APRIL 2011

South East Natural Resources Management Board

GUIDE TO THE DEVELOPMENT AND CONTENTS OF THE 2009 PADTHAWAY WATER ALLOCATION PLAN

Government of South Australia
South East Natural Resources Management Board

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This document should not be taken as constituting legal advice on the application or construction of the *Natural Resources Management Act 2004* and no liability will be accepted for any such reliance on its contents.

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FOREWORD

The Minister for Environment and Conservation adopted the Water Allocation Plan for the Padthaway Prescribed Wells Area on 26 April 2009. The adoption of the Plan is the result of over six years of development by the South East Natural Resources Management Board in association with the community, assisted by the Department for Water. Particular recognition must be given to the members of the Board's community-based Padthaway Groundwater Management Committee, who met over 40 times over the six years and volunteered hundreds of hours of their time. It is through their endeavors that the plan is of the character it is, suiting as far as possible the people and water resources of Padthaway.

Padthaway has been at the forefront of change for water resources management. It has been a long and at times a difficult journey from the initial prescription of the resource and the first Water Allocation Plan in 2001, through the development of a community-based method to ensure volumetric allocations are at an environmentally acceptable level while protecting both the water resources and the productive capacity of the region. This community-driven method of allocation is a first for the State. Many lessons have been learned along the way. Transition from an over-allocated to an adaptively managed resource has been complex. Arising from this, however, is innovative policy that has set standards for the region and the State. This is clearly illustrated in the nominations of both the Padthaway Groundwater Management Committee's community members and the 2009 Padthaway Water Allocation Plan for the 2009 Premier's NRM Awards.

This Guide to the development and contents of the 2009 Padthaway Water Allocation Plan provides an explanation of the key policy directions in the Plan, as well as a history of how these policies were arrived at. It includes details of the community-developed method of water allocation that aims at finding a balance between sustainable extraction of the water resources and the management of the social and economic impacts of reducing allocations.

The Plan makes a very strong start in pursuit of the goal of a balance between the social, economic and environmental demands and needs for water. It is the result of significant scientific research of the area, combined with extensive and rigorous community participation and consideration of a significant array of community input. The Plan will enable landholders and industry in the region to responsibly conduct their water-based operations while ensuring the underground water resource is managed sustainably.

I commend the 2009 Padthaway Water Allocation Plan and this Guide to you, as an important reference point for all water using activities in the area.

Mark Braes
Presiding Member
South East Natural Resources Management Board

1. Introduction

1.1 Purpose of this guide

This non-statutory document is designed to accompany the 2009 Water Allocation Plan for the Padthaway Prescribed Wells Area (2009 Padthaway WAP) and includes:

1. a description of the Padthaway Prescribed Wells Area and the capacity and condition of the groundwater resources;
2. the background to the development of the policies in the 2009 Padthaway WAP, including issues, scientific findings and updates;
3. explanation of the policies (principles) contained within the 2009 Padthaway WAP;
4. Appendices (including volumetric conversion of allocations and a brief history of water management and community consultation in the Padthaway PWA).

1.2 The Padthaway Prescribed Wells Area (Padthaway PWA)

The Padthaway Proclaimed Region was gazetted on 13 May 1976 under the provisions of the *Water Resources Act 1976,* following concern that increasing irrigation activity may lower the water table. Upon introduction of the *Water Resources Act 1997* the Padthaway Proclaimed Region became known as the Padthaway Prescribed Wells Area (PWA).

The Padthaway PWA is located approximately 150 km north of Mount Gambier and covers an area of approximately 67,000 hectares (700 km^2), including the Hundreds of Glen Roy, Parsons and the north-eastern half of Marcollat. It incorporates the town of Padthaway and the locality of Keppoch (Figure 1, page 6).

Groundwater resources

In the Padthaway PWA, underground water is extracted from two sub-aquifers, the Padthaway Formation and the Bridgewater Formation, which form part of the regional unconfined aquifer. These water resources have been fully allocated in most of the PWA since the time of proclamation.

The confined aquifer is generally absent, or thin (less than 2.5 m in thickness), over much of the Padthaway PWA and is not utilised as a water resource.

Land and water use

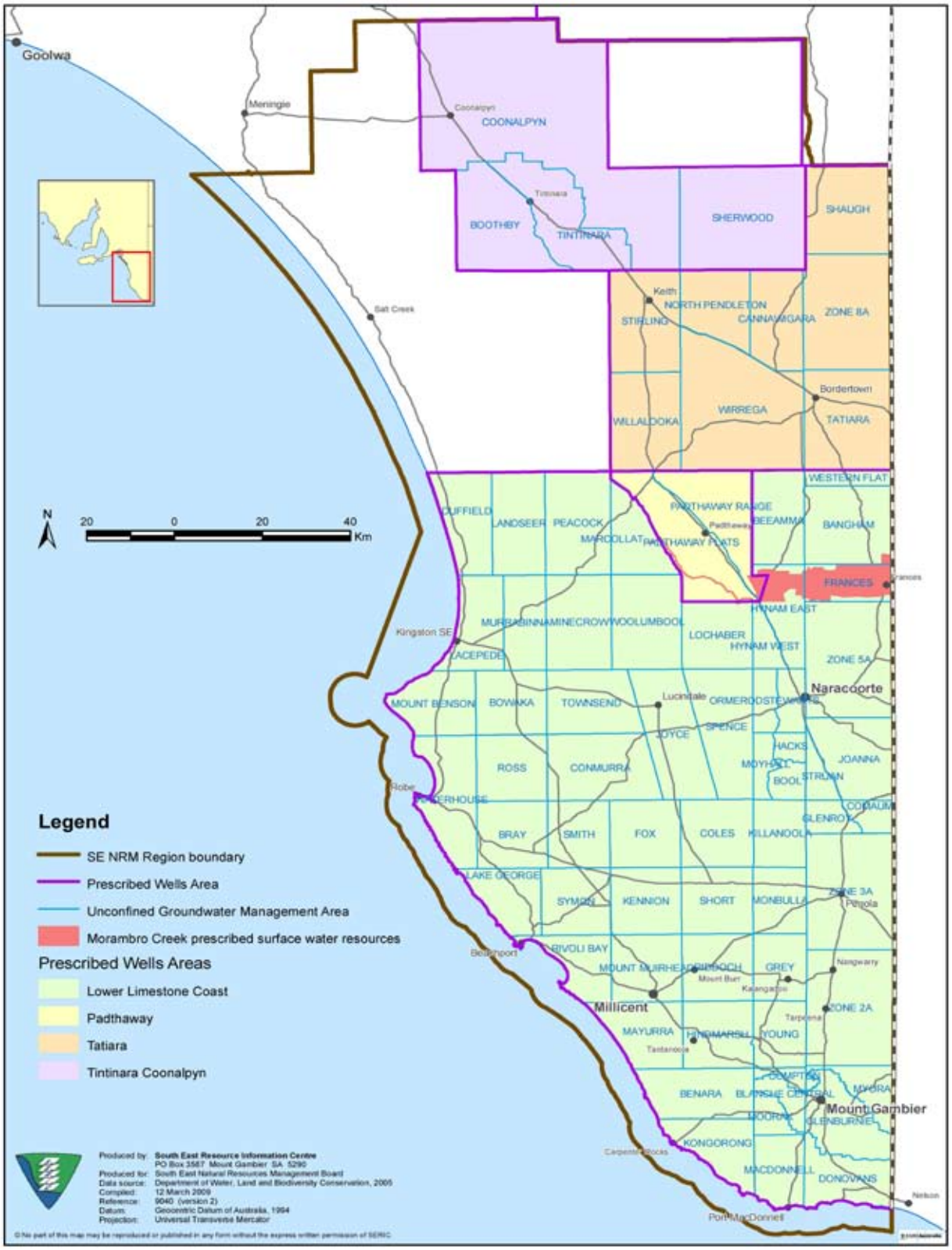
Most of the 67,000 hectares of the Padthaway PWA is comprised of irrigated agriculture and horticulture, and improved pastures for sheep and cattle grazing. Grapes are the main crop produced in the region, which are for the most part processed for the wine industry.

Irrigation is concentrated on the inter-dunal Flats, along the main Keith-Naracoorte road, due to the combination of suitable soil types, good quality shallow underground water (compared to other areas) and high well yields.

1.3 History of water resources management in the South East

Prior to May 1998, two Water Resources Planning Committees (WRPCs), the Upper South East WRPC and the Lower South East WRPC, guided groundwater management in the South East. These committees developed some of the cornerstones of the current policy framework contained in the WAPs, including the groundwater trading rules and the basis for hydrogeological tests.

Figure 1: South East Natural Resources Management Region and Prescribed Water Resources Areas



The South East Catchment Water Management Board (SECWMB) was formed on 15 May 1998, replacing the two existing Water Resources Planning Committees. The Board was established under the *Water Resources Act 1997* and the policy development environment changed to a process of highly structured ongoing planning with direct community participation, as required under the Act.

The South East Natural Resources Management Board (the Board) was formed on 20 April 2005, replacing the SECWMB and bringing together the activities of the Animal and Plant Control Boards, Soil Conservation Boards and South East Natural Resources Consultative Committee.

The Board was established under the *Natural Resources Management Act 2004*. The policy development environment is the same as the one undertaken under the *Water Resources Act 1997*, including a process of highly structured ongoing planning with direct community participation. The Board's role is to bring together the complex interaction between soil, water, land, pest plants and animals and coast and marine environments to be sustainably managed in a unified approach.

The initial 2001 Water Allocation Plan for the Padthaway Prescribed Wells Area (2001 Padthaway WAP) was adopted on 14 October 2001. Its review was initiated by the SECWMB and continued by the South East Natural Resources Management Board.

Appendix C contains a brief history of water use and management in the Padthaway PWA.

1.4 What is a WAP?

A Water Allocation Plan, commonly referred to as a WAP, is a legal document prepared under the *Natural Resources Management Act 2004* (formerly the *Water Resources Act 1997*) that outlines the rules for allocation, transfer and use of available water from prescribed resources. The *Natural Resources Management Act 2004* (the NRM Act) requires the Board to prepare a WAP for each of the prescribed water resources in its area.

A WAP sets the limits on the amount of water that can be taken and used for all uses. In setting the limits, a WAP considers the needs of both the environment and consumptive water uses. It also considers the water resource's capacity, the demands upon it, and the potential impacts of its use on other water resources.

1.5 Why has the Padthaway WAP been amended?

Although the *Water Resources Act 1997* (now superseded by the NRM Act) required that water allocation plans be reviewed every 5 years, the review of the 2001 Padthaway WAP was initiated in 2002 in recognition of the fact that the area was overallocated and that the groundwater resources were showing signs of decline.

A series of issues and required changes had been identified in the Padthaway PWA during the preparation of the 2001 Padthaway WAP (SECWMB 2001 *Companion to the South East Water Allocation Plans*):

- overallocation
- rising groundwater salinity
- dropping water tables
- the need to convert area-based allocations to a volume
- the need to review acceptable levels of extraction.

The 2001 Water Allocation Plan identified two of the four original management areas (referred to as management areas 2 and 3) (Figure 10, page 31) as over-allocated, and also identified the

rising trend in groundwater salinity. However, the 2001 WAP did not include a method to address these issues.

Concerns regarding the impact of the levels of allocation on water tables, prompted the then Minister for Water Resources to declare a Notice of Restriction on the taking of water in December 2001, to hold water extraction at current levels while sustainable management options were developed.

1.6 The Padthaway Groundwater Management Committee

The Padthaway Groundwater Management Committee was formed in 2002, as part of a range of measures to examine and ensure sustainable groundwater management in the Padthaway area, following the December 2001 announcement by the then Minister for Water Resources regarding a Notice of Restriction on groundwater use in this area.

The Committee consisted of a number of community representatives, as well as Department of Water, Land and Biodiversity Conservation (now Department for Water) and Board staff. The Committee was initially chaired by a Committee member, and later, by the Presiding member of the Board.

Over an almost 7-year period, the Committee played a fundamental role in the development of the WAP through the discussion of issues and provision of recommendations to the Board. The Committee's efforts were recognised by the Board in a nomination for the 2009 Premier's Natural Resources Management Awards[1], in which the Committee was selected as a finalist in the Integrated Project category.

1.7 How does the Padthaway WAP relate to the South East's Regional Natural Resources Management Plan and other plans in the Region?

Under the *Natural Resources Management Act 2004*, the South East Natural Resources Management Board is responsible for preparing natural resources management plans. Plans include a comprehensive Regional Natural Resources Management Plan for the South East as well as separate water allocation plans for the prescribed water resources within the Board's jurisdiction (Figure 1).

The 2009 Padthaway WAP is one of six groundwater allocation plans prepared by the Board and currently implemented by the Department for Water. The Water Allocation Plans for the Comaum-Caroline, Lacepede Kongorong and Naracoorte Ranges Prescribed Wells Areas (now amalgamated to form the Lower Limestone Coast Prescribed Wells Area) were adopted by the former Minister for Water Resources on 14 October 2001. The Tintinara-Coonalpyn WAP was adopted on 30 May 2003. The 2009 Padthaway WAP was adopted on 26 April 2009, while the 2001 Tatiara WAP was replaced by the 2010 Tatiara WAP on 07 June 2010.

[1] The 2009 Padthaway Water Allocation Plan was also nominated (by DWLBC) for the Premier's NRM Award.

2. Groundwater resources in the Padthaway Prescribed Wells Area (PWA)

The regional underground water flow moves down a potentiometric gradient from east to west in the Naracoorte Range (also known as the Padthaway Range) into the Padthaway Flats where the flow changes to a north-westerly direction through the valley.

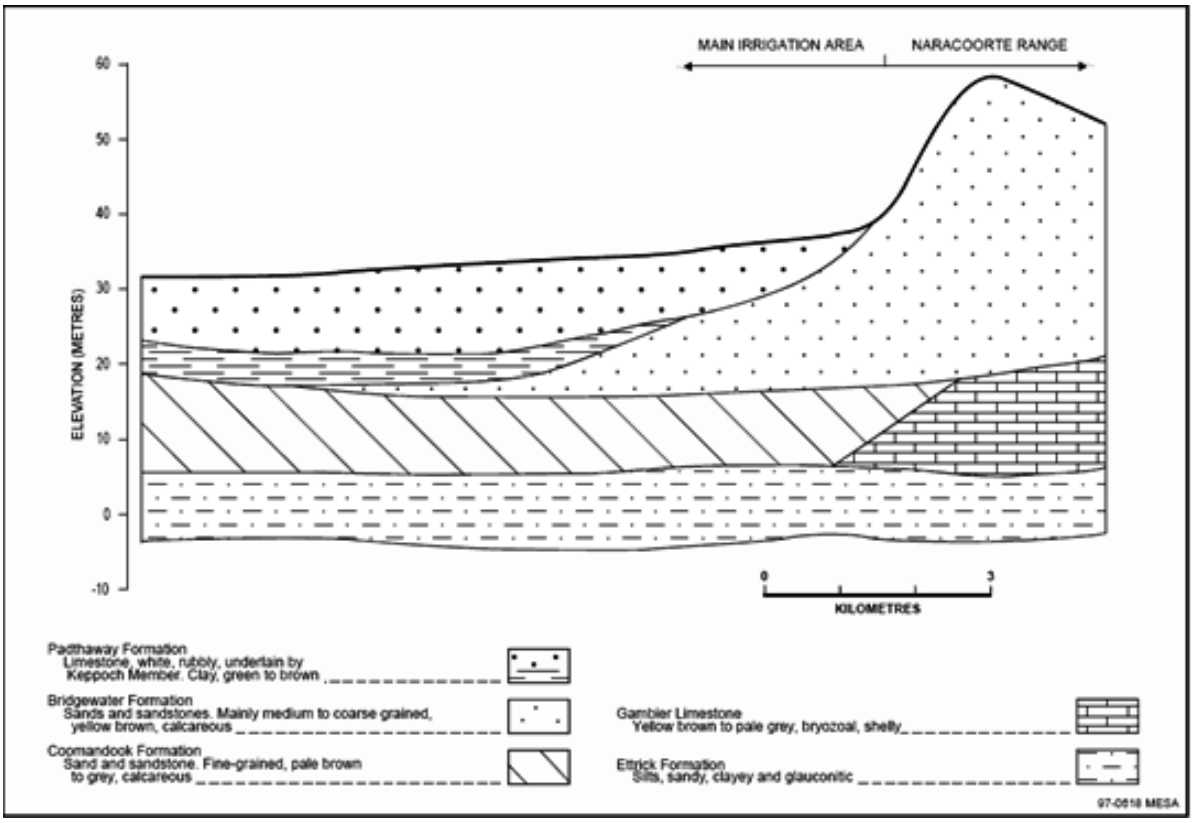
Unconfined aquifer

In the Padthaway PWA, underground water is extracted from two sub-aquifers, the Padthaway Formation and the Bridgewater Formation, which form part of the regional unconfined aquifer (Figure 2). These water resources have been fully allocated in the Padthaway Flats since the time of proclamation.

The Padthaway Formation is the most utilised sub-aquifer in the PWA, with the main irrigation area, commonly referred to as the Padthaway Flats, located over this formation. It is generally highly transmissive (ie has high well yields) and depth to water generally ranges between 2 and 6 metres.

The Bridgewater Formation sub-aquifer forms the main aquifer in the Naracoorte Range. Average well yields are approximately 30 litres/second and the quality of the underground water from the aquifer is better than its equivalent on the Flats, but the formation is not as consolidated and can produce fine sand when pumped.

Figure 2. Schematic east-west geological cross-section through the Padthaway PWA



Confined aquifer

The confined aquifer is generally absent, or thin (less than 2.5 m in thickness), within much of the Padthaway PWA and therefore the yield is poor and the capacity of the confined aquifer resource is limited. Although there is a potential for licenced extraction from this aquifer it is generally not utilised as a water resource and currently it is only used for stock and domestic use.

2.1 Condition of the groundwater resources in the Padthaway PWA

2.1.1 Water level trends

Long-term (1973-2005) water level trends in the Padthaway Prescribed Wells Area (PWA) indicate that there have been no significant long-term changes in water levels. However, a number of the wells showed a rising water level trend beginning in the mid to late 1980s. This rise in the water table is considered a result of the clearance of native vegetation and the failure of lucerne crops in the mid-1970s (SECWMB 2001). Water levels then dropped at a rate of approximately 100 mm/year from 1992-2002 and rainfall was below average for the same period.

In the Padthaway Flats (located over the Padthaway Formation on the western side of the Prescribed Wells Area) (Figure 2), depth to the water table is lower, ranging between 2 and 6 m, than in the Naracoorte Range (where it ranges between 5m and 30 m), and fluctuations in groundwater levels show a strong correlation with rainfall patterns.

In the Padthaway Range, located over the Bridgewater Formation (Figure 2) and also referred to as the Naracoorte Range, hydrographs from observation wells show long-term underground water level rises of between 0.04 and 2.0 m/year over the monitoring record. The predominant cause of the rise in the water table is considered to be an increase in recharge caused by the clearance of native vegetation and the failure of lucerne crops in the late 1970s. The majority of these hydrographs indicate the water table has reached or is approaching a new state of equilibrium.

The five year water level trends for 2003-2007 indicated that there has been a general decline in water level across the whole region at an average rate of between 0.01 m/year and 0.40 m/year. The decline in the Padthaway Range was generally less than 0.15 m/year while the decline on the Padthaway Flats was generally greater than 0.15 m/year. This decline is in excess of the average 0.1 m/year limit for water table declines set out in both the 2001 and 2009 Padthaway Water Allocation Plans.

2.1.2 Salinity

Generally, the salinity of underground water in the Padthaway Range is lower than on the Padthaway Flats (SECWMB, 2001). Groundwater salinity in the Naracoorte Range varies between approximately 860 mg/L and 1700 mg/L, with increases of up to 20 mg/L/year being observed. On the Padthaway Flats, groundwater salinity ranges between 1000 mg/L and 1900 mg/L, increasing by up to 44 mg/L/year.

In the eastern-most part of the Padthaway Flats, previously known as management area 1 (Figure 10, page 31), many observation wells show a declining underground water salinity trend of between 10 and 50 mg/L annually. This is attributed to a lowering of the water table related to the establishment of the drainage system in the western margin and to the resulting increase in lateral flow of lower salinity underground water from the east.

In the main irrigated area of the Padthaway Flats (previously defined as management areas 2 and 3 (Figure 10, page 31), the salinity of the underground water has been increasing on average between 5 and 18 mg/L/year for more than 20 years.

Groundwater salinity in the Padthaway PWA is generally considered to be well within the accepted limits for livestock. Of more concern is the effect the rising salinity will have on crop yields. The salinity of the groundwater from the unconfined aquifer in some parts of the Padthaway Flats already exceeds the recommended threshold for grape vines of 1,500 mg/L.

The Padthaway Salt Accession Project (refer to *2.4 The Padthaway Salt Accession Project*), initiated in 2002, quantified underground water extraction, irrigation application, crop water use, evaporation and salt accession to the aquifer under different irrigation practices. This study concluded that the historical salinity increase had been predominantly caused by the increased recharge in the Padthaway Range (Figure 11, page 32) (commonly referred to as Naracoorte Ranges) due to the clearance of native vegetation between the 1950s and 1970s, which has flushed the salts from the unsaturated zone of the soil profile in that part of the Prescribed Wells Area. This historic salt load has then moved with the natural underground water flow out beneath the Padthaway Flats.

Groundwater salinity in the Padthaway Range is increasing at a rate of 5 to 18 mg/L annually (DWLBC 2004/61), as a result of higher rates of recharge (reflected in the rising water table) flushing salts stored in the soil profile and the unsaturated zone into the aquifer. A large quantity of salt still remains in the unsaturated zone in significant areas of the Padthaway Range and is predicted to continue to move into the underground water system over the next decades, causing further salinity impacts in the Padthaway Flats. However, this unsaturated zone salt store is finite and results show that parts of the Padthaway Range have been completely flushed and fresh water is now being recharged in its place.

Salinity impacts from irrigation drainage water are also considered to be significant on the Padthaway Flats. Rainfall events and drainage from irrigation can flush the salts which have been delivered and stored in the soil profile from previous irrigations. The impact of saline irrigation drainage water on underground water salinity is much more evident in the north of the PWA than in the south, possibly due to the greater occurrence of flood and centre pivot irrigation in that area and/or the cumulative effect of all irrigation practices along the underground water flow path. In addition to this, bodies of saline soil water have built up in the unsaturated zone under drip and centre pivot irrigation. The risk associated with leakage of these stored salts into the groundwater system is not yet fully understood.

2.1.3 Level of allocation and use

A total of 5,923 hectare irrigation equivalents (haIEs) have been allocated in the Padthaway PWA. Based on the volumetric conversion model developed by DWLBC (now DFW) and published in 2006 (*Appendix A*), the volume of water required by reasonable irrigators to irrigate this area based on their irrigation system type, climate, predominant soil types and other factors, can be estimated as 86,546 ML/year. Under flood irrigation, it is assumed that a significant percentage of this volume returns to the unconfined aquifer. Actual volumes pumped over the last years have ranged between 33,515 ML/year to 40,740 ML/year. The majority of the water allocated was used for irrigation, with the remainder being allocated to industry, recreational use and public water supply.

2.2 Capacity of the resource to meet demands

Whilst the potential impacts of salt accumulation beneath different irrigation activities on the Padthaway Flats are still to be quantified, the Padthaway Salt Accession Project has shown that maintaining the lateral inflow of fresh underground water (and therefore the current level of recharge) from the Padthaway Range is crucial for ensuring the long-term sustainability of irrigation development in this area.

A number of activities have the potential to affect the current levels of recharge in the Padthaway Range, including an increase in the current levels of water allocation and extraction. As a result, the Plan precludes any further allocation of underground water. In addition, recent studies in the Lower South East, where plantation forestry has been regulated as a significant water-affecting activity since 2004, have allowed the quantification of the effects of land use change on the water balance due to afforestation activities.

The potential impact of afforestation in the Upper South East was raised as a concern by members of the Padthaway community. The SE NRM Board's recently adopted NRM Regional Plan contains policy for the management of the impact of plantation forestry throughout the entire South East NRM Region, including Padthaway. The implementation of this policy is subject to a regulation being made (for more details refer to 2.10 *Managing the impacts of land use change* and the Board's *2010 Regional Natural Resources Management Plan*).

A re-evaluation of the volume of underground water that can be extracted sustainably was undertaken during the development of the 2009 Padthaway WAP using a 3D model of salt and water fluxes. This process found that the current levels of groundwater extraction are sustainable, but the potential demand of 86,546 ML (based on the volumetric conversion of existing area-based licences) on the unconfined aquifer exceeds the capacity of the resource. This is further described in section 2.5.3 (*Allocation scenarios modeled through the 3D numerical model (PadMod 1)*).

2.3 Addressing the issue of increasing groundwater salinity

2.3.1 Background

In the main irrigated area of the Padthaway Prescribed Wells Area (PWA), the salinity of the groundwater has been increasing for more than 20 years (between 5 and 18 mg/L/year (DWLBC 2004/61).

The water quality guideline for salinity of drinking water for human consumption is 1,000 mg/L or less. Water with salt levels above 4,000 mg/L is marginal for stock, while above 7,000 mg/L it currently has few economic uses. Crop yields tend to decrease with increases in salinity, and few higher value crops will achieve optimal production where groundwater salinity is above 2,000 mg/L.

The crop with the greatest area under irrigation (3,900 hectares) in the Padthaway PWA is grape vines. Grape vines are moderately sensitive to salt and grow best when salinity of irrigation water is less than 500 mg/L. At groundwater salinity levels of 1,500 mg/L vine productivity is reduced by about 25%, while at about 2,500 mg/L the yield will reduce to 50% of the optimum. High levels of sodium in wine may also restrict their marketability overseas (Kaye, G., July 2005, pers. comm.).

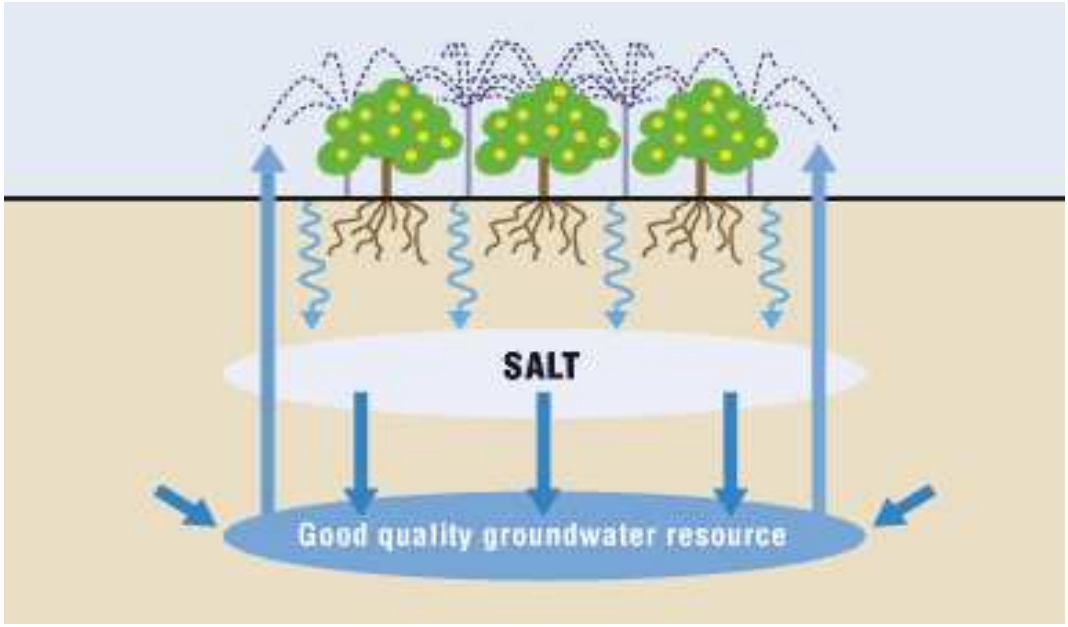
The main source of irrigation water in the Padthaway PWA is groundwater. Water applied to the crop is lost to the system through transpiration and evaporation. While water is evaporated out of the system the salt is not, and may remain in the soil profile. Rainfall events, which also contain low concentrations of salt, and drainage from irrigation, flush the salts that have been stored in the soil profile into the underlying aquifer (Figure 3, page 13).

The slow horizontal movement of groundwater and the high density of irrigation activity in the main irrigation area of the Padthaway Flats have resulted in a recycling of water as it is pumped from the aquifer to the surface before draining back down to the water table. This further concentrates the salt in the groundwater.

The other process whereby salt is added to the system in the Padthaway PWA is from horizontal inflow from the Padthaway Range. Increased rainfall recharge resulting from historical land use changes in the Padthaway Range, including clearance of native vegetation, has led to a rise of

1.0 – 2.0 metres in groundwater levels in the Range and has mobilised the high concentrations of salts stored in the soil profile. Once in the groundwater system, this salt has the potential to move down-gradient and into the main Padthaway irrigation area and further increase groundwater salinity (Figure 4 a) and b), page 13).

Figure 3. Effect of irrigation on groundwater salinity



DWLBC (now Department for Water) recommended the following actions at the time of preparing the 2001 Padthaway PWA Water Allocation Plan:

1. water allocation and use in each management area be reduced so that groundwater use does not exceed the average rainfall recharge volume;

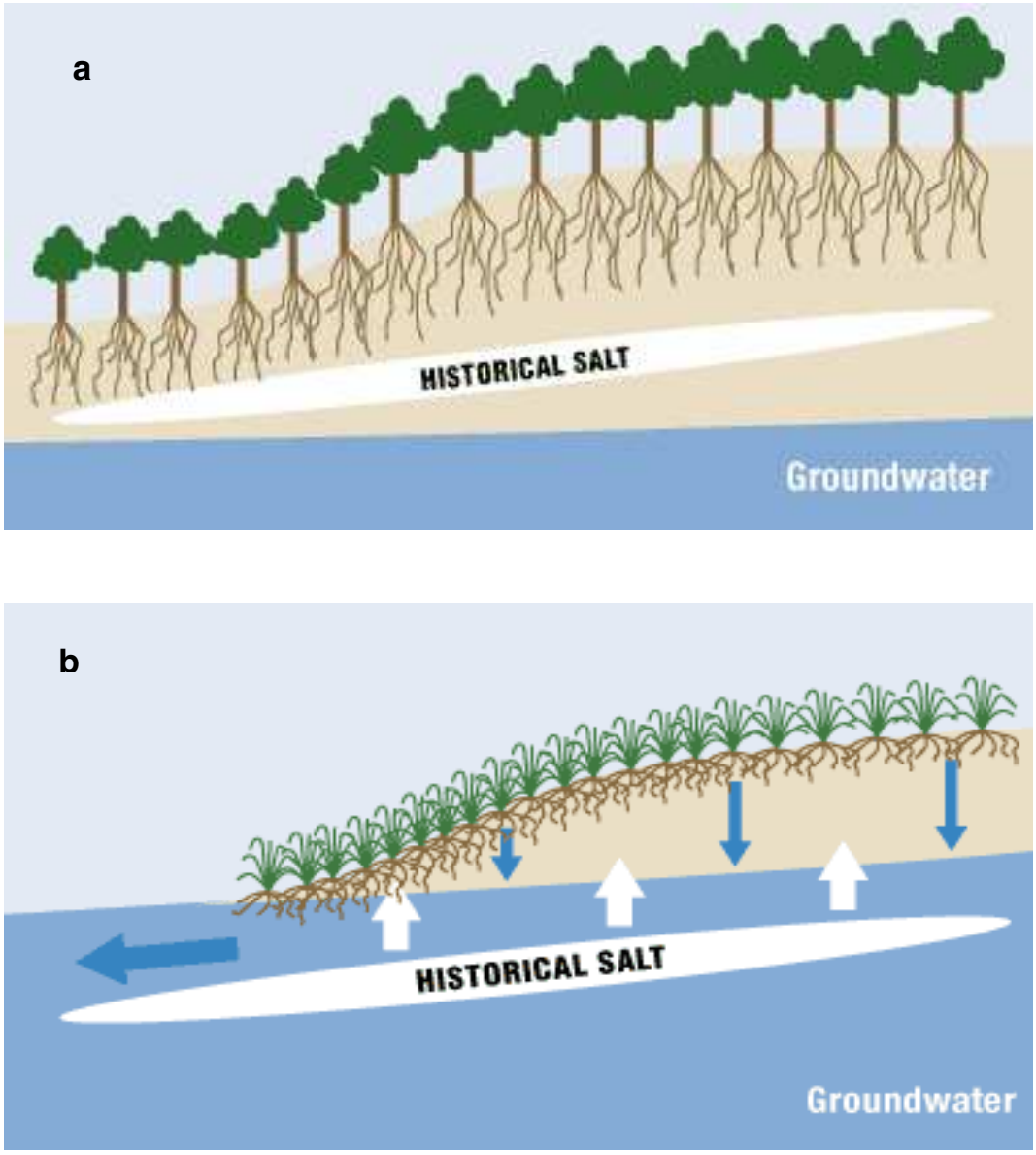
2. a salinity increase not exceeding 10 mg/L per annum be used as a target for sustainable management of the underground resource;

3. a suitable method of measuring actual underground water use be implemented as a matter of priority; and

4. no further underground water be allocated in the remaining management areas because of the complex aquifer interactions between the management areas.

The 2001 Water Allocation Plan identified but did not address the issues of over-allocation and rising groundwater salinity. The Minister implemented a Notice of Restriction soon after the adoption of the 2001 WAP (see 2.3.4 *Notice of Restriction in the Padthaway PWA* for more details*).* However, the 2001 Padthaway WAP incorporated a resource condition trigger for groundwater salinity. Mean (arithmetic) increases in groundwater salinity of greater than 10 mg/L/year (measured over the preceding 5 years) were chosen as an indicator of a detrimental increase in groundwater salinity and as a trigger for the development of management options to address the issue.

Figure 4 (a & b). Effects of land use change on recharge in the Naracoorte Range



2.3.2 Notice of Restriction in the Padthaway PWA

As mentioned above, the 2001 Water Allocation Plan identified but did not address the issue of over-allocation. Instead, in response to the need to hold water use at current levels whilst the South East Catchment Water Management Board (now South East Natural Resources Management Board), DWLBC and the community, through the Board's proposed Padthaway Groundwater Management Committee and other community members, developed a plan for the sustainable management of the groundwater in the Padthaway PWA, a Notice of Restriction (NoR) was implemented in the Padthaway PWA. The NoR did not impact on a licensee's property right (their licensed allocation) but instead limited the water use at current levels.

The first *Notice of Restriction on Water Use in Padthaway* came into effect on 29 December 2001 for a period of two years. It limited water use to the maximum recorded use during the period 30 June 1998 to 30 June 2001, except where a significant financial commitment had already been made for additional use.

The second *Notice of Restriction on Water Use in Padthaway* came into effect on 7 November 2003, with more flexible conditions for licensees. A third and fourth Notice of Restriction were brought into effect in 2005 and 2007, with the same conditions as the second notice.

The NoR achieved the objective of holding water use at current levels. Nevertheless, conversion of other crop types to grapes could occur under the NoR, where an authorisation was granted under the Notice guidelines. However, it was hoped that irrigators, in recognition of the seriousness of the issue, would not convert, or undertake limited conversion to grapevines, which are a perennial, salt sensitive crop. This proved not to be the case, with conversions from other crop types to grapes still occurring under the NoR.

The Board, DWLBC (now Department for Water) and the Padthaway Groundwater Management Committee considered it necessary to complete the review of the Padthaway WAP prior to the removal of the NoR. The Padthaway WAP was adopted on 26 April 2009 by the Minister for Environment and Conservation and the Notice of Restriction lifted on 25 June 2009.

2.3.3 Management options to reduce the rate of salt accession

A number of management options have been suggested to reduce the rate of salt accession in the aquifer. These include:

- importing lower salinity water for direct irrigation use or injection into the aquifer for storage and subsequent recovery;
- sourcing irrigation water of lower salinity from deeper parts of the aquifer or from nearby aquifers;
- reducing irrigated crop water use by retiring areas from irrigation;
- desalinating groundwater prior to irrigation use;
- inducing a greater throughflow of groundwater, to encourage the flow of water of lower salinity from under the Padthaway Range into the Padthaway Flats.

Of these, the management options considered to be the most feasible were:

a) reduce water allocations and use in parts of Padthaway;
b) artificial recharge from Morambro Creek;
c) construction of a desalination plant.

These options are further discussed below.

a) Reduction of water allocations

One option to attempt to arrest the ongoing salinity-induced decline in water quality in the Padthaway PWA is to reduce the level of water allocations and therefore use within the region. A reduced amount of irrigation in Padthaway could assist in correcting the salt imbalance by directly addressing one of the causes of rising groundwater salinity in Padthaway, ie the concentration and recycling of irrigation water.

Water allocations may be reduced by the Minister in certain circumstances set out in the *Natural Resources Management Act 2004*. Such circumstances include the need to prevent deterioration of water quality, prevention of damage to ecosystems and if there is insufficient water to meet demand. Compensation is not payable by the South Australian government in these circumstances. Under the NRM Act, the Minister must reduce the allocations of all the licences

proportionately (by the same percentage), unless another method of reducing allocations is supported.

The beneficiaries of a reduction in licenced volumes are the existing and future users who will benefit from the sustainable management of the water resource and therefore greater licence security. Water dependent ecosystems and stock and domestic users also benefit from the halting or slowing of irrigation induced salinity.

However, the finalisation of a 3D model of salt and water fluxes (PadMod, developed by Aquaterra and the former Department of Water, Land and Biodiversity Conservation) within the Padthaway PWA, showed that reductions in the current level of extraction could result in further increases in groundwater salinity on the Padthaway Flats. The numerical model showed that reducing the level of extraction would result in a rise in the already shallow water tables, increasing the risk of groundwater salinisation through evapotranspiration and/or leaching of the salt store located beneath the root zone of crops.

The volumetric conversion model developed by DWLBC (now Department for Water) (Appendix A) and adopted by the Board with minor changes (Appendix B) indicated that the volume of allocation represented by the existing area-based allocations was in excess of 80,000 ML. The 3D model showed that extraction of 78,645 ML/annum (100% of allocation as estimated at the time) would be detrimental to the groundwater resources (2.5.3 Allocation scenarios modeled through the 3D numerical model (PadMod)) and, therefore, the existing level of allocation posed a risk to the resource if extracted.

As a result, volumetric allocations in the Padthaway PWA have been issued according to a community-developed process that resulted in allocations being reduced to an Acceptable Level of Extraction (currently set at 48,000 ML) with no significant reduction to the current levels of extraction (approximately 40,000 ML/year) and no detrimental impacts on water levels or salinity (for more details, refer to *2.6 Developing a method to allocate water at the Acceptable Level of Extraction).*

This method of allocation meets the National Water Initiative (of which South Australia is a signatory) requirement of reducing allocations to environmentally sustainable levels of extraction.

b) Artificial recharge from Morambro Creek

The Padthaway Grape Growers Association (PGGA) undertook some preliminary investigations to explore options to improve the quality of groundwater in the Padthaway region (Tonkin, 2001). The use of the surface water resource of Morambro Creek was initially identified as a priority option. This led to the Morambro Creek watercourse and surface water area (including Cockatoo Lake and Nyroca Channel) being prescribed on 12 April 2001.

A Water Allocation Plan for the creek (*Water Allocation Plan for the Morambro Creek and Nyroca Channel Prescribed Watercourses including Cockatoo Lake and the Prescribed Surface Water Area*) was adopted by the Minister for Environment and Conservation on 13 January 2006. However, the unreliability of flows in Morambro Creek prompted the PGGA to consider additional options for improving the quality of groundwater in the Padthaway region, such as the construction of a desalination plant.

c) Construction of a desalination plant

A consultancy commissioned in 2002 by the Padthaway Grape Growers Association (PGGA), resulted in Tonkin Consulting identifying desalination of groundwater using reverse osmosis technology as the preferred option for improving the quality of groundwater in the region. In July 2003, Tonkin Consulting completed a feasibility study on behalf of the PGGA, for a reverse osmosis desalination plant. The study showed that the desalination plant would be feasible and viable, provided that the tail water could be disposed of satisfactorily (Tonkin 2003).

2.4 The Padthaway Salt Accession Project

2.4.1 Background

A detailed study referred to as the Padthaway Salt Accession Project, was initiated in 2002 by the Department for Water, Land and Biodiversity Conservation (DWLBC) (now Department for Water) to investigate the two mechanisms of salt accession to the aquifer described under *2.3 Addressing the issue of increasing groundwater salinity,* to determine their relative importance and how they are contributing to the observed changes in salinity in the groundwater in Padthaway.

The objective of the study was to quantify groundwater extraction, irrigation application, crop water use, evaporation and salt/water accession, to the aquifer under the different irrigation practices, and, through this, assess the risk of groundwater salinisation under different land uses and irrigation methods.

The project installed a number of fully instrumented investigation sites on the Padthaway Flats, including 4 drip irrigated vineyard sites, 2 flood irrigation sites, 1 spray irrigation site and 2 background dryland pasture sites (Figure 5, page 18). Continuously logged measurements of pumped groundwater volumes, irrigation application rates, soil moisture and soil water salinity at different depths in the soil profile and groundwater levels were recorded (DWLBC, 2005).

In addition, a groundwater sampling program and analyses of soil cores collected from 16 investigative drill hole sites was carried out in the Padthaway Range east of the Padthaway Flats. All of this data was evaluated by DWLBC (now the Department for Water) in terms of the historical salt store in the unsaturated zone of the Padthaway Range, current recharge rates under different land uses, and timescales for movement of this salt into the groundwater system.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) also had a number of study sites within the vineyards in the Padthaway Flats, which collected data on irrigation applications, soil moisture and drainage, and salinity. The CSIRO also employed mobile weather stations to obtain micrometeorological data to calculate the evapotranspiration component of the water balance. This information fed into the Padthaway Salt Accession Project. Data was collected over three full irrigation seasons.

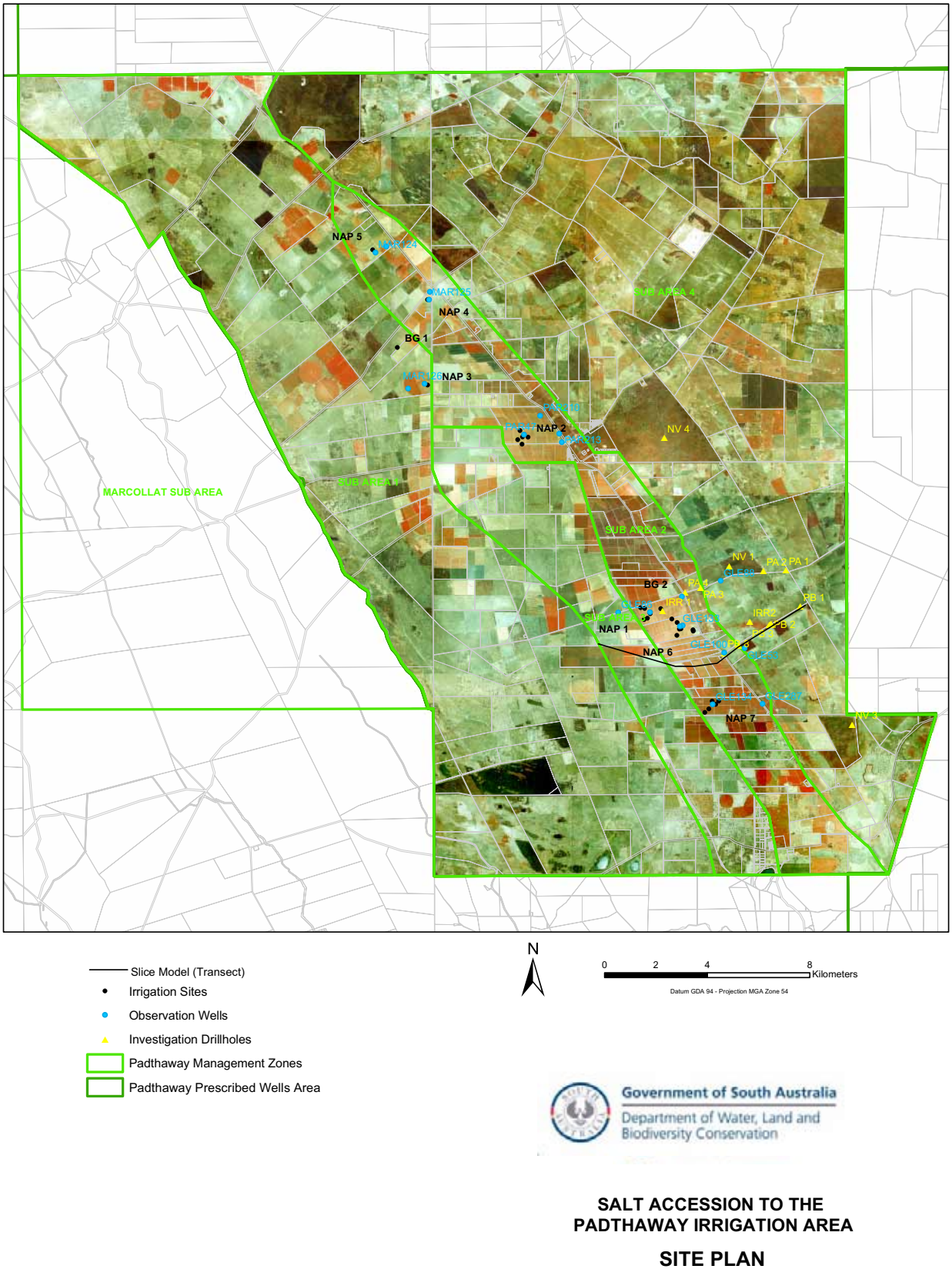
The Salt Accession Project was funded by the National Action Plan for Salinity and Water Quality through the South East Natural Resources Consultative Committee; with the Padthaway Grape Growers Association, the Grape and Wine Development Corporation, and the SE Catchment Water Management Board (now the SE NRM Board) contributing funding to the vineyard component of the research project. DWLBC (now Department for Water) provided in-kind project management, data collection and interpretation.

The results of this project indicated that there are 2 main drivers of salinity increases in the Padthaway PWA:

1. the clearance of native vegetation in the 1960s-1970s in the Naracoorte Range, which led to water tables rising and the leaching out of the historical salt store from the soil into the groundwater, which has since flowed down-gradient towards the main irrigation area, and

2. recycling of water under the main irrigation area, with plants taking up water but leaving the salt in the soil, where it accumulates until it is flushed into the underground water.

Figure 5. Location of instrumentation sites for the Padthaway Salt Accession Project



In the Padthaway Range (Fig 11, page 32), the increase in groundwater levels (2 metres from 1975 to 2003) has begun to level off, indicating that possibly a new equilibrium is being reached.

In the Padthaway Flats (Fig 11, page 32), groundwater levels have dropped at a rate of about 100 mm/year over the last 10 years. This does not appear to be significant since the depth to the water table on the Flats (approx. 5 m) is much less than in the Naracoorte Range (approx. 30 m), and is therefore much more responsive to rainfall. The same decrease in water levels has been observed in other areas outside the Padthaway PWA with similar depth to groundwater.

The quality of groundwater underlying the study sites can differ from the quality of irrigation water applied, as irrigation water is often sourced from bores located closer to the Range. In addition, flood irrigation sites are applying water of greater salinity (already 2,000 mg/L) than the drip sites (< 1,000 mg/L). Finally, at the non-irrigated (dryland) sites groundwater salinity can be as low as 300 mg/L (van den Akker et al 2006).

In the vineyard and centre pivot study sites, a lower drainage volume as a percentage of the total inputs generally resulted in a higher salinity impact to the aquifer. The converse was true for the flood sites, where a higher salinity impact occurred at the site with the highest percentage of drainage, indicating that flood irrigation is likely to be the largest contributor of irrigation-induced salinity impacts to the aquifer in the Padthaway PWA.

Qualitative interpretation of the groundwater chemistry data suggested that the evapotranspiration of irrigation water has contributed less than 25% of the groundwater salinity under the main viticulture area and less than 35% under the predominantly flood irrigation district in the north of the Padthaway PWA.

The groundwater sampling program and analyses of soil cores (soil water chloride, soil water content, etc) from the Padthaway Range, indicate that in several areas in the Range salt has already been flushed from the soil profile and fresher water is being recharged in its place. In other areas, large amounts of salt still exist in the soil profile and this is moving towards the aquifer.

The CSIRO study sites determined average evapotranspiration (ET) over entire vineyard blocks, and provide a much more precise value of ET for the region than could otherwise be determined. In a vineyard, the inter-row vegetation's use of water can be an important part of the water balance and, using CSIRO's approach, this is incorporated into the spatially averaged measurements.

An outcome of the project was estimates of drainage calculated from the water balance equation using the measurements of the different components of the water balance. In addition, new technology, in the form of drainage meters developed by CSIRO, was tested in the Padthaway area, to confirm the drainage values obtained from the water balance.

2.4.2 Conceptual model of salinity movement

A key outcome of the study was a preliminary conceptual model to simulate the salt movement as it mixes in the groundwater system and moves through the Naracoorte Ranges towards the main irrigation area. Prior to clearing of native vegetation in the Naracoorte Ranges, groundwater salinity on the Padthaway Flats was controlled by inflowing regional groundwater. Saline soil water, up to approximately 15,800 mg/L TDS, had accumulated below native vegetation in the Naracoorte Ranges and low recharge rates (approximately 0.1 mm/y) meant that very little of this was leached into the groundwater (Fig 6 a, next page).

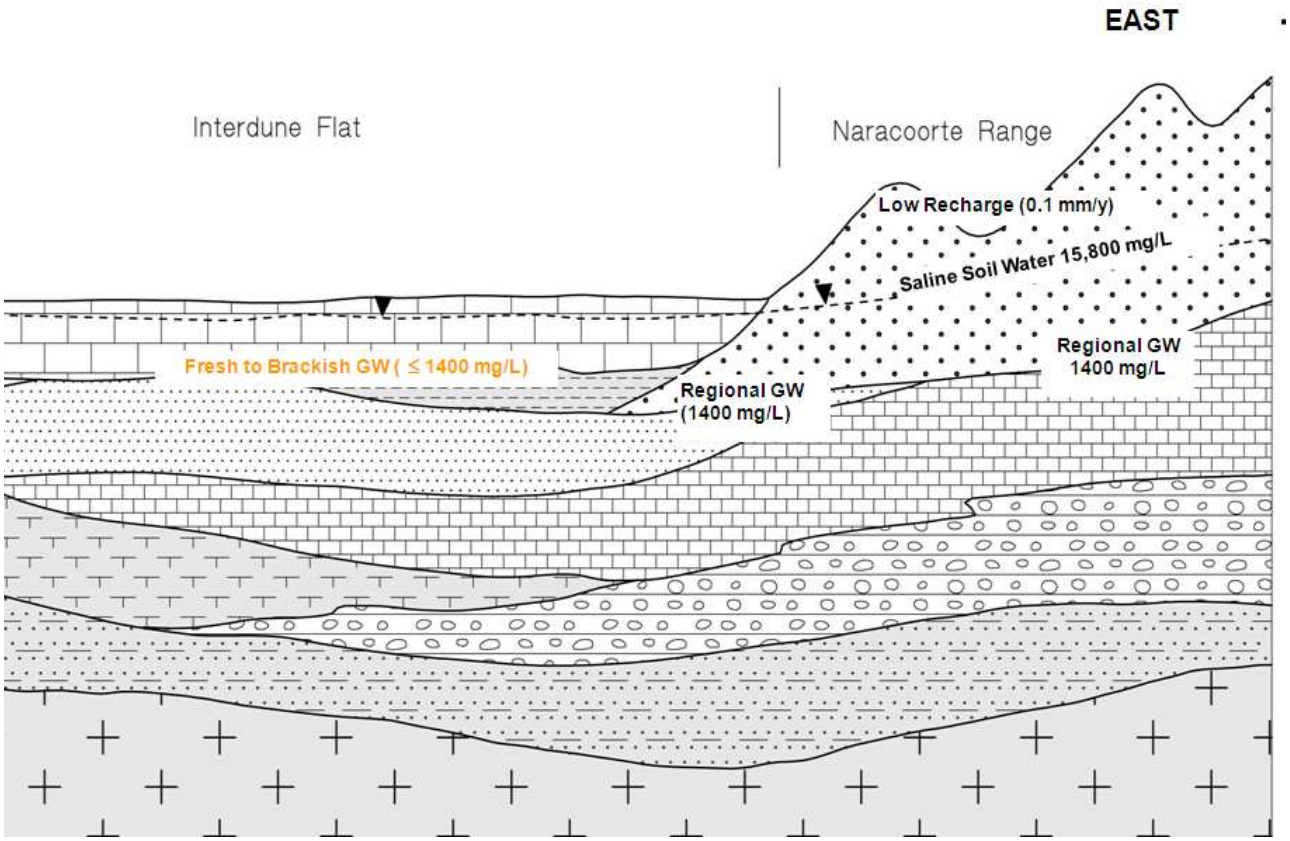
Soon after clearing in the Naracoorte Ranges (1960s and 1970s), an increase in drainage caused by removal of the water-efficient vegetation caused leaching of the highly saline soil water to

begin in some areas. This mixed with groundwater flowing underneath and resulted in an increase in salinity of groundwater flowing into the Padthaway Flats (Fig 6 b, next page).

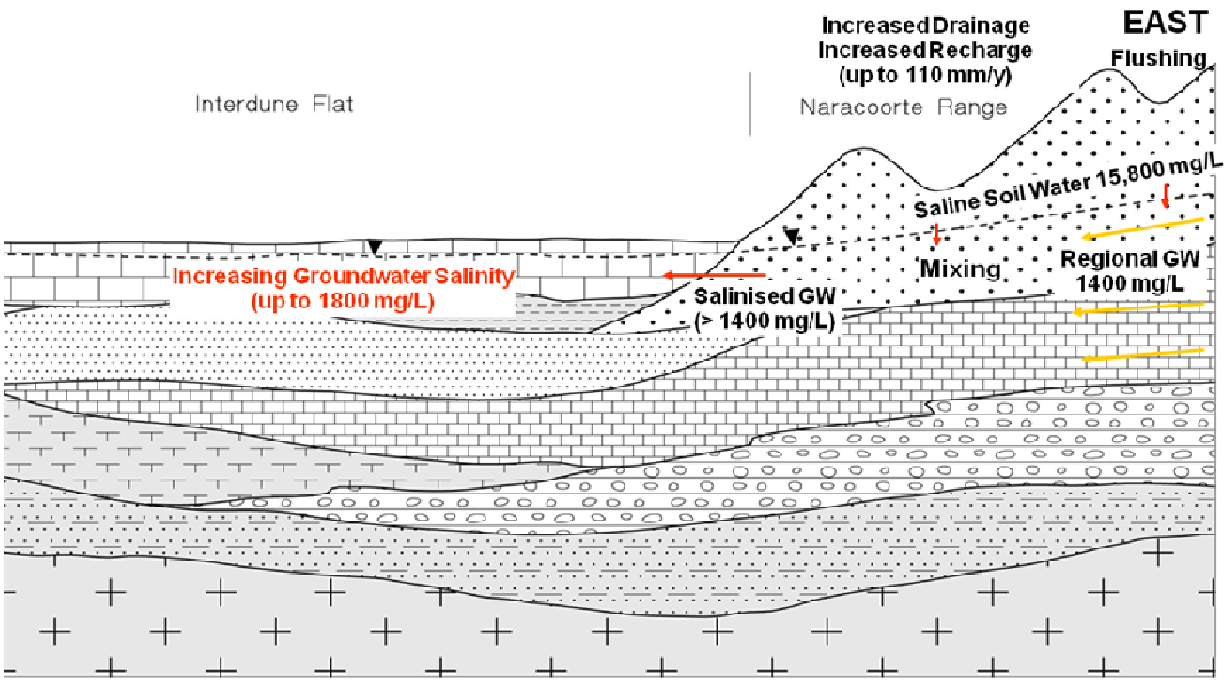
Currently, while the flushing of saline soil water is commencing in some areas of the Naracoorte Ranges with deeper water tables, flushing is now complete in the lower-lying areas and fresher recharge is now occurring. This fresh water helps to offset the effects of the saline soil water, and the quality of groundwater flowing from below the Ranges is starting to improve. Meanwhile, groundwater on the Flats still contains the remnant salinity from the original flushing event. High levels of groundwater extraction at the base of the Naracoorte Ranges are intercepting at least some the fresher groundwater before it moves out onto the Flats. Evapotranspiration (and concentration of the salts) of this water during irrigation means that the benefits of the fresher inflow are reduced (Figure 6 c, next page).

Fig 6. Conceptual model of salt and groundwater movement in the Padthaway Prescribed Wells Area.

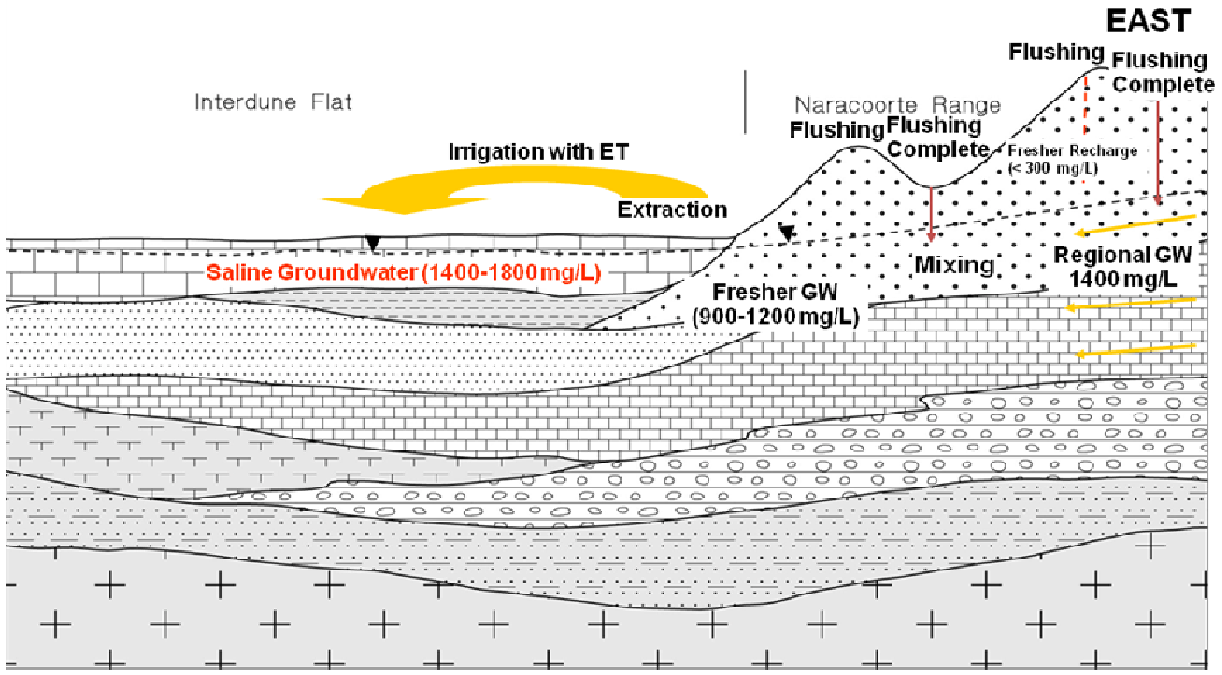
a) **Conceptual model of conditions prior to clearing of native vegetation in the Naracoorte Ranges.**



b) Conceptual model of conditions soon after clearing in the Naracoorte Ranges (1960s - 1970s).



c) Conceptual model of processes believed to currently control groundwater salinity.



The outcomes of the Padthaway Salt Accession Project emphasised the need to:

1. maintain lateral through-flow of groundwater through the Padthaway PWA to ensure salts are removed from the area, and
2. ensure the level of recharge in the Padthaway Range management area continues.

A key outcome of the study was a model to simulate the salt movement as it mixes in the groundwater system and moves through the Padthaway Range towards the main irrigation area. The data was extrapolated to other areas of similar soil and irrigation type in the Padthaway area, to develop a model to evaluate different management scenarios for the region (see 2.4.3 below).

2.4.3 The 3D numerical model

The Salt Accession Project culminated in 2007 with the development of the 3D computer model of groundwater and salinity flows through the Padthaway PWA, referred to as PadMod1, by consultants Aquaterra, in consultation with DWLBC (now Department for Water). The model was presented to the community at a public meeting in August 2007 and was pivotal in determining an acceptable level of groundwater extraction (see *2.5 Determining an Acceptable Level of Groundwater Extraction (ALE) with the community,* for more details*).*

The objectives for PadMod 1 were to quantify groundwater flow and salinity fluxes in the Padthaway area, and to evaluate future management options for the groundwater resource. Merrick (2008) provided an independent peer review of PadMod1, finding the model was suitable for its stated purpose.

2.5 Determining an Acceptable Level of Groundwater Extraction (ALE) with the community

2.5.1 Community involvement

Prior to the development of the 3D numerical model (PadMod), a proposal to reduce allocations in each management area to the volume of recharge available was presented to the Padthaway community in December 2006. The proposal used the management area boundaries as at the time of development of the 2001 WAP and a volume of recharge available estimated as 90% of total recharge in each management area plus the estimated deep drainage from active flood irrigation (TARd) (the sum total of TARd for the Padthaway PWA was 49,489 ML). The reductions to allocations were proposed to occur in yearly steps over a period of 5 years, with a review of the conditions of the groundwater resource after the third step of reductions, in order to determine whether reductions should continue.

The fundamental principles behind the Board's proposal were:

- allocation to be below 100% of recharge; and
- management of the groundwater resource according to aquifer response, ie if a resource is showing signs of stress, demands on the resource need to be reduced; if the resource then shows signs of recovery, these measures can be reviewed and adjusted.

This proposal resulted in reductions in allocations ranging from 0% in the Padthaway Range to 75% in the more intensely irrigated areas of the Padthaway Flats. The economic impacts of this option were of significant concern to the community, as expressed at the December 2006 non-statutory consultation. In addition, there was also significant community concern regarding the basis for the management area boundaries and whether these should be revised. The community also expressed the view that they wished to manage the resource sustainably, so that it would be available for use in the long term.

The Board invited community members to write or email submissions containing suggestions, concerns and/or endorsement of current or proposed policy. At the request of the Padthaway Groundwater Management Committee, the date for comments was extended to March 2007.

The Board continued to meet with the Padthaway Groundwater Management Committee, community and members of the Padthaway Flood Irrigators and the Padthaway Grape Growers Association, to discuss and develop the best way to ensure resource sustainability, including reducing the level of demand on the resource. A proposal was put forward from community representatives that each stakeholder group develop a preferred option to be presented to the other group and the Board, in order to identify points in common and points of difference as a basis for the development of an overall community position.

The Board supported the community development of an alternative form of allocation, within legislative requirements. These legislative requirements included:

1. providing for National Water Initiative requirements, including:

- *Return all over-allocated and over-extracted systems to environmentally sustainable levels of extraction (substantial progress by end of 2010).*
- *Provide for adaptive management of groundwater systems.*

2. providing for *Natural Resources Management Act 2004* requirements, including:

- *The needs of the natural environment and human demands be considered in determining appropriate limits of extraction.*
- *The rate of use of the water is sustainable, including to meet the reasonably foreseeable needs of future generations.*
- *If there are threats of serious or irreversible damage to natural resources, lack of full scientific certainty should not be used as a reason for postponing measures to prevent degradations.*

In order to develop an option with a sound technical basis, stakeholders sought to engage the services of a consultant. The Padthaway Flood Irrigators wrote to the Board requesting financial support for this purpose.

Resulting discussions between the Board and DWLBC (now DFW) led to the engagement of REM by DWLBC to work with community stakeholders in the development of management options for the groundwater resources in Padthaway, as one of the final stages in the Padthaway Salt Accession Project. The Padthaway Salt Accession Project contained 5 main components, of which one was the development of management policies for the region, through use of the model to assist with determining the sustainable extraction limits for the areas of concentrated irrigation activity and the region as a whole. The sustainable extraction limit should result in stable groundwater salinity in the long term, and allow unimpeded aquifer throughflow.

The Padthaway Groundwater Management Committee recommended the involvement of additional community members, as the Committee considered that the entire irrigator community was too large a group to work with the consultants, but representation in addition to the Committee members was required. A public meeting was held on the engagement of REM and an additional 6 community representatives were selected, raising the number of community representatives working with REM to thirteen.

REM then worked with the 13 community representatives to establish:

- resource condition limits for the unconfined aquifer (including the maximum acceptable changes in groundwater salinity and depth to the water table);
- management scenarios to be tested with the numerical model; and
- an Acceptable Level of Groundwater Extraction.

The objective of this exercise was to determine what level of extraction would result in resource conditions remaining within the agreed resource condition limits.

Setting resource condition limits

The resource condition limits established by the community representatives were:

- no increase in the salinity of groundwater;
- water tables no lower than the June 2004 levels; and
- no reduction to lateral through-flow of groundwater through the area (to ensure salts are flushed).

The June 2004 water levels were chosen based on anecdotal evidence that at that time a number of flood irrigators had had difficulty in obtaining sufficient yields from their wells (and DWLBC observation bores confirmed that water tables had dropped at this time).

Allocation scenarios modeled through the 3D numerical model (PadMod)

Different allocation scenarios were chosen to be run through the model, to determine what level of allocation would result in the conditions of the resource remaining within the agreed resource condition limits. These were:

1. extracting groundwater at 100% of volumetric allocation (estimated as 78,645 ML/year)
2. extracting 45% of volumetric allocation
3. extracting 60% of volumetric allocation
4. reducing allocations to total available recharge + deep drainage component (TARd)[2] on a management area basis (as proposed at the December 2006 non-statutory community consultation).

Figures 7 (page 26) and 8 (page 27) show the outcomes of the modeling for depth to groundwater[3] and groundwater salinity, respectively. Simulations were run from 2006 until 2120. The outcomes of the modeling of the 4 allocation scenarios selected by the Padthaway community representatives, indicated that extracting groundwater at 100% of volumetric allocation (78,645 ML/annum) results in significant drops in depth to water, in particular in the north-western parts of the Padthaway PWA. Extraction at 45% of volumetric allocation resulted in the least impact on the groundwater resource, while extraction at 60% of allocation caused limited long-term decline. Finally, reductions in allocations to the TARd for each management area as mapped in the 2001 Padthaway WAP (ie the reductions scenario proposed by the Board at the non-statutory community consultation), results in an outcome for the resource similar to the extraction of 60% of allocation on a Prescribed Wells Area basis.

[2] The sum total of the TARd values for the management areas in the Padthaway PWA was 49,489 ML/year.

[3] It should be noted that the decreases in the depth to water table in the Padthaway Range are the result of the modeling assuming a level of allocation in that area equivalent to the TARd for management area 4 (as per 2001 WAP management areas). In reality, the level of allocation has historically been below TARd -when the model was re-run based on the actual level of allocation in the Range, no decreases in depth to the water table were observed.

Acceptable Level of Groundwater Extraction

The outcomes of the modeling indicated that a level of groundwater extraction above 49,000 ML/year results in lowering of the water table, which could significantly affect irrigators. In contrast, extractions below 35,000 ML resulted in rising groundwater tables, which led to greater evapotranspiration and a risk of salinisation (Aquaterra 2008).

Extracting groundwater at 100% of volumetric allocation (estimated as 78,645 ML/yr) was shown to be unsustainable in the long term, as it results in significant increases in depth to water, in particular in the north-western parts of the Padthaway PWA.

Although extraction at 45% of volumetric allocation resulted in the least impact on the groundwater resource, reducing allocations to this value would affect the current level of extraction of approximately 33,000 - 40,000 ML/year (Table 1) and therefore would be expected to have an economic impact.

Extraction at 60% of allocation or setting allocation levels at TARd[4] for each area (scenarios 3 and 4), both cause only limited long-term decline. However, while the final level of allocation (and therefore allowed extraction) as a result of these two scenarios is similar (Table 1), scenario 3 has a similar impact on all licensees, while scenario 4 affected each management area to a different degree.

Scenario outcomes were compared to the level of groundwater extraction in the 3 years prior to 2007 (a drought year) to determine the level of extraction required to sustain the current economic output from the region (Table 1).

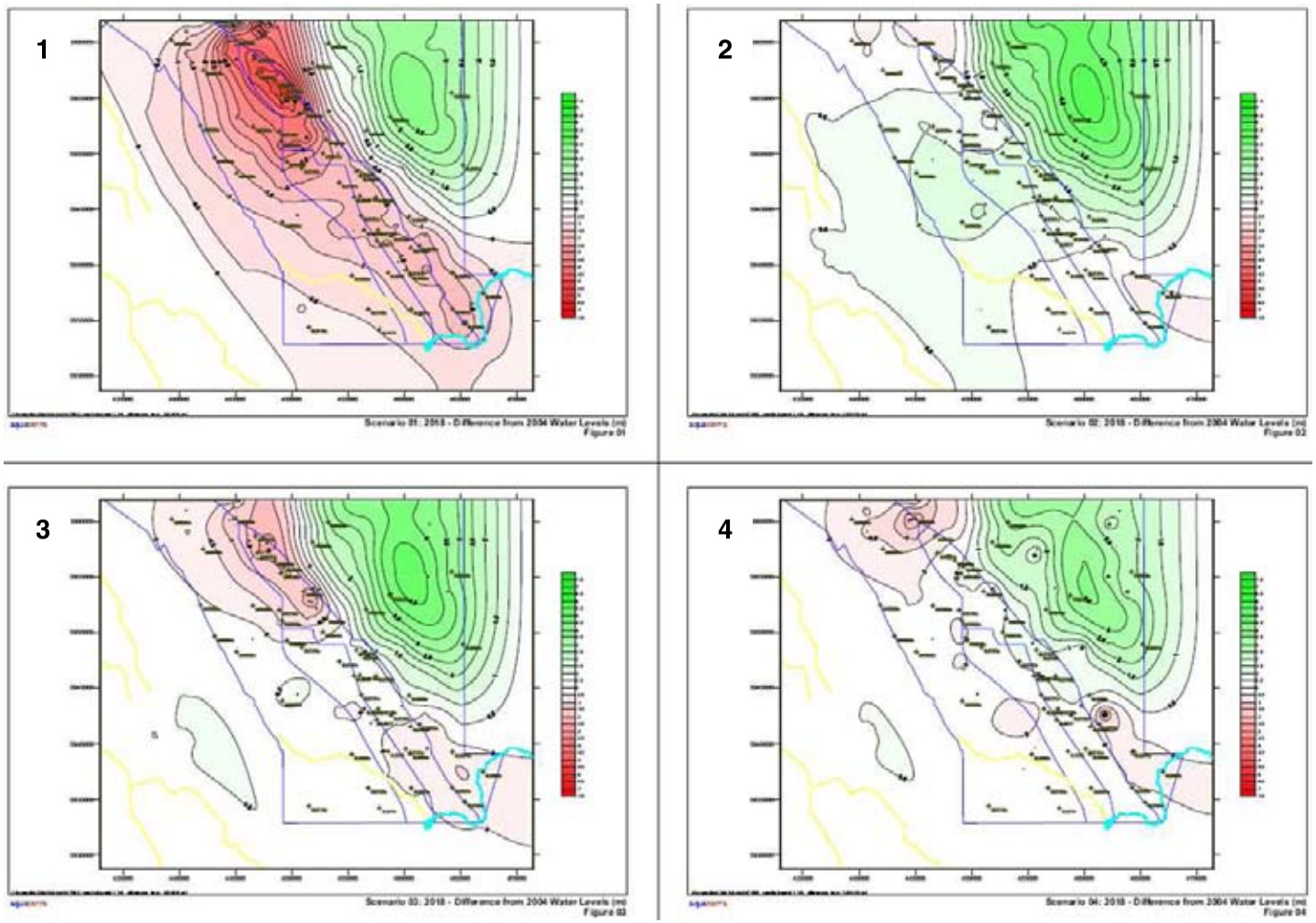
Table 1. Volume of groundwater extraction/year for each modelling scenario and for the 2003/04 – 2005/06 water use years

SCENARIO	1 100% allocation	2 45% allocation	3 60% allocation	4 allocation = TARD	2003/04 extraction	2004/05 extraction	2005/06 extraction
ML/year extraction	78,645	35,392	47,187	49,489	39,632	33,515	40,740

Taking into account both the economic needs of the Padthaway area and resource sustainability, the community representatives adopted a volume of 48,000 ML/year as the acceptable level of underground water extraction for the Padthaway PWA.

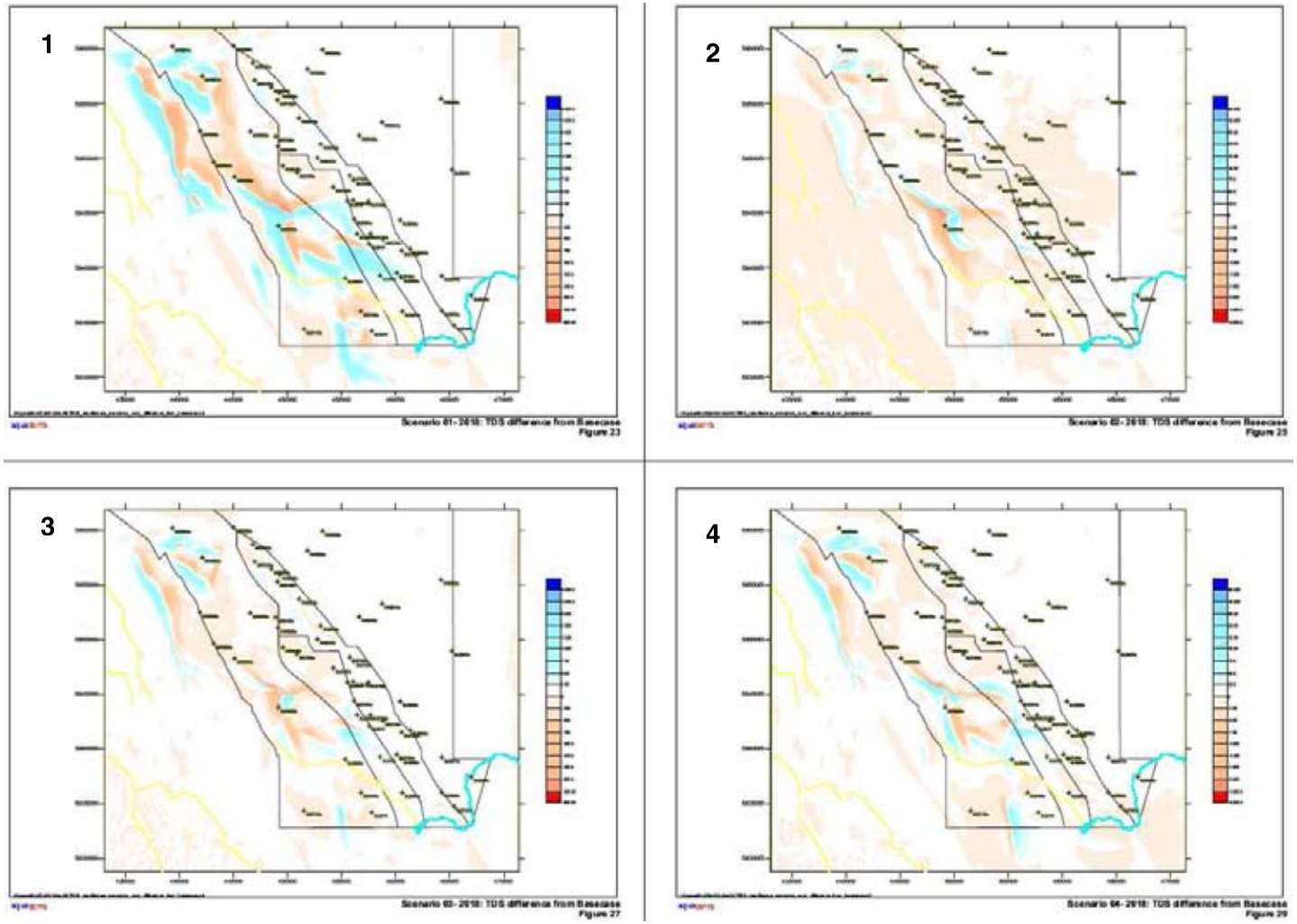
[4] TARd is calculated as 90% of total recharge in each management area plus the estimated deep drainage from active flood irrigation (see 2.5.1 for more details)

Figure 7: Changes in depth to the depth to the water table of the unconfined aquifer for the allocation scenarios selected by community representatives: 1) abstraction at 100% of volumetric allocation; 2) abstraction at 45% of allocation; 3) abstraction at 60% of allocation; 4) abstraction at TARd for each management area*



*Based on abstraction = TARd (total available recharge + estimated deep drainage from flood irrigation) for the 4 management areas as shown in Figure 10 of document.

Figure 8: changes in groundwater salinity of the unconfined aquifer for the allocation scenarios selected by community representatives: 1) abstraction at 100% of volumetric allocation; 2) abstraction at 45% of allocation; 3) abstraction at 60% of allocation; 4) abstraction at TARd for each management area*



*Based on abstraction = TARd (total available recharge + estimated deep drainage from flood irrigation) for the 4 management areas as shown in Figure 10 of document.

2.6 Developing a method to allocate water at the Acceptable Level of Extraction

Following the establishment of an Acceptable Level of Extraction (ALE), REM was engaged separately by both the Padthaway Grape Growers Association and the Padthaway Flood Irrigators to help develop options to reduce volumetric allocations (approx 85,000 ML/year) to within the ALE of 48,000 ML/year. It was considered by the community that having the two main irrigator groups working separately would allow easier discussion of options.

The management options considered by both groups included:

a) pro rata cut of all allocations;

b) reductions dependent on history of use (commonly referred to as the "use it or lose it" approach);

c) determining the average use per haIE for each system type for the Prescribed Wells Area and reducing irrigators to that value;

d) a sliding scale approach where licensees receive a different proportion of their allocation based on proportion of historical use.

Management area boundaries in Padthaway were not originally established on a hydrogeological basis, but instead drawn around the existing heavily developed areas to preclude the possibility of their expansion This resulted in significantly greater levels of over-allocation in the areas referred to as management areas 2 & 3 in the 2001 WAP (Figure 10, page 31).

As a result, stakeholders agreed to develop options on a PWA rather than a management area basis, and include both the Flats and the Range.

The average volume extracted over the previous 3 years per irrigation system type (on a PWA basis) was determined with the assistance of DWLBC (now Department for Water) from meter readings reported on Annual Water Use Returns or, in those cases where a meter reading was not provided, the application of the volumetric conversion model to the reported area and crop irrigated.

This calculation showed that the average use per irrigation system type was approximately 31%, 27 % and 10 % less than the volumes provided by DWLBC's volumetric conversion model for drip, spray and flood irrigation systems, respectively; indicating that all irrigation types could be encouraged to become more efficient. However, this was insufficient to reach the agreed Acceptable Level of Extraction of 48,000 ML/annum, as it only reduced overall allocation by approximately 10,000 ML/year. As a result, additional measures were considered.

The approaches to issuing volumetric allocations at an acceptable level developed by the Padthaway Grape Growers Association and the Padthaway Flood Irrigators were virtually identical (*G. Harrington (REM), personal comm, 2007)*:

1. cap each individual at the average use estimated for the PWA for the 2004/05 and 2005/06 water use year, or at the irrigator's individual average use (if below the PWA average);

2. this allocation issued only for those hectare irrigation equivalents (haIEs) under irrigation at 30 June 2007;

3. any remaining water to be banked and issued to irrigators with non-irrigated haIEs at June 2007 (whether under Notice of Restriction or by the licensee's own choice);

4. licensees would receive the volumetric allocations determined by DWLBC's model at date of adoption and work back to the values determined through the above proposal, over 5 years;

5. as allocations are reduced, additional water would be placed in a bank for allocation to non-irrigated haIEs;

6. any further reductions required would be equal for all licensees, regardless of their irrigation system and history of use.

This proposal was presented to the Board by REM at its November 2007 meeting. Although willing to adopt a method of addressing over-allocation that included differential approaches to allocation (subject to community support), the Board was concerned at the potential for 0 ML allocations for inactive irrigators.

The PGGA/PFI proposal was taken to the Padthaway Groundwater Management Committee (which included members of both stakeholder groups) for further discussion and development. The Committee determined the following changes to the allocation system:

- the setting of a minimum allocation for every haIE (3.95 ML/haIE), regardless of whether it was irrigated at June 2007, to avoid penalising irrigators using no water or significantly below the PWA average (Fig 9, next page). The 3.95 ML/haIE was selected as equivalent to 50% of the tradeable component of 7.95 ML/haIE derived from DWLBC's Volumetric Conversion model (Appendix A);

- the remaining volume of water (ie the Acceptable Level of Extraction minus total minimum allocation) to be issued on the basis of both:

    - area: the haIEs under irrigation at 30 June 2006 or 30 June 2007 (whichever was the greater area); and

    - system type: irrigation system in place at 30 June 2007;

    with the volume issued per eligible haIE calculated as the average volume pumped over the 2004/05 and 2005/06 irrigation seasons or the PWA average for the system type (Fig 9, next page), whichever is the lesser;

- allocations to be issued at the date of volumetric conversion (no stepped reductions from the higher volume based on DWLBC's volumetric conversion model);

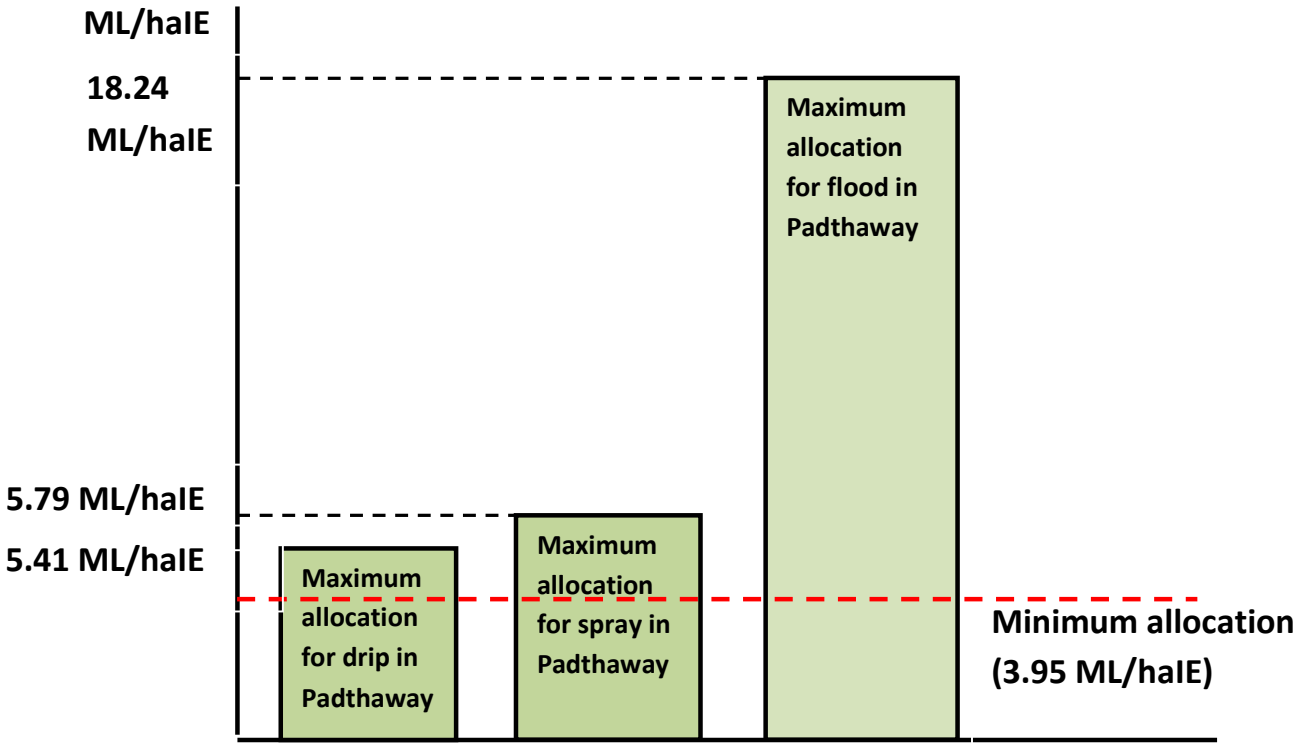
- irrigators to receive a 10% bridging volume to expire after 12 months, for the first 2 years (in order to provide them with time to adjust to their volumetric allocations); and

- any further reductions required to reduce allocations to the Acceptable Level of Extraction to occur on a pro rata basis in Year 5 of the Padthaway Water Allocation Plan.

The issuing of a minimum allocation of 3.95 ML/haIE to the 5,913 haIEs allocated in Padthaway, resulted in a total volume of 23,356 ML/year from the Acceptable Level of Extraction of 48,000 ML/year. The sum of this volume plus the additional ML issued to the haIEs under irrigation, were estimated to result in approximately 55,037 ML being allocated in the Padthaway PWA, a 14% excess in allocation above the agreed limit. As a result, all licences will be reduced by the percentage required to meet the Acceptable Level of Extraction in Year 5 of the Water Allocation Plan[5].

[5] It should be noted that the 2009 Padthaway Water Allocation Plan proposes that in the fifth year of the Plan allocations be reduced to the Acceptable Level of Extraction (ALE) as determined at that date. As a result, it is proposed to recalculate the ALE by means of incorporating updates to data (including meter readings and recharge) to the 3D model and determining the level of extraction at which the resource condition limits continue to be met.

Figure 9. Minimum and maximum allocations for each irrigation system type



It was considered by the Committee that this proposal provided all licensees with certainty (as there was no requirement to wait for reductions to active irrigators to occur in order to receive an allocation) and a minimum allocation. The proposal was presented to the Board at its December 2007 meeting, and was accepted for incorporation into the draft Padthaway Water Allocation Plan.

2.7 Changes to the management areas

At the time the previous (2001) water allocation plan was adopted, the unconfined aquifer (Tertiary Limestone Aquifer) in the Padthaway PWA was managed as four separate management areas referred to as management areas 1,2, 3 and 4 (Figure 10, next page). Management areas 2 and 3, in particular, were established around the more densely irrigated areas, in order to protect the resource from the impact of further irrigation expansion.

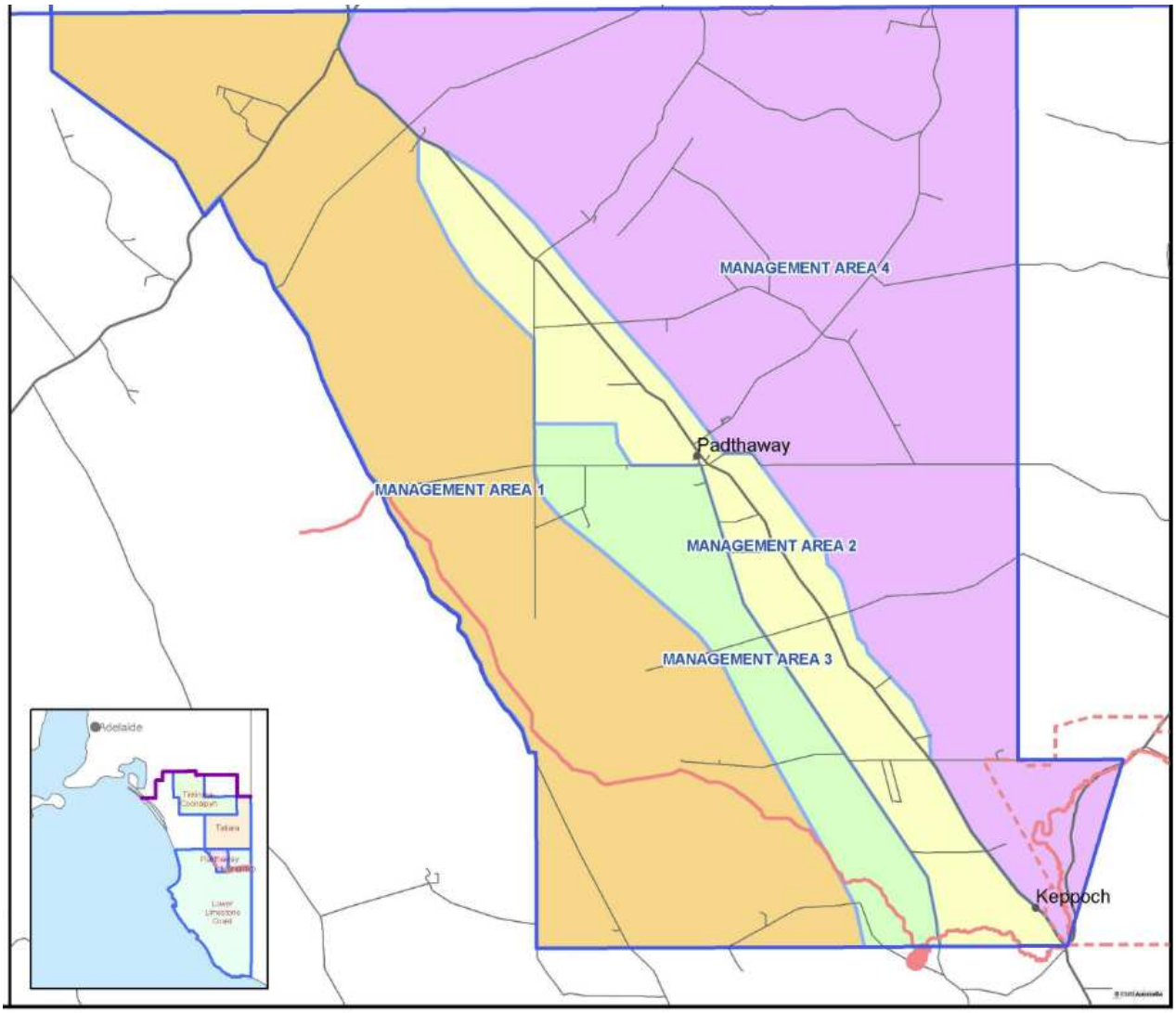
During the review of the 2001 Water Allocation Plan, the community expressed its concern regarding the impact of using these management areas as the basis for any reductions to allocations. As a result, the community developed a process for issuing allocations within the Acceptable Level of Extraction on a Prescribed Wells Area rather than a management area basis.

The Padthaway PWA comprises two discrete landforms separated by the north west-south east trending Kanawinka Fault. To the south west of the fault, is a low-lying inter-dunal Flats. The width of the Flats is approximately ten kilometres and slopes gently downwards to the north-west. North-east of the fault a remnant dunal ridge rises to about 50 to 60 m above the Flats, forming part of the Naracoorte Range (DWLBC, 2004/61).

The Padthaway Salt Accession Project had clearly indicated the need to maintain the current level of recharge in the Range to the east of the intensively irrigated Flats. As a result, it was

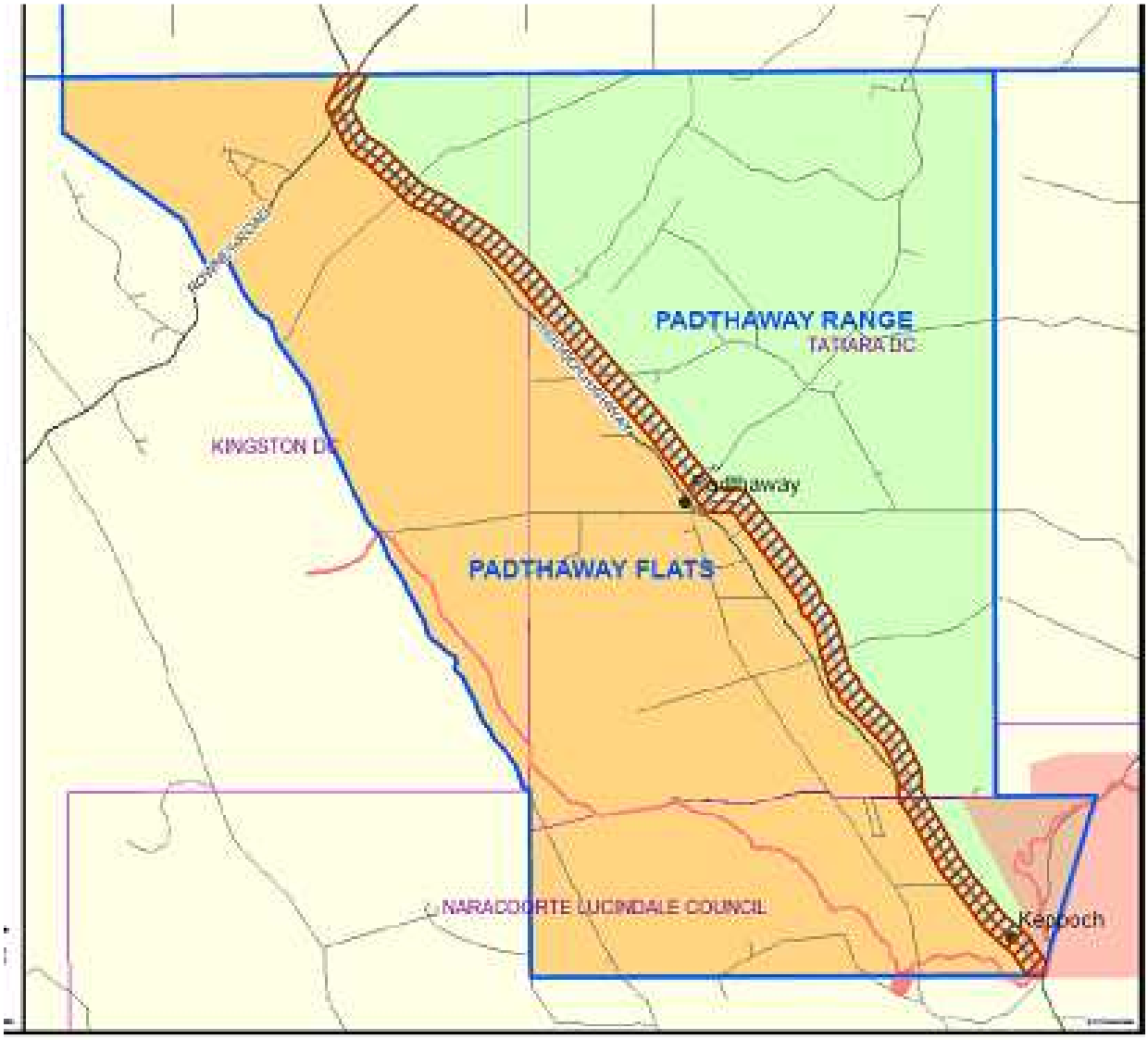
proposed that no further allocation should occur in the Padthaway Range and that transfers of existing licences into this area from the Flats should be precluded. The Salt Accession Project had also shown that irrigation recycling on the Flats had contributed to the rising groundwater salinity, leading to the proposal that no increases in allocation through new allocations or transfers of existing allocations into the area should occur either.

Figure 10. Management areas for the Padthaway PWA in the 2001 Padthaway Water Allocation Plan



As a result, for the purposes of the 2009 Padthaway WAP, the PWA has been divided into two unconfined management areas: Padthaway Flats to the west and Padthaway Range to the east (Figure 11, next page). The Padthaway Flats comprises the previous management areas 1, 2 and 3, while the Padthaway Range corresponds to management area 4. These new management areas reflect the hydrogeology of the region, while providing increased opportunity for trading water through the amalgamation of management areas 1, 2 and 3.

Figure 11. New management areas and limited extraction zone (hatched) for the 2009 Padthaway Water Allocation Plan



2.8 Limited extraction zone

The Padthaway Salt Accession Project has indicated that flushing of saline soil water is commencing in some areas of the Naracoorte Ranges with deeper water tables, while flushing is now complete in the lower-lying areas and fresher recharge is occurring. This fresh water helps to offset the effects of the saline soil water, and the quality of groundwater flowing from below the Range is starting to improve. High levels of groundwater extraction at the base of the Range are intercepting at least some the fresher groundwater before it moves out onto the Flats. Evapotranspiration (and concentration of the salts) of this water during irrigation means that the benefits of the fresher inflow are reduced.

In order to ensure that no increased interception of fresher groundwater at the foot of the Range occurs, and that lateral through-flow of fresher water from the Padthaway Range continues, the 2009 Water Allocation Plan establishes a limited extraction zone 800 m wide along the boundary of the two management areas (Figure 11, hatched). Within this zone, no new wells may be drilled and any replacement wells must be located no closer to the boundary between the Padthaway

Flats and the Padthaway Range management areas. Transfers of water into this area are subject to hydrogeological assessment and, if approved, the volume would be required to be extracted from an existing or replacement well.

2.9 PadMod: further upgrades to the 3D numerical model and applications

Following the development of the 3D model of groundwater flow and solute transport (Padmod1) (Aquaterra 2008) and the development of a method to address over-allocation, the South East Natural Resources Management Board requested that DWLBC (now DFW) perform a series of allocation and abstraction scenarios based on the expected lifting of the Notice of Restriction at the adoption of the new Water Allocation Plan (Wohling 2008). These were run using an upgraded version of PadMod1, referred to as PadMod2, which included improvements to the time varying recharge and solute concentration inputs for the Naracoorte Ranges (Wohling 2008).

The scenarios requested were the following:

- abstraction at 55,096 ML (the level of allocation following adoption of the 2009 Water Allocation Plan), at current location;
- abstraction at 55,096 ML, assuming that the groundwater permitted to be extracted following the removal of the Notice of Restriction is distributed equally amongst existing flood irrigators;
- abstraction at 55,096 ML assuming that the groundwater permitted to be extracted following the removal of the Notice of Restriction is distributed equally amongst existing drip irrigators.

The outcomes of the modeling showed that:

a) the level of allocation at date of adoption does not result in significant changes to groundwater levels or salinity;
b) the potential purchase of the allocations that had been under a Notice of Restriction since 2001 by either a majority of flood irrigators or of drip irrigators (located in different areas of the Padthaway PWA) does not result in significant changes to groundwater levels or salinity.

The Water Allocation Plan proposes that the Acceptable Level of Extraction (ALE) be reviewed using PadMod in 2014. These results indicate that the level of allocation at the date of adoption is currently sustainable, and that there would be no need to determine the new ALE at an earlier date. In addition, the results indicate that there would appear to be no need to restrict transfers of the water released following the lifting of the Notice of Restriction to any particular area/s of the Padthaway Flats management area.

National Water Initiative funding was secured by DWLBC (now DFW) to carry out further investigations to improve PadMod, upgrade the groundwater salinity monitoring network to provide a greater understanding of current and future salinity trends, and enhance knowledge of salt accession processes beneath drip irrigated vineyards.

Subsequent work by Aquaterra (Aquaterra 2009) and DWLBC (now DFW) (Wohling 2009) further upgraded PadMod2 to PadMod3. PadMod3 incorporates new understanding of basement topography and revised recharge and recharge concentration from drip irrigated vineyard zones. This new understanding led to the understanding that in some of the irrigated areas beneath the vineyards, the shallow basement produces localised barriers to groundwater flow.

Further improvements to the current PadMod3 groundwater flow and solute transport model can be achieved by:

1. the inclusion of metered abstraction data;
2. the model domain to be extended northwards to encapsulate the entire PWA;
3. the Digital Elevation Model to be upgraded to reduce the uncertainty of the evapotranspiration extinction depth.

2.10 Managing the impacts of land use change

In the Padthaway PWA, the Salt Accession Project has highlighted the need to maintain the current level of recharge occurring on the Padthaway Range, and groundwater throughflow through the entire area, including the Padthaway Flats. The Padthaway Groundwater Management Committee expressed concern as to the potential impacts of land use change, such as forestry, on recharge and throughflow.

Land use change has the potential to affect the amount of water that is able to recharge to the unconfined aquifer. Changes in land use may include a move away from grazing to cropping, from agriculture to plantation forestry, a change in the crop type or an increase in the density of plants that can be grown on an area as a result of clay spreading. These changes all have the potential to alter the level of plant or crop water use and may therefore impact on groundwater recharge.

Changes in land use that reduce recharge may require a reduction in the amount of groundwater available for extraction. In fully allocated management areas, a reduction in available groundwater will translate to a reduction in licensed allocations. In contrast, in the upper South East, deliberately decreasing recharge by revegetation, forestry and changed agricultural practices is an integral part of the strategy employed in the fight against dryland salinity and aquifer salinisation.

The 2009 Padthaway WAP does not contain policy to manage land use change. However, the WAP forms part of the Board's recently adopted Regional Natural Resources Management Plan (SE NRM Plan, 2010), which contains policy to manage the groundwater impacts of commercial and farm forestry.

In the case of the Padthaway, Tatiara and Tintinara Coonalpyn Prescribed Wells Areas, the South East Natural Resources Management Plan includes a requirement for a permit for commercial forests to manage the impacts of forests on groundwater. However, this permit policy relating to commercial forests will not come into effect until a regulation is made and in operation pursuant to section 127(5)(k) prescribing the activity of undertaking of commercial forestry as a water affecting activity requiring a permit.

The SE NRM Plan permit for commercial forestry builds on and extends the existing permit system in the Lower Limestone Coast.

In relation to the Padthaway PWA, the main elements of the NRM Plan permit system are:

- farm forestry requires a permit but is exempt from requiring an offsetting water allocation where the total area does not exceed or will not exceed 10% of the eligible area of the allotment or 20 ha per allotment, whichever is greater;
- all existing farm and commercial forests to be retrospectively issued a permit, on application;
- hydrogeological assessment of plantation impacts for first rotation plantations;
- setback distances for commercial forestry & farm forestry apply to wetlands of high or very high conservation value which are dependent on groundwater and considered to be under threat;
- where the deemed rate of recharge interception is set at the maximum rate of 100% of the management area's annual average vertical recharge rate, and the direct groundwater extraction rate is set at 1.82 ML/ha/year for all species;
- once issued, a permit will continue to authorise commercial forestry including clearfelling and replanting for subsequent rotations, in the manner and in the area specified in the permit unless any relevant approval for use of the land for commercial forestry under the Development Act 1993 lapses or is revoked or, in the case where the plantation is required to be offset by a water allocation, the forestry activity is no longer offset by an allocation;
- a hardwood plantation requires a new permit and an amount of water to be quarantined or set aside equivalent to its deemed impact.

3. Overview of the 2009 Padthaway Water Allocation Plan (WAP)

This section provides an explanation of the main principles set out in the 2009 Padthaway WAP. The relevant principles are referenced next to each subtitle.

3.1 Allocation of water

Limit to total allocation (Principles 1 & 2)
The 2009 Padthaway WAP states that there will be no new allocations from the unconfined aquifer, except where required to give effect to the volumetric conversion of existing area-based licences, the recalculation of some volumetric licences in existence at the date of adoption, the temporary and permanent transfers of water, the allocation of imported water drained and discharged according to this Plan, and the issuing of bridging volumes in the first two years of the Plan.

What happens to water that is returned? (Principle 43)
Any water that is forfeited is returned to the Minister and will not be available for allocation.

Types of water licenses & volumetric conversion (Principles 5-27)
There are two main types of water licences/allocations in the Padthaway PWA and other prescribed areas in the South East NRM Region. They are water (holding) licence or allocations and water (taking) licences or allocations.

A water (holding) allocation represents a share in the limit to allocation in the Padthaway PWA and cannot be extracted and used without converting it to a water (taking) allocation. Water (holding) allocations are referenced to a management area but not to a specific allotment of land.

A water (taking) allocation means the quantity of water that the licensee is entitled to take and use in a water use year from a specified water resource within a particular management area, subject to the conditions of the licence. In the Padthaway PWA there may be up to four separate components of a water (taking) allocation:

1. tradeable component
2. delivery supplement
3. specialised production requirements
4. bridging volume.

The Plan specifies that all water allocated through this Plan shall be allocated by volume. As a result, all existing area-based allocations are converted to a volume according to a community-derived method of allocation (refer to Section 2.6 *Developing a method to allocate water at the Acceptable Level of Extraction* of this document, for more details).

Tradeable component (principles 17-19)
The tradeable component is that portion of a water allocation that can be traded. The tradeable component of a water (taking) allocation is the volume allocated on the licence, minus any delivery supplement, specialised production requirements, carry-overs and/or bridging volumes.

In the case of a water (holding) allocation, the tradeable component means the entire volume expressed on the water (holding) allocation licence.

All licensees will be allocated a minimum of 3.95 ML for every hectare irrigation equivalent (haIE) of licence as a tradeable component, regardless of whether the area was under irrigation. In addition, and for haIEs under irrigation in the year ending 30 June 2006 or 30 June 2007 (whichever is the greater area), an additional volume of water will be allocated. The additional

allocation for areas under irrigation will be based on the average volume of water pumped by the irrigator in the 2004-05 and 2005-06 water use years, or, if this volume exceeds the average volume required for the irrigation system type, the latter volume (this means that allocations are capped at a maximum of the average volume required by the irrigation system type for the Padthaway PWA).

The average volume required per irrigation system type in the Padthaway PWA has been determined to be:

- for drip: 5.41 ML/haIE
- for spray: 5.79 ML/haIE
- for flood: 18.24 ML/haIE.

In those cases where the licensee's average water use is below 3.95 ML/haIE, a minimum allocation of 3.95 ML/haIE will still be allocated.

Any water holding allocations expressed as an area will be allocated a volume of 3.95 ML/haIE.

EXAMPLE OF ALLOCATION CALCULATION

A licensee with a 100 haIE allocation who was drip irrigating 50 haIEs in the year ending June 2006 and 75 haIEs in the year ending June 2007, would be considered to have 75 haIEs under irrigation and 25 haIEs not under irrigation for the purpose of calculating their allocation. In addition, if the licensee had pumped 4.2 ML/haIE in the 2004-2005 water use year and 4.4 ML/haIE in 2005-2006, the average of these volumes would be used as the allocation which would be issued as:

- 25 haIE x 3.95 ML/haIE = 98.75 ML (minimum allocation for the non-irrigated area), and
- 75 haIE x 4.3 ML/haIE = 322.5 ML (average of volumes pumped in the 2004-05 and 2005-06 years for the irrigated area).

As a result, the licensee's final allocation would be 98.75 ML + 322.5 ML = 421.3 ML.

If instead, the licensee had pumped 6.7 ML/haIE and 6.6 ML/haIE in 2004-05 and 2005-06, respectively, on the same area, they would receive an allocation of 5.41 ML/haIE (the average volume for drip irrigation) for the 75 haIEs considered as under irrigation, since the average volume pumped for the two years exceeds the average volume required for their system type.

Delivery supplement for flood irrigation (principles 20-24)

The delivery supplement for flood irrigation is the volume of water in addition to the tradeable component that eligible flood irrigators are allowed to extract from the aquifer, and which is assumed to return to the aquifer.

The delivery supplement for flood irrigators is a temporary allocation of water until 30 June 2014. At this date, the delivery supplement will be reviewed in order to determine whether the volume is representative of the average flood irrigator's needs, based on any relevant new studies or research regarding the deep drainage of this supplement. The delivery supplement will then be reissued at the same or a lesser volume.

Specialised production requirements (principles 25 & 26)

Specialised production requirements means the water required for crop production in addition to crop water use and delivery volumes. This may include activities such as frost protection for vines, drift control for potatoes and maximum production pasture. A licensee may receive a volume known as specialised production requirements, subject to the eligibility criteria set out in the WAP.

A specialised production requirements allocation shall be allocated on a temporary basis until 30 June 5 years after date of adoption and, subject to review, will be reissued at a value either less than or equal to the value issued at date of adoption.

In the case of specialised production requirements in the form of water for frost control for grapevines, water can only be extracted between 1 July and 30 November in each water use year.

Bridging volume (principle 27)

A bridging volume is a temporary allowance which is granted to all licensees in the first and second operational years of this Plan. In order to provide licensees with time to adjust to their new allocations, it is proposed that all licensees will be issued a bridging volume equal to 10% of their allocation for the first two years of the new Plan.

Can flood irrigation continue to expand? (principles 20 & 80)

Existing flood irrigation will be allowed to continue from the unconfined aquifer, however, any new flood irrigation systems must source their own delivery supplement, as it cannot be applied for. However, if a tradeable allocation is purchased from a flood irrigator for the purposes of flood irrigation, the delivery supplement surrendered by the vendor is reissued to the purchaser.

Recalculation of allocations that were already a volume (principles 28 & 29)

Allocations that were already expressed as a volume prior to the adoption of the 2009 WAP will remain of the same volume, with the exception of recreational allocations granted without accounting for delivery losses. The allocations will receive an additional 18% of volume (based on the delivery requirements calculated for spray irrigation systems by the Volumetric Conversion Model developed by DWLBC (Appendix A).

Water holding allocations (principles 36-42)

No new water holding allocations will be available, except where a taking allocation is converted to a holding allocation at the request of the licensee (in which case only the tradeable component becomes the holding allocation and any additional volumes shall be forfeited).

A water holding allocation can be converted to a water taking allocation of the same volume, subject to hydrogeological assessment.

Wild flooding (principle 52)

Wild flooding is flood irrigation where no adequate system such as land leveling or irrigation bays is used to ensure uniform distribution of water. The WAP specifically prohibits wild flooding, as this practice is not consistent with the efficient use of water.

Aquaculture (principle 53)

The WAP specifies criteria for the use of groundwater for aquaculture, including:

- meeting current best industry practice in the volume of tailwater produced for disposal;
- no increase of groundwater levels as the result of this disposal;
- no accelerated increase in salinity or pollution of the groundwater; and
- a requirement that ponds, tanks and other places for the keeping of water for aquaculture have no significant hydraulic connection to the groundwater.

Protection of groundwater-dependent ecosystems (principles 3 & 4)
The Plan provides for the protection of groundwater dependent ecosystems of high ecological importance in the Padthaway PWA, by calculating a setback distance for any new wells or transfers of water to a well, where the proposed point of taking lies within 2.25 km of the wetland and water tables have dropped around the wetland in the previous years. An equation is applied to determine the minimum distance required from the wetland for the proposed point of taking.

Active and expeditious use requirements
The 2009 WAP does not contain active and expeditious use principles, as there are no new allocations available.

The 2001 WAP contained principles requiring the active and expeditious use of water allocations, according to an Irrigation Development Management Plan. In the case that irrigation infrastructure had not been completed to the extent required to make full use of the allocation, then any "unused" portion was to be surrendered.

Licensing of unlicensed pre-existing use of water
The 2001 WAP included principles that provided for the licensing of pre-existing unlicensed use of water, such as dairy washdown, public water supply, caravan parks, etc.

These principles are not included in the 2009 WAP, as the period for application for a licence for these purposes has now ended.

Carry-over of unused allocation (principles 30-35)
In recognition of the fact that licensees are now limited to a volume (rather than limited to an area with the ability to pump an unlimited volume of water), the Plan includes principles to allow licensees to manage annual variability in climate, including rainfall.

A recent study of seasonal variability in the South East over the last 46 years (Climatic Variability and Volumetric Allocations in the South East, Government of South Australia, 2006) has calculated the variation in net irrigation requirement over this period. The analysis indicated that 90% of the likely variation in climate (ie in 9 out of 10 seasons) could be satisfied by access to an additional 8%-18% of water in a season, depending on location in the South East.

The study of these same records have also revealed that the maximum variation in net irrigation requirement over the last decades has been 55% in one extreme season in Mount Gambier, and no higher than 22%-33% at all other sites.

As a result, the Plan provides for licensees to carry-over unused water from one water use year into the subsequent year to a maximum volume of 20% of the licensee's allocation. This carry-over is then assumed to be extracted first through the meter in the following year. Additional water can be temporarily sought from other licensees' unused water (refer to Temporary trade in of unused water from another licensee (principles 85-87), below).

Requirements for frost control can be more variable than net irrigation requirements. A study of the number of frost events recorded over the last 20 years, has indicated that the number of frost events can vary from 1 to 14/year, with an average of 6.2 events.

As a result, it is proposed that a 3-year rolling average system be used to manage carry-overs of water allocated for frost control (a form of specialised production requirements).

Temporary trade in of unused water from another licensee (principles 85-87)

In 3 of every 5 years, licensees can transfer in an additional volume (capped at 20% of their allocation) of unused water from that water use year from another licensee, with no hydrogeological assessment. This type of transfer expires in the same water use year and intends to provide for those cases where a licensee does not have a carry-over or it is an exceptionally dry year and the carry-over is insufficient. It also provides licensees with the opportunity to trade any annual allocation not used in the water use year.

As a result of the above policy, irrigators can have access to up to as much as 40% additional allocation in a water use year. Licensees will not be eligible to extract water from the next year's allocation in the form of an advanced draw.

A numerical example of the above carry-over and temporary trade in principles is shown below, in the form of a "water account" for simplicity.

An irrigator has an annual allocation of 100 ML. The first year the irrigator pumps only 90 ML .The unused 10 ML can be carried over into the following year.

Year 1	**Credit**	**Debit**	**Balance**
Annual Allocation	100 ML		
Volume pumped		90 ML	
Carry-over			10 ML

In Year 2, the irrigator is entitled to 100 ML of annual allocation, as well as the 10 ML of carry-over. Towards mid-season the irrigator realises that they will require additional water due to seasonal conditions, and temporarily trades in 20 ML of unused annual allocation from another licensee, with no hydrogeological assessment. The irrigator then pumps the entire volume of 130 ML, leaving no carry-over for the following year. The irrigator's "water account" will thus look as follows:

Year 2	**Credit**	**Debit**	**Balance**
Carry-over	10 ML		
Temporary trade in	20 ML		
Annual allocation	100 ML		130 ML
Volume pumped		130 ML	
			0 ML

The following year, the licensee will be entitled to 100 ML.

The order of use of the different components of a licensee's "water account" is assumed to be:

1. carry-over
2. temporary trade portion
3. the licensee's annual allocation.

Underground water resource condition triggers and hydrogeological assessment (principles 44-51 and 90-92)

The 2009 Water Allocation plan contains resource condition triggers for trends in groundwater salinity and depth to the water table. These triggers are designed to protect the resource from the risk of detrimental impacts from new wells and/or increased extraction.

For purposes other than industry, energy generation or public water supply, the Plan states that extraction activities should not cause an average increase in groundwater salinity greater than 1% per year (measured over the preceding 5 years) or an average drop in water tables of greater than 0.1 m/year (measured over the preceding 5 years). The depth to water trigger has not changed from the one developed for the previous (2001) water allocation plan, but a salinity trigger of 1% was considered more representative than 10 mg/L.

The resource condition triggers are also be used as indicators of whether trends in depth to the water table and/or salinity should be of concern.

In addition, Padthaway community representatives determined a series of resource condition limits, including depth to water table and salinity values that should not be exceeded. Although not specifically included in the policy section of the WAP, these limits are used in the determination of the Acceptable Level of Extraction through the 3D numerical model (see Section 2 of this document for more details).

The successful implementation of the resource condition triggers provisions relies on the availability of regular and comprehensive monitoring data for underground water levels and salinities throughout the region. Section 11 of the WAP defines the monitoring that will occur.

The hydrogeological assessment (including the 4x4 km square test) set out in the 2001 Water Allocation Plan has undergone some minor modifications in the 2009 Plan. In addition to the change to the salinity trigger described in the section above, the 4x4 km square has been changed to a circle of the same area (16 km^2). This eliminates the potential issue of the orientation of the square affecting the results of the hydrogeological assessment.

In addition, the hydrogeological assessment has been made less stringent for the purposes of irrigating rotational crops for a period of 1 year or less: rather than considering the level of allocation within the 16 km^2 circle, the test considers the level of extraction in the preceding water use year.

Finally, temporary transfers to manage seasonal variability (principles 85-87) are not subject to hydrogeological assessment.

Use of water allocations on divided allotments and allotments held in adjacent management areas (principle 59)

Where an allotment or 2 or more adjoining allotments belonging to the same owner are divided by a management area or Prescribed Wells Area (PWA) boundary, but a water allocation is held in only one of these management areas or PWAs, the allocation may be taken and used anywhere throughout the allotment/s, as long as:

a) the use complies with the hydrogeological assessment (principles 44 to 51) and does not detrimentally affect any nearby groundwater-dependent ecosystems (principles 3 and 4);

b) the point of extraction is not moved more than 2 km into an adjacent management area or PWA unless it can be demonstrated that the water was being extracted at that point prior to the adoption date of this Plan;

c) an allocation from outside the Padthaway PWA is not taken in the Padthaway PWA, unless it was being extracted within the Padthaway PWA, prior to the adoption date of this Plan;

d) the allocation remains referenced to, and accounted for, in the originating management area and PWA; and

e) the allocation will not be available for further transfer within the receiving management area or PWA under this principle.

Endorsement of Certificates of Title on licences (principles 60-62)

The 2009 WAP contains provisions that allow allocations to be used in another management area for the purpose of irrigating rotational crops such as potatoes, subject to hydrogeological assessment. This is generally administered by adding a Certificate of Title (CT) for a land allotment in another management area to the licence as a condition of that licence. A licence endorsed with an allocation that was used for irrigating rotational crops may continually be endorsed with new CTs from other management areas in this fashion.

In the past, there has been no requirement that these CTs be removed from the licence once the licensee moves on to another location. The provisions of the 2009 WAP now limit the use of an allocation in another management area for the purpose of irrigating a rotational crop to a maximum period of five years. However, a number of licences with multiple CTs which are not being used or are not needed continue to exist.

The community consultation on the WAPs identified this as an issue, as each CT endorsed on a licence occupies hydrogeological space as a result of the 16 km^2 circle test used to assess applications for new allocations and transfers. This may prevent others from accessing the water resource, thus limiting economic development. Licence holders may also be denied a water allocation where they lease their land for the purpose of irrigating a rotational crop. The CT is added to the lessee's licence, and as a result the lessee is casting a 'shadow' over the property, even though the lessee may no longer have any intention to use the allocation to irrigate a rotational crop on that land allotment again.

As a result, the 2009 WAP states that following adoption of this Plan, additional CTs may not be endorsed on licences to allow the water to be used on additional allotments, unless the land is owned by the applicant, or an application to do so is accompanied by a legally binding agreement between the licensee and the registered proprietor of the land. Upon expiration of the legally binding agreement, the Certificate of Title shall be removed from the water licence.

In addition, the CT may only be endorsed on a licence where the licensee is able to physically extract and use the water on the specified allotment and is not prevented from doing so by the presence of, for example, native vegetation, plantations, roadways or structures.

Finally, CTs endorsed on licences prior to the date of adoption, where the licensee is not the registered proprietor of the land or does not have legal access to the land, may only remain endorsed on the licence if the registered proprietor of the land provides evidence of his or her written permission in the form of a statutory declaration to the Department for Water by 5 pm on the nearest business day following 6 months after date of adoption of the plan.

Addressing overallocation (principle 55)

The method of allocation set out in the 2009 WAP under principles 5-27, significantly reduced the level of allocation that resulted from the volumetric conversion of existing area-based allocations. Nevertheless, the level of allocation at date of adoption exceeded the Acceptable level of Extraction of 48,000 ML/year by around 8,000 ML.

The National Water Initiative requires the reduction of allocations to an environmentally sustainable level of extraction. In the Padthaway PWA, the Acceptable Level of Extraction was determined as the level of extraction at which resource condition remained with agreed limits (including no further increases in salinity, and depth to water not to exceed June 2004 levels).

As a result, in order to meet NWI requirements, the Plan states that if at 5 years from date of adoption, the Padthaway PWA remains over-allocation with respect to the ALE, allocations will be reduced proportionally by 1 July 2014, such that the total allocation in the PWA equals the ALE.

It should be noted that it is proposed that the ALE be determined by again running the PadMod model in 2014, in order to incorporate updated data (including meter readings, rainfall, etc).

Aquifer Storage and Recovery (principles 67-71 and 125-128)
The 2001 Padthaway WAP did not provide for the allocation and extraction of recharged imported water. As a result, the option of freshening the aquifer by injecting fresh imported water such as water from Morambro Creek or desalinating groundwater allocations and then injecting them underground to later extract for irrigation, would not have been possible.

In contrast, the 2009 Padthaway Water Allocation Plan contains provisions that enable the injection of imported water into the unconfined aquifer for later withdrawal and use.

These aquifer storage and recovery provisions in the WAP contain a number of safeguards designed to protect the water resource from contamination and over-extraction. Firstly, water may only be used for the purposes of aquifer storage and recovery (ASR) where it is imported into a management area by means of a pipe or channel, and the water (including surface water) has been extracted and piped, or directed into a channel, under licence from the originating management area. This safeguard has been employed to prevent water that would have otherwise contributed to natural aquifer recharge being used for the purposes of ASR.

The 2009 WAP provides for the recovery of any recharged water that has been either desalinated or imported, as long as it is recovered from within a radius of 500 m and within 3 years of discharge.

3.2 Trading and transfer of water

Transfers of allocations (principles 72-87)

Consistent with the 2001 WAP, water may be transferred both permanently and temporarily within the same management area. However, no transfers of allocations may occur between the two management areas in Padthaway (the Padthaway Flats and the Padthaway Range). This last measure is in response to the outcomes of the Padthaway Salt Accession Project, which showed that maintaining the current level of recharge in the Padthaway Range and ensuring no increases in the level of groundwater extraction on the Flats, are key to maintaining lateral groundwater throughflow (and therefore flushing of salt).

The 2009 WAP does provide for water to be permanently or temporarily (for a maximum of 5 years) transferred into a under-allocated management area outside the Padthaway PWA (for example into the Lower Limestone Coast PWA).

Licensees are entitled to trade or lease the tradeable component of their allocation. Delivery supplements are not tradeable and must be surrendered upon transfer of the associated tradeable component; however, they may be reissued to the purchaser/lessee in the case that they will continue to use it for the purposes of flood irrigation. In addition, in the case of a temporary transfer, the delivery supplement shall be reissued to the original licensee at the end of the temporary transfer period.

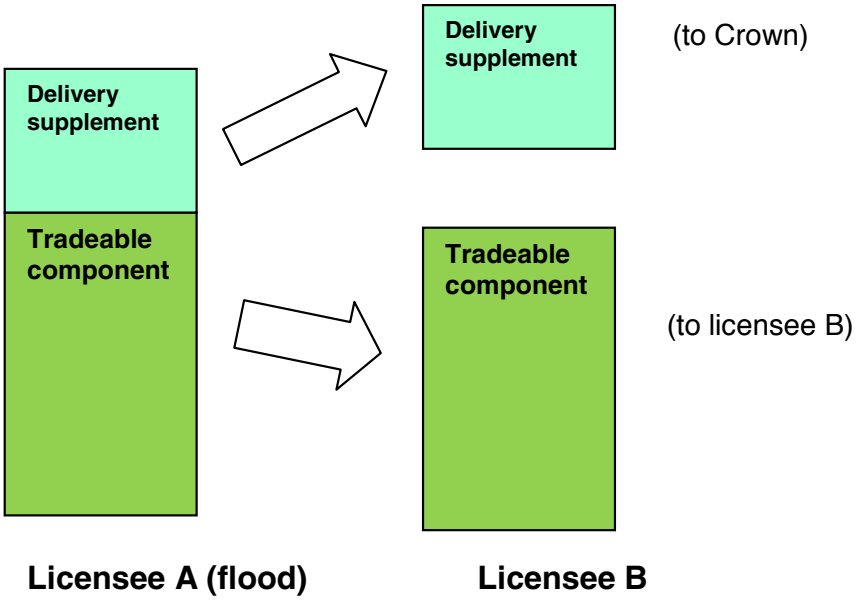
Specialised production requirements, seasonal carry-overs and /or bridging volumes may not be transferred, except where the licence or allocation is transferred in its entirety and is to be taken and used on the same allotment or allotments for the same purpose.

Where a part of an allocation is transferred, any delivery supplement, specialised production requirements and/o bridging volume for the remaining allocation not transferred shall be reduced proportionately.

EXAMPLES OF WATER TRADING

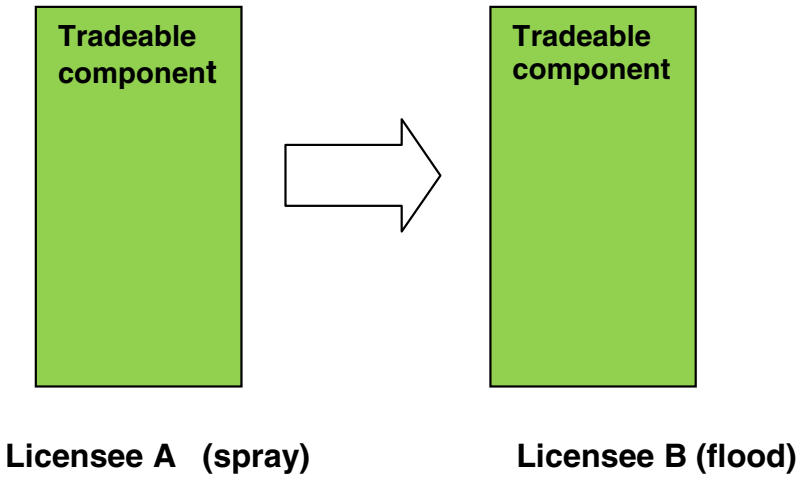
Example 1.

Licensee A holds an allocation for flood irrigation and sells or leases their tradeable component to Licensee B who is a spray irrigator. The tradeable component is assigned to Licensee B, while the delivery supplement is forfeited and returned to the Crown as unallocated water.

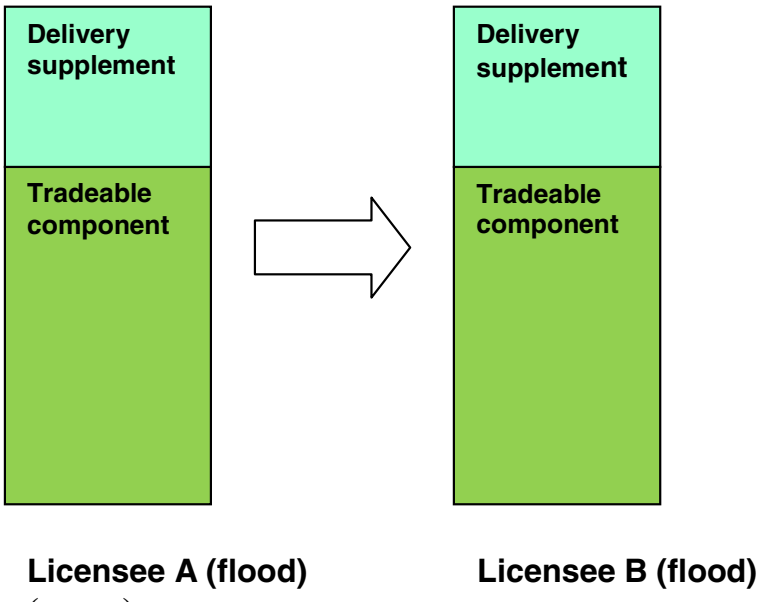


Example 2.

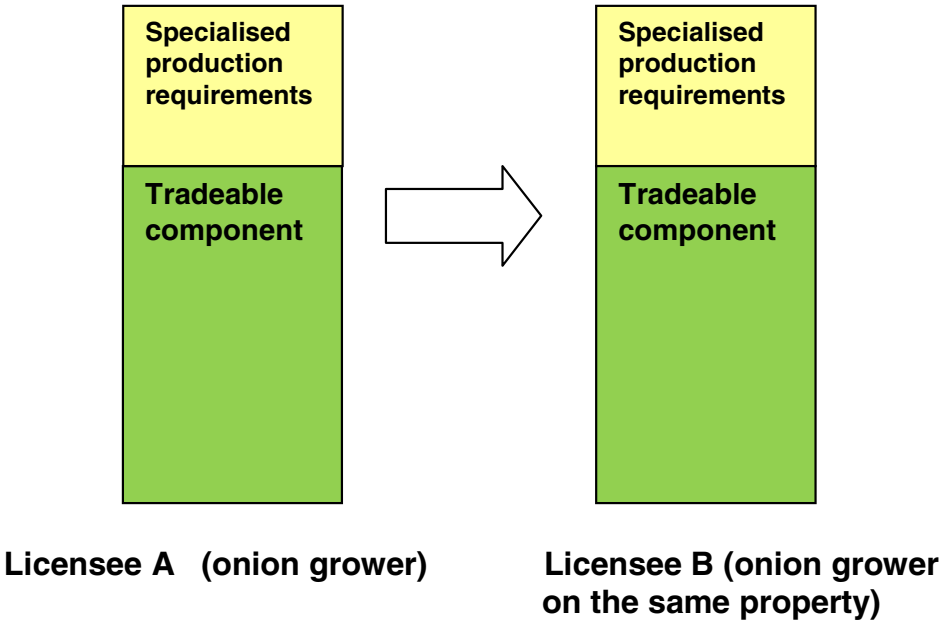
Licensee A holds an allocation for spray irrigation and sells or leases their tradeable component to a flood irrigator. The tradeable component is assigned to the flood irrigator, but the flood irrigator is not eligible to apply for a delivery supplement.



Example 3.
Licensee A holds an allocation for flood irrigation and sells or leases their tradeable component to another flood irrigator (Licensee B). The delivery supplement is surrendered by Licensee A and is reissued to Licensee B.



Example 4.
Licensee A is an onion grower who holds an allocation for spray irrigation which includes an additional volume in the form of special production requirements for control of soil drift. Licensee A sells their entire allocation to Licensee B who will continue to use the allocation for the same purpose and on the same allotment, resulting in a whole of licence transfer.



4. Summary of actions resulting from this Water Allocation Plan

Below is a summary of the actions resulting from the 2009 Padthaway WAP and this Explanatory Document, that the Board will endeavor to support and, where possible, complete through the implementation of the 2009 Padthaway WAP.

Action No.	Date for completion	Action	Reference
1	30 June 2014	DFW and Board to review the Delivery Supplement for flood and determine whether any changes are necessary.	principle 22 of the 2009 Padthaway WAP
2	30 June 2014	DFW and Board to review allocations for Specialised Production Requirements and determine whether any changes are necessary.	principle 25 f) of the 2009 Padthaway WAP
3	ongoing	DFW to regularly monitor and record recharge, depth to water table and salinity of the groundwater resources.	Section 11of the 2009 Padthaway WAP
4	30 June 2014	Board and DFW to consider further improvements to the current PadMod3 groundwater flow and solute transport model, as recommended by Wohling (2009).	DWLBC Report 2009/32
5	30 June 2014	DFW to run the 3D numerical model (PadMod) in 2014 to determine the Acceptable Level of Extraction and whether changes need to be made to allocations.	principle 66 of the 2009 Padthaway WAP
6	from 30 June 2014*	Allocations in the Padthaway PWA to be unbundled	NRM Act
6	from 30 June 2014	Policy for the management of land use change (currently in the Regional NRM Plan) to be incorporated in the reviewed Padthaway WAP	2010 Regional NRM Plan

*The State is proposing the unbundling of allocations in order of review of existing Water Allocation Plans. Subject to changes in legislative requirements, the 2009 Padthaway WAP would be required to be reviewed 5 years from date of adoption (26 April 2009).

5. References for Guide and Appendices

(Aquaterra (2008). *Padthaway Groundwater Flow and Solute Transport model (PadMod1).* Aquaterra reference A47/011F. 29th October 2008. Unpublished report submitted to Department of Water, Land and Biodiversity Conservation, Adelaide.

Aquaterra (2009). *Padthaway Model: Upgrade to PadMod3* (Aquaterra reference A47C/R001a). 27th October 2009. Unpublished report submitted to Department of Water, Land and Biodiversity Conservation, Adelaide.

Brown, K., Harrington. G., and Lawson, J. 2006. Review of underground water resource condition and management principles for the Tertiary Limestone Aquifer in the South East of South Australia. South Australia. Department of Water, Land and Biodiversity Conservation DWLBC Report 2006/02.

Carruthers, R, Latcham, B & Pudney, S. 2006. Volumetric Conversion in the South East of South Australia: Summary of the Conversion Model and Associated Conversion Rates, DWLBC Report 2006/29, 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.

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.

Harrington, N, Van den Akker, J, and Brown, K. 2006. Padthaway Salt Accession Study Volume Three: Conceptual Models, DWLBC Report 2005/21, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide.

Harrington, N., van den Akker, J. Brown, K. and Mackenzie, G. 2004. Padthaway Salt Accession Study. Volume One: Methodology, site description and instrumentation. South Australia. Department of Water, Land and Biodiversity Conservation. DWLBC Report 2004/61.

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.

Latcham, B., Carruthers, R., and Harrington, G. 2007. A new understanding on the level of development of the unconfined tertiary limestone aquifer in the South East of South Australia., Department of Water, Land and Biodiversity Conservation DWLBC Report 2007/11.

Merrick, N.P. (2008). Peer Review of the Padthaway Groundwater Flow and Solute Transport Model (PadMod1). Heritage Consulting Report Number HC2008/8. October 2008.

Pudney, S, Latcham B & Carruthers, R. 2006. Volumetric Conversion in the South East of South Australia: Calculation of Specialised Production Requirements, DWLBC Report 2006/31, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

Pudney, S. 2006. Volumetric Conversion in the South East of South Australia: Validating the allocation model, DWLBC Report 2006/30, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

South East Catchment Water Management Board, 2001. Water Allocation Plan for the Padthaway Prescribed Wells Area.

South East Catchment Water Management Board, 2001.Companion to the South East Water Allocation Plans).

South East Natural Resources Management Board, 2009. Water Allocation Plan for the Padthaway Prescribed Wells Area.

South East Natural Resources Management Board, 2010. Regional Natural Resources Management Plan.

Tonkin Engineering 2003. Feasibility of a Reverse Osmosis Desalination Plant.

Van den Akker, J. 2005. Padthaway Salt Accession Study. Volume two: Results. South Australia. Department of Water, Land and Biodiversity Conservation. DWLBC Report 2005/15.

Wohling D. (2008) Padthaway Groundwater Flow and Solute Transport Model (PADMOD2), New Scenarios Requested by the SENRM Board, DWLBC Technical Note 2008/22. Government of South Australia through Department of Water, Land and Biodiversity Conservation, Adelaide.

Wohling, D., 2009. Investigations to enhance the Padthaway groundwater model. South Australia. Department of Water, Land and Biodiversity Conservation, DWLBC Report 2009/32

Other Information/Further Reading

Please feel free to contact the South East NRM Board in Mount Gambier or any of the Department for Water offices throughout the South East, if you require further information about your particular area of interest (contact details can be found on page 3 of this document).

Appendix A. The Department for Water, Land and Biodiversity's[6] Volumetric Conversion Project

1. Background

Historically, allocation of water licences for irrigation has been based on area (haIE) and the irrigated crop water use requirement relative to a reference crop. The crop water use is then estimated from annual seasonal returns supplied by water users and correlation with aerial photography. The volume of water used by crops is calculated by converting the area of irrigated crops to megalitres, using the reference crop water use factor for the relevant management area and the appropriate crop area ratio. The irrigated crop water requirement method does not reflect the total volume of underground water extracted from the aquifer. Estimation of the volume used by each licensee relies on the veracity of the water user and the method of calculating the irrigated crop water use requirement.

In contrast, allocations of water for industrial and recreational purposes have historically been issued in volumetric terms. Similarly, over 1,100 volumetric licences were issued in the South East during the pro-rata roll out. Despite the existence of volumetric allocations and the fact that some wells are equipped with meters, there has been no regular meter-reading program.

During the development of the 2001 Padthaway WAP, the Water Allocation Planning Committees identified that under the haIE system, the only incentive to improve irrigation efficiency and use less water was to reduce pumping costs. Within the community, mixed views were evident on the issue of conversion of haIE allocations to volumetric allocations. Some felt it was imperative to convert to a volumetric system to promote water use efficiency and to provide the ability for irrigators to grow a larger area of crop or sell/lease water in excess to their requirements, if they used water more efficiently. Others had strong concerns about the complex matter of the difference between the crop water use volumes and volumes pumped (particularly for flood irrigation), and were concerned that the move to a volumetric allocation system could result in higher water use and threaten the sustainability of the underground water resources. The Parliamentary Select Committee on Water Allocations in the South East in its report of August 1999 (Parliament of South Australia, 1999: 19), recommended conversion of haIE allocations to a volumetric allocation system.

The question of whether haIE allocations should be converted to volumetric allocations was largely answered by the Government of South Australia in the State Water Plan 2000 (Department for Water Resources, 2000: 58): "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".

The 2001 Padthaway WAP determined that the basis for allocations of water granted after 5.00pm on 29 June 2001 will be volumetric, but did not determine the method of conversion from haIE to volumetric allocations.

The Board and the then Department for Water Resources funded a four-year science-based program to examine and implement the conversion of the area-based water allocation system to a volumetric system, ensuring that there was community involvement in the process. The project commenced in 2002.

2. Project overview

The Volumetric Conversion project was a 4-year (2002-06), $2.275 million project funded by the Department of Water, Land and Biodiversity Conservation (DWLBC) (now Department for Water) the South East Catchment Water Management Board (now SE NRM Board) and Primary Industries and Resources South Australia (PIRSA).

[6] Now Department for Water

The aim of the project was to conduct a science-based program to convert the area-based allocation system to a volumetric system.

The project was implemented via three concurrent phases:

- Phase 1: review of the existing Irrigation Equivalents (IE) area based allocation system;
- Phase 2: collection of on-farm data related to volumes extracted for irrigation and irrigation practices; and
- Phase 3: development and implementation of conversion methodology in conjunction with key stakeholders.

The project was applied to South East region of South Australia comprising the following Prescribed Wells Areas (PWA):

- Padthaway PWA;
- Tatiara PWA ;and
- Lower Limestone Coast PWA.

2.1 Existing area-based water allocation system

The irrigation equivalent (IE) area-based water allocation system is a method of irrigation licensing based on FAO guidelines that has been used in Prescribed Wells Areas in South Australia where unmetered groundwater supplies are extracted for irrigation. Under the IE system, the irrigation licences are expressed as an area of irrigation equivalents. One hectare Irrigation Equivalent is the net annual average quantity of irrigation water (in addition to the average rainfall) required to meet the 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 (ETo) is defined as “the rate of evapotranspiration from an extensive surface of 8 to 15 centimetres tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water” (Doorenbos and Pruitt 1977).

Using input from irrigators on their practices in the Prescribed Wells Areas of Padthaway, Tatiara and the Lower Limestone Coast, the 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 is:

Reference crop irrigation requirement= 634 mm
Sub-clover seed irrigation requirement = 361 mm
CAR for sub clover seed is 634/361= 1.8

As a result, 1.8 ha area of sub-clover seed can be irrigated compared with one hectare of reference crop. An irrigator with a 10 ha IE license, for example, is able to irrigate a maximum of 18 hectares of crop for sub-clover seed. The area based allocation system limits the area of crops irrigated, rather than the quantity of groundwater that can be extracted.

2.2 Phase One – Review of theoretical crop irrigation requirements

The most recently reviewed global standard FAO methodology (Allen *et al* 1998) was used to review theoretical crop irrigation requirements that are integral to the Irrigation Equivalents allocation system. This enabled the assessment of the potential effects of changes in crop varieties, irrigation methods and agronomic practices on crop water use that have occurred since some of this data was developed. This was particularly valid in parts of the Lower Limestone Coast Prescribed Wells Area where crop irrigation requirements were only extrapolated from data in adjacent areas and were not derived from first principles with community input.

This process allowed the community to participate in the review of the reference crop irrigation requirements based on current practice, thus promoting endorsement and acceptance of the conversion approach that was adopted by South Australia for the South East region. It also ensured

that the theoretical crop irrigation requirement data used as the basis for conversion was sound, based on contemporary methodology and was defendable as a basis for conversion.

Consultants Rural Solutions SA from the Irrigated Crop Management Service in Loxton undertook the technical work associated with the review using FAO methodology. Phase 1 commenced with a series of 18 irrigator workshops held in centres across the region in August and September 2002 that was attended by a total of 300 irrigators. At the workshops irrigators were provided information about the proposed volumetric conversion process and were asked to contribute to the development of crop calendars as part of the review of theoretical crop irrigation requirements. A further series of 18 workshops in August and September 2003 was used to 'check' the crop calendars that had been developed and to fill knowledge gaps.

Rural Solutions SA carried out a review of the net irrigation requirement for a reference crop grown in the South East. Evaporation and rainfall data were accessed from the Bureau of Meteorology, for 26 sites across the South East. Long-term average rainfall data and evaporation data (derived from Class A Pan readings) were collected. Pan factors were used to convert the evaporation data to Reference Crop evapotranspiration (ETo). Climatic bands were updated to better represent evapotranspiration and rainfall across the South East (Figure A1, page 52).

The methodology for calculation of the NIRo values for each climatic band and the determination of climatic bands is further described in the report *Definition of Net Irrigation Requirements in the South East of South Australia* (Skewes, 2006).

The "*Definition of Net Irrigation Requirements for the South East of South Australia"* report also identified a number of crops where the existing calculations of the crop area ratios (ie ratio of water required for the crop compared to reference crop) results in an allocation that does not provide sufficient volume to meet net irrigation requirements of that crop.

2.2 Phase Two – Data collection phase

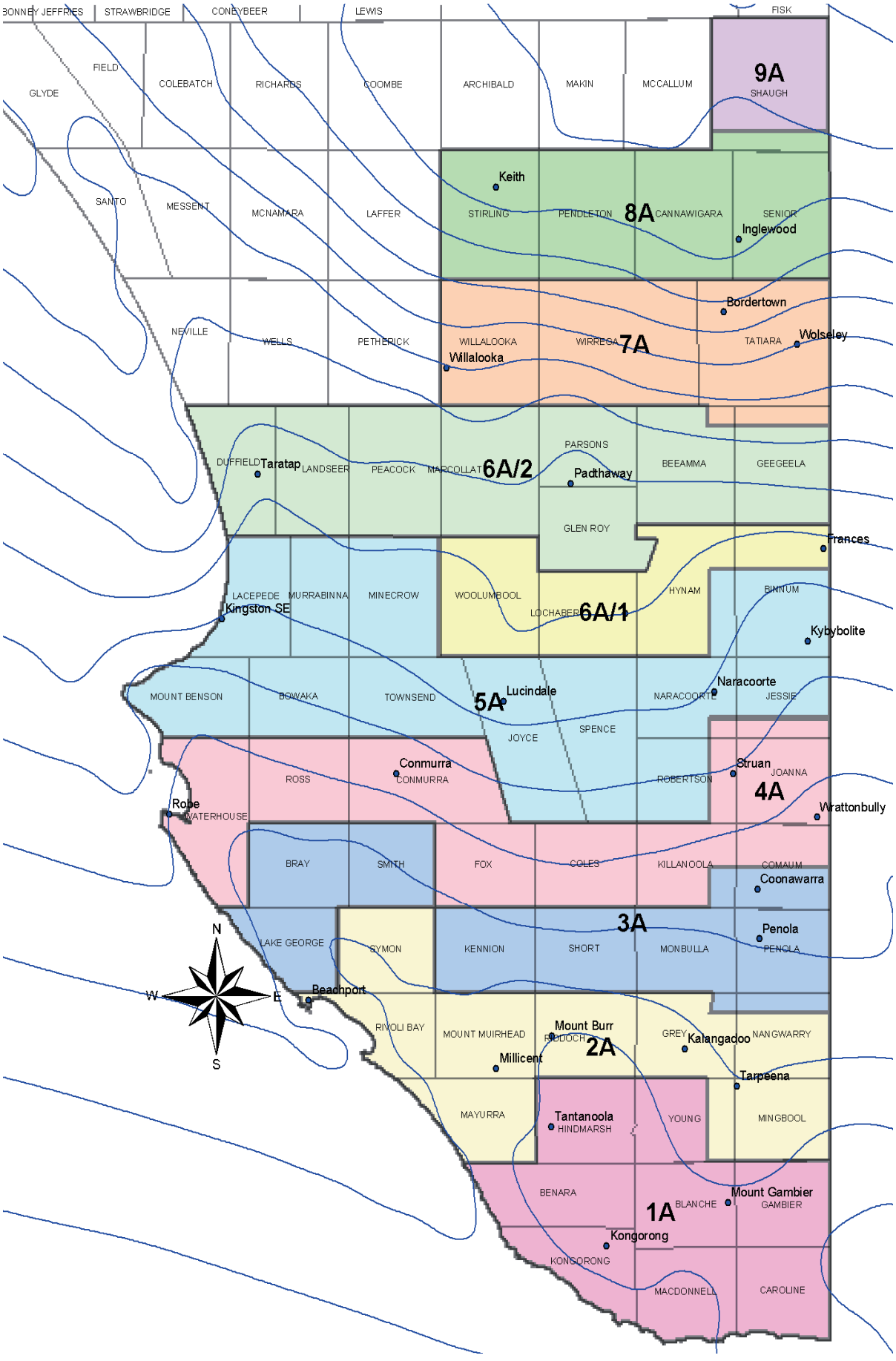
The existing Irrigation Equivalents water allocation system considered only the theoretical net water use of the crop. In moving to a volumetric allocation system, the conversion model must consider the volume of water that needs to be extracted through the well head to result in that net crop water use.

A range of variables including crop type and management practices, irrigation system, soil type, water quality and climatic zone all impact on the volume of water extracted by the irrigator to meet on-farm irrigation needs. The aim of this phase of the project was to collect a matrix of irrigation-related water extraction and use information from a range of on-farm data sources and data collection processes. The dataset of information provided the foundation for on-ground validation of the reviewed theoretical crop irrigation requirements data. It also provided accurate information on the volumes of water currently being extracted by irrigators and associated on-farm efficiencies. This information was used to develop a volumetric conversion approach capable of dealing with the range of variables that impact on the rates of water extraction.

The data collection process included:

1. Metered Extraction Trials (MET) Program: collection of accurate pumped extraction volumes per hectare irrigated from more than 160 metered trial sites (Figure A2, page 54);
2. Field Irrigation System Trials (FIST) Program: collection of detailed information on the on-farm water balance on 36 representative intensely monitored trial sites (Figure A2, page 54); and
3. collection of additional irrigation related data from available sources including:
    - Annual Water Use Returns from all licensees;
    - data sourced through commodity groups (eg. viticulture & potato industries); and
    - data sourced from other related studies.

Figure A1 – Climatic bands in the South East



2.3 Metered extraction trials (MET) program

The metered extraction trials (MET) program was developed to obtain accurate data on the volume extracted per area irrigated from a wide range of representative sites across the region over a 3-year period.

The program's objectives were:

- to provide accurate 'irrigator owned' information on the volumes of water actually pumped to irrigate a range of crops under a range of situations; and
- to enable comparison of water extracted through the well-head with theoretical crop irrigation requirements;

to assist in the determination of the relative efficiencies of various irrigation systems.

The MET program was comprised of 160 meters installed on 120 properties providing information on 200 separate crop sites. Data was compared against the Irrigation Equivalent (IE) value for each crop type. The IE value represents the theoretical crop irrigation requirement for an average season. The difference between the Irrigation Rate and the IE value was expressed as a percentage of the IE value and called the Comparative Volume Pumped. This provides a means for comparing the volumes pumped by individual irrigators as well as viewing the range in volumes pumped for different irrigation systems.

2.4 Field irrigation system trials (FIST) program

The field irrigation system trials (FIST) program was aimed at collecting detailed information on the on-farm water balance from 36 representative trial sites (7 of which were located in the Padthaway PWA) across the South East. The trials 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 was analysed and used to develop an on-farm water balance for each of the sites.

Critical outcomes of the trials included:

- Validation of theoretical crop irrigation requirements;
- accurate point source information on the application efficiencies of various irrigation methods used in the SE;
- calculation of the volumes of applied water returned to the aquifer through drainage; and
- calculation of the volumes of applied water lost through evaporation and other processes.

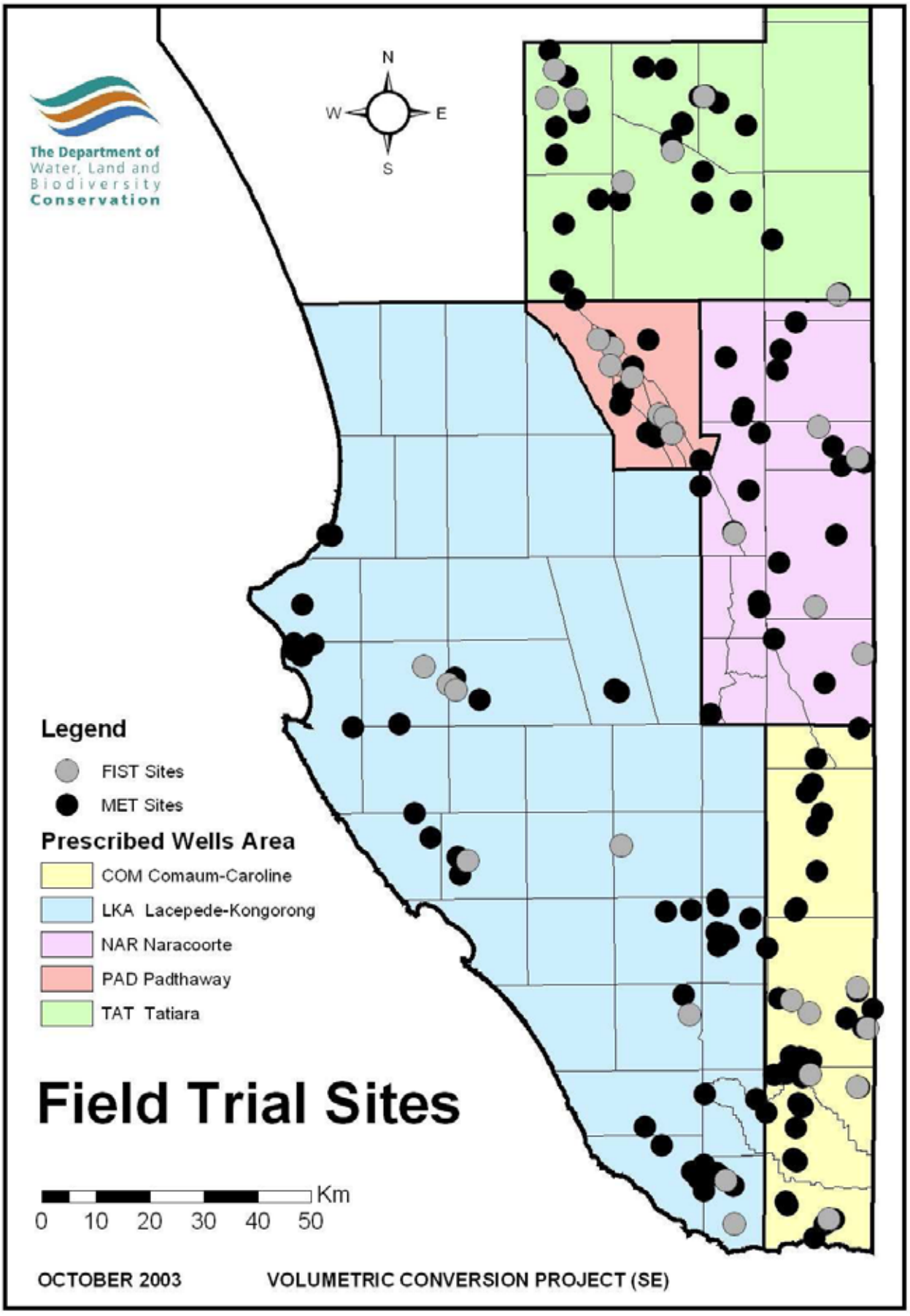
The FIST network consisted of 36 sites and included properties using flood irrigation, travelling gun irrigators, centre pivots and drip irrigation. Sites were selected from existing MET program sites to represent the range of irrigation methods, crop types and soil types found in the South East.

Monitoring instruments installed at trial sites included:

- telemetry equipment: data collected from the sites was transmitted by telemetry to the data storage device in Adelaide for access by Project staff through the Agwise web site, enabling data to be collected continuously and monitored for performance;
- soil moisture: capacitance probes were installed at each site to measure soil moisture in different 'representative' soil types within the irrigated area:
- water table fluctuations: piezometers were been drilled into the water table and water level transducers installed in the piezometers to measure changes in water table levels.

The location of the MET and FIST trial sites are shown in Figure A2.

Figure A2 – Location of metered extraction trials and field investigation trials



2.5 Collection of additional data

DLWBC (now DFW) obtains data from irrigators on their irrigation activities annually through licensees' Annual Water Use Returns. These returns provide valuable information that was used to extend and confirm data obtained from the MET and FIST programs. Emphasis has been placed on the importance of irrigators keeping good records of water extraction so that information supplied to DFW through the Annual Water Use Returns is as accurate as possible. Whilst the data obtained from Annual Water Use Returns may not be as accurate as that obtained from the project's trial sites, it provided a means of comparing trial data against the full range of practices within the wider irrigator community. Existing data from irrigators who already had meters installed, in particular the viticulture industry, was also collected through the representative commodity groups.

2.6 Evaluation of data collected & validation of the model

Information obtained during the data collection phase was used to analyse and check the theoretical crop irrigation requirement figures determined in Phase 1. It was also used to quantify the additional volumes of water that individual irrigators need to apply to provide the theoretical net crop water requirement to their crop. This provided the basis for the development of delivery components for each irrigation system, within representative conversion zones (Figure A3).

The volumetric conversion model was developed to enable "reasonably" efficient irrigators to continue their current practices. To assess whether this objective was met, the annual volume pumped at each of the project's Field Irrigation System Trial (FIST) sites was compared to the proposed allocation for the relevant licence. The percentage of flood irrigators affected by the conversion (ie the percentage that would have insufficient water to continue current practices) ranged from 0% in 2002-03 to 25% in 2004-05. For spray irrigation, in two of the three seasons in which the program was run, approximately 10% of irrigators were affected; only in 2004-05 were > 25% of irrigators affected (27%). No drip irrigators were affected by the conversion.

Two of the FIST sites were found to be extracting more water than would be allocated. Irrigation practices at these sites were investigated using a computer model, and it was found that there was potential to improve irrigation practices and therefore reduce volumes extracted.

The validation process provides confidence that the 75th percentile is a reliable cut-off point to define "reasonably efficient" irrigators, ie licensees extracting more water than will be allocated should have the capacity to alter their irrigation practices to align with the allocated volume.

2.7 Phase Three – Development and implementation of conversion methodology

The volumetric conversion model comprises the following primary components:

1. Base allocation relating to the crop water requirements; and
2. Delivery component relating to transmission and application losses.

2.7.1 Base allocation

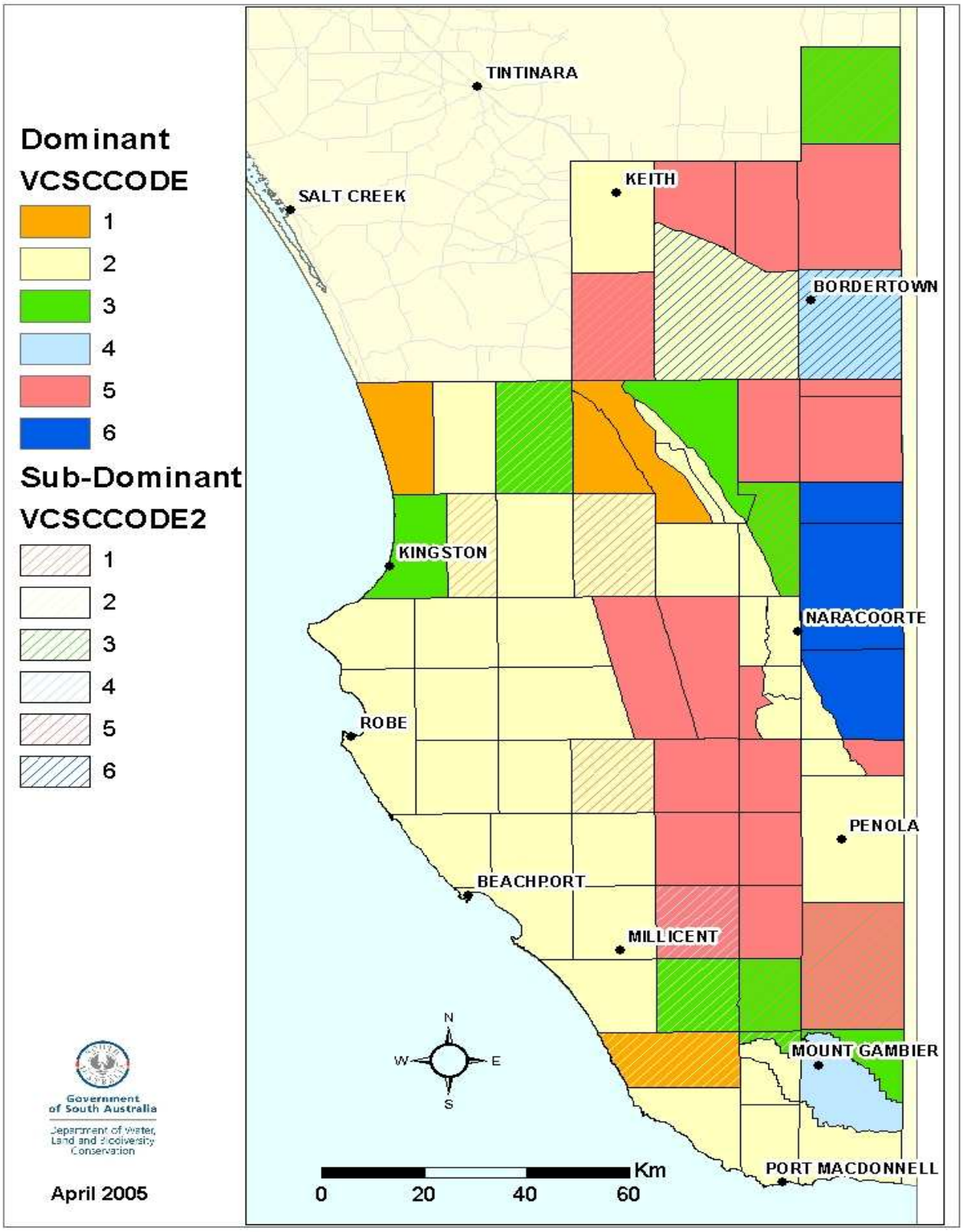
The Base allocation is the crop water requirement component and equates to the irrigation requirement for the reference crop from the existing area-based irrigation equivalents (haIE) allocation system, as follows:

Base Allocation (ML) = haIE x NIRo X CAF

where:

- haIE is the current area-based allocation;
- NIRo is the net irrigation requirement for the reference crop for the climatic band associated with the allocation (Figure A1);
- CAF is the Crop Adjustment Factor to be allocated to eligible irrigators growing specific crops during the period (2002-05).

Figure A3 – Delivery component zones in the South East of South Australia



1 – Shallow sand over limestone 3 – Deep sand 5 – Sand over clay

2 – Shallow loam over limestone 4 – Deep loam/clay 6 – Loam/Clay over clay

2.7.2 Delivery component

The delivery component is the volume of water that a reasonably efficient irrigator needs to extract in excess of the crop water requirements to irrigate and grow the crop.

Irrigation efficiencies of 65%[7] (or, in some cases, lower due to the predominant soil type) for flood systems, 85% for spray systems and 90% for drip systems are globally accepted. Therefore in volume of water comprising the delivery component that is in addition to the base allocation is as follows:

- flood systems: 54%-199% of base allocation;
- spray systems: 18% of base allocation; and
- drip systems: 11% of base allocation.

2.7.3 Specialised production requirements and crop adjustment factors

In developing the model it was recognised that there are circumstances where the calculations above did not provide sufficient volume to meet existing irrigation practices. Such practices include irrigation of high water use crops (e.g. maize, carrots, and onion) and water applied to control soil drift or to protect against frost damage. To enable continued operations the model comprises the following supplementary elements:

- crop adjustment factor forming part of the base allocation;
- specialised production requirements.

2.7.4 Bridging volumes

In addition, in recognition that the model provides for 75% of irrigators to continue their current practices, a temporary bridging volume was developed to provide the 25% of irrigators who would receive insufficient water, with time to adjust.

[7] The percentage of irrigation efficiency indicates the percentage of the total water applied that represents crop water requirements, eg an allocation of 154 ML for flood will provide 100 ML of crop water requirements, where 100 ML represents 65% of the water applied.

Appendix B. Application of the volumetric conversion model in the 2009 Padthaway Water Allocation Plan

The volumetric conversion model derived by the Department of Water, Land and Biodiversity (now Department for Water) was used to determine the level of volumetric allocation represented by the total hectare irrigation equivalents allocated in the Padthaway PWA. Application of the volumetric conversion model indicated that the total volumetric allocation required for reasonable irrigators to be able to irrigate the haIEs allocated in the Padthaway PWA was in excess of 89,000 ML/year.

The PadMod 3D model of salt and groundwater movement was used to determine what level of groundwater extraction would ensure the groundwater condition remained within the agreed resource condition limits (see 2.5.3 *Allocation scenarios modeled through the 3D numerical model (PadMod)* for more details). An Acceptable Level of Extraction (ALE) was set at 48,000 ML/year.

Following the establishment of an ALE, REM was engaged separately by both the Padthaway Grape Growers Association and the Padthaway Flood Irrigators to help develop options to reduce volumetric allocations (approx 89,000 ML/year) to within the ALE of 48,000 ML/year. It was considered by the community that having the two main irrigator groups working separately would allow easier discussion of options.

Management area boundaries in Padthaway were not established on a hydrogeological basis, but instead drawn around the existing heavily developed areas to preclude the possibility of their expansion, resulting in significantly higher reductions being required in these areas. As a result, stakeholders agreed to develop options on a PWA basis (including both the Flats and the Range).

The volumetric conversion model developed by DWLBC allowed the calculation of the volumes required by the 75th percentile of irrigators to irrigate the area represented by their haIE allocations. As a first step in reducing allocations to the Acceptable Level of Extraction (ALE), stakeholders proposed to determine the *average* requirements for each irrigation system, to determine whether these were below the volumes provided by the volumetric conversion model.

The average volume extracted over the previous 3 years per irrigation system type (on a PWA basis) was determined with the assistance of DWLBC (now Department for Water). This calculation showed that the average use per irrigation system type was approximately 31%, 27 % and 10 % less than the volumes provided by DWLBC's volumetric conversion model for drip, spray and flood irrigation systems, respectively, indicating that all irrigation types could be encouraged to become more efficient. However, this was insufficient to reach the Acceptable Level of Extraction, as it only reduced overall allocation by approximately 10,000 ML/year. As a result, additional measures were considered.

The approaches to issuing volumetric allocations at an acceptable level developed by PGGA and PFI were virtually identical (*G. Harrington (REM), personal comm, 2007)*. This proposal was presented to the Board by REM at its November 2007 meeting. Although willing to adopt a method to address over-allocation that included differential approaches to allocation (subject to it receiving community support), the Board was concerned at the potential for 0 ML allocations for inactive irrigators.

The PGGA/PFI proposal was taken to the Padthaway Groundwater Management Committee (which included members of both stakeholder groups) for further discussion and development. The Committee determined a number of changes to the allocation system, which were accepted by the Board at its December 2007 meeting. The final proposal is described below.

Basis for allocation

Regardless of their system type or level of use of their allocation, all licensees will be allocated a minimum allocation of 3.95 ML for every haIE. The 3.95 ML/haIE was selected as equivalent to 50% of the allocation provided for spray irrigation systems (7.95 ML/haIE) from DWLBC's Volumetric Conversion model (Appendix A).

The issuing of a minimum allocation of 3.95 ML/haIE to the 5,913 haIEs allocated in Padthaway, resulted in a total volume of 23,356 ML/year. The remaining volume of water (ie the Acceptable Level of Extraction – 23,356 ML) to be issued on the basis of:

- area: determined as the haIEs under irrigation at 30 June 2006 or 30 June 2007 (whichever was the greater area);
- system type: determined as the irrigation system in place at 30 June 2007;

with the volume issued per eligible haIE calculated as the average volume pumped over the 2004/05 and 2005/06 irrigation seasons or the PWA average for the system type (Fig B1), whichever is the lesser.

The allocation scheme also determined that allocations were to be issued at the date of volumetric conversion.

With respect to water (holding) allocations endorsed as haIE, the 2009 Padthaway WAP states that these will be converted at a volume of 3.95 ML per each haIE.

Tradeable component

The terms "base allocation" and "delivery component" developed for DWLBC's volumetric conversion model are not used. Instead the term tradeable component is used to describe:

a) the whole of the volume assigned for the purposes of irrigation by means of drip or spray systems;
b) a volume equivalent to 5.79 ML/haIE, in the case of flood irrigation.

Delivery Supplement

The delivery supplement represents the volume of water from flood irrigation which is assumed to deep drain past the root zone and return to the source aquifer. Delivery supplements are calculated by subtracting the tradeable component of 5.79 ML/haIE from the allocation calculated according to principles described above.

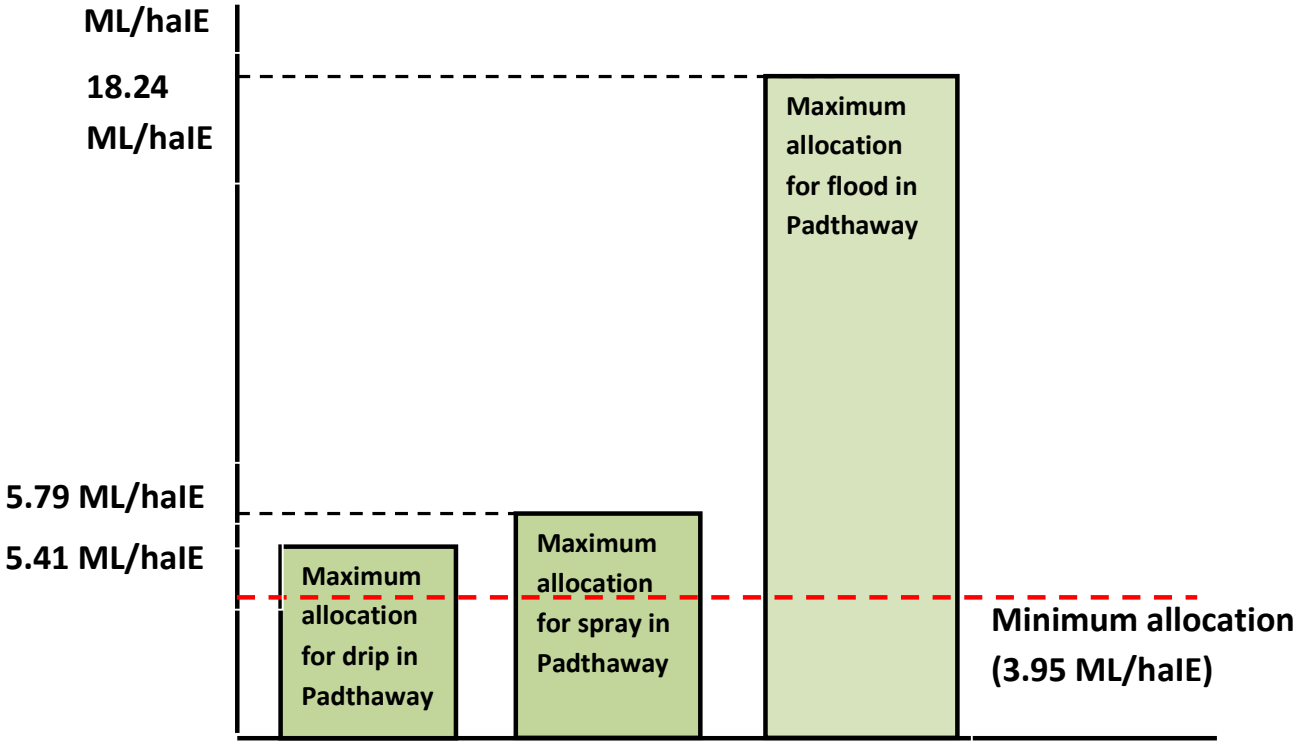
The 2009 WAP issues delivery supplements for the purposes of flood irrigation and only upon volumetric conversion of existing area-based licences. The delivery supplement is issued for the hectare irrigation equivalents under flood irrigation at 30 June 2006 or 30 June 2007, whichever is the greatest area.

Delivery supplements are allocated on a temporary basis until 30 June 2014 and, subject to review, will be reissued at a volume lesser than or equal to the volume allocated at date of adoption of the WAP.

No additional delivery supplements can be applied for under the 2009 WAP. Delivery supplements are not tradeable but instead must be surrendered at the time of transferring/selling the corresponding tradeable component. If the purchaser / lessee will be using the tradeable component for the purposes of flood irrigation, the delivery supplement will be reissued to the purchaser / lessee.

As delivery supplements can be used only for the purposes of flood irrigation, where a licensee converts their flood irrigation system to a different type (eg spray or flood), the delivery supplement must be surrendered, as this volume will no longer return to the aquifer through deep drainage.

Figure B1. Minimum and maximum allocations for each irrigation system type.



Bridging volume

DWLBC's (now DFW) volumetric conversion model proposed the allocation of temporary bridging volumes, in order to provide licensees with time to adjust to their volumetric allocations. This concept was adopted in the Padthaway WAP in the form of a 10% bridging volume for the first 2 years of the Plan. These bridging volumes expire after 12 months (ie a second bridging volume is issued in Year 2 of the Plan) and cannot be carried over into the following water use year.

Specialised production requirements

The volumetric conversion model developed by DWLBC (now DFW) recognised that there are circumstances where the base allocation and the delivery component did not provide sufficient volume to meet existing irrigation practices. Such practices include irrigation of high water use crops (e.g. maize, carrots, and onion) and water applied to control soil drift or to protect against frost damage. To enable continued operations, the model comprises the following supplementary elements:

- crop adjustment factor forming part of base allocation;
- specialised production requirements

The 2009 Padthaway WAP also provides for the allocation of crop adjustment factors and specialised production requirements to eligible licensees. The volumes assigned to these additional components of the licence are those developed by DWLBC for the Volumetric Conversion Model.

Total allocation vs Acceptable Level of Extraction (ALE)

The application of the above policy resulted in a total allocation of approximately 55,037 ML, which was in excess of the ALE of 48,000 ML/year. It was agreed that the additional reductions required to meet the ALE would apply equally to all licensees.

As a result, the 2009 WAP states that in 2014 (the fifth year of the Plan) all licences will be reduced equally by the percentage required to meet the Acceptable Level of Extraction[8], with the exception of public water supply, industry and recreational licences. These last three types of licences are excluded from reductions as the result of a recommendation from the Padthaway Groundwater Management Committee to the Board, as these allocations represent only a small volume of the total water allocated but the social impact and risk of employment loss from their reduction can be significant.

It was considered by the Committee that this allocation proposal provided all licensees with certainty and a minimum allocation. The proposal was presented to the Board at its December 2007 meeting, and was accepted for incorporation into the draft Padthaway Water Allocation Plan.

[8] It should be noted that the 2009 Padthaway Water Allocation Plan proposes that in the fifth year of the Plan (2014) allocations be reduced to the Acceptable Level of Extraction (ALE) as determined at that date. As a result, it is proposed to determine the ALE by means of incorporating updates to data (including meter readings and recharge) to the 3D model and determining the level of extraction at which the resource condition limits continue to be met.

Appendix C – Brief history of the Padthaway Prescribed Wells Area

1960s	Broadacre irrigation begins
Early 1960s	Trial plantings of vines
Late 1960s	Irrigators express concern as groundwater levels appear to be falling
Late 1960s / early 1970s	Detailed hydrogeological investigations undertaken
1975	Padthaway PWA is proclaimed in response to potential salinity increases and concerns that increasing irrigation activities will lower the watertable. As part of this, the annual total withdrawal of groundwater is reduced to 95% of total usage of the 1972/73 season, to prevent further lowering of the watertable. The Padthaway Water Resources Advisory Committee is formed.
1983	A working group reporting to the Padthaway Water Resources Advisory Committee concludes that if total water allocations are fully utilised, then serious salinity problems will develop. Recommends that water allocation be restricted to the highest usage between 1975 and the 1982/83 season as well as any commitment to new development. Licences are subsequently reduced in this manner.
1997	Water allocation planning process under the *Water Resources Act 1997* is commenced.
1999	Padthaway Water Allocation Planning Committee is formed. Report of the Select Committee of Inquiry on Water Allocations in the South East is released in August 1999. The key recommendation from the 1999 Select Committee of Parliament on Water Allocations in the South East were: • volumetric conversion should be implemented in the South East • all licensed irrigator water use should be metered • 10% of groundwater should be reserved for the environment.
2001	Morambro Creek watercourse (including Cockatoo Lake and Nyroca Channel) and the Morambro Creek Surface Water Area, are prescribed on 12 April 2001. Padthaway Water Allocation Plan is adopted by the Minister for Water Resources on 29 June 2001. The Plan identifies but does not address overallocation and rising groundwater salinity issues. Minister implements a first notice of restriction on water use in the Padthaway PWA in December 2001, while management options to deal with rising groundwater salinity are developed.
2002	2001 Padthaway Water Allocation Plan review commenced. Padthaway Groundwater Management Committee formed.

Padthaway Salt Accession project commenced by the Department of Water, Land and Biodiversity Conservation (now Department for Water) to quantify groundwater extraction, irrigation application, crop water use, evaporation and salt/water accession to the aquifer under the different irrigation practices. Through this process the risk of groundwater salinisation under different land uses and irrigation methods was assessed.

2003 Minister implements a second notice of restriction of water use in the Padthaway PWA.

2004 *Natural Resources Management Act 2004* adopted, but no change required to the water allocation plan review process.

Proposal Statement adopted by the Minister In September 2004.

2005 The results of the Padthaway Salt Accession project confirm that there are 2 main drivers of salinity increases in the Padthaway PWA:

1. the clearance of native vegetation in the 1960s-1970s in the Naracoorte Range, which led to water tables rising and leaching out of the historical salt store from the soil into the groundwater, which has since flowed down-gradient towards the main irrigation area; and

2. the recycling of water under the main irrigation area.

The project also indicates that the maintenance of the current level of recharge and the lateral throughflow of groundwater are key to ensuring salt continues to flush from the Padthaway PWA.

Minister implements a third notice of restriction of water use in the Padthaway PWA.

2007 Minister implements a fourth notice of restriction of water use in the Padthaway PWA.

3D computer model of salt and groundwater movement through the Padthaway PWA completed and used to determine an Acceptable Level of Extraction.

2008 Community representatives develop a method to allocate water at the Acceptable Level of Extraction. This method is adopted by the Board for incorporation into the draft Padthaway Water Allocation Plan.

2009 Water Allocation Plan adopted by the Minister for Environment and Conservation on 26 April 2009.

Notice of Restriction lifted by the Minister on 25 June 2009.

Volumetric allocations implemented on 1 July 2009.

Appendix D – Schedule of Public Consultation

Table 1: Consultation phases during the development of the 2009 Padthaway WAP

Consultation	Date	Meetings	Community members in attendance	Submissions
Consultation on the preparation of the Proposal Statement	February - March 2004	0	NA	3
Consultation on the Draft Proposal Statement	June- August 2004	0	NA	10
A1 – consultation on the preparation of the Draft Water Allocation Plan & Discussion Papers	July - September 2005	1	30	10
A2 – consultation on the Draft Principles of the Plan	November 2006- January 2007	1	69	2
B – Statutory consultation on the Draft Water Allocation Plan	September – November 2008	1	31	12
Water Allocation Plan adoption by Minister	26 April 2009	NA	NA	NA

NA – not applicable

The community consultation process

2002. Formation of the Padthaway Groundwater Management Committee

This skills-based committee was formed after extensive publicity and personal contact. The committee comprised community appointments, two technical advisors (one for licensing and one for hydrogeology) from the Department of Water, Land and Biodiversity Conservation (now Department for Water), a Board member (as Chair) and a Board staff member.

The Water Allocation Planning Committee was formed to provide the Board with knowledgeable and well-reasoned community input into the WAP, and to assist the Board by providing an analysis of the effect of decisions on individual licensees in the PWA. The Committee met over 40 times over seven years and had a major influence on the content of the Plan.

February - March 2004. Consultation on the preparation of the Proposal Statement (statutory)

As required by Section 102 of the *Water Resources Act 1997* (now superseded by the NRM Act 2004), the Board, prior to the preparation of the draft proposal statement, advertised in newspapers in the Padthaway region and posted a letter to all licensees and landholders in the Padthaway PWA announcing the intention to review the 2001 Water Allocation Plan for the Padthaway PWA and inviting submissions for preparation of the Proposal Statement (now called a Concept Statement under the Natural Resources Management Act 2004).

A total of 3 written submissions were received. The Board reviewed the submissions and in conjunction with the Padthaway Groundwater Management Committee, prepared a draft Proposal Statement for consideration by the Minister. The Minister agreed to the draft Proposal Statement on 10 June 2004.

June – August 2004. Consultation on the draft Proposal Statement (statutory)
Public comment was invited on the Draft Proposal Statement (now Concept Statement) by placing a public notice advertisement in local newspapers and the Adelaide *Advertiser*. As only 3 written submissions were received by the due date, a new call for comments was advertised through a media release and an appearance by the project officer on WIN TV in the last week of July 2004. An additional 6 written submissions were received by the due date, and an additional submission received on 7 September, taking the total to 10 submissions.

The Minister approved the Proposal Statement on 18 October 2004, together with approval to proceed with the preparation of a draft water allocation on the basis of the proposal statement.

July - September 2005. A1 Consultation on the preparation of the Water Allocation Plan (statutory)
Board staff developed a booklet of discussion papers *Papers for Community Comment* to form the basis of the statutory consultation on the preparation of the draft Water Allocation Plans for the Padthaway, Tatiara, Lacepede Kongorong, Comaum-Caroline and Naracoorte Range PWAs (these last three amalgamated as Lower Limestone Coast PWA).

Public comment on the proposed content of the revised Water Allocation Plans and the issues in the Discussion Papers were invited by advertising in local newspapers and the *Advertiser* as well as on local radio. A letter of invitation to request a copy of the discussion papers and to attend a community consultation meeting was sent to all landholders within each PWA.

Seven community consultation meetings were held between 5 and 14 September 2005, with a total of 177 attendees, with the Padthaway meeting held on 14 September 2005 with 30 attendees.

Attendees received and overview of the WAP review process to date, as well as the steps to follow after the A1 consultation. A presentation on the current conditions of the resource and the review of available recharge was provided by DWLBC (now Department for Water) staff. Attendees were asked to break into discussion groups based on what topics they would prefer to discuss.

A total of 30 written submissions were received, of which 9 made reference to issues that applied to the 2001 WAPs in general, while 1 submission referred specifically to the Padthaway area. The record of the community forums, the written submissions and the workshops were considered by the Board. Written submissions were acknowledged in writing.

November 2006 - January 2007. A2 Consultation on the draft principles of the Plan (non-statutory)
This two-month statutory consultation was extended to three months (ending 24 January 2007), in consideration of the fact that it extended over the Christmas and summer holiday period. The consultation was advertised in the Advertiser, local newspapers and on local and ABC radio.

A letter of invitation to the public meeting was sent to all landholders. The meeting was held at Padthaway and a total of 69 people attended.

September to November 2008 - B Consultation on the draft Water Allocation Plan (statutory)

Approval to release the draft Water Allocation Plan for the Padthaway Prescribed Wells Area was obtained from the Minister on 27 August 2008. Licensees and landholders were sent a series of information sheets outlining the main proposals in the draft Plan and an invitation to attend a community consultation meeting on the contents of the draft Plan and/or provide comment in writing by 4 November 2008.

The community meeting was held on 18 September 2008 with 31 community members in attendance.

In addition to community comments recorded at the community consultation meeting, a total of 12 written submissions on the draft Plan were received. It should also be noted that a number of community members approached Board staff after the meeting to express their support for the proposed policy.

Community comments were considered by the WAP Policy Working Group (composed of SENRMB and DWLBC staff) and recommendations developed for consideration by the Board. After considering the outcomes of this final consultation, the Board recommended to the Minister that some minor changes be made to the WAP.

A copy of the summary report of the consultation meetings and the written submissions was sent to the Minister for his consideration prior to the adoption of the Plan.

April 2009. Aadoption of the Water Allocation Plan by the Minister

Upon receipt of the Board's report on the B statutory consultation on the draft Padthaway WAP, together with copies of written submissions and the Board's recommendations for some minor changes to be made to the WAP, Ministerial consultation was carried out in accordance with the NRM Act 2004.

Board staff provided a briefing on the contents of the WAP and its alignment with the State NRM Plan to the NRM Council.

The WAP was adopted by the Minister on 26 April 2009.

Outcomes of the community consultation process

The various phases of community consultation undertaken during the development of the Padthaway Water Allocation Plan generated a large amount of interest and represented a wide variety of views and ideas.

The Board considered the information collected through the consultation process when drafting the policies contained within the WAP. It has been impossible for the WAP to reflect all the ideas and viewpoints provided by the community. However, the significant role played by the community during the consultation process has added considerable value to the WAP.

Key issues raised during the various consultation phases of consultation included:

- concern regarding the potential economic impact of the level of reduction required, including the impact of making reductions based on the management areas set out in the 2001 Water Allocation Plan;

Community input has been a vital component of the water allocation planning process, as it has produced robust, practical and workable policy solutions tailored to the unique issues of the Padthaway PWA.

Appendix E – Results from the investigations identified in the Proposal Statement

Prior to amending the 2001 Padthaway Prescribed Wells Area Water Allocation Plan, the Board was required to prepare a Proposal Statement in accordance with the *Water Resources Act*.

A Proposal Statement must:

- set out in general terms the proposed content of the water allocation plan; and
- specify matters to be investigated by the Board before preparation of the draft plan; and
- set out the proposals (if any) for consultation on the draft plan that are in addition to the requirements of the *Water Resources Act 1997*.

In its Proposal Statement, the Board identified a number of matters to be investigated during the preparation of amendments to the 2001 Water Allocation Plan for the Padthaway Prescribed Wells Area. The table below describes these investigations and indicates whether they were completed during the amendment of the WAP.

Investigation in the Proposal Statement	**Outcome**
Review of the concept of an environmental provision for ecosystems in the Padthaway PWA.	10% of recharge set aside for environmental provision and lateral groundwater throughflow.
Review of the effect of taking and using water from the prescribed resource on other water resources.	Completed by DWLBC (now Department for Water)
Review of the needs and health of ecosystems dependent on groundwater.	Carried out by consultants REM
Padthaway Salt Accession Project: • Quantify the historic salt store contained within the soil profile, determine the recharge rates, and determine the time lag associated with groundwater salinisation at selected sites. • Quantify groundwater extraction, irrigation application, crop water use, evaporation, and salt/water accession to the unconfined aquifer using different irrigation practices and the risk of groundwater salinisation at selected sites. • Undertake a qualitative risk assessment by the extrapolation of the site specific results obtained from the first and second dot points above, and determining the current salt and water budgets for the critical sub-areas of concentrated irrigation activity, and for the region as a whole. • Determine the sustainable extraction limit (PAV) for individual groundwater management areas that will result in sustainable resource management and arrest groundwater quality deterioration (and, where relevant, groundwater level	Carried out by DWLBC (now Department for Water) • Mechanisms of salt accession identified. • Conceptual and 3D numerical models of salt and groundwater movement completed. • Resource conditions limits (including for salinity) determined. • Allocation scenarios developed for testing against the resource condition limits. • Acceptable Level of Groundwater Extraction determined. • Limited extraction zone established along the base of the Padthaway Range.

decline) for the areas of concentrated irrigation activity, and the region as a whole, and revise management prescriptions. • Determine effective groundwater resource management strategies for the areas of concentrated irrigation activity, and the region as a whole and predict the response of the aquifer system to them. • Review of the groundwater salinity monitoring program to ensure that the program is effective and relevant.	
Review the current groundwater management area boundaries	Management areas reviewed and amended to reflect the hydrogeology of the Padthaway PWA.
Socio-economic study of the impacts of reducing water allocations in the Padthaway PWA, should allocations need to be reduced in Padthaway.	Community-developed method of reducing allocation ensures the level of allocation is within the Acceptable level for Extraction, thereby ensuring salinity and depth to water table are maintained within resource condition limits. This minimises impacts to the groundwater resources and dependent ecosystems, while maintaining the current economic output of the region.
Volumetric Conversion Project to convert area based water licences to volumetric licences.	DWLBC's (now DFW) completed Volumetric Conversion project formed the basis to determine the total level of allocation in the Padthaway PWA, and to determine values for specialised production requirements and crop adjustment factors. Padthaway community representatives developed a method of allocation that ensured total allocation was reduced to the Acceptable Level of Extraction.

Appendix F – Definitions and Abbreviations

Definitions of abbreviations and technical terms used in this document appear in Section 5 of the 2009 Padthaway Water Allocation Plan. A number have also been included below:

The Act	*Natural Resources Management Act 2004*
the Board / SE NRM Board	South East Natural Resources Management Board (formerly the South East Catchment Water Management Board)
DFW	Department for Water (formerly Department of Water, Land and Biodiversity Conservation)
DWLBC	Department of Water, Land and Biodiversity Conservation (now DFW)
ML	megalitres (million litres)
PWA	Prescribed Wells Area
WAP	Water Allocation Plan
haIE / IE	hectare Irrigation Equivalent / Irrigation Equivalent

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