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Bakers Creek system repair site – water quality report 2014/15

MAY 2015
Ken Rohde

Catchment Solutions
ABN 89 158 982 186
www.catchmentsolutions.com.au
(07) 4968 4200
Suite 4/85 Gordon St | Mackay QLD 4740

Bakers Creek system repair site – water quality report

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Ken Rohde

For further information contact:
Ken Rohde
Coordinator Water Science
Catchment Solutions – Water Quality Services
Ph: (07) 4968 4219

Enquires should be addressed to:
Manager
Catchment Solutions Pty Limited
PO Box 815, Mackay Qld 4740
Tel: +61 7 4968 4200
Email: info@catchmentsolutions.com.au

Cover Figure: Wetland at the outlet of the Bakers Creek system repair site (23rd January 2015)

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Table of Contents

EXECUTIVE SUMMARY 3
1. INTRODUCTION 4
2. METHODOLOGY 4
2.1. Site description 4
2.2. Water quality sampling 6
3. RESULTS AND DISCUSSION 7
3.1. Rainfall and runoff events 7
3.2. Water quality – sediment 8
3.3. Water quality – nitrogen and phosphorus 9
3.4. Water quality – herbicides 11
3.4.1. Herbicide mixtures 15
4. CONCLUSIONS 16
5. RECOMMENDATIONS 16
6. REFERENCES 16
APPENDIX 1 – Laboratory results 16

List of Figures

Figure 1 Location of the Bakers Creek system repair site 5
Figure 2 The three components of the system repair site, and the location of the water quality samplers 5
Figure 3 Water quality sampling equipment at the outlet of the Bakers Creek system repair site, showing the ISCO Avalanche sampler in the grey enclosure. The float switch is attached to the star picket in the centre of the photo 6
Figure 4 Daily rainfall (mm), Mackay Airport for 1st November 2014 to 30th April 2015 7
Figure 5 The bare, battered banks are a possible cause of increased sediment concentrations at the outlet (looking downstream from the inlet sampler, along the sediment basin) 8
Figure 6 Box plots of sediment (TSS) and nitrogen concentrations from the inlet and outlet of the Bakers Creek system repair site, measured over two runoff events during the 2014/15 wet season 9
Figure 7 Box plots of total phosphorus (TP) and ortho-P concentrations from the inlet and outlet of the Bakers Creek system repair site, measured over two runoff events during the 2014/15 wet season 10
Figure 8 Box plots of herbicide concentrations from the inlet and outlet of the Bakers Creek system repair site, measured over two runoff events during the 2014/15 wet season 12

List of Tables

Table 1 Actual and long-term average monthly rainfall, Mackay Airport for November 2014 to April 2015 7
Table 2 Individual concentrations of the five PSII herbicides, and results of the ms-PAF assessment 13

List of Acronyms

DIN	Dissolved inorganic nitrogen (sum of ammonia-N and NO_x-N)
GBR	Great Barrier Reef
LCMS	Liquid chromatography mass spectrometry
ms-PAF	Multi-substance potentially affected fraction
N	Nitrogen
NO_x-N	Nitrogen oxides (sum on nitrate and nitrite, but mainly nitrate)
Ortho-P	Ortho-phosphate (inorganic forms of phosphate)
P	Phosphorus
PSII	Photosystem II
TKN	Total Kjeldahl nitrogen (sum of ammonia-N and organic based nitrogen)
TN	Total nitrogen (sum of TKN and NO_x-N)
TP	Total phosphorus
TSS	Total suspended solids
WQIP	Water quality improvement plan

EXECUTIVE SUMMARY

Water quality studies over the past decade have shown that regions with sugarcane as a major land use export high concentrations of dissolved inorganic nitrogen and some herbicides (particularly ametryn, atrazine, diuron and hexazinone). To halt and reverse this decline in water quality, several federal and state government funded programs have been implemented to improve land management practices and monitor the results. One such program, the Australian Government's Reef Programme, is a five year investment in systems repair and urban water quality on-ground grants. One project funded under this program in the Mackay Whitsunday region is the Bakers Creek (Cowley's Road) system repair site.

At this project site, inlet and outlet water quality (sediment, nutrients and herbicides) concentrations were measured during the 2014/15 wet season. Rainfall during the season was less than half of the long-term average, and resulted in only two rainfall runoff events being monitored. This was the first wet season after construction of the site, and revegetation had not occurred. As a result, the sediment concentrations at the outlet (13-178 mg/L) were slightly higher than the inlet (4-107 mg/L), but concentrations were similar to those measured from other small sugarcane catchments in the Mackay region. Concentrations of nitrogen species responded differently between the two events, presumably due to the interaction between inlet water and the wetland water quality prior to Event 1 (dilution, release of organic material, etc.). In the much larger Event 2, there was little difference between inlet and outlet water quality for nitrogen (except a reduction in ammonia-N concentrations) and phosphorus.

Of those herbicides detected (particularly atrazine, diuron and hexazinone), outlet concentrations during Event 1 were at least half of those detected at the inlet. This may simply be due to dilution through the system for this relatively small runoff event. Concentrations in Event 2 were much higher than those measured in Event 1 (except diuron), with small reductions in the range of concentrations (and median) measured between the inlet and outlet. The results from the ms-PAF assessment show that, of all the samples collected, at least 91% of photosynthetic species were potentially affected. The median ms-PAF value at the outlet (95%) was slightly lower than the inlet (97%) for these two runoff events. These results highlight that the assessment of mixtures of herbicides are critical to understand the potential impact of herbicides on aquatic ecosystems.

It is recommended that monitoring continue in future wet seasons to determine the full benefits of improvements in water quality at this site as the components of the site become established and the site is revegetated.

1. INTRODUCTION

Several water quality studies in the past decade have shown that regions with sugarcane as a major land use export high concentrations (compared to pre-European or "natural" state) of dissolved inorganic nitrogen (DIN or NO_x-N, consisting primarily of nitrate). In a modelling study, estimates show that DIN exports from the Mackay Whitsunday region has increased 4.6 times since pre-European condition, and the Wet Tropics increased 6.4 times, with increases in other regions of 1.8-2.2 times (Kroon et al. 2012). Catchment scale monitoring during the 2011/12 wet season showed the yield of DIN in the high rainfall coastal catchments (Pioneer, Plane, Barratta, North Johnstone, South Johnstone and Tully catchments) ranged from 73-700 kg/km^2 (Wallace et al. 2014). These catchments also contain a high proportion of irrigated cropping (mainly sugarcane). The load from all other catchments was considerably lower (<30 kg/km^2). The herbicides most commonly found in surface waters in the Great Barrier Reef (GBR) region where sugarcane is grown (ametryn, atrazine, diuron and hexazinone) are largely derived from sugarcane farming land-use (Bainbridge et al. 2009, Lewis et al. 2009, Rohde et al. 2013).

Various federal and state government funded programs (e.g. Reef Plan, Reef Programme, etc.) have been implemented to halt and reverse the decline in the quality of water flowing to the Great Barrier Reef by improving land management practices and monitoring the results. One such government initiative is the Australian Government's commitment to improving water quality via a $23.5 million investment over five years for systems repair and urban water quality on-ground grants. One project funded under this program in the Mackay Whitsunday region is the Bakers Creek system repair site.

At this project site, inlet and outlet water quality (sediment, nutrients and herbicides) concentrations were measured during two rainfall runoff events during the 2014/15 wet season. This report provides an overview of the measured water quality at the inlet of the system repair site, and the change in water quality at the outlet.

2. METHODOLOGY

2.1. Site description

The Bakers Creek (Cowley's Road) system repair site (21° 12' 25"S, 149° 7' 59"E) is located approximately 6.5 km south-west of Mackay airport (Figure 1). The area draining to the site is approximately 650 ha (the general area south of Racecourse), and is almost entirely farmed for sugar cane. The remaining area is predominantly roads, household yards and associated farm infrastructure.

The soil across the catchment area could be broadly described as hard pedal mottled-yellow duplex soils on level alluvial plains. The dominant principal profile form has been described as Dy3.43, a duplex yellow-grey hard setting A horizon, A2 horizon conspicuously bleached, alkaline pedal mottled B horizon (Atlas of Australian Soils, polygon 3282).

The system repair site consists of three components of a treatment train constructed during 2014 (Figure 2):

- The water from the catchment area enters a shallow **sediment trap/basin** of approx. 1 ML capacity.
- This then flows into a **first flush** irrigation sump (approx. 4 ML), which would ideally be pumped out onto adjacent cane paddocks after it has filled from the first flush of runoff.
- This then flows into a rehabilitated natural **wetland** (approx. 15-20 ML).

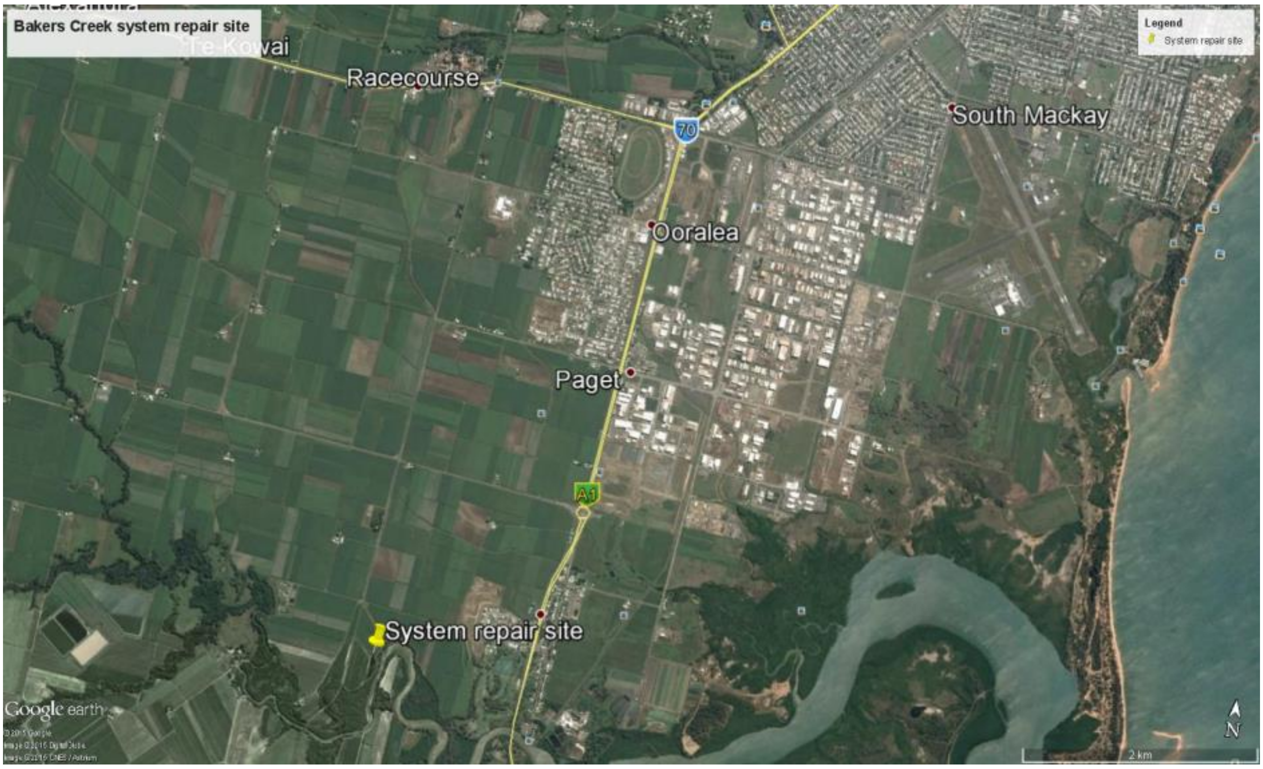

Figure 1 Location of the Bakers Creek system repair site

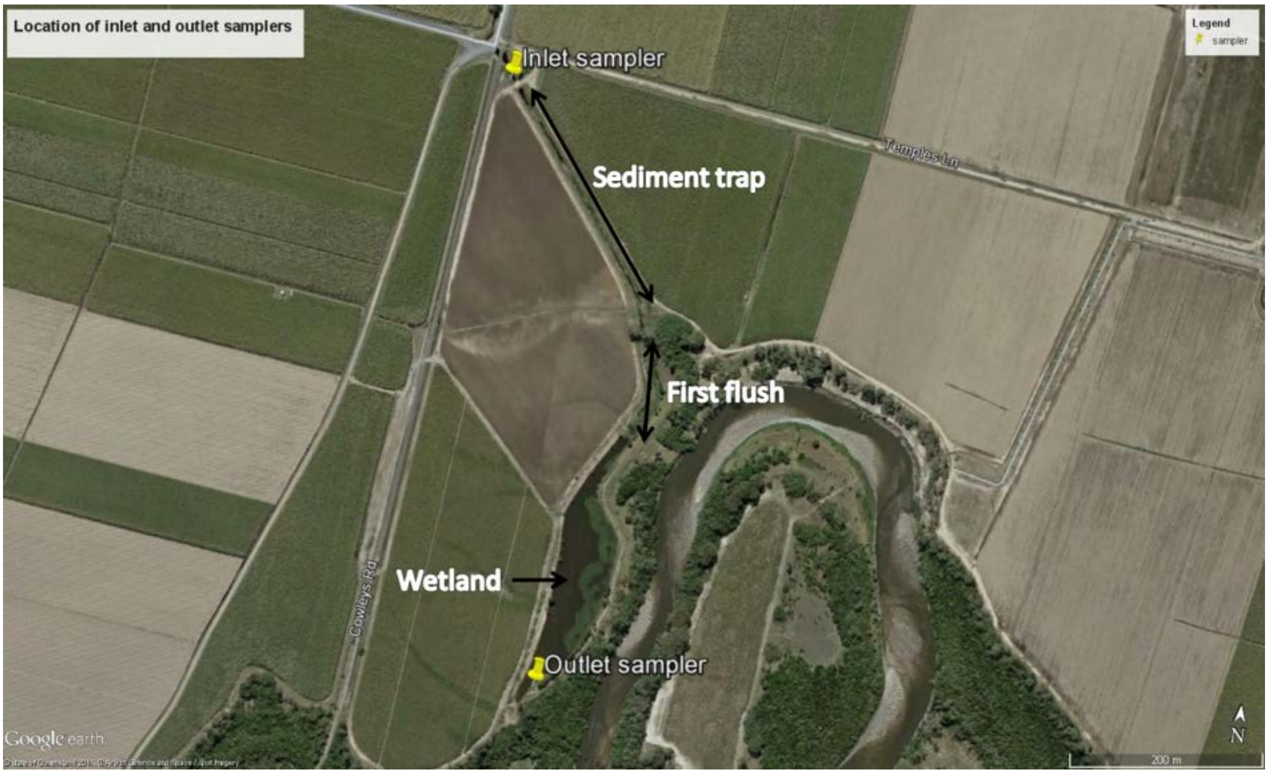

Figure 2 The three components of the system repair site, and the location of the water quality samplers

2.2. Water quality sampling

Water samples from the inlet and outlet of the system repair site were collected using an ISCO Avalanche auto-sampler containing 14 x 1 L plastic bottles. The refrigeration system was activated after collection of the first sample. The samplers were triggered by float switches set approximately 100 mm above cease to flow levels. The samplers were then programmed to sample every 3 – 6 hours until the water level dropped below the triggered water height.

The water samples were retrieved within 48 hours of collection and delivered directly to the Water and Waste Laboratories, Mackay Regional Council, for sub-sampling and analysis. All samples were analysed for sediment and nutrient (total and filtered) concentrations, with selected samples analysed for herbicides (sub-contracted to Queensland Health and Forensic Scientific Services laboratory, Brisbane).

It should be noted when interpreting the water quality results that during the sampling period, no revegetation had occurred since construction of the site.

Figure 3 Water quality sampling equipment at the outlet of the Bakers Creek system repair site, showing the ISCO Avalanche sampler in the grey enclosure. The float switch is attached to the star picket in the centre of the photo.

3. RESULTS AND DISCUSSION

3.1. Rainfall and runoff events

The seasonal rainfall, measured at the Mackay Airport (6.5 km NE of the site) was less than half of the long-term average (Table 1) (data sourced from http://www.bom.gov.au/climate/data/index.shtml?bookmark=136; May 2015). January was the only month that received at least half of the long-term average rainfall.

Table 1 Actual and long-term average monthly rainfall, Mackay Airport for November 2014 to April 2015

	Actual monthly rainfall (mm)	Long-term average rainfall (mm)	% of long-term average rainfall
November 2014	13.0	79.1	16.4
December 2014	47.4	131	36.2
January 2015	295	313	94.2
February 2015	103	356	28.9
March 2015	54.2	238	22.8
April 2015	55.6	170	32.7
Total	**568**	**1287**	**44.1**

Daily rainfall totals above 30 mm only occurred on 6th/7th January (total 72.4 mm) and 23rd January 2015 (133.2 mm) (shown by the red bars in Figure 4). Both of these events caused sufficient runoff to be sampled. These runoff events are referred to as “Event 1” and “Event 2” throughout this report.

On 14th December 2014, the 29 mm rainfall event ran water into the sediment basin, but did not flow beyond that. A very minor runoff event also occurred in mid-February, but these samples were not analysed.

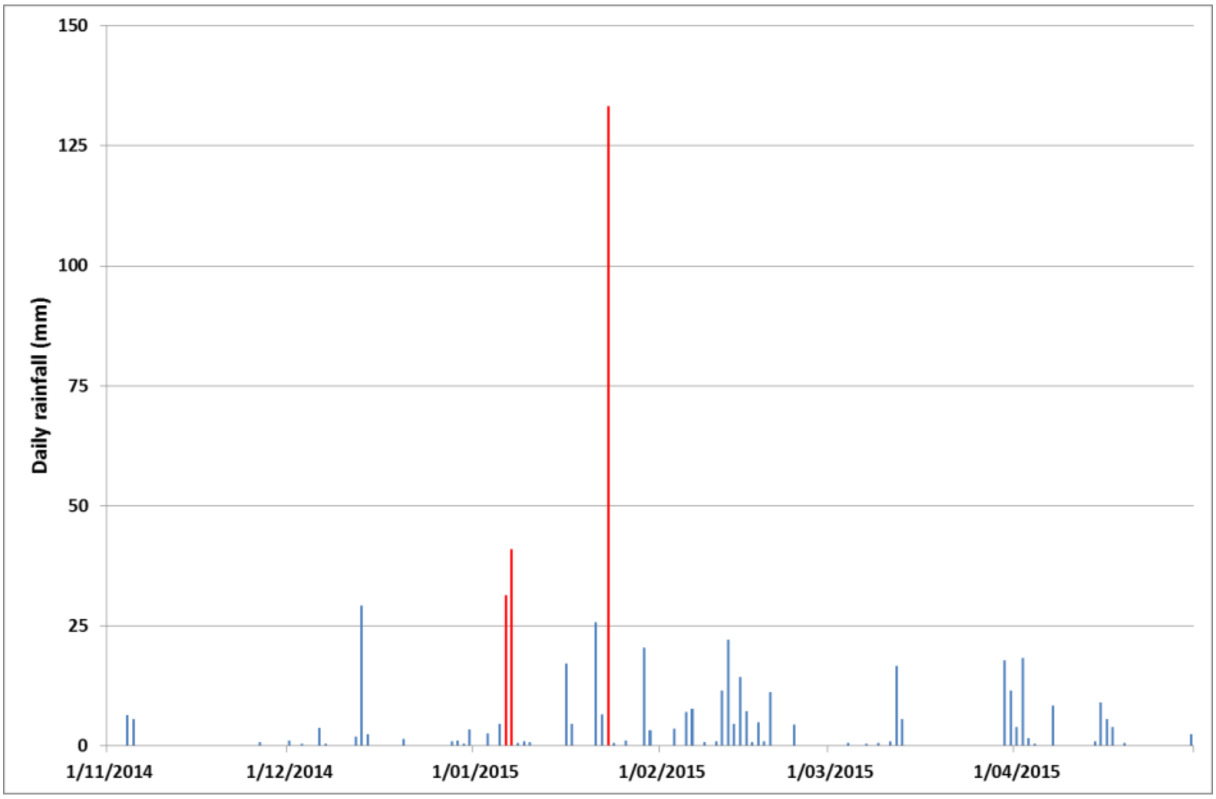

Figure 4 Daily rainfall (mm), Mackay Airport for 1st November 2014 to 30th April 2015

(Note – the red bars denote the rainfall that caused sufficient runoff to be sampled)

3.2. Water quality – sediment

The range of sediment concentrations in both events was lower at the inlet than the outlet (Figure 6), with the smaller runoff event (Event 1) having lower concentrations than Event 2, the larger event. These concentrations are very similar to the range of concentrations measured in a three year study approximately 17 km west of this study where concentrations were generally less than 200 mg/L at the paddock scale (under a green cane trash blanket) and 50 ha and 2950 ha catchment scales (Rohde et al. 2013).

Sediment concentration in runoff is driven by peak runoff rate, ground cover and roughness (surface consistency); while peak runoff is influenced by rainfall intensity, runoff depth and ground cover (Freebairn et al. 2009). Freebairn et al. (2009) reported that peak discharge was the most important factor influencing sediment concentration leaving a paddock (accounting for 41% of variation), as it best represents stream power, a measure of energy available for detachment and transport of soil in runoff. This was observed in our study when the much larger runoff event (Event 2) had a median sediment concentration approximately double that of the much smaller event (Event 1).

The increase in sediment concentrations at the outlet (compared to the inlet) are thought to be a function of the bare battered banks during the period of sampling (e.g. Figure 5). Sampling during future seasons should see a decrease in sediment concentrations at the outlet due to the revegetation of the banks.

Figure 5 The bare, battered banks are a possible cause of increased sediment concentrations at the outlet (looking downstream from the inlet sampler, along the sediment basin)

3.3. Water quality – nitrogen and phosphorus

There were very little differences in TN concentrations between the inlet and outlet, with concentrations in Event 2 approximately double those of Event 1 (Figure 6).

The median concentrations of TKN in Event 1 were similar between inlet and outlet, but were reduced at the outlet in Event 2 (Figure 6).

Ammonia-N concentrations responded differently between runoff events. Concentrations at the inlet of Event 1 were much lower than those measured at the outlet, with the inverse being observed in Event 2 (Figure 6). Decomposition processes in wetlands are believed to convert a significant part of the organic nitrogen to ammonia (Mayo and Mutamba, 2004, cited by Lee et al., 2009). Although no water sampling was undertaken prior to Event 1 from the wetland of our site, it is thought these decomposition processes during the dry season may be the reason for the higher ammonia-N concentrations in Event 1.

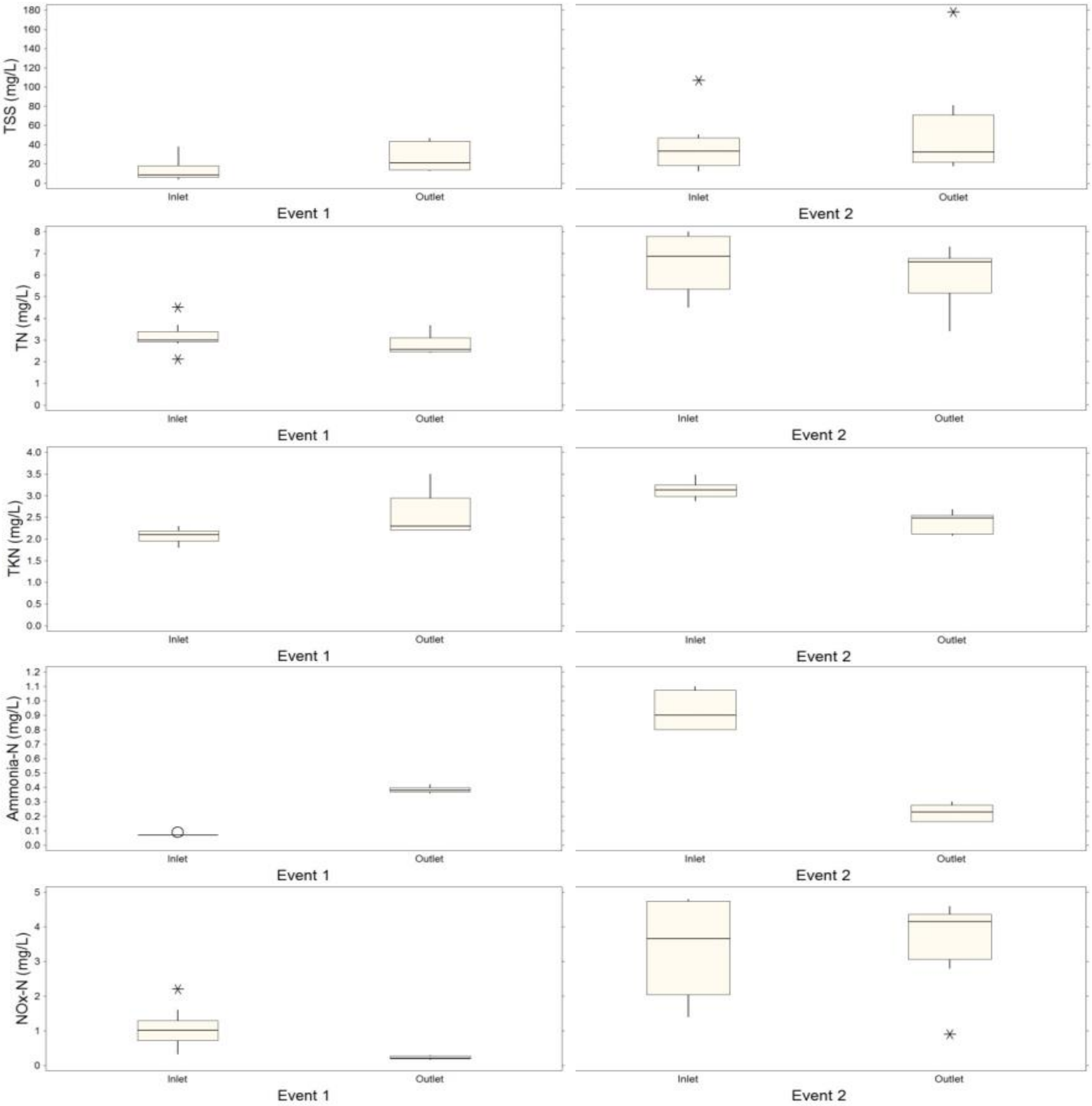

Figure 6 Box plots of sediment (TSS) and nitrogen concentrations from the inlet and outlet of the Bakers Creek system repair site, measured over two runoff events during the 2014/15 wet season

In Event 2 (16 days after Event 1), ammonia-N concentrations at the outlet were approximately ¼ of those at the inlet. There would have been little time for further decomposition as observed in Event 1, and the reduction in concentrations are thought to be due to nitrification. Biological nitrification, which is performed by nitrifiers, followed by denitrification is believed to be the major pathway for ammonia removal in constructed wetlands (Gersberg et al. 1985). In traditional nitrogen treatments, the biological nitrogen removal requires a two-step-process: nitrification followed by denitrification. Nitrification implies a chemolithoautotrophic oxidation of ammonia to nitrate under strict aerobic conditions and is performed in two sequential oxidative stages: ammonia to nitrite (ammonia oxidation) and nitrite to nitrate (nitrite oxidation) (Lee et al. 2009). Each stage is performed by different bacterial genera which use ammonia or nitrite as an energy source.

Concentrations of NO_x-N at the inlet during Event 1 were generally <2 mg/L, and <0.3 mg/L at the outlet (Figure 6). As mentioned previously, no water quality sampling was undertaken prior to Event 1, so the reduction in concentrations could simply be due to dilution as the water flowed through the system. In Event 2, concentrations were similar at the inlet and outlet, but much higher than those measured during Event 1. The range in NO_x-N concentrations measured at this site were similar to those measured at a larger catchment scale (2950 ha) over a three year period (Rohde et al. 2013), but the median was much higher. This may be due to the much drier period of monitoring at this site compared to the monitoring period at the larger catchment scale – only two runoff events measured in the current study, compared to in excess of nine per season reported in Rohde et al. (2013).

Concentrations of phosphorus (total and ortho-P) at the outlet during Event 1 were approximately half those of the inlet, but similar during Event 2 (Figure 7). Similar to the NO_x-N findings, the reduction in concentrations for Event 1 may be due to dilution through the system for the small runoff event, whereas the much larger Event 2 fully flushed the system.

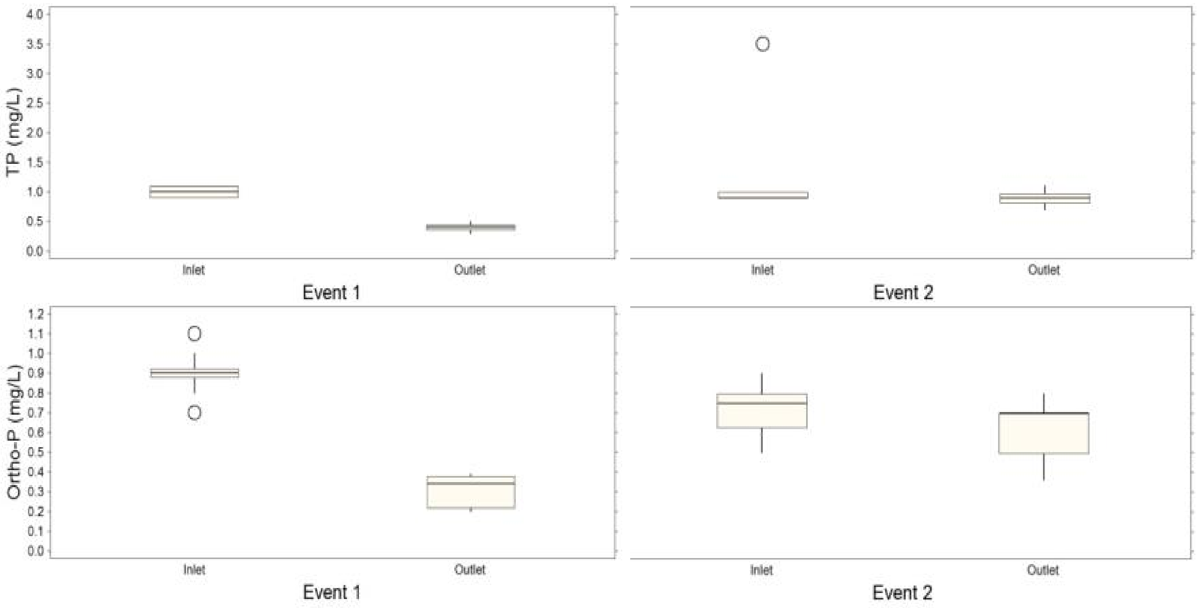

Figure 7 Box plots of total phosphorus (TP) and ortho-P concentrations from the inlet and outlet of the Bakers Creek system repair site, measured over two runoff events during the 2014/15 wet season

Overall, there was no consistent reduction in nitrogen and phosphorus concentrations measured at this site. This is not surprising, as only two runoff events were measured, and the site had not been vegetated since construction. Therefore some nitrogen removal processes (e.g. plant uptake) were not evident during the monitoring period. The uptake of ammonia-N and nitrate by macrophytes converts inorganic nitrogen into organic compounds. The uptake and storage rate of nutrients by plants depend on the nutrient concentration of their tissues. Thus, desirable features of a plant used for nutrient assimilation and storage include fast growth, high tissue nutrient content, and the ability to obtain a high-standing crop (Lee et al. 2009).

3.4. Water quality – herbicides

Herbicides not detected in any samples include (but not limited to) bromacil, fluometuron, imidacloprid (an insecticide), metolachlor, prometryn, simazine and tebuthiuron. A number of herbicides were commonly detected in samples collected from the inlet and outlet during each event (Figure 8).

Ametryn was not detected at the inlet during Event 1, but was detected at low concentrations (<0.03 µg/L) at the outlet. It was not detected (<0.01 µg/L) in any samples collected during Event 2. All samples collected were below the ametryn ecotoxicity threshold for 95% of species protection (0.1 µg/L) as described in the draft Mackay Whitsunday WQIP (Folkers et al. 2015).

For all other herbicides detected during Event 1, the outlet concentrations were at least half of those detected at the inlet. This may simply be due to dilution through the system for this relatively small runoff event. Concentrations in Event 2 were much higher than those measured in Event 1 (except diuron), with small reductions in the range of concentrations (and median) measured between the inlet and outlet (Figure 8).

Atrazine concentrations at the inlet during both events tended to increase as each event progressed (i.e. concentrations increased with time). This is not commonly observed in catchments in the Mackay region, as dilution and exhaustion of the herbicide source generally decreases the concentration observed in waterways as events progress (i.e. concentrations decrease with time). One possible explanation for this may be that the main source of atrazine was towards the top of the catchment, and the time taken to reach the inlet was similar to the sampling duration of the event. The median atrazine concentration of Event 2 (20 µg/L) was approximately double that measured at two catchments scales over a three year period near Mackay (Rohde et al. 2013). This may be due to the much drier period during the current study compared to the previous study, although no management practice data is available to assess atrazine applications. Overall, the median concentration at the outlet (0.74 µg/L) was 76% lower than the median inlet concentration (3.1 µg/L). Only one inlet sample from Event 1 had a concentration (10 µg/L) above the atrazine ecotoxicity threshold for 95% of species protection (6 µg/L) as described in the draft Mackay Whitsunday WQIP (Folkers et al. 2015), whereas four of the five samples collected during Event 2 were above the threshold.

Concentrations of diuron were high (13-39 µg/L) at the inlet during both events (median concentrations for Event 1 and 2 were 15 and 22 µg/L, respectively). Concentrations of this magnitude (and higher) were measured from a 50 ha catchment in 2009/10 (Rohde et al. 2013). Overall, the median concentration at the outlet (17 µg/L) was 45% lower than the median inlet concentration (31 µg/L). All samples collected were well above the diuron ecotoxicity threshold for 95% of species protection (0.3 µg/L) as described in the draft Mackay Whitsunday WQIP (Folkers et al. 2015).

Hexazinone concentrations also tended to increase as each event progressed, with a maximum concentration of 3.1 µg/L measured in Event 2. Overall, the median concentration at the outlet (0.87 µg/L) was slightly higher than the inlet median concentration (0.77 µg/L). This may be due to the lower concentrations detected, and the variability in sampling bewteen the inlet and outlet. Half of the inlet samples from Event 1 had concentrations above the hexazinone ecotoxicity threshold for 95% of species protection (0.7 µg/L) as described in the draft Mackay Whitsunday WQIP (Folkers et al. 2015), whereas four of the five samples collected during Event 2 were above the threshold.

Median concentrations of 2,4-D and fluroxypyr showed a 50% and 61% reduction between the inlet and outlet, respectively.

Although laboratory results show that imazapic was detected in Event 1 and not in Event 2, the laboratory limit of detection used in Event 2 (0.5 µg/L) was higher than that of Event 1 (0.07 µg/L) due to the more turbid water of Event 2. Of those samples collected during Event 1, only one sample (0.59 µg/L) was above the Event 2 limit of detection.

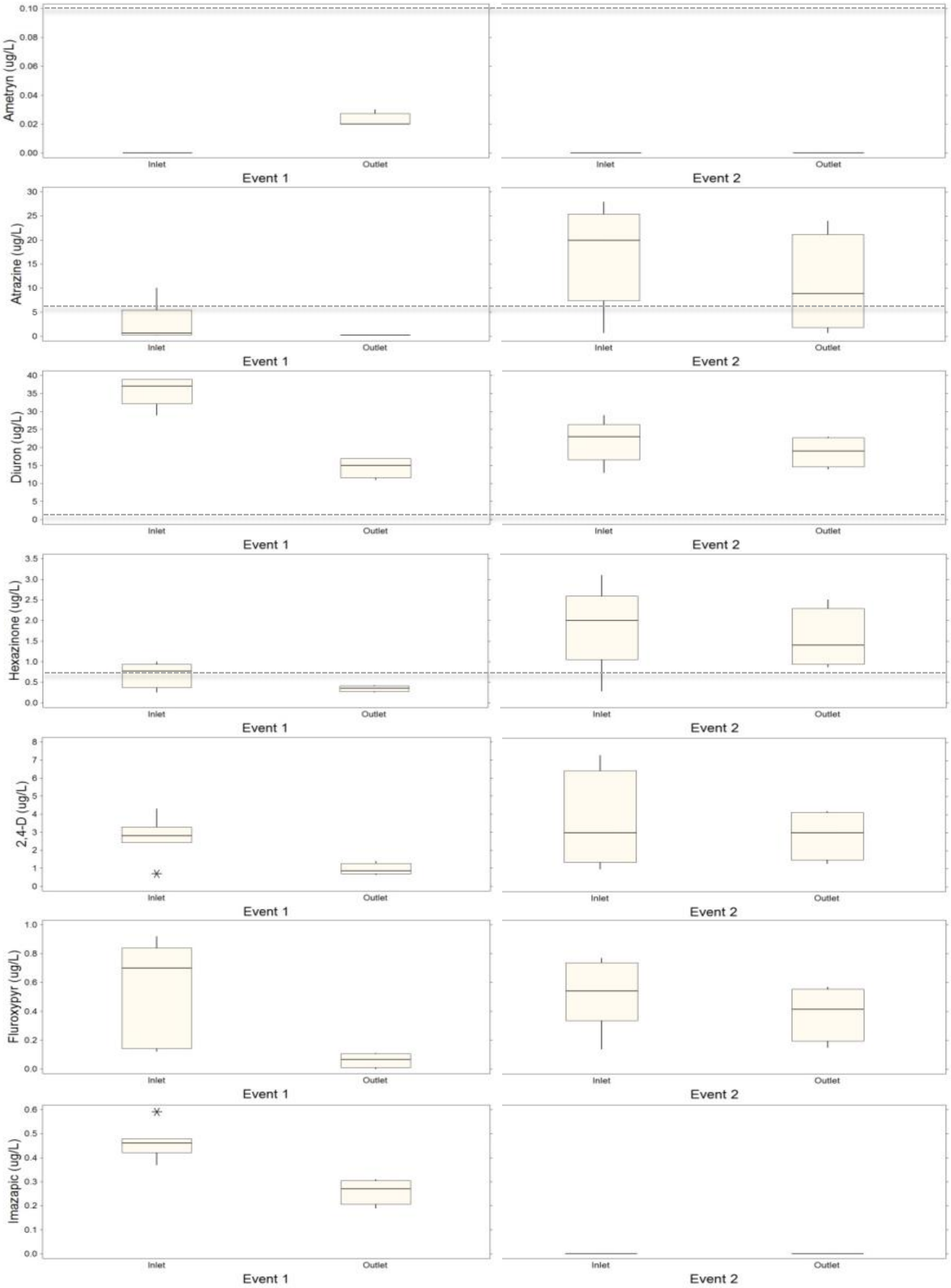

Figure 8 Box plots of herbicide concentrations from the inlet and outlet of the Bakers Creek system repair site, measured over two runoff events during the 2014/15 wet season

(Note – the dotted line shown on the ametryn, atrazine, diuron and hexazinone plots are the ecotoxicity threshold for 95% species protection as proposed in the draft Mackay Whitsunday WQIP (Folkers et al. 2015))

3.4.1. Herbicide mixtures

The impact of mixtures of herbicides (rather than individual herbicides in isolation) can be assessed using the multi-substance potentially affected fraction (ms-PAF) method. The ms-PAF method provides a more comprehensive assessment of the potential ecological impacts of herbicides that are present at the same time and have the same mode of action. The ms-PAF method was used to assess the effects of mixtures of the five PSII herbicides of interest (ametryn, atrazine, diuron, hexazinone and tebuthiuron (not detected)). The detailed methodology is discussed in Delaney et al. (2014) and follows the general approach of Traas et al. (2002).

The results from the ms-PAF assessment (Table 2) show that, of all the samples collected, at least 91% of phototrophic species would potentially have experienced toxic effects. The median ms-PAF value at the outlet (95%) was slightly lower than the inlet (97%) for these two runoff events. An ms-PAF value of 5% for moderately disturbed catchments is required to provide adequate protection to species (Folkers et al. 2015).

These results highlight that the assessment of mixtures of herbicides are critical to understand the potential impact of herbicides on aquatic ecosystems, and that the impacts of these mixtures are greater than the sum of the impacts of the individual herbicides at the same concentrations.

Table 2 Individual concentrations of the five PSII herbicides, and results of the ms-PAF assessment

Date/time	Ametryn (µg/L)	Atrazine (µg/L)	Diuron (µg/L)	Hexazinone (µg/L)	Tebuthiuron (µg/L)	ms-PAF
Inlet – event 1						
06/01/15 12:27	<0.01	0.23	29	0.26	<0.01	97.1
06/01/15 15:27	<0.01	0.20	39	0.36	<0.01	98.0
06/01/15 21:27	<0.01	0.35	37	0.47	<0.01	97.8
07/01/15 03:27	<0.01	0.62	35	0.77	<0.01	97.7
07/01/15 09:27	<0.01	0.70	32	0.94	<0.01	97.4
07/01/15 15:27	<0.01	5.5	38	1.0	<0.01	97.9
07/01/15 21:27	<0.01	10	39	0.90	<0.01	98.0
Median	<0.01	0.62	37	0.77	<0.01	97.8
Inlet – event 2						
22/01/15 14:11	<0.01	0.73	13	0.28	<0.01	92.7
22/01/15 20:11	<0.01	14	24	1.8	<0.01	96.6
23/01/15 02:11	<0.01	28	29	2.1	<0.01	97.3
23/01/15 20:11	<0.01	23	23	3.1	<0.01	96.6
24/01/15 08:11	<0.01	20	20	2.0	<0.01	95.9
Median	<0.01	20	23	2.0	<0.01	96.6
Outlet – event 1						
07/01/15 09:10	0.03	0.21	11	0.26	<0.01	91.2
07/01/15 15:14	0.02	0.21	13	0.29	<0.01	92.7
07/01/15 21:14	0.02	0.27	17	0.42	<0.01	94.6
08/01/15 09:14	0.02	0.26	17	0.41	<0.01	94.6
Median	0.02	0.24	15	0.35	<0.01	93.6
Outlet – event 2						
22/01/15 13:59	<0.01	0.74	14	0.87	<0.01	93.3
22/01/15 19:59	<0.01	4.7	16	1.1	<0.01	92.8
23/01/15 01:59	<0.01	13	22	1.7	<0.01	94.9
23/01/15 19:59	<0.01	25	24	2.0	<0.01	95.5
24/01/15 07:59	<0.01	24	23	2.5	<0.01	95.3
Median	<0.01	13	22	1.7	<0.01	94.9

4. CONCLUSIONS

Water quality monitoring was undertaken at the inlet and outlet of a system repair project during the 2014/15 wet season. Rainfall during the season was less than half of the long-term average, and resulted in only two rainfall runoff events being monitored. This was the first wet season after construction and revegetation had not occurred at the site. As a result, the sediment concentrations at the outlet (13-178 mg/L) were slightly higher than the inlet (4-107 mg/L), but concentrations were similar to those measured from other small sugarcane catchments in the Mackay region. Concentrations of nitrogen species responded differently between the two events, presumably due to the interaction between inlet water and the wetland water quality prior to Event 1 (dilution, release of organic material, etc.). In the much larger Event 2, there was little difference between inlet and outlet water quality for nitrogen (except a reduction in ammonia-N concentrations) and phosphorus.

Of those herbicides detected (particularly atrazine, diuron and hexazinone), outlet concentrations during Event 1 were at least half of those detected at the inlet. This may simply be due to dilution through the system for this relatively small runoff event. Concentrations in Event 2 were much higher than those measured in Event 1 (except diuron), with small reductions in the range of concentrations (and median) measured between the inlet and outlet. The results from the ms-PAF assessment show that, of all the samples collected, at least 91% of photosynthetic species were potentially affected. The median ms-PAF value at the outlet (95%) was slightly lower than the inlet (97%) for these two runoff events. These results highlight that the assessment of mixtures of herbicides are critical to understand the potential impact of herbicides on aquatic ecosystems.

Further monitoring in future wet seasons should show further improvements in water quality at this site as the components of the site become established and the site is revegetated.

5. RECOMMENDATIONS

1. Revegetate or mulch the battered banks prior to the next wet season to reduce bank erosion.
2. Vegetate the sediment basin to allow accumulation, volatilization and/or transformation/degradation of nutrients and herbicides.
3. If possible, limit the amount of water draining directly into the system repair site from the sugar cane blocks directly to the west of the site (approx. 10 ha). This direct runoff may be limiting the measured efficiency of the site.
4. Conduct regular water quality sampling (monthly?) in the lead-up to the next wet season to assess the quality of water contained within the system. This will assist in the interpretation of the first runoff event for the following season.
5. Conduct regular water quality sampling after the wet season to assess the persistence and breakdown of pollutants (mainly herbicides) in this system.

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APPENDIX 1 – Laboratory results

a) Sediment and nutrient results

Date/time	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia-N (mg/L)	NO_x-N (mg/L)	TP (mg/L)	Ortho-P (mg/L)
Inlet – event 1							
06/01/15 12:27	38	2.11	1.8	0.09	0.32	0.9	0.7
06/01/15 15:27	26	4.5	2.3	0.07	2.2	1.1	1.1
06/01/15 18:27	6	3.7	2.1	0.07	1.6	1.1	0.9
06/01/15 21:27	16	3.3	2.1	0.07	1.2	1.0	0.9
07/01/15 00:27	15	3.2	2.0	0.07	1.2	1.0	0.9
07/01/15 03:27	9	3.0	1.8	0.07	1.1	0.9	0.9
07/01/15 06:27	7	3.0	2.1	0.07	0.92	0.9	0.9
07/01/15 09:27	8	2.91	2.2	0.07	0.69	1.0	0.8
07/01/15 15:27	4	2.98	2.2	0.07	0.80	0.9	0.9
07/01/15 21:27	4	2.86	2.2	0.07	0.71	1.1	1.0
Inlet – event 2							
22/01/15 14:11	107	5.4	3.5	1.0	1.9	0.9	0.5
22/01/15 20:11	51	7.3	3.3	1.1	4.0	3.5	0.6
23/01/15 02:11	38	7.8	3.2	1.1	4.6	0.9	0.8
23/01/15 08:11	21	7.8	3.0	0.8	4.8	1.0	0.9
23/01/15 14:11	29	8	3.2	0.8	4.8	0.9	0.8
23/01/15 20:11	38	6.4	3.0	0.8	3.3	0.9	0.8
24/01/15 02:11	13	5.3	2.9	0.9	2.4	0.9	0.7
24/01/15 08:11	17	4.5	3.1	0.9	1.4	1.0	0.7
Outlet – event 1							
07/01/15 09:10	41	2.57	2.4	0.38	0.18	0.3	0.20
07/01/15 15:14	47	3.67	3.5	0.37	0.17	0.5	0.23
07/01/15 21:14	21	2.46	2.2	0.38	0.3	0.4	0.34
08/01/15 03:14	14	2.59	2.3	0.36	0.29	0.4	0.39
08/01/15 09:14	13	2.43	2.2	0.42	0.2	0.4	0.37
Outlet – event 2							
22/01/15 13:59	178	3.40	2.5	0.25	0.90	0.7	0.36
22/01/15 19:59	81	4.9	2.1	0.16	2.8	0.8	0.49
23/01/15 01:59	42	5.9	2.1	0.16	3.8	0.8	0.5
23/01/15 07:59	32	6.8	2.5	0.16	4.3	0.9	0.7
23/01/15 13:59	33	7.3	2.7	0.21	4.6	0.9	0.7
23/01/15 19:59	27	6.6	2.2	0.25	4.4	1.1	0.7
24/01/15 01:59	18	6.7	2.5	0.29	4.2	1.0	0.7
24/01/15 07:59	20	6.6	2.6	0.30	4.1	0.9	0.8

b) Herbicide results

Date/time	Ametryn (µg/L)	Atrazine (µg/L)	Diuron (µg/L)	Hexazinone (µg/L)	2,4-D (µg/L)	Fluropxypyr (µg/L)	Imazapic (µg/L)
Inlet – event 1							
06/01/15 12:27	<0.01	0.23	29	0.26	0.7	0.51	<0.01
06/01/15 15:27	<0.01	0.20	39	0.36	2.4	0.12	<0.01
06/01/15 18:27	n/a	n/a	n/a	n/a	n/a	n/a	n/a
06/01/15 21:27	<0.01	0.35	37	0.47	3.1	0.14	<0.01
07/01/15 00:27	n/a	n/a	n/a	n/a	n/a	n/a	n/a
07/01/15 03:27	<0.01	0.62	35	0.77	2.8	0.73	<0.01
07/01/15 06:27	n/a	n/a	n/a	n/a	n/a	n/a	n/a
07/01/15 09:27	<0.01	0.70	32	0.94	2.7	0.84	<0.01
07/01/15 15:27	<0.01	5.5	38	1.0	3.3	0.92	<0.01
07/01/15 21:27	<0.01	10	39	0.9	4.3	0.70	<0.01
Inlet – event 2							
22/01/15 14:11	<0.01	0.73	13	0.28	0.98	0.14	<0.01
22/01/15 20:11	<0.01	14	24	1.8	5.6	0.71	<0.01
23/01/15 02:11	<0.01	28	29	2.1	7.3	0.77	<0.01
23/01/15 08:11	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23/01/15 14:11	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23/01/15 20:11	<0.01	23	23	3.1	3.0	0.53	<0.01
24/01/15 02:11	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24/01/15 08:11	<0.01	20	20	2.0	1.7	0.54	<0.01
Outlet – event 1							
07/01/15 09:10	0.03	0.21	11	0.26	0.76	<0.03	0.19
07/01/15 15:14	0.02	0.21	13	0.29	0.65	0.03	0.25
07/01/15 21:14	0.02	0.27	17	0.42	1.4	0.11	0.29
08/01/15 03:14	n/a	n/a	n/a	n/a	n/a	n/a	n/a
08/01/15 09:14	0.02	0.26	17	0.41	0.97	0.10	0.31
Outlet – event 2							
22/01/15 13:59	<0.01	0.74	14	0.87	1.3	0.15	<0.50
22/01/15 19:59	<0.01	4.7	16	1.1	2.0	0.32	<0.50
23/01/15 01:59	<0.01	13	22	1.7	4.2	0.57	<0.50
23/01/15 07:59	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23/01/15 13:59	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23/01/15 19:59	<0.01	25	24	2.0	4.1	0.51	<0.50
24/01/15 01:59	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24/01/15 07:59	<0.01	24	23	2.5	4.0	0.51	<0.50

n/a not analysed

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