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Agricultural Management Practices for Water Quality Improvement in the Great Barrier Reef Catchments

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EXECUTIVE SUMMARY

This report provides a detailed description of management practices intended to reduce the adverse impacts of agriculture on water quality improvement in the Great Barrier Reef (GBR) catchments. The report addresses the Natural Resource Management (NRM) regions of the Wet Tropics (WT), Burdekin Dry Tropics (BDT) and Mackay Whitsundays (MWS). In this report the agricultural production systems in the GBR catchment are identified that 1) have the highest financial impact and 2) that have the highest adverse impacts on water quality from nutrients, sediments and pollutants. Furthermore, the management actions for each identified production system are prioritised according to water quality improvement potential.

To create this report we followed a step wise approach in regards to information gathering. First we performed a literature review of Water Quality Improvement Plans (WQIPs) followed by expert consultation (Natural Resource Management boards, scientific organisations). Last we consulted on-ground experts such as extension officers and farmer groups. This report contains the synthesised results from these steps.

The key income generating agricultural industries in the GBR region are sugarcane growing, banana cultivation and grazing. The regions where these industries are most prevalent by area are the WT, BDT and MWS for sugarcane, BDT Rangelands and WT coasts for grazing and the WT for banana cultivation. The identified priority management actions which address the issue of water pollution are: nutrient, pesticide and soil management for sugarcane; pasture, riparian and gully management for grazing; and nutrient, soil, insect/disease and irrigation management for banana cultivation. Management actions are ranked using a classification based on the ABCD frameworks developed during Water Quality Improvement Plans. In relation to water quality improvement potential, the ABCD framework is structured to describe that management practices classified as ‘Best’ (B) practices currently hold the highest potential for improving water quality, and ‘Dated’ (D) practices the lowest. ‘Aspirational’ (A) management practices may further improve water quality but are currently under research and commercial viability has not yet been proven (therefore these practices are difficult to accurately model because data on their water quality improvement is not yet available).

1. INTRODUCTION

This report provides a detailed description of management practices for water quality improvement in the Great Barrier Reef (GBR) catchments, to be more specific, the Natural Resource Management (NRM) regions of the Wet Tropics (WT), Burdekin Dry Tropics (BDT) and Mackay Whitsundays (MWS). In this report the agricultural production systems in the GBR catchment are identified that 1) make the most profit and 2) that have the highest adverse impacts on water quality from nutrients, sediments and pollutants. Furthermore, the management actions for each identified production system are prioritised according to water quality improvement potential. The benchmark date for water quality improvement management practices described in this report is 2008, the beginning of the Australian Government Reef Rescue Program.

To create this report we followed a step wise approach in regards to information gathering. First we performed a literature review of Water Quality Improvement Plans (WQIPs; Drewry et al. 2008, Dight 2009 and Kroon 2008) followed by expert consultation (Natural Resource Management boards, scientific organisations). Last we consulted on-ground experts such as extension officers and farmer groups. This report contains the synthesised results from these steps.

2. MANAGEMENT PRACTICES FOR WATER QUALITY IMPROVEMENT

2.1. Identification and prioritisation

2.1.1. Identification of most important agricultural production systems

The industries shown in Table 1 are the key industries in the GBR region from a profit point of view, more specifically their gross direct economic value (from: *Measuring the economic & financial value of the Great Barrier Reef Marine Park, report by Access Economics Pty Ltd for Great Barrier Reef Marine Park Authority. 16 June 2005*), as well as from a water quality point of view (from: *Reef Rescues Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, Reef Catchments, 28 July 2009*). Besides recognition of the industries, the regions where these industries are most prevalent by area are identified.

Table 1: Production systems by GBR region

Production system	***Dominant region***
Sugarcane	Wet Tropics, Burdekin Dry Tropics, Mackay Whitsundays
Grazing	Rangelands, Wet Coastal grazing
Horticulture	Wet Tropics (bananas)

2.1.2. Identification of priority management actions

Table 2 describes the priority management actions for each identified industry to address the issue of water pollution by nutrients, pesticides and sedimentation (from: *Reef Rescue's Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, Reef Catchments, 28 July 2009*).

Table 2: Priority management actions by production systems

Production system	***Priority actions***
Sugarcane	Nutrient, Pesticide and Soil management
Grazing	Pasture, Riparian (frontage) and Gully management
Horticulture	Nutrient, soil management, insect/disease and irrigation management

2.1.3. Prioritization of management actions

The report is structured such that each NRM region is described individually. While there is considerable overlap between the different regions in their description of management practices for water quality improvement, there are also enough differences to warrant individual description. In relation to water quality improvement potential, this is structured that management practices classified as 'Best' (B) practices currently hold the highest potential for improving water quality, and 'Dated' (D) practices the lowest. 'Aspirational' (A) management practices may further improve water quality but are currently under research and commercial viability has not yet been proven (therefore these practices are difficult to accurately model because data on their water quality improvement is not yet available). Table 3 describes the four management practices classes or farming systems.

Table 3: Classification of management practices

Practice class / farming system	***Description***
A: Aspirational	Proof of concept, practice/farming system under research/scientifically sound but commercial viability not yet proven
B: Best practice	Best practice / farming system currently available
C: Common practice	Currently code of practice level of farming system
D: Dated practice	Dated and likely degrading practice / farming system

2.1.4. Assumptions and limitations

The following assumptions and limitations underpin the model.

- For APSIM modelling legume crops are assumed of good quality. This results in no additional nitrogen (N) fertiliser application when cane is planted under B and A;
- Farmers can be in one class for soil management but in a different one for nutrient management;
- The class 'A' farming system relates to 'Proof of concept' practices. All the information that is being presented on this class in this report is based on farming systems under research, scientifically sound but their commercial viability is not yet proven and caution must be taken with the interpretation of the actual numbers presented in this report.

2.2. Descriptions of management practices according to classifications

The tables below describe the various individual management practices, classified according to their prioritisation. The order is as follows; first farming systems are described for sugarcane in the WT, BDT and MWS, next grazing in the BDT followed by banana growing in the WT.

2.2.1. Sugarcane

This section describes management practices for sugarcane growing in the NRM regions WT, BDT (Delta and BRIA region) and MWS as identified in the ABCD framework. The identification of management practices is required so that economic modelling can predict the impact on growers from moving between management practice classes. Load reductions associated with moving between the management practice classes can also be predicted. Consequently, descriptions of the different management practice classes require absolute figures for inputs so that economic costs can be accurately assigned.

Wet Tropics (reference soil type for modelling is S2: A loam soil poorly drained formed on alluvium)

Soil Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Cultivated ratoons	Cultivation of interrow in all ratoon crops (Green Cane Trash Blanketing)	One pass (Ripper/Coulter) of all ratoon cane	All trash incorporated by tillage after last ratoon only and even then very occasional.
D	Cultivated plant cane	Cultivation of block prior to planting cane and cultivation used for weed control in plant cane	Up to six passes of all blocks prior to planting. Four cultivations for weed control and filling in after planting.	Pre planting = Rotary x 1 plus 2 x disking plus 2 x rip pus 1 x line marking Post planting = 3 x cutaway plus 2 x weeder plus 2 x hill up
D	Cultivated bare fallow or ploughout replant	Where a fallow is used it is cultivated for weed control. Otherwise PORP	Three cultivations of all blocks in between final ratoon and preparation for planting.	Bare cultivated fallow
D	Record keeping	No record keeping		
C	Grassy fallow	Final ratoon ploughed out and fallow block left alone without any cultivation	One cultivation of block after final ratoon.	Bare uncultivated fallow
C	Cultivated plant cane	Cultivation of block prior to planting cane and cultivation used for weed control in plant cane	Five passes prior to planting.	1 x rotary hoe plus 1 x ripping plus 2 x discing plus 1 x line marking
C	Cultivation minimised in plant cane	Less cultivation of plant cane with chemicals used for weed control	Spray of residual chemicals post planting and four tillage passes after planting.	Post planting = 1 x cutaway plus 1 x weeder plus 2 x hill up
C	Cultivated ratoons	1x Ripper/Coulter in all ratoons (Green Cane Trash Blanketing)	One tillage operation	
C	Riparian management	Riparian vegetation along natural waterways kept to a minimum		
C	Record keeping	Diary with basic records		
B	Controlled traffic permanent beds	Row width matches machinery, beds for growing cane established and retained between crop cycles	Zonal tillage used– see below.	3 x discing plus 1 x ripper/rotary hoe 2 x hill up
B	Traffic controlled by GPS	Planting uses satellite guidance	Guidance required for	Reduced curve number specific to

	guidance for planting		planting	soil type (85% of conventional curve number)
B	Zero till ratoons	No tillage used for weed control in ratoons		
B	Spray out cane	Final ratoon sprayed out	Roundup used (6 L/ha 450 g glyphosate a.i) to spray out cane.	
B	Cowpea legume fallow	Legumes planted direct drill	legumes direct drilled into cane trash after final ratoon spray out	
B	Riparian management	Native riparian vegetation at a width and density which limits erosion and allows filtering of farm runoff along sections of the natural waterways on the farm		
B	Record keeping	Paper based records of block activities correlated with mill supplied production records		
A	This class 'Aspirational' relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Controlled traffic permanent beds	Row width matches machinery 1.9m row spacing		Reduced curve number specific to soil type (85% of conventional curve number)
A	Strategic tillage prior to planting	1 x ripper / rotary hoe	Double disk opener planter with formed mound at planting No tillage post planting	Legume fallow Plant with double disk opener planter
A	Traffic controlled by GPS guidance	All machinery uses satellite guidance	Planting, spraying, harvesting, haul out equipment using guidance.	
A	Cowpea legume fallow	Legumes planted direct drill	legumes direct drilled into cane trash after final ratoon spray out	

A	Spray out cane	Final ratoon sprayed out	Roundup used (6 L/ha 450 g glyphosate a.i) to spray out cane.	
A	Riparian management	Native riparian vegetation at a width and density which limits erosion and allows filtering of farm runoff along the length of both sides of all natural waterways on the farm		
A	Record keeping	Computer based records covering all block activities and production , trends in soil nutrient content, weed survey data and water quality testing results		
Nutrient Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Single application rates over whole farm to ratoons and another to plant	Nutrients applied at a rate that is historic or rule of thumb	N = 135 kg N/ha to plant cane N = 180 kg N/ha to ratoon cane	N = 135 kg N/ha to plant cane N = 180 kg N/ha to ratoon cane
D	Surface applied	Applied to surface of trash		
D	Soil testing	Soil or leaf testing not considered worthwhile		
D	Calibration of fertiliser activity	No calibration of equipment done		
D	Timing of fertiliser applications	Weather only impacts on ability to do application at that time.		
D	Record keeping	No record keeping		
C	Application rates based on old recommendations	Nutrients applied at a rate that is at the Calcino recommendations	N = 113 kg N/ha to plant cane N = 150 kg N/ha to ratoon cane	N = 113 kg N/ha to plant cane N = 150 kg N/ha to ratoon cane
C	Granular fertiliser applied sub surface	Fertiliser applied sub-surface beside the stool		
C	Application rates account for mill by products and	Where mill mud or legumes are used, fertiliser rate is reduced		Assume no mill mud used, discount for legumes reflected in 113 kg

	legumes			N/ha to plant cane.
C	Soil testing	Soil and possibly leaf test sampling frequency once per crop cycle per soil type		
C	Calibration of fertiliser activity	Calibrates once per season for each fertiliser product		
C	Timing of fertiliser applications	Follows weather (i.e. 4-5 days ahead) but does not use directly		
C	Record keeping	Diary with basic records		
B	Soil tested each cycle	Soil sampled every block at least once per crop cycle	Soil test once per crop cycle	
B	Rates block specific	Rate determined for each block based on soil test (six easy steps)	N = As calculated for specific soil types by Six easy steps N = 0 kg N/ha to plant cane – Assumption: perfect legume crop Practical: 55kg N/ha to plant cane following a legume fallow. N = 140 kg N/ha to ratoon cane	N = As calculated for specific soil types by Six easy steps N = 0 kg N/ha to plant cane – Assumption: perfect legume crop N = 140 kg N/ha to ratoon cane
B	Applications sub surface	Nutrients applied underground	Split stool fertiliser application	
B	Calibrated between batches	Fertiliser box calibrated each time a new fertiliser batch or product is changed		
B	Nutrient timing	With respect to crop stage and rainfall		
B	Application rates account for mill by products and legumes	Where mill mud or legumes are used, fertiliser rate is reduced following	Plant cane receives no nitrogen application.	
B	Legume is tilled into soil	Legumes cultivated into soil using discing		
B	Record keeping	Paper based records of block activities correlated with mill supplied production records		
A	This class ‘Aspirational’ relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems			

	under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Soil sample based on soil and yield mapping	Soil samples taken in areas identified in yield or soil mapping	Soil sampling once per crop cycle.	
A	Fertiliser rates variable within blocks	Fertiliser applied variably within blocks based on yield, soil mapping	EM mapping of blocks (once). Variable application machinery. N = Variable N rates for sub-blocks N = 0 kg N/ha to plant cane – Assumption: perfect legume crop Practical: 55 kg N/ha to plant cane following a legume fallow (average quality). 120 kg N/ha to ratoon cane	N = Variable N rates for sub-blocks N = 0 to plant cane N = N-replacement for APSIM modelling
A	Yield monitoring	yield monitors used	Harvester with yield monitors.	
A	Placement of fertiliser	Applies fertiliser subsurface within the stool using a stool splitter where topography and soil type allow, taking into account the types and form of fertiliser		
A	Record keeping	Computer based records covering all block activities and production , trends in soil nutrient content, weed survey data and water quality testing results		
Pesticide Management				
Class	**Practice**	**Description**		**Inputs**
D	One strategy for whole farm	Based on historic application rates		Plant Cane - 1.0L/ha Gramoxone + 3kg/ha Velpar K4 - 0.5L/ha 2,4-D Amine + 0.75L/ha Tordon 75D Ratoon Cane - 0.5L/ha 2,4-D Amine + 0.75L/ha Tordon 75D

			- 1.5L/ha Gramoxone + 3kg/ha Velpar K4
D	Maximum label rate	Rates based on the maximum label rates	
D	Limited calibration	Calibrated once per year	
D	General herbicide issues	ChemCert qualified and up to date	
C	Flexible chemical strategy	At least two strategies used over the farm	Fallow - 6L/ha Glyphosate (450 g glyphosate a.i) + 1L/ha 2,4-D Plant Cane - 1.0L/ha Gramoxone + 3L/ha Stomp Xtra + 2kg/ha Atrazine + 0.5L/ha 2,4-D - 2.5kg/ha Velpar K4 + 1.5L/ha Gramoxone - 0.5L 2,4-D Amine + 0.75L Tordon 75D Ratoon Cane - 0.5L/ha 2,4-D Amine + 0.75L/ha Tordon 75D - 1.5L/ha Gramoxone + 2kg/ha Velpar K4
C	Rate and product	Residuals at maximum and use of knockdowns	
C	Calibration	Each time a new product or rate is used	
C	Herbicide planning	Basic herbicide management plan developed and implemented	
C	Herbicide application timing	Uses correct application timing only taking into account weather conditions	
C	General herbicide issues	Keeps records of wind speed, direction, time of spraying, herbicide rate & weed pressure	
B	Herbicide strategy variable	Each block receives chemicals based on pressure	Legume Fallow - 6L/ha Glyphosate (450 g glyphosate a.i) + 0.5L/ha 2,4-D Plant Cane - 1.0L/ha Gramoxone + 3L/ha Stomp Xtra + 2kg/ha Atrazine +

			0.5L/ha 2,4-D - 2.5kg/ha Velpar K4 + 1.5L/ha Gramoxone - 0.5L 2,4-D Amine + 0.75L Tordon 75D Ratoon Cane - 1.0L/ha Gramoxone + 0.5kg/ha Diurex + 0.5L/ha 2,4-D Amine - 1.2L/ha Gramoxone + 2kg/ha Velpar K4 + 0.5L/ha 2,4-D
B	Knockdowns	Knockdowns used instead of residuals where appropriate	
B	Application technology	Equipment used to improve placement	
B	Timing	Application timed to stage of growth, rainfall, irrigation	
B	Pre emergents	Used in plant cane at correct timing and label rates	
B	Herbicide planning	Basic herbicide management plan developed and implemented	
B	General herbicide issues	Keeps records of wind speed, direction, time of spraying, herbicide rate & weed pressure	
A	This class ‘Aspirational’ relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.		
A	Variable herbicide within blocks	herbicide application varies within block based on need using GPS	Legume Fallow - 6L/ha Glyphosate (450 g glyphosate a.i) + 0.5L/ha 2,4-D Plant Cane - 1.0L/ha Gramoxone + 3L/ha Stomp Xtra + 2kg/ha Atrazine + 0.5L/ha 2,4-D - 1.0kg/ha Velpar K4 + 1.5L/ha Gramoxone - 4.0L/ha Glyphosate (450 g glyphosate a.i) + 1L/ha Gramoxone (hooded sprayer_ Ratoon Cane - 1.0L/ha Gramoxone + 0.5kg/ha Diurex + 0.5L/ha 2,4-D Amine

			- 1.2L/ha Gramoxone + 1.5kg/ha Velpar K4 + 0.5L/ha 2,4-D
A	Knockdown replaces residual	Knockdown herbicides used in preference to residuals	
A	Herbicide planning	Identify weeds using a survey of types/pressure and soil types within blocks for GIS-based weed management plan	
A	Herbicide rates	Apply variable weed strategies within blocks e.g. row ends, patches of vines	

Burdekin Delta Region (Reference soil type is NEIL)

Irrigation Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Irrigation	Furrow irrigation – not optimised producing significant losses to runoff and/or deep drainage	Crop water requirements + 200%	Crop water requirements + 200%
C	Irrigation	Furrow irrigation – not optimised producing significant losses to runoff and/or deep drainage	Crop water requirements + 100%	Crop water requirements + 100%
B	Irrigation	Furrow irrigation – optimised to minimise deep drainage and runoff losses	Crop water requirements + 50%	Crop water requirements + 50%
A	This class 'Aspirational' relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Irrigation	Drip, Overhead Low Pressure or Optimised Furrow to match crop requirements	Crop water requirements	Crop water requirements
Soil Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Cultivated ratoons	Cultivation of interrow for weed control in all ratoon crops	All ratoons have four passes.	One centrebust plus one trash incorporator plus two scarifier/hill up operations for full trash

				incorporation
D	Cultivated plant cane	Cultivation of block prior to planting cane and cultivation used for weed control in plant cane	Nine passes in block during preparation for planting.	Pre-planting = 4 x discing plus 2 x rip plus 2 x rotary hoe plus 1 x line marking Establishment = 3 x cutaway plus 1 x strawberry harrow plus 1 x ripper roller plus 1 x weeder plus 2 x scarifier/hill up
D	Cultivated bare fallow or ploughout replant	Where a fallow is used it is cultivated for weed control. Otherwise PORP	Seven passes in block during fallow period.	Bare fallow tillage 4 x disk plus 2 x rip plus 2 x rotary hoe
D	Record keeping	No record keeping		
C	Cultivated ratoons			1 x trash incorporator plus 1 x hill up
C	Reduced tillage in fallow	Bare fallow cultivated less than a full tillage fallow	Five passes for weed control.	Bare fallow tillage 3 x disc plus 2 x rip
C				
C	Cultivated plant cane	Cultivation of block prior to planting cane and cultivation used for weed control in plant cane	Six passes for planting preparation and four passes during plant establishment.	Pre-planting = 2 x discing plus 2 x rip plus 1 x rotary plus 1 x markout Post planting = 1 x cutaway plus 1 x weeder plus 2 x scarifier/hill up
C	Record keeping	Basic with records farm diary and spray log book		
B	Cultivated bare fallow or ploughout replant	Where a fallow is used it is cultivated for weed control. Otherwise PORP	Four passes in block during fallow period.	Bare fallow tillage 4 x disk
B	Controlled traffic	Row width matches machinery	Two passes for planting preparation and three passes during plant establishment.	Pre-planting tillage operations = 2 x disk Post planting tillage operations = 1 x weeder plus 2 x scarifier/hill up
B	Traffic controlled by GPS guidance	Planting and harvesting machinery uses satellite guidance	Planting and harvesting machinery using guidance.	Reduced curve number specific to soil type (85% of conventional curve number)
B				

B	Zero till ratoons	Zero tillage in all ratoons for weed control.		Zero tillage in ratoons
B	Legume fallow cover crop	Soybeans grown as a cover crop in fallow	Three passes prior to planning legumes	Legume fallow tillage = 2 x discing plus 1 x bed former
B	Record keeping	BSES journal and/or spray journal		
A	This class 'Aspirational' relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Controlled traffic permanent beds	Row width matches machinery, legumes and sugarcane grown on pre-formed beds		
A	Traffic controlled by GPS guidance	All machinery uses satellite guidance	Planting, spraying, harvesting and haul out equipment	Reduced curve number specific to soil type (85% of conventional curve number)
A	Traffic controlled by GPS guidance	Planting and harvesting machinery uses satellite guidance		
A	Legume fallow	Fallows planted to legumes on mounds. Tillage prior to planting legumes is only used if required – for example lasering, changes to paddock design or need for re-forming beds.	50% of fallow uses permanent mounds and 50% is re-mounded using 3 x discing plus 1 x bed former. 50% of the fallow area is lasered.	Soybean crop is grown for grain
A	Zero till plant cane	Cane planted into permanent bed using double disk opener	Double disk opener. No tillage prior to planting.	Zero tillage
A	Green Cane Trash Blanket	Trash splitter used to improve flow of irrigation water	2 x trash splitter	Green Cane Trash Blanket
A	Record keeping	Computer based with farm management software		
Nutrient Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Single application rates over whole farm	Nutrients applied to all blocks at the same rate using surface application	N = 327 kg N/ha to plant cane N = 400 kg N/ha to ratoon cane	N = 327 kg N/ha to plant cane N = 400 kg N/ha to ratoon cane

D	Record keeping	No record keeping		
C	Application rate based on old recommendations	Nutrients applied at a rate that is at the Calcino recommendations	N = 150 kg N/ha to plant cane N = 250 kg N/ha to ratoon cane	N = 150 kg N/ha to plant cane N = 250 kg N/ha to ratoon cane
C	Granular fertiliser applied sub surface	Fertiliser applied underground beside the stool		
C	Record keeping	No record keeping		
B	Soil tested each cycle	Soil sampled every block at least once per crop cycle	All blocks soil sampled once per crop cycle.	
B	Rates block specific	Rate determined for each block based on soil test (six easy steps)	N = As calculated for specific soil types by Six easy steps N = 0 kg N/ha to plant cane – Assumption: perfect legume crop Practical: 100kg N/ha to plant cane following a legume fallow (average quality) N = 185 kg N/ha to ratoon cane	N = As calculated for specific soil types by Six easy steps N = 0 kg N/ha to plant cane – Assumption: perfect legume crop N = 185 kg N/ha to ratoon cane
B	Applications sub surface	Nutrients applied underground	Stool splitter applicator	
B	Record keeping	No record keeping		
A	This class ‘Aspirational’ relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Soil sample based on soil and yield mapping	Soil samples taken in areas identified in yield or soil mapping	EM mapping (once only).	
A	Fertiliser rates variable within blocks	Fertiliser applied variably within blocks based on yield, soil mapping	EM mapping of blocks (once). Variable application machinery.	N = Variable N rates for sub-blocks N = 0 to plant cane N = N-replacement for APSIM

			N = Variable N rates for sub-blocks N = 0 kg N/ha to plant cane – Assumption: perfect legume crop Practical: 66 kg N/ha to plant cane following a legume fallow (average quality) 120 kg N/ha to ratoon cane	modelling
A	Yield monitoring	Yield monitors used	Yield monitors on harvesting machinery.	
A	Record keeping	No record keeping		
Pesticide Management				
Class	**Practice**	**Description**	**Inputs**	**Justification**
D	One strategy for whole farm	based on historic application rates	Ratoon Cane - 2.0L 2,4-D Amine Aerial Application (20% of ratoons) - 1.5L/ha Gramoxone + 2.0kg/ha Diurex + 1.5L/ha 2,4-D Amine	
D	Maximum label rate	Rates based on the maximum label rates		
D	Record keeping	No record keeping		
C	flexible chemical strategy	At least two strategies used over the farm	Fallow - 3L/ha Glyphosate (450 g glyphosate a.i) + 1.0L/ha 2,4-D Plant Cane - 1.5L/ha Gramoxone + 1.5L/ha 2,4-D Amine + 0.5kg/ha Atrazine - 3.0kg/ha Velpar K4 + 1.5L/ha Gramoxone	

			Ratoon Cane - 2.0L 2,4-D Amine Aerial Application (20% of ratoons) - 1.5L/ha Gramoxone + 2.2kg/ha Atrazine + 1.5L/ha 2,4-D Amine	
C	Rate and product	Residuals at maximum and use of knockdowns		
C	Record keeping	No record keeping		
B	Herbicide strategy variable	Each block receives chemicals based on weed pressure	Legume Fallow - 2.5L/ha Sprayseed + 1L/ha 2,4-D (spray-out legume) - 3L/ha Stomp Xtra + 1L/ha Gramoxone - 2L/ha Glyphosate (450 g glyphosate a.i) + 0.5L/ha 2,4-D Amine Plant Cane - 1.0L/ha Gramoxone + 1.0L/ha 2,4-D Amine - 2.0kg/ha Velpar K4 + 1.5L/ha Gramoxone Ratoon Cane - 2.0L 2,4-D Amine Aerial Application (20% of ratoons) - 1.5L/ha Gramoxone + 2.2kg/ha Atrazine + 1.5L/ha 2,4-D Amine - 1.5L/ha Gramoxone + 1.0L/ha 2,4-D Amine	
B	Knockdowns	Knockdowns used instead of residuals where appropriate		
B	Application technology	Equipment used to improve placement		
B	Record keeping	No record keeping		
A	This class ‘Aspirational’ relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems			

	under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Knockdown replaces residual	Knockdown herbicides used in preference to residuals	Legume Fallow - 1.0L/ha Gramoxone + 0.5L/ha 2,4-D (hooded sprayer) - 7L/ha Glyphosate (450 g glyphosate a.i) + 1.0L/ha 2,4-D Amine Plant Cane - 1.0L/ha Gramoxone + 1.0L/ha 2,4-D Amine - 2.0L/ha Glyphosate (450 g glyphosate a.i) + 0.75l/ha 2,4-D Amine (hooded sprayer) Ratoon Cane - 2.0L 2,4-D Amine Aerial Application (20% of ratoons) - 1.3L/ha Starane + 1.0L/ha 2,4-D Amine (40% of ratoons) - 1.5L/ha 2,4-D Amine (40% of ratoons)	
A	Application technology	Equipment used to improve placement. Hooded sprayers used where suited.		
A	Record keeping	No record keeping		

<u>Burdekin BHWSS Region (reference soil type is HAT)</u>

Irrigation Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Irrigation	Furrow irrigation – not optimised producing significant losses to runoff and/or deep drainage	Crop water requirements + 100%	Crop water requirements + 100%

C	Irrigation	Furrow irrigation – not optimised producing significant losses to runoff and/or deep drainage	Crop water requirements + 50%	Crop water requirements + 50%
B	Irrigation	Furrow irrigation – optimised to minimise deep drainage and runoff losses	Crop water requirements + 20%	Crop water requirements + 20%
A	This class 'Aspirational' relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Irrigation	Drip, Overhead Low Pressure or Optimised Furrow to match crop requirements	Crop water requirements	Crop water requirements
Soil Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Cultivated ratoons	Cultivation of interrow for weed control in all ratoon crops	All ratoons have four passes.	1 x rip plus 3 x scarifier/hill up
D	Cultivated plant cane	Cultivation of block prior to planting cane and cultivation used for weed control in plant cane	Eight passes of block in preparation for planting.	Pre-planting = 4 x discing plus 2 x rip plus 1 x rotary hoe plus 1 x line marking Establishment = 1 x ripper/roller plus 2 x cutaway plus 1 x strawberry harrow plus 2 x scarifier/hill up
D	Cultivated bare fallow or ploughout replant	Where a fallow is used it is cultivated for weed control. Otherwise PORP	Six passes of bare fallow for weed control.	Bare fallow tillage 4 x disk plus 2 x rip
D	Record keeping	No record keeping		
C	Minimum till bare fallow	Bare fallow tilled less than a fully cultivated bare fallow	Six passes of block prior to planting	4 x discing plus 1 x rip plus 1 x bed former.
C	Cultivated plant cane	Zero cultivation of block prior to planting cane and cultivation used for weed control in plant cane	Three passes during plant establishment.	Post planting = 3 x scarifier/hill up

C	Cultivated ratoons			2 x scarifier/hill up
C	Record keeping	Basic with records farm diary and spray log book		
B	Controlled traffic with pre-formed beds	Row width matches machinery, beds for growing cane established	Zonal cultivation used to form beds	
B	Traffic controlled by GPS guidance	Planting and harvesting machinery uses satellite guidance	Planting and harvesting machinery using guidance.	Reduced curve number specific to soil type (85% of conventional curve number)
B	Double Disc Opener Planter	Cane is planted using DDO planter	Zero cultivation pre and post planting of cane	
B	Minimum till ratoons	Zero tillage in ratoons		Zero tillage in ratoons
B	Legume fallow cover crop	Legumes broadcasted prior to mounding	Fallow tillage operations = 4 x disk plus 1 x rip plus 1 x bedform.	Legume fallow cover crop
B	Record keeping	BSES journal and/or spray journal		
A	This class 'Aspirational' relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Controlled traffic permanent beds	Row width matches machinery, beds for growing cane established		
A	Traffic controlled by GPS guidance	All machinery uses satellite guidance	Planting, spraying, harvesting and haul out equipment	Reduced curve number specific to soil type (85% of conventional curve number)
A	Traffic controlled by GPS guidance	Planting and harvesting machinery uses satellite guidance		
A	Legume fallow grain crop	Fallows planted to legumes with zonal tillage used. Legumes are grown for grain.	Fallow tillage operations = 4 x disk plus 1 x rip plus 1 x bedform.	Soybean crop for grain
A	Zero till plant cane	Cane planted into permanent bed using double disk opener	Double disk opener. Zero cultivation pre and post planting of cane	Zero tillage

A	Green Cane Trash Blanket	One pass with rake to clear trash from irrigation furrow	1 x raking operation	Green Cane Trash Blanket
A	Record keeping	Computer based with farm management software		
Nutrient Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Single application rates over whole farm	Nutrients applied to all blocks at the same rate	N = 327 kg N/ha to plant cane N = 400 kg N/ha to ratoon cane	N = 327 kg N/ha to plant cane N = 400 kg N/ha to ratoon cane
D	Surface application	Surface application		
D	Record keeping	No record keeping		
C	Application rate based on old recommendations	Nutrients applied at a rate that is at the Calcino recommendations Plant cane and ratoons receive different rates	N = 150 kg N/ha to plant cane N = 250 kg N/ha to ratoon cane	N = 150 kg N/ha to plant cane N = 250 kg N/ha to ratoon cane
C	Granular fertiliser applied sub surface	Fertiliser applied sub-surface beside stool		
C	Record keeping	No record keeping		
B	Soil tested each cycle	Soil sampled every block at least once per crop cycle	All blocks soil sampled once per crop cycle.	
B	Rates block specific	Rate determined for each block based on soil test (six easy steps)	N = As calculated for specific soil types by Six easy steps N = 0 kg N/ha to plant cane – Assumption: perfect legume crop Practical: 100kg N/ha to plant cane following a legume fallow (average quality) N = 185 kg N/ha to ratoon	N = As calculated for specific soil types by Six easy steps N = 0 kg N/ha to plant cane – Assumption: perfect legume crop N = 155 kg N/ha to ratoon cane

			cane	
B	Applications sub surface	Nutrients applied underground	Stool splitter applicator	
B	Record keeping	No record keeping		
A	This class 'Aspirational' relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Soil sample based on soil and yield mapping	Soil samples taken in areas identified in yield or soil mapping	EM mapping (once only).	
A	Fertiliser rates variable within blocks	Fertiliser applied variably within blocks based on yield, soil mapping	EM mapping of blocks (once). Variable application machinery. N = Variable N rates for sub-blocks N = 0 kg N/ha to plant cane – Assumption: perfect legume crop Practical: 66 kg N/ha to plant cane following a legume fallow (average quality) 120 kg N/ha to ratoon cane	N = Variable N rates for sub-blocks N = 0 to plant cane N = N-replacement for APSIM modelling
A	Yield monitoring	Yield monitors used	Yield monitors on harvesting machinery.	
A	Record keeping	No record keeping		

Pesticide Management

Class	Practice	Description	Inputs	Justification
D	One strategy for whole farm	based on historic application rates	Plant Cane - 1.5L/ha Gramoxone + 1.0L/ha 2,4-D Amine + 0.5kg/ha Diurex Ratoon Cane - 2.0L 2,4-D Amine Aerial Application (20% of ratoons)	

			- 1.0L/ha Gramoxone + 1.0 2,4-D Amine (2 applications)	
D	Maximum label rate	Rates based on the maximum label rates		
D	Record keeping	No record keeping		
C	flexible chemical strategy	At least two strategies used over the farm	Fallow - 3L/ha Glyphosate (450 g glyphosate a.i) + 1.0L/ha 2,4-D Amine Plant Cane - 1.5L/ha Gramoxone + 3.0L/ha Stomp Xtra + 2.0kg/ha Atrazine - 1.5L/ha Gramoxone + 1.0L/ha Velpar K4 Ratoon Cane - 2.0L 2,4-D Amine Aerial Application (20% of ratoons) - 1.0L/ha Gramoxone + 1.0 2,4-D Amine (2 applications)	
C	Rate and product	Residuals at maximum and use of knockdowns		
C	Record keeping	No record keeping		
B	Herbicide strategy variable	Each block receives chemicals based on pressure	Legume Fallow - 3L/ha Glyphosate (450 g glyphosate a.i) + 1.0L/ha 2,4-D Amine Plant Cane - 1.5L/ha Gramoxone + 100g/ha Balance + 1.0kg/ha Soccer - 1.5L/ha Gramoxone + 1.0L/ha Velpar K4 Ratoon Cane - 1.0kg/ha Soccer + 100g/ha Balance	

			- 1.0L/ha Gramoxone + 1.0 2,4-D Amine	
B	Knockdowns	Knockdowns used instead of residuals where appropriate		
B	Application technology	Equipment used to improve placement		
B	Record keeping	No record keeping		
A	This class 'Aspirational' relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Knockdown replaces residual	Knockdown herbicides used in preference to residuals	Legume Fallow - 3L/ha Stomp Xtra - 2L/ha Glyphosate (450 g glyphosate a.i) + 0.25L/ha Surpass - 1L/ha Blazer Plant Cane - 1.5L/ha Gramoxone + 1.0L/ha 2,4-D Amine - 2L/ha Glyphosate (450 g glyphosate a.i) + 0.75L/ha 2,4-D Amine (hooded sprayer) (2 applications) - 3L/ha Glyphosate (450 g glyphosate a.i) + 1.0L/ha 2,4-D Amine Ratoon Cane - 1.0L/ha Gramoxone + 1.0 2,4-D Amine (outside hoods) + 2L/ha Glyphosate + 0.25L/ha Surpass (inside hoods) (hooded sprayer) - 1.5L/ha 2,4-D Amine + 1.0L/ha Starane (20% of ratoons aerial application)	
A	Application technology	Equipment used to improve placement.		

		Hooded sprayers used where suited.		
A	Record keeping	No record keeping		

Mackay (reference soil type is Eton)

Irrigation Management		Note: APSIM → Average 1 ML/ha in two irrigations (0.5 ML/ha). Consequences could be that yield and DIN numbers are underestimated!		
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Irrigation	Applied as overhead water (traveller and pivot)	3 ML/ha	3 ML/ha
C	Irrigation	Applied as overhead water (traveller and pivot)	3 ML/ha	3 ML/ha
B	Irrigation	Applied as overhead water (traveller and pivot)	3 ML/ha	3 ML/ha
A	Irrigation	Applied as overhead water (traveller and pivot)	3 ML/ha	3 ML/ha
Soil Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Cultivated ratoons	Cultivation of interrow for weed control in all ratoon crops	Two passes in all ratoon cane.	After harvest of cane, 1 x “centrebust” tillage operation 1 x trash incorporator
D	Cultivated plant cane	Cultivation of block prior to planting cane and cultivation used for weed control in plant cane	Nine passes of all blocks prior to planting. Six cultivations for weed control and filling in after planting.	Pre-planting 2 x disk plus 2 x rip plus 2 x rotary plus 2 x grubber plus markout plus conventional planter. Post planting 3 x cutaway plus 2 x weeder rake plus 1 x hillup
D	Cultivated bare fallow or ploughout replant	Where a fallow is used it is cultivated for weed control. Otherwise PORP	Three passes of fallow prior to preparation for planting.	Bare fallow, 3 x disc
D	Conventional traffic			
D	Record keeping	No record keeping		

C	Minimum till bare fallow	Bare fallow ploughed less than a cultivated bare fallow	Two passes of fallow prior to preparation for planting.	Bare fallow, 2 x disc
C	Cultivated legume or grassy fallow	Legume planted in fallow with cultivation for weed control or block left alone without any cultivation		
C	Cultivated plant cane	Cultivation of block prior to planting cane and cultivation used for weed control in plant cane	Seven passes for planting preparation. Four cultivations for weed control and filling in after planting.	Pre-planting 2 x disk plus 2 x rip plus 1 x rotary plus 1 x grubber plus markout plus conventional planter. Post planting 2 x cutaway plus 1 x semi-hillup (weeder rake) plus 1 x hillup
C	Cultivated ratoons	Cultivation of interrow for weed control in all ratoon crops	One pass in all ratoon cane.	0.5 x trash incorporator (only on areas that require it)
C	Conventional traffic			
C	Record keeping	Records kept in daily diary		
B	Controlled traffic permanent beds	Row width matches machinery, beds for growing cane established and retained between crop cycles	Cultivation of bed zone only.	
B	Traffic controlled by GPS guidance	Planting and harvesting machinery uses satellite guidance	Planter and harvester fitted with guidance.	Reduced curve number specific to soil type (85% of conventional curve number)
B	Zonal tillage	Only the beds where cane is grown (and traffic is kept off) cultivated	Five cultivations of bed zone only for planting preparation.	Pre-planting zonal 1 x rotary hoe plus 1 x rip plus 1 x drum roller plus 1 x grubber (S tyne) plus 1 x hillup plus planter
B	Zero till ratoons	No tillage used for weed control in ratoons		
B	Fallow		Two cultivations of bed zone for legume planting preparation.	Cover crop in fallow 1 x zonal rip plus 1 x zonal rotary hoe
B	Record keeping	Records kept in paddock journal		
A	This class ‘Aspirational’ relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems			

	under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Controlled traffic permanent beds	Row width matches machinery, beds for growing cane established and retained between crop cycles		
A	Zero till		Two cultivations of bed zone for cane planting preparation.	2 x zonal ripper/rotary hoe combined plus planter
A	Traffic controlled by GPS guidance	All machinery uses satellite guidance	Planting, spraying, harvesting and haul out equipment.	Reduced curve number specific to soil type (85% of conventional curve number)
A	Fallow		Two cultivations of bed zone for legume planting preparation.	Grain crop in fallow 1 x zonal rotary plus 1 x zonal rip
A	Record keeping	Records kept in computer data base		
Nutrient Management				
Class	**Practice**	**Description**	**Inputs**	**Description for modelling**
D	Single application rates over whole farm	Nutrients applied to all blocks at the same rate	N = 192 kg N/ha to plant cane N = 240 kg N/ha to ratoon cane	N = 192 kg N/ha to plant cane N = 240 kg N/ha to ratoon cane
D	Surface application			
D	Record keeping	No record keeping		
C	Application rate based on old recommendations	Nutrients applied at a rate that is at the Calcino recommendations	N = 144 kg N/ha to plant cane N = 180 kg N/ha to ratoon cane	N = 144 kg N/ha to plant cane N = 180 kg N/ha to ratoon cane
C	One or two rates for the whole farm	Plant cane and ratoons receive different rates		
C	Record keeping	Daily diary		
C	Sub-surface application			
B	Soil tested each cycle	Soil sampled every block at least once per	Each block once per crop	

		crop cycle	cycle.	
B	Rates block specific	Rate determined for each block based on soil test (six easy steps)	N = As calculated for specific soil types by Six easy steps N = 0 kg N/ha to plant cane – Assumption: good legume crop Practical: 33kg N/ha to plant cane following a legume fallow to achieve the phosphorus and potassium requirements of the crop. N = 150 kg N/ha to ratoon cane Typical for the Mackay Whitsunday region are very low to medium low N mineralisation indices, suggesting baseline N rates of 150 to 170 kg N/ha.	N = As calculated for specific soil types by Six easy steps N = 0 kg N/ha to plant cane – Assumption: good legume crop N = 140 kg N/ha to ratoon cane Assumption: Medium N mineralisation (based on experiments Eton site by Bronwyn Masters)
B	Applications sub surface	Nutrients applied underground	Stool splitter	
B	Calibrated between batches	Fertiliser box calibrated each time a new fertiliser batch or product is changed		
B	Record keeping	Records kept in paddock journal		
A	This class ‘Aspirational’ relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Soil sample based on soil and yield mapping	Soil samples taken in areas identified in yield or soil mapping	EM mapping once	
A	Fertiliser rates variable within blocks	Fertiliser applied variably within blocks based on yield, soil mapping	Assumption: good legume crop. Assumption: Medium N mineralisation (based on experiments Eaton site by Bronwyn Masters) EM mapping of blocks (once).	Assumption: good legume crop Assumption: Medium N mineralisation (based on experiments Eaton site by Bronwyn Masters) N = Variable N rates for sub-blocks N = 0 to plant cane

			Variable application machinery. N = Variable N rates for sub-blocks N = 0 kg N/ha to plant cane	N = N-replacement for APSIM modelling
A	Yield monitoring	Yield monitors used	Yield monitors on harvesters.	
A	Record keeping	Records kept in computer database and or paddock journal		
Pesticide Management				
Class	**Practice**	**Description**	**Inputs**	**Justification**
D	One strategy for whole farm	based on historic application rates		
D	Maximum label rate	Rates based on the maximum label rates	Plant cane: 1.5L 2,4-D 4kg Atrazine 1.5L Gramoxone 3kg Diuron Ratoon cane: 3L 2,4-D 4kg Atrazine 1.5L Gramoxone 3kg Diuron	
D	Record keeping	No record keeping		
C	flexible chemical strategy	At least two strategies used over the farm		
C	Rate and product	Residuals at maximum and use of knockdowns	Plant cane: 1.5L 2,4-D 4kg Velpar 1.5L Gramoxone 3L Stomp Ratoon cane: 2L 2,4-D 4kg Atrazine 2L Gramoxone	

			3kg Diuron	
C	Record keeping	No record keeping		
B	Herbicide strategy variable	Each block receives chemicals based on pressure		
B	Knockdowns	Knockdowns used instead of residuals where appropriate	Plant cane: 3kg Velpar 2kg Atrazine 3.3L Stomp Extra 2.5L Roundup PowerMax Ratoon cane: 1.5L 2,4-D 0.35L Flame Soy: 9.5L Roundup PowerMax 0.045L Verdict 0.3L Blazer 0.14kg Spinnaker	
B	Application technology	Equipment used to improve placement		
B	Timing	Application timed to stage of growth, rainfall, irrigation		
B	Record keeping	No record keeping		
A	This class ‘Aspirational’ relates to Proof of concept practices. All the information that is being presented in this section is based on farming systems under research, scientifically sound but commercial viability not yet proven and caution must be taken with the interpretation of the actual numbers presented below.			
A	Variable herbicide within blocks	herbicide application varies within block based on need using GPS		
A	Knockdown replaces residual	Knockdown herbicides used in preference to residuals	Plant cane: 1kg Velpar 0.6kg Atrazine 1L Stomp Extra 3.5L Roundup PowerMax Ratoon cane:	

			0.105L Flame 0.5L 2,4-D 3.5L Roundup PowerMax Soy: 9.5L Roundup PowerMax 0.045L Verdict 0.3L Blazer 0.14kg Spinnaker	
A	Application technology	Equipment used to improve placement		
A	Record keeping	No record keeping		

2.2.2. Grazing

This section describes management practices for rangeland (BDT) and wet coastal grazing (WT) identified in the UBCD framework. The identification of management practices is required so that economic modelling can predict the impact on farmers from moving between management practice classes. Load reductions associated with moving between the management practice classes can also be predicted. Consequently, descriptions of the different management practice classes require absolute figures for inputs so that economic costs can be accurately assigned.

Rangeland (BDT)			
Class	**Practice**	**Description**	**Inputs**
D	Stocking rate	Continuous high stocking rates with no monitoring of pastures. Only estimates of overall stock numbers known and stock numbers in breeder paddocks generally kept constant.	
D	Pasture spelling	Spelling rarely or not practiced	
D	Grazing management	Overgrazing of river frontage and other sensitive land type areas unavoidable and evidence of invasive non-palatable plants (weeds), notably lantana and rubber vine. Ground cover targets exceeded for most grazing land types in most years.	
D	Ground cover	Usually have less than 40% ground cover in 70% of years.	
D	Off-stream watering	No off-stream watering points developed	
D	Paddock sub-division	No subdivisional fencing or capacity to manage land condition	
D	Gully management	Gully management not used for any grazing land types	
D	Frontage country management	Riparian / frontage grazing land types are not managed independently of other grazing land type. Frontage areas in poor condition (e.g. stock damage/serious	

		erosion evident, non-palatable plant infestation (weeds))	
C	Stocking rate	Stocking to carrying capacity and prepared to reduce stock in dry periods.	
C	Pasture spelling	Occasional wet season spelling on paddocks of concern	Some additional fencing and labour for moving of stock
C	Grazing management	Pasture management strategy based on the major grazed land type. Pasture monitoring in spring and autumn conducted for the major grazing land type. Stocking rates adjusted in response to pasture monitoring if required to achieve ground cover targets.	Some additional fencing and labour for moving of stock
C	Ground cover	Maintaining ground cover of 40% at break-of-season rain.	Some additional fencing and labour for moving of stock
C	Off-stream watering	Only a few strategically placed off-stream watering points at pressure areas	Some watering points
C	Paddock sub-division	Limited subdivisional fencing and little capacity to manage land condition effectively	
C	Gully management	Gully management not used for any grazing land types	
C	Frontage country management	Frontage areas in reasonable condition and some management practices applied to large paddocks which include river frontage	Some additional fencing and labour for moving of stock
B	Stocking rate	Stocking to a safe carrying capacity with adjustments as required according to pasture observation in the wet and dry seasons	Additional fencing and labour for moving of stock
B	Pasture spelling	Where necessary, early or entire wet season spelling of all paddocks every 4-6 years	Additional fencing and labour for moving of stock
B	Grazing management	Pasture management strategy that independently manages the resilient and less resilient grazing land types. Pasture monitoring in spring and autumn conducted for one resilient and one less resilient grazing land type. Stocking rates adjusted independently for the resilient and less resilient grazing land types in response to pasture monitoring if required to achieve ground cover targets. Riparian / frontage grazing land types are managed independently of other grazing land types. 30-70% of utilised frontage country fenced to manage ground cover, particularly through wet season spelling.	Additional fencing and labour for moving of stock
B	Ground cover	Maintaining 60% ground cover for break-of-season rain	Additional fencing and labour for moving of stock
B	Fire management	Planned use of fire for targeting woody weeds or timber thickening	
B	Off-stream watering	Off-stream watering points 4 – 6 km apart along waterways within frontage	Additional fencing and watering

		paddocks with more possible	points
B	Paddock sub-division	Some subdivision fencing of land types and some ability to segregate stock classes and manage ground cover, as well as ease of mustering	Additional fencing and labour for moving of stock
B	Gully management	Prevent establishment of new gullies and contain expansion of established gullies in susceptible or less resilient grazing land types.	
B	Frontage country management	Riparian / frontage grazing land types are managed independently of other grazing land types. Pasture monitoring in spring and autumn conducted for riparian / frontage grazing land types. 30-70% of utilised frontage country fenced to manage ground cover, particularly through wet season spelling	Additional fencing and labour for moving of stock
A	Pasture spelling	Where necessary, early or entire wet season spelling of all paddocks every 3-4 years	Additional fencing and labour for moving of stock
A	Grazing management	Pasture management strategy based on all grazing land types. Pasture monitoring in spring and autumn conducted for all grazing land types. Stocking rates adjusted independently for all grazing land types in response to pasture monitoring if required to achieve ground cover targets. Almost all frontage country on utilised sections of the property fenced enabling effective management of all classes of stock, use of wet season spelling, management of stock numbers to maintain good land condition and river bank integrity.	
A	Ground cover	Maintaining 80% ground cover for break-of-season rain.	Additional fencing and labour for moving of stock
A	Fire management	Fire either excluded or used in a planned way for targeting woody weeds or timber thickening or other management purposes	
A	Off-stream watering	Off-stream watering points 2 - 4 km apart along waterways within frontage paddocks	Additional fencing and watering points
A	Paddock sub-division	Utilised sections of the property effectively fenced and watered enabling management of all classes of stock and land types to maintain good land condition.	Additional fencing and labour for moving of stock
A	Gully management	Prevent establishment of new gullies and contain expansion of established gullies in all grazing land types.	
A	Frontage country management	Almost all frontage country on utilised sections of the property fenced enabling effective management of all classes of stock, use of wet season spelling, management of stock numbers to maintain good land condition and river bank integrity	Additional fencing and labour for moving of stock

Wet Coastal Grazing (WT)			
Class	**Practice**	**Description**	**Inputs**
D	Stocking rate	Stocking level maximised as much as possible so that carrying capacity may be frequently exceeded	
D	Grazing management	Pastures continuously grazed and evidence of substantial non-palatable plant infestation (weeds) in pasture	
D	Ground cover	Limited ground cover with substantial non-palatable plant infestation (weeds) and/or soil erosion	
D	Paddock sub-division	No subdivisional fencing or capacity to manage land condition	
D	Land type management	Different land types not understood and not accounted for in property management	
C	Stocking rate	Stocking to carrying capacity but prepared to reduce stock and emergency feed in dry periods.	Some additional fencing and labour for moving of stock
C	Grazing management	Grazing management does not always allow recovery of pasture mix and some evidence of excessive non-palatable plants	
C	Ground cover	Reasonable ground cover and some evidence of excessive non-palatable plants and/or soil erosion	Some additional fencing and labour for moving of stock
C	Riparian management	Riparian areas in poor condition (e.g. stock damage/serious erosion evident)	
C	Paddock management	Limited subdivisional fencing and little capacity to manage land condition effectively	Some additional fencing and labour for moving of stock
C	Land type management	Land types known but not considered in paddock design.	
B	Stocking rate	Stocking to sustainable carrying capacity but stock numbers still adjusted according to pasture observation and management	Additional fencing and labour for moving of stock
B	Grazing management	Strategic grazing management that allows recovery of pasture mix	Additional fencing and labour for moving of stock
B	Ground cover	Maintaining complete ground cover relevant to seasonal conditions	Additional fencing and labour for moving of stock
B	Riparian management	Riparian areas in reasonable condition and some management practices applied (e.g. strategic off-stream watering, causeways, fencing)	Additional fencing and some watering points
B	Paddock sub-division	Some subdivision fencing and some ability to segregate stock classes and to manage ground cover	Additional fencing and labour for moving of stock

B	Land type management	Land types known and used for placement of fencing and property management	Land survey
A	Grazing management	Strategic grazing management that always allows full recovery of pasture mix	Additional fencing and labour for moving of stock
A	Ground cover	Maintaining complete ground cover and pasture mix relevant to seasonal conditions	Additional fencing and labour for moving of stock
A	Riparian management	Riparian areas in good condition and effective management practices applied (e.g. strategic off-stream watering, causeways, fencing)	Additional fencing and watering points
A	Paddock sub-division	Property effectively fenced and watered, enabling management of all classes of stock to maintain good land condition	Additional fencing and labour for moving of stock

2.2.3. Bananas

This section describes management practices identified in the WT for bananas as identified in the UBCD framework. The identification of management practices is required so that economic modelling can predict the impact on growers from moving between management practice classes. Load reductions associated with moving between the management practice classes can also be predicted. Consequently, descriptions of the different management practice classes require absolute figures for inputs so that economic costs can be accurately assigned.

Wet Tropics

Soil Management			
Class	**Practice**	**Description**	**Inputs**
D	Full cultivation	Full cultivation of block in preparation for planting at any time of the year (includes rotary hoeing)	Eight passes of entire block in preparation for planting
D	Zero fallow	No fallow period	
C	Full cultivation considering timing	Full cultivation of block in preparation for planting, avoiding high risk (heavy rainfall) times of the year	Eight passes in preparation for planting, avoiding cultivation in the November to April period
C	Unmanaged fallow	Weedy or bare fallow	
C	Planting on slopes	Slope not taken into account when planting	

B	Reduced tillage	Crop removal using spray out then tillage minimized to less than 5 operations	Five passes of only the planted area in preparation for planting
B	Fallow cropping	Fallow cropping of all cropped area	Rotation crop planted (usually sugarcane)
B	Contour banks used	Area contoured where slope is an issue	Part of farm establishment
B	Field drain design	Grassed spoon or stable, battered drains	Part of farm establishment
B	Block drainage	Laser levelling used where appropriate	Part of farm establishment
B	Sediment traps	Used where appropriate	Part of farm establishment
A	Zonal tillage	Preformed beds used for crop, using zonal tillage for planting preparation	Beds permanently established, tillage only of the bed area. Four passes in preparation for planting
A	Fallow crop preformed beds	Preformed beds used for cropping and fallow crop	Rotation crop grown on permanent beds, usually a green manure
A	Low slope planting	Plant on slopes only where soil loss can be managed	Part of farm establishment
A	Controlled traffic	Permanent machinery tracks established	Part of farm establishment
A	Headland management	Headlands managed to prevent erosion	Part of farm establishment
Nutrient Management			
Class	**Practice**	**Description**	**Inputs**
D	Crop nutrient status analysis	No soil or leaf testing	
D	Fertiliser rate	One NPK rate for farm based on historical rates used that take no account of recommended rates	600N, 100P, 900K
D	Fertiliser application method	Applied using a broadcasting fertiliser spreader on a calendar basis with no accounting for high risk periods	Fertiliser spread fortnightly with spreader
C	Soil and leaf analysis	Annual soil test pre plant all blocks for nutrient & pH levels then annually in indicator blocks only	One leaf test and one soil test annually in blocks to be planted
C	Fertiliser rate	One NPK rate for farm based on historical rates used that take no account of recommended rates	400N, 50P, 600K
C	Fertiliser application method	Applied using a broadcast type spreader every 4-6 weeks	Fertiliser spread monthly with spreader

B	Soil and leaf analysis	Soil(including pre plant) and leaf testing carried out to determine annual nutrient & pH needs in relation to a nutrient target then applied at planting	One leaf test and one soil test annually in blocks to be planted
B	Fertiliser rate	Use recommended rates of N and applied fortnightly by block & use recommended rate of P and applied on a regular basis.	300N, 50P, 450K
B	Fertiliser application method	Fertigate and banded surface applications when fertigation unsuitable due to rainfall	Fertigation equipment and spreader
B	Spatial soil ameliorants	Site specific soil ameliorants used to improve soil health.	Geo-referenced soil testing and targeted application
B	Banana waste nutrient input accounted for	Returning banana waste from shed to paddock	
A	Soil and leaf analysis	Soil(including pre plant) and leaf test more than once a year per block carried out to determine annual nutrient & pH needs in relation to a nutrient target then applied at planting	Two soil tests and two leaf tests per year in every block
A	Fertiliser rate	Use recommended rates of N & P and applied fortnightly by block and each application relates to growth rate and stage of growth of plants	300N, 50P, 450K
A	Spatial fertiliser management	Yield mapping used with other data to apply fertiliser according to soil variations	Soil properties determined at farm establishment, fertiliser applied spatially
A	Slow release fertiliser	Using innovative/alternative sources of fertiliser	Slow release nitrogen fertiliser used and organic sources of nitrogen and potassium accounted for

Weed Management

Class	Practice	Description	Inputs
D	Application frequency	Application at standard interval regardless of weather	Monthly application of crop area
D	Interrow management	Bare inter row and cultivated	Monthly cultivation of interrow
D	Mulch management	Trash residue removed or disposed of with bare inter rows	
C	Equipment calibration	Equipment calibrated based on historical experience.	
C	Interrow management	Either a weedy interrow or spray out the interrow in ratoons	Monthly spraying of interrow
C	Mulch management	Trash kept but left where it drops	

B	Equipment calibration	Equipment calibrated prior to job and nozzles suited to job.	
B	Application frequency	Application based on informal monitoring and weather forecast	Six weekly application to cropped area
B	Interrow management	Ground cover kept in inter row in periods of highest risk and slashed as required	Interrow slashed monthly
B	Mulch management	Leaf mulch kept largely on the beds	
B	Herbicide selection	Product selected according to climatic conditions	
A	Equipment calibration	Equipment calibrated prior to job and nozzles suited to job plus calibration records including application testing	
A	Application frequency	Application based on thresholds for weed size, species etc including crop stage	Targeted spraying, spatially and temporally
A	Companion planting	Companion planting such as millet with banana plantlets	Millet planted at crop establishment
A	Interrow management	Ground cover promoted and maintained in fallow and inter row all the time	Monthly slashing
A	Weedicide selection	Product selected according to climatic conditions and consideration of risk of movement of chemical	
Insect/Disease Management			
Class	**Practice**	**Description**	**Inputs**
D	Chemical application	Chemicals applied intermittently	
C	Calibration	Annual calibration	
C	Chemical application	Applied on informal monitoring of disease or calendar basis	
B	Calibration	Calibrated and nozzles used as per label	
B	Chemical application	Products applied according to monitoring threshold for frequency and product	
B	Application placement	Under canopy application targeted to seasonal conditions, disease incidence in combination with aerial application	
B	Chemical selection	Product selected based on monitoring data, seasonal condition and disease incidence and fungicide resistance management	
A	Monitoring	Off site testing for chemical residues in place	

Irrigation			
Class	**Practice**	**Description**	**Inputs**
D	Irrigation method	Travelling irrigation used	Capital at farm establishment
D	Irrigation management	Same strategy used across the whole farm	
D	Irrigation scheduling	Scheduling based on experience of growing the crop previously often on a calendar basis	
D	Irrigation application	Uniformity of application unknown	
C	Irrigation method	Overhead sprinklers	Capital at farm establishment
C	Irrigation management	Application rates vary with crop stage only not soil type	
C	Irrigation scheduling	Scheduling based on subjective tools e.g. feel , inspection of soil, water availability & area	
C	Irrigation application	Uniformity of distribution not as good as it could be possibly below industry benchmark or 80%	
B	Irrigation method	Manually operated irrigation system under canopy irrigation with fertigation capacity	Capital at farm establishment
B	Irrigation management	Manually operated application rate suited with a different strategy for each soil type and crop stage	Soil types mapped
B	Irrigation scheduling	Scheduling based on the use of tools such as tensiometers to measure soil moisture only	
B	Irrigation application	Uniformity of distribution at industry benchmark of 81-85%	
A	Irrigation method	Automated drip or micro irrigation systems with fertigation capacity	Capital at farm establishment
A	Irrigation management	Application rate suited to soil type & crop stage using automated irrigations systems	Soil types mapped
A	Irrigation scheduling	Scheduling of irrigation based on an assessment of likely soil moisture using tools such as tensiometers, capacitance probes, weather stations, evaporation pans & knowledge of crop water requirements and projected rainfall.	Tools such as enviroscan installed
A	Irrigation application	Uniformity of distribution of irrigation water consistently above industry benchmark (typically >90% (Distribution uniformity)	

DISCUSSION AND CONCLUSION

The identification of management practices is required so that economic modelling can predict the impact of growers moving between farming systems. Load reductions associated with moving between these systems can also be predicted. Consequently, descriptions of the different management practices and corresponding systems require absolute figures for inputs so that economic costs can be accurately assigned. Where these figures are not available, assumptions have been made to generate these numbers. As an example, the 'A' class relates to Proof of concept practices. All the information that is being presented in this section is based on management practices and or farming systems under research, scientifically sound but commercial viability has not yet been proven and caution must be taken with the interpretation of the actual numbers presented in this report.

The framework presented in this report will form the basis for economic modelling under the MTSRF project 3.7.5 and Reef Rescue Monitoring & Evaluation Paddock to Reef Cane Economics project. The reports that currently build on this work are:

East, M. and Van Grieken, M.E., 2010. Paddock to Reef Monitoring & Evaluation: Economic analysis of ABCD cane management practices for the Mackay Whitsunday region. The State of Queensland, Department of Employment, Economic Development and Innovation, 2010.

Poggio, M., Page, J. and Van Grieken, M.E., 2010. Paddock to Reef Monitoring & Evaluation: Economic analysis of ABCD cane management practices for the Wet Tropics region. The State of Queensland, Department of Employment, Economic Development and Innovation, 2010.

Poggio, M., Page, J. and Van Grieken, M.E., 2010. Paddock to Reef Monitoring & Evaluation: Economic analysis of ABCD cane management practices for the Burdekin Dry Tropics BRIA region. The State of Queensland, Department of Employment, Economic Development and Innovation, 2010.

Van Grieken, Poggio, M., East, M. and Page, J., 2010. Reef Rescue Paddock To Reef Monitoring and Evaluation: Cane economics. A report to Reef Catchments. CSIRO: Water for a healthy Country National Research Flagship.

Van Grieken, M.E., Webster, A.J., Poggio, M., Thorburn and P. Biggs, J., 2010. Implementation costs of Agricultural Management Practices for Water Quality Improvement in the Great Barrier Reef Catchments. A report to the MTSRF. CSIRO: Water for a Healthy Country National Research Flagship.

REFERENCES

Dight, I 2009 Burdekin Water Quality Improvement Plan, NQ Dry Tropics, Townsville.

Drewry, J., Higham, W. and Mitchel, C., 2008. Water Quality Improvement Plan. Final report for Mackay Whitsundays region.

Kroon, F.J. 2008. Draft Tully Water Quality Improvement Plan. CSIRO: Water for a Healthy Country National Research Flagship.

Measuring the economic & financial value of the Great Barrier Reef Marine Park, 2005-06. Report by Access Economics Pty Ltd for Great Barrier Reef Marine Park Authority, February 2007.

Reef Rescues Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, Reef Catchments, 28 July 2009. (http://www.nrm.gov.au/business-plan/10-11/priorities/coastal/reef/pubs/reef-rescue-r-and-d-plan.doc)

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