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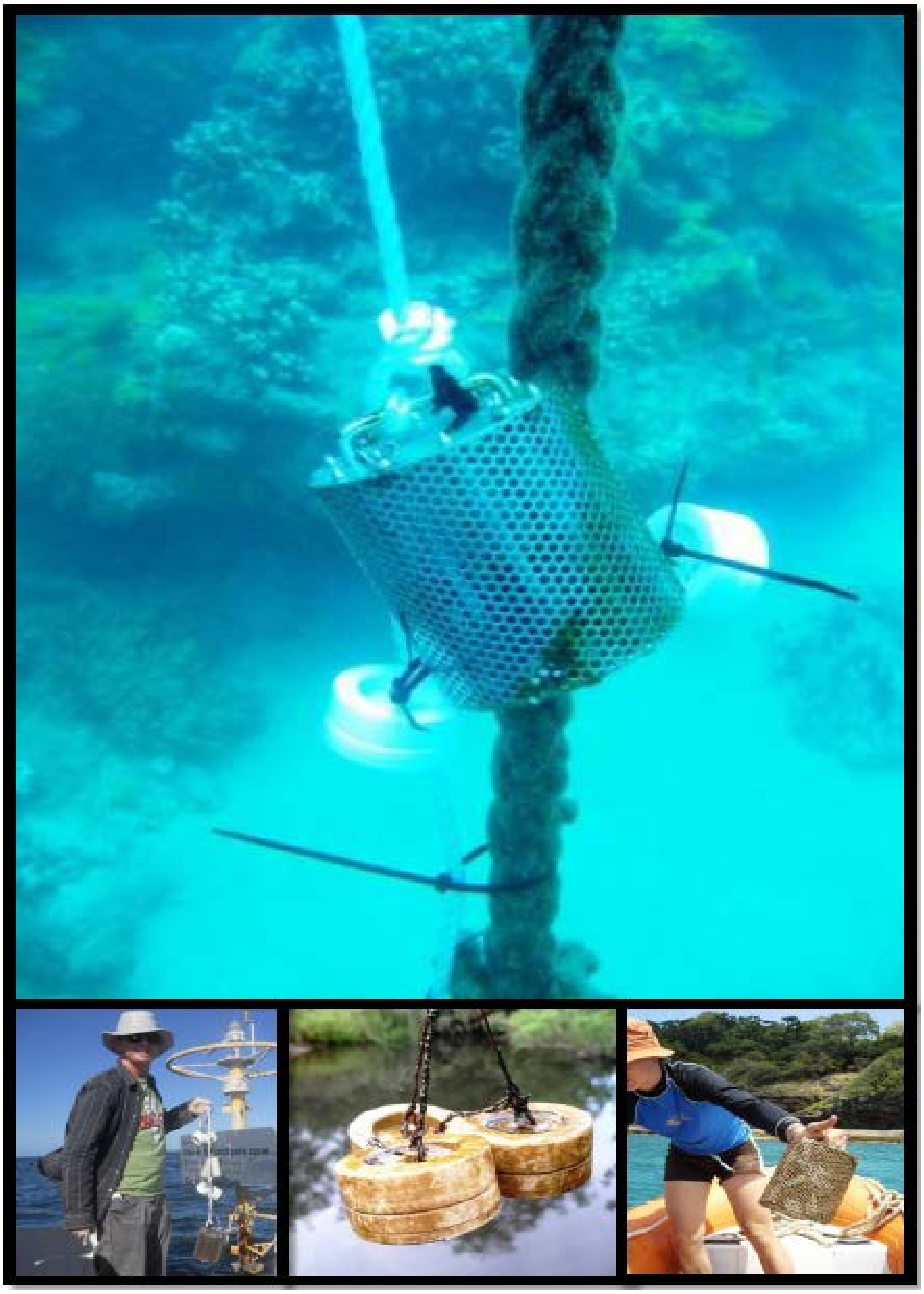

Pesticide monitoring in inshore waters of the Great Barrier Reef using both time-integrated and event monitoring techniques (2011 - 2012)

September 2012

Prepared for – The Program Manager, The Great Barrier Reef Marine Park Authority

Project Teams –

- **Inshore Marine Water Quality Monitoring**

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- **Assessment of Terrestrial Run-off Entering the Reef**

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Taylor's Beach Caravan Park	Ingham Travel	Australian Centre for Tropical and Freshwater Research
Sarina Bait Supplies	Frankland Island Cruise & Dive	North Keppel Island Environmental Education Centre
Jace Services	Reef Safari Diving	Department of Environment and Resource Management
Reef Fleet Terminal	Orpheus Island Research Station	Australian Institute of Marine Science
Low Isles Caretakers	Big Cat Green Island	
Quicksilver Connections	Hamilton Island Enterprises	
Raging Thunder	Mission Beach/ Dunk Island Water Taxi	

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About the Reef Rescue Marine Monitoring Program –
The Reef Rescue Marine Monitoring Program is a water quality and ecosystem health long-term monitoring program in the Great Barrier Reef lagoon to track the effectiveness of the Reef Rescue Plan. This project is supported by the Great Barrier Reef Marine Park Authority, through funding from the Australian Government's Caring for Our Country.

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Acronyms

ANZECC	Australian and New Zealand Environment and Conservation Council
APVMA	Australian Pesticides and Veterinary Medicines Authority
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
C_W	Concentration in water
DEET	*N*,*N*-Diethyl-*meta*-toluamide
EC_{20}	20 % maximal effective concentration is observed
EC_{50}	50 % maximal effective concentration is observed
ED	Empore Disk™ passive sampler
Entox	National Research Centre for Environmental Toxicology
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GC-MS	Gas Chromatography-Mass Spectrometry
GPC	Gel Permeation Chromatography
IWL	Interim working level
K_{OW}	Octanol-water partition coefficient
LC-MS	Liquid Chromatography-Mass Spectrometry
LOD	Limit of Detection
LOR	Limit Of Reporting
MMP	Reef Rescue Marine Monitoring Program
NATA	National Association of Testing Authorities
PDMS	Polydimethylsiloxane passive sampler
PFM	Passive/Plaster Flow Monitor
PSII-HEq	Photosystem II -Herbicide Equivalent Concentration
PTFE	Polytetrafluoroethylene : Common brand name - Teflon
QHFSS	Queensland Health Forensic & Scientific Services
RWQPP	Reef Water Quality Protection Plan
SDB-RPS	Poly(styrenedivinylbenzene) copolymer – reverse phase sulfonated
SPMD	Semi-permeable Membrane Devices

1 EXECUTIVE SUMMARY

In 2011-2012, Entox carried out monitoring activities utilising a combination of passive sampling and grab sampling techniques in the Great Barrier Reef Marine Park as part of the Reef Rescue Marine Monitoring Program (MMP). The MMP was implemented to evaluate changes in water quality in the Great Barrier Reef (GBR) and the status of key ecosystems under the Reef Water Quality Protection Plan (RWQPP) 2003 (which was further updated in 2009). Monitoring was conducted within two components of the MMP; ***Inshore Marine Water Quality Monitoring*** and the ***Assessment of Terrestrial Run-off Entering the Reef***. The key objectives of these components were to assess the temporal and spatial trends in water quality at fixed inshore GBR sites and the exposure to organic pollutants delivered to the reef lagoon during flood events in the wet season. The focus of both monitoring components was the assessment of exposure to pesticides in inshore GBR waters.

Long-term trends in pesticide exposure were monitored using passive sampling techniques at twelve fixed sites located in four Natural Resource Management (NRM) regions (Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy). These sites stretch approximately 1000 km down the Queensland coast from Low Isles in the Wet Tropics region, the northernmost site, through to North Keppel Island, in the Fitzroy Region being the southernmost site. Polar passive samplers that target relatively hydrophilic herbicides were deployed bimonthly during the dry season (May 2011 – October 2011) and monthly at every fixed site. Non-polar passive samplers that target relatively hydrophobic pesticides were deployed monthly during the wet season at selected sites only, with the exception of Normanby Island which had both sampler types deployed year-round. Exposure to pesticides from terrestrial run-off entering the reef lagoon was assessed using both 1 L grab samples and passive samplers in flood plumes in the Wet Tropics and Burdekin regions, along transects extending north and south from the Herbert River mouth. However, in the Cape York region and Wet Tropics region proper, exposure to pesticides was assessed by 1 L grab samples along transects extending from the Normanby River and the Tully River mouths, respectively. Overall, four transects (Tully River, Herbert River Northern, Herbert River Southern and Herbert River Barge) were established in the Wet Tropics/ Burdekin regions, and one in the Cape York region.

Photosystem II (PSII) herbicides have been identified as priority chemicals for monitoring in the GBR due to the predominantly agricultural use of the land adjacent to the reef and the fact that they have been found previously as ubiquitous contaminants of inshore waters, rivers and flood waters using both passive samplers and grab samples. Thusly, the focus of the passive sampling regime has been using the polar passive samplers year-round that target these types of chemicals. Unlike other water quality indicators such as *chlorophyll a* and turbidity that are present in the environment at low levels naturally and can be enhanced by anthropogenic activities, the presence of herbicides in inshore waters is a direct indicator of the influence of human activities, such as agricultural practices, on this world heritage ecosystem.

The PSII herbicides' mode of action is to inhibit photosynthesis and thus, exposure to these herbicides poses a risk to photosynthetic organisms such as seagrass, corals, algae and aquatic plant life. The concentrations of these herbicides within the present MMP report are expressed as PSII herbicide equivalent concentrations (PSII-HEq), which incorporate both the relative potency and relative abundance of individual PS-II herbicides relative to the reference PSII herbicide diuron. The PSII-HEq Index was developed as an indicator of the risk of exposure to PSII herbicides and the potential for PSII inhibition caused by the additive effects of mixtures of herbicides. The risk of PSII inhibition may therefore be underestimated when concentrations of herbicides are considered individually rather than as part of a more complex mixture. The index consists of five Categories which range from Category 1 (> 900 ng.L^{-1}), which represents the highest risk of exposure (above the 99 % species protection trigger value derived for the reference PSII herbicide diuron (GBRMPA 2010)), to Category 5 (≤10 ng.L^{-1}), which represents concentrations below which no published PSII inhibition effects have been observed.

In this report, the reporting parameters are the maximum PSII-HEq concentration (PSII-HEq Max) within each monitoring year and the average PSII-HEq during the wet season (PSII-HEq Wet Avg) at each site. These parameters have been selected to provide a simple means of highlighting temporal trends in herbicide exposure, where PSII HEq Max shows the maximum risk of exposure to PSII herbicides (with reference to diuron) in the current monitoring year, and PSII HEq Av shows the average risk of exposure to herbicides during the wet season of the current monitoring year. The temporal profile for the PSII-HEq Max at each of the routine monitoring sites since monitoring commenced is provided in Figure 1. The PSII herbicide diuron continues to be the dominant contributor to PSII-HEq at all sites due to its abundance and potency as a PSII inhibitor.

The, PSII-HEq Max and PSII-HEq Wet Avg for 2011/12 are provided in Table 1, which summarises key results from the routine monitoring and terrestrial run-off programs utilizing both snapshot (grab) and passive sampling techniques. For routine monitoring sites where long-term, time-integrated monitoring with passive sampling occurred, these reporting parameters are compared to those obtained in the baseline reporting year (2008-2009 unless otherwise stated) using ratios (Table 1). In this current monitoring year, the PSII-HEq Max for each of the twelve routine passive sampling sites did not exceed PSII-HEq Index Category 4. PSII-HEq Max of passive samplers deployed in the terrestrial run-off assessment ranged from Category 3 to 5, and from Category 4 to 5 for the grab samples collected.

Where pesticides other than PSII herbicides (i.e. metolachlor, imidacloprid, imazapic) or industrial chemicals (galaxolide and tonalide) have been detected, these are also indicated in Table 1 together with the maximum concentrations detected.

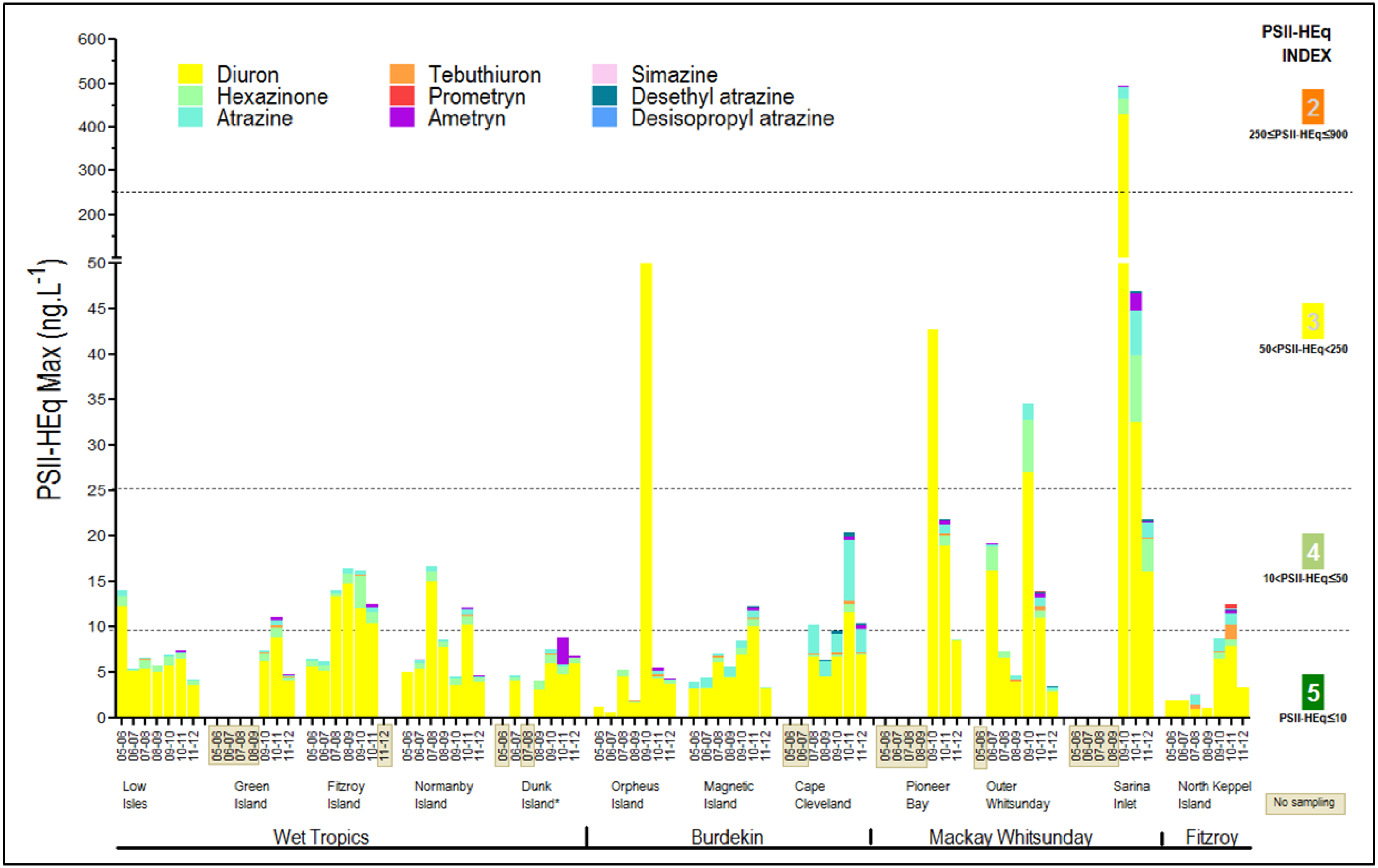

Figure 1 The temporal trends in PSII-HEq Max at routine monitoring sites in inshore waters of the GBR determined using time-integrative sampling

1.1 Key findings for the 2011-2012 monitoring year

A wide range of PSII herbicides, other pesticides and industrial chemicals were frequently detected at pesticide monitoring sites in 2011-2012 using both polar and non-polar passive samplers and grab samples. No PSII herbicides, other pesticides or industrial chemicals with an individual guideline to assess against, were detected in concentrations which met or exceeded Water Quality Guidelines (ANZECC and ARMCANZ 2000; GBRMPA 2010). This was the case in any sampling mode (time-integrated, equilibrium, snap-shot/grab sampling) and in both the routine monitoring or flood plume sampling components in 2011-2012.

A. Routine monitoring sites:

The most abundant and frequently detected PSII herbicides in each region were (from highest to lowest):

- **Wet Tropics** – diuron (maximum concentration of 6.0 $ng.L^{-1}$ at Dunk Island), hexazinone (maximum concentration of 1.5 $ng.L^{-1}$ at Dunk Island) and atrazine (maximum concentration of 1.0 $ng.L^{-1}$ maximum at Green Island)
- **Burdekin** – diuron (maximum concentration of 6.2 $ng.L^{-1}$ maximum at Cape Cleveland), atrazine (maximum concentration of 15 $ng.L^{-1}$ at Cape Cleveland), and hexazinone (maximum concentration of 0.76 $ng.L^{-1}$ at Orpheus Island)
- **Mackay Whitsunday** – diuron (maximum concentration of 18 $ng.L^{-1}$ at Sarina Inlet), atrazine (maximum concentration of 10 $ng.L^{-1}$ at Sarina Inlet) and hexazinone (maximum concentration of 9.6 $ng.L^{-1}$ at Sarina Inlet)
- **Fitzroy** – diuron (maximum concentration of 3.4 $ng.L^{-1}$), atrazine (maximum concentration of 1.6 $ng.L^{-1}$) and tebuthiuron (maximum of 1.9 $ng.L^{-1}$)

Pesticides other than PSII herbicides were also frequently detected at routine monitoring sites, with metolachlor detected at all twelve sites and notably in all polar passive samplers deployed at Magnetic Island, Normanby Island, Orpheus Island and Sarina Inlet.

The trends in the reporting parameters PSII-HEq Max and PSII-HEq Wet Avg during the 2011-2012 monitoring year and the baseline reporting year were:

- **Wet Tropics** –With the exception of Fitzroy Island, where no successful monitoring occurred this year, Dunk Island remains the only site in the Wet Tropics with an elevated PSII-HEq Max when compared to the baseline reporting year. A decrease in the PSII-HEq Max at Normanby Island and Green Island, from the previous monitoring year to Index Category 5 is notable. The PSII-HEq Wet Avg remained fairly consistent when compared with values from the baseline reporting year, indicating less prolonged risk of exposure to PSII herbicides during the wet season.
- **Burdekin** – PSII-HEq Max and PSII-HEq Wet Avg remain elevated at Cape Cleveland and Orpheus Island respectively, when compared to the baseline reporting year, indicating elevated exposure to herbicides during the wet season at these sites. At Magnetic Island, PSII-HEq Max has improved from Category 4 to Category 5 on the PSII-HEq Index.
- **Mackay Whitsunday** – PSII-HEq Max and PSII-HEq Wet Avg at Sarina Inlet and Pioneer Bay have decreased substantially from 2009-2010 when monitoring commenced. Outer Whitsunday has also seen significant improvement in the PSII-HEq Wet Avg from the baseline reporting year (2006-2007). Pioneer Bay and Outer Whitsunday have improved from Category 4 sites to Category 5, while Sarina Inlet has improved from a Category 2 site in 2009-2010 to a low Category 4 site in 2011-2012.
- **Fitzroy –** Both PSII-HEq Max and the PSII-HEq Wet Avg at North Keppel Island have increased in 2011-2012, when compared to the baseline monitoring year. However, the PSII-HEq Max improved from Category 4 to Category 5 on the PSII-HEq Index, compared to the previous monitoring year.
- In all four NRM regions, there have been significant decreases in PSII-HEq Max values when compared to the previous monitoring year (Figure 1).

B. <u>Terrestrial Run-Off (flood plumes)</u>

- No herbicides were detected in 1 L grab samples collected at two sites in the Cape York region in a transect that extended approximately 2 km from the Normanby River mouth.
- In the Wet Tropics region, diuron, hexazinone and imadicloprid were detected in grab samples collected from four sites on a transect extending up to 35 km from the Tully River. Diuron (maximum concentration of 21 ng.L^{-1}) was the most frequently detected and abundant PSII herbicide and was found at all transect sites including the most distant site to the Tully River mouth. Hexazinone (maximum concentration of 13 ng.L^{-1}) and imidacloprid (24 ng.L^{-1}) were detected only at the Tully River mouth. PSII herbicides detected in the grab samples indicated either PSII-HEq Category 4 or 5 exposures. No passive samplers were deployed on this transect. Whilst a clear gradient in the diuron concentrations could be seen with increasing distance from the river mouth at one time point, another time point showed consistent concentrations at all sites, suggesting little dilution of the flood plume.
- A more intensive sampling campaign was undertaken on transects extending north (four sites; approximately 55 km) and south (four sites; approximately 7 km) from the Herbert River in the Wet Tropics region using a combination of grab and passive sampling techniques. Diuron (maximum concentration of 44 ng.L^{-1} on the southern transect), atrazine (maximum concentration of 18 ng.L^{-1} on the southern transect) and simazine (single detection of 29 ng.L^{-1} on the northern transect) were the only PSII herbicides detected in the grab samples on either transect, with diuron being the most frequently detected and abundant. A greater number of herbicides were detected in the passive samplers deployed on both transects including ametryn, hexazinone, tebuthiuron, metolachlor and imadicloprid. Grab samples collected on both the northern and southern transects, indicated either PSII-HEq Category 4 or 5 exposures.
- Diuron (maximum concentration of 40 ng.L^{-1} on the southern transect) , hexazinone (9.2 ng.L^{-1} on the southern transect), atrazine (maximum concentration of 9.0 ng.L^{-1} on the southern transect) and simazine (maximum concentration 3.2 ng.L^{-1} on the southern transect) were the most abundant PSII herbicides detected in polar passive samplers deployed on either the northern or southern Herbert River transects. The PSII-HEq Max for the northern transect was 30 ng.L^{-1} (indicating a Category 4 exposure) whereas the southern transect detected the highest PSII-HEq Max of all passive samplers deployed in both monitoring components of 50 ng.L (indicating a Category 3 exposure)

Table 1 An overview of key results for pesticide monitoring on the GBR in 2011-2012

NRM Region	Transect	Site Name	Monitoring Component	Sampler Type	Sampling Mode	PSII-Heq Max	Ratio to Baseline Year	PSII-Heq Wet Avg	Ratio to Baseline Year	Other Pesticides detected	Max Concentration (ng. L^{-1})	GBRMPA Guideline Exceedances
Cape York	Normanby River	Site 7 - Normanby River mouth	TR	GRAB	SS	n.d.						
		Site 13 - approx 2 km from Normanby River mouth	TR	GRAB	SS	n.d.						
Wet Tropics		Low Isles	R	ED	TI	4.2	0.74	2.1	1.0	Metolachlor	0.10	
										Imazapic	0.15	
		Green Island	R	ED	TI	4.8		1.9		Metolachlor	0.10	
										Imazapic	0.15	
										Imidacloprid	0.20	
				PDMS	TI					Galaxolide	0.14	
		Fitzroy Island	R	ED	TI	No sampling occurred						
				PDMS	E							
		Normanby Island	R	ED	TI	4.7	0.55	2.6	0.77	Metolachlor	0.1	
				PDMS	TI					Galaxolide	0.16	
					TI					Tonalid	0.01	
		Dunk Island	R	ED	TI	6.8	1.65	-	-	Metolachlor	0.07	
										Imazapic	0.01	
										Imidacloprid	1.1	
				PDMS								
	Tully River	Tully River mouth	TR	GRAB	SS	24				Imidacloprid	24	
		Bedarra Island - approx 9 km from Tully River mouth	TR	GRAB	SS	21						
		North Dunk - approx 15 km from Tully River mouth	TR	GRAB	SS	n.d.						
		Sisters Island - approx 35 km from Tully River mouth	TR	GRAB	SS	13						
	Herbert River Northern	Channel North - approx 36 km from Herbert River mouth	TR	ED	TI	30						
				GRAB	SS	39						
		Goold Island - approx 50 km from Herbert River mouth	TR	ED	TI	10						
				GRAB	SS	13						
		Cape Richards - approx 55 km from Herbert River mouth	TR	GRAB	SS	13						
Wet Tropics/ Burdekin	Herbert River Southern	Seymour River mouth	TR	GRAB	SS	13						
		Herbert River mouth	TR	GRAB	SS	14						
		South Site 2 - approx 3 km from Herbert River mouth	TR	ED	TI	50						
				GRAB	SS	47						
		South Site 3 - approx 7 km from Herbert River mouth	TR	GRAB	SS	n.d.						
	Herbert River Barge	Barge Site 2 - approx 8 km from Herbert River mouth	TR	GRAB	SS	n.d.						
		Barge Site 3 - approx 11 km from Herbert River mouth	TR	GRAB	SS	n.d.						
Burdekin		Orpheus Island	R	ED	TI	4.3	2.1	1.6	2.8	Bromacil	0.03	
										Metolachlor	0.20	
		Magnetic Island	R	ED	TI	3.4	0.6	3.0	1.3	Metolachlor	0.13	
				PDMS	E					Metolachlor	1.3	
					TI					Galaxolide	0.16	
					TI					Tonalid	0.01	
		Cape Cleveland	R	ED	TI	10	1.6	4.4	1.9	Metolachlor	0.21	
										Imazapic	0.04	
				PDMS	E					Atrazine	40	
					E					Metolachlor	1.2	
					TI					Galaxolide	0.13	
					TI					Tonalid	0.02	
Mackay Whitsunday		Pioneer Bay	R	ED	TI	11		7.9		Metolachlor	0.12	
		Outer Whitsunday	R	ED	TI	3.4	0.18	1.4	0.18	Metolachlor	0.02	
				PDMS								
		Sarina Inlet	R	ED	TI	22		12		Bromacil	0.18	
										Metolachlor	0.21	
										Imidacloprid	0.52	
Fitzroy		North Keppel Island	R	ED	TI	3.4	3.1	1.7	2.34	Bromacil	0.11	
										Metolachlor	0.90	

R = Routine Monitoring Site, TR = Terrestrial Run-off sample; TI = Time-integrated Passive Sampling, E = Equilibrium Phase Passive Sampling, SS = Snap Shot Sample i.e. (1 L grab); The reporting parameters PSII-HEq Max and Wet Avg are colour coded according to PSII-HEq Index Categories (refer Figure 1); Ratios of these time-integrated reporting parameters to the same parameters in the baseline reporting year 2008-2009.(Exception: Outer Whitsunday (2006-2007).

2 INTRODUCTION

The World Heritage Great Barrier Reef Marine Park covers an area of 344,400 km^2 and spans 2,600 km along the Queensland coast. This unique ecosystem lies adjacent to land that is predominantly used for intensive agricultural activities. Approximately 70 % of the land in the GBR catchment area is occupied by agriculture including sugar cane, beef grazing, horticulture, cropping, pastures and cotton (Smith et al 2012), and thus exposure to pesticides from these adjacent catchments poses a direct threat to the inshore waters of the GBR. Different climate conditions and patterns of land use between regions dictates the fertiliser and pesticide usage requirements within those regions, and thusly influences the risk of adverse changes in water quality parameters such as nutrients (dissolved inorganic nitrogen and phosphorous), suspended sediment and exposure to PSII herbicides (Waterhouse et al 2012). Depending on the agricultural activities existing along rivers within catchments, the herbicide profiles between regions can vary dramatically.

Nutrients, sediments and agricultural chemicals from these adjacent catchments are introduced into the inshore waters of the reef by terrestrial discharge during the wet season. These pollutants have been identified as key contributors to declining water quality in the inshore reef (Furnas, 2003; Brodie et al 2008; Brodie and Waterhouse 2009; Packett et al 2009; van Dam et al 2010). During peak flood events, elevated concentrations of these pollutants are discharged into the reef waters, exposing these fragile ecosystems to pollutants for extended periods of time (Devlin and Scaffelke, 2009). The influence of flood plumes has been found to extend vast distances, up to 100 km from the coast (Rohde et al 2008). A decline in water quality will affect the reef's overall resilience and continued ability to adapt to change and recover from multiple stressors whether they be local (eg. crown-of-thorn starfish outbreak, cyclone) or global (the impact of climate change).

The contaminants assessed as an indicator of water quality, either routinely or during flood events were pesticides (insecticides, herbicides and fungicides). Temporal and spatial trends in water quality were assessed through fixed site routine monitoring at twelve sites across four Natural Resource Management (NRM) regions - Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy. This monitoring has been conducted for between three to seven years at these locations.

The focus of the terrestrial run-off component in 2011-2012 was to analyse the spatial and temporal pollutant profiles from adjacent catchments, with an emphasis on the Herbert River in the Wet Tropics (bordering the Burdekin) region. Polar passive samplers were deployed at three fixed sites in the inshore waters extending from the Herbert River. Grab sampling was undertaken coinciding with the deployment and retrieval of the passive samplers. This more intensive sampling approach aims to illustrate the temporal and spatial variation which may exist within the Wet Tropics region which may not be adequately captured by routine monitoring sites alone. Terrestrial run-off was also assessed at other locations in the Wet Tropics (Tully River transect) and Cape York (Normanby River transect) regions during flood plume events using 1 L grab samples only.

3 METHODOLOGY

Routine water quality monitoring at fixed sites was conducted using passive sampling techniques. These samplers accumulate chemicals into a sorbing material from water via passive diffusion. The passive sampling techniques which are utilized in this component of the MMP include:

- SDB-RPS Empore™ Disk (ED) based polar passive samplers for relatively hydrophilic organic chemicals with relatively low octanol-water partition coefficients ($logK_{OW}$) such as the PSII herbicides (example: diuron).
- Polydimethylsiloxane (PDMS) and Semipermeable Membrane Devices (SPMDs) non-polar passive samplers for organic chemicals which are relatively more hydrophobic (higher $log\ K_{OW}$) such as chlorpyrifos.

Terrestrial run-off assessments conducted in the Wet Tropics/ Burdekin regions during the wet season have used a combination of time-integrated passive sampling (EDs) (at three sites additional to the routine monitoring sites) and 1 L grab water sampling. Combining these techniques has allowed both time-integrated and “snapshots” of concentration to be profiled through time at these locations. 1 L grab water samples were also taken during flood plume events at other sites in the Wet Tropics and Cape York regions. Full details regarding these methodologies have been described in the *Reef Rescue Marine Monitoring Program: Quality Assurance/Quality Control Methods and Procedures Manual 2011* (GBRMPA 2011) and in previous reports (Kennedy et al. 2011; Kennedy et al. 2010a;).

Figures 2 and 3 show the typical configuration of polar and non-polar samplers together with PFMs. Typically, samplers are deployed on a rope or chain using shackles or cable ties from either a buoy or fixed point such as a jetty or pontoon. It is recommended that the samplers sit in the middle of the water column or are at a level where they are not exposed at low tide, without resting on the bottom. The transportation lid on the EDs are removed and replaced with a deployment ring which holds a protective mesh in place. The caps of PFMs are also removed (except in the dry season where flow-limiting caps are deployed). Once the samplers are attached to the rope or chain they are lowered into the water, shaking to remove any air bubbles. The date of deployment is then recorded by the volunteer. Upon retrieval, samplers are removed from the water, shaking to remove excess debris and water. The cage is detached from the rope or chain and re-sealed in a tin. The EDs and PFMs are also detached and the lids of the PFMs replaced. The ED is filled with water from the site to prevent drying and the transportation lids screwed on. The sampler set is then refrigerated until being returned to Entox in an esky packed with ice bricks.

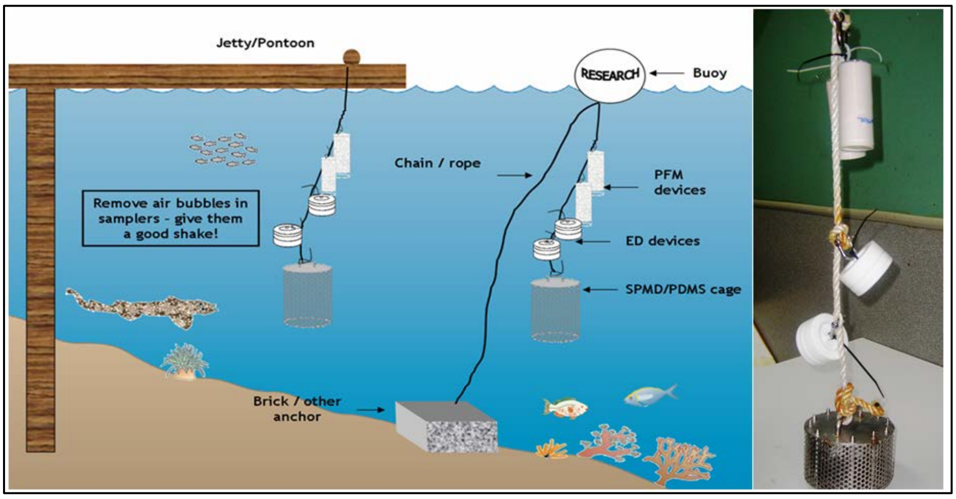

Figure 2

The participation of volunteers (Table 3) from various community groups, agencies and tourist operations is a key feature of the routine pesticide monitoring program and integral to the success of maintaining the program in often remote locations. These volunteers assist by receiving, deploying, retrieving and returning the passive samplers to Entox for subsequent extraction and analysis. This active participation of volunteers within the program is made possible by training from GBRMPA and/or Entox staff in Standard

Operating Procedures to ensure a high level of continuous sampling and high quality usable data is obtained from these deployments.

Figure 3 Deployment of passive samplers in the field

3.1 Target Chemicals and Limits of Reporting

The pesticides targeted for analysis using the different sampling techniques and the limits of reporting (LOR) are indicated in Table 2. This list of target chemicals was derived at the commencement of the MMP through consultation with GBRMPA based on the following criteria: pesticides detected in recent studies, those recognised as a potential risk, analytical affordability, pesticides within the current analytical capabilities of Queensland Health Forensic and Scientific Services (QHFSS) and those likely to be accumulated within one of the passive sampling techniques (i.e. that exist as neutral species and are not too polar).The limits of reporting (LOR) for the LCMS and GCMS instrument data have been defined by Queensland Health Forensic and Scientific Services laboratory as follows: The LORs are determined by adding a very low level of analyte to a matrix and injecting 6-7 times into the analytical instrument. The standard deviation of the resultant signals is obtained and a multiplication factor of 10 is applied to obtain the LOR.

Table 2. Pesticides specified under the MMP for analysis with different sampling techniques together with the limits of reporting ($ng.L^{-1}$)

Pesticide	Description	LOR			
		SPMD	PDMS	ED[a]	GRAB
Bifenthrin	Pyrethroid insecticide		<1		
Fenvalerate	Pyrethroid insecticide		<0.5		
Bromacil[b]	PSII herbicide-uracil			<0.04 - 2	<10
Tebuthiuron	PSII herbicide-thiadazolurea		<25	<0.04 - 2	<10
Terbutryn[c]	PSII herbicides-methylthiotriazine			<0.04 – 0.4	<10
Flumeturon	PSII herbicide-phenylurea		<30	<0.08 - 2	<10
Ametryn	PSII herbicide-methylthiotriazine		<10	<0.04 – 2	<10
Prometryn	PSII herbicide-methylthiotriazine		<5	<0.04 - 2	<10
Atrazine	PSII herbicide-chlorotriazine		<10	<0.04 - 2	<10
Propazine	PSII herbicide-chlorotriazine		<10		
Simazine	PSII herbicide-chlorotriazine		<30	<0.04 - 2	<10
Hexazinone	PSII herbicide- triazinone		<25	<0.04 - 2	<10
Desethylatrazine	PSII herbicide breakdown product (also active)			<0.04 - 2	<10
Desisopropylatrazine	PSII herbicide breakdown product (also active)		<25	<0.08 - 2	<10
Diuron	PSII herbicide - pheynylurea		<25	<0.04 - 2	<10
Oxadiazon	Oxadiazolone herbicide		<0.5		
Chlorfenvinphos	Organophosphate insecticide		<2		
Chlorpyrifos	Organophosphate insecticide	<0.03	<0.5		
Diazinon	Organophosphate insecticide	<5	<5		
Fenamiphos	Organophosphate insecticide		<5		
Prothiophos	Organophosphate insecticide	<0.09	<0.5		
Chlordane	Organochlorine insecticide	<0.1	<0.5		
DDT	Organochlorine insecticide	<0.08	<0.5		
Dieldrin	Organochlorine insecticide	<0.2	<0.5		
Endosulphan	Organochlorine insecticide	<1.9	<5		
Heptachlor	Organochlorine insecticide	<0.07	<0.5		
Lindane	Organochlorine insecticide	<0.5	<5		
Hexachlorobenzene	Organochlorine fungicide	<0.09	<0.5		
Imidacloprid[c]	Nicotinoid insecticide			<0.04 - 4	<10
Trifluralin	Dintiroaniline		<0.5		
Pendimethalin	Dinitroaniline herbicide	<0.4	<0.5		
Propiconazole	Conazole fungicide		<2		
Tebuconazole	Conazole fungicide		<5		
Metolachlor	Chloracetanilide herbicide		<10	<0.04 - 2	<10
Propoxur	Carbamate insecticide		<25		

[a] Prior to this monitoring year, ED sample extracts were routinely analysed on the API 300 LCMS, LOR ranges reflect both changes in sampling rates under event (no membrane) and routine configurations (with membrane) and differences in sensitivities on the different instruments for an assumed 30-day deployment period; [b]Bromacil was included in the list of target analytes from 2009-2010; [c]Imidacloprid and terbutryn were routinely analysed in this monitoring year.

All empore disc sampler extracts (routine monitoring and terrestrial run-off assessment) and grab samples (terrestrial run-off assessment) were routinely analysed using liquid chromatography mass spectrometry on the (ABSciex 4000 QTrap LCMSMS) run in positive analysis mode. This excludes the analysis of several hydrophilic pesticides such as 2,4-D, MCPA, mecoprop, and picloram, detected in negative analysis mode only. This LCMSMS run includes two additional pesticides (imidacloprid and terbutryn) which were not routinely run prior to this monitoring year. PDMS and SPMD sampler extracts are analysed for pesticides using gas chromatography mass spectrometry (GCMS). While priority chemicals are targeted using SPMDs and PDMS in this MMP (Table 2), a broader suite of organic chemicals including other pesticides and industrial chemicals are simultaneously analysed in the PDMS and SPMD sampler extracts (Appendix A, Table 19).

3.2 Sampling Sites

Passive samplers were routinely deployed at twelve inshore GBR sites in 2011-2012, including three sites that were only incorporated into the MMP in 2009-2010 (refer to Figure 4). These sites were Green Island in the Wet Tropics region and Pioneer Bay and Sarina Inlet in the Mackay Whitsunday region. Pioneer Bay and Sarina Inlet are also seagrass monitoring sites within the MMP. Polar passive samplers to assess terrestrial run-off were deployed at three additional sites in the Wet Tropics/ Burdekin regions.

3.3 Routine Sampling Periods

The monitoring year for routine pesticide sampling is from May 2011 to April 2012. The year is arbitrarily divided into "Dry 11" (May 2011 to October 2011) and "Wet 11-12" (November 2011 – April 2012) sampling periods for reporting purposes. Within each dry season deployment period, samplers are typically deployed for two months (maximum of three deployment periods each monitoring year) and within each wet season deployment period, samplers are typically deployed for one month (maximum of six deployment periods within each monitoring year). The maximum number of samples which should be obtained from each location within each monitoring year is nine. Table 3 indicates the numbers of passive sampler sets sent to each location, successfully deployed and returned to Entox.

Table 3 Sampling return record for the 2011-2012 monitoring year

NRM Region	Site Name	No of samplers sent	No of samplers returned	Comments
Wet Tropics	Low Isles	9	9	New volunteer from November 2011.
	Green Island	9	8	Very reliable site. All samplers lost in May/ June 2011.
	Fitzroy Island	7	0	Volunteer has since left.
	Normanby Island	7	6	2 samplers returned unused.
	Dunk Island	8	7	Only 3 samplers able to be extracted due to incorrect deployment technique. Mooring and samplers lost in February 2012.
Burdekin	Orpheus Island	9	9	Very reliable site this year.
	Magnetic Island	9	8	One sampler lost after retrieval in transit.
	Cape Cleveland	9	8	New deployment personnel in early 2012. No major problems.
Mackay Whitsunday	Pioneer Bay	8	7	Some late deployments due to volunteer availability.
	Outer Whitsunday	6	4	Lost mooring caused 4 month delay.
	Sarina Inlet	9	9	Very reliable site this year.
Fitzroy	North Keppel Island	9	9	Very reliable site this year.

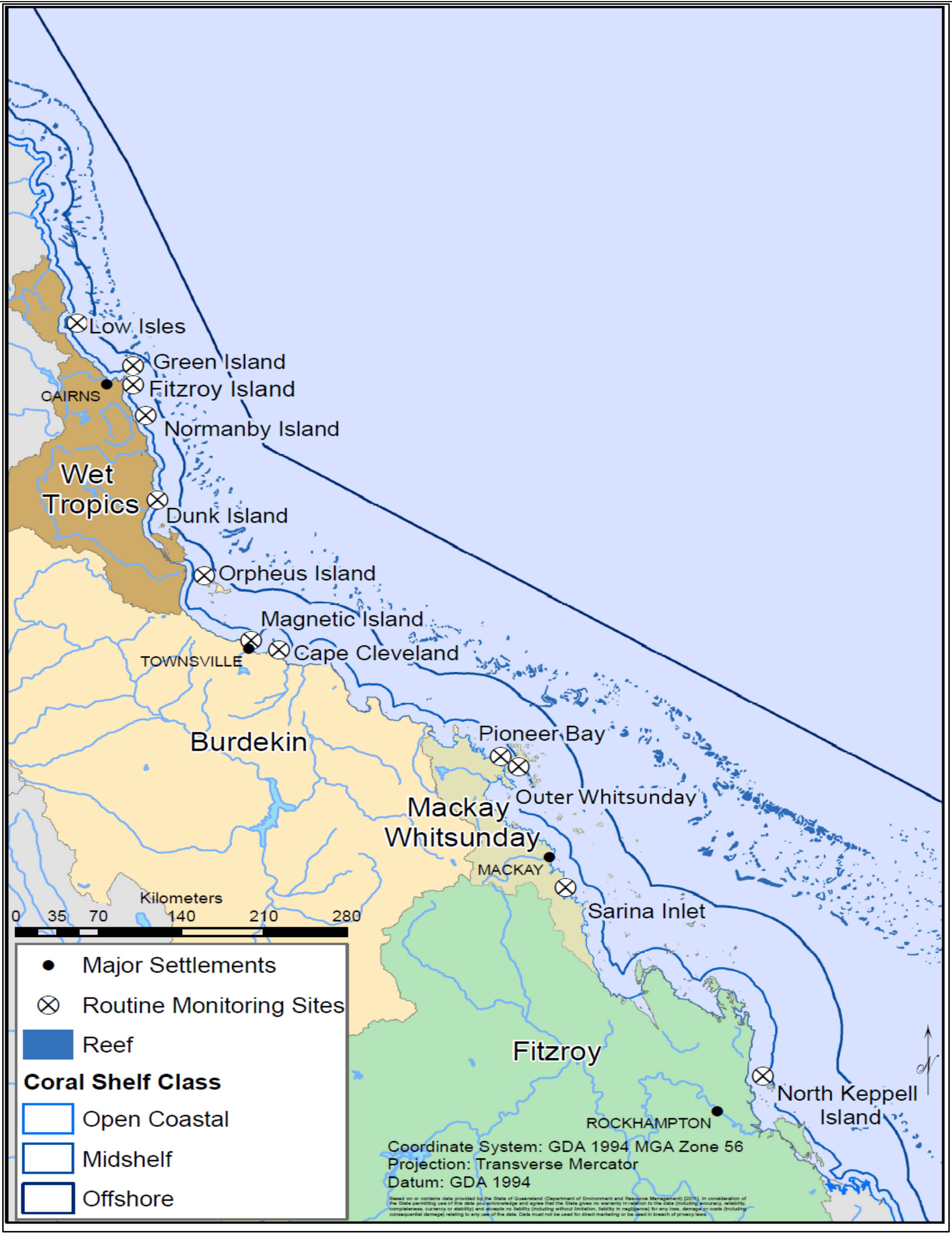

Figure 4 Locations of current inshore GBR routine monitoring sites where time-integrated sampling of pesticides occurred in 2011-2012

(Source – Adam Thom and Alex Shanahan, School of Geography, Planning and Environmental Management, the University of Queensland)

3.4 Types of samplers deployed for routine sampling for the Assessment of Water Quality

The types of samplers deployed at each site are indicated in Table 4 below. All twelve sites are routinely monitored in both the dry and wet periods using EDs, while six of these sites have additional PDMS samplers deployed during the wet season - three sites located in the Wet Tropics region, two in the Burdekin region and one in the the Mackay Whitsunday region. Normanby Island (located in the Wet Tropics) is the only site which is monitored year-round using PDMS in both the dry and wet period. SPMDs are also deployed at this site only. The sampling records and results for each routine monitoring site are provided in Appendix D, Tables 22-32.

Table 4 The types of passive samplers deployed at each routine monitoring site in 2011-2012

Region	Site	EDs (polar)		PDMS (non-polar)		SPMD (non-polar)	
		Dry	Wet	Dry	Wet	Dry	Wet
Wet Tropics	Low Isles	✓	✓	×	×	×	×
	Green Island	✓	✓	×	✓	×	×
	Fitzroy Island	✓	✓	×	✓	×	×
	Normanby Island	✓	✓	✓	✓	✓	✓
	Dunk Island	✓	✓	×	✓	×	×
Burdekin	Orpheus Island	✓	✓	×	×	×	×
	Magnetic Island	✓	✓	×	✓	×	×
	Cape Cleveland	✓	✓	×	✓	×	×
Mackay - Whitsunday	Pioneer Bay	✓	✓	×	×	×	×
	Outer Whitsunday	✓	✓	×	✓	×	×
	Sarina Inlet	✓	✓	×	×	×	×
Fitzroy	North Keppel Island	✓	✓	×	×	×	×

3.5 Sampling for the Assessment of Terrestrial Run-Off by Region in the Wet Season

3.5.1 Flood plume sampling

A total of thirty-six 1 L grab samples were collected to monitor terrestrial run-off from three NRM regions (Cape York and the Wet Tropics/ Burdekin) during flood plume events in the 2011-2012 wet season (refer to Table 5). Polar passive samplers were deployed at three sites additional to the routine monitoring sites in two transects extending from the Herbert River, and grab samples collected at these sites also. Further details for these samples including date and time of collection, co-ordinates and results for individual herbicides detected are provided in Appendix E, Tables 33 - 36. The hydrographs for the closest major rivers influencing these sampling sites are provided in Appendix F.

Table 5 The number and timing of grab samples collected to assess terrestrial run-off during the 2011-2012 wet season

Catchment	Transect	Site Name	Date
Cape York	Normanby River	Site 7	29-Mar-12
		Site 13	29-Mar-12
		Samples collected 1 day after peak, following a major peak 12 days prior	
Tully	Tully	Bedarra Island	09-Sep-11
		Dry Season Baseline sample	
		Tully River mouth	05-Jan-12
		Bedarra Island	05-Jan-12
		Sisters Island	05-Jan-12
		Samples collected 4 days after the latest discharge event on a falling hydrograph	
		Tully River mouth	11-Feb-12
		Bedarra Island	11-Feb-12
		Samples collected 6 days after peak discharge event in the Tully River	
		Tully River mouth	08-Mar-12
		Bedarra Island	08-Mar-12
		Sisters Island	08-Mar-12
		Samples collected 6 days after peak discharge event in the Tully River	
		Tully River mouth	31-Mar-12
		Bedarra Is	31-Mar-12
		Nth Dunk	31-Mar-12
Herbert		Samples collected 3 days after 2 peak discharge events, which occurred in the previous 10 days	
	Northern	Channel North (Passive Site 1)	19-Dec-11
	Northern	Goold Island (Passive Site 2)	19-Dec-11
	Southern	South Site 2 (Passive Site 3)	20-Dec-11
		No significant flow event, but after first flushes in the Herbert River in late November - early December 2011	
	Northern	Channel North (Passive Site 1)	20-Jan-12
	Northern	Goold Island (Passive Site 2)	20-Jan-12
	Southern	South Site 2 (Passive Site 3)	21-Jan-12
		Samples collected during peak discharge in Herbert River	
	Northern	Cape Richards	13-Feb-12
	Northern	Channel North (Passive Site 1)	13-Feb-12
	Northern	Goold Island (Passive Site 2)	13-Feb-12
	Southern	South Site 2 (Passive Site 3)	14-Feb-12
		Samples collected 8 to 9 days after peak discharge in Herbert River	
	Northern	Channel North (Passive Site 1)	05-Mar-12
	Northern	Goold Island (Passive Site 2)	06-Mar-12
	Southern	South Site 2 (Passive Site 3)	06-Mar-12
	Southern	Seymour River mouth	06-Mar-12
	Barge	Barge Site 2	06-Mar-12
	Southern	Herbert River mouth	06-Mar-12
		Samples collected 3 to 4 days after peak discharge in Herbert River	
	Southern	South Site 2 (Passive Site 3)	30-Mar-12
	Southern	Seymour River mouth	30-Mar-12
	Barge	Barge site 3	30-Mar-12
	Southern	South site 3	30-Mar-12
	Southern	Herbert River mouth	30-Mar-12
	Northern	Channel North (Passive Site 1)	31-Mar-12
	Northern	Goold Island (Passive Site 2)	31-Mar-12
		Samples collected on falling hydrograph 9 to 10 days after the major peak event in the Herbert River	

3.6 Water Quality Guideline Trigger Values

In order to interpret the potential significance of measured concentrations, these were compared with available Water Quality Guideline Trigger Values (Guidelines). Guidelines have been developed by both the GBRMPA (GBRMPA 2010) and as part of the National Water Quality Management Strategy for fresh and marine waters (ANZECC and ARMCANZ 2000). A selection of relevant Guidelines and Interim Working Levels (IWLs) for priority chemicals identified in the MMP, are provided in Table 6.

Table 6. Water quality guideline trigger values available for specific pesticides

Chemical	GBRMPA[a]		ANZECC and ARMCANZ[b]	
	$ng.L^{-1}$	Notes	$ng.L^{-1}$	Notes
Dinitroaniline Herbicides				
Trifluralin			**2600**	**99% species protection; Freshwater**
Organophosphate Pesticides				
Chlorpyrifos	**0.5**	**99% species protection; High reliability**	**0.5**	**99% species protection; Marine water**
	9	**95% species protection; High reliability**	**9**	**95% species protection; Marine water**
			0.04	**99% species protection; Fresh water**
			10	**95% species protection; Fresh water**
Choracetanilide herbicides				
Metolachlor			**20***	**Low reliability; Fresh water**
			20*	**Low reliability; Marine water**
Triazine or Triazinone Herbicides				
Atrazine	**600**	**99% species protection; Moderate reliability**	**700**	**99% species protection; Fresh water**
	1400	**95% species protection; Moderate reliability**	**1300**	**95% species protection; Fresh water**
Hexazinone	**1200**	**Low reliability**		
Simazine	**200**	**99% species protection; Low reliability**	**200**	**99% species protection; Fresh water**
			3200	**95% species protection; Fresh water**
Ametryn	**500**	**99% species protection; Moderate reliability**		
	1000	**95% species protection; Moderate reliability**		
Urea Herbicides				
Diuron	**900**	**99% species protection; Moderate reliability**	**200 ***	**Low reliability ; Fresh water**
	1600	**95% species protection; Moderate reliability**	**200 ***	**Low reliability ; Marine water**
Tebuthiuron	**20**	**99% species protection; Low reliability**	**20**	**99% species protection; Fresh water**
			2200	**95% species protection; Fresh water**
Transformation Product				
3,4-dichloroaniline			**85000**	**99% species protection; Marine water**

[a] Sourced from Table 26 & Table 27 of the Water Quality Guidelines for the Great Barrier Reef Marine Park 2010 (GBRMPA 2010) ; [b] Sourced from Table 3.4-1 of the ANZECC and ARMCANZ Guidelines (ANZECC and ARMCANZ 2000); "*" indicates values which are Interim Working Levels rather than Guidelines as indicated in Chapter 8.3.7 Volume 2 of the ANZECC and ARMCANZ Guidelines.

Conservative guidelines which are protective of 99 % of species are the most suitable for water bodies of such uniqueness as the GBR World Heritage Area (GBRMPA 2010). In certain cases, only freshwater guidelines (ANZECC and ARMCANZ) or "low reliability" Guidelines or "interim working levels" (IWLs) rather than marine water quality Guideline values are available for assessing the concentrations of specific chemicals. In many cases, no Guideline values are available to assess the concentrations of specific chemicals detected in this current monitoring year.

3.7 Calculation of PSII-Herbicide Equivalent Concentrations (PSII-HEq)

In this report, PSII herbicide concentrations ($ng.L^{-1}$) are expressed as PSII herbicide equivalent concentrations (PSII-HEq) (also in $ng.L^{-1}$). PSII-HEq values were derived using relative potency factors (REP) for each individual PSII herbicide with respect to a reference PSII herbicide diuron.

A given PSII herbicide with an REP of 1, is equally as potent as diuron. If it is more potent than diuron it will have a REP of >1, while if it is less potent than diuron it will have an REP of <1. To calculate the PSII-HEq concentration of a given grab or passive sample, it is assumed that these herbicides act additively (Escher et al. 2006; Muller et al. 2008; Magnusson et al. 2010). The PSII-HEq ($ng.L^{-1}$) is therefore the sum of the individual REP-corrected concentrations of each individual PSII herbicide (Ci, $ng.L^{-1}$) detected in each sample using Equation 1.

$$\text{PSII-HEq} = \sum C_i \times REP_i \qquad \text{Equation 1}$$

REP values for the chemicals of interest were obtained from relevant laboratory studies (Table 7). For the initial determination of REP consensus values, average values from studies obtained using corals, Phaeodactylum and Chlorella were used (different organisms were not weighted). The PSII-HEq concentrations in this report were then predicted using these mean preliminary consensus REP values giving equal weight to EC_{50} and EC_{20} values. These initial consensus values were developed and applied to determine PSII-HEq since the baseline reporting year 2008-09 and have not been updated for the sake of consistency. However it should be acknowledged that as more data continues to be published (Magnusson et al. 2010), it is likely that these values would benefit from review and updating in the future to include not only more data for these chemicals but also additional PSII herbicides that are detected in GBR waters such as bromacil and terbutryn.

Table 7 Relative potency factors (REP) for PSII herbicides and selected transformation products

PSII Herbicides	Relative potency (range)		Relative potency (mean based on various EC values)				
Diuron (reference)	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Ametryn	1.2-1.35	0.94	0.9 -2.7	1.28	0.94	1.71	**1.31**
Atrazine	0.05-0.06	0.1-0.4	0.15 -0.3	0.05	0.22	0.21	**0.16**
Desethyl-atrazine			0.01-0.2			0.105	**0.11**
Desisopropyl-atrazine			0.003			0.003	**0.003**
Flumeturon			0.04			0.04	**0.04**
Hexazinone	0.2-0.26	0.27-0.82	0.17-0.95	0.23	0.46	0.44	**0.38**
Prometryn			1-1.1			1.05	**1.05**
Simazine	0.02	0.03-0.05	0.02-0.26	0.02	0.04	0.14	**0.07**
Tebuthiuron	0.01	0.07	0.11-0.2	0.01	0.07	0.15	**0.08**
Terbuthylazine			0.3			0.3	**0.3**

[a](Jones and Kerswell 2003);[b] (Muller et al. 2008); [c] (Bengtson-Nash et al. 2005); [d] (Schmidt 2005); [e] Macova et al., unpublished data (Entox); [f]Based on a preliminary summary of available data when derived in 2009 - it should be noted that bromacil (routinely analysed for since 2009-2010) and terbutryn (beginning to be routinely analysed for from the end of 2010-2011) are also PSII herbicides and not currently incorporated into PSII-HEq estimates (no REP). Similarly while terbuthylazine does have a REP it is not a target chemical in the analysis of EDs, but is part of the GCMS pesticide screen for PDMS. The herbicides which contribute to PSII-HEq in this report are shaded.

3.8 PSII Herbicide Index

To interprete the PSII-herbicide data reported as PSII-HEq, the PSII Herbicide Index has been compiled (with the GBRMPA) as an indicator of PSII inhibition to report against across the MMP (Table 8). This index uses published scientific evidence with respect to the effects of the reference PSII herbicide diuron (summarized for each index category in Table 20 Appendix B). These index criteria have been slightly modified from those indicated in the baseline reporting year 2008-2009 (Kennedy et al. 2010b). Note that an increase in the concentrations of herbicides detected, which translates to an increase in PSII-HEq, can subsequently result in a decline in Index category (for e.g. Category 5 to Category 4).

Table 8 PSII-Herbicide Equivalent Index developed as an indicator for reporting of PSII herbicides across the Reef Rescue Marine Monitoring Program

Category	Concentration ($ng.L^{-1}$)	Description
5	PSII-HEq ≤ 10	No published scientific papers that demonstrate any effects on plants or animals based on toxicity or a reduction in photosynthesis. The upper limit of this category is also the detection limit for pesticide concentrations determined in field collected water samples
4	10 < PSII-HEq ≤ 50	Published scientific observations of reduced photosynthesis for two diatoms.
3	50 < PSII-HEq < 250	Published scientific observations of reduced photosynthesis for two seagrass species and three diatoms.
2	250 ≤ PSII-HEq ≤ 900	Published scientific observations of reduced photosynthesis for three coral species.
1	PSII-HEq > 900	Published scientific papers that demonstrate effects on the growth and death of aquatic plants and animals exposed to the pesticide. This concentration represents a level at which 99 per cent of tropical marine plants and animals are protected, using diuron as the reference chemical.

For categories 2 – 4:

- The published scientific papers indicate that this reduction in photosynthesis is reversible when the organism is no longer exposed to the pesticide;
- Detecting a pesticide at these concentrations does not necessarily mean that there will be an ecological effect on the plants and animals present;
- These categories have been included as they indicate an additional level of stress that plants and animals may be exposed to in the Marine Park. In combination with a range of other stressors (e.g. sediment, temperature, salinity, pH, storm damage, and elevated nutrient concentrations) the ability of these plant and animal species to recover from impacts may be reduced.

The Herbicide Index provides a means of classifying the vast amount of data generated in this MMP, to provide an indication of where in the PSII concentration effect level are PSII herbicide detections being made. The Index shows where relevant effect levels are being exceeded (either plant, algal or animal) and helps to inform management to act accordingly to the risks indicated.

4 GBR-WIDE SUMMARY RESULTS 2011-2012

4.1 Routine Monitoring Results – Water Quality

The 2011-2012 wet season was not subject to the severity of weather events (e.g. cyclones) and major flooding seen in the previous wet season. Notably, most major rivers from the Burdekin region south had median flows of between 1.4 to three times greater than the long term median.The long-term median discharges of major rivers within the Wet Tropics region were only just met (by factors ranging from 1.1 to 1.4). This is in comparison to the previous monitoring year in which major rivers in this region exceeded long-term median flows by 1.5 to greater than three times (Kennedy et al, 2012a). As discussed in further detail in Section 4, there is a general trend of increased risk of exposure to PSII herbicides in sites located in the Burdekin – Fitzroy regions in comparison to sites located in the Wet Tropics. Table 9 shows the comparison between the long-term median discharge from major rivers in the four NRM regions, and the total discharge for the current monitoring year. Long-term median discharge figures were provided by Shaffelke et al (2011). Historical annual discharge of major rivers influencing routine monitoring sites are provided in Table 21, Appendix C.

Table 9 Comparison of long-term median flows in major rivers with total discharge of current monitoring year

NRM Region	River	Long-term median discharge (ML)	Total Discharge 2011-2012 (ML)*	Ratio to long-term median discharge
Wet Tropics	Barron	604,729	713,928	1.2
	Mulgrave	751,149	1,011,734	1.3
	Russell	983,693	1,166,997	1.0
	Tully	3,056,169	3,535,675	1.2
	Herbert	3,067,947	4,315,677	1.4
Burdekin	Burdekin	6,093,360	15,386,199	2.6
Mackay Whitsunday	Proserpine	17,140	51,193	3.0
	O'Connell	205,286	281,409	1.9
Fitzroy	Fitzroy	2,754,600	7,886,091	2.9

*River discharge data compiled by Michelle Devlin. (Data Source Department of Environment and Resource Management, Stream Gauging Network). Long-term median flow data was determined from the commencement of river monitoring up to the year 2000. Long-term median water year is from October 1st to September 30th the following year. Annual discharge for current monitoring year is incomplete

The flow graphs of the major rivers located close to routine monitoring sites within the four NRM regions are presented in Appendix F. The PSII-HEq concentrations detected using passive samplers is also presented in relation to these flow events. The difference in the number and intensity of flow peaks between the current and previous monitoring year is clear. In addition, the link between a decrease in flow events and the subsequent decrease in the PSII-HEq detected at the nearest passive sampling site is also clear.

No herbicide with an individual Guideline to assess against met or exceeded its Guideline value in routine passive sampling. The PSII herbicides detected at inshore reef locations in the current monitoring year were ametryn, atrazine, bromacil, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, prometryn, simazine and tebuthiuron. The most frequently detected and highest concentration herbicides in this current monitoring year were diuron (maximum concentration of 18 ng.L^{-1} at Sarina Inlet), atrazine (maximum concentration of 15 ng.L^{-1} at Cape Cleveland) and hexazinone (maximum concentration of 9.6 ng.L^{-1} at Sarina Inlet). Metolachlor and tebuthiuron were also detected with a high frequency in this current monitoring year, albeit at relatively low concentrations (< 2.0 ng.L^{-1}), (Table 10).

Notably, despite the lack of large flow events in the major rivers when compared to the previous monitoring year, many herbicides were detected with greater frequency (although at lower concentrations). These herbicides include ametryn, atrazine, diuron, hexazinone, simazine, tebuthiuron and metolachlor. This may be due to the routine use of the more sensitive LCMSMS (ABSiex 4000 QTrap) for the analysis of both grab and passive samples during the current monitoring year.

The maximum concentrations of each individual herbicide measured in EDs at routine sites from the baseline reporting year in 2008-2009 to the current monitoring year are presented in Figure 5. Distinct changes in the herbicide profiles detected at these sites can be seen when compared to the previous monitoring year, as described below. Table 10 summarises the ranges of concentrations of individual herbicides detected at each site, and the proportion of sampling periods that the herbicide was detected.

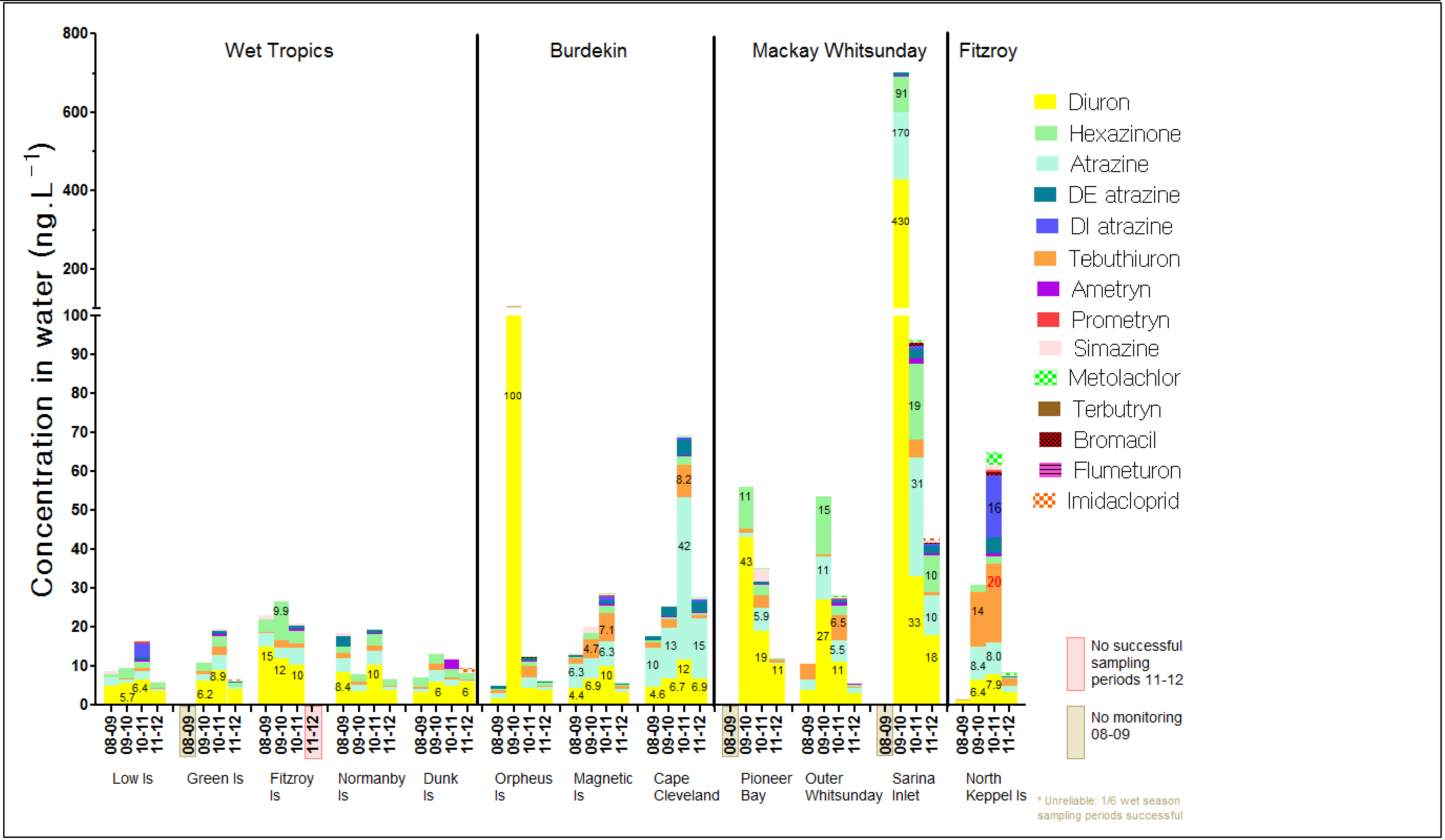

Figure 5 Maximum concentrations of each individual herbicide at routine monitoring sites from the baseline reporting year (2008-2009) to 2011-2012

Table 10 The range in time-integrated concentrations of pesticides in water (ng.L^{-1}) measured using EDs at routine monitoring sites in 2011-2012

		PSII Herbicides (Included in Index)												Other Herbicides (Not indexed)				Insecticides
NRM Region	Site	Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron	PS II Heq (ng/L)	PSII Heq Max	Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Wet Tropics	Low Isles	n.d. - 0.06	n.d. - 0.49	n.d.	n.d. - 0.01	0.29 - 3.6	n.d.	0.10 - 1.2	n.d.	n.d. - 0.09	n.d. - 0.36	0.42 - 4.2	4.2	n.d.	n.d.	n.d. - 0.10	n.d. - 0.15	n.d.
	% detects	67	89	0	11	100	0	100	0	11	56	100		0	0	89	20	0
	Green Island	n.d. - 0.07	0.03 - 1.0	n.d. - 0.33	n.d. - 0.01	0.27 - 4.1	n.d.	0.03 - 0.95	n.d.	n.d. - 0.17	n.d. - 0.28	0.30 - 4.8	4.8	n.d.	n.d.	n.d. - 0.10	n.d. - 0.15	n.d. - 0.20
	% detects	50	100	38	13	100	0	100	0	50	63	100		0	0	75	20	13
	Fitzroy Island																	
	% detects																	
	Normanby Island	n.d. - 0.08	0.29 - 0.76	n.d. - 0.15	n.d.	0.36 - 3.9	n.d.	0.17 - 1.4	n.d.	n.d. - 0.13	n.d. - 0.34	0.52 - 4.7	4.7	n.d.	n.d.	0.03 - 0.10	n.d.	n.d.
	% detects	80	100	60	0	100	0	100	0	60	80	100		0	0	100	0	0
	Dunk Island[a]	n.d. - 0.12	n.d. - 0.30	n.d.	n.d.	n.d. - 6.0	n.d.	n.d. - 1.5	n.d.	n.d. - 0.02	n.d. - 0.38	n.d. - 6.8	6.8	n.d.	n.d.	n.d. - 0.07	n.d. - 0.01	n.d. - 1.1
	% detects	33	67	0	0	67	0	67	0	33	67	67		0	0	67	50	33
	% detects for region	**58**	**89**	**24**	**6**	**92**	**0**	**92**	**0**	**39**	**66**	**92**		**0**	**0**	**83**	**23**	**11**
Burdekin	Orpheus Island	n.d. - 0.08	0.08 - 0.77	n.d. - 0.15	n.d.	0.10 - 3.7	n.d.	n.d. - 0.76	n.d.	n.d. - 0.13	0.04 - 0.42	0.13 - 4.3	4.3	n.d. - 0.03	n.d.	0.01 - 0.20	n.d.	n.d.
	% detects	44	100	22	0	100	0	89	0	67	89	100		11	0	100	0	0
	Magnetic Island	n.d. - 0.05	0.11 - 2.2	n.d. - 0.49	n.d. - 0.14	0.84 - 3.3	n.d.	0.04 - 0.33	n.d.	0.01 - 0.21	0.04 - 0.72	0.89 - 3.4	3.4	n.d.	n.d.	0.01 - 0.13	n.d.	n.d.
	% detects	75	100	63	13	100	0	100	0	100	100	100		0	0	100	0	0
	Cape Cleveland	n.d. - 0.27	0.37 - 15	n.d. - 2.6	n.d. - 0.68	0.17 - 6.9	n.d.	0.05 - 0.51	n.d.	n.d. - 0.18	n.d. - 0.92	0.30 - 10	10	n.d.	n.d.	n.d. - 0.21	n.d. - 0.04	n.d.
	% detects	88	100	50	50	100	0	100	0	63	88	100		0	0	63	25	0
	% detects for region	**69**	**100**	**45**	**21**	**100**	**0**	**96**	**0**	**76**	**92**	**100**		**4**	**0**	**88**	**8**	**0**
Mackay Whitsunday	Pioneer Bay	n.d. - 0.06	n.d. - 0.49	n.d.	n.d.	2.5 - 11	n.d.	n.d. - 0.88	n.d. - 0.04	n.d.	0.05 - 0.61	2.6 - 11	11	n.d.	n.d.	n.d. - 0.12	n.d.	n.d.
	% detects	50	83	0	0	100	0	83	17	0	100	100		0	0	83	0	0
	Outer Whitsunday[b]	n.d. - 0.05	0.16 - 1.4	n.d. - 0.16	n.d. - 0.05	0.28 - 2.8	n.d.	0.03 - 0.75	n.d.	n.d. - 0.03	n.d. - 0.06	0.32 - 3.4	3.4	n.d.	n.d.	n.d. - 0.02	n.d.	n.d.
	% detects	33	100	33	33	100	0	100	0	33	67	100		0	0	67	0	0
	Sarina Inlet	0.01 - 0.30	0.10 - 10	n.d. - 2.0	n.d. - 0.71	0.53 - 18	n.d.	0.18 - 9.6	n.d. - 0.03	n.d. - 0.42	0.08 - 0.72	0.66 - 22	22	n.d. - 0.18	n.d.	0.02 - 0.21	n.d.	n.d. - 0.52
	% detects	100	100	78	44	100	0	100	11	89	100	100		44	0	100	0	33
	% detects for region	**61**	**94**	**37**	**26**	**100**	**0**	**94**	**9**	**41**	**89**	**100**		**15**	**0**	**83**	**0**	**11**
Fitzroy	North Keppel Island	n.d. - 0.13	0.05 - 1.6	n.d. - 0.24	n.d. - 0.21	0.18 - 3.4	n.d.	n.d. - 0.15	n.d. - 0.04	n.d. - 0.17	n.d. - 1.9	0.19 - 3.4	3.4	n.d. - 0.11	n.d.	n.d. - 0.90	n.d.	n.d.
	% detects	50	100	40	30	100	0	80	20	60	90	100		10	0	90	0	0
	% detects for region	**50**	**100**	**40**	**30**	**100**	**0**	**80**	**20**	**60**	**90**	**100**		**10**	**0**	**90**	**0**	**0**

[a] Dunk Island only includes 2/6 potential wet season sampling periods and 1/3 potential dry season sampling periods (refer Table 24) and should be interpreted with caution; [b] Outer Whitsunday range only include 3/6 potential wet season sampling periods (refer Table 29) and 0/3 potential dry season sampling periods so the minimum values on these ranges and the frequency of detection should be interpreted with caution; % Detects indicates the proportion of sampling periods out of the total number of sampling periods that a herbicide was detected.

There was a clear decrease in the maximum concentrations of herbicides detected at all twelve routine monitoring sites when compared to the previous monitoring year (Figure 5) with the greatest decreases observed in the Burdekin, Mackay Whitsundays and Fitzroy regions. When compared to the baseline reporting year (typically 2008-2009 or the year in which sampling commenced) the majority of sites show a decrease in the maximum concentrations of herbicides, although Cape Cleveland and North Keppel Island are exceptions and show an increase (refer to Figure 5).

Typically, the maximum concentrations of herbicides detected in polar passive samplers in the Wet Tropics are lower than in other NRM regions. This may in part, be due to the lower median discharge of major rivers impacting passive samplers in this region, when compared to other regions such as the Burdekin and Mackay Whitsunday which are more frequently impacted by higher river discharges (Figure 23) and typically detect higher concentrations of herbicides (Figure 5). Since the baseline monitoring year, 72 % of PSII-HEq Max values in the Wet Tropics were Category 5. When compared to the previous monitoring year, the herbicide profiles have changed as herbicides detected in relative abundance in the previous monitoring year (such as hexazinone, atrazine and atrazine breakdown products) were detected in decreased concentrations in the current monitoring year. Despite these lower concentrations, the frequency of detection of several herbicides (including ametryn, simazine and tebuthiuron) has increased. Notably, Green Island and Normanby Island improved from Category 4 to Category 5 sites on the PSII-HEq Index.

Since the baseline monitoring year in the Burdekin region, 67 % of PSII-HEq Max values were Category 5 on the PSII-HEq Index. Clear decreases in the maximum concentrations of herbicides were detected at all sites, with the most significant decreases seen in atrazine and tebuthiuron at Magnetic Island and Cape Cleveland. Despite this decrease, Cape Cleveland still had the highest concentration of atrazine (15 $ng.L^{-1}$) detected at any site during this monitoring year. Typically, this site is dominated by atrazine rather than diuron as seen at the other routine monitoring sites in the region. Similarly to the Wet Tropics, despite falling concentrations of herbicides, many herbicides were detected with greater frequency this monitoring year (including ametryn, simazine and metolachlor).

The sites located in the Mackay Whitsundays region have encountered the greatest risk of exposure to herbicides over a number of years. Since the baseline monitoring year, only 20 % of PSII-HEq Max values were classified as Category 5. However, this region shows some of the most significant decreases in herbicide concentration (most notably diuron) since monitoring commenced. Whilst concentrations have decreased, Pioneer Bay and Sarina Inlet still have the highest diuron levels detected at all routine monitoring sites (11 $ng.L^{-1}$ and 18 $ng.L^{-1}$ respectively). Sarina Inlet remains the most ‘at risk’ site with the most frequent detections of herbicides (ametryn, atrazine, diuron, hexazinone and teburthiuron detected in all sampling periods) and the highest PSII-HEq Max (22 $ng.L^{-1}$) of all routine monitoring sites.

With the exception of the previous monitoring year, North Keppel Island (the only routine monitoring site in the Fitzroy region) is typically a Category 5 on the PSII-HEq Index (Figure 6). The most noticeable change in the herbicide concentration profile occurred at this site when compared to the previous monitoring year. In the previous monitoring year, the profile was dominated by tebuthiuron (detected at levels which exceeded Guideline values), atrazine and its breakdown products (Figure 5). In the current monitoring year, there was a 20-fold decrease in the concentration of tebuthiuron (maximum concentration of 1.9 $ng.L^{-1}$) and improvement from a Category 4 to 5 on the PSII-HEq Index.

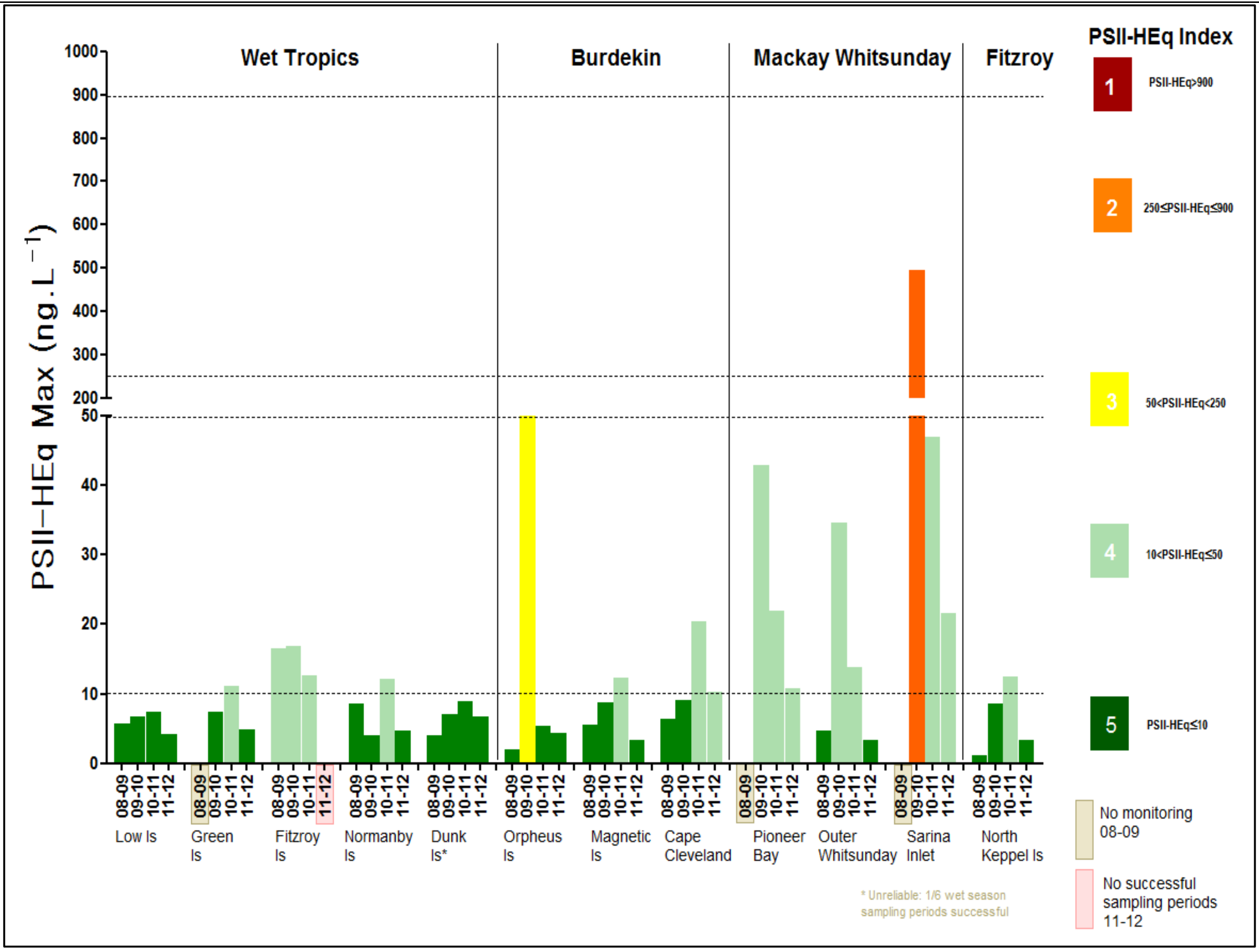

Figure 6 PSII-HEq Max at each site in from the baseline reporting year 2008-2009 to 2011-2012

The PSII-HEq Max values for each site in 2011-2012 are compared to the baseline reporting year 2008-2009 and the previous two monitoring years (Figure 6). In 2011-2012, the PSII-HEq Max for the regions ranged from 4.2 – 6.8 ng.L^{-1} in the Wet Tropics, 3.4 – 10 ng.L^{-1} in the Burdekin Region, 3.4 – 22 ng.L^{-1} in the Mackay Whitsunday and was 3.4 ng.L^{-1} in the Fitzroy region. These values indicate maximum PSII-HEq Index Categories of 4 or 5 for each region in 2011-2012. All sites showed a decrease in PSII-HEq Max compared to the previous monitoring year, although this only resulted in a maximum change in Index Category from 4 to 5 for some sites.

In this current monitoring year, Sarina Inlet in the Mackay Whitsundays, for the third consecutive year had the highest PSII-HEq Max of 22 ng.L^{-1}. With the exception of Fitzroy Island (where no sampling occurred) all other sites in the Wet Tropics were Category 5 on the PSII-HEq Index. In both the Burdekin and Mackay Whitsunday regions, two out of the three monitoring sites were classified as Category 5, as was the single site in the Fitzroy region.

The results clearly show the wide range of variation in herbicide profiles between sites within the same region (such as the Burdekin). Overall, the routine passive sampling sites provide a good indicator of the risk of exposure to pesticides at fixed locations, and changes of that risk over time and in particular the influence of seasons of extreme weather events on the risk of herbicide exposure. However, the integrity of this long-term monitoring record depends on the regular deployment of samplers, particularly during the wet season to obtain reliable trends, and capture peaks (time-integrated) in herbicide concentrations. The relatively low number of sites within a region and the varying proximity of these sites to major rivers (and their subsequent degree of impact from river run-off), all contribute to this regional variability. Sites within the same region can be influenced by the run-off delivered by different major rivers, and thus their profiles can vary dramatically (as seen at the diuron-dominated site Orpheus Island and the atrazine- dominated site Cape Cleveland, both in the Burdekin region). There appears to be a general trend of increasing risk of exposure to herbicides moving south from the Wet Tropics region to the Mackay Whitsunday region, which may be driven by a range of factors including the above median flows from major rivers located in the Burdekin and Mackay Whitsunday regions.

4.2 Flood Plume Sampling

Grab sampling was conducted in three NRM regions – Cape York and Wet Tropics/ Burdekin regions. Grab sampling was undertaken on transects extending from three major rivers in these regions – the Normanby River (Cape York), the Tully River and the Herbert River (both in the Wet Tropics, but some southern locations bordering on the Burdekin region). Further details for the grab samples including date and time of collection, co-ordinates and results for individual herbicides detected are provided in Appendix E, Tables 33 - 36.

4.2.1 Normanby River transect

Two grab samples were taken on the 29 March 2012, one day after a flow event which followed two higher peaks in the previous 12 days in the Normanby River (Figure 7). A single sample was collected at both the Normanby River mouth and a site 2 km from the mouth. No herbicides were found at detectable levels in either sample, and thus both samples indicated a Category 5 risk of exposure on the PSII-HEq Index. No passive samplers were deployed in this region, although passive samplers deployed up until 2010 in Pixies Garden, showed the area was relatively pristine with no PSII herbicides detected in 2009-10, and a PSII-HEq Max of 1.8 $ng.L^{-1}$ in the baseline reporting year (Kennedy et al 2010).

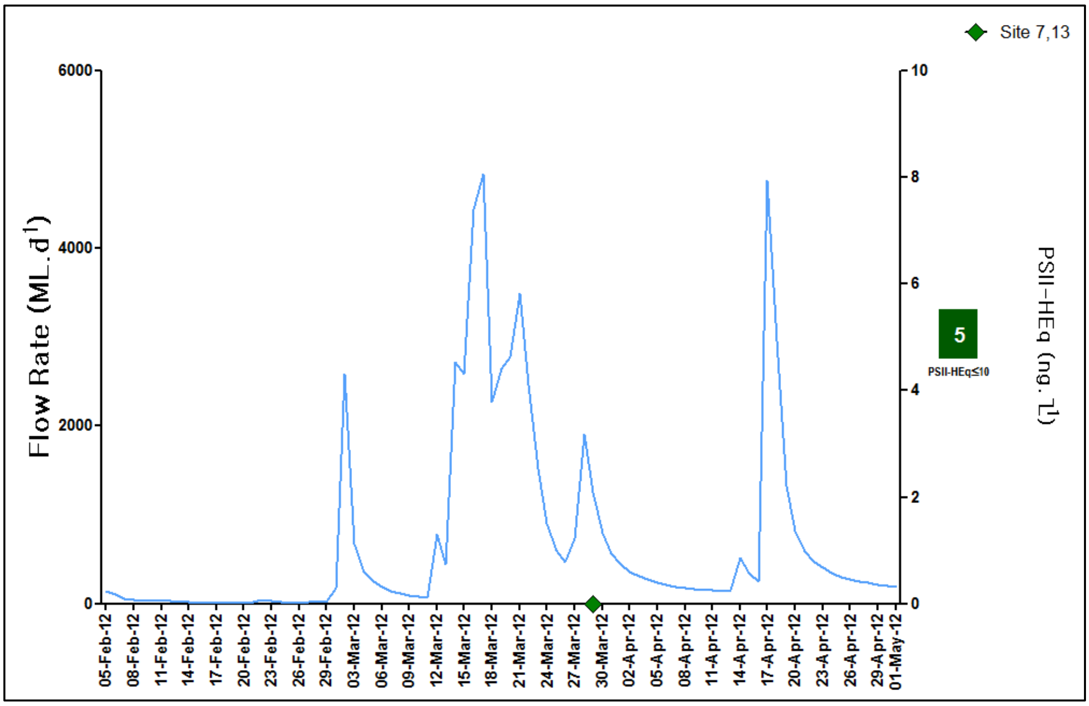

Figure 7 Timing of grab samples taken on the Normanby River transect, Cape York, during 2011-2012

4.2.2 Tully River transect

Twelve grab samples were collected at four sites (Tully River mouth, Bedarra Island, Sisters Island and north Dunk Island) on a transect which extended up to 35 km from the Tully River mouth between 9 September 2011 and 31 March 2012 (Figure 8).

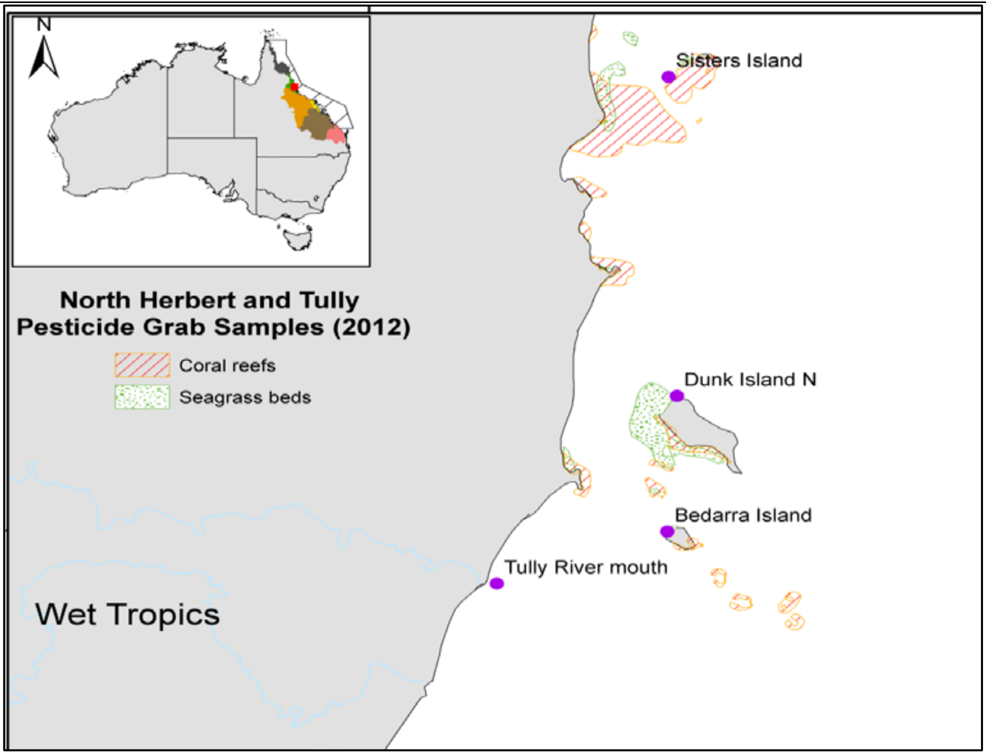

Figure 8 Locations of grab samples collected on the Tully River transect, Wet Tropics, during 2011-2012

Three of these sites – Tully River mouth, Bedarra Island and Sisters Island - were sampled intensively using a combination of grab sampling and passive sampling over the flood season in the prevoius 2010-2011 monitoring year as part of the Tully transect case study (Kennedy et al, 2011). In this current monitoiring year, terrestrial run-off was assessed on this transect using grab sampling only. North Dunk Island was sampled only once, whereas the other three sites were sampled several times over the course of the assessment. Figure 9 shows the timing of grab samples collected and the PSII-HEq Index Category indicated of each sample in relation to the mean daily flow of the Tully River. No herbicides were detected in the single grab sample collected at North Dunk Island. Diuron, hexazinone and imidacloprid were the only PSII herbicides detected at the other three locations. Diuron was the most frequently detected and abundant herbicide (ranging from 10 $ng.L^{-1}$ to 21 $ng.L^{-1}$) and was found at all three locations, detected up to 35 km from the Tully River mouth. Hexazinone was detected twice in the Tully River mouth only (11 $ng.L^{-1}$ and 13 $ng.L^{-1}$) and imidacloprid was detected in a single sample collected at the Tully River mouth (24 $ng.L^{-1}$). The PSII-HEq Max values of the grab samples indicated a Category 4 or 5 on the PSII-HEq Index.

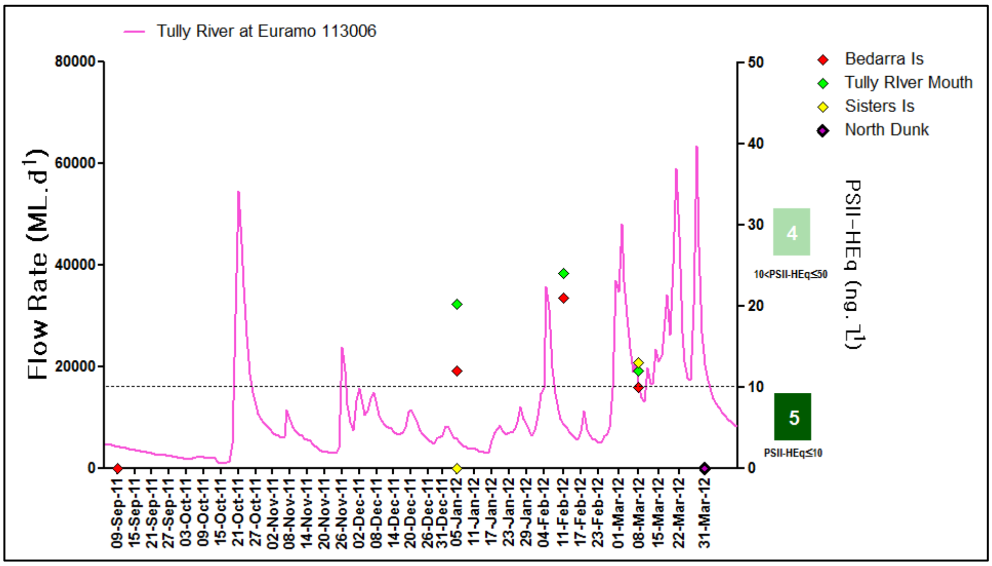

Figure 9 Timing and results of grab samples collected on the Tully River transect, Wet Tropics, during 2011-2012

Generally, there appears to be a decline in the risk of exposure to PSII herbicides with increasing distance from the Tully River mouth. On 5 January 2012, a clear decrease in diuron concentrations was observed ranging from 20 ng.L^{-1} at the Tully River mouth, to 12 ng ng.L^{-1} at Bedarra Island (approximately 9 km from the River mouth) to no diuron detected at Sisters Island (approximately 35 km from the River mouth). Similarly, the PSII-HEq measured in grab samples collected on 11 February 2012 were 24 ng.L^{-1} at the Tully River mouth declining to 21 ng.L^{-1} at Bedarra Island. No grab sample was collected from Sisters Island on that day. However, on 8 March 2012, following a peak event 7 days prior, samples collected at all three sites detected diuron concentrations extending as far as Sisters Island that were comparable to concentrations found in the Tully River mouth itself. The increased turbidity of flood waters may have resulted in the slower degradation of the diuron carried in the discharge, leading to elevated levels and prolonged exposure of sensitive ecosystems to flood water contaminants, at greater distances.

4.2.3 Herbert River transect

Twenty three grabs samples were collected between 19 December 2011 and 31 March 2012 at sites located on two transects extending approximately 55 km north or 7 km south from the Herbert River mouth. The location of these grab samples are pictured in Figure 10 below.

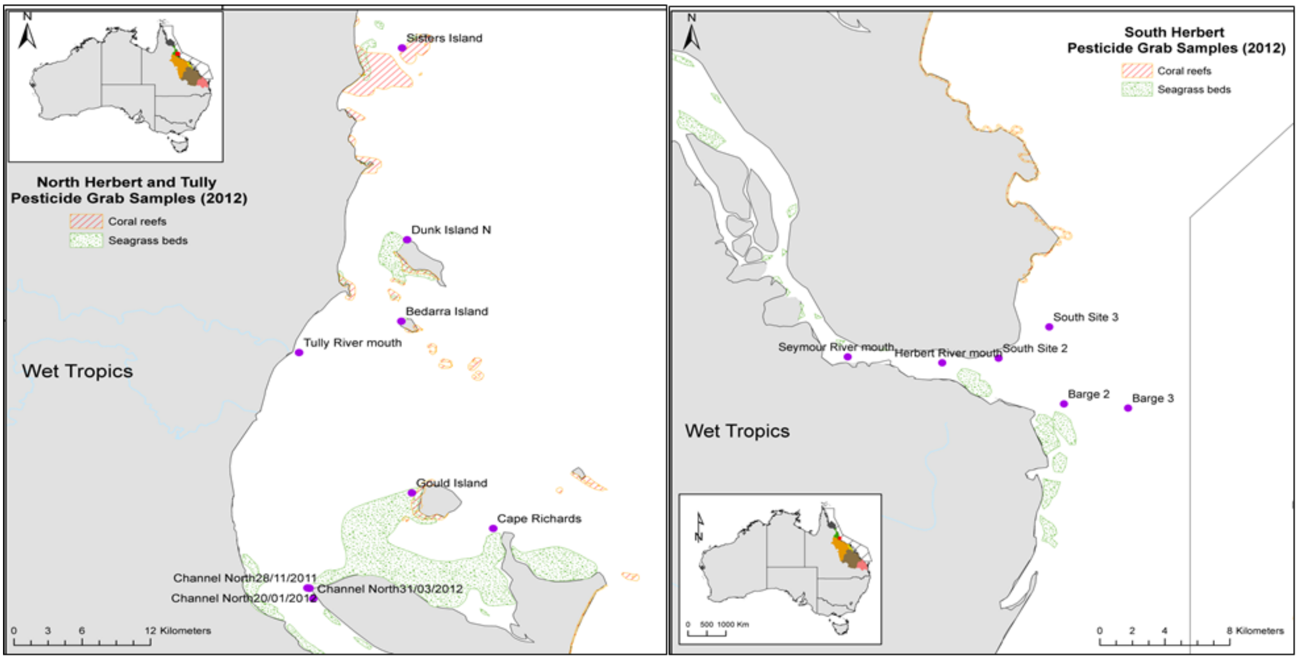

Figure 10 Locations of grab samples collected in the Herbert catchment during 2011-2012 on either the Northern transect (left) or Southern transect (right)

During this same period, polar passive samplers were deployed at three fixed sites – Channel North, Goold Island and South Site 2 for five consecutive deployment periods. Channel North and Goold Island were located on the northern transect (extending approximately 36 and 55 km respectively from the Herbert River mouth) and South Site 2 (extending approximately 7 km from the Herbert River mouth) located on the southern transect. Due to damage incurred in the field, passive samplers from only three sampling periods could be analysed from both Channel North and Goold Isand and only four sampling periods could be analysed from South Site 2. Grab samples were also collected at the passive sampling locations and coincided with the deployment and retrieval of passive samplers. Further information regarding, deployment dates, dates and times of grab sample collection, co-ordinates and the results of individual herbicides detected in samples can be found in Appendix E, Tables 33 - 36.

Of the twenty three grab samples collected to assess terrestrial run-off from the Herbert River, fifteen samples collected from 6 sites detected the presence of PSII herbicides. No PSII herbicides were detected in grab samples collected from Barge Site 2, Barge Site 3 and South Site 3. Diuron was the most frequently detected herbicide found in all fifteen of these samples (ranging in concentration from 12 ng.L^{-1} to 44 ng.L^{-1}). Atrazine was found in two samples (11 ng.L^{-1} at Channel North and 18 ng.L^{-1} at South Site 2), and a single detection of simazine (29 ng.L^{-1}) was detected at Channel North. The risk of exposure to herbicides indicated from the grab samples ranged from high Category 4 to Category 5 on the PSII-HEq Index. Most of the herbicide detections occurred at the locations where passive samplers were deployed.

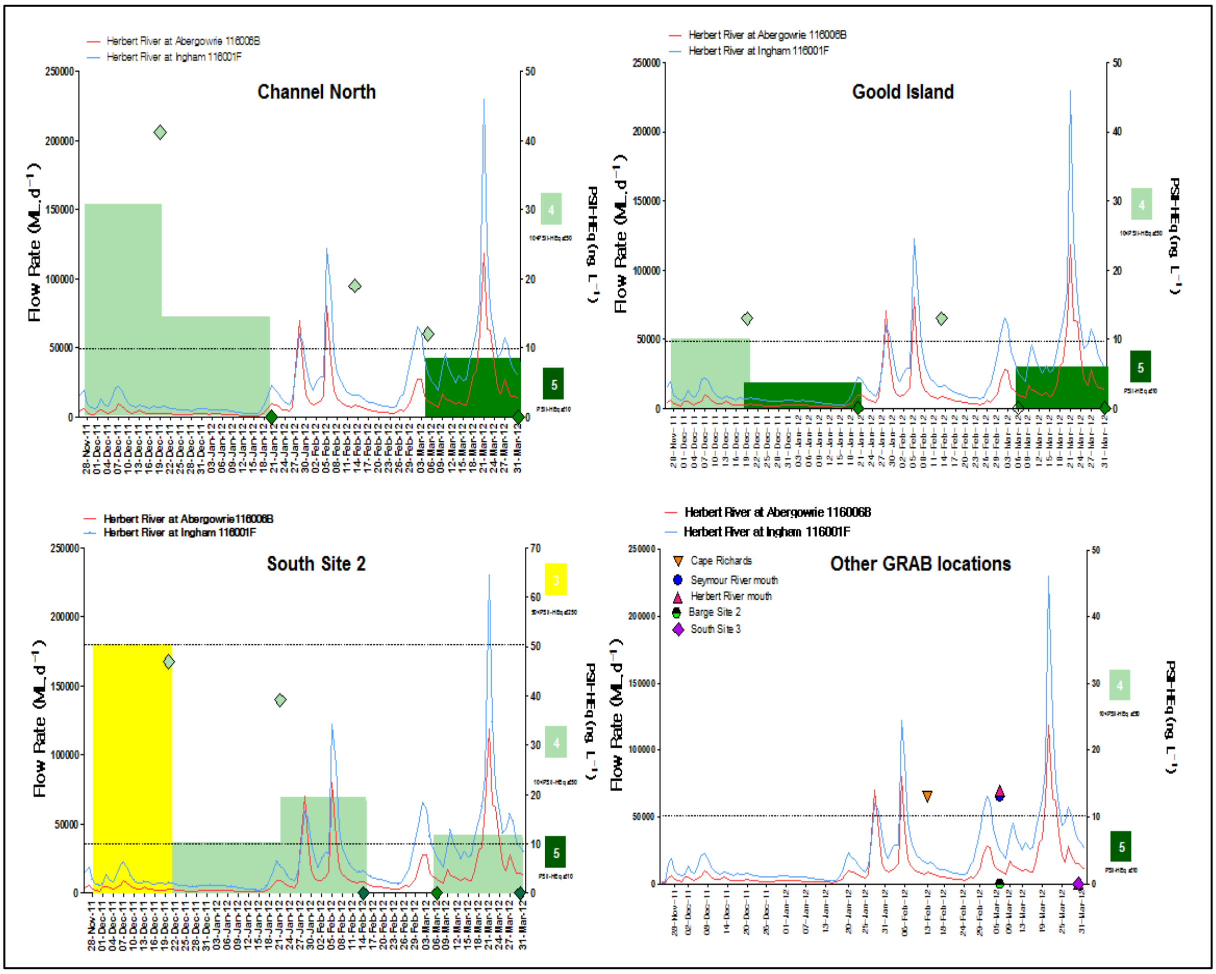

Figure 11 Timing and Index categories of passive samplers deployed and grab samples collected in the Herbert catchment in 2011-2012

Passive samplers deployed at the three fixed sites detected a wider range of PSII herbicides then the grab samples collected at the same sites, including ametryn, atrazine (and its breakdown products), diuron, hexazinone, simazine and tebuthiuron. Other herbicides were also detected which included bromacil (detected only once at all three passive sites), terbutyrn (detected only once each at Channel North and South Site 2), metolachlor, imazapic and imidacloprid. On the northern transect, Channel North (located approximately 36 km north of the Herbert River mouth), had higher concentrations of herbicides detected in both the passive and grab samples than Goold Island (located approximately 50 km north of the Herbert River). The PSII-HEq Maxima of the passive samplers were 30 ng.L^{-1} (Category 4), 13 ng.L^{-1} (Category 4) and 50 ng.L^{-1} (Category 3) for Channel North, Goold Island and South Site 2 respectively. The passive samplers deployed at South Site 2 recorded the highest concentrations of PSII herbicides detected in the entire pesticide monitoring program. Figure 11 shows the PSII-HEq of the passive and grab samples taken at all Herbert River transect locations with respect to the mean daily flow of the Herbert River.

Similarly to the grab samples, diuron was the most frequently detected PSII herbicide in the passive samplers, detected in 100% of passive samplers deployed at all three locations. The highest concentrations of diuron were detected in the deployment period 28 November 2011 to 20 December 2011 with 28 ng.L^{-1} at Channel North, 6.4 ng.L^{-1} at Goold Island and 40 ng.L^{-1} at South Site 2 which also coincided with the highest herbicide detections in grab samples.

Due to the relatively low flow events this wet season, event samplers (EDs without diffusion-limiting membranes typically deployed for 3 days) were not deployed to capture peaks in herbicide concentrations in the plume waters.

5 REGIONAL SUMMARIES 2011-2012

5.1 Wet Tropics Region

Routine sampling sites in the Wet Tropics region in 2011-2012 were at Low Isles, Green Island, Fitzroy Island, Normanby Island and Dunk Island (Figure 12). Low Isles, Fitzroy Island and Normanby Island have been monitored since 2005 while Dunk Island has been monitored routinely since 2008 (once in 2007) and Green Island since 2009. Unfortunately, due to a combination of weather and staffing issues, no successful sampling periods were achieved at Fitzroy Island in this current monitoring year, which has created a large information gap in a seven year sampling record. Also, Dunk Island had only two out of six potential wet season sampling periods and one out of three potential dry season sampling periods successfully deployed.

Figure 12 Location of routine monitoring sites in the Wet Tropics region

Green Island and Normanby Island also experienced entire losses of samplers in the field due to human error and other factors. However, Low Isles and Green Island had 6/6 successful wet season deployments, with Low Isles having all samplers for the monitoring year successfully deployed and returned to Entox.

The historical concentrations of individual herbicides at these sites are indicated in Appendix G, Figures 30 - 31. A key feature of the results for this region in 2011-2012, was a decrease in the concentrations of PSII herbicides detected in the wet season sampling periods across all sites, and a decrease in the number of sampling periods that these sites were exposed to elevated levels of herbicides. The decrease in herbicide concentrations and subsequent PSII-HEq concentration correlates with decreased flows in major rivers in the region (see Appendix F, Figure 26). This is most evident in the profiles for Low Isles and Green Island which both had an unbroken record of wet season sampling.

PSII herbicides (and transformation products) detected in the Wet Tropics region in 2011-2012 using EDs include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, simazine and tebuthiuron. The average and maximum of the detected PSII-HEq concentrations for each routine site in this region are provided in Table 11. The most frequently detected PSII herbicides in the Wet Tropics were (from highest to lowest) diuron (detected in 92 % of samplers; maximum concentration 6.0 $ng.L^{-1}$ at Dunk Island), hexazinone (detected in 92 % of samplers; maximum concentration 1.5 $ng.L^{-1}$ at Dunk Island) and atrazine (detected in 89 % of samplers; maximum concentration 1.0 ng.L^{-1} at Green Island). Metolachlor was also frequently detected in EDs at all sites (<1.0 ng.L^{-1}).

Table 11 Summary statistics for the concentrations (ng.L^{-1}) of individual PSII herbicides and PSII-HEq in 2011-2012 in comparison to the baseline reporting year in the Wet Tropics.

		PSII Herbicides (Included in Index)										PS II Heq (ng/L)					Other Herbicides (Not indexed)				
Site		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron	2011-12	2010-11	2009-10	2008-09	Ratio to Baseline Year[b] (2008-09)	Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Low Isles	Avg[a]	0.04	0.22	n.d.	-	1.4	n.d.	0.40	n.d.	-	0.23	2.1	4.4	1.9	2.1	1.0	n.d.	n.d.	0.04	-	n.d.
	Max	0.06	0.49	n.d.	*0.01*	3.6	n.d.	1.2	n.d.	*0.09*	0.36	4.2	7.4	6.7	5.7	0.7	n.d.	n.d.	0.10	*0.15*	n.d.
Green Island	Avg[a]	0.04	0.36	0.22	-	1.4	n.d.	0.33	n.d.	0.12	0.11	1.9	5.7	1.7		1.1	n.d.	n.d.	0.03	-	-
	Max	0.07	1.0	0.33	*0.01*	4.1	n.d.	0.95	n.d.	0.17	0.28	4.8	11	7.4		0.6	n.d.	n.d.	0.10	*0.15*	*0.20*
Fitzroy Island	Avg[a]												8.8	5.1	5.7						
	Max												13	17	16						
Normanby Island	Avg[a]	0.04	0.47	0.16	n.d.	1.5	n.d.	0.49	n.d.	0.09	0.34	1.8	6.2	1.9	2.6	0.7	n.d.	n.d.	0.05	n.d.	n.d.
	Max	0.08	0.76	0.15	n.d.	3.9	n.d.	1.4	n.d.	0.13	0.34	4.7	12	4.0	8.6	0.5	n.d.	n.d.	0.10	n.d.	n.d.
Dunk Island	Avg[a]	-	0.18	n.d.	n.d.	3.0	n.d.	0.77	n.d.	-	0.22	-	8.8	4.4	3.0		n.d.	n.d.	0.04	-	-
	Max	*0.12*	0.30	n.d.	n.d.	6.0	n.d.	1.5	n.d.	*0.02*	0.38	6.8	8.8	7.1	4.1	1.7	n.d.	n.d.	0.07	*0.01*	*1.07*

[a] Averages for individual herbicides are across both wet and dry season sampling periods. Averages indicated for PSII-HEq are for the wet season sampling periods only (PSII-HEq Avg Wet) as this parameter will be used for trend monitoring in subsequent reports. [b] These are the ratio of PSII-HEq Avg Wet and PSII-HEq Max in the current year with respect to the baseline reporting year (08-09), except at Green Island which was only monitored from 2009-2010 Block colours indicate the maximum PSII-Heq Index category for that year. Values in italics indicate a single measurement for that year

Seasonal average PSII-HEq values are indicated for each routine site in the Wet Tropics region across all monitoring years in Figure 13. Average wet season PSII-HEqs have decreased at all sites by factors ranging from 2.1 at Low Isles to 3.4 at Normanby Island, when compared to the previous reporting year.

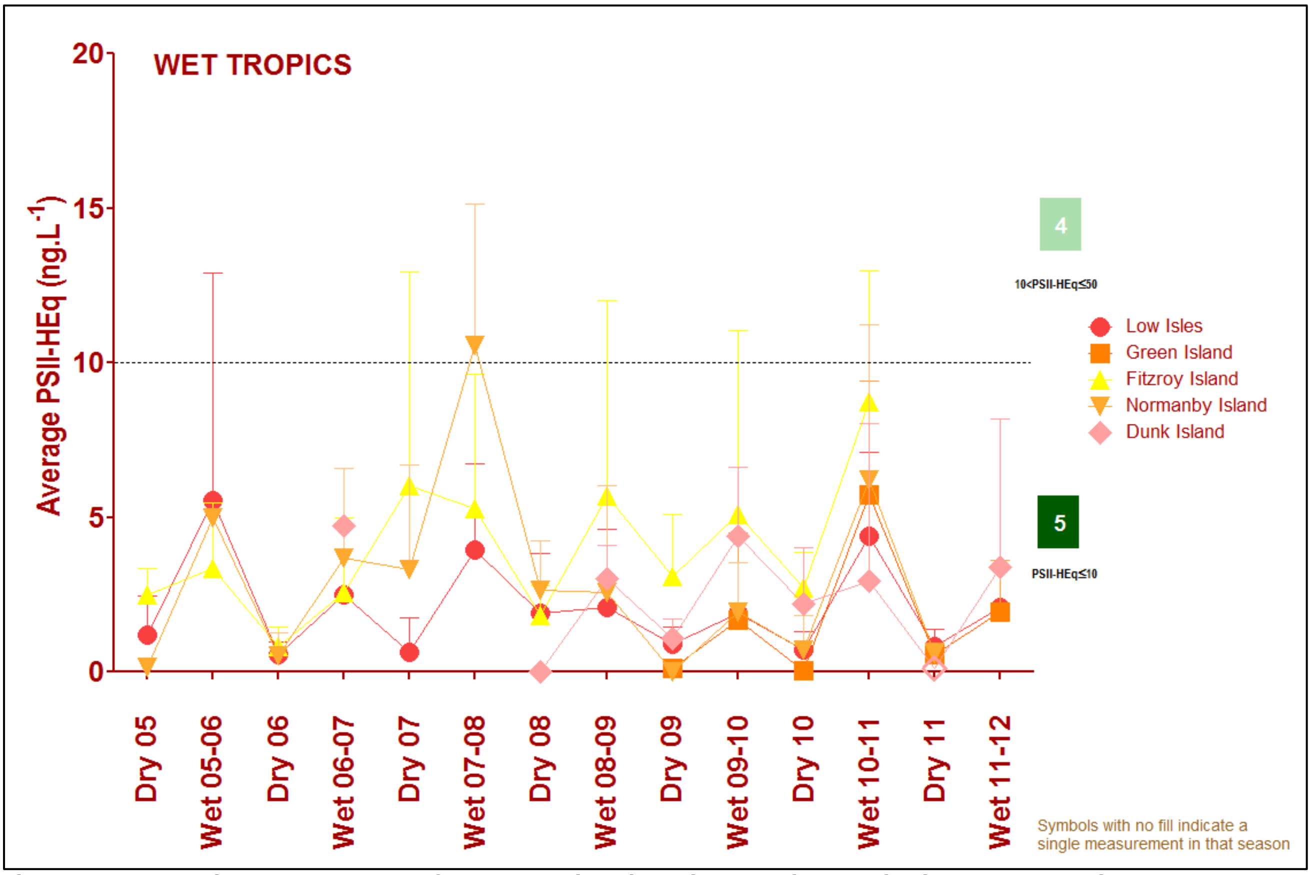

Figure 13 Seasonal average PSII-HEq for Wet Tropics sites since routine monitoring commenced

Dunk Island is the only Wet Tropics site (with the exception of Fitzroy Island where no sampling occurred this monitoring year), where the PSII-HEq Max exceeds the baseline reporting year (by a factor of 1.7). The PSII-HEq maxima at routine passive sampling sites in the Wet Tropics in 2011-2012 did not exceed

Category 5 on the PSII-HEq Index. However, three additional passive samplers deployed to assess terrestrial run-off from the Herbert River (also in the Wet Tropics), detected concentrations of PSII herbicides up to Category 3 and 4, with PSII-HEq maxima ranging from 10 $ng.L^{-1}$ to 50 $ng.L^{-1}$. Grab sampling conducted as part of the terrestrial run-off assessment (flood plume sampling) in both the Herbert River and Tully River transects detected a wide range of concentrations from no detections (Category 5) to 47 $ng.L^{-1}$ (very high Category 4, approaching a Category 3).

Other non PSII herbicides such as imidacloprid, imazapic and metolachlor were also analysed (imazapic was not analysed in every sample). Imidacloprid was also routinely analysed in grab samples from the Tully River and Herbert River transects, but was only detected once at the Tully mouth at a concentration of 24 $ng.L^{-1}$. T

Pesticide results obtained using PDMS samplers in the region are summarised in Table 12 with metolachlor (detected once at Dunk Island), galaxolide (detected at Green Island and Normanby Island) and tonalid (detected once at Normanby Island) all detected at <1 $ng.L^{-1}$. Both galaxolide and tonalid are polycyclic musks used in detergents, toiletries and cosmetics. These results all represent equilibrium concentration estimates and are higher than the time-averaged estimates obtained using EDs. No pesticides have exceeded the GBRMPA Guidelines (GBRMPA 2010) at Wet Tropics sites in 2011-2012 or in the previous monitoring year.

Table 12 Concentrations of pesticides ($ng.L^{-1}$) measured using PDMS samplers in the Wet Tropics Region in 2011-2012

Site		Atrazine	Metolachlor	Galaxolide	Tonalid
Low Isles	Avg				
	Max				
Green Island	Avg	n.d.	n.d.	0.1	n.d.
	Max	n.d.	n.d.	0.14	n.d.
Fitzroy Island	Avg				
	Max				
Normanby Island	Avg	n.d.	n.d.	-	-
	Max	n.d.	n.d.	*0.16*	*0.01*
Dunk Island	Avg	n.d.	-	n.d.	n.d.
	Max	n.d.	*0.64*	n.d.	n.d.

Where only one detection was made (indicated in italics), the result is presented as Max concentration only.

5.2 Burdekin Regional Summary

Routine sampling sites in the Burdekin region in 2011-2012 were Orpheus Island, Magnetic Island and Cape Cleveland (Figure 14). Orpheus and Magnetic Island have been monitored since 2005, while Cape Cleveland has been monitored since 2007. The historical concentrations of individual PSII herbicides and other non-PSII indexed herbicides at these sites are indicated in Appendix G, Figure 32 - 33. All three sites have an excellent sampling record in 2011-2012 with only one sampler lost in transit from Magnetic Island.

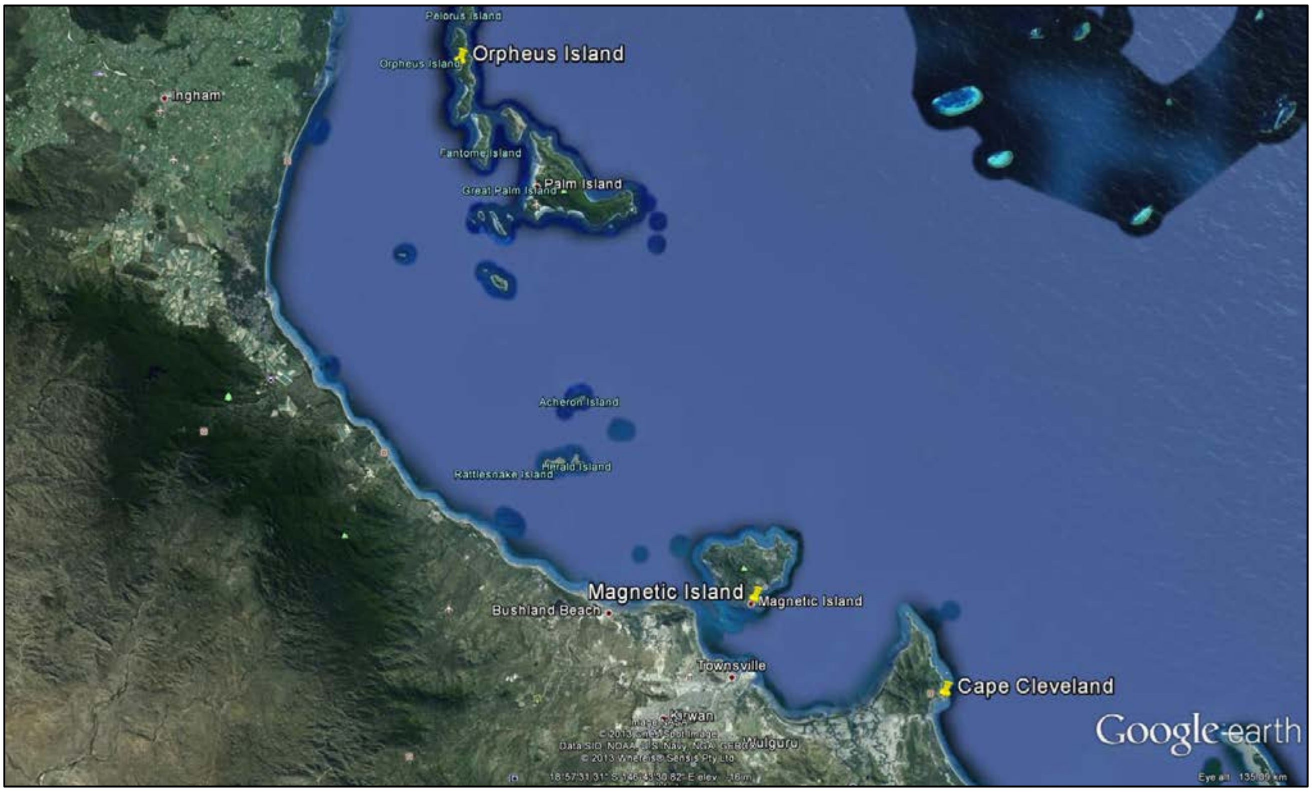

Figure 14 Location of routine monitoring sites in the Burdekin region

PSII herbicides (and transformation products) detected at routine sites in this region include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, simazine, tebuthiuron and bromacil (Orpheus Island only). The non PSII-indexed herbicides metolachlor and imazapic (Cape Cleveland only) were also detected. The average and maximum of the detected PSII herbicide concentrations for each routine site in this region are provided in Table 13.

The most abundant and frequently detected PSII herbicides in this region are atrazine (100 % detection; maximum concentration 15 $ng.L^{-1}$ at Cape Cleveland), diuron (detected in 100 % of samplers; maximum concentration 6.9 $ng.L^{-1}$ at Cape Cleveland), hexazinone (detected in 96 % of samplers; maximum concentration 0.76 $ng.L^{-1}$ at Orpheus Island) and tebuthiuron (detected in 92 % of samplers; maximum concentration 0.92 $ng.L^{-1}$ at Cape Cleveland). Atrazine and atrazine breakdown products typically dominate the herbicide profile at Cape Cleveland rather than diuron. The herbicide profile at Magnetic Island has also been frequently dominated by atrazine and its breakdown products in addition to tebuthiuron, which have historically been the highest detected for all regions. The herbicide profile of Orpheus Island more closely reflects the sites in the Wet Tropics, where diuron is the PSII herbicide present at highest concentrations. Cape Cleveland has the highest maximum concentrations of each of the dominant herbicides in this region and also the highest PSII-HEq maximum for the region (PSII-HEq Max 10 $ng.L^{-1}$). Magnetic Island was the only site where the PSII-HEq Max in 2011-2012 was less than that of the baseline reporting year. Cape Cleveland and Orpheus Island remained factors of 1.6 to 2.1 times higher than in the baseline reporting year of 2008-2009.

Table 13 Summary statistics for the concentrations (ng.L^{-1}) of individual PSII herbicides and PSII-HEq in 2011-2012 in comparison to the baseline reporting year in the Burdekin region.

		PSII Herbicides (Included in Index)										PS II Heq (ng/L)				Ratio to Baseline Year[b] (2008-09)	Other Herbicides (Not indexed)				
Site		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron	2011-12	2010-11	2009-10	2008-09		Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Orpheus Island	Avg[a]	0.05	0.32	0.14	n.d.	1.0	n.d.	0.25	n.d.	0.06	0.18	1.6	4.2	2.4	0.59	2.8	-	n.d.	0.05	n.d.	n.d.
	Max	0.08	0.77	0.15	n.d.	3.7	n.d.	0.76	n.d.	0.13	0.42	4.3	5.4	100	2	2.1	*0.03*	n.d.	0.20	n.d.	n.d.
Magnetic Island	Avg[a]	0.03	0.82	0.26	-	2.3	n.d.	0.16	n.d.	0.07	0.33	2.97	6.8	3.4	2.3	1.3	n.d.	n.d.	0.06	n.d.	n.d.
	Max	0.05	2.2	0.49	*0.14*	3.3	n.d.	0.33	n.d.	0.21	0.72	3.4	12	8.8	5.6	0.6	n.d.	n.d.	0.13	n.d.	n.d.
Cape Cleveland	Avg[a]	0.11	3.5	1.6	0.37	2.2	n.d.	0.28	n.d.	0.09	0.47	4.43	11	3.2	2.3	1.9	n.d.	n.d.	0.12	-	n.d.
	Max	0.27	15	2.6	0.68	6.9	n.d.	0.51	n.d.	0.18	0.92	10	20	9.1	6.3	1.6	n.d.	n.d.	0.21	*0.04*	n.d.

[a] Averages for individual herbicides are across both wet and dry season sampling periods. Averages indicated for PSII-HEq are for the wet season sampling periods (PSII-HEq Wet Avg) only as this parameter will be used for trend monitoring in subsequent reports. [b] These are the ratio of PSII-HEq Wet Avg and PSII-HEq Max in the current year with respect to the baseline reporting year (2008-2009) . Block colours indicate the maximum PSII-Heq Index category for that year.

Seasonal average PSII-HEq values are indicated for each routine site in the region across all monitoring years in Figure 15. Average wet season PSII-HEq have increased by factors ranging from 1.3 at Magnetic Island to 2.8 at Orpheus Island between 2011-2012 and the baseline reporting year. While risk of exposure to herbicides over the wet season is higher than that of the baseline reporting year, the PSII-HEq Wet Avg has decreased significantly from the previous monitoring year.

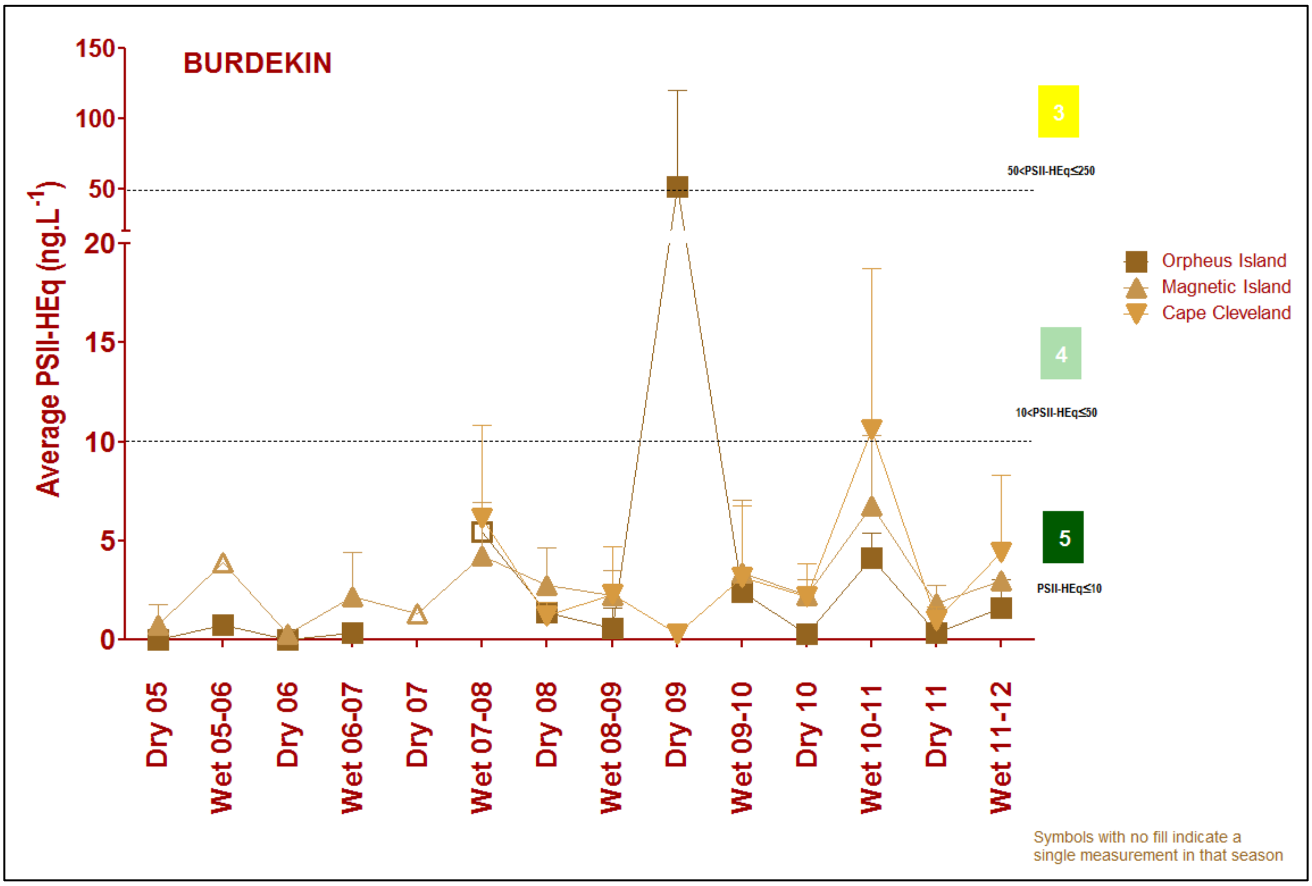

Figure 15 Seasonal average PSII-HEq for Burdekin sites since routine monitoring commenced

Metolachlor was detected using EDs at all sites including all samplers deployed at both Orpheus Island and Magnetic Island, however the maximum concentration at both of these sites was < 1ng.L^{-1}.

Pesticide results obtained using PDMS samplers at Cape Cleveland and Magnetic Island are summarised in Table 14. Metolachlor and the polycyclic musks galaxolide and tonalid were detected at both sites (single detection of tonalid at each site). No herbicides were detected in concentrations that met or exceeded GBRMPA Guidelines.

Table 14 Equilibrium concentrations of pesticides ($ng.L^{-1}$) measured using PDMS samplers in the Burdekin region in 2011-2012

Site		Atrazine	Metolachlor	Galaxolide	Tonalid
Orpheus Island	Avg				
	Max				
Magnetic Island	Avg	n.d.	1.2	0.10	-
	Max	n.d.	1.3	0.16	*0.01*
Cape Cleveland	Avg	-	0.65	0.10	-
	Max	*40*	1.2	0.13	*0.02*

Where only one detection was made (indicated in italics), the result is presented as Max concentration only.

5.3 Mackay Whitsunday Regional Summary

Routine sampling sites in the Mackay Whitsunday region in 2011-2012 were Pioneer Bay, Outer Whitsunday (Hamilton Island) and Sarina Inlet (Figure 16). Outer Whitsunday has been monitored since 2006 while the Pioneer Bay and Sarina Inlet sites were established in 2009. The historical concentrations of individual PSII herbicides and other non-PSII indexed pesticides at these sites are indicated in Appendix G, Figure 33 - 34. Both Pioneer Bay and Sarina Inlet had nine out of a possible nine successful sampling periods. Unfortunately, Outer Whitsunday had only two wet season deployments successfully completed for this monitoring year.

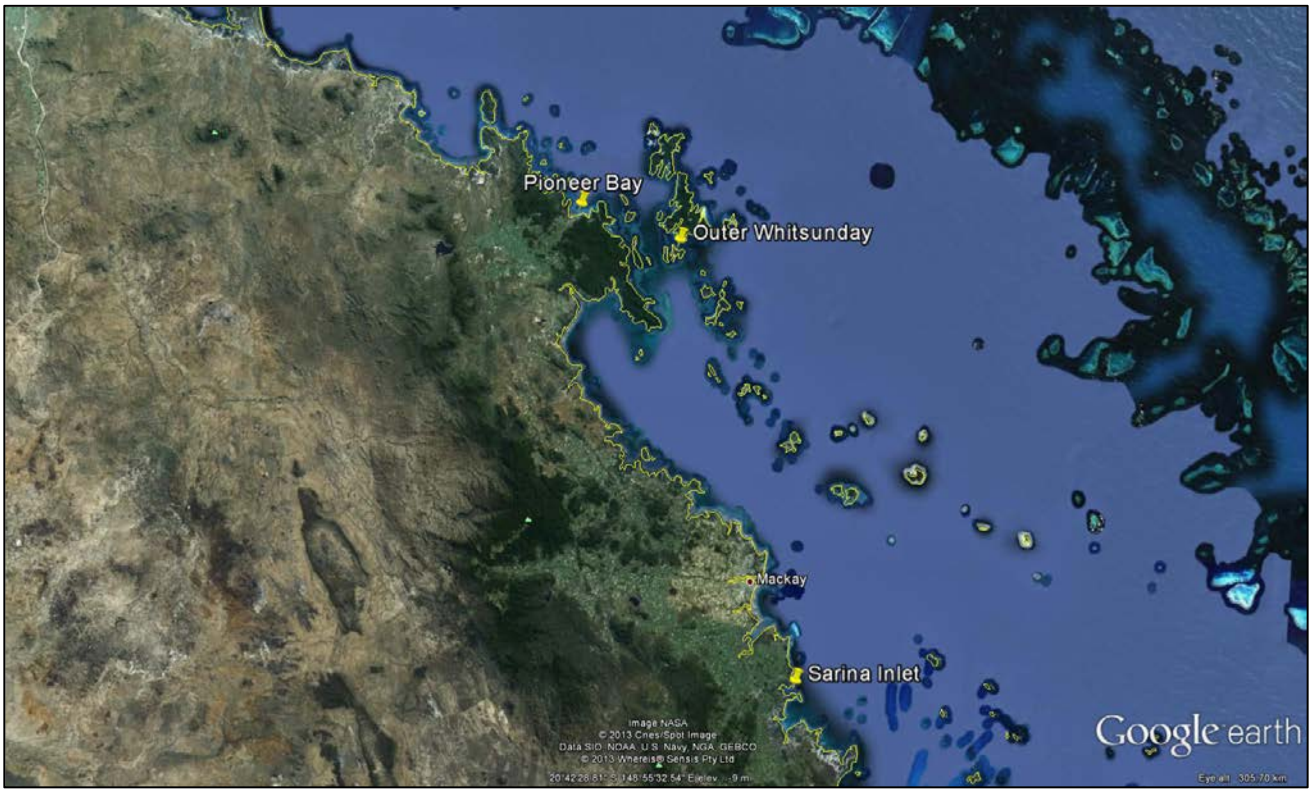

Figure 16 Location of routine monitoring sites in the Mackay Whitsunday region

PSII herbicides (and transformation products) detected at routine sites in this region include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, simazine, tebuthiuron, and bromacil (Sarina Inlet only). The average and maximum of the detected PSII herbicide concentrations for each routine site in this region are provided in Table 15. The most abundant and frequently detected PSII herbicides in this region are diuron (detected in 100 % of samplers; maximum concentration 18 $ng.L^{-1}$ at Sarina Inlet), atrazine (detected in 94 % of samplers; maximum concentration 10 $ng.L^{-1}$ at Sarina Inlet) and hexazinone (detected in 94 % of samplers; maximum concentration 9.6 $ng.L^{-1}$ at Sarina Inlet). Diuron is the PSII herbicide present in the highest concentration at each site in this region with maximum concentrations ranging from 2.8 $ng.L^{-1}$ at Outer Whitsunday to 18 $ng.L^{-1}$ at Sarina Inlet.

Sarina Inlet has the highest concentration of the dominant PSII herbicide diuron than any other routine site. It also has the highest PSII-HEq Max for this region of 22 $ng.L^{-1}$, which is a mid-Category 4 risk of herbicide exposure on the PSII-HEq Index, and the highest PSII-HEq Max of all routine monitoring sites in 2011-2012. The PSII-HEq Max at Pioneer Bay (11 $ng.L^{-1}$) is approximately half that of Sarina Inlet and Outer Whitsunday is the lowest for the region at 3.4 $ng.L^{-1}$. At Pioneer Bay and Sarina Inlet the PSII-HEq Maxima in 2011-2012 were 4 to 22 times lower than in the first monitoring year (2009-2010) respectively (Table 15).

Table 15 Summary statistics for the concentrations (ng.L^{-1}) of individual PSII herbicides and PSII-HEq in 2010-2011 in comparison to the baseline reporting year in the Mackay Whitsunday region

Site		PSII Herbicides (Included in Index)										PS II Heq (ng/L)				Ratio to Baseline Year[b] (2008-09)	Other Herbicides (Not indexed)				
		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron	2011-12	2010-11	2009-10	2006 - 07		Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Pioneer Bay	Avg[a]	0.05	0.31	n.d.	n.d.	7.3	n.d.	0.32	-	n.d.	0.21	7.9	12	29		0.3	n.d.	n.d.	0.05	n.d.	n.d.
	Max	0.06	0.49	n.d.	n.d.	10.65	n.d.	0.88	*0.04*	n.d.	0.61	11	22	43		0.3	n.d.	n.d.	0.12	n.d.	n.d.
Outer Whitsunday	Avg[a]	-	0.54	-	-	1.2	n.d.	0.27	n.d.	-	0.06	1.4	9.2	13	7.5	0.2	n.d.	n.d.	0.02	n.d.	n.d.
	Max	*0.05*	1.4	*0.16*	*0.05*	2.8	n.d.	0.75	n.d.	*0.03*	0.06	3.4	14	35	19	0.2	n.d.	n.d.	0.02	n.d.	n.d.
Sarina Inlet	Avg[a]	0.11	2.7	0.55	0.25	6.9	n.d.	2.9	-	0.15	0.35	12.3	22	114		0.1	0.10	n.d.	0.09	n.d.	0.36
	Max	0.30	10	2.0	0.71	18	n.d.	9.6	*0.03*	0.42	0.72	22	47	495		0.04	0.18	n.d.	0.21	n.d.	0.52

[a] Averages for individual herbicides are across both wet and dry season sampling periods. Averages indicated for PSII-HEq are for the wet season sampling periods only (PSII-HEq Wet Avg) as this parameter will be used for trend monitoring in subsequent reports. [b] These are the ratio of PSII-HEq Avg Wet and PSII-HEq Max in the current year with respect to the first monitoring year for Sarina Inlet and Pioneer Bay – 2009-2010, and 2006-2007 at Outer Whitsunday due to the unreliable sampling record in the baseline reporting year (08-09) Block colours indicate the maximum PSII-Heq Index category for that year

PSII-HEq comparisons to the baseline reporting year used in other regions (2008-2009) are not possible in Mackay Whitsunday due to unreliable sampling records in 2008-2009 (at Outer Whitsunday only one wet season sampling period was successful with nothing detected) and because Pioneer Bay and Sarina Inlet were not established until the 2009-2010 monitoring year. In this case, 2009-2010 is used as the baseline reporting year for the new sites, and 2006-2007 is used for Outer Whitsunday since this was the only previous year with a good sampling record in the wet season (5 samples). PSII-HEq Max has reduced by approximately two-fold between the previous reporting year and current monitoring year at Pioneer Bay and Sarina Inlet. The reduction at Sarina Inlet since monitoring commenced has been very significant with the PSII-HEq Max improving from a Category 2 to a mid Category 4. The PSII-HEq Max at Outer Whitsunday is four times lower than 2010-2011 and 5.5 times lower than in the baseline monitoring year. Pioneer Bay saw improvement to a PSII-HEq Max of 11 ng.L^{-1}, approaching a Category 5 for the first time since monitoring commenced at the site.

Seasonal average PSII-HEq values are indicated for each routine site in the region across all monitoring years in Figure 17. The PSII-HEq Wet Avg have decreased significantly at Pioneer Bay and Sarina Inlet respectively, since monitoring commenced. While the Outer Whitsunday PSII-HEq Wet Avg has also decreased significantly since the baseline year, it must be noted that the results for this monitoring year must be interpreted with caution as only two sampling periods in the current wet season were successful. The Mackay Whitsunday region has seen the most dramatic improvement in PSII-HEq Max and PSII-HEq Wet Avg of all regions since monitoring commenced. Overall, in spite of discharges in both the Pioneer and O'Connell Rivers in the Mackay Whitsunday region being greater than 3 times the long term median in the previous monitoring year, the PSII-HEq Max continues to show signs of improvement in this region.

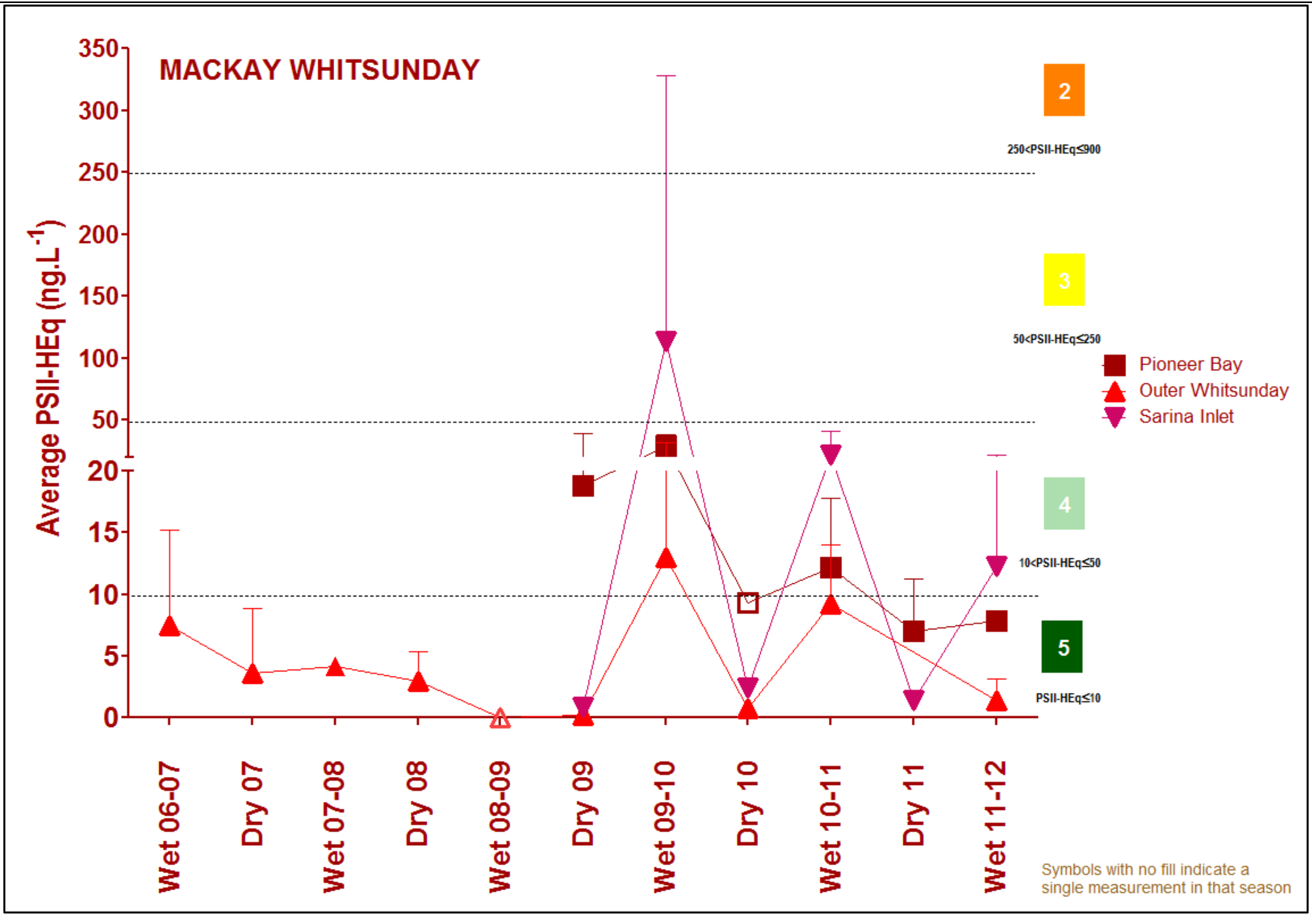

Figure 17 Seasonal average PSII-HEq for Mackay Whitsunday sites since routine monitoring commenced

Metolachlor was also detected using EDs at all sites at concentrations <1 ng.L^{-1}. Pesticide results obtained using PDMS samplers at Outer Whitsunday are summarised in Table 16. No pesticides were detected in PDMS during this monitoring year. There were no exceedances of GBRMPA Guidelines (GBRMPA 2010) for any herbicides detected in the Mackay Whitsunday region in 2011-2012.

Table 16 Equilibrium concentrations of pesticides (ng.L^{-1}) measured using PDMS samplers in the Mackay Whitsunday region in 2011-2012

Site		Atrazine	Metolachlor	Galaxolide	Tonalid
Pioneer Bay	Avg				
	Max				
Outer Whitsunday	Avg	n.d.	n.d.	n.d.	n.d.
	Max	n.d.	n.d.	n.d.	n.d.
Sarina Inlet	Avg				
	Max				

5.4 Fitzroy Regional Summary

The only routine monitoring site in the Fitzroy region is at North Keppel Island (Figure 18). This site has been monitored since 2005 although it has had broken periods of sampling in some years. The historical concentrations of individual PSII herbicides and other non-PSII indexed pesticides at this site are indicated in Appendix G, Figure 33.

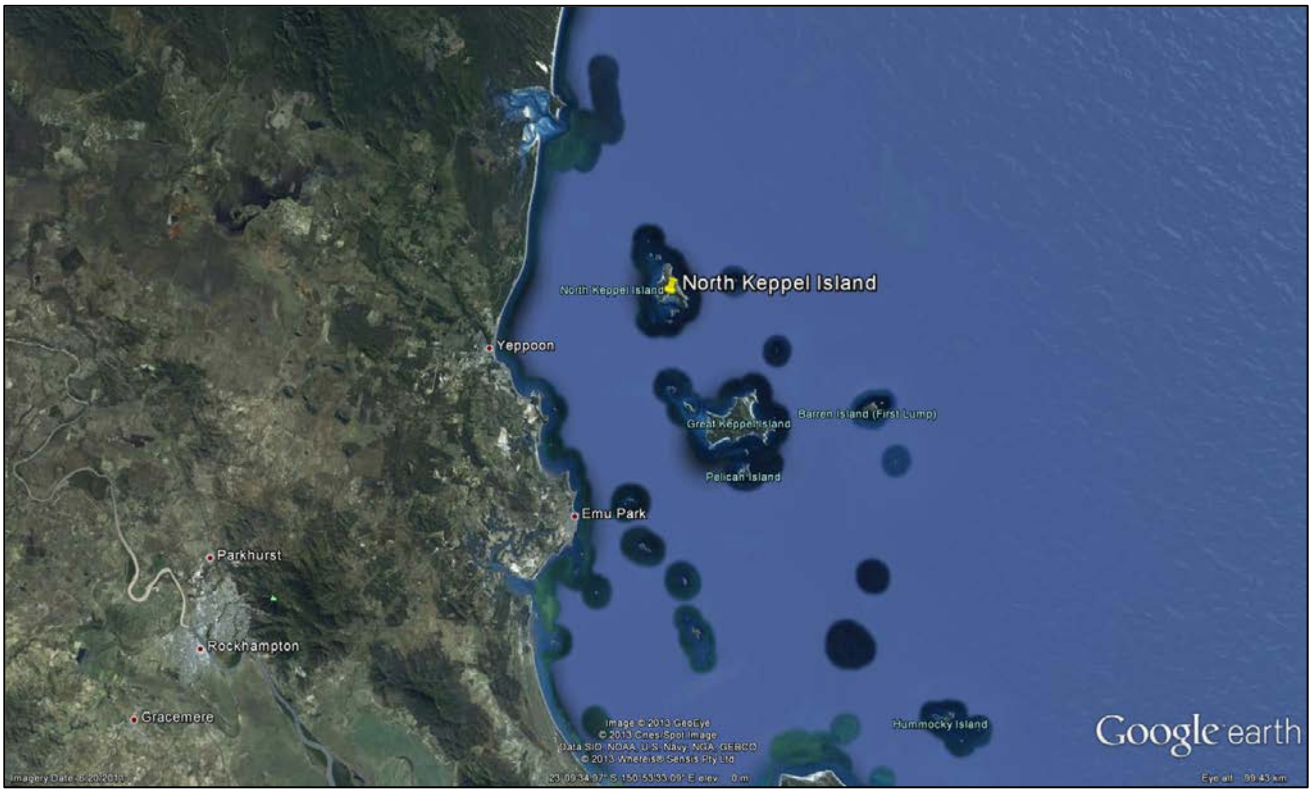

Figure 18 Location of routine monitoring sites in the Fitzroy region

PSII herbicides (and transformation products) detected at this site in 2011-2012 include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, simazine, tebuthiuron and bromacil (detected once only). The PSII herbicides detected with the greatest frequency were atrazine (detected in 100% of samplers; maximum concentration 1.6 $ng.L^{-1}$), diuron (detected in 100 % of samplers; maximum concentration 3.4 $ng.L^{-1}$) and tebuthiuron (detected in 90 % of samplers; maximum concentration 1.9 $ng.L^{-1}$). In the previous monitoring year, tebuthiuron and atrazine (and its breakdown products) were the dominant herbicides with the site heavily impacted by flood waters in 2010-2011 (Kennedy et al. 2011). The herbicide profile in this region is similar to sites in the Burdekin region such as Cape Cleveland and Magnetic Island, which are also dominated by tebuthiruon and atrazine. The average and maximum concentration for these herbicides at North Keppel Island in 2011-2012 are provided in Table 17.

The PSII-HEq Max for 2011-2012 at North Keppel Island was 3.4 $ng.L^{-1}$ indicating a Category 5 risk of herbicide exposure on the PSII-HEq Index. This is an increase by a factor of 3.1 when compared to the baseline reporting year, but an approximately three-fold improvement on the previous monitoring year. The 'wet years' of 2009-2010 and 2010-2011 saw a five-fold increase in the PSII-HEq Wet Avg from the baseline monitoring year. Despite a reduction from the previous monitoring year in 2010-2011, the PSII-HEq Wet Avg remains greater than the baseline reporting year.

Table 17 Summary statistics for the concentrations (ng.L^{-1}) of individual PSII herbicides and PSII-HEq in 2010-2011 in comparison to the baseline reporting year in the Mackay Whitsunday region

		PSII Herbicides (Included in Index)										PS II Heq (ng/L)				Ratio to Baseline Year[b] (2008-09)	Other Herbicides (Not indexed)				
Site		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron	2011-12	2010-11	2009-10	2008-09[c]		Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
North Keppel	Avg[a]	0.06	0.50	0.11	0.10	1.11	n.d.	0.06	0.04	0.06	0.54	1.71	4	4.1	0.73	2.34	-	n.d.	0.19	n.d.	n.d.
Island	Max	0.13	1.6	0.24	0.21	3.4	n.d.	0.15	0.04	0.17	1.9	3.4	12	8.7	1.1	3.08	*0.11*	n.d.	0.90	n.d.	n.d.

[a] Averages for individual herbicides are across both wet and dry season sampling periods. Averages indicated for PSII-HEq are for the wet season sampling periods (PSII-HEq Wet Avg) only as this parameter will be used for trend monitoring in subsequent reports. [b] These are the ratio of PSII-HEq Wet Avg and PSII-HEq Max in the current year with respect to the baseline monitoring year 2008-2009; [c]In 2008-2009 North Keppel Island PSII HEq maximum was derived from 4 dry season sampling periods and 2 wet season sampling period, the average for the wet season is therefore from only two sampling periods. For comparison the ratios with respect to 2009-2010 for the average wet season and maximum are 0.98 and 1.4 respectively. Block colours indicate the maximum PSII-Heq Index category for that year.

Seasonal average PSII-HEq values are indicated for North Keppel Island (Figure 19). The PSII-HEq Wet Avg has been consistently Category 5 since monitoring commenced.

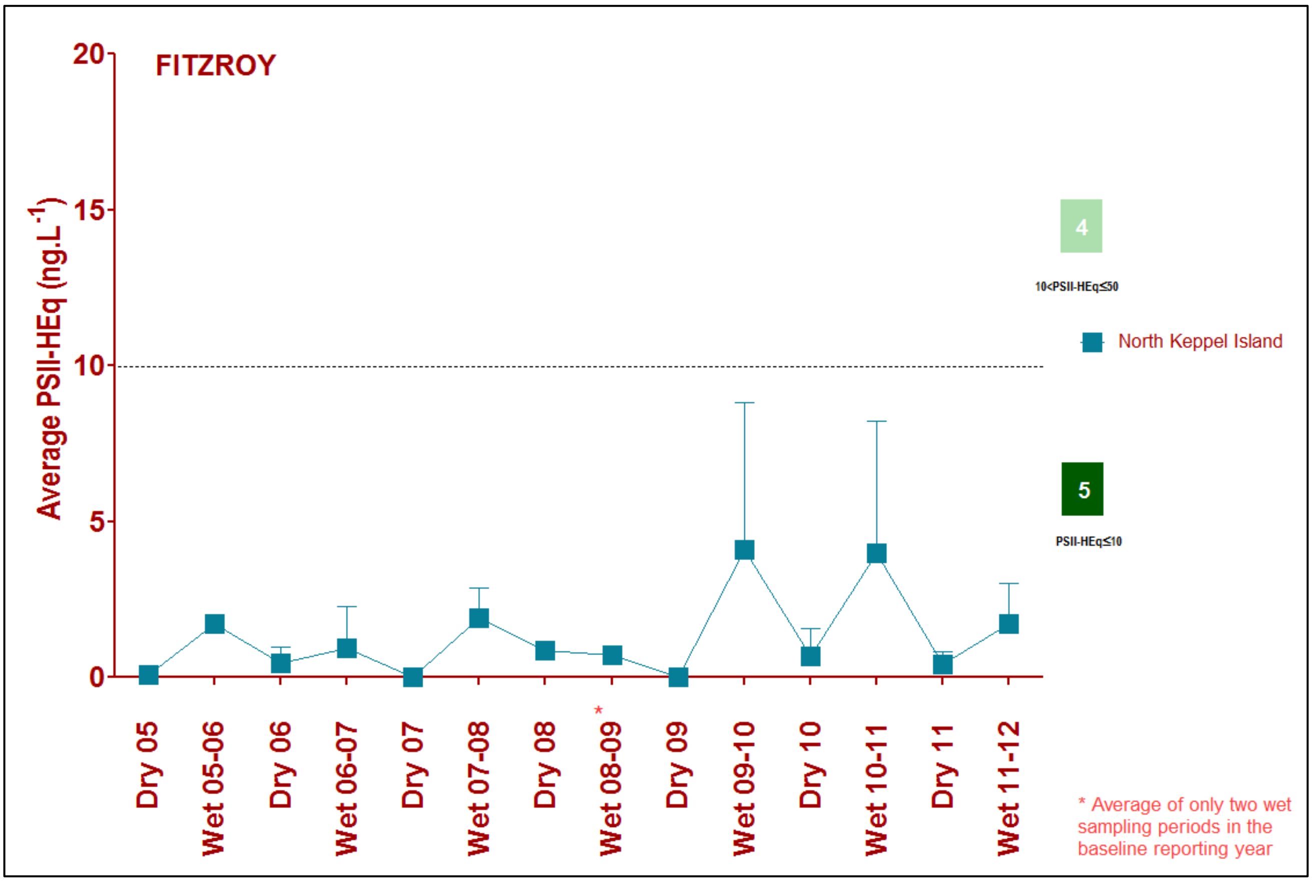

Figure 19 Seasonal average PSII-HEq for North Keppel Island in the Fitzroy region since routine monitoring commenced

The herbicide metolachlor was also detected in routine sampling at North Keppel Island. Bromacil was detected once at a concentration of 0.11 ng.L^{-1}. No PDMS sampling is undertaken at North Keppel Island. There were no exceedances of the GBRMPA Guideline for any herbicides detected in the Fitzroy region in 2011-2012.

6 DISCUSSION

Under the influence of La Nina, the 2010-2011 wet season was characterized by several severe physical disturbance phenomena (including the most powerful Category 5 cyclone on record) and the highest rainfall events recorded for the State of Queensland, which caused widespread floodingon an unprecedented scale (Figure 20).

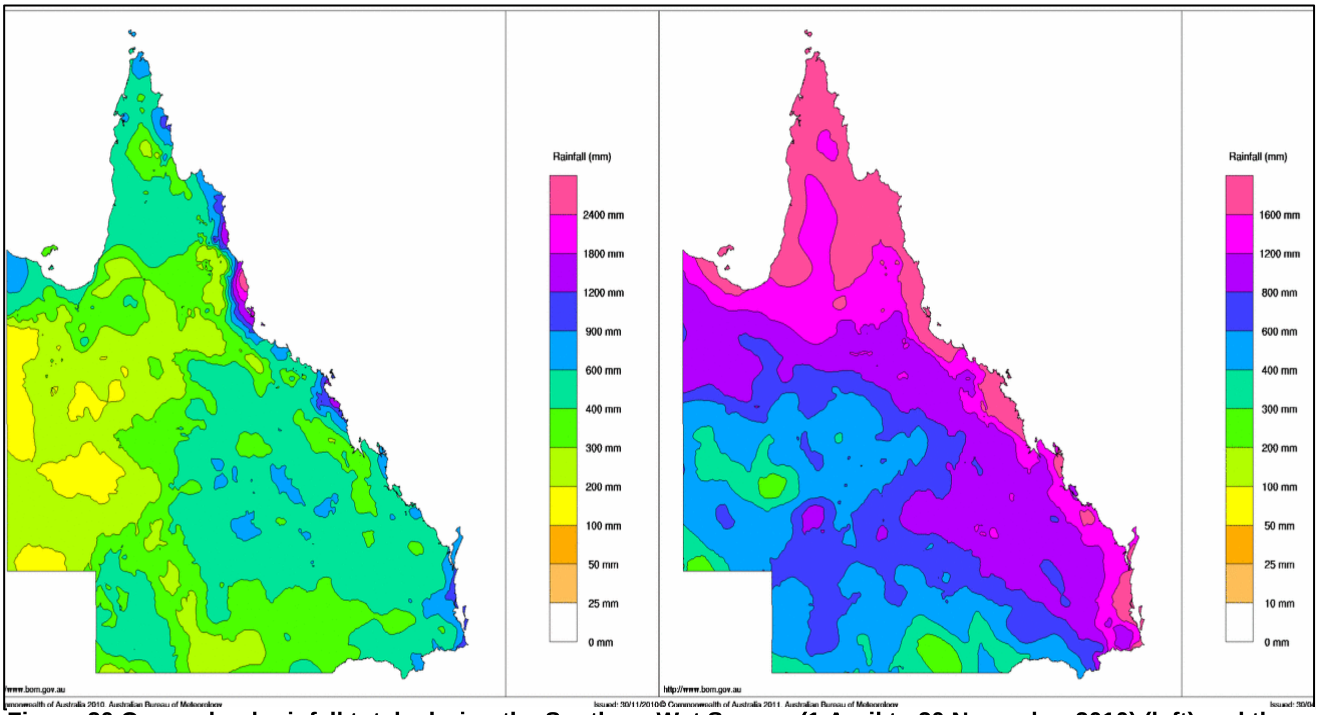

Figure 20 Queensland rainfall totals during the Southern Wet Season (1 April to 30 November 2010) (left) and the Northern Wet Season (1 October 2010 to 30 April 2011) (right)

Figures obtained from Australian Bureau of Meterology

As a result, there was an increase in the total discharge of freshwater into the inshore waters of the GBR, of 2 to 15 times the last 10 years of input (Figure 21) (Kennedy et al 2012a).

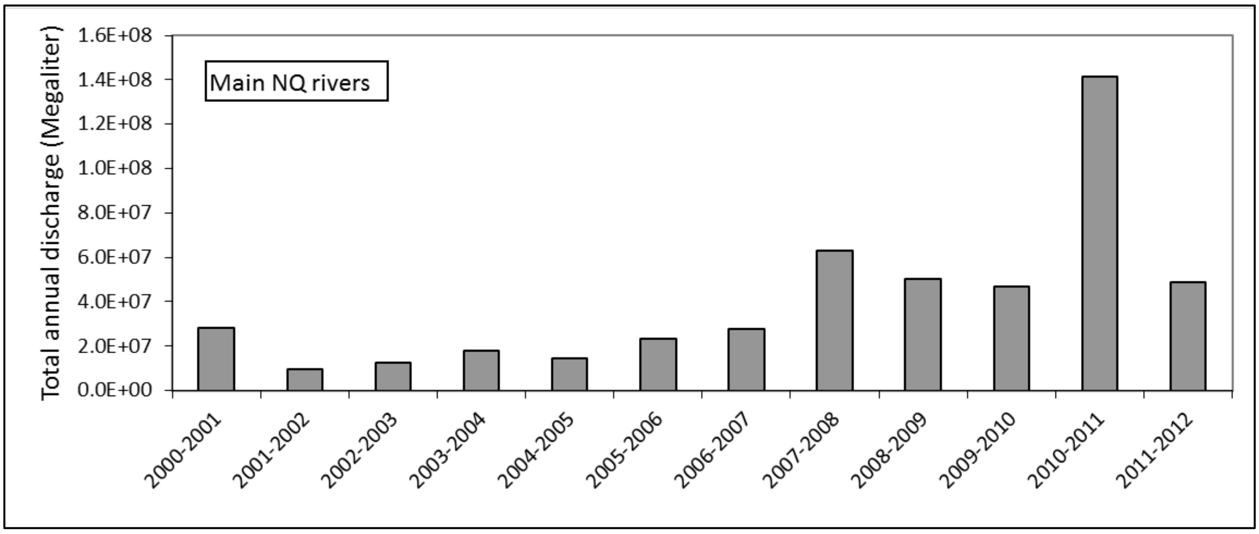

Figure 21 Total annual discharge of major rivers into the inshore waters of the GBR.

Data provided by Michelle Devlin (unpublished). The water year is considered October 1st to September 30th the following year, and thus the discharge for the current year remains incomplete.

In the GBR, discharge of major rivers increased from 1.5 to greater than 3 times the long-term median discharge (Schaffelke et al 2011), which lead to significant increases in the frequency of PSII herbicide detections, concentrations of herbicides (and subsequent PSII-HEq concentrations) and emergence of previously undetected PSII herbicides in several regions (Kennedy et al 2011).There appears to be a clear link between extreme wet weather events and an increased risk of exposure to PSII herbicides delivered by river discharge in the GBR (Kennedy et al 2012a; Kennedy et al 2012b). Conversely, during this current monitoring year, the drier conditions produced by a shift back to the El Nino weather cycle (Figure 22), resulted in lower flows in the major rivers located in the four NRM regions, which typically did not exceed their long-term medians by more than a factor of 1.4.

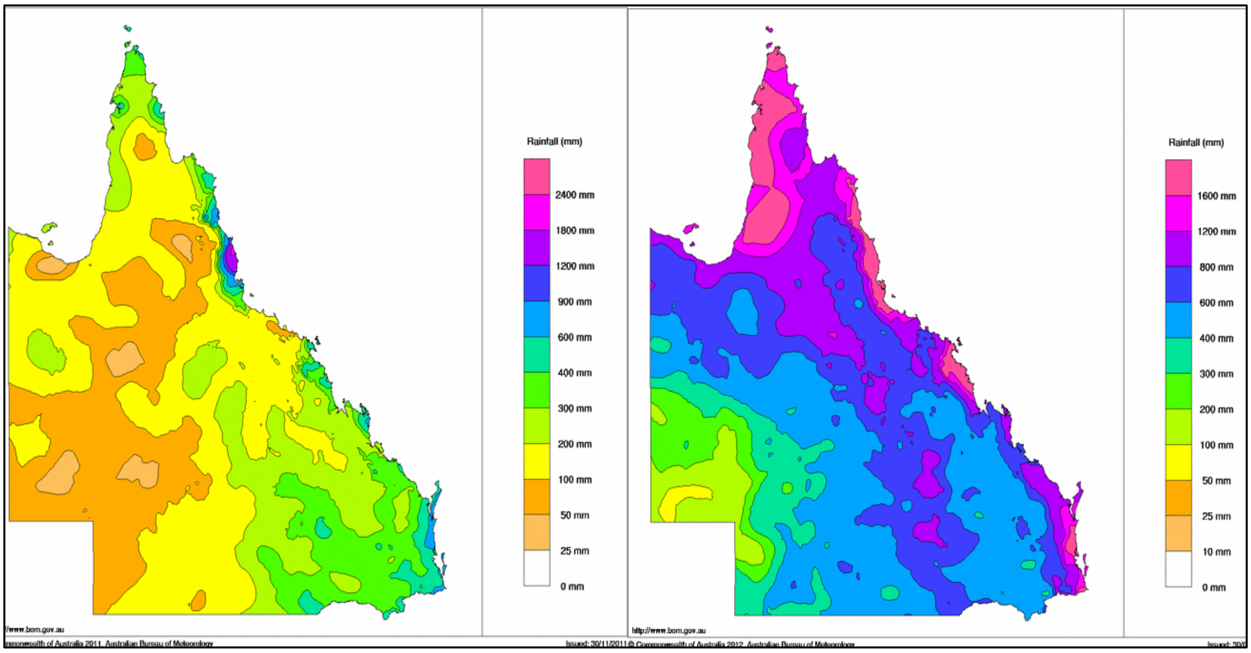

Figure 22 Queensland rainfall totals during the Southern Wet Season (1 April to 30 November 2011) (left) and the Northern Wet Season (1 October 2011 to 30 April 2012) (right)

Figures obtained from Australian Bureau of Meterology

There was a subsequent reduction in both the concentration and variety of PSII herbicides detected in 2011-12 (and therefore a reduced potential for PSII inhibition). These fluctuations in discharge can obscure the true changes in pesticide usage and improvements in land management practices. Figure 23 shows the total annual discharge of selected GBR rivers from 2000 to 2012, and most notably, the significant reduction in annual discharge between 2010-2011 and 2011-2012.

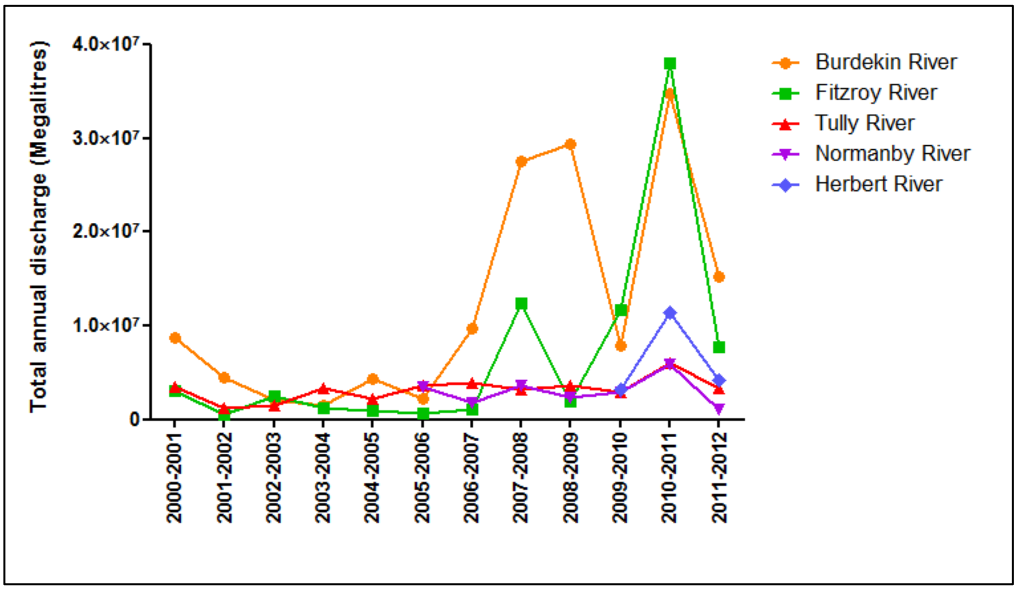

Figure 23 Total annual discharge of selected rivers in adjacent catchments to the GBR
Discharge data provided by Michelle Devlin (unpublished). The water year is considered October 1st to September 30th the following year, and thus the discharge for the current year remains incomplete

In most regions, major rivers discharged at approximately their long term medians (Table 9), with fewer peak events with reduced daily flow within the wet season, when compared to the flow events of the previous wet season. In general, this decrease in discharge saw a subsequent decrease in PSII-HEq as an indicator of risk of exposure to pesticides at the routine monitoring sites. The clear link between river discharge and PSII-HEq at nearby routine monitoring sites is highlighted for Green Island (Wet Tropics region) and Sarina Inlet (Mackay Whitsunday region) sites in Figure 24. The PSII-HEq of each deployment period since monitoring commenced is plotted with respect to the mean daily flow rate of the closest major river and the PSII-HEq Index Category for each passive sampler deployment indicated. Plots of the PSII-HEq indicated using passive samplers at all routine monitoring sites with respect to the mean daily river discharge are provided in Appendix F, Figures 26 - 29.

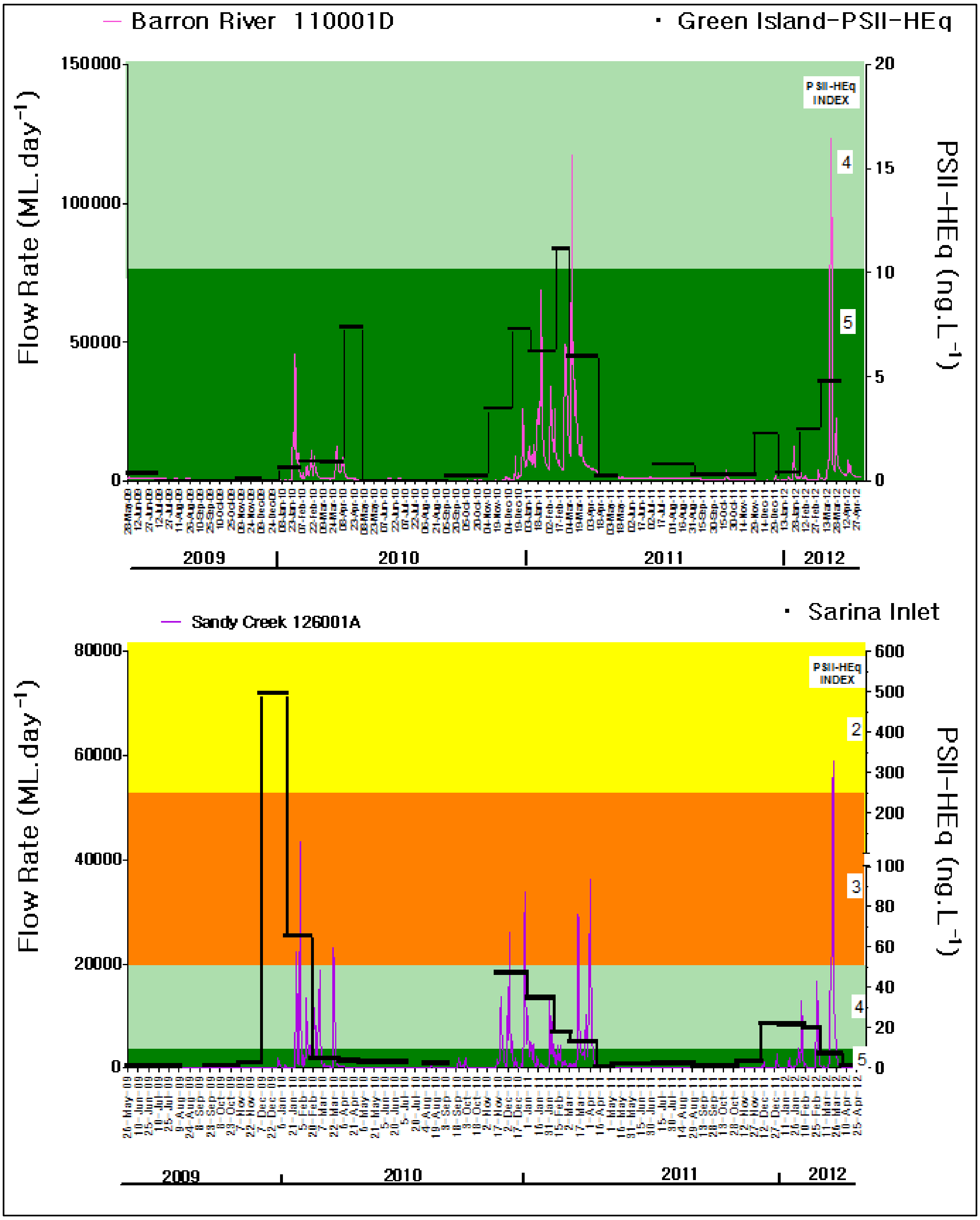

Figure 24 Temporal trends in flow rate and PSII-HEq in rivers in adjacent catchments at inshore GBR sites

The influence of increases in discharge on concentrations of individual PSII herbicides has also been demonstrated by correlations with the remotely sensed parameter coloured dissolved organic matter as an indicator for freshwater extent (reduced salinity) (Kennedy et al. 2011; Schroeder et al. 2012).

When trying to identify trends in herbicide exposure over time, it is important to consider the multiple factors driving that change. It can be difficult to ellucidate meaningful trends and assess the progress of Reef Plan (Anon 2009) when concurrent changes in pesticide application, river discharge and rainfall occur simultaneously. Quite often, the necessary data needed to interpret these changes (such as pesticide application rates) are not available. These factors make it difficult to assess real change in any pesticide application and improvements in land management practises as a direct result of Reef Rescue initiatives, and gain a true understanding of the input of herbicides into the system. Any reported changes in exposure to herbicides should therefore be interpreted in context with these potential drivers of change. Despite there being multiple factors influencing the spatial and temporal trends in herbicide detections, they are not naturally occurring. Thus, the long-term data record from this MMP may be able to eventually elucidate some sorts of trends in herbicide exposure, given enough time and data points, that can be correlated to land management practices.

In March 2012, the Australian Pesticides and Veterinary Medicine Authority (APVMA) further extended the suspension initiated in November 2011 on certain uses of diuron, to the 30 November 2012. The final review of diuron by the APVMA has affirmed the registration of most diuron products but with significant changes to their use including reduced rates of application, a ban on spraying when heavy rain is forecast and spraydrift buffer zones. This MMP will provide valuable baseline data to assess any potential future decline in risk of exposure to PSII herbicides for inshore waters of the GBR as a direct result of this and any future regulatory activity.

Despite the overall general reduction in concentration of individual herbicides and PSII-HEq/ PSII-HEq Max at most sites, many herbicides were detected more frequently this monitoring year, including ametryn, atrazine, diuron, hexazinone, simazine, tebuthiuron and metolachlor in all regions. In addition, the insecticide imidacloprid was routinely analysed for the first full monitoring year and was detected at Green Island, Dunk Island and Sarina Inlet.

The herbicide imazapic was not routinely analysed in 2011-2012, but was detected at several sites within the wet season in the Wet Tropics and Burdekin regions. Imazapic is an imidazolinone herbicide which shares the same mode of action as the sulfonylurea herbicides, inhibiting the action of the enzyme acetolactate synthase (ALS) and formation of essential amino acids in the plant. This herbicide is rapidly absorbed via the roots and foliage and transported to growing regions of the plant (Cox, 2003). Imazapic is an active constituent of many products registered for use in Australia including MIDAS, EMAZ, Impose and Furnace for the pre and post-emergence treatment of annual grass and broadleaf weeds (Farmoz, 2012). It is considered a ‘safe’ herbicide having little effect on mammals, birds and fish (Tu et al, 2001). Imazapic is deemed ‘moderately persistent’ but immobile in soil (half life up to 150 days) and is rapidly degraded by photolysis in water within 2 days (Tu et al, 2001) No water guidelines are currently available for imazapic in Australia.

A summary of the PSII-HEq Max for routine monitoring sites in 2011-2012 is indicated in Figure 25. The relative contributions of individual PSII herbicides to these equivalent concentrations (which account for the relative potency of each) are indicated.

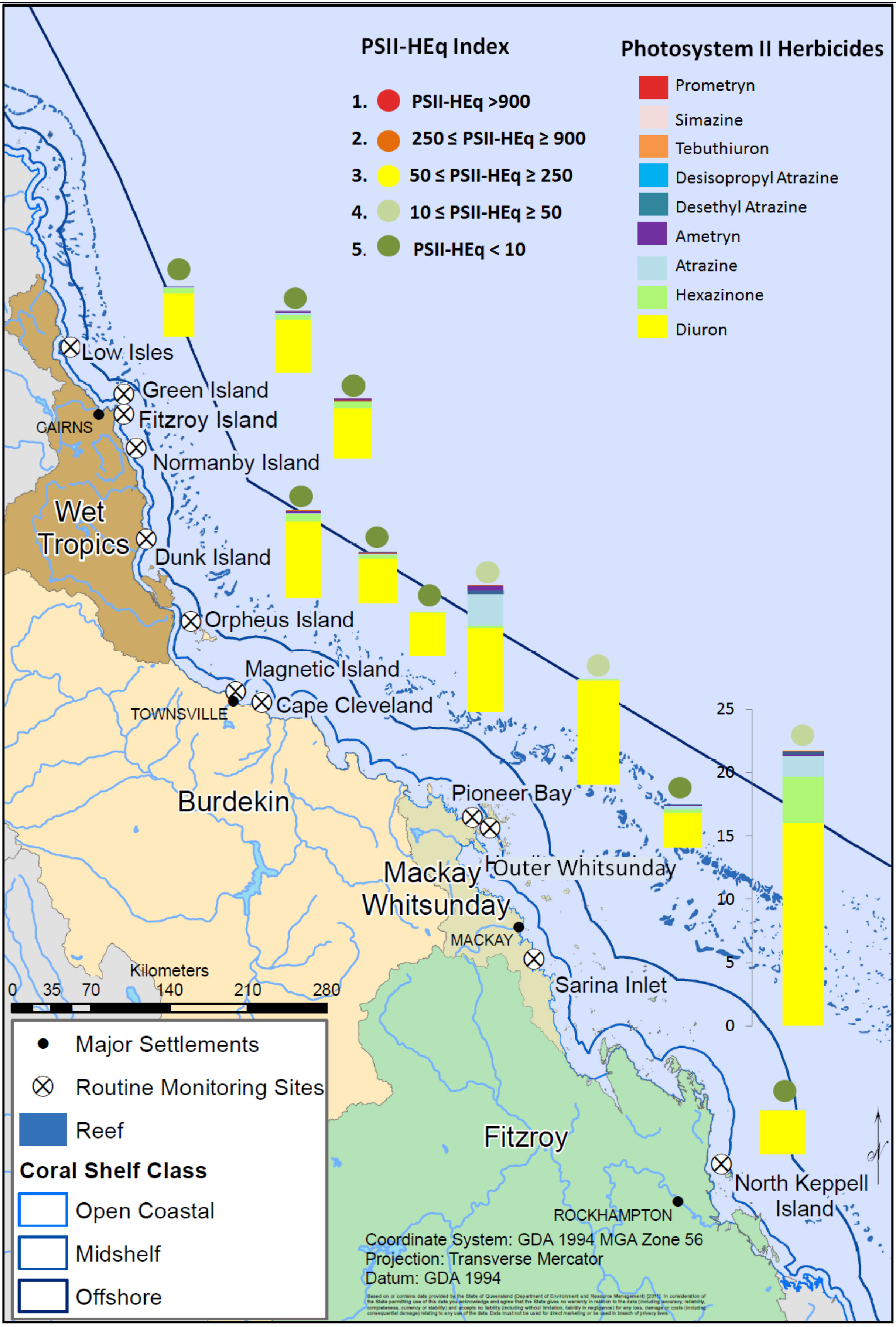

Figure 25 PSII-HEq Max (ng.L^{-1}) with the PSII-HEq Index of each value indicated for each routine site 2011-2012

(Modification of original map provided by Adam Donovan and Alex Shanahan, School of Geography, Planning and Environmental Management, The University of Queensland)

The largest single land use within the GBR is cattle grazing for beef production, with other uses including sugar cane cropping, plantation forestry and mining (Brodie et al, 2001). Sugar cane farming is clustered heavily along the Tully River (Wet Tropics region), Burdekin River (Burdekin region) and Pioneer River (Mackay-Whitsunday region) (Lewis et al, 2009). The herbicide residues detected in the greatest abundance in this MMP (diuron, atrazine and hexazinone) are consistent with the applications of the sugar cane industry. In addition, metoloachlor which was detected at all routine monitoring sites (and in 100 % of passive samplers deployed at four sites) is also registered for sugar cane use. Historically the Burdekin and Fitzroy catchments have seen the highest concentrations of tebuthiuron detected of all regions since monitoring commenced (maximum concentration of 20 $ng.L^{-1}$ detected at North Keppel Island in 2010-2011, exceeding guideline values). These catchments are extensively used for cattle grazing, and tebuthiruon is used to control woody plants on grazing land (Lewis et al, 2009; Brodie et al, 2001).

Diuron is the dominant contributor to the PSII-HEq Max at every routine site which is consistent with previous years of monitoring. Diuron contributes an average of 85 % to the PSII-Max in the Wet Tropics (excluding Dunk Island and Fitzroy Island), 84 % in the Burdekin, 85 % in the Mackay Whitsundays and 99 % at North Keppel Island in the Fitzroy region to the PSII-HEq Max. The contribution of diuron to the PSII-HEq Max of each site remains relatively consistent between the sites within the Wet Tropics (83 % - 86 %) but varies more widely within the Burdekin region (68 % at Cape Cleveland to 97% at Magnetic Island) and Mackay Whitsunday region (74 % at Sarina Inlet to 99 % at Pioneer Bay).

Despite the APVMA's temporary suspension on diuron being in place since November 2011, diuron remains the dominant herbicide detected at all sites. Whilst there is a decrease in the concentration of diuron detected when compared to the previous wet season, it is difficult to acertain whether that decrease is due to the reduced terrestrial discharge delivered into the reef during this wet season or as a result of reduction in the application of the herbicide.

In the Wet Tropics, the contributions of atrazine to PSII-HEq Max are consistently low across all sites, averaging 3 % (excluding Dunk Island). Hexazinone has a greater contribution averaging approximately 10 % across all Wet Tropics sites. In the Burdekin region the contributions were highly variable, with atrazine contributing up to 24 % at Cape Cleveland and only up to 3 % at other sites. Atrazine has previously been found to be a dominant herbicide in rivers discharging in the Burdekin region (Davis et al. 2008). The contribution of hexazinone to PSII-HEq Max was also variable contributing only 1 % at Magnetic Island and up to a maximum of 7 % at Orpheus Island. The contribution of hexazinone in the Mackay Whitsunday region ranged from 3 % at Pioneer Bay to 17 % at Sarina Inlet, which detected the highest concentration of hexazinone all routine monitoring sites this year. A maximum contribution of 8 % of atrazine was seen at Sarina Inlet. Only 1 % of the PSII-HEQ Max was from atrazine at North Keppel Island, with the remainder contributed by diuron. The contribution of ametryn across all sites in all regions was low, averaging 2 %. Simazine, desethyl atrazine and desisopropyl atrazine all contributed ≤ 1% to these maxima in all regions with the exception of Cape Cleveland where desethyl atrazine contributed 3 %.

The PSII-HEq Index Categories for these maxima are Category 5 in the Wet Tropics and Fitzroy regions, and either Category 4 or Category 5 in the Burdekin and Mackay Whitsunday regions. The PSII-HEq at the Sarina Inlet site in the Mackay Whitsunday region was again the highest of all routine monitoring sites, but had improved by a factor of 2 when compared to the previous monitoring year and from a Category 3 site when monitoring commenced in 2009. Sites within the Mackay Whitsunday region have made the most significant improvements in terms of PSII-HEq Max values.

The 1 L grab samples collected to assess terrestrial run-off in flood plumes in the Wet Tropics/ Burdekin region were either Category 4 or 5. Passive samplers deployed in the Herbert River transect were also Category 4 or 5 on the Index. Both passive and grab sampling indicated the same general trend in exposure to PSII herbicides during this current wet season. There were no exceedances of the GBRMPA Guidelines for any detected herbicides in either passive or grab sampling during this current monitoring year.

SUMMARY

Pesticide monitoring activities in four NRM regions undertaken in 2011-2012 have included routine monitoring at twelve fixed sites using polar passive samplers (at all sites) and non-polar passive samplers (at selected sites). Terrestrial run-off was monitored in parallel during the wet season in three NRM regions utilising both grab sampling and passive sampling techniques. A transect extending 2 km from the Normanby River in the Cape York region was established using 1 L grab samples only. A transect extending 35 km from the Tully River in the Wet Tropics was established, also using 1 L grab samples only. A more intensive sampling campaign was established on two transects extending north (50 km) and south (7 km) from the Herbert River in the Wet Tropics/ Burdekin region utilising both 1 L grab samples and passive samplers (at three fixed sites).

Passive and grab sampling in both the terrestrial run-off and routine monitoring components of the program showed that diuron continued to be the dominant PSII herbicide detected in all four NRM regions. Due to its potency, it was also the major contributing PSII herbicide to the PSII-HEq Max concentrations at each site. Also observed at the routine monitoring sites in 2011-2012, were the increasing frequency of detection of herbicides such as ametryn, atrazine, diuron, hexazinone, simazine, tebuthiuron and metolachlor in all regions when compared to the previous monitoring year. This was despite a significant decrease in the volume of river discharge that was delivered into inshore reef waters during the current wet season when compared to the previous monitoring year, although the use of a more sensitive LCMSMS instrument for analysis may have contributed to this increase. PSII-HEq Max indicated by passive samplers deployed at routine sites were predominantly Category 5 on the PSII-HEq Index in all regions, with the exception of Sarina Inlet, Pioneer Bay and Cape Cleveland. Several routine sites (Green Island, Normanby Island, Magnetic Island, Outer Whitsunday and North Keppel Island) improved from a Category 4 in the previous monitoring year.

The reporting parameter PSII-HEq Max decreased from the baseline reporting year (or the year in which monitoring commenced) at several sites (including Low Isles, Green Island, Normanby Island, Magnetic Island, Pioneer Bay, Outer Whitsunday and Sarina Inlet). The most significant decreases in PSII-HEq Max occurred in the Mackay Whitsunday region (ranging between 4 and 22 times lower than the baseline reporting year). During the wet season, the PSII-HEq (PSII-HEq Wet Avg) at every routine site had decreased from the previous monitoring year, although some sites remained elevated above the baseline reporting year (Cape Cleveland and North Keppel Island). This indicates that in general, exposure to PSII herbicides at routine monitoring locations was not as elevated or prolonged on the GBR across this wet season when compared to previous wet seasons dominanted by extreme weather events.

Characterising herbicide exposure remains challenging in an area as vast as the Great Barrier Reef Marine Park. This year, the Herbert River transects attempted to gain greater resolution of this variability in exposure (spatially and temporally) by using multiple sampling techniques during the wet season. In general, there was a higher risk of exposure to PSII herbicides within this small area of the Wet Tropics (Category 3 PSII-HEq Max indicated by passive samplers) than the current routine monitoring sites in the region (which are not impacted by the flood plume) have indicated (Category 4 PSII-HEq Max). It is possible that the current routine monitoring sites are underestimating the risk of exposure to herbicides from flood waters within this region due to their location. In both the Tully River and Herbert River transects, grab samples collected indicated a decline in PSII herbicide exposure with increasing distance from the River mouths. However, at times the risk of exposure at the more distant locations (such as Sisters Island 35 km from the Tully River mouth) was comparable with concentrations detected at the Tully Mouth, showing little dilution of plume waters. Typically, grab samples routinely detected PSII herbicides at higher concentrations than co-deployed passive samplers.

Whilst no GBRMPA guidelines were exceeded in this current monitoring year, low level chronic exposure to PSII herbicides may still have a profound effect on this fragile ecosystem (Pennington et al, 2001; Cantin et al, 2007). In particular, the compound effects of simultaneous stressors on key organisms on the reef including the effects of global climate change (increasing sea temperatures, ocean acidification), an increase in the severity and frequency of damaging weather events such as cyclones, and increase in flood events, which are key vehicles for the delivery of nurtrients, sediment and complex mixtures of pollutants into the sensitive inshore waters of the reef is also not fully understood. Interpreting trends considering

these multiple driving factors for change remains difficult, but is essential in ascertaining whether improving or declining water quality is driven by land management practices or is an artefact of weather. Normalising pesticide concentration data with rainfall and/ or river discharge data may help to provide more meaningful results.

The upcoming review of the pesticide monitoring program will assist in determining whether the current program design delivers relevant results that help to address the goals of the Reef Plan ‘to halt and reverse the decline in water quality entering the GBR by 2013. Collaboration and integration with other programs monitoring the reef may provide a more comprehensive and robust program that is capable of identifying the true risks of exposure on the GBR.

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8 APPENDIX A: COMPLETE ANALYTE LIST FOR LCMS AND GCMS ANALYSIS

Table 18 LCMS Analyte List for Positive Mode

Ametryn
Atrazine
Bromacil
Clethodim[a]
Clomazone[a]
Cynazine[a]
Desethyl Atrazine
Desisopropyl Atrazine
Diuron
Ethametsulfuron methyl[a]
Flumeturon
Flusilazole[a]
Hexazinone
Imazapic[a]
Imazethapyr[a]
Imidacloprid
Metolachlor
Mesosulfuron methyl[a]
Napropamide[a]
Prometryn
Propachlor[a]
Propazin-2-hydroxy[a]
Sethoxydim[a]
Simazine
Sulfosulfuron[a]
Tebuthiuron
Terbuthylazine[a]
Terbuthylazine desethyl[a]
Terbutryn
Trifloxysulfuron-sodium[a]

[a] **Not routinely analysed in 2011-2012**

Table 19 GCMS analyte list for PDMS extracts with cells shaded grey to indicate chemicals which are not calibrated within the fraction collected during gel permeation (size exclusion) chromatography of extracts and cells shaded blue to indicated industrial chemicals/personal care products which may be detected but are not reported along with pesticides in the MMP results

ACEPHATE	DICHLORVOS	METOLACHLOR
ALDRIN	DICLOFOP METHYL	METRIBUZIN
AMETRYN	DICOFOL o,p	MEVINPHOS z+E
AMITRAZ	DICOFOL p,p bd	MOLINATE
ATRAZINE	DIELDRIN	MONOCROTOPHOS
AZINPHOS ETHYL	DIMETHOATE	MUSK KETONE
AZINPHOS METHYL	DIMETHOMORPH E,Z	MUSK XYLENE
BENALAXYL	DIOXATHION	NICOTINE
BENDIOCARB	DISULFOTON	NONACHLOR cis
BIFENTHRIN	Diuron bd	NONACHLOR trans
BIORESMETHRIN	ENDOSULFAN alpha	OMETHOATE
BITERTANOL	ENDOSULFAN beta	OXADIAZON
BROMACIL	ENDOSULFAN ETHER	OXYCHLOR
BROMOPHOS ETHYL	ENDOSULFAN LACTONE	OXYDEMETON METHYL
CADUSAPHOS	ENDOSULFAN SULPHATE	OXYFLUORFEN
CAPTAN	ENDRIN	PARATHION ETHYL
CARBARYL	ENDRIN ALDEHYDE	PARATHION METHYL
CARBOPHENOTHION	ETHION	PENDIMETHALIN
CHLORDANE cis	ETHOPROP	PERMETHRIN isomers
CHLORDANE trans	ETRIMIPHOS	PHENOTHRIN isomers
CHLORDENE	FAMPHUR	PHORATE
CHLORDENE EPOXIDE	FENAMIPHOS	PHOSMET
CHLORDENE, 1-HYDROXY	FENCHLORPHOS	PHOSPHAMIDON peak1 **200**
CHLORDENE, 1-OH-2,3-EPOXY	FENITROTHION	PHOSPHAMIDON peak2 **800**
CHLORFENVINPHOS e+Z	FENTHION ETHYL	PHOSPHATE TRI-n-BUTYL
CHLOROTHALONIL	FENTHION METHYL	PIPERONYL BUTOXIDE
CHLORPYRIFOS	FENVALERATE isomers	PIRIMICARB
CHLORPYRIFOS ME	FIPRONIL	PIRIMIPHOS METHYL
CHLORPYRIFOS OXON	FLUAZIFOP BUTYL	PROCYMIDONE
COUMAPHOS	FLUOMETURON	PROFENOPHOS
CYFLUTHRIN isomers	FLUVALINATE isomers	PROMETRYN
CYHALOTHRIN isomers	FURALAXYL	PROPAGITE
CYPERMETHRIN isomers	GALOXOLIDE	PROPANIL
DCPP isomers	HALOXYFOP 2-EtOEt	PROPAZINE
DDD o,p	HALOXYFOP METHYL	PROPICONAZOL isomers
DDD p,p	HCB	PROPOXUR
DDE o,p	HCH-a	PROTHIOPHOS
DDE pp	HCH-b	PYRAZAPHOS
DDT o,p	HCH-d	ROTENONE
DDT p,p	HEPTACHLOR	SIMAZINE
DEET	HEPTACHLOR EPOXIDE	SULPROFOS
DELTAMETHRIN isomers	HEXAZINONE	TCEP
DEMETON-S-METHYL	IPRODIONE	TERBUTHYLAZINE
DESETHYLATRAZINE	ISOPHENOPHOS	TERBUTRYN
DESISOPROPYLATRAZINE *900*	LINDANE (HCH-g)	TETRACHLORVINPHOS
DIAZINON	MALATHION	TETRADIFON
DICHLOROANILINE 3,4	METALAXYL	TETRAMETHRIN isomers
TEBUTHIURON TEBUCONAZOLE	METHAMIDOPHOS	THIABENDAZOLE
TCPP	METHIDATHION	TONALID
TEMEPHOS	METHOMYL	TRANSFLUTHRIN
TEP	METHOPRENE	TRIADIMEFON
TERBUPHOS	METHOXYCHLOR	TRIADIMENOL ISOMERS

TRIALLATE TRIFLURALIN VINCLOZALIN		

9 APPENDIX B – SUPPORING LITERATURE FOR THE DEVELOPMENT OF THE PSII-HEQ INDEX

Table 20 Scientific publications indicating the effect concentrations and the end-points for the reference PSII herbicide diuron used to define specific PSII-HEq Index categories as an indicator for reporting purposes

Category	PSII-HEq Range (ng.L^{-1})	Description	Supporting Literature with Respect to the Reference Chemical Diuron				
			Species	**Effects Concentration (ng.L^{-1})**	**Endpoint**	**Toxicity measure**	**Reference**
5	HEq ≤ 10	No published scientific papers that demonstrate any effects on plants or animals based on toxicity or a reduction in photosynthesis. The upper limit of this category is also the detection limit for pesticide concentrations determined in field collected water samples.					
4	10 < HEq ≤ 50	Published scientific observations of reduced photosynthesis for two diatoms.	**Diatoms**				
			D. tertiolecta	50	↓photosynthesis	LOEC	Bengston Nash *et al* 2005
			N. closterium	50	Sensitivity	LOEC	Bengston Nash *et al* 2005
3	50 < HEq < 250	Published scientific observations of reduced photosynthesis for two seagrass species and three diatoms.	**Seagrass**				
			H. ovalis	100	↓photosynthesis	LOEC	Haynes et al 2000
			Z. capriconi	100	↓photosynthesis	LOEC	Haynes et al 2000
			Diatoms				
			N. closterium	100	Sensitivity	IC10	Bengston Nash *et al* 2005
			P. tricornutum	100	Sensitivity	IC10	Bengston Nash *et al* 2005
			D. tertiolecta	110	↓photosynthesis	IC10	Bengston Nash *et al* 2005
2	250≤ HEq ≤ 900	Published scientific observations of reduced photosynthesis for three coral species.	**Coral - Isolated zooxanthellae**				
			S. pistillata	250	↓photosynthesis	LOEC	Jones *et al* 2003
			Coral - Adult colonies				
			A. formosa	300	↓photosynthesis	LOEC	Jones & Kerswell, 2003
			S. hystrix	300	↓photosynthesis	LOEC	Jones *et al* 2003
			S. hystrix	300	↓photosynthesis	LOEC	Jones & Kerswell, 2003
1	HEq > 900	Published scientific papers that demonstrate effects on the growth and death of aquatic plants and animals exposed to the pesticide. This concentration represents a level at	**Seagrass**				
			Z. capriconi	1000	↓photosynthesis	LOEC	Chesworth *et al* 2004
			Z. capriconi	5000	↓growth	LOEC	Chesworth *et al* 2004
			Z. capriconi	10000	↓photosynthesis	LOEC	Macinnis-Ng & Ralph, 2004
			C. serrulata	10000	↓photosynthesis	LOEC	Haynes *et al* 2000b

Category	PSII-HEq Range ($ng.L^{-1}$)	Description	Supporting Literature with Respect to the Reference Chemical Diuron				
			Species	**Effects Concentration ($ng.L^{-1}$)**	**Endpoint**	**Toxicity measure**	**Reference**
		which 99 per cent of tropical marine plants and animals are protected, using diuron as the reference chemical.	**Coral - Isolated zooxanthellae**				
			M. mirabilis	1000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			F. fragum	2000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			D. strigosa	2000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			Larvae				
			A. millepora	300	↓ Metamorphosis	LOEC	Negri *et al* 2005
			Coral recruits				
			P. damicornis	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			P. damicornis	10000	Loss of algae	LOEC	Negri *et al* 2005
			Coral - Adult colonies				
			A. formosa	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			P. cylindrica	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			M. digitata	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			S. hystrix	1000	↓ photosynthesis	LOEC	Jones *et al* 2003, Jones 2004
			A. millepora	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			P. damicornis	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			S. hystrix	2300	↓ photosynthesis	EC50	Jones *et al* 2003
			A. formosa	2700	↓ photosynthesis	EC50	Jones & Kerswell, 2003
			M. digitata	10000	Loss of algae	LOEC	Jones *et al* 2003
			P. damicornis	10000	Loss of algae	LOEC	Negri *et al* 2005
			S. hystrix	10000	Loss of algae	LOEC	Jones 2004
			P. cylindrica	10000	GPP* rate, GPP to respiration ration, effective quantum yield	LOEC	Råberg *et al* 2003
			Macro Algae				
			H. banksii	1650	↓ photosynthesis	EC50	Seery *et al* 2006
			Red Algae				
			P. onkodes	2900	↓ photosynthesis	LOEC	Harrington *et al* 2005
			Diatoms				
			Navicula sp	2900	↓ photosynthesis	IC50 Acute, 6 m	Magnusson *et al* 2006
			P. tricornutum	3300	↓ photosynthesis	I50	Schreiber *et al* 2002
			Mangroves				
			A. marina	1100	Health	NOEC	Duke *et al* 2003, 2005
			A. marina	1500	Reduced health	LOEC	Duke *et al* 2003, Bell & Duke 2005
			A. marina	2000	Dieback/ absence	Mortality	Duke et al 2003, Bell & Duke 2005
			A. marina	1500	Reduced health	LOEC	Duke *et al* 2003, Bell & Duke 2005

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Organisms and comments	**Toxicity (ug.L^{-1}) test substance (95% CL)**	**Year reported**	**US EPA category**
Fish			
M. cephalus (striped mullet) tech. (95%) static	6300 (NR) 48h, acute	1986	S
C. variegates (Sheephead minnow) 99% active constituent; static	6700 (NR) 96h, acute NOEC = 3600	1986	Core
Invertebrates			
M. bahia (Mysid shrimp) 99% active constituent; static	LC50 = 110 96h, acute NOEC = 1000	1987	Core
M. bahia (Mysid shrimp) 96.8% active constituent; early life stage; static	28d LOEC = 110 560 NOEC = 270	1992	Core
P. aztecus (Brown shrimp) 95% active constituent; flow through	LC50 = 1000 48h acute	1986	S
C. virginica (Eastern oyster) 96.8% active constituent; flow through	EC50 = 4800 96h, acute NOEC = 2400	1991	Core
C. virginica (Eastern oyster) 96.8% active constituent; flow through	EC50 = 3200 96h acute	1986	Core
Algae			
D. tertiolecta 95% active constituent; static	EC50 = 20 240h chronic	1986	S
Platmonas sp 95% active constituent; static	EC50 = 17 72h chronic	1986	S
P. cruentum (red algae) 95% active constituent; static	EC50 = 24 72h chronic	1986	S
M. lutheri 95% active constituent; static	EC50 = 18 72h chronic	1986	S
I. galbana 95% active constituent; static	EC50 = 10 72h chronic	1986	S
Marine diatoms			
N. incerta 95% active constituent; static	EC50 = 93 72h chronic	1986	S
N. closterium 95% active constituent; static	EC50 = 50 72h chronic	1986	S
P. tricornutum 95% active constituent; static	EC50 = 10 240h chronic	1986	S
S. amphoroides 95% active constituent; static	EC50 = 31 72h chronic	1986	S
T. fluviatilis 95% active constituent; static	EC50 = 95 72h chronic	1986	S
C.nana 95% active constituent; static	EC50 = 39 72h chronic	1986	S
A. exigua 95% active constituent; static	EC50 = 31 72h chronic	1986	S

10 APPENDIX C - ANNUAL FRESHWATER DISCHARGE (ML) FOR RIVERS INFLUENCING ROUTINE MONITORING SITES

Table 21 Annual freshwater discharge of rivers influencing routine monitoring sites (ML)

Region	River	Long-term median	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Wet Tropics	Daintree 108002A	727,872		132,216	1,429,195	489,927	1,252,971	715,190	873,694		1,215,914	1,654,757	865,139
	Barron 110001D	604,729	165,896	113,639	950,207	383,440	745,781	413,328	1,606,907	772,722	500,756	1,924,506	713,928
	Mulgrave 111007A	751,149	183,890	333,262	1,132,755		937,024	738,709	930,657	670,019	680,091	1,422,790	1,011,734
	Russell 111101D	1,193,577	433,936	615,927	1,345,241	990,735	1,280,589	1,281,621	1,088,458	1,130,682	1,221,231	1,806,202	1,166,997
	North Johnstone 112004A	1,746,102	657,456	819,663	2,304,375	1,447,193	2,155,313	2,071,610	1,858,252	1,925,821	1,825,452	3,551,393	1,054,108
	South Johnstone 112101B	820,304	345,067	311,763		542,835	1,014,727	886,683	794,698	1,019,195	709,887	1,673,604	931,355
	Tully 113006A	3,074,666	1,208,802	1,442,044	3,283,940	2,200,706	3,624,289	3,949,123	3,195,153	3,596,264	3,087,403	6,094,549	3,535,675
	Herbert 116001F	3,067,947	929,944	688,778	3,303,805	1,186,808	3,990,498	3,985,721	3,337,660	9,468,229	3,167,698	11,419,015	4,315,677
Burdekin	Burdekin 120006B	5,982,681	4,485,315	2,092,834	1,516,191	4,328,245	2,199,744	9,768,935	27,502,704	29,951,685	7,947,563	34,602,113	15,386,199
Mackay Whitsunday	Proserpine 122005A	17,140	19,969	18,583	10,350	23,782	20,393	44,740	76,447	65,556	52,341	349,085	51,193
	O'Connell 124001B	145,351	85,202	23,236		75,989	84,267	168,513	229,994	165,637	313,605	574,154	281,409
	Pioneer 125007A	355,228	218,366	111,589	44,939	196,084	72,633	716,235	1,300,252	822,925	1,180,449	3,044,648	1,339,252
Fitzroy	Fitzroy 130005A	2,754,600	581,373			921,670	680,627	1,057,441	12,046,873	2,028,795	11,666,996	38,058,960	7,886,091
Burnett Mary	Burnett 136007A	n/a	106,888	523,464	221,477	136,959	69,506	29,880	17,155	23,138	1,034,804	7,081,587	562,482

Table provided by Schaffelke, B. Shaded cells highlight years for which river flow exceeded the median annual flow as estimated from available long-term time series for each river (LT median; from earliest available records to September 2000): yellow= 1.5 to 2-times LT median, orange= 2 to 3-times LT median, red= >3-times LT median. Records for the 2012 water year are incomplete (to August 2012). Discharge data were supplied by the Queensland Department of Natural Resources and Mines (gauging station codes given after river names). Missing values represent years for which >15% of daily flow estimates were not available.

11 APPENDIX D – ROUTINE MONITORING – INDIVIDUAL SITE RESULTS

Table 22 Low Isles, Wet Tropics region – Concentration in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	06-May-11	04-Jul-11	ED	n.d.	0.15	n.d.	n.d.	0.29	n.d.	0.20	n.d.	n.d.	0.36	0.42	n.d.	n.d.	0.10	N/A	n.d.		
Jun 11																					
Jul 11	04-Jul-11	05-Sep-11	ED	0.05	0.49	n.d.	n.d.	1.2	n.d.	0.25	n.d.	n.d.	0.36	1.5	n.d.	n.d.	0.06	N/A	n.d.		
Aug 11																					
Sep 11	05-Sep-11	04-Nov-11	ED	0.01	0.04	n.d.	0.01	0.50	n.d.	0.12	n.d.	n.d.	0.02	0.57	n.d.	n.d.	0.01	N/A	n.d.		
Oct 11																					
Nov 11	04-Nov-11	27-Nov-11	ED	0.06	0.38	n.d.	n.d.	3.6	n.d.	1.2	n.d.	n.d.	n.d.	4.2	n.d.	n.d.	0.03	N/A	n.d.		
Dec 11	27-Nov-11	16-Jan-12	ED	0.03	0.11	n.d.	n.d.	1.4	n.d.	0.43	n.d.	n.d.	n.d.	1.6	n.d.	n.d.	0.01	n.d.	n.d.		
Jan 12	16-Jan-12	10-Feb-12	ED	n.d.	n.d.	n.d.	n.d.	0.52	n.d.	0.10	n.d.	n.d.	n.d.	0.56	n.d.	n.d.	n.d.	n.d.	n.d.		
Feb 12	10-Feb-12	29-Feb-12	ED	n.d.	0.29	n.d.	n.d.	1.9	n.d.	0.48	n.d.	0.09	n.d.	2.1	n.d.	n.d.	0.02	0.15	n.d.		
Mar 12	29-Feb-12	12-Apr-12	ED	0.05	0.17	n.d.	n.d.	2.6	n.d.	0.63	n.d.	n.d.	0.03	2.9	n.d.	n.d.	0.02	n.d.	n.d.		
Apr 12	12-Apr-12	08-May-12	ED	0.03	0.15	n.d.	n.d.	1.0	n.d.	0.18	n.d.	n.d.	0.36	1.2	n.d.	n.d.	0.03	n.d.	n.d.		
ED Summary																					
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	5	9		
Detects (n)				6	8	0	1	9	0	9	0	1	5	9	0	0	8	1	0		
% Detects				67	89	0	11	100	0	100	0	11	56	100	0	0	89	20	0		
Minimum concentration				0.01	0.04	n.d.	0.01	0.29	n.d.	0.10	n.d.	0.09	0.02	0.42	n.d.	n.d.	0.01	0.15	n.d.		
Average concentration				0.04	0.22	n.d.	-	1.4	n.d.	0.40	n.d.	-	0.23	1.7	n.d.	n.d.	0.04	-	n.d.		
Maximum concentration				0.06	0.49	n.d.	0.01	3.6	n.d.	1.2	n.d.	0.09	0.36	4.2	n.d.	n.d.	0.10	0.15	n.d.		
Max/ min ratio				5.3	13.6	-	-	12.3	-	12.2	-	-	16.0	10.0	-	-	10.7	-	-		

[a] Photosystem II herbicides but not currently included in the index *Galaxolide and tonalid are detected in non-polar samplers only. N/A indicates not analysed in that particular sampler

Table 23 Green Island, Wet Tropics region – Concentration in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insecticides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	LOST		ED																		
Jun 11																					
Jul 11	06-Jul-11	31-Aug-11	ED	n.d.	0.38	n.d.	n.d.	0.69	n.d.	0.14	n.d.	0.10	0.21	0.82	n.d.	n.d.	n.d.	N/A	n.d.		
Aug 11																					
Sep 11	31-Aug-11	05-Nov-11	ED	0.01	0.03	n.d.	0.01	0.27	n.d.	0.08	n.d.	n.d.	0.01	0.31	n.d.	n.d.	0.01	N/A	n.d.		
Oct 11																					
Nov 11	05-Nov-11	30-Nov-11	ED	n.d.	0.09	n.d.	n.d.	0.28	n.d.	0.03	n.d.	n.d.	0.01	0.30	n.d.	n.d.	0.01	N/A	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Dec 11	30-Nov-11	01-Jan-12	ED	0.06	0.41	n.d.	n.d.	1.9	n.d.	0.64	n.d.	n.d.	n.d.	2.3	n.d.	n.d.	0.10	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Jan 12	01-Jan-12	02-Feb-12	ED	n.d.	0.06	n.d.	n.d.	0.38	n.d.	0.08	n.d.	n.d.	n.d.	0.42	n.d.	n.d.	n.d.	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Feb 12	02-Feb-12	03-Mar-12	ED	n.d.	0.33	0.05	n.d.	2.2	n.d.	0.48	n.d.	0.11	n.d.	2.5	n.d.	n.d.	0.02	0.15	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Mar 12	03-Mar-12	03-Apr-12	ED	0.07	1.0	0.33	n.d.	4.1	n.d.	0.95	n.d.	0.17	0.06	4.8	n.d.	n.d.	0.02	n.d.	0.20		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.06	n.d.
Apr 12	03-Apr-12	05-May-12	ED	0.02	0.53	0.27	n.d.	1.1	n.d.	0.20	n.d.	0.09	0.28	1.4	n.d.	n.d.	0.02	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.14	n.d.
ED Summary																					
Samples (n)				8	8	8	8	8	8	8	8	8	8	8	8	8	8	5	8		
Detects (n)				4	8	3	1	8	0	8	0	4	5	8	0	0	6	1	1		
% Detects				50	100	38	13	100	0	100	0	50	63	100	0	0	75	20	13		
Minimum concentration				0.01	0.03	0.05	0.01	0.27	n.d.	0.03	n.d.	0.09	0.01	0.30	n.d.	n.d.	0.01	0.15	0.20		
Average concentration				0.04	0.36	0.22	-	1.4	n.d.	0.33	n.d.	0.12	0.11	1.6	n.d.	n.d.	0.03	-	-		
Maximum concentration				0.07	1.0	0.33	0.01	4.1	n.d.	0.95	n.d.	0.17	0.28	4.8	n.d.	n.d.	0.10	0.15	0.20		
Max/ min ratio				13.3	29.5	6.4	-	15.4	-	34.4	-	1.9	27.3	15.7	-	-	18.6	-	-		
PDMS Summary																					
Samples (n)				6	6	6	6		6	6	6	6	6				6			6	6
Detects (n)				0	0	0	0		0	0	0	0	0				0			2	0
% Detects				0	0	0	0		0	0	0	0	0				0			33	0
Minimum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.06	n.d.
Average concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.10	n.d.
Maximum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.14	n.d.
Max/ min ratio				-	-	-	-		-	-	-	-	-				-			2.3	-

[a] Photosystem II herbicides but not currently included in the index; *Galaxolide and tonalid are detected in non-polar samplers only. Concentrations are time-integrated estimates. N/A indicates not analysed in that particular sampler

Table 24 Normanby Island, Wet Tropics region – Concentration in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	14-May-11	08-Jul-11	ED	n.d.	0.29	n.d.	n.d.	0.56	n.d.	0.19	n.d.	n.d.	0.34	0.71	n.d.	n.d.	0.10	N/A	n.d.		
Jun 11			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.04	n.d.
			SPMD	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Jul 11	08-Jul-11	02-Sep-11	ED	0.01	0.32	n.d.	n.d.	0.36	n.d.	0.17	n.d.	0.07	0.30	0.52	n.d.	n.d.	0.04	N/A	n.d.		
Aug 11			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
			SPMD	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Sep 11	LOST		ED																		
Oct 11			PDMS																		
			SPMD																		
Nov 11	11-Nov-11	06-Jan-12	ED	0.08	0.76	0.09	n.d.	3.9	n.d.	1.4	n.d.	0.13	n.d.	4.7	n.d.	n.d.	0.04	n.d.	n.d.		
Dec 11			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
			SPMD	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Jan 12	LOST		ED																		
Feb 12	06-Jan-12	23-Mar-12	PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
			SPMD	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Mar 12	23-Mar-12	20-Apr-12	ED	0.05	0.52	0.15	n.d.	1.9	n.d.	0.45	n.d.	0.06	0.27	2.2	n.d.	n.d.	0.04	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.04	0.01
			SPMD	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Apr 12	20-Apr-12	05-May-12	ED	0.01	0.46	0.23	n.d.	0.70	n.d.	0.21	n.d.	n.d.	0.45	0.92	n.d.	n.d.	0.03	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.33	n.d.
			SPMD	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
ED Summary																					
Samples (n)				5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	5		
Detects (n)				4	5	3	0	5	0	5	0	3	4	5	0	0	5	0	0		
% Detects				80	100	60	0	100	0	100	0	60	80	100	0	0	100	0	0		
Minimum concentration				0.01	0.29	0.09	0.00	0.36	0.00	0.17	0.00	0.06	0.27	0.52	n.d.	n.d.	0.03	n.d.	n.d.		
Average concentration				0.04	0.47	0.16	n.d.	1.5	n.d.	0.49	n.d.	0.09	0.34	1.8	n.d.	n.d.	0.05	n.d.	n.d.		
Maximum concentration				0.08	0.76	0.15	n.d.	3.9	n.d.	1.4	n.d.	0.13	0.34	4.7	n.d.	n.d.	0.10	n.d.	n.d.		
Max/ min ratio				7.8	2.6	1.6	-	10.8	-	8.5	-	2.1	1.3	9.0	-	-	3.3	-	-		
PDMS Summary																					
Samples (n)				5	5	5	5		5	5	5	5	5				5			5	5
Detects (n)				0	0	0	0		0	0	0	0	0				0			2	1
% Detects				0	0	0	0		0	0	0	0	0				0			40	20
Minimum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.04	0.01
Average concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			-	-
Maximum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.16	0.01
Max/ min ratio				-	-	-	-		-	-	-	-	-				-			4.0	-

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only. Concentrations are time-integrated estimates. N/A indicates not analysed in that particular sampler

Table 25 Dunk Island, Wet Tropics region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	NO RESULTS		ED																		
Jun 11																					
Jul 11	20-Jul-11	12-Sep-11	ED	n.d.	0.07	n.d.	n.d.	0.08	n.d.	0.04	n.d.	n.d.	0.05	0.12	n.d.	n.d.	n.d.	N/A	n.d.		
Aug 11																					
Sep 11	NO RESULTS		ED																		
Oct 11																					
Nov 11	LOST		ED																		
	20-Nov-11	07-Dec-11	PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		n.d.			n.d.	n.d.
Dec 11	07-Dec-11	09-Jan-12	ED	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.01	n.d		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		0.64			n.d.	n.d.
Jan 12	NO RESULTS		ED																		
	09-Jan-12	06-Feb-12	PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		n.d.			n.d.	n.d.
Feb 12	LOST		ED																		
			PDMS																		
Mar 12	06-Mar-12	23-Apr-12	ED	0.12	0.30	n.d.	n.d.	6.0	n.d.	1.5	n.d.	0.02	0.38	6.8	n.d.	n.d.	0.07	n.d.	1.1		
Apr-12			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		n.d.			n.d.	n.d.
ED Summary																					
Samples (n)				3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3		
Detects (n)				1	2	0	0	2	0	2	0	1	2	2	0	0	2	1	1		
% Detects				33	67	0	0	67	0	67	0	33	67	67	0	0	67	50	33		
Minimum concentration				0.12	0.07	n.d.	n.d.	0.08	n.d.	0.04	n.d.	0.02	0.05	0.12	n.d.	n.d.	0.01	0.01	1.07		
Average concentration				-	0.18	n.d.	n.d.	3.0	n.d.	0.77	n.d.	-	0.22		n.d.	n.d.	0.04	-	-		
Maximum concentration				0.12	0.30	n.d.	n.d.	6.0	n.d.	1.5	n.d.	0.02	0.38	6.8	n.d.	n.d.	0.07	0.01	1.1		
Max/ min ratio				-	4.3	-	-	70.6	-	36.1	-	-	7.1	56.4	-	-	8.5	-	-		
PDMS Summary																					
Samples (n)				4	4	4	4		4	4	4	4	4				4			4	4
Detects (n)				0	0	0	0		0	0	0	0	0				1			0	0
% Detects				0	0	0	0		0	0	0	0	0				25			0	0
Minimum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				0.64			n.d.	n.d.
Average concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				-			n.d.	n.d.
Maximum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				0.64			n.d.	n.d.
Max/ min ratio				-	-	-	-		-	-	-	-	-				-			-	-

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are time-integrated estimates. Metolachlor has been detected in a single PDMS deployment in December 2011, the concentration of 0.64 ng.L^{-1} is an equilibrium estimate. N/A indicates not analysed in that particular sampler

Table 26 Orpheus Island, Burdekin region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	09-May-11	04-Jul-11	ED	n.d.	0.30	n.d.	n.d.	0.29	n.d.	n.d.	n.d.	n.d.	0.17	0.35	n.d.	n.d.	0.10	N/A	n.d.		
Jun 11																					
Jul 11	04-Jul-11	09-Sep-11	ED	n.d.	0.43	n.d.	n.d.	0.33	n.d.	0.18	n.d.	0.09	0.42	0.50	n.d.	n.d.	0.20	N/A	n.d.		
Aug 11			ED																		
Sep 11	09-Sep-11	05-Nov-11	ED	n.d.	0.08	n.d.	n.d.	0.10	n.d.	0.03	n.d.	0.01	0.05	0.13	n.d.	n.d.	0.02	N/A	n.d.		
Oct 11																					
Nov 11	05-Nov-11	02-Dec-11	ED	n.d.	0.23	n.d.	n.d.	0.22	n.d.	0.09	n.d.	0.03	0.08	0.30	n.d.	n.d.	0.02	N/A	n.d.		
Dec 11	02-Dec-11	01-Jan-12	ED	0.04	0.33	n.d.	n.d.	1.23	n.d.	0.35	n.d.	n.d.	0.06	1.5	n.d.	n.d.	0.02	n.d.	n.d.		
Jan 12	01-Jan-12	01-Feb-12	ED	0.02	0.15	n.d.	n.d.	0.77	n.d.	0.19	n.d.	0.05	n.d.	0.89	n.d.	n.d.	0.01	n.d.	n.d.		
Feb 12	01-Feb-12	02-Mar-12	ED	0.08	0.77	0.15	n.d.	3.7	n.d.	0.76	n.d.	0.13	0.04	4.3	0.03	n.d.	0.04	n.d.	n.d.		
Mar 12	02-Mar-12	06-Apr-12	ED	0.05	0.26	n.d.	n.d.	1.8	n.d.	0.28	n.d.	0.03	0.31	2.0	n.d.	n.d.	0.04	n.d.	n.d.		
Apr 12	06-Apr-12	04-May-12	ED	n.d.	0.38	0.12	n.d.	0.68	n.d.	0.15	n.d.	n.d.	0.29	0.83	n.d.	n.d.	0.02	n.d.	n.d.		
ED Summary																					
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	5	9		
Detects (n)				4	9	2	0	9	0	8	0	6	8	9	1	0	9	0	0		
% Detects				44	100	22	0	100	0	89	0	67	89	100	11	0	100	0	0		
Minimum concentration				0.02	0.08	0.12	n.d.	0.10	n.d.	0.03	n.d.	0.01	0.04	0.13	0.03	n.d.	0.01	n.d.	n.d.		
Average concentration				0.05	0.32	0.14	n.d.	1.0	n.d.	0.25	n.d.	0.06	0.18	1.2	-	n.d.	0.05	n.d.	n.d.		
Maximum concentration				0.08	0.77	0.15	n.d.	3.7	n.d.	0.76	n.d.	0.13	0.42	4.3	0.03	n.d.	0.20	n.d.	n.d.		
Max/ min ratio				4.2	9.4	1.3	-	38.1	-	26.4	-	12.2	9.6	33.9	-	-	14.9	-	-		

[a] Photosystem II herbicides but not included in the index at this stage. *Galaxolide and tonalid are detected in non-polar samplers only. N/A indicates not analysed in that particular sampler

Table 27 Magnetic Island, Burdekin Region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	06-May-11	04-Jul-11	ED	0.03	0.94	0.15	n.d.	2.4	n.d.	0.33	n.d.	0.08	0.64	2.8	n.d.	n.d.	0.13	N/A	n.d.		
Jun 11																					
Jul 11	04-Jul-11	01-Sep-11	ED	0.03	0.40	n.d.	n.d.	1.6	n.d.	0.16	n.d.	0.07	0.32	1.8	n.d.	n.d.	0.06	N/A	n.d.		
Aug 11																					
Sep 11	01-Sep-11	03-Nov-11	ED	0.01	0.11	n.d.	n.d.	0.84	n.d.	0.04	n.d.	0.01	0.07	0.89	n.d.	n.d.	0.02	N/A	n.d.		
Oct 11																					
Nov 11	03-Nov-11	01-Dec-11	ED	n.d.	0.29	0.05	n.d.	2.6	n.d.	0.04	n.d.	0.03	0.06	2.7	n.d.	n.d.	0.01	N/A	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		n.d.			n.d.	n.d.
Dec 11	01-Dec-11	04-Jan-12	ED	n.d.	0.40	n.d.	n.d.	3.3	n.d.	0.04	n.d.	0.05	0.04	3.4	n.d.	n.d.	0.01	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		n.d.			n.d.	n.d.
Jan 12	LOST IN		ED																		
	TRANSIT		PDMS																		
Feb 12	05-Feb-12	05-Mar-12	ED	0.05	2.2	0.49	0.14	2.6	n.d.	0.18	n.d.	0.21	0.19	3.2	n.d.	n.d.	0.06	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		1.3			n.d.	n.d.
Mar 12	05-Mar-12	02-Apr-12	ED	0.05	1.3	0.37	n.d.	2.0	n.d.	0.19	n.d.	0.07	0.72	2.4	n.d.	n.d.	0.08	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		1.1			0.04	0.01
Apr 12	02-Apr-12	05-May-12	ED	0.02	0.99	0.25	n.d.	2.8	n.d.	0.29	n.d.	0.06	0.63	3.2	n.d.	n.d.	0.07	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		n.d.			0.16	n.d.
ED Summary																					
Samples (n)				8	8	8	8	8	8	8	8	8	8	8	8	8	8	4	8	4	4
Detects (n)				6	8	5	1	8	0	8	0	8	8	8	0	0	8	0	0	1	1
% Detects				75	100	63	13	100	0	100	0	100	100	100	0	0	100	0	0	25	25
Minimum concentration				0.01	0.11	0.05	0.14	0.84	n.d.	0.04	n.d.	0.01	0.04	0.89	n.d.	n.d.	0.01	n.d.	n.d.	0.04	0.01
Average concentration				0.03	0.82	0.26	-	2.3	n.d.	0.16	n.d.	0.07	0.33	2.5	n.d.	n.d.	0.06	n.d.	n.d.	-	-
Maximum concentration				0.05	2.2	0.49	0.14	3.3	n.d.	0.33	n.d.	0.21	0.72	3.4	n.d.	n.d.	0.13	n.d.	n.d.	0.04	0.01
Max/ min ratio				7.1	19.3	9.4	-	3.9	-	8.4	-	27.6	18.5	3.8	-	-	10.9	-	-	-	-
PDMS Summary																					
Samples (n)				5	5	5	5		5	5	5	5	5				5			5	5
Detects (n)				0	0	0	0		0	0	0	0	0				2			2	1
% Detects				0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0				40.0			40.0	20.0
Minimum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				1.1			0.04	0.01
Average concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				1.2			0.10	-
Maximum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				1.3			0.16	0.01
Max/ min ratio				-	-	-	-		-	-	-	-	-				1.19			4.0	-

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are time-integrated estimates. Metolachlor has been detected in two PDMS deployments, the concentrations are equilibrium estimates. N/A indicates not analysed in that particular sampler

Table 28 Cape Cleveland, Burdekin Region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	05-May-11	01-Jul-11	ED	n.d.	0.67	n.d.	n.d.	1.3	n.d.	0.29	n.d.	n.d.	0.52	1.5	n.d.	n.d.	n.d.	N/A	n.d.		
Jun 11																					
Jul 11	01-Jul-11	30-Aug-11	ED	0.11	0.93	n.d.	n.d.	0.72	n.d.	0.34	n.d.	0.18	0.70	1.2	n.d.	n.d.	n.d.	N/A	n.d.		
Aug 11																					
Sep 11	30-Aug-11	03-Nov-11	ED	0.03	0.37	n.d.	0.02	0.17	n.d.	0.05	n.d.	0.03	0.08	0.30	n.d.	n.d.	n.d.	N/A	n.d.		
Oct 11																					
Nov 11	03-Nov-11	07-Dec-11	ED	0.04	0.47	n.d.	n.d.	0.33	n.d.	0.07	n.d.	n.d.	0.09	0.50	n.d.	n.d.	0.03	N/A	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Dec 11	07-Dec-11	16-Feb-12	ED	0.27	15	2.6	0.51	6.9	n.d.	0.51	n.d.	0.08	0.19	10	n.d.	n.d.	0.21	0.04	n.d.		
Jan 12			PDMS	n.d.	40	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Feb 12	16-Feb-12	29-Feb-12	ED	0.18	5.9	2.1	0.68	4.6	n.d.	0.35	n.d.	0.11	0.79	6.2	n.d.	n.d.	0.19	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				1.2			n.d.	n.d.
Mar 12	29-Feb-12	03-Apr-12	ED	0.12	3.4	1.0	0.26	2.7	n.d.	0.35	n.d.	0.04	0.92	3.8	n.d.	n.d.	0.12	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.07	0.02
Apr 12	03-Apr-12	03-May-12	ED	0.02	0.99	0.59	n.d.	1.2	n.d.	0.27	n.d.	n.d.	n.d.	1.5	n.d.	n.d.	0.05	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				0.13			0.13	n.d.
ED Summary																					
Samples (n)				8	8	8	8	8	8	8	8	8	8	8	8	8	8	4	8		
Detects (n)				7	8	4	4	8	0	8	0	5	7	8	0	0	5	1	0		
% Detects				88	100	50	50	100	0	100	0	63	88	100	0	0	63	25	0		
Minimum concentration				0.02	0.37	0.59	0.02	0.17	n.d.	0.05	n.d.	0.03	0.08	0.30	n.d.	n.d.	0.03	0.04	n.d.		
Average concentration				0.11	3.5	1.6	0.37	2.2	n.d.	0.28	n.d.	0.09	0.47	3.2	n.d.	n.d.	0.12	-	n.d.		
Maximum concentration				0.27	15	2.6	0.68	6.9	n.d.	0.51	n.d.	0.18	0.92	10	n.d.	n.d.	0.21	0.04	n.d.		
Max/ min ratio				13.5	41.2	4.5	27.7	40.8	-	10.1	-	7.1	11.6	34.5	-	-	6.7	-	-		
PDMS Summary																					
Samples (n)				5	5	5	5		5	5	5	5	5				5			5	5
Detects (n)				0	1	0	0		0	0	0	0	0				2			2	1
% Detects				0	20	0	0		0	0	0	0	0				40			40	20
Minimum concentration				n.d.	40	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				0.13			0.07	0.02
Average concentration				n.d.	-	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				0.65			0.10	-
Maximum concentration				n.d.	40	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				1.2			0.13	0.02
Max/ min ratio				-	-	-	-		-	-	-	-	-				8.92			1.9	-

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are are time-integrated estimates. Metolachlor has been detected in two PDMS deployments, the concentrations are equilibrium estimates. Atrazine was detected in a single PDMS deployment in December 2011, the concentration is anequilibrium estimate. N/A indicates not analysed in that particular sampler

Table 29 Pioneer Bay, Mackay Whitsunday – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	12-May-11	01-Jul-11	ED	n.d.	n.d.	n.d.	n.d.	2.5	n.d.	n.d.	n.d.	n.d.	0.19	2.5	n.d.	n.d.	n.d.	N/A	n.d.		
Jun 11																					
Jul 11	01-Jul-11	10-Sep-11	ED	0.06	0.33	n.d.	n.d.	7.5	n.d.	0.24	0.04	n.d.	0.61	7.8	n.d.	n.d.	0.12	N/A	n.d.		
Aug 11																					
Sep 11	10-Sep-11	17-Nov-11	ED	n.d.	0.37	n.d.	n.d.	11	n.d.	0.18	n.d.	n.d.	0.23	11	n.d.	n.d.	0.07	N/A	n.d.		
Oct 11																					
Nov 11	17-Nov-11	10-Jan-12	ED	n.d.	0.10	n.d.	n.d.	8.5	n.d.	0.07	n.d.	n.d.	0.05	8.5	n.d.	n.d.	0.01	n.d.	n.d.		
Dec 11																					
Jan 12	10-Jan-12	10-Mar-12	ED	0.05	0.26	n.d.	n.d.	6.8	n.d.	0.26	n.d.	n.d.	0.05	7.0	n.d.	n.d.	0.02	n.d.	n.d.		
Feb 12																					
Mar 12	NOT SENT		ED																		
Apr 12	10-Mar-12	03-Jun-12	ED	0.05	0.49	n.d.	n.d.	7.5	n.d.	0.88	n.d.	n.d.	0.15	8.0	n.d.	n.d.	0.03	n.d.	n.d.		
ED Summary																					
Samples (n)				6	6	6	6	6	6	6	6	6	6	6	6	6	6	3	6		
Detects (n)				3	5	0	0	6	0	5	1	0	6	6	0	0	5	0	0		
% Detects				50	83	0	0	100	0	83	17	0	100	100	0	0	83	0	0		
Minimum concentration				0.05	0.10	n.d.	n.d.	2.5	n.d.	0.07	0.04	n.d.	0.05	2.5	n.d.	n.d.	0.01	n.d.	n.d.		
Average concentration				0.05	0.31	n.d.	n.d.	7.3	n.d.	0.32	-	n.d.	0.21	7.5	n.d.	n.d.	0.05	n.d.	n.d.		
Maximum concentration				0.06	0.49	n.d.	n.d.	11	n.d.	0.88	0.04	n.d.	0.61	11	n.d.	n.d.	0.12	n.d.	n.d.		
Max/ min ratio				1.3	5.0	-	-	4.2	-	12.4	-	-	12.2	4.2	-	-	9.4	-	-		

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only. N/A indicates not analysed in that particular sampler

Table 30 Outer Whitsunday, Mackay Whitsunday region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	LOST		ED																		
Jun 11																					
Jul 11	NOT USED		ED																		
Aug 11																					
Sep 11	NOT USED		ED																		
Oct 11																					
Nov 11	02-Nov-11	04-Dec-11	ED	n.d.	0.16	n.d.	n.d.	0.28	n.d.	0.03	n.d.	n.d.	0.06	0.32	n.d.	n.d.	0.02	N/A	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Dec 11	LOST IN		ED																		
	TRANSIT		PDMS																		
Jan 12	06-Jan-12	06-Feb-12	ED	n.d.	0.09	n.d.	n.d.	0.35	n.d.	0.04	n.d.	n.d.	n.d.	0.38	n.d.	n.d.	n.d.	n.d.	n.d.		
	LOST		PDMS																		
Feb 12	06-Feb-12	10-Mar-12	ED	0.05	1.4	0.16	0.05	2.8	n.d.	0.75	n.d.	0.03	0.06	3.4	n.d.	n.d.	0.02	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Mar 12	10-Mar-12	05-May-12	ED																		
	SAMPLERS DAMAGED																				
Apr 12	LOST		PDMS																		
ED Summary																					
Samples (n)				3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3		
Detects (n)				1	3	1	1	3	0	3	0	1	2	3	0	0	2	0	0		
% Detects				33	100	33	33	100	0	100	0	33	67	100	0	0	67	0	0		
Minimum concentration				0.05	0.09	0.16	0.05	0.28	n.d.	0.03	n.d.	0.03	0.06	0.32	n.d.	n.d.	0.02	n.d.	n.d.		
Average concentration				-	0.54	-	-	1.2	n.d.	0.27	n.d.	-	0.06	1.4	n.d.	n.d.	0.02	n.d.	n.d.		
Maximum concentration				0.05	1.4	0.16	0.05	2.8	n.d.	0.75	n.d.	0.03	0.06	3.4	n.d.	n.d.	0.02	n.d.	n.d.		
Max/ min ratio				-	15.8	-	-	10.2	-	22.9	-	-	1.0	10.7	-	-	1.0	-	-		
PDMS Summary																					
Samples (n)				2	2	2	2		2	2	2	2	2				2			2	2
Detects (n)				0	0	0	0		0	0	0	0	0				0			0	0
% Detects				0	0	0	0		0	0	0	0	0				0			0	0
Minimum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Average concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Maximum concentration				n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Max/ min ratio				-	-	-	-		-	-	-	-	-				-			-	-

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only. There were no pesticides detected in PDMS samplers during this monitoring year. N/A indicates not analysed in that particular sampler

Table 31 Sarina Inlet, Mackay Whitsunday region – Concentrations in water ($ng.L^{-1}$)

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	06-May-11	04-Jul-11	ED	0.17	1.4	0.19	n.d.	0.88	n.d.	0.40	n.d.	0.16	0.72	1.6	n.d.	n.d.	0.21	N/A	n.d.		
Jun 11																					
Jul 11	04-Jul-11	01-Sep-11	ED	0.04	1.8	0.41	0.19	1.2	n.d.	0.41	0.03	0.42	0.67	1.9	n.d.	n.d.	0.13	N/A	n.d.		
Aug 11																					
Sep 11	01-Sep-11	04-Nov-11	ED	0.02	0.16	n.d.	n.d.	0.53	n.d.	0.18	n.d.	0.03	0.09	0.66	0.02	n.d.	0.04	N/A	n.d.		
Oct 11																					
Nov 11	04-Nov-11	09-Dec-11	ED	0.09	1.1	0.10	0.04	2.3	n.d.	1.0	n.d.	0.25	0.25	3.0	n.d.	n.d.	0.10	N/A	n.d.		
Dec 11	09-Dec-11	05-Jan-12	ED	0.11	10	2.0	0.71	16	n.d.	9.6	n.d.	0.16	0.08	22	0.07	n.d.	0.06	n.d.	n.d.		
Jan 12	05-Jan-12	09-Feb-12	ED	0.17	3.7	0.24	0.04	18	n.d.	6.6	n.d.	0.02	0.20	21	0.12	n.d.	0.13	n.d.	0.15		
Feb 12	09-Feb-12	03-Mar-12	ED	0.30	4.0	0.55	n.d.	16	n.d.	5.5	n.d.	0.08	0.57	20	0.18	n.d.	0.12	n.d.	0.40		
Mar 12	03-Mar-12	03-Apr-12	ED	0.10	1.5	0.43	n.d.	5.7	n.d.	2.0	n.d.	0.09	0.34	6.9	n.d.	n.d.	0.04	n.d.	0.52		
Apr 12	03-Apr-12	06-May-12	ED	0.01	0.10	n.d.	n.d.	0.77	n.d.	0.31	n.d.	n.d.	0.27	0.94	n.d.	n.d.	0.02	n.d.	n.d.		
ED Summary																					
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	5	9		
Detects (n)				9	9	7	4	9	0	9	1	8	9	9	4	0	9	0	3		
% Detects				100	100	78	44	100	0	100	11	89	100	100	44	0	100	0	33		
Minimum concentration				0.01	0.10	0.10	0.04	0.53	n.d.	0.18	0.03	0.02	0.08	0.66	0.02	n.d.	0.02	n.d.	0.15		
Average concentration				0.11	2.7	0.55	0.25	6.9	n.d.	2.9	-	0.15	0.35	8.6	0.10	n.d.	0.09	n.d.	0.36		
Maximum concentration				0.30	10	2.0	0.71	18	n.d.	9.6	0.03	0.42	0.72	22	0.18	n.d.	0.21	n.d.	0.52		
Max/ min ratio				29.6	101.8	19.8	18.5	34.0	-	52.2	-	18.1	8.6	33.0	7.7	-	10.3	-	3.5		

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only. N/A indicates not analysed in that particular sampler

Table 32 North Keppel Island, Fitzroy Region – Concentrations in water ($ng.L^{-1}$)

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May 11	08-Apr-11	14-Jun-11	ED	0.05	0.73	0.05	n.d.	0.96	n.d.	0.11	0.03	n.d.	0.60	1.3	n.d.	n.d.	0.19	N/A	n.d.		
Jun 11	14-Jun-11	05-Jul-11	ED	n.d.	0.43	n.d.	n.d.	0.82	n.d.	n.d.	n.d.	n.d.	0.50	0.93	n.d.	n.d.	n.d.	N/A	n.d.		
Jul 11	05-Jul-11	04-Oct-11	ED	n.d.	0.05	n.d.	n.d.	0.18	n.d.	0.01	n.d.	0.01	0.03	0.19	n.d.	n.d.	0.01	N/A	n.d.		
Aug 11																					
Sep 11																					
Oct 11	04-Oct-11	07-Nov-11	ED	n.d.	0.05	n.d.	0.05	0.21	n.d.	0.01	n.d.	0.01	0.03	0.23	n.d.	n.d.	0.01	N/A	n.d.		
Nov 11	07-Nov-11	06-Dec-11	ED	n.d.	0.08	n.d.	n.d.	0.34	n.d.	0.02	n.d.	0.01	0.04	0.37	n.d.	n.d.	0.01	N/A	n.d.		
Dec 11	06-Dec-11	09-Jan-12	ED	n.d.	0.11	n.d.	n.d.	3.4	n.d.	n.d.	n.d.	n.d.	0.04	3.4	n.d.	n.d.	0.02	n.d.	n.d.		
Jan 12	09-Jan-12	06-Feb-12	ED	0.02	0.05	n.d.	n.d.	0.60	n.d.	0.02	n.d.	n.d.	n.d.	0.65	n.d.	n.d.	0.01	n.d.	n.d.		
Feb 12	06-Feb-12	05-Mar-12	ED	0.13	1.6	0.13	0.04	2.6	n.d.	0.15	0.04	0.06	1.9	3.3	0.11	n.d.	0.90	n.d.	n.d.		
Mar 12	05-Mar-12	13-Apr-12	ED	0.05	1.6	0.24	0.21	1.2	n.d.	0.09	n.d.	0.17	1.5	1.7	n.d.	n.d.	0.42	n.d.	n.d.		
Apr 12	13-Apr-12	29-May-12	ED	0.03	0.27	0.03	n.d.	0.79	n.d.	0.08	n.d.	0.07	0.21	0.90	n.d.	n.d.	0.10	n.d.	n.d.		
ED Summary																					
Samples (n)				10	10	10	10	10	10	10	10	10	10	10	10	10	10	5	10		
Detects (n)				5	10	4	3	10	0	8	2	6	9	10	1	0	9	0	0		
% Detects				50	100	40	30	100	0	80	20	60	90	100	10	0	90	0	0		
Minimum concentration				0.02	0.05	0.03	0.04	0.18	n.d.	0.01	0.03	0.01	0.03	0.19	0.11	n.d.	0.01	n.d.	n.d.		
Average concentration				0.06	0.50	0.11	0.10	1.11	n.d.	0.06	0.04	0.06	0.54	1.3	-	n.d.	0.19	n.d.	n.d.		
Maximum concentration				0.13	1.6	0.24	0.21	3.4	n.d.	0.15	0.04	0.17	1.9	3.4	0.11	n.d.	0.90	n.d.	n.d.		
Max/ min ratio				5.5	32.4	9.5	5.9	19.2	-	13.9	1.2	15.5	64.1	17.7	-	-	117.0	-	-		

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only. N/A indicates not analysed in that particular sampler

12 APPENDIX E – TERRESTRIAL RUN-OFF ASSESMENT- RESULTS

Table 33 Concentrations in water (ng.L^{-1}) measured at Channel North using passive samplers and 1 L grab samples during terrestrial run-off events during the wet season

Catchment	Transect	Date Deployed/ Collected	Date Retrieved	Time	Site	Sampler Type	Latitude	Longtitude	PSII Herbicides (Included in Index)										PSII-HEq (ng.L^{-1})	Other Herbicides (Not indexed)				Other
									Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Herbert	Northern	28-Nov-11	19-Dec-11		Channel North (Passive Site 1)	ED	-18.246	146.0675	1.8	3.8	0.11	n.d.	28	n.d.	7.9	n.d.	2.5	0.03	30	n.d.	0.06	0.91	0.03	0.66
		19-Dec-11		08:55:00		GRAB	-18.246	146.0675	n.d.	11	n.d.	n.d.	35	n.d.	n.d.	n.d.	29	n.d.	41	n.d.	n.d.	n.d.	n.d.	n.d.
		19-Dec-11	20-Jan-12		Channel North (Passive Site 1)	ED	-18.246	146.0675	0.32	0.31	n.d.	n.d.	14	n.d.	3.6	n.d.	0.31	0.03	14	0.04	n.d.	0.10	0.63	0.20
		20-Jan-12		14:10:00		GRAB	-18.2464	146.0691	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		20-Jan-12	13-Feb-12		Channel North (Passive Site 1)	ED	-18.2464	146.0691																
		13-Feb-12		10:15:00		GRAB	-18.246	146.0691	n.d.	n.d.	n.d.	n.d.	19	n.d.	n.d.	n.d.	n.d.	n.d.	19	n.d.	n.d.	n.d.	n.d.	n.d.
		13-Feb-12	05-Mar-12		Channel North (Passive Site 1)	ED	-18.2457	146.0694																
		05-Mar-12		16:20:00		GRAB	-18.2558	146.0722	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.	n.d.
		05-Mar-12	31-Mar-12		Channel North (Passive Site 1)	ED	-18.2457	146.0694	0.14	0.64	0.15	n.d.	7.0	n.d.	1.9	0.00	0.12	0.09	8.0	n.d.	n.d.	0.06	0.22	0.78
		31-Mar-12		11:05:00		GRAB	-18.2559	146.0719	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Deployment 3 and 4 were damaged in the field and were not able to be extracted.

Table 34 Concentrations in water (ng.L^{-1}) measured at Goold Island using passive samplers and 1 L grab samples during terrestrial run-off events during the wet season

Catchment	Transect	Date Deployed/ Collected	Date Retrieved	Time	Site	Sampler Type	Latitude	Longtitude	PSII Herbicides (Included in Index)										PSII-HEq (ng.L^{-1})	Other Herbicides (Not indexed)				Other
									Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Herbert	Northern	28-Nov-11	19-Dec-11		Goold Island (Passive Site 2)	ED	-18.1586	146.1502	0.25	0.89	n.d.	n.d.	6.4	n.d.	2.4	n.d.	0.29	0.06	10	n.d.	n.d.	0.105	n.d.	0.16
		19-Dec-11		12:05:00		GRAB	-18.1586	146.1502	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.
		19-Dec-11	20-Jan-12		Goold Island (Passive Site 2)	ED	-18.1586	146.1502	0.08	0.26	n.d.	n.d.	3.2	n.d.	0.92	n.d.	0.07	0.05	3.7	0.06	n.d.	0.03	0.04	n.d.
		20-Jan-12		13:00:00		GRAB	-18.1585	146.1502	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		20-Jan-12	13-Feb-12		Goold Island (Passive Site 2)	ED	-18.1585	146.1502																
		13-Feb-12		12:40:00		GRAB	-18.1598	146.1509	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.
		13-Feb-12	06-Mar-12		Goold Island (Passive Site 2)	ED	-18.1598	146.1509																
		06-Mar-12		14:50:00		GRAB	-18.1587	146.1502	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		06-Mar-12	31-Mar-12		Goold Island (Passive Site 2)	ED	-18.0858	146.1158	0.09	0.91	0.24	n.d.	5.2	n.d.	1.4	n.d.	0.12	0.14	6.0	n.d.	n.d.	0.05	n.d.	0.79
		31-Mar-12		11:05:00		GRAB	-18.1585	146.1502	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Deployment 3 and 4 were damaged in the field and were not able to be extracted.

Table 35 Concentrations in water (ng.L^{-1}) measured at South Site 2 using passive samplers and 1 L grab samples during terrestrial run-off events during the wet season

Catchment	Transect	Date Deployed/ Collected	Date Retrieved	Time	Site	Sampler Type	Latitude	Longtitude	PSII Herbicides (Included in Index)										PSII-HEq (ng.L^{1})	Other Herbicides (Not indexed)				Other
									Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Herbert	Southern	29-Nov-11	20-Dec-12		South Site 2 (Passive Site 3)	ED	-18.494	146.318	2.2	9.0	0.80	0.32	40	n.d.	9.2	0.00	3.2	0.08	50	0.32	0.04	0.85	n.d.	0.47
		20-Dec-11		10:55:00		GRAB	-18.494	146.318	n.d.	18	n.d.	n.d.	44	n.d.	n.d.	n.d.	n.d.	n.d.	47	n.d.	n.d.	n.d.	n.d.	n.d.
		20-Dec-11	21-Jan-12		South Site 2 (Passive Site 3)	ED	-18.494	146.318	0.33	0.62	n.d.	n.d.	8.1	n.d.	2.4	n.d.	0.27	n.d.	9.6	n.d.	n.d.	0.13	1.1	0.7
		21-Jan-12		10:45:00		GRAB	-18.494	146.318	n.d.	n.d.	n.d.	n.d.	35	n.d.	11	n.d.	n.d.	n.d.	39	n.d.	n.d.	n.d.	n.d.	n.d.
		21-Jan-12	13-Feb-12		South Site 2 (Passive Site 3)	ED	-18.494	146.318	0.37	0.71	n.d.	n.d.	16	n.d.	4.9	n.d.	0.42	n.d.	19	n.d.	n.d.	0.24	n.d.	0.99
		14-Feb-12		6:30:00		GRAB	-18.494	146.318	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		13-Feb-12	06-Mar-12		South Site 2 (Passive Site 3)	ED	-18.494	146.318																
		06-Mar-12		8:40:00		GRAB	-18.494	146.318	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		06-Mar-12	30-Mar-12		South Site 2 (Passive Site 3)	ED	-18.494	146.318	0.19	0.76	0.21	n.d.	9.9	n.d.	2.2	n.d.	0.09	0.14	11	n.d.	n.d.	0.13	0.08	0.71
		30-Mar-12		11:40:00		GRAB	-18.475	146.346	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Deployment 4 was damaged in the field and was not able to be extracted.

Table 36 Concentrations in water (ng.L^{-1}) measured at various locations using passive samplers and 1 L grab samples during terrestrial run-off events during the wet season

							PSII Herbicides (Included in Index)											Other Herbicides (Not indexed)				Other
Catchment	Transect	Date	Time	Site Name	Latitude	Longtitude	Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Fluometuron	Hexazinone	Prometryn	Simazine	Tebuthiuron	PSII-HEq (ng.L^{-1})	Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Cape York	Normanby River	29-Mar-12	12:35:00	Site 7	-14.42365	144.145	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		29-Mar-12	14:35:00	Site 13	-14.39002	144.136	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Tully	Tully	09-Sep-11	11:41:00	Bedarra Island	-18	146.142	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		05-Jan-12	10:08:00	Tully River mouth	-18.029083	146.061	n.d.	n.d.	n.d.	n.d.	16	n.d.	11	n.d.	n.d.	n.d.	20	n.d.	n.d.	n.d.	n.d.	n.d.
		05-Jan-12	11:18:00	Bedarra Island	-18.000467	146.142	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.	n.d.
		05-Jan-12	13:10:00	Sisters Island	-17.7492	146.143	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		11-Feb-12	10:25:00	Tully River mouth	-18.0288	146.061	n.d.	n.d.	n.d.	n.d.	19	n.d.	13	n.d.	n.d.	n.d.	24	n.d.	n.d.	n.d.	n.d.	n.d.
		11-Feb-12	11:30:00	Bedarra Island	-18.000567	146.142	n.d.	n.d.	n.d.	n.d.	21	n.d.	n.d.	n.d.	n.d.	n.d.	21	n.d.	n.d.	n.d.	n.d.	n.d.
		08-Mar-12	10:10:00	Tully River mouth	-18.029467	146.061	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.	n.d.
		08-Mar-12	10:40:00	Bedarra Island	-18.000433	146.142	n.d.	n.d.	n.d.	n.d.	10	n.d.	n.d.	n.d.	n.d.	n.d.	10	n.d.	n.d.	n.d.	n.d.	n.d.
		08-Mar-12	12:30:00	Sisters Island	-17.7492	146.143	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Mar-12	09:40:00	Tully River mouth	-18.029467	146.061	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	24
		31-Mar-12	13:30:00	Bedarra Is	-18.000433	146.142	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Mar-12	14:10:00	Nth Dunk	-17.925667	146.146	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Herbert	Northern	13-Feb-12	10:55:00	Cape Richards	-18.191233	146.215	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.
	Southern	06-Mar-12	12:30:00	Seymour River mouth	-18.493117	146.234	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.	13	n.d.	n.d.	n.d.	n.d.	n.d.
	Barge	06-Mar-12	11:15:00	Barge Site 2	-18.52165	146.354	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	Southern	06-Mar-12	12:10:00	Herbert River mouth	-18.49675	146.287	n.d.	n.d.	n.d.	n.d.	14	n.d.	n.d.	n.d.	n.d.	n.d.	14	n.d.	n.d.	n.d.	n.d.	n.d.
	Southern	30-Mar-12	13:10:00	Seymour River mouth	-18.493567	146.235	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	Barge	30-Mar-12	10:15:00	Barge site 3	-18.524267	146.39	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	Southern	30-Mar-12	11:40:00	South site 3	-18.474933	146.346	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	Southern	30-Mar-12	12:55:00	Herbert River mouth	-18.496633	146.284	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

13 APPENDIX F – MEAN FLOW RATES IN MAJOR RIVERS VS PSII-HEQ OF PASSIVE SAMPLERS

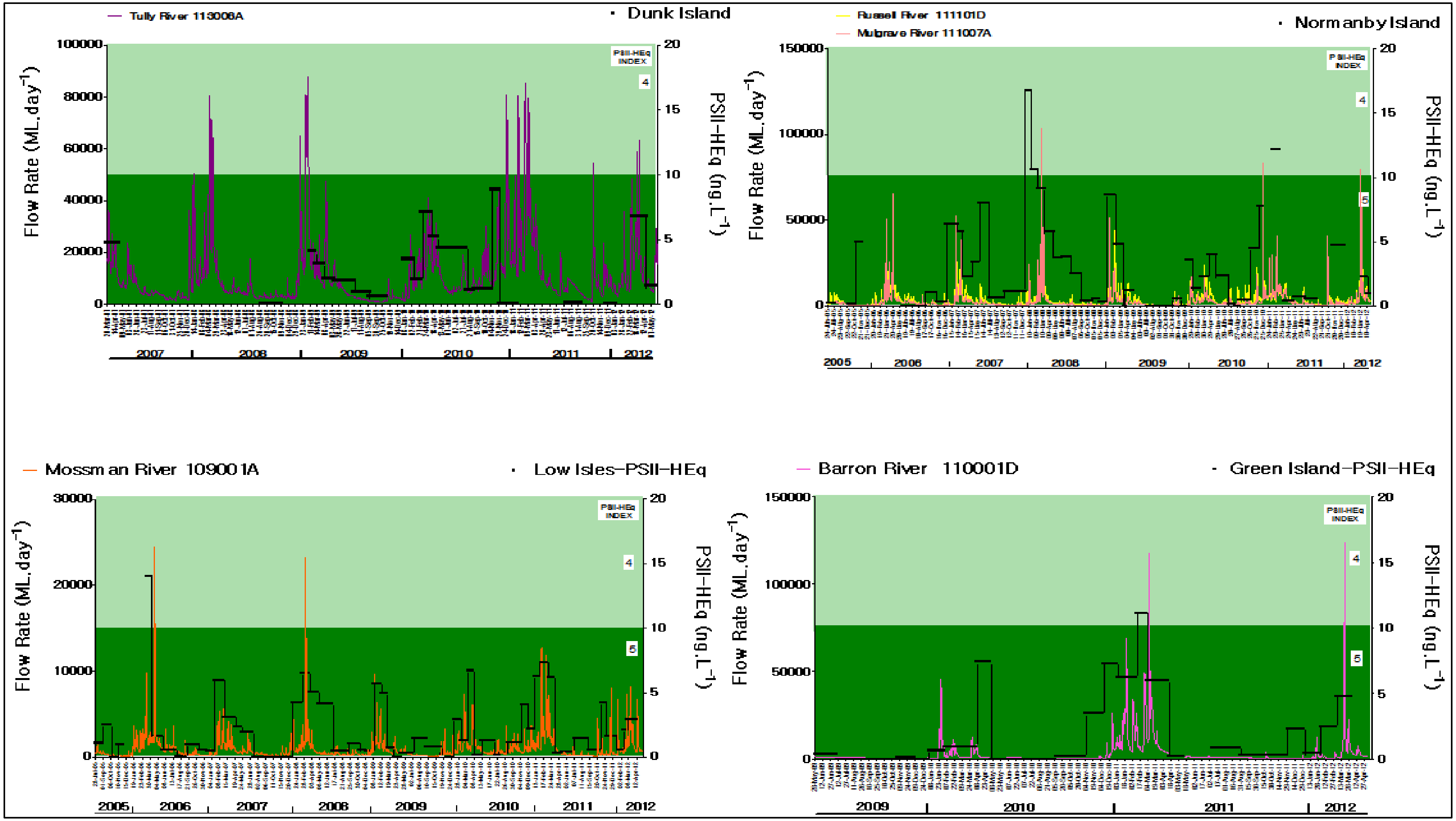


Figure 26 Temporal trends in both flow rate in rivers in adjacent catchments and PSII-HEq at inshore GBR sites in the Wet Tropics since routine monitoring commenced (Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

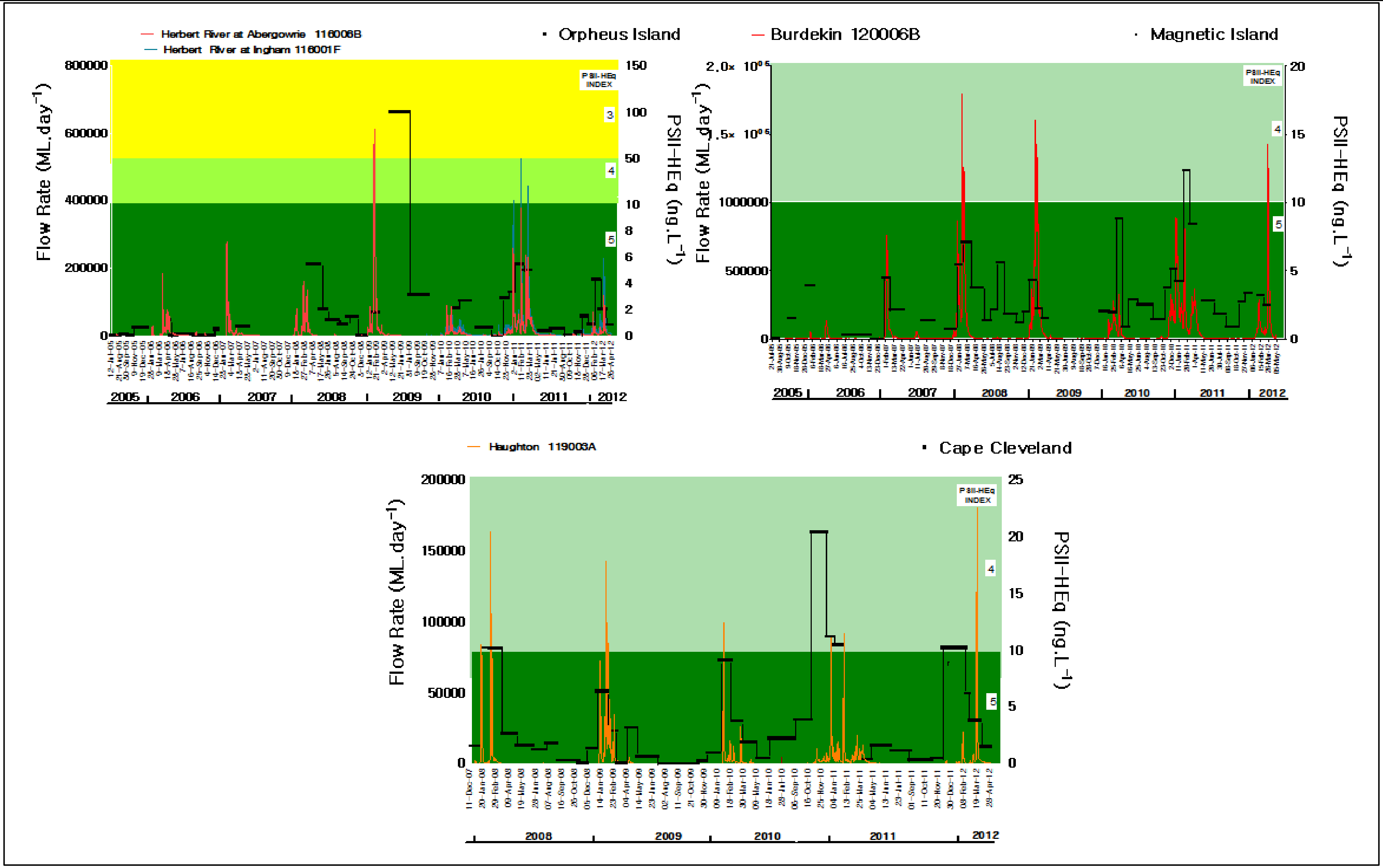


Figure 27 Temporal trends in both flow rate in rivers in adjacent catchments and PSII-HEq at inshore GBR sites in the Burdekin since routine monitoring commenced (Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

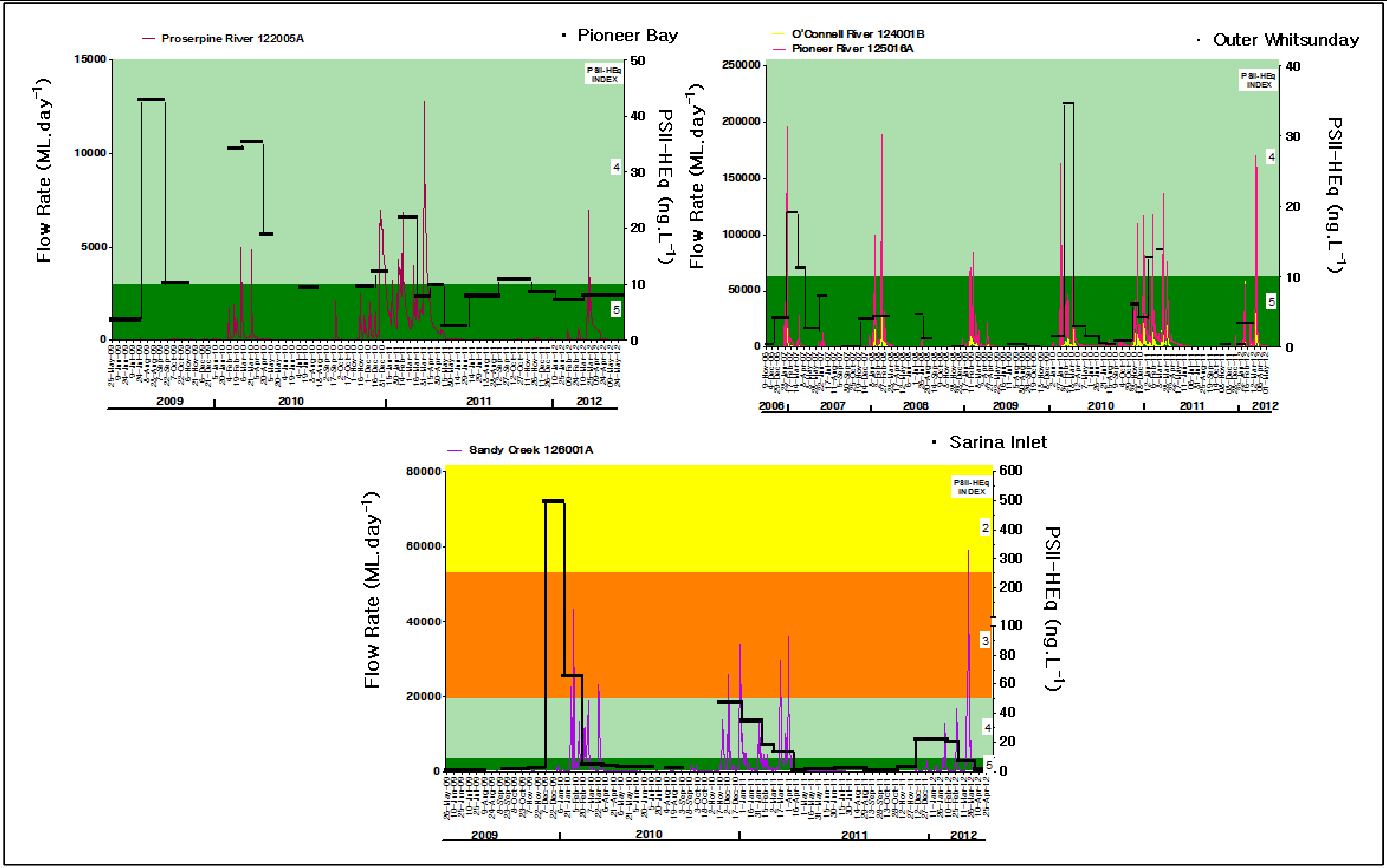


Figure 28 Temporal trends in both flow rate in rivers in adjacent catchments and PSII-HEq at inshore GBR sites in Mackay Whitsunday since routine monitoring commenced (Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

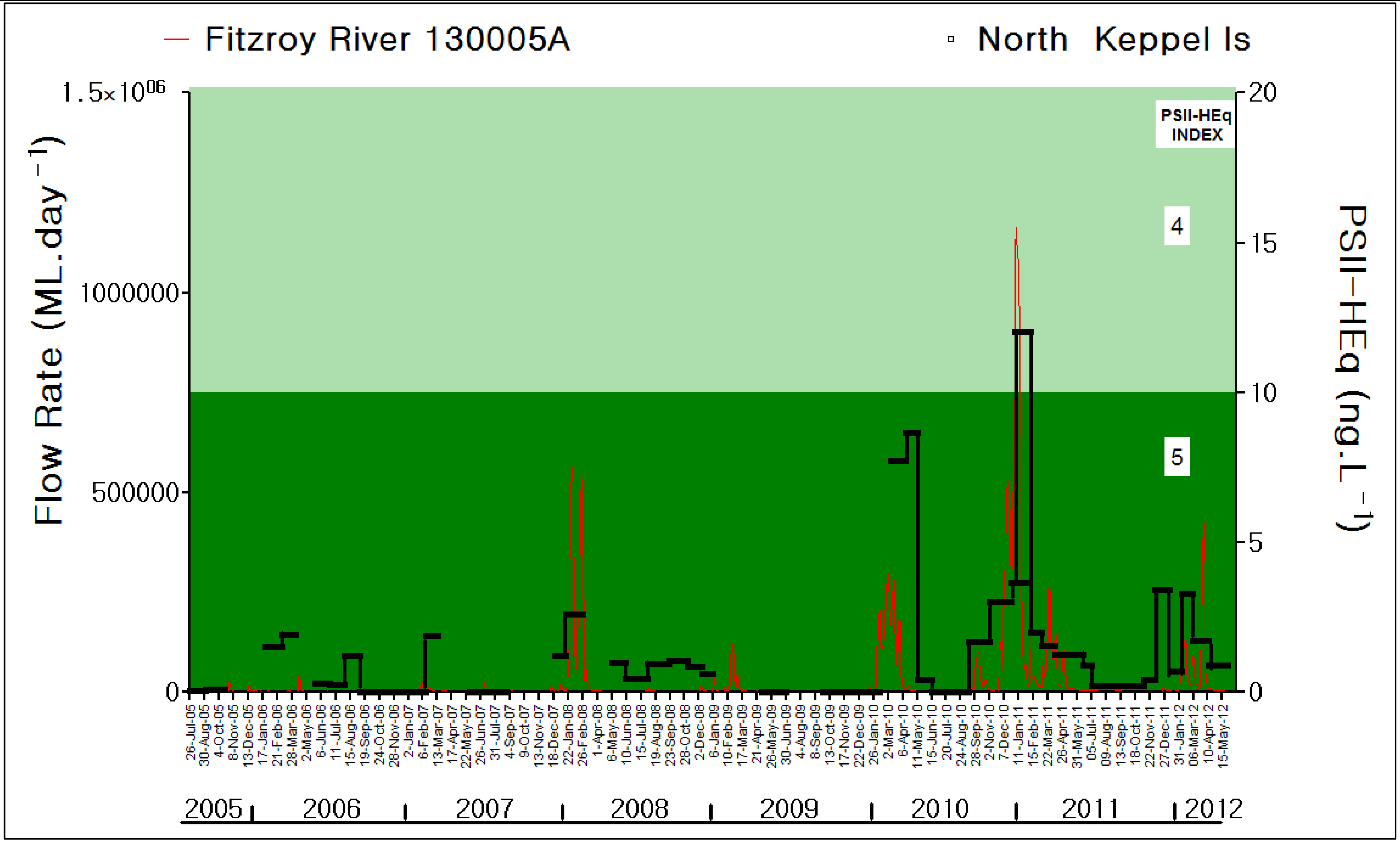


Figure 29 Temporal trends in both flow rate in rivers in adjacent catchments and PSII-HEq at inshore GBR sites in Fitzroy since routine monitoring commenced (Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

14 APPENDIX G – HISTORICAL CONCENTRATION PROFILES AT ROUTINE MONITORING SITES

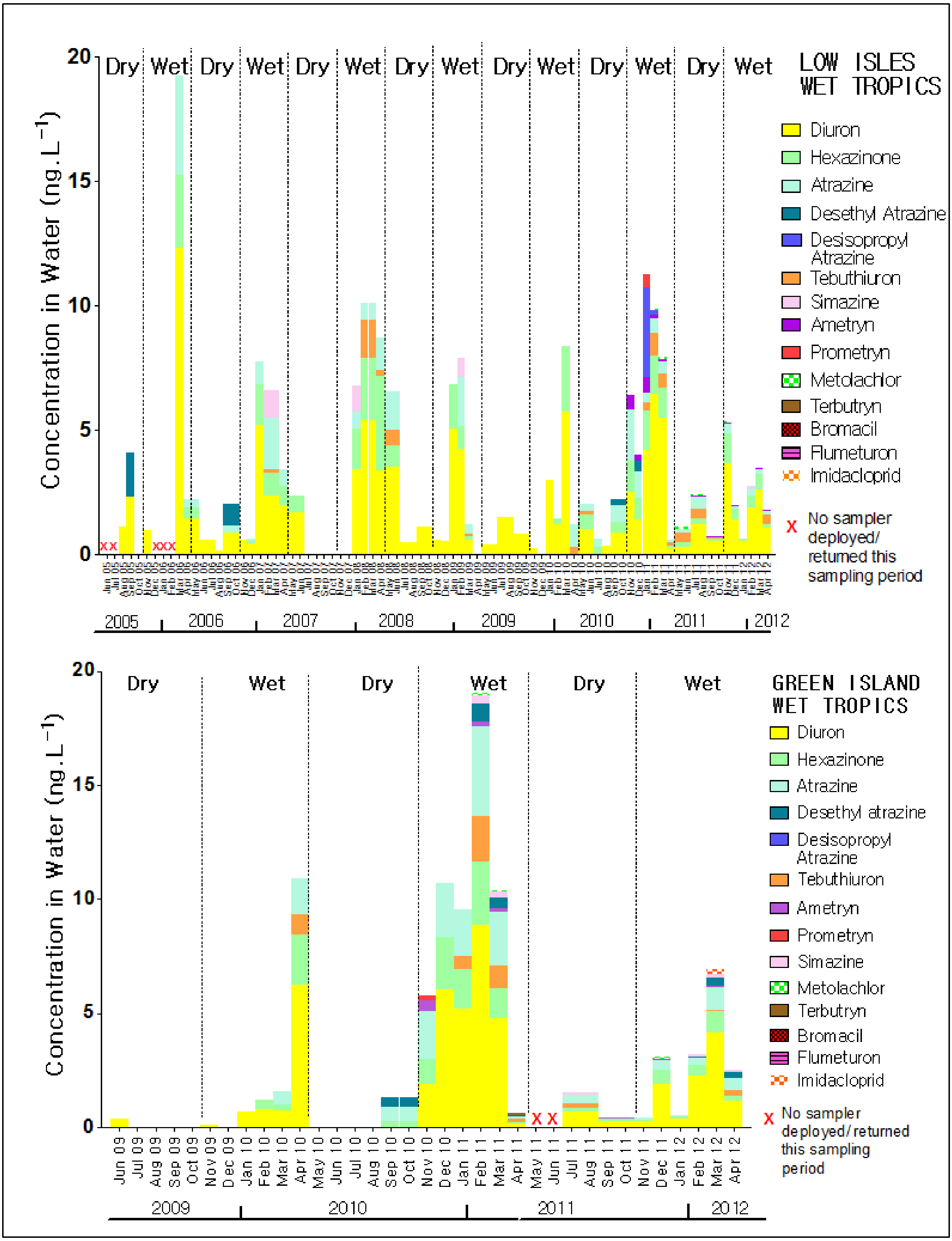


Figure 30 Temporal concentration profiles of individual herbicides at Low Isles and Green Island in the Wet Tropics region

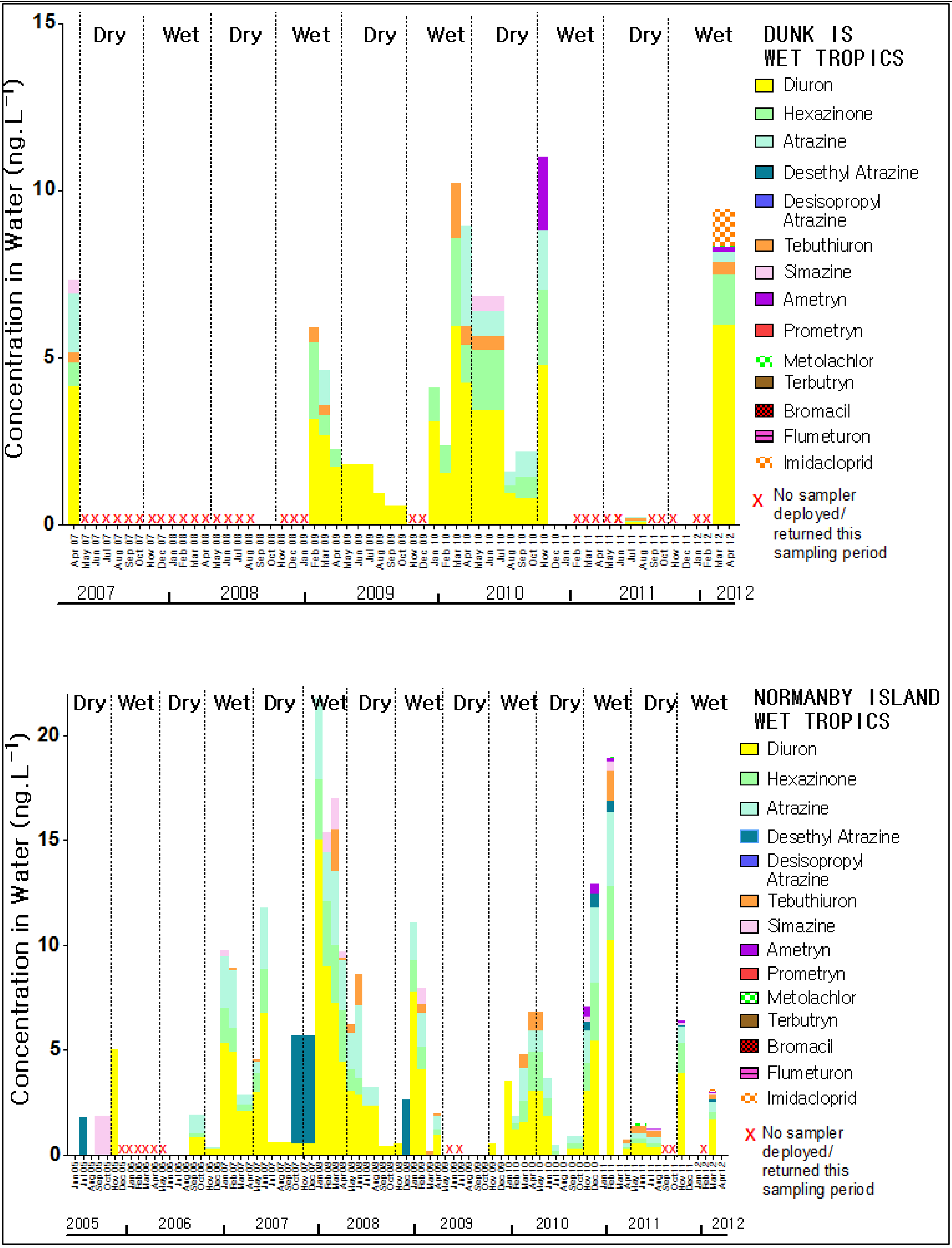


Figure 31 Temporal concentration profiles of individual herbicides at Dunk Island and Normanby Island in the Wet Tropics region

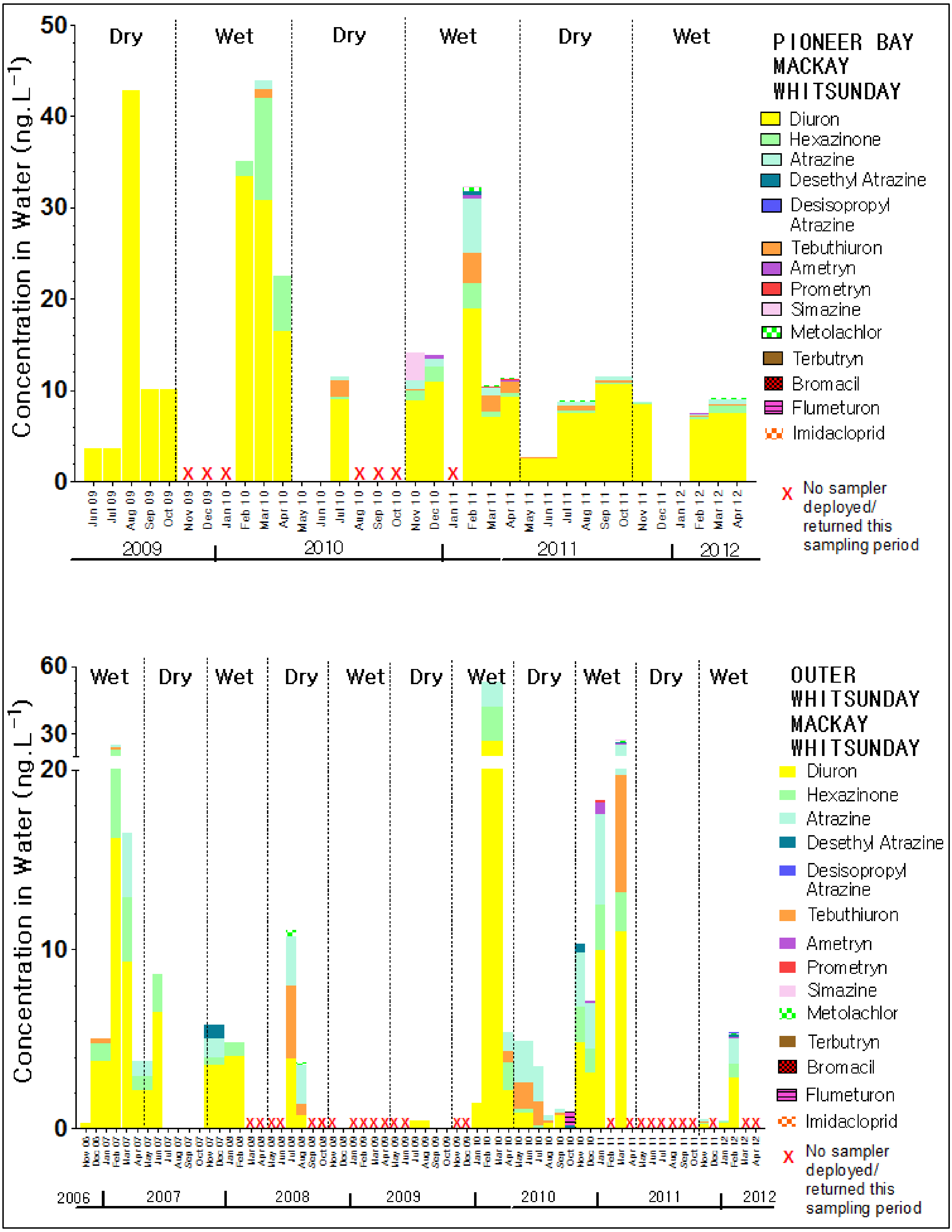


Figure 32 Temporal concentration profiles of individual herbicides at Pioneer Bay and and Outer Whitsunday in the Mackay Whitsunday region

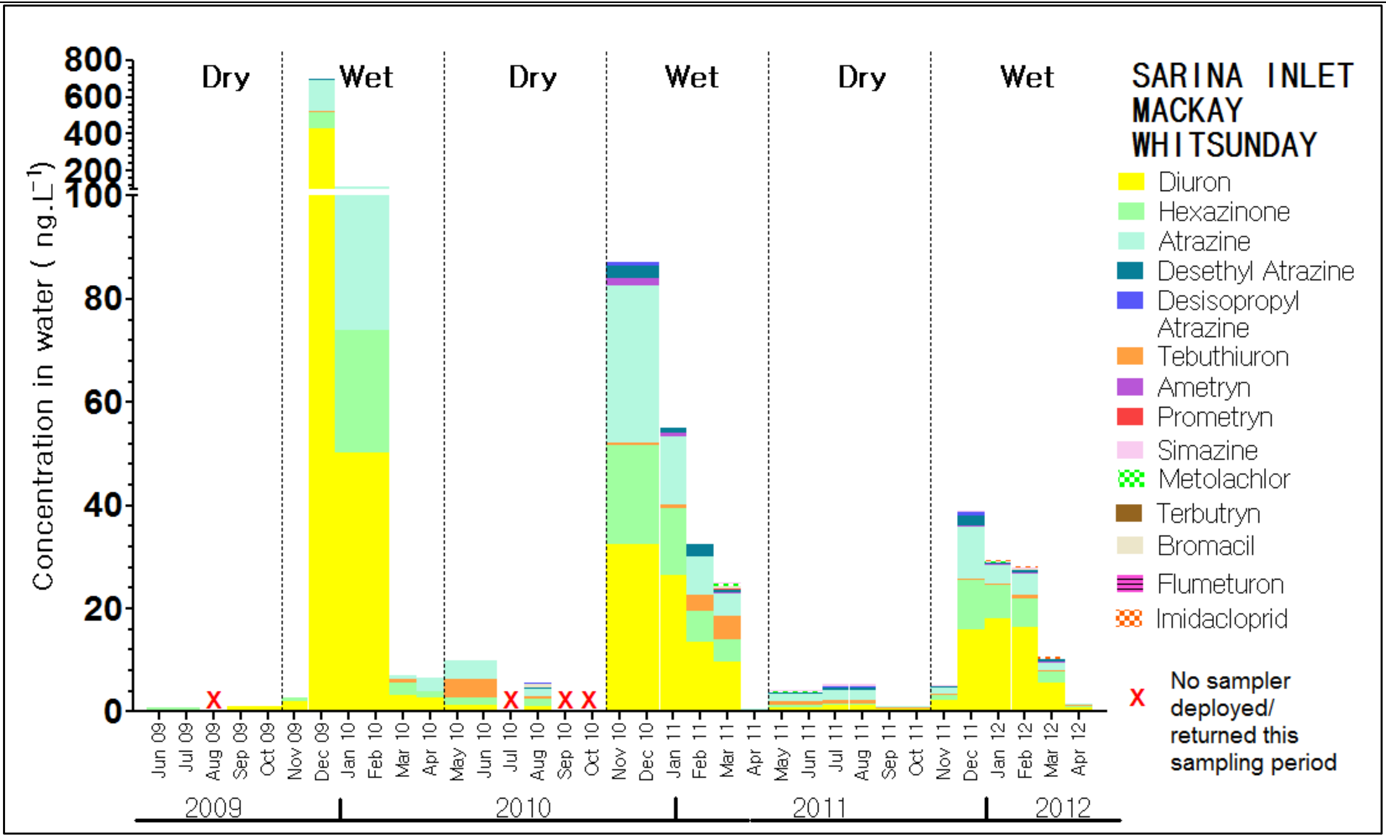
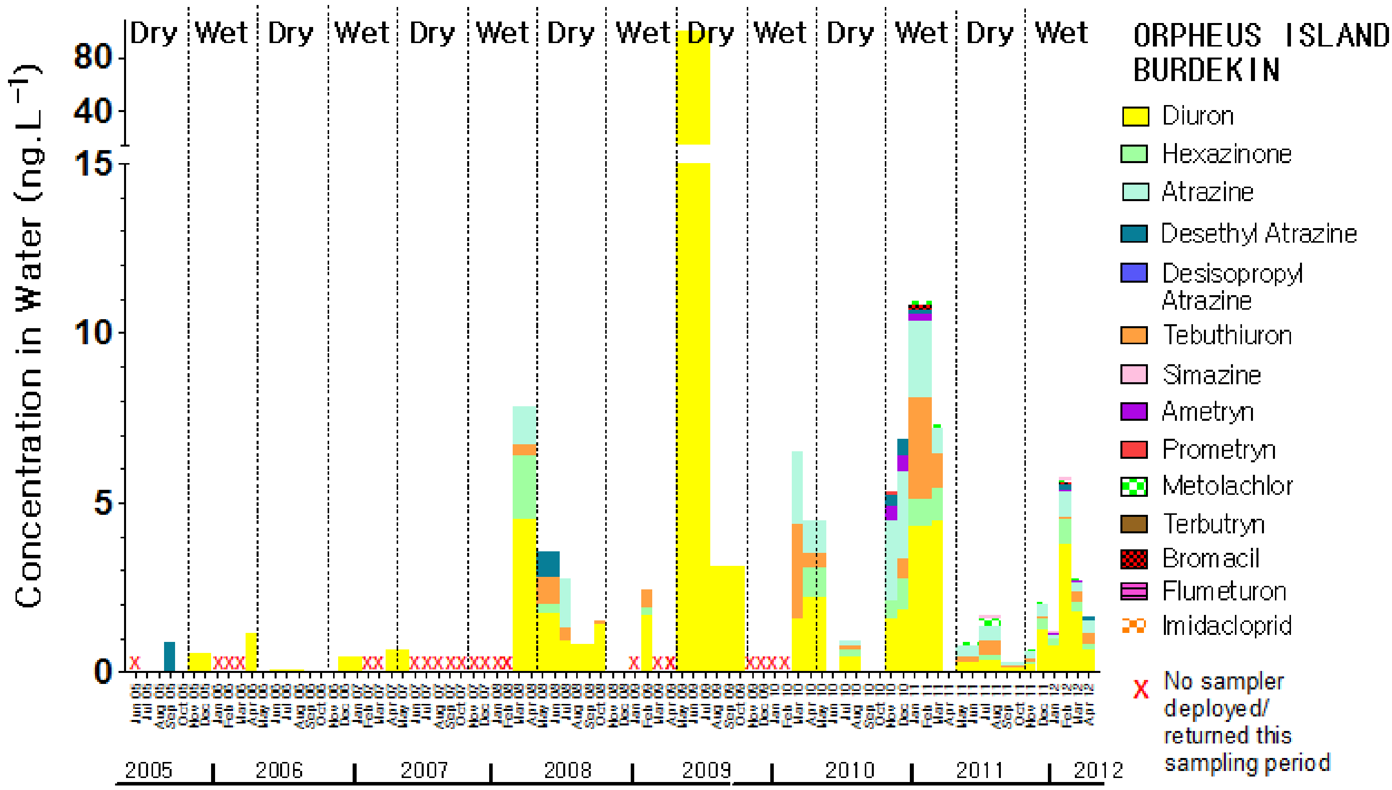


Figure 33 Temporal concentration profiles of individual herbicides at Sarina Inlet in the Mackay Whitsunday region



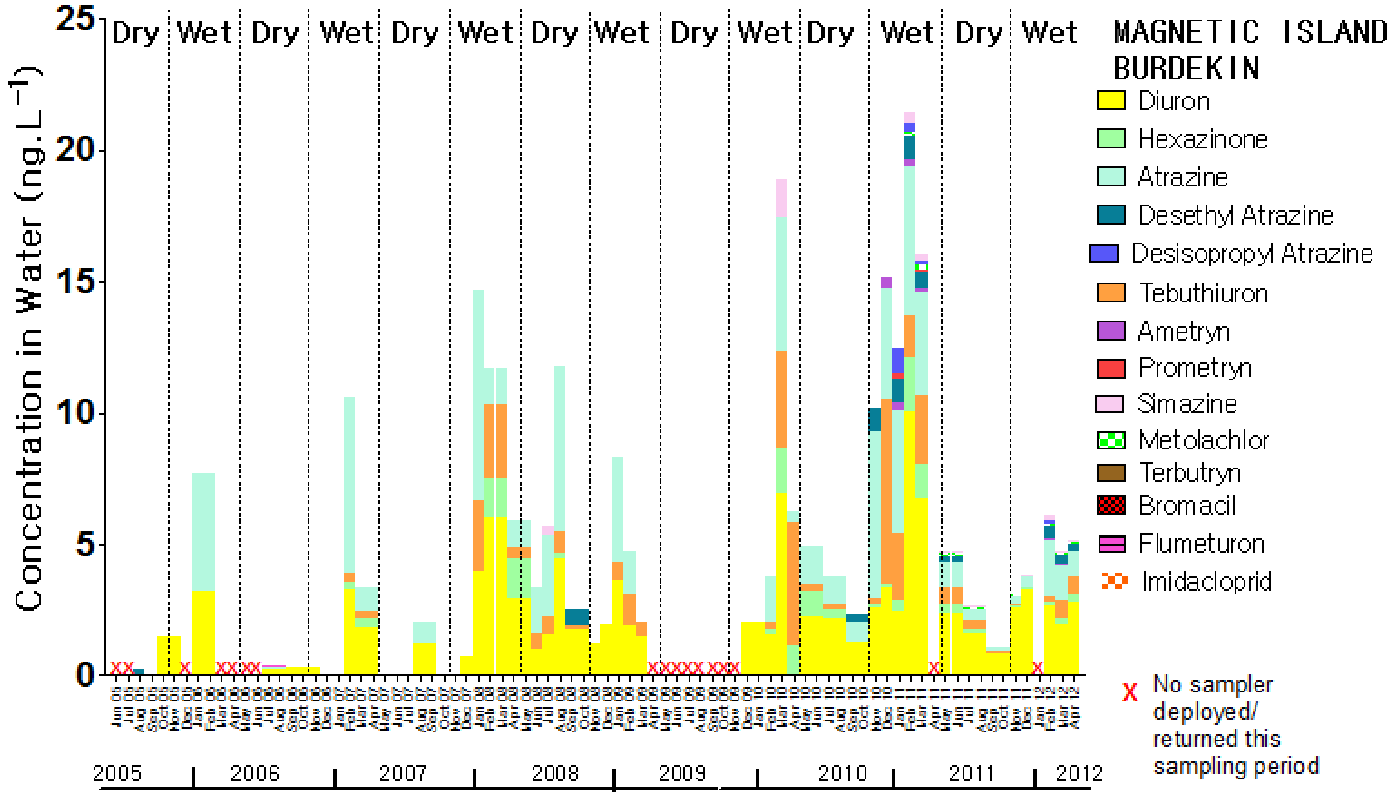


Figure 34 Temporal concentration profiles of individual herbicides at Orpheus Island and Magnetic Island in the Burdekin region

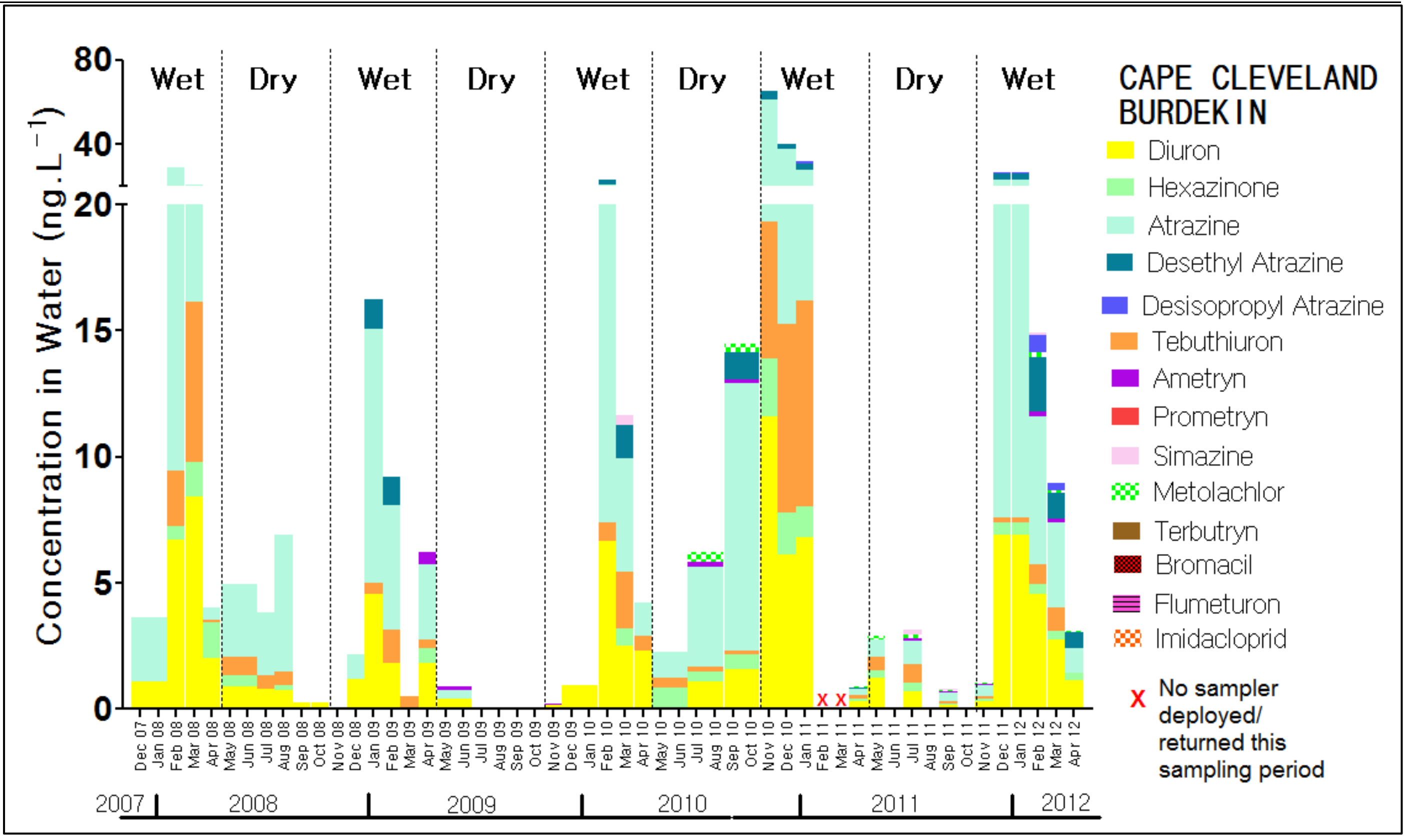


Figure 35 Temporal concentration profiles of individual herbicides at Cape Cleveland in the Burdekin region

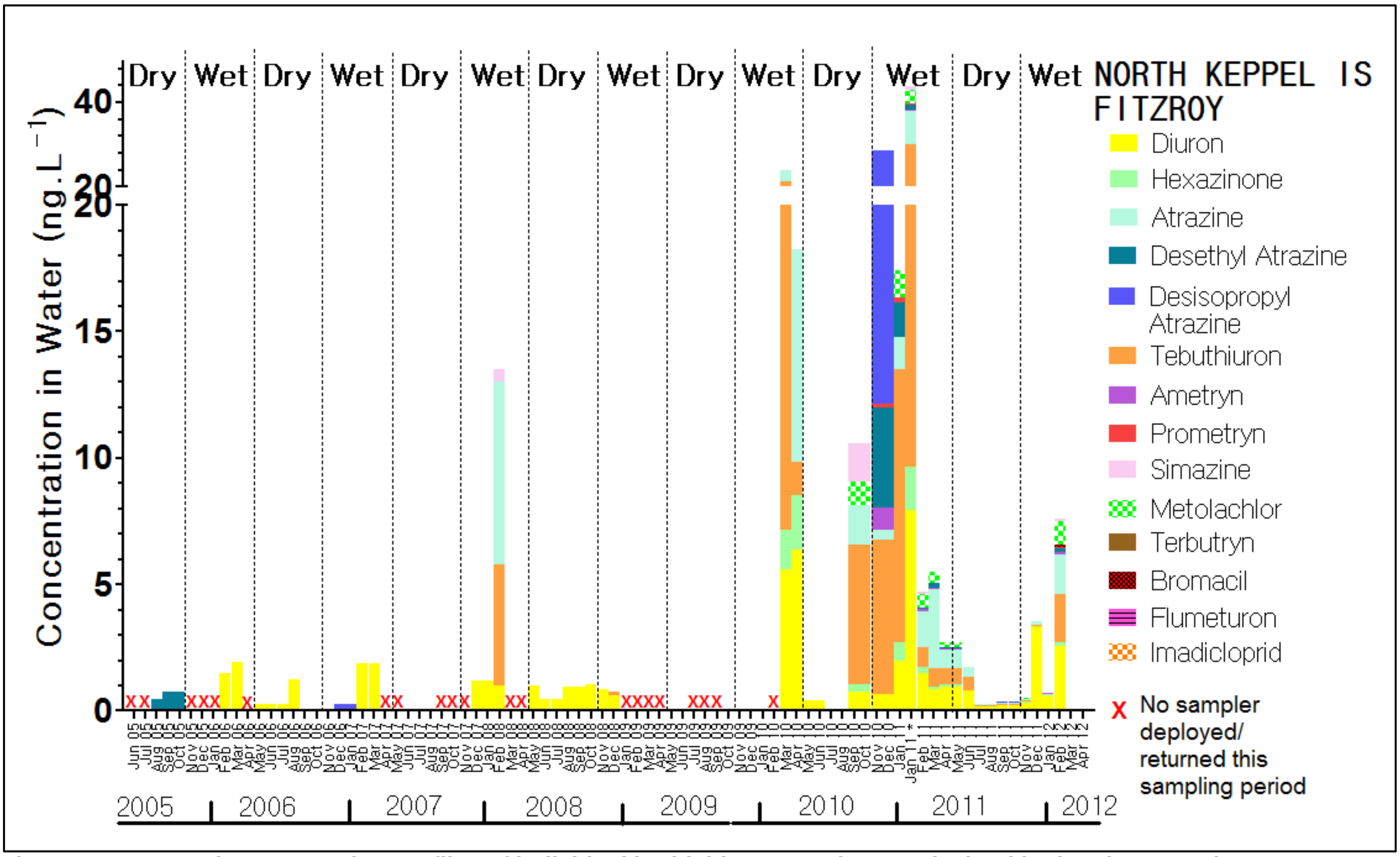


Figure 36 Temporal concentration profiles of individual herbicides at North Keppel Island in the Fitzroy region