Aggregated Nutrient Emissions to the Murray-Darling Basin

Prepared for the

National Pollutant Inventory

Environment Australia

by

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Contents

About this report i
Acknowledgments i
Study team i
Disclaimer i
Contents iii
Abbreviations iv

1. Introduction 1

2. Description of the Problem 2
2.1 Scope 3
2.2 Issues 4

3. Estimating aggregate emissions of TN and TP 5
3.1 Generalised Structure of the Approach 5

4. Characteristics of Existing Land Use Data 7
4.1 Issues with Existing Land Use Data 7

5. Methodology 9
5.1 The Basis of the Adopted Approach 9
5.2 Definition of Catchments for Estimation Purposes 10
5.3 Land Use Mapping 15
5.4 The NLWRA 1:1 Million Digital Land Use Data Set 15
5.5 Defining the Set of Land Uses 17
5.6 Nutrient-Generation Rates for Land Uses 20
5.7 Environmental and Management Factors Modifying Nutrient Emissions 22
5.8 Sub-Threshold Nutrient Point Sources 28

6. Results 29
6.1 Land Use in the MDB Catchment Regions 29
6.2 Diffuse Nutrient Emissions 32
6.3 Sub-Threshold Nutrient Point Source Loads 36
6.4 Aggregated Nutrient Emissions 40

7. Conclusions 43
7.1 Basis of the Study 43

7.2 Data and Approach for Diffuse Sources 43
7.3 Data and Approach for Sub-Threshold Point Sources 45
7.4 Aggregated Nutrient Emissions 46
7.5 Reliability of the Estimates 47

8. Bibliography 49

Appendix 1: Existing Land Use, CMSS and Related Information for Catchments 53

Appendix 2: Detailed Land Use Breakdown by Catchment Region 59

Appendix 3.1: Breakdown of Diffuse Total-Phosphorus Loads by Land Use and Catchment 102

Appendix 3.2: Breakdown of Diffuse Total-Nitrogen Loads by Land Use and Catchment 103

Appendix 4: Total and Sub-Threshold Nutrient Point Sources for each Catchment 104

Appendix 5: Summary of Annual Diffuse, Sub-Threshold and Aggregated Nutrient Emissions by Catchment 118

Abbreviations

ACT	Australian Capital Territory
AEAM	Adapative Environmental Assessment and Management (model)
ANU	Australian National University
AVHRR	Advanced Very High Resolution Radiometer
AWRC	Australian Water Resources Council
BRS	Bureau of Rural Sciences (formerly Bureau of Resource Science)
CAPAD97	The Collaborative Australian Protected Areas Dataset-1997
CMA	Catchment Management Authority
CMC	Catchment Management Committee
CMR	Catchment Management Region
CMSS	Catchment Management Support System
CREAMS	Chemical Runoff and Erosion from Agricultural Management Systems
CRES	Centre for Resource and Environmental Studies
CSIRO L&W	CSIRO Land and Water
DCNR	Department of Conservation and Natural Resources (Vic, now DNRE)
DEHAA	Department of Environment, Heritage and Aboriginal Affairs (SA)
DNR	Department of Natural Resources (Qld)
DLWC	Department of Land and Water Conservation (NSW)
DNRE	Department of Natural Resources and the Environment (Vic)
EA	Environment Australia
ERIN	Environmental Resources Information Network
GIS	Geographical Information System
IWG	Implementation Working Group
LU	Land Use
LWRRDC	Land and Water Resources Research and Development Corporation
MDB	Murray-Darling Basin
MDBC	Murray-Darling Basin Commission
MDBMC	Murray-Darling Basin Ministerial Council
MULU	Mapping Units-Land UIse
NDVI	Normalized Difference Vegetation Index (remote sensing)
NEPC	National Environment Protection Council
NFI	National Forest Inventory
NLWRA	National Land and Water Resources Audit
NPI	National Pollutant Inventory
SA EPA	South Australia Environment Protection Agency

SKM	Sinclair Knight Merz
STED	Septic Tank Effluent Disposal (scheme)
STP	Sewage treatment plant
SWMM	Storm Water Management Model
TCM	Total Catchment Management
TN	Total Nitrogen
TP	Total Phosphorus
WinCMSS	Windows based Catchment Management Support System
WWW	World Wide Web

1. Introduction

The National Pollutant Inventory (NPI) is an Internet database on the types and amounts of pollutants being emitted to the air, land and water. More specifically the NPI has objectives to:

- Provide communities with access to consistent and reliable information about pollution emissions and sources to Australia's land, water and atmospheric environments.
- Assist governments with environmental planning, management and policy development.
- Assist industry and the community in becoming aware of the activities that lead to pollution, and to identify activities which could result in reduced emissions.

Information on pollutant sources for the NPI is principally determined in two different ways:

1. From facilities which are required to report — essentially 'Major' pollutant point sources.
2. Aggregated emissions data — which consist of 'Minor' pollutant point sources and diffuse sources of pollutants such as from agricultural land.

Two pollutants — total phosphorus (TP) and total nitrogen (TN) — that are significant in aquatic environments are included on the NPI reporting list. The surface waters of the Murray-Darling Basin (MDB) - Australia's 'breadbasket' - have exhibited toxic blue-green algal blooms that in part are symptomatic of excessive levels of these substances (MDBMC, 1994). The MDB's selection as a priority catchment by the NPI for evaluating TN and TP emissions is in part because of its agricultural importance and environmental susceptibility, as well as the availability of relevant data.

The object of this report is to compile an inventory of aggregated TN and TP emissions in the MDB catchment, excluding those point sources that are required to report directly to the NPI. More specifically it will include a description of the approach and techniques that can, as much as possible, be consistently and appropriately applied across the MDB and elsewhere to estimate aggregated TP and TN emissions. This would form a generic 'Methods Manual' for the determination of nutrient emissions for other large catchments.

2. Description of the Problem

The accurate determination of the amounts of pollutant emissions from diffuse sources in catchments is difficult and resource hungry, as pollutant concentrations vary dramatically with water flow. Consequently, for example, determining annual diffuse emissions of phosphorus (or nitrogen) from a catchment requires a detailed knowledge of phosphorus concentrations in runoff in relation to flow — not just over one runoff event, but many runoff events. In some catchments such detailed information has enabled the development of water quality models such as AQUALM for the Upper Murrumbidgee including the Australian Capital Territory (ACT). In most catchments there is insufficient information available to enable the development of such models for nutrient emissions or exports.

Experience of small catchment studies from many countries, including Australia, has found, however, that the more intensive the land use in a catchment, the greater the export of nutrients. Furthermore, collation of information for such studies found similar ranges of annual nutrient exports for land uses even though these came from widely different geographic regions. This is because a specific land use tends to integrate a range of factors such as slope, soil/geology type, rainfall, land management etc. What this has meant is that long-term annual nutrient emissions could be estimated from catchment land use information coupled with generic land-use nutrient-export coefficients.

Increasing information on other factors influencing land use nutrient exports, such as proximity to streams or land management practices, have resulted in the development of simple models such as WinCMSS (Windows based Catchment Management Support System) that enable estimates of annual diffuse nutrient exports. There are limitations to the use of the WinCMSS approach, however. The land use-nutrient export relationship is affected by scale, and consequently the use of models such as WinCMSS has been restricted to smaller catchments. In larger catchments in-stream nutrient processes such sedimentation, assimilation and stream bank erosion begin to dominate over catchment sources. Furthermore, abstraction of water for consumptive purposes also greatly modifies nutrient loads. Consequently for such larger catchments care needs to be taken in selecting nutrient export coefficients approaches to determining TN and TP emissions.

Another limitation is that export data generated by many models, including WinCMSS, generally represent longer-term, average annual emissions. This has to be taken into account when using the data to assess changes over shorter periods of time. For example, considerable care has to be taken in environments where climatic extremes — say flood and drought — are frequent occurrences.

2.1 Scope

The scope of work to estimate aggregate nutrient emissions in the Murray-Darling Basin has been defined in discussions between the study team and Environment Australia. These discussions have resulted in the following clarifications that further define the scope of the project:

- The study will essentially be based on the use of WinCMSS, with alternative methods for estimating nutrient emissions only considered where WinCMSS cannot give meaningful results.
- Alternative methods would only be employed to provide basic estimates of nutrient emissions — determining detailed nutrient export figures from flow and nutrient concentrations for a subcatchment is a major time-consuming and complex project in itself.
- For the same reason as indicated above, it will not be possible to undertake verification of estimates of nutrient emissions from sub-catchments against real data, although there will be a level of reality checking to ensure estimates are in the right range.
- The study will restrict itself to estimating primary nutrient emissions from the land into the drainage network at the agreed subcatchment level. It will not try to model the movement or transformation of nutrients either across the landscape or down the streams and rivers of the Basin.
- Sub-catchments will, as much as possible be based on the Australian Water Resources Council (AWRC) standard drainage basin subdivision network.
- Land use categories will be determined on the basis of practicality, availability of information, as well as consistency — between States and Territories and with other organisations such as the National Land and Water Resources Audit (NLWRA). It is suggested that primary land use subdivision is likely to be in the order of around six types. Apart from the usual categories of land use in such studies there will be an additional category particularly for this study, called 'sub-threshold' point sources. This will be designed to accommodate the particular reporting thresholds for the NPI (and to prevent double counting of 'sub-threshold' point sources).
- The study is required to meet ERIN's (Environmental Resources Information Network) ArcInfo requirements for geographical information. However, it is acknowledged that the study is reliant on the provision of land use and other information from third parties. Consequently, the study team will only be able to use and pass on information with the level of detail provided to it.
- The study will attempt to incorporate linear nutrient inputs from gully and streambank erosion where this is likely to be important and information is available.
- The study will not generate new subcatchment land use or other related data or new land use nutrient emission rates — it will only use or manipulate existing information.

- The study will not deal with airborne nutrients, although it will flag this as an issue for future consideration, and will seek to provide some indicative figures.
- Ammonia will be treated as part of total nitrogen only.
- Nutrient emission rates will be determined as a composite figure in kilograms of TP or TN per hectare per year ($kg.ha^{-1}.yr^{-1}$), for each subcatchment. Underlying this information will be the percentage land uses for the subcatchment area, and the nutrient export figures used for these land uses.

2.2 Issues

Various issues were addressed in this study, such as:

- How wide a range of land use types will be used to describe catchments (for example, agricultural lands could be separated into pasture, broad-acre crops, tree plantations watered naturally or by recycled water, animal feedlots, aquaculture, and horticulture; noting that these can be further sub-divided).
- Compatibility of different techniques that may have been used by others to estimate nutrient exports from catchments in the Murray-Darling Basin.
- The benefits of also applying models such as WinCMSS to catchments where extensive data sets ('data rich' catchments) are available.
- Comparison of more sophisticated models and direct estimation from detailed data sets, where such data sets are available they may be considered for 'reality checking' purposes.
- How to estimate the reliability of the various methods to be used.
- In consultation with local jurisdictions, the development of guidelines for selecting sub-catchments that are considered as major contributors to water pollution.
- Selected sub-catchments recognised as major contributors to water pollution may need to be assessed by additional direct methods other than WinCMSS, either because of its limitations or because its use could be inappropriate.
- A problem is that emission estimates using such alternative methods are likely to include point sources which are reporting facilities. These will unfortunately not be able to be separated out from such estimates, as emissions in aquatic environments are not simply additive.
- It is important for users of the database to be aware of how current the information is, as users will want information to be as up-to-date as possible. As it is very unlikely that data for the whole of a large catchment such as the MDB would be updated simultaneously, or even regularly, it will be essential to date tag all primary and calculated data and make this information readily accessible to users.

3. Estimating aggregate emissions of TN and TP

3.1 Generalised Structure of the Approach

The methodology comprises an essentially linear approach, although it incorporates the potential for reiteration if 'reality checks' indicate that estimates are outside of a range considered to be reasonable. The process is generic and comparatively simple, and does not have to be undertaken in WinCMSS, but can be undertaken using a GIS. While WinCMSS can undertake some of the mechanical calculations automatically, it does necessitate digitised map information to be transferred from the GIS to the program.

The sequential steps in the process to determine aggregated emissions for a catchment are provided below. The key steps in the process are also indicated in Figure 1. It assumes that the land use data is NLWRA digital data according the Baxter and Russell (1994) classification.

- Determine whether the NLWRA 1:1 million digital land use data set (based on 1km^2 pixels) is an appropriate scale for the size of the catchment, or whether a more detailed NLWRA or alternative land use data set is available and more suitable for the catchment.
- Identify major sub-catchments or regions.
- Obtain catchment shapefiles (boundaries in digital – GIS - format).
- Use GIS to determine the land uses for each sub-catchment from the digitised data set.
- Determine the (broad) aggregated land use classes to be used for determining nutrient emissions - few is best.
- Attribute the Baxter-Russell land uses into the aggregated land use classes for nutrient emission determination.
- Determine the typical nutrient emission rates for each NPI land use class.
- Modify these nutrient emission rates on the basis of appropriate local research where appropriate.
- Assess the key environmental and management factors at the sub-catchment scale that may influence nutrient emissions.
- Determine the modification classes – such as geology, runoff etc. - for those factors for which there are catchment-wide digital data.
- Determine the modification factors that will be applied to the nutrient emission rates for each NPI land use class – note that phosphorus and nitrogen may not be treated the same.
- Determine the area of land uses - broken down by modification factors - for each sub-catchment region.

- Derive the nutrient emission loads for each land use in each sub-catchment, using the modified nutrient emission rates.
- Determine all nutrient point sources for each sub-catchment.
- Determine the annual nitrogen and phosphorus loads for each point source.
- Determine which of the nutrient point sources – phosphorus and/or nitrogen - are sub-threshold, and not required to be reported directly to the NPI.
- Sum the annual phosphorus and nitrogen loads for sub-threshold point sources for each sub-catchment.
- Total up all diffuse and sub-threshold phosphorus and nitrogen loads for each sub-catchment.
- Provide the data to the NPI in accordance with the current version of the NPI Data Transfer Protocol (available from ERIN).

4. Characteristics of Existing Land Use Data

4.1 Issues with Existing Land Use Data

Atech Group was commissioned by the NPI to use a WinCMSS approach to determine aggregated nutrient emissions for the Murray-Darling Basin. Since the WinCMSS approach involves the use of catchment land use to determine nutrient emissions, a review of the land use data available for the MDB was undertaken. This involved exploring the availability and nature of such information through the State, Murray-Darling Basin Commission (MDBC) GIS agencies and other sources, as well as that in previous Windows or DOS Catchment Management Support System (CMSS) studies.

The review of the available land use and related data - undertaken prior to Environment Australia's decision to use NLWRA land use data - revealed that:

- Land use information is held by state agency GIS units in head offices, often in regional GIS centres and sometimes in local agency or catchment management group offices – there is often no central group that has or is aware of all relevant land use data.
- There is incomplete coverage of land use information in the Murray-Darling Basin – and there is almost no land use information available for the western half of the Basin.
- Where land use information is available it is generally a mosaic of material produced for different purposes, and of different origin and character.
- A large-scale digital vegetation cover data set is available for much of the Murray-Darling Basin, however this is unsuitable and incomplete for use in a WinCMSS study.
- The available land use data for different parts of the Basin is of different ages, sometimes of mixed age, and sometimes of indeterminate age.
- The available land use data is of different origin - most from satellite imagery, but some from aerial photographs – some land use figures have been used that can no longer be linked to their original source.
- The available land use data has different levels of resolution – some highly detailed, some very coarse, reflecting different intended uses or purpose.
- The land use categories used in different studies and states are inconsistent – jurisdictional and management categories are often used interchangeably with land use - making interpretation difficult for CMSS.
- Different interpretation means that land uses often change (or appear to) at State boundaries, and sometimes with single studies – e.g. the Murrumbidgee CMSS.
- Agency reorganisation, staff changes and other factors mean that information on CMSS files, reports and the origin of land use and other data is lost in the system.

- Most GIS units will provide digitised information for a fee.

Appendix 1 provides a brief catchment by catchment overview of data availability.

5. Methodology

5.1 The Basis of the Adopted Approach

The proposed approach is to estimate aggregate emissions of nutrients on a catchment by catchment basis. A number of models have been developed to make such estimates.

For point sources the techniques are straightforward and generally take the form of determining the nutrient load in facility effluent streams. For example, by analysing effluent samples for nutrient concentration, multiplying this by the rate of flow at the time the samples were taken and then pro-rating these results to the total annual flow.

For emissions from non-point or diffuse sources, the techniques are more complicated because flow volume, flow rate and nutrient concentration varies enormously with respect to time. Water and nutrient runoff can range from nothing during drought to extremely high volumes and rates during major floods. The nutrient generation rate per hectare also varies significantly between different land uses as well as a range of other factors such as slope, geology etc. Models for estimating diffuse emissions range from simple approximations that consider only one or two parameters (e.g. land use and management régime) to complex models that take account of variations in many factors such as rainfall; infiltration; groundwater movements; evapotranspiration; and, pollutant accumulation; washoff; and transformation. An example of the simpler models is WinCMSS. At the extreme of the more complicated models is the US developed CREAMS (Chemical Runoff and Erosion from Agricultural Management Systems). Models such as AQUALM and SWMM (Storm Water Management Model) fall between the simple and complex (Hyman, 1999).

As a rule, the more sophisticated and complex a model is, the more information it requires for its use, and the less it is able to be applied generically. Many of these models are in any case developed for small catchments. The cost and effort to use such models on a large scale is also prohibitive. See a detailed review of relevant erosion and sediment-nutrient runoff models in Letcher *et al*. (1999).

This study uses the simple land use-nutrient export approach of the WinCMSS model. It will not actually use WinCMSS as the same procedure can be carried out more simply using a GIS. The main reason for adopting such a simple model is that it does not demand large amounts of detailed information that more complex models require. Such data is simply unavailable for the 1 million square kilometres of the Murray-Darling Basin, and for the current development stage of the NPI it is important to use a consistent technique for the whole Basin. In any case, the level of precision associated with nutrient emissions using a WinCMSS approach is adequate and appropriate for the NPI.

The use of WinCMSS for nutrient runoff estimation relies on observations that:

- land use is largely a reflection of a range of environmental parameters such as rainfall, soil type and topography; and
- nutrient emissions for a particular land use are similar despite different locations.

Thus for the determination of nutrient runoff, knowing the land uses of a catchment means that the need for collecting detailed information on these characteristics is avoided. The WinCMSS approach does, however, require information on generic or local, nutrient emission rates for each land use category. Additional catchment information on land management practices, geology, slope or runoff etc. enables a more refined estimate of aggregated nutrient emissions to be made.

Besides these diffuse nutrient sources, small point nutrient sources that fall outside the NPI's criteria of reportable point sources also need to be calculated separately, and added to the diffuse sources for determining aggregated nutrient emissions for a catchment.

In general, the WinCMSS approach requires:

- Identification of the major catchments and sub-catchment divisions in the Murray-Darling Basin.
- Identification of the principal land use types within each subcatchment.
- Determination of the area of each type of land use within each subcatchment.
- The determination of nutrient generation rates for each of these types of land use.
- The modification of nutrient generation rates in light of geology, slope, rainfall or other factors.

The spatial data requirements are:

- A digitised map of the major catchment and sub-catchment boundaries.
- A digitised map of land uses within each subcatchment (to enable estimates of the area of each land use within each subcatchment).

GIS software such as ArcView can be used to manipulate and transfer spatial data to, or be used with Excel or Access in place of WinCMSS.

5.2 Definition of Catchments for Estimation Purposes

One of the first tasks to be undertaken was digital boundary mapping. This was necessary for collecting spatial data and providing coordinates so that the results calculated by the WinCMSS approach could be mapped. For the Murray-Darling Basin the task includes determining and digitally mapping the major catchment or catchment region boundaries.

5.2.1 Major Catchment Regions

In choosing catchments and boundaries for the Murray-Darling Basin NPI aggregated nutrient study, Atech Group was faced with a choice of:

- hydrological boundaries as defined by the Australian Water Resources Council (AWRC 1987);

- Catchment Management Regions defined by the Murray-Darling Basin Commission;
- boundaries used by agency and catchment management groups in their CMSS or nutrient studies; and
- other variants of catchment and regional boundaries used by State and Commonwealth agencies and other organisations.

Of these the Murray-Darling Basin Commission's Catchment Management Regions (CMRs) reflect in part hydrological boundaries, but take into account state jurisdiction, as well as other intra-state management boundaries. The MDBC's CMR boundaries would seem to be appropriate for this NPI study, and are more regionally recognised than some of the hydrological catchments. This is not without problems, however, as the MDBC CMRs have fluctuated between 14 and 19 regions and with different regional boundaries. Thus the North West CMR in NSW has recently been split into the Namoi, Gwydir and Border Rivers Catchment Management Regions. On the other hand, the South Australian Murray-Darling CMR was a recent amalgamation of the dryland and riverine corridor regions.

Keeping in mind the NPI requirement that catchment regions should as much as possible reflect jurisdictional boundaries, it was decided to adopt the most recent of the MDBC's CMRs and boundaries with one minor change. The SA Murray-Darling Basin has been split into a dryland region and two 10 km wide riverine corridors either side of the River Murray and Lake Alexandrina north and south of Blanchtown. This change was undertaken to reflect the substantially dramatically different land uses and management practices and consequently nutrient emissions into the River Murray in these regions. There is a negligible drainage network in the dryland region of the SA MDB except for a small area in the south-west draining the Adelaide Hills.

This provided a total of 20 major catchments and regions for use in this NPI study. Table 5.1 below indicates the AWRC hydrological catchments, the MDBC CMRs, and the catchment regions adopted for this NPI study. The related catchments for these three approaches have, as much as possible, been aligned to enable comparison. The adopted catchment regions are illustrated in Figure 5.1.

The areas and percentages of Murray-Darling Basin catchment used for this study are shown in Table 5.2.

Some catchment regions, despite having identical names, showed significant discrepancies between digitised boundaries as produced and/or used by AUSLIG, the MDBC, and Department of Land and Water Conservation (DLWC) in their CMSS studies. This is particularly the case with the Lachlan, Murrumbidgee and Murray catchments, where at their lower extremity the hydrological boundaries are very poorly defined. The MDBC boundaries were used in such cases.

Table 5.1: A comparison of AWRC hydrological, MDBC Catchment Management Regions, and the catchment regions adopted for this NPI study (related catchments and regions have as much as possible been located in adjacent columns).

AWRC Hydrological Catchments	MDBC Catchment Management Regions	Catchment Regions used for the NPI
Macquarie-Bogan	Central West (NSW)	Central West Catchment (Macquarie, Castlereagh & Bogan rivers, NSW)
Castlereagh		
Lachlan	Lachlan (NSW)	Lachlan Catchment (NSW)
	Lower-Murray Darling (NSW)	Lower Murray-Darling Region, (NSW)
Benanee		
Murrumbidgee	Murrumbidgee (NSW)	Murrumbidgee Catchment (NSW)*
Lake George		
Murray Riverina	Murray (NSW)	Murray Catchment (NSW)
Border	Border Rivers (Qld)	Qld Border Rivers Catchment (Qld)
	Border Rivers (NSW)	NSW Border Rivers Catchment (NSW)
Gwydir	Gwydir (NSW)	Gwydir Catchment (NSW)
Namoi	Namoi	Namoi Catchment (NSW)
Darling	Western Region (NSW)	Western Region (NSW)
Condamine-Culgoa	Condamine (Qld)	Condamine-Balonne Catchment (Qld)
	Maranoa-Balonne (Qld)	
Moonie		
Warrego	Warrego-Paroo (Qld)	Warrego-Paroo Catchment (Qld)
Paroo		
Kiewa	North East (Vic)	North East Catchment (Kiewa, Mitta Mitta, Ovens & Murray catchments, Vic)
Ovens		
Upper Murray		
Goulburn	Goulburn-Broken (Vic)	Goulburn-Broken Catchment (Vic)
Broken		
Campaspe	North Central (Vic)	North Central Catchment (Campaspe, Loddon & Avoca rivers, Vic)
Loddon		
Avoca		
Mallee	Mallee (Vic)	Mallee Region (Vic)
Wimmera-Avon	Wimmera (Vic)	Wimmera Region (Vic)
Lower Murray	South Australian MDB (SA)	Dryland Region (SA)
		North Riverine Corridor (SA)
		South Riverine Corridor (SA)

*It should be noted that the ACT is wholly contained within the Murrumbidgee Catchment.

Figure 5.1: The Murray-Darling Basin catchment regions adopted for this NPI study.

Table 5.2: Areas and percentages of Murray-Darling Basin catchments used for this study.

Catchment Region	**Total area (km^2)**	**% of Basin**
Warrego-Paroo Catchment (Qld)	126,490	11.94
Condamine-Balonne Catchment (Qld)	96,040	9.06
Qld Border Rivers Catchment (Qld)	37,940	3.58
NSW Border Rivers Catchment (NSW)	24,160	2.28
Gwydir Catchment (NSW)	26,540	2.51
Namoi Catchment (NSW)	41,900	3.95
Western Region (NSW)	158,600	14.97
Central West Catchment (NSW)	91,990	8.62
Lachlan Catchment (NSW)	90,760	8.57
Murrumbidgee Catchment (NSW)	67,090	6.33

Catchment Region	**Total area (km^2)**	**% of Basin**
Lower Murray-Darling Region (NSW)	62,680	5.92
Murray Catchment (NSW)	35,890	3.39
North East Catchment (Vic)	20,100	1.90
Goulburn-Broken Catchment (Vic)	24,120	2.28
North Central Catchment (Vic)	25,730	2.43
Wimmera Region (Vic)	22,450	2.12
Mallee Region (Vic)	37,950	3.58
North Riverine Corridor (SA)	4,580	0.43
South Riverine Corridor-(SA)	5,800	0.55
Dryland Region (SA)	58,700	5.54
Murray-Darling Basin	**1,059,500 km^2**	**99.95%**

5.2.2 Sub-Catchment Regions

It was initially proposed to sub-divide most of the twenty large (4,600-158,000 km^2) catchment regions into smaller sub-catchment regions (equivalent to mapping units in WinCMSS) for the determination of nutrient emissions. It was thought that this step would be appropriate for greater precision in the determination of nutrient emissions for areas of similar climate, rainfall, slope and other characteristics. It was also felt that such sub-catchment regions, if appropriately selected, could be more meaningful to local communities.

Considerable difficulties were faced determining sub-catchment regions, and obtaining digitised boundaries. It was impossible to obtain sub-catchment regions that were consistent or comparable across states and catchment regions. Different states and agencies use different regional and local boundaries for different purposes. For example the DLWC defined a limited number of sub-catchment regions for selected NSW catchments for use in CMSS studies. Currently some DLWC staff proposed that the Stressed Rivers boundaries - which are at least order of ten smaller - should be employed for this study. Other regions, however, such as the Western Region in NSW or the Dryland Region of SA, are flat, arid and largely without a drainage network, and have no logical boundaries.

On reflection it was decided that no benefit would be obtained for the use of sub-catchment regions. This was in part because at the scale of the Murray-Darling Basin it was not possible to provide the level of additional detail necessary for all sub-catchment regions. It was also because additional modifying factors (e.g. runoff and geology) were uniformly applied across the Basin. Any additional modifying factors relating to nutrient emission rates were applied uniformly at the catchment level.

Consequently aggregated nutrient emissions were determined on the 20 identified catchments regions of the Murray-Darling Basin.

5.3 Land Use Mapping

Atech Group - as part of this project - was requested to develop a consistent approach to the determination of aggregated nutrient emissions in the Murray-Darling Basin. However the subsequent unavailability, unsuitability, unreliability and variable land use information - which forms the very basis of the WinCMSS approach to determining diffuse nutrient exports - made it impossible for Atech Group to develop such an approach. Consequently the NPI agreed that the Atech Group should use the soon to be completed Australia-wide 1:1 million land use data set being developed by the Bureau of Rural Sciences (BRS) for the NLWRA. This uniform Basin-wide data set collected by a consistent methodology and essentially at a single point in time, means that consistent land use classification is possible for all catchment regions.

The land use information used for this project is based on the digitised land use data set (Interim Version 2) currently being developed by the BRS for the NLWRA. This project has created a land use map of most of Australia at approximately 1 km^2 pixel resolution for the year April 1996-March 1997. The non-agricultural land uses and the distribution of agricultural land was determined by overlaying raster versions of four existing data sets. Specific agricultural land uses are interpretive and were allocated by automated analysis of the Normalized Difference Vegetation Index (NDVI) images.

The final land use classification follows the modified Baxter and Russell classification (1994), that has been agreed to by all the states and Commonwealth. It is a hierarchical land use classification that enables easy aggregation of land-use categories which is necessary and appropriate for the WinCMSS approach.

5.4 The NLWRA 1:1 Million Digital Land Use Data Set

This data set is a digitised land use map of Australia showing both agricultural and non-agricultural land uses. Input data have been selected so that, as nearly as possible, the map shows land use for the year 1/4/96 to 31/3/97. The map is an interim product of the NLWRA National Land Use Mapping Project. It is a categorical raster data set with geographical coordinates referred to the datum WGS84. The cell size is 0.01 degrees and the nominal scale is 1:1,000,000. The non-agricultural land uses and the distribution of agricultural land was determined by overlaying raster versions of four existing data sets. Specific agricultural land uses are interpretive and were allocated by automated analysis of NDVI images. The final land use classification follows the modified Baxter and Russell classification – see http://www.brs.gov.au/land&water/landuse/class.html - and is given in a lookup table. However, the attribute table accompanying the data set retains the attributes of the underlying data so that the user can adopt an alternative land use classification. The map may be of use to researchers and policy makers in need of national or regional-scale land use data.

5.4.1 Lineage

Non-agricultural land uses and the distribution of agricultural land were determined by overlaying raster versions of four existing data sets:

- The 1997 Collaborative Australian Protected Areas Dataset at 1:250,000 scale (CAPAD97).
- The 1997 BRS National Forest Inventory (NFI) tenure 250 m raster data set.
- The 1997 NFI combined native and plantation forestry 250 m raster data set.
- A February 1999 update of the Australian Surveying and Land Information Group 1:250,000 scale topographic data set, TOPO-250K (Version 1).

Minor modifications were made to both the NFI tenure data set and the NFI forestry data set. Line and point features in TOPO-250K were buffered prior to conversion to raster format. Specific agricultural land uses were allocated using a method called SPREAD (Walker and Mallawaarachchi 1998). The SPREAD program, written by compleXia Pty Ltd, Canberra, requires three inputs all relating to a particular time period (1/4/96 to 31/3/97 in this instance), namely:

- a time sequence of NDVI images (captured by the Australian Centre for Remote Sensing and processed by CSIRO Division of Marine Research, Hobart and ERIN);
- a set of control sites - known locations and known agricultural land use (collected by state and territory agriculture departments); and
- agricultural census data - reported on small regions and giving the area of each region devoted to each relevant agricultural land use (from the Australian Bureau of Statistics' AgStats database).

The final land use classification follows the modified Baxter and Russell classification and is given in a lookup table. See e.g.:

- http://www.brs.gov.au/land&water/landuse/landuse.html
- http://www.brs.gov.au/land&water/landuse/class.html

5.4.2 Positional Accuracy

Non-agricultural land uses and the distribution of agricultural land is based on four existing data sets. Of these, two are vector data sets derived from source material at 1:250,000 scale or smaller, and two are 250 m raster data sets derived from variable scale source material, largely 1:250,000 scale or smaller. Subdivision of agricultural land into specific agricultural land uses is based on automated analysis of composited, georeferenced and rectified AVHRR (Advanced Very High Resolution Radiometer) satellite imagery with geographic coordinates and 0.01 degree-pixels. The final land use data set was produced in raster format with geographical coordinates and 0.01-degree (approximately 1 km) cell size. The horizontal positional accuracy of the final data set for boundaries between different non-agricultural land uses and between non-agricultural and agricultural land use is therefore approximately 500 m. The horizontal positional accuracy of the final data set for boundaries between different agricultural land uses is likely to be larger than 500 m due to errors introduced by the georeferencing and rectification of the satellite images.

5.4.3 Attribute Accuracy

Non-agricultural land uses were assigned, initially, on the basis of existing data sets showing protected areas, tenure, forest type and topographic features. Specific agricultural land uses were then assigned by automated interpretation of NDVI images. Accuracy of assignments based on existing data sets depends mainly on the attribute accuracy of the underlying data sets but also on the validity of the rules used for land use assignment. The attribute accuracy of the underlying data sets has not been tested except for the topographic features data set (TOPO-250K, Version 1), for which the range of allowable attribute errors is from 0.5% to 5% at a 99% confidence level. However, the attribute accuracies of the other three underlying data sets are expected to be high, with consequent high accuracy in initial land use assignments. The accuracy of the specific agricultural land use assignments based on automated interpretation of NDVI images is likely to be variable, ranging from low to high, but has also not been tested. The final version of the data set, however, will include computer-generated measures of the accuracy of these specific agricultural land use assignments.

5.4.4 Logical Consistency and Completeness

Assignment of land uses based on the four underlying data sets was done with the aid of a macro. The attribute combination corresponding to each land use assignment was tested by inspection to verify that land use assignments were as intended.

Coverage and classification are complete. No validation of spatial and attribute data has yet been undertaken for Interim Version 2.

5.5 Defining the Set of Land Uses

The following general factors will be considered when defining land use types for this NPI nutrient emissions project. Land use type definitions will be:

- representative of actual land uses in the catchment or sub-catchment region;
- may involve aggregation with another land use where the extent of land use is minor;
- comparatively few and broadly defined to match the availability and precision of data, including particularly nutrient emission data;
- as much as possible be comparable to those used in past CMSS or related nutrient emission studies; and
- exclusive of ‘sub-threshold’ point sources - i.e. those point source facilities that are below the NPI reporting threshold.

While the Baxter-Russell land use classification forms the basis of the land use subdivision for this study, only a simplified and aggregated subset of its categories have been adopted.

Adopted land use categories will be further modified to reflect other environmental or management characteristics such as geology, runoff etc. (see later).

5.5.1 The Baxter and Russell Land Use Classification

The modified Baxter and Russell (1994) classification for land use that forms the basis for this study is provided in Table 5.3 below.

Table 5.3: The hierarchical Baxter and Russell land use classification. Note the **BOLD TEXT** is the Level 1 land use descriptor, the 4th column is the land use category adopted for this NPI study.

Land use Descriptor-2	Land use Descriptor-3	Land use Descriptor-4	NPI Adopted Land use Category
CONSERVATION LAND USES			
Strict nature reserve			Woodland/forest/forestry
Wilderness area			Woodland/forest/forestry
National park			Woodland/forest/forestry
National monument			Woodland/forest/forestry
Habitat/species management area			Woodland/forest/forestry
Managed resource protected area			Woodland/forest/forestry
Unmanaged land	Vacant crown land		Woodland/forest/forestry
Unmanaged land	Defence land		Woodland/forest/forestry
Water	Lakes		Water/wetlands
Water	Rivers		Water/wetlands
Water	Wetlands		Water/wetlands
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS			
Grazing of native pastures	Residual/Native pastures		Unimproved pasture
Production forests			Woodland/forest/forestry
Production forests	Commercial native forest production	Woodland/forest/forestry	
INTENSIVE LAND USES			
Urban uses			Urban
Institutional uses			Urban
Utilities	Water storage		Water/wetlands
Transport	Airports		Urban
PRIMARY PRODUCTION LAND USES			
Agricultural land	Unallocated agricultural land		Unimproved pasture
Plantation	Plantation forest production		Woodland/forest/forestry
Grazing improved & fertilised pastures	Pastures		Improved pasture
Farm forestry	Agroforestry		Woodland/forest/forestry
Permanent cropping	Cereals	Cereals excluding rice	Cropping
Permanent cropping	Cereals	Rice	Cropping
Permanent cropping	Hay and silage	Non-cereal forage crops	Cropping
Permanent cropping	Oilseeds	Oilseeds	Cropping
Agricultural land	Other non-cereal crops		Cropping
Agricultural land	Legumes		Cropping
Agricultural land	Cotton		Cotton
Horticulture	Vegetables	Other vegetables	Horticulture - annual
Horticulture	Vegetables	Potatoes	Horticulture - annual
Horticulture	Fruit	Citrus	Horticulture - perennial
Horticulture	Fruit	Apples	Horticulture - perennial
Horticulture	Fruit	Pears	Horticulture - perennial
Horticulture	Fruit	Stone fruit	Horticulture - perennial
Horticulture	Fruit	Plantation fruit	Horticulture - perennial
Horticulture	Fruit	Grapes	Horticulture - perennial
Horticulture	Nuts	Nuts	Horticulture - perennial
NO DATA AVAILABLE			Woodland/forest/forestry

5.5.2 Land Use Categories Adopted for this Study

The hierarchical Baxter and Russell land use classification provides far too many land use categories for aggregated nutrient estimation for this NPI project for the Murray-Darling Basin. This is because of:

- the limited Australian nutrient generation data available for various land uses;
- the comparative crudeness of the nutrient emission data for various land uses;
- the scale at which this project is being undertaken - 1 million km^2; as well as
- the relatively coarse resolution - 1 km^2 pixels - of the digitised NLWRA land use data set.

Consequently the Baxter and Russell land use categories have been aggregated and simplified into the following 9 land use categories (see Table 5.4), for use in Atech Group's approach to the determination of diffuse nutrient emissions. This approach of fewer land uses for nutrient estimation is supported by the sensitivity study undertaken by Baginska and Prichard (2000). The allocation of the various Baxter and Russell land use classes into the broader land use categories used for this study is indicated in Table 5.4.

Table 5.4: Aggregated land use categories used for this Murray-Darling Basin NPI study.

Woodland/forest/forestry
Unimproved pasture
Improved pasture
Cropping
Cotton
Horticulture (perennial – essentially fruit)
Horticulture (annual – essentially market garden and vegetables)
Urban
Water

The reason for including a specific commodity - cotton - is because it is generally (but not always) irrigated and subject to extensive drainage water management and reuse.

5.6 Nutrient-Generation Rates for Land Uses

Diffuse source nutrient export, generation or emission rates are defined as the amount of nutrient that moves off the land into the drainage system. It is generally expressed as kilograms of total phosphorus or total nitrogen lost per hectare per year ($kg.ha^{-1}.y^{-1}$). Information on nutrient exports for various land uses is derived from longer-term scientific studies undertaken on small plots or mini-catchments. In these small-scale studies, processes such as instream assimilation, sedimentation or irrigation extraction have generally not significantly modified nutrient loads. It is important to note that nutrient exports determined

from nutrient concentrations and flow at the bottom of larger catchments are misleadingly low because these other processes can greatly diminish the real nutrient load. Consequently monitoring studies undertaken for larger catchments are particularly inappropriate for determining, checking or modifying loads. Short-term nutrient monitoring studies are similarly inappropriate because they do not take into account the wide fluctuations in runoff associated with wet, dry or normal years.

5.6.1 Information Sources for Nutrient Generation Rates

While extensive information is available on nutrient emission or generation rates in many regions of the world, comparatively limited information is available for Australia. A number of Australian and overseas studies have summarised available information on nutrient emissions (e.g. Banens 1978; Rosich and Cullen 1982; Marston *et al*. 1995; Young *et al*. 1996).

The following sources have principally been used for the determination of nutrient generation rate for various land uses:

- the Nutrient Generation Rates Databook (Marston *et al*. 1995);
- the NEXSYS software program provided with WinCMSS;
- the nutrient exports and land use in Australian catchments paper by (Young *et al*. 1996);
- figures used in CMSS or WinCMSS studies;
- local and other Australian and overseas scientific studies; and
- expert opinion.

5.6.2 Adopted Nutrient Generation Rates

The typical nutrient generation rate for each land use as indicated by Marston *et al*. (1995) and Young *et al*. (1996) was adopted for this Basin-wide NPI study, unless local studies or information suggested better and more appropriate values (see Tables 5.5 and 5.6). Ranges for land use nutrient generation rates provided are generally derived from Marston *et al*. 1995, NEXSYS, and Young *et al*. 1996. These were used to guide any changes, although local information was the principal guide. Nutrient emission from diffuse sources was determined only from typical generation values.

Table: 5.5: Primary total-phosphorus generation rates used for this study in $kg.ha^{-1}.yr^{-1}$. Lower and upper bounds are shown for comparison.

Basic Land Use	Typical	Lower	Upper
Woodland/forest/forestry	0.06	0.03	0.1
Unimproved pasture	0.1	0.05	0.35
Improved pasture	0.3	0.1	0.7
Cropping	1.0	0.2	5.0
Cotton	0.5	0.1	2.5
Horticulture (perennial)	1.4	0.7	5

Basic Land Use	Typical	Lower	Upper
Horticulture (annual)	2.7	0.2	15
Urban	1.0	0.4	3.6
Water	0	0	0

Table: 5.6: Primary total-nitrogen generation rates used for this study in $kg.ha^{-1}.yr^{-1}$. Lower and upper bounds are shown for comparison.

Basic Land Use	Typical	Lower	Upper
Woodland/forest/forestry	1.1	0.9	1.5
Unimproved pasture	2.2	1.1	3.3
Improved pasture	3.3	0.6	4.6
Cropping	8.0	2.0	15
Cotton	4.0	1.0	7.5
Horticulture (perennial)	14	2.0	20
Horticulture (annual)	20	6	30
Urban	6.6	3.2	22.4
Water	0	0	0

5.7 Environmental and Management Factors Modifying Nutrient Emissions

It is recognised that other major environmental and other factors besides land use can significantly affect nutrient exports. These factors include:

- Slope
- Rainfall (amount, intensity and seasonality)
- Runoff
- Land management
- Irrigation
- Drainage management
- Groundwater management
- Geology
- Soil erodibility
- Gullying
- other

Because of the large scale of the Murray-Darling Basin, only a very limited degree of modification of the basic nutrient generation rates – by environmental factors - was attempted. These modification factors included rainfall and geology for which complete datasets were available for the Basin. These were selected because of their known influence

on water and nutrient runoff. If information on water runoff for the Basin becomes available, this could be used in place of rainfall. While it is recognised that other environmental factors may also significantly modify nutrient generation rates in areas of the Murray-Darling Basin, the limited extent and availability of such data precluded their use over the whole Basin. The law of diminishing returns as well as the comparatively crude method for determining nutrient emissions must be kept in mind for any attempts to improve the accuracy of the aggregated nutrient estimates. Nevertheless some further modification as a result of environmental or management factors may be applied for selected catchments. This applies particularly to 'irrigation' and 'drainage management' factors.

Keeping in mind the preceding comments, the criteria and associated modification factors to be applied to land use nutrient emission figures have been kept as simple as possible.

5.7.1 Geology

Geology has been demonstrated to have important influence on phosphorus emissions particularly because of the nutrient content, but also because of the erodibility of their associated soils. Tertiary basalts and their associated soils have been shown to have up to ten-times the phosphorus concentration of most non-basaltic rocks and soils (Banens 1982; Caitchon *et al*. 1994).

For this study the only geological modification to nutrient emission rates related to whether the underlying geology was Tertiary basalt or not. For non-Tertiary basalt land uses the primary phosphorus emission rate stayed unchanged, while for land uses on Tertiary basalt soils the phosphorus emission rate was increased by a factor of 1.5. The latter was derived from available data, and familiarity with the nutrient runoff in high basalt regions (Banens 1989).

Polygon data representing the presence or absence of basalt were derived from the MDBC dataset "Geology of the Murray-Darling Basin - simplified lithostratigraphic groupings". That data incorporates 92 - 1:250,000 scale map sheets and combines existing 1:250,000 scale geological, metallogenic and surficial geology mapping from the NSW Dept. of Mineral Resources, the Victorian Dept. of Natural Resources and Environment, the Queensland Geological Survey and Australian Geological Survey Organisation (AGSO). These were supplemented with more recent 1:100,000 scale mapping where available.

The huge area of the MDB, together with the varying geological history of the tectonic units located within the Basin, meant that the MDBC could not treat the Basin as a single entity for lithostratigraphic classification. Consequently the MDBC sub-divided the Basin into major tectonic units using the framework devised by Palfreyman (1984). Within these tectonic units, rock types were grouped according to the dominant lithology for broad geological time periods, thus providing a simple classification. The presence/absence of "Cainozoic volcanics" indicated in the MDBC dataset was used to identify Tertiary basalts in the Basin.

The aerial extent of this lithological group is shown in Figure 5.2. It shows that Tertiary basalts in the Murray Darling Basin are generally located on the higher and south-east uplands of the Basin. Most of these basalt areas are devoted to agriculture and, because of their fertility, are typically used for improved pastures or cropping. It is recognised that for

some land uses, such as urban land use, phosphorus emissions will not be greatly affected by underlying basalt geology. While at the Basin scale this is not expected to be significant, the geological modification factor for urban land use is nevertheless set at 1.0. It needs to be stated clearly, that emission rates for nitrogen are not modified by the presence or absence of Tertiary basalt within a catchment region.

The area and proportion of basalt for each catchment region are given in Table 5.7.

Figure 5.2: The spatial extent of Tertiary basalt in catchment regions of the Murray-Darling Basin.

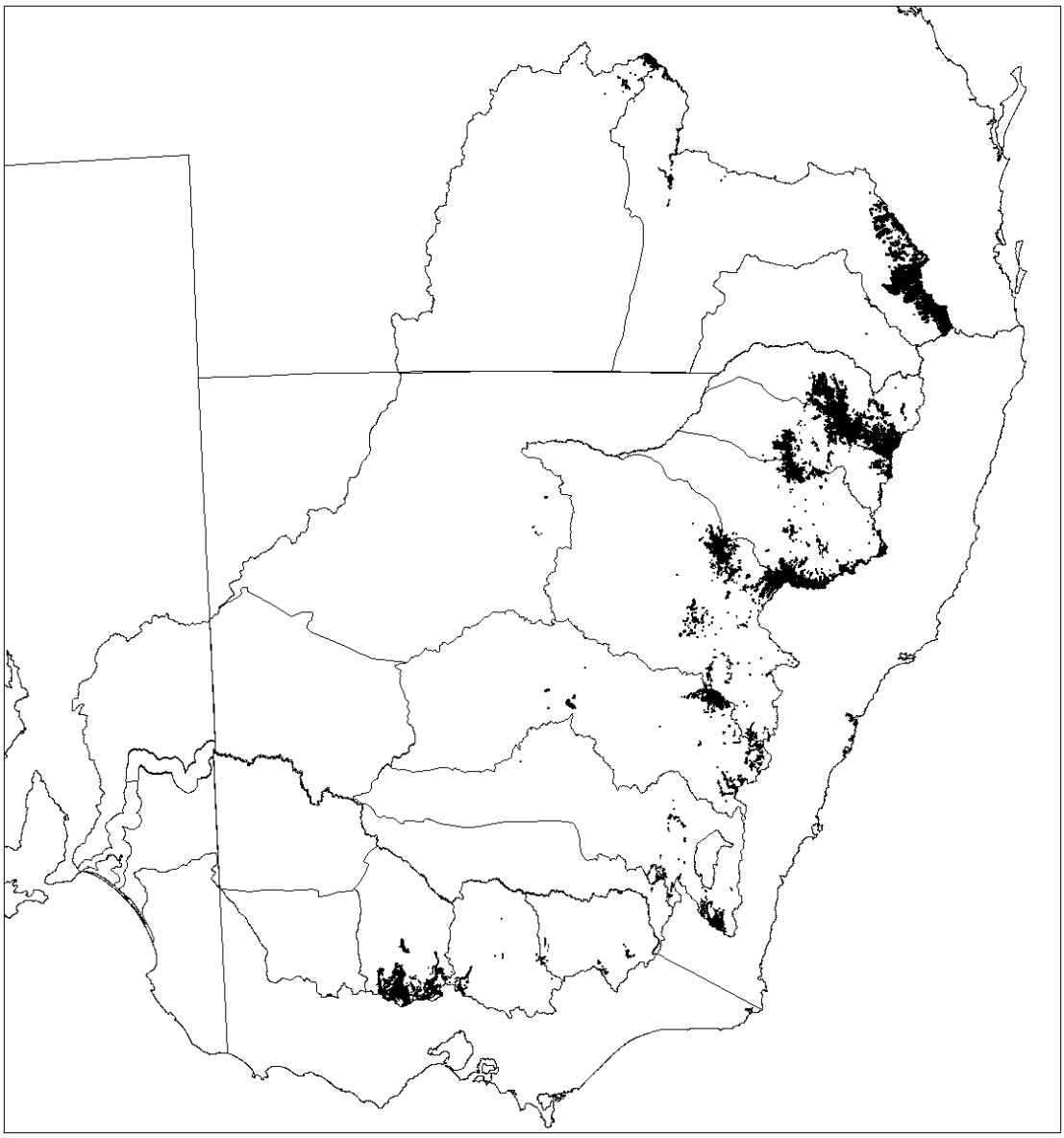


Table 5.7: The area and percent of Tertiary basalt geology in the MDB catchments.

Catchment Region	Total area (km^2)	Area basalt (km^2)	Percent basalt
Warrego-Paroo Catchment	126,490	310	0.25
Condamine-Balonne Catchment	96,040	5,120	5.33
Qld Border Rivers Catchment	37,940	20	0.05
NSW Border Rivers Catchment	24,160	3,560	14.73
Gwydir Catchment	26,540	2,650	9.98
Namoi Catchment	41,900	2,810	6.71
Western Region	158,600	20	0.01
Central West Catchment	91,990	2,570	2.79
Lachlan Catchment	90,760	1,020	1.13
Murrumbidgee Catchment	67,090	670	0.99
Lower Murray-Darling Region	62,680	-	-
Murray Catchment	35,890	100	0.27
North East Catchment	20,100	110	0.56
Goulburn-Broken Catchment	24,120	170	0.70
North Central Catchment	25,730	1,920	7.46
Wimmera Region	22,450	20	0.07
Mallee Region	37,950	-	-
North Riverine Corridor	4,580	-	-
South Riverine Corridor	5,800	-	-
Dryland Region	58,700	-	-
Murray-Darling Basin	**1,059,500**	**21,070 km^2**	**1.98%**

5.7.2 Rainfall – Proxy for Runoff

Rainfall - in conjunction with slope - is another important factor influencing water runoff and consequently nutrient runoff or emissions. Thus livestock grazing on the slopes where there is higher rainfall and a denser drainage network will generate substantially more nutrients than livestock grazing in the flat arid landscape west of the Darling River. Ideally the land use nutrient emission modification factor should be based on runoff. However, while some graphical information on runoff in the MDB is available in Crabb (1997) (based on work by Brendan Mackie formerly of CSIRO, now at the Australian National University), this information is not available in GIS form.

The broad topographic regions - the Plains, the Slopes and, the Tablelands and the Mountains (MDBMC 1987) – are commonly used in relation to climate, particularly in NSW. However they do not translate well to other areas and States in the Basin. Furthermore they are neither standard, nor available in GIS format.

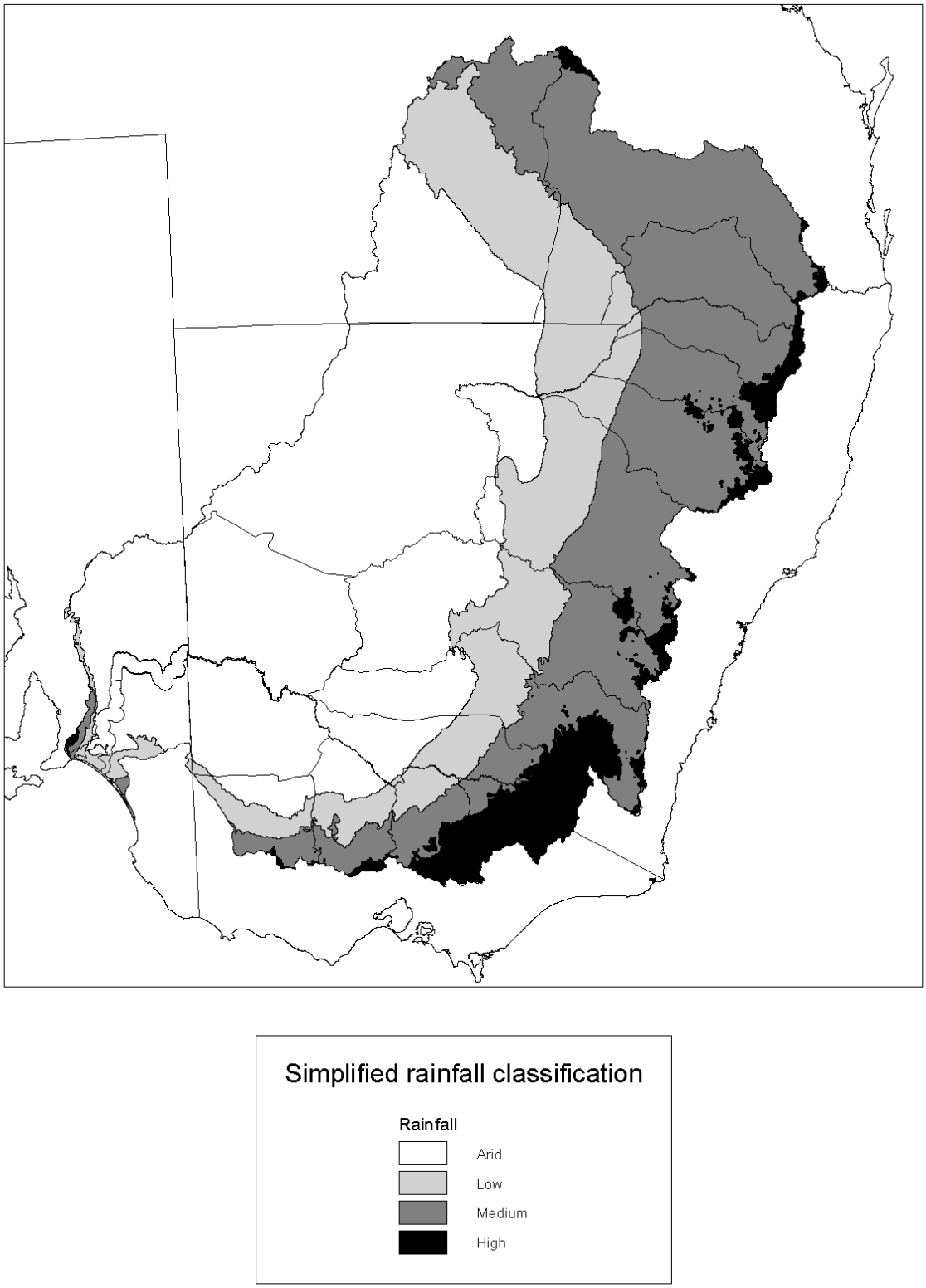
In the absence of runoff data for the MDB, calculated rainfall data were considered as the best and most appropriate proxy for runoff. These data were extracted from the MDBC dataset: "Climate data for the Murray-Darling Basin", which includes calculated evaporation, rainfall, rain-days, dewpoint, radiation, relative humidity and wet and dry-bulb temperature data for the whole of the Murray-Darling Basin. The data contains over 42,000 points that were derived from the spot height closest to a 5-kilometre grid sample. The points are not regularly spaced but reflect the variation in the AUSLIG spot height data. Rainfall and other climate data in this dataset are not measured data, but calculated by the ESOCLIM climate model from Centre for Research in Earth Sciences (CRES) at ANU in Canberra, using location and elevation as input. The predicted model values were used to produce a polygon-coverage for rainfall in 11 rainfall classes - from <100 mm, 100-200 mm, 200-300 mm and so forth in 100 mm steps to >1,000 mm. These rainfall classes were simplified into four broad rainfall zones – arid, low, medium and high rainfall for the purpose of modifying primary land use nutrient emissions (see Table 5.8). These selected zones - not surprisingly - largely parallel the topographic regions indicated in MDBMC (1987), and the runoff contours presented in (Crabb 1997). Figure 5.3 maps the boundaries of these rainfall zones.

The modification factors associated with diffuse nutrient emissions within each of these simplified rainfall classes are based on an assessment of available surface runoff data, other CMSS studies, as well as familiarity with the nutrient runoff variation with rainfall (Banens 1988). It is recognised that phosphorus and nitrogen are predominantly mobilised by different mechanisms – one more by erosion and the other more by solution. However, given the coarseness of any rainfall modifications, and for simplicity, these emission modification factors will apply equally to total phosphorus and total nitrogen (see Table 5.8).

Table 5.8: Simplified rainfall classes and land use nutrient-emission modification factors.

Simplified rainfall class	Rainfall range	Modification factor
High	>800 mm	1.25
Medium	500-800 mm	1
Low	300-500 mm	0.5
Arid	<300 mm	0.1

Figure 5.3: Simplified rainfall boundaries as used for nutrient emission rate modification.



5.8 Sub-Threshold Nutrient Point Sources

Sub-threshold nutrient point sources are those that are below the NPI reporting threshold. These thresholds are 3,000 kg annually for total phosphorus and 15,000 kg annually for total nitrogen. Nutrient point-source emitters above these threshold levels are required to report separately to the NPI. Sub-threshold nutrient point-sources will be determined and added separately to the total diffuse-source nutrient emissions for each catchment region to provide the (total) aggregated nutrient emission figures. Data on nutrients derived from sub-threshold point sources will be obtained from:

- CMSS or related nutrient studies;
- State and Territory agencies emission licence information - where this exists;
- personal contact with relevant individuals; and
- other literature.

The point-source database in the nutrient pollution study of the Murray-Darling river system (GHD 1992) is useful for identifying point sources in some Catchment Regions. However, the age of the report – containing information from 1990-1991, and the change in effluent management over the past ten years - means that it is less than optimal for generating sub-threshold nutrient point sources from generic per capita or livestock rates.

It is recognised that it is important that sub-threshold nutrient point source data takes into account, 'wet', 'dry' as well as 'normal' years to arrive at an overall representative emission figure. However, this was not generally possible to determine within the scope of this project. For practical purposes, a lower limit for inclusion of sub-threshold point sources was set at 10 kg TP and 50 kg TN per annum. This is generally consistent with the emission for a 1 km^2 pixel at the lowest runoff rate – 6 kg TP and 11 kg TN.

Where possible, individual sub-threshold point source data was used to derive total sub-threshold nutrient loads. Estimates were made for catchment regions for which sub-threshold nutrient point source information was not available. It is important to note that neither septic tanks, irrigation drains nor urban stormwater were included under the sub-threshold point source nutrient emissions.

6. Results

6.1 Land Use in the MDB Catchment Regions

A summary of aggregated land use for the Murray-Darling Basin and each catchment region is provided in Table 6.1. Detailed land use breakdown for each catchment region according to the Baxter and Russell land use classification is provided in Appendix 2.

A perusal of Table 6.1 enables the following observations to be made:

- The land use breakdown for the whole of the MDB shows that by far the dominant land use is grazing on unimproved pastures. This is followed by natural woodland/forest or forestry, cropping and then grazing on improved pastures - irrigated or rain fed. All other land uses are minor on a percentage basis, but given the size of the Basin, still constitute significant areas of land.
- Victoria's North East and Mallee are the most natural catchment regions.
- The greatest extent of unimproved pastures are found in the arid zone catchments, particularly Western and Warrego-Paroo catchment regions.
- The highest level of improved pasture is associated with the irrigation regions of the Victorian and NSW Riverine plains, particularly in the Goulburn-Broken and North Central catchments.
- Most catchments in the less arid areas of the Basin have a significant cropping component, with the Wimmera and Mallee being particularly significant in the southern part, and the Gwydir and NSW Border Rivers in the north.
- Cotton was a significant crop in the Gwydir, Namoi and NSW Border Rivers catchments.
- On a percentage basis annual horticulture was not significant in any catchment region.
- Perennial horticulture was particularly significant in the SA North Riverine Corridor, and to a lesser extent in the Mallee and Goulburn Broken and Murrumbidgee catchment regions.
- Urban land use was not particularly significant on a percentage basis in any catchment with the highly developed Goulburn-Broken Catchment showing the highest percentage. It should be noted that Canberra is the biggest single urban area in the MDB, however, combined with other urban areas of the Murrumbidgee, it still represented less than 0.5% of overall land use.
- The SA South Riverine Corridor containing Lake Alexandrina and the Coorong, showed the greatest extent of the water/wetland land use category. The Lower Murray-Darling Region in NSW, with the Menindee Lakes, also exhibited a significant percentage in the area.

- It needs to be noted that the figures presented are percentages and not absolute figures – small percentages in very large catchments may represent substantially greater areas than larger percentages in smaller catchments.

Table 6.1: Percentage breakdown according to the aggregated land use classes for each of the Murray-Darling Basin's catchments. A dash indicates that there was no recorded land use under that category, while '0.0' indicated value of less than 0.05%.

Catchment Region	Area (km^2)	Woodland/ forest /forestry	Unimproved pasture	Improved pasture	Cropping	Cotton	Annual horticulture	Perennial horticulture	Urban	Water/ wetlands
Warrego-Paroo Catchment	126,490	8.3	89.6	1.7	0.1	-	0.0	-	0.0	0.3
Condamine-Balonne Catchment	96,040	20.0	66.6	3.6	8.8	0.9	0.0	0.0	0.1	0.0
Qld Border Rivers Catchment	37,940	26.3	58.4	2.5	12.0	0.6	0.0	0.1	0.0	0.0
NSW Border Rivers Catchment	24,160	22.1	49.0	4.3	21.9	2.5	0.0	0.0	0.1	0.0
Gwydir Catchment	26,540	16.0	58.3	4.6	18.1	2.8	0.0	0.0	0.1	0.1
Namoi Catchment	41,900	17.5	62.3	5.7	11.8	2.1	-	-	0.1	0.3
Western Region	158,600	3.4	93.2	0.1	1.3	0.1	-	0.0	0.0	1.9
Central West Catchment	91,990	6.7	68.8	9.8	13.9	0.4	0.0	0.0	0.1	0.2
Lachlan Catchment	90,760	7.7	68.8	10.5	12.1	0.0	0.0	0.0	0.1	0.8
Murrumbidgee Catchment	67,090	17.5	56.7	9.7	14.9	-	0.1	0.3	0.4	0.5
Lower Murray-Darling Region	62,680	7.3	87.0	0.1	1.1	0.0	0.0	0.1	0.0	4.4
Murray Catchment	35,890	12.6	60.5	10.1	15.7	-	0.1	0.1	0.1	0.9
North East Catchment	20,100	64.8	23.4	9.8	1.5	-	0.0	0.1	0.4	0.1
Goulburn-Broken Catchment	24,120	30.5	36.2	25.7	6.1	-	0.1	0.5	0.7	0.2
North Central Catchment	25,730	13.1	38.6	27.4	20.0	-	0.1	0.1	0.3	0.4
Wimmera Region	22,450	13.4	29.8	16.8	39.7	-	-	0.0	0.1	0.1
Mallee Region	37,950	42.9	28.3	6.4	21.5	-	0.1	0.5	0.1	0.2
North Riverine Corridor	4,580	13.2	64.3	3.8	11.2	-	0.3	5.8	0.2	1.2
South Riverine Corridor	5,800	7.3	47.8	12.6	15.6	-	0.2	0.1	0.5	15.9
Dryland Region	58,700	17.0	66.9	5.6	10.3	-	0.0	0.1	0.0	0.1
Murray-Darling Basin	**1,059,500**	**14.10**	**68.59**	**6.21**	**9.61**	**0.36**	**0.02**	**0.10**	**0.11**	**0.86**

6.2 Diffuse Nutrient Emissions

A summary of calculated total annual diffuse nutrient emissions and emission rates from catchments are presented in Table 6.2. These were calculated from the extent of various land uses in catchments (Table 6.1), the generic emission rates for aggregated land uses (Section 5.6.2), and the geology and rainfall modification (Sections 5.7.1 & 5.7.2). Diffuse phosphorus and nitrogen emission rates for each catchment are also graphically presented in Figures 6.1 and 6.2. A detailed breakdown of nutrient loads per land use per catchment is provided in Appendix 3.

Table 6.2: Diffuse annual nutrient emissions and average emission rates for MDB catchment regions.

Catchment Region	**Annual diffuse TP emission (kg x 10^3)**	**Average TP emission rate (kg.ha^{-1})**	**Annual diffuse TN emission (kg x 10^3)**	**Average TN emission rate (kg.ha^{-1})**	**N:P ratio**
Warrego-Paroo Catchment	531	0.04	11,040	0.87	20.8
Condamine-Balonne Catchment	1,701	0.18	22,250	2.32	13.1
Qld Border Rivers Catchment	752	0.20	9,634	2.54	12.8
NSW Border Rivers Catchment	794	0.33	8,071	3.34	10.2
Gwydir Catchment	742	0.28	7,955	3.00	10.7
Namoi Catchment	923	0.22	11,170	2.67	12.1
Western Region	284	0.02	4,991	0.32	17.5
Central West Catchment	1,543	0.17	18,560	2.02	12.0
Lachlan Catchment	1,242	0.14	14,220	1.57	11.4
Murrumbidgee Catchment	1,022	0.15	12,130	1.81	11.9
Lower Murray-Darling Region	65	0.01	1,316	0.21	20.2
Murray Catchment	487	0.14	5,597	1.56	11.5
North East Catchment	263	0.13	4,057	2.02	15.4
Goulburn-Broken Catchment	441	0.18	5,654	2.36	12.8
North Central Catchment	401	0.16	4,291	1.67	10.7
Wimmera Region	425	0.19	4,237	1.90	10.0
Mallee Region	115	0.01	1,206	0.21	10.5
North Riverine Corridor	13	0.03	158	0.35	12.1
South Riverine Corridor	25	0.06	278	0.65	10.9
Dryland Region	222	0.04	2,819	0.49	12.7
Murray-Darling Basin	**11,990**	**0.11**	**149,600**	**1.42**	**12.5**

Points to note from Table 6.2 are:

- Annual nutrient loads from diffuse catchment sources varied greatly between catchments, ranging from 13 to 1,701 tonnes TP, and 158 to 22,250 tonnes TN.
- Size generally had little bearing on overall diffuse source nutrient loads, with the largest catchment – the Western Region having one of the smallest nutrient loads. Nevertheless, the two very small riverine catchments did have the lowest nutrient loads.
- Average diffuse nutrient emission rates for different catchments also varied widely, ranging from 0.01 to 0.33 kg TP per hectare and 0.21 to 3.35 kg TN per hectare.
- The highest phosphorus emission rates were found in the NSW Border Rivers and Gwydir catchments, while the lowest emission rates were found in the arid catchment regions of the western part of the Basin.
- The highest nitrogen emission rates were found in the NSW Border Rivers Catchment with the lowest emission rates also from the arid western catchments.
- It needs to be remembered these figures are estimates for diffuse nutrient emissions to the waterways on the Basin. They do not take into account assimilation, de-nitrification, sedimentation and loss through abstraction or other instream processes.
- There is a wide range in nitrogen:phosphorus ratios of nutrient emissions from various catchments, ranging from 10.0 to 20.8. Low ratios, such as those of the Wimmera, are generally more reflective of intensive land uses such as cropping. On the other hand high TN:TP ratios such as for the Warrego-Paroo reflect high levels of unimproved pastures and possibly woodlands/forests.

Figure 6.1: Spatial representation of diffuse phosphorus emission rates for catchments of the Murray-Darling Basin.

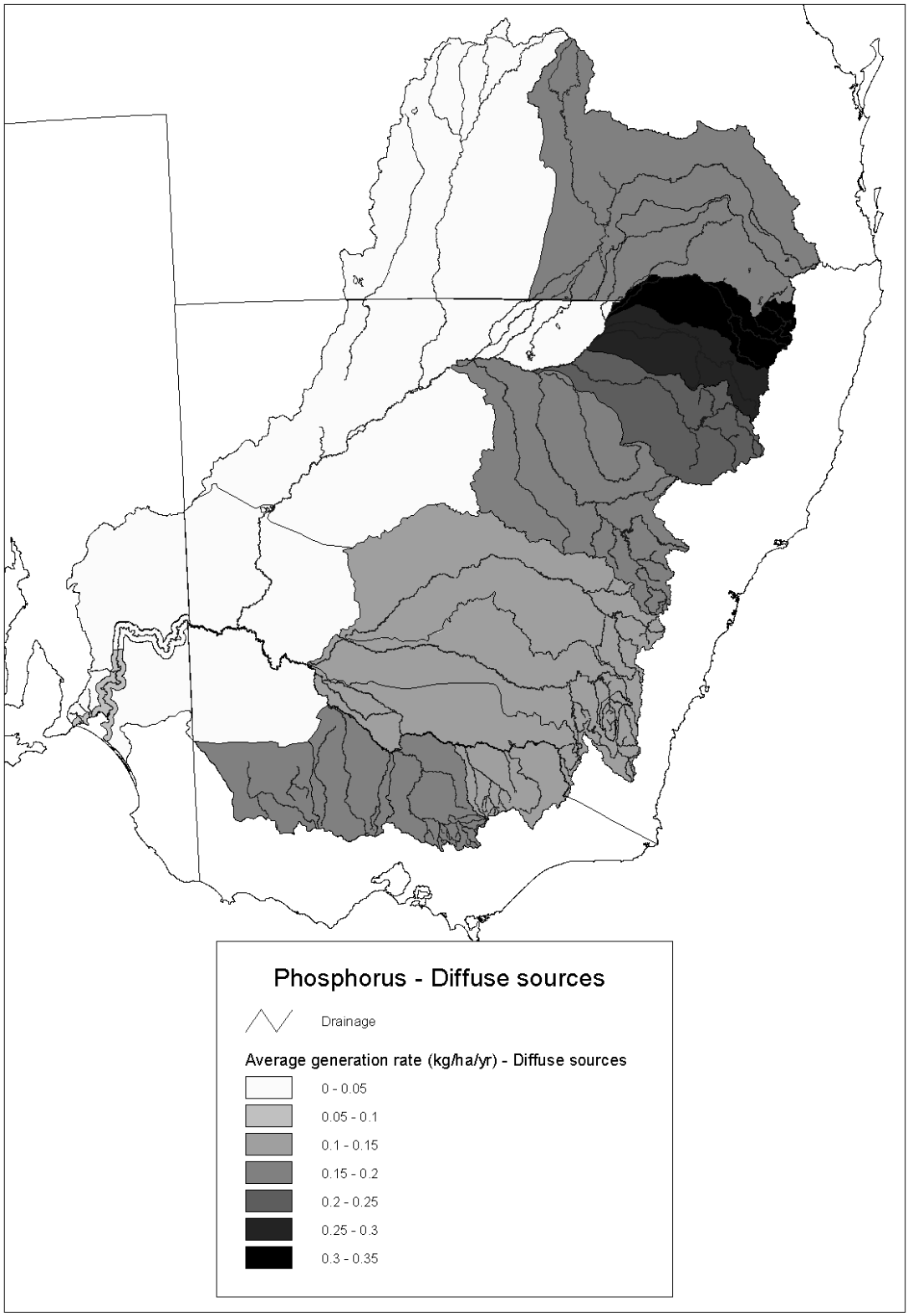
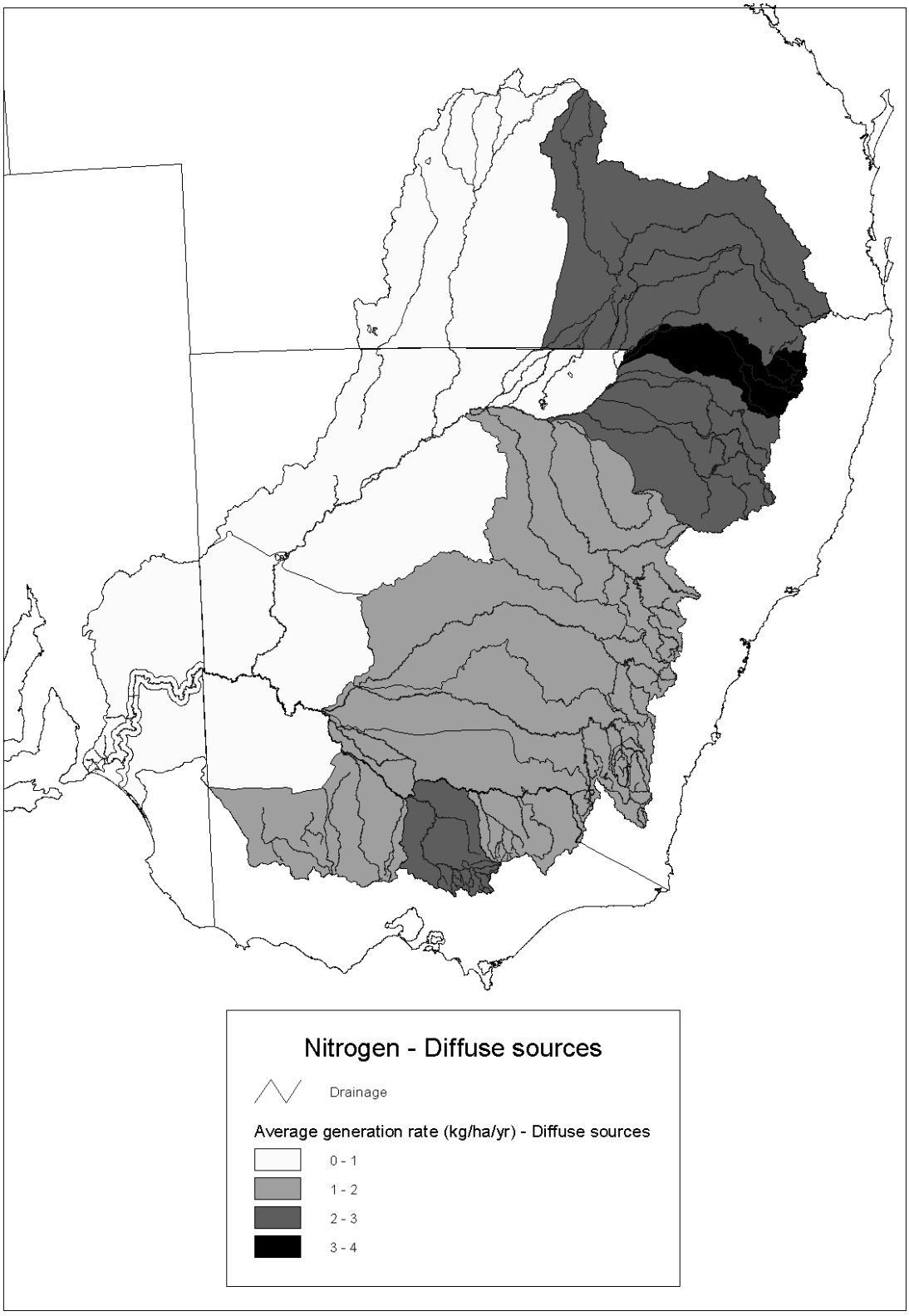


Figure 6.2: Spatial representation of diffuse nitrogen emission rates for catchments of the Murray-Darling Basin.



6.3 Sub-Threshold Nutrient Point Source Loads

Sub-threshold nutrient point source loads for each of the catchment regions are provided in Table 6.3. These are also presented spatially for each of the MDB catchment regions and spatially in Figures 6.3 and 6.4. Appendix 4 provides more detail on the origin of sub-threshold point source load derivation.

Table 6.3: Annual sub-threshold nutrient point-source loads for MDB catchment regions.

Catchment Region	**Annual sub-threshold TP (kg x 10^3)**	**Annual sub-threshold TN (kg x 10^3)**
Warrego-Paroo Catchment	0	0
Condamine-Balonne Catchment	15	76
Qld Border Rivers Catchment	11	20
NSW Border Rivers Catchment	14	41
Gwydir Catchment	5	19
Namoi Catchment	9	48
Western Region	2	5
Central West Catchment	16	72
Lachlan Catchment	20	84
Murrumbidgee Catchment	10	55
Lower Murray-Darling Region	0	0
Murray Catchment	3	18
North East Catchment	12	57
Goulburn Broken Catchment	41	240
North Central Catchment	19	50
Wimmera Region	2	4
Mallee Region	0	0
North Riverine Corridor	2	6
South Riverine Corridor	50	191
Dryland Region	0	0
Murray-Darling Basin	**231***	**986***

*To the nearest 1000 kg.

Points to note from Table 6.3 and Appendix 4 are:

- For most catchments sub-threshold nutrient point source loads are insignificant in relation to diffuse catchment sources.

- In a number of arid inland catchments these are estimated to be zero.
- The sub-threshold nutrient point source load is significant for the Goulburn Broken Catchment and the South Riverine Corridor.
- For the Goulburn Broken Catchment this high nutrient load can be explained by its very high level of agricultural development
- For the South Riverine Corridor the high sub-threshold nutrient load is related to the very large loads derived from the pumping of dairy flat drainage effluent into the River below Murray Bridge. It has been argued that this published estimate is now out of date.
- STP effluent is the most important of these sub-threshold sources, followed by cattle feedlot effluent, and then dairy and piggery effluents.
- Fish farm effluent is significant in a number of catchments, particularly the Goulburn-Broken Catchment.
- Estimates have been derived from a range of sources of varying ages or derived by various mechanisms using data from different ages – consequently it has to be recognised that that these estimates can be further refined.
- Nevertheless at the scale of the MDB and given the dominance of diffuse nutrient loads, little improvement in precision of aggregated nutrient loads would be obtained from a detailed updating of sub-threshold data.

Figure 6.3: Annual sub-threshold phosphorus loads for catchment regions of the Murray-Darling Basin.

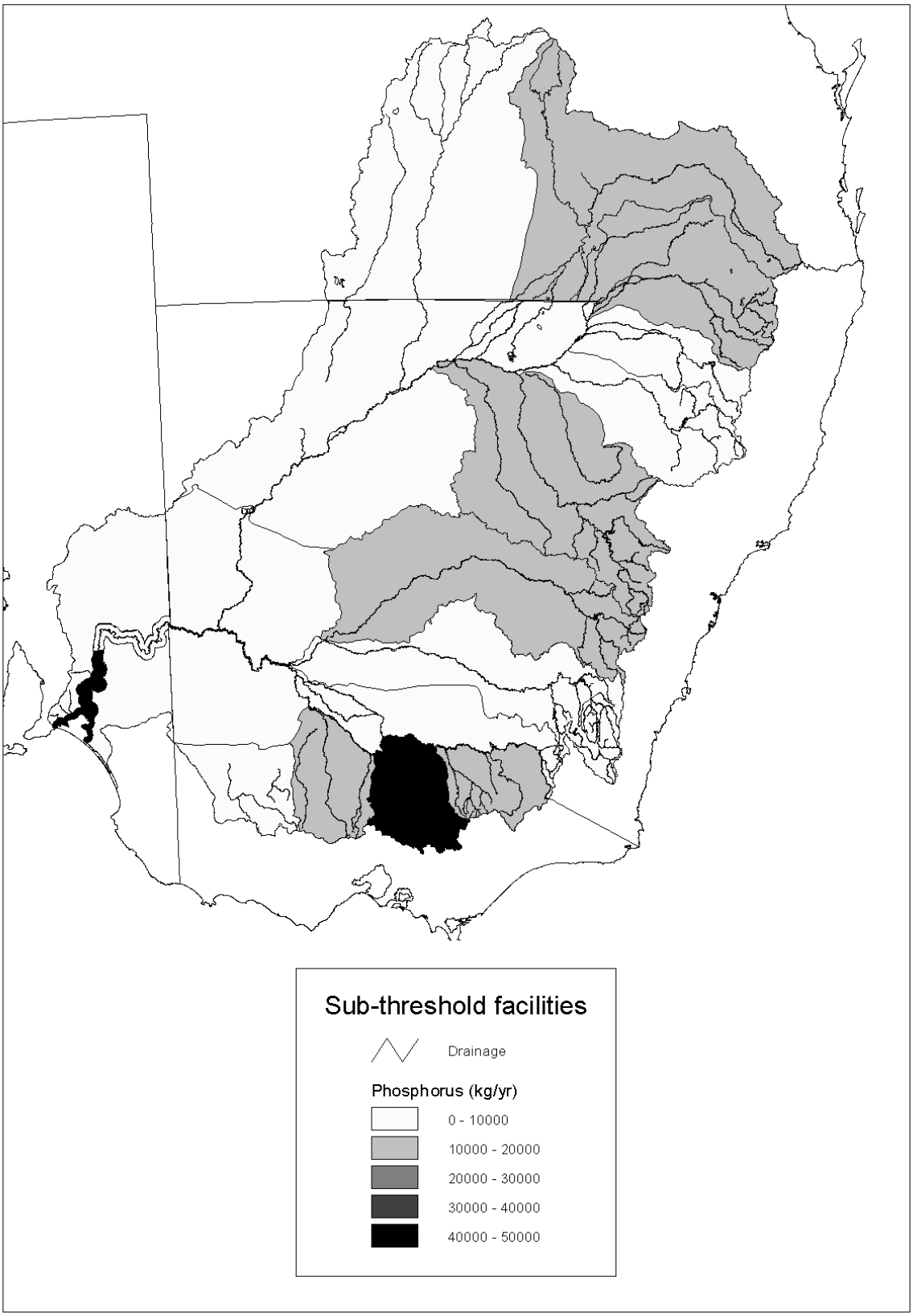
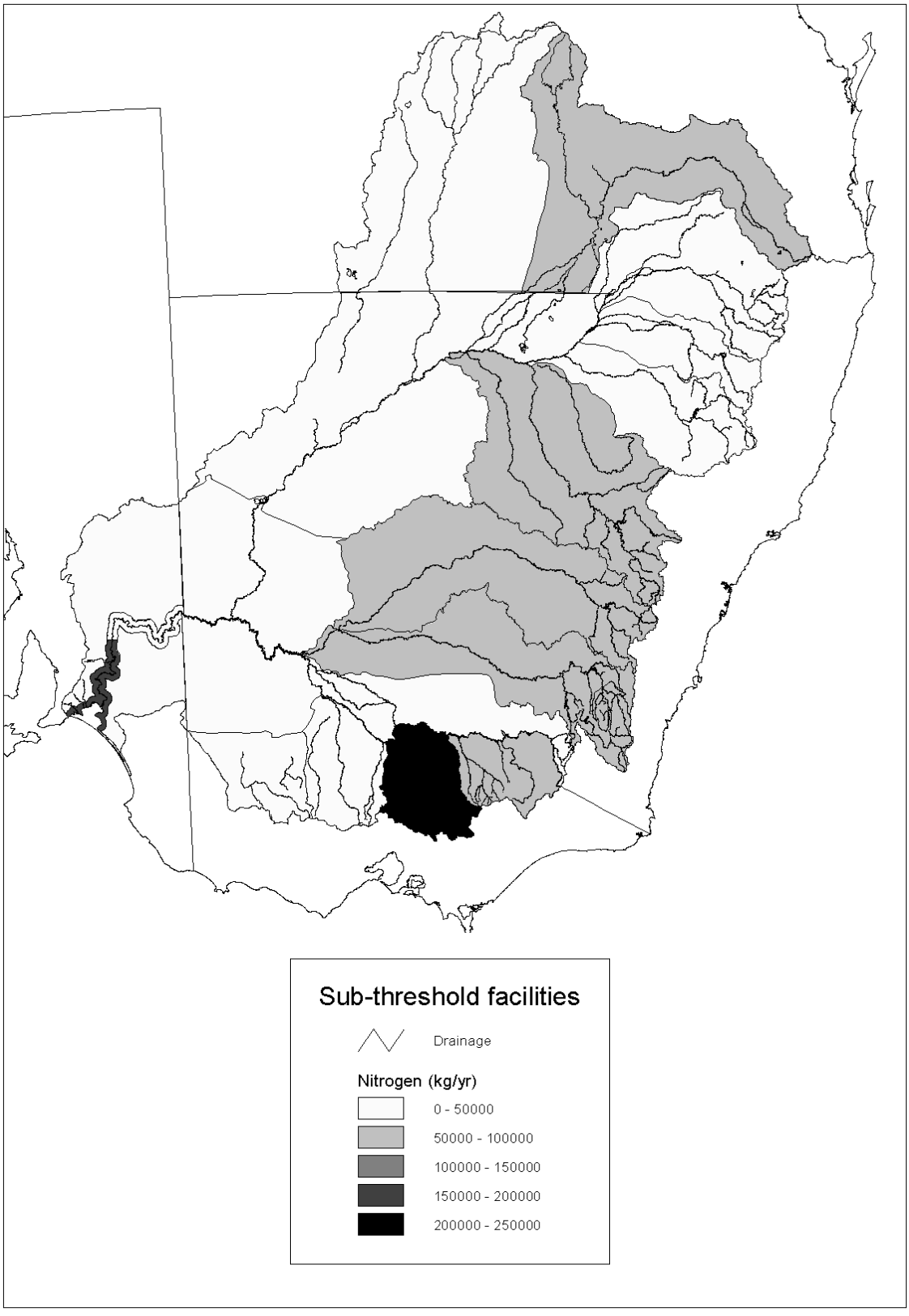


Figure 6.4: Annual sub-threshold nitrogen loads for catchment regions of the Murray-Darling Basin.



6.4 Aggregated Nutrient Emissions

The aggregated nutrient emissions for each of the Basin's catchments were determined by adding annual diffuse and sub-threshold nutrient loads for each catchment. The aggregated figures are presented in Table 6.4. Details are provided in Appendix 5. Aggregated nutrient emissions for the Murray-Darling Basin catchment regions are also presented graphically in Figures 6.6 and 6.7.

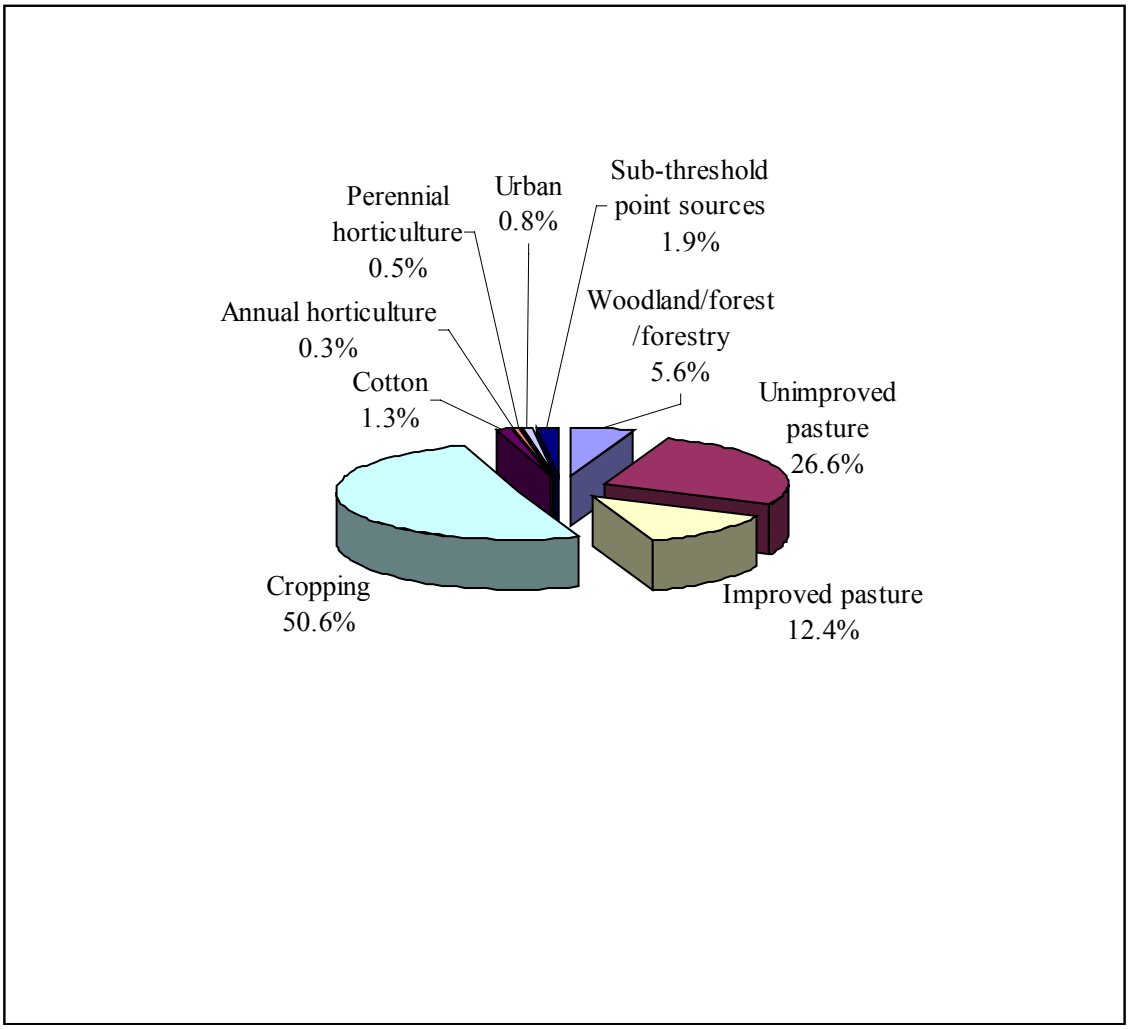
Table 6.4: Annual aggregated nutrient emissions for catchments of the Murray-Darling Basin (in 1000s kg or tonnes).

Catchment Region	**Annual aggregated TP emission**	**Annual aggregated TN emission**
Warrego-Paroo Catchment	531	11,040
Condamine-Balonne Catchment	1,716	22,326
Qld Border Rivers Catchment	763	9,654
NSW Border Rivers Catchment	808	8,112
Gwydir Catchment	747	7,974
Namoi Catchment	932	11,218
Western Region	286	4,996
Central West Catchment	1,559	18,632
Lachlan Catchment	1,262	14,304
Murrumbidgee Catchment	1032	12,185
Lower Murray-Darling Region	65	1,316
Murray Catchment	490	5,615
North East Catchment	275	4,114
Goulburn-Broken Catchment	482	5,894
North Central Catchment	420	4,341
Wimmera Region	427	4,241
Mallee Region	115	1,206
North Riverine Corridor	15	164
South Riverine Crridor	75	469
Dryland Region	222	2,819
Murray-Darling Basin	**12,221**	**150,620**

Points to note for aggregated total-phosphorus emissions are:

- At the Basin scale the dominant phosphorus load is from cropping, which provides just over 50% of the total aggregated emissions, despite making up less than 10% of land use in the Basin.
- Cropping together with unimproved and improved pastures makes up the bulk – almost 90% - of aggregated phosphorus emissions in the Basin.
- Besides woodland/forest/forestry, the other land uses make up less than 5% of aggregated phosphorus emissions in the Basin.
- Sub-threshold phosphorus point sources - emitting less than 3,000 kg annually – are comparatively insignificant compared to diffuse loads.
- It should be remembered that point source emissions greater than the NPI threshold have not been considered.
- Only for the Lower Riverine Corridor was the sub-threshold nutrient point source significant, indeed greater than diffuse nutrient sources. This was attributed to drainage pumping from the dairy flats adjacent to the River Murray.

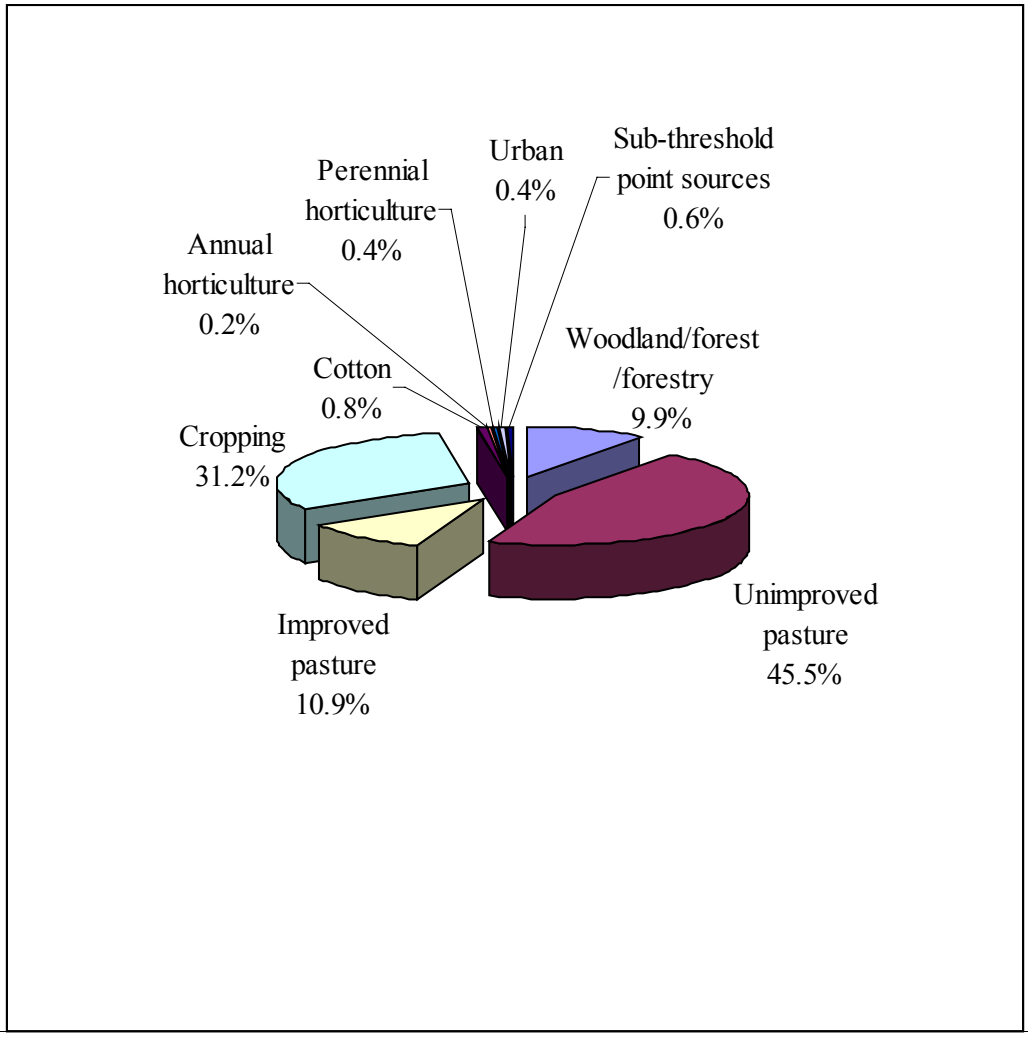
Figure 6.5: Percent aggregated total-phosphorus emissions in the Murray-Darling Basin



For aggregated total nitrogen emissions the points to note are:

- At the Basin scale the dominant nitrogen emission is from unimproved pastures, which provides just over 45% of the total aggregated emissions. This compares with its dominance of almost 89% of land use in the Basin.
- Cropping makes up just over 31% aggregated TN emissions, compared to its contribution of over 50% for TP.
- Unimproved pastures together with cropping and improved pastures makes up the bulk - almost 88% - of aggregated total nitrogen emissions in the Basin.
- Woodland/forest/forestry contributes a significant 10% of aggregated TN emissions.
- Sub-threshold total-nitrogen point sources - emitting less than 15,000 kg annually – are comparatively insignificant compared to diffuse loads.
- Perennial and annual horticulture, urban, cotton land uses together with sub threshold point sources make up less than 2.5% of aggregated total-nitrogen emissions in the Basin.
- It has to be pointed out that point-source nitrogen emissions greater than the NPI threshold have not been considered in this analysis.
- Only for the Lower Riverine Corridor was the sub-threshold nutrient point source significant in relation to diffuse nutrient sources. This was attributed to drainage pumping from the dairy flats adjacent to the River Murray.

Figure 6.6: Percent aggregated total nitrogen emissions for the Murray-Darling Basin.



7. Conclusions

7.1 Basis of the Study

The dominant component of aggregated nutrient emissions from catchments is invariably diffuse nutrient sources. Consequently, it was important to have a consistent method and a uniform data set for estimating these diffuse sources, and enabling comparisons.

The estimation of nutrient emissions from diffuse sources to waterways for this NPI study is based on the premise that the rate of nutrient emission is predominantly related to land use. Furthermore, such emission rates are modified by a range of environmental and management factors.

An important issue is that instream assimilation, sedimentation or irrigation extraction can significantly modify nutrient loads in streams.

This NPI emission study has therefore restricted itself to estimating primary nutrient emissions from the land into the drainage network. It has not attempted to model the movement or transformation of nutrients either across the landscape or downstream.

Consequently aggregated nutrient emission estimates for catchments determined from this study can not be compared with nutrient loads calculated from flow and concentration at the bottom of a catchment.

7.2 Data and Approach for Diffuse Sources

The most recent and only complete land use data set for the whole of the Murray-Darling Basin was an interim (version 2) NLWRA 1:1 million-scale digital land-use map of Australia. Developed by the Bureau of Rural Sciences, it is based on a modified Baxter & Russell hierarchical land use classification, that has been agreed to by all the States. The final version of the data is not expect to change greatly.

The primary data used to develop land use data set is based on 1996-97 satellite imagery and related statistical land use information.

The Murray-Darling Basin and catchment shape files were obtained from the Murray-Darling Basin Commission, with the exception of the North and South Riverine Corridors in South Australia. The latter were drawn on a GIS by specifying a 10 km wide zone either side of the River Murray, split into north and south components at Blanchtown.

Using the land use nutrient export approach for determining diffuse emissions at the scale of large catchments within the Murray-Darling Basin necessitated a restricted number of (broad or aggregated) land use categories.

These land use categories were:

- Woodland/forest/forestry
- Unimproved pasture
- Improved pasture
- Cropping
- Cotton
- Perennial horticulture (mainly fruit and nuts)
- Annual horticulture (mainly vegetable market gardens)
- Urban
- Water/wetlands

The generic nutrient emission rate adopted for each of these land uses were based on reviews of nutrient generation studies in the Murray-Darling Basin and elsewhere, and expert opinion.

A table showing the annual nutrient emission rates for land uses as used in this NPI study of the Murray-Darling Basin is reproduced below:

Table: 7.1: Phosphorus and nitrogen generation rates used for this study in $kg.ha^{-1}.yr^{-1}$.

Land Use	**TP**	**TN**
Woodland/forest/forestry	0.06	1.1
Unimproved pasture	0.1	2.2
Improved pasture	0.3	3.3
Cropping	1.0	8.0
Cotton	0.5	4.0
Horticulture (perennial)	1.4	14
Horticulture (annual)	2.7	20
Urban	1.0	6.6
Water/wetlands	0	0

A wide range of environmental and management factors modify nutrient emission rates, however only a couple were appropriate and available over the whole of the Basin.

The two key modifying factors used were basalt geology and rainfall.

Geological influence is taken into account by increasing the basic 'total-phosphorus' generation rate by a factor of 1.5 for that proportion of land use uses underlain by (high phosphorus) Tertiary basalt. The exception is 'urban land use', which is not considered to be affected. Total nitrogen emissions are not influenced by geology.

The influence of runoff is taken into account by using average annual rainfall as a proxy.

Rainfall estimates were used to define four rainfall zones in the Basin – arid, low, medium, and high. A Table showing the modifying factors adopted for each zone is reproduced below:

Table 7.2: Simplified rainfall classes and land use nutrient-emission modification factors.

Simplified rainfall class	Rainfall range	Modification factor
High	>800 mm	1.25
Medium	500-800 mm	1
Low	300-500 mm	0.5
Arid	<300 mm	0.1

The digital geology and rainfall data for the Murray-Darling Basin (produced using the ANU's ESOCLIM model) were obtained from the Murray-Darling Basin Commission.

The procedure used for estimating diffuse nutrient loads involved multiplying the area of a given land use for a catchment by a generic nutrient generation rate, then multiplying this product by modifying factors representing the influence of geology and rainfall.

7.3 Data and Approach for Sub-Threshold Point Sources

The NPI defines sub-threshold nutrient point sources as those emitting less than 3 tonnes (3,000 kg) of phosphorus and less than 15 tonnes (15,000 kg) of nitrogen during the reporting year. Point sources above these levels are required to report separately to the NPI.

Sub-threshold nutrient point-source loads are invariably – with one exception in this study – comparatively minor in relation to diffuse-source loads.

There is no single source of up-to-date information for sub-threshold point sources at either the Basin or State level. Consequently information was obtained from a variety of studies and reports.

Where such studies have been undertaken and the information made available, these were generally past water quality or nutrient studies. In some cases these were CMSS or AEAM (Adaptive Environmental Assessment and Management) computer files.

There was little consistency in the approach and detail of these studies.

Where such information on nutrient point sources was available it was taken at face value - sub threshold point source were identified and nutrient emissions totalled.

It was not appropriate or possible - operating at the Basin scale - to verify that all sub-threshold nutrient point sources had been identified or that the nutrient loads were correct.

Most of the sub-threshold nutrient point-source information obtained from existing studies was from the period 1994-1998.

For catchments for which there was no published information on nutrient point source loads, information was obtained either through personal communication with relevant individuals or by estimating STP or feedlot nutrient point sources from the 1992 GHD nutrient study for the Murray-Darling Basin.

Where information was provided by relevant agency staff in some catchments it was taken and reported at face value, with no further investigation.

For a number of catchments sub-threshold nutrient sources were taken as zero on the basis of available reports or verbal advice.

For those catchments for which there was no recent information, sub-threshold STP nutrient loads were estimated by multiplying the population of towns discharging to streams (from the GHD 1992) by typical 'per capita' generation rates.

The typical 'per capita' generation rates were calculated by averaging data for other STPs in the MDB for which load and population figures were available, and were determined to be 0.5 $kg.person^{-1}.yr^{-1}$ for TP, and 1.3 $kg.person^{-1}.yr^{-1}$ for TN.

For those catchments for which there was no information on livestock emissions, a indicative value was estimated from comparison of the livestock numbers (Tucker 1991) with that of the Namoi Catchment for which there was detailed information.

7.4 Aggregated Nutrient Emissions

Aggregated nutrient emissions were determined by simply adding up diffuse and sub-threshold emission loads for each of the catchments, and totalling these for the whole of the Murray-Darling Basin.

Final data on aggregated emissions of TP and TN for each land use category and catchment region were provided to the NPI in digital form in accordance with the NPI data transfer protocol. The catchment region boundaries used for calculating the aggregate emissions were provided to the NPI in ArcView (GIS) shapefile format.

Table 7.3 showing the annual aggregated TP and TN emissions for each catchment region of the Murray-Darling Basin is provided below:

Table 7.3: Annual aggregated nutrient emissions for catchment regions of the Murray-Darling Basin (in 1000s kg or tonnes).

Catchment Region	**Annual aggregated TP emission**	**Annual aggregated TN emission**
Warrego-Paroo Catchment	531	11,040
Condamine-Balonne Catchment	1,716	22,326
Qld Border Rivers Catchment	763	9,654
NSW Border Rivers Catchment	808	8,112
Gwydir Catchment	747	7,974
Namoi Catchment	932	11,218
Western Region	286	4,996
Central West Catchment	1,559	18,632
Lachlan Catchment	1,262	14,304
Murrumbidgee Catchment	1032	12,185
Lower Murray-Darling Region	65	1,316
Murray Catchment	490	5,615
North East Catchment	275	4,114
Goulburn-Broken Catchment	482	5,894
North Central Catchment	420	4,341
Wimmera Region	427	4,241
Mallee Region	115	1,206
North Riverine Corridor	15	164
South Riverine Crridor	75	469
Dryland Region	222	2,819
Murray-Darling Basin	**12,221**	**150,614**

7.5 Reliability of the Estimates

The approach used for this NPI study, while appropriate for large catchments such as the Murray-Darling Basin, or the Fitzroy Basin, does nevertheless lead to large uncertainties in the nutrient generation estimates.

In the case of emissions from diffuse sources these uncertainties may result from:

- The misclassification of, or possible inappropriate aggregation of land uses.
- The use of generic and possibly inappropriate long-term average annual emission rates.

- The use of a limited range and possibly inappropriate modifying factors – for example no account is taken of irrigation, erosion or other management factors.

In the case of sub-threshold facilities - small nutrient point sources - uncertainties may result from:

- The use of data from studies that use different estimation techniques and level of rigor in identifying and determining nutrient loads from point sources.
- The incomplete identification of sub threshold point sources.
- The use of out of date or incorrect data and information for estimating sewage treatment plant or livestock feedlot nutrient loads.

In light of the preceding comments it should be pointed out that the aggregated nutrient emission data for the 20 catchments of the Murray-Darling Basin are indicative rather than precise.

There are opportunities to further refine aggregated nutrient emissions through more detailed catchment and regional studies, however it must be remembered that the land use-nutrient emission approach is essentially a coarse tool for estimating diffuse nutrient loads.

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Appendices

Appendix 1: Existing Land Use, CMSS and Related Information for Catchments

A brief summary on data availability for each of the major catchments of the Murray-Darling Basin is provided below. The discussion of land use information represents the situation prior to the availability of the NLWRA land use data. Given that a decision was made to undertake the project with the NLWRA data it was not considered worthwhile and necessary to provide more detail.

Warrego-Paroo Catchment (Queensland)

- North west part of the Darling Basin – 130,000 km^2, mainly flat and predominantly used for grazing.
- No CMSS or related nutrient study has been undertaken for this catchment.
- Limited land use data available from the Department of Natural Resources (DNR) - sourced 1989 and 1995.
- No sub-catchment regions or shape files are available for this catchment.
- No nutrient export figures are available for this catchment.
- An ADVISE model was being adapted with GIS to provide decision support applications to help with nutrient exports from various land uses. It is not clear what its current status is.

Condamine-Balonne Catchment (Queensland)

- Northern part of the Darling Basin - 93,000 km^2, contains extensive areas of relict and current floodplains including the Darling Downs, largest area of broad-acre farming – irrigated and dryland - in Queensland.
- An NPI WinCMSS study is currently being undertaken for this catchment by DNR in conjunction with Sinclair Knight Merz (SKM).
- Limited land use data is available from DNR 1989-95 that is being supplemented with more detailed land use data from the mid-late ’90s. Recent data is to be used for intensive livestock sites.
- Sub-catchment shape files as used in the WinCMSS study have been provided.
- Land use export coefficients used in the study have been provided.
- An ADVISE model was being adapted with GIS to provide decision support applications to help with nutrient exports from various land uses in the mid 1990s. It is not clear what its current status is.

Border Rivers Catchments (Queensland & New South Wales)

- North east part of the Darling Basin – mainly flat, land use is mixed with dryland grazing and cropping, and irrigated cropping and horticulture predominantly on floodplains and the Granite Belt.
- A CMSS study was undertaken for this catchment by Patterson Britton for DLWC in 1998 (Atech Group has the CMSS files but not the report).
- It is not clear what the origin of the land use information used for this study is.
- Nutrient export data are available in the CMSS files however the code descriptions are unable to be deciphered at present.
- Shape files for sub-catchments are available from the WinCMSS files.

Gwydir Catchment

- North east part of the Darling Basin in northern NSW.
- A CMSS study was undertaken for this catchment by DLWC and the North West Catchment Management Committee in 1995 (Atech Group has CMSS files but not the report).
- It is presumed that DLWC land use information was used for this study, however details and the date of origin of this information is not clear.
- Shape files for sub-catchments are available from the CMSS files.
- Nutrient export data are available from the CMSS files - difficult to decipher however.

Namoi Catchment

- North east part of the Darling Basin in northern NSW.
- A CMSS study was undertaken for this catchment by DLWC and the North West Catchment Management Committee in 1996 (Atech Group have the CMSS files but not the report).
- It is presumed that DLWC land use information was used for this CMSS study, however details and the date origin of this information is not clear.
- Shape files for sub-catchments are available from the CMSS files.
- Nutrient export data are available from the CMSS files.

Central West Catchment

- Consists of the Macquarie, Castlereagh and Bogan catchments in the north east part of the Darling Basin in the central west NSW.
- A CMSS study was undertaken for this catchment by the Macquarie TCM Committee and DLWC in the mid 1990s (no report or CMSS files are available).
- An AEAM study was undertaken on the Macquarie Marshes in 1990, however this has little relevance for the whole catchment (Atech Group has files).

- It is presumed that DLWC land use information was used for this study, however details and the date origin of this information is not clear.
- No sub-catchments shape files as used in the CMSS study are available.
- No information on the nutrient export data used in the CMSS study is available.
- It is not clear whether the Castlereagh catchment was part of this study or the subject of a separate study.

Western Region

- A generally arid and flat region in the north west part of the Darling Basin in north and central NSW.
- At 158,000 km^2 it is easily the biggest catchment region in the MDB.
- No CMSS or nutrient study has been undertaken for this region.
- Limited land use information available from DLWC for this catchment.
- There are no recognised sub-catchment regions, consequently no shape files are available.
- There is no information on the nutrient export data for the area.

Lachlan Catchment

- Northern part of the Murray catchment in central NSW.
- A nutrient management plan involving a CMSS study was undertaken for this catchment by the Lachlan Catchment Management Committee and DLWC in 1998 (Atech Group has the CMSS report but not the CMSS files).
- The origin of the land use data used in CMSS is uncertain but is pre 1995, and probably largely from DLWC.
- Shape files for sub-catchments are available from the CMSS files.
- Nutrient export data as used in the CMSS study are available.

Murrumbidgee Catchment

- Northern part of the Murray Basin in southern NSW, which encompasses the Basin's largest urban area – Canberra.
- A nutrient management plan, involving a CMSS study, was undertaken for this catchment by the Murrumbidgee Catchment Management Committee and DLWC in the mid 1990s. (Atech Group was not able to access the CMSS report or files).
- The origin of the land use data used in CMSS is unknown but is probably largely from DLWC.
- The sub-catchments shape files as used in the CMSS study are not available.
- Information on the nutrient export data used in the CMSS study is not available.

Murray Catchment

- The Murray catchment north of the River Murray in NSW.

- The catchment boundaries vary depending on the source and age of the document.
- A nutrient management plan involving a CMSS study was undertaken for this catchment by the NSW Murray Catchment Management Committee in 1999 (Atech Group was not able to access the report or files on the CMSS study, although it does have a copy of the catchment Water Quality Strategy report).
- The origin of the land use data used in CMSS is unknown but is probably largely from DLWC.
- The sub-catchments shape files as used in the CMSS study are not available.
- Information on the nutrient export data used in the CMSS study is not available.

Lower Murray-Darling Region

- South west part of the Murray-Darling catchment in western NSW.
- No CMSS or nutrient study has been undertaken for this region.
- Limited land use information is available from DLWC and the MDBC for this region.
- No sub-catchment regions or shape files are available for this region.
- No nutrient export figures are available for this region.

Upper North East Catchment

- A comparatively small headwater region in the south eastern part of the Murray Basin in Victoria which includes the Kiewa and Mitta Mitta rivers.
- Part of the north East Catchment Region.
- CMSS and water quality strategy studies have been undertaken for this region (Atech Group does not have details of the CMSS study report or files, but does have a detailed Water Quality Strategy report).
- A land use map presented in the water quality strategy study was generated by DNRE in 1998 however, the date of origin or details of the sources of the information is not clear.
- No sub-catchment regions or shape files are available for this catchment.
- No nutrient export figures are available for this catchment.

Ovens River

- A comparatively small catchment in the south east part of the Murray Basin in Victoria.
- Part of the north East Catchment Region.
- A water quality strategy (1998) and associated AEAM (1997) study have been undertaken for this region (Atech Group has copies of both reports).
- Land use information used in the water quality strategy and AEAM studies was generated by DNRE, however the date of origin or details of the sources of the information is uncertain.
- Sub-catchment regions or shape files are not currently available for this catchment.

- Nutrient export figures are currently not available for this catchment (AEAM uses nutrient concentration value in runoff rather than nutrient exports per hectare).

Goulburn-Broken Catchment

- A highly agricultural catchment in the south central part of the Murray Basin in Victoria.
- A water quality strategy (1998) and associated AEAM (1994) and CMSS (1994) studies have been undertaken for this region (Atech Group has copies of these and other reports and the AEAM and CMSS files).
- It is not clear where the land use data as used in the AEAM and CMSS studies was derived from.
- Only crude sub-catchment shape files are available for this catchment at present.
- Nutrient export data as used in the CMSS study is available.

North Central Catchment

- Southern part of the Murray Basin in Victoria which includes the Campaspe, Lodden and Avoca rivers.
- Water quality studies and AEAM nutrient studies has been undertaken for the Campaspe and Lodden catchments (Atech Group has a copy of the AEAM files only).
- It is not clear where the land use data as used in the AEAM studies was derived from.
- Only crude sub-catchment shape files are available for this catchment at present.
- There is no information on any nutrient export rates for the region.

Wimmera Region

- Lower south western part of the Murray Basin in Victoria.
- It is believed that a new water quality study is being undertaken for this region, however no details were available.
- Nutrient study based on CMSS modelling was undertaken in 1997 (Atech Group was unable to access the CMSS files or report).
- There is no knowledge about the nature of any land use information used in such studies.
- There is no information on nutrient export rates for the region.

Mallee Region

- Upper south western part of the Murray Basin in Victoria adjoining the River Murray.

- A water quality study has been undertaken for this region by Aegis Consulting on behalf of the Mallee CMA (1999) – this was based on an AEAM study (Atech Group has a copy of a draft of the water quality report).
- There is little detail about the land use information used in this study.
- Nutrient export rates as used in the study are available.

Riverine Corridor

- A narrow riverine corridor either side of the River Murray in the South Australian Murray-Darling Basin – within which a significant portion of land is devoted to intensive irrigated agriculture.
- A WinCMSS type of study for the Riverland region around Berri, Barmera, Loxton and Renmark was commenced by the SA EPA however this was abandoned because virtually all drainage was collected and disposed of into evaporation basins for salinity management purposes.
- Details of the land use data used for this study are not known.
- Details of nutrient export rates used in this study are not yet available.
- Sub-catchment regions in this region do not appear to exist and the shape files are not available. Discussions with Doug McMurray (SA EPA) suggest that this region is sensibly divided into an upper and lower corridor at Murray Bridge.

Dryland Region

- All of the South Australian part of the Murray catchment except for the Riverine Corridor - largely flat and arid.
- No CMSS or nutrient study has been undertaken for this region.
- Little other than very general land use information is available for this region.
- There are no recognised sub-catchment regions, consequently no shape files are available.
- There is no information on the nutrient export data for the area.

Appendix 2: Detailed Land Use Breakdown by Catchment Region

MURRAY-DARLING BASIN

Baxter and Russell Land Use classification	Area (km^2)	Percentage	Aggregated Land Use Attribution	LU code
NO DATA	146	0.014	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	10,824	1.025	Woodland/forest/forestry	1
CONSERVATION-Wilderness area	5,699	0.539	Woodland/forest/forestry	1
CONSERVATION-National park	24,812	2.349	Woodland/forest/forestry	1
CONSERVATION-National monument	460	0.044	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	1,188	0.112	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	738	0.070	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	17,244	1.632	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Defence land	145	0.014	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	6,529	0.618	Water/wetlands	0
CONSERVATION-Water-Rivers	75	0.007	Water/wetlands	0
CONSERVATION-Water-Wetlands	2,367	0.224	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	721,726	68.318	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	45,124	4.271	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	39,595	3.748	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	665	0.063	Urban	8
INTENSIVE USES-Institutional uses	457	0.043	Urban	8
INTENSIVE USES-Utilities-Water storage	120	0.011	Water/wetlands	0
INTENSIVE USES-Transport-Airports	67	0.006	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	2,963	0.280	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	3,030	0.287	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	65,581	6.208	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	28	0.003	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	89,266	8.450	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Cereals-Rice	1,570	0.149	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	114	0.011	Cropping	4

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PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	3,548	0.336	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	216	0.020	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	6,855	0.649	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	3,866	0.366	Cotton	5
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	153	0.014	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	114	0.011	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	244	0.023	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Apples	57	0.005	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Pears	41	0.004	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	218	0.021	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Plantation fruit	3	0.000	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	520	0.049	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	50	0.005	Horticulture - perennial	7
Total Basin	**1,056,418**	**100.000**		

MURRAY-DARLING BASIN

Aggregated primary land use	Area in km^2	% Area	Aggregated land Use Code
Woodland/forest/forestry	149,030	14.10	1
Unimproved pasture	724,690	68.59	2
Improved pasture	65,580	6.21	3
Cropping	101,570	9.61	4
Cotton	3,870	0.36	5
Horticulture - annual	270	0.02	6
Horticulture - perennial	1,130	0.10	7
Urban	1,190	0.11	8
Water/wetlands	9,090	0.86	0
Total area	**1,056,420**	**99.96**	

WARREGO-PAROO CATCHMENT - Queensland

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggre-gated LU Code
CONSERVATION-National park	255,506	2.02	Woodland/forest/forestry	1
CONSERVATION-National monument	222	0.00	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	337,300	2.67	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	32,776	0.26	Water/wetlands	0
CONSERVATION-Water-Wetlands	1,477	0.01	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	11,313,948	89.60	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	380,380	3.01	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	71,247	0.56	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	220	0.00	Urban	8
INTENSIVE USES-Institutional uses	1,228	0.01	Urban	8
INTENSIVE USES-Transport-Airports	438	0.00	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	108	0.00	Unimproved pasture	2
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	216,836	1.72	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	13,585	0.11	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	329	0.00	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	902	0.01	Cropping	4
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	108	0.00	Horticulture - annual	6
Total area in hectares	**12,626,610**	**100.00**		

WARREGO-PAROO CATCHMENT - Queensland

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	10,447	8.27	1
Unimproved pasture	113,141	89.60	2
Improved pasture	2,168	1.72	3
Cropping	148	0.12	4
Horticulture - annual	1	0.00	6
Urban	19	0.01	8
Water/wetlands	343	0.27	0
Total area	**126,266**	**100.00**	

CONDAMINE-BALONNE CATCHMENT - Queensland

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
NO DATA	163	0.00	Woodland/forest/forestry	1
CONSERVATION-National park	85,132	0.89	Woodland/forest/forestry	1
CONSERVATION-National monument	1,318	0.01	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	986	0.01	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	91,419	0.95	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	1,297	0.01	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	6,348,235	66.21	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	1,138,608	11.87	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	601,501	6.27	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	5,949	0.06	Urban	8
INTENSIVE USES-Institutional uses	219	0.00	Urban	8
INTENSIVE USES-Utilities-Water storage	2,296	0.02	Water/wetlands	0
INTENSIVE USES-Transport-Airports	771	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	35,644	0.37	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	431	0.00	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	340,209	3.55	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	790,256	8.24	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	1,432	0.01	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	17,196	0.18	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	5,305	0.06	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	31,291	0.33	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	87,098	0.91	Cotton	5
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	878	0.01	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	545	0.01	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	109	0.00	Horticulture - perennial	7
Total area in hectares	**9,588,287**	**100.00**		

CONDAMINE-BALONNE CATCHMENT - Queensland

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	19,196	20.02	1
Unimproved pasture	63,839	66.58	2
Improved pasture	3,402	3.55	3
Cropping	8,455	8.82	4
Cotton	871	0.91	5
Horticulture - annual	14	0.01	6
Horticulture - perennial	1	0.00	7
Urban	69	0.07	8
Water/wetlands	36	0.04	0
Total area	**95,883**	**100.00**	

QLD BORDER RIVERS - Queensland

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
NO DATA	1,149	0.03	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	1,088	0.03	Woodland/forest/forestry	1
CONSERVATION-National park	35,982	0.95	Woodland/forest/forestry	1
CONSERVATION-National monument	109	0.00	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	2,702	0.07	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	37,433	0.99	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Defence land	1,607	0.04	Woodland/forest/forestry	1
CONSERVATION-Water-Wetlands	217	0.01	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	2,214,841	58.39	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	545,870	14.39	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	371,730	9.80	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	817	0.02	Urban	8
INTENSIVE USES-Institutional uses	3	0.00	Urban	8
INTENSIVE USES-Transport-Airports	217	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	1,864	0.05	Unimproved pasture	2
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	93,525	2.47	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	444,410	11.72	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	109	0.00	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	654	0.02	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	726	0.02	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	10,733	0.28	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	21,150	0.56	Cotton	5
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	1,409	0.04	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Apples	1,691	0.04	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Pears	108	0.00	Horticulture - perennial	7

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PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	2,815	0.07	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	325	0.01	Horticulture - perennial	7
Total area in hectares	**3,793,284**	**100.00**		

QLD BORDER RIVERS - Queensland

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	9,977	26.30	1
Unimproved pasture	22,167	58.44	2
Improved pasture	935	2.47	3
Cropping	4,566	12.04	4
Cotton	212	0.56	5
Horticulture - annual	14	0.04	6
Horticulture - perennial	49	0.13	7
Urban	10	0.03	8
Water/wetlands	2	0.01	0
Total area	**37,933**	**100.00**	

NSW BORDER RIVERS - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
CONSERVATION-Strict nature reserve	5,054	0.21	Woodland/forest/forestry	1
CONSERVATION-Wilderness area	323	0.01	Woodland/forest/forestry	1
CONSERVATION-National park	6,735	0.28	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	93,156	3.86	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Defence land	682	0.03	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	215	0.01	Water/wetlands	0
CONSERVATION-Water-Wetlands	108	0.00	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	1,181,759	48.96	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	382,892	15.86	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	44,439	1.84	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	1,231	0.05	Urban	8
INTENSIVE USES-Institutional uses	1,931	0.08	Urban	8
INTENSIVE USES-Transport-Airports	107	0.00	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	1,259	0.05	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	162	0.01	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	102,507	4.25	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	496,396	20.57	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	527	0.02	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	8,871	0.37	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	430	0.02	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	23,147	0.96	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	61,408	2.54	Cotton	5
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	108	0.00	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	217	0.01	Horticulture - perennial	7
Total area in hectares	**2,413,663**	**100.00**		

NSW BORDER RIVERS - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	5,334	22.10	1
Unimproved pasture	11,830	49.01	2
Improved pasture	1,025	4.25	3
Cropping	5,294	21.93	4
Cotton	614	2.54	5
Horticulture - annual	1	0.00	6
Horticulture - perennial	2	0.01	7
Urban	33	0.14	8
Water/wetlands	3	0.01	0
Total area	**24,137**	**100.00**	

GWYDIR CATCHMENT - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggre-gated LU Code
CONSERVATION-Strict nature reserve	2,560	0.10	Woodland/forest/forestry	1
CONSERVATION-National park	10,844	0.41	Woodland/forest/forestry	1
CONSERVATION-National monument	106	0.00	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	107	0.00	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	61,502	2.32	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	214	0.01	Water/wetlands	0
CONSERVATION-Water-Wetlands	1,176	0.04	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	1,544,780	58.24	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	307,851	11.61	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	40,261	1.52	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	428	0.02	Urban	8
INTENSIVE USES-Institutional uses	1,598	0.06	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	1,495	0.06	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	480	0.02	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	122,279	4.61	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	453,123	17.08	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	119	0.00	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	6,322	0.24	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	429	0.02	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	20,834	0.79	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	75,320	2.84	Cotton	5
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	107	0.00	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	538	0.02	Horticulture - perennial	7
Total area in hectares	**2,652,472**	**100.00**		

GWYDIR CATCHMENT - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	4,237	15.97	1
Unimproved pasture	15,463	58.30	2
Improved pasture	1,223	4.61	3
Cropping	4,808	18.13	4
Cotton	753	2.84	5
Horticulture - annual	1	0.00	6
Horticulture - perennial	5	0.02	7
Urban	20	0.08	8
Water/wetlands	14	0.05	0
Total area	**26,525**	**100.00**	

NAMOI CATCHMENT - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggre-gated LU Code
CONSERVATION-Strict nature reserve	86,826	2.07	Woodland/forest/forestry	1
CONSERVATION-National park	38,327	0.92	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	744	0.02	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	49,697	1.19	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	6,635	0.16	Water/wetlands	0
CONSERVATION-Water-Wetlands	1,366	0.03	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	2,605,823	62.24	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	134,986	3.22	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	417,810	9.98	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	2,537	0.06	Urban	8
INTENSIVE USES-Institutional uses	1,271	0.03	Urban	8
INTENSIVE USES-Utilities-Water storage	2,866	0.07	Water/wetlands	0
INTENSIVE USES-Transport-Airports	213	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	2,854	0.07	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	5,746	0.14	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	245,278	5.86	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	458,519	10.95	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	319	0.01	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	22,110	0.53	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	1,479	0.04	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	12,604	0.30	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	88,457	2.11	Cotton	5
Total area in hectares	**4,186,466**	**100.00**		

NAMOI CATCHMENT - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	7,341	17.54	1
Unimproved pasture	26,087	62.31	2
Improved pasture	2,453	5.86	3
Cropping	4,950	11.82	4
Cotton	885	2.11	5
Urban	40	0.10	8
Water/wetlands	109	0.26	0
Total area	**41,865**	**100.00**	

WESTERN REGION - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggre-gated LU Code
CONSERVATION-Strict nature reserve	82,180	0.52	Woodland/forest/forestry	1
CONSERVATION-National park	66,896	0.42	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	114,880	0.73	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	133,441	0.85	Water/wetlands	0
CONSERVATION-Water-Wetlands	160,237	1.01	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	14,721,701	93.24	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	197,808	1.25	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	74,830	0.47	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	1,497	0.01	Urban	8
INTENSIVE USES-Institutional uses	1,692	0.01	Urban	8
INTENSIVE USES-Utilities-Water storage	427	0.00	Water/wetlands	0
INTENSIVE USES-Transport-Airports	215	0.00	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	942	0.01	Unimproved pasture	2
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	13,929	0.09	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	608	0.00	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	194,317	1.23	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	3,154	0.02	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	6,189	0.04	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	14,732	0.09	Cotton	5
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	106	0.00	Horticulture - perennial	7
Total area in hectares	**15,789,780**	**100.00**		

WESTERN REGION - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	5,372	3.40	1
Unimproved pasture	147,226	93.24	2
Improved pasture	139	0.09	3
Cropping	2,037	1.29	4
Cotton	147	0.09	5
Horticulture - perennial	1	0.00	7
Urban	34	0.02	8
Water/wetlands	2,941	1.86	0
Total area	**157,898**	**100.00**	

CENTRAL WEST REGION - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
CONSERVATION-Strict nature reserve	23,562	0.26	Woodland/forest/forestry	1
CONSERVATION-Wilderness area	8,244	0.09	Woodland/forest/forestry	1
CONSERVATION-National park	54,406	0.59	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	17,675	0.19	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	150,443	1.64	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	1,154	0.01	Water/wetlands	0
CONSERVATION-Water-Rivers	420	0.00	Water/wetlands	0
CONSERVATION-Water-Wetlands	16,501	0.18	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	6,287,939	68.40	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	100,029	1.09	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	211,598	2.30	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	7,043	0.08	Urban	8
INTENSIVE USES-Institutional uses	5,748	0.06	Urban	8
INTENSIVE USES-Utilities-Water storage	1,969	0.02	Water/wetlands	0
INTENSIVE USES-Transport-Airports	524	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	40,163	0.44	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	45,976	0.50	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	904,006	9.83	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	245	0.00	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	1,246,582	13.56	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	830	0.01	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	15,061	0.16	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	1,677	0.02	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	9,922	0.11	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	37,254	0.41	Cotton	5

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PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	830	0.01	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	104	0.00	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	208	0.00	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Apples	1,032	0.01	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	619	0.01	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	1,555	0.02	Horticulture - perennial	7
Total area in hectares	**9,193,321**	**100.00**		

CENTRAL WEST REGION - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	6,122	6.66	1
Unimproved pasture	63,281	68.83	2
Improved pasture	9,040	9.83	3
Cropping	12,741	13.86	4
Cotton	373	0.41	5
Horticulture – annual	9	0.01	6
Horticulture – perennial	34	0.04	7
Urban	133	0.14	8
Water/wetlands	200	0.22	0
Total area	**91,933**	**100.00**	

LACHLAN CATCHMENT - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
CONSERVATION-Strict nature reserve	225,009	2.48	Woodland/forest/forestry	1
CONSERVATION-National park	87,633	0.97	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	103	0.00	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	128,419	1.42	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Defence land	1,240	0.01	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	64,171	0.71	Water/wetlands	0
CONSERVATION-Water-Rivers	409	0.00	Water/wetlands	0
CONSERVATION-Water-Wetlands	8,098	0.09	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	6,216,471	68.51	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	114,097	1.26	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	107,095	1.18	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	3,592	0.04	Urban	8
INTENSIVE USES-Institutional uses	2,576	0.03	Urban	8
INTENSIVE USES-Utilities-Water storage	102	0.00	Water/wetlands	0
INTENSIVE USES-Transport-Airports	308	0.00	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	25,305	0.28	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	30,626	0.34	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	955,608	10.53	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	204	0.00	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	1,007,932	11.11	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Cereals-Rice	4,326	0.05	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	206	0.00	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	58,885	0.65	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	308	0.00	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	22,784	0.25	Cropping	4

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PRIMARY PRODUCTION-Agricultural land-Cotton	1,062	0.01	Cotton	5
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	1,997	0.02	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	819	0.01	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	206	0.00	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	2,536	0.03	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	1,232	0.01	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	11	0.00	Horticulture - perennial	7
Total area in hectares	**9,073,367**	**100.00**		

LACHLAN CATCHMENT - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	6,944	7.65	1
Unimproved pasture	62,418	68.79	2
Improved pasture	9,556	10.53	3
Cropping	10,944	12.06	4
Cotton	11	0.01	5
Horticulture - annual	28	0.03	6
Horticulture - perennial	40	0.04	7
Urban	65	0.07	8
Water/wetlands	728	0.80	0
Total area	**90,734**	**100.00**	

MURRUMBIDGEE CATCHMENT - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
CONSERVATION-Strict nature reserve	35,685	0.53	Woodland/forest/forestry	1
CONSERVATION-Wilderness area	466	0.01	Woodland/forest/forestry	1
CONSERVATION-National park	413,925	6.18	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	608	0.01	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	88,244	1.32	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Defence land	6,777	0.10	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	26,237	0.39	Water/wetlands	0
CONSERVATION-Water-Wetlands	6,873	0.10	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	3,754,275	56.01	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	343,448	5.12	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	159,274	2.38	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	21,044	0.31	Urban	8
INTENSIVE USES-Institutional uses	4,364	0.07	Urban	8
INTENSIVE USES-Utilities-Water storage	1,415	0.02	Water/wetlands	0
INTENSIVE USES-Transport-Airports	508	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	43,948	0.66	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	120,730	1.80	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	649,838	9.69	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	407	0.01	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	791,258	11.80	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Cereals-Rice	85,071	1.27	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	405	0.01	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	85,089	1.27	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	1,827	0.03	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	37,935	0.57	Cropping	4

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PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	3,006	0.04	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	1,323	0.02	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	7,646	0.11	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Apples	908	0.01	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	3,570	0.05	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	6,936	0.10	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	91	0.00	Horticulture - perennial	7
Total area in hectares	**6,703,133**	**100.00**		

MURRUMBIDGEE CATCHMENT - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	11,696	17.45	1
Unimproved pasture	37,982	56.66	2
Improved pasture	6,498	9.69	3
Cropping	10,016	14.94	4
Horticulture - annual	43	0.06	6
Horticulture - perennial	192	0.29	7
Urban	259	0.39	8
Water/wetlands	345	0.52	0
Total area	**67,031**	**100.00**	

LOWER MURRAY-DARLING REGION - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
NO DATA	281	0.00	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	94,707	1.51	Woodland/forest/forestry	1
CONSERVATION-National park	71,795	1.15	Woodland/forest/forestry	1
CONSERVATION-National monument	253	0.00	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	5,354	0.09	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	1,686	0.03	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	210,291	3.36	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	265,528	4.24	Water/wetlands	0
CONSERVATION-Water-Rivers	70	0.00	Water/wetlands	0
CONSERVATION-Water-Wetlands	8,638	0.14	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	5,453,182	87.01	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	9,008	0.14	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	66,122	1.05	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	245	0.00	Urban	8
INTENSIVE USES-Institutional uses	414	0.01	Urban	8
INTENSIVE USES-Transport-Airports	103	0.00	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	319	0.01	Unimproved pasture	2
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	6,309	0.10	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	62,636	1.00	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	3,807	0.06	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	204	0.00	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Cotton	104	0.00	Cotton	5
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	267	0.00	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	2,425	0.04	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	102	0.00	Horticulture - perennial	7

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PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	3,660	0.06	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	75	0.00	Horticulture - perennial	7
Total area in hectares	**6,267,584**	**100.00**		

LOWER MURRAY-DARLING REGION - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	4,595	7.33	1
Unimproved pasture	54,535	87.01	2
Improved pasture	63	0.10	3
Cropping	666	1.06	4
Cotton	1	0.00	5
Horticulture - annual	3	0.00	6
Horticulture - perennial	63	0.10	7
Urban	8	0.01	8
Water/wetlands	2,742	4.38	0
Total area	**62,676**	**100.00**	

MURRAY CATCHMENT - New South Wales

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
CONSERVATION-Strict nature reserve	312	0.01	Woodland/forest/forestry	1
CONSERVATION-National park	156,337	4.36	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	730	0.02	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	31,764	0.89	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	10,918	0.30	Water/wetlands	0
CONSERVATION-Water-Rivers	327	0.01	Water/wetlands	0
CONSERVATION-Water-Wetlands	20,200	0.56	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	2,159,588	60.20	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	64,976	1.81	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	174,586	4.87	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	2,788	0.08	Urban	8
INTENSIVE USES-Institutional uses	986	0.03	Urban	8
INTENSIVE USES-Utilities-Water storage	763	0.02	Water/wetlands	0
INTENSIVE USES-Transport-Airports	201	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	9,867	0.28	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	24,814	0.69	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	360,865	10.06	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	101	0.00	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	426,013	11.88	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Cereals-Rice	66,556	1.86	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	904	0.03	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	37,919	1.06	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	416	0.01	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	30,330	0.85	Cropping	4
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	960	0.03	Horticulture - annual	6

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PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	2,147	0.06	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	802	0.02	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Apples	101	0.00	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	11	0.00	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Plantation fruit	6	0.00	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	1,155	0.03	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	25	0.00	Horticulture - perennial	7
Total area in hectares	**3,587,468**	**100.00**		

MURRAY CATCHMENT - New South Wales

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	4,536	12.64	1
Unimproved pasture	21,695	60.47	2
Improved pasture	3,609	10.06	3
Cropping	5,621	15.67	4
Horticulture - annual	31	0.09	6
Horticulture - perennial	21	0.06	7
Urban	40	0.11	8
Water/wetlands	322	0.90	0
Total area	**35,875**	**100.00**	

NORTH EAST CATCHMENT - Victoria

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
NO DATA	2,706	0.13	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	14,876	0.74	Woodland/forest/forestry	1
CONSERVATION-Wilderness area	19,308	0.96	Woodland/forest/forestry	1
CONSERVATION-National park	359,054	17.89	Woodland/forest/forestry	1
CONSERVATION-National monument	7,810	0.39	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	800	0.04	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	656	0.03	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	82,133	4.09	Woodland/forest/forestry	1
CONSERVATION-Water-Rivers	76	0.00	Water/wetlands	0
CONSERVATION-Water-Wetlands	298	0.01	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	465,093	23.18	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	100,906	5.03	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	668,262	33.30	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	2,810	0.14	Urban	8
INTENSIVE USES-Institutional uses	5,434	0.27	Urban	8
INTENSIVE USES-Utilities-Water storage	842	0.04	Water/wetlands	0
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	3,344	0.17	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	43,003	2.14	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	196,669	9.80	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	24,776	1.23	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Cereals-Rice	22	0.00	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	299	0.01	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	1,203	0.06	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	2,493	0.12	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	1,701	0.08	Cropping	4

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PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	71	0.00	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Apples	100	0.00	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	200	0.01	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	1,452	0.07	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	175	0.01	Horticulture - perennial	7
Total area in hectares	**2,006,574**	**100.00**		

NORTH EAST CATCHMENT - Victoria

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	12,995	64.76	1
Unimproved pasture	4,684	23.35	2
Improved pasture	1,967	9.80	3
Cropping	305	1.52	4
Horticulture - annual	1	0.00	6
Horticulture - perennial	19	0.10	7
Urban	82	0.41	8
Water/wetlands	12	0.06	0
Total area	**20,066**	**100.00**	

GOULBURN-BROKEN CATCHMENT - Victoria

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
NO DATA	199	0.01	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	10,159	0.42	Woodland/forest/forestry	1
CONSERVATION-National park	84,731	3.52	Woodland/forest/forestry	1
CONSERVATION-National monument	5,870	0.24	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	1,988	0.08	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	10,611	0.44	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	88,089	3.66	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	500	0.02	Water/wetlands	0
CONSERVATION-Water-Wetlands	4,116	0.17	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	822,117	34.16	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	73,460	3.05	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	434,823	18.07	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	3,606	0.15	Urban	8
INTENSIVE USES-Institutional uses	12,715	0.53	Urban	8
INTENSIVE USES-Utilities-Water storage	1,098	0.05	Water/wetlands	0
INTENSIVE USES-Transport-Airports	299	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	49,080	2.04	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	23,210	0.96	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	618,463	25.70	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	299	0.01	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	129,330	5.37	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Cereals-Rice	957	0.04	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	1,395	0.06	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	5,007	0.21	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	1,097	0.05	Cropping	4

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PRIMARY PRODUCTION-Agricultural land-Legumes	9,163	0.38	Cropping	4
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	1,400	0.06	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	699	0.03	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	508	0.02	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Apples	1,000	0.04	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Pears	4,003	0.17	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	5,108	0.21	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Plantation fruit	295	0.01	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	1,095	0.05	Horticulture - perennial	7
Total area in hectares	**2,406,491**	**100.00**		

GOULBURN-BROKEN CATCHMENT - Victoria

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	7,334	30.48	1
Unimproved pasture	8,712	36.20	2
Improved pasture	6,185	25.70	3
Cropping	1,469	6.11	4
Horticulture - annual	21	0.09	6
Horticulture - perennial	120	0.50	7
Urban	166	0.69	8
Water/wetlands	57	0.24	0
Total area	**24,065**	**100.00**	

NORTH CENTRAL CATCHMENT - Victoria

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
NO DATA	3,888	0.15	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	13,975	0.54	Woodland/forest/forestry	1
CONSERVATION-National park	17,102	0.67	Woodland/forest/forestry	1
CONSERVATION-National monument	1,642	0.06	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	2,201	0.09	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	10,421	0.41	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	43,640	1.70	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	5,635	0.22	Water/wetlands	0
CONSERVATION-Water-Wetlands	3,501	0.14	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	942,475	36.68	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	49,136	1.91	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	187,850	7.31	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	6,000	0.23	Urban	8
INTENSIVE USES-Institutional uses	2,112	0.08	Urban	8
INTENSIVE USES-Utilities-Water storage	199	0.01	Water/wetlands	0
INTENSIVE USES-Transport-Airports	390	0.02	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	48,207	1.88	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	5,211	0.20	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	704,922	27.43	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	702	0.03	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	407,656	15.86	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	1,308	0.05	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	16,239	0.63	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	982	0.04	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	88,688	3.45	Cropping	4

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PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	1,254	0.05	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	1,678	0.07	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	101	0.00	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Apples	894	0.03	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	292	0.01	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	1,293	0.05	Horticulture - perennial	7
Total area in hectares	**2,569,591**	**100.00**		

NORTH CENTRAL CATCHMENT - Victoria

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	3,358	13.07	1
Unimproved pasture	9,907	38.55	2
Improved pasture	7,049	27.43	3
Cropping	5,149	20.04	4
Horticulture - annual	29	0.11	6
Horticulture - perennial	26	0.10	7
Urban	85	0.33	8
Water/wetlands	93	0.36	0
Total area	**25,696**	**100.00**	

WIMMERA REGION - Victoria

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
NO DATA	100	0.00	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	25,628	1.15	Woodland/forest/forestry	1
CONSERVATION-Wilderness area	7,047	0.32	Woodland/forest/forestry	1
CONSERVATION-National park	120,473	5.39	Woodland/forest/forestry	1
CONSERVATION-National monument	398	0.02	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	1,698	0.08	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	4,384	0.20	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	43,512	1.95	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	1,295	0.06	Water/wetlands	0
CONSERVATION-Water-Wetlands	1,896	0.08	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	662,938	29.68	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	9,169	0.41	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	86,544	3.87	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	1,995	0.09	Urban	8
INTENSIVE USES-Transport-Airports	1,100	0.05	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	1,896	0.08	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	265	0.01	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	375,826	16.83	Improved pasture	3
PRIMARY PRODUCTION-Farm forestry-Agroforestry	201	0.01	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	579,986	25.97	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	1,398	0.06	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	63,682	2.85	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	1,996	0.09	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	239,388	10.72	Cropping	4
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	597	0.03	Horticulture - perennial	7

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PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	298	0.01	Horticulture - perennial	7
Total area in hectares	**2,233,708**	**100.00**		

WIMMERA REGION - Victoria

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	2,994	13.40	1
Unimproved pasture	6,648	29.76	2
Improved pasture	3,758	16.83	3
Cropping	8,864	39.69	4
Horticulture - perennial	9	0.04	7
Urban	31	0.14	8
Water/wetlands	32	0.14	0
Total area	**22,337**	**100.00**	

MALLEE REGION - Victoria

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
NO DATA	6,125	0.16	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	109,738	2.89	Woodland/forest/forestry	1
CONSERVATION-Wilderness area	534,812	14.09	Woodland/forest/forestry	1
CONSERVATION-National park	606,159	15.97	Woodland/forest/forestry	1
CONSERVATION-National monument	3,205	0.08	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	8,696	0.23	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	23,868	0.63	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	69,252	1.82	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	6,193	0.16	Water/wetlands	0
CONSERVATION-Water-Rivers	31	0.00	Water/wetlands	0
CONSERVATION-Water-Wetlands	1,530	0.04	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	1,068,927	28.17	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	6,795	0.18	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	258,100	6.80	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	1,795	0.05	Urban	8
INTENSIVE USES-Institutional uses	1,935	0.05	Urban	8
INTENSIVE USES-Transport-Airports	316	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	2,917	0.08	Unimproved pasture	2
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	244,373	6.44	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	699,104	18.42	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Cereals-Rice	34	0.00	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	707	0.02	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	7,902	0.21	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	1,412	0.04	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	108,160	2.85	Cropping	4

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PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	1,870	0.05	Horticulture - annual	5
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	202	0.01	Horticulture - annual	5
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	3,080	0.08	Horticulture - perennial	6
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	1,622	0.04	Horticulture - perennial	6
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	14,290	0.38	Horticulture - perennial	6
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	1,655	0.04	Horticulture - perennial	6
Total area in hectares	**3,794,805**	**100.00**		

MALLEE REGION - Victoria

Aggregated Primary Land Use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	16,267	42.87	1
Unimproved pasture	10,718	28.25	2
Improved pasture	2,444	6.44	3
Cropping	8,173	21.54	4
Horticulture - annual	21	0.05	5
Horticulture - perennial	206	0.54	6
Urban	40	0.11	8
Water/wetlands	78	0.20	0
Total area	**37,948**	**100.00**	

NORTH RIVERINE CORRIDOR - South Australia

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggre-gated LU Code
CONSERVATION-Strict nature reserve	2,047	0.45	Woodland/forest/forestry	1
CONSERVATION-National monument	17,749	3.88	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	5,337	1.17	Woodland/forest/forestry	1
CONSERVATION-Managed resource protected area	17,802	3.89	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	658	0.14	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	3,766	0.82	Water/wetlands	0
CONSERVATION-Water-Rivers	1,328	0.29	Water/wetlands	0
CONSERVATION-Water-Wetlands	512	0.11	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	273,207	59.71	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	16,846	3.68	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	510	0.11	Urban	8
INTENSIVE USES-Transport-Airports	511	0.11	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	21,178	4.63	Unimproved pasture	2
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	17,255	3.77	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	50,874	11.12	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	102	0.02	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	102	0.02	Cropping	4
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	920	0.20	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	306	0.07	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	8,705	1.90	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	3,986	0.87	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	12,206	2.67	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	1,635	0.36	Horticulture - perennial	7
Total area in hectares	**457,542**	**100.00**		

NORTH RIVERINE CORRIDOR - South Australia

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	604	13.21	1
Unimproved pasture	2,944	64.34	2
Improved pasture	173	3.77	3
Cropping	511	11.16	4
Horticulture - annual	12	0.27	6
Horticulture - perennial	265	5.80	7
Urban	10	0.22	8
Water/wetlands	56	1.23	0
Total area	**4,575**	**100.00**	

SOUTH RIVERINE CORRIDOR - South Australia (includes Lake Alexandrina and the Coorong)

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggre-gated LU Code
CONSERVATION-Strict nature reserve	1,119	0.19	Woodland/forest/forestry	1
CONSERVATION-National monument	559	0.10	Woodland/forest/forestry	1
CONSERVATION-National park	30,248	5.23	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Defence land	2,996	0.52	Woodland/forest/forestry	1
CONSERVATION-Water-Rivers	92,005	15.90	Water/wetlands	0
CONSERVATION-Habitat/species management area	404	0.07	Woodland/forest/forestry	1
CONSERVATION-Strict nature reserve	227	0.04	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	275,908	47.68	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	6,715	1.16	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	1,793	0.31	Urban	8
INTENSIVE USES-Institutional uses	691	0.12	Urban	8
INTENSIVE USES-Transport-Airports	506	0.09	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	696	0.12	Unimproved pasture	2
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	72,682	12.56	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	86,083	14.88	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	203	0.04	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	3,599	0.62	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	0	0.00	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	101	0.02	Cropping	4
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	105	0.02	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	1,214	0.21	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	304	0.05	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	5	0.00	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	397	0.07	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	101	0.02	Horticulture - perennial	7
Total area in hectares	**578,661**	**100.00**		

SOUTH RIVERINE CORRIDOR - South Australia

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	423	7.30	1
Unimproved pasture	2,766	47.80	2
Improved pasture	727	12.56	3
Cropping	900	15.55	4
Horticulture - annual	13	0.23	6
Horticulture - perennial	8	0.14	7
Urban	30	0.52	8
Water/wetlands	920	15.90	0
Total area	**5,787**	**100.00**	

DRYLAND REGION - South Australia

Baxter & Russell Land Use Description	Area (ha)	Area (%)	Aggregated Land Use Attribution	Aggregated LU Code
CONSERVATION-Strict nature reserve	348,002	5.98	Woodland/forest/forestry	1
CONSERVATION-Wilderness area	202	0.00	Woodland/forest/forestry	1
CONSERVATION-National park	14,901	0.26	Woodland/forest/forestry	1
CONSERVATION-National monument	6,793	0.12	Woodland/forest/forestry	1
CONSERVATION-Habitat/species management area	73,118	1.26	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Vacant crown land	3,237	0.06	Woodland/forest/forestry	1
CONSERVATION-Unmanaged land-Defence land	1,156	0.02	Woodland/forest/forestry	1
CONSERVATION-Water-Lakes	7,549	0.13	Water/wetlands	0
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Grazing of native pastures-Residual/Native pastures	3,884,796	66.77	Unimproved pasture	2
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests	535,120	9.20	Woodland/forest/forestry	1
PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS-Prod forests-Commercial native forest production	794	0.01	Woodland/forest/forestry	1
INTENSIVE USES-Urban uses	607	0.01	Urban	8
INTENSIVE USES-Institutional uses	838	0.01	Urban	8
PRIMARY PRODUCTION-Agricultural land-Unallocated agricultural land	6,300	0.11	Unimproved pasture	2
PRIMARY PRODUCTION-Plantation-Plantation forest production	2,723	0.05	Woodland/forest/forestry	1
PRIMARY PRODUCTION-Grazing improved and fertilised pastures-Pastures	326,248	5.61	Improved pasture	3
PRIMARY PRODUCTION-Permanent cropping-Cereals-Cereals excluding rice	565,242	9.71	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Hay and silage-Non-cereal forage crops	1,116	0.02	Cropping	4
PRIMARY PRODUCTION-Permanent cropping-Oilseeds-Oilseeds	1,418	0.02	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Other non-cereal crops	101	0.00	Cropping	4
PRIMARY PRODUCTION-Agricultural land-Legumes	28,764	0.49	Cropping	4
PRIMARY PRODUCTION-Horticulture-Vegetables-Other vegetables	301	0.01	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Vegetables-Potatoes	2,126	0.04	Horticulture - annual	6
PRIMARY PRODUCTION-Horticulture-Fruit-Citrus	388	0.01	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Fruit-Stone fruit	300	0.01	Horticulture - perennial	7

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PRIMARY PRODUCTION-Horticulture-Fruit-Grapes	5,857	0.10	Horticulture - perennial	7
PRIMARY PRODUCTION-Horticulture-Nuts-Nuts	507	0.01	Horticulture - perennial	7
Total area in hectares	**5,818,506**	**100.00**		

DRYLAND REGION - South Australia

Aggregated primary land use	Area in km^2	% Area	Aggregated Land Use Code
Woodland/forest/forestry	9,860	16.95	1
Unimproved pasture	38,911	66.87	2
Improved pasture	3,262	5.61	3
Cropping	5,966	10.25	4
Horticulture - annual	24	0.04	6
Horticulture - perennial	71	0.12	7
Urban	14	0.02	8
Water/wetlands	75	0.13	0
Total area	**58,185**	**100.00**	

Appendix 3.1: Breakdown of Diffuse Total-Phosphorus Loads by Land Use & Catchment

Catchment Region	**Area (km^2)**	**Woodland/ forest /forestry**	**Unimproved pasture**	**Improved pasture**	**Cropping**	**Cotton**	**Annual horticulture**	**Perennial horticulture**	**Urban**	**Water/ wetlands**	**Total annual TP load**
Warrego-Paroo Catchment	126,490	39.9	450.6	33.0	6.4	-	0.0	-	0.8	0	530.7
Condamine-Balonne Catchment	96,040	117.5	568.1	97.0	867.9	38.9	4.4	0.1	7.4	0	1701.2
Qld Border Rivers Catchment	37,940	59.6	208.2	27.1	434.5	10.0	3.9	7.4	1.1	0	751.7
NSW Border Rivers Catchment	24,160	34.2	131.2	41.9	554.9	27.9	0.3	0.3	3.3	0	793.9
Gwydir Catchment	26,540	28.5	147.7	48.4	481.7	32.6	0.4	0.7	2.3	0	742.3
Namoi Catchment	41,900	47.4	247.5	87.4	492.8	43.4	-	-	4.0	0	922.6
Western Region	158,600	3.9	190.3	0.9	89.1	0.7	-	0.0	0.5	0	285.5
Central West Catchment	91,990	29.1	398.1	249.1	837.7	10.0	2.5	5.4	10.7	0	1542.7
Lachlan Catchment	90,760	18.6	250.9	244.3	711.8	0.1	6.3	5.0	5.1	0	1242.1
Murrumbidgee Catchment	67,090	78.1	195.2	166.2	547.1	-	3.4	9.9	22.5	0	1022.4
Lower Murray-Darling Region	62,680	2.8	54.5	0.2	6.7	0.0	0.1	0.9	0.1	0	65.2
Murray Catchment	35,890	26.5	86.8	74.5	292.1	-	3.2	1.2	3.0	0	487.2
North East Catchment	20,100	97.0	54.4	68.5	30.6	-	0.2	3.2	9.4	0	263.3
Goulburn-Broken Catchment	24,120	49.9	81.5	163.5	114.6	-	4.0	11.4	16.1	0	440.9
North Central Catchment	25,730	16.3	61.9	124.4	183.2	-	7.1	1.7	6.0	0	400.5
Wimmera Region	22,450	11.9	33.7	80.6	296.4	-	-	1.3	1.5	0	425.4
Mallee Region	37,950	10.9	10.7	7.3	81.7	-	0.6	2.9	0.4	0	114.5
North Riverine Corridor	4,580	0.4	2.9	0.5	5.1	-	0.3	3.7	0.1	0	13.1
South Riverine Corridor	5,800	0.1	4.0	6.0	14.3	-	0.4	0.3	0.4	0	25.5
Dryland Region	58,700	7.6	58.8	44.5	105.6	-	1.5	3.6	0.7	0	222.3
Murray-Darling Basin	**1,059,500**	**680.2**	**3,237.0**	**1,515.3**	**6,154.2**	**163.6**	**38.6**	**59.0**	**95.4**	**0**	**11,993**

Appendix 3.2: Breakdown of Diffuse Total-Nitrogen Loads by Land Use and Catchment

Catchment Region	**Area (km^2)**	**Woodland/ forest /forestry**	**Unimproved pasture**	**Improved pasture**	**Cropping**	**Cotton**	**Annual horticulture**	**Perennial horticulture**	**Urban**	**Water/ wetlands**	**Total annual TN Load**
Warrego-Paroo Catchment	126,490	723.1	9,893.5	362.9	0.2	-	0.2	-	5.4	0.0	10,985.3
Condamine-Balonne Catchment	96,040	2,094.1	12,174.9	1,038.4	6,561.2	306.2	28.5	0.8	48.9	0.0	22,253.0
Qld Border Rivers Catchment	37,940	1092.2	4,579.7	298.4	3,473.9	80.0	28.6	73.6	7.2	0.0	9,633.6
NSW Border Rivers Catchment	24,160	606.8	2,635.5	372.8	4,207.7	221.3	2.2	3.0	21.6	0.0	8,070.9
Gwydir Catchment	26,540	493.4	3,121.3	453.6	3,611.0	251,3	2.7	6.8	15.5	0.0	7,958.3
Namoi Catchment	41,900	830.8	5,280.5	888.5	3,799.3	346.1	-	-	26.5	0.0	11,171.7
Western Region	158,600	72.4	4,186.4	10.3	712.5	5.9	-	0.1	3.1	0.0	4,990.7
Central West Catchment	91,990	518.7	8,574.7	2,689.0	6,551.7	80.0	18.7	52.2	70.9	0.0	18,555.9
Lachlan Catchment	90,760	334.4	5,454.7	2,638.9	5,660.3	0.4	45.8	50.4	33.8	0.0	14,218.7
Murrumbidgee Catchment	67,090	4,423.4	4,240.6	1,824.2	4,372.6	-	25.3	98.5	148.3	0.0	15,132.9
Lower Murray-Darling Region	62,680	50.5	1,199.8	2.1	53.3	0.0	0.5	8.8	0.5	0.0	1,315.5
Murray Catchment	35,890	481.9	1,906.7	816.8	2,336.7	-	24.1	11.5	19.5	0.0	5,597.2
North East Catchment	20,100	1,773.1	1,194.2	751.7	245.2	-	1.4	30.8	62.2	0.0	4,058.6
Goulburn-Broken Catchment	24,120	913.0	1,779.0	1,795.8	916.8	-	29.4	113.7	106.1	0.0	5,653.8
North Central Catchment	25,730	294.5	1,260.2	1,248.9	1,390.8	-	39.8	17.4	39.3	0.0	4,290.9
Wimmera Region	22,450	218.2	739.6	886.3	2,370.5	-	-	12.5	10.1	0.0	4,237.2
Mallee Region	37,950	199.3	236.4	80.6	653.9	-	4.1	28.9	2.7	0.0	1205.9
North Riverine Corridor	4,580	6.6	64.8	5.7	40.7	-	2.5	37.1	0.7	0.0	158.1
South Riverine Corridor	5,800	1.5	87.1	66.3	114.2	-	3.2	3.4	2.5	0.0	278.2
Dryland Region	58,700	138.6	1,294.6	489.8	844.8	-	11.1	35.8	4.6	0.0	2,819.3
Murray-Darling Basin	**1,059,500**	**15,266.5**	**69,904.2**	**16,721.0**	**47,917.3**	**1,293.9**	**268.1**	**585.3**	**629.4**	**0.0**	**152,585.7**

Appendix 4: Total and Sub-Threshold Nutrient Point Sources for each Catchment

Warrego-Paroo Catchment Region

The Warrego-Paroo is a large, sparsely populated Catchment Region in the north west of the Murray-Darling Basin. It only contains two towns of note, Charleville (pop. 3,600) and Cunnamulla (pop. 1,700), with minor communities at Augathella, Hungerford and Morven. Only Charleville and Cunnamulla have STPs, and both discharge their effluents to land. Other nutrient point sources such as intensive feedlots were not estimated, although these are believed to be small. Consequently the sub-threshold nutrient point source loads for the Warrego-Paroo Catchment Region are taken as zero for both TP and TN.

Condamine Balonne Catchment

Intensive animal industries, particularly cattle feedlots are a major industry in the Condamine-Balonne Catchment, with feedlot capacity by far the biggest of any catchment in the Murray-Darling Basin (Tucker *et al*. 1991; Wylie 1993). As current figures for cattle feedlots and nutrient discharges are not yet available for the Condamine-Balonne, total and sub-threshold nutrient emissions were estimated through a comparison with the Namoi Catchment, for which detailed figures were available.

Table A4.1 Estimated$^{\Phi}$ total and sub-threshold feedlot nutrient loads for the Condamine Balonne Catchment from a comparison with the Namoi Catchment.

Catchment	Feedlot capacity*	All TP	Sub-threshold TP	All TN	Sub-threshold TN
Namoi	37,400	60,300	3,340	302,000	16,700
Condamine-Balonne	119,000	192,000	10,600	960,000	53,000

*Tucker *et al*. (1991).

$^{\Phi}$Namoi feedlot TP and TN values was multiplied by 3.18 (the ratio of feedlot capacity fo the two catchments) to obtain an estimate of all TP and TN generated by feedlots in the Condamine-Balonne Catchment. These overall load estimates were then multiplied by 0.055 (the proportion of sub-threshold nutrient loads for both TP & TN for the Namoi Catchment), to obtain indicative sub-threshold feedlot emissions for the Condamine-Balonne Catchment.

Nutrient point sources for sewage treatment plants in the Condamine-Balonne Catchment were estimated using population data and STP effluent disposal mode from GHD (1992), and generic per capita emission rates from STPs. Nutrient loads were only determined for those STPs that discharged to streams. Sub-threshold loads were determined according to the NPI criteria.

Table A4.2: Estimated[Ω] total and sub-threshold STP and other nutrient point source loads in the Condamine Balonne Catchment in kg/yr.

Community	Population[Φ]	Sewage effluent disposal[Φ]	Total phosphorus	Total nitrogen
Toowoomba	79,000	stream	39,500*	103,000*
Warwick	9,400	land	0	0
Dalby	8,300	stream	4,200*	10,800
Roma	6,100	land	0	0
Oakey	3,300	stream	1,700	4,300
St George	2,300	land	0	0
Chinchilla	2,200	stream	1,100	2,900
Pittsworth	2,000	stream	1,000	2,600
Miles	1,400	land	0	0
Mitchell	1,200	land	0	0
Milmerran	1,200	land	0	0
Tara	930	stream	470	1,200
Jandowae	860	land	0	0
Clifton	770	stream	390	1,000
Dirranbandi	520	land	0	0
Surat	500	land	0	0
Cecil Plains	250	stream	130	330
Bollon	200	land	0	0
Amby	200	land	0	0
Mungallala	200	stream	100	260
Meandarra	200	land	0	0
Estimated annual sub-threshold STP loads			**4,890**	**23,400**
Estimated annual sub-threshold feedlot loads			**10,600**	**53,000**
Total estimated annual sub-threshold nutrient loads			**15,490 kg TP**	**76,400 kg TN**

*Excluded point sources that are above the NPI threshold level.

[Ω]Determined using generic per capita nutrient emission rates and population numbers for sewered communities. Generic per capita nutrient emission rates were determined from an average for STPs across the MDB. These were 0.5 kg.person^{-1}.yr^{-1} for TP, and 1.3 kg.person^{-1}.yr^{-1} for TN.

[Φ]GHD 1992

Other sub-threshold nutrient point source loads were not estimated for the Condamine-Balonne Catchment. It should be noted that an NPI CMSS study is currently being undertaken for the Condamine-Balonne by Sinclair Knight Merz, in conjunction with the Department of Natural Resources in Toowoomba. Data for that study were not available for this report.

Qld Border Rivers Catchment

Total and sub-threshold nutrient point sources for the Queensland Border Rivers Catchment were derived from a combined Border Rivers CMSS study (Border Rivers CMSS files, 1998). Because it was uncertain from the CMSS files where the intensive livestock industries were located, the emissions were split evenly between the Queensland and NSW Border River catchments.

Table A4.3: Total and sub-threshold nutrient point sources in the Queensland Border Rivers Catchment in kg/yr.

Point source type	All point source TP	Sub-threshold TP
Sewage Treatment Plants	3,760	3,760
Feedlots[φ]	5,760	5,760
Piggeries[φ]	970	970
Dairy	-	-
All other point sources[Ψ]	50	50
Total annual phosphorus load	**10,540 kg**	**10,540 kg**

Point source type	All point source TN	Sub-threshold TN
Sewage Treatment Plants	7,900	7,900
Feedlots	5,760	5,760
Piggeries[φ]	6,310	6,310
Dairy	-	-
All other point sources[Ψ]	160	160
Total annual nitrogen load	**20,130 kg**	**20,130 kg**

[φ]Taken as half the total value for the whole (NSW & Qld) Border Rivers Catchment.
[Ψ]Stanthorpe Abattoir.

NSW Border Rivers Catchment

Total and sub-threshold nutrient point sources for the NSW Border Rivers Catchment were derived from a combined Border Rivers CMSS study (Border Rivers CMSS files, 1998). Because it was uncertain from the CMSS files where the intensive livestock industries were located the values were split evenly between the NSW and Queensland Border River catchments.

Table A4.4: Total and sub-threshold nutrient point sources in the NSW Border Rivers Catchment in kg/yr.

Point source type	All point source TP	Sub-threshold TP
Sewage Treatment Plants	10,620	4,720[θ]
Feedlots*	5,760	5,760
Piggeries[φ]	970	970

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Dairy	60	60
All other point sources[Ψ]	2,330	2,330
Total annual phosphorus load	**19,740 kg**	**13,840 kg**

Point source type	**All point source TN**	**Sub-threshold TN**
Sewage Treatment Plants	21,230	21,230
Feedlots[φ]	5,760	5,760
Piggeries[φ]	6,310	6,310
Dairy	600	600
All other point sources[Ψ]	7,160	7,160
Total annual nitrogen load	**41,060 kg**	**41,060 kg**

[θ]Excludes Inverell STP.
[φ]Taken as half the total value for the whole (NSW & Qld) Border Rivers Catchment.
[Ψ]All saleyards and the Inverell abattoir.

Gwydir Catchment

Total and sub-threshold nutrient point sources for the Gwydir Catchment of New South Wales were derived from a CMSS study for the catchment (Gwydir CMSS files, 1995-96).

Table A4.5: Total and sub-threshold nutrient point sources in the Gwydir Catchment in kg/yr.

Point source type	**All point source TP**	**Sub-threshold TP**
Sewage Treatment Plants	9,670	3,890[θ]
Feedlots	23,040	240*
Piggeries	180	180
All other point sources[Ψ]	390	390
Total annual phosphorus load	**33,280 kg**	**4,700 kg**

Point source type	**All point source TN**	**Sub-threshold TN**
Sewage Treatment Plants	16,080	16,080
Feedlots	115,180	1,180*
Piggeries	250	250
All other point sources[Ψ]	1,460	1,460
Total annual nitrogen load	**132,960 kg**	**18,960 kg**

[θ]Excludes Moree STP.
*Excludes Hemmingford, Welcannah and Tallawanta feedlots.
[Ψ]All saleyards.

Namoi Catchment

Total and sub-threshold nutrient point sources for the Namoi Catchment of NSW were derived from a CMSS study undertaken for the catchment (Namoi CMSS files, 1996).

Table A4.6: Total and sub-threshold nutrient point sources in the Namoi Catchment in kg/yr.

Point source type	All point source TP	Sub-threshold TP
Sewage Treatment Plants	46,960	1,860[θ]
Feedlots	60,340	3,340*
Piggeries[φ]	520	520
Dairy[φ]	60	60
All other point sources[Ψ]	2,980	2,980
Total annual phosphorus load	**110,870 kg**	**8,770 kg**

Point source type	All point source TN	Sub-threshold TN
Sewage Treatment Plants	122,750	19,750
Feedlots	301,720	16,720*
Piggeries[φ]	850	850
Dairy[φ]	310	310
All other point sources[Ψ]	10,220	10,220
Total annual nitrogen load	**435,860 kg**	**47,860 kg**

[θ]Excludes Gunnedah, Narrabri and both Tamworth STPs.
*Excludes Caroona, Killara, Bective, Coomelah and Windy Station feedlots.
[Ψ]All saleyards.

Western Region

The Western Region of New South Wales is the largest and most inland Catchment Region of the MDB, and is largely arid and flat with a total population of 60,000 people.

Nutrient point sources for sewage treatment plants in the Western Region were estimated using population data and STP effluent disposal mode from GHD (1992), and generic per capita emission rates from STPs. Nutrient loads were only determined for those STPs that discharged to streams. Sub-threshold loads were determined according to the NPI criteria.

No attempt was made to estimate nutrient loads for intensive livestock industries or other point sources, which are believed to be small.

Table A4.7: Estimated STP nutrient point-source loads[Φ] for the Western Region in kg/yr.

Community	Population[Ψ]	Sewage effluent disposal[Ψ]	Total phosphorus	Total nitrogen
Broken Hill	24,400	land	0	0
Cobar	4,300	land	0	0
Bourke	3,000	land	0	0
Lightning Ridge	2,300	land	0	0
Walgett	2,200	stream	1,100	2,900
Brewarrina	1,200	stream	600	1,600
Wilcannia	1,000	land	0	0
Estimated annual sub-threshold STP nutrient loads			**1,700 kg TP**	**4,500 kg TN**

[Φ]Determined using generic per capita nutrient emission rates and population numbers for sewered communities. Generic per capita nutrient emission rates were determined from an average for STPs across the MDB. These were 0.5 kg.person^{-1}.yr^{-1} for TP, and 1.3 kg.person^{-1}.yr^{-1} for TN.
[Ψ]GHD (1992).

Central West Catchment

Total and sub-threshold nutrient point sources for the Central West Region of New South Wales were derived from a Nutrient Management Plan for the catchment (CWCMC 1998).

Table A4.8: Total and sub-threshold nutrient point source loads for the Central West Catchment in kg/yr.

Point source type	All point source TP	Sub-threshold TP
Sewage Treatment Plants	44,950	9,310[θ]
Feedlots	52,760	2,280*
Dairies*	520	520
Piggeries	8,440	1,120[φ]
All other point sources[Ψ]	2,960	2,960
Total annual phosphorus load	**109,640 kg**	**16,200 kg**

Point source type	All point source TN	Sub-threshold TN
Sewage Treatment Plants	141,020	43,640[θ]
Feedlots	252,400	0*
Dairies	1,950	1,950
Piggeries	16,220	16,220
All other point sources[Ψ]	10,290	10,290
Total annual nitrogen load	**421,890 kg**	**72,110 kg**

[θ]Excludes Bathurst and Orange STPs.
*Excludes 4 out of the 5 feedlots (44, 40, 43, 41).
[φ]Excludes two piggeries (52, 51).
[Ψ]All saleyards.

Lachlan Catchment

Total and sub-threshold nutrient point sources for the Lachlan Catchment of New South Wales were derived from a Nutrient Management Plan for the catchment (LCMC 1998).

Table A4.9: Total and sub-threshold nutrient point-source loads for the Lachlan Catchment in kg/yr.

Point source type	All point source TP	Sub-threshold TP
Sewage Treatment Plants	14,250	7,860$^{\theta}$
Cattle feedlots	25,220	3,180*
Piggeries	8,370	4,450$^{\varphi}$
All other point sources	4,520	4,520$^{\Psi}$
Total annual phosphorus load	**52,360 kg**	**20,010 kg**

Point source type	All point source TN	Sub-threshold TN
Sewage Treatment Plants	52,230	29,240$^{\theta}$
Cattle feedlots	126,100	15,900*
Piggeries	9,010	9,010
All other point sources	29,480	29,480$^{\Psi}$
Total annual nitrogen load	**216,820 kg**	**83,630 kg**

*Excludes four large cattle feedlots at Springdale, Wirrinya, Canowindra and Forbes.
$^{\varphi}$Excludes a large piggery at Young.
$^{\theta}$Excludes the Young STP.
$^{\Psi}$This includes various saleyards and the Woolscour at Cowra.

Murrumbidgee Catchment

The Murrumbidgee Catchment of New South Wales is a significant catchment region of the MDB, with a largest population including the Basin's largest urban centre – Canberra. A CMSS study was undertaken for the catchment in 1995, however it was not possible to obtain access to this information.

Because current figures for cattle feedlots and nutrient discharges were not available for the Murrumbidgee, total and sub-threshold nutrient emissions were estimated through a comparison with the Namoi Catchment, for which detailed figures were available (Tucker *et al*. 1991; Wylie 1993).

Nutrient point sources for sewage treatment plants in the Murrumbidgee Catchment were estimated using population data and STP effluent disposal mode from GHD (1992), and generic per capita emission rates from STPs. Nutrient loads were only determined for those STPs that discharged to streams. Sub-threshold loads were determined according to the NPI criteria. No attempt was made to estimate nutrient loads from other point sources for the Murrumbidgee Catchment.

Table A4.10: Estimated[Φ] total and sub-threshold feedlot nutrient loads for the Murrumbidgee Catchment from a comparison with the Namoi Catchment.

Catchment	Feedlot capacity*	All TP	Sub-threshold TP	All TN	Sub-threshold TN
Namoi	37,400	60,300	3,340	302,000	16,700
Murrumbidgee	13,450	22,800	1,250	109,000	5,980

*Tucker *et al*. (1991).

[Φ]Namoi feedlot TP and TN values were multiplied by 0.36 (the ratio of feedlot capacity for the two catchments) to obtain an estimate of all TP and TN generated by feedlots in the Condamine-Balonne Catchment. These overall load estimates were then multiplied by 0.055 (the proportion of sub-threshold nutrient loads for both TP & TN for the Namoi Catchment), to obtain indicative sub-threshold feedlot emissions for the Murrumbidgee Catchment.

Table A4.11: Estimated total and sub-threshold STP[Φ] and other nutrient point source loads for the Murrumbidgee Catchment in kg/yr.

Community	Population	Sewage effluent disposal	Total phosphorus	Total nitrogen
Canberra	350,000+	Stream and land	n.d.*	n.d.*
Wagga Wagga	37,300	94% stream	18,700*	48,500*
Queenbeyan	21,900	Stream	11,000*	28,500*
Griffith	13,600	Stream	6,800*	17,700*
Cooma	7,400	Stream	3,700*	9,600
Leeton	6,400	Land	0	0
Cootamundra	6,300	Stream	3,200*	8,200
Tumut	6,100	Stream	3,050*	7,900
Narranderra	4,800	Stream	2,400	6,200
Hay	3,000	Land	0	0
Gundagai	2,100	Stream	1,100	2,700
Harden-Murrumbateman	2,000	Stream	1,000	2,600
Yass	1,700	50% stream	850	2,200
Balranald	1,400	Land	0	0
Batlow	1,300	Stream	650	1,700
Coolamon	1,100	Land	0	0
Culcairn	1,100	Land	0	0
Bungendore	1,000	Stream	500	1,300
Lockhart	900	Stream	450	1,200
Adelong	900	Stream	450	1,200
Henty	900	Land	0	0
The Rock	800	Stream	400	1,000

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Junee	750	Land	0	0
Darlington Point	700	Stream	350	910
Walla Walla	700	Stream	350	910
Colleambally	600	Land	0	0
Uranquity	500	Land	0	0
Yanco	400	Stream	200	520
Captains Flat	400	Stream	200	520
Adaminaby	300	Stream	150	390
Estimated annual sub-threshold STP loads			**9,050 kg TP**	**49,100 kg TN**
Estimated annual sub-threshold feedlot loads			**1,250**	**5,980**
Total estimated annual sub-threshold nutrient loads			**10,300kg TP**	**55,080 kg TN**

*Excluded point sources that are above the NPI threshold level.
n.d. not determined.
$^{\Phi}$Determined using generic per capita nutrient emission rates and population numbers for sewered communities. Generic per capita nutrient emission rates were determined from an average for STPs across the MDB. These were 0.5 kg.person^{-1}.yr^{-1} for TP, and 1.3 kg.person^{-1}.yr^{-1} for TN.

Lower Murray-Darling Region

The Lower Murray-Darling of New South Wales is another inland and largely uninhabitated catchment region of the MDB. It is arid, mainly flat, and dissected by the Darling River and its various anabranches, and contains the Menindee Lakes and associated irrigation activities. The only (and largest) community with a STP is Wentworth with a total population of 1,400 people - two other minor communities in the region are Pooncarie and Menindee. The Menindee sewage treatment plant effluent is discharged to land (GHD 1992). No attempt was made to estimate nutrient loads for any intensive livestock industries and other point sources, which in any case are believed to be negligible. Consequently the sub-threshold nutrient point source loads for the Lower Murray-Darling Catchment Region are taken as zero for both TP and TN.

Murray Catchment

The Murray Catchment Region of New South Wales Western Region of New South Wales is a significant Catchment Region of the MDB adjacent to the River Murray (MCWQWG 1999). Nutrient point sources for sewage treatment plants in the Murray catchment region were estimated using population data and STP effluent disposal mode from GHD (1992), and generic per capita emission rates from STPs. Nutrient loads were only determined for those STPs that discharged to streams. Sub-threshold loads were determined according to the NPI criteria.

It was not possible to estimate nutrient loads for intensive livestock industries and other point sources.

Table A4.12: Estimated total and sub-threshold STP nutrient point source loads[Φ] for the Murray catchment in kg/yr.

Community	Population	Sewage effluent disposal	Total phosphorus	Total nitrogen
Albury	37,200	stream	19,000*	48,000*
Deniliquin	7,600	stream	3,800*	9,900
Finley	2,200	land	0	0
Moama	2,000	land	0	0
Holbrook	1,800	stream	900	2,300
Jerilderie	1,700	stream	850	2,200
Tumbarumba	1,600	stream	800	2,100
Culcairn	1,100	land	0	0
Berriquin	1,000	stream	500	1,300
Barham	1,000	land	0	0
Corowa	800	stream	400	1,000
Estimated annual sub-threshold loads			**3,450 kg TP**	**18,800 kg TN**

*Excluded point sources that are above the NPI threshold level.

[Φ]Determined using generic per capita nutrient emission rates and population numbers for sewered communities. Generic per capita nutrient emission rates were determined from an average for STPs across the MDB. These were 0.5 kg.person^{-1}.yr^{-1} for TP, and 1.3 kg.person^{-1}.yr^{-1} for TN.

North East Catchment

Details of total and sub-threshold nutrient point source loads for the North East Catchment Region of Victoria were determined from draft Water Quality Strategies for the Ovens Basin and Upper North East (OBWQWG, 1998 and UNEWQWG, 1998).

Table A4.13: Total and sub-threshold nutrient point source loads for the North East Catchment in kg/yr.

Point source type	All point source TP	Sub-threshold TP
Sewage Treatment Plants	52,220	6,710[θ]
Dairies	1,280	1,280
Fish farms	2,680	2,680
Poultry	140	140
All other point sources[Ψ]	1,580	1,580
Total annual phosphorus load	**57,900 kg**	**12,390 kg**

Point source type	All point source TN	Sub-threshold TN
Sewage Treatment Plants	156,790	17,760[θ]

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Dairies	9,380	9,380
Fish farms	13,510	13,510
Poultry	170	170
All other point sources[Ψ]	15,940	15,940
Total annual nitrogen load	**195,790 kg**	**56,760 kg**

[θ]Excludes Wangaratta, Myrtleford, Wodonga and West Wodonga STPs, and the Wangaratta Trade Waste Plant.
[Ψ]Emissions associated with "Hydroelectricity production", "Alpine resorts" and "Mining".

Goulburn Broken Catchment

Total and sub-threshold nutrient point sources in the Goulburn-Broken Catchment of Victoria were derived from a Nutrients in Irrigation Drains: Issues Paper, the draft Goulburn Broken Catchment Water Quality Strategy and associated AEAM and CMSS studies (GBWQWG 1995; 1996; Goulburn-Broken AEAM & CMSS files, 1995-96). More recent data on STP effluent loads were provided by Peter Donlon (Goulburn-Valley Water), however these were received too late to be incorporated.

Table A4.14: Total and sub-threshold nutrient point source loads for the Goulburn-Broken Catchment in kg/yr.

Point source type	**All point source TP**	**Sub-threshold TP**
Sewage Treatment Plants	50,490	14,260[θ]
Dairies*	8,400	8,400
Fish farms	18,000	18,000
Piggeries	600	600
All other point sources	-	-
Total annual phosphorus load	**77,490 kg**	**41,260 kg**

Point source type	**All point source TN**	**Sub-threshold TN**
Sewage Treatment Plants	179,300	84,700[*]
Dairies	65,300	65,300
Fish farms	87,000	87,000
Piggeries	3,200	3,200
All other point sources	-	-
Total annual nitrogen load	**334,800 kg**	**240,200 kg**

[θ]This excludes Shepparton, Mooroopna, Seymore, and Benalla STPs.
* This excludes Shepparton STP.

North Central Catchment

Total and sub-threshold nutrient point source loads for the North Central Catchment of Victoria were derived from the Loddon Catchment Water Quality Strategy, the Campaspe Water Quality Strategy, and an AEAM study undertaken for the Loddon Catchment (Read Sturgess & Associates and McGuckian, 2000; GMW, 1997; Loddon AEAM files, 1994-95).

Table A4.15: Total and sub-threshold nutrient point sources for the North Central Catchment in kg/yr.

Point source type	All point source TP	Sub-threshold TP
Sewage Treatment Plants	47,470$^{\omega}$	6,120$^{\theta}$
Dairies*	3,900	3,900
Piggeries	8,790$^{\varphi}$	8,790$^{\varphi}$
Total annual phosphorus load	**60,160 kg**	**18,810 kg**

Point source type	All point source TP	Sub-threshold TN
Sewage Treatment Plants	49,800$^{\omega\Psi}$	30,200$^{\Psi}$
Dairies	6,100	6,100
Piggeries	13,800$^{\varphi\Psi}$	13,800$^{\varphi\Psi}$
Total annual nitrogen load	**69,700 kg**	**50,100 kg**

$^{\theta}$Excluding Kyneton, Bendigo and Castlemaine STPs, includes Murray Goulburn Coop
*calculated as 5% 0f 78 tonnes P (see Exec Summary and diagram in Intro – GMW 1997).
$^{\omega}$Includes 35,000 TP and 34,000 kg TN from Loddon catchment STPs.
$^{\varphi}$Includes 7,000 kg TP and 11,000 kg TN from intensive livestock in Loddon catchment which is assumed to be mainly piggeries.
$^{\Psi}$Campaspe TN figures estimated from TN:TP ratio of equivalent Loddon catchment point sources.

Wimmera Region

The Wimmera Region of Victoria is a flat and comparatively arid sandy region with a negligible drainage network, and a total population of 47,000 people. Most point source effluent is discharged to land and negligible amounts reaches the drainage system. A CMSS nutrient study has been undertaken for Wimmera Region (Halliwell & O'Shanassy 1997 – WCMA), however it was not possible to obtain files in time for this study. Consequently, nutrient point sources for sewage treatment plants in the Wimmera Region were estimated using population data and STP effluent disposal mode from GHD (1992), and generic per capita emission rates from STPs. Nutrient loads were only determined for those STPs that discharged to streams. Sub-threshold loads were determined according to the NPI criteria.

It was not possible to estimate nutrient loads for intensive livestock industries and other point sources, which in any case are believed to be minor.

Table A4.16: Estimated total and sub-threshold STP nutrient point source loads[Φ] for the Wimmera Region in kg/yr.

Community	Population	Sewage effluent disposal	Total phosphorus	Total nitrogen
Horsham	12,400	11% stream[#]	680	1,800
Stawell	6,500	43% stream[#]	1,400	3,600
Warracknabeal	2,900	land	0	0
Nhill	2,100	land	0	0
Dimboola	1,800	land	0	0
Kaniva	1,000	land	0	0
Edenhope	1,000	land	0	0
Estimated annual sub-threshold loads			**2,080 kg TP**	**4,400 kg TN**

[#]Emission load estimated proportionately

[Φ]Determined using generic per capita nutrient emission rates and population numbers for sewered communities. Generic per capita nutrient emission rates were determined from an average for STPs across the MDB. These were 0.5 kg.person^{-1}.yr^{-1} for TP, and 1.3 kg.person^{-1}.yr^{-1} for TN.

Mallee Region

The Mallee Region of Victoria is flat, has a low-rainfall and is sandy in character, and is bounded by the River Murray at its northern end. While there are a number of significant urban centres such as Mildura, Robinvale, Swan Hill and Ouyen, the Mallee Region Surface Water Quality Inception Report (Egis Consulting, 1999) states that their STP as well as other industry effluent, is discharged to land and does not enter waterways. Consequently sub-threshold nutrient loads for the Mallee Region are taken as zero.

North Riverine Corridor

Information on total and sub-threshold nutrient point source loads for the North Riverine Corridor of South Australia were obtained from Ray Ledger (SA Department of Environment, Heritage and Aboriginal Affairs) and John Cugley (SA Environmental Protection Authority). It was stated that there was no STP, winery or other horticultural effluent in this region discharged to the River Murray. The only nutrient source was from the Septic tank effluent disposal (STED) schemes for the towns of Berri, Loxton, Glossop, Barmera, Waikerie and Morgan. While these are disposed of on-land during summer, they are largely discharged to backwaters during winter. It was assumed that ½ of the total load enters the drainage network (1999 data supplied Ray Ledger DEHAA). Sub-threshold nutrient loads for the North Riverine Corridor from the STED schemes was 2,330 kg of TP and 5,830 kg of TN.

South Riverine Corridor

Total and sub-threshold nutrient point sources for South Riverine Corridor of South Australia in kg/yr were derived from a dairy effluent study for the Lower Murray (Murray & Philcox

1995) and information about STED schemes provided by Ray Ledger (DEHAA). All STP and other industry effluent is recycled on-land away from the River Murray.

Concern has been expressed that the dairy flat effluent data is based on old data, and grossly overestimates nutrient input to the River Murray. A new study to determine a more accurate and up-to-date nutrient budget is currently being developed through the Lower Murray Irrigators Action Group, the NHT and CSIRO. In the mean time this study can only rely on the published figures.

Table A4.17: Total and sub-threshold nutrient point source loads for the South Riverine Corridor in kg/yr.

Point source type	**All point source TP**	**Sub-threshold TP**
STEDs$^{\theta}$	280	280$^{\theta}$
Dairy	50,000	50,000
Annual phosphorus load	**50,280 kg**	**50,280 kg**

Point source type	**All point source TN**	**Sub-threshold TN**
STEDs$^{\theta}$	710	710$^{\theta}$
Dairy	190,000	190,000
Annual nitrogen load	**190,710 kg**	**190,710 kg**

$^{\theta}$Septic tank effluent disposal (STED) schemes for Walker Flat and Tailem Bend – these are disposed of on-land during summer and largely discharged to backwaters during winter. Assume ½ of the total load enters the drainage network – 1999 STED data supplied by Ray Ledger DEHAA.
$^{\Psi}$All STP and other industry effluent is recycled on-land.

Dryland Region

The Dryland Region of South Australia is dry flat, and has essentially no drainage with the exception of a very small area in the lower south-west corner. It is also very sparsely inhabited. It is suggested by Ray Ledger (DEHAA) and John Cugley (SA EPA) that there are no nutrient point sources discharging into drainage systems in this region. Consequently, sub-threshold nutrient loads for the Dryland Region have been taken as zero.

Appendix 5: Summary of Annual Diffuse, Sub-Threshold and Aggregated Nutrient Emissions by Catchment

Catchment Region	**Diffuse TP emission**	**Sub-threshold TP emission**	**Aggregated TP emission**	**Diffuse TN emission**	**Sub-threshold TN emission**	**Aggregated TN emission**
Warrego-Paroo Catchment	531	0	**531**	11,040	0	**11,040**
Condamine-Balonne Catchment	1,701	15	**1,716**	22,250	76	**22,326**
Qld Border Rivers Catchment	752	11	**763**	9,634	20	**9,654**
NSW Border Rivers Catchment	794	14	**808**	8,071	41	**8,112**
Gwydir Catchment	742	5	**747**	7,955	19	**7,974**
Namoi Catchment	923	9	**932**	11,170	48	**11,218**
Western Region	284	2	**286**	4,991	5	**4,996**
Central West Catchment	1,543	16	**1,559**	18,560	72	**18,632**
Lachlan Catchment	1,242	20	**1,262**	14,220	84	**14,304**
Murrumbidgee Catchment	1,022	10	**1032**	12,130	55	**12,185**
Lower Murray-Darling Region	65	0	**65**	1,316	0	**1,316**
Murray Catchment	487	3	**490**	5,597	18	**5,615**
North East Catchment	263	12	**275**	4,057	57	**4,114**
Goulburn-Broken Catchment	441	41	**482**	5,654	240	**5,894**
North Central Catchment	401	19	**420**	4,291	50	**4,341**
Wimmera Region	425	2	**427**	4,237	4	**4,241**
Mallee Region	115	0	**115**	1,206	0	**1,206**
North Riverine Corridor	13	2	**15**	158	6	**164**
South Riverine Corridor	25	50	**75**	278	191	**469**
Dryland Region	222	0	**222**	2,819	0	**2,819**
Murray-Darling Basin	**11,991**	**230**	**12,221**	**149,634**	**980**	**150,614**