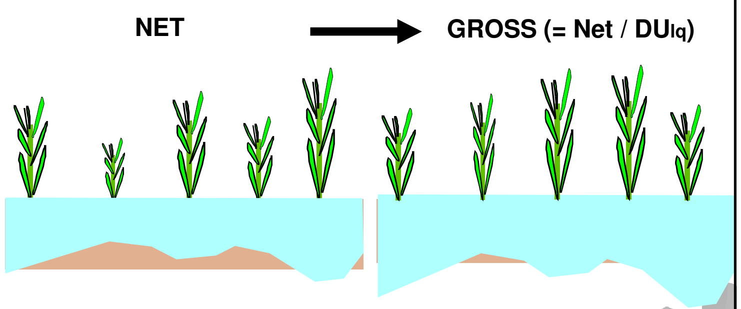


(After Burt and Styles, 2007)

WATER DESTINATION DIAGRAM



(After Burt and Styles, 2007)



International Scene - Summary

- Burt et al. (2007) explain introduction of DU_{lq} in net to gross calculations,
  - to ensure the ¼ of the field receiving the least amount of water, receives sufficient water to meet a target requirement
- Approach to adjusting for DU_{lq} leads to over-irrigation on 87% of the field
- Approach to adjusting for DU_{lq} is based on the premise that over-irrigation is OK but that under-irrigation is detrimental?

Proposed New Approach to Net to Gross Calculations

- Specify and quantify/estimate specific losses
- Query the benefits of adjusting for non-uniformity, DU_{lq}, by simply increasing water application depths

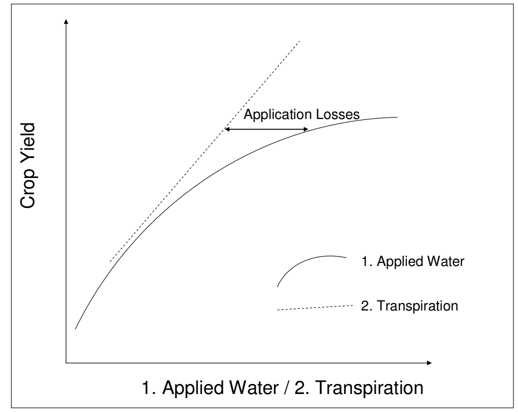
Proposed New Approach to Net to Gross Calculations (after Reinders et al., 2008)

	Leakages / Losses				Proposed net as percent of gross (%)
	Non-beneficial spray evap and wind drift (%) (b)	In-field conveyance losses (%) (c)	Filter and minor losses (%) (d)	Total Leakages / losses (%) (e) = b+c+d	(f) = 100 - e
Drip (surface and subsurface)	0	0	5	5	**95**
Microspray	10	0	5	15	**85**
Centre Pivot, Linear move	8	0	2	10	**90**
Centre Pivot LEPA	8	0	2	10	**90**
Flood: Piped supply	0	0	2	2	**98**
Flood: Lined canal supplied	0	5	2	7	**93**
Flood: Earth canal supplied	0	12	2	14	**86**
Sprinkler permanent	8	0	2	10	**90**
Sprinkler movable	10	5	2	17	**83**
Traveling gun	15	5	2	22	**78**

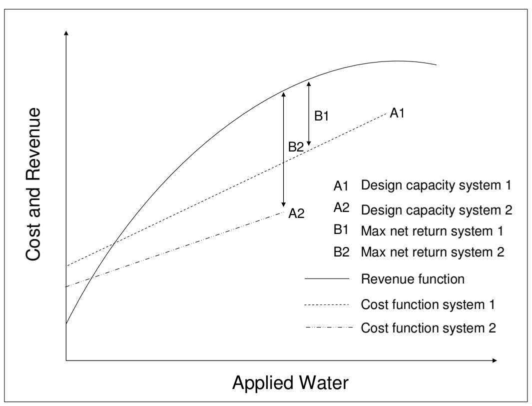
Should Distribution Uniformity, DUlq, Be Accounted For in Net to Gross Calculations??

- Consider deficit irrigation concepts – optimise returns
- Review/Query the rationale or reasoning for adjusting for DUlq
- Assess simulations based on field trials and current state of science

Deficit Irrigation Concepts (after English, 1990)



Deficit Irrigation Concepts (after English, 1990)



Re-thinking the Original Concepts of Accounting for non-uniformity, DUlq………

- Under-irrigation avoided at all costs
- how serious given deficit irrigation concepts??
- Over-irrigation acceptable
- is not over-irrigation nearly as serious as under irrigation, especially without excellent drainage, eg table grapes
- 7/8th or 87.5% of field over-irrigated
- surely this will be *very detrimental* to crop yields - rise in water table, asphyxiation of roots, nutrient leaching!
- Over-irrigation costs water, money and energy!

Worked Example: Furrow irrigation
Old η_s Assumption vs New Net : Gross Reasoning

Assumptions
ETcrop = 8 mm/d
Readily Available Water = 50 mm

Old Approach: System Efficiency = 60%

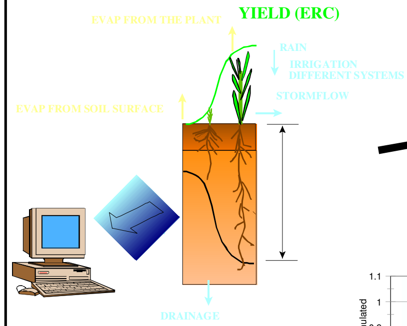
Day	Calculated Soil Water Deficit (mm)	Irrigation Applic (mm)	Real Soil Water Deficit (mm)
1	42		
2	50	83	
3	8		draining
4	16		draining
5	24		draining
6	32		8
7	40		16
8	48	83	24

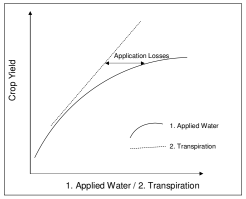
New Approach: Gross = Net / 98%

Day	Calculated Soil Water Deficit (mm)	Irrigation Applic (mm)	Real Soil Water Deficit (mm)
1	42		
2	50	51	
3	8		8
4	16		16
5	24		24
6	32		32
7	40		40
8	48	51	48

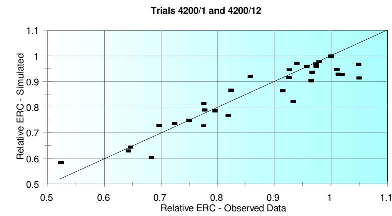
Which is better?

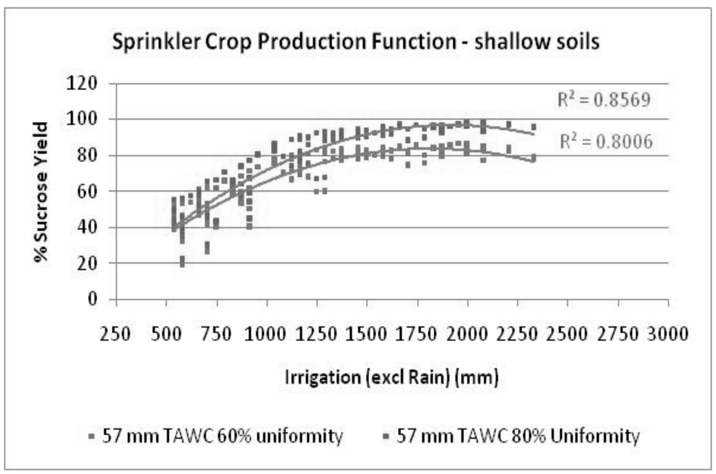
ZIMsched 2.0 Model Simulations



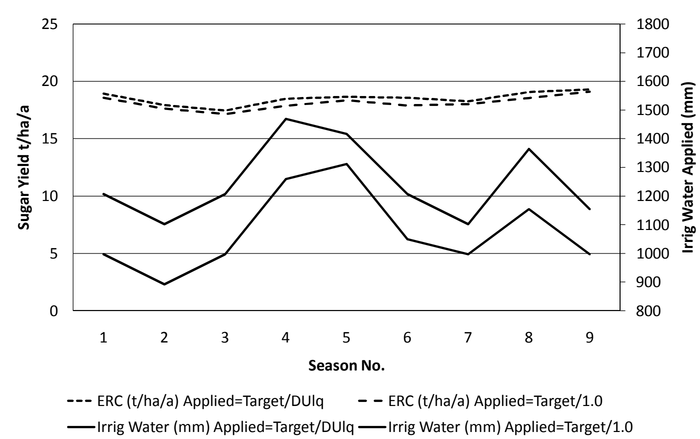


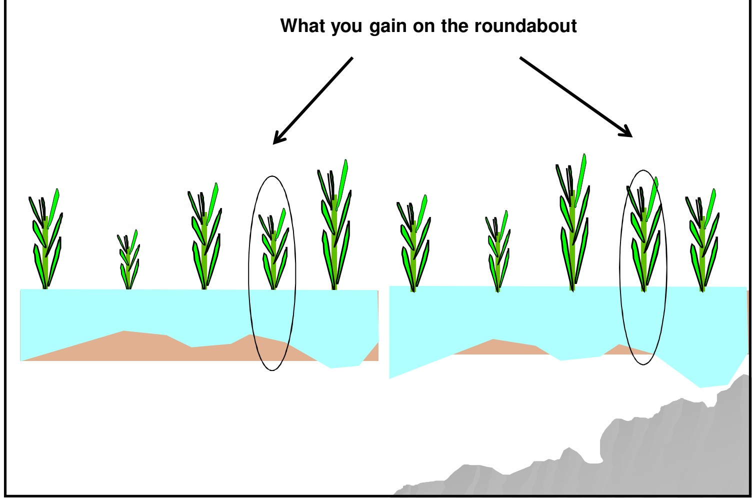
Can account for variations In DU_{lq}

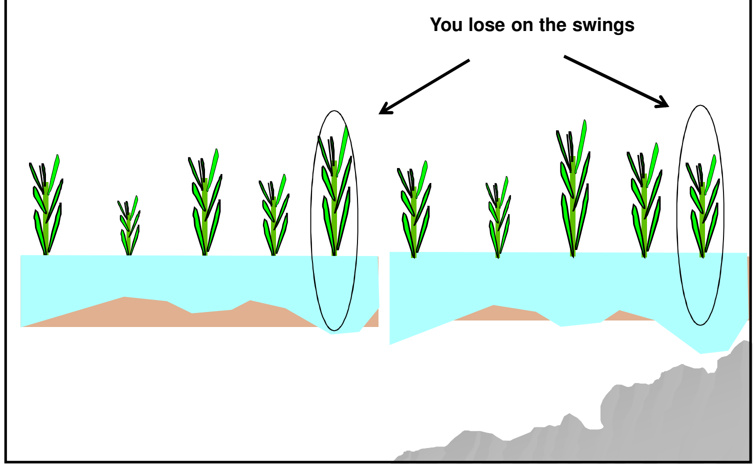




SIMULATED WATER APPLIED AND CROP YIELDS FOR DIFFERENT NET TO GROSS ASSUMPTIONS







RECOMMENDATIONS FOR IMPROVEMENT

- Recognise that obtaining a high DU_{lq} through good design and maintenance is of primary importance
- Re-visit traditional assumptions on the system efficiencies, η_s,of different systems, eg why should a furrow field be thought of as only 60% efficient, especially if the DU_{lq} is high?
- Only add actual well-specified 'non-beneficial' losses to convert from net to gross, e.g. a portion of spray evaporation and wind-drift for sprinkler systems.
- Do not adjust water applications for DU_{lq} – design or refine to ensure DU_{lq} > 75

RECOMMENDATIONS FOR IMPROVEMENT (Cont)

- Develop and apply tools to determine accurate or appropriate "target applications", e.g. *SAsched,* soil water monitoring apparatus, scheduling calendars
- Recognise which components of the water balance contribute to "lost" or "consumed" water and which components remain in the wider catchment or system

  – only actions to reduce non-beneficial "consumed" components of the water balance, eg evaporation from the soil surface, will likely result in overall water savings to the wider catchment

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