Updated 2013

Paddock to Reef Integrated Monitoring, Modelling and Reporting Program

Paddock Monitoring Final Design

Mackay Whitsunday, Dec-2009

2013 Amendments to
Paddock to Reef Integrated Monitoring, Modelling and Reporting Program
Paddock Monitoring Final Design
Mackay Whitsunday (January 2013)

Summary
The Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, Paddock Monitoring Design for Mackay Whitsunday was finalised in December 2009 and updated in 2011 (detailed on page four). The original design set out the treatments, monitoring and reporting methods for two paddock monitoring sites, as well as water quality monitoring for a multi-farm and a multi-block site.

1.0 Trial Updates

1.1 Equipment removed
In late 2012 some major changes were made to the monitoring program. Monitoring equipment was removed from the Marian site due to repeated extreme flooding preventing the collection of reliable samples. The site has been maintained for productivity purposes and it is hoped that rainfall simulation can be used to gather water quality data. Water quality monitoring equipment was removed from the multi-block site for the same reasons. Water quality monitoring will continue at the multi-farm site.

1.2 New treatments installed
Two new treatments were added to the Victoria Plains site. This includes a treatment looking at best management practice nutrient and soil management with banded herbicide application and a comparative treatment with best management practice soil, conventional nutrient management and broadcast residual herbicide. Additional treatments are on 1.8m-row spacing with ten rows each.

Table 1: Description of treatments at Victoria Plains 2012/2013

	ABCD	Soil	Nutrient	Herbicide
Treatment 1 30 Rows	CCC	1.5m current practice	Generalised recommendation	Broadcast residual[1]
Treatment 2 25 Rows	BBB	1.8m controlled traffic	Six easy steps	Broadcast Knockdown[2]
Treatment 3 10 Rows (new)	BCC	1.8m controlled traffic	Generalised recommendation	Broadcast residual
Treatment 4 10 Rows (new)	BBB	1.8m controlled traffic	Six easy steps	Banded residual

1. For example, Velpar K4 at 3kg/ha and possible 2,4-D and paraquat if needed for vine control.
2. For example, Flame, and possible Gramoxone and 2,4-D if needed for vine control.

1.3 Soil management new treatments
The two new treatments at the Victoria Plains site consist of ten rows each and both planted at 1.8m row spacing. The cane is at third ratoon stage.

1.4 Nutrient treatment management new treatments
Treatment 3 has conventional nutrient management with a generalised recommendation of 197 kg of N applied per hectare. Nutrients are surface applied as a liquid, as with Treatments 1 and 2.

1.5 Herbicide management new treatments
The new treatments compare broadcast and banded application of residual herbicides. Treatment three has Velpar broadcast at 3.8kg per hectare. Treatment four has Velpar applied as a band at 3.8 kg per hectare. Depending on weed pressure a knock down may be applied in the inter-row.

Table 2: Nutrient schedules for 2012/13

Treatments	N	P	K	S
T1& T3 Traditional: 1.5 m & 1.8m @ 1.63 ha	200	25	80	5-10
T1 & T3 MKY 200P @ 3.8 m3/ha	197	25	97	33
T2 & T4 six easy steps 1.8m 1.33 ha	135	25	80	5-10
T2 & T4 PMR2 @ 3.7 m3/ha	135	25	100	30

Table 3: Herbicide schedules for 2012/13

T1 30 rows	**T2 25 rows**	**T3 10 rows** (new)	**T4 10 rows** (new)
1.5m Broadcast regulated residual (Velpar 3.8 kg/ha)	1.8m Broadcast non reg residual (Flame 400ml/ha)	1.8m Broadcast regulated residual (Velpar 3.8 kg/ha)	1.8m **Banded** regulated residual (Velpar 3.8 kg/ha) – inter row weed control with knock down if required

2011 Amendments to
Paddock to Reef Integrated Monitoring, Modelling and Reporting Program
Paddock Monitoring Final Design
Mackay Whitsunday, (Dec-2009)

Summary
The Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, Paddock Monitoring Design for Mackay Whitsunday was finalised in December 2009. The design set out the treatments, monitoring and reporting methods for two paddock monitoring sites, as well as water quality monitoring for a multi-farm and a multi-block site.

There has since been a slight alteration for two treatments, resulting in a shift from an A to a B level management practice for nutrient management in treatment 2 at the Victoria Plains site and A to B level herbicide management in treatment 4 at the Marian site.

1.0 Project staff

There has been a change in the project staff as from mid- 2011 – the regional coordinator Adam Folkers has been replaced by Belinda Billing and Amanda Bush, the project officer, has been replaced by Kaela McDuffie.

Position	Name	FTE	Organisation location	Position Funder	Comments
GBR M&M:					
Regional coordinator	Belinda Billing	1.0	Mackay Whitsunday (Reef Catchments)	Qld Govt.	
Technical leader	Ken Rohde	0.5	DERM (Mackay)	DERM	
Project officer(s) 1:	Kaela McDuffie	1.0	DERM (Mackay)	Reef Catchments	
2:	Vacant	1.0	DERM (Mackay)	DERM	
Technician(s) 1:	John Agnew	0.5	Mackay	Reef Catchments	
Associated projects:					
Project Catalyst	Phil Trendell	0.5	Mackay Whitsunday (Reef Catchments)	Coca Cola Fund	

2.0 Nutrient management

The Victoria Plains site nutrient management regime changed from N-Replacement (A classification) to Six Easy Steps (B classification) prior to the trials beginning.

This was conducted because a very strong legume crop planted in the fallow which produced high levels of nutrient, far exceeding what may be termed N-replacement. For this reason, it was decided that it would be more appropriate to change to the B level Six Easy Steps, in lieu of the unproven commercial viability of the N-replacement.

Table 1. Management practices paddock scale trial - Victoria Plains site

	ABCD Classification	Soil management	Nutrient management	Herbicide management
Treatment 1	CCC	1.5m current practice	Generalised [1] recommendation (e.g. 150 kg N/ha)	Residual [2]
Treatment 2	BBB	1.8m controlled traffic	Six easy steps	Knockdown[3]

1. Nitrogen rate applied does not take into account the contribution from the soybean crop
2. For example, Velpar K4 at 3kg/ha and possible 2,4-D and paraquat if needed for vine control.
3. For example, Flame, and possible Gramoxone and 2,4-D if needed for vine control.

3.0 Nutrient management practices for plant and ratoon cane

Both the Marian and the Victoria Plains trial sites began with the use of granular fertiliser on their plant cane.

In the first and second ratoon, site managers swapped to liquid fertiliser which . Application of varying rates of N and P is easier using liquid products because of the range of products available. This is important because products are applied by contractors. See technical reports for specific annual applications of nutrients; products and rates will vary from year to year, but will always comply to the allocated A, B or C management practice standard for each treatment.

4.0 Herbicide management practices

Treatment 4 at the Marian site is currently being treated with B level herbicide management practice (See appendix A for ABCD frame work description). The treatment was initially to receive A level herbicide management, however the land owners do not own a shielded spray unit, which is required to meet the A level management practice. This has meant that the original design was altered to B level management practice with knockdown herbicides applied as a directed spray to the interspace and base of the cane stool.

See technical reports for specific annual applications of herbicides; products and rates will vary from year to year, but will always comply to the allocated A, B or C management practice standard for each treatment.

Table of Contents

Paddock to Reef Program Integrated Monitoring and Modelling
Final Design Plan Report
Mackay Whitsunday, Dec-2009

This document describes the final design for paddock monitoring for the Mackay Whitsunday region, including strip scale, multi-block & multi-farm sites. Where sites are funded from other sources and subsequent data is related to the paddock monitoring program objectives, these sources have been described.

2.0 Project staff

Position	Name	FTE	Organisation location	Position Funder	Comments
GBR M&M:					
Regional coordinator	Belinda Billing	1.0	Mackay Whitsunday (Reef Catchments)	Qld Govt	
Technical leader	Ken Rohde	0.5	DERM (Mackay)	DERM	
Project officer(s) 1:	Kaela McDuffie	1.0	DERM (Mackay)	Reef Catchments	
2:	Vacant	1.0	DERM (Mackay)	DERM	
Technician(s) 1:	John Agnew	0.5	Mackay	Reef Catchments	
Associated projects:					
Project Catalyst	Phil Trendell	0.5	Mackay Whitsunday (Reef Catchments)	Reef Catchments	

1. Experimental design

1.1. Paddock scale plots (strip scale)

The Mackay Whitsunday region has two paddock water quality monitoring sites (both within the Sandy Creek catchment), with five sugar cane runoff treatments located in one paddock and two sugar cane runoff treatments located within another paddock. The seven treatments will look to quantify water quality improvements at a strip scale through improved sugar cane farming practices.

Funding for the strip scale treatments are provided by the Paddock to Reef Monitoring & Evaluation Program (four treatments) and Reef Catchments "Project Catalyst" (three treatments). Treatments funded by Project Catalyst are defined as A class cutting edge practices according to the Mackay Whitsunday Water Quality Improvement Plan (Refer to Appendix A).

Site 1 Marian Soil (Sugar Cane)

Site 1 is a sugar cane farming system and is located near North Eton, south west of Mackay (Farm 3120, Block 2-2; **Figure 1**). The site is situated on Marian soil type (duplex soil) which makes up 28% of the regions' cane land.

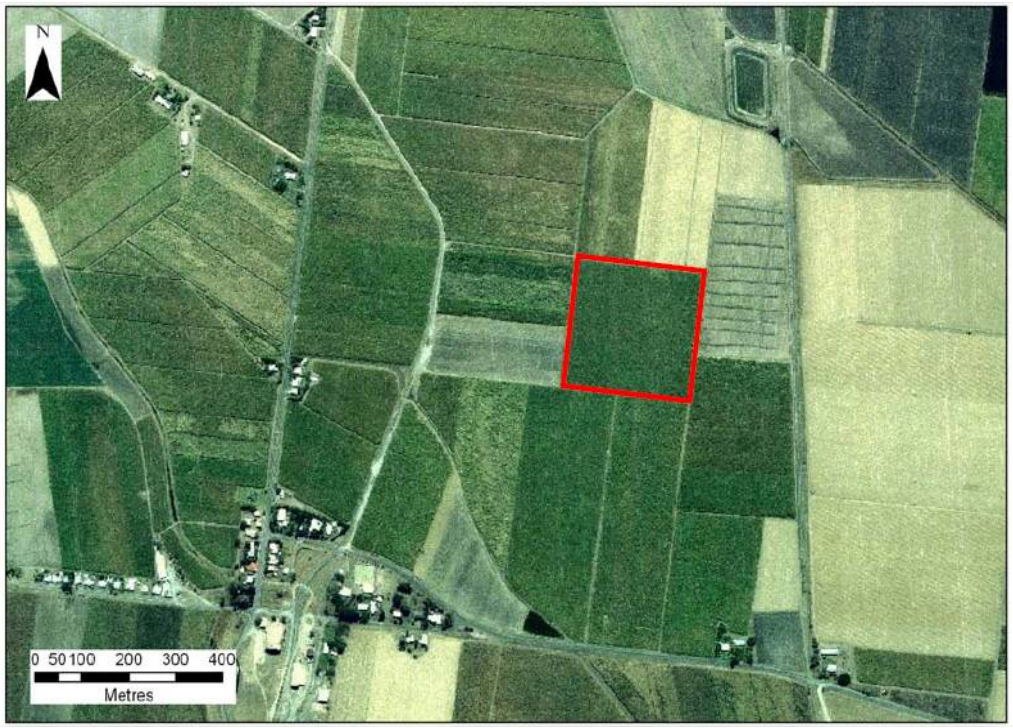

Figure 1. Location of the block selected for the strip-scale monitoring on the Marian soil.

The style of management for each plot under the ABCD management framework is consistent with the Mackay Whitsunday Water Quality Improvement Plan (MWWQIP), as described in Table 1 below. An outline of the ABCD management framework for cane farming land from the MWWQIP is listed in Appendix A. Details of management practices for each plot at the Marian site are described in Table 3.

Each plot treatment will demonstrate a system of management practices targeting ABC or D. However, the following practices are directly comparable (i.e. all other influential factors are equal). The main management comparisons will be:

Soil Management

- 1.5m current practice vs 1.8m controlled traffic vs 1.8m controlled traffic skip row.

Nutrient Management

- Generalised recommendation (~ 200kg N/ha) vs Six easy steps vs N replacement

Herbicide Management

- Residual Herbicide vs Knockdown/Residual vs Knockdown

Table 1. Management Practices Paddock Scale Trial Site 1, Marian Soil

	ABCD Classification	Soil Management	Nutrient Management	Herbicide Management[1]
Treatment 1	CCC	1.5 m current practice	Generalised recommendation (200kg N/ha)	Residual[2]
Treatment 2	BCC	1.8 m controlled traffic	Generalised recommendation (200kg N/ha)	Residual[2]
Treatment 3	BBB	1.8 m controlled traffic	Six easy steps	Knockdown/Residual[3]
Treatment 4	BAB	1.8 m controlled traffic	N replacement	Knockdown[4]
Treatment 5	ABB	1.8 m controlled traffic skip row	Six easy steps	Knockdown/Residual[5]

Notes

1 – All treatments may also need 2, 4-D (knockdown herbicide applied for vine control)
2 – Atradex and Diurex residual herbicides at 2.2 kg/ha each
3 – Combination of low or banded rate of residual and knockdown herbicides
4 – Application of Glyphosate
5 – Combination of low or banded rate of residual herbicides on cane rows, plus Glyphosate knockdown via shielded sprayer on skip rows

Site 2 Victoria Plains Soil (Sugar Cane)

Site 2 is a sugar cane farming system located near Mt Vince, west of Mackay (Farm 3434A, Block 14-1; **Figure 2**). The site is situated on Victoria Plains soil type (uniform cracking clay), which makes up 16% of the regions' cane land.

Figure 2. Location of the block selected for the strip-scale monitoring on Victoria Plains soil.

The style of management for each plot, under the ABCD management framework is consistent with the MWWQIP, as given in Table 2. An outline of ABCD management framework for cane farming land from the MWWQIP is listed in Appendix A with the style of management practices for each plot at the Victoria Plains site described in

Table .

Each plot treatment will demonstrate a system of management practices targeting ABC or D. However, the following practices are directly comparable (i.e. all other influential factors are equal). The main management comparisons will be:

Soil Management

- 1.5m current practice vs 1.8m controlled traffic

Nutrient Management

- Generalised recommendation (~ 150kg N/ha) vs Six Easy Steps

Herbicide Management

- Residual herbicide vs knockdown

Table 2. Management practices paddock scale trial Site 2, Victoria Plains Soil

	ABCD Classification	Soil management	Nutrient management	Herbicide management
Treatment 1	CCC	1.5m current practice	Generalised recommendation (150kg N/ha) [6]	Residual [7]
Treatment 2	BBB	1.8m controlled traffic	Six easy steps	Knockdown[8]

Notes

6 – Nitrogen rate applied does not take into account the contribution from the soybean crop

7 – Velpar K4 at 3kg/ha (may also need 2,4-Dand Paraquat applied for vine control)

8 - Paraquat and 2,4-D and/or Flame

1.2. Details of management for each plot

Table 3. Site 1 Marian Soil - Style of Management for each plot – Plant cane

	Replant 2009		TREATMENTS				
3120, 2-2			T1 (1.5m)	T2	T3 (6ES)	T4 (N rep)	T5 (skip)
CULTIVATION: in crop							
implement			cutaway		cutaway		cutaway
date			9/20/2009		9/20/2009		9/20/2009
implement			weeder rake				
date			20/9 & 15/10				
implement			grubber/multiweeder (hill-up)				
date			10/21/2009				
FERTILISER							
planting mix	DAP	250 kg/ha					
sidedress	NKS (27.1, 16.5, 3.4%)	2 row side dresser	538 kg/ha	538	469	100	439

date	10/15/2009						
other fertiliser 1	Murate of potash	broadcast spreader	70 kg/ha	70	70	185	70
date	11/18/2009						
other fertiliser 2	Granam	broadcast spreader				125 kg/ha	
date	11/15/2009						
HERBICIDE							
general x all trts 1:							
herbicide	Hero	boomspray	250g/ha				
date	8/30/2009						
general x all trts 2:							
herbicide	2,4-d amicide 625g/l	boomspray	1L/ha				
date	10/28/2009						
herbicide			atradex + diurex	atradex + diurex	dual gold	MCPA 625 + Starane 400	MCPA 625 + Starane 400
rate			2.2kg/ha each	2.2kg/ha each	1.2 kg/ha	1L/ha + 0.3L/ha	1L/ha + 0.3L/ha
application method			directed spray	directed spray	directed spray	helicopter	helicopter
date			10/30/2009	10/30/2009	10/30/2009	2/19/2009	2/19/2009
IRRIGATION (pivot)	applied across all treatments						
date	8/5/2009	10/10/2009	10/22/2009	11/16/2009	11/26/2009	12/5/2009	12/15/2009
rate (mm)	40	25	30	40	40	40	40
	pre-plant water	in crop water					

in crop water	30-Dec
rate (mm)	40

Table 5. Victoria Plains Soil - Style of management for each plot – Plant cane

	TREATMENTS	
fallow plant 2009	**T1 (1.5m)**	**T2 (1.8m)**
planting date	8/2/2009	8/2/2009
variety	Q208	Q208
CULTIVATION		
implement	cutaway	cutaway
date	8/26/2009	8/26/2009
implement	hill-up/fill-in (grubber with wings)	
date	10/27/2009	
FERTILISER		
planting mix	DAP	
rate	210 kg/ha	
date	8/2/2009	

sidedress	urea	Nil
rate	207 kg/ha	
application method	2 row box	
date	10/6/2009	
HERBICIDE		
general x all trts:		
herbicide	mcpa 625 g/l + starane 400 g/l	
rate	1.5 l/ha + 0.5 l/ha	
application method	boomspray	
date	1/17/2009	
specific treatments:		
herbicide	velpar + gramoxone + baton	gramoxone + baton
rate	4 kg/ha + 1 l/ha + 0.7kg/ha	1 l/ha + 0.7 kg/ha
application method	irvin legs, directed spray	irvin legs, directed spray
date	1/17/2009	1/17/2009
IRRIGATION		
method	spray line	
date	11-14 August 2009	
rate	50mm	
method	spray line	
date	9-15 October 2009	
rate	65mm	
pre-plant cultivation	sprayed-out (roundup powermax 3.5 l/ha) green manure soybean	
7/18/2009	offset	
7/19/2009	hoe	
7/28/2009	rip	
7/29/2009	hoe	

1.3. Multi-block scale monitoring

Multi-block scale site

A multi-block monitoring site is installed at North Eton (21^{o} 13' 36"S 148^{o} 57' 57"E; **Figure 3**). The catchment is ~53.5 ha, currently with approximately 100% cane land use. Runoff is measured within a farm drain using a 1 in 40 flat "v" notch weir (**Figure 4**) with depth of flow being recorded by a pressure transducer at one minute intervals.

Figure 3. Location of the multi-block scale monitoring site (identified by the arrow).

The aim of this site is to identify water quality improvement from the adoption of improved sugar cane land management practices adopted from multiple cane blocks.

Figure 4. V notch weir located at the multi-block scale monitoring site.

1.4. Multi-farm scale monitoring

Multi-farm scale site

A multi-farm monitoring site is installed at North Eton (21^{o} 13' 49"S 148^{o} 57' 45"E; **Figure 5**). The catchment is ~2965ha, currently with approximately 95% cane land use.

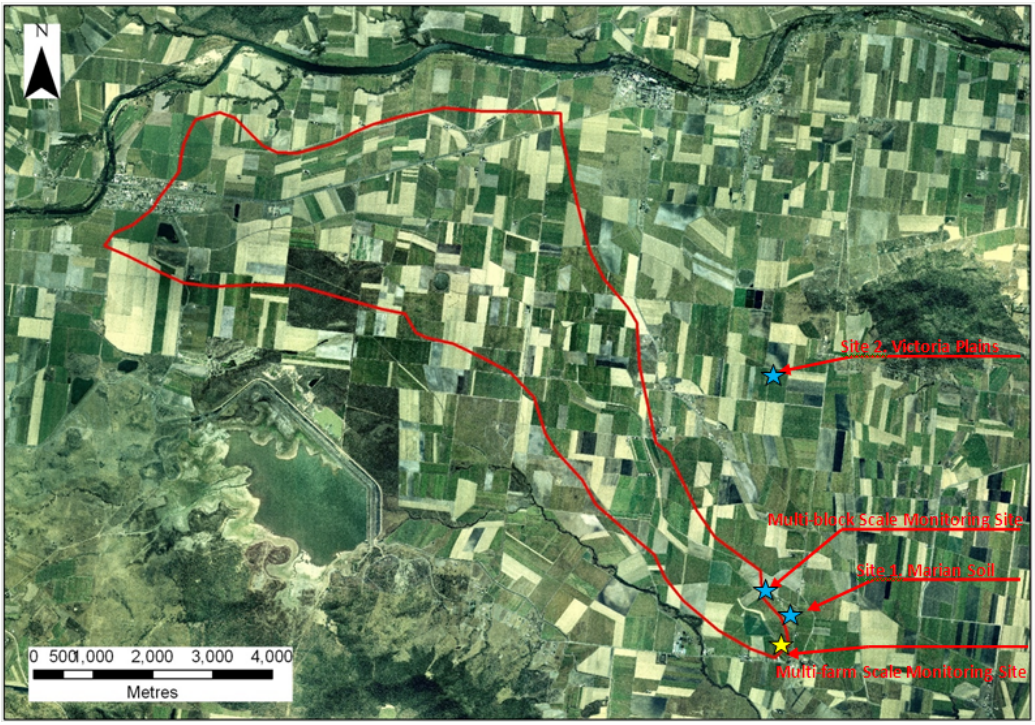

Figure 5. Location of the multi-farm scale monitoring site (identified by yellow star).
(Note: Other monitoring locations (paddock and multi-block) are identified by blue stars)

The aim of this site is to identify water quality improvements resulting from the adoption of improved sugar cane land management practices at a larger scale than that of the multi-block scale monitoring.

2. Implementation to date

2.1. Paddock scale monitoring

Sites 1 Marian Soil: The site has been operational since October 2009 (Figure 6) collecting treatment data as described at 4.3.
Site 2 Victoria Plains Soil: The site has been operational since October 2009 collecting treatment data as described at 4.3

Figure 6. Installation of Marian Soil strip scale water quality monitoring equipment.

2.2. Multi-block and multi-farm implementation

The multi-block and multi-farm monitoring sites have been operational since October 2009.

3. Locations, soils, layout of plots/stations

A complete soil analysis has been completed at each strip scale treatment and can be seen in the supporting document Mackay Whitsunday Paddock to Reef Soil Analysis.(Appendix B)

3.1. Physical features of each plot implemented

Table 7. The physical features for each plot implemented

Site/plot	Area (ha)	Length (m)	Width (m)	Slope (%)
Marian Soil				
T1	0.68	250	27	0.4
T2	0.80	250	32	0.4
T3	0.80	250	32	0.4
T4	0.80	250	32	0.4
T5	0.80	250	32	0.4
Victoria Plains Soil				
T1	0.97	215	45	1.1
T2	0.97	215	45	1.1

4. Measurements

4.1. Equipment

Table 8. List of equipment at each treatment and the equipment supplier.

CR800 data logger	Campbell Scientific
CS450 Pressure transducer	Campbell Scientific
RF411 base radio module	Campbell Scientific
Surge suppressor kit	Campbell Scientific
3dB omni antenna	Campbell Scientific
10W solar panel	Cairns Solar Equipment
40W solar panel	Cairns Solar Equipment
Regulator (2 per site)	Cairns Solar Equipment
18 A/hr sealed deep cycle battery for logger	Jaycar
100 A/hr deep cycle batteries for sampler (2 per site)	Battery World
300 mm San Dimas flume	Locally manufactured
Waterproof enclosure (B&R NI05042)	B&R Enclosures
Equipment "hut"	Locally manufactured
ISCO Avalanche pumping sampler	John Morris Scientific
Soil water samplers (2 per site)	ICT International

4.2. Additional equipment at some sites.

Table 9. List of additional equipment at some sites and the equipment supplier.

LoggerNet software	Campbell Scientific
Next G digital cell phone kit (2 sites)	Campbell Scientific
TB4/0.2 mm tipping bucket rain gauge (2 sites)	Hydrological Services
TB334 mounting bracket (2 sites)	Hydrological Services
TB333 bird guard (2 sites)	Hydrological Services
Soil moisture sensors (5 treatments)	EnviroSCAN

The flume size and plot area were chosen to handle up to a 1:5 year 30 minute rainfall event with 100% runoff (Figure 7). Irrigation inflows are measured using rain gauges. Drainage below 90cm soil depth is collected using soil solution samplers, two per treatment.

Figure 7. Example of a flume installed at each strip scale monitoring site.

4.3. Water quality samples

Water quality samples from runoff are being collected as composite samples for each event by bulking a 160 mL aliquot every 3900-5400 L of flow through the flume (dependent on plot area) into single containers (clear glass 1.8 L bottle). Each sample bottle will be full after 39,000-54,000 L of cumulated flow (10 aliquots; approx 30 mm of runoff). If more than one glass bottle is filled per event (maximum 4 bottles), these will be bulked and subsampled.

Nutrients and pesticides in drainage water are sampled following significant runoff events. Suction will be applied to the soil solution samplers for approximately two days to ensure sufficient sample volume is obtained.

Table 10. Estimated number of samples per year & laboratory we expect to use

Site	**Sediment concentration**	**Nutrients**	**Pesticides**
	Total No. Required	*Total No Required.*	*Total No. Required*
Lab	ACTFR	ACTFR	QHFSS
Site 1 (5 plots)			
- runoff	50	50	50
- drainage	15	15	15
- soil		30	30
- trash		30	30
Site 2 (2 plots)			
- runoff	20	20	20
- drainage	6	6	6
- soil		12	12
- trash		12	12

4.4. Nutrients

The suite(s) of nutrient parameters measured in water samples are listed in Table 11. The suite(s) used at this site(s) are underlined.

Table 11. Nutrient parameters measured in water samples

Parameters	Lab	Method
TSS	*ACTFR*	2540 D
Turbidity	*ACTFR*	??
Electrical conductivity	*ACTFR*	2510 B
TKN	*ACTFR*	??
TKP	*ACTFR*	??
Nitrite	*ACTFR*	Automated 4500-NO_2^- F
Nitrate	*ACTFR*	4500-NO_3^- F
NO_x	*ACTFR*	Calculation?? Nitrite + Nitrate
NH_3	*ACTFR*	Filtered Sample: 4500- NH_3 G with gas diffusion membrane
DON	*ACTFR*	Calculation: TFN – (NH_3 + NO_X)
Urea	*ACTFR*	??
TDN	*ACTFR*	Filtered Sample: 4500-NO_3^- F after alkaline persulfate digestion
TDP	*ACTFR*	Filtered Sample: 4500-P F after alkaline persulfate digestion
PO_4	*ACTFR*	4500-P F
PN	*ACTFR*	Calculation: TN – TFN
PP	*ACTFR*	Calculation: TP - TFP
TOC	*ACTFR*	5310 B
DOC	*ACTFR*	??

4.5. Pesticides

The suite(s) of pesticides targeted for measurement in water, soil and trash samples are listed in Table 12.

Table 12. Pesticides measured in water, soil and trash samples (all QHFSS)

QHFSS Analytical Suite	Pesticides of interest on our plot	Frequency
Note Registration fee ($27.50/batch submitted) and freight costs need to be additionally costed into budgets. (Prices below: Oct'09)	*Pesticide names below beside suitable group*	*All/most/selected events & strategy*
LCMS Herbicides A (Standard) (triazine/urea based + many more) $140/sample (detection limit 0.01 µg/L) Requires GLASS bottles	Atrazine, Desethyl-Atr, Desisopropyl-Atr, Diuron (Velpar K4 or similar) Hexazinone (Velpar K4) Tebuthiuron (Grasslans)	1 composite sample per event
GCMS Herbicides B (includes many of new herbicide products) $140/sample (detection limit 0.1 µg/L) Requires GLASS bottles	Pendimethalin (Stomp Extra) Metribuzin (Soccer) Trifluralin (Treflan)	NIL
LCMS + GCMS C $194/sample	Would need both LCMS/GCMS if using diuron/atrazine as well as new products such as Stomp or Soccer	
Note all parameters below require an additional bottle to be collected		
Phenoxyacid Herbicides D $170/sample (detection limit 0.1 µg/L) Requires GLASS bottles	2,4-D	Dependent on if applied for vine control.
Paraquat/diquat E Batch sizes: 11-19 samples: $125/sample >20 samples: $97/sample (1 sample: $651! so need >11 samples) (detection limit 0.1 µg/L) Requires PLASTIC bottles (NO glass)	Paraquat/Diquat (Sprayseed)	Nil
Glyphosate F $108/sample (detection limit 1.0µg/L) Requires GLASS bottles	Glyphosate	
Glyphosate & its breakdown product (AMPA) G $162/sample (detection limit 1.0µg/L) Requires GLASS bottles	Glyphosate/AMPA	Not applied in year 1. One composite sample 1st event.
Products not listed	Are there products in use or breakdown products in your region that are not available here? Name:	

Groups include:

A – Herbicides by LCMS:

Bromacil, Ametryn, Atrazine, Desethyl Atrazine, Desisopropyl Atrazine, Diuron, Fluometuron, Hexazinone, Metolachlor, Prometryn, Simazine, Tebuthiuron, Terbutryn

B – Herbicides by GCMS:

Diclofop methyl, Haloxyfop-2-etotyl, Haloxyfop methyl, Metribuzin, Oxyfluorfen, Pendimethalin, Propanil, Propazine, Terbuthylazine, Tri-allate, Trifluralin,

Bromacil, Diclofop methyl, Haloxyfop-2-etotyl, Haloxyfop methyl, Metolachlor, Metribuzin, Oxyfluorfen, Pendimethalin, Propanil, Propazine, Terbuthylazine, Terbutryn, Tri-allate, Trifluralin, Ametryn, Atrazine, , Desethyl Atrazine, Desisopropyl Atrazine, Hexazinone, Prometryn, Simazine, Tebuthiuron

Additional Pesticides with GCMS Suite:

Organochlorine pesticides, Organophosphate pesticides, Other Pesticides, Synthetic Pyrethroids

C – Includes all parameters in A and B listed above

D – Phenoxy acid herbicides:

2,4-D, 2,4-DB, 2,4-DP, 2,4,5-T, Clopyralid, Dicamba, Fenoprop (2,4,5-TP), Fluroxypyr, Haloxyfop, MCPA, MCPB, Mecoprop, Picloram, Triclopyr

E – Paraquat/diquat only

F – Glyphosate only

G – Glyphosate/AMPA (breakdown product) only

Other pesticides: Benalaxyl, Bitertinol, Carbaryl, Dichlorfluanid, Dichloran, Fipronil, Furalaxyl, Metalaxyl, Oxadiazinon, Piperonyl Butoxide, Pirimicarb, Procymidone, Propiconazole, Propoxur, Tebuconazole, Tetradifon, Vinclozolin

The pesticides the grower will be applying, or which may exist, on our plots are:
Site 1 (Marian): Applying – Atradex, Diurex, Velpar, Glyphosate, 2,4-D (if required); pre-existing: Atradex, Diurex, Velpar, Glyphosate, 2,4-D
Site 2 (Victoria Plains): Applying - Velpar, Flame, 2,4-D/Paraquat (if required); pre-existing: Velpar, Glyphosate, 2,4-D/Paraquat

4.6. Soil sampling

Site 1 Marian soil & Site 2 Victoria Plains soil

Continuous soil moisture monitoring will be undertaken directly below the stool within treatments that are expected to have different runoff/infiltration (Treatments 1, 2 and 5 on the Marian soil, and both treatments on the Victoria Plains soil). Moisture content will be recorded at a one hourly interval (using EnviroSCAN systems) and logged using the CR800 dataloggers. Six sensors will be used at each monitoring site, with final depth intervals dependent on soil properties. A typical depth distribution would be 20 cm intervals to 1 m, with the final sensor at 1.5 m.

Plant available water content (PAWC), bulk density, drained upper limit (DUL) and crop lower limit (LLcrop) are needed to model the plots. We will characterise these properties by:

- Maximum and minimum field moisture contents from probe & selected soil coring
- Pond subareas under plastic, allow to drain and measure by soil coring
- Laboratory measurements, using pressure plate analysis (at -0.1 & -0.3 bar undisturbed small core and -15 bar ground, or complete moisture retention curves), and/or
- Estimate from other measured data & e.g. PAWCER.

Detailed soil profile nutrient sampling will be undertaken on an annual basis (post-harvest). Four cores (two from the row, and two from the interspace; sampled outside of the flume catchment area) will be taken from each treatment (0-10, 10-20, 20-30, 30-60, 60-90, 90-120 and 120-150 cm). The two row cores will be composited to form a single sample per depth increment per treatment; similarly for the two interspace cores. Samples will be analysed for nitrogen and phosphorus. Bulk density sampling will also be undertaken at selected times.

Following the application of herbicides, surface residue will be collected from 12 locations per treatment (six from the top of the bed, and six from the interspace). These will be composited, sub-

sampled and chilled. The mass per unit area will be measured. Surface soil samples (0-25 mm) will be taken from the same locations, and composited. Sampling will be undertaken on a log interval after application (e.g. 1, 3, 5, 10, 25, 50 and 100 days) and analysed for herbicide concentrations.

4.7. Management practice and agronomy

Events, such as farm operations (including tillage, nutrient and pesticide applications), action that change ground cover and growth stages of the crop (including date of emergence, canopy closure, crop destruction) will be recorded in a comprehensive field diary. Table 3 below outlines the major events experienced by most crops along with specific information that will be recorded. The date of the event and any relevant information will also be captured.

Table 13. Example of information recorded in event diary.

Event	**Specific information**			
Crop start	Date of planting	Date of ratooning		
Irrigation	Amount applied	Application method	Quality of incoming water	
Nutrition	Product used	Nutrient analysis	Amount applied	Placement
Pesticide	Product used	Active ingredient	Amount applied	Placement
Cultivation	Type of operation	Depth of cultivation	Zone cultivated	% of residue incorporated
Harvest	Date	Method used		

Yield, biomass and N and P removal will be measured at harvest.. Cover and biomass from trash/stubble and crops will be collected. Cover will also be measured after major events/key changes in trash/crop. Where possible, photographs will be taken to provide additional support to measurements and observations.

5. Data storage and analysis

Time series and water quality data are stored in Excel in the short term (and in the HYDSTRA and DARTS databases in the long term). Loads in runoff and drainage are calculated by linear interpolation using Brolga. (If our composite sampling works correctly, it will be as simple as discharge x concentration).

5.1. Rainfall simulation

We are planning to have rainfall simulations performed on:

- The 5 treatments at paddock monitoring Site 1, Marian soil type, post-harvest, for "calibration" of treatments and soil types.
- The 2 treatments at paddock monitoring Site 2 post-harvest, for "calibration" of treatments and soil types.
- Treatments at other sites within the region are not yet determined.

6. Site characterisation

Both sites were characterised by Peter Muller (LRO, DERM) according to the standard profile suite on 24/09/09. Sampling for additional parameters required for modelling purposes have not been collected.

Table 14. Site requiring characterisation (enough info so LRO can locate site)

Name	Area/length	Lat/long (flume)	farmer	progress	Priority	When accessible
Site 1				Done		
Site 2				Done		

Table 15. Site characterisation elements collected at each site.

Characterisation data	Site 1	Site 2
• Soil profile descriptions	Y1	Y
• Number of soils per site		1
• Texture (particle size analysis)	Y	Y
• including fine sand	√	√
• pH	√	√
• EC	√	√
• Cl^- (**all layers**)	N	N
• exchangeable cations	√	√
• CEC	√	√
• ESP	√	√
• Bulk density (for swelling soils, at DUL)	N	N
• drained upper limit, DUL		
• field measurement	N	N
• pressure plate @ 0.3bar	N	N
• MIR	N	N
• lower limit		
• field measurement (LLcrop)		N
• pressure plate @ 15bar (LL15)	N	√
• MIR	√	N
	N	
• Site characteristics		
• Ranking of "runoff potential" c.f. other soils in region (surface soft, firm or hard when settled)	√	√
• Slope and slope length/curvature per plot	√	√
• Plot areas have been surveyed (GPS/Measuring tape)	√	√
• Water table depth and nitrate concentration and salinity	N	N
• Soil cores		
• Stored for future reference	N	N
• Frozen	N	N
• Organic Carbon		
• organic C "quality" (total C, particulate OC, Char-C)	Y	Y
• Profiles submitted for Mid Infra Red (MIR) spectroscopy to:		
• DERM ERS	N	N
• CSIRO Adelaide	N	N
• Nitrogen		
• Soil initial conditions (each layer of each plot)	N	N
• Total N (0-10cm only)	√	√

• Organic N • NO3-N and NH4-N • Soil N monitored through crop cycle	N N N	N N N
• Soil water content • Soil water content at start of designed program • Continuous monitoring	 N √	 N √
• Pesticides • Background levels established in 0-10cm layer.	 N	 N
• Surface soil (0-25mm & 0-10cm) sampled for nutrients and pesticides (background levels).	N	N

7. **Appendix A.** Sugar Cane ABCD Management Framework

Soil management practices for cane classified in the ABCD framework.

D Class Cane Soil Management	C Class Cane Soil Management
Description: **1.** Cultivated bare fallow or plough out/replant **2.** Cultivated plant cane **3.** Cultivated ratoons	**Description:** **1.** Minimum till bare fallow **2.** Cultivated plant cane **3.** Zero till ratoons
Resource condition indicators (one or more indicators at this level): (to be determined)	**Resource condition indicators (one or more indicators at this level):** (to be determined)
Planning and record keeping: **1.** Records kept in head	**Planning and record keeping:** **1.** Develop basic Soil Management Plan **2.** Keep basic records
Machinery: **1.** Standard equipment	**Machinery:** **1.** Standard equipment
B Class Cane Soil Management	**A Class Cane Soil Management**
Description: **1.** Controlled traffic permanent beds maintained by zonal tillage with GPS guidance of bed-forming and harvesting operations **2.** Strategic or zonal tillage plant cane and rotational crops managed for green manure or grown to harvest **3.** Zero till ratoons **4.** Drains and waterways managed as filter strips **5.** Headlands widened and smoothed to reduce soil compaction of row ends **6.** Harvester modifications to accommodate wide rows (includes harvester front, automatic base cutter height control, roller train optimisation, and elevator extensions)	**Description:** **1.** Controlled traffic permanent beds with GPS guidance of all operations including planting zonal tillage and spraying **2.- 5.** Same as Class B **6.** Harvester modifications to accommodate wide rows (includes harvester front, automatic base cutter height control, roller train optimisation, automatic primary extractor fan speed control, and elevator extensions) **7.** Haulout modifications to accommodate wide rows (includes rear wheel steering and GPS guidance)
Resource condition indicators (one or more indicators at this level): (to be determined)	**Resource condition indicators (all indicators at this level):** (to be determined)
Planning and record keeping: **1.** Identify soil types and productivity zones for each block using existing farm maps **2.** Develop Soil Management Plan (includes Harvest Management Plan) using existing paddock scale soil and yield mapping techniques. **3.** Keep records (including timing of operations and harvest cane loss assessments) **4.** Adjust soil management for next year if required	**Planning and record keeping:** **1.** Identify soil types and productivity zones for each block using GPS mapping **2.** Develop GPS based Soil Management Plan (includes Harvest Management Plan) using new within paddock scale soil and yield mapping techniques (link to mill data) **3.** Automatic record keeping in computer database **4.** Same as Class B
Machinery: **1.** Standard wheel spacing on all equipment and GPS Guidance of bed former and harvester, yield monitor on harvester. **2.** Other machinery includes zonal tillage equipment, minimum till seed planter, minimum till cane planter. **3.** Harvester modifications to accommodate wide rows (includes harvester front, automatic base cutter height control, roller train optimisation, and elevator extensions).	**Machinery:** **1.** Standard wheel spacing and GPS Guidance (with variable rate screen) on all equipment, yield monitor on harvester. **2.** Same as class B **3.** Harvester and haulout modifications to accommodate wide rows (includes harvester front, automatic base cutter height control, roller train optimisation, automatic primary extractor fan speed control, elevator extensions, haulout GPS guidance and rear wheel steering)

Nutrient management practices for cane classified in the ABCD framework.

D Class Cane Nutrient Management	C Class Cane Nutrient Management
Description: **1**. One rate for whole farm **2.** Application rates based on historic application rates or rules of thumb	**Description:** **1**. Some soil testing **2.** One or two rates for the whole farm **3**. Application based on old industry recommendations
Resource condition indicators (one or more indicators at this level): (to be determined)	**Resource condition indicators (one or more indicators at this level):** (to be determined)
Planning and record keeping: **1.** Records kept in head	**Planning and record keeping:** **1.** Conduct soil tests **2.** Develop basic Nutrient Management Plan **3.** Keep basic records
Machinery costs: **1**. Surface or sub-surface fertiliser box	**Machinery costs:** **1**. Subsurface fertiliser box, or surface applied and irrigated into soil
B Class Cane Nutrient Management	**A Class Cane Nutrient Management**
Description: **1**. Soil test fallow blocks each year **2**. Variable rate between blocks **3.** Application rates based on latest industry recommendations taking mill by-products and fallow history into account **4**. Timing nutrient applications with respect to crop stage, irrigation and rainfall	**Description:** **1**. Soil test specific areas within fallow blocks and some ratoon blocks each year. **2.** Some plant tissue testing **3.** Variable rate within blocks **4.** Application rates based on specialist interpretation of the latest industry recommendations taking mill by-products and fallow history into account **5.** Timing nutrient applications with respect to crop stage, irrigation and rainfall
Resource condition indicators (one or more indicators at this level): (to be determined)	**Resource condition indicators (all indicators at this level):** (to be determined)
Planning and record keeping: **1**. Identify soil types/productivity zones for each block **2.** Develop Nutrient Management Plan using yield, soil mapping and latest industry recommendations **3**. Change fertiliser rates between blocks **4**. Attend nutrient management training **5.** Conduct soil tests (and leaf analysis if required) **6**. Keep records (including timing, rates, product and yield) **7.** Adjust nutrient rates for next year if required	**Planning and record keeping:** **1.** Identify soil types/productivity zones within each block using GPS yield and soil mapping **2.** Develop GPS based Nutrient Management Plan using yield, soil mapping and specialist interpretation of latest industry recommendations **3.** Apply variable fertiliser rates within blocks **4 – 5.** Same as Class B **6.** Automated record keeping in computer database **7.** Same as Class B
Machinery: **1**. Variable rate application of granular sub-surface or liquid surface with manually controlled rate	**Machinery:** **1**. Variable rate application of granular sub-surface or liquid surface with remote/automatic controlled rate and GPS guidance

Pesticide management practices for cane classified in the ABCD framework.

D Class Cane Pesticide Management	C Class Cane Pesticide Management
Description: **1**. One herbicide strategy for the whole farm based on historic application rates or rules of thumb **2.** Often uses maximum label rate residual and knockdown products irrespective of weed pressure	**Description:** **1**. One or two herbicide strategies for the whole farm **2.** Often uses residual and knockdown products at rates appropriate to weed pressure
Resource condition indicators (one or more indicators at this level): (to be determined)	**Resource condition indicators (one or more indicators at this level):** (to be determined)
Planning and record keeping: **1.** Records kept in head	**Planning and record keeping:** **1.** Develop basic Herbicide Management Plan **2.** Keeps Material Safety Data Sheets (MSDSs) **3**. Keep basic records
Machinery costs: **1.** Standard spray rig both high and low clearance	**Machinery costs:** **1.** Same as Class D
B Class Cane Pesticide Management	**A Class Cane Pesticide Management**
Description: **1.** Implementation of new application technology for improved placement and timing to improve application efficiency, accuracy and to extend the window of opportunity **2.** Knockdown herbicides replace residual herbicides where practical (strategic use of residual herbicides in fallow and plant cane to lower overall crop cycle herbicide application and help avoid resistance to knockdown herbicides) **3.** Timing pesticide applications with respect to crop stage irrigation and rainfall **4.** Variable herbicide strategies between blocks **5**. Storage – lockable with bunding and emergency wash down facilities **6.** Dispose of used pesticide containers in drum muster	**Description:** **1 – 3.** Same as Class B **4.** Variable herbicide strategies within blocks. **5–6.** Same as Class B
Resource condition indicators (one or more indicators at this level): (to be determined)	**Resource condition indicators (all indicators at this level):** (to be determined)
Planning and record keeping: **1**. Identify – weed types/pressure, soil types and productivity zones for each block **2.** Develop Herbicide Management Plan using weed pressure, soil types, crop stage which focuses on good weed control in fallow and plant cane stages, and includes strategic residual herbicide use **3.** Change herbicide strategy between blocks **4.** Attend herbicide training including spray nozzle technology **5.** Monitor weed pressure **6.** Keeps Material Safety Data Sheets (MSDSs) and first aid procedures **7.** Keep records (including wind speed, time of spraying, products and block rate) **8.** Adjust herbicide strategy for next year if required	**Planning and record keeping:** **1.** Identify – Weed types/pressure, soil types and productivity zones within each block using GPS weed survey and soil mapping **2.** Develop GPS based Herbicide Management Plan using weed pressure, soil types, crop stage which focuses on good weed control in fallow and plant cane stages, and includes strategic residual herbicide use **3.** Apply variable herbicide strategies within blocks **4 – 6.** Same as Class B **7.** Automated record keeping in computer database **8**. Adjust herbicide strategy for whole of crop cycle
Machinery: **1**. Hooded sprayers, more accurate nozzles (matched to job), multiple tank setups and high clearance tractors with manual rate control	**Machinery:** **1**. Hooded sprayers, more accurate nozzles (matched to job), multiple tank setups and high clearance tractors with remote/ automatic rate control and GPS guidance with variable rate screen