Australian Government

Australian Pesticides and Veterinary Medicines Authority

DIURON

REVIEW FINDINGS REPORT

The reconsideration of the registrations of selected products containing diuron and their associated labels

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FOREWORD

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is an independent statutory authority with responsibility for the regulation of agricultural and veterinary chemicals in Australia. Its statutory powers are provided in the Agvet Codes scheduled to the *Agricultural and Veterinary Chemicals Code Act 1994*.

The APVMA can reconsider the approval of an active constituent, the registration of a chemical product or the approval of a label for a container for a chemical product at any time. This is outlined in Part 2, Division 4 of the Agvet Codes.

A reconsideration may be initiated when new research or evidence has raised concerns about the use or safety of a particular chemical, a product containing that chemical, or its label.

The reconsideration process includes a call for information from a variety of sources, a review of that information and, following public consultation, a decision about the future use of the chemical or product. The information and technical data required by the APVMA to review the safety of new and existing chemical products must be derived according to accepted scientific principles, as must the methods of assessment undertaken.

In undertaking reconsiderations (referred to as reviews hereafter), the APVMA works in close cooperation with advisory agencies including the Office of Chemical Safety and Environmental Health (OCSEH) within the Department of Health and Ageing, the Department of Sustainability, Environment, Water, Heritage and the Arts (DSEWPaC), and state and territory departments of agriculture, as well as other expert advisers as appropriate.

The APVMA has a policy of encouraging openness and transparency in its activities and community involvement in decision-making. The publication of review reports is a part of this process. The APVMA also makes these reports available to the regulatory agencies of other countries as part of bilateral agreements. The APVMA recommends that countries receiving these reports will not utilise them for registration purposes unless they are also provided with the raw data from the relevant applicant.

The basis for the current reconsideration is whether the APVMA is satisfied that continued use of products containing diuron in accordance with the instructions for their use:

- would not be likely to have an effect that is harmful to human beings
- would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment.

The APVMA also considered whether product labels carry adequate instructions and warning statements.

The review of diuron active constituents, and the registration of products intended for use as cotton defoliants, anti-fouling paints, pond and aquarium products was completed in March 2012. At this time approvals of active constituents were affirmed, cotton defoliant labels were varied and registration was subsequently affirmed, and the registration and associated label approvals for anti-fouling paints, aquarium and pond products were affirmed.

These conclusions were based on the published environmental and human health reports which identified no risk to the environment or human health from continued registration and approval in these situations. No further consideration was given in this assessment to these active constituents or products.

This *Diuron Review Findings Report: The reconsideration of the registrations of selected products containing diuron and their associated labels* relates to all products containing diuron whose continued registrations are subject to the outcomes of the review. This report should be read in conjunction with Volumes 1–4 of the diuron technical assessment reports prepared by DSEWPaC:

- Supplementary Environmental Assessment Report: Technical Report Volume 1 – *Overview*
- Supplementary Environmental Assessment Report: Technical Report Volume 2 – *Runoff risk assessment*
- Supplementary Environmental Assessment Report: Technical Report Volume 3 – *Assessment of additional data*
- Supplementary Environmental Assessment Report: Technical Report Volume 4 – *Responses to submissions.*

The review's findings and regulatory decisions are based on information collected from a variety of sources. The information and technical data required by the APVMA to review the safety of new and existing chemical products must be derived according to accepted scientific principles, as must the methods of assessment undertaken.

This Review Findings Report and associated technical assessment reports are available from the APVMA website at www.apvma.gov.au/products/review/index.php.

ACRONYMS AND ABBREVIATIONS

Time

d	Day
h	Hour
min	Minute
mo	Month
wk	Week
yr	Year

Length

cm	Centimetre
m	Metre
mm	Millimetre

Volume

L	Litre
mL	Millilitre
µL	Microlitre

Weight

Bw	Body weight
G	Gram
Kg	Kilogram
Mg	Microgram
Mg	Milligram
Wt	Weight

Concentration

Ppb	Parts per billion
Ppm	Parts per million

Chemistry

DCPMU	N'-(3,4-dichlorophenyl)-N-methyl urea
DMSO	Dimethyl sulfoxide
GC	Gas chromatography
GLC	Gas liquid chromatography
HPLC	High pressure liquid chromatography
LSC	Liquid scintillation counter
M-CPDMU	3-(3-chlorophenyl)-1,1-dimethyl urea
MCS	Minimum compositional standard
MS	Mass spectrometry
RIA	Radioimmunoassay
TCAB	3,3,4,4-tetrachloroazobenzene
TCAOB	3,3,4,4-tetrachloroazoxybenzene

Terminology

AC	Active Constituent
ADI	Acceptable Daily Intake

ARfD	Acute Reference Dose
DF	Dry Flowables
DT50	Time for 50% of the substance to dissipate
E_BC50	The concentration of a test substance resulting in a 50% inhibition of biomass in an algal test
EC25	The concentration of a test substance resulting in an effect on 25% of the test species.
EC50	The concentration of a test substance resulting in an effect on 50% of the test species.
E_RC50	The concentration of a test substance resulting in a 50% inhibition of growth rate in an algal test
G	Granules
GLP	Good Laboratory Practice
HA	Hectare
KD	Soil Sorption Constant
KOC	Soil Sorption/desorption Coefficient, normalised to organic carbon content
LC50	Lethal Concentration (for example, in water, food or soil) resulting in a 50% mortality of the test organism.
LD50	Lethal Dose (oral) [the dose resulting in a 50% mortality of the test organism]
LOD	Limit Of Detection
LOEC	Lowest Observed Effect Concentration ie the test concentration at which some effect occurs
LOEL	Lowest Observed Effect Level
LOQ	Limit Of Quantification
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration ie the test concentration at which no effect is observed
NOEL	No Observed Effect Level
OP	Organophosphorus Pesticide
SC	Suspension Concentrates
SP	Soluble Powders
SSD	Species Sensitivity Distribution
WDG	Water-Dispersible Granules
WP	Wettable Powders

Organisations and publications

APVMA	Australian Pesticides and Veterinary Medicines Authority
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (previously Department of the Environment and Heritage)
FAO	Food and Agriculture Organization of the UN

JMPR	Joint Meeting on Pesticide Residues
NRA	National Registration Authority for Agricultural and Veterinary Chemicals
OCSEH	Office of Chemical Safety and Environmental Health
OECD	Organisation for Economic Co-operation and Development
PRF report	Diuron Preliminary Review Findings report (APVMA, 2005)
SUSDP	Standard for the uniform scheduling of drugs and poisons
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

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Executive Summary

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has completed its review of selected products containing diuron and their associated approved labels.

Diuron is a broad-spectrum residual herbicide that has been registered in Australia for over 20 years. Diuron is used in agriculture for pre and post-emergent control of broadleaf and grass weeds in sugarcane, cotton, broadacre cereals (oats, wheat, barley, triticale), apples and pears, citrus and in tropical crops such as pineapples and bananas. It is used for weed control in irrigation channels and drainage ditches, around buildings, railway lines, sheds and driveways and for other industrial applications.

In 2002, diuron active constituent approvals, product registrations and associated label approvals were placed under review as part of the APVMA's Review Program. Specific concerns included the impacts of diuron on marine environments – specifically the Great Barrier Reef – and also on mangroves, coral and seagrass. There were also human health concerns associated with the toxicity of impurities in the active constituent.

In 2005, the APVMA released a *Diuron Preliminary Review Findings* (PRF) report which identified that current uses of diuron posed risks to the environment. Without significant changes to how these products were used (specifically a significant reduction in application rates) there was the potential for contamination of aquatic systems and adverse impacts on non-target aquatic and terrestrial organisms.

In 2011, the APVMA published human health assessment report and environmental assessment reports relevant to the review and at the same time proposed suspension of diuron products. These assessment reports considered information provided in response to the PRF report as well as the availability of new scientific information and international regulatory activity. The APVMA received over 100 submissions in response to these assessment reports.

In November 2011, the APVMA suspended the registration of selected diuron products, issuing new instructions for use during the period of suspension (PER 13198). The suspension was put in place to mitigate risks while new information was considered.

In March 2012, the APVMA completed its review of diuron in respect of active constituent approvals and the registration of diuron products intended for use as cotton defoliants, anti-fouling paints and pond and aquarium products. These conclusions were based on findings from the 2011 human health and environmental assessments. At the same time, the suspension for the remaining diuron products was continued as the assessment had not yet concluded.

Environmental assessment 2012

The Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) has examined the additional information provided for the review, revised the assessment in relation to diuron and has made recommendations to the APVMA for the continued use of diuron products in Australia.

This assessment considered earlier assessments of diuron along with new information addressing environmental fate and effects, information on use from users and results from environmental monitoring programs. Also considered were international assessments as well as information available in the public domain.

The 2012 assessment largely focused on the risk to aquatic organisms from runoff, which is the main concern with the use of diuron products. The overview and associated technical assessment reports prepared by DSEWPaC are attachments to this report.

The assessment concluded that continued use of diuron in many situations is likely to cause adverse effects to the environment, specifically aquatic ecosystems.

Final review outcomes 2012

On the basis of the findings contained in the 2012 DSEWPaC assessment, the following regulatory decisions apply to diuron product registrations and associated label approvals listed in Appendix A.

1. Vary conditions of label approval – to remove those uses no longer supported on environmental grounds and to include additional information where necessary (restraints and environmental warning statements).
2. Affirm product registrations (once variations have been made).
3. Cancel 'old' product label approvals – instructions on these labels are no longer considered adequate.
4. Cancel product registrations – where no uses on the label can be supported on the basis of unintended effects to the environment (13 products).

Tables 1 and 2 summarise the recommendations for each use pattern featured on diuron product labels.

Table 1: Supported uses

Situation	Recommendations 2012
Asparagus	Use on labels is currently "All States". The assessment has only considered information relating to the major production in Victoria. Use will be restricted to Victoria only via label instructions.
Bananas	Only the use on the label in combination with paraquat (lower rate 250 g ac/ha to 450 g ac/ha) is supported.
Bore drains	Continued use supported based on unique characteristics of the areas in which this use occurs.
Cotton	**Irrigated cotton only** – maximum rates of application (up to 1.8 kg ac/ha) are supported only when irrigation tailwater and up to 25 mm rainfall can be captured.
Irrigation channels, drainage ditches	Only where all water can be contained on farm.
Lupins	Continued use supported at rates of 900 g ac/ha.
Pulses – including chickpea, faba beans, lentils, naibon beans, field	Only supported where no-till farming practices are utilised (label statement required). Faba beans – only low rate of application supported post-sowing pre-

Situation	Recommendations 2012
peas, vetch	emergent.
Sugarcane	**Diuron-only products –** when used in combination with paraquat rates 250 g ac/ha up to 450 g ac/ha. **Diuron / hexazinone products –** only low rate of 250 g ac/ha supported and spot spraying.
Summer fallows	Only very low rate of application (0.25 kg ac/ha), continued use supported.
Wheat, barley, oats, triticale, cereal rye	All rates of application can continue.

Table 2: Uses not supported

Situation	Comments
Apples and pears (established at least 1 year)	Use only supported in Goulburn Valley (label restraint). Risk in other areas, even at lower rates of application not supported mostly based on larger slopes, therefore increased runoff. A number of areas fail on tier 1 assessment and have insufficient information to progress to tier 2. Control of use issues mean such a restriction could not be enforced.
Bananas	High rates of application cannot continue.
Citrus	High rates of use (up to 3.6 kg ac/ha). Tier 1 assessment, based on apple and pear assessment, indicates unacceptable risk from continued use even taking into consideration that only 50% of area is treated.
Coffee	Rates of application too high resulting in unacceptable risk from tier 1 assessment. Assessment based on sugarcane areas of use as limited information on coffee-growing regions.
Cotton	Dryland cotton with no ability to capture rainfall, cannot be supported.
Driveways, paths, lanes, drains, ditches, fence lines, car parks, tennis courts	Use in these situations is at high application rates with limited or no potential to control runoff.
Duboisia	No information provided in submissions for this use. Labels indicate use in NSW and Qld so can assume similar areas of use to sugarcane. Rates of application are a single rate of 1.8 kg ac/ha. Even if band spraying under trees, use would be unacceptable.
Factory sites, commercial and industrial areas	Use in these situations is at high application rates with limited or no potential to control runoff.
Lucerne (established	Rates of application at 750 g ac/ha can be supported on environmental

Situation	Comments
for 1 year or more)	grounds, however this rate is outside the range on current labels. To continue the use, the issue of the efficacy of these lower rates would need to be addressed. This would be done through the registration process and is not the role of the Chemical Review process.
Non-crop areas	Rates of application high and risk unacceptable. Only for control of giant sensitive plant in WA.
Ornamentals – daffodils, gladioli and tulips, lilium, iris	Rate of application are high (1.35–1.8 kg ac/ha). Tier 1 assessment shows unacceptable risk. No further information available to progress to tier 2 assessment.
Paw paws (not for use on trees under 9 months old	High rate of application resulting in unacceptable risk.
Peas	Continued use not acceptable as rates of application result in unacceptable risk.
Perennial grass and seed crops, phalaris and cocksfoot	Continued use not acceptable based on tier 1 level assessment. Insufficient information on area of use to allow a more detailed analysis, although using similar areas of use to wheat etc. result in unacceptable risk.
Phalaris cultivars sirolan and sirosa	Continued use not acceptable based on tier 1 level assessment. Insufficient information on area of use to allow a more detailed analysis, although using similar areas of use to wheat etc. result in unacceptable risk.
Pineapple	Rates of application high in areas of high rainfall and large slopes, resulting in unacceptable runoff.
Rights-of-way	Use in these situations is at high application rates with limited or no potential to control runoff. Continued use cannot be supported.
Sugarcane	Not supported use in sugarcane for pre and post-emergent use at rates of 1.8 kg ac/ha or band sprayed at lower rates.
Tea plantation	Continued use is not supported based on tier 3 in-stream analysis as well as consideration of mitigation options.
Vineyards (vines must be older than 3 years)	Information from tier 1 assessment indicates unacceptable risk based on regions from apple assessment. Rates of application are high and compliance with 3% slope unlikely.

Label restraints – all products

DO NOT apply by air.

DO NOT use in water-logged areas.

DO NOT apply if greater than 50 mm rainfall is expected within 3 days of application.

DO NOT irrigate within 3 days of application.

DO NOT apply to fields where the slope exceeds 3%.

Apply as a **COARSE** spray only.

DO NOT spot spray greater than 5% of total farm area.

Label restraints – use-specific

Cotton

DO NOT USE in cotton **UNLESS ALL** irrigation tailwater and up to 25 mm rainfall can be captured and held on farm.

Pulse crops

DO NOT USE in pulse crops **UNLESS** application can be made using no-till farming practices.

Irrigation channels and drains

DO NOT USE in irrigation channels or drains **UNLESS ALL** irrigation tailwater and rainfall can be captured and held on farm.

Desert channels (bore drains)

DO NOT apply between 1 December and 30 March each year.

DO NOT apply more than once per calendar year.

DO NOT open drains for 72 hours following treatment.

Label buffer zones

DO NOT apply when there is non-target terrestrial vegetation within the specified distances set out in 3.

DO NOT apply when there are aquatic areas within the specified distances set out in Table 3.

Table 3: Downwind buffer zone

Situation	Rate (g ac/ha)	Downwind buffer zone (m)	
		Aquatic	Terrestrial
Broadacre crops / situations			
Winter cereals			
Wheat, barley, triticale, cereal rye and oats – WA only	250–500	30	60
Wheat, barley, triticale and oats – WA only	180–250	15	30
Wheat, barley and oats – NSW, Vic, ACT and SA only	450	25	50
Wheat and barley – SA only	640–880	50	100
Wheat and barley – NSW, Vic, ACT and SA only	250	15	30
Summer fallow – SA only	250	15	30
Cotton, irrigated cotton, capacity to retain runoff	900–1,800	100	200
Lupins – WA only	990	30	80
Pulses incorporated by sowing	750–990	30	80
post-sowing pre-emergent	495–750	50	100
Tropical / sub-tropical crops – sugarcane, bananas	250–450	25	50
Miscellaneous – asparagus	1,800	100	200
Bore drains – Qld only	32,000	N/R	N/R

Label approval numbers

The variation to labels will also include variation to the APVMA approval number, to uniquely identify the labels resulting from this review. The new number is likely to be [product_number]/1112.

1 INTRODUCTION

The APVMA has reviewed the registration of selected products containing diuron and the associated label approvals and has made recommendations relating to the continued registration of selected diuron products in Australia.

This Review Findings Report must be read in conjunction with Volumes 1–4 of the Supplementary Environmental Assessment Technical Reports prepared by the Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC). These documents contain the detailed technical assessments that underpin the regulatory actions outlined in Section 7 of this summary document:

- Technical Report Volume 1 – *Overview*
- Technical Report Volume 2 – *Runoff risk assessment*
- Technical Report Volume 3 – *Assessment of additional data*
- Technical Report Volume 4 – *Responses to submissions.*

2 REASONS FOR DIURON REVIEW

In October 1994, the APVMA invited the public to nominate active constituents, chemical products or labels for consideration for review. Diuron was one of the 80 active constituents prioritised for review at this time. Community groups, individuals and government agencies nominated diuron for review on the basis of toxicological and environmental concerns.

The Great Barrier Reef lagoon was a key area of concern in relation to aquatic contamination due to the sensitive nature of this ecosystem. There were concerns about the impact diuron may have on aquatic areas that receive runoff from agricultural areas, the possible toxicity of some impurities in the active constituent, as well the relevance to humans of findings of carcinogenicity in a rat study.

In December 2002, the APVMA initiated the review of diuron.

Scope of the review

The scope of the review considered the reasons for the nomination of diuron, the information already available on this chemical and how it is approved for use in Australia. It was determined that registrations and approvals for diuron should be subject to reconsideration under Part 2, Division 4 of the Agvet Codes. The review scope was announced in the NRA Gazette 12, 3 December 2002.

The APVMA reviewed the following aspects of active constituent approvals, product registrations and label approvals for diuron:

a. Human Health, including:

- toxicology of two impurities (3,3’,4,4’-tetrachloroazobenzene and 3,3’,4,4’-tetrachloroazoxybenzene) specified in the minimum compositional standard (MCS) for diuron active constituent
- the potential for diuron to be a carcinogen.

b. Environment, including the:

- impact of runoff water containing diuron on the Great Barrier Reef
- impact of diuron found in sediment and water on various species of sea grass
- potential role of diuron as a cause of dieback in mangroves
- possible contribution of diuron in runoff water to reported incidents of off-target damage to farmlands.

The APVMA also considered whether product labels carry adequate instructions and warning statements. These instructions include:

- the circumstances in which the product should be used
- how the product should be used
- the times when the product should be used
- the frequency of the use of the product
- the withholding period after the use of the product
- the disposal of the product and its container
- the safe handling of the product.

The basis for a reconsideration of the registration and approvals for a chemical is whether the APVMA is satisfied that the requirements prescribed by the Agvet Codes for continued registration and approval are being met. In the case of diuron, these requirements are that the continued use of the product in accordance with the instructions for its use:

- would not be likely to have an effect that is harmful to human beings
- would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment.

Regulatory options

There can be three possible outcomes of reconsideration. Based on the information reviewed, the APVMA may be:

- **satisfied** that the products and their labels continue to meet the prescribed requirements for registration and approval and therefore **affirms** the registrations and approvals
- **satisfied** that the conditions to which the registration or approval is currently subject can be varied in such a way that the requirements for continued registration and approval will be complied with and therefore **varies** the conditions of registration or approval
- **not satisfied** that the requirements for continued registration and approval continue to be met and **suspends** or **cancels** the registration and/or approval.

3 REGULATORY STATUS OF DIURON IN AUSTRALIA

At 30 August 2012, there were 63 products containing the active constituent diuron, whose registrations are currently suspended and remain affected by this review. These are listed in Appendix A and are grouped as follows:

- Table A-1 – Industrial use-only products
- Table A-2 – Sugarcane use-only products
- Table A-3 – Mixed use agriculture 400 g/kg
- Table A-4 – Mixed use agriculture 800 g/kg
- Table A-5 – Mixed use agriculture 500 g/kg
- Table A-6 – Mixed use agriculture 900 g/kg.

Products containing diuron are used in a wide variety of crops (Table 4) for control of a diverse range of weeds (refer to product labels).

Table 4: Diuron uses

Tree and vine crops			
Apples and pears (established at least 1 year)	Citrus	Duboisia	Vineyards (vines must be older than 3 years
Broadacre crops			
Barley	Cereal rye	Cotton	Lucerne (established for 1 year or more)
Lupins	Oats	Peas	Perennial grass and seed crops, phalaris and cocksfoot
Phalaris cultivars sirolan and sirosa	Pulses – chickpea, faba beans, lentils, naibon beans, field peas, vetch	Summer fallows	Triticale
Wheat			
Sugarcane, tropical fruit, coffee and tea			
Bananas	Coffee	Paw paws (not for use on trees under 9 months old)	Pineapple
Sugarcane	Tea plantation		

Miscellaneous			
Asparagus	Bore drains	Driveways, paths, lanes, drains, ditches, fence lines, car parks, factory sites, tennis courts	Irrigation channels, drainage ditches
Non-crop areas	Ornamentals – daffodils, gladioli and tulips, iris lilium	Right-of-way, commercial and industrial areas	

Diuron products are available in a range of formulation types as outlined in Table 5. Products are formulated on their own or in combination with hexazinone, bromacil, 2,2-DPA or amitrole. Product labels contain directions for use of diuron in combination with other knockdown herbicides such as paraquat, MCPA, trifluralin, metalochlor or 2,4-D to achieve the most effective weed control.

Table 5: Diuron formulation types

Formulation type	Level of active constituent
Dry flowables (DF)	400 g/kg
– packaged in measured water-soluble bags	468 g/kg
	533 g/kg
	900 g/kg
Granules (G)	100 g/kg
Soluble powders (SP)	160 g/kg
Suspension concentrates (SC)	500 g/L
Water-dispersible granules (WG)	702 g/kg
	900 g/kg
Wettable powders (WP)	468 g/kg
	800 g/kg

Diuron products can be applied for either pre or post-emergent weed control. Maximum rates of diuron application vary significantly across the diuron product range. In general for broadacre cereals, diuron can be applied at rates around 180–880 g ac/ha, and up to 2.8 kg ac/ha for perennial grass seed crops. In horticultural situations such as citrus, apples and pear, diuron rates vary from 0.9 kg ac/ha (split application in apples and pears) to a maximum 3.6 kg ac/ha. Rates of application in sugarcane can be as high as 3.6 kg ac/ha or as low as 250 g ac/ha when used in combination with paraquat. Other tropical uses range from 900 g ac/ha to 3.6 kg ac/ha with cotton rates ranging from 900 g ac/ha to 1.8 kg ac/ha. In all situations, rates of applications tend to be highest for pre-emergent weed control with post-emergent application often only applied to a proportion of the crop area such as under trees or between rows (band sprays) as opposed to the full area.

The highest rates of diuron application are by far for weed control in industrial or non-crop situations. These include bore drains, driveways, fence lines, car parks, factory sites, irrigation channels, drainage ditches, rights-of-way, commercial and industrial areas. When used in these situations, application rates can be as high as 90 kg ac/ha.

Diuron can be applied by ground or aerial application methods, high-volume spraying or with hand-held application for small areas of weed control (spot spraying).

Submissions to the APVMA diuron review provided valuable information on use practices occurring in various industries and the importance of diuron in these production systems. This information has been utilised in the assessment where appropriate. Many industries rely on diuron as a primary chemical for weed control while others, although they may have moved away from diuron, still rely on diuron for difficult weed control.

4 HISTORY OF DIURON REVIEW

Since the APVMA commenced its diuron review in 2002, it has published reports on three separate occasions (Review Scope Document 2002, Preliminary Review Findings 2005, Environmental and Human Health assessments 2011), proposed suspension action twice (2005 and mid 2011) and taken suspension action (end 2011). Further information relating to these activities is provided below.

4.1 Proposed suspension (2005)

In 2005, the APVMA received the draft environmental assessment report from DSEWPaC that identified that runoff containing diuron was having unacceptable effects on the environment, specifically mangroves, seagrasses and the Great Barrier Reef Marine Park.

To reduce this risk, the APVMA proposed to limit the use of diuron to a maximum rate of application in sugarcane of 0.9 kg ac/ha (i.e. a 75% reduction, equal to broadacre rates). This would theoretically reduce peak levels to close to the lowest observable effect concentration (LOEC) for mangroves, seagrasses, crustal coralline algae and corals. This was to be achieved by suspending diuron's registration and issuing new instructions for use.

Registrants were advised of the proposed suspension in March 2005. The main points of contention with this proposal as raised by registrants and user groups at this time were:

- The haste of the proposed suspension was considered excessive and in conjunction with the lack of consultation with industry, resulted in insufficient time to enable investigation of further alternatives.
- The proposal presented only a limited number of options – rate reduction or cancellation of the use.
- There appeared to be very little justification for the significant reduction in application rates for sugarcane. There was concern the proposed suspension decision and associated rate reduction was based on a single incident of mangrove dieback in the Pioneer River (Mackay region, Queensland) where limited science pointed to diuron as the cause. No other incidents near diuron areas of use had been reported.
- Continued use of diuron at reduced rates should only be undertaken in conjunction with a scientifically-valid assessment. This should include the role of management practices as well as investigations into the potential impact of reduced rates on weed control efficiency, diuron's place in minimum till agriculture and the introduction of replacement herbicides. This was not done.
- Registrants advised they had no efficacy information available to support a rate reduction (to 0.9 kg ac/ha).
- While some areas of horticulture indicated the lower rates could be accommodated (apples and pears, bananas and paw paw) others considered the measures unnecessary, and, if implemented, would significantly impact production.

On the basis of these comments, the APVMA chose not to proceed with suspension action but to proceed to publish the Preliminary Review Findings (PRF) report.

4.2 Preliminary Review Findings report (2005)

In 2005, the APVMA published its Preliminary Review Findings (PRF) report. This report addressed the toxicological as well as the environmental aspects of the registration of diuron products in Australia.

The PRF report identified that significant restrictions on diuron use would be required to ensure continued protection of the environment. Recommendations made in this report were that:

- active constituent approvals could be affirmed, on the basis of limited human health concerns
- environmental exposure from uses of diuron at current label rates in irrigation channels and drainage ditches was likely to have an unacceptable environmental impact and use was recommended for cancellation
- environmental exposure from uses of diuron at current label rates on sugarcane, cotton, citrus, horticultural crops (apples, pears, bananas, pawpaw, coffee, grapes and pineapples) and general purpose non-crop uses would likely have an unacceptable environmental impact with risk mitigation strategies required to substantially reduce the environmental load, including a reduction in application rates
- there is an unacceptable environmental risk is posed from spray drift (from fine sprays and current high label rates) from diuron use when applied by air and ground spray to winter cereals and cotton, which could be managed with the introduction of appropriate buffer zones
- the use of diuron for algal control in aquariums and ornamental ponds, in anti-fouling paints, broadacre crops (wheat, barley, triticale, oats, lucerne, lupins and grass seed crops) asparagus, summer fallow, peas, vineyards (vines over 3 years), duboisia and ornamentals (daffodils, gladioli and tulips) could be retained.

The report was made available for a 2-month public consultation after which the APVMA intended to proceed to finalising the review.

Consideration of comments on PRF report

The publication of the PRF report in 2005 resulted in the provision of 23 submissions to the review. These submissions identified concerns with technical aspects of the review, together with comments on the proposed findings and the implications of these for continued use of diuron.

Submissions were received from state and territory governments with an interest in agriculture and water quality, as well as from universities and other research organisations, user groups, chemical manufacturers, the general public and environmental groups. The information provided included scientific data, results of water monitoring programs and comprehensive information on the role of diuron in various agricultural production systems.

Some common themes raised in submissions to the PRF (2005) were:

- the validity of assumptions used in risk assessment
- diuron use in irrigation channels and non-agricultural areas
- the importance of diuron
- the availability and effectiveness of alternatives
- sediment loss

- continued support for diuron anti-fouling paints
- damage to mangroves
- buffers.

The key issues raised in the submissions, together with comments from DSEWPaC in relation to these, are provided in Appendix B. The comments and information have not previously been published and are included in this report for completeness.

Provision of additional data (post PRF)

As outlined in the PRF report, the data package to support continuation of many diuron uses from an environmental perspective was insufficient. In response, additional data was made available for assessment.

Water monitoring results from a number of areas (agricultural and marine) were provided for consideration. This covered the Barwon and Mackay/Whitsunday regions, Great Barrier Reef coral, field sampling data from New South Wales, data from the Namoi, Gwydir and Border River valleys, monitoring data and work in drainage canals in rice-growing areas between Leeton and Griffith (NSW) and modelling information from the Pioneer River (Qld) and the Sunraysia water monitoring project (Vic). Results from the Mackay Mangrove Nursery project addressing the germination potential of mangrove propagules taken from dieback areas and then replanted into dieback areas were also provided.

Additional spray drift modelling data was generated from AgDrift and addressed ASAE fine/medium, medium and coarse droplets. This was provided by a registrant.

As a registrant involved in the review, DuPont undertook additional work to investigate ways the environmental load of diuron could be reduced in the sugar industry. High-level modelling data indicated significant reductions in water contamination resulting from runoff could be achieved by altering management practices. These practices included decreasing the amount of diuron applied to 0.9 kg ac/ha through band spraying, limiting application to specific times of the year to avoid the wet season, improved cultivation using reduced tillage, adding vegetative buffer strips and sugarcane trash layers, not planting sugarcane on slopes >5% and the actual proximity of the treated area to waterways.

The World Wildlife Fund (WWF) provided the APVMA with a draft science summary from the Reef and Rainforest Research Centre (RRRC) which included discussion on research believed to demonstrate that pesticide and herbicide runoff from farming systems is damaging aquatic communities in the Great Barrier Reef. A comprehensive assessment of this document was conducted by DSEWPaC which has not previously been published. The full response from DSEWPaC on this submission is provided in Appendix B.

DSEWPaC has also provided comment on the comprehensive guidelines prepared under the Queensland Government's reef protection legislation for use of diuron in sugarcane. These regulations were designed to minimise the drift and runoff of diuron-based products from sugarcane properties into the Great Barrier Reef lagoon.

4.3 Human health and environmental assessment (2011)

In July 2011, the APVMA published revised human health and environmental assessment reports for the review of diuron. These reports considered the information provided in response to the 2005 PRF.

Human health assessment

The 2011 human health assessment report consolidated data on metabolism, subchronic and chronic toxicity, reproductive and developmental toxicity and genotoxicity. The full technical assessment report is available on the APVMA website.

On the basis of this assessment, in March 2012 the APVMA affirmed the approvals of diuron active constituents.

Environmental assessment

Taking into consideration the comments and new information provided following publication of the PRF, the environmental assessment report was significantly revised. The revisions saw a complete reworking of the risk assessment, resulting in a report very different to the previous version presented in the PRF.

The new assessment was based on revised ecotoxicity end points, improved modelling, a greater use of monitoring data and a generally more balanced approach to risks associated with broadacre agriculture. Key differences between the 2011 environmental assessment report and the PRF were:

- The emphasis of the assessment was on 'broadacre' agricultural uses rather than primarily sugarcane, with risk assessment based on application rates rather than crop-specific considerations.
- Runoff exposure concentrations were predicted for three scenarios, namely primary streams, secondary streams and coastal waters.
- The exposure concentrations were based on a mixture of modelled values (using a runoff model available in the public domain that considered factors such as soil type, slope, application rate, soil sorption and runoff volumes) and monitoring data, depending on which provided the greater level of confidence. Where monitoring data were used, a probabilistic approach was adopted using the 90^{th} percentile water concentration.
- A species sensitivity distribution (SSD) approach was adopted for the choice of aquatic toxicity values used in the risk assessment, and only standard toxicity data (test species and test protocols) were used. Two SSDs were constructed, namely for primary producers (algae and aquatic plants) and primary and secondary aquatic consumers (aquatic invertebrates and fish). The 95^{th} protection level was used except for high protection areas (primarily the Great Barrier Reef lagoon), where the 99^{th} protection level was used.

The 2011 environmental assessment report found that current rates of application of diuron present a risk to aquatic systems in most situations. Very low use rates (up to 200 times lower) may be acceptable in some situations from an environmental perspective but it is not known if the products are effective at very low rates.

On the basis of the findings of this assessment, DSEWPaC recommended to the APVMA that it was not satisfied the continued use of diuron would not likely have any unintended effects harmful to animals, plants or things or to the environment.

The APVMA published a revised environmental assessment report in July 2011, with a 2-month period of public comment.

At the same time, on the basis of the findings of the 2011 environmental assessment report, the APVMA proposed to suspend the registration of diuron products and restrict use of diuron in certain situations while it allowed stakeholders to review the report and provide any information relevant to the APVMA's proposed decision to restrict or cancel most registrations.

Public comment on the 2011 report

The release of the revised environmental assessment in 2011 and the proposed suspension of diuron generated significant comment and provision of new information. The APVMA received over 100 submissions to the review.

The main theme of submissions related to the relevance and applicability of the Murrumbidgee Irrigation Area (MIA) monitoring data to predict diuron concentrations in runoff water for all uses of diuron. This was especially the case for broadacre, dryland farming where arguments consistently related to the limited rainfall in the farming regions and lack of surface waters over much of the year, minimising the potential for contamination of aquatic areas.

Other issues raised by submissions included:

- selection of end points in the assessment
- inability to comply with suspension instructions including no-spray window and buffers
- availability of new information not previously provided, including the new reef requirements for diuron use in Queensland
- the variation in climatic conditions and potential for runoff in Western Australia
- situations of low application rates and therefore limited potential for runoff
- the importance of diuron in various industries
- management practices used to reduce potential for runoff
- lack of alternatives
- relevance of current label statements mostly in respect of application rates
- risk to birds in various cropping situations.

Where possible the comments were considered in the assessment and are addressed further in Technical Report Volume 4: *Responses to submissions.*

4.4 Suspension of diuron (2011)

Following initial consideration of the submissions to the review in 2011, the APVMA determined that additional time was needed to adequately assess all submissions. At the same time however, the concerns first identified with diuron in the 2005 Preliminary Review Findings (PRF) had not significantly changed. As a result, while the information was being assessed the APVMA determined it appropriate to take action to reduce the risks in the short term. This was achieved by suspending registration and label approvals and issuing new instructions for the use of suspended diuron products. The suspension was in force from 28 November 2011 to 31 March 2012.

The suspension enabled the APVMA to reduce a major concern with continued high use rates of diuron, which was the risk of diuron runoff into waterways.

The suspension prohibited use around agricultural buildings, in right-of-way areas, on driveways, paths, lanes, drains, ditches, fence lines, car parks, tennis courts and in non-crop areas. Use of diuron was not permitted on bananas, coffee, paw paws, pineapples, sugarcane or tea from 5 December 2011 to 31 March 2012. Use in factory sites, commercial and industrial areas was only permitted if the area was adequately bunded to retain any runoff, the use in irrigation channels or drainage ditches only permitted if all irrigation tailwater and rainfall could be captured and held on farm and application to tree crops was only permitted as a directed band spray over a maximum of 50% of the area.

Additional restraints designed to reduce the potential for runoff were also introduced. These included a maximum rate of application of 1.8 kg ac/ha, restrictions on application methods (no aerial application, coarse spray only) together with the requirement for addition environmental restraint statements.

4.5 Regulatory decisions (March 2012)

On the basis of the human health assessment and environmental assessment reports published in July 2011, the APVMA finalised the review for active constituents and selected products (anti-fouling paints, aquarium and pond products, cotton defoliants) in March 2012.

At the same time the APVMA extended the suspension for the remaining diuron products until November 2012 and reissued new instructions for use of suspended products.

Although the suspension instructions issued in 2012 did not change from those issued in 2011, their effect was that use in tropical situations was now permitted. This was on the premise that the risk of rainfall and subsequent runoff was expected to be less between April and November each year than during the wetter months (December–March). Rates of application in these circumstances were restricted to a maximum of 1.8 kg ac/ha.

5 ENVIRONMENTAL ASSESSMENT 2012

The Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC) undertook the environmental assessment for the review of diuron, considering all of the environmental data and information submitted for the review together with new information available in the public domain since the commencement of the review. This 2012 Review Findings Report focuses on the issues raised in submissions in response to the 2011 Environmental Assessment report. This assessment is focused largely on the risk to aquatic organisms from runoff.

The environmental technical report contains four volumes. Volume 1 is the overview and addresses the findings from assessment of submitted data and argument to address the areas of unacceptable risk identified in the APVMA's 2011 environmental assessment report. Volume 2 reassesses the runoff risk associated with diuron use. The additional environmental fate and ecotoxicity data that were supplied and considered relevant to providing further input into the assessment are discussed in technical detail in Volume 3. Comment on the argument and data in submissions are contained in Volume 4.

Runoff risk assessment

A comprehensive assessment of risks to algae and aquatic plants has been undertaken based on information and argument provided in submissions, and through the development of modelling and intensive use of Australian-specific climatic data to assess different cropping situations and regions. In the 2011 assessment report, the modelling capacity to extend the runoff risk assessment methodology was not developed and a much greater reliance on the available monitoring data was necessary.

The challenge for this revised Review Findings Report was to provide a risk assessment framework consistently across the large range of use patterns and growing conditions where diuron may be applied. The methodology used in this report has substantially built on the modelling capacity from the 2011 report and, in developing the new framework has allowed a consistent approach to be applied to all use patterns, with validation of the model undertaken wherever possible using the most recent modelling data. The approach taken in this assessment is outlined in Figure 1 below. More detailed information on the approach is provided in Technical Report Volume 2: *Runoff risk assessment.*

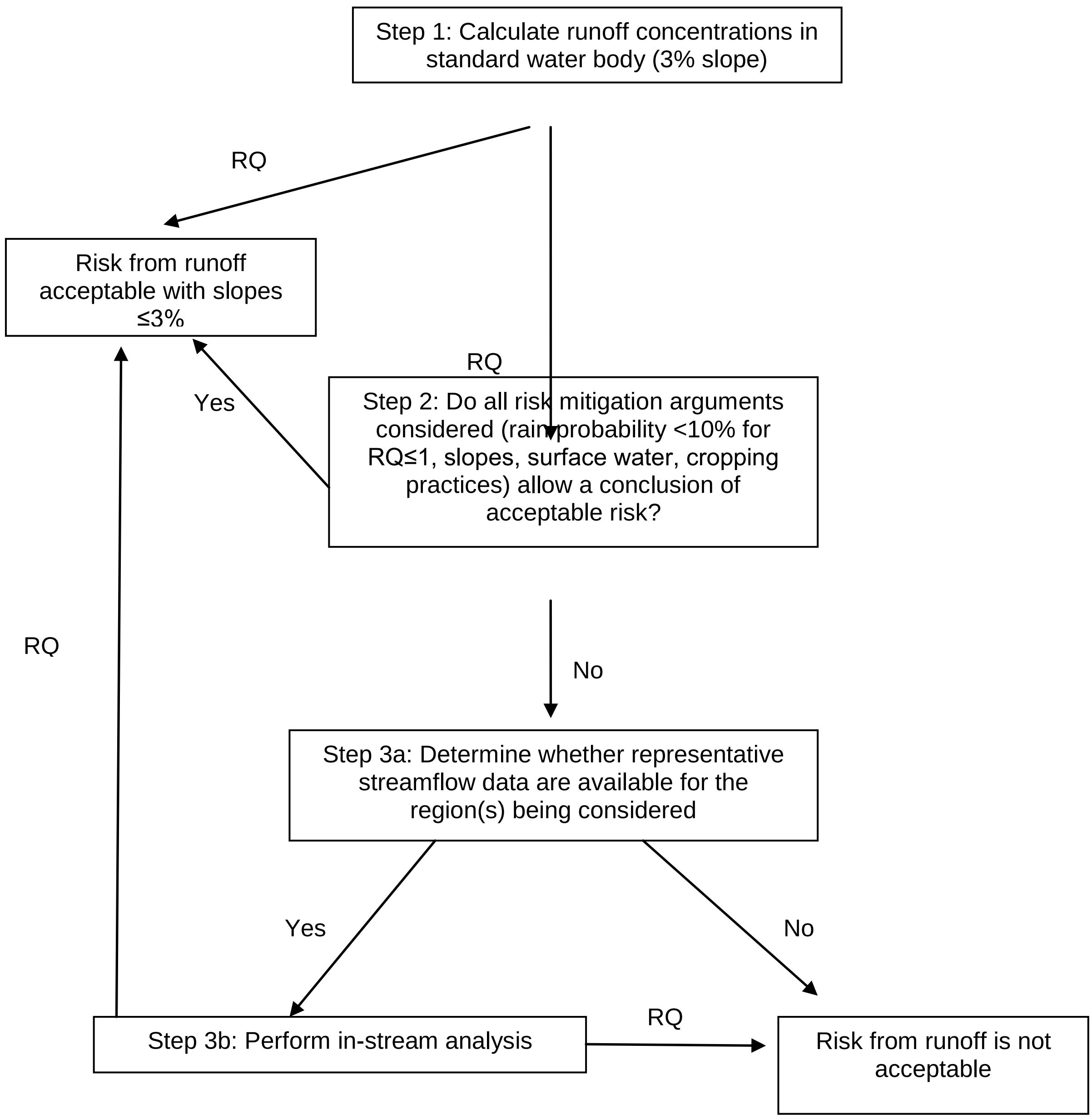
The runoff risk assessment framework now features three steps. The first is a basic runoff calculation based on a typical daily rainfall event for the region, application rate and use scenario. All three steps restrict the slope to 3%. While the first step is otherwise the same as the DSEWPaC model described in the APVMA's *Manual of Requirements and Guidelines (MORAG)*, a realistic daily rainfall for the region estimated from the rainfall intensity duration data available from the Bureau of Meteorology (BOM) is now used.

The second and third steps move to a more complex and probabilistic assessment incorporating combined rainfall probability values and in-stream analysis.

The second step of the framework required calculation of combined rainfall probability values that take into account the likelihood of rain along with the expected amount of rain on wet days. The data required for this step have included obtaining daily rainfall data for up to 120 years' of records for around 70 town centres across Australia and separating the records by seasons to allow a comparison with diuron use periods. The third step of the calculations involved an assessment of in-stream concentrations for different cropping situations. It has required the collection of daily stream flow data for up to 10 years' of records for representative streams and rivers in different use areas.

The approach now provides, for example, a separate runoff risk assessment for broadacre cropping situations such as cereals which are grown under conditions of lower rainfall and limited surface water flow compared with the tropical and sub-tropical areas. By being able to factor the specific conditions under which diuron is likely to be applied (including the type of soil, its moisture levels and amount of cover, the probability of rain falling during this time as well as possible stream flow conditions during this period) the revised assessment has allowed crop-specific recommendations and expanded the ranges of uses for which runoff risk is now concluded to be acceptable.

Figure 1: Flow diagram of runoff risk assessment framework



Additional data (environmental fate and toxicity)

Many papers published since the APVMA's 2011 assessment reports address the issue of diuron mobility. These arguments mainly relate to increased sorption of diuron with increasing time after application. These papers (see Technical Report Volume 3: *Assessment of additional data*) and associated arguments were considered with a view as to how they may be used to refine the Kd value (soil/water partition coefficient) used in the runoff modelling.

Several literature papers describing higher tier aquatic toxicity testing were provided to address the issues surrounding recovery and pulse exposure effects on aquatic plants and communities. It is acknowledged that the standard toxicity studies for algae and aquatic plants demonstrate recovery can occur, but the main concern relates to effects following continued or pulsed exposure at levels considered to exceed the toxicity threshold established through the use of a species sensitivity distribution.

Additional new data provided address the impact of diuron on sediment microbial communities. These findings help alleviate previous concerns regarding long-term exposure of aquatic flora when exposed through sediment pore water, as the results from this study demonstrated that diuron contamination via runoff and erosion may stimulate the diuron mineralisation capacities of the sediments (see Technical Report Volume 3: *Assessment of additional data*).

The assessment of additional data either provided in submissions or obtained separately is considered in the assessment. For environmental fate, these mainly relate to the choice of the distribution constant Kd (soil/water partition coefficient) and data obtained from field studies and environmental monitoring conducted under the Queensland Reed Rescue program. The outcomes of these studies and monitoring were critical in the revised runoff risk assessment, including the validation of results from the refined runoff model.

The outcomes of the additional ecotoxicity data assessed have been used to confirm the aquatic end point employed in the 2011 environmental assessment report and to allow revisions to the assessment of risk to sediment flora.

DSEWPaC recommendations

DSEWPaC has recommended the APVMA should no longer be satisfied that the use of diuron in accordance with label instructions for many situations would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment.

The specific recommendations made by DSEWPaC, together with additional comments are provided in Tables 6 and 7 below.

Table 6: Summary of acceptable uses based on runoff risk

Situation	Rate (g ac/ha)	Notes
Broadacre crops / situations		
Winter cereals		
Wheat, barley, triticale, cereal rye and oats – WA only	250–500	
Wheat, barley, triticale and oats – WA only (tank-mixed with MCPA or 2,4-D)	180–250	
Wheat, barley and oats – NSW, Vic, ACT and SA only	450	
Wheat and barley – SA only (soursob control)	640–880	1
Wheat and barley – NSW, Vic, ACT and SA only	250	
Summer fallow – SA only (mixed with paraquat)	250	
Cotton – irrigated cotton, capacity to retain runoff	900–1,800	
Lupins – WA only	990	2
Pulses incorporated by sowing (50% incorporation)	750–990	3
Post-sowing pre-emergent (except faba beans)	495–750	4
Post-sowing pre-emergent (faba beans)	495	5
Tree and vine crops – apples and pears – Goulburn Valley only	900–1,800	6
Tropical / sub-tropical crops – sugarcane, bananas	250–450	7
Miscellaneous		
Asparagus	1,800	8
Desert channels (Bore drains)	32,000	9

Comments on acceptable uses

1. The more localised assessment (SA only) allowed the use of higher organic carbon in the soil, which lowers the runoff risk.
2. This apparently high application rate is supported based on acceptable runoff risk due to application being restricted to lighter (sandy) soils, which lowers the runoff potential and application occurring earlier in the season where soils are expected to be drier, again lowering the potential for runoff.
3. With restrictions on tillage system and application machinery.
4. With restrictions on tillage system (only for use in no-till situations).
5. Use on faba beans in Western Australia is not supported for post-sowing pre-emergent application at the higher application rate (750 g ac/ha).
6. Runoff risk assessment could confidently predict an acceptable risk for use only in the Goulburn Valley, Victoria.
7. General use rates in sugarcane and bananas up to 450 g ac/ha are included on labels where the product is tank-mixed with paraquat. These have been shown to have an acceptable runoff risk. In sugarcane, diuron in combination with hexazinone has general use rates of 280 g ac/ha and 560 g ac/ha, also when tank-mixed with paraquat. For products co-formulated with hexazinone, the runoff risk with the lower rate is acceptable (and is within the range in Table 6 above), but the runoff risk with the higher rate is not considered acceptable.

8. The runoff risk for this high application rate is acceptable in asparagus based on the highly localised assessment demonstrating very high organic carbon in the soils within the primary asparagus-growing region in Australia (Victoria), which significantly lowers the runoff potential. The highest tier of assessment (in-stream analysis) was undertaken and this demonstrated acceptable runoff risk.
9. While these rates are very high, application is limited to 1-m strips along the sides of bore drains, which are man-made structures that do not drain to natural surface waters.

Table 7: Summary of unacceptable uses based on runoff risk

Situation	Rate (g ac/ha)	Notes
Broadacre crops / situations		
Cotton		
Irrigated cotton, no capacity to retain runoff	900–1800	1
Dryland cotton	900–1,800	1, 2
Phalaris pastures	1,530	3, 4
Grass seed crops	1,530–3,000	3, 4
Lucerne	900–1,710	3, 5
Peas – WA only	750–1,080	2,6
Tree and vine crops		
Apples and pears (other than the Goulburn Valley)	900–1,800	2, 3
Citrus	900–1,800	2, 3
Grapevines	900–1,800	2, 3
Tropical / sub-tropical crops		
Sugarcane		
Pre-emergent	560–1,800	1
Post-emergent	560–1,800	1
Bananas	1,800	1
Tea plantations	900	1,2
Coffee	1,755	1,2
Paw paws	1,800	1,2
Pineapples	2,000–4,000	1
Miscellaneous		
Gladioli, tulips, daffodils, lilium and iris	1,350–1,800	2
Industrial uses	1,800–8,800	7

Comments on unacceptable uses

1. Highest tier of refinement undertaken and unacceptable Q-values still calculated.
2. Based on available data, the tier 1 assessment indicated an unacceptable risk. A higher tier assessment was not possible due to insufficient data to properly characterise use area (such as a lack of representative stream flow data in more localised use areas).
3. Use areas too diverse to adequately characterise but tier 1 assessment, based on use of apple and pear assessment as surrogate indicated an unacceptable risk.
4. It is possible that lower use rates could be supported in certain areas if these were shown to be efficacious.
5. The assessment demonstrated that if use remained efficacious at lower rates (up to 750 g ac/ha), the runoff risk was acceptable in dryland agricultural regions (cereal and cotton-growing regions) as rainfall patterns in these were sufficient such that P(com) was <10% and slopes were predominantly 3% or less.
6. This outcome may appear counter intuitive given the result for lupins in Western Australia. Technical Report Volume 2: *Runoff risk assessment* (Section V2.8) should be consulted, but essentially the difference is due to application in lupins to relatively dry and sandy soils resulting in significantly lower runoff potential compared with peas in heavier and moist soils.
7. DSEWPaC accepts some industrial uses of diuron could be supported where all runoff can be contained, but based on current labels and use rates it is not possible to do so for all current industrial uses. This Review Findings Report provides recommendations to limit environmental exposure through some use patterns.

Chronic risk to birds

The finding in the APVMA's 2011 environmental assessment of an unacceptable chronic risk to birds at an application rate higher than 370 g ac/ha has been reassessed following a revised approach which focused on refining exposure estimates to better reflect diuron use situations. This is revised in this Review Findings Report to indicate the risk to birds is acceptable up to a maximum rate of application of 1.8 kg ac/ha (cotton).

Spray drift buffer zones

The 2011 assessment only considered spray drift buffer zones for cotton defoliation as only this use continued to be supported due to application rates at much lower rates (24 g ac/ha). Downwind spray drift buffer zones for diuron use in different cropping situations have now been assessed for ground application only (see Section 8: *Regulatory decisions* below).

6 OVERSEAS REGULATORY STATUS

According to the PAN* database, diuron products are registered in many countries, including New Zealand, the United States of America (USA), Canada, Europe, South Africa, the Philippines and the United Kingdom (UK).

European Union

Diuron was reviewed in the second stage of the European Union (EU) review program that was considering all plant protection products registered in the EU before 26 July 1993. The report released in September 2007 recommended the non-inclusion of diuron in Annex 1 to Directive 91/414/EEC due to insufficient information on operator exposure, potential contamination to groundwater and safety to birds and mammals. On this basis it was not possible to conclude that diuron met the safety criteria for inclusion into Annex 1.

In response to that report, additional data was provided by The European Diuron Task Force (consisting of DuPont de Nemours and Lanxess Distributions GMBH) that reversed the earlier decision to not list diuron in Annex 1, to allow continued use under strict conditions. Use was only permitted in orchards (pome fruit), vines and professional outdoor use. Formulations must only be wettable granules with a maximum rate of 0.5 kg ac/ha. Application must be directed and limited to ground in strip-band application under the rows avoiding drift by using low pressure and shields. No further studies were identified as necessary to support including into Annex 1.

Registration of diuron in Sweden was cancelled in 1992 due to concerns about its carcinogenicity. Use of diuron has been restricted in Sweden with use on railway embankments banned after 1994 (Torstensson et al. 2002). It was banned in The Netherlands in 1999 due to problems with water quality.

In 2003, Denmark prohibited the use of diuron in anti-fouling paints for boats to protect the aquatic environment. The Statutory Order issued by the Ministry of Environment and Energy states it is not permitted to import, sell or use anti-fouling bottom paint containing the biocide diuron on ships shorter than 25 m (Fact Sheet No 24: Anti-fouling bottom paint, 07/01/2003).

Following an incident where it was claimed that irrigation water contaminated by pesticides from railway tracks caused crop damage, the German Railways (DB) stopped using diuron for weed control on railway lines in 1996. DB switched to glyphosate and trialled alternate means of control such as superheated steam. The German federal parliament subsequently imposed a legal ban on the use of diuron on railways, due to high levels of diuron in groundwater.

Diuron has been included in a list of Priority Hazard substances being considered by the European Commission. Substances on the list are those shown to be of major concern for European waters which must be phased out under the Water Framework Directive.

* PAN – Pesticide Action Network, North America, www.pesticideinfo.org

United States Environmental Protection Agency (US EPA) activity

In 1996, the US EPA scheduled a re-registration of diuron for 2002 under the *Federal Insecticides, Fungicides and Rodenticides Act*, which requires review of chemicals registered before November 1984. A draft re-registration eligibility decision (RED) diuron environmental report was made available for comment in March 2003 (US EPA 2003).

The US EPA review concluded that diuron is stable to hydrolysis and photolysis, is very persistent on soil and does not readily degrade. It is moderately mobile and is found in surface and ground waters. The major metabolites are sequentially demethylated compounds, which have no herbicidal effects. The review found diuron is practically non-toxic or slightly toxic to birds and mammals, moderately toxic to most aquatic animals (fish and aquatic invertebrates) but highly toxic to one species of fish (cutthroat trout) and scud. Terrestrial and aquatic plants are very sensitive to diuron. Based on screening level risk assessments, the review found that diuron poses a potential risk to terrestrial and aquatic animals and a higher risk to terrestrial and aquatic plants. The RED requested several additional environmental fate and toxicity studies – several for diuron but the majority for the metabolite 3,4-DCA (3,4-dichloroaniline).

The diuron risk mitigation measures implemented in the USA at this time included use restrictions, rate reductions and increased retreatment intervals on 10 crops. In addition, aerial application was eliminated except for rights-of-way, alfalfa, winter barley, winter wheat, sugarcane and grass seed crops. All wettable powder formulation products are being cancelled.

A large water quality monitoring program in the USA showed that diuron is mainly found in surface water with the maximum concentration from agricultural area (14 µg/L) but urban areas in the program also had high levels (8.04 µg/L). Routine monitoring for diuron in 1996 and 1997 in the USA showed a range of values reaching 51.3 µg/L. In marine areas the highest levels occurred in marinas with maximum concentration of 6,742 µg/L.

Canada

Diuron was evaluated as part of Canada's Pest Management Regulatory Agency (PMRA) Re-evaluation program. A final report was published in October 2007. Based on the comparison of Canadian and USA use patterns of diuron, the US EPA RED (2003) was considered an adequate basis for the Canadian re-evaluation. Diuron products (5) are registered in Canada to control annual and perennial broadleaf and grassy weeds in food crops (grapes and asparagus) and in non-crop areas including industrial sites, and irrigation and drainage ditches. All products are wettable granule formulations.

New risk reduction measures were recommended for inclusion on product labels. These included:

- discontinuation of wettable power formulations
- additional protective clothing requirements
- addition of re-entry intervals
- advisory label statements for management of drift and runoff
- addition of buffer zones for aquatic and terrestrial habitats

- maximum application rates per year for non-crop areas (9 kg ac/application), maximum two applications per year, maximum 13.5 kg ac/ha for sites receiving high rainfall and covered in dense vegetation
- no aerial application
- no direct application to ponds.

Additional data was required by October 2009 to confirm that acceptable levels of diuron and its metabolites were not exceeded in groundwater.

United Kingdom

As part of a review of all chemicals used in marine anti-foulants, the United Kingdom (UK) Advisory Committee on Pesticides took the decision to cancel the use of diuron in anti-fouling treatments at its September 2000 meeting, due to environmental and human health concerns. Concerns about human health were raised because the available exposure data showed an insufficient margin of safety when compared with the no observable adverse effect level (NOAEL). Significant levels of diuron were detected in water and sediment throughout UK estuary and coastal sites as well as freshwater sites.

In July 2007 the approvals of diuron in the UK were revoked. This followed the decision by the EU to not list diuron in Annex 1, a decision which was subsequently reversed. At this time there were 19 home garden and 31 professional products containing diuron registered in the UK. The deadline for sale, supply and use of remaining diuron products in the UK was 13 December 2008.

New Zealand

The Environmental Protection Authority (EPA) in New Zealand commenced a reassessment of all biocides used as active ingredients in anti-fouling paints that are imported, manufactured and used in New Zealand in June 2012. This included the use of products containing diuron as anti-fouling paints.

Before the formal reassessment began, a preliminary assessment of the risks and benefits of using anti-fouling paints as well as possible risk management options was undertaken.

Preliminary conclusions and recommendations are provided in the Call for Information document at www.epa.govt.nz.

In considering the continued use of these products, the formal reassessment may recommend some biocides are withdrawn from the New Zealand market because the risks they pose have been shown to outweigh the benefits.

7 REVIEW FINDINGS 2012

Taking into consideration the findings from the revised environmental assessment, the APVMA has made recommendations relating to future use of diuron in Australia. Tables 8 and 9 summarise the outcomes of the review on a crop and situation basis. Specific product recommendations are outlined in Appendix A.

Table 8: Supported uses

Situation	Recommendations 2012
Asparagus	Use on labels is currently "All States". The assessment has only considered information relating to the major production in Victoria. Use will be restricted to Victoria only via label instructions.
Bananas	Only the use on the label in combination with paraquat (lower rate 250 g ac/ha to 450 g ac/ha) is supported.
Bore drains	Continued use supported based on unique characteristics of the areas in which this use occurs.
Cotton	**Irrigated cotton only** – maximum rates of application (up to 1.8 kg ac/ha) are supported only when irrigation tailwater and up to 25 mm rainfall can be captured.
Irrigation channels, drainage ditches	Only where all water can be contained on farm.
Lupins	Continued use supported at rates of 900 g ac/ha.
Pulses – including chickpea, faba beans, lentils, naibon beans, field peas, vetch	Only supported where no-till farming practices are utilised (label statement required). Faba beans – only low rate of application supported post-sowing pre-emergent.
Sugarcane	**Diuron-only products** – when used in combination with paraquat rates 250 g ac/ha up to 450 g ac/ha. **Diuron / hexazinone products** – only low rate of 250 g ac/ha supported and spot spraying.
Summer fallows	Only very low rate of application (0.25 kg ac/ha), continued use supported.
Wheat, barley, oats, triticale, cereal rye	All rates of application can continue.

Table 9: Uses not supported

Situation	Comments
Apples and pears (established at least 1 year)	Use only supported in Goulburn Valley (label restraint). Risk in other areas, even at lower rates of application not supported mostly based on larger slopes, therefore increased runoff. A number of areas fail on tier 1 assessment and have insufficient information to progress to tier 2. Control of use issues mean such a restriction could not be enforced.
Bananas	High rates of application cannot continue.
Citrus	High rates of use (up to 3.6 kg ac/ha). Tier 1 assessment, based on apple and pear assessment, indicates unacceptable risk from continued use even taking into consideration that only 50% of area is treated.
Coffee	Rates of application too high resulting in unacceptable risk from tier 1 assessment. Assessment based on sugarcane areas of use as limited information on coffee-growing regions.
Cotton	Dryland cotton with no ability to capture rainfall, cannot be supported.
Driveways, paths, lanes, drains, ditches, fence lines, car parks, tennis courts	Use in these situations is at high application rates with limited or no potential to control runoff.
Duboisia	No information provided in submissions for this use. Labels indicate use in NSW and Qld so can assume similar areas of use to sugarcane. Rates of application are a single rate of 1.8 kg ac/ha. Even if band spraying under trees, use would be unacceptable.
Factory sites, commercial and industrial areas	Use in these situations is at high application rates with limited or no potential to control runoff.
Lucerne (established for 1 year or more)	Rates of application at 750 g ac/ha can be supported on environmental grounds, however this rate is outside the range on current labels. To continue the use, the issue of the efficacy of these lower rates would need to be addressed. This would be done through the registration process and is not the role of the Chemical Review process.
Non-crop areas	Rates of application high and risk unacceptable. Only for control of giant sensitive plant in WA.
Ornamentals – daffodils, gladioli and tulips, lilium, iris	Rate of application are high (1.35–1.8 kg ac/ha). Tier 1 assessment shows unacceptable risk. No further information available to progress to tier 2 assessment.
Paw paws (not for use on trees under 9 months old)	High rate of application resulting in unacceptable risk.

Situation	Comments
Peas	Continued use not acceptable as rates of application result in unacceptable risk.
Perennial grass and seed crops, phalaris and cocksfoot	Continued use not acceptable based on tier 1 level assessment. Insufficient information on area of use to allow a more detailed analysis, although using similar areas of use to wheat etc. result in unacceptable risk.
Phalaris cultivars sirolan and sirosa	Continued use not acceptable based on tier 1 level assessment. Insufficient information on area of use to allow a more detailed analysis, although using similar areas of use to wheat etc. result in unacceptable risk.
Pineapple	Rates of application high in areas of high rainfall and large slopes, resulting in unacceptable runoff.
Rights-of-way	Use in these situations is at high application rates with limited or no potential to control runoff. Continued use cannot be supported.
Sugarcane	Not supported use in sugarcane for pre and post-emergent use at rates of 1.8 kg ac/ha or band sprayed at lower rates.
Tea plantation	Continued use is not supported based on tier 3 in-stream analysis as well as consideration of mitigation options.
Vineyards (vines must be older than 3 years)	Information from tier 1 assessment indicates unacceptable risk based on regions from apple assessment. Rates of application are high and compliance with 3% slope unlikely.

Label restraints - all products

DO NOT apply by air.

DO NOT use in water-logged areas.

DO NOT apply if greater than 50 mm rainfall is expected within 3 days of application.

DO NOT irrigate within 3 days of application.

DO NOT apply to fields where the slope exceeds 3%.

Apply as a **COARSE** spray only.

DO NOT spot spray greater than 5% of total farm area.

Label restraints - use-specific

Cotton

DO NOT USE in cotton **UNLESS ALL** irrigation tailwater and up to 25 mm rainfall can be captured and held on farm.

Pulse crops

DO NOT USE in pulse crops **UNLESS** application can be made using no-till farming practices.

Irrigation channels and drains

DO NOT USE in irrigation channels or drains **UNLESS ALL** irrigation tailwater and rainfall can be captured and held on farm.

Desert channels (bore drains)

DO NOT apply between 1 December and 30 March each year.

DO NOT apply more than once per calendar year.

DO NOT open drains for 72 hours following treatment.

Label buffer zones

DO NOT apply when there is non-target terrestrial vegetation within the specified distances set out in Table 10**.**

DO NOT apply when there are aquatic areas within the specified distances set out in Table 3.

Table 10: Downwind buffer zone

Situation	**Rate (g ac/ha)**	**Downwind buffer zone (m)**	
		Aquatic	**Terrestrial**
Broadacre crops / situations			
Winter cereals			
Wheat, barley, triticale, cereal rye and oats – WA only	250–500	30	60
Wheat, barley, triticale and oats – WA only	180–250	15	30
Wheat, barley and oats – NSW, Vic, ACT and SA only	450	25	50
Wheat and barley – SA only	640–880	50	100
Wheat and barley – NSW, Vic, ACT and SA only	250	15	30
Summer fallow – SA only	250	15	30
Cotton, irrigated cotton, capacity to retain runoff	900–1,800	100	200
Lupins – WA only	990	30	80
Pulses incorporated by sowing	750–990	30	80
post-sowing pre-emergent	495–750	50	100
Tropical / sub-tropical crops – sugarcane, bananas	250–450	25	50

Miscellaneous – asparagus	1,800	100	200
Bore drains – Qld only	32,000	N/R	N/R

Label approval numbers

The variation to labels will also include variation to the APVMA approval number, to uniquely identify the labels resulting from this review. The new number is likely to be [product_number]/1112.

Additional comments on recommendations

Apples and pears

It is noted the environmental assessment continued to support the use of diuron in apples and pears in the Goulburn Valley region only. It is anticipated that limiting the use on a regional basis would not prevent use in other jurisdictions which cannot be supported on environmental grounds. This is due to the ensuing legislation in Victoria. On this basis, the APVMA has chosen not to support this recommendation, and instead recommends the continued use of diuron in apples and pears not be supported.

Lucerne

Current labels indicate use of diuron at rates of application 900 g ac/ha to 1.8 kg ac/ha. At these rates the assessment has identified concerns for the environment. Information in submissions indicated it is widespread practice to apply rates less than those on labels, and in fact the APVMA has a long-term permit for diuron application to lucerne at 500 g ac/ha in New South Wales.

DSEWPaC considered these lower rates of application in the environmental assessment and found the use at a maximum rate of 750 g ac/ha could be supported.

However, the APVMA has concluded the use of diuron in lucerne cannot continue because the acceptable rate of application (750 g ac/ha) is below current label rates. The review cannot therefore vary labels to reduce label rates to this level. In this situation the continued use at the lower rates would require the provision of efficacy data. This would require an application through the registration process.

8 REGULATORY DECISIONS

On the basis of the evaluation of the submitted data and information (including protected information) the following regulatory decisions are proposed relating to the continued registration and approval of diuron use in Australia:

1. Vary conditions of label approval.
2. Affirm product registrations.
3. Cancel 'old' product label approvals.
4. Cancel product registrations.

Vary conditions of label approval

This action relates to those products where one or more uses on product labels are supported.

The APVMA is **NOT SATISFIED** that labels for selected products contain adequate instructions in relation to the criteria set out in s.14(3)(g) of the Agvet Codes.

However, the APVMA **IS SATISFIED** the conditions of label approval can be **VARIED**, in accordance with s.34(5) of the Agvet Codes.

The variations will mean the removal of those uses from labels in Table 9. The label restraints listed in this section will also be required.

Affirm product registrations and label approval

Once the label variations are made, the APVMA can be **SATISFIED** that labels contain adequate instructions. On this basis, the APVMA can also be **SATISFIED** that continued registration of the products in accordance with its instructions for use:

- would not be likely to have an effect that is harmful to human beings
- would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment.

The APVMA will **AFFIRM** the registration of certain products on this basis.

Cancel registrations and label approvals

This action relates to those products where none of the uses appearing on product labels are supported.

The APVMA is **NOT SATISFIED** that labels for selected products listed in Appendix A contain adequate instructions in relation to the criteria set out in s.14(3)(g) of the Agvet Codes, as well as those referred to in regulations 11 and 12 of the Agvet Code Regulations.

The APVMA is **NOT SATISFIED** that conditions of registration of these products can be varied in such a way that the requirements for continued registration will be complied with. On this basis, the APVMA is **NOT SATISFIED** that continued registration of the product in accordance with its instructions for use would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment.

The registration of these products will be **CANCELLED**.

Related regulatory action for products registered after the commencement of the review

The following recommendations relate to products not included in the review but whose registrations are subject to the outcomes of the review (identified in Appendix A product tables by an *).

The APVMA considers continued use of, or any other dealing with, the products containing diuron as outlined in Appendix A may likely have an effect that is harmful to animals, plants or things or to the environment (as per the findings of the review).

The APVMA is **SATISFIED** that, having regard to the matters set out in subsections 14 (4) and (5) the conditions of registration, some of these products can be varied in such a way that the requirements for continued registration will be complied with.

The APVMA is **NOT SATISFIED** that having regard to the matters set out in subsections 14 (4) and (5) the conditions of registration of some of these products can be varied in such a way that the requirements for continued registration will be complied with. As such, the registration of these products will be **CANCELLED** under s.41 of the Agvet Codes.

Cancel all but the most recently approved label

The APVMA is **NOT SATISFIED** that previously approved product labels for currently-registered products included in the review as well as subject to the outcomes of the review listed in Appendix A contain adequate instructions in relation to the criteria set out in s.14(3)(g) of the Agvet Codes. On this basis, these labels will be **CANCELLED**.

Appendix A Products included in the review and regulatory outcomes

Product registrations

Product numbers featuring an * indicate these are products registered after the review commenced which are subject to the outcomes of the review.

Table A-1: Industrial use-only products

Regulatory action: Cancel the registration of these products. Use in these situations is at high application rates with limited or no potential to control runoff.

Product number	Product name	Registrant	Label approval numbers
31275	Agspray Kill-All Total Herbicide	Agspray Chemical Co. Pty Ltd	31275/50432
45441	Macspred Dymac G Granular Herbicide	Macspred Pty Ltd	45441/02
47764	Macspred Kromac Industrial Herbicide	Macspred Pty Ltd	47764/02

Table A-2: Sugar case use-only products

Product number	Product name	Registrant	Label approval numbers	Regulatory action
45909	DuPont Velpar K4 DF Herbicide	DuPont (Australia) Ltd	45909/02 45909/0506	Retain low rate only and spot spray. Label restraints.
54182	Agricultural Product Services Diuron/Hexazinone DF Herbicide	Agricultural Product Services Pty Ltd	54182/0501	Cancel registration.
58128*	4Farmers Diuron/Hexazinone WG Herbicide	4Farmers Pty Ltd	58128/1103	Cancel registration.
59463*	Chemag Diuron/Hexazinone WG Herbicide	Imtrade Australia Pty Ltd	59463/0805	Cancel registration.
59557*	Barrage Herbicide	Crop Care Australia Pty Ltd	59557/0105	Cancel registration.
60768*	Farmoz Bobcat Combi WG Herbicice	Farmoz Pty Ltd	60768/0806	Retain low rate only and spot spray. Label restraints.
60926*	Whitestar Hexon 900 WG herbicide	Agricultural Product Services Pty Ltd	60926/0506	Cancel registration.
62012*	Generex Sugarhex Herbicide	Generex Australia Pty Ltd	62012/0707	Cancel registration.
62797*	Grandpar K4 Cane Herbicide	Sipcam Pacific Australia Pty Ltd	62797/0508	Cancel registration.
63917*	Rygel Dihex 900 WG Herbicide	Profeng Australia Pty Ltd	63917/0409	Cancel registration.
64301*	Imtrade Velchem Dust Herbicide	Imtrade Australia Pty Ltd	64301/0909	Cancel registration.
65037*	AC Vertex Herbicide	Axichem Pty Ltd	65037/0710	Cancel registration.

Product number	Product name	Registrant	Label approval numbers	Regulatory action
65215*	AW Dethrone Herbicide	Agri West Pty Ltd	65215/50428	Cancel registration.
65562*	Choice Diuhex Cane Herbicide	Grow Choice Pty Ltd	65562/51292	Cancel registration.
66261	AAKO Brave 60 WG Herbicide	AAKO Australia Pty Limited	66261/53102	Cancel registration.

Table A-3: Mixed use agricultural products (400 g/kg)

Product number	Product name	Registrant	Label approval numbers	Regulatory action
31253	DuPont Krovar DF Herbicide	DuPont (Australia) Ltd	31253/01 31253/4732	Cancel registration.

Table A-4: Mixed use agricultural (800 g/kg)

Product number	Product name	Registrant	Label approval numbers	Regulatory action
31682	Agspray Die-It 800 Wettable Powder Diuron Herbicide	Agspray Chemical Co. Pty Ltd	Labels transitioned from the states and not having an approval number	Delete all uses except asparagus and industrial areas. Add restraints.
48974	Zee-Uron 800 WP Herbicide	United Phosphorus Ltd	48974/01	Delete all uses except those listed in Table 9 plus restraints.

Table A-5: Mixed use agricultural (500 g/kg)

Regulatory action: Delete all uses except those listed in Table 8 plus addition of label restraints.

Product number	Product name	Registrant	Label approval numbers
31685	Bayer Diuron 500 SC Liquid Herbicide	Lanxess Pty Ltd	31685/0399 31685/1103
31702	Nufarm Flowable Diuron Liquid Herbicide	Nufarm Australia Ltd	31702/0200 31702/0605 31702/1007
47661	Striker 500 SC Selective Herbicide by Sanonda	Sanonda (Australia) Pty Ltd	47661/02
49540	Zee-Uron 500 SC Herbicide	United Phosphorus Ltd	49540/01 49540/0705
50481	Agcare Biotech Flowable Diuron 500 SC Herbicide	Agcare Biotech Pty Ltd	50481/0398
52176	Farmoz Diuron 500 Flowable Herbicide	Farmoz Pty Ltd	52176/0100 52176/0305 52176/1106
52342	Chemag Diuron Liquid Herbicide	Imtrade Pty Ltd	52342/0100
52672	Sipcam Diuron 500 SC Herbicide	Sipcam Pacific Australia Pty Ltd	52672/0200 52672/0800
53046	Smart Diuron 500 Flowable Liquid Herbicide	Agcare Biotech Pty Ltd	53046/0600
55612	Kenso Agcare Diuron 500 Herbicide	Kenso Corporation (M) SDN BHD	55612/0102 55612/0402
56349	4 Farmers Diuron 500 SC Liquid Herbicide	4 Farmers Pty Ltd	56349/1002 56349/0204
56602*	Halley Diuron 500 SC Herbicide	Halley International Enterprise (Australia) Pty Ltd	56602/0603
57823*	Echem Diuron 500 SC Herbicide	Echem (Aust) Pty Ltd	57823/0204

Product number	Product name	Registrant	Label approval numbers
58440*	Ospray Diuron 500 Flowable Herbicide	Ospray Pty Ltd	58440/0304 58440/1206
63621*	Country Diuron 500SC Herbicide	Accensi Pty Ltd	63621/1108
66184*	Apparent Diuron 500 SC Herbicide	Apparent Pty Ltd	66184/52944

Table A-6: Mixed use agricultural (900 g/kg)

Regulatory action: Delete all uses except those listed in Table 8 plus addition of label restraints.

Product number	Product name	Registrant	Label approval numbers
39201	Nufarm Diuron 900 DF Herbicide	Nufarm Australia Ltd	39201/1298 39201/0499 39201/0802 39201/0605 39201/0507
45177	Bayer Diuron 900 WG Herbicide	Lanxess Pty Ltd	45177/03 45177/0204
45772	Diurex WG Herbicide	Crop Care Australasia Pty Ltd	45772/1098 45772/0101 45772/1107
46812	Farmoz Diuron 900 WDG Herbicide	Farmoz Pty Ltd	46812/02 46812/0207 46812/0305 46812/0807

Product number	Product name	Registrant	Label approval numbers
49541	Zee-Uron 900 WG Herbicide	United Phosphorus Ltd	49541/01 49541/0108 49541/0508
53812	Imtrade Diuron 900 WG Herbicide	Imtrade Australia Pty Ltd	53812/0901
55094	Country Diuron 900 WG Herbicide	A&C Rural Pty Ltd	55094/0102
55561	Conquest Diuron 900 WG Herbicide	Conquest Agrochemicals Pty Ltd	55561/0302 55561/0106
56356*	4Farmers Diuron 900 DF Herbicide	4 Farmers Pty Ltd	56356/0405 56356/1207
57886*	Summit Diuron WG Herbicide	Sipcam Pacific Australia Pty Ltd	57886/1003 57886/0306
57934*	Runge Agrichems Diuron 900 WG Herbicide	Runge Agrichems Pty Ltd	57934/0104
58451*	Ospray Diuron 900 WG Herbicide	Ospray Pty Ltd	58451/0304 58451/0406
58455*	United Farmers Diuron 900 WG Herbicide	Ravensdown Fertiliser Cooperative Limited	58455/0204 58455/0305
60152*	Agroreg Diuron 900 WG Herbicide	Agroreg Pty Ltd	60152/0106 60152/0309
60286*	Genfarm Diuron 900WG Herbicide	Genfarm Crop Protection Pty Ltd	60286/0206 60286/1008
61309*	CMS Diuron 900 WG Herbicide	CMS Trade Pty Ltd	61309/0906
62189*	Titan Diuron 900 WG Herbicide	Titan Ag Pty Ltd	62189/1108 62189/1207
62426*	Chemforce Diuron 900WG Herbicide	Chemforce 2010 Pty Ltd	62426/1007
62700*	Ozcrop Diuron 900 WG Herbicide	CMS Trade Pty Ltd	62700/0108 62700/0309

Product number	Product name	Registrant	Label approval numbers
63571*	United Phosphorus Zee-uron 900 WG Herbicide	United Phosphorus Ltd	63571/0210 63571/1108
64359*	Farmalinx Diuron 900 WG Herbicide	Farmalinx Pty Ltd	64359/0610 64359/52352
64727*	Agriron 900 WG Herbicide	Agri Environmental Pty Ltd	64727/0610
65501*	Apparent Diuron 900 WG Herbicide	Apparent Pty Ltd	65501/51062
65536*	Sanonda Herbicide Diuron 900WG	Sanonda (Australia) Pty Ltd	65536/51149
66239*	Rainbow Diuron 900 WG Herbicide	Shandong Rainbow International Co. Ltd	66239/53043

Appendix B Public submissions on the Preliminary Review Findings report (2005) and comments provided to APVMA by DSEWPaC

Note: Appendix B summarises submissions to the APVMA following release of the 2005 *Diuron Preliminary Review Findings* (PRF) report. These were taken into consideration where relevant when preparing the 2011 human health assessment and environmental assessments. They are included here for information only, as they have not previously been published.

The publication of the 2005 PRF resulted in 23 submissions to the review. These submissions identified concerns with technical aspects of the review, together with comments on the proposed findings and the implications of these for continued use of diuron.

The submissions came from state governments with an interest in agriculture and water quality as well as from universities and other research organisations, user groups, chemical manufacturers, the general public and environmental groups. The information provided included scientific data, results of water-monitoring programs and comprehensive information on the role that diuron plays in various agricultural production systems.

The main issues raised in the submissions and the impacts these had on the review are discussed below.

Diuron in irrigation channels and non-agricultural areas

There was strong support from some respondents to limiting the use of diuron in some areas through removal of diuron use for weed control in industrial areas, irrigation channels, bore drains, commercial and industrial areas, driveways and car parks where high rates of diuron are applied.

It was the view of some respondents that surface water detections stem largely from current use of diuron on channels and drains, although this issue is difficult to assess without specific monitoring data.

However, in industries such as cotton where full recirculating irrigation systems are available to capture irrigation and rainfall runoff, the argument was presented that use in channels and drains in these circumstances should continue. Advice from Victoria highlighted the important role of diuron in the management of weeds in irrigation channels as it provides long-term weed control. Without diuron, spraying more frequently with other chemicals will be required.

Importance of diuron and alternatives

Many submissions highlighted the importance of diuron for agricultural production. Removing diuron was thought by many respondents to result in increased tillage and cultivation, greater post-emergent application of herbicides and in the case of sugarcane, the need to burn cane. This increased cultivation would also have the undesirable effect of making soils more vulnerable to loss during irrigation or rainfall.

In sugarcane, diuron is noted as one of the most commonly used herbicides and is normally applied in combination with other herbicides such as hexazinone, paraquat and 2,4-D sodium salt, to improve the spectrum of control and enhance efficacy. Diuron is added to products that give good control of broadleaf weeds to improve control of grass weeds. In the absence of diuron, chemical options to control some major grass weeds will be limited. It is also reported there are no registered alternatives for the control of Rottboellia species in sugarcane. Without diuron, additional soil tillage and cultivation will be required to keep weeds in check. A significant amount of work will be required to investigate effective alternatives before use of diuron should be withdrawn.

The cotton industry is also a significant user of diuron, with three main areas of use: pre and post-emergent weed control at planting; residual control of weeds in irrigation channels; and cotton defoliation. The industry has introduced management practices and procedures that, in combination with the use of pesticide-resistant varieties, have reduced the load of diuron in the environment through recirculating irrigation and the ability to capture first-flush storm. Limited monitoring of cotton in 2004–05 has shown a reduction in detections of diuron which also coincides with best management practices and resistant variety activities. It was therefore thought by the industry that diuron use in cotton was unlikely to be a significant contaminator of the environment.

All cotton farms have recirculating irrigation and the ability to capture first-flush storm water that minimises the risk of water or sediment containing pesticides moving off farm. The application of diuron to plants at defoliation was also considered a minimal drift risk due to the presence of significant foliage to trap chemicals. As not all cotton is mature at the same time, producers are very careful with application of defoliants to ensure minimal drift to immature cotton or other non-target crops.

Diuron is one of the most widely used residual herbicides used on asparagus. Asparagus industry respondents identified that limited options were available for long-term weed control. Asparagus is a long-term crop, remaining in the soil for up to 20 years and residual weed control is thus important.

In temperate grass seed production, diuron is used extensively as a post-emergent spray. Respondents noted there are a very limited number of chemicals available in this production enterprise. Unlike broadacre crops, grasses are very susceptible to chemical damage, particularly on lighter soils. This industry does not have a replacement chemical available with the same degree of plant safety as diuron. Trials are being undertaken into alternatives, so far with little success.

Various industries also noted that diuron is a useful tool in resistance management programs. Its loss would restrict the number of effective chemicals available for these programs.

Many respondents were concerned their particular industry was not a leading contaminator of the environment with diuron. While these comments were noted, for cropping situations considered as part of broadacre agriculture the risk assessment has been performed based on application rates rather than specific cropping industries. This is a national assessment, and consequently takes a much broader approach than required if only considering a specific crop or geographical area. This is also appropriate given agricultural product labels are approved at national level. The concern that diuron use in some situations may not result in the same environmental exposure as use in other crops is noted, but it is not possible to assess the contribution of each use.

Sediment loss

Given that diuron is strongly bound to soil particles and that substantial off-site movement of diuron results from the movement of sediment, a major focus of research efforts in sugar is to minimise sediment runoff from cane farms to reduce transportation of sediment and attached nutrients and agricultural chemicals to the riverine environment.

The Bureau of Sugar Experiment Stations (BSES) provided information on practices used by the sugar industry aimed at minimising these soil losses. The widespread adoption of green-cane harvesting and trash retention has significantly reduced soil erosion. Minimum till planting is also widely adopted and sediment traps are a mandatory requirement for new farms in the Burdekin River Irrigation Area. Large scale losses potentially only occur in fields prepared for planting or recently planted (once every 5–6 years) and only if there is a significant rainfall event.

There was some criticism that the PRF report had focused on off-farm movement through runoff without distinction between diuron in the sorbed phase (that is, bound to sediment and therefore associated with erosion loss) or in the aqueous phase.

Accumulation of diuron in the sediments of habitats of the Clarence and Tweed rivers was raised as a concern. A lack of water circulation and flow may promote diuron accumulation in these vulnerable ecosystems.

Continued support for diuron anti-fouling paints

Respondents raised concerns about the recommendation to continue the use of diuron as an anti-fouling paint. Many believed these products create unacceptable levels of diuron in the marine environment due to their presence in water for significant periods of time. Further restrictions in the use of biocidal paints were considered appropriate to minimise the potential to contaminate the Great Barrier Reef.

In response to these comments, DSEWPaC noted the risk assessment approach showed an acceptable risk to organisms in the Great Barrier Reef lagoon regardless of the source of diuron (compared to an unacceptable risk in freshwater river systems). Further, for marinas, DSEWPaC used the currently agreed OECD MAMPEC model (Marine Antifoulant Model to Predict Environmental Concentrations), which is a very conservative model that also showed an acceptable risk. Under these circumstances it is not possible to require further data to be submitted for anti-foulant use patterns.

Damage to mangroves

Some respondents raised the potential damage to mangroves from diuron in sediments as a concern. Advice from the NSW Department of Environment and Conservation (Marine Protected Areas Unit) identified that significant areas of mangroves in New South Wales are located in estuaries that received runoff from sugar-growing areas (Tweed, Brunswick, Richmond and Clarence rivers). Combined, these marine protected areas include approximately 300 ha of vulnerable mangrove populations that provide valuable habitats for wading and migratory bird species.

Buffers

The use of very large buffers as proposed (100 m for ground application, 500–750 m for aerial application) was considered to not reflect the low risk of diuron drift. The implementation of these buffer zones would have a significant impact on the effective use of the product.

The asparagus industry was concerned if the buffer zone requirements remained, the use of diuron in the industry would be unviable due to the region where asparagus is grown. These growing areas in the Kooweerup and Dalmore areas of Victoria just outside Melbourne (Australia's largest asparagus-growing district) are criss-crossed with drains and creeks and the application of buffer zones would significantly limit the areas available for planting.

The introduction of buffer zones was supported by the cotton industry which expressed the view the industry could manage these under their current best management practice system.

Validity of assumptions used in risk assessment

Significant criticism was received from registrants, state departments, user groups and research organisations on the methodology employed in the environmental assessment in the PRF report. There was much debate between the APVMA, DSEWPaC and these groups on the science underpinning the recommendations. Some of the specific concerns raised and the corresponding response from DSEWPaC follow.

Poor statistical basis for LOEC for mangroves

The statistical basis for the mangrove LOEC was based solely on the field observations of Duke et al (2001) and as such does not have the normal rigour. Subsequent field data for the Mackay region has failed to support the original observation of Duke et al (2001) and the risk assessment no longer relies on the mangrove data.

Lack of a reliable LOEC for seagrasses

A pre-publication draft of the paper where the LOEC was 0.1 µg/L was used for the PRF assessment, but in the final publication this result was deleted. The Haynes et al. data shows a LOEC of 10 µg/L but when the study was examined there was a clear dose response at 0.1 and 1.0 µg/L. Also, it was not a sensitive study, was conducted as a range-finding study and has several other limitations. Another more reliable seagrass study (more plants per replicate) has been included which shows a LOEC of 1.0 µg/L and a NOEC of 0.5 µg/L, but this is for an overseas temperate species rather than an Australian tropical species. The seagrass toxicity data is therefore no longer used in the risk assessment as results are based on a non-standard end point for regulatory decision-making.

The use of the species sensitivity distribution (SSD) approach

DSEWPaC has used a statistical approach to derive a species sensitivity distribution of available ecotoxicity data obtained using standard species, standard test protocols and standard, biologically-relevant end points. The non-standard test data from mangroves, sea grasses or corals was no longer used but it was noted that for sea grasses and corals, the toxicity data (measuring effects on photosynthetic activity) are similar to many of the standard growth effects found to species of algae and aquatic plants, so are considered protected by the SSD approach.

Making recommendations based on a tier 1 level assessment

The assessment approach for runoff in the new report follows a probabilistic methodology for determining aquatic ecotoxicity effects concentrations and receiving water concentrations. The former is based on a species sensitivity distribution with the 95th percentile protection value used for normal situations, and the 99th percentile protection value used for high protection situations. The receiving water concentrations are based on a combination of modelled and monitored levels, with the final value depending on the value with the greatest confidence.

The use of chlorophyll fluorescence as end point

As diuron is a Hill reaction inhibitor and its toxicity to plants is due to this activity, the chlorophyll fluorescence measurement is the first effect of diuron on the Hill reaction and it is thus considered to be the first indication of a toxic effect, albeit a sublethal one. While such an end point for PSII inhibitors may be relevant, the use of chlorophyll fluorescence as an end point for regulatory decision-making is untested. Consequently, a statistical approach has now been adopted to determine the aquatic effect concentrations based on results from standard test protocols with standard test species and standard ecotoxicological end points.

Use of freshwater algal species in marine environments

A statistical approach for deriving aquatic toxicity values has now been adopted. The distribution uses all standard available data and now includes marine species of algae and diatoms. It is not unusual to use freshwater species for marine assessment, particularly where data are limited or not available for marine systems. For this assessment, there were a number of non-standard tests on marine plant species including corals and seagrasses. These results suggest their toxicity was not remarkably different from standard results for a number of freshwater or marine algae species.

Use of Kd to calculate residue levels in water and sediment

While the PRF report relied on a largely unexplained Kd value, this Review Findings Report does not. In calculating residue levels in water and sediment, revised modelling now uses the lowest definitive Koc value. Importantly however, the modelled values with regard to predicted water concentrations resulting from runoff have been carefully compared with available monitoring data, and the end result used in the risk assessment is the value that provides the highest level of confidence. In the case of secondary rivers and coastal waters highest confidence was assigned to monitoring data, while the modelled value was used for primary streams.

All relevant comments and information provided have been taken into consideration by the APVMA and its evaluating agencies (DSEWPaC and OCSEH) in the preparation of the Review Findings Report.

Additional information

Legislative amendments related to diuron use

After 1 January 2010, the use of diuron in commercial sugarcane-growing operations in Queensland must be in accordance with new requirements under the Chemical Usage (Agricultural and Veterinary) Control Regulation (1999). Under the Queensland Government initiative on the Reef Protection Package, comprehensive guidelines on chemical use have been prepared, *Sugarcane Grower's Guide to Chemical Use under the Reef Protection Legislation*, which applies to all sugarcane properties in the wet tropics, the Burdekin Dry Tropics and the Mackay Whitsunday catchments. It provides a number of mandatory requirements when using diuron (and some other herbicides), based on the use of a 20-m No-Spray Zone or a 5-m effective vegetated treatment area (EVTA) and a maximum annual application rate of 1.8 kg ac/ha. There is also a requirement for users to have a specific land management plan, but no requirements for testing water or sediment.

These regulations are designed to minimise the drift and runoff of diuron-based products from sugarcane properties into the Great Barrier Reef lagoon. These new regulations are in addition to existing label instructions. To use diuron products, users must be suitably trained but also comply with the following conditions of use:

- Do not prepare the product at a place where it can easily runoff into a water body.
- Do not prepare the product within 20 m of a water body*.
- Do not apply the product if heavy rain (including scattered or widespread storms) has been forecast within 48 hours.
- Do not apply the product to a drainage depression or drainage line.
- Do not apply the product to waterlogged soil.
- Do not apply the product within 30 m of a downwind water body unless you are using a shielded sprayer*.
- Do not apply the product in wind speeds greater than 20 km/h.
- Do not apply the product in wind speed less than 3 km/h unless the application method is under canopy or by shielded sprayer.
- For shielded sprayers use spray nozzles under conditions that produce a medium or larger spray droplet spectra.
- For other equipment types, use spray nozzles under conditions that produce a coarse or larger spray droplet spectra.
- You must not irrigate the application area to the point of runoff within 48 hours of applying the product.
- You must not apply greater than a total of 1.8 kg of a diuron active ingredient per hectare per year.
- You are required to keep records of the use of all diuron-based herbicides.

DSEWPaC was not involved with these requirements and is not aware of the basis for these restrictions. The effectiveness of the Queensland initiatives remains to be demonstrated. DSEWPaC has considered the use of vegetative buffer strips in assessments in the past and has failed to find convincing data to include the use of such tools in its assessments to date. Further, the basis for the prescribed spray drift buffer zone is not known, and where shielded sprayers are not used, the modelling using standard APVMA parameters indicates this may not be sufficiently protective.

Reef and Rainforest Research Centre (RRRC)

The World Wildlife Fund (WWF) provided the APVMA a draft science summary from the Reef and Rainforest Research Centre (RRRC) discussion on research believed to demonstrate that pesticide and herbicide runoff from farming systems is damaging aquatic communities in the Great Barrier Reef.

A comprehensive assessment of this document was undertaken by DSEWPaC, and its full response is provided in Appendix B.

DSEWPaC has concluded there appears to be evidence that agricultural activities (along with a range of other human activities) are leading to undesirable impacts on the Great Barrier Reef's inshore areas and the Department agrees with the general direction of the RRRC science summary. However, the impacts of agricultural activities are wider than the issue of just pesticides. In this regard, it is noted the RRRC science summary attempts to assign a degree of certainty to the impacts of pesticide residues on the inshore reefs of the Great Barrier Reef that is not reflected by the data in the references cited. This does not mean, however, that further management action is not warranted. The Great Barrier Reef is a high conservation area, and given the number of uncertainties in our current knowledge of how different activities impact this area, a precautionary approach is necessary, including further consideration of the levels of pesticide entering the reef's lagoon via the adjacent freshwater system.

Summary statement from the Reef Science Panel on water quality

The RRRC science summary states that the weight of scientific evidence indicates that inshore reef health is negatively affected by pollutants, including pesticides, flowing from rivers and into the Great Barrier Reef lagoon. To support this statement, the summary refers readers to the Australian Government's Summary Statement from the Reef Science Panel on water quality at www.environment.gov.au/coasts/pollution/reef/science/pubs/science.pdf. The reference to 'the federal government's summary statement' is incorrect. It is believed it refers to the scientific consensus statement on Reef Water Quality published by the Queensland Government and prepared under the auspices of the joint Australian–Queensland Reef Water Quality Protection Plan. The summary statement itself is underpinned by a report on the study of land-sourced pollutants and their impacts on water quality in and adjacent to the Great Barrier Reef, dated 10 January 2003 (Baker 2003). The report appears well balanced, and reports data available at the time. However, it considers a wide range of factors other than just pesticides that lead to a decline in water quality in Great Barrier Reef catchments. The report and summary also acknowledge the spatial extent of impacts and the resilience of the reef's systems to sediments, nutrients and pesticides are not well understood. This remains the case several years after this report was completed.

In the main report underpinning this summary, evidence of factors leading to decline in water quality in Great Barrier Reef catchments is reported as particles of eroded soil, re-mobilised stream sediments, nutrients such as nitrogen and phosphorus, pesticide residues, industrial chemicals, heavy metals and organic matter.

Reef Water Quality Protection Plan

The RRRC science summary states that the strength of the accumulated evidence saw governments and managing agencies develop the Reef Water Quality Protection Plan to build reef resilience by reducing environmental stress caused by agricultural pollutants. The recently-published scientific consensus statement on water quality in the Great Barrier Reef reviews and summarises knowledge and current understanding, as the Reef Plan approaches its halfway mark – see www.reefplan.qld.gov.au/about/assets/scientific-consensus-statement-on-water-quality-in-the-gbr.pdf.

This statement certainly lends support to the RRRC statement and acknowledges agricultural land use, along with other factors such as hydrological change, riparian degradation and weed infestation impact the ecosystem health. The consensus statement concludes that land-derived contaminants, including suspended sediments, nutrients and pesticides are present in the Great Barrier Reef at concentrations likely to cause harm.

While pesticides are included, they are not stated as the only contributor to poor water quality. The issue of their presence at concentrations likely to cause environmental harm is considered in more detail below, it is agreed that a range of pesticides are moving off farm as they are consistently found in river waters, and in inshore reef areas within flood plumes.

Lewis et al. (2009)

The RRRC science summary makes the following statements with respect to this research:

- *“The herbicides atrazine and diuron have been identified in water samples taken from flood plumes in the Great Barrier Reef lagoon at concentrations known to have negative effects on seagrass and corals”.*
- *“These atrazine and diuron herbicide residues persist in the lagoon at low concentrations even during non-flooding seasons”.*

DSEWPaC comments

The research presented in Lewis et al. (2009) is a dataset examining the sources, transport and distribution of pesticide residues from a selection of Great Barrier Reef catchments to the Great Barrier Reef lagoon. The study traced pesticide residues from rivers and creeks in three catchment regions to the adjacent marine environment. Based on these findings, the authors discuss the potential ecotoxicological risks of these chemicals to the health and productivity of the Great Barrier Reef.

The majority of surface water sampling outcomes were provided from other published research, and these were analysed by DSEWPaC. In the supplementary information of the Lewis et al. (2009) paper, data is provided for 106 marine surface water samples, noting the river systems of influence and detailing salinity and herbicide concentrations (8 herbicides). However, the authors note in their supplementary information these all relate to pesticides **in river water plumes**, and the chemical residues are thus expected to be at elevated levels within the plume compared with the wider inshore lagoon water levels.

A short review of the data based on published material indicates that of the 106 samples, 58 (~55%) were sampled in major plumes with a further 20 (~20%) sampled within the major plume zone shortly (1–2 weeks) after the main plume sampling.

Based on these 106 samples, a brief analysis of diuron concentrations shows the following:

- Where sampled in a major flood plume (58 samples), diuron was detected in 55 samples (~95%), and where detected, the levels ranged from 0.008 to 1.70 µg/L. The 50^{th} percentile and 90^{th} percentile concentrations (in the detected range) were 0.10 and 0.71 µg/L respectively.
- Where sampled at a time close to the main plume sampling (to consider persistence), and within a known plume zone (20 samples identified by DSEWPaC in the data set, but possibly more), diuron was found in 19 samples (95%) in a narrow range of 0.02 to 0.08 µg/L. Within this detected range, the 50^{th} percentile and 90^{th} percentile concentrations were 0.03 and 0.07 µg/L respectively.

- The remaining 28 samples, while still noted as being within a river water plume, are possibly more reflective of marine waters in the sampling zone where concentrations are more indicative of ‘background’, that is, not associated with major runoff events. In these samples, diuron was only detected once, at a concentration of 0.01 µg/L in what appears to be an inshore area. At all other times, diuron was below 0.01 µg/L (10 ng/L), and other herbicides were sporadically detected with a maximum level of 0.03 µg/L (30 ng/L) tebuthiuron found in what seems to be an inshore area near a river outlet.

In addition, atrazine was found in 71 of the 106 flood plume samples (67%) with a 90th percentile concentration of 0.12 µg/L and a 50th percentile concentration of 0.02 µg/L.

It is claimed in Lewis et al. (2009) that mixing plots showed “physical, chemical and biological processes did not remove herbicides, thus herbicides were detectable to at least 50 km offshore from some river mouths and therefore reach inshore reefs of the GBR [Greater Barrier Reef] lagoon”. From analysis of the diagrams and corresponding samples provided in the supplementary information, it is not clear which sampling location was located 50 km offshore, or what herbicides were detected.

There is little doubt that agricultural chemicals are found in river water plumes, but the statement that they are found in the lagoon “at concentrations that are known to have negative effects on seagrass and corals” is not supported by data in the reference cited. Some further discussions on ecotoxicological end points are provided below.

Secondly, the RRRC statement that “atrazine and diuron herbicide residues persist in the lagoon at low concentrations even during non-flooding seasons” is also not supported by data in the reference cited. The above analysis of the reported concentrations suggests that diuron may persist in the plume zone for several days, however, based on the data set provided here, there doesn’t seem to be evidence of continuing low-level exposure (at the measureable 0.01 µg/L).

The comment in Lewis et al. (2009) relating to persistence of the herbicides in the flood plume indicates a half-life in the plume waters of <1.5 weeks, and does not mean the substances are persistent in the plume waters. Lewis et al. (2009) also refer to data taken from time-integrated passive samplers showing that herbicide residues in the Great Barrier Reef lagoon persist at low concentrations (0.001–0.010 µg/L range) throughout the year. DSEWPaC has separately obtained some of these data and the 2006–07 data are summarised below.

Kapernick et al. (2007) describe results from routine passive sampling from 12 inshore reef sites. Sampling continued throughout the wet and dry seasons of 2006–07. The results in Table B-1 are summarised for hexazinone, atrazine and diuron.

Table B-1: Estimated concentration in inshore reef waters (ng/L) predicted from passive samplers

		Diuron		Atrazine		Hexazinone	
Site		dry	wet	dry	wet	Dry	wet
Pixie's Pinnacle	Max	<1	0.59	<1	0.34	<1	<1
	Min	<1	0.51	<1	<1	<1	<1
	n	1	2	1	2	1	2
Low Isles	Max	1.0	5.2	0.39	2.10	<1	1.7
	Min	0.08	0.44	<1	<1	<1	<1
	n	4	6	4	6	4	6
Fitzroy Island	Max	1.8	5.1	0.24	2.6	<1	1.7
	Min	0.22	<1	<1	0.14	<1	<1
	n	4	5	4	5	4	5
High Island	Max	0.54	14	0.35	1.5	0.16	3.9
	Min	<1	3.9	<1	0.87	<1	1.8
	n	2	2	2	2	2	2
Normandy Island	Max	0.84	5.3	0.94	2.7	0.16	1.7
	Min	<1	0.28	<1	<1	<1	<1
	n	2	5	2	5	2	5
Orpheus Island	Max	0.07	0.67	<1	<1	<1	<1
	Min	<1	<1	<1	<1	<1	<1
	n	3	3	3	3	3	3
Magnetic Island	Max	0.29	3.3	0.08	6.71	<1	0.35
	Min	0.25	<1	<1	<1	<1	<1
	n	3	3	3	3	3	3
Inner Whitsundays	Max		9.4		1.8		4.4
	Min		0.89		<1		<1
	n	0	5	0	5	0	5
Outer Whitsundays	Max		17		3.6		7.1
	Min		<1		<1		<1
	n	0	6	0	6	0	6
Heron Island	Max		0.69		<1		<1
	Min		<1		<1		<1
	n	0	2	0	2	0	2
North Keppel Island	Max	1.3	2.6	<1	<1	<1	<1
	Min	<1	<1	<1	<1	<1	<1
	n	4	3	4	3	4	3

These data suggest inshore reef concentrations are higher in the wet season. For diuron, the highest estimated concentration was approaching 20 ng/L (0.02 µg/L), but were generally <10 ng/L (0.01 µg/L) in the wet season while for atrazine, the maximum estimated concentration was 6.7 ng/L (0.0067 µg/L). In the dry season, levels were generally <1 ng/L (<0.001 µg/L) for all three herbicides. Nonetheless, passive samplers provide average concentrations based on the sampling period, and the finding of diuron particularly, and atrazine and hexazinone occasionally, at such detectable levels in marine waters does suggest continued monitoring efforts are necessary.

The RRRC science summary acknowledges that long-term effects of such chronic low-level exposure on the Great Barrier Reef ecosystem are unknown, but then points to the research by Cantin et al. (2007), which is discussed below.

Cantin et al. (2007)

The RRRC science summary makes the following statements with respect to this research:

- "While the possible long-term effects of this chronic low-level exposure on the Great Barrier Reef ecosystem are unknown, laboratory tests have indicated that sublethal concentrations of diuron can negatively affect the reproductive capacity of corals."

DSEWPaC comments

Cantin et al. (2007) examined the importance of energy derived from photosynthesis to the gametogenesis of corals following long-term experimental exposures to diuron. Two broadcast spawning corals, *Acropora tenuis* and *A. valida*, and a brooding coral, *Pocillopora damicornis*, were exposed to 0 (controls), 1.0 (low) and 10 µg/L (moderate) diuron concentrations for 2–3 months before spawning on planulation. The following findings were reported:

- Diuron caused photoinhibition in each species, with pulse amplitude modulation (PAM) fluorometery recording consistent declines in effective quantum yields of 20% and 75% at 1 and 10 µg/L respectively.
- *A. valida* and *P. damicornis* were both sensitive to this photoinhibition, becoming severely bleached at 10 µg/L.
- At 10 µg/L, *A. valida* sustained both partial and full colony mortality. However, *A. tenuis* was more resistant and neither bleached or sustained mortality at any treatment.
- Polyp fecundity was reduced by 6-fold in *A. valida* and both *A. valida* and *P. damicornis* were unable to spawn or planulate following long-term exposures to 10 µg/L diuron.

The LOEC from this study appeared to be 10 µg/L with a NOEC of 1.0 µg/L based on polyp fecundity. In comparison, our current diuron assessment concludes a 99th percentile protection level, based on standard test NOEC data, of 0.47 µg/L.

While this test is non-standard in terms of regulatory ecotoxicity tests, it does not mean the results should be disregarded. However, it is important to place them in context with the statement made in the RRRC science summary. In this regard, we offer the following comments:

- The NOEC from this study is still higher than that used in our environmental risk assessment of diuron (0.47 µg/L), which was based on a statistical distribution using standard regulatory test results, so the results are not considered remarkably sensitive.

- This test used an exposure period of 2–3 months. This would not appear particularly environmentally realistic given the plume concentrations in Lewis et al. (2009) above showed a maximum diuron detection of 1.70 µg/L in one plume over the last several years of monitoring. It would be more appropriate to determine realistic chronic exposure levels (which would appear to be below 0.01 µg/L based on the above data, and 2 orders of magnitude lower than the test NOEC), and perform tests at this level.

Magnusson et al. (2008)

The RRRC science summary makes the following statement with respect to this research:

- "Growth rate and photosynthesis of two tropical estuarine microalgae species are negatively affected by diuron at concentrations detected in inshore areas of the Great Barrier Reef."

DSEWPaC comments

This research is valuable in that it provides a basis for comparing non-standard PAM results with more traditional algae toxicity end points of growth and biomass. The study involved a 3-day (72-h) exposure period using two tropical benthic microalgae; *Navicula sp*. (Heterokontophyta) and *Nephroselmis pyriformis* (Chlorophyta). Replicate mother cultures for both organisms (n=5) in exponential growth phase were dosed with a dilution series of seven concentrations of herbicide (diuron, hexazinone or atrazine) and a DMSO carrier control. Results are provided in Table B-2.

Table B-2: 72-h growth rate (µ), biomass increase and effective quantum yield [Y(II) values (/L)

	Navicula sp.			*Nephroselmis pyriformis*		
	µ	Biomass	*Y*(II)	µ	Biomass	*Y*(II)
EC50						
Diuron	7.8**	3.7	5.5	8**	5.8	5.9
Atrazine	130*	65	99	50	35	28
Hexazinone	27*	14	16	10	8.4	6.2
EC10						
Diuron	2.4**	0.5	1.0	5.2**	2.2	1.1
Atrazine	35*	26	19	23	11	6.8
Hexazinone	6.5*	3.4	3.3	4.8	3.8	2.1

* n=4; ** n=3; otherwise, n=5

These results indicate that the PAM methodology would appear to give outcomes not dissimilar to the standard toxicity end points. Growth was less sensitive than reduction in quantum yield for both species and all chemicals tested, and this is important as the growth end point is the preferred one for reporting and use in the risk assessment of a standard regulatory assessment over results determined through biomass measurements. In this sense, use of PAM results may slightly overestimate toxicity compared with growth results, but nonetheless, the outcomes are in relatively good agreement. We note the PAM exposure period in this study was 3 days, which allowed it to be directly comparable with the growth and biomass results. However, many PAM studies seem to be for a shorter exposure period (24 h). To confidently use results generated using PAM methodology, these 24-hour results would need to be related to standard 72-hour growth and reproduction studies.

The RRRC science summary notes these results show growth rate and photosynthesis of the tested species are negatively affected by diuron at concentrations that have been detected in **inshore areas** of the Great Barrier Reef. To this statement, the following comments are offered:

- The EC50s for diuron for both species tested from either growth or reduction in quantum yield are 5.5 to 8 µg/L. These levels to our knowledge have never been found in inshore areas and levels as high as this have only rarely been found in river systems based on several years of monitoring.
- The lowest EC10 values for diuron for both species tested from either growth or reduction in quantum yield are 1.0–2.4 µg/L. From 106 flood plume samples provided above in Lewis et al. (2009), only four samples showed levels (all from the same plume on the same sampling day) exceeded 1 µg/L, and none were >1.7 µg/L. The 90th percentile concentration from the highest detected levels in these flood plume data was ~0.7 µg/L. Further, the EC10 is often taken to represent a statistical, or biologically significant, "NOEC" so a >10% reduction in quantum yield, which may be considered adverse, would appear unlikely to occur from current measured levels.

The results from these toxicity tests allow, for the first time, a comparison between the PAM methodology and a standard algal test end point of growth rate. However, subject to the comments about the lengths of PAM testing above, these results do not show the tested species to be more sensitive than the ecotoxicity end point used in our diuron review, where a statistical end point was used for undertaking the risk assessment, or that concentrations of diuron detected in inshore areas will negatively affect microalgae species.

Humphrey et al. (2007)

The RRRC science summary attributes several findings to this innovative biomarker research:

- Significantly reduced cholinesterase activity in muscle tissues of barramundi from the Johnstone and Herbert rivers, relative to barramundi from other rivers with less modified catchments – suggested to be the result of exposure to pesticides, particularly insecticides of the organophosphorus and carbamate variety, and specifically mentions chlorpyrifos.
- A five-fold and three-fold increase in EROD (ethoxyresofurin-O-deethylase) activity in barramundi from the Johnstone and Herbert rivers respectively, relative to barramundi from other rivers with less modified catchments – stated as known to occur from exposure to some kinds of hydrocarbons, PCBs (polychlorinated biphenyl), pesticides, dioxins and furans.
- Significantly increased rates of DNA damage in barramundi from the Johnstone River relative to barramundi from other rivers.
- Although sublethal, these low-level effects can significantly reduce survival and growth of individuals over time, and eventually flow through to negatively affect populations or ecosystems if exposure to contaminants is continued or increases.

DSEWPaC comments

While the increase in EROD activity is broadly attributed to a range of different chemicals, the RRRC's conclusions relating to reduced cholinesterase activity are much more specific. The research, while stating that significant comparative inhibition of cholinesterase activity in fish suggests exposure to organophosphorus and carbamate insecticides in the Herbert and Johnstone rivers, then notes that chemical analysis of both sediments and water (based on grab samples) failed to detect either of these classes of compound in any river system.

The Johnstone and Herbert rivers are shown to be much more impacted by human activity, and have higher human populations associated with them than other rivers considered in this research. While we do not dispute the multi-biomarker approach used in the study, its findings must be interpreted with a degree of caution.

As an example, the heaviest populations are found in the catchments of the Herbert and Johnstone rivers. Therefore, it follows that other human activity such as release from waste water treatment plants would be increased in these areas. There are many human pharmaceuticals and industrial chemicals known to inhibit cholinesterase activity or increase EROD activity in fish that could be released to the river systems through treatment plants, and these impacts of human activity should not simply be ignored.

Harrington et al. (2005)

The RRRC science summary makes the following statements with respect to this research:

- "Research by these authors has shown that even short-term exposure to trace concentrations of diuron impaired the resilience of a crustose coralline alga (CCA)."

DSEWPaC comments

This paper studied the synergistic effects of sedimentation and diuron exposure of several 'clean' sediments and diuron with sediment, and investigated the effects of such exposures on photosynthesis and survival of these organisms. Three species of CCA were collected from mid-shelf reefs and subjected to sediments (*Hydrolithon reinboldii*, *Neogoniolithon fosliei* and *Porolithon onkodes*). One of these species (*P. onkodes*) was then exposed to diuron and sediments in combination. The primary responses of interest was altered photophysiology (quantified using PAM fluorometry), bleaching and survival.

Four types of sediments were used. Estuarine sediment (upper 5 cm of a mud bank) from the Herbert River was sieved into fine (<63 µm) and medium (63–250 µm). Fine offshore sediments were collected from Otter Reef and sieved to retrieve the <63 µm fraction, and a fine calcareous sediment was prepared as sawdust by cutting dried skeletons of *Porites* corals. Analysis of the first three sediments revealed diuron contamination at 0.20, 0.28 and 0.16 µg/kg respectively, showing even in the offshore sediments, diuron is a low level contaminant.

Sediment exposure studies: CCA fragments were transferred to 25 L aquaria (2 per sediment type). The sediments were stirred to ensure uniform distribution and allowed to settle. Measured levels of sediment deposition were 96–105 mg/cm^2. Flow-through sea water was provided during the exposure period (84 h) after which the fragments were subsequently transferred back to sediment free aquaria to recover (84 h). Sedimentation adversely affected all species with all sediment types. Following removal to sediment free aquaria, recovery was observed for all species. The most significant effects were found for the Herbert River fine sediment, and the most sensitive species was *P. onkodes*, which after an 84-hour recovery, still only had photosynthetic activity around 80% of control levels.

Combined diuron and sediment exposure: This part of the experiment was performed to determine whether sedimentation strees is altered by the presence of diuron and was performed with the sediment shown to cause the greatest strees and the CCA species shown to be the most susceptible. *P. onkodes* was exposed to four diuron concentrations (measured at 0 and 105 h with mean values of 0, 0.79, 2.27, 6.36, 21.3 µg/L) for 105 hours. In addition, diuron was added to aerated Herbert River fine sediments suspended on sea water at mean (0 and 105 h) concentrations of 0, 0.79, 2.50, 7.86, 24.65 µg/L. *P. onkodes* was exposed to this mixture sufficient to give a final sedimentation rate of 96 mg/cm^2. Following exposure, CCA were transferred back to sediment and contaminant free aquaria for a recovery period of 9 days.

Results

In the diuron-only experiment, the only concentration to reduce photosynthetic activity was the highest test concentration with around 65% inhibition at the end of the exposure period. Recovery continued after cessation of exposure and photosynthetic activity for this group was the same as control values after 9 days. In the combined diuron/sedimentation experiment, at the end of the exposure period, all treatments (including the uncontaminated sediment treatment) showed similar reduction in photosynthetic activity (around 20% of control values) indicating the strees was caused by sedimentation rather than diuron. However, during the recovery period, the uncontaminated sediment group showed stronger recovery and after 9 days, had recovered to within about 75% of control levels. Meanwhile, all the diuron treatment groups showed a statistically similar recovery and ranged from 40–60% of control values at the end of the recovery period. The implication of this is that while initial strees is caused by sedimentation, the occurrence of additional strees (in this case, diuron) can impede the recovery of the CCA, even though in this case diuron did not cause any lasting adverse effects on the test organism when exposed in water alone up to 21 µg/L.

In the sediment-only experiments, the most sensitive species, *P. onkodes,* had parts of the fragments showing loss of pigmentation, although no mortality occurred after the treatments. With the additional streesor of diuron, some fragments were considered dead (17%) with 59% bleached.

These results cannot be used in a standard risk assessment approach. No dose/response relationship can be determined although it could be noted that diuron in the absence of sedimentation exhibited an LOEC of 21.3 µg/L and a NOEC of 6.36 µg/L to *P. onkodes*. As concluded in the paper, sediment deposition can negatively affect the photosynthetic activity of CCA and this strees can be significantly enhanced by the presence of diuron. The presence of diuron did not enhance the strees caused by sedimentation during the period of sedimentation but it did appear to adversely affect the ability of the CCA to recover.

Negri et al. (2005)

The RRRC science summary makes the following statements with respect to this research:

- "Low diuron concentrations are also known to reduce survivorship of larval and recruit corals."

DSEWPaC comments

In this research, effects of diuron on the early life history stages of broadcast spawning and brooding corals were examined in laboratory experiments. Exposure periods were 96 hours (4 d) and a 14-day recovery period was included. The experiments showed:

- Fertilisation of *Acropora millepora* and *Montipora aequituberculata* oocytes were not inhibited at diuron concentrations of up to 1000 µg/L.
- Metamorphosis of symbiont-free *A. millepora* larvae was only significantly inhibited at 300 µg/L diuron.
- *Pocillopora damicornis* larvae, which contain symbiotic dinoflagellates, were able to undergo metamorphosis after 24-hour exposure to diuron at 1000 µg/L.
- On the other hand, 2-week old *P. damicornis* recruits were as susceptible to diuron as adult colonies, with expulsion of symbiotic dinoflagellates (bleaching) evident at 10 µg/L diuron after a 96-hour exposure. Reversible metamorphosis was observed at high diuron concentrations, with fully-bleached polyps escaping from their skeletons.
- Pulse amplitude modulation (PAM) chlorophyll fluorescence techniques demonstrated a reduction in photosynthetic efficiency (ΔF =F'm) in illuminated *P. damicornis* recruits after a 2-hour exposure to 1 µg/L diuron.
- The dark-adapted quantum yields (Fv/Fm) also declined at 1 µg/L and higher, which is claimed by the authors to indicate chronic photoinhibition and damage to photosystem II.

The research reports NOECs from recruit coral PAM findings of 0.1 µg/L. However, the study also investigated recovery. This is an important aspect, and showed that following cessation of exposure, recovery was complete with quantum yields at exposure groups of 0.1, 1.0 and 10 µg/L being equivalent to controls within 1 day. Recovery was somewhat slower at the highest 30 µg/L tested, but was still complete within 7 days of exposure ceasing.

These were the most sensitive end points in this non-standard study, and effects did not persist beyond the period of exposure. It is therefore difficult to conclude that low levels of diuron, in the context of levels found in inshore areas of the Great Barrier Reef, will reduce survivorship of larval and recruit corals based on this study. However, it is unclear how continual exposure to low levels (lower than those used in this study) will affect (including development of resistance) aquatic communities.

RRRC conclusion

The RRRC science summary notes research currently being undertaken to test the effects of exposure of corals, seagrasses and foraminiferans to concentrations of atrazine and diuron that are already known to occur on the Great Barrier Reef, including testing the potential for synergistic effects using combinations of temperature, turbidity and salinity strees. Even without this research, the RRRC concludes that current science indicates there is a risk that agricultural chemical residues are negatively affecting the resilience of inshore reefs, and this is especially likely during the wet season when floods result in concentrations spikes in the Great Barrier Reef lagoon. Their final conclusion is therefore: "*Runoff pesticides and herbicides are therefore likely to be contributing to erosion of ecosystem resilience of inshore reefs in the Great Barrier Reef lagoon".*

DSEWPaC comments and recommendations

- The RRRC science summary is selective in the use of the available data in compiling the science summary. The experiments cited have generally been well conducted, and provide further useful information for use in a wider environmental risk assessment framework. However, risk is a function of exposure and effects, and combination of the two needs to be kept in perspective. In this regard:

- The Great Barrier Reef Marine Park Authority (GBRMPA) has draft water quality guidelines (GBRMPA 2008) for a range of pesticides and herbicides, and these are often used as the basis for determining if a chemical may pose a risk to the Great Barrier Reef based on monitored levels. However, the temporal scale of exposure needs to be carefully considered. The GBRMPA guideline values are based largely on Australian and New Zealand Environment and Conservation Council (ANZECC)-derived water quality guidelines, and the GBRMPA document notes that the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ 2000) guidelines were not intended to be applied as mandatory standards. In this, it is reinforced that detection does not translate to risk, in that they recognise there is significant uncertainty associated with the derivation and application of water quality guidelines and as such, the water quality guidelines should be viewed as being a trigger for further management action. For example, the GBRMPA advises these trigger levels are regularly exceeded in dry and also wet seasons in the Great Barrier Reef. Current monitoring results indicate that levels of pesticides detected in farm drains and adjacent waterways regularly exceed the current ANZECC Water Quality Guideline trigger values and therefore pose a significant threat to riverine and coastal ecosystems. Pesticide concentrations exceeding these trigger values are most frequently detected in areas adjacent to irrigated agriculture (Leigh Gray, GBRMPA, personal comment).
- Where possible, available monitoring data need to be considered in terms of their spatial and temporal trends. For example, determining the probability that levels approaching maximum detected levels will be present in the environment. The high number of good quality monitoring values for the chemicals considered in the Great Barrier Reef rivers monitoring programs indicates it is not appropriate to take the maximum residue found in monitoring trials and use this as an exposure concentration in a risk assessment context because there is an extensive database of monitoring results clearly showing such levels are not frequent, or found long term.
- The issue of recovery following short-term exposure to the higher detected levels is important, and in our view, not adequately taken into account. In limited studies where this was considered, results tended to support a conclusion that lasting adverse effects will not result from short-term exposure found during runoff events entering the Great Barrier Reef lagoon.
- For a robust scientific environmental risk assessment, it is important to compare the exposure based on analysis of monitoring data with the levels shown to cause toxic effects, and this should consider both the spatial and temporal scale of exposure. For example, longer-term exposure concentrations at some locations are found in the low to sub ng/L range, while the more sensitive toxicity test results from the studies considered above are in the low µg/L range, or orders of magnitude higher than long-term exposure levels. Despite this, it is noted that some continual exposure (for example, diuron) may occur to inshore reef areas. Such levels appear much lower than those used in ecotoxicity tests, and the impact of such continual exposure is not known.
- Ongoing research to quantify the impact of agricultural pesticides on freshwater systems flowing into the Great Barrier Reef lagoon is supported.
- Diuron is one of the most toxic and widespread contaminants in freshwater systems flowing into the Great Barrier Reef.

In conclusion, there certainly appears to be evidence that agricultural activities (along with a range of other human activities), are leading to undesirable impacts on the Great Barrier Reef inshore areas and the Department agrees with the general direction of the RRRC science summary. However, the impacts of agricultural activities are wider than the issue of just pesticides. In this regard, it is noted the RRRC science summary attempts to assign a degree of certainty to the impacts of pesticide residues on the inshore reefs of the Great Barrier Reef that is not reflected by the data in the references cited. This does not mean, however, that further management action is not warranted. The Great Barrier Reef is a high conservation area, and given the number of uncertainties in our current knowledge of how different activities impact this area, a precautionary approach is necessary, including further consideration of the levels of pesticides entering the Great Barrier Reef lagoon via the adjacent freshwater systems.

In addition, the Department noted in the conclusion of the APVMA's review of diuron that risk to algae and aquatic plants in primary streams (freshwater habitats) is unacceptable at all broadacre rates of 0.45 to 3.6 kg/ha, and in secondary streams at rates of 0.9–3.6 kg/ha based on 95% protection level. Regarding coastal waters, our assessment concluded that risk was deemed acceptable due to dilution of diuron in the marine environment. Nonetheless, diuron is routinely detected in coastal waters and its properties of persistence in water and very high toxicity make the presence of such chemicals undesirable.

References

ANZECC (Australian and New Zealand Environment and Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand), 2000, 'Australian and New Zealand guidelines for fresh and marine water quality', *National Water Quality Management Strategy*, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Baker J, 2003, *A Report on the Study of Land-Sourced Pollutants and Their Impacts on Water Quality in and Adjacent to the Great Barrier Reef. An Assessment to Guide the Development of Management Plans to Halt any Decline in the Water Quality of River Catchments Draining to the Reef, as a Result of Land-Based Pollution, and to Achieve the Long-Term Goal of Reversing any Trend in Declining Water Quality.*

Cantin N E, Negri A P & Willis B L, 2007, 'Photoinhibition from chronic herbicide exposure reduces reproductive output of reef-building corals', *Marine Ecology Progress Series 344*: 81–93

GBRMPA, 2008, *Draft Water Quality Guideline for the Great Barrier Reef Marine Park*, Australian Government, Great Barrier Reef Marine Park Authority. Available at: Harrington L, Fabricius K, Eaglesham G & Negri A 2005, 'Synergistic effects of diuron and sedimentation on photosynthesis and survival of crustose coralline algae', *Marine Pollution Bulletin 51*: 415-427.

Humphrey C A, Codi King S & Klumpp D W, 2007, 'A multibiomarker approach in barramundi (*Lates calcarifer*) to measure exposure to contaminants in estuaries of tropical north Queensland', *Marine Pollution Bulletin 54*: 1569–1581.

Kapernick A, Shaw C, Dunn A, Komarova T, Mueller J, Carter S, Eaglesham G, Alberts V, Masters B, Rhode K, Packett R, Prange J & Haynes D , 2007, 'River Pesticide Loads and GBR Lagoon Pesticide Data (2006–2007). Report to: Great Barrier Reef Marine Park Authority, Great Barrier Reef Water Quality Protection Plan (RWQPP) – GBR Monitoring Partnership (2006–2007)

Lewis S E, Brodie J E, Bainbridge Z T, Rohde K W, Davis A M, Masters B L, Maughan M, Devlin M J, Mueller J F & Schaffelke B, 2009, 'Herbicides: A new threat to the Great Barrier Reef', Environmental Pollution in press.

Magnusson M, Heimann K and Negri A P, 2008, Comparative effects of herbicides on photosynthesis and growth of tropical estuarine microalgae', *Marine Pollution Bulletin 56*: 1545–1552.

Negri A P, Vollhardt C, Humphrey C, Heyward A, Jones R, Eaglesham G & Fabricius K, 2005, 'Effects of the herbicide diuron on the early life history stages of coral', *Marine Pollution Bulletin 51*: 370–38.