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**
  Christie Bentley¹, Chris Paxman¹, Kristie Lee Chue¹, Jochen Mueller¹

• **Assessment of Terrestrial Run-off Entering the Reef**
  Christie Bentley¹, Chris Paxman¹, Kristie Lee Chue¹, Jochen Mueller¹, Jorge Alvarez Romero², Amelia Wengner², Michelle Devlin²

¹*The University of Queensland, The National Research Centre for Environmental Toxicology (Entox)*
²*Australian Centre for Tropical and Freshwater Research (ACTFR), Catchment to Reef Research Group, James Cook University*

Report should be cited as –


Direct Enquiries to –

Professor Jochen Mueller  
Phone: +61 7 3000 9197  
Fax: +61 7 3274 9003  
Email: j.mueller@uq.edu.au  
Web: www.entox.uq.edu.au

The University of Queensland  
The National Research Centre for Environmental Toxicology (Entox)  
39 Kessels Rd  
Coopers Plains QLD 4108
Acknowledgements

Other contributors to this work include:

- Carol Honchin of the GBRMPA for her work on the PSII-HEq Index in 2010.
- Britta Schaffelke and staff of the Australian Institute of Marine Sciences for the assessment of long term discharge data.
- Steve Carter and Vince Alberts of Queensland Health Forensic and Scientific Services for the analysis and reporting of pesticide data for the project.
- Adam Thom and Alex Shanahan of the School of Geography, Planning and Environmental Management, University of Queensland for mapping project support (mapping).
- The early work of David Haynes, Joelle Prange and Deb Bass of the GBRMPA in establishing and managing this monitoring program.

These routine monitoring activities have been undertaken in some form since 2005. Entox therefore acknowledges the significant contribution of past staff—Dr Karen Kennedy, Andrew Dunn, Dr Michael Bartkow, Dr Tatiana Komarova, Dr Melanie Shaw, Anita Kapernick, Jake O’Brien

The assistance of the numerous volunteers who have deployed passive samplers is gratefully acknowledged –

<table>
<thead>
<tr>
<th>Whitsunday Moorings</th>
<th>Fitzroy Island Resort</th>
<th>Great Barrier Reef Marine Park Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taylor’s Beach Caravan Park</td>
<td>Ingham Travel</td>
<td>Australian Centre for Tropical and Freshwater Research</td>
</tr>
<tr>
<td>Sarina Bait Supplies</td>
<td>Frankland Island Cruise &amp; Dive</td>
<td>North Keppel Island Environmental Education Centre</td>
</tr>
<tr>
<td>Jace Services</td>
<td>Reef Safari Diving</td>
<td>Department of Environment and Resource Management</td>
</tr>
<tr>
<td>Reef Fleet Terminal</td>
<td>Orpheus Island Research Station</td>
<td>Australian Institute of Marine Science</td>
</tr>
<tr>
<td>Low Isles Caretakers</td>
<td>Big Cat Green Island</td>
<td>Hamilton Island Enterprises</td>
</tr>
<tr>
<td>Quicksilver Connections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raging Thunder</td>
<td>Mission Beach/ Dunk Island Water Taxi</td>
<td></td>
</tr>
</tbody>
</table>

In particular Entox thanks the GBRMPA Program Manager Katherine Martin and the GBRMPA Regional coordinators for the role they have played in managing and facilitating this monitoring program throughout the years: - Carolyn Thompson, Cath McLean, Phil Laycock, Warwick Sheldon

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.
# Table of Contents

1 EXECUTIVE SUMMARY 1

1.1 Key findings for the 2011-2012 monitoring year 4

2 INTRODUCTION 7

3 METHODOLOGY 8

3.1 Target Chemicals and Limits of Reporting 9

3.2 Sampling Sites 11

3.3 Routine Sampling Periods 11

3.4 Types of samplers deployed for routine sampling for the Assessment of Water Quality 13

3.5 Sampling for the Assessment of Terrestrial Run-Off by Region in the Wet Season 13

3.5.1 Flood plume sampling 13

3.6 Water Quality Guideline Trigger Values 15

3.7 Calculation of PSII-Herbicide Equivalent Concentrations (PSII-HEq) 16

3.8 PSII Herbicide Index 17

4 GBR-WIDE SUMMARY RESULTS 2011-2012 18

4.1 Routine Monitoring Results – Water Quality 18

4.2 Flood Plume Sampling 24

4.2.1 Normanby River transect 24

4.2.2 Tully River transect 24

4.2.3 Herbert River transect 26

5 REGIONAL SUMMARIES 2011-2012 28

5.1 Wet Tropics Region 28

5.2 Burdekin Regional Summary 31

5.3 Mackay Whitsunday Regional Summary 34

5.4 Fitzroy Regional Summary 37

6 DISCUSSION 39

7 SUMMARY 45

8 REFERENCES 47

9 APPENDIX A: Complete analyte list for LCMS and GCMS analysis 50

10 APPENDIX B – Supporing literature for the development of the PSII-HEq Index 53

11 Appendix C - Annual freshwater discharge (ML) for rivers influencing routine monitoring sites 57

12 APPENDIX D – Routine monitoring – Individual site results 58
<table>
<thead>
<tr>
<th>Page</th>
<th>Appendix Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>APPENDIX E – Terrestrial run-off assessment Results</td>
<td>69</td>
</tr>
<tr>
<td>14</td>
<td>APPENDIX F – Mean flow rates in major rivers vs psii-heQ of passive samplers</td>
<td>72</td>
</tr>
<tr>
<td>15</td>
<td>APPENDIX G – Historical concentration profiles at routine monitoring sites</td>
<td>76</td>
</tr>
</tbody>
</table>
List of Figures

Figure 1 The temporal trends in PSII-HEq Max at routine monitoring sites in inshore waters of the GBR determined using time-integrative sampling .................................................................3
Figure 2........................................................................................................................................8
Figure 3 Deployment of passive samplers in the field.................................................................9
Figure 4 Locations of current inshore GBR routine monitoring sites where time-integrated sampling of pesticides occurred in 2011-2012 .................................................................12
Figure 5 Maximum concentrations of each individual herbicide at routine monitoring sites from the baseline reporting year (2008-2009) to 2011-2012 .................................................................20
Figure 6 PSII-HEq Max at each site in from the baseline reporting year 2008-2009 to 2011-2012 .................................................................23
Figure 7 Timing of grab samples taken on the Normanby River transect, Cape York, during 2011-2012 .................................................................24
Figure 8 Locations of grab samples collected on the Tully River transect, Wet Tropics, during 2011-2012 .................................................................25
Figure 9 Timing and results of grab samples collected on the Tully River transect, Wet Tropics, during 2011-2012 .................................................................25
Figure 10 Locations of grab samples collected in the Herbert catchment during 2011-2012 on either the Northern transect (left) or Southern transect (right) .................................................................26
Figure 11 Timing and Index categories of passive samplers deployed and grab samples collected in the Herbert catchment in 2011-2012 .................................................................27
Figure 12 Location of routine monitoring sites in the Wet Tropics region .....................................28
Figure 13 Seasonal average PSII-HEq for Wet Tropics sites since routine monitoring commenced .................................................................29
Figure 14 Location of routine monitoring sites in the Burdekin region ........................................31
Figure 15 Seasonal average PSII-HEq for Burdekin sites since routine monitoring commenced 32
Figure 16 Location of routine monitoring sites in the Mackay Whitsunday region ........................34
Figure 17 Seasonal average PSII-HEq for Mackay Whitsunday sites since routine monitoring commenced .................................................................36
Figure 18 Location of routine monitoring sites in the Fitzroy region ............................................37
Figure 19 Seasonal average PSII-HEq for North Keppel Island in the Fitzroy region since routine monitoring commenced .................................................................38
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) .................................................................39
Figure 21 Total annual discharge of major rivers into the inshore waters of the GBR .................39
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) .....................40
Figure 23 Total annual discharge of selected rivers in adjacent catchments to the GBR ............40
Figure 24 Temporal trends in flow rate and PSII-HEq in rivers in adjacent catchments at inshore GBR sites .................................................................41
Figure 25 PSII-HEq Max (ng.L⁻¹) with the PSII-HEq Index of each value indicated for each routine site 2011-2012 ........................................................................................................................................43
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 .................................................................72
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 .................................................................72
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 .................................................................73
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 .................................................................74
Figure 30 Temporal concentration profiles of individual herbicides at Low Isles and Green Island in the Wet Tropics region ........................................................................................................75
Figure 31 Temporal concentration profiles of individual herbicides at Dunk Island and Normanby Island in the Wet Tropics region ........................................................................................................77
Figure 32 Temporal concentration profiles of individual herbicides at Pioneer Bay and Outer Whitsunday in the Mackay Whitsunday region......................................................................................... 78
Figure 33 Temporal concentration profiles of individual herbicides at Sarina Inlet in the Mackay Whitsunday region........................................................................................................................................ 79
Figure 34 Temporal concentration profiles of individual herbicides at Orpheus Island and Magnetic Island in the Burdekin region............................................................................................................................. 80
Figure 35 Temporal concentration profiles of individual herbicides at Cape Cleveland in the Burdekin region.................................................................................................................................................. 81
Figure 36 Temporal concentration profiles of individual herbicides at North Keppel Island in the Fitzroy region...................................................................................................................................................... 81
List of Tables

Table 1 An overview of key results for pesticide monitoring on the GBR in 2011-2012
Table 2. Pesticides specified under the MMP for analysis with different sampling techniques together with the limits of reporting (ng.L⁻¹)
Table 3 Sampling return record for the 2011-2012 monitoring year
Table 4 The types of passive samplers deployed at each routine monitoring site in 2011-2012
Table 5 The number and timing of grab samples collected to assess terrestrial run-off during the 2011-2012 wet season
Table 6. Water quality guideline trigger values available for specific pesticides
Table 7 Relative potency factors (REP) for PSII herbicides and selected transformation products
Table 8 PSII-Herbicide Equivalent Index developed as an indicator for reporting of PSII herbicides across the Reef Rescue Marine Monitoring Program
Table 9 Comparison of long-term median flows in major rivers with total discharge of current monitoring year
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
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
Table 12 Concentrations of pesticides (ng.L⁻¹) measured using PDMS samplers in the Wet Tropics Region in 2011-2012
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
Table 14 Equilibrium concentrations of pesticides (ng.L⁻¹) measured using PDMS samplers in the Burdekin region in 2011-2012
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
Table 16 Equilibrium concentrations of pesticides (ng.L⁻¹) measured using PDMS samplers in the Mackay Whitsunday region in 2011-2012
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 Wet Tropics
Table 18 LCMS Analyte List for Positive Mode
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
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
Table 21 Annual freshwater discharge of rivers influencing routine monitoring sites (ML)
Table 22 Low Isles, Wet Tropics region – Concentration in water (ng.L⁻¹)
Table 23 Green Island, Wet Tropics region – Concentration in water (ng.L⁻¹)
Table 24 Normanby Island, Wet Tropics region – Concentration in water (ng.L⁻¹)
Table 25 Dunk Island, Wet Tropics region – Concentrations in water (ng.L⁻¹)
Table 26 Orpheus Island, Burdekin region – Concentrations in water (ng.L⁻¹)
Table 27 Magnetic Island, Burdekin Region – Concentrations in water (ng.L⁻¹)
Table 28 Cape Cleveland, Burdekin Region – Concentrations in water (ng.L⁻¹)
Table 29 Pioneer Bay, Mackay Whitsunday – Concentrations in water (ng.L⁻¹)
Table 30 Outer Whitsunday, Mackay Whitsunday region – Concentrations in water (ng.L⁻¹)
Table 31 Sarina Inlet, Mackay Whitsunday region – Concentrations in water (ng.L⁻¹)
Table 32 North Keppel Island, Fitzroy Region – Concentrations in water (ng.L⁻¹)
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
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 ........................................ 69
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 ........................................ 70
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 .............................. 71
## Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANZECC</td>
<td>Australian and New Zealand Environment and Conservation Council</td>
</tr>
<tr>
<td>APVMA</td>
<td>Australian Pesticides and Veterinary Medicines Authority</td>
</tr>
<tr>
<td>ARMCANZ</td>
<td>Agriculture and Resource Management Council of Australia and New Zealand</td>
</tr>
<tr>
<td>C&lt;sub&gt;w&lt;/sub&gt;</td>
<td>Concentration in water</td>
</tr>
<tr>
<td>DEET</td>
<td>N,N-Diethyl-meta-toluamide</td>
</tr>
<tr>
<td>EC&lt;sub&gt;20&lt;/sub&gt;</td>
<td>20 % maximal effective concentration is observed</td>
</tr>
<tr>
<td>EC&lt;sub&gt;50&lt;/sub&gt;</td>
<td>50 % maximal effective concentration is observed</td>
</tr>
<tr>
<td>ED</td>
<td>Empore Disk™ passive sampler</td>
</tr>
<tr>
<td>Entox</td>
<td>National Research Centre for Environmental Toxicology</td>
</tr>
<tr>
<td>GBR</td>
<td>Great Barrier Reef</td>
</tr>
<tr>
<td>GBRMP</td>
<td>Great Barrier Reef Marine Park</td>
</tr>
<tr>
<td>GBRMPA</td>
<td>Great Barrier Reef Marine Park Authority</td>
</tr>
<tr>
<td>GC-MS</td>
<td>Gas Chromatography-Mass Spectrometry</td>
</tr>
<tr>
<td>GPC</td>
<td>Gel Permeation Chromatography</td>
</tr>
<tr>
<td>IWL</td>
<td>Interim working level</td>
</tr>
<tr>
<td>K&lt;sub&gt;ow&lt;/sub&gt;</td>
<td>Octanol-water partition coefficient</td>
</tr>
<tr>
<td>LC-MS</td>
<td>Liquid Chromatography-Mass Spectrometry</td>
</tr>
<tr>
<td>LOD</td>
<td>Limit of Detection</td>
</tr>
<tr>
<td>LOR</td>
<td>Limit Of Reporting</td>
</tr>
<tr>
<td>MMP</td>
<td>Reef Rescue Marine Monitoring Program</td>
</tr>
<tr>
<td>NATA</td>
<td>National Association of Testing Authorities</td>
</tr>
<tr>
<td>PDMS</td>
<td>Polydimethylsiloxane passive sampler</td>
</tr>
<tr>
<td>PFM</td>
<td>Passive/Plaster Flow Monitor</td>
</tr>
<tr>
<td>PSII-HEq</td>
<td>Photosystem II-Herbicide Equivalent Concentration</td>
</tr>
<tr>
<td>PTFE</td>
<td>Polytetrafluoroethylene : Common brand name - Teflon</td>
</tr>
<tr>
<td>QHFSS</td>
<td>Queensland Health Forensic &amp; Scientific Services</td>
</tr>
<tr>
<td>RWQPP</td>
<td>Reef Water Quality Protection Plan</td>
</tr>
<tr>
<td>SDB-RPS</td>
<td>Poly(styrenedivinylbenzene) copolymer – reverse phase sulfonated</td>
</tr>
<tr>
<td>SPMD</td>
<td>Semi-permeable Membrane Devices</td>
</tr>
</tbody>
</table>
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 remain elevated 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. Terrestrial Run-Off (flood plumes)

- 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 imidacloprid 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 imidacloprid. 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

<table>
<thead>
<tr>
<th>NRM Region</th>
<th>Transect</th>
<th>Site Name</th>
<th>Monitoring Component</th>
<th>Sampling Mode</th>
<th>PSII-Heq Max Ratio to Baseline Year</th>
<th>PSII-Heq Wet Avg Ratio to Baseline Year</th>
<th>Other Pesticides detected</th>
<th>Max Concentration (ng L⁻¹)</th>
<th>GBMMPA Guideline Exceedances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cape York</td>
<td>Normanby River</td>
<td>Site 7 - Normanby River mouth</td>
<td>TR GRAB SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site 13 - approx 2 km from Normanby River mouth</td>
<td>TR GRAB SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet Tropics</td>
<td></td>
<td>Low Isles</td>
<td>R ED TI</td>
<td>4.2 0.74</td>
<td>2.1 1.0 Metolachlor</td>
<td></td>
<td></td>
<td>Metolachlor 0.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Green Island</td>
<td>R ED TI</td>
<td>4.8 1.65</td>
<td>- - Metolachlor Imazapic</td>
<td></td>
<td></td>
<td>Imazapic 0.15</td>
<td>Imidacloprid 0.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Galaxolide 0.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fitzroy Island</td>
<td>R ED TI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normanby Island</td>
<td>R ED TI</td>
<td>4.7 0.55</td>
<td>2.6 0.77 Metolachlor</td>
<td></td>
<td></td>
<td>Galaxolide 0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tonalid 0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dunk Island</td>
<td>R ED TI</td>
<td>6.8 1.65</td>
<td>- - Metolachlor Imazapic</td>
<td></td>
<td></td>
<td>Imazapic 0.01</td>
<td>Imidacloprid 1.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tully River mouth</td>
<td>TR GRAB SS</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bedarra Island - approx 9 km from Tully River</td>
<td>TR GRAB SS</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>North Dunk - approx 15 km from Tully River</td>
<td>TR GRAB SS</td>
<td>n.d.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sisters Island - approx 35 km from Tully River</td>
<td>TR GRAB SS</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Channel North - approx 36 km from Herbert River</td>
<td>TR ED TI</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Herbert River Northern</td>
<td>TR GRAB SS</td>
<td>39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goold Island - approx 50 km from Herbert River</td>
<td>TR ED TI</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cape Richards - approx 55 km from Herbert River</td>
<td>TR GRAB SS</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seymour River mouth</td>
<td>TR GRAB SS</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Herbert River mouth</td>
<td>TR GRAB SS</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>South Site 2 - approx 3 km from Herbert River</td>
<td>TR ED TI</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Barge Site 3 - approx 8 km from Herbert River</td>
<td>TR GRAB SS</td>
<td>n.d.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Barge Site 3 - approx 11 km from Herbert River</td>
<td>TR GRAB SS</td>
<td>n.d.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orpheus Island</td>
<td>R ED TI</td>
<td>4.3 2.1</td>
<td>1.6 2.8 Bromacil</td>
<td></td>
<td></td>
<td>Metolachlor 0.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magnetic Island</td>
<td>R ED TI</td>
<td>3.4 0.6</td>
<td>3.0 1.3 Metolachlor</td>
<td></td>
<td></td>
<td>Metolachlor 1.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Galaxolide 0.16</td>
<td>Tonalid 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cape Cleveland</td>
<td>R ED TI</td>
<td>10 1.6</td>
<td>4.4 1.9 Metolachlor</td>
<td></td>
<td></td>
<td>Metolachlor 0.21</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Imazapic 0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Atrazine 4.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Metolachlor 1.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Galaxolide 0.13</td>
<td>Tonalid 0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pioneer Bay</td>
<td>R ED TI</td>
<td>11</td>
<td>7.9 Metolachlor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outer Whitsunday</td>
<td>R ED TI</td>
<td>3.4 0.18</td>
<td>1.4 0.18 Metolachlor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sarina Inlet</td>
<td>R ED TI</td>
<td>22</td>
<td>15 Metolachlor</td>
<td></td>
<td></td>
<td>Metolachlor 0.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Imidacloprid 0.52</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>North Keppel Island</td>
<td>R ED TI</td>
<td>3.4 3.1</td>
<td>1.7 2.34 Bromacil</td>
<td></td>
<td></td>
<td>Metolachlor 0.90</td>
<td></td>
</tr>
</tbody>
</table>

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 km² 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 (logKOW) 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 KOW) 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.

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)

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Description</th>
<th>SPMD</th>
<th>PDMS</th>
<th>ED</th>
<th>GRAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bifenthrin</td>
<td>Pyrethroid insecticide</td>
<td>&lt;1</td>
<td></td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td>Fenvalerate</td>
<td>Pyrethroid insecticide</td>
<td>&lt;1</td>
<td></td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td>Bromacil⁹</td>
<td>PSII herbicide-uracil</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>Tebutiuron</td>
<td>PSII herbicide-thiadazolurea</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>Terbutryn⁷</td>
<td>PSII herbicides-methylthiotriazine</td>
<td>&lt;0.04</td>
<td>&lt;0.4</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>Flumeturon</td>
<td>PSII herbicide-phenylurea</td>
<td>&lt;30</td>
<td>&lt;0.08</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Ametryn</td>
<td>PSII herbicide-methylthiotriazine</td>
<td>&lt;10</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Prometryn</td>
<td>PSII herbicide-methylthiotriazine</td>
<td>&lt;5</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Atrazine</td>
<td>PSII herbicide-chlorotriazine</td>
<td>&lt;10</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Propazine</td>
<td>PSII herbicide-chlorotriazine</td>
<td>&lt;10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simazine</td>
<td>PSII herbicide-chlorotriazine</td>
<td>&lt;30</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Hexazinone</td>
<td>PSII herbicide- triazinone</td>
<td>&lt;25</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Desethylatrazine</td>
<td>PSII herbicide breakdown product (also active)</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>Desisopropylatrazine</td>
<td>PSII herbicide breakdown product (also active)</td>
<td>&lt;25</td>
<td>&lt;0.08</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Diuron</td>
<td>PSII herbicide - phenoxyurea</td>
<td>&lt;25</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Oxadiazon</td>
<td>Oxadiazolone herbicide</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorfenvinphos</td>
<td>Organophosphate insecticide</td>
<td>&lt;2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>Organophosphate insecticide</td>
<td>&lt;0.03</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diazinon</td>
<td>Organophosphate insecticide</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fenamiphos</td>
<td>Organophosphate insecticide</td>
<td>&lt;5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prothiophos</td>
<td>Organophosphate insecticide</td>
<td>&lt;0.09</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlordane</td>
<td>Organochlorine insecticide</td>
<td>&lt;0.1</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDT</td>
<td>Organochlorine insecticide</td>
<td>&lt;0.08</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dieldrin</td>
<td>Organochlorine insecticide</td>
<td>&lt;0.2</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endosulphan</td>
<td>Organochlorine insecticide</td>
<td>&lt;1.9</td>
<td>&lt;5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heptachlor</td>
<td>Organochlorine insecticide</td>
<td>&lt;0.07</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lindane</td>
<td>Organochlorine insecticide</td>
<td>&lt;0.5</td>
<td>&lt;5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>Organochlorine fungicide</td>
<td>&lt;0.09</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imidacloprid³</td>
<td>Nicotinoid insecticide</td>
<td>&lt;0.04</td>
<td>&lt;4</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>Trifluralin</td>
<td>Dinitroaniline</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pendimethalin</td>
<td>Dinitroaniline herbicide</td>
<td>&lt;0.4</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propiconazole</td>
<td>Conazole fungicide</td>
<td>&lt;2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tebuconazole</td>
<td>Conazole fungicide</td>
<td>&lt;5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metolachlor</td>
<td>Chloracetanilide herbicide</td>
<td>&lt;10</td>
<td>&lt;0.04</td>
<td>&lt;2</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Propoxur</td>
<td>Carbamate insecticide</td>
<td>&lt;25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⁹ 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; ⁷Bromacil was included in the list of target analytes from 2009-2010; ³Imidacloprid and terbutryn were routinely analysed in this monitoring year.

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

<table>
<thead>
<tr>
<th>Region</th>
<th>Site</th>
<th>EDs (polar)</th>
<th>PDMS (non-polar)</th>
<th>SPMD (non-polar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dry</td>
<td>Wet</td>
<td>Dry</td>
</tr>
<tr>
<td>Wet Tropics</td>
<td>Low Isles</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Green Island</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Fitzroy Island</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Normanby Island</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Dunk Island</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Burdekin</td>
<td>Orpheus Island</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Magnetic Island</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Cape Cleveland</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mackay - Whitsunday</td>
<td>Pioneer Bay</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Outer Whitsunday</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Sarina Inlet</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fitzroy</td>
<td>North Keppel Island</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Chemical</th>
<th>GBRMPA[^a]</th>
<th>ANZECC and ARMCANZ[^b]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ng L^{-1}</td>
<td>Notes</td>
</tr>
<tr>
<td>Dinitroaniline Herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trifluralin</td>
<td>2600</td>
<td>99% species protection; Freshwater</td>
</tr>
<tr>
<td>Organophosphate Pesticides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>0.5</td>
<td>99% species protection; High reliability</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>95% species protection; High reliability</td>
</tr>
<tr>
<td></td>
<td>0.04</td>
<td>99% species protection; Fresh water</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>95% species protection; Fresh water</td>
</tr>
<tr>
<td>Choracelanilide herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metolachlor</td>
<td>20*</td>
<td>Low reliability; Fresh water</td>
</tr>
<tr>
<td>Triazine or Triazine Herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrazine</td>
<td>600</td>
<td>99% species protection; Moderate reliability</td>
</tr>
<tr>
<td></td>
<td>1400</td>
<td>95% species protection; Moderate reliability</td>
</tr>
<tr>
<td>Hexazinone</td>
<td>1200</td>
<td>Low reliability</td>
</tr>
<tr>
<td>Simazine</td>
<td>200</td>
<td>99% species protection; Low reliability</td>
</tr>
<tr>
<td></td>
<td>3200</td>
<td>95% species protection; Fresh water</td>
</tr>
<tr>
<td>Ametryn</td>
<td>500</td>
<td>99% species protection; Moderate reliability</td>
</tr>
<tr>
<td>Urea Herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diuron</td>
<td>900</td>
<td>99% species protection; Moderate reliability</td>
</tr>
<tr>
<td></td>
<td>1600</td>
<td>95% species protection; Moderate reliability</td>
</tr>
<tr>
<td>Tebuthiuron</td>
<td>20</td>
<td>99% species protection; Low reliability</td>
</tr>
<tr>
<td></td>
<td>2200</td>
<td>95% species protection; Fresh water</td>
</tr>
</tbody>
</table>

[^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.

---

National Research Centre for Environmental Toxicology

Entox is a joint venture between The University of Queensland and Queensland Health
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.

\[
\text{PSII-HEq} = \sum C_i \times REP_i \quad \text{Equation 1}
\]

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 EC50 and EC20 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>
<thead>
<tr>
<th>PSII Herbicides</th>
<th>Relative potency (range)</th>
<th>Relative potency (mean based on various EC values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diuron (reference)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Aminopyralid</td>
<td>1.2-1.35</td>
<td>0.94</td>
</tr>
<tr>
<td>Atrazine</td>
<td>0.05-0.06</td>
<td>0.1-0.4</td>
</tr>
<tr>
<td>Desethyl-atrazine</td>
<td>0.01-0.2</td>
<td>0.01-0.2</td>
</tr>
<tr>
<td>Desisopropyl-atrazine</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>Flumeturon</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Hexazinone</td>
<td>0.2-0.26</td>
<td>0.27-0.82</td>
</tr>
<tr>
<td>Prometryn</td>
<td>1-1.1</td>
<td>1-1.1</td>
</tr>
<tr>
<td>Simazine</td>
<td>0.02</td>
<td>0.03-0.05</td>
</tr>
<tr>
<td>Tebuthiuron</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Terbutylazine</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

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 terbutylazine 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 interpret 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Concentration (ng.L⁻¹)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>PSII-HEq ≤ 10</td>
<td>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</td>
</tr>
<tr>
<td>4</td>
<td>10 &lt; PSII-HEq ≤ 50</td>
<td>Published scientific observations of reduced photosynthesis for two diatoms.</td>
</tr>
<tr>
<td>3</td>
<td>50 &lt; PSII-HEq &lt; 250</td>
<td>Published scientific observations of reduced photosynthesis for two seagrass species and three diatoms.</td>
</tr>
<tr>
<td>2</td>
<td>250 ≤ PSII-HEq ≤ 900</td>
<td>Published scientific observations of reduced photosynthesis for three coral species.</td>
</tr>
<tr>
<td>1</td>
<td>PSII-HEq &gt; 900</td>
<td>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.</td>
</tr>
</tbody>
</table>

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

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

*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

<table>
<thead>
<tr>
<th>NRM Region</th>
<th>Site</th>
<th>Atrazine</th>
<th>DE Atrazine</th>
<th>Diuron</th>
<th>Flumeturon</th>
<th>Hexazinone</th>
<th>Prometryn</th>
<th>Simazine</th>
<th>Teluron</th>
<th>PS II Heq (ng/L)</th>
<th>PSII Heq Max</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Tropics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Isles</td>
<td></td>
<td>n.d. - 0.06</td>
<td>n.d. - 0.49</td>
<td>n.d. - 0.01</td>
<td>0.29 - 3.6</td>
<td>n.d. - 0.10 - 1.2</td>
<td>n.d. - 0.09</td>
<td>n.d. - 0.36</td>
<td>0.42 - 4.2</td>
<td>4.2</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d. - 0.10</td>
</tr>
<tr>
<td></td>
<td>% detects</td>
<td>67</td>
<td>89</td>
<td>0</td>
<td>11</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>11</td>
<td>56</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Green Island</td>
<td></td>
<td>n.d. - 0.07</td>
<td>0.03 - 1.0</td>
<td>n.d. - 0.33</td>
<td>n.d. - 0.01</td>
<td>0.27 - 4.1</td>
<td>n.d. - 0.03 - 0.95</td>
<td>n.d. - 0.17</td>
<td>n.d. - 0.28</td>
<td>0.30 - 4.8</td>
<td>4.8</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>% detects</td>
<td>50</td>
<td>100</td>
<td>38</td>
<td>13</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>50</td>
<td>63</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Fitzroy Island</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normanby Island</td>
<td></td>
<td>n.d. - 0.08</td>
<td>0.29 - 0.76</td>
<td>n.d. - 0.15</td>
<td>n.d. - 0.36 - 3.9</td>
<td>n.d. - 0.17 - 1.4</td>
<td>n.d. - 0.13</td>
<td>n.d. - 0.34</td>
<td>0.52 - 4.7</td>
<td>4.7</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d. - 0.03</td>
</tr>
<tr>
<td>Dunk Island</td>
<td></td>
<td>80</td>
<td>100</td>
<td>60</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>% detects</td>
<td>33</td>
<td>67</td>
<td>0</td>
<td>67</td>
<td>0</td>
<td>67</td>
<td>0</td>
<td>33</td>
<td>67</td>
<td>67</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Orpheus Island</td>
<td></td>
<td>n.d. - 0.08</td>
<td>0.08 - 0.77</td>
<td>n.d. - 0.15</td>
<td>n.d. - 0.10 - 3.7</td>
<td>n.d. - 0.76</td>
<td>n.d. - 0.13</td>
<td>0.04 - 0.42</td>
<td>0.13 - 4.3</td>
<td>4.3</td>
<td>n.d.</td>
<td>n.d.</td>
<td>0.03 - 0.20</td>
</tr>
<tr>
<td>Magnetic Island</td>
<td></td>
<td>44</td>
<td>100</td>
<td>22</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>89</td>
<td>0</td>
<td>67</td>
<td>89</td>
<td>100</td>
<td>11</td>
</tr>
<tr>
<td>Cape Cleveland</td>
<td></td>
<td>75</td>
<td>100</td>
<td>63</td>
<td>13</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>% detects for region</td>
<td></td>
<td>58</td>
<td>89</td>
<td>24</td>
<td>6</td>
<td>92</td>
<td>0</td>
<td>92</td>
<td>0</td>
<td>39</td>
<td>66</td>
<td>92</td>
<td>0</td>
</tr>
<tr>
<td>Burdekin</td>
<td></td>
<td>n.d. - 0.05</td>
<td>0.11 - 2.2</td>
<td>n.d. - 0.49</td>
<td>n.d. - 0.14</td>
<td>0.84 - 3.3</td>
<td>n.d. - 0.04 - 0.33</td>
<td>n.d. - 0.01 - 0.21</td>
<td>n.d. - 0.04 - 0.72</td>
<td>0.89 - 3.4</td>
<td>3.4</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Pioneer Bay</td>
<td></td>
<td>75</td>
<td>100</td>
<td>63</td>
<td>13</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>% detects for region</td>
<td></td>
<td>69</td>
<td>100</td>
<td>45</td>
<td>21</td>
<td>100</td>
<td>0</td>
<td>96</td>
<td>0</td>
<td>76</td>
<td>92</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>Mackay Whitsunday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer Whitsunday</td>
<td></td>
<td>33</td>
<td>100</td>
<td>63</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>33</td>
<td>67</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>67</td>
</tr>
<tr>
<td>Sarina Inlet</td>
<td></td>
<td>0.01 - 0.30</td>
<td>0.10 - 0.01</td>
<td>n.d. - 2.0</td>
<td>n.d. - 0.71</td>
<td>0.53 - 18</td>
<td>n.d. - 0.18 - 9.6</td>
<td>n.d. - 0.03</td>
<td>n.d. - 0.42</td>
<td>0.08 - 0.72</td>
<td>0.66 - 2.2</td>
<td>2.2</td>
<td>n.d.</td>
</tr>
<tr>
<td>% detects for region</td>
<td></td>
<td>106</td>
<td>100</td>
<td>78</td>
<td>44</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>11</td>
<td>89</td>
<td>100</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Fitzroy</td>
<td></td>
<td>n.d. - 0.13</td>
<td>0.05 - 1.6</td>
<td>n.d. - 0.24</td>
<td>n.d. - 0.21</td>
<td>0.18 - 3.4</td>
<td>n.d. - 0.15</td>
<td>n.d. - 0.04</td>
<td>n.d. - 0.17</td>
<td>n.d. - 1.9</td>
<td>0.19 - 3.4</td>
<td>3.4</td>
<td>n.d.</td>
</tr>
<tr>
<td>% detects for region</td>
<td></td>
<td>50</td>
<td>100</td>
<td>40</td>
<td>30</td>
<td>100</td>
<td>0</td>
<td>80</td>
<td>20</td>
<td>60</td>
<td>90</td>
<td>100</td>
<td>10</td>
</tr>
</tbody>
</table>

* 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; 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 tebuthiuron 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).

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).
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 previous 2010-2011 monitoring year as part of the Tully transect case study (Kennedy et al, 2011). In this current monitoring 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.
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.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)](image)

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 Island 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.

Passive samplers deployed at the three fixed sites detected a wider range of PSII herbicides than 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), terbutryn (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.

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.

<table>
<thead>
<tr>
<th>Site</th>
<th>Ametryn</th>
<th>Atrazine</th>
<th>DI Atrazine</th>
<th>Diuron</th>
<th>Floretabron</th>
<th>Hexazinone</th>
<th>Prometryn</th>
<th>Tebuturon</th>
<th>2011-12</th>
<th>2010-11</th>
<th>2009-10</th>
<th>2008-09</th>
<th>Ratio to Baseline</th>
<th>Year</th>
<th>Bromacil</th>
<th>Terbutryn</th>
<th>Metolachlor</th>
<th>Imidacloprid</th>
<th>Imazapic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Isles</td>
<td>0.04</td>
<td>0.22</td>
<td>n.d.</td>
<td>1.4</td>
<td>0.40</td>
<td>n.d.</td>
<td>0.23</td>
<td>2.1</td>
<td>4.4</td>
<td>1.9</td>
<td>2.1</td>
<td>1.0</td>
<td>n.d.</td>
<td>0.04</td>
<td>-</td>
<td>n.d.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.06</td>
<td>0.49</td>
<td>n.d.</td>
<td>3.6</td>
<td>n.d.</td>
<td>1.2</td>
<td>0.09</td>
<td>4.2</td>
<td>7.4</td>
<td>6.7</td>
<td>5.7</td>
<td>0.7</td>
<td>n.d.</td>
<td>0.10</td>
<td>0.15</td>
<td>n.d.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Island</td>
<td>0.04</td>
<td>0.36</td>
<td>0.22</td>
<td>1.4</td>
<td>0.33</td>
<td>0.12</td>
<td>0.11</td>
<td>1.9</td>
<td>5.7</td>
<td>1.7</td>
<td>1.1</td>
<td>n.d.</td>
<td>n.d.</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.07</td>
<td>1.0</td>
<td>0.33</td>
<td>4.1</td>
<td>0.95</td>
<td>0.17</td>
<td>0.28</td>
<td>1.8</td>
<td>11.7</td>
<td>7.4</td>
<td>6.6</td>
<td>0.6</td>
<td>n.d.</td>
<td>0.30</td>
<td>0.15</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fitzroy Island</td>
<td>0.04</td>
<td>0.47</td>
<td>0.16</td>
<td>1.5</td>
<td>0.49</td>
<td>0.09</td>
<td>0.34</td>
<td>1.8</td>
<td>6.2</td>
<td>2.6</td>
<td>0.7</td>
<td>n.d.</td>
<td>n.d.</td>
<td>0.05</td>
<td>n.d.</td>
<td>n.d.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.08</td>
<td>0.76</td>
<td>0.15</td>
<td>3.9</td>
<td>n.d.</td>
<td>1.4</td>
<td>0.13</td>
<td>4.7</td>
<td>12.0</td>
<td>4.0</td>
<td>8.6</td>
<td>0.5</td>
<td>n.d.</td>
<td>0.10</td>
<td>n.d.</td>
<td>n.d.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dunk Island</td>
<td>0.12</td>
<td>0.30</td>
<td>n.d.</td>
<td>6.0</td>
<td>0.15</td>
<td>0.02</td>
<td>0.38</td>
<td>6.8</td>
<td>8.8</td>
<td>7.1</td>
<td>4.1</td>
<td>1.7</td>
<td>n.d.</td>
<td>0.07</td>
<td>0.01</td>
<td>1.07</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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-HEq values 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

<table>
<thead>
<tr>
<th>Site</th>
<th>Atrazine</th>
<th>Metolachlor</th>
<th>Galaxolide</th>
<th>Tonalid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Isles</td>
<td>Avg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Island</td>
<td>Avg</td>
<td>n.d.</td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>n.d.</td>
<td></td>
<td>0.14</td>
</tr>
<tr>
<td>Fitzroy Island</td>
<td>Avg</td>
<td>n.d.</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>n.d.</td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td>Normanby Island</td>
<td>Avg</td>
<td>n.d.</td>
<td>n.d.</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>n.d.</td>
<td>n.d.</td>
<td>0.16</td>
</tr>
<tr>
<td>Dunk Island</td>
<td>Avg</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>n.d.</td>
<td>0.64</td>
<td>n.d.</td>
</tr>
</tbody>
</table>

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](image)

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 PSI I 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.
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

<table>
<thead>
<tr>
<th>Site</th>
<th>Atrazine</th>
<th>Metolachlor</th>
<th>Galaxolide</th>
<th>Tonalid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg</td>
<td>Max</td>
<td>Avg</td>
<td>Max</td>
</tr>
<tr>
<td>Orpheus Island</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic Island</td>
<td>n.d.</td>
<td>1.2</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n.d.</td>
<td>1.3</td>
<td>0.16</td>
<td>0.01</td>
</tr>
<tr>
<td>Cape Cleveland</td>
<td></td>
<td></td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>1.2</td>
<td>0.13</td>
<td>0.02</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Site</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PS II Heq (ng/L)</th>
<th>Other Herbicides (Not indexed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pioneer Bay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg</td>
<td>0.05</td>
<td>0.31</td>
<td>0.32</td>
</tr>
<tr>
<td>Max</td>
<td>0.06</td>
<td>0.49</td>
<td>0.88</td>
</tr>
<tr>
<td>Outer Whitsunday</td>
<td></td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>Avg</td>
<td>0.05</td>
<td>1.4</td>
<td>0.05</td>
</tr>
<tr>
<td>Max</td>
<td>0.05</td>
<td>0.42</td>
<td>0.72</td>
</tr>
<tr>
<td>Sarina Inlet</td>
<td></td>
<td>2.7</td>
<td>0.25</td>
</tr>
<tr>
<td>Avg</td>
<td>0.30</td>
<td>10</td>
<td>0.18</td>
</tr>
</tbody>
</table>

* 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 monitoring 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.
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

<table>
<thead>
<tr>
<th>Site</th>
<th>Atrazine</th>
<th>Metolachlor</th>
<th>Galaxolide</th>
<th>Tonalid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pioneer Bay</td>
<td>Avg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer Whitsunday</td>
<td>Avg</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Sarina Inlet</td>
<td>Avg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 tebuthiuron 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

<table>
<thead>
<tr>
<th>Site</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PS II Heq (ng/L)</th>
<th>Other Herbicides (Not indexed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ametryn</td>
<td>Atrazine</td>
<td>DE Atrazine</td>
</tr>
<tr>
<td>North Keppel Island Avgs&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.06</td>
<td>0.50</td>
<td>0.11</td>
</tr>
<tr>
<td>North Keppel Island Max&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.13</td>
<td>1.6</td>
<td>0.24</td>
</tr>
</tbody>
</table>

<sup>a</sup> 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. <sup>b</sup> 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; <sup>c</sup> 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 flooding on an unprecedented scale (Figure 20).

Figures obtained from Australian Bureau of Meteorology

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).

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)](image)

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](image)

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.
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 elucidate 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 practices 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 tebuthiuron 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 ascertain 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 dominated 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 nutrients, 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.
7 REFERENCES


Eichner, R. (1994 (Web 2001)). Imidacloprid in the Product Confidor Insecticide, National Registration Authority for Agricultural and Veterinary Chemicals, ACT.


Pennington, P. and Scott, G. (2001) "Toxicity of atrazine to the estuarine phytoplankter pavlova sp. (prymnesiophyceae): Increased sensitivity after long-term, low-level population exposure" Environmental Toxicology and Chemistry (20) 10: 2237-2242


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

Table 18 LCMS Analyte List for Positive Mode

<table>
<thead>
<tr>
<th>Analyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ametryn</td>
</tr>
<tr>
<td>Atrazine</td>
</tr>
<tr>
<td>Bromacil</td>
</tr>
<tr>
<td>Clethodim&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Clomazone&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cynazine&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Desethyl Atrazine</td>
</tr>
<tr>
<td>Desisopropyl Atrazine</td>
</tr>
<tr>
<td>Diuron</td>
</tr>
<tr>
<td>Ethametsulfuron methyl&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flumeturon</td>
</tr>
<tr>
<td>Flusilazole&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hexazinone</td>
</tr>
<tr>
<td>Imazapic&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Imazethapyr&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Imidacloprid</td>
</tr>
<tr>
<td>Metolachlor</td>
</tr>
<tr>
<td>Mesosulfuron methyl&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Napropamide&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Prometryn</td>
</tr>
<tr>
<td>Propachlor&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Propazin-2-hydroxy&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sethoxydim&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Simazine</td>
</tr>
<tr>
<td>Sulfosulfuron&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tebuthiuron</td>
</tr>
<tr>
<td>Terbuthylazine&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Terbuthylazine desethyl&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Terbutryn</td>
</tr>
<tr>
<td>Trifloxsulfuron-sodium&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> 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

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Pesticides - Inshore Marine Water Quality Monitoring &amp; Terrestrial Run-off – 2011-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACEPHATE</td>
<td>DICHLORVOS</td>
</tr>
<tr>
<td>ALDRIN</td>
<td>DICLOFOP METHYL</td>
</tr>
<tr>
<td>AMETRYN</td>
<td>DICOFOl o,p</td>
</tr>
<tr>
<td>AMITRAZ</td>
<td>DICOFOl p,p bd</td>
</tr>
<tr>
<td>ATRAZINE</td>
<td>DIELDRIN</td>
</tr>
<tr>
<td>AZINPHOS ETHYL</td>
<td>DIMETHOATE</td>
</tr>
<tr>
<td>AZINPHOS METHYL</td>
<td>DIMETHOMORPH E,Z</td>
</tr>
<tr>
<td>BENALAXYL</td>
<td>DIOXATHION</td>
</tr>
<tr>
<td>BENDIOCARB</td>
<td>DISULFOTON</td>
</tr>
<tr>
<td>BIORESMETHRIN</td>
<td>Diuron bd</td>
</tr>
<tr>
<td>BITERTANOL</td>
<td>ENDOSULFAN alpha</td>
</tr>
<tr>
<td>BROMACIL</td>
<td>ENDOSULFAN beta</td>
</tr>
<tr>
<td>BROMOPHOS ETHYL</td>
<td>ENDOSULFAN ETHEMER</td>
</tr>
<tr>
<td>CADUSAPHOS</td>
<td>ENDOSULFAN LACTONE</td>
</tr>
<tr>
<td>CAPTAN</td>
<td>ENDOSULFAN SULPHATE</td>
</tr>
<tr>
<td>CARBARYL</td>
<td>ENDRIN</td>
</tr>
<tr>
<td>CARBOPHENOTHION</td>
<td>ENDRIN ALDEHYDE</td>
</tr>
<tr>
<td>CHLORDANE cis</td>
<td>ETHION</td>
</tr>
<tr>
<td>CHLORDANE trans</td>
<td>ETHOPROP</td>
</tr>
<tr>
<td>CHLOREDENE</td>
<td>ETRIMIPHOS</td>
</tr>
<tr>
<td>CHLOREDENE EPOXIDE</td>
<td>FAMPHUR</td>
</tr>
<tr>
<td>CHLOREDENE, 1-HYDROXY</td>
<td>FENAMIPHOS</td>
</tr>
<tr>
<td>CHLOREDENE, 1-OH-2,3-EPOXY</td>
<td>FENCHLORPHOS</td>
</tr>
<tr>
<td>CHLORFENVINPHOS e+Z</td>
<td>FENITROTHION</td>
</tr>
<tr>
<td>CHLOROTHALONIL</td>
<td>FENTHION ETHEYL</td>
</tr>
<tr>
<td>CHLORPYRIFOS</td>
<td>FENTHION METHYL</td>
</tr>
<tr>
<td>CHLORPYRIFOS ME</td>
<td>FENVALERATE isomers</td>
</tr>
<tr>
<td>CHLORPYRIFOS OXON</td>
<td>FIPRONIL</td>
</tr>
<tr>
<td>COUMAPHOS</td>
<td>FLUAZIFOP BUTYL</td>
</tr>
<tr>
<td>CYFLUTHRIN isomers</td>
<td>FLUOMETURON</td>
</tr>
<tr>
<td>CYHALOTHIRIN isomers</td>
<td>FLUVALINATE isomers</td>
</tr>
<tr>
<td>CYPERMETHRIN isomers</td>
<td>FURALAXYL</td>
</tr>
<tr>
<td>DCPP isomers</td>
<td>GALOXOLIDE</td>
</tr>
<tr>
<td>DDD o,p</td>
<td>HALOXYFOP 2-EIOEi</td>
</tr>
<tr>
<td>DDD p.p</td>
<td>HALOXYFOP METHYL</td>
</tr>
<tr>
<td>DDE o,p</td>
<td>HCB</td>
</tr>
<tr>
<td>DDE pp</td>
<td>HCH-a</td>
</tr>
<tr>
<td>DDT o,p</td>
<td>HCH-b</td>
</tr>
<tr>
<td>DDT p.p</td>
<td>HCH-d</td>
</tr>
<tr>
<td>DEET</td>
<td>HEPTACHLOR</td>
</tr>
<tr>
<td>DELTAMETHRIN isomers</td>
<td>HEPTACHLOR EPOXIDE</td>
</tr>
<tr>
<td>DEMETON-S-METHYL</td>
<td>HEXAZINE</td>
</tr>
<tr>
<td>DESETHYLATRAZINE</td>
<td>IPRODION</td>
</tr>
<tr>
<td>DESISOPROPYLATRAZINE &quot;900&quot;</td>
<td>ISOPHENOPHOS</td>
</tr>
<tr>
<td>DIAZINON</td>
<td>LINDANE (HCH-g)</td>
</tr>
<tr>
<td>DICHLOROANILINE 3,4</td>
<td>MALATHION</td>
</tr>
<tr>
<td>TEBUTHIURON</td>
<td>METALAXY</td>
</tr>
<tr>
<td>TEBUTICONAZOLE</td>
<td>METHAMIDOPHOS</td>
</tr>
<tr>
<td>TCPP</td>
<td>METHIDATHION</td>
</tr>
<tr>
<td>TEMEPHOS</td>
<td>METHOMYL</td>
</tr>
<tr>
<td>TEP</td>
<td>METHOPRENE</td>
</tr>
<tr>
<td>TERBUPHOS</td>
<td>METHOXYCHL</td>
</tr>
<tr>
<td>METOLACLOR</td>
<td>METRIBUZIN</td>
</tr>
<tr>
<td>MEVINPHOS z+E</td>
<td>MOLINATE</td>
</tr>
<tr>
<td>MONOCROTOPHOS</td>
<td>MUSK KETONE</td>
</tr>
<tr>
<td>MUSK XYLENE</td>
<td>NICOTINE</td>
</tr>
<tr>
<td>NONACHLOR cis</td>
<td>NONACHLOR trans</td>
</tr>
<tr>
<td>OXADIAZON</td>
<td>OXYCHLOR</td>
</tr>
<tr>
<td>OXYDEMETON METHYL</td>
<td>OXYFLUORFEN</td>
</tr>
<tr>
<td>PARATHION ETHYL</td>
<td>PARATHION METHYL</td>
</tr>
<tr>
<td>PENDIMETHALIN</td>
<td>PERMETHRIN isomers</td>
</tr>
<tr>
<td>PHENOTHIRIN isomers</td>
<td>PHORATE</td>
</tr>
<tr>
<td>PHOSMET</td>
<td>PHOSMET</td>
</tr>
<tr>
<td>PHOSPHAMIDON peak1 <strong>200</strong></td>
<td>PHOSPHAMIDON peak2 <strong>800</strong></td>
</tr>
<tr>
<td>PHOSPHATE Tri-n-BUTYL</td>
<td>PHOSPHATE</td>
</tr>
<tr>
<td>PIPERONYL BUTOXIDE</td>
<td>PIRIMICARB</td>
</tr>
<tr>
<td>PIRIMIPHOS METHYL</td>
<td>PROCYMIDONE</td>
</tr>
<tr>
<td>PROFENOPHOS</td>
<td>PROMETRYN</td>
</tr>
<tr>
<td>PROPAGITE</td>
<td>PROPAZINE</td>
</tr>
<tr>
<td>PROPANIL</td>
<td>PROPICONAZOL isomers</td>
</tr>
<tr>
<td>PROPOXUR</td>
<td>PROTHIOPHOS</td>
</tr>
<tr>
<td>PYRAZAPHOS</td>
<td>ROTENONE</td>
</tr>
<tr>
<td>SIMAZINE</td>
<td>SULPROFOS</td>
</tr>
<tr>
<td>TCEP</td>
<td>TETRATHION</td>
</tr>
<tr>
<td>TERBUTHYLAZINE</td>
<td>TERBUTRY</td>
</tr>
<tr>
<td>TETRACHLORVINPHOS</td>
<td>TETRADIIFON</td>
</tr>
<tr>
<td>TETRAMETHRIN isomers</td>
<td>THIABENDAZOLE</td>
</tr>
<tr>
<td>TONALID</td>
<td>TRANSFLUTHRIN</td>
</tr>
<tr>
<td>TRADIIMEFON</td>
<td>TRADIMENOL ISOMERS</td>
</tr>
<tr>
<td>PESTICIDES - INSHORE MARINE WATER QUALITY MONITORING &amp; TERRESTRIAL RUN-OFF – 2011-2012</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td></td>
</tr>
<tr>
<td>TRIALLATE</td>
<td></td>
</tr>
<tr>
<td>TRIFLURALIN</td>
<td></td>
</tr>
<tr>
<td>VINCLOZALIN</td>
<td></td>
</tr>
</tbody>
</table>
## 9 APPENDIX B – SUPPORTING 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

<table>
<thead>
<tr>
<th>Category</th>
<th>PSII-HEq Range (ng.L⁻¹)</th>
<th>Description</th>
<th>Species</th>
<th>Effects Concentration (ng.L⁻¹)</th>
<th>Endpoint</th>
<th>Toxicity measure</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>HEq ≤ 10</td>
<td>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.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10 &lt; HEq ≤ 50</td>
<td>Published scientific observations of reduced photosynthesis for two diatoms.</td>
<td><strong>Diatoms</strong></td>
<td>D. tertiolecta</td>
<td>50</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N. closterium</td>
<td>50</td>
<td>Sensitivity</td>
<td>LOEC</td>
<td>Bengston Nash et al 2005</td>
</tr>
<tr>
<td>3</td>
<td>50 &lt; HEq &lt; 250</td>
<td>Published scientific observations of reduced photosynthesis for two seagrass species and three diatoms.</td>
<td><strong>Seagrass</strong></td>
<td>H. ovalis</td>
<td>100</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Z. capricorni</td>
<td>100</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
<td>Haynes et al 2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Diatoms</strong></td>
<td>N. closterium</td>
<td>100</td>
<td>Sensitivity</td>
<td>IC10</td>
<td>Bengston Nash et al 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. tricornutum</td>
<td>100</td>
<td>Sensitivity</td>
<td>IC10</td>
<td>Bengston Nash et al 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>D. tertiolecta</td>
<td>110</td>
<td>↓photosynthesis</td>
<td>IC10</td>
<td>Bengston Nash et al 2005</td>
</tr>
<tr>
<td>2</td>
<td>250 ≤ HEq ≤ 900</td>
<td>Published scientific observations of reduced photosynthesis for three coral species.</td>
<td><strong>Coral - Isolated zooxanthellae</strong></td>
<td>S. pistillata</td>
<td>250</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Coral - Adult colonies</strong></td>
<td>A. formosa</td>
<td>300</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
<td>Jones &amp; Kerswell, 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S. hystrix</td>
<td>300</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
<td>Jones et al 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S. hystrix</td>
<td>300</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
<td>Jones &amp; Kerswell, 2003</td>
</tr>
<tr>
<td>1</td>
<td>HEq &gt; 900</td>
<td>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</td>
<td><strong>Seagrass</strong></td>
<td>Z. capricorni</td>
<td>1000</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Z. capricorni</td>
<td>5000</td>
<td>↓growth</td>
<td>LOEC</td>
<td>Chesworth et al 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Z. capricorni</td>
<td>10000</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
<td>Macinnis-Ng &amp; Ralph, 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C. serrulata</td>
<td>10000</td>
<td>↓photosynthesis</td>
<td>LOEC</td>
<td>Haynes et al 2000b</td>
</tr>
<tr>
<td>Category</td>
<td>PSII-HEq Range (ng.L⁻¹)</td>
<td>Description</td>
<td>Species</td>
<td>Effects Concentration (ng.L⁻¹)</td>
<td>Endpoint</td>
<td>Toxicity measurement</td>
<td>Reference</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------</td>
<td>------------------------------------------</td>
<td>-----------------------</td>
<td>-------------------------------</td>
<td>-------------------</td>
<td>----------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Coral - Isolated zoanthellae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M. mirabilis</td>
<td>1000</td>
<td>↓ C₁⁴ incorporation</td>
<td>LOEC</td>
<td>Owen et al 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>F. fragum</td>
<td>2000</td>
<td>↓ C₁⁴ incorporation</td>
<td>LOEC</td>
<td>Owen et al 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>D. strigosa</td>
<td>2000</td>
<td>↓ C₁⁴ incorporation</td>
<td>LOEC</td>
<td>Owen et al 2003</td>
</tr>
<tr>
<td>Larvae</td>
<td></td>
<td></td>
<td>A. millepora</td>
<td>300</td>
<td>↓ Metamorphosis</td>
<td>LOEC</td>
<td>Negri et al 2005</td>
</tr>
<tr>
<td>Coral recruits</td>
<td></td>
<td></td>
<td>P. damicornis</td>
<td>1000</td>
<td>↓ photosynthesis</td>
<td>LOEC</td>
<td>Negri et al 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. damicornis</td>
<td>10000</td>
<td>Loss of algae</td>
<td>LOEC</td>
<td>Negri et al 2005</td>
</tr>
<tr>
<td>Coral - Adult colonies</td>
<td></td>
<td></td>
<td>A. formosa</td>
<td>1000</td>
<td>↓ photosynthesis</td>
<td>LOEC</td>
<td>Jones et al 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. cylindrica</td>
<td>1000</td>
<td>↓ photosynthesis</td>
<td>LOEC</td>
<td>Jones et al 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M. digitata</td>
<td>1000</td>
<td>↓ photosynthesis</td>
<td>LOEC</td>
<td>Jones et al 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S. hystrix</td>
<td>1000</td>
<td>↓ photosynthesis</td>
<td>LOEC</td>
<td>Jones et al 2003, Jones 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A. millepora</td>
<td>1000</td>
<td>↓ photosynthesis</td>
<td>LOEC</td>
<td>Negri et al 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. damicornis</td>
<td>1000</td>
<td>↓ photosynthesis</td>
<td>LOEC</td>
<td>Negri et al 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S. hystrix</td>
<td>2300</td>
<td>↓ photosynthesis</td>
<td>EC50</td>
<td>Jones et al 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A. formosa</td>
<td>2700</td>
<td>↓ photosynthesis</td>
<td>EC50</td>
<td>Jones &amp; Kerswell, 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M. digitata</td>
<td>10000</td>
<td>Loss of algae</td>
<td>LOEC</td>
<td>Jones et al 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. damicornis</td>
<td>10000</td>
<td>Loss of algae</td>
<td>LOEC</td>
<td>Negri et al 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S. hystrix</td>
<td>10000</td>
<td>Loss of algae</td>
<td>LOEC</td>
<td>Jones 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. cylindrica</td>
<td>10000</td>
<td>GPP* rate, GPP to respiration ration, effective quantum yield</td>
<td>LOEC</td>
<td>Råberg et al 2003</td>
</tr>
<tr>
<td>Macro Algae</td>
<td></td>
<td></td>
<td>H. banksii</td>
<td>1650</td>
<td>↓ photosynthesis</td>
<td>EC50</td>
<td>Seery et al 2006</td>
</tr>
<tr>
<td>Red Algae</td>
<td></td>
<td></td>
<td>P. onkodes</td>
<td>2900</td>
<td>↓ photosynthesis</td>
<td>LOEC</td>
<td>Harrington et al 2005</td>
</tr>
<tr>
<td>Diatoms</td>
<td></td>
<td></td>
<td>Navicula sp</td>
<td>2900</td>
<td>↓ photosynthesis</td>
<td>IC50 Acute, 6 m</td>
<td>Magnusson et al 2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P. tricornutum</td>
<td>3300</td>
<td>↓ photosynthesis</td>
<td>I₅₀</td>
<td>Schreiber et al 2002</td>
</tr>
<tr>
<td>Mangroves</td>
<td></td>
<td></td>
<td>A. marina</td>
<td>1100</td>
<td>Health</td>
<td>NOEC</td>
<td>Duke et al 2003, 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A. marina</td>
<td>1500</td>
<td>Reduced health</td>
<td>LOEC</td>
<td>Duke et al 2003, Bell &amp; Duke 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A. marina</td>
<td>1500</td>
<td>Reduced health</td>
<td>LOEC</td>
<td>Duke et al 2003, Bell &amp; Duke 2005</td>
</tr>
</tbody>
</table>


Chesworth JC, Donkin ME and Brown DT (2004). The interactive effects of the antifouling herbicides Irgarol 1051 and Diuron in the seagrass *Zostera marina* (L.). *Aquatic Toxicology* 66:293-305.


55

National Research Centre for Environmental Toxicology

Entox is a joint venture between The University of Queensland and Queensland Health
Additionally the following marine data is an excerpt from the Australian Pesticides and Veterinary Medicines Authority (APVMA 2005), Volume I and II as preliminary findings for diuron. Effects concentrations are reported in μg.L⁻¹. This data set has also been used in the derivation of Category 1 of the PSII-HEq Index.

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Tropics</td>
<td>Daintree</td>
<td>108002A</td>
<td>727,872</td>
<td>132,216</td>
<td>1,429,195</td>
<td>489,927</td>
<td>1,252,971</td>
<td>715,190</td>
<td>873,694</td>
<td>1,215,914</td>
<td>1,654,757</td>
<td>865,139</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barron</td>
<td>110001D</td>
<td>604,729</td>
<td>165,896</td>
<td>113,639</td>
<td>950,207</td>
<td>383,440</td>
<td>745,781</td>
<td>413,328</td>
<td>1,606,907</td>
<td>772,722</td>
<td>500,756</td>
<td>1,924,506</td>
</tr>
<tr>
<td></td>
<td>Mulgrave</td>
<td>111007A</td>
<td>751,149</td>
<td>183,890</td>
<td>333,262</td>
<td>1,132,755</td>
<td>937,024</td>
<td>738,709</td>
<td>930,657</td>
<td>670,019</td>
<td>680,091</td>
<td>1,422,790</td>
<td>1,011,734</td>
</tr>
<tr>
<td></td>
<td>Russell</td>
<td>111101D</td>
<td>1,193,577</td>
<td>433,936</td>
<td>615,927</td>
<td>1,345,241</td>
<td>990,735</td>
<td>1,280,589</td>
<td>1,281,621</td>
<td>1,088,458</td>
<td>1,221,231</td>
<td>1,806,202</td>
<td>1,166,997</td>
</tr>
<tr>
<td></td>
<td>North Johnstone</td>
<td>1112004A</td>
<td>1,746,102</td>
<td>657,456</td>
<td>819,663</td>
<td>2,304,375</td>
<td>1,447,193</td>
<td>2,155,313</td>
<td>2,071,610</td>
<td>1,858,252</td>
<td>1,925,821</td>
<td>1,825,452</td>
<td>3,551,393</td>
</tr>
<tr>
<td></td>
<td>South Johnstone</td>
<td>1112101B</td>
<td>820,304</td>
<td>345,067</td>
<td>311,763</td>
<td>1,208,802</td>
<td>1,442,044</td>
<td>3,283,940</td>
<td>2,200,706</td>
<td>3,624,289</td>
<td>3,949,123</td>
<td>3,195,153</td>
<td>3,596,264</td>
</tr>
<tr>
<td></td>
<td>Tully</td>
<td>1131006A</td>
<td>3,074,666</td>
<td>1,208,802</td>
<td>1,442,044</td>
<td>3,283,940</td>
<td>2,200,706</td>
<td>3,624,289</td>
<td>3,949,123</td>
<td>3,195,153</td>
<td>3,596,264</td>
<td>3,087,403</td>
<td>6,094,549</td>
</tr>
<tr>
<td>Burdekin</td>
<td>Burdekin</td>
<td>120006B</td>
<td>5,982,681</td>
<td>4,485,315</td>
<td>2,092,834</td>
<td>1,516,191</td>
<td>4,328,245</td>
<td>2,199,744</td>
<td>9,768,935</td>
<td>27,502,704</td>
<td>29,951,685</td>
<td>7,947,563</td>
<td>34,602,113</td>
</tr>
<tr>
<td>Mackay</td>
<td>Proserpine</td>
<td>122005A</td>
<td>17,140</td>
<td>19,969</td>
<td>18,583</td>
<td>10,350</td>
<td>23,782</td>
<td>20,393</td>
<td>44,740</td>
<td>76,447</td>
<td>65,556</td>
<td>52,341</td>
<td>349,085</td>
</tr>
<tr>
<td></td>
<td>O'Connell</td>
<td>124001B</td>
<td>145,351</td>
<td>85,202</td>
<td>23,236</td>
<td>75,989</td>
<td>84,267</td>
<td>168,513</td>
<td>229,994</td>
<td>165,637</td>
<td>313,605</td>
<td>574,154</td>
<td>281,409</td>
</tr>
<tr>
<td></td>
<td>Pioneer</td>
<td>125007A</td>
<td>355,228</td>
<td>218,366</td>
<td>111,589</td>
<td>44,939</td>
<td>196,084</td>
<td>72,633</td>
<td>716,235</td>
<td>1,300,252</td>
<td>822,925</td>
<td>1,190,449</td>
<td>3,044,648</td>
</tr>
<tr>
<td>Fitzroy</td>
<td>Fitzroy</td>
<td>130005A</td>
<td>2,754,600</td>
<td>581,373</td>
<td>221,477</td>
<td>136,959</td>
<td>69,506</td>
<td>29,880</td>
<td>17,155</td>
<td>23,138</td>
<td>1,034,804</td>
<td>7,081,587</td>
<td>562,482</td>
</tr>
<tr>
<td>Burnett Mary</td>
<td>Burnett</td>
<td>136007A</td>
<td>n/a</td>
<td>106,888</td>
<td>523,464</td>
<td>221,477</td>
<td>136,959</td>
<td>69,506</td>
<td>29,880</td>
<td>17,155</td>
<td>23,138</td>
<td>1,034,804</td>
<td>7,081,587</td>
</tr>
</tbody>
</table>

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.
### Table 22 Low Isles, Wet Tropics region – Concentration in water (ng.L⁻¹)

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampler Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PSII-HEq (ng/L)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>START</td>
<td>END</td>
<td>Amitryn</td>
<td>Atrazine</td>
<td>DE Atrazine</td>
<td>DJ Atrazine</td>
</tr>
<tr>
<td>May 11</td>
<td>06-May-11</td>
<td>04-Jul-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.15</td>
<td>n.d.</td>
</tr>
<tr>
<td>Jun 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>06-May-11</td>
<td>04-Jul-11</td>
<td>ED</td>
<td>0.05</td>
<td>0.49</td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>04-Jul-11</td>
<td>05-Sep-11</td>
<td>ED</td>
<td>0.01</td>
<td>0.04</td>
<td>n.d.</td>
</tr>
<tr>
<td>Aug 11</td>
<td>05-Sep-11</td>
<td>04-Nov-11</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep 11</td>
<td>05-Sep-11</td>
<td>04-Nov-11</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 11</td>
<td>04-Nov-11</td>
<td>27-Nov-11</td>
<td>ED</td>
<td>0.06</td>
<td>0.38</td>
<td>n.d.</td>
</tr>
<tr>
<td>Dec 11</td>
<td>27-Nov-11</td>
<td>16-Jan-12</td>
<td>ED</td>
<td>0.03</td>
<td>0.11</td>
<td>n.d.</td>
</tr>
<tr>
<td>Jan 12</td>
<td>16-Jan-12</td>
<td>10-Feb-12</td>
<td>ED</td>
<td>n.d.</td>
<td>0.52</td>
<td>n.d.</td>
</tr>
<tr>
<td>Feb 12</td>
<td>10-Feb-12</td>
<td>29-Feb-12</td>
<td>ED</td>
<td>0.29</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Mar 12</td>
<td>29-Feb-12</td>
<td>12-Apr-12</td>
<td>ED</td>
<td>0.05</td>
<td>0.17</td>
<td>n.d.</td>
</tr>
<tr>
<td>Apr 12</td>
<td>12-Apr-12</td>
<td>08-May-12</td>
<td>ED</td>
<td>0.03</td>
<td>0.15</td>
<td>n.d.</td>
</tr>
</tbody>
</table>

**ED Summary**

<table>
<thead>
<tr>
<th>Samples (n)</th>
<th>9</th>
<th>9</th>
<th>9</th>
<th>9</th>
<th>9</th>
<th>9</th>
<th>9</th>
<th>9</th>
<th>9</th>
<th>5</th>
<th>9</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detects (n)</td>
<td>6</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>% Detects</td>
<td>67%</td>
<td>89%</td>
<td>0%</td>
<td>11%</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>11%</td>
<td>56%</td>
<td>100%</td>
<td>0%</td>
</tr>
</tbody>
</table>

| 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. | 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. | 0.10 | 0.15 | n.d. |
| Max/ min ratio | 5.3  | 13.6 | -   | 12.3 | -   | 12.2 | -   | 16.0| 10.0 | -   | 10.7 | -   | -   | -   | -   |

*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)

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Samples Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PSII-HEq (ng/L)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Amitryn</td>
<td>Atrazine</td>
<td>DiAtrazine</td>
<td>Duuron</td>
</tr>
<tr>
<td>May 11</td>
<td>LOST</td>
<td>ED</td>
<td>0.38</td>
<td>0.14</td>
<td>0.10</td>
<td>0.21</td>
</tr>
<tr>
<td>Jun 11</td>
<td></td>
<td></td>
<td>0.03</td>
<td>0.08</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Aug 11</td>
<td></td>
<td></td>
<td>0.01</td>
<td>0.01</td>
<td>0.27</td>
<td>0.08</td>
</tr>
<tr>
<td>Sep 11</td>
<td>31-Aug-11</td>
<td>05-Nov-11</td>
<td>ED</td>
<td>0.06</td>
<td>0.64</td>
<td>0.38</td>
</tr>
<tr>
<td>Oct 11</td>
<td></td>
<td></td>
<td>0.41</td>
<td>0.38</td>
<td>0.38</td>
<td>0.48</td>
</tr>
<tr>
<td>Nov 11</td>
<td>05-Nov-11</td>
<td>30-Nov-11</td>
<td>ED</td>
<td>0.33</td>
<td>0.95</td>
<td>2.2</td>
</tr>
<tr>
<td>Dec 11</td>
<td>30-Nov-11</td>
<td>01-Jan-12</td>
<td>ED</td>
<td>0.07</td>
<td>1.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Jan 12</td>
<td>01-Jan-12</td>
<td>02-Feb-12</td>
<td>ED</td>
<td>0.02</td>
<td>0.53</td>
<td>1.1</td>
</tr>
<tr>
<td>Feb 12</td>
<td>02-Feb-12</td>
<td>03-Mar-12</td>
<td>PDMS</td>
<td>0.33</td>
<td>0.33</td>
<td>2.2</td>
</tr>
<tr>
<td>Mar 12</td>
<td>03-Mar-12</td>
<td>03-Apr-12</td>
<td>PDMS</td>
<td>0.07</td>
<td>1.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Apr 12</td>
<td>03-Apr-12</td>
<td>05-May-12</td>
<td>PDMS</td>
<td>0.02</td>
<td>0.53</td>
<td>1.1</td>
</tr>
</tbody>
</table>

**ED Summary**

<table>
<thead>
<tr>
<th>Samples (n)</th>
<th>Detects (n)</th>
<th>% Detects</th>
<th>Minimum concentration</th>
<th>Average concentration</th>
<th>Maximum concentration</th>
<th>Max/ min ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>4</td>
<td>50%</td>
<td>0.01</td>
<td>0.04</td>
<td>0.07</td>
<td>13.3</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>37.5%</td>
<td>0.03</td>
<td>0.36</td>
<td>1.0</td>
<td>29.5</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>12.5%</td>
<td>0.01</td>
<td>0.22</td>
<td>0.33</td>
<td>6.4</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.12</td>
<td>0.95</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.11</td>
<td>0.17</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.13</td>
<td>0.28</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.10</td>
<td>0.17</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.15</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.20</td>
<td>0.15</td>
<td>-</td>
</tr>
</tbody>
</table>

**PDMS Summary**

<table>
<thead>
<tr>
<th>Samples (n)</th>
<th>Detects (n)</th>
<th>% Detects</th>
<th>Minimum concentration</th>
<th>Average concentration</th>
<th>Maximum concentration</th>
<th>Max/ min ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.04</td>
<td>0.07</td>
<td>13.3</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.36</td>
<td>1.0</td>
<td>29.5</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.22</td>
<td>0.33</td>
<td>6.4</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.12</td>
<td>0.95</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.11</td>
<td>0.17</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.13</td>
<td>0.28</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.10</td>
<td>0.15</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.15</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0%</td>
<td>0.01</td>
<td>0.20</td>
<td>0.15</td>
<td>-</td>
</tr>
</tbody>
</table>

*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)

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampler Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>START</td>
<td>END</td>
<td>Antrazin</td>
<td>Atrazine</td>
<td>DE Atrazine</td>
</tr>
<tr>
<td>May 11</td>
<td>14-May-11</td>
<td>08-Jul-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.29</td>
</tr>
<tr>
<td>Jul 11</td>
<td>08-Jul-11</td>
<td>02-Sep-11</td>
<td>ED</td>
<td>0.01</td>
<td>0.32</td>
</tr>
<tr>
<td>Nov 11</td>
<td>11-Nov-11</td>
<td>06-Jan-12</td>
<td>ED</td>
<td>0.08</td>
<td>0.76</td>
</tr>
<tr>
<td>Apr 12</td>
<td>02-Apr-12</td>
<td>05-May-12</td>
<td>PDMS</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
</tbody>
</table>

**ED Summary**

<table>
<thead>
<tr>
<th>Samples (n)</th>
<th>Detects (n)</th>
<th>% Detects</th>
<th>Minimum concentration</th>
<th>Average concentration</th>
<th>Maximum concentration</th>
<th>Max/ min ratio</th>
<th>PDMS Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>0.29</td>
<td>0.09</td>
<td>0.00</td>
<td>0.36</td>
<td>0.06</td>
<td>0.27</td>
<td>0.52</td>
</tr>
<tr>
<td>0.04</td>
<td>0.47</td>
<td>0.16</td>
<td>n.d.</td>
<td>1.5</td>
<td>0.49</td>
<td>0.09</td>
<td>0.34</td>
</tr>
<tr>
<td>0.08</td>
<td>0.76</td>
<td>0.15</td>
<td>n.d.</td>
<td>3.9</td>
<td>1.4</td>
<td>0.13</td>
<td>0.34</td>
</tr>
<tr>
<td>7.8</td>
<td>2.6</td>
<td>1.6</td>
<td>-</td>
<td>10.8</td>
<td>-</td>
<td>2.1</td>
<td>1.3</td>
</tr>
<tr>
<td>5.5</td>
<td>5.5</td>
<td>3.5</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*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>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampler Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ametryn</td>
<td>Atrazine</td>
<td>Di Atrazine</td>
</tr>
<tr>
<td>May 11</td>
<td>NO RESULTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun 11</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul 11</td>
<td>20-Jul-11 - 12-Sep-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.07</td>
<td>n.d.</td>
</tr>
<tr>
<td>Aug 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep 11</td>
<td>NO RESULTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 11</td>
<td>LOST</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 12</td>
<td>NO RESULTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb 12</td>
<td>LOST</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar 12</td>
<td>06-Mar-12 - 23-Apr-12</td>
<td>ED</td>
<td>0.12</td>
<td>0.30</td>
<td>n.d.</td>
</tr>
<tr>
<td>Apr-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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 4 4 4 4
- **Detects (n):** 0 0 0 0 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 0 0 0 0
- **Max/ min ratio:** - - - - - - - - - - - - - - - -

*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>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampling Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PSII-HEq (ng/L)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 11</td>
<td>09-May-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.35</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>04-Jul-11</td>
<td></td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>09-Sep-11</td>
<td></td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>05-Nov-11</td>
<td></td>
<td>0.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Jan-12</td>
<td></td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Feb-12</td>
<td></td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>02-Mar-12</td>
<td></td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>04-May-12</td>
<td></td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>02-Jun-12</td>
<td></td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>04-Jul-12</td>
<td></td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 11</td>
<td>04-Jul-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.50</td>
<td>n.d.</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>09-Sep-11</td>
<td></td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>05-Nov-11</td>
<td></td>
<td>0.33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Jan-12</td>
<td></td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Feb-12</td>
<td></td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>02-Mar-12</td>
<td></td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>04-May-12</td>
<td></td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug 11</td>
<td>09-Sep-11</td>
<td>ED</td>
<td>n.d.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>05-Nov-11</td>
<td></td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Jan-12</td>
<td></td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Feb-12</td>
<td></td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>02-Mar-12</td>
<td></td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>04-May-12</td>
<td></td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep 11</td>
<td>09-Sep-11</td>
<td>ED</td>
<td>0.08</td>
<td></td>
<td></td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>05-Nov-11</td>
<td></td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Jan-12</td>
<td></td>
<td>0.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Feb-12</td>
<td></td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>02-Mar-12</td>
<td></td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>04-May-12</td>
<td></td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct 11</td>
<td>09-Sep-11</td>
<td>ED</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 11</td>
<td>05-Nov-11</td>
<td>ED</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 11</td>
<td>02-Dec-11</td>
<td>ED</td>
<td>0.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Jan-12</td>
<td></td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Feb-12</td>
<td></td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>02-Mar-12</td>
<td></td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>04-May-12</td>
<td></td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 11</td>
<td>02-Dec-11</td>
<td>ED</td>
<td>0.33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 11</td>
<td>01-Jan-12</td>
<td>ED</td>
<td>0.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>01-Feb-12</td>
<td></td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>02-Mar-12</td>
<td></td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>04-May-12</td>
<td></td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 11</td>
<td>01-Feb-12</td>
<td>ED</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 12</td>
<td>01-Jan-12</td>
<td>ED</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb 11</td>
<td>01-Feb-12</td>
<td>ED</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar 12</td>
<td>02-Mar-12</td>
<td>ED</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>06-Apr-12</td>
<td>ED</td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>04-May-12</td>
<td>ED</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>02-Jun-12</td>
<td></td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>04-May-12</td>
<td></td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>02-Jun-12</td>
<td></td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>04-May-12</td>
<td></td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>02-Jun-12</td>
<td></td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ED Summary**

| Samples (n) | 9 | 9 | 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. | n.d. | 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. | n.d. | n.d. | 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. | n.d. | n.d. | 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 | - |   |   |   |   |   |

* 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>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampler Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hemibromacil</td>
<td>Terbutryn</td>
<td>Metolachlor</td>
</tr>
<tr>
<td>May 11-Jun 11</td>
<td>06-May-11 04-Jul-11</td>
<td>ED</td>
<td>0.03 0.94 0.15 n.d. 2.4 n.d. 0.33 n.d. 0.08 0.64</td>
<td>2.8 n.d. n.d. 0.13 N/A n.d.</td>
<td></td>
</tr>
<tr>
<td>Jul 11-Aug 11</td>
<td>04-Jul-11 01-Sep-11</td>
<td>ED</td>
<td>0.03 0.40 n.d. n.d. 1.6 n.d. 0.16 n.d. 0.07 0.32</td>
<td>1.8 n.d. n.d. 0.06 N/A n.d.</td>
<td></td>
</tr>
<tr>
<td>Sep 11-Oct 11</td>
<td>01-Sep-11 03-Nov-11</td>
<td>ED</td>
<td>0.01 0.11 n.d. n.d. 0.84 n.d. 0.04 n.d. 0.01 0.07</td>
<td>0.89 n.d. n.d. 0.02 N/A n.d.</td>
<td></td>
</tr>
<tr>
<td>Nov 11-Dec 11</td>
<td>03-Nov-11 01-Dec-11</td>
<td>ED</td>
<td>n.d. 0.29 0.05 n.d. 2.6 n.d. 0.04 n.d. 0.03 0.06</td>
<td>2.7 n.d. n.d. 0.01 N/A n.d.</td>
<td></td>
</tr>
<tr>
<td>Dec 11-Jan 12</td>
<td>01-Dec-11 04-Jan-12</td>
<td>ED</td>
<td>n.d. 0.40 n.d. n.d. 3.3 n.d. 0.04 n.d. 0.05 0.04</td>
<td>3.4 n.d. n.d. 0.01 n.d.</td>
<td></td>
</tr>
<tr>
<td>Jan 12-Feb 12</td>
<td>05-Feb-12 05-Mar-12</td>
<td>ED</td>
<td>n.d. 2.2 0.49 0.14 2.6 n.d. 0.18 n.d. 0.21 0.19</td>
<td>3.2 n.d. n.d. 0.06 n.d.</td>
<td></td>
</tr>
<tr>
<td>Feb 12-Mar 12</td>
<td>05-Mar-12 02-Apr-12</td>
<td>ED</td>
<td>0.05 1.3 0.37 n.d. 2.0 n.d. 0.19 n.d. 0.07 0.72</td>
<td>2.4 n.d. n.d. 0.08 n.d.</td>
<td></td>
</tr>
<tr>
<td>Mar 12-Apr 12</td>
<td>02-Apr-12 05-May-12</td>
<td>ED</td>
<td>0.02 0.99 0.25 n.d. 2.8 n.d. 0.29 n.d. 0.06 0.63</td>
<td>3.2 n.d. n.d. 0.07 n.d.</td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- **PSII-HEq (ng/L):** Photochemical degradation products of PSII herbicides that are included in the index.
- **PSII-HEq (ng/L):** Photochemical degradation products of PSII herbicides that are not included in the index.
- **Other Herbicides:** Bromacil, Terbutryn, Metolachlor, Imazapic, Imidacloprid, Galaxolide, Tonalid.
- **Insecticides and other:** Atrazine, Atrazine (DE), Atrazine (DI), Diuron, Flumeturon, Hexazinone, Prometryn, Simazine, Tebuthiuron, Ametryn, Bromacil, Metolachlor, Imazapic, Imidacloprid.
- **Samples (n):** Number of samples analyzed.
- **Max/ min ratio:** Maximum concentration divided by minimum concentration.
- **ED Summary:** Detection summary for each sampling period.
- **PDMS Summary:** PDMS summary for each sampling period.

*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\(^{-1}\))

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sample Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>START</td>
<td>END</td>
<td>Atrazine</td>
<td>DE Atrazine</td>
<td>Di Atrazine</td>
</tr>
<tr>
<td>May 11</td>
<td>05-May-11</td>
<td>01-Jul-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.67</td>
</tr>
<tr>
<td>Jun 11</td>
<td>01-Jul-11</td>
<td>30-Aug-11</td>
<td>ED</td>
<td>0.11</td>
<td>0.93</td>
</tr>
<tr>
<td>Jul 11</td>
<td>01-Jul-11</td>
<td>03-Nov-11</td>
<td>ED</td>
<td>0.03</td>
<td>0.37</td>
</tr>
<tr>
<td>Aug 11</td>
<td>30-Aug-11</td>
<td>03-Nov-11</td>
<td>ED</td>
<td>0.04</td>
<td>0.47</td>
</tr>
<tr>
<td>Sep 11</td>
<td>07-Dec-11</td>
<td>16-Feb-12</td>
<td>ED</td>
<td>0.27</td>
<td>15</td>
</tr>
<tr>
<td>Oct 11</td>
<td>07-Dec-11</td>
<td>29-Feb-12</td>
<td>ED</td>
<td>0.18</td>
<td>5.9</td>
</tr>
<tr>
<td>Nov 11</td>
<td>03-Nov-11</td>
<td>03-Apr-12</td>
<td>ED</td>
<td>0.12</td>
<td>3.4</td>
</tr>
<tr>
<td>Dec 11</td>
<td>03-Apr-12</td>
<td>03-May-12</td>
<td>ED</td>
<td>0.02</td>
<td>0.99</td>
</tr>
<tr>
<td>ED Summary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Samples (n)</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Detects (n)</td>
<td>7</td>
<td>8</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>% Detects</td>
<td>88</td>
<td>100</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Minimum concentration</td>
<td>0.02</td>
<td>0.37</td>
<td>0.59</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Average concentration</td>
<td>0.11</td>
<td>3.5</td>
<td>1.6</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>Maximum concentration</td>
<td>0.27</td>
<td>15</td>
<td>2.6</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>Max/ min ratio</td>
<td>13.5</td>
<td>41.2</td>
<td>4.5</td>
<td>27.7</td>
</tr>
<tr>
<td>PDMS Summary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Samples (n)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Detects (n)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>% Detects</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Minimum concentration</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Average concentration</td>
<td>n.d.</td>
<td>0.04</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>Maximum concentration</td>
<td>n.d.</td>
<td>0.40</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td></td>
<td>Max/ min ratio</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* 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. Atrazine was detected in a single PDMS deployment in December 2011, the concentration is an equilibrium estimate. N/A indicates not analysed in that particular sampler.
### Table 29: Pioneer Bay, Mackay Whitsunday – Concentrations in water (ng/L)

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampler Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PSII-HEq (ng/L)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ametryn</td>
<td>Atrazine</td>
<td>DE Atrazine</td>
<td>DJ Atrazine</td>
</tr>
<tr>
<td>Jun 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul 11</td>
<td>01-Jul-11</td>
<td>10-Sep-11</td>
<td>ED</td>
<td>0.06</td>
<td>0.33</td>
<td>n.d.</td>
</tr>
<tr>
<td>Sep 11</td>
<td>10-Sep-11</td>
<td>17-Nov-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.10</td>
<td>n.d.</td>
</tr>
<tr>
<td>Oct 11</td>
<td></td>
<td>10-Jan-12</td>
<td>ED</td>
<td>0.05</td>
<td>0.26</td>
<td>n.d.</td>
</tr>
<tr>
<td>Nov 11</td>
<td>17-Nov-11</td>
<td>10-Jan-12</td>
<td>ED</td>
<td>0.05</td>
<td>0.26</td>
<td>n.d.</td>
</tr>
<tr>
<td>Dec 11</td>
<td></td>
<td>10-Mar-12</td>
<td>ED</td>
<td>0.05</td>
<td>0.26</td>
<td>n.d.</td>
</tr>
<tr>
<td>Jan 12</td>
<td>10-Jan-12</td>
<td>10-Mar-12</td>
<td>ED</td>
<td>0.05</td>
<td>0.26</td>
<td>n.d.</td>
</tr>
<tr>
<td>Feb 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar 12</td>
<td>NOT SENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>10-Mar-12</td>
<td>03-Jun-12</td>
<td>ED</td>
<td>0.05</td>
<td>0.49</td>
<td>n.d.</td>
</tr>
</tbody>
</table>

**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 | 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 | - | - |

*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)

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampler Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ametryn</td>
<td>Atrazine</td>
<td>DE Atrazine</td>
</tr>
<tr>
<td>May 11</td>
<td>LOST</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun 11</td>
<td>NOT USED</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul 11</td>
<td>NOT USED</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug 11</td>
<td>NOT USED</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep 11</td>
<td>NOT USED</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 11</td>
<td>02-Nov-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.16</td>
<td>n.d.</td>
</tr>
<tr>
<td>Dec 11</td>
<td>LOST IN TRANSIT</td>
<td>ED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 12</td>
<td>06-Jan-12</td>
<td>PDMS</td>
<td>n.d.</td>
<td>1.0</td>
<td>n.d.</td>
</tr>
<tr>
<td>Feb 12</td>
<td>06-Feb-12</td>
<td>PDMS</td>
<td>0.05</td>
<td>1.4</td>
<td>0.16</td>
</tr>
<tr>
<td>Mar 12</td>
<td>10-Mar-12</td>
<td>PDMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr 12</td>
<td>LOST</td>
<td>PDMS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ED Summary**

<table>
<thead>
<tr>
<th>Samples (n)</th>
<th>Detects (n)</th>
<th>% Detects</th>
<th>Minimum concentration</th>
<th>Average concentration</th>
<th>Maximum concentration</th>
<th>Max/ min ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td></td>
<td>0.05</td>
<td>1.2</td>
<td>0.05</td>
<td>15.8</td>
</tr>
</tbody>
</table>

**PDMS Summary**

<table>
<thead>
<tr>
<th>Samples (n)</th>
<th>Detects (n)</th>
<th>% Detects</th>
<th>Minimum concentration</th>
<th>Average concentration</th>
<th>Maximum concentration</th>
<th>Max/ min ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td></td>
<td>0.05</td>
<td>1.2</td>
<td>0.05</td>
<td>15.8</td>
</tr>
</tbody>
</table>

*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>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampler Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>START</strong></td>
<td><strong>END</strong></td>
<td><strong>PSII Herbicides (Included in Index)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ametryn</td>
</tr>
<tr>
<td>May 11</td>
<td>06-May-11</td>
<td>04-Jul-11</td>
</tr>
<tr>
<td>Jun 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul 11</td>
<td>04-Jul-11</td>
<td>01-Sep-11</td>
</tr>
<tr>
<td>Aug 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep 11</td>
<td>01-Sep-11</td>
<td>04-Nov-11</td>
</tr>
<tr>
<td>Oct 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 11</td>
<td>04-Nov-11</td>
<td>09-Dec-11</td>
</tr>
<tr>
<td>Dec 11</td>
<td>09-Dec-11</td>
<td>05-Jan-12</td>
</tr>
<tr>
<td>Jan 12</td>
<td>05-Jan-12</td>
<td>09-Feb-12</td>
</tr>
<tr>
<td>Feb 12</td>
<td>09-Feb-12</td>
<td>03-Mar-12</td>
</tr>
<tr>
<td>Mar 12</td>
<td>03-Mar-12</td>
<td>03-Apr-12</td>
</tr>
<tr>
<td>Apr 12</td>
<td>03-Apr-12</td>
<td>06-May-12</td>
</tr>
<tr>
<td><strong>ED Summary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Samples (n)</strong></td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td><strong>Detects (n)</strong></td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td><strong>% Detects</strong></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Minimum concentration</strong></td>
<td>0.01</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Average concentration</strong></td>
<td>0.11</td>
<td>2.7</td>
</tr>
<tr>
<td><strong>Maximum concentration</strong></td>
<td>0.30</td>
<td>10</td>
</tr>
<tr>
<td><strong>Max/ min ratio</strong></td>
<td>29.6</td>
<td>101.8</td>
</tr>
</tbody>
</table>

*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)

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Deployment Dates</th>
<th>Sampler Type</th>
<th>PSII Herbicides (Included in Index)</th>
<th>Other Herbicides (Not indexed)</th>
<th>Insecticides and other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>PSII-HEq (ng/L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ametryn</td>
<td>Atrazine</td>
<td>DE Atrazine</td>
</tr>
<tr>
<td>May 11</td>
<td>08-Apr-11</td>
<td>ED</td>
<td>0.05</td>
<td>0.73</td>
<td>0.05</td>
</tr>
<tr>
<td>Jul 11</td>
<td>05-Jul-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.05</td>
<td>n.d.</td>
</tr>
<tr>
<td>Aug 11</td>
<td>04-Oct-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.05</td>
<td>n.d.</td>
</tr>
<tr>
<td>Oct 11</td>
<td>07-Oct-11</td>
<td>ED</td>
<td>n.d.</td>
<td>0.08</td>
<td>n.d.</td>
</tr>
<tr>
<td>Dec 11</td>
<td>09-Jan-12</td>
<td>ED</td>
<td>0.02</td>
<td>0.05</td>
<td>n.d.</td>
</tr>
<tr>
<td>Jan 12</td>
<td>06-Feb-12</td>
<td>ED</td>
<td>0.13</td>
<td>1.6</td>
<td>0.13</td>
</tr>
<tr>
<td>Feb 12</td>
<td>05-Mar-12</td>
<td>ED</td>
<td>0.05</td>
<td>1.6</td>
<td>0.24</td>
</tr>
<tr>
<td>Mar 12</td>
<td>13-Apr-12</td>
<td>ED</td>
<td>0.03</td>
<td>0.27</td>
<td>0.03</td>
</tr>
<tr>
<td>Apr 12</td>
<td>29-May-12</td>
<td>ED</td>
<td>0.03</td>
<td>0.27</td>
<td>0.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ED Summary</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Samples (n)</td>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Detects (n)</td>
<td></td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>% Detects</td>
<td></td>
<td>50</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Minimum concentration</td>
<td></td>
<td>0.02</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Average concentration</td>
<td></td>
<td>0.06</td>
<td>0.50</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Maximum concentration</td>
<td></td>
<td>0.13</td>
<td>1.6</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>Max/ min ratio</td>
<td></td>
<td>5.5</td>
<td>32.4</td>
<td>9.5</td>
</tr>
</tbody>
</table>

*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 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

<table>
<thead>
<tr>
<th>Date Deployed/Collected</th>
<th>Date Retrieved</th>
<th>Time</th>
<th>Site</th>
<th>Sampler Type</th>
<th>Latitude</th>
<th>Longitude</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PSII-HEq (ng.L(^{-1}))</th>
<th>Other Herbicides (Not indexed)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Amaryn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Atrazine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Di Atrazine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Diuron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Flumeturon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hexazinone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Prometryn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Simazine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tebufluron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bromacil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Terbutryn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Metolachlor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Imazapic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Imidacloprid</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Date Deployed/Collected</th>
<th>Date Retrieved</th>
<th>Time</th>
<th>Site</th>
<th>Sampler Type</th>
<th>Latitude</th>
<th>Longitude</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PSII-HEq (ng.L(^{-1}))</th>
<th>Other Herbicides (Not indexed)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Amaryn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Atrazine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Di Atrazine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Diuron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Flumeturon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hexazinone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Prometryn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Simazine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tebufluron</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deployment 3 and 4 were damaged in the field and were not able to be extracted.
<table>
<thead>
<tr>
<th>Catchment</th>
<th>Transect</th>
<th>Date Deployed/Retrieved</th>
<th>Time</th>
<th>Site</th>
<th>Sampler Type</th>
<th>Latitude</th>
<th>Longitude</th>
<th>PSII Herbicides (Included in Index)</th>
<th>PSII-Heq (ng.L⁻¹)</th>
<th>Other Herbicides (Not Indexed)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbert</td>
<td>Southern</td>
<td>29-Nov-11/20-Dec-12</td>
<td>10:55:00</td>
<td>South Site 2 (Passive Site 3)</td>
<td>ED</td>
<td>-18.494</td>
<td>146.318</td>
<td>2.2 9.0 0.80 0.32 40 n.d. 9.2 0.00 3.2 0.08</td>
<td>50</td>
<td>0.32 0.04 0.85 n.d. 0.47</td>
<td></td>
</tr>
<tr>
<td>Herbert</td>
<td>Southern</td>
<td>21-Jan-12/13-Feb-12</td>
<td>6:30:00</td>
<td>South Site 2 (Passive Site 3)</td>
<td>GRAB</td>
<td>-18.494</td>
<td>146.318</td>
<td>n.d. n.d. n.d. n.d. 16 n.d. 4.9 n.d. 0.42 n.d.</td>
<td>19</td>
<td>n.d. n.d. 0.24 n.d. 0.99</td>
<td></td>
</tr>
<tr>
<td>Herbert</td>
<td>Southern</td>
<td>06-Mar-12/30-Mar-12</td>
<td>11:40:00</td>
<td>South Site 2 (Passive Site 3)</td>
<td>ED</td>
<td>-18.494</td>
<td>146.318</td>
<td>0.19 0.76 0.21 n.d. 9.9 n.d. 2.2 n.d. 0.09 0.14</td>
<td>11</td>
<td>n.d. n.d. 0.13 0.08 0.71</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Transect</th>
<th>Date</th>
<th>Time</th>
<th>Site Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Ametryn</th>
<th>Atrazine</th>
<th>DE Atrazine</th>
<th>DI Atrazine</th>
<th>Diuron</th>
<th>Fluometuron</th>
<th>Hexazinone</th>
<th>Prometryn</th>
<th>Simazine</th>
<th>Tebuhiuron</th>
<th>PSII-HEq (ng.L(^{-1}))</th>
<th>Other Herbicides (Not indexed)</th>
<th>Other</th>
<th>Other</th>
<th>Other</th>
</tr>
</thead>
</table>
**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)
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