FINAL REPORT

REVIEW OF ATRAZINE

April 2002

NRA Chemical Review Program

National Registration Authority for Agricultural and Veterinary Chemicals

Canberra
Australia

NRA DRAFT

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

© National Registration Authority 2002

ISSN 1443 2528

This work is copyright. Apart from any use permitted under the *Copyright Act 1968*, no part may be reproduced without permission from the National Registration Authority for Agricultural and Veterinary Chemicals.

This review is published by the National Registration Authority for Agricultural and Veterinary Chemicals. For further information about the review or the Chemical Review Program, contact:

Manager, Chemical Review
National Registration Authority
PO Box E240
Kingston ACT 2604

Telephone: 02-6272-5588
Facsimile: 02-6272-3551

NRA DRAFT

FOREWORD

The National Registration Authority for Agricultural and Veterinary Chemicals (NRA) is an independent statutory authority with responsibility for the regulation of agricultural and veterinary chemicals.

The NRA's Review Program examines agricultural and veterinary chemicals registered in the past to determine whether they continue to meet current standards for registration. Chemicals for review are chosen according to pre-determined, publicly available selection criteria. Public participation is a key aspect of this program.

In undertaking reviews, the NRA works in close cooperation with advisory agencies including the Department of Health and Aged Care (Chemicals and Non-Prescription Medicines Branch), Environment Australia (Risk Assessment and Policy Section), National Occupational Health and Safety Commission (Chemical Assessment Division) and State Departments of Agriculture.

The NRA has a policy of encouraging openness and transparency in its activities and community involvement in decision-making. The publication of evaluation documents for all reviews is a part of that process.

The NRA also makes these reports available to the regulatory agencies of other countries as part of bilateral agreements or as part of the OECD *ad hoc* exchange program. Under this program it is proposed 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.

This report covers the findings from the assessment of additional data presented to address the deficiencies that were highlighted in the interim report completed in November 1997. These assessments will allow a final decision to be made on the future of atrazine use in Australia.

The interim review report on atrazine published in November 1997, containing assessments completed by the NRA and its advisory agencies, is also available. It can be viewed free of charge in the NRA Library, on the NRA website *http://www.nra.gov.au* or obtained by contacting the NRA.

NRA DRAFT

TABLE OF CONTENTS

NRA DRAFT

Acronyms and Abbreviations

ACPH	Australian Committee for Pesticides and Health
ADI	Acceptable Daily Intake
AGAL	Australian Government Analytical Laboratories
ai	active ingredient
ANZECC	Australian and New Zealand Environment and Conservation Council
ARfD	acute reference dose
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BMP	Best Management Practices
bw	body weight
CAR	Catchment Area Ratio
Codex	FAO/WHO Codex Alimentarius Commission
DALA	Days after last application
DEA	Desethylatrazine
DIA	Desisopropylatrazine
ECRP	Existing Chemical Review Program
ESI	Export slaughter interval
FAO	Food and Agriculture Organisation of the United Nations
FHRMG	Forest Herbicide Research Management Group
GAP	good agricultural practice
GC-MS	gas chromatography-mass spectrometry
HPLC	High Performance Liquid Chromatography
JMPR	Joint FAO/WHO Meeting on Pesticide Residues
LC50	The concentration at which 50% of a test population dies
LOD	Limit of detection
LOQ	Limit of analytical quantitation, also referred to as limit of determination
LOR	Limit of reporting
µg	microgram
mg	milligram
MRL	Maximum residue limit
MRL	Maximum Residue Limit
NEDI	national estimated dietary intake
NESTI	national estimated short-term intake
NH&MRC	National Health and Medical Research Council
NOEL	No Observed Effect Level
OECD	Organisation for Economic Cooperation and Development
PACSC	Pesticide and Agricultural Chemical Standing Committee
PMRL	Provisional MRL
PPE	Personal Protective Equipment
ppm	Parts per million
TMRL	Temporary MRL
USGS	United States Geological Survey
WHO	World Health Organisation
WHP	withholding period

NRA DRAFT

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

SECTION 1 – REVIEW SUMMARY

1. BACKGROUND

Atrazine is a selective systemic herbicide providing knockdown and residual action. It is mainly absorbed through the roots, then transported to the actively growing tips and leaves where it inhibits photosynthesis and interferes with other metabolic activities in the plant to produce yellowing and death.

Atrazine is used for the control of grass and broadleaf weeds and is one of the most widely used herbicides in Australian agriculture. Major agricultural uses in Australia include summer crops such as sorghum and maize. It is also used on sugarcane and is widely used in Western Australia on lupins. Minor uses include lucerne, grass seed, pasture and potatoes. It is also important in the establishment of pine and eucalypt plantations and Parthenium weed control in Queensland, Northern Territory and northern parts of New South Wales. A major new use pattern for atrazine is the application to triazine tolerant (TT) canola.

The review of the chemical atrazine was announced in December 1995 as part of the NRA's first cycle of reviews of existing chemicals. Atrazine (the active ingredient), products containing atrazine and their product labels were placed under review due to concerns over:

- human and animal carcinogen claims;
- moderate potential chronic toxicity risk;
- potential to contaminate ground and surface water;
- absence of MRLs for major commodities; and
- reported breakdown in efficacy.

While these were initially the major reasons why high priority was given to the review of atrazine, the scope of the review was not confined to those issues alone, but covered all aspects for continued registration and approval of atrazine as prescribed by the Agvet Code Regulations.

NRA DRAFT

2. INTERIM REVIEW RECOMMENDATIONS (NOVEMBER 1997)

A report (referred to as an interim report) of the NRA's findings from its review of existing data for atrazine was released in November 1997. The interim report identified that additional studies and information was required for the purposes of completing the review of atrazine. The new requirements stated in that report were as follows:

- all approvals of atrazine, the active, were confirmed;
- non-agricultural/home garden uses were to be cancelled as they posed an undue risk to the environment;
- approvals of extensions of some uses were to be considered;
- residue data were required to confirm animal feed commodity Maximum Residue Limits (MRLs);
- MRLs for which there were no associated registered uses were to be deleted.
- information on annual sales was to be provided to the NRA;
- incidents of herbicide resistance were to be reported to the NRA;
- additional water monitoring studies were to be conducted to determine whether the levels of atrazine in the environment were above or below the level that would impact on the environment;
- modifications to recommended personal protective equipment were required to increase protection of users; and
- product labels were to be modified to include suitable warnings to protect the environment and worker safety.

3. KEY AREAS OF ACTION

Cancellation of home garden/non-agricultural use patterns

Environmental contamination with atrazine was highlighted as a concern in the review. At the commencement of the review atrazine was registered for application to lawns, golfcourses, irrigation channels, drains, roadsides, industrial premises and other non-agricultural areas. It was concluded that these uses contributed significantly to the total environmental load of atrazine and the continuation of such uses could not be supported. Use in these situations was permitted only until 30 June 1999. Where a product was only registered for these uses, registration of such products ceased. In other cases where there was a combination of both agricultural and non-agricultural use patterns on the label, the non-agricultural uses were deleted when new labels were approved in December 1998.

When the new labels that contained adequate instructions consistent with the review outcomes were approved in December 1998, previously approved 'old' labels were not cancelled at that time. The reports of continued use of atrazine according to old label instructions (that is use for weed control in non-agricultural situations) were of concern. The NRA Board at its meeting in March 2001 therefore decided to cancel the approval of all of the old atrazine labels that did not contain adequate instructions. These label cancellations were effected 23 March 2001.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

NRA DRAFT

Extensions of use

At the time of the release of the 'interim' report, atrazine was not registered for use on triazine tolerant (TT) canola or chickpeas although the NRA had issued a trial permit for TT canola use. The interim review report recognised that applications for approval of extensions to atrazine use would be likely. Such applications were subsequently received by the NRA and evaluation of the data supplied were found to satisfy the legislative criteria for approval. A number of atrazine products are now registered for use on chickpeas and TT canola.

In addition to the above extensions, the interim review report recognised that parthenium weed had expanded from Queensland into both New South Wales and the Northern Territory. The interim report noted that extension of use to these States would be appropriate and a number of products now have such a use in these States.

Maximum Residue Limits

The interim review report required the deletion of the MRLs for citrus fruits, grapes and pineapples as there were no such registered use patterns. In addition, new MRLs were established (primary animal feed commodities, edible offal and milks). The MRL Standard has been updated to reflect these recommendations.

Additional forage and fodder residue data for sorghum, pasture and lucerne was required in order for the NRA to confirm residue levels for primary animal feed commodity MRLs and those of animal commodities. This data was supplied by the 30 June 2000 deadline and the evaluation findings are discussed in Section 2 of the report.

Reporting requirements

Registrants were to provide the NRA with information on the annual amounts of atrazine products sold. This information was collected from one year only. A total of 2100 tonne of active ingredient was sold in the financial year 1997/1998.

Registrants were also required to report any incidents of herbicide resistance to atrazine to the NRA and any follow-up investigations conducted by the registrant. Registrants advise that no reports of herbicide resistance have been received. However, it has been noted that current labels do not provide users with an address or contact to report resistance incidents.

To ensure that an appropriate mechanism for reporting herbicide resistance is available for users, a recommendation to modify labels will be made. See Section 1.6, "Recommendations", for the recommended label statement.

Environmental Issues

-water monitoring

Atrazine is a common contaminant of waterways. The review required certain measures to reduce the overall load of atrazine on the environment. In order to determine whether these measures were having the desired effect, it was

NRA DRAFT

recommended that water monitoring be conducted. This would also provide information on the trends in atrazine contamination in both ground and surface water.

Initial investigations found that many water monitoring programs were already established in various areas of Australia and that these programs included records for the detection of atrazine. The principal registrant, Syngenta Crop Protection P/L (then Novartis Crop Protection), collated information from all of these programs. As sufficient information was available from these surveys, no additional studies were required.

In 1994 the NRA issued a provisional label for use of atrazine in forestry. This label was issued on the understanding that the forestry industry would undertake a nationwide series of trials to evaluate the effects of atrazine, applied at the nominated rates, on water quality in forestry use situations. In order to establish research proposals for design, assessment and management of field trials, the Forest Herbicide Research Management Group (FHRMG) was formed. This committee consists of both independent and forest scientists from both the public and private sector.

The final report from the FHRMG dealing with atrazine contamination following use in forestry was presented to the NRA in May 2000 and together with the collection of information from around Australia, forms the basis for the environmental assessment, found in Section 3 of this report.

Water quality Guidelines

- **drinking water**

The review found that exposure of the population to atrazine in food was very unlikely, although concerns were raised over the potential for exposure from drinking water. The fact that atrazine is both mobile in soil and reasonably stable in the environment indicates that exposure to the population would most likely occur from the contamination of drinking water. It was therefore recommended that consideration be given to updating the Australian Drinking Water Guidelines for atrazine. It was proposed that the guideline include not only atrazine but also include at least three of the four metabolites in the definition.

Deliberations by the Australian Committee for Pesticides and Health (ACPH) agreed that only the atrazine specific metabolites, desethylatrazine and hydroxyatrazine, should be included with atrazine in the definition for the guideline value. This issue was referred to the National Health and Medical Research Council (NH&MRC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) for consideration by the Joint Committee responsible for updating the Australian water quality guidelines. The NH&MRC drinking water review coordinating group has now finalised the drinking water guidelines for atrazine.

Atrazine should not be detected in drinking water. However if present in drinking water, atrazine would not be a health concern unless concentrations exceeded 0.04 mg/L. If atrazine is detected, then remedial action should be taken to stop contamination. The practical limit of determination of atrazine is 0.0001 mg/L.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

- **aquatic ecosystems**

When the interim review report was released in 1997, Australia had yet to establish a water quality guideline for protection of aquatic ecosystems. A guideline value for atrazine of 2 µg/L operated overseas and had been proposed for local application. Redrafted Guidelines for Fresh and Marine Water Quality, prepared under the auspices of Australia's National Water Quality Management Strategy, were released for public comment in July 1999. The water quality guidelines are estimates of concentrations at which individual chemicals should not cause direct toxic effects in the environment. The guidelines are the recommended limits to acceptable changes in water quality that will continue to protect the associated environmental values but it should not be reasoned that water quality can be degraded to these levels. The values apply to the overall or surrounding quality of water and they do not apply to a point of discharge or mixing zone.

The final guidelines were published in April 2001. If the guideline value for a chemical is exceeded, there is a potential risk of an environmental impact. The freshwater moderate reliability trigger value for atrazine was set at 13 µg/L. This value compares with a level 1 trigger value of 0.5 µg /L in the 1999 draft guidelines and is the result of the adoption of a more robust statistical procedure. Therefore while some recorded values were considered violations under the original draft guidelines, they now can be considered as acceptable based on the final guidelines.

Labelling

The potential for atrazine to contaminate ground and surface water was one of the key reasons for the review of atrazine. The potential for water contamination had originally been investigated in 1993 at which time recommendations were made to modify use patterns. These recommendations included the addition of buffer zones, restriction of use patterns and the setting of maximum application rates. These restrictions were to apply from the end of December 1995.

When the formal review of atrazine commenced in 1995, it was discovered that the 1993 recommendation had not been fully implemented. Most product labels did not reflect the recommended changes. The 1993 recommendations were therefore incorporated into the formal review in 1995 and were part of the suite of required label changes listed in the interim review report.

The requirements stated in the interim atrazine review report of 1997 were intended to reduce the overall load of atrazine in the environment, especially its presence in water. The key outcomes including four new label statements are shown below.

- no mixing/loading or application within 20 m of any well, sink holes, intermittent or perennial stream.
- no application within 60 m of natural or impounded lakes or dams.
- no use in channels and drains.
- limited the maximum annual rate of application to 3 kg ai/ha in all crops except plantation forestry. In plantation forestry, the maximum rates were to be 4.5 kg ai/ha per year in sandy soils and those defined as "highly erodible" and 8 kg ai/ha per year in clay loams and heavier textured soils.

NRA DRAFT

- Do NOT apply under meteorological conditions or from equipment which could be expected to cause drift of this product or spray mix onto adjacent areas, particularly wetlands, waterbodies or watercourses.
- Do NOT apply to waterlogged soil.
- Do NOT apply if heavy rains or storms that are likely to cause surface runoff are forecast within two days of application.
- Do NOT irrigate to the point of runoff for at least two days after application.

4. ADDITIONAL DATA ASSESSMENT (SUMMARIES)

Additional data (environmental and residue data) were required in certain areas to address the deficiencies highlighted in the 1997 review. The following information summarises the assessments conducted with the detailed assessment reports found in Section 2 (residues) and Section 3 (environment) of this document.

Residues

The animal transfer studies evaluated as part of the 1997 review indicate that measurable residues of atrazine were unlikely to occur in animal commodities. However, no Table 4 entries for atrazine existed in the MRL Standard. Consequently information on group residues was necessary to set animal feed commodity MRLs.

The specific information required was forage and fodder residue data for sorghum, pastures and lucerne in order to confirm the primary animal feed commodity MRL and those of animal commodities. These data were also needed to permit confirmation or appropriate changes to withholding periods for grazing these crops.

Syngenta Crop Protection P/L (previously Novartis Crop Protection) submitted new residue data for forage sorghum, grain sorghum and maize. These residue data allowed the confirmation of MRLs to cover residues in primary animal feed commodities and animal commodities. In respect of the MRLs, a 28 day grazing withholding period is to be observed in approved crop uses (except canola). Grazing and harvesting withholding periods established for canola remain unchanged. The residues assessment concluded that when atrazine is used according to label directions and good agricultural practice (GAP), residues are unlikely to pose an unacceptable risk to human health.

Environmental monitoring

Data provided on the monitoring of atrazine in Australia from FHRMG and from consolidated information from water monitoring programs that had been or are currently being run in Australia has been assessed.

This assessment showed that the key risk factors affecting the potential for water contamination following atrazine application were:

- vulnerability of soil to surface runoff;
- treatment of ephemeral drainage lines;
- treatment of runoff water – the need to channel it into areas other than directly into waterways;

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

- careless handling of atrazine near water or where soil surface runoff is likely;
- careless handling of atrazine near bore sites or recharge areas where water tables are shallow and soils are permeable such as sandy soils or in areas of cracking clay soil that may permit rapid bypass;
- site preparation practices (especially forestry) – mounding perpendicular to contour banks increases the rate of transport from crop areas to waterways; and
- runoff from storm events.

The information shows that it is unlikely that atrazine use in accordance with the label recommendations, paying particular attention to environmental restrictions, will contaminate waterways to any extent likely to present hazard to the environment or to human beings through the consumption of contaminated drinking water. Levels of atrazine in water that increase during storms events may temporarily exceed the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines but long-term contamination at levels above the ANZECC guideline is unlikely.

Leaching studies at forestry sites and groundwater monitoring results indicate a low likelihood of groundwater contamination from atrazine use even in areas of sandy soils. However, careless handling of atrazine concentrate and working solutions near bores or over permeable recharge areas could result in incidents of local groundwater contamination. Note that the current atrazine label already contains a restraint forbidding mixing, loading or application within 20 metres of a well or sinkhole as well as intermittent or perennial streams and rivers.

It is recognised that Best Management Practices (BMPs) have a key role to play in reducing chemical losses in runoff, especially in forestry production. If BMPs are followed for atrazine use, atrazine concentrations in rivers and in groundwater aquifers should be below the relevant water quality guidelines.

5. RECENT INTERNATIONAL ACTIVITY

In September 2001, the Belgium Ministry of Health announced its decision to cancel all authorisations of plant protection products containing atrazine as the only active ingredient, permitting a sell-out period until 30April 2002 and a use-up period until 30June 2002. The intent of the decision was to stop the suspected excessive use of atrazine for total weed control, a use that had been banned for many years. Syngenta supports this decision aimed at stopping the misuse of atrazine for total weed control while maintaining the focused use of atrazine in ready mixtures with other herbicides in maize.

In October 2001, the French Minister for Agriculture and Fisheries initiated the withdrawal of atrazine products used in maize and other crops because of excessive use of triazine herbicides. However, this action has been reported to have had serious economic and crop protection consequences, particularly for maize growers in France.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

6. REGULATORY ACTIONS FOR THE CONTINUED REGISTRATION AND APPROVAL OF ATRAZINE

In addition to the outcomes of the initial phase of the review (completed November 1997), and following evaluation of supplementary information relating to environmental and residue issues, this report makes the following recommendations with regard to new label instructions and MRLs.

New Label instructions
In addition to the labelling requirements as defined in the Ag Labelling Code (2001) and the interim report for the review of atrazine (November 1997), the following instructions must also be included.

(1) Resistance
In order to ensure that any incidents of resistance following use of atrazine come to the attention of the NRA, the following label statement is required.

Any incidents of resistance should be reported to {*the company name and contact details*}

(2) Withholding periods
The following withholding period for crops (other than canola) is required.

Grazing (except canola): DO NOT graze treated area or cut for stock food for 28 days after application

(3) Protection of Livestock
The following statement is to be deleted from labels.

Where treating native pasture, keep stock off for 14 days while product takes effect

(4) Protection of the Environment
The following new label statements are required for forestry uses.

- DO NOT apply product to any surface channel that flows, even for a short time, following rain
- DO NOT handle, mix, apply or conduct testing operations in areas susceptible to runoff where drainage results in rapid entry into waterways. These areas include roads, access tracks, snig tracks and compacted log dumps
- DO NOT apply to sites that have been mounded perpendicular to the contour

The following new advisory label statement is required for forestry uses.

Before using this product in forestry situations, users should seek and follow information on forestry Best Management Practices (BMP). BMP guidelines are available from “www” or “company”.

Confirmation of Maximum Residue Limits (MRLs)

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

NRA DRAFT

Changes to Table 1 of the MRL Standard

Compound		Food	MRL (mg/kg)
Atrazine			
Delete:	MO 0105	Edible offal (mammalian)	T*0.1
	MM 0095	Meat [mammalian]	T*0.01
	ML 0106	Milks	T*0.01
Add:	MO 0105	Edible offal (mammalian)	*0.1
	MM 0095	Meat [mammalian]	*0.01
	ML 0106	Milks	*0.01

*set at or about the limit of analytical quantitation

Changes to Table 4 of the MRL Standard

Compound	Animal feed	MRL (mg/kg)
Atrazine		
Delete:	Primary feed commodities	T40
Add:	Forage and fodder derived from cereals, pastures, legumes, sweet corn and sugar cane	40

Timeframe for Implementation of Review Recommendations

Cancellation of old labels/approval of new labels (*still to be determined*)
MRL Standard (*still to be determined*)
BMP guidelines (*still to be determined*)

7. CONCLUSION

Based on the outcomes of the initial review and subsequent assessment of the required supplementary information, the NRA is satisfied:

- that conditions of registration and label approval for use of products in agricultural situations could be varied in such a way that the requirements for continued approval or registration will be complied with and
- that the continued use of products in agricultural situations meets the criteria for continued registration and label approval as prescribed by the Agvet Codes provided product labels are revised to include new label instructions.

APPENDIX 1 LIST OF PRODUCT REGISTRATIONS/ACTIVE CONSTITUENT APPROVALS AFFECTED BY THIS REVIEW

The following list is those products registered and active constituents approved at the time of completion of this review. Any proposed new product or active constituent approval will be subject to all recommendations made in this report together with those that were made in November 1997.

(total products as of August 2001)

	Product	Registrant
52674	4 FARMERS ATRAZINE 500 SC	4FARMERS PTY LTD
50472	ATRAZMAX FLOWABLE HERBICIDE	ARTFERN PTY LTD
50527	ATRAMAX GRANULES 900 WG HERBICIDE	ARTFERN PTY LTD
45774	ATRADEX WG HERBICIDE	CROP CARE AUSTRALASIA PTY LTD
50243	ATRAGRANZ HERBICIDE	CROP CARE AUSTRALASIA PTY LTD
52584	CROP CARE ATRAZINE FLOWABLE HERBICIDE	CROP CARE AUSTRALIA PTY LTD
51630	DOW AGROSCIENCES ATRAZINE 500 FLOWABLE HERBICIDE	DOW AGRAOSCIENCES
45178	FARMOZINE 500 FLOWABLE HERBICIDE	FARMOZ PTY LTD
46810	FARMOZ FARMOZINE 900 WDG HERBICIDE	FARMOZ PTY LTD
48252	FARMOZ AA COMBI 500 FLOWABLE HERBICIDE	FARMOZ PTY LTD
40579	DAVISON ATRAZINE 500 FLOWABLE HERBICIDE	JOYCE RURAL PTY LTD (RECEIVERS AND MANAGERS APPOINTED)
46995	DAVISON ATRAZINE 900 WDG HERBICIDE	JOYCE RURAL PTY LTD (RECEIVERS AND MANAGERS APPOINTED)
40411	MACSPRED FOREST MIX GRANULAR HERBICIDE	MACSPRED PTY LTD
51532	MACSPRED FOREST MIX WATER DISPERSIBLE HERBICIDE	MACSPRED PTY LTD
51538	MACSPRED FOREST MIX SPECIAL BLEND GRANULAR HERBICIDE	MACSPRED PTY LTD
45370	ATRANEX ATRAZINE WETTABLE POWDER HERBICIDE	MAKHTESHIM-AGAN (AUSTRALIA) PTY LIMITED
46526	ATRAMET COMBI SC HERBICIDE	MAKHTESHIM-AGAN (AUSTRALIA) PTY LIMITED
47324	ATRANEX 500 SC HERBICIDE	MAKHTESHIM-AGAN (AUSTRALIA) PTY LIMITED
51091	ATRANEX 900 WG HERBICIDE	MAKHTESHIM-AGAN (AUSTRALIA) PTY LIMITED
31237	NUFARM FLOWABLE NU-ZINOLE AA LIQUID HERBICIDE	NUFARM AUSTRALIA LIMITED
31586	NUFARM FLOWABLE NU-TRAZINE LIQUID HERBICIDE	NUFARM AUSTRALIA LIMITED
31587	FARMCO ATRAZINE FLOWABLE LIQUID HERBICIDE	NUFARM AUSTRALIA LIMITED
31589	NUFARM NU-TRAZINE 900 DF HERBICIDE	NUFARM AUSTRALIA LIMITED
50164	SIPCAM PACIFIC MAIZINA 500 FLOWABLE HERBICIDE	SIPCAM PACIFIC AUSTRALIA PTY LTD

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

50456	SIPCAM PACIFIC MAIZINA 900 WDG HERBICIDE	SIPCAM PACIFIC AUSTRALIA PTY LTD
49547	ATRAZINE 900DF HERBICIDE	SUMITOMO AUSTRALIA LTD
49548	SUMMIT ATRAZINE 500 HERBICIDE	SUMITOMO AUSTRALIA LTD
51814	SUMMIT COMBI SC HERBICIDE	SUMITOMO AUSTRALIA LTD
31545	PRIMEXTRA HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
40121	CIBA-GEIGY ATRAZINE GRANULES 900 WG HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
47434	MARKSMAN HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
47615	FLOWABLE GESAPRIM 500 SC LIQUID HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
47616	GESAPAX COMBI 500 SC LIQUID HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
47928	GESAPAX COMBI 800 WG HERBICIDE GRANULES	SYNGENTA CROP PROTECTION PTY LIMITED
49552	GESAPRIM GRANULES 900 WG HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
50032	NOVARTIS ATRAZINE GRANULES 900 WG HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
50059	NOVARTIS ATRAZINE FLOWABLE 500 SC LIQUID HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
50885	ORIMEXTRA GOLD HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED
53892	FLOWABLE GESAPRIM 600 SC LIQUID HERBICIDE	SYNGENTA CROP PROTECTION PTY LIMITED

	Active constituents	**Approval holder**
44367	ATRAZINE	SYNGENTA CROP PROTECTION PTY LIMITED
48797	ATRAZINE	SIPCAM PACIFIC AUSTRALIA PTY LTD
44047	ATRAZINE	MAKHTESHIM-AGAN (AUSTRALIA) PTY LIMITED
45076	ATRAZINE	FARMOZ PTY LTD

NRA DRAFT

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

APPENDIX 2 STATUS OF PROTECTED INFORMATION

The NRA operates a program of data protection which provides compensation to those who submit data for a review and which meets the criteria specified in the Agvet Codes. The objectives of the program are:

- to provide an incentive for the development of products and data applicable to Australian or local conditions
- to encourage the availability of overseas products and data; and
- to provide reciprocal protection for Australian products and data under overseas' data protection systems.

In general the NRA designates information as protected registration information for a protection period of two to seven years if the information:

- is requested by the NRA for the purposes of a review;
- is relevant to the scope of the review; and
- relates to the interaction between the products and the environment of living organisms or naturally occurring populations in ecosystems, including human beings.

If the NRA proposes to use the same information to determine whether to register or continue registration of another chemical product, the NRA must not use the information until the parties come to an agreement as to terms for compensation, unless the protection period has expired or the NRA is satisfied that it is in the public interest to use the information.

At the completion of the review in November 1997 there were (*check final number*???) studies submitted for the review where the protection period had not elapsed. As of {March 2001 – *check date*} there still remain 7 studies protected as a result of the initial atrazine review.

The environmental data submitted for atrazine is not eligible for protection under the above scheme. The residue data (forage and fodder data) is eligible for protection and relevant to the review. A period of 2 years from date of receipt has been given. All registrants wishing to maintain registration will need to negotiate with the providers of this information to support the continued registration of their products.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

SECTION 2 – RESIDUES ASSESSMENT REPORT

1. History of the Atrazine Residue Assessment

The residues in food implications of atrazine were reviewed as part of the first cycle of the Existing Chemicals Review Program (ECRP). The interim review report was published in November 1997.

The following recommendations were made in the interim review report and are relevant to the subsequent consideration of residues issues:

Changes to the MRL Standard

Commodity	Existing MRL, mg/kg	Proposed new MRL, mg/kg
Table 1		
Citrus fruits	*0.1	Deleted
Grapes	*0.1	Deleted
Pineapple	*0.1	Deleted
Edible offal (mammalian)	*0.1	T*0.1
Meat (mammalian)	*0.01	T*0.01
Milks	*0.01	T*0.01
Table 4		
Primary animal feed commodities	-	T40

* set at or about the limit of analytical quantitation

Requirement for further data

Applicants were required to provide the NRA with forage and fodder residue data for sorghum, pastures and lucerne to confirm the primary animal feed commodity MRL and those of animal commodities. These data were required to permit confirmation or appropriate change to withholding periods for grazing these crops. The trial data was required to be consistent with Australian use patterns for agricultural products that contain atrazine.

2. Basis for the original recommendations

The MRLs for citrus, grapes and pineapple were recommended for deletion due to lack of registered use patterns.

Residue data for animal forage and fodder were not available. The recommended temporary MRL for primary animal feed commodities was based on the highest feeding level administered in a dairy cattle transfer study. Residues of atrazine were not observed in tissues or milk following continuous feeding at doses equivalent to 3.75, 11.25 and 37.5 ppm in the diet. Metabolites of atrazine (particularly 2-chloro-4,6-diamino-s-triazine) were present at levels above the Limit of Quantitation (LOQ) of the analytical method, however, it was determined that the residue definition should remain as parent compound only.

The existing animal commodity MRLs were maintained as temporary MRLs subject to provision of residue data for primary animal feed commodities.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

3. Summary of the current Residue Assessment

Syngenta Crop Protection P/L (formerly Novartis Crop Protection) provided new Australian residue data for forage sorghum, grain sorghum and maize. Assessment of these data has confirmed the following.

- These data are considered adequate to allow confirmation of the MRLs for primary animal feeds, edible offal, meat and milk. The data are adequate to allow the establishment of a grazing withholding period for forage and fodder crops. The outstanding residue data requirements are considered to have been fulfilled.

- Dietary exposure to atrazine from residues arising from good agricultural practice would not pose an unacceptable risk to human health.

The following section summarises the relevant information and discusses the basis for the recommendations. Detailed summaries of the individual scientific studies and raw data can be found in Appendix 1 at the end of the report.

4. Discussion

Current relevant MRLs and toxicological information

Australian MRLs[Ψ] for atrazine are listed below:

Table 1

Commodity			MRL (mg/kg)
MO	0105	Edible offal (mammalian)	T*0.1
VD	0545	Lupin (dry)	*0.02
GC	0645	Maize	*0.1
MM	0095	Meat [mammalian]	T*0.01
ML	0106	Milks	T*0.01
VR	0589	Potato	*0.01
SO	0495	Rape seed	*0.02
GC	0651	Sorghum	*0.1
GS	0659	Sugar cane	*0.1
VO	0447	Sweet corn (corn-on-the-cob)	*0.1

* set at or about the limit of analytical quantitation

Table 4

Animal feed	MRL (mg/kg)
Primary animal feed commodities	T40
Rape seed forage	10
Rape seed straw or fodder	0.5

The prefix "T" denotes a MRL associated with a temporary use. It may also be used when an MRL is being phased out. The prefix "*" denotes an MRL set at or about the limit of analytical determination (also referred to as limit of quantitation or LOQ).

Ψ *MRL Standard*, as at 10 September 2001.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

The Australian residue definition is:
Atrazine Atrazine

Atrazine has an Acceptable Daily Intake (ADI) of 0.005 mg/kg bw/day based on a no observable effect level (NOEL) of 0.5 mg/kg bw/day.

The Therapeutic Goods Administration, Commonwealth Department of Health and Aged Care has determined that the establishment of an acute reference dose (ARfD) for atrazine is not necessary (Advisory Committee on Pesticides and Health, Background Paper, 2 May 2001, Agenda item 8).

Maximum treatment regime

The Syngenta product Flowable Gesaprim 500 SC Liquid Herbicide (NCRIS No. 47615) is registered for use as a herbicide in the following situations where forage or fodder would be produced: lucerne, grass pastures, lupins, maize, sweet corn, sorghum, broom millet, saccaline, forage sorghum, sugar cane and canola (triazine tolerant). Canola forage and fodder were considered in a registration application following release of the initial Review Report. Suitable Table 4 entries have already been established for this use and it will not be considered further in this assessment.

As a result of the review, the maximum application rate of atrazine in crop situations was fixed at 3 kg ai/ha per year. Depending on the situation applications can be made (i) pre-plant followed by post-emergence or (ii) at sowing followed by post-emergence or (iii) at sowing only or (iv) post-emergence only. Where two applications are made, the total application rate must be less than 3 kg ai/ha.

There are currently no grazing withholding periods established other than for canola crops.

The Flowable Gesaprim 500 SC product currently has the following statement on the label under the heading "Protection of Livestock": Where treating native pasture, keep stock off for 14 days while Gesaprim 500 SC takes effect.

Residues in animal feed commodities

A total of 3 Australian residue trials were provided for evaluation. The original data requirement out of the 1997 Review Report was for provision of residue data for sorghum, pastures and lucerne. The applicant provided data for 2 sorghum crops and a maize crop. Although this deviates from the original requirement, the data are considered satisfactory for the intended purpose of confirming the "primary animal feed" MRL.

The treatment regime addressed in the trials was considered to adequately reflect the maximum label use pattern for Flowable Gesaprim 500 SC. The product was applied post-emergence of the crop at the maximum yearly label rate for crops (3 kg ai/ha). Residues of atrazine in foliage were expressed on a dry weight basis and are shown below.

- ***Summary of Australian residue trials in forage crops***

NRA DRAFT

Location, year, reference, crop	Rate, kg ai/ha	No.	Volume, L/ha	PHI*, days	Atrazine, mg/kg
Tamworth, NSW, 1998, forage sorghum	3	1	167	-0 0 3 7 14 28 42	<0.04, <0.04 2127, 2532 1392, 1278 42, 21 0.35, 0.67 0.30, 9.3 0.70, <0.04
Dalby, Qld, 1999, grain sorghum	3	1	140	-0 0 3 7 14 28 42	123, 0.06 3202, 6101 981, 2108 218, 351 27, 60 0.53, 0.11 0.54, <0.04
Millthorpe, NSW, 1998, forage maize	3	1	155	-0 0 3 7 14 28 41	<0.04, <0.04 1142, 1597 731, 649 190, 384 12, 20 0.10, <0.04 <0.04, <0.04

*PHI – post harvest interval

The highest feeding level investigated in the dairy cattle transfer study was approximately 40 ppm in the diet (37.5 ppm). The MRLs for animal commodities (currently temporary) have been established on the basis of a maximum feeding level of 40 ppm. Since the magnitude of residues in animal tissues and milk cannot be reliably estimated at feed levels greater than 40 ppm, the grazing withholding period for forage crops needs to reflect this point.

The applicant proposed a grazing withholding period of 28 days for forage crops other than canola where separate withholding periods have been established. At 28 days after post-emergence application at 3 kg ai/ha atrazine, residues in foliage were <0.04, 0.10, 0.11, 0.53, 0.3 and 9.3 mg/kg. All results were therefore less than 40 mg/kg. At the earlier sampling point of 14 days, residues of atrazine were up to 60 mg/kg.

It should be noted that general MRL entries such as "primary animal feed commodities" are no longer recommended by the NRA on a routine basis. There is a clear preference to establish MRLs to cover narrower groups of commodities according to the Codex classification system. In this case the confirmation of the general animal feed MRL was a specific recommendation of the Review Report. It is also apparent that detectable residues of atrazine are unlikely to occur in animal tissues or milk. The absence of residues probably extends to feeding levels higher than 40 ppm although there are no data to confirm this. In the circumstances, the establishment of a permanent MRL for "primary animal feed commodities" is acceptable. The temporary MRL should be converted to a standard MRL at 40 mg/kg. The commodity description will be changed to "forage and fodder derived from cereals, pastures, legumes, sweet corn and sugar cane".

The following grazing withholding period should be established in conjunction with the animal feed MRL:

NRA DRAFT

Grazing (except canola)- DO NOT graze treated area or cut for stock food for 28 days after application.

Note that specific withholding period statements have previously been established for canola in extension applications subsequent to the Review.

Residues in animal commodities

Since the magnitude of atrazine residues in animal feed commodities have now been confirmed, the animal commodity MRLs can also be confirmed.

Detectable residues of atrazine are not expected to occur in meat, edible offal or milk following continuous feeding at up to 40 ppm in the diet. The temporary MRLs for animal commodities should be converted to standard MRLs. No change to the magnitude of the MRLs is required.

Dietary risk assessment

- Chronic dietary exposure

The chronic dietary risk is estimated by the National Estimated Daily Intake (NEDI) calculation encompassing all registered/temporary uses of the chemical and dietary consumption data from the 1995 National Nutrition Survey of Australia. The NEDI calculation is made in accordance with the *Guidelines for Predicting Dietary Intake of Pesticide Residues (revised)* (WHO, 1997).

The NEDI for atrazine is equivalent to 4% of the ADI. It is concluded that when atrazine is used according to good agricultural practice, the chronic human dietary exposure is small and the risk to human health is acceptably low. The calculation is shown in Appendix 2.

- Acute dietary exposure

Acute dietary exposure to atrazine does not require further consideration. The establishment of an acute reference dose was not considered necessary.

5. Conclusions

The outstanding residue data requirements from the NRA Review of Atrazine are considered to be fulfilled.

Adequate residue data were provided to allow the establishment of permanent MRLs to cover residues in primary animal feed commodities and animal commodities when atrazine is used according to good agricultural practice. Residues of atrazine in the diet do not pose an unacceptable risk to human health.

It is recommended that:

1. The following changes be made to the *MRL Standard*

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

NRA DRAFT

Table 1

Compound		Food	MRL (mg/kg)
Atrazine			
Delete:	MO 0105	Edible offal (mammalian)	T*0.1
	MM 0095	Meat [mammalian]	T*0.01
	ML 0106	Milks	T*0.01
Add:	MO 0105	Edible offal (mammalian)	*0.1
	MM 0095	Meat [mammalian]	*0.01
	ML 0106	Milks	*0.01

* set at or about the limit of analytical quantitation

Table 4

Compound	Animal feed	MRL (mg/kg)
Atrazine		
Delete:	Primary feed commodities	T40
Add:	Forage and fodder derived from cereals, pastures, legumes, sweet corn and sugar cane	40

2. The following withholding period is required in respect of the above MRLs:

Grazing (except canola): DO NOT graze treated area or cut for stock food for 28 days after application.

Note that grazing and harvest withholding periods have been established for triazine tolerant canola crops, subsequent to the Review. These withholding periods will remain unchanged.

3. The current Protection of Livestock label statement (“Where treating native pasture, keep stock off for 14 days while Product X takes effect”) must be removed because they are inconsistent with the new grazing withholding period.

4. The residue data supported a maximum total application rate of 3 kg ai/ha, consistent with the maximum in-crop application rate recommended in the Review Report.

APPENDIX 1: RESIDUE DATA

All trials included untreated control plots. Samples were stored frozen until analysis. Atrazine residues were <LOQ in all untreated control samples unless specified otherwise. Results are not corrected for recovery unless specified otherwise.

Reference: McKee, K., Residue Report, Residues of atrazine in forage sorghum, grain sorghum and forage maize following a single post-emergent application of Gesaprim 500 SC, Study No. P98/51, 3 May 2000, Novartis Crop Protection Australasia.

Experiment: Trials to determine the decline of atrazine residues in forage sorghum, grain sorghum and maize were conducted in 1998-99 in Queensland and NSW. Flowable Gesaprim 500 SC (500 g/L atrazine) was applied to post-emergent crops approximately 14-28 days after sowing at rates equivalent to 3 or 6 kg ai/ha. The product was applied using a hand-held small plot boom sprayer in 140-167 L/ha of water. BS 1000 surfactant (0.2% v/v) or crop oil (1% v/v) was added to the spray mixture for application to sorghum and maize respectively. Plot sizes were 120-180 m^2 with one replicate. Separate samples of plant foliage were collected from each replicate plot just prior to application and then 0, 3, 7, 14, 28 and 42 days later. Residues of atrazine were determined by GC-MS following extraction with refluxing methanol and solid phase clean-up. Residues were expressed on a dry weight basis and were not corrected for recovery.

Recovery of atrazine from fortified samples of maize and sorghum

Fortification level, mg/kg	% Recovery	Mean, %
0.005	78, 109, 91	93
0.01	73, 99, 98, 93, 98, 109, 94	95
0.1	73, 71, 106, 86	84
0.5	80, 90, 78	83
25	103, 84, 100, 82, 91, 89, 81, 82, 81, 105	90

Results:

Atrazine residues in sorghum and maize foliage following post-emergent application

Location, year, reference, crop	Rate, kg ai/ha	No.	Volume, L/ha	PHI*, days	Atrazine, mg/kg[a]
Tamworth, NSW, 1998, forage sorghum	3	1	167	-0 0 3 7 14 28 42	<0.04, <0.04 2127, 2532 1392, 1278 42, 21 0.35, 0.67 0.30, 9.3 0.70, <0.04
	6	1	167	-0 0 3 7 14 28 42	<0.04, <0.04 6462, 5924 2323, 2747 300, 924 1.3, 0.87 4.8, 0.08 204, 8.6

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Location, year, reference, crop	Rate, kg ai/ha	No.	Volume, L/ha	PHI*, days	Atrazine, mg/kg[a]
Dalby, Qld, 1999, grain sorghum	3	1	140	-0 0 3 7 14 28 42	123, 0.06 3202, 6101 981, 2108 218, 351 27, 60 0.53, 0.11 0.54, <0.04
	6	1	140	-0 0 3 7 14 28 42	63, 187 5038, 5759 2297, 3405 579, 797 84, 59 7.2, 3.1 0.37, 0.22
Millthorpe, NSW, 1998, forage maize	3	1	155	-0 0 3 7 14 28 41	<0.04, <0.04 1142, 1597 731, 649 190, 384 12, 20 0.10, <0.04 <0.04, <0.04
	6	1	155	-0 0 3 7 14 28 41	<0.04, <0.04 2463, 2552 2149, 1194 584, 192 59, 46 0.60, 0.15 0.04, <0.04

*PHI – post harvest interval

a. Expressed on a dry weight basis

Comment: Residues up to 0.94 mg/kg were observed in samples taken from untreated plots. At the Dalby Queensland site residues of up to 187 mg/kg were observed in samples collected prior to the application of the product. It is unclear if this represents contamination in the field from earlier use of the chemical or an analytical problem. It was stated that carry-over from samples containing high residues was eliminated as the cause of the contamination. Significant differences in residue levels were observed between samples from replicate plots. This is likely to be due to the inhomogeneous nature of the treated crop and resulting samples. The 42 day result of 204 mg/kg for the Tamworth trial is not consistent with any other results seen across the 3 trials. This result is excluded, as that trial is likely to be faulty. Despite this, the results demonstrate decline of residues from the very high levels seen immediately after application. The trial results are accepted as reflecting good agricultural practice.

NRA DRAFT

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

APPENDIX 2: Dietary exposure calculations

Calculation of NEDI
Atrazine

ADI for atrazine 0.005 mg/kg of body weight

Commodity	Food Consumption g/kg bw/day		MRL mg/kg	NEDI mg/kg bw/day	
Edible offal (mammalian)	0.0151	*	0.1	0.00000151	
Lupin (dry)	0.0001	*	0.02	0.000000002	default intake
Maize	0.0522	*	0.01	0.000000522	maize flour
Meat (mammalian)	1.7276	*	0.01	0.000017276	
Milks	8.9933	*	0.01	0.000089933	
Potato	0.9821	*	0.01	0.000009821	
Rape seed	0.001	*	0.02	0.00000002	
Sorghum	0.0001	*	0.1	0.00000001	default intake
Sugar cane	0.7328	*	0.1	0.00007328	DM0659
Sweet corn (corn-on-the-cob)	0.0881	*	0.1	0.00000881	
Total				0.000201184	mg/kg bw/day

Equivalent to 4 % of the ADI

These calculations have been made in accordance with 'Guidelines for Predicting Dietary Intake of Pesticide Residues' (World Health Organization)
MRL - Maximum Residue Limit
* - Denotes MRL set at or about the limit of analytical determination
NEDI - National Estimate of Dietary Intake
ADI - Acceptable Daily Intake
Food consumption data from 1995 National Nutrition Survey of Australia

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

SECTION 3 - ENVIRONMENTAL ASSESSMENT REPORT

1. Introduction

Atrazine was one of the first chemicals to be reviewed under the NRA's Existing Chemicals Review Program and an interim review report was issued in November 1997. This triazine herbicide is widely used in Australia for control of grass and broadleaf weeds in a variety of crops, including maize, sorghum, sugarcane, timber plantations (pines and eucalypts), established lucerne, grass seed crops and potatoes. It is also used for weed control in conservation tillage farming systems, for seed bed establishment prior to planting sorghum, or for fallow maintenance prior to wheat, peas or lupins.

Atrazine is a slightly hydrophilic (water solubility about 30 mg/L) and persistent herbicide that can be transported in surface and groundwaters. Because of these properties and its widespread use, atrazine is a common contaminant of Australian surface waters, and is also often found in groundwater aquifers at low levels. Concentrations in surface water mostly remain below the threshold for ecological effects, generally accepted to be about 13 µg/L, but safety margins can be narrow in some areas. Accordingly, it is important to reduce levels of aquatic contamination by atrazine, particularly where levels detected breach water quality guidelines.

Atrazine mostly enters aquatic ecosystems in the dissolved phase of surface runoff. The risk of surface water contamination via runoff declines with time after application. Risks can be mitigated by techniques that improve water infiltration and retention. The NRA's risk assessment resulted in label restrictions regarding application to waterlogged soil or where heavy rain is expected and recommended that monitoring of atrazine levels in Australian surface waters should continue in order to determine the effectiveness of these and other restrictions.

This further report briefly reviews recent literature data on monitoring of atrazine. The report then evaluates the environmental significance of atrazine residues in water and describes the results obtained from:

- Forestry industry studies on contamination of groundwater and surface water and
- Monitoring activities in annual cropping areas.

2. Previous Australian Regulatory Actions

The NRA announced in July 1994 that previous uses in non-crop situations such as fencelines, rights of way and irrigation channels would be discontinued by December 1995 because of concerns for aquatic contamination. These discontinued uses generally involved much higher rates of application in situations conducive to off-target movement of water.

To retain forestry uses, the NRA introduced restrictions to use patterns and agreed to the establishment of a broadly based taskforce (the Forest Herbicide Research

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Management Group, FHRMG) whose role was to determine the effectiveness of these restrictions in reducing contamination of water.

Remaining uses of atrazine were evaluated in the NRA's existing chemicals review of November 1997, which concluded that improved management was also required in annual cropping situations in order to reduce the risk of contaminated runoff entering waterways. Further monitoring was recommended in order to confirm that safety margins are maintained or improved. Canola production was identified as an issue needing attention, as triazine tolerant varieties have allowed considerable expansion of this crop and an associated increased need for atrazine.

The principal registrant, Novartis, now Syngenta Crop Protection P/L, has provided data on monitoring activities in ground and surface waters from various locations within Australia. Collaborative projects are underway on the Atherton Tablelands, Darling Downs, Liverpool Plains, Lachlan River near Cowra, Naracoorte, and several sites in Western Australia. The FHRMG has also reported on its intensive program of monitoring activities in forestry.

3. Australian Water Quality Guidelines

Redrafted Guidelines for Fresh and Marine Water Quality, prepared under the auspices of Australia's National Water Quality Management Strategy, were released for public comment in July 1999. The water quality guidelines are estimates of concentrations at which individual chemicals should not cause direct toxic effects in the environment. "The guidelines are the recommended limits to acceptable changes in water quality that will continue to protect the associated environmental values, but it should not be reasoned that water quality can be degraded to these levels". The values are ambient, ie apply to the overall or surrounding quality of water and they do not apply to a point of discharge or associated mixing zones.

The final guidelines were published in April 2001. The freshwater moderate reliability trigger value for atrazine is 13 µg/L. This value compares with a level 1 trigger value of 0.5 µg/L in the 1999 draft guidelines and is the result of the adoption of a more robust statistical procedure. It should be noted that the final value for atrazine was derived using the statistical distribution method with 95% protection and an acute-to-chronic toxicity ratio (ACR) of 20.2. Moderate reliability trigger values are calculated from acute data and the application of an acute-to-chronic (ACR) ratio.

If the guideline value for a chemical is exceeded, there is a potential risk of an environmental impact. In such a case, further assessment, using a hierarchical decision framework, should be carried out to determine if that risk is reduced by the interaction of the toxicant with other site-specific environmental factors that can modify its toxicity or bioavailability.

The current 1996 NH&MRC Australian Drinking Water Guideline value for atrazine is 0.5 µg/L, and the health value is 20 µg/L. Both of these values are under review. The draft proposed guideline value has been lowered to 0.1 µg/L and the health value has been increased to 40 µg/L. This decrease in the guideline value is due to better detection methods. The higher health value is due to an increase in the proportionality factor of the ADI and is based on the assumption that at least 50% of the ADI will arise from the consumption of drinking water. Atrazine has not been found in the Australian food supply.

The guidelines assume that if a pesticide is detected at or above the guideline value, steps should be taken to determine the source and stop further contamination.

The health guidelines are set to assist health authorities in managing the health risks associated with inadvertent exposure such as a spill or mis-use of a pesticide.

Atrazine has rarely been found in Australian reticulated supplies. It has been reported in groundwater supplies at concentrations up to 2 µg/L in an area where atrazine was used to suppress weed growth in irrigation channels (NH&MRC, 1996).

4. International Perspective

Reviews Of Aquatic Risk

A review of the aquatic ecotoxicology of atrazine concluded that no permanent damage will be caused to aquatic ecosystems at concentrations up to 20 µg/L (Huber, 1993).

Another such review used a probabilistic approach, based on acute toxicity data for 52 species. The LC50 of the tenth percentile of species sensitivity was determined to be 37 µg/L. Affected species at this concentration were all plants. It was assumed that protecting 90% of species would also protect the ecosystem as a whole. This assumption was shown to be conservative. A similar analysis of chronic NOECs found a tenth percentile of 3.7 µg/L. A review of more than 20 microcosm and mesocosm studies found that exposures below 20 µg/L generally caused no effects on aquatic plants, and that occasional effects were always followed by recovery. Effects that sometimes occurred at exposures between 10 and 100 µg/L were similarly followed by recovery. It was concluded that atrazine exposures up to 20 µg/L caused no lasting harm to aquatic plant communities, even when exposure was maintained for extended periods. The lowest effect concentration was conservatively estimated to be 50 µg/L, with any effects followed by recovery (Giddings and Hall, 1998).

A detailed probabilistic risk assessment, focusing on watersheds in the Midwest of the USA where most use occurs, concluded that atrazine does not pose a significant risk to that aquatic environment. Ecological risks were considered highest in the midwest because of heavy use and high rainfall across this region during the critical growing season, which washes atrazine into surface water.

Risk was assessed against 90th percentile exposure values determined from probability distributions of monitoring data for rivers in Ohio, Iowa, Illinois and Nebraska. The 4 day average concentrations (0.56-9.0 µg/L) were very similar to the 90th percentile instantaneous concentrations. The analysis found that 4 day average concentrations rarely exceeded 20 µg/L, with frequencies of 0-3%. Effects on biomass and primary productivity in microcosm and mesocosm studies were only significant at concentrations above 50 µg/L. Some taxonomic shifts were evident at these concentrations, with a tendency for resistant species to expand into niches vacated by sensitive species. The analysis concludes that there is only a low probability that atrazine concentrations in US surface waters will exceed the tenth percentile of the

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

sensitivity distribution (37 µg/L) and that this concentration does not represent an ecologically significant risk to the aquatic environment. Risk was found to be highest in some small watersheds with extensive pesticide use, and in reservoirs receiving drainage from these watersheds. In these higher risk situations, site specific risk assessments should be conducted, bearing in mind the use to which the ecosystem is likely to be put, and the effectiveness and cost-benefit aspect of any risk mitigation measures that may be applied (Solomon *et al*, 1996).

A simplistic approach to determining safe levels of exposure to a toxicant involves application of an assessment factor to laboratory toxicity data. A recent paper using such an approach predicted no effect concentrations of 0.074 or 0.37 µg/L by application of assessment factors to the most sensitive laboratory NOEC, 3.7 µg/L for growth inhibition in the unicellular alga *Chlamydomonas reinhardi.* More refined methods based on the distribution of toxicities across various species, predicted no effect concentrations in the order of 0.8-0.9 µg/L. A comprehensive approach based on stream and pond mesocosm experiments yielded a predicted no effect concentration of < 3 µg/L, based on chlorophyll *a* concentration in periphyton (Girling *et al*, 2000).

A guideline of 2.0 µg/L has been developed in Canada for protection of aquatic life (CCREM, 1989). The final guideline was derived by application of an assessment factor of 10 to the most sensitive of several comparable MATCs, 17.9 µg/L in freshwater microbial communities.

It can be seen from the above that a range of water quality criteria can be developed for atrazine, depending on the approach taken. Use of assessment factors tends to favour conservative outcomes. The key determinant, however, of acceptable levels of atrazine in water, is the selection of the attribute to be protected. Criteria are much more conservative where the effect against the protection sought is a subtle sub-lethal parameter such as reversible suppression of chlorophyll *a* rather than measures of ecosystem function such as total biomass or primary productivity. As noted above ANZECC Water Quality Guideline is 13 µg/L, which is in line with the above considerations.

No regulatory reviews of atrazine have been published. The US EPA published a notice of initiation of special review in November 1994, because of concerns over human cancer risks. Concerns were also expressed over ecological risks, but these were not used as a special review trigger. A qualitative assessment raised serious concerns about the ecological risks of continuing to apply such massive quantities of toxic chemicals across ecosystems and watersheds. The notice included some details of atrazine levels in the US, including reports of 480 µg/L in runoff entering Chesapeake Bay and 1000 µg/L leaving treated areas in Colorado and Kansas. Streamwater contamination was noted as a problem, with levels of 5-10 µg/L not uncommon in streamwater during the peak use period (late April to early July) and one sample recording 245 µg/L. A recent status report (US EPA, 2000) is assessing a number human health issues regarding atrazine, including drinking water exposure, ground and surface water contamination and cancer risk. A preliminary assessment was released on 8 February 2001. It found that atrazine is widespread in surface drinking water supplies in the mid west of the US and is the pesticide most commonly detected in groundwater. Exposure from food was minimal, and there are some issues

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

to be addressed for occupational exposures. The assessment concluded that atrazine was not likely to be carcinogenic in humans. No environmental risks were addressed in this report.

Risk Factors

Three key factors have been identified for assessing the vulnerability of a watershed to surface water contamination by agricultural chemicals (Blanchard and Lerch, 2000). The chemical properties of a compound determine which hydrologic pathways are available for the chemical to be lost from soil. Moderately sorbed compounds such as atrazine are more likely to be lost in surface runoff or degraded in the soil rather than leached. The hydrology of a region will determine the relative importance of runoff and leaching. Land use, including proportions and locations within a watershed that are cropped and the chemicals that are used, is the third factor. Climate is an implicit fourth factor, as streamflow represents the hydrologic response of a watershed to climate. The extent of contaminant transport is critically determined by the frequency, intensity and duration of rainfall events following application. The bulk (80-90%) of the annual atrazine transport can occur during a few post-application runoff events. Best management practices to minimise water quality problems need to be tailored to fit the hydrology of a watershed.

The authors review monitoring data from North America and elsewhere, finding that land use factors (applied mass of pesticide or row-cropping intensity) are generally the key determinant of herbicide concentrations or mass flux in streams but may not always be the dominant factor. For example, surface water draining the Deep Loess Hills of southwestern Iowa and northwestern Mississippi contained relatively low concentrations of triazine herbicides despite high cropping intensity. Contamination tends to be higher in smaller tributaries or runoff-prone basins than in catchments with higher infiltration soils. Concentrations in streams and reservoirs of the midwestern US are significantly higher than in groundwater, largely because chemicals used on summer crops are lost in surface runoff from spring rains or by degradation within the soil, before groundwater recharge occurs in autumn and winter.

Atrazine In USA Surface And Ground Water

Considerable information on the occurrence of atrazine in surface and ground water in the United States is available on the publications home page of the US Geological Survey (USGS) website (http://water.usgs.gov/pubs/). Some of these data were used in the probabilistic assessment by Solomon *et al* (1996) and the review by Blanchard and Lerch (2000).

The USGS collects data on pesticide contamination of surface and groundwaters under the National Water-Quality Assessment (NAWQA) Program. The building blocks of the NAWQA Program are Study-Unit Investigations in 60 major hydrologic basins (study units). The 60 NAWQA study units cover about one-half of the conterminous United States, encompass 60-70 percent of national water use of the population served by public water supplies and include diverse hydrologic systems that differ widely in the natural and human factors that affect water quality. This selection of study units ensures that the most important national water-quality issues can be addressed by comparative studies. The study units are divided into three groups, which are intensively studied on a rotational schedule. The first cycle of

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

assessment for each group of 20 study units consists of 2 years of initial planning and Retrospective Analysis of existing data, 3 years of intensive data collection and analysis, and 6 years of report preparation and low-level assessment activity before the second cycle of intensive data collection and analysis begins. One-third of the study units are in the intensive study phase at any given time, and the 10 year cycle is repeated perennially. The first complete cycle of intensive investigations of all 60 study units is scheduled to be completed in 2002 (Gilliom *et al*).

Results available at this time from the first cycle of NAWQA water-quality data collection during 1992-1996 include analyses of 76 pesticides and 7 selected pesticide degradation products in about 8,500 samples of ground water and surface water in 20 study units. The 76 herbicides, insecticides, and fungicides targeted in the study account for approximately 75 percent of agricultural pesticide use in the US and a substantial portion of urban and suburban use.

The occurrence of pesticides in streams and ground water follows broad patterns in land use and associated pesticide use. The patterns are complex, however, and differ between streams and ground water because of the wide range of use practices and processes that govern the movement of pesticides in the hydrologic environment.

Herbicides are the most common type of pesticide found in streams and ground water within agricultural areas. The most common herbicides in agricultural streams were atrazine and its breakdown product desethylatrazine (DEA), metolachlor, cyanazine, alachlor, and EPTC *in full.* All 5 of the parent compounds rank in the top 10 in national use.

Atrazine was found in about two-thirds of all samples from agricultural streams, often occurring year-round. Similar to streams, the most common compounds found in shallow ground water were atrazine and DEA, but only about one-third of the samples had detectable levels. The lower rates of atrazine and DEA detection in ground water compared to streams result from longer travel times, greater opportunity for sorption or breakdown, and greater variability of source water in wells. One of the most striking results for shallow ground water in agricultural areas, compared with streams, is the low rate of detection for several high-use herbicides other than atrazine. This is probably because these herbicides break down faster in the natural environment compared to atrazine (USGS, 1999a).

In December 2000, full reports of results were available on the USGS website as USGS circulars for sixteen study units from the first cycle, with summary reports for the remaining four. Atrazine was detected in at least 50% of surface water samples taken from nine of the sixteen study units. Three study units exceeded this frequency of detection for ground water. The metabolite DEA was found in at least half the samples of surface water taken from six study units, and in ground water from three study units. Atrazine concentrations above 1 µg/L occurred in surface water from eight and ground water from six study units. DEA only exceeded 1 µg/L in groundwater samples taken from three study units. Surface water contamination in excess of 10 µg/L atrazine (accompanied by DEA at around 1 µg/L) was recorded in three study units (Central Nebraska Basin, Potomac River Basin and Trinity River Basin). High concentrations occurred in drainage basins dominated by row crops, notably corn, during late spring and early summer, often in conjunction with storm events.

Information is also available on contamination of the Mississippi River Basin. Maximum concentrations during 1991-92 of the most extensively used herbicides such as alachlor, atrazine, cyanazine, and metolachlor ranged from 3 µg/L to about 6 µg/L in large rivers such as the Mississippi, Missouri, and Ohio, compared to 50 to more than 100 µg/L reported in previous studies of smaller tributaries. Most of the pesticides used are applied in the upper parts of the Mississippi Basin.

The maximum concentration of atrazine reached about 4 µg/L in the Mississippi during 1987-92, and about 6 µg/L in smaller rivers such as the Illinois and Missouri during 1991-92. Runoff caused by rainstorms following the application of atrazine to cornfields early in the growing season flushes a portion of the atrazine into streams that eventually flow into the Mississippi River. These high concentrations generally represent extreme conditions that do not persist past midsummer (Goolsby and Pereira, 1995).

Atrazine continued to be found in samples of water taken from the Mississippi River at Baton Rouge (Louisiana) during 1991-97. The temporal pattern of contamination was characterised by a spring peak, typically in the range 2-4 µg/L, in late May and early June. The annual average load discharged to the Gulf of Mexico was around 2% of annual use across the basin, or 3% if dealkylated metabolites are included (USGS, 1999b).

Atrazine was detected in 82.1% of samples taken from the outflow from reservoirs in the midwest of the United States during 1992-93. The median concentration was 0.43 µg/L, with a mean of 1.36 µg/L for positive samples and a peak of 12.4 µg/L. Dealkylated metabolites were also commonly detected (71.6% of samples for DEA with median of 0.17 µg/L and mean in positive samples of 0.39 µg/L, and 61.8% for DIA (desisopropylatrazine) with median of 0.08 µg/L and mean in positive samples of 0.26 µg/L). Atrazine concentrations were lowest during winter and early spring, before planting of corn, and peaked during summer. Similar but less pronounced trends were evident for DEA, with the peak concentration tending to be later in the summer. Peak concentrations tended to be higher leaving smaller impoundments but more protracted leaving larger reservoirs. The key determinant of reservoir concentrations appeared from statistical models to be the quantity of herbicide used in the drainage basin. The models also indicate that when drainage basins have steep slopes and poorly drained clay-rich soils, the receiving reservoirs tend to have higher herbicide concentrations. These findings suggest that best-management practices targeted at reducing the use of herbicides and reducing the loss of herbicides to surface- and ground-water systems will be the most successful in lowering herbicide concentrations in reservoirs (USGS, 1998).

5. Forestry Trials

In the early 1990's, Syngenta proposed to discontinue registration of atrazine for a number of uses, including forestry. The latter was opposed by both public and private forestry interests and as a compromise the NRA introduced restrictions on the use of

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

atrazine, requesting forest plantation users to provide objective evidence on the effects of these restrictions on water quality.

The Forest Herbicide Research Management Group (FHRMG) was formed to co-ordinate a nation wide research and monitoring study.

The study was divided into two components, the first utilised large-scale study sites (catchments 8-3351 ha) to assess risk to surface waters and the second, using small-scale plots (<1 ha) to assess the risk of atrazine leaching through the soil profile to groundwater. At the surface water study sites stream monitoring stations were established in catchments with either high or low catchment area ratio (CAR - ratio of atrazine treated area to untreated area). Sampling at the high CAR catchments allowed evaluation of peak atrazine concentrations from adjacent treated areas, whereas sampling at low CAR catchments provided an opportunity to assess the level of dilution provided by streamflow from untreated areas of the catchment. The monitoring program was based around collecting routine grab samples during periods of baseflow or zero flow and intensive event sampling collected by automated samplers during flood events. Most monitoring stations were within catchments solely managed by individual stakeholders, thus minimising outside influences. Local best management practices for plantation establishment were followed with respect to site preparation techniques and herbicide application methods.

At the groundwater sites, the study design consisted of sampling the soil profile at graduated intervals of increasing length following a single application of atrazine to a number of replicate plots. At sites where shallow aquifers existed, groundwater was also sampled. The groundwater monitoring program was also repeated during a range of seasonal periods at a number of sites.

Experimental details

Surface water monitoring studies were conducted in a 1st rotation hoop pine (*Araucaria cunninghamii*) plantation at Imbil Qld, radiata pine plantations at Canobolas NSW (1st and 2nd rotation) and Merriang VIC (2nd rotation), and a 1st rotation *Eucalyptus nitens* plantation at Watson's TAS. Surface water monitoring data were also received from the catchment for the Warren Reservoir in the Mt Lofty ranges of SA.

Leaching studies were conducted on small plots at Imbil Qld (2nd rotation hoop pine), Toolara Qld (2nd rotation *Pinus elliottii* and *Pinus caribea* var *hondurensis*), Watson's TAS (1st rotation *Eucalyptus nitens*), Mt Gambier SA and Myalup WA (2nd rotation radiata pine).

The studies entailed sampling the soil profile to at least 90 cm at intervals (-1, 1, 7, 14, 28, 56, 112 days after treatment, and immediately after rainfall of more than 100 mm) until neither atrazine nor metabolites could be detected. Intact core samples were taken at Mt Gambier, a split tube corer was used at Watson's and Myalup, and small soil pits were excavated at Imbil and Toolara to allow sampling of the freshly cut profile. Four samples were taken, bulked and sub-sampled for each depth interval (0-10, 10-20, 20-30, 30-45, 45-60 and 60-90 cm, with additional sampling at 90-120 and 120-150 cm at Myalup and Mt Gambier). Atrazine was determined by reverse phase HPLC after wet extraction and filtration. Groundwater was sampled at one site (Toolara) with a shallow perched aquifer.

Full experimental details and raw data are contained in the FHRMG report to the NRA (Bubb and Barnes, 2000). Key results are summarised below.

Surface Water Studies
Surface Water Monitoring for Atrazine in NSW Forestry

Surface water monitoring in NSW was conducted at Canobolas in the central-west of the State, near the town of Orange. This is a high altitude location where rainfall is relatively evenly distributed through the year. Two moderately sloping catchments on acidic (pH 5.0-5.5) basaltic loam soils were studied, situated on the eastern and western flanks of Mount Canobolas. Soils were deep (at least 60 cm, and up to 2-3 m) and free draining with good infiltration capacity.

A first rotation site on the western flank (slope 0-12^o) was established on former pasture by strip cultivation, with mound ploughing along the contours and retention of pasture between. A second rotation site (slope 12-25^o) on the eastern flank was prepared by heaping and burning debris. The site was mound ploughed with retention of much of the smaller size debris and litter. Both sites received two applications of atrazine (4-4.5 kg/ha) in consecutive years (October 1996 and August 1997). Rainfall remained below long-term averages. Ground based spray equipment was used to apply atrazine in strips at the first rotation site, and aerial broadcast methods at the second. Liquid formulations were applied in the first year, and core-coated granules in the second.

Atrazine concentrations in water were monitored at two locations leaving the first rotation site and a third station downstream. Concentrations remained below 1 µg/L at both upstream locations in the second year, reflecting the prolonged dry conditions. They were above the threshold in the first year for about 2 months at one station (maximum 2.9 µg/L 25 days after treatment) and about a month at the other station (maximum 20 µg/L on the morning of the fourth day after treatment, declining to 5 µg/L by the evening of the same day). The peak of 20 µg/L occurred in the first of four flood events that were sampled during the first year in the high CAR (78%) station. Peak concentrations were 1.0, 0.9 and 0.2 µg/L, respectively, in subsequent flood events at 25, 34 and 120 days after treatment. Desethylatrazine (DEA) was found at the former station at concentrations up to 0.9 µg/L, but only in the second year of the trial. Atrazine was the only analyte detected at the low CAR (8.1%) downstream station, and only in the first season. Concentrations of 2 µg/L were detected in two samples taken during the early event on the fourth day after treatment.

Atrazine undergoes moderate sorption to soil, where it degrades through dealkylation and dechlorination reactions. Dealkylated metabolites sorb less strongly than parent atrazine. The occurrence of DEA in the second year of the study probably reflects the treatment applied in the first year, part of which appears to have been dealkylated in the soil and leached to groundwater. Streamflow is a combination of baseflow, as provided by groundwater, and surface runoff. With prolonged dry conditions, streamflow would consist almost entirely of groundwater, and the DEA contaminant would receive no dilution from surface runoff. In a normal season, the DEA concentration would be expected to be considerably reduced, but accompanied by significant concentrations of atrazine transported in surface runoff.

The second rotation site was served by two monitoring stations, one at the exit to the plantation and the second 7 km downstream. Atrazine concentrations in stream water leaving the site did not exceed 1 µg/L in the first year, except for the day of treatment when 13 µg/L was recorded. In the second year, a marked spike of atrazine (61 µg/L) was detected in water at the first weir on the first day after treatment (20 August 1997). Concentrations remained elevated at this location for the next three months (26.5 µg/L on 5 September, 4.7 µg/L on 8 October, 1.2 µg/L on 7 November). Residues were diluted below 0.2 µg/L at the downstream monitoring station, except for a single sample in September 1997 containing 0.6 µg/L. Metabolites remained undetectable in the first season, but desethylatrazine reached 1 µg/L in September 1997 at the upstream station.

The spike of 61 µg/L was attributed to overflying first order gullies of intermittent streams. Drainage depressions which are not incised and only carry water from heavy rainfall events were not buffered against treatment. The main (second order) intermittent streams were adequately buffered. The granular formulation may have contributed to this incident, as surface applied granules will have a tendency to move with overland water flow. Higher contributions to streams from pelleted rather than liquid herbicides have been reported elsewhere (Michael and Neary, 1993).

Two flood events were sampled, 131 days after the first treatment and 15 days after the second. Peak concentrations at the high CAR station were 1.0 and 26.5 µg/L, respectively. The higher figure in the second year probably reflects the closer proximity to the treatment date and difficulties with aerial application rather than a general problem with runoff from the total plantation area.

Despite no further testing to confirm these hypotheses having been carried out, overall, results from this site indicate that, with good management, herbicide residues in surface water leaving treated plantation areas should not exceed 20 µg/L. Peak concentrations occur for short periods (in the order of a day) but concentrations may remain elevated (above 2 µg/L) for up to 3 months after treatment. Higher concentrations can occur if care is not taken to avoid application to ephemeral drainage lines, and this aspect requires careful management. Application should not occur to any surface channel that flows after rainfall. Atrazine concentrations further down the catchment are diluted by water from other sources, such that concentrations above 2 µg/L are unlikely to occur, even for brief periods.

Surface Water Monitoring for Atrazine in Queensland Forestry

Surface water monitoring in Queensland was conducted in a hoop pine plantation at Imbil in the south-east corner of the State. The 8 ha study site was situated on silty clay soils, at an elevation of 100-300 m with slopes of 5 to 30^{o}. Atrazine was manually applied along the tree row, by knapsack at 5 kg/ha (overall rate 2.25 kg/ha) on six occasions over a 2 year period. The subtropical climate demanded more frequent treatments in order to achieve satisfactory weed control, but also leads to a shorter half-life for atrazine in soil. Summer rainfall is dominant at this subtropical location, and was near average at 1130 mm in year 1 and well above at 1703 mm in year 2, with a correspondingly high number of flood events (19 at the upstream station and 21 downstream). One large storm in February of the second year delivered 540 mm over a 3 day period and caused a major flood event.

Atrazine was applied four times in the first year, in December 1997 and April, August and November 1998. Flood events occurred 2, 34 and 53 days after the first treatment, 1 and 9 days after the second, 27 and 91 days after the third, and 2, 29 and 43 days after the fourth in the high CAR (94%). Atrazine concentrations at the upstream station remained in the low ppb range for the first and last treatments, but reached 109 µg/L for the second treatment (in the second event) and 127.7 µg/L for the third (first event). Atrazine was accompanied by significant amounts (in the order of 10%) of the dealkylated metabolites DEA and DIA, the former being predominant. Peak concentrations at the low CAR (4.4%) downstream station, after each application were 7.6, 18.2, 105.5 and 25.6 µg/L (note not always in the first flood event, and that the duration of the peaks was brief).

Previous experience with hoop pine plantation establishment had indicated that surface runoff is much more likely to be generated from point sources than from the general plantation area, the high infiltration capacity of which is enhanced by slash retention and contoured windrows which pond runoff water. Direct contamination of water courses was discounted as these were protected and chemical was applied manually. Road areas (including access tracks and snig tracks within the plantation) were suspected as the main source of contamination because of their high rainfall runoff coefficient. Drainage outlets compounded the problem as they flowed directly to watercourses via roadside drains, rather than being directed back into the general plantation area via water spreading structures.

A number of procedural changes were introduced in late 1998 to minimise the risk of contamination. Roadside transfer of herbicide mix from tanker to knapsacks was restricted to areas where drainage was directed back into the plantation, with staff instructed to minimise the possibility of spillage during transfer and test the spray units only within the plantation area. Application to potential point sources in the general plantation area, such as access tracks and snig tracks, was to be avoided.

Treatments in 1999 occurred in February and October, with flood events at the high CAR station 11, 77, 126, 189 and 234 days after the first treatment and 1 and 13 days after the second. Atrazine concentrations, at the upstream stations, were elevated after the first treatment, reaching 41.8 µg/L in the first of two events 11 days after treatment, and 50.4 µg/L in the second. Concentrations remained in the low ppb range after the second treatment. At the downstream station, concentrations did not exceed 2.3 µg/L.

Results indicate that with improvements to application practices, runoff from hoop pine plantations should not give rise to atrazine concentrations above 2 µg/L downstream from the plantation, although much higher concentrations may occur in water leaving the plantation in flood events.

Surface Water Monitoring for Atrazine in Victorian Forestry
Surface water monitoring in Victoria was conducted in a second rotation *Pinus radiata* plantation situated on clay loam soils at an elevation of 460-740 m at

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Merriang in the NE of the State. The site has a predominant winter rainfall pattern, with annual precipitation of 1042 mm. Rainfall was 79% of average in the first year, and 111% in the second. Atrazine was spot applied manually at 4.24 kg/ha (overall rate 0.78 kg/ha) in September 1997 and by helicopter at 5.1 kg/ha (overall rate 4.5 kg/ha) in September 1998. Although slopes were fairly steep at 16-28^{o}, surface runoff was limited by the high infiltration capacity of the soils.

A single grab sample from the high CAR station tested positive for atrazine, at 0.2 µg/L some 48 days after the initial treatment. Only one flood event was sampled in year one, 272 days after treatment, and only at the low CAR station. Two flood events in the second year, 260 and 336 days after treatment, were sampled. All tested negative for atrazine.

Surface Water Monitoring for Atrazine in Tasmanian Forestry
Surface water monitoring in Tasmania was conducted in a first rotation *Eucalyptus nitens* plantation at an elevation of 410-492 m in a high winter rainfall area of Tasmania (annual precipitation 1536 mm). The plantation was situated on free draining clay loam soils (10% organic carbon in the surface 10 cm) with good infiltration capacity. Slopes ranged from 6 to 20^{o}. Atrazine was broadcast applied by tractor in November 1996 and October 1997 at 8 kg/ha (overall rate 5.4 kg/ha including inter-row, buffer zones and roading). Rainfall was 85% of average in the first year and 113% in the second.

A single sampling station with a high catchment area ratio (67.5%) was used. The maximum concentration of atrazine detected in routine grab samples was 0.2 µg/L, with all but three samples remaining below 0.5 µg/L. Flood event samples were taken 5, 52 and 59 days after the first treatment and 7 and 171 days after the second. Only the initial sample, at 2 µg/L, contained more than 1 µg/L atrazine. This peak level was maintained for about 2 hours. The herbicide could not be detected in flood events that occurred more than 2 months after treatment. The only metabolite detected was DIA, at 0.4 µg/L in the November 1997 event.

Atrazine in South Australian Water Catchments.
Surface water monitoring in South Australia did not form part of the formal forest herbicide research program, but was implemented in response to a contamination incident. Problems with persistent atrazine and hexazinone contamination in three reservoirs providing raw water to the Barossa Water Treatment Plant were brought to the attention of the NRA by SA Water in early 1999. Monitoring data were provided for the Barossa Reservoir (near the outlet to the water treatment plant) between September 1997 and July 1999, and for the two upstream impoundments (South Para and Warren) between July 1998 and July 1999, as tabulated below for atrazine (Note - all of the concentrations are above the draft NHMRC guideline value). Hexazinone concentrations in the reservoirs followed similar trends. Contamination has incurred significant additional operating expenditure, including the need for activated carbon treatment.

Reservoir	Year	No of samples	Minimum Atrazine	Maximum Atrazine	Mean
Barossa	1997	4	2.10 µg/L	2.50 µg/L	2.20 µg/L
	1998	38	1.03 µg/L	2.26 µg/L	1.64 µg/L
	1999	25	1.3 µg/L	1.80 µg/L	1.53 µg/L

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

South Para	1998	19	1.40 µg/L	2.12 µg/L	1.76 µg/L
	1999	26	1.2 µg/L	1.80 µg/L	1.49 µg/L
Warren	1998	20	2.47 µg/L	5.69 µg/L	3.95 µg/L
	1999	18	1.4 µg/L	2.93 µg/L	2.02 µg/L

The Barossa Reservoir system consists of three reservoirs (see table) located in the northern part of the Mount Lofty Ranges. The Warren Reservoir receives water from the South Para River, Waterholes Creek, and by pipeline from the Murray River. It discharges into the South Para Reservoir, which also receives water from other tributary streams such as Victoria Creek and Malcolm Creek. Water then flows downstream to the Barossa Weir where it either discharges to the Gawler River or is diverted through a tunnel to the Barossa Reservoir. Ambient water conditions in the Barossa reservoir are strongly dependent on residual conditions in the much larger South Para reservoir upstream.

Reservoir	Capacity	Catchment area	Surface area at full supply level
Warren	4770 ML	11900 ha	105 ha
South Para	44770 ML	22100 ha	399 ha
Barossa	4510 ML	800 ha	62 ha

For historical and operational reasons, plantation establishment ocurred only in the Warren catchment during 1996-98, rather than being spread across other catchments as in previous years. Some relatively large areas established in 1995-97 were treated twice in 2 years with Forest Mix granules (label rate 1.5 kg/ha hexazinone and 4.5 kg/ha atrazine). Shallow soils with limited moisture holding capacity favoured storm runoff, which was exacerbated by mounding perpendicular to the contour to minimise problems with waterlogging. Logging debris was pushed into windrows and burnt, rather than being retained as a mulch as now occurs. Application by helicopter in 1998 meant that internal firebreaks and ephemeral drainage lines were treated.

Areas treated are identified on the attached map (Attachment A). The two main plantation areas were situated on each side of a ridge, one draining east to the South Para River and the other west to Waterholes Creek.

Tributary streams in the larger South Para catchment drain an extensive area, mostly under agricultural or pasture use but with pine plantations located mainly in the Big Flat area. Soil at this location is typically a sandy duplex, with a highly permeable sand layer overlying an impervious clay that permits runoff. Previous studies in the area had indicated that atrazine contamination is likely when treatment occurs within 4-5 m of a stream or incised drain on coarse grained soils or in landscape with low relief. Three areas of 1997 plantation were treated with Forest Mix granules in May 1997 and again in May 1998, at a lower rate. The largest area (Dewells East, 31.3 ha) to be monitored was mounded perpendicular to the contour almost continuously from ridge-top to valley flat. Runoff ponded along the eastern firebreak where a metalled road diverted water through culverts into an adjacent stream. Areas treated in 1998 are tabulated below, as total area and percentage of catchment.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Site	Flows to:	Treated area (cumulative)	Catchment area	Catchment area ratio
Dewells 1997 East (10)	2	31.3 ha	56.9 ha	55%
Sandy Corner (2)	3	31.3 ha	626 ha	5%
Centennial Drive Ford (3)	4	31.3 ha	7825 ha	0.4%
Rocky Ford (4)	Warren	49.0 ha	8032 ha	0.6%

Concentrations of atrazine (µg/L) detected at the four monitoring stations during the spring of 1998 are represented graphically (see Attachment B). High concentrations were detected leaving the treated plantation (Dewells 1997 East) even though 3 months elapsed between application and the first sampling. It is possible that concentrations were even higher closer to the time of application. Significant streamflow is estimated to have commenced in early July, with major streamflow and spillway flow at Warren following a major storm event on 28 July. This event is likely to have delivered the largest load of atrazine to Warren Reservoir. Some care is needed in interpreting the data, as streamflow was not measured and some relatively high concentrations were recorded when flow declined during spring, particularly in 1999.

Atrazine concentrations at sampling points further down the catchment declined rapidly through dilution, but still reached more than 3 µg/L during August at station 4 just above the Warren reservoir. Concentrations in the following season when no atrazine was applied remained for the most part below 1 µg/L, but with occasional values above 2 µg/L at stations 10 and 2 close to the sites of treatment. Stream concentrations declined rapidly with passage of less contaminated water, but reservoir concentrations declined only slowly even when the source of contamination was removed. Note only the concentrations at site 2, close to the plantation exit, exceeded the ANZECC guideline.

Waterholes Creek is relatively small, consisting of ephemeral drainage lines that flow for short periods (a few days). Most of the catchment is forested, either with pine plantations or native forest. Second rotation sites, mounded perpendicular to the contour to minimise waterlogging, were treated with Forest Mix granules in 1997 and again at a marginally lower rate in 1998. Catchment details are tabulated below.

Site	Flows to:	Treated area (cumulative)	Catchment area	Catchment area ratio
Dewells 1997 West (11)	6	51.0 ha	157.9 ha	32.3%
Forties 1998 inlet (9)	3	0.0 ha	300.0	0.0
Forties 1998 Exit 1 (8)	6	16.0 ha	333.3 ha	4.8%
Forties 1998 Exit 2 (7)	6	6.0 ha	63.8 ha	9.4%
Road bridge (6)	23	86.2 ha	2308.1 ha	3.7%
Ford (23)	5	94.9 ha	2630.0 ha	3.6%
Yatala 1998 W Exit (12)	5	4.0 ha	9.0 ha	44.4%
Forbes Ford (5)	Warren	98.9 ha	2719.0 ha	3.6%

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Atrazine concentrations found in the catchment are represented graphically Appendix B. Highest concentrations were again found in the upper part of the catchment as water left Dewells 1997 West. High concentrations were also found just below Forties 1998. No data were available for Yatala 1998 over this sampling period, but sub-ppb levels were detected the following winter. Atrazine contamination above 20 µg/L was detected at station 5, just above Warren Reservoir, during August 1998. This indicates significant inputs from Yatala 1998 as concentrations at station 23 just upstream remained in the low ppb range. The picture is more complicated here due to the three contributing sites, but again the ANZECC guidelines fail to be met only at sampling sites relatively close to the plantation exits.

Hexazinone concentrations followed similar trends during 1998, but tended to be higher than atrazine concentrations in the following season, with peaks after rain events.

Site preparation practices have been modified since the 1998 season. Rather than pushing into windrows and burning, logging debris on second rotation sites is now largely retained, after chopper rolling. More woody biomass is removed. Ripping and/or mound ploughing now conforms more closely to the contour. Care continues to be taken to avoid spraying in 10 m buffer strips retained along each side of stream lines, including first and second order drainage lines. Spraying occurred in these areas during 1998 because of uncertainties regarding their definition. Tracks, streams and buffer strips occupied only 2% of the treated area, but it is possible that they contributed the bulk of the contamination to downstream reservoirs.

Summary Of Surface Water Studies

Surface water sampling at a range of Australian forestry sites detected atrazine in a number of samples, with most samples collected during periods of baseflow remaining below the detection limit in low CAR stations. Some samples collected as water left plantation areas in Queensland and NSW following storm events were found to contain residues in excess of 20 µg/L. Contamination in Queensland is thought to have arisen from point sources such as road areas rather than runoff from the general plantation area. Changes to management practices were effective in reducing this contamination, although residues around 2.0 µg/L remained in low CAR stations downstream from the plantation. Also flood events for the second year were mainly months after application, not days as in the previous year. Contamination in NSW is thought to have occurred because ephemeral drainage lines were treated, although this hypothesis was not confirmed.

Stream monitoring in the Mount Lofty ranges occurred in response to low level contamination detected in downstream impoundments. Residues reached as high as 100 µg/L in water leaving treated areas, but were diluted to the low µg/L level further down the catchment. Downstream impoundments were persistently contaminated in the low µg/L range. Contamination at this site reflected its vulnerable soils, with a highly permeable sand layer overlying an impervious clay that permits runoff. Site preparation practices were also a major contributor, as mounding perpendicular to the contour facilitated runoff, which was diverted into streams after leaving the treated area.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Leaching Studies
Leaching Studies in Queensland Forestry

Leaching studies at Imbil were conducted on a slightly acidic red podzolic loam soil with high levels (4-7%) of organic carbon in the surface 20 cm. Site preparation in the preceding winter consisted of raking large woody debris into windrows spaced at 15 m intervals across the contour. Atrazine was applied manually by knapsack at 5 kg/ha in February, April and August 1998 and February 1999, to a small cover of weeds on each occasion. Significant rainfall (65 and 44 mm respectively) was recorded in the week following the first two treatments. Conditions were dry in the week following the third treatment, and 156 mm was recorded in the 3 weeks following the fourth.

Application rates were confirmed using alfoil targets. Anomalous results were obtained after the third application when only 10% of the nominal rate was recovered. The reasons for this shortfall are unclear. Field recovery from the soil was quantitative for this treatment with around 6 mg/kg recovered from the surface 10 cm on the day after treatment, but only 4% of applied for the preceding treatment and well below expected for the remainder, suggesting interception by and dissipation from surface debris. Bromide tracer leached to the 60-90 cm sample by 14 days after treatment, but atrazine residues mostly remained confined to the surface 30 cm, with detections deeper in the soil on one occasion attributed to sample contamination. Both dealkylated metabolites were recovered at low levels, with DEA reaching 0.12 mg/kg at 60-90 cm 14 days after the third treatment and 0.22 mg/kg at 20-30 cm 21 days after treatment, and DIA recovered from the surface 10 cm at 0.24 mg/kg on the day after the fourth treatment. The half-life was 12 days after the third treatment but could not be determined for the other three treatments because of low initial recoveries. Residue accumulation with successive treatments was neither expected nor detected. The limit of detection was 0.04 mg/kg.

The Toolara studies were conducted on an acidic gleyed podzolic sand with less than 1% organic carbon. Atrazine leaching was considered more likely to occur at Toolara than other sites because of high rainfall, low organic carbon (less than 1%) and high sand content (88%) in the soil. The site was prepared in the preceding winter with a single pass using a dozer drawn winged ripper to provide 2 m wide cultivated planting strips spaced 5 m apart, which carried a small cover of weeds. Atrazine was applied manually at 5 kg/ha in August and November 1998 and March and June 1999.

Bromide tracer was not used at this site. Atrazine residues reached a maximum of about 6 mg/kg in the surface 10 cm on the day after the third treatment and remained confined mostly to the surface 30 cm, with concentrations remaining below 0.7 mg/kg deeper in the soil. The half-life was 21 days after the initial treatment and 14 days after the later treatments. Residue accumulation with successive treatments was neither expected nor detected. Dealkylated metabolites were occasionally detected at low levels in surface samples, for example 0.16 mg/kg DEA and 0.33 mg/kg DIA in the surface 10 cm on the day after the final treatment.

A network of piezometers was installed to a depth just above the clay restriction layer (1.6-1.8 m) in order to sample shallow groundwater. Atrazine was detected at a maximum concentration of 0.6 µg/L 14 days after treatment, accompanied by

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

NRA DRAFT

0.3 µg/L DEA. The residence time was less than 43 days, with disappearance thought to reflect degradation as the low slope and modest soil hydraulic conductivity typical of the study area would have allowed only limited lateral flow to occur.

Leaching Studies in Tasmanian Forestry
Tasmanian investigations were carried out on a free draining acidic ferrosol with 8% organic carbon in the surface 5 cm. Atrazine was applied by tractor to bare ground at 8 kg/ha in November 1996, immediately prior to planting of *Eucalyptus nitens*. The former pasture was sprayed out with glyphosate and the site was cultivated with a mound plough on a 3.5 m spacing. Significant rain (44 mm) fell in the week after treatment.

Bromide was only detected in the surface 5 cm, and only at the fourth analytical attempt nearly 3 years after sampling. The failure to detect the tracer can not be explained.

Atrazine recovery from alfoil plates was about half that expected from the application rate. Atrazine residues remained confined to the surface 30 cm, apart from some low level detections in the 30-60 cm segment between 7 and 28 days after treatment. Maximum residues in the surface 10 cm were about 4 mg/kg, 7 days after treatment. Results from the final (912 day) sampling are not yet available. The estimated half-life of atrazine in the soil was 140 days (this was confirmed by Environment Australia as 144 days using a pseudo-first order kinetics, $r^2 = 0.7321$). Only one of the dealkylated metabolites (DEA) was detected, reaching significant levels near the surface (for example, 0.66 mg/kg 112 days after treatment) but remaining below 0.1 mg/kg deeper in the profile.

Leaching Studies in Western Australian Forestry
The Myalup site was situated on an acidic podzolised sand with low organic carbon (less than 1%) that was cultivated in April 1996 with retention of considerable harvest debris from the previous pine crop. Atrazine was applied manually at 4.5 kg/ha to weed free ground prior to planting. Significant rain (39 mm) fell in the week after treatment.

The bromide tracer leached rapidly through the soil profile, being found in all samples to 150 cm taken at 7 days after treatment.

Recovery of atrazine from alfoil collectors was double that expected from the application rate, perhaps reflecting separation of atrazine and the bromide tracer in the spray tank. Recovery from soil was less than expected based on the application rate, perhaps reflecting interception by surface debris. Atrazine residues reached a peak of 1.6 mg/kg in the surface 10 cm on the day after treatment and were mainly retained in the surface 30 cm, with traces (0.02 mg/kg) detected to 90 cm in 7 day samples and to 60 cm in 14 and 28 day samples. Traces of DEA (0.03-0.06 mg/kg) were recovered from surface samples at 28 and 56 days after treatment. The estimated half-life for atrazine was 25 days.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Leaching Studies in South Australian Forestry

The Mt Gambier site was situated on an acidic podzolised sand with high organic carbon (6.5%) in the surface 5 cm. The site was mound ploughed on a 2.5 m spacing in November 1995 after preparation with a crusher roller in February 1995. Atrazine was applied by knapsack at 4.5 kg/ha to a small cover of grass and broad leafed weeds in August 1996 and June 1997. Only the second treatment was closely followed by rain (23 mm over 7 days).

Bromide leached rapidly through the soil profile, being found in all samples to 150 cm by 14 days after the first treatment, and to 90 cm by 7 days after the second treatment.

Atrazine recovery from the soil was low after the first treatment (initial residues of 0.93 mg/kg in the surface 10 cm) but more normal after the second (initial surface residues of 4.53 mg/kg). Residues were retained in the surface 30 cm after the first treatment, but some low level detections (0.08-0.19 mg/kg) were detected to 90 cm on the day after the second treatment. The estimated half-life of atrazine at this site was 35 days, and accumulation with successive treatments was neither expected nor detected. As at Myalup, DEA was the only metabolite detected, at 0.05-0.08 mg/kg in the surface 20 cm at the 28 and 56 day samplings.

Summary Of Leaching Studies

Leaching studies at forestry sites indicated a low likelihood of groundwater contamination. Low level groundwater contamination can occur at vulnerable sites, notably those where opportunities exist for rapid contamination via bypass flow.

The studies also provided insights regarding the effect of climate on persistence of atrazine. Short soil half-lives of 2-3 weeks in Queensland support the use of multiple treatments to control heavier weed growth in that State. Accumulation of residues is not expected, even with three treatments per year.

6. Atrazine In Annual Cropping Areas

Atrazine is a commonly found contaminant of surface and ground waters in Australia, because of its widespread use particularly within irrigated agriculture and forestry areas. The NRA's existing chemicals review records that atrazine at concentrations in the order of 100 µg/L have been found in irrigation drainage water from rice growing areas. It occurs commonly in natural surface waters, generally at concentrations below 10 µg/L. A concentration of 8.1 µg/L was found in Tasmanian streams, draining forestry plantations on the day of application. Only limited monitoring of groundwater has been conducted, but atrazine was detected at concentrations in the order of 1 µg/L, accompanied at some sites by the metabolite DEA.

Monitoring has continued in annual cropping areas since the NRA review in 1997. Results from Syngenta Crop Protection P/L are from projects on the Atherton Tablelands, Darling Downs, Liverpool Plains, Lachlan River near Cowra, and Western Australian canola growing areas.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

NRA DRAFT

Atrazine is a common contaminant of surface waters, particularly in the summer months, but occurs at relatively low levels (for the most part below 1 µg/L). The highest concentration found was 15 µg/L in a farm dam at Blackwood, indicating that runoff transports atrazine from canola growing areas. Significant metabolite concentrations also occurred, indicative of high metabolic activity. Unless a major rainfall event occurs, such dams are well suited for retaining contaminated runoff as they are kaolin lined and will not leak to groundwater.

Occasional low level detections occurred in groundwaters. More work is needed to determine their significance, but no widespread problems with groundwater are apparent from results to date.

Western Australian Canola

Monitoring for atrazine has been carried out in Western Australia from November 1998 to July 1999 as part of a requirement for a permit for atrazine use in TT canola (Stubbs and Eksteen 1999). Three geographically distinct areas were selected (near Geraldton, the Blackwood River catchment and Esperance) and a total of 113 samples were taken from surface (river, creek, dam or seep) and groundwaters (bores or peizometers). Seventy-four detections (65%) higher than the level of quantification *detection?* (LOD = 0.05 µg/L for atrazine and desethylatrazine) were found with the highest of 15 µg/L of atrazine from a dam (all dams are used for stock water only) in the Blackwood catchment and 12 µg/L for desethylatrazine in a dam in the Arrowsmith River catchment near Geraldton. The highest concentration from a natural waterway was 9.4 µg/L atrazine from a creek in the Blackwood catchment. Surface and groundwaters in the Esperance region experienced rare low-level spikes of atrazine only from runoff (maxima of 0.68 and 0.16 µg/L respectively). The highest concentration of desethylatrazine, which is reported to be of comparable toxicity as the parent atrazine, was 9.6 µg/L from a creek in the Blackwood catchment. Together with the atrazine concentration of 5.8 µg/L in that sample, the combined concentration of 15.4 µg/L can be taken as total atrazine. Hydroxyatrazine was never detected above its LOD of 0.05 mg/L.

The two bores in the Arrowsmith catchment registered pulses of atrazine which may require further investigation as little is known about the fate of pesticides in water-repellent sands. Streit (1999) suggests a possible point source contamination, a shallow waterbody beneath a treated sandy soil or possible extensive groundwater contamination.

Most river samples were below the LOD. There were 46 positive surface water samples for atrazine but only one sample, from a dam, exceeded the ANZECC/ARMCANZ Australian Water Quality Guideline value of 13 µg/L. The data suggests that the atrazine appears to be runoff from treated TT canola fields and is metabolised to desethylatrazine. As on-farm stock water dams in WA are lined with kaolin clay to reduce seepage into groundwater, they are well suited for retaining runoff from treated fields unless high rainfalls occur (Streit 1999). The detections in the Irwin and Arrowsmith Rivers indicate that monitoring should continue and management measures may need to be implemented if detections exceeding the guideline continue. The monitoring should be more targeted to creeks and rivers in vulnerable areas that have high triazine use, high water tables and sandy soils. Flow and rainfall data should also be included.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

When monitoring of stream and groundwater in WA for the year 2000 was to commence, issues were raised on the methodology and the suitability of bores when selecting the sites (Eksteen 2000). The uncertainty delayed implementation and no data are available from the Blackwood and Irwin areas. However, as the sites were already selected in Esperance, monitoring continued from April to December 2000. Three bore sites and one river site was selected. Rainfall data and bore depth was also provided. The use of atrazine in this catchment increased substantially from 1000 L in 1998 to 7800 L in 1999. 19 samples were taken from bores and 7 samples from the river. Six samples were positive, three from the bores and three from the river. Concentrations from the bore sites varied from 0.08 to 0.57 µg/L and from the river varied from 0.30 to 0.39 µg/L. All were well below the ANZECC Guidelines for Fresh and Marine Water Quality value of 13 µg/L. However, they were well above the NH&MRC guideline value of 0.1 µg/L. The study recommended further monitoring and “that monitoring commences in the groundwater tables of regions where drinking water is derived from aquifers (eg Geraldton and Mingenew). This matter has already been taken up in a separate report for use of atrazine (and simazine) on TT canola.

Liverpool Plains

Syngenta has commissioned an assessment of the transport and fate of atrazine on the Liverpool Plains after studies in the late 1990s found atrazine at concentrations up to 14 µg/L in a significant proportion of groundwater samples (Peirson *et al*, 1999). Atrazine is commonly used in this area for weed control in sorghum, which tends to be grown on long rotations with wheat, with each crop followed by a long fallow period (at least 10 months) to allow soil moisture to accumulate.

Rainfall is variable but generally heaviest during the summer growing season, often occurring in heavy storms that cause flooding. Floodplain soils are prone to waterlogging after winter floods. Ephemeral streams or flood runners are present in many paddocks, facilitating the transport of contaminants in surface runoff following rain.

Atrazine is commonly detected in surface waters of the region, generally at concentrations in the order of 1 µg/L when present. Higher concentrations occur at some locations, for example 17 µg/L in the Mooki River at Ruvigne in September 1996, 25 µg/L upstream at Caroona in January 1997, and 29 µg/L higher in the catchment in Big Jacks Creek at Warrah Ridge in August 1996. The metabolite DEA was present in these samples at about 10% of the atrazine concentration. Estimated mass flux of atrazine from the Liverpool Plains in fluvial transport is about 500 kg per annum, or 0.1% of the estimated use (470 tonnes).

Peak atrazine concentrations were synchronised across the region, tending to follow periods of heavy atrazine use but not necessarily associated with periods of heavy rain. Similar patterns of contamination in Canada, independent of runoff events, have been linked to carelessness associated with operating equipment close to streams. Evidence was found for the deposition of pesticides close to or directly into stream water during the process of drawing water, mixing pesticides, spraying, or cleaning equipment, or from seepage from containers discarded in and around the spray site (Fawcett, 1998).

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Groundwater beneath the Liverpool Plains is commonly contaminated by atrazine, usually in the order of 1 µg/L but reaching 14 µg/L in one sample. Higher levels generally occur close to sorghum crops. Some of the detections are thought to reflect rapid bore leakage as atrazine detections were accompanied by chemicals regarded as non-mobile, and discarded chemical drums were found around some bores. Rapid bypass flow is also possible as the reactive clay soils of the area are prone to cracking.

Central and North West Regions of NSW Water Quality Program
Earlier results from this long running and valuable program were described in the NRA interim review report published in November 1997. Residues are found in the Gwydir, Namoi and Border Rivers of NSW, but have been absent from the Macquarie basin in recent years, perhaps reflecting better flows and improved farm management practices (Cooper, 1995). Atrazine can be found throughout the river basins including their headwaters, with levels approaching 10 µg/L occurring within irrigated agriculture sites. Detailed investigations at one site on the Gwydir revealed that the contamination arose via irrigation supply channels, notwithstanding that no applications of atrazine to the channels had been made for at least 12 months. It was noted that some 25% of cotton growers used atrazine for irrigation channel hygiene during the 1994-95 season, and that only 45% of growers were aware of the proposed removal of this use, to take effect by December 1995.

Detection of atrazine continued to be a common feature when monitoring in the Gwydir, Namoi and Border river basins during the 1995-96 season, but with no clear temporal pattern. The Macquarie basin, where impacts from the drought continued to be felt, was again free of this contaminant (Cooper, 1996). Detections occurred upstream of and within irrigation areas, with 19% of samples taken within irrigated areas between November and March recording more than 0.5 µg/L. Peak concentrations approached 5 µg/L in Coxs Creek and exceeded 4 µg/L in the Mooki River following storm events during January, with peak instantaneous loads of 120 and 100 kg/day, respectively. The Liverpool Plains in the Upper Namoi valley, where dryland farming of cotton, sorghum, sunflowers and maize predominates during summer, was identified as a problem area due to a limited capacity to harvest storm runoff and store the water on-farm. Atrazine loads were considerably increased from the previous season when planting was reduced by drought and peak instantaneous loads during January storms were relatively low at 29 kg/day.

All river basins showed a stable or declining trend of atrazine levels in the 1996-97 season (Muschal, 1997). Slight seasonal fluctuations were evident, from higher concentrations over summer to generally lower levels during the winter months, consistent with the use pattern. Use occurs predominantly in spring prior to planting of summer crops.

Results from the 1997-98 season (Muschal, 1998) indicated that the upper Namoi River basin had the highest frequency of atrazine detections and the highest concentrations of all catchments, reflecting the high usage of atrazine on broadacre dryland cropping in the Liverpool Plains area. Highest concentrations (6.5-7.5 µg/L) occurred in late spring and early summer, but 1-2 µg/L were recorded throughout the year.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

NRA DRAFT

The highest median concentration of atrazine in the 1998-99 season was 0.2 µg/L at two sites on the Darling River, at Bourke and 25 km upstream. The Namoi and Gwydir Rivers also recorded substantial levels of atrazine contamination. Broadacre farming in the upper Namoi River area was again identified as a significant contributor to the total atrazine load in this catchment. No overall rising or falling trends were evident for the catchments studied, although some fluctuations had occurred since 1991, including the slight upward trend for the Darling River this season (Muschal, 2000).

The report notes that broadacre dryland cropping adjacent to waterways and through natural drainage lines means that runoff flows through crops and directly into waterways. The major source of atrazine across the central and north west regions of NSW is believed to be dryland farms that are not designed to collect and control surface runoff arising from storms. No real increasing or decreasing trends were discernible over the last few seasons for any river basin.

North Queensland – Atherton Tableland Cane fields

This site was selected because it represented a newly developed cane growing area that was previously used for growing rice. The site has a significant component of surface-driven hydrology, but also a number of ground water issues. This site is also unique for the sugar industry as it drains west into the Gulf of Carpentaria, rather than into the Pacific Ocean.

Monitoring in Cattle Creek commenced in 1997 and included monitoring the concentrations of a number pesticides in surface runoff from three sites, upper catchment (mainly horticulture) sugarcane, sub-catchment (100% sugarcane) and downstream of Cattle creek (whole catchment). Monitoring in stream samples over a three year period showed virtually no atrazine in the upper catchment. The sugarcane sub-catchment showed concentrations similar to that found in the lower catchment. The lower catchment site was well below the mixing zone and concentrations of atrazine were up to 25 µg/L but mainly below 15 µg/L in the “wet” November-February. Many were above ANZECC Water Quality Guideline of 13 µg/L. In the seasonal dry periods, atrazine concentrations were usually <5 µg/L.

During early 1999, bore sampling was commenced at monthly intervals at three sites that are located near the existing surface sampling sites. Bores from the upper catchment and downstream (whole catchment) showed no detectable levels of atrazine over the sampling period indicating that atrazine was not entering these aquifers in any significant quantity. Both bores showed limited hydrological response to seasonal changes with bore height changes ranging between approximately 0.3 and 0.8 m even after heavy rainfall.

The sugarcane sub-catchment was the most hydrologically responsive with approximately 5 m recharge response between wet and dry seasons. Atrazine concentrations varied from approximately 0.12 µg/L, increasing over the monitoring period of 19 months to approximately 0.95 µg/L. Desethylatrazine concentrations varied from approximately 0.25 µg/L at the start of the monitoring period to 4 µg/L at the end of the monitoring period.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

The data suggest that the main pathway for off-site movement of atrazine in this study area is via surface runoff. Data indicates that 90% of the annual loss of atrazine occurs during the wet season, even though only 35% of the total atrazine is applied during this period. If applications of atrazine were confined to the "dry" 8 months, exports would be approximately 10% of that currently occurring (Simpson 2001).

South West Victoria

A study to assess the environmental impacts of three different cropping treatments was undertaken in south-west Victoria. Surface runoff samples were collected and analysed for atrazine and simazine as well as a number of other parameters (Hollywell, 2001).

All samples were below the LOD (0.5 µg/L) for atrazine and simazine. However, south-west Victoria experienced very dry conditions for a number of years and water samples could not be collected and analysed until 17 months after applying the herbicides making it very unlikely that target chemicals would be detected.

Summary Of Monitoring In Annual Cropping Areas

Data from studies across Australia in major atrazine use areas, indicate atrazine is a commonly detected contaminant. Generally levels are below 1 µg/L but some are found in excess of 20 µg/L. As in forestry situations, the main contributor to riverine contamination appears to be surface runoff. Dryland paddocks in the upper Namoi, for example, often contain ephemeral flood runners. Overland flow of water during flood events transports atrazine residues into waterways.

7. Conclusions

Available monitoring data for atrazine in Australian and US surface waters indicate broadly similar patterns of contamination. At vulnerable sites, atrazine may reach concentrations in the order of 100 µg/L in small streams leaving high CAR treated sites, if storm events occur within a short time of application. Concentrations in larger rivers and reservoirs downstream tend to be below 1 µg/L, but may exceed this threshold in areas with intensive atrazine use on soils conducive to runoff. Contamination is likely to persist year round with little variation in reservoirs with limited outflow, but declines between seasons in flowing waters. Degradation half-lives of atrazine in soil range from 12 days in Queensland to 213 days in Tasmania depending on the climate and soil temperature.

The pattern of atrazine contamination in Australian surface waters indicates that safety margins continue to be narrow in some areas, both for forestry and annual cropping. The key factor that determines the likelihood of aquatic contamination appears to be the vulnerability of the soil to surface runoff. Water infiltration into the soil needs to be addressed and rapid movement of surface runoff to waterways minimised. Best management practices (BMPs) have a key role to play in reducing chemical losses in runoff. BMPs can be defined as practices or combinations of practices, industrial techniques and good house keeping principles determined to be the most effective and practical known means of preventing or reducing the amount of non-point source pollution.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

Storm events pose the highest risk. A major risk factor in both forestry and annual cropping appears to be the treatment of ephemeral drainage lines. Subsequent water flow mobilises atrazine residues. Ephemeral drainage lines should not be treated with atrazine, particularly if runoff events are likely to follow. Ideally, they would not be cultivated, nor cropped.

An associated risk factor is the treatment of runoff water. This water should be directed into permeable areas, ideally through spreading structures, rather than channelled into waterways. Retention in dams may be another option for reducing river contamination.

Careless handling can also be a major contributor to stream contamination, as exemplified by the high residues found in Queensland and linked to mixing and loading activities on runoff prone surfaces (forestry roads). The observation that broadscale surface water contamination in NSW cotton areas is synchronised with heavy use but not necessarily with rainfall suggests that careless handling may also be a problem in annual cropping areas. Such contamination can be reduced by avoiding handling and mixing activities in areas such as roads and river margins from which surface runoff can move easily to surface waters.

Site preparation practices are also important, particularly in forestry. Mounding perpendicular to the contour improves drainage but facilitates the rapid transport of atrazine residues from general cropping areas into waterways. Mounding along the contour helps retain water on site, which provides greater opportunity for residues to inflitrate the soil. Where drainage may be a problem, trees can be grown on top of these mounds.

Improving infiltration and discouraging drainage to waterways reduces risks of surface water contamination but potentially increases risks to groundwater. Moderately sorbed compounds such as atrazine are more likely to be lost in surface runoff or degraded in the soil. Although groundwater contamination appears in general to be a lesser problem than contamination of surface water for such chemicals, risks may still be significant at vulnerable sites. Groundwater is vulnerable to contamination where soils are permeable and water tables are shallow. Permeable soils are usually sandy, but rapid bypass flow in cracking clay soils or in karstic terrain can also lead to groundwater contamination. Particular care is needed when handling chemicals in such areas, with strict avoidance of such activities in the vicinity of bores or recharge areas. For example, some recorded instances of higher groundwater contamination appear to have been caused by careless handling of atrazine concentrate or working solutions near bores.

A key reason for conducting the FHMRG trials was to demonstrate that, with the label restrictions introduced in the mid 1990's, the Water Quality Guidelines could be met. The data show that this effort has largely been successful but modifications to practices already made need to be underpinned through development of a forestry wide BMP. A variety of BMPs, appropriate to local conditions, have been developed for forestry activities across Australia. BMPs covering use of atrazine in forestry need to be refined and consolidated by the industry into a single reference document

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

which would describe the BMPs and their suitability for various situations. If BMPs are followed, atrazine concentrations in rivers should be below the relevant water quality guidelines.

The ANZECC Guidelines for Fresh and Marine Waters are recommended limits to acceptable changes in water quality that will continue to protect the environmental values. It should be noted that water quality should not be degraded to these levels. Whether ambient water quality is above or below the guideline values, the philosophy of continual improvement is promoted. Long-term management aims should be to improve water quality to levels that are better than those defined by the guidelines.

The NHMRC 1996 Australian Drinking Water Guidelines has the same philosophy as the ANZECC guidelines as indicated by the following. "The guidelines should never be seen as a licence to degrade the quality of a drinking water supply to the guideline level" (the guideline value for atrazine is 0.1 µg/L). Pesticides should not be found in drinking water, hence the guideline value is set at the limit of detection. This value is the level at which the pesticide can be reliably detected using practicable and readily available and validated analytical methods. If a pesticide is detected at or above this value the source should be identified and action taken to prevent further contamination. The health value is intended to be used by health authorities in managing the health risks associated with inadvertent exposure such as a spill or mis-use of a pesticide.

Based on the data available, the results indicate that contamination of streams during periods of baseflow and zero flow is low when following BMP. Reducing runoff from storm events in particular, requires further attention to minimise contamination of streams.

It is recommended that:

1. The following labelling restrains are required for forestry uses as appropriate:

    - DO NOT apply product to any surface channel that flows, even for a short time, following rain;

    - DO NOT handle, mix, apply or conduct testing operations to point sources susceptible to runoff such as roads, access tracks, snig tracks and compacted log dumps where drainage facilitates rapid entry into waterways;

    - DO NOT apply to sites which have been mounded perpendicular to the contour.

2. The following labelling statement is required for forestry uses as appropriate:

Before using this product in forestry situations, users should seek information on forestry Best Management Practices (BMP). BMP guidelines are available from "www" or "company".

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

The BMPs should be flexible, allowing management of atrazine use to be optimised at specific locations, and facilitating the inclusion of improved management techniques as they become available. The reference document describing the BMPs and their suitability for various situations should make reference to minimising atrazine use during the “wet” season in North Queensland and the development of catchment/retention ponds on high runoff sites to reduce contamination in streams.

3. Use patterns may be modified

Due to the climatic conditions in Queensland forestry (and areas in northern NSW with a similar climate) up to three treatments per season may be required because the climate favours growth of weeds and atrazine has been shown to degrade relatively quickly in such a climate. The available monitoring data supports this application frequency.

Should registrants wish to incorporate these instructions on to product labels, they would still need to make application to the NRA. However the data requirements for the environmental component of this application may be reduced in light of the findings noted in this report.

NRA DRAFT

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

REFERENCES

Blanchard PE & Lerch RN (2000) Watershed Vulnerability to Losses of Agricultural Chemicals: Interactions of Chemistry, Hydrology and Land-Use. Environ Sci Technol, 34: 3315-3322.

Bubb K & Barnes C (2000) Results from a Nation-wide Study on the Risk of Atrazine Contamination to Surface Water and Groundwater Resulting from Routine Application by Australian Forest Growers. Forest Herbicide Management Group. Draft report dated May 2000 to the NRA.

CCREM (1989) Canadian Water Quality Guidelines, Appendix V. Canadian Council of Resource and Environment Ministers, September 1989.

Cooper B (1995) Central and North West Regions Water Quality Program, 1994/95 Report on Pesticides Monitoring. TS95.087 Water Quality Unit, Department of Land and Water Conservation NSW.

Cooper B (1996) Central and North West Regions Water Quality Program, 1995/96 Report on Pesticides Monitoring. TS96.048 Water Quality Services Unit, Department of Land and Water Conservation NSW.

Eksteen, D (2000) Report on Atrazine Monitoring in Western Australia. Agriculture Western Australia.

Fawcett RS (1998) The Role of Best Management Practices in Reducing Triazine Runoff. In: Ballantine LG, McFarland JE & Hackett DS (Eds) Triazine Herbicides: Risk Assessment. Americal Chemical Society, Washington DC. Oxford University Press.

Giddings JM & Hall LW (1998) The Aquatic Ecotoxicology of Triazine Herbicides. In: Ballantine LG, McFarland JE & Hackett DS (Eds) Triazine Herbicides: Risk Assessment. American Chemical Society, Washington DC. Oxford University Press.

Gilliom RJ, Alley WM & Gurtz ME, Design of the National Water-Quality Assessment Program: Occurrence and Distribution of Water-Quality Conditions. USGS Circular 1112.

Girling AE, Tattersfield L, Mitchell GC, Crossland NO, Pascoe D, Blockwell SJ, Maund SJ, Tayloer EJ, Wenzel A, Janssen CR & Jüttner I (2000) Derivation of Predicted No-Effect Concentrations for Lindane, 3,4-Dichloroaniline, Atrazine and Copper. Ecotoxicology and Environmental Safety, 46: 148-162.

Goolsby DA & Pereira WE (1995) Pesticides in the Mississippi River. In: Meade RH (Ed) Contaminants in the Mississippi River. USGS Circular 1133, Reston, Virginia, 1995.

NRA DRAFT

Gruessner, B & Watzin, MC (1996) Response of Aquatic Communities from a Vermont Stream to Environmentally Realistic Atrazine Exposure in Laboratory Microcosms. Environ Toxicol Chem, 15: 410-419.

Hollywell, 2001 Department of Natural Resources and Energy, VIC, Letter to the NRA, 13 February 2001.

Huber, W (1993) Ecotoxicological Relevance of Atrazine in Aquatic Systems. Environ Toxicol Chem, 12: 1865-1881.

Michael JL & Neary DG (1993) Herbicide Dissipation Studies in Southern Forest Ecosystems. Environmental Toxicology and Chemistry, 12: 405-410.

Muschal M (1997) Central and North West Regions Water Quality Program, 1996/97 Report on Pesticides Monitoring. CNR97.063 Ecosystem Management, Department of Land and Water Conservation NSW.

Muschal M (1998) Central and North West Regions Water Quality Program, 1997/98 Report on Pesticides Monitoring. CNR98.038 Ecosystem Management, Department of Land and Water Conservation NSW.

Muschal M (2000) Central and North West Regions Water Quality Program, 1998/99 Report on Pesticides Monitoring. CNR2000.004 Ecosystem Management, Department of Land and Water Conservation NSW.

NH&MRC (1996) Australian Drinking Water Guidelines, National Health and Medical Research Council/Agricultural and Resource Management Council of Australia and New Zealand.

Peirson WL, Acworth RI, Timms W & Dorairaj S (1999) Preliminary Assessment of the Transport and Fate of Atrazine on the Liverpool Plains. WRL Technical Report 99/13 dated November 1999, University of New South Wales Water Research Laboratory.

Simpson B (2001) Atrazine Monitoring Program, Atherton Tablelands, North Queensland. Department of Natural Resources, Queensland.

Solomon KR, Baker DB, Richards RP, Dixon KR, Klaine SJ, La Point TW, Kendall RJ, Weisskopf CP, Giddings JM, Giesy JP, Hall LW Jr & Williams WM (1996) Ecological Risk Assessment of Atrazine in North American Surface Waters. Environ Toxicol Chem, 15: 31-76.

Streit L, (1999) Monitoring for Atrazine in Ground and Surface Water – Progress Report December 1999. Novartis Crop Protection Australasia P/L

Stubbs P & Eksteen D (1999) Final Preliminary Report on Atrazine Monitoring in Western Australia. Moora District Office, Agriculture Western Australia, Moora, Western Australia.

Not to be used for commercial or registration purposes without the consent of the owner of the cited information.

NRA DRAFT

US EPA (2000) Status of Chemicals in Special Review. EPA-738-R-00-001 dated March 2000, Office of Prevention, Pesticides and Toxic Substances.

USGS (1998) Herbicides in Midwestern Reservoir Outflows, 1992-93. USGS Fact Sheet 134-98, December 1998

USGS (1999a) The Quality of Our Nation's Waters - Nutrients and Pesticides. USGS Circular 1225, Reston, Virginia.

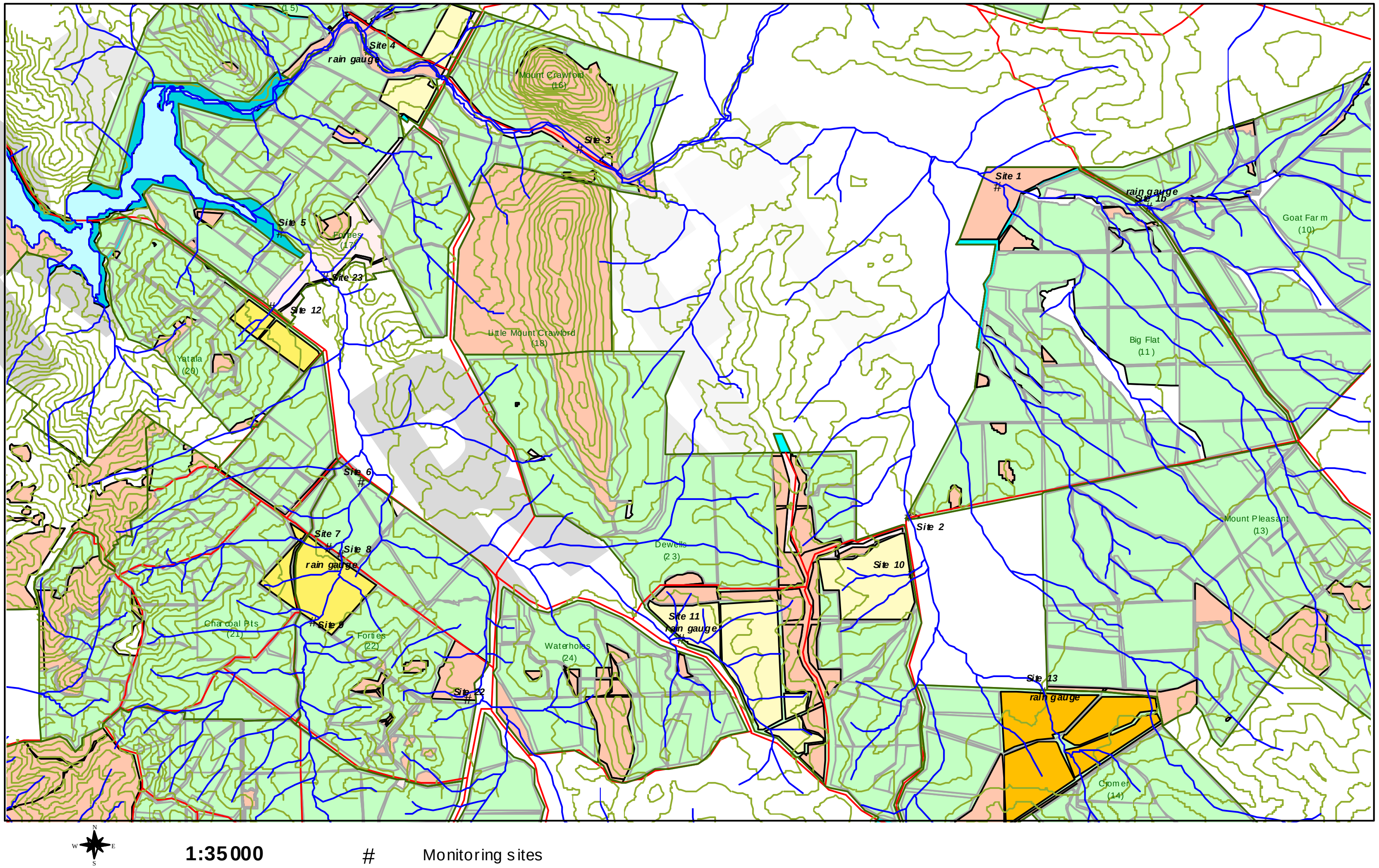
USGS (1999b) Discharge of Herbicides From the Mississippi River Basin to the Gulf of Mexico, 1991-97. USGS Fact Sheet 163-98, April 1999.

NRA DRAFT

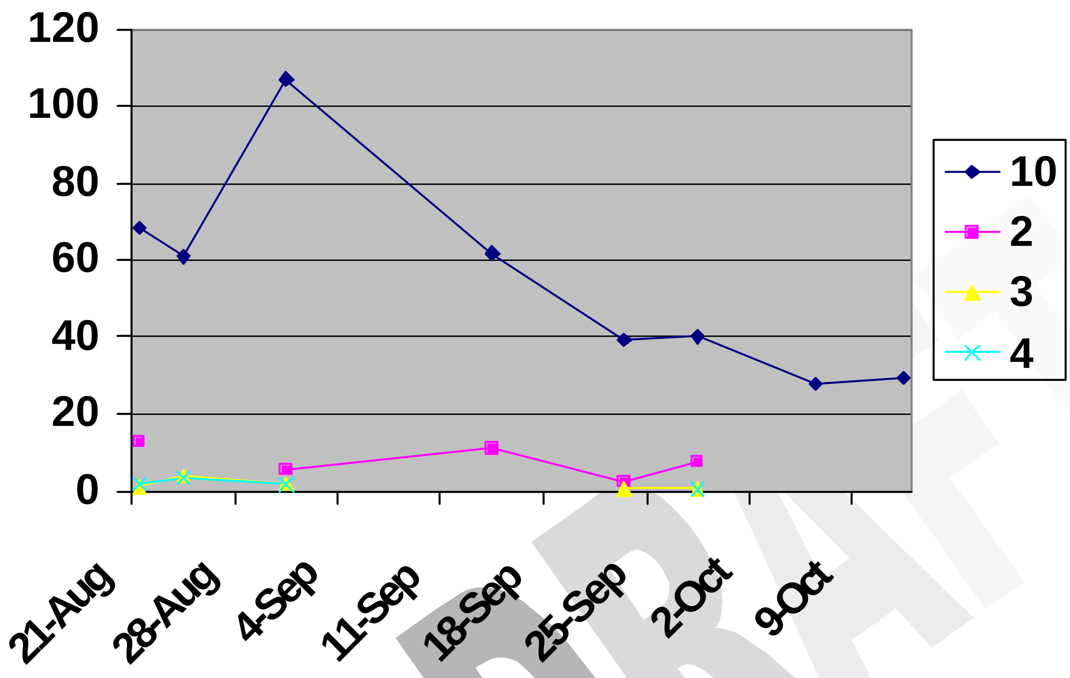
Attachment A – Water Monitoring Sites

Green areas are *Pinus radiata* plantation, with 1997 plantings represented as pale yellow and 1998 plantings as yellow. Orange areas were planted in 1999 but treated with Trounce (glyphosate/metsulfuron) rather than atrazine/hexazinone, following a directive from the SA EPA. Brown areas are native forest under ForestrySA control, while areas around reservoirs are native forest under SAWater control.

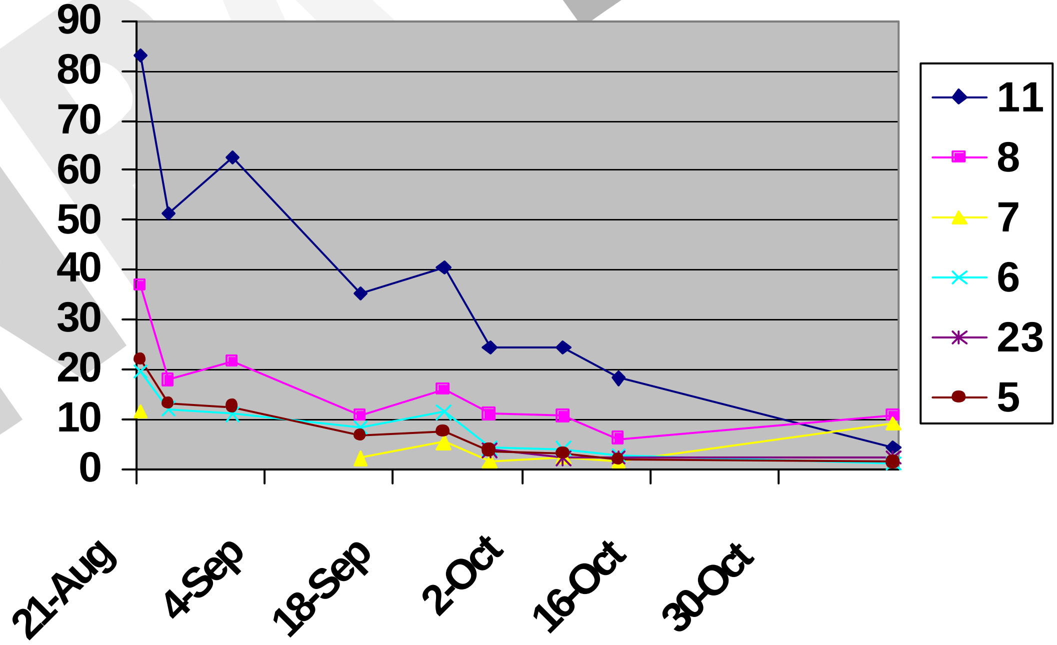
Water Monitoring Sites - Mt Crawford Forest



Attachment B – Atrazine Monitoring data



Atrazine concentrations in South Para catchment during spring 1998.



Atrazine concentrations in Waterholes Creek catchment during spring 1998.

NRA DRAFT