DWLBC REPORT

Volumetric Conversion in the South East of South Australia: Summary of the Conversion Model and Associated Conversion Rates

2006/29

Government of South Australia
Department of Water, Land and Biodiversity Conservation

Volumetric Conversion in the South East of South Australia: Summary of the Conversion Model and Associated Conversion Rates

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Resource Allocation
Department of Water, Land and Biodiversity Conservation

September 2006

Report DWLBC 2006/29

Government of South Australia
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FOREWORD

South Australia's unique and precious natural resources are fundamental to the economic and social wellbeing of the State. It is critical that these resources are managed in a sustainable manner to safeguard them both for current users and for future generations.

The Department of Water, Land and Biodiversity Conservation (DWLBC) strives to ensure that our natural resources are managed so that they are available for all users, including the environment.

In order for us to best manage these natural resources it is imperative that we have a sound knowledge of their condition and how they are likely to respond to management changes. DWLBC scientific and technical staff continues to improve this knowledge through undertaking investigations, technical reviews and resource modelling.

The Volumetric Conversion Project was a four-year project initiated in 2002 to facilitate the process of converting the existing area based water licences in the South East of South Australia to licences with a volumetric basis for allocation. The conversion approach was developed following a comprehensive community consultation process, using the best available science and extensive field data.

The conversion approach will be implemented through the review of Water Allocation Plans for the Padthaway, Tatiara and Lower Limestone Coast Prescribed Wells Areas that is being conducted by the South East Natural Resource Management Board. The reviewed Water Allocation Plans will define the arrangements for the issue of new volumetric allocations, taking into account the recommendations of this report, the sustainability of the resource and input from the stakeholder community.

Rob Freeman
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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The author acknowledges the contributions of all those associated with the development of the volumetric conversion model and associated conversion rates including the Project Advisory Committee, landholders and collaborating researchers involved with our field trial programs, and all who attended workshops and meetings and provided input to the process.

ASSOCIATED REPORTS

Carruthers, R 2006, *Volumetric Conversion in the South East of South Australia: Community Consultation Processes,* DWLBC Report 2006/33, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

Carruthers, R, Skewes, M, Latcham, B & Pudney, S 2006, *Volumetric Conversion in the South East of South Australia: Calculation of the Crop Adjustment Factor,* DWLBC Report 2006/32, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

Latcham, B, Pudney, S & Carruthers, R 2006, *Volumetric Conversion in the South East of South Australia: Calculation of the Delivery Component and Bridging Volume,* DWLBC Report 2006/34, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

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EXECUTIVE SUMMARY

There are currently 2500 area-based water licences across the South East of South Australia. The four-year Volumetric Conversion Project (2002–06) has developed a volumetric conversion approach to convert the area-based water licences to licences with a volumetric basis of allocation. The project was jointly funded by the Department of Water, Land and Biodiversity Conversion (DWLBC), the South East Natural Resource Management Board (SENRMB) and the Department of Primary Industries and Resources, South Australia (PIRSA).

The development of the volumetric conversion approach has a strong technical basis, while recognising the importance of community participation and education.

The conversion approach considers the range of variables including crop type, irrigation system, soil type, water quality and climatic zone that impact on the volume of water extracted by the irrigator to meet on-farm irrigation needs. The Project faced the difficult task of implementing a volumetric conversion process that is fair and equitable to all commodity groups yet does not compromise the sustainability of the resource.

The conversion approach includes a volumetric conversion model that describes the components of the allocation and volumetric conversion rates that are used to calculate the allocation for each component. The conversion model is shown below (Fig. 1).

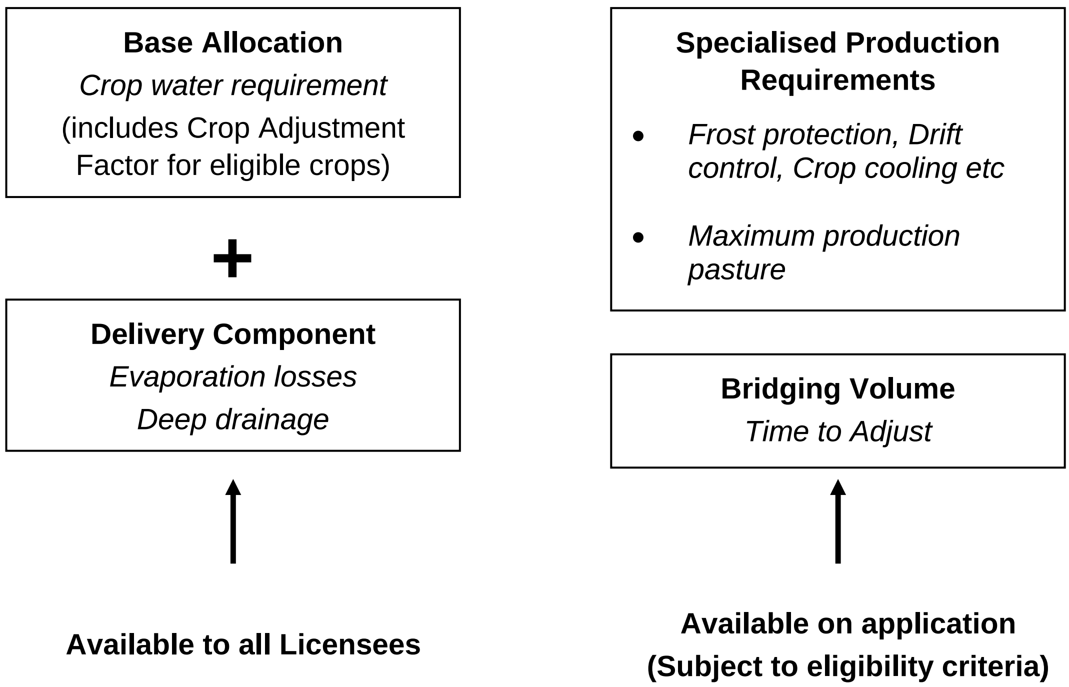

Figure 1. Proposed Conversion Model.

All licensees will receive a Base Allocation and a Delivery Component. The base allocation provides for crop irrigation requirements and is the tradeable component of the allocation. Some licensees may also be eligible for a Crop Adjustment Factor that provides additional base allocation for licensees where, due to initial calculation problems, the existing area based licences do not provide adequate allocation.

The delivery component is the volume of water needed in excess of the crop irrigation requirements, to account for irrigation system losses (evaporation losses, deep drainage etc.). In certain crop production systems it is necessary to use water for other activities, this water will be provided through the Specialised Production Requirements model component. The Bridging Volume is an additional temporary water allocation designed to give irrigators who are currently pumping in excess of their new volumetric allocation time to adjust to the new system. The Specialised Production Requirements and Bridging Volume model components may be available on application, subject to meeting eligibility criteria.

The conversion approach that has been developed establishes equity between licensees and will provide a basis for the sharing of the available resource. The conversion approach has general support from licensees, despite the considerable change and costs associated with its implementation, and with the introduction of water metering. This can largely be attributed to the forming of effective partnerships with licensees and irrigator/commodity groups, and to the considerable efforts made to involve licensees in data collection and in the development of the conversion model.

This report summarises the development of the conversion approach, including the components of the conversion model and the volumetric conversion rates that are used to calculate the allocation for each component. Other reports (listed in 'Associated Reports') detail the calculation of the various model components as well as the community consultation processes used in this project.

1. INTRODUCTION

There are currently 2500 area-based water licences across the South East of South Australia. Following the recommendations of two Parliamentary Select Committees, and in alignment with the State Water Plan, the then Department of Water Resources and the South East Catchment Water Management Board collaborated to instigate the Volumetric Conversion Project.

The Volumetric Conversion Project has developed a volumetric conversion approach to convert the area-based water licences to licences with a volumetric basis of allocation. The four-year project (2002–06) was jointly funded by the Department of Water, Land and Biodiversity Conversion (DWLBC), the South East Natural Resource Management Board (SENRMB) and the Department of Primary Industries and Resources, South Australia (PIRSA).

The development of the volumetric conversion approach has had a strong technical basis while recognising the importance of community education and participation in the process.

The conversion approach considers the range of variables including crop type, irrigation system, soil type, water quality and climatic zone that impact on the volume of water extracted by the irrigator to meet on-farm irrigation needs. The Project faced the difficult task of implementing a volumetric conversion process that is fair and equitable to all commodity groups, yet does not compromise the sustainability of the resource.

The methodology for conversion is based on active community participation in the collection of on-farm water extraction and use data and in the development of the volumetric conversion approach.

A four phase approach to project implementation has been adopted:

Phase 1 – Use global standard Food and Agriculture Organisation (FAO) methodology to review net irrigation requirements with input from the irrigator community.

Phase 2 – Development of a detailed dataset of information on irrigation-related water extraction and use. Use the field data collected to refine and enhance the outcomes from phase 1 and to calculate conversion rates in accordance with the conversion model.

Phase 3 – Develop a volumetric conversion approach in consultation with water licence holders and other key stakeholders.

Phase 4 – Implementation of the conversion approach including issue of new volumetric licenses and facilitation of the change management process for both regulators and irrigators.

This report summarises the outcomes of the first three phases of the project. The report also details the conversion model and associated conversion rates as determined by the project. Other reports (listed in ‘Associated Reports’) provide further details on the calculation of the components of the conversion model and on the community consultation processes and activities used in this project.

2. EXISTING AREA BASED ALLOCATION SYSTEM

The Irrigation Equivalent (IE) area-based water allocation system was developed for use in Prescribed Wells Areas (PWA) in South Australia where unmetered groundwater supplies are used for irrigation. Under the IE system the irrigation licences are expressed as an area of Irrigation Equivalents. One hectare Irrigation Equivalent is the net quantity of irrigation water (in addition to rainfall) required to meet the annual evapotranspiration (i.e. plant transpiration plus soil evaporation) from one hectare of reference crop grown under the average climatic conditions for that region. The internationally accepted concept of reference crop evapotranspiration (ET_0) is defined as “the rate of evapotranspiration from an extensive surface of 8–15 cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water” (Doorenbos and Pruitt 1977).

When each of the existing PWA’s was prescribed, Evapotranspiration of the Reference Crop (ET_0) was used as the basis for calculating Irrigation Requirements for the range of crop types. However, ET_0 was estimated from climatic data for locations often remote from the PWA in question, depending on where there were suitable Bureau of Meteorology Class A Evaporation Pans.

There was also a gradual refinement of methodology as each new PWA was prescribed, and IE was determined for each new area (Skewes 2006).

- In Tatiara PWA (1988), Reference Crop Irrigation Requirement (IR) was calculated as Annual ET_0 minus Annual Rainfall.
- In Naracoorte Ranges (1989) and Comaum Caroline (1990) PWA’s, Reference Crop IR was calculated as the sum of Monthly ET_0 minus Monthly Rainfall, with an allowance for stored soil moisture of 20 mm deducted from the result.
- In Padthaway PWA (1992), Reference Crop IR was calculated as the sum of Monthly ET_0 minus Monthly Rainfall, with an allowance for stored soil moisture of 25 mm deducted from the result.
- In Lacepede Kongorong PWA, Reference Crop IR was estimated from the figures for Naracoorte Ranges and Comaum Caroline PWA’s.

The Food and Agriculture Organisation (FAO) approach for assessing the water requirements of irrigated crops was used to develop conversion factors known as Crop Area Ratios (CAR) for the various crops irrigated in the Region.

An example of the CAR for Sub Clover seed in Tatiara PWA is:

Reference crop irrigation requirement= 634 mm

Sub Clover seed irrigation requirement = 361 mm

The CAR for Sub Clover seed is 634/361= 1.8

This means that an irrigator in Tatiara PWA is permitted to irrigate 1.8 times the area of Sub Clover seed compared with the reference crop. An irrigator with a 10 ha IE license, for example, is able to irrigate a maximum of 18 hectares of Sub Clover seed.

EXISTING AREA BASED ALLOCATION SYSTEM

The area-based allocation system manages irrigation extraction by controlling the area of crops grown, rather than the amount of water applied. Irrigators may apply as much or as little irrigation as they choose, as long as they don't apply water to an area of crops greater than the equivalent value of the Irrigation Equivalents endorsed on their water licence.

Whilst the existing area based water allocation system has been effective in regulating the maximum equivalent area of crop irrigated, it does not limit the volume of water that is pumped for irrigation, and does not require the volumes pumped to be measured. This inhibits the capacity of water managers to manage the resource, including both the calculation of the available resource and management of problem areas.

3. DRIVERS FOR CHANGE

There were a number of drivers that resulted in the initiation of the Volumetric Conversion Project. The Parliamentary Select Committee's report on Water Allocations in the South East (August 1999) recommended that, within three years, the existing area-based water allocation system be replaced by a system which reflects water allocations as a percentage of the available resource, and that all water use be measured volumetrically.

South Australia's State Water Plan (1999) required that 'The Government will, by 2005, have converted all water allocations to a volumetric basis and all water use will be measured so that the Department for Water Resources can determine the annual amount of water taken' (p. 58). Additionally, the Interim Report of the Select Committee on Groundwater Resources in the South East (December 2001) recommended that 'The conversion to volumetric allocations and the introduction of meters in the South East should proceed as a matter of urgency.'

Whilst in general the majority of irrigators were reasonably happy with the existing area based system, there was a growing awareness in the stakeholder community of the need for a more accountable system of water allocation that would contribute to a sustainable groundwater resource.

Agencies responsible for water management in the South East had long recognised the need for a volumetric allocation system, in terms of both improved resource management and to fall in line with national water reform agendas. In January 2001 the Executive of the then Department for Water Resources approved a project proposal for the Department to jointly fund the Volumetric Conversion Project together with the South East Catchment Water Management Board (SECWMB).

4. AIMS, OBJECTIVES AND PRINCIPLES FOR CONVERSION

4.1 AIM

The project team will conduct a science-based program in partnership with the community to convert the area-based water allocation system in the South East to a volumetric system.

4.2 OBJECTIVES

By the end of 2005, the project will have:

1. An agreed science-based process for conversion from the area-based Irrigation Equivalents water allocation system to a new volumetric basis for allocation.
2. Accurate data on volumes extracted for irrigation from at least 130 field sites covering the range of conditions and variables across the South East.
3. A community that has been involved in and has ownership of the outcomes of the project with 95% of licensees supporting conversion of area-based licences to volumetric licences.
4. Recommendations for implementation of volumetric conversion through the review of Water Allocation Plans.

4.3 PRINCIPLES FOR CONVERSION

It was recognised that a framework was required to set boundaries and guidelines for the project's operation. The following principles were developed for use as a framework and 'check list' in the development of the conversion model. The principles relate to both the process of developing the conversion model and to the final outcomes achieved through that process.

Process

- Use best available information.
- Actively address information gaps.
- Regular 2-way communication.
- Community involvement throughout.
- Transparency.

Outcomes

- Move to best practice (continuous improvement).
- Incentives for efficient water use.
- Time for adjustment.
- No additional risk to the resource (water quality and quantity) sustainability.
- Protection of water access rights.
- Minimise windfall gains.
- Fairness and equity.

5. METHODOLOGY

The project is based on active community participation in the collection of on-farm water extraction and use data, and in the development of the volumetric conversion approach. The methodology has been implemented through a four-phase approach as described below.

5.1 PHASE 1 – REVIEW THEORETICAL CROP WATER REQUIREMENTS DATA

Review the theoretical crop irrigation requirements data that forms the basis of the existing IE area-based allocation system, using contemporary FAO methodology and crop management practices and the best available climatic data. The review includes reassessment of the existing allocation zones and development of new climatic bands that better represent the climatic conditions across the region.

5.2 PHASE 2 – COLLECTION OF ON-FARM DATA

Collect accurate on-farm data through field-based trials and other data collection methods, to develop a comprehensive database of water extraction and irrigated crop management information. There are three field data collection programs associated with the project:

- Metered Extraction Trials (MET) Program – Collect accurate data on volumes extracted per hectare irrigated from more than 200 metered trial sites.
- Annual Water Use Returns (AWUR) Program – Collect annual volume extracted data as calculated by licensees from over 1500 sites using information from Annual Water Use Returns.
- Field Irrigation System Trials (FIST) Program – Collect detailed information on the on-farm water balance from 36 representative sites including data on irrigation practices, volume extracted for irrigation, soil moisture profiles, water table fluctuations and climatic data.

5.3 PHASE 3 – DEVELOPMENT OF THE VOLUMETRIC CONVERSION APPROACH

Develop a volumetric conversion approach in consultation with the irrigator community, including an agreed conversion model. Use the data from phases 1 and 2 to determine conversion rates for each component of the conversion model.

5.4 PHASE 4 – IMPLEMENTATION

The change from area to volumetric allocations will require a major paradigm shift for both irrigators and regulators. This phase of the project involves implementation and facilitation of the conversion process, including development of systems for licence issue and water accounting, as well as extension programs to help irrigators manage the change process.

6. RESULTS

6.1 PHASE 1 – REVIEW THEORETICAL CROP WATER REQUIREMENTS DATA

The Irrigated Crop Management Service group of Rural Solutions SA has undertaken a comprehensive review of the theoretical crop water requirements data that forms the basis of the existing Irrigation Equivalents (IE) area-based allocation system. The process and outcomes of the review is documented in the report 'Definition of Net Irrigation Requirements in the South East of South Australia' (Skewes, 2006), and is summarised below.

6.1.1 CLIMATIC BANDS

The existing IE allocation system is applied across the region according to Prescribed Wells Areas (PWA's) and groundwater management areas within the PWA's. It was recommended by the irrigation industry based Project Advisory Committee that the existing system for applying allocations across the region, especially in relation to climatic variation across the region, be reviewed.

To better represent the range of evapotranspiration and rainfall across the South East, and to simplify the allocation process, 10 Climatic Bands were identified (Fig. 2). It is proposed that these Climatic Bands form the basis for determination of each irrigator's volumetric allocation.

6.1.2 CALCULATION OF NET IRRIGATION REQUIREMENT FOR REFERENCE CROP (NIR0)

Monthly evaporation data was sourced from the Bureau of Meteorology (BoM). Monthly pan coefficients were derived using the methodology of Allen et al. (1998), and were used to calculate average monthly Reference Crop Evapotranspiration (ET_0) for the 27 BoM sites, as well as for each of the climatic bands identified above.

Monthly Effective Rainfall was subtracted from monthly ET_0 to determine monthly Net Irrigation Requirement for the Reference Crop (NIR_0), which was summed to give Annual NIR_0, at the 27 BoM sites, and for each of the Climatic Bands.

6.1.3 REVIEW OF ET_0

Methodologies and algorithms change over time, and the data set used for calculation of ET_0 above is an improvement on that available when Irrigation Equivalents and Crop Area Ratios were initially determined for each of the PWA's.

As ET_0 is the starting point for all of the calculations leading to volumetric allocations, the ET_0 figures calculated from the current data set were compared with the ET_0 figures used in the initial calculation of IE and CAR. Because ET_0 was not previously determined for the Lacepede Kongorong PWA, Irrigation Requirement of the reference crop was also compared.

Comparison based on the existing PWA's and Zones showed that ET_0 figures calculated by the method used by Skewes (2006) are very similar to ET_0 calculated by the method used at the original prescription of the PWA's, when averaged across each PWA (up to 4% variation from old to new figures). In comparison to the Irrigation Requirement for Reference Crop (IR_0) values that are used to monitor allocation in comparison to PAV in the current area-based allocation system, the new NIRo values for individual Unconfined Groundwater Management Areas range from 6.3% higher up to 35.9% higher.

6.1.4 CROP CALENDARS

Crop calendars depicting the timing of critical events in the development of crops were sourced from irrigators at a series of workshops. These crop calendars formed the basis for determining monthly crop coefficients from Allen et al. (1998), which in turn were used to determine crop water requirements. It was thus important that the calendars were accurate.

Across the series of 18 workshops, numerous calendars were provided, and most crops were represented by more than one calendar. For some crops, up to 19 calendars were provided. These calendars sometimes contained significant variation in the length and timing of crop growth stages.

The variation in calendars was analysed against geographic location. Crops represented by a large number of calendars were analysed for variation in season length and harvest date, both within and between PWA's.

It was determined that there was significant variation in some calendars moving from North to South. As a result, two sets of crop calendars were derived for each crop, although there was no difference between the two calendars for most crops.

Irrigators at a second series of workshops reviewed the crop calendars derived for each crop, with only minor changes required as a result. The crop calendars were also reviewed towards the end of the project using crop management data collected during phase 2.

6.1.5 CROP COEFFICIENTS

The crop calendars derived above were used to delineate the timing and length of crop growth stages for each crop within the two regions (Northern and Southern). Crop coefficients were sourced from Allen et al. (1998), unless otherwise noted, and applied across the months of the year according to the crop calendars. The crop coefficients were combined with average monthly ET_0 and effective rainfall for each Climatic Band, to determine Net Irrigation Requirement.

6.1.6 NET IRRIGATION REQUIREMENT

Net Irrigation Requirement (NIR) is the water required by a plant for transpiration, which is not met by effective rainfall. NIR was calculated for all crops for the 10 Climatic Bands across the South East (App. A). These NIR figures do not include any allowance for leaching or distribution and application losses, or for any environmental requirements associated with producing an economic product. They are, however, directly comparable with the Irrigation Requirement figures from which the IE and CAR figures were derived.

There is significant variation from the original prescription figures for many crops, with examples of both higher and lower requirements, for a variety of reasons.

6.1.7 SOUND TECHNICAL BASIS FOR CONVERSION

The best available science and data has been used to review theoretical crop water requirements across the PWA’s. Irrigators have provided input on current crop management practices to ensure that the data used is locally relevant, and this local data has been matched to internationally recognised crop coefficients to provide the best available information on crop water requirements. Climatic Bands have been derived from sound climatic data provided by the Bureau of Meteorology, and have been reviewed by local irrigators as a cross check. Consequently, the outcomes of the review provide a sound technical basis to the volumetric conversion process.

6.2 PHASE 2 – COLLECTION OF ON-FARM DATA

It is recognised that no two irrigators grow the same crops the same way using the same amount of water. The existing Irrigation Equivalents water allocation system considered only the theoretical crop water use. In moving to a volumetric allocation system, it is important to know the volume of water extracted through the well head to meet crop water use.

The aim of this phase of the project was to collect irrigation related water extraction and use information from a range of on-farm data sources, using various data collection processes. The aim was to provide representative data on current practices and water extraction patterns for use in developing the conversion approach.

Three data collection programs were implemented.

6.2.1 METERED EXTRACTION TRIALS – MET PROGRAM

The MET program involved supplying monetary incentives to irrigators for the purchase and installation of water meters, in return for the collection of accurate data on the volumes pumped per hectare irrigated.

Participants were required to record meter readings at the start and end of each irrigation event for all individual crops irrigated. A total of 120 irrigators participated in the trial, generating volume pumped data from a wide range of representative sites across the region. Approximately 200 irrigated crop sites were monitored over three irrigation seasons, from 2002–03 to 2004–05.

6.2.2 ANNUAL WATER USE RETURNS – AWUR PROGRAM

The AWUR process requires all water license holders to report their water use activities at the completion of each season. Since 2001–02 irrigators have been asked to provide information on their annual volume pumped, either through metered measurements or by way of estimates. An information sheet was provided to growers to assist them with the calculations.

The risk of including unreliable volume pumped estimates was minimised by assigning accuracy ratings to each of the AWUR estimates and statistical screening (Latcham 2006). Of the 2500 irrigation licences, the AWUR process yielded some 1500 useable records for each of the three irrigation seasons from 2002–03 to 2004–05.

Data from the MET and AWUR programs has been used to determine conversion rates for the delivery component. Latcham et al. (2006) provides detailed descriptions of the data collection and data analysis processes associated with these programs.

6.2.3 FIELD IRRIGATION SYSTEM TRIALS (FIST) PROGRAM

The Field Irrigation System Trials (FIST) program resulted in the collection of detailed information on the on-farm water balance from 36 representative trial sites across the South East. Collaborative research partnerships formed with the dairy, viticulture and lucerne seed industries (De Barro 2005) helped fund additional field trial sites in areas where there were previously knowledge gaps. The program involved the continuous monitoring of a range of parameters including water extraction rates, soil moisture, water table and weather-related parameters linked to calculation of evapotranspiration.

Data from the FIST sites has been used to confirm the conversion model and conversion rates as described by Pudney et al. (2006). Sites consistently pumping in excess of proposed allocations have been analysed using IRES software (Meldrum 2005), and issues that may be causing use in excess of the proposed allocation identified.

Data from the FIST program will be invaluable for a range of future resource management activities, including the development of best management practices for irrigation, and the assessment of recharge rates under irrigated areas.

6.2.4 COMMUNITY INVOLVEMENT IN DATA COLLECTION

The involvement of irrigators in the collection and reporting of field data has provided multiple benefits. Trial participants have ‘ownership’ of the data that has been used as the basis for conversion, and have been great advocates for the conversion process. Trial participants are using the data collected to assess irrigation system efficiency and amend their systems.

Irrigators in general now have a far greater understanding of the volumes of water they are pumping and this will assist them when the change to volumetric allocations occurs. The requirement for irrigators to calculate their volumes pumped has also brought about a recognition in the irrigation community that volumetric conversion will happen, and has helped prepare irrigators for the big change from area based on-farm water management to volumetric management.

6.3 PHASE 3 – DEVELOPMENT OF THE VOLUMETRIC CONVERSION APPROACH

From the irrigator's point of view, the current water allocation system has only required the management of irrigated areas within area-based entitlements, with no limits on the volume extracted for irrigation. In moving to a volumetric allocation system the total volume of water extracted through the wellhead needs to be considered. There is an expectation in the community that 'most' irrigators or 'reasonably efficient' irrigators will receive an allocation through the volumetric conversion process that would enable the continuation of their historical irrigation regimes.

A range of variables including climate, irrigation system, soil type and crop management system impact on the volume of water extracted by the irrigator to meet on-farm irrigation needs. The volumetric conversion approach that has been developed considers all of these variables. The conversion approach includes a volumetric conversion model that describes the components of the allocation, and volumetric conversion rates that are used to calculate the allocation for each component.

The volumetric conversion model has been developed in consultation with the community using an iterative process of review and amendment. A detailed description of the consultative processes and activities used in the development of the model is available for reference (Carruthers 2006). The conversion rates have been determined using the best available science and extensive field data.

7. DESCRIPTION OF THE CONVERSION MODEL

The proposed conversion model is detailed in Figure 1.

7.1 BASE ALLOCATION

The Base Allocation is the crop water requirement component of the license, and equates to the irrigation requirement for reference crop from the existing Irrigation Equivalents (IE) water allocation system.

The Base Allocation will be calculated as follows:

Base Allocation (ML) = HaIE x NIRo (ML/haIE)

Where HaIE is the current area based allocation on the water licence and NIRo is the Net Irrigation Requirement for reference crop for the new climatic band associated with that license. This means that the Base Allocation for each HaIE of licence will be consistent for all licensees across a climatic band no matter the crop type, area irrigated or irrigation system used, and represents the licensees equity in the resource and/or 'share' of the resource. It is recommended that the Base Allocation be the tradeable component of the allocation.

Figure 2 shows the 10 climatic bands (1A–9A) and associated NIRo values for use in calculating the base allocation. Appendix B details the NIRo values for each of the 73 Unconfined Groundwater Management Areas (UGMA). It should be noted that Wirrega UGMA has been split into Wirrega North and Wirrega South (Fig. 2) to align with climatic band boundaries (7A and 8A) and Hundred boundaries (Wirrega and Pendleton).

It is recommended that these NIRo values also apply to area-based licences issued from the confined aquifer and that each confined aquifer licence be assigned to an unconfined groundwater management area for the conversion process only.

The methodology for calculation of the net irrigation requirement for reference crop values and the process for determining climatic bands is described by Skewes (2006).

7.2 CROP ADJUSTMENT FACTOR (CAF)

Early in the consultation process associated with volumetric conversion, licensees raised concerns about the Crop Area Ratios (CARs) of certain crops, and whether they provided sufficient water to grow those crops under the crop management practices currently used. In response to these concerns the review of the net irrigation requirements of crops irrigated in the South East has identified a number of crops where, for a range of reasons, the existing Crop Area Ratios provide insufficient water.

The Crop Adjustment Factor is a one-off adjustment to the base allocation available to licensees growing eligible crops during the period of eligibility. The Crop Adjustment Factor will provide affected licensees with sufficient allocation to continue growing these crops 'post conversion', under the conversion principle that irrigators should be able to continue to do what they legitimately did before conversion.

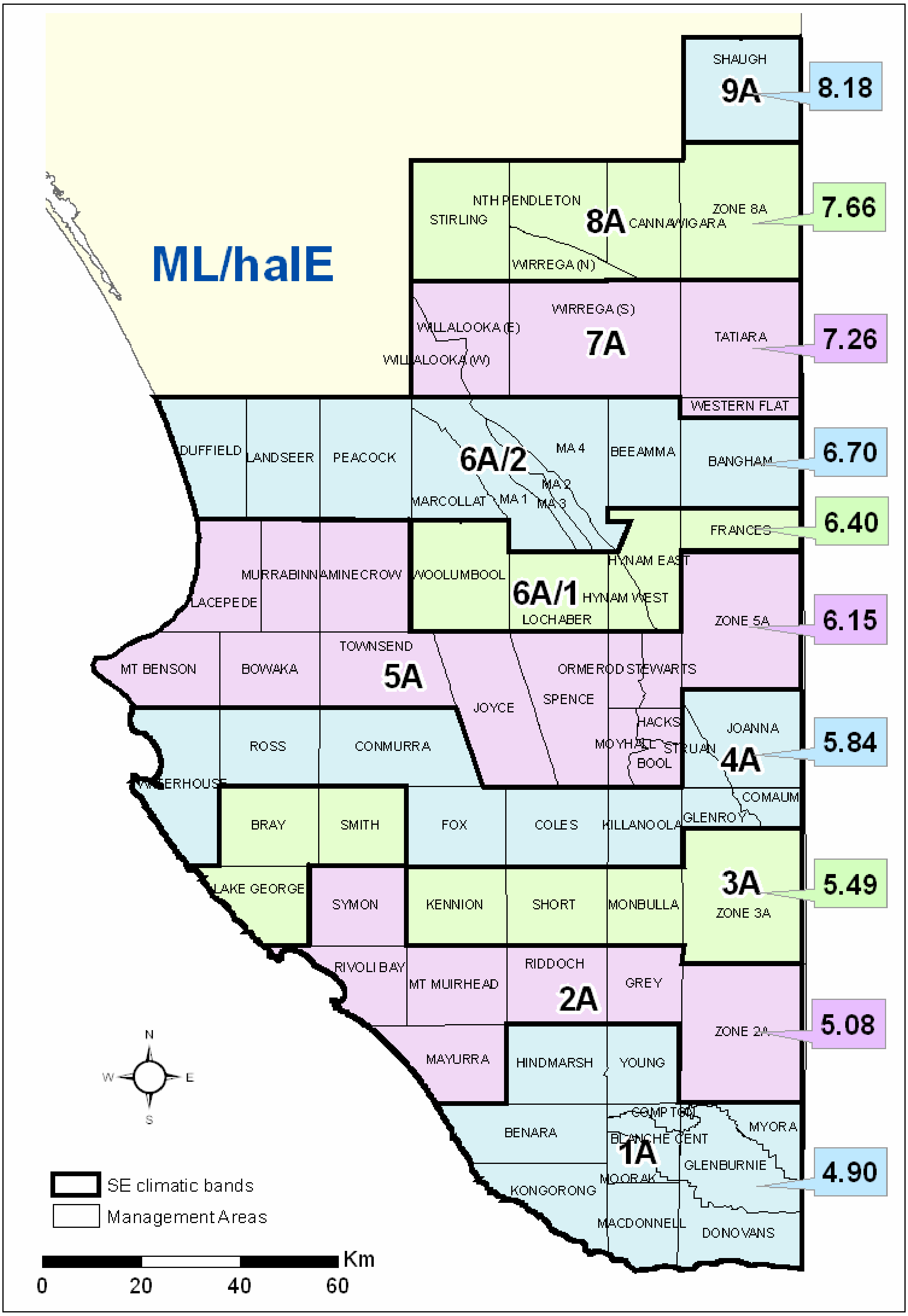

Figure 2. Climatic bands and associated NIRo values for calculation of the base allocation

The methodology and processes used to calculate the Crop Adjustment Factors is described by Carruthers et al. (2006). Table 1 details the crops eligible for a CAF listed by Prescribed Wells Area. Crop Adjustment Factors that will apply per hectare of crop grown for each of the 73 unconfined groundwater management areas are detailed in Appendix C.

Table 1. Crops eligible for a Crop Adjustment Factor by Prescribed Wells Area.

Tatiara	Lower Limestone Coast	Padthaway
Beans – Broad / Faba	Coriander	Perennial Clover Seed
Chinese Cabbage Seed	Fruit Trees	Coriander
Perennial Clover Seed	Maize	Onions
Coriander	Native Flowers	Grass Seed
Fruit Trees	Native Foliage	Carrot Seed
Maize	Onions	
Onions	Grass Seed	
Lupins		
Mustard		
Peas – Field		
Potatoes		
Native Flowers		
Native Foliage		

7.3 DELIVERY COMPONENT

The delivery component is the volume of water in excess of the crop water requirement that a reasonably efficient irrigator needs to extract to irrigate and grow the crop. Delivery zones of like characteristics have been developed using volume pumped data, soils data and other relevant information (see Fig. 3). The delivery zones consist of groupings of whole unconfined groundwater management areas (UGMAs), with the exception of Willalooka UGMA, which has been split between delivery zone 3 (Willalooka East) and delivery zone 4 (Willalooka West).

The delivery component is determined for each irrigation system type within these delivery zones. It is proposed that there be a minimum delivery component based on irrigation system efficiencies of 65% for flood systems, 85% for pressurised spray systems and 90% for drip systems (Latcham et al., 2006). This relates to a delivery component of an additional 54% (on top of the base allocation) for flood systems, 18% for pressurised spray systems and 11% for drip systems.

The porous nature of soils in some areas of the South East often results in considerable drainage, with water moving back to the shallow source aquifer. In these areas, the minimum delivery components may provide insufficient allocation for many irrigators to continue their existing irrigated cropping regimes. Where this is the case, the delivery component has been determined using volume pumped data for each irrigation system type within each delivery zone, with the 75th percentile used to determine the delivery component value. The methodology and process used to calculate the delivery components is outlined by Latcham et al. (2006).

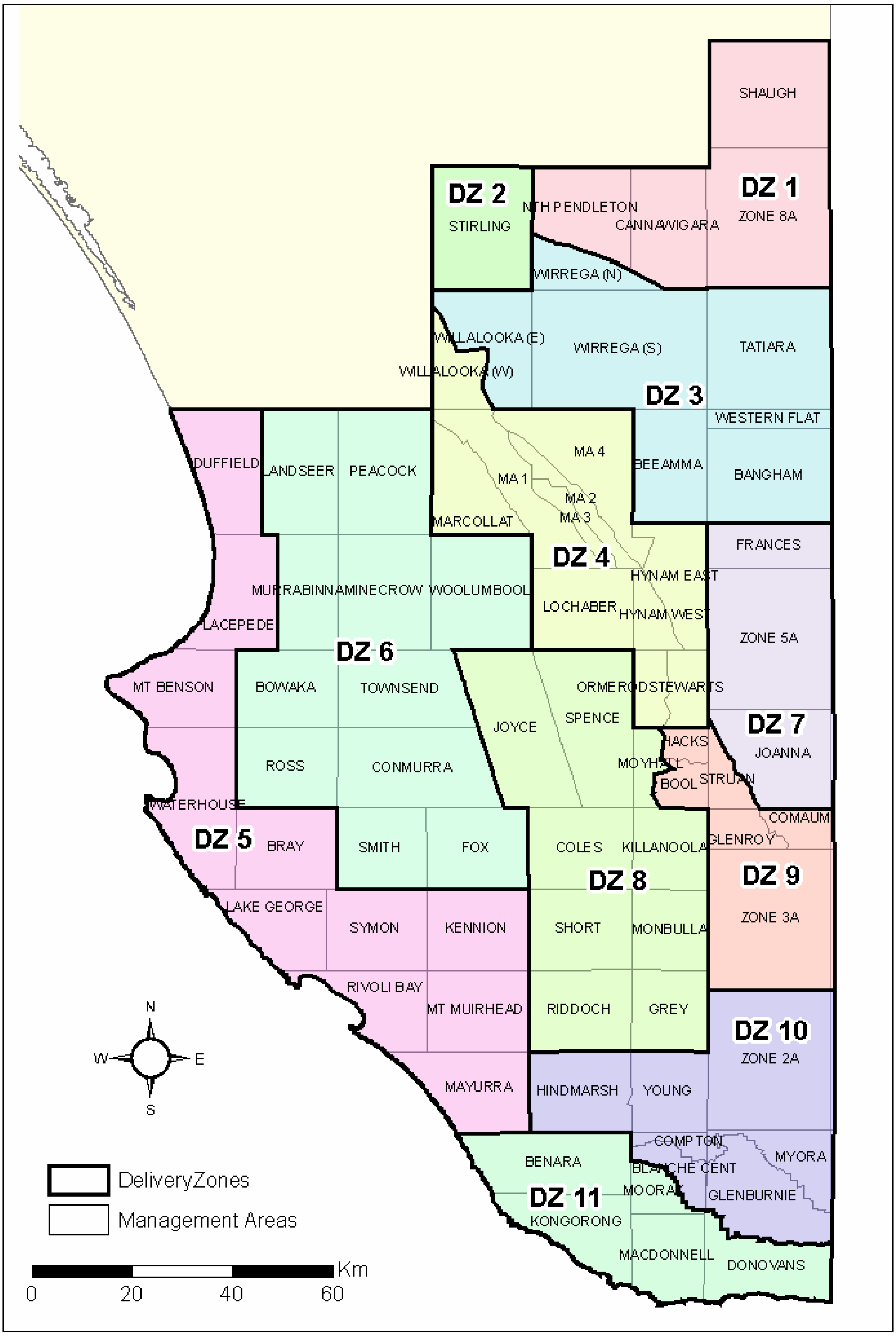

Figure 3. Delivery zones for determination of the Delivery Component.

It is recommended that the delivery component be a temporary component of the allocation, reviewed every five years as part of the review of Water Allocation Plans. It is also recommended that the delivery component be non-tradable, but available on application following a trade. Table 2 details the delivery component (expressed as a percentage of the base allocation) that has been determined for each of the delivery zones. Appendix B details the delivery component expressed as both a percentage of the base allocation and as a volume for each unconfined groundwater management area (UGMA).

Table 2. Delivery Component (as a percentage of Base Allocation) for each of the Delivery Zones

Delivery Zone	Flood	Spray	Drip
DZ 1	54%	18%	11%
DZ 2	152%	18%	11%
DZ 3	102%	18%	11%
DZ 4	199%	18%	11%
DZ 5	132%	18%	11%
DZ 6	132%	18%	11%
DZ 7	54%	18%	11%
DZ 8	132%	18%	11%
DZ 9	123%	18%	11%
DZ 10	54%	18%	11%
DZ 11	54%	27%	11%

8. SPECIALISED PRODUCTION REQUIREMENTS (SPR)

The Base Component of the volumetric conversion model accounts for water that is used for crop growth processes, and the Delivery Component accounts for water that is 'lost' during the process of applying the water. In certain crop production systems it is necessary to use water for other activities. In these instances the base and delivery components will not provide enough water to enable a reasonably efficient irrigator to continue their current practices.

Specialised production requirements (SPR) include:

1. Water that is necessarily applied as a part of the crop production process that does not contribute to crop water use and is not included in the delivery component (e.g. to prevent soil drift or to protect against frost damage).

2. Water that is required in addition to base allocation due to significant changes in the crop production system (as recognised by FAO 56 (Allen et al., 1998)). For example Maximum Production Pasture.

The report by Pudney et al. (2006) describes the methodology and processes used in the calculation of SPR allocations. Table 3 details the crop production processes that are entitled to a 'Specialised Production Requirement', and the associated volumetric allocation. Specialised Production Requirements allocations that will apply per hectare of crop grown for each of the 73 unconfined groundwater management areas are listed in Appendix D.

It is recommended that the SPR be a temporary component of the allocation, reviewed every 5 years as part of the review of Water Allocation Plans. Licensees will need to apply for the SPR, with applications assessed against defined assessment criteria.

Table 3. Summary of Specialised Production Requirements and Volumetric Allocations.

Crop	Process for which additional water is required	Allocation Volume (ML/ha)
Fruit Trees (Apples)	Cooling for prevention of sunburn, cooling to aid the development of red pigment	0.39
Onions	Prevention of soil drift, establishment of a post harvest cover crop	1.10* 1.47^
Potatoes	Prevention of soil drift, inter-mound losses, harvest (in ground storage, cooling, bruising), establishment of a post harvest cover crop	1.35* 1.70^
Vines	Prevention of frost damage	1.55
Olives	Salt leaching	0.28
Subterranean - Cover Seed	Establishment of a post harvest cover crop	0.31* 0.38^
Maximum Production Pasture	Increased net irrigation requirement due to significant changes in pasture management systems (as recognised by FAO 56).	0.6–2.87#

* = South: Management areas within Climatic Bands 1A-3A

^ = North: Management areas within Climatic Bands 4A-9A

= Depending on management area and irrigation system type (see App. D)

9. BRIDGING VOLUME

The bridging volume is a temporary allocation that may be granted on application (subject to eligibility criteria), where licensees find that they are pumping in excess of their combined base allocation, delivery component and specialised production requirement (if eligible). It is designed to give irrigators time to adjust their systems to their new volumetric allocation. The maximum bridging volume has been calculated (Latcham et al. 2006) using the 95th percentile of data from each delivery zone (as compared to the 75th percentile for the delivery component).

Table 4 details the maximum Bridging Volume that a licensee may apply for in addition to their volumetric allocation (base allocation, delivery component and specialised production requirement). The percentage refers to the additional percentage of base allocation. Maximum Bridging Volumes that will apply for each of the 73 unconfined groundwater management areas, as both a percentage of base and as a volume, are detailed in Appendix E.

Table 4. Maximum Bridging Volume (as a percentage of base allocation) for each of the Delivery Zones.

Delivery Zone	Flood	Spray	Drip
DZ 1	54%	18%	11%
DZ 2	103%	18%	11%
DZ 3	136%	31%	11%
DZ 4	114%	19%	11%
DZ 5	145%	50%	11%
DZ 6	145%	22%	11%
DZ 7	54%	38%	11%
DZ 8	104%	23%	11%
DZ 9	156%	27%	11%
DZ 10	54%	44%	11%
DZ 11	54%	39%	11%

10. APPLICATION OF THE CONVERSION APPROACH TO CALCULATE DRAFT VOLUMETRIC ALLOCATIONS

As described by Carruthers 2006, participants at the November 2005 workshop series were presented with the volumetric conversion approach described in this report and assisted to calculate draft volumetric allocations for their water licences based on the possible conversion model and draft conversion rates. Many participants brought along historical pumping records and were able to compare the draft allocations to their volume pumped calculations. Even though a number of participants observed that they were currently pumping in excess of their draft allocations, there was general support for the model and draft conversion rates.

Examples of the use of the conversion approach to calculate draft volumetric allocations can be found in Appendix F.

11. PROPOSED PROCESS FOR CONVERSION OF ALLOCATIONS

The Volumetric Conversion Project has been working with licensees for the past four years to develop the conversion approach outlined in this report. The conversion model has been developed following a comprehensive community consultation process. The associated conversion rates have been determined using the best available science and extensive field data. This data includes a dataset of more than 5000 volume pumped records collected from South East irrigation properties, as well as comprehensive information on climatic conditions, soil variability and crop production systems.

The conversion approach will be implemented through the review of Water Allocation Plans for the Padthaway, Tatiara and Lower Limestone Coast Prescribed Wells Areas. The South East Natural Resource Management Board is currently conducting the review of these plans. The reviewed Water Allocation Plans will define the arrangements for the issue of new volumetric allocations, taking into account the recommendations of this report, the sustainability of the resource and input from the stakeholder community. Once the Minister adopts the reviewed Water Allocation Plans, the process of amending existing water licences to include the new volumetric allocations will commence.

APPENDICES

A. NET IRRIGATION REQUIREMENTS OF CROPS

Average NIR$_C$ per band	Band 1A^	Band 2A^	Band 3A^	Band 4A	Band 5A	Band 6A/1	Band 6A/2	Band 7A	Band 8A	Band 9A
Reference crop	4.90	5.08	5.49	5.84	6.15	6.40	6.70	7.26	7.66	8.18
Beans - broad/faba	0.97	1.02	1.09	1.20	1.31	1.33	1.42	1.51	1.61	1.80
Canola	0.43	0.49	0.61	0.23	0.34	0.40	0.49	0.62	0.75	0.92
Carrot seed	2.00	2.09	2.25	2.41	2.56	2.63	2.81	3.06	3.25	3.53
Cereals	0.57	0.62	0.71	0.84	0.97	0.99	1.09	1.18	1.30	1.52
Chinese cabbage seed	1.13	1.18	1.25	1.36	1.48	1.50	1.60	1.69	1.78	1.98
Clover seed - annual	1.62	1.68	1.79	1.93	2.07	2.09	2.23	2.37	2.50	2.77
Clover seed - perrennial	3.20	3.34	3.63	3.90	4.21	4.37	4.65	5.08	5.41	5.83
Clover seed - subterranean	1.77	1.83	1.94	2.08	2.23	2.25	2.40	2.60	2.76	3.04
Coriander	1.71	1.77	1.89	2.03	2.17	2.21	2.36	2.56	2.71	3.01
Fruit trees	3.96	4.13	4.50	4.76	4.96	5.14	5.37	5.73	5.95	6.29
Grass seed	3.09	3.16	3.34	3.52	3.68	3.73	3.94	4.20	4.41	4.77
Lucerne hay/graze*	3.40	3.52	3.84	4.08	4.28	4.43	4.63	4.94	5.15	5.50
Lucerne seed*	2.48	2.59	2.86	3.09	3.29	3.38	3.57	3.81	4.02	4.38
Lupins	0.98	1.03	1.10	1.21	1.32	1.34	1.43	1.52	1.61	1.81
Maize	4.80	4.87	5.16	5.33	5.44	5.61	5.76	6.04	6.19	6.47
Mustard	1.15	1.19	1.26	1.33	1.42	1.41	1.51	1.61	1.69	1.89
Native flowers	2.02	2.10	2.35	2.52	2.65	2.75	2.88	3.06	3.18	3.41
Native foliage	0.84	0.90	1.08	1.23	1.35	1.45	1.55	1.72	1.83	1.99
Olive - fresh	2.61	2.77	3.09	3.33	3.55	3.70	3.89	4.20	4.42	4.77
Olive - oil	2.26	2.41	2.71	2.93	3.12	3.25	3.43	3.69	3.90	4.22
Onion	4.82	4.92	5.24	5.47	5.64	5.82	5.99	6.30	6.49	6.83
Onion seed	3.09	3.16	3.38	3.55	3.71	3.78	3.96	4.20	4.38	4.71
Pasture - full	4.53	4.68	5.01	5.28	5.50	5.66	5.88	6.20	6.44	6.79
Pasture - half	1.74	1.80	1.93	2.07	2.20	2.22	2.37	2.52	2.68	2.94
Pasture - starter/finisher	0.25	0.29	0.36	0.45	0.54	0.55	0.63	0.74	0.86	1.03
Pasture - max production	6.03	6.19	6.57	6.86	7.11	7.31	7.56	8.00	8.27	8.69
Peas - field	0.77	0.81	0.88	0.98	1.09	1.10	1.19	1.27	1.34	1.52
Potatoes	4.16	4.23	4.49	4.68	4.83	4.94	5.12	5.38	5.54	5.89
Potatoes - seed	2.83	2.87	3.06	3.16	3.23	3.33	3.41	3.60	3.68	3.86
Radish seed	1.10	1.15	1.26	1.39	1.52	1.53	1.65	1.80	1.94	2.17
Summer fodder	2.44	2.54	2.79	2.95	3.07	3.19	3.31	3.51	3.65	3.83
Sunflower	3.01	3.08	3.31	3.43	3.51	3.65	3.73	3.94	4.04	4.22
Sweetcorn	3.21	3.25	3.46	3.57	3.63	3.76	3.83	4.03	4.12	4.30
Winegrape	1.56	1.65	1.89	2.05	2.18	2.26	2.42	2.61	2.74	2.96

^ = Southern Climatic Bands, some calendars vary

*For Lucerne grown in the hundred of Stirling please use table below

Lucerne NIR for the Hundred of Stirling

LUCERNE CATEGORY	DESCRIPTION	NIR_C (ML/ha)
STIRLING LUCERNE **CAT 1**	Starter or finisher lucerne	1.00
STIRLING LUCERNE **CAT 2**	Spring lucerne	1.31
STIRLING LUCERNE **CAT 3**	Spring & autumn lucerne	2.54
STIRLING LUCERNE **CAT 4**	13 week lucerne seed	1.81
STIRLING LUCERNE **CAT 5**	16 week lucerne seed	2.51
STIRLING LUCERNE **CAT 6**	13 week lucerne seed plus autumn fodder	2.36
STIRLING LUCERNE **CAT 7**	Lucerne spring fodder plus seed	3.64
STIRLING LUCERNE **CAT 8**	Lucerne full	4.17

B. BASE VALUES AND DELIVERY COMPONENTS

Management Area	Base Value (ML/haIE)	Delivery Zone	Drip Delivery Component		Flood Delivery Component		Spray Delivery Component	
			Factor (%)	*Volume (ML/haIE)*	*Factor (%)*	*Volume (ML/haIE)*	*Factor (%)*	*Volume (ML/haIE)*
Bangham	6.7	DZ 3	0.11	0.74	1.02	6.83	0.18	1.21
Beeamma	6.7	DZ 3	0.11	0.74	1.02	6.83	0.18	1.21
Benara	4.9	DZ 11	0.11	0.54	0.54	2.65	0.27	1.32
Blanche Central	4.9	DZ 10	0.11	0.54	0.54	2.65	0.18	0.88
Bool	6.15	DZ 9	0.11	0.68	1.23	7.56	0.18	1.11
Bowaka	6.15	DZ 6	0.11	0.68	1.32	8.12	0.18	1.11
Bray	5.49	DZ 5	0.11	0.60	1.32	7.25	0.18	0.99
Cannawigara	7.66	DZ 1	0.11	0.84	0.54	4.14	0.18	1.38
Coles	5.84	DZ 8	0.11	0.64	1.32	7.71	0.18	1.05
Comaum	5.84	DZ 9	0.11	0.64	1.23	7.18	0.18	1.05
Compton	4.9	DZ 10	0.11	0.54	0.54	2.65	0.18	0.88
Conmurra	5.84	DZ 6	0.11	0.64	1.32	7.71	0.18	1.05
Donovans	4.9	DZ 11	0.11	0.54	0.54	2.65	0.27	1.32
Duffield	6.7	DZ 5	0.11	0.74	1.32	8.84	0.18	1.21
Fox	5.84	DZ 6	0.11	0.64	1.32	7.71	0.18	1.05
Frances	6.4	DZ 7	0.11	0.70	0.54	3.46	0.18	1.15
Glenburnie	4.9	DZ 10	0.11	0.54	0.54	2.65	0.18	0.88
Glenroy	5.84	DZ 9	0.11	0.64	1.23	7.18	0.18	1.05
Grey	5.08	DZ 8	0.11	0.56	1.32	6.71	0.18	0.91
Hacks	6.15	DZ 9	0.11	0.68	1.23	7.56	0.18	1.11
Hindmarsh	4.9	DZ 10	0.11	0.54	0.54	2.65	0.18	0.88
Hynam East	6.4	DZ 4	0.11	0.70	1.99	12.74	0.18	1.15
Hynam West	6.4	DZ 4	0.11	0.70	1.99	12.74	0.18	1.15
Joanna	5.84	DZ 7	0.11	0.64	0.54	3.15	0.18	1.05
Joyce	6.15	DZ 8	0.11	0.68	1.32	8.12	0.18	1.11
Kennion	5.49	DZ 5	0.11	0.60	1.32	7.25	0.18	0.99
Killanoola	5.84	DZ 8	0.11	0.64	1.32	7.71	0.18	1.05
Kongorong	4.9	DZ 11	0.11	0.54	0.54	2.65	0.27	1.32
Lacepede	6.15	DZ 5	0.11	0.68	1.32	8.12	0.18	1.11
Lake George	5.49	DZ 5	0.11	0.60	1.32	7.25	0.18	0.99
Landseer	6.7	DZ 6	0.11	0.74	1.32	8.84	0.18	1.21
Lochaber	6.4	DZ 4	0.11	0.70	1.99	12.74	0.18	1.15
Macdonnell	4.9	DZ 11	0.11	0.54	0.54	2.65	0.27	1.32
Management Area 1 (MA1)	6.7	DZ 4	0.11	0.74	1.99	13.33	0.18	1.21
Management Area 2 (MA2)	6.7	DZ 4	0.11	0.74	1.99	13.33	0.18	1.21
Management Area 3 (MA3)	6.7	DZ 4	0.11	0.74	1.99	13.33	0.18	1.21

Management Area	Base Value (ML/haIE)	Delivery Zone	Drip Delivery Component		Flood Delivery Component		Spray Delivery Component	
			Factor (%)	*Volume (ML/haIE)*	*Factor (%)*	*Volume (ML/haIE)*	*Factor (%)*	*Volume (ML/haIE)*
Management Area 4 (MA4)	6.7	DZ 4	0.11	0.74	1.99	13.33	0.18	1.21
Marcollat	6.7	DZ 4	0.11	0.74	1.99	13.33	0.18	1.21
Mayurra	5.08	DZ 5	0.11	0.56	1.32	6.71	0.18	0.91
Minecrow	6.15	DZ 6	0.11	0.68	1.32	8.12	0.18	1.11
Monbulla	5.49	DZ 8	0.11	0.60	1.32	7.25	0.18	0.99
Moorak	4.9	DZ 11	0.11	0.54	0.54	2.65	0.27	1.32
Mount Benson	6.15	DZ 5	0.11	0.68	1.32	8.12	0.18	1.11
Mount Muirhead	5.08	DZ 5	0.11	0.56	1.32	6.71	0.18	0.91
Moyhall	6.15	DZ 8	0.11	0.68	1.32	8.12	0.18	1.11
Murrabinna	6.15	DZ 6	0.11	0.68	1.32	8.12	0.18	1.11
Myora	4.9	DZ 10	0.11	0.54	0.54	2.65	0.18	0.88
North Pendleton	7.66	DZ 1	0.11	0.84	0.54	4.14	0.18	1.38
Ormerod	6.15	DZ 4	0.11	0.68	1.99	12.24	0.18	1.11
Peacock	6.7	DZ 6	0.11	0.74	1.32	8.84	0.18	1.21
Riddoch	5.08	DZ 8	0.11	0.56	1.32	6.71	0.18	0.91
Rivoli Bay	5.08	DZ 5	0.11	0.56	1.32	6.71	0.18	0.91
Ross	5.84	DZ 6	0.11	0.64	1.32	7.71	0.18	1.05
Shaugh	8.18	DZ 1	0.11	0.90	0.54	4.42	0.18	1.47
Short	5.49	DZ 8	0.11	0.60	1.32	7.25	0.18	0.99
Smith	5.49	DZ 6	0.11	0.60	1.32	7.25	0.18	0.99
Spence	6.15	DZ 8	0.11	0.68	1.32	8.12	0.18	1.11
Stewarts	6.15	DZ 4	0.11	0.68	1.99	12.24	0.18	1.11
Stirling	7.66	DZ 2	0.11	0.84	1.52	11.64	0.18	1.38
Struan	5.84	DZ 9	0.11	0.64	1.23	7.18	0.18	1.05
Symon	5.08	DZ 5	0.11	0.56	1.32	6.71	0.18	0.91
Tatiara	7.26	DZ 3	0.11	0.80	1.02	7.41	0.18	1.31
Townsend	6.15	DZ 6	0.11	0.68	1.32	8.12	0.18	1.11
Waterhouse	5.84	DZ 5	0.11	0.64	1.32	7.71	0.18	1.05
Western Flat	7.26	DZ 3	0.11	0.80	1.02	7.41	0.18	1.31
Willalooka (east)	7.26	DZ 3	0.11	0.80	1.02	7.41	0.18	1.31
Willalooka (west)	7.26	DZ 4	0.11	0.80	1.99	14.45	0.18	1.31
Wirrega (south)	7.26	DZ 3	0.11	0.80	1.02	7.41	0.18	1.31
Wirrega (north)	7.66	DZ 3	0.11	0.84	1.02	7.81	0.18	1.38
Woolumbool	6.4	DZ 6	0.11	0.70	1.32	8.45	0.18	1.15
Young	4.9	DZ 10	0.11	0.54	0.54	2.65	0.18	0.88
Zone 2A	5.08	DZ 10	0.11	0.56	0.54	2.74	0.18	0.91
Zone 3A	5.49	DZ 9	0.11	0.60	1.23	6.75	0.18	0.99
Zone 5A	6.15	DZ 7	0.11	0.68	0.54	3.32	0.18	1.11
Zone 8A	7.66	DZ 1	0.11	0.84	0.54	4.14	0.18	1.38

* Note – See Figure 3 in Appendix G for location of Management Areas

C. CROP ADJUSTMENT FACTOR BY MANAGEMENT AREA (EXTRA ML PER HA OF CROP GROWN)

Management Area*	Beans broad/ faba	Carrot seed	Chinese cabbage seed	Clover seed perennial	Coriander	Fruit trees	Grass seed	Lupins	Maize	Mustard	Native flowers	Native foliage	Onion	Peas field	Potatoes
Bangham					0.87	1.65			1.82		1.97	0.64	0.84		
Beeamma					0.87	1.65			1.82		1.97	0.64	0.84		
Benara					0.88	0.55	0.21		2.35	0.32	1.19		0.74		
Blanche Central					0.88	0.55	0.21		2.35	0.32	1.19		0.74		
Bool					0.80	1.54			1.82		1.82	0.52	0.91		
Bowaka					1.01	0.44			2.20	0.26	1.61	0.31	0.52		
Bray					0.93	0.70			2.27	0.30	1.42	0.15	0.67		
Cannawigara	0.39		0.90	0.62	1.83	1.69		0.39	2.71	0.81	1.88	0.53	2.23	0.12	1.03
Coles					0.93	0.46			2.26	0.23	1.53	0.24	0.60		
Comaum					0.99	0.72			2.26	0.29	1.53	0.24	0.98		
Compton					0.88	0.55	0.21		2.35	0.32	1.19		0.74		
Conmurra					0.93	0.46			2.26	0.23	1.53	0.24	0.60		
Donovans					0.84	0.58	0.21		2.22	0.28	1.19		1.05		
Duffield					0.93	1.65			1.82	0.08	1.74	0.41	0.41		
Fox					0.93	0.46			2.26	0.23	1.53	0.24	0.60		
Frances					0.79	1.58			1.85		1.89	0.59	0.90		
Glenburnie					0.84	0.58	0.21		2.22	0.28	1.19		1.05		
Glenroy					0.99	0.72			2.26	0.29	1.53	0.24	0.98		
Grey					0.88	0.62	0.17		2.20	0.30	1.24		0.69		
Hacks					0.80	1.54			1.82		1.82	0.52	0.91		
Hindmarsh					0.88	0.55	0.21		2.35	0.32	1.19		0.74		
Hynam East					0.79	1.58			1.85		1.89	0.59	0.90		
Hynam West					0.79	1.58			1.85		1.89	0.59	0.90		
Joanna					0.73	1.52			1.89		1.73	0.44	0.98		
Joyce					0.94	1.54			1.82	0.19	1.61	0.31	0.91		
Kennion					0.93	0.70			2.27	0.30	1.42	0.15	0.67		
Killanoola					0.93	0.46			2.26	0.23	1.53	0.24	0.60		
Kongorong					0.88	0.55	0.21		2.35	0.32	1.19		0.74		
Lacepede					0.94	1.54			1.82	0.19	1.61	0.31	0.91		
Lake George					0.96	0.66			2.42	0.33	1.42	0.15	0.67		
Landseer					0.93	1.65			1.82	0.08	1.74	0.41	0.41		
Lochaber					0.85	1.58			1.85		1.67	0.37	0.49		

Management Area*	Beans broad/ faba	Carrot seed	Chinese cabbage seed	Clover seed perennial	Coriander	Fruit trees	Grass seed	Lupins	Maize	Mustard	Native flowers	Native foliage	Onion	Peas field	Potatoes
Macdonnell					0.88	0.55	0.21		2.35	0.32	1.19		0.74		
Management Area 1 (MA1)		1.18		0.46	0.13	1.65	0.41		2.04		1.76	0.43	0.84		
Management Area 2 (MA2)		1.18		0.46	0.13	1.65	0.41		2.04		1.76	0.43	0.84		
Management Area 3 (MA3)		1.18		0.46	0.13	1.65	0.41		2.04		1.76	0.43	0.84		
Management Area 4 (MA4)		1.18		0.46	0.13	1.65	0.41		2.04		1.76	0.43	0.84		
Marcollat					0.93	1.65			1.82	0.08	1.74	0.41	0.41		
Mayurra					0.91	0.59	0.17		2.33	0.33	1.24		0.69		
Minecrow					0.94	1.54			1.82	0.19	1.61	0.31	0.91		
Monbulla					0.93	0.70			2.27	0.30	1.42	0.15	0.67		
Moorak					0.88	0.55	0.21		2.35	0.32	1.19		0.74		
Mount Benson					1.01	0.44			2.20	0.26	1.61	0.31	0.52		
Mount Muirhead					0.91	0.59	0.17		2.33	0.33	1.24		0.69		
Moyhall					0.80	1.54			1.82		1.82	0.52	0.91		
Murrabinna					0.94	1.54			1.82	0.19	1.61	0.31	0.91		
Myora					0.84	0.58	0.21		2.22	0.28	1.19		1.05		
North Pendleton	0.39		0.90	0.62	1.83	1.69		0.39	2.71	0.81	1.88	0.53	2.23	0.12	1.03
Ormerod					0.80	1.54			1.82		1.82	0.52	0.91		
Peacock					0.89	1.66			1.93		1.74	0.38	0.51		
Riddoch					0.91	0.59	0.17		2.33	0.33	1.24		0.69		
Rivoli Bay					0.91	0.59	0.17		2.33	0.33	1.24		0.69		
Ross					1.01	0.72			2.26	0.31	1.53	0.24	0.60		
Shaugh	0.50		1.04	0.72	2.07	1.75		0.51	2.75	0.95	2.02	0.60	2.29	0.22	1.08
Short					0.93	0.70			2.27	0.30	1.42	0.15	0.67		
Smith					0.93	0.70			2.27	0.30	1.42	0.15	0.67		
Spence					0.86	1.54			1.82	0.11	1.61	0.31	0.52		
Stewarts					0.80	1.54			1.82		1.82	0.52	0.91		
Stirling	0.39		0.90	0.62	1.83	1.69		0.39	2.71	0.81	1.88	0.53	2.23	0.12	1.03
Struan					0.73	1.52			1.89		1.73	0.44	0.98		
Symon					0.91	0.59	0.17		2.33	0.33	1.24		0.69		
Tatiara	0.36		0.86	0.54	1.73	1.70		0.37	2.74	0.78	1.83	0.49	2.27	0.12	1.11
Townsend					1.01	0.44			2.20	0.26	1.61	0.31	0.52		
Waterhouse					1.01	0.72			2.26	0.31	1.53	0.24	0.60		
Western Flat					0.95	1.70			1.77		2.08	0.74	0.72		

Management Area*	Beans broad/ faba	Carrot seed	Chinese cabbage seed	Clover seed perrennial	Coriander	Fruit trees	Grass seed	Lupins	Maize	Mustard	Native flowers	Native foliage	Onion	Peas field	Potatoes
Willalooka (east)	0.36		0.86	0.54	1.73	1.70		0.37	2.74	0.78	1.83	0.49	2.27	0.12	1.11
Willalooka (west)	0.36		0.86	0.54	1.73	1.70		0.37	2.74	0.78	1.83	0.49	2.27	0.12	1.11
Wirrega (south)	0.36		0.86	0.54	1.73	1.70		0.37	2.74	0.78	1.83	0.49	2.27	0.12	1.11
Wirrega (north)	0.39		0.90	0.62	1.83	1.69		0.39	2.71	0.81	1.88	0.53	2.23	0.12	1.03
Woolumbool					0.93	1.58			1.85	0.13	1.67	0.37	0.90		
Young					0.88	0.55	0.21		2.35	0.32	1.19		0.74		
Zone 2A					0.86	0.62	0.17		2.20	0.28	1.24		1.01		
Zone 3A					0.91	0.70			2.27	0.28	1.42	0.15	1.02		
Zone 5A					0.80	1.54			1.82		1.82	0.52	0.91		
Zone 8A	0.39		0.90	0.62	1.83	1.69		0.39	2.71	0.81	1.88	0.53	2.23	0.12	1.03

* Note – See Figure 3 in Appendix G for location of Management Areas

D. SPECIALISED PRODUCTION REQUIREMENTS (ML)

Management Area*	Vines - Frost Protection	Fruit Trees	Potatoes	Olives	Onions	Sub Clover Seed	Maximum Production Pasture*		
							Spray	*Flood*	*Drip*
Bangham	1.55	0.38	1.70	0.28	1.47	0.38	1.01	1.74	0.95
Beeamma	1.55	0.38	1.70	0.28	1.47	0.38	1.01	1.74	0.95
Benara	1.55	0.38	1.35	0.28	1.10	0.31	1.44	1.74	1.25
Blanche Central	1.55	0.38	1.35	0.28	1.10	0.31	1.33	1.74	1.25
Bool	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.14	1.07
Bowaka	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Bray	1.55	0.38	1.35	0.28	1.10	0.31	1.27	2.51	1.20
Cannawigara	1.55	0.38	1.70	0.28	1.47	0.38	0.72	0.94	0.68
Coles	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.37	1.13
Comaum	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.27	1.13
Compton	1.55	0.38	1.35	0.28	1.10	0.31	1.44	1.74	1.25
Conmurra	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.37	1.13
Donovans	1.55	0.38	1.35	0.28	1.10	0.31	1.44	1.74	1.25
Duffield	1.55	0.38	1.70	0.28	1.47	0.38	1.01	2.00	0.95
Fox	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.37	1.13
Frances	1.55	0.38	1.70	0.28	1.47	0.38	1.07	1.40	1.01
Glenburnie	1.55	0.38	1.35	0.28	1.10	0.31	1.33	1.74	1.25
Glenroy	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.27	1.13
Grey	1.55	0.38	1.35	0.28	1.10	0.31	1.31	2.58	1.23
Hacks	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.14	1.07
Hindmarsh	1.55	0.38	1.35	0.28	1.10	0.31	1.33	1.74	1.25
Hynam East	1.55	0.38	1.70	0.28	1.47	0.38	1.07	2.72	1.01
Hynam West	1.55	0.38	1.70	0.28	1.47	0.38	1.07	2.72	1.01
Joanna	1.55	0.38	1.70	0.28	1.47	0.38	1.20	1.57	1.13
Joyce	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Kennion	1.55	0.38	1.35	0.28	1.10	0.31	1.27	2.51	1.20
Killanoola	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.37	1.13
Kongorong	1.55	0.38	1.35	0.28	1.10	0.31	1.44	1.74	1.25
Lacepede	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Lake George	1.55	0.38	1.35	0.28	1.10	0.31	1.27	2.51	1.20
Landseer	1.55	0.38	1.70	0.28	1.47	0.38	1.01	2.00	0.95
Lochaber	1.55	0.38	1.70	0.28	1.47	0.38	1.07	2.72	1.01
Macdonnell	1.55	0.38	1.35	0.28	1.10	0.31	1.44	1.74	1.25
Management Area 1 (MA1)	1.55	0.38	1.70	0.28	1.47	0.38	1.01	2.57	0.95
Management Area 2 (MA2)	1.55	0.38	1.70	0.28	1.47	0.38	1.01	2.57	0.95
Management Area 3 (MA3)	1.55	0.38	1.70	0.28	1.47	0.38	1.01	2.57	0.95
Management Area 4 (MA4)	1.55	0.38	1.70	0.28	1.47	0.38	1.01	2.57	0.95

Management Area*	Vines - Frost Protection	Fruit Trees	Potatoes	Olives	Onions	Sub Clover Seed	Maximum Production Pasture*		
							Spray	*Flood*	*Drip*
Marcollat	1.55	0.38	1.70	0.28	1.47	0.38	1.01	2.57	0.95
Mayurra	1.55	0.38	1.35	0.28	1.10	0.31	1.31	2.58	1.23
Minecrow	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Monbulla	1.55	0.38	1.35	0.28	1.10	0.31	1.27	2.51	1.20
Moorak	1.55	0.38	1.35	0.28	1.10	0.31	1.44	1.74	1.25
Mount Benson	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Mount Muirhead	1.55	0.38	1.35	0.28	1.10	0.31	1.31	2.58	1.23
Moyhall	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Murrabinna	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Myora	1.55	0.38	1.35	0.28	1.10	0.31	1.33	1.74	1.25
North Pendleton	1.55	0.38	1.70	0.28	1.47	0.38	0.72	0.94	0.68
Ormerod	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.87	1.07
Peacock	1.55	0.38	1.70	0.28	1.47	0.38	1.01	2.00	0.95
Riddoch	1.55	0.38	1.35	0.28	1.10	0.31	1.31	2.58	1.23
Rivoli Bay	1.55	0.38	1.35	0.28	1.10	0.31	1.31	2.58	1.23
Ross	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.37	1.13
Shaugh	1.55	0.38	1.70	0.28	1.47	0.38	0.60	0.79	0.57
Short	1.55	0.38	1.35	0.28	1.10	0.31	1.27	2.51	1.20
Smith	1.55	0.38	1.35	0.28	1.10	0.31	1.27	2.51	1.20
Spence	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Stewarts	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.87	1.07
Stirling	1.55	0.38	1.70	0.28	1.47	0.38	0.72	1.54	0.68
Struan	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.27	1.13
Symon	1.55	0.38	1.35	0.28	1.10	0.31	1.31	2.58	1.23
Tatiara	1.55	0.38	1.70	0.28	1.47	0.38	0.87	1.49	0.82
Townsend	1.55	0.38	1.70	0.28	1.47	0.38	1.13	2.23	1.07
Waterhouse	1.55	0.38	1.70	0.28	1.47	0.38	1.20	2.37	1.13
Western Flat	1.55	0.38	1.70	0.28	1.47	0.38	0.87	1.49	0.82
Willalooka (east)	1.55	0.38	1.70	0.28	1.47	0.38	0.87	1.49	0.82
Willalooka (west)	1.55	0.38	1.70	0.28	1.47	0.38	0.87	2.21	0.82
Wirrega (south)	1.55	0.38	1.70	0.28	1.47	0.38	0.87	1.49	0.82
Wirrega (north)	1.55	0.38	1.70	0.28	1.47	0.38	0.72	1.23	0.68
Woolumbool	1.55	0.38	1.70	0.28	1.47	0.38	1.07	2.11	1.01
Young	1.55	0.38	1.35	0.28	1.10	0.31	1.33	1.74	1.25
Zone 2A	1.55	0.38	1.35	0.28	1.10	0.31	1.31	1.71	1.23
Zone 3A	1.55	0.38	1.35	0.28	1.10	0.31	1.27	2.41	1.20
Zone 5A	1.55	0.38	1.70	0.28	1.47	0.38	1.13	1.48	1.07
Zone 8A	1.55	0.38	1.70	0.28	1.47	0.38	0.72	0.94	0.68

* Note – See Figure 3 in Appendix G for location of Management Areas

E. MAXIMUM BRIDGING VOLUMES

Management Area*	Base Value (ML/haIE)	Delivery Zone	Drip Bridging Volume		Flood Bridging Volume		Spray Bridging Volume	
			Factor (%)	*Volume (ML/haIE)*	*Factor (%)*	*Volume (ML/haIE)*	*Factor (%)*	*Volume (ML/haIE)*
Bangham	6.7	DZ 3	0.11	0.74	1.36	9.11	0.31	2.08
Beeamma	6.7	DZ 3	0.11	0.74	1.36	9.11	0.31	2.08
Benara	4.9	DZ 11	0.11	0.54	0.54	2.65	0.39	1.91
Blanche Central	4.9	DZ 10	0.11	0.54	0.54	2.65	0.44	2.16
Bool	6.15	DZ 9	0.11	0.68	1.56	9.59	0.27	1.66
Bowaka	6.15	DZ 6	0.11	0.68	1.45	8.92	0.22	1.35
Bray	5.49	DZ 5	0.11	0.60	1.45	7.96	0.50	2.75
Cannawigara	7.66	DZ 1	0.11	0.84	0.54	4.14	0.18	1.38
Coles	5.84	DZ 8	0.11	0.64	1.04	6.07	0.23	1.34
Comaum	5.84	DZ 9	0.11	0.64	1.56	9.11	0.27	1.58
Compton	4.9	DZ 10	0.11	0.54	0.54	2.65	0.44	2.16
Conmurra	5.84	DZ 6	0.11	0.64	1.45	8.47	0.22	1.28
Donovans	4.9	DZ 11	0.11	0.54	0.54	2.65	0.39	1.91
Duffield	6.7	DZ 5	0.11	0.74	1.45	9.72	0.50	3.35
Fox	5.84	DZ 6	0.11	0.64	1.45	8.47	0.22	1.28
Frances	6.4	DZ 7	0.11	0.70	0.54	3.46	0.38	2.43
Glenburnie	4.9	DZ 10	0.11	0.54	0.54	2.65	0.44	2.16
Glenroy	5.84	DZ 9	0.11	0.64	1.56	9.11	0.27	1.58
Grey	5.08	DZ 8	0.11	0.56	1.04	5.28	0.23	1.17
Hacks	6.15	DZ 9	0.11	0.68	1.56	9.59	0.27	1.66
Hindmarsh	4.9	DZ 10	0.11	0.54	0.54	2.65	0.44	2.16
Hynam east	6.4	DZ 4	0.11	0.70	1.14	7.30	0.19	1.22
Hynam West	6.4	DZ 4	0.11	0.70	1.14	7.30	0.19	1.22
Joanna	5.84	DZ 7	0.11	0.64	0.54	3.15	0.38	2.22
Joyce	6.15	DZ 8	0.11	0.68	1.04	6.40	0.23	1.41
Kennion	5.49	DZ 5	0.11	0.60	1.45	7.96	0.50	2.75
Killanoola	5.84	DZ 8	0.11	0.64	1.04	6.07	0.23	1.34
Kongorong	4.9	DZ 11	0.11	0.54	0.54	2.65	0.39	1.91
Lacepede	6.15	DZ 5	0.11	0.68	1.45	8.92	0.50	3.08
Lake george	5.49	DZ 5	0.11	0.60	1.45	7.96	0.50	2.75
Landseer	6.7	DZ 6	0.11	0.74	1.45	9.72	0.22	1.47
Lochaber	6.4	DZ 4	0.11	0.70	1.14	7.30	0.19	1.22
Macdonnell	4.9	DZ 11	0.11	0.54	0.54	2.65	0.39	1.91
Management Area 1 (MA1)	6.7	DZ 4	0.11	0.74	1.14	7.64	0.19	1.27
Management Area 2 (MA2)	6.7	DZ 4	0.11	0.74	1.14	7.64	0.19	1.27
Management Area 3 (MA3)	6.7	DZ 4	0.11	0.74	1.14	7.64	0.19	1.27
Management Area 4 (MA4)	6.7	DZ 4	0.11	0.74	1.14	7.64	0.19	1.27

Management Area*	Base Value (ML/haIE)	Delivery Zone	Drip Bridging Volume		Flood Bridging Volume		Spray Bridging Volume	
			Factor (%)	*Volume (ML/haIE)*	*Factor (%)*	*Volume (ML/haIE)*	*Factor (%)*	*Volume (ML/haIE)*
Marcollat	6.7	DZ 4	0.11	0.74	1.14	7.64	0.19	1.27
Mayurra	5.08	DZ 5	0.11	0.56	1.45	7.37	0.50	2.54
Minecrow	6.15	DZ 6	0.11	0.68	1.45	8.92	0.22	1.35
Monbulla	5.49	DZ 8	0.11	0.60	1.04	5.71	0.23	1.26
Moorak	4.9	DZ 11	0.11	0.54	0.54	2.65	0.39	1.91
Mount Benson	6.15	DZ 5	0.11	0.68	1.45	8.92	0.50	3.08
Mount Muirhead	5.08	DZ 5	0.11	0.56	1.45	7.37	0.50	2.54
Moyhall	6.15	DZ 8	0.11	0.68	1.04	6.40	0.23	1.41
Murrabinna	6.15	DZ 6	0.11	0.68	1.45	8.92	0.22	1.35
Myora	4.9	DZ 10	0.11	0.54	0.54	2.65	0.44	2.16
North Pendleton	7.66	DZ 1	0.11	0.84	0.54	4.14	0.18	1.38
Ormerod	6.15	DZ 4	0.11	0.68	1.14	7.01	0.19	1.17
Peacock	6.7	DZ 6	0.11	0.74	1.45	9.72	0.22	1.47
Riddoch	5.08	DZ 8	0.11	0.56	1.04	5.28	0.23	1.17
Rivoli bay	5.08	DZ 5	0.11	0.56	1.45	7.37	0.50	2.54
Ross	5.84	DZ 6	0.11	0.64	1.45	8.47	0.22	1.28
Shaugh	8.18	DZ 1	0.11	0.90	0.54	4.42	0.18	1.47
Short	5.49	DZ 8	0.11	0.60	1.04	5.71	0.23	1.26
Smith	5.49	DZ 6	0.11	0.60	1.45	7.96	0.22	1.21
Spence	6.15	DZ 8	0.11	0.68	1.04	6.40	0.23	1.41
Stewarts	6.15	DZ 4	0.11	0.68	1.14	7.01	0.19	1.17
Stirling	7.66	DZ 2	0.11	0.84	1.03	7.89	0.18	1.38
Struan	5.84	DZ 9	0.11	0.64	1.56	9.11	0.27	1.58
Symon	5.08	DZ 5	0.11	0.56	1.45	7.37	0.50	2.54
Tatiara	7.26	DZ 3	0.11	0.80	1.36	9.87	0.31	2.25
Townsend	6.15	DZ 6	0.11	0.68	1.45	8.92	0.22	1.35
Waterhouse	5.84	DZ 5	0.11	0.64	1.45	8.47	0.50	2.92
Western Flat	7.26	DZ 3	0.11	0.80	1.36	9.87	0.31	2.25
Willalooka (east)	7.26	DZ 3	0.11	0.80	1.36	9.87	0.31	2.25
Willalooka (west)	7.26	DZ 4	0.11	0.80	1.14	8.28	0.19	1.38
Wirrega (south)	7.26	DZ 3	0.11	0.80	1.36	9.87	0.31	2.25
Wirrega (north)	7.66	DZ 3	0.11	0.84	1.36	10.42	0.31	2.37
Woolumbool	6.4	DZ 6	0.11	0.70	1.45	9.28	0.22	1.41
Young	4.9	DZ 10	0.11	0.54	0.54	2.65	0.44	2.16
Zone 2A	5.08	DZ 10	0.11	0.56	0.54	2.74	0.44	2.24
Zone 3A	5.49	DZ 9	0.11	0.60	1.56	8.56	0.27	1.48
Zone 5A	6.15	DZ 7	0.11	0.68	0.54	3.32	0.38	2.34
Zone 8A	7.66	DZ 1	0.11	0.84	0.54	4.14	0.18	1.38

* Note – See Figure 3 in Appendix G for location of Management Areas

F. CALCULATIONS OF DRAFT VOLUMETRIC ALLOCATIONS

Calculating draft allocations where only one irrigation system type is used

Example: 100 haIE licence in Zone 2A

NIR_0 = 5.08 ML/haIE

Delivery Component Factor: Drip (+11%), Flood (+54%), Spray (+18%)

(For values for NIR_0 and Delivery Component Factor see App. B)

For licences where drip irrigation systems are used

Base Allocation	=	NIR_0 x haIE
	=	5.08 x 100
	=	**508 ML**
Delivery Component	=	Base Allocation x Delivery Component Factor
	=	508 x 0.11
	=	**56 ML**
Total Allocation	=	Base Allocation + Delivery Component
	=	508 + 56
	=	**564 ML per annum**

For licences where flood irrigation systems are used

Base Allocation	=	NIR_0 x haIE
	=	5.08 x 100
	=	**508 ML**
Delivery Component	=	Base Allocation x Delivery Component Factor
	=	508 x 0.54
	=	**274 ML**
Total Allocation	=	Base Allocation + Delivery Component
	=	508 + 274
	=	**782 ML per annum**

For licences where spray irrigation systems are used

Base Allocation	=	NIR_0 x haIE
	=	5.08 x 100
	=	**508 ML**
Delivery Component	=	Base Allocation x Delivery Component Factor
	=	508 x 0.18
	=	**91 ML**
Total Allocation	=	Base Allocation + Delivery Component
	=	508 + 91
	=	**599 ML per annum**

Calculating draft allocations where more than one irrigation system type is used

Example: 100 haIE licence in Zone 5A, irrigating 40 ha of lucerne seed under flood & 35ha of pasture under spray.

NIR_0: 6.15 ML/haIE

Delivery Component Factor: Flood (+54%), Spray (+18%)

Determine the net NIR_C under each irrigation system

Net NIR_C	=	NIR_C (haIE) x area (ha) (see App. A)		
Net NIR_C (Flood)	=	3.29 x 40	=	131.6 ML
Net NIR_C (Spray)	=	5.50 x 35	=	192.5 ML

Determine proportional split of each irrigation system type

System Proportion = $\frac{Net\ NIRc\ for\ system 1}{Total\ Net\ NIRc}$

System Proportion (Flood) = $\frac{131.6}{324.1}$ = 0.406 (or 40.6%)

System Proportion (Spray) = $\frac{192.5}{324.1}$ = 0.594 (or 59.4%)

Base Allocation	=	NIR_0 x haIE
	=	**615 ML**
Delivery Components	=	(Base x system proportion) x delivery component factor
Flood Delivery	=	(615 x 0.406) x 0.54
	=	**135 ML**

Spray Delivery	=	(615 x 0.594) x 0.18
	=	**66 ML**
Total Allocation	=	Base Allocation + Delivery Components
	=	615 + 135 + 66
	=	**816 ML per annum**

Calculating draft allocations where licensees are eligible for a Crop Adjustment Factor

Example: 100 haIE licence in Zone 3A, irrigating 60 ha of Apple trees using spray irrigation

NIR_0: 5.49 ML/haIE

Delivery Component Factor: Spray (+18%)

Extra requirement for Apples: 0.70 ML per ha of apples grown (see App. 3)

Crop Adjustment Factor	=	Area of crop grown (ha) x Extra requirement (ML/ha)
	=	60 x 0.70
	=	**42 ML**
Base Allocation	=	(haIE x NIR_0) + Crop Adjustment Factor
	=	100 x 5.49 + 42
	=	**591 ML**
Delivery Component	=	Base Allocation x Delivery Component Factor
	=	591 x 0.18
	=	**106 ML**
Total Allocation	=	Base Allocation + Delivery Component
	=	591 + 106
	=	**697 ML per annum**

Calculating draft allocations where licensees are eligible for a Specialised Production Requirement

Example: 100 haIE licence in Zone 3A, irrigating 120 ha of Potatoes using spray irrigation

NIR_0: 5.49 ML/haIE

Delivery Component Factor: Spray (+18%)

SPR for Potatoes in Zone 3A: 1.35 ML per ha of potatoes grown (see App. D)

Base Allocation	=	NIR_0 x haIE
	=	5.49 x 100
	=	**549 ML**

Delivery Component	=	Base Allocation x Delivery Component Factor
	=	549 x 0.18
	=	**99 ML**
SPR Allocation	=	Area of crop grown (ha) x SPR requirement (ML/ha)
	=	120 x 1.35
	=	**162 ML**
Total Allocation	=	Base Allocation + Delivery Component + SPR
	=	549 + 99 + 162
	=	**810 ML per annum**

Calculating the Maximum Bridging Volume Available (where licensee eligible)

Example: 100 haIE licence in Zone 3A requiring the maximum bridging volume, with no Crop Adjustment Factor or Specialised Production Requirements – Calculation performed for Flood and Spray irrigation.

Zone 3A

Base Allocation Value (NIR_0):	5.49 ML/haIE (see App. B)
Delivery Component Value:	Flood (+123%), Spray (+18%) (see App. B)
Bridging Volume Value:	Flood (+156%), Spray (+27%) (see App. E)

For licences where flood irrigation systems are used

Base Allocation	=	NIR_0 x haIE
	=	5.49 x 100
	=	**549 ML**
Delivery Component	=	Base Allocation x Delivery Component Factor
	=	549 x 1.23
	=	**675 ML**
Bridging Volume	=	Base Allocation x Bridging Volume Value
	=	549 x 1.56
	=	**856 ML**
Total Allocation	=	Base + Delivery + Bridging
	=	549 + 675 + 856
	=	**2080 ML per annum**

For licences where spray irrigation systems are used

Base Allocation	=	NIR_0 x haIE
	=	5.08 x 100
	=	**549 ML**
Delivery Component	=	Base Allocation x Delivery Component Factor
	=	549 x 0.18
	=	**99 ML**
Bridging Volume	=	Base Allocation x Bridging Volume Value
	=	549 x 0.27
	=	**148 ML**
Total Allocation	=	Base + Delivery + Bridging
	=	549 + 99 + 148
	=	**796 ML per annum**

G. LOCATION OF MANAGEMENT AREAS

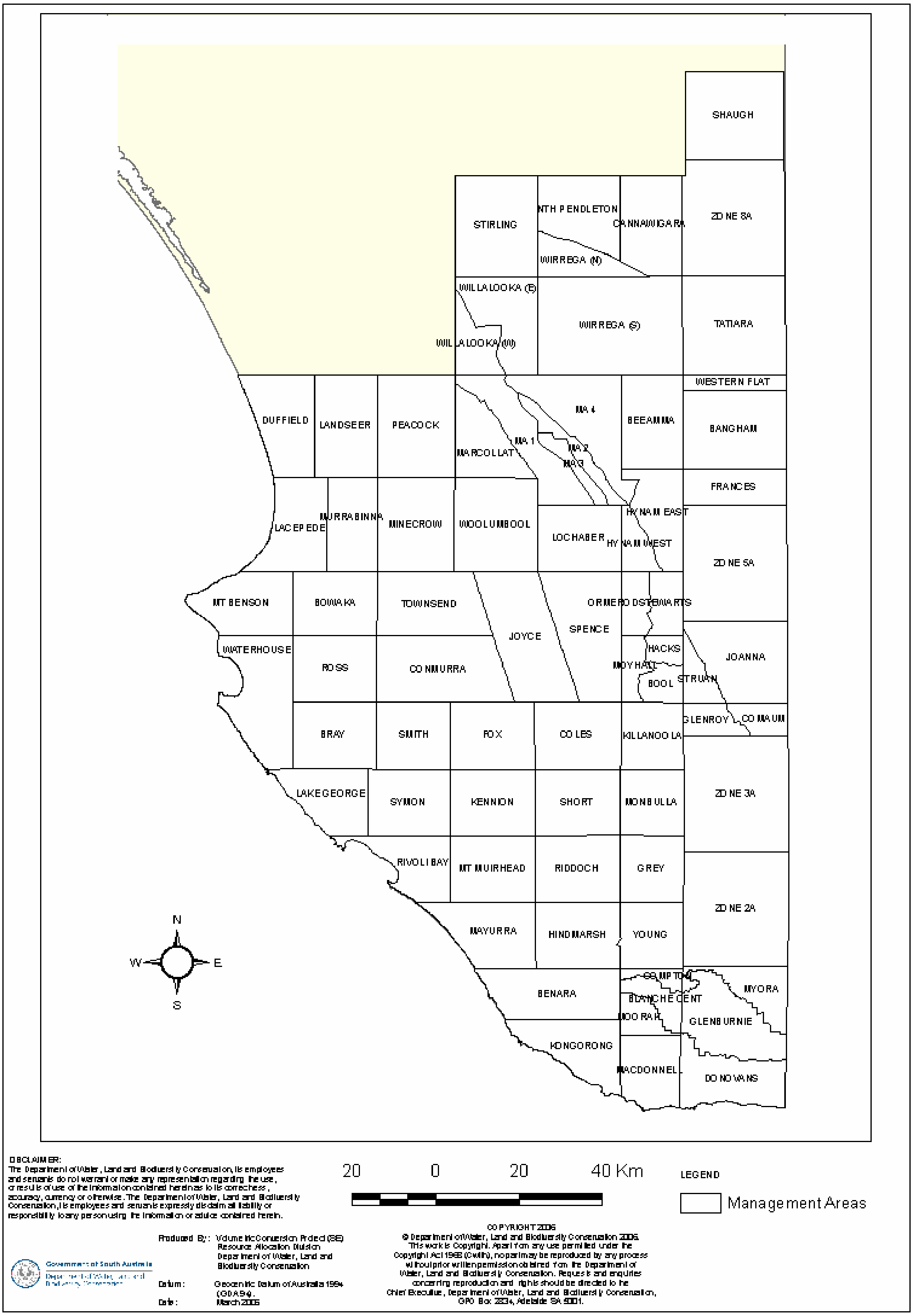

Figure 4. Location of Management Areas

UNITS OF MEASUREMENT

Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
centimetres	cm	10¬-2m	length
day	d	24 h	time interval
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
Irrigation rate / requirement	ML/ha	mm depth	Rate
kilolitre	kL	1 m^3	volume
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
percent	%	Fractions, decimal	Proportion
percentile	$X_{\%}$	Median (50^{th} percentile)	Frequency distribution

EC electrical conductivity (µS/cm)

TDS total dissolved solids (mg/L)

GLOSSARY

Annual Water Use Returns (AWUR's). End of season reporting process whereby water license holders detail their water use activities for the given season. The details required include areas of crop types grown and assessments of volumes pumped.

Application Losses. Water delivered to the border of the field, which is lost during application to the field and therefore not made available to the crop. Includes evaporation, run-off, deep drainage and drift.

Area-Based Licensing System (haIE). Existing water access entitlements to irrigate a given area of crop per annum, with no restrictions on the volume of water applied to the crop. Measured in terms of hectares of irrigation equivalents (haIE).

Base Allocation (BA). The crop water requirement component of the proposed volumetric licenses. Base Allocation (ML) = haIE x NIRo

Bridging Volume (BV). The Bridging volume is an additional temporary water allocation that may be granted on application subject to eligibility criteria. The bridging volume is designed to give irrigators who are pumping in excess of their new volumetric allocation time to adjust to the new system.

Climatic Bands. 10 Climatic Bands across the South East that were developed to better represent the range of evapotranspiration and rainfall rates across the SE of SA. It is proposed that these Climatic Bands form the basis for determination of each irrigator's volumetric allocation.

Crop Adjustment Factor (CAF). The Crop Adjustment Factor provides additional base allocation for licensees where, due to initial calculations problems, the existing area-based licensing system does not provide adequate allocation.

Crop Area Ratio (CAR). Used in the existing area-based licensing system to determine area of crops that may be grown in relation to the theoretical irrigation requirement.

Crop Calendar. Representation of the critical periods of crop growth and development for a crop in a particular geographical location, under certain management practices. Used to assign crop coefficients to months of the year to represent the crop water requirements of the crop at that location under those management practices.

Crop Coefficient (Kc). Ratio between crop evapotranspiration (ETC) and the reference crop evapotranspiration (ET_0) when crop is grown in large fields under optimum growing conditions, or ETC = Kc x ET_0 (Doorenbos and Pruitt, 1977).

Crop Water Requirement. Depth of water required by a crop…for evapotranspiration (ETC) during a given period (Doorenbos and Pruitt, 1977).

CWMB. Catchment Water Management Board.

Deep Drainage. Water that percolates past the crop root zone and is no longer available to the crop for transpiration.

Delivery Component (DC). The volume of water that a reasonably efficient irrigator needs to extract in excess of the crop water requirement to irrigate and grow the crop to account for application and distribution losses.

Delivery Zones (DZ). Areas of like characteristics within the SE. They were used to calculate delivery components and have been developed using soil mapping data, volume pumped data and other hydrogeological information sources (ie depth to water table, salinity).

Distribution Losses. Water pumped from the aquifer or from storage, which is lost during the delivery of water to the border of the field. May include evaporation and seepage from channel delivery systems, and leakage from piped delivery systems.

Drip Irrigation. High precision irrigation where water is delivered via emitters (drip, trickle, micro-spray) spaced evenly along a supply line, usually located along each crop row.

DWLBC. Department of Water, Land and Biodiversity Conservation. Government of South Australia.

Effective Rainfall (Pe). Rainfall useful for meeting crop water requirement, it excludes deep percolation, surface runoff and interception (Doorenbos and Pruitt, 1977). Calculated by the method of Dastane (1974), using the metricated algorithm of Cuenca (1989).

Evapotranspiration (ET). Rate of water loss through transpiration from vegetation plus evaporation from the soil (Doorenbos and Pruitt, 1977).

FAO 56. Food and Agriculture Organization of the United Nations. FAO Irrigation and Drainage Paper, 56 (1998) - Crop Evapotranspiration; Guidelines for Computing Crop Water Requirements.

Field Irrigation System Trials (FIST Program). Field trial sites equipped with monitoring equipment to collect detailed information on the on-farm irrigation water balance.

Flood / Surface Irrigation. Non-pressurised gravity feed irrigation, whereby water is delivered from the pump via channels to fields constructed to form rectangular bays using parallel check banks. Water flows down the bay's slope as a sheet guided by the check banks.

Frost Protection. Water applied to the crop canopy using fixed overhead sprinklers to prevent frost damage to the crop.

haIE. The number of hectares of irrigation equivalents endorsed on an existing area-based water licence.

Irrigation Equivalents (IE's). The current area-based water licensing system shown in hectares, where 1 haIE is equivalent to the evapotranspiration minus contribution by effective precipitation from one hectare of reference crop under the average climatic conditions for that region.

Irrigation Rate (ML/ha). The annual volume pumped for irrigation expressed in Megalitres (ML) divided by the area irrigated in hectares (ha).

Leaching. The application of irrigation water to minimise the built up of salts from the crop root zone.

Management Area (unconfined). Part of a Prescribed Wells Area used for groundwater management.

Maximum Production Pasture (MPP). A category of pasture that has been recognised as having increased NIR_C due to significant changes in pasture management systems.

Megalitre (ML). One million litres (1 000 000).

ML. *See megalitre.*

Metered Extraction Trials (MET Program). A field trial program aimed at generating accurate 'real-life' volume pumped data representative of irrigation practices in the region.

Net Irrigation Requirement – Crop (NIR_C). Net irrigation requirement for a specific crop, grown according to a defined crop calendar, calculated according to the FAO 56 method (Allen et al., 1998).

Net Irrigation Requirement – Reference Crop (NIR_0). Net irrigation requirement for the reference crop, reflecting the evapotranspiration demand at a certain location, according to climatic conditions in that location, calculated according to the FAO 56 method (Allen et al., 1998).

Net Irrigation Requirement (NIR). Depth of water required for meeting evapotranspiration minus contribution by effective precipitation, ground water, stored soil water; does not include operational losses and leaching requirements (Doorenbos and Pruitt, 1977).

Percentile. Increments of 1% that divides a distribution into 100 groups of equal frequency. For example the 50th percentile is a point where 50% of the data below this point and 50% is above.

Post-Harvest Cover Crop. A crop sown after the harvest of annual crops to stabilise and retain the bare soil.

Prescribed Wells Area (PWA). A water resource declared by the Governor to be prescribed under the Water Resources Act 1997, and includes underground water to which access is obtained by prescribed wells.

Project Advisory Committee (PAC). A community-based committee made up of industry representatives from major commodity groups to provide advice to the PMC on the implementation of the Volumetric Conversion Project.

Project Management Committee (PMC). Representatives from the key water management agencies associated with and responsible for implementing volumetric conversion in the region.

Reference Crop Evapotranspiration (ET_0). Rate of evapotranspiration from an extended surface of 8 to 15cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water (Doorenbos and Pruitt, 1977).

Soil Drift Control. The application of irrigation water to a bare field or emergent crop for the purpose of preventing soil from being lost or causing crop damage due wind drift.

South East Natural Resource Management Board (SENRMB). Responsible for natural resources planning, public consultation and education and in advising the Minister for Environment and Conservation on various natural resource management issues and policies.

Specialised Production Requirements (SPR). (1) Water that is necessarily applied as a part of the crop production process that does not contribute to crop water use and is not included in the delivery component (e.g. to prevent soil drift or to protect against frost damage). (2) Water that is required in addition to base allocation due to significant changes in the crop production system (as recognised by FAO 56). For example Maximum Production Pasture.

Spray Irrigation. Pressurised irrigation systems with water applied through some form of sprinkler/s. Water is delivered from the pump to the sprinkler through pipe works. Includes centre pivots, fixed sprinklers and travelling irrigators.

Transpiration. Rate of water loss through the plant which is regulated by physical and physiological processes (Doorenbos and Pruitt, 1977).

Volumetric Conversion Model. Describes the components and methodologies for the conversion of existing area-based allocations to volumetric allocations.

Volumetric Licensing System. Licensees are entitled to pump a certain volume of water per annum, but are not restricted by the area of crop/s grown.

Water allocation plan (WAP). A plan prepared by a CWMB or water resources planning committee and adopted by the Minister in accordance with Division 3 of Part 7 of the Act.

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