The development of site-specific, risk-based water quality guidelines for irrigation*

by

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* Emanating from a Water Research Commission directed research call

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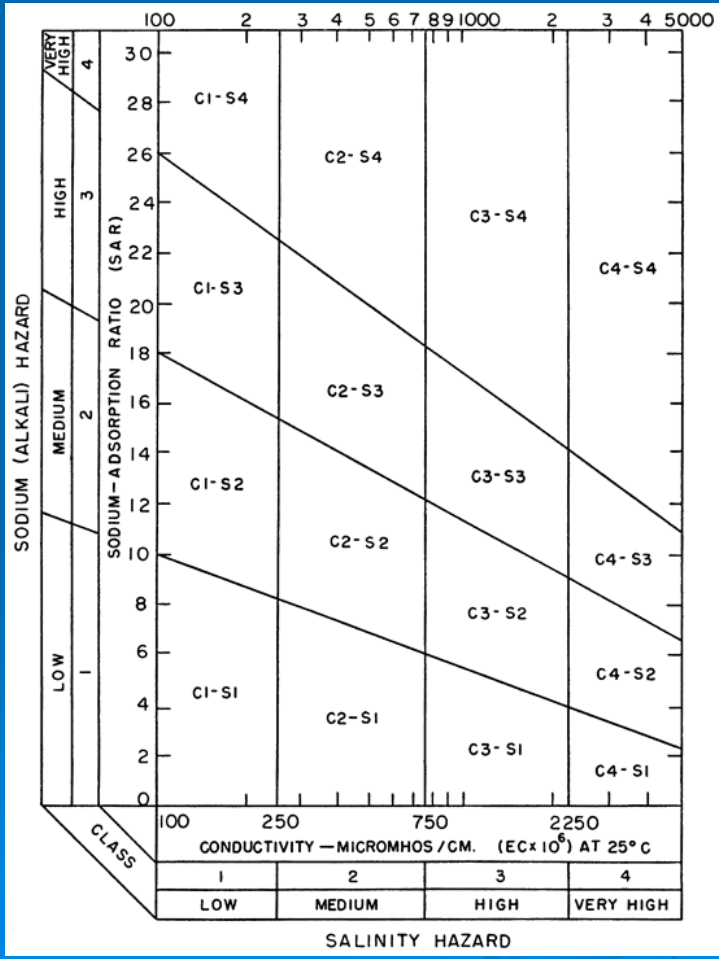
Outline of Presentation

- Background – What are the guidelines and why change them
- Our approach to revising the guidelines
- Examples of envisaged Input and Output
- The way forward

Why do we need Water Quality Guidelines?

- Evaluate the fitness-for-use (for irrigation) of a specific water (Irrigator, water analysis laboratory)
- Setting of water quality objectives to meet needs of irrigation water use (Water resource manager at DWS)

Several guideline documents are currently in use



- Irrigation water quality classification diagram by US Salinity Laboratory Staff (1954)

SA Water Quality Guidelines (1996)

EC Range (mS/m)	Crop Yield
Target Water Quality Range ***< 40***	***Should ensure that salt-sensitive crops can be grown without yield decreases when using low frequency irrigation systems. A leaching fraction of up to 0.1 may be required and wetting of the foliage of sensitive crops should be avoided***
40 - 90	A 95 % relative yield of moderately salt-sensitive crops can be maintained by using a low-frequency irrigation system. A leaching fraction of up to 0.1 may be required and wetting of the foliage of sensitive crops should be avoided
90 - 270	A 90 % relative yield of moderately salt-tolerant crops can be maintained by using a low-frequency application system. A leaching fraction of up to 0.15 may be required and wetting of the foliage of sensitive crops should be avoided
270 - 540	A 80 % relative yield of moderately salt-tolerant crops can be maintained provided that a high-frequency irrigation system is used. A leaching fraction of up to 0.2 may be required and wetting of the foliage of sensitive crops should be avoided
> 540	These waters can still be used for irrigation of selected crops provided sound irrigation management is practised and yield decreases are acceptable. However, the management and soil requirements become increasingly restrictive and the likelihood of sustainable irrigation decreases rapidly

Why revise the current guidelines?

- Current guidelines are very generic in nature – no site specificity (climate, soil, crop, irrigation management)
- Focussed on inorganic constituents (COD, regulatory issues, biological constituents, nutrients, pesticides)
- Current guidance are unambiguous (in practice uncertainty)
- Currently only one level of guidance provided (foresee guidance at different levels or tiers)
- Currently only hard copy guidelines (foresee an electronic Decision Support System)
- Need for a common philosophical basis and currency with which to quantify and compare the impact of water quality on different water users (e.g. recreation, stock watering, domestic use etc)

Approach to revising the guidelines

- Identified the effects of WQ on agricultural production systems
- Identified WQ constituents of concern
- Introducing a multi-tier approach to assess quality
- Designed envisaged output of DSS
- Developing a *Technology Demonstrator*
- Develop the full-scale DSS
- Continuously solicit feedback from potential users

Potential effects of WQ on agricultural production systems

Soil Quality	Crop Yield & Quality	Irrigation Equipment
Root zone salinity	Crop yield	Clogging
Soil structure	Product quality	Corrosion
Contaminant build-up	Specific ion toxicity	
Effect on soil biota	Foliar injury	
Contaminant release to crops	Contamination by pathogens	
	Regulatory compliance	

Potential interaction between WQ and agricultural production systems

	Soil quality		Crop yield and quality				Irrig Equip	
Major Ions	Root zone salinity	Soil structure	Crop yield	Product quality	Specific ion tolerance	Foliar injury	Clogging	Corrosion
Bicarbonate				X		X	X	X
Calcium		X					X	
Chloride			X	X	X	X		X
Magnesium		X	X					
Sodium		X	X		X	X		
Sulfate								
Electrical Conductivity	X		X			X		X

Constituents for Guidelines

Macro ions	Biological parameters	General
Calcium	**Algae?**	pH
Carbonate / Bicarbonate	**Cyanobacteria?**	Corrosion
Chloride	**Human and animal**	Clogging
Magnesium	**pathogens**	**Suspended solids**
Sodium	**Plant pathogens?**	
Sulphate	**COD**	
	POPs? EDCs?	

Salinity and sodicity	Nutrients	Pesticides
Electrical conductivity	Nitrogen	**Atrazine**
Sodicity (SAR)	**Phosphorus**	**????**

Trace elements		
Aluminium	Copper	Molybdenum
Arsenic	Fluoride	Nickel
Beryllium	Iron	Selenium
Boron	Lead	Uranium
Cadmium	Lithium	Vanadium
Chromium(VI)	Manganese	Zinc
Cobalt	**Mercury**	

Multi-tier approach to assess fitness-for-use of WQ

Tier 1	Tier 2	Tier 3
National scale	Regional scale	Site scale
Generic	→	Site specific
Conservative	→	Appropriate
Fixed parameters	Selectable parameters	Site specific parameters
Static / steady state calculator	Simplified cascading dynamic model	Appropriate sophisticated models

Tier 1 Input parameters

Parameter	Selectablity
Water quality	Input analysis of available constituents
Crop	Pre-defined generic crop (sensitive to EC, Cl, Na, B). No crop specific water requirement.
Soil	Pre-defined soil sensitive to Na
Climate	No rain. ET as function of LF
Leaching Fraction (LF)	Pre-defined, conservative (= 0.1)
Irrigation system	Pre-defined (conservative = leaf wetting)

Tier 2 Input parameters

Parameter	Selectablity
Water quality	Input analysis of available constituents
Crop	Selectable crop (associated water requirement, sensitivity to EC, Cl, Na, B etc)
Soil	Selectable soil (associated water holding capacity, sensitivity to Na etc)
Climate	Selectable climatic region with 25 year data
Irrigation timing and refill	Selectable from pre-defined timing and refill options
Irrigation system	Selectable irrigation type with associated characteristics

Tier 1 Output (1)

Assessment of water sample for Fitness-for-Use as Irrigation Water

Sample Identification	2597/14
Site identification	J Jacobs Borehole 3 new irrigation field

Irrigation Water Constituents

Macro Cations (mg/L)		Macro Anions (mg/L)	
Calcium	120	Bicarbonate	61
Magnesium	24	Chloride	213
Sodium	46	Sulphate	144

Other constituents		Biological Parameters	
pH	7.5	Cyanobacteria	
EC	100	E. coli	100
TDS	610	COD	10
Suspended solids	-		
N as NO_3	10		
Total P	0.1		
Total N			

Tier 2 Output (1)

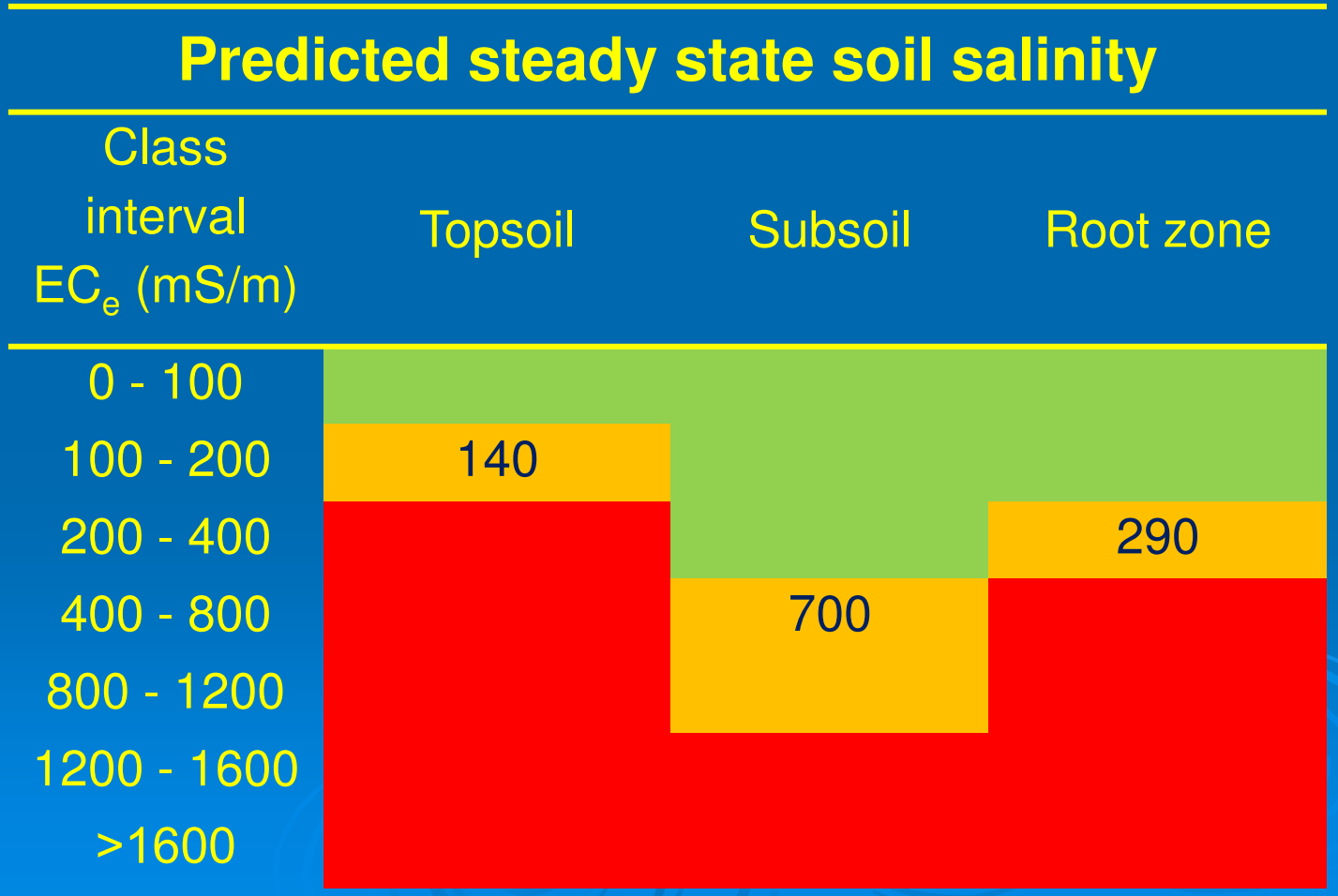
Assessment of water sample for Fitness-for-Use as Irrigation Water	
Sample Identification	2597/14
Site identification	J Jacobs Borehole 3 new irrigation field

Site specific characteristics	
Climate data	Eastern Mpumalanga lowveld region
Soil	1.7 m deep loam
Crop	Citrus
Irrigation system	Microjets
Irrigation management level	Medium
Irrigation scheduling approach	Irrigate at 75% level of PAWC depletion
Fertilisation	Optimal

Tier 2 Output (2)

Irrigation Water Constituents			
Macro Cations (mg/L)		**Macro Anions (mg/L)**	
Calcium	120	Bicarbonate	61
Magnesium	24	Chloride	213
Sodium	46	Sulphate	144
Other constituents		**Biological Parameters**	
pH	7.5	Cyanobacteria	
EC	100	E. coli	100
TDS	610	COD	10
Suspended solids	-		
N as NO_3	10		
Total P	0.1		
Total N			
Trace Elements			
Aluminium		Lead	
Arsenic		Lithium	
Beryllium		Manganese	

Tier 1 Output – Soil Quality: Salinity Risk



Tier 2 Output – Soil Quality: Salinity Risk

% of time soil salinity is within class			
Class interval EC_e (mS/m)	Topsoil	Subsoil	Root zone
0 - 100	90		5
100 - 200	7		20
200 - 400	3	10	50
400 - 800		60	20
800 - 1200		20	5
1200 - 1600		10	
>1600			

Tier 2 Output – Soil Quality: Soil Structure

	% of time infiltration or permeability problem to be expected in	
Problem	Soil surface	Subsoil
No effect	80	70
Moderate effect	20	30
Severe effect	0	0

Tier 2 Output – Crop Yield & Quality: Salinity Affected Crop Yield

Relative crop yield	% of time crop yield is within class
95 – 100	74
90 – 95	20
85 - 90	5
80 – 85	1
75 – 80	
70 - 75	
<70	

Tier 2 Output – Irrigation Equipment: Corrosion and Scaling

Langelier Index	Corrosive / Scaling	Calculated Langelier Index
< -2.0	Corrosive	
-2.0 to -0.5		-0.6
-0.5 to +0.5		
+0.5 to +2.0	Scaling	
> +2.0		

The Way Forward

- Develop a *Technology Demonstrator* that has the look and feel of the final DSS for six water quality constituents (Jan 2015)
- Obtain feed-back from user community
- Develop final DSS (July 2016)
- Invite everyone to provide feedback and contact me if you would like to evaluate beta versions of the DSS as it becomes available.

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Thank you for your attention!