DWLBC REPORT

Clare Prescribed Water Resources Area Groundwater Monitoring Status Report 2005

2005/18

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

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Report DWLBC 2005/18

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FOREWORD

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

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

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

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

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1. INTRODUCTION

The Clare Prescribed Water Resources Area (PWRA) is situated ~100 km north of Adelaide within the northern Mount Lofty Ranges. The area covers ~700 km^2 and incorporates a number of catchments and sub-catchments (Fig. 1).

Groundwater in the Clare Valley is stored in Quaternary Sedimentary Aquifers and Proterozoic Fractured Rock Aquifers present in the Adelaide Geosyncline. These aquifer systems have been monitored by an Observation Well Network (Obswell) since 1987.

This monitoring report discusses water level data collected up to February 2005 and salinity data collected up to July 2003. The information compiled was obtained from 198 observation wells throughout the Clare PWRA. This report provides a summary of the trends observed from the current monitoring data in relation to groundwater levels and groundwater quality.

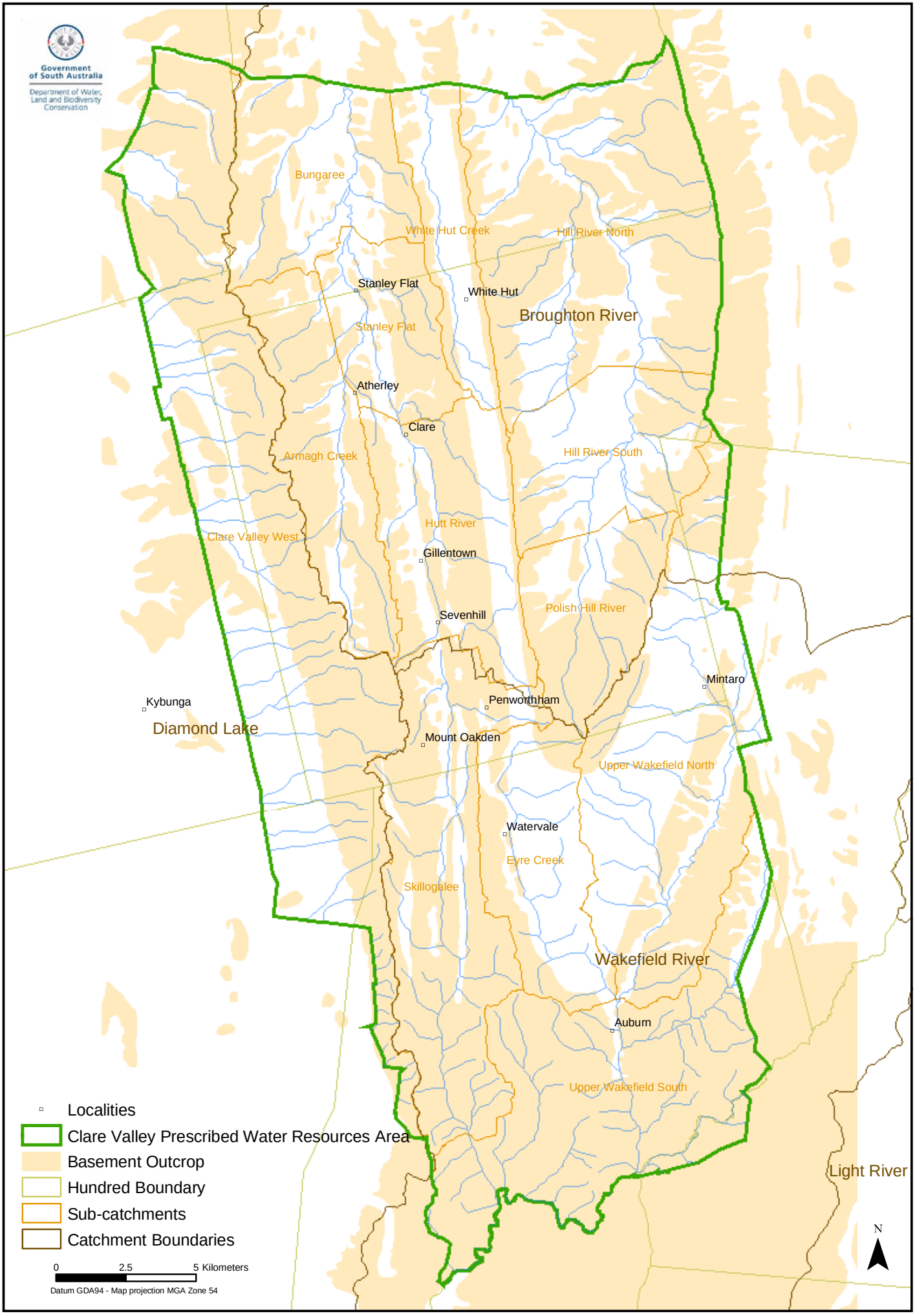

Figure 1. Clare Valley Prescribed Water Resources Area locality plan

2. CLIMATE

The climate of the Clare region is characterised by hot, dry summers and cool to cold, wet winters. Maximum temperatures average around 30°C in summer and 14°C in winter, with June through to August being the wetter months.

Three Bureau of Meteorology rainfall stations; Clare (Calcannia): 21 075, Clare (Hill River): 21 025, and Watervale: 21 054 were chosen for analysis of rainfall trends. Monthly rainfall data collected between 1938–2005 was analysed and is shown in Figure 2a. Figure 2b indicates the location of these stations and demonstrates the distribution of rainfall isohyets throughout the Clare Valley.

Annual average rainfall, for the 1938–2004 period is 543 mm at Clare (Calcannia), 642 mm at Clare (Hill River), and 633 mm at Watervale. The highest rainfall corresponds to areas of higher elevation, which are also the central and southern portions of the region.

Cumulative deviation from mean monthly rainfall is graphed to identify periods where rainfall trends are above or below average. Cumulative deviation from mean monthly rainfall is calculated by taking the average rainfall for each month since 1938 from the actual rainfall for each month. This produces a value indicating how far the rainfall for that month varies from the long-term average. This difference is then cumulatively added to produce a trend curve. A positive slope indicates a period where the rainfall is greater than the average, while a negative slope indicates a period where the rainfall is below the average.

Figure 2a indicates that over the previous 65 years rainfall has been highly variable throughout the Clare Valley, with the three rainfall stations demonstrating differing long-term and short-term rainfall trends.

Clare (Calcannia) station shows alternating above and below average trends lasting between 15–25 years. For the immediate past three years the downward trend indicates that rainfall has been below average.

Clare (Hill River) station indicated a period of below average rainfall from 1938–46, followed by 36 years of above average to average rainfall. Apart from the wet 1992–93, rainfall trends have been average to below average to present time.

Watervale station displays a different trend to the other two stations; it indicates quite a consistent above average rainfall from 1938–56, followed by a consistent below average trend from 1957–91. From 1992 until 2002 the region experienced above average rainfall, with the period 2003 until present showing below average rainfall conditions.

Aquifer systems have been observed to rise in response to local high rainfall recharge events, thus it is concluded that these systems are replenished annually from local precipitation. Groundwater is not sourced from any other region (Morton et al., 1998). Groundwater levels are controlled by recharge to both Quaternary and Fractured Rock Aquifer systems. Periods of above average rainfall should result in rising groundwater levels and decreasing groundwater salinity, while years of below average rainfall should result in declining groundwater levels and increasing groundwater salinity.

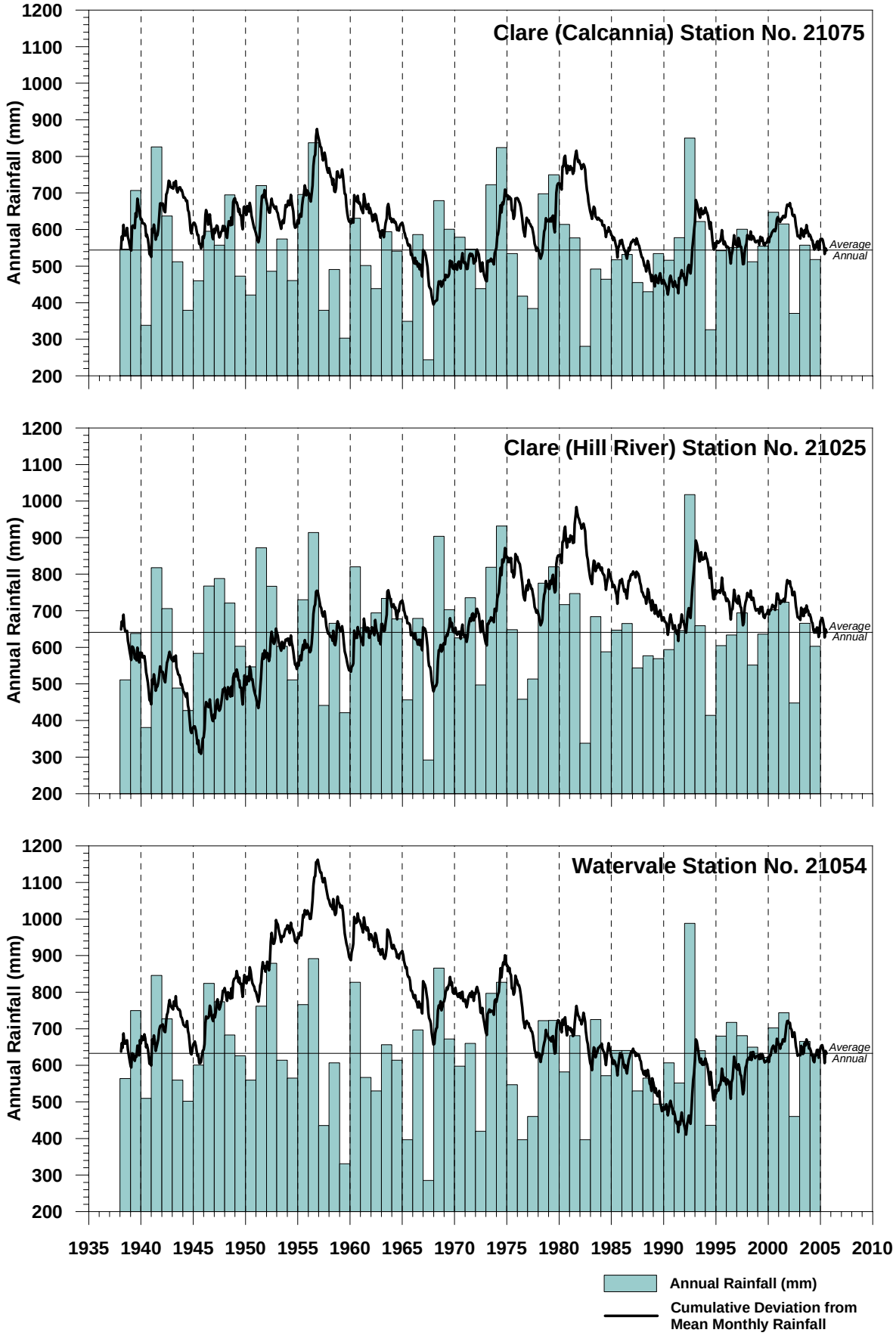

Figure 2a. Annual rainfall and cumulative deviation for mean monthly rainfall

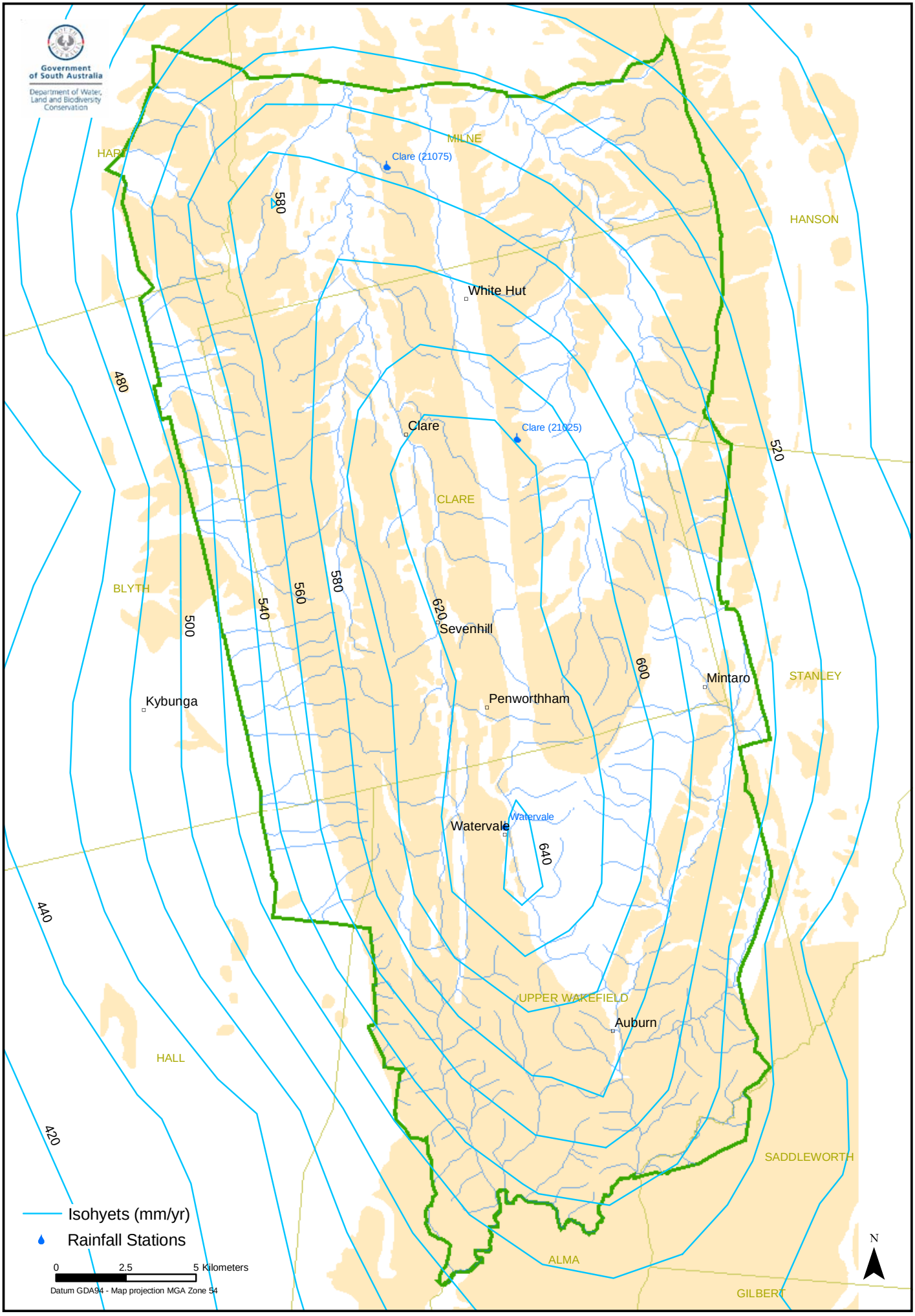

Figure 2b. Rainfall distribution throughout the Clare Valley

3. HYDROGEOLOGY

There are two aquifer systems within the Clare Valley region; an alluvial–colluvial Quaternary Aquifer, which is best developed in the vicinity Stanley Flat, and a substantial Fractured Rock Aquifer, which underlies the Quaternary Aquifer and is dominant throughout the rest of the region. The unconfined Quaternary Aquifer system occurs at shallow depths (<15 m). Sedimentary deposits exist within valleys between basement outcrops, which isolate Quaternary Aquifers. The Quaternary Aquifer is not extensive in the Clare PWRA and provides only a small portion of the groundwater resource (DWR, 2000). The Fractured Rock Aquifer is composed of Proterozoic rocks of the Burra and Umberatanna Groups, consisting of siltstones, shales, dolomites and quartzites. Table 1 summarises the stratigraphic units within the Clare Valley.

The major fractured rock units that provide groundwater for irrigation in the Clare region come from the Mintaro Shale, Saddleworth Formation, Undalya Quartzite, and the Skillogalee Dolomite (Morton et al., 1998). Fracturing in the region is considered to be ubiquitous and groundwater can flow across geological units (Love et al., 2001). Within the Fractured Rock Aquifer, the fractures act as conduits for groundwater flow. The yield of groundwater from a particular well is dependent on the size and spacing between fractures and the orientation of fractures intercepted. Variations in supply from individual bores are likely to be the result of fracturing or other structural constraints, rather than rock type (Love et al., 2001).

The Fractured Rock Aquifer can be divided into two zones; a relatively permeable zone in the upper 20–40 m within which fractures are closely spaced (generally <0.5 m), and a deeper low permeability regional zone (Love et al., 2001). The size and spacing of fractures tends to decrease with depth (Love et al., 2001).

Table 1. Stratigraphic units within the Clare PWRA

Age (y)	**Stratigraphic Unit**	**Stratigraphic name**	**Stratigraphic description**	**Aquifer**	**Comments**
Holocene 0–10 000	Q	Undifferentiated Quaternary	Alluvial and colluvial sediments.	Quaternary Aquifer	Unconfined aquifers; groundwater occurs within the alluvium filling the valleys, and at shallow depths. Best developed in the north at Stanley Flat. Salinity generally <2000 mg/L.
Sturtian 650–700 million years	N		Undifferentiated Neoproterozoic rocks.	Fractured Rock Aquifer	Poor groundwater yields. Salinity in the vicinity of <1000–3500 mg/L.
	Nnt	Tapley Hill Formation	Siltstone; grey to black, dolomitic and pyritic grading upwards to calcareous, thinly laminated, locally cross-bedded; dolomite, grey, flaggy to massive; limestone conglomerate, intraformational; greywacke. Contains Tindelpina Shale Member.		
	Nya	Appila Tillite	Tillite; quartzite; siltstone. Massive, grey.		
	Nyw	Wilyerpa Formation	Siltstone; green. Lower third is fine grained, includes glacial dropstones; middle unit is medium to coarse sandstone; upper unit is siltstone with minor sandstone. Minor diamictite, sandy and pebbly dolomite.		
	Nlg	Gilbert Range Quartzite	Quartzite; arkose.		Can have high yields up to 25 L/s. Sustainable yields are much lower, and the percentage of successful water wells from drilling is low. Salinity ranges from 580–1050 mg/L
	Nli	Mintaro Shale	Siltstone; with very rare pebbles of sandstone, quartzite and limestone.		Groundwater occurs in fractures, with well yields in the range of 0.25–3.5 L/s and salinities in the vicinity of 600–1500 mg/L.
	Nlk	Kadlunga Slate	Slate; grey, sericitic, graphitic.		

Age (y)	**Stratigraphic Unit**	**Stratigraphic name**	**Stratigraphic description**	**Aquifer**	**Comments**
Torrensian 700–780 million years	Nds	Saddleworth Formation	Mudstone; siltstone; shale, partly carbonaceous. Contains Auburn Dolomite and Watervale Sandstone Members		Generally a unit of low permeability. Yields of ~0.2–2 L/s; variable salinity of <500–3500 mg/L. Groundwater is used extensively for irrigation.
	Ndu	Undalya Quartzite	Quartzite; white to cream, medium- grained, well bedded, feldspathic; interbeds of sandy, carbonaceous and pyritic shale.		Groundwater prospects are generally good. Poor to nil visual porosity due to quartz over growths. Main source of groundwater remains within the fractures and joints. Salinities of up to 2000 mg/L.
	Ndw	Woolshed Flat Shale	Shale; black; dolomitic siltstone; dolomite; grey laminated siltstone.		
	Nms	Skillogalee Dolomite	Dolomite; marble, with magnesite mud-pellet conglomerates. Contains minor sandstone member.		Salinity of ~1100 mg/L or less with yields averaging 5 L/s.
	Nob	Bungaree Quartzite	Sandstone; fine- to coarse-grained, feldspathic, quartzitic, to arkosic, ripple marks, cross-bedding, lenticular, minor pale-grey to greenish siltstone, minor pale-grey dolomite.		
	Nov	River Wakefield Formation	Dolomite; sandstone; siltstone; quartzite.		
	Noq	Blyth Dolomite	Sandstone; siltstone, grey; dolomite marble, grey and cream; dolomite, grey, flaggy, medium-bedded, fine-grained to coarsely crystalline; minor grey to black chert.		
	Nor	Rhynie Sandstone	Sandstone; coarse-grained, feldspathic, conglomeratic. Contains Anama Siltstone and Jarrold Basalt Members.		Salinity ranges from 1000–2200 mg/L. Yields are ~1.0 L/s. Groundwater is held interstitially and in a network of joints and fractures. Nature of the fractures is unknown.

4. MONITORING NETWORK

Groundwater monitoring of the Clare Valley began in 1987. Currently there is a total of 198 observation wells; of which 173 wells monitor standing water level (SWL), and 73 monitor salinity (Figs 3–4, respectively). Table 2 details the number of wells monitoring the Quaternary and Fractured Rock Aquifers.

Table 2. Current observation wells in the Clare PWRA

Aquifer	Monitor water level	Monitor salinity
Fractured Rock	140	56
Quaternary	13	8
No assigned aquifer	20	9
Total	**173**	**73**

Large proportions of these wells are monitored on a quarterly basis to enable the assessment of the long-term and short-term health of the groundwater resource. Groundwater bores monitored include: privately owned irrigation and stock bores (90%); along with newly constructed DWLBC bores (10%).

Of the 198 observation bores ~18% are used for irrigation, while the remainder are either domestic, stock, observation, or industrial wells.

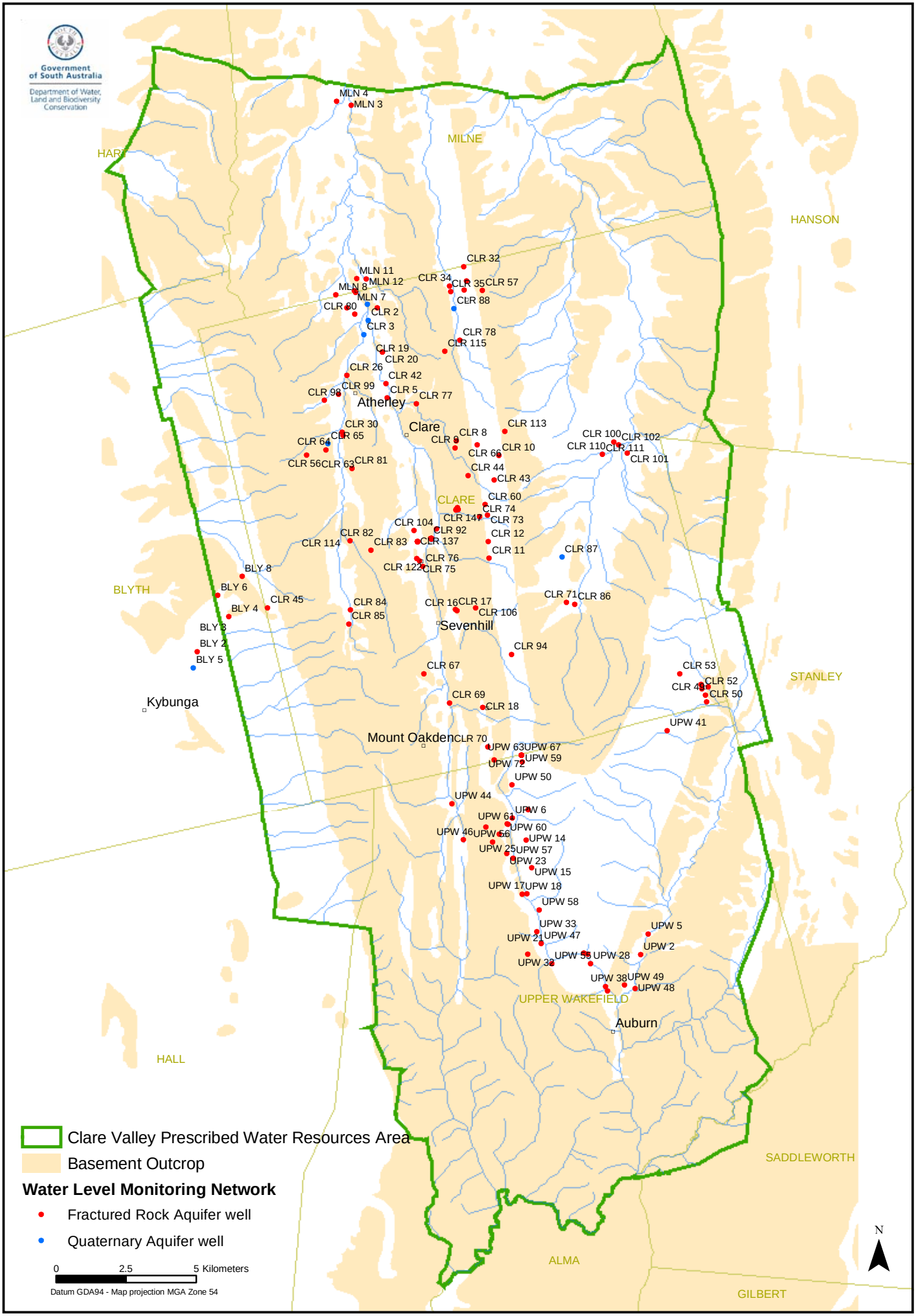

Figure 3. Water level monitoring network

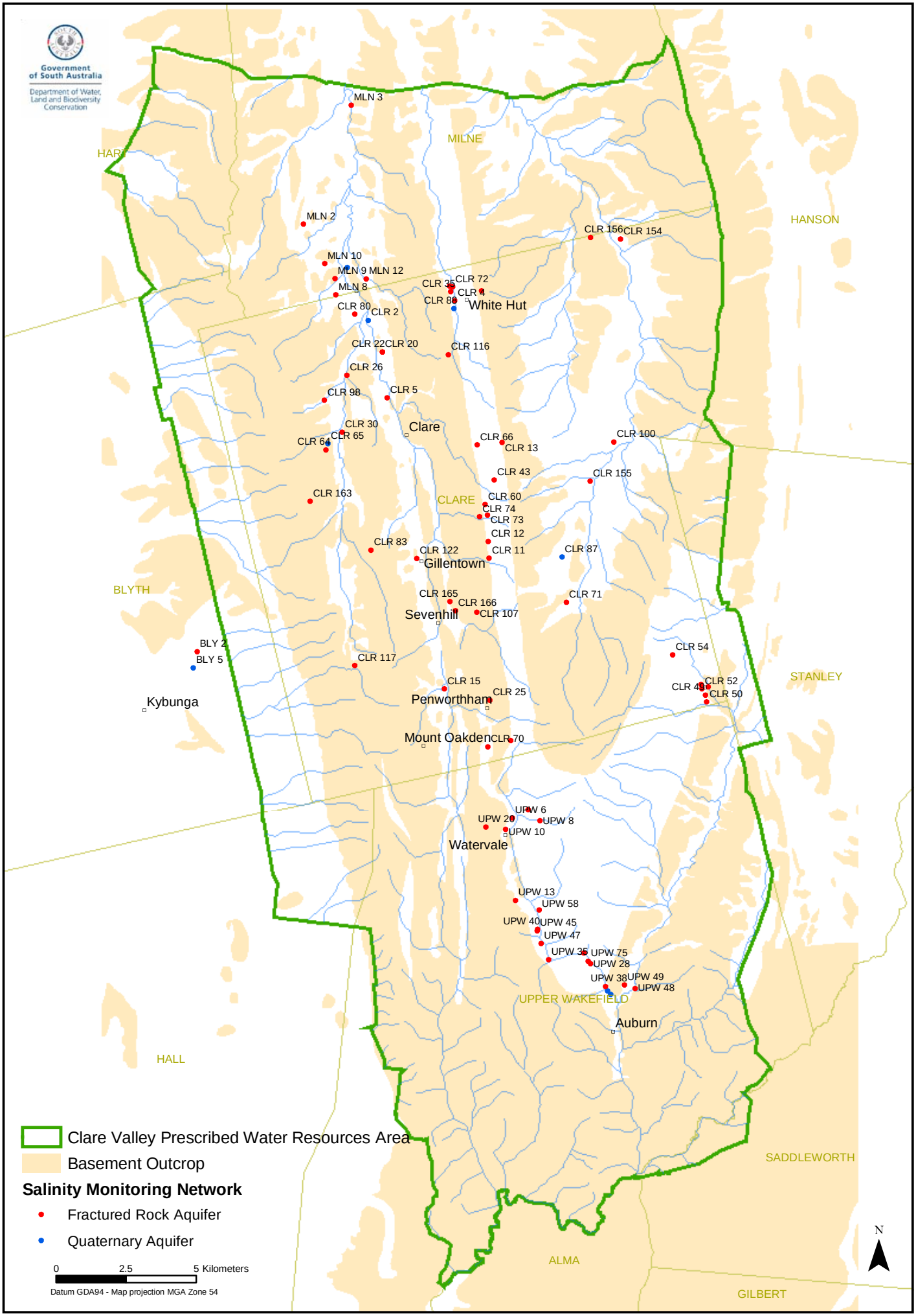

Figure 4. Salinity monitoring network

5. WATER LEVEL ANALYSIS

5.1 FRACTURED ROCK AQUIFER

Potentiometric surface maps were calculated utilising the February 2005 watertable depth data, collected from the observation well network (Fig. 3). The elevation of each observation well reference point, relative to sea level, minus the measured depth to water equals the reduced standing water level (RSWL) as shown in Figure 5. The potentiometric surface map is calculated from this data. The calculated potentiometric surface suggests that the lateral hydraulic gradients may vary from ~10% on the steep ridge slopes to much flatter gradients of 0.5% in the valley floors.

Groundwater flow in the Clare Valley appears to follow a subdued form of the topography, with groundwater flowing in approximately the same direction as surface water (Love et al., 2001). The fractured rock potentiometric surface indicates an east–west groundwater divide, which exists to the north of Penworthham. Groundwater north of this line flows primarily to the north, and south of the divide, flow is generally to the south. Due to the highly anisotropic nature of the geological medium, detailed flow orientations cannot be constructed. The anisotropic nature refers to the fractures, which have a preferred orientation, meaning that the groundwater flow will often be in a different direction to the calculated potential hydraulic gradient (Schreiber et al., 1999).

The average annual groundwater level trends for the previous five years were determined and plotted from data obtained by observation wells. Trends were determined by calculating the average rate of change in water levels from January 2000 to February 2005 (Fig. 6). A disadvantage of this process is that it could fail to detect trends that are non-linear, such as in the hydrographs shown in Figures 7a–b where the water levels fluctuate with large seasonal variations. Results of the trend analysis for each observation well were plotted throughout the region to assess the regional distribution of water level trends. Trends shown in Figure 6 were contoured to separate the regions of increasing and decreasing water levels.

Groundwater trends in the PWRA generally vary between –0.99 m/y and 0.61 m/y. On average, groundwater levels are moderately decreasing throughout the northwest corner of the Clare PWRA, throughout the central area between Clare and Gillentown, and throughout all areas south of Watervale. Groundwater level trends are generally increasing around Mintaro and White Hut.

An observation well just south of Mount Oakden (UPW 52) indicates a concerning decreasing water level trend of -1.32 m/y. However, this appears to be localised and doesn't necessarily reflect the general water level trend in these areas, with surrounding wells indicating a rising trend in water level.

Examination of hydrographs for the previous 20 years does not indicate any particular area is more inclined to variations of water levels. Apart from Wells UPW 52 and CLR 60 (Fig. 7a), very few hydrographs exhibit any long-term declines in water levels. Various other wells indicate long term increases in water levels, for example CLR 57 and CLR 133 (Fig. 7b).

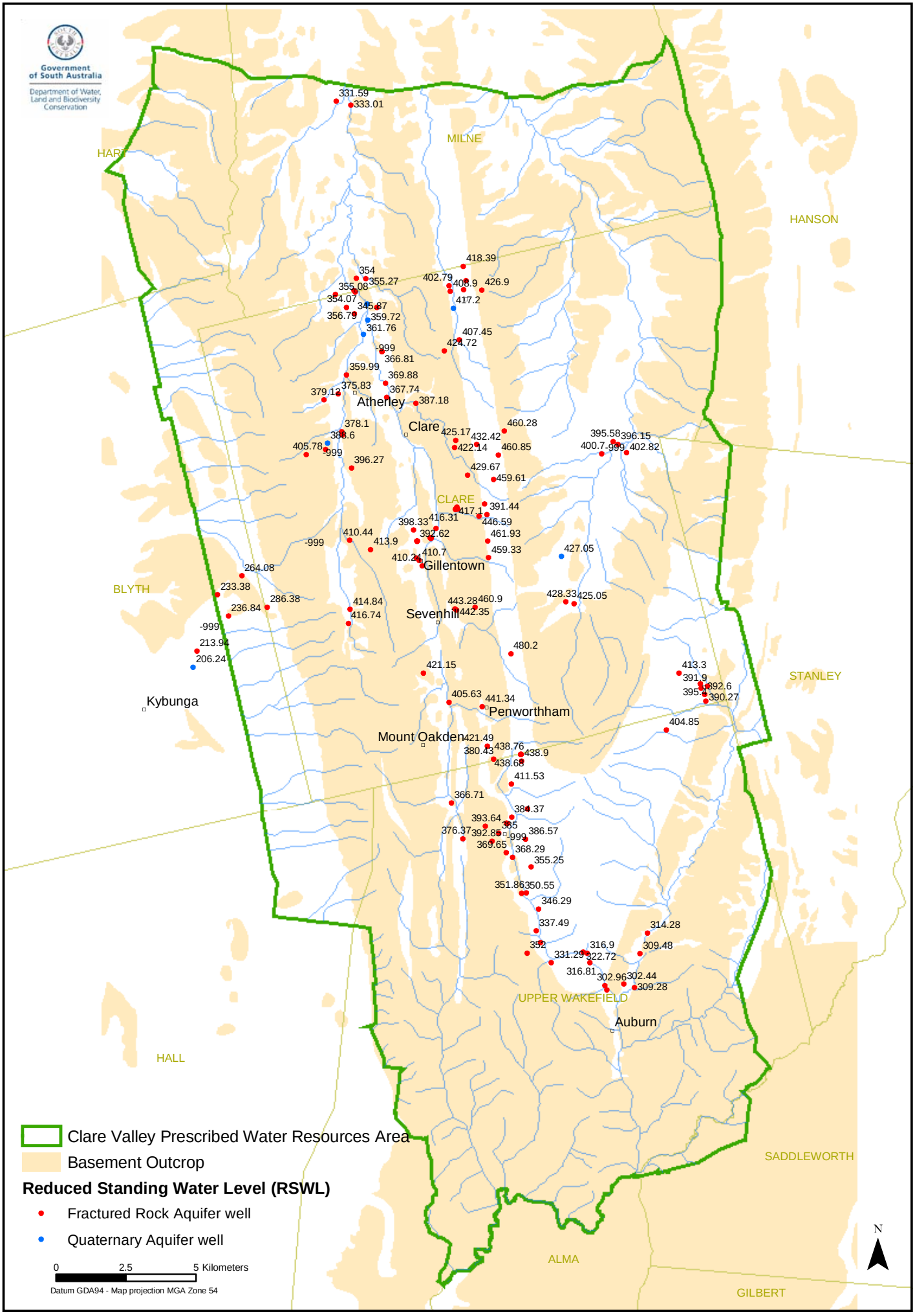

Figure 5. Potentiometric surface, February 2005

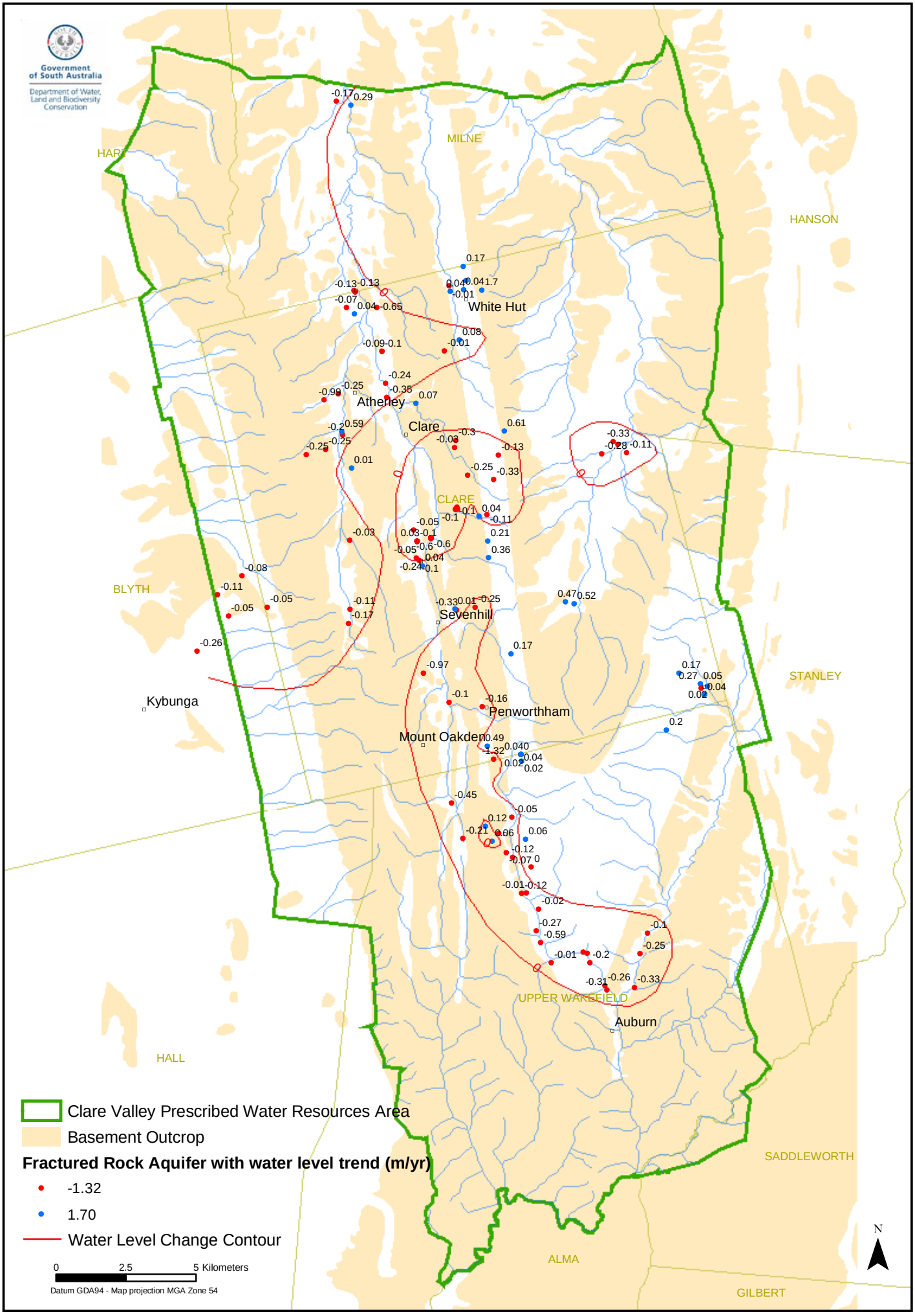

Figure 6. Fractured Rock Aquifer water level trend, 2000–05

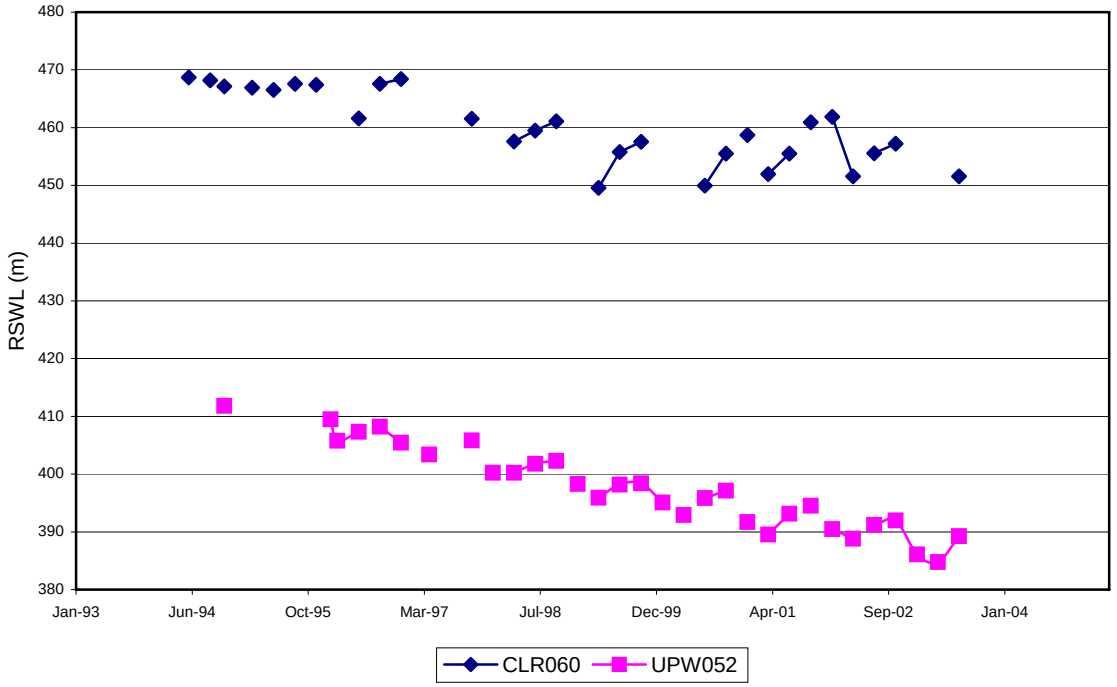

Figure 7a. Fractured Rock Aquifer hydrographs for wells with decreasing water levels

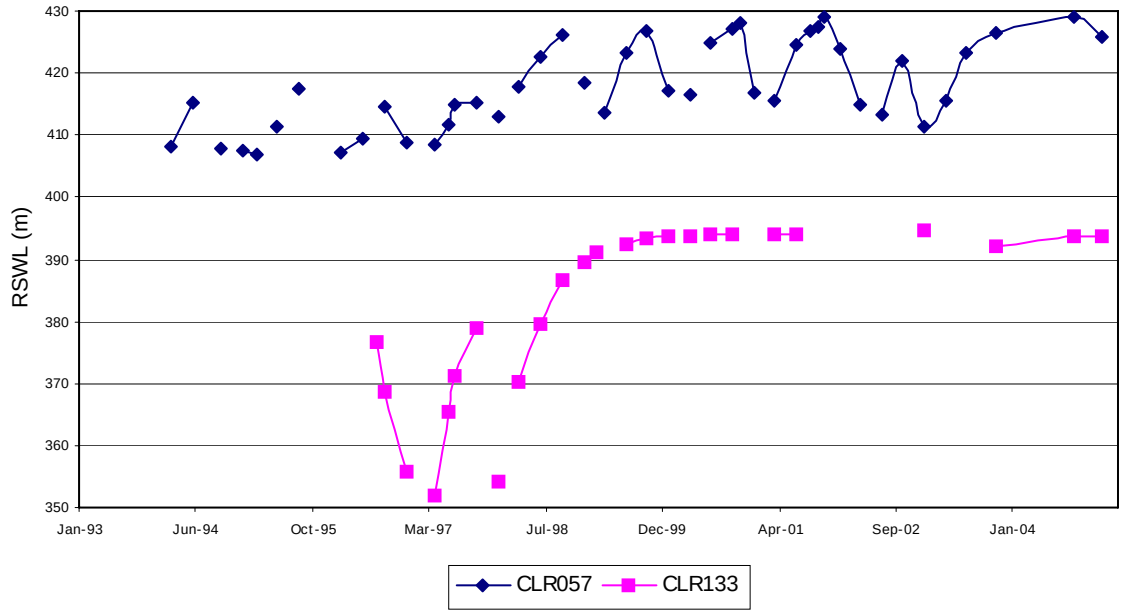

Figure 7b. Fractured Rock Aquifer hydrographs for wells with increasing water levels

5.2 QUATERNARY AQUIFER

Quaternary Aquifers exist as an isolated resource in the Clare Valley. Due to the presence of only five current wells located in this aquifer, a separate potentiometric surface of the Quaternary Aquifer was not constructed. Water levels in the Quaternary Aquifer range between 206.24 m AHD and 427.05 m AHD. Long-term (1984–2005) water levels in this aquifer are generally quite stable with no drastic changes in water levels identified (Fig. 8).

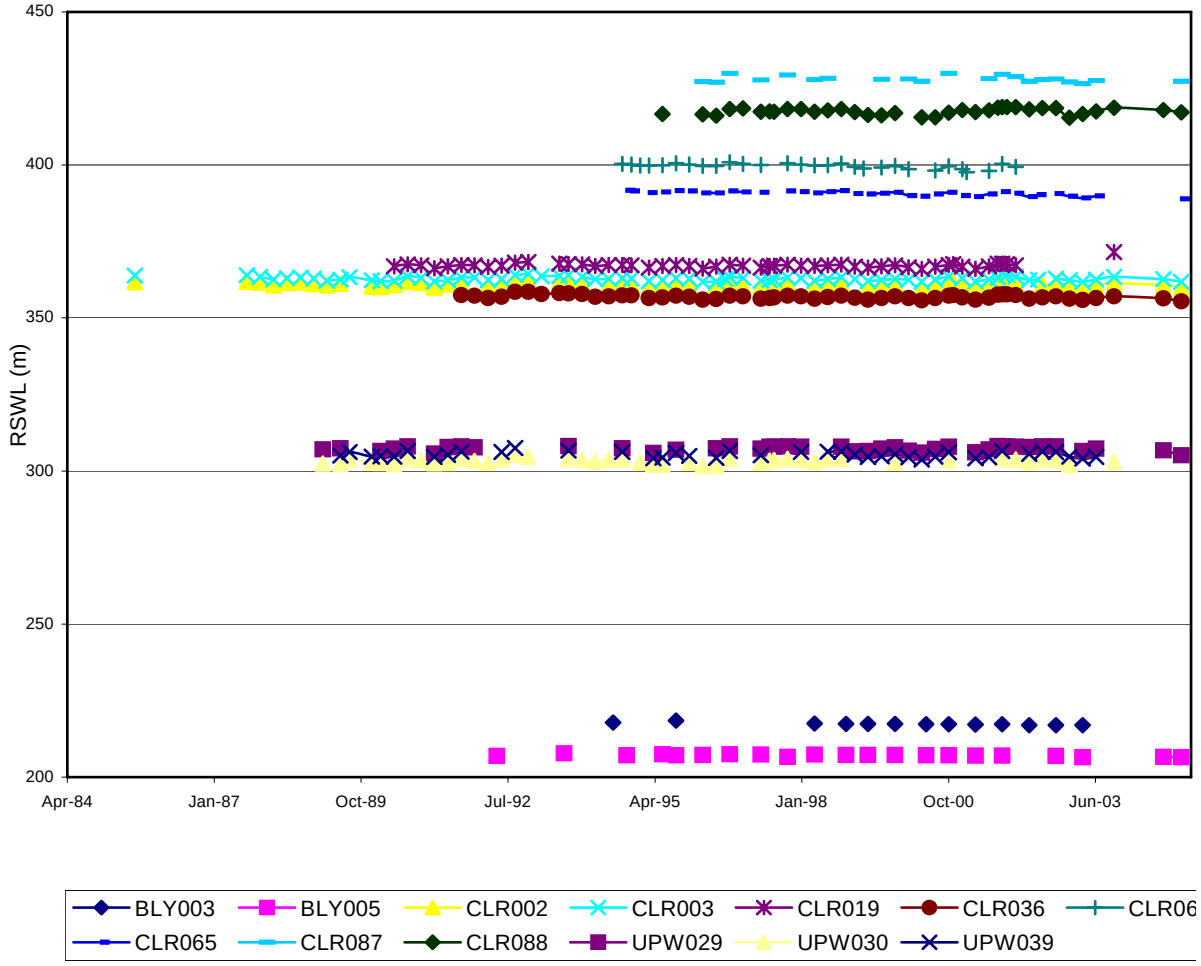

Figure 8. Quaternary Aquifer hydrographs 1984–2005

6. SALINITY

Data from the observation wells network was used to construct a groundwater salinity map for the Quaternary and Fractured Rock Aquifers. Figure 9 demonstrates the large spatial variation in water quality within the Fractured Rock Aquifer. Groundwater salinity varies from less than 500 mg/L to greater than 3000 mg/L. In areas of dense well development such as Watervale and Mintaro, groundwater salinity can vary considerably between adjacent bores. The best quality groundwater is associated with higher rainfall, higher topography and generally the Mintaro Shale Formation between Clare and Gillentown (<500–1000 mg/L). Groundwater salinity generally increases away from this central band, where salinity exceeds 1000 mg/L.

Average annual salinity trends over the previous four years were determined and plotted from observation wells, which monitor the fractured rock aquifers. Trends in Figure 10 were contoured to separate regions of increasing and decreasing salinity. Average annual salinity is decreasing in the southwestern corner of the PWRA (-1 to -69 mg/L/y), and within the region of White Hut, Stanley Flat and Atherley (-7 to -34 mg/L/y). On average salinity is increasing near Mintaro (13–209 mg/L/y) and throughout a north-south central band from Clare to Watervale (2–62 mg/L/y). Salinity trends in the PWRA are highly variable as can be seen at Mintaro, where the highest salinity increase (209 mg/L/y) and the highest decrease (-297 mg/L/y) are within 300 m of one another.

Many wells within the Clare region exhibit an increase in salinity with increasing depth below the watertable. During periods of low rainfall, when pumping for groundwater is at its maximum, a proportion of the pumped water is sourced from deeper within the aquifer where salinity is generally higher (Love et al., 2001). This is evident, when comparing Fractured Rock water level and salinity trends (Figs 6 and 10). It can be seen that in areas of declining water level, such as the region between Clare and Gillentown, salinity trends increase, and in areas of increasing water level, such as White Hut, salinity is decreasing. Figures 11a and 11b demonstrate the inverse relationship between groundwater salinity and watertable elevation as observed at well CLR 12.

At the time of sampling, it is often unknown if a well has been pumped recently, and if the watertable has recovered. Therefore, samples may be sourced at different stressed periods within the aquifer, and consequently produce a broad representation of salinity trends for that aquifer.

Water quality throughout the Quaternary Aquifer is generally good, with salinity in the range of 500–1500 mg/L.

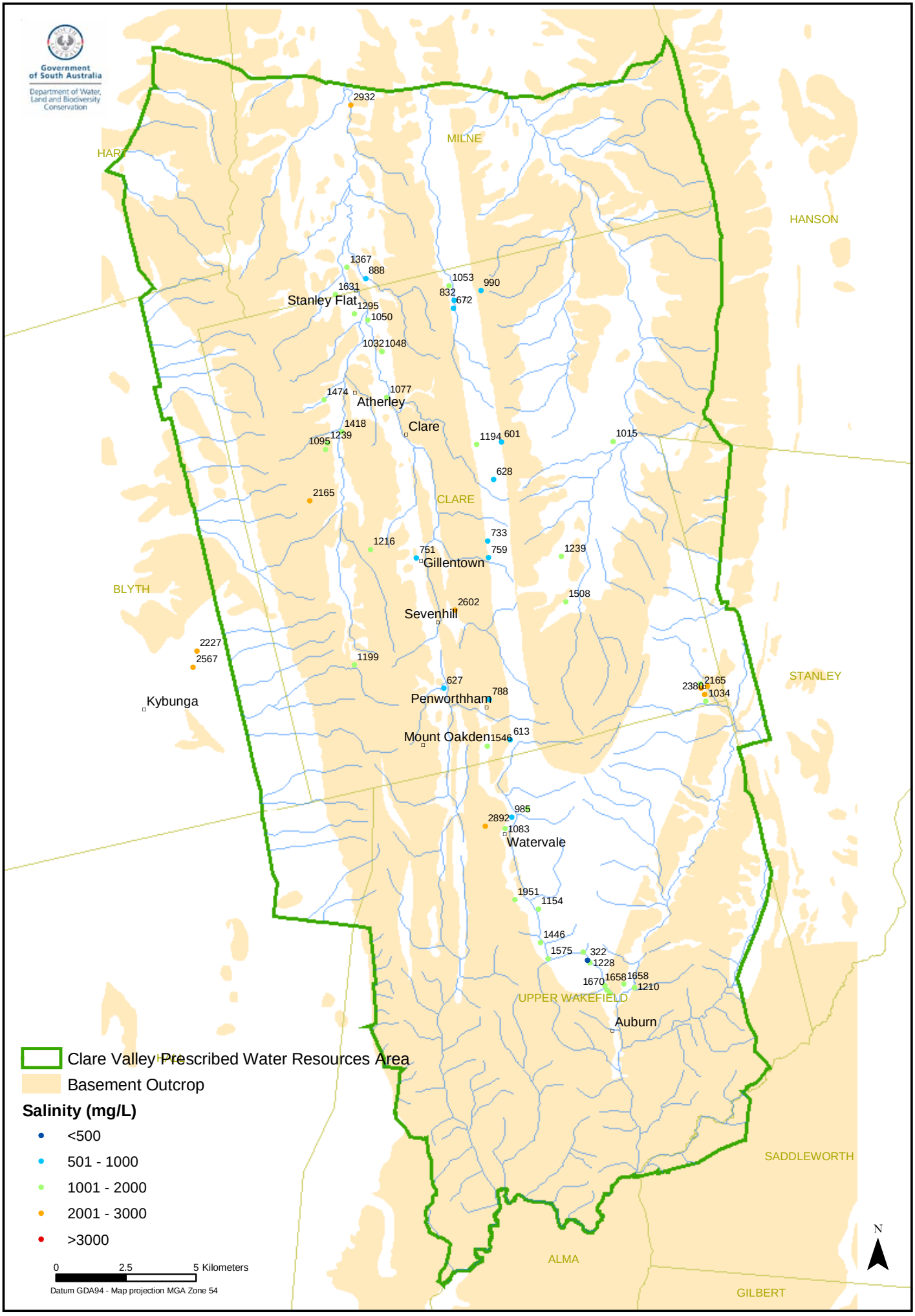

Figure 9. Salinity map, April–July 2003

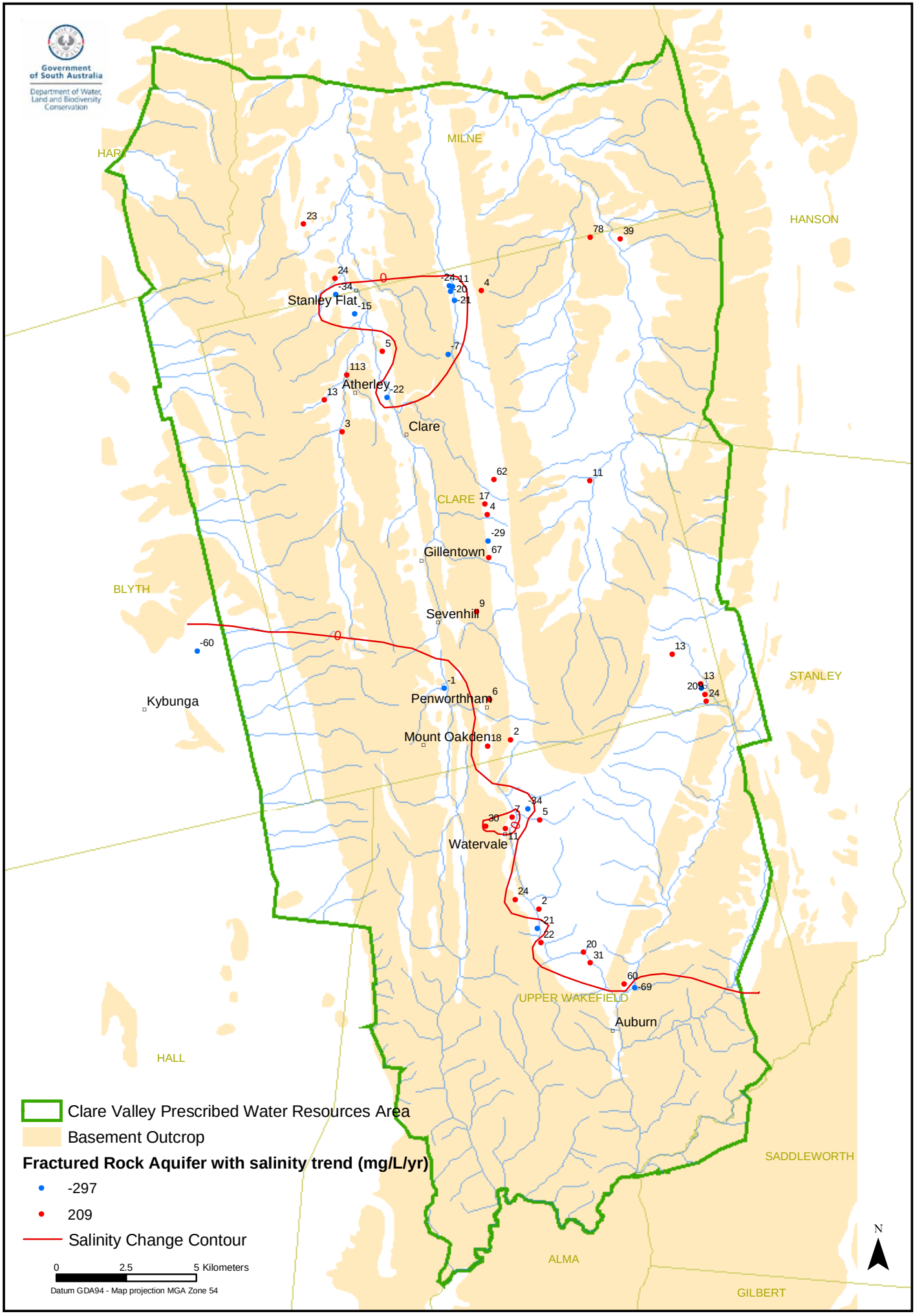

Figure 10. Fractured Rock Aquifer salinity trend, 1999–2003

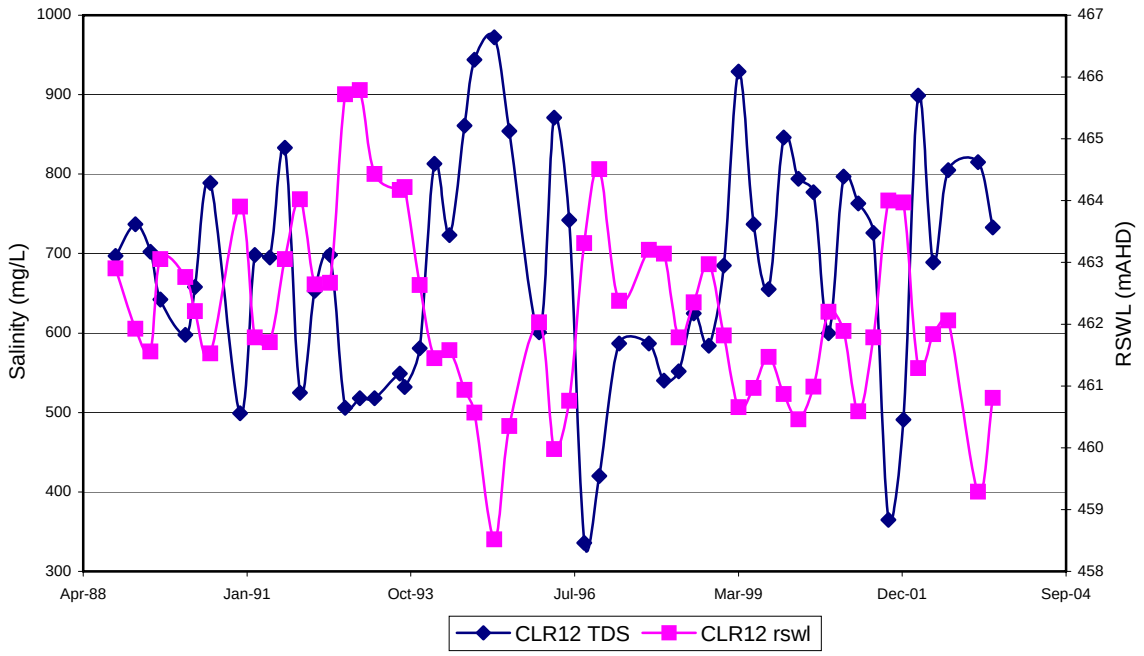

Figure 11a. Inverse relationship between RSWL and salinity as observed at well CLR 12

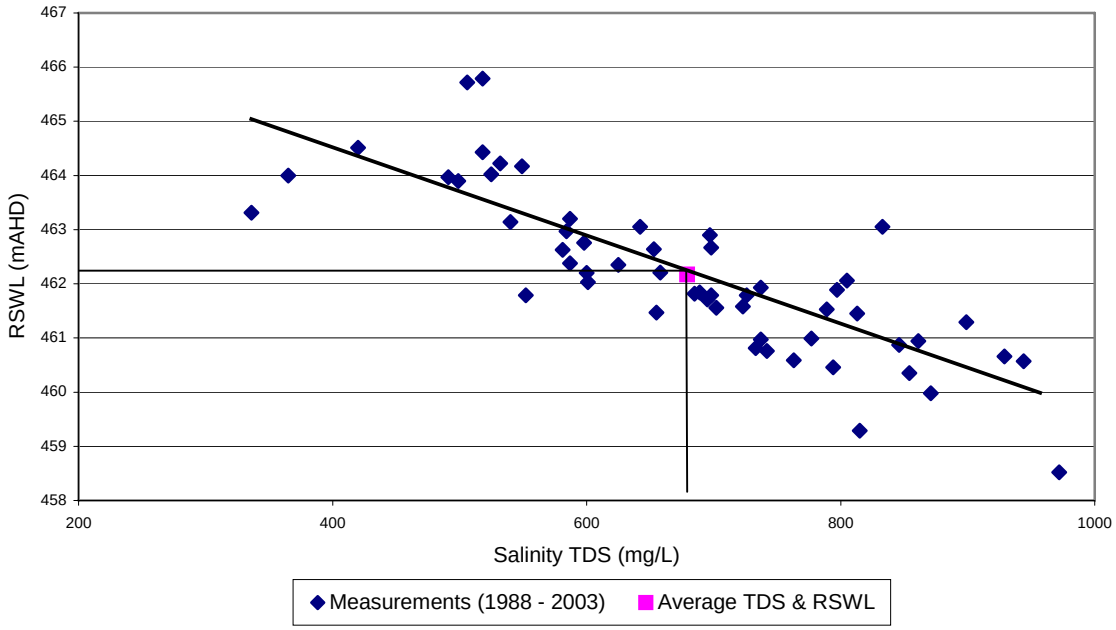

Figure 11b. Salinity and water table variations in observation well CLR 12

7. SUMMARY

There are two main monitored aquifer systems that underlie the Clare PWRA. The upper aquifer is the Quaternary Aquifer, which overlays the Fractured Rock Aquifer.

Within the Fractured Rock Aquifer, groundwater flow appears to follow a subdued form of the topography. An east–west groundwater divide exists north of Penworthham, north of the divide flow is predominantly towards the north and south of the divide it is towards the south. Water level trends over the previous five years are regarded as moderate and no areas were identified as stressed.

The best quality groundwater is associated with areas of high rainfall and high topography, between the areas between Clare and Gillentown (500–1000 mg/L), with salinity generally exceeding 1000 mg/L in surrounding areas. Salinity trends over the last four years indicate that the region between White Hut, Clare and Stanley Flat, and areas near Watervale have decreasing trends, while Gillentown and Mintaro show increasing trends.

Fractured Rock Aquifer groundwater level trends and salinity trends are related. Areas that show a decreasing trend in water level indicate an increasing trend in salinity. Other factors which influence trends are rainfall distribution and pumping intensity.

Water levels in the Quaternary Aquifer range between 206.24 m AHD and 427.05 m AHD. Long-term (1984–2005) water levels in this aquifer are generally quite stable with no drastic changes in water levels identified. Water quality throughout the Quaternary Aquifers is generally good, with salinity in the range of 500–1500 mg/L.

UNITS OF MEASUREMENT

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

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	μg	10^{-6} g	mass
microlitre	μL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	365 or 366 days	time interval

~	approximately equal to
δD	hydrogen isotope composition
$\delta^{18}O$	oxygen isotope composition
^{14}C	carbon-14 isotope (percent modern carbon)
CFC	chlorofluorocarbon (parts per trillion volume)
EC	electrical conductivity (μS/cm)
pH	acidity
ppm	parts per million
ppb	parts per billion
TDS	total dissolved solids (mg/L)

GLOSSARY

Act (the). In this document, refers to The *Natural Resources Management Act* (South Australia) 2004.

Adaptive management. A management approach, often used in natural resource management, where there is little information and/or a lot of complexity and there is a need to implement some management changes sooner rather than later. The approach is to use the best available information for the first actions, implement the changes, monitor the outcomes, investigate the assumptions and regularly evaluate and review the actions required. Consideration must be given to the temporal and spatial scale of monitoring and the evaluation processes appropriate to the ecosystem being managed.

AHD. Australian Height Datum - the datum used for the determination of elevations in Australia. The determination used a national network of benchmarks and tide gauges, and set mean sea level as zero elevation.

Algal bloom. A rapid accumulation of algal biomass (living organic matter) which can result in deterioration in water quality when the algae die and break down, consuming the dissolved oxygen and releasing toxins.

Ambient. The background level of an environmental parameter (e.g. a background water quality like salinity).

Anabranch. A branch of a river that leaves the main stream.

Annual adjusted catchment yield. Annual catchment yield with the impact of dams removed.

Aquifer. An underground layer of rock or sediment which holds water and allows water to percolate through.

Aquifer, confined. Aquifer in which the upper surface is impervious and the water is held at greater than atmospheric pressure. Water in a penetrating well will rise above the surface of the aquifer.

Aquifer, storage and recovery (ASR). The process of recharging water into an aquifer for the purpose of storage and subsequent withdrawal.

Aquifer test. A hydrological test performed on a well, aimed to increase the understanding of the aquifer properties, including any interference between wells, and to more accurately estimate the sustainable use of the water resource available for development from the well.

Aquifer, unconfined. Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure.

Aquitard. A layer in the geological profile that separates two aquifers and restricts the flow between them.

Arid lands. In South Australia arid lands are usually considered to be areas with an average rainfall of less than 250 mm and support pastoral activities instead of broad acre cropping.

Artesian. Under pressure such that when wells penetrate the aquifer water will rise to the ground surface without the need for pumping.

Artificial recharge. The process of artificially diverting water from the surface to an aquifer. Artificial recharge can reduce evaporation losses and increase aquifer yield. *(See recharge, natural recharge, aquifer.)*

Barrage. Specifically any of the five low weirs at the mouth of the River Murray constructed to exclude seawater from the Lower Lakes.

Baseflow. The water in a stream that results from groundwater discharge to the stream. (This discharge often maintains flows during seasonal dry periods and has important ecological functions.)

Basin. The area drained by a major river and its tributaries.

Benchmark condition. Points of reference from which change can be measured.

Biological diversity (biodiversity). The variety of life forms: the different life forms including plants, animals and micro-organisms, the genes they contain and the *ecosystems (see below)* they form. It is usually considered at three levels — genetic diversity, species diversity and ecosystem diversity.

Biota. All of the organisms at a particular locality.

Bore. *See well.*

Buffer zone. A neutral area that separates and minimises interactions between zones whose management objectives are significantly different or in conflict (e.g. a vegetated riparian zone can act as a buffer to protect the water quality and streams from adjacent land uses).

Catchment. A catchment is that area of land determined by topographic features within which rainfall will contribute to runoff at a particular point.

Catchment water management board. A statutory body established under Part 6, Division 3, s. 53 of the Act whose prime function under Division 2, s. 61 is to implement a catchment water management plan for its area.

Catchment water management plan. The plan prepared by a CWMB and adopted by the Minister in accordance with Part 7, Division 2 of the Water Resources Act 1997.

Codes of practice. Standards of management developed by industry and government, promoting techniques or methods of environmental management by which environmental objectives may be achieved.

Cone of depression. An inverted cone-shaped space within an aquifer caused by a rate of groundwater extraction which exceeds the rate of recharge. Continuing extraction of water can extend the area and may affect the viability of adjacent wells, due to declining water levels or water quality.

Conjunctive use. The utilisation of more than one source of water to satisfy a single demand.

Council of Australian Governments (COAG). A council of the Prime Minister, State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association which exists to set national policy directions for Australia.

CWMB. Catchment Water Management Board.

Dams, off-stream dam. A dam, wall or other structure that is not constructed across a watercourse or drainage path and is designed to hold water diverted, or pumped, from a watercourse, a drainage path, an aquifer or from another source. Off-stream dams may capture a limited volume of surface water from the catchment above the dam.

Dams, on-stream dam. A dam, wall or other structure placed or constructed on, in or across a watercourse or drainage path for the purpose of holding and storing the natural flow of that watercourse or the surface water.

Dams, turkey nest dam. An off-stream dam that does not capture any surface water from the catchment above the dam.

Diffuse source pollution. Pollution from sources such as an eroding paddock, urban or suburban lands and forests; spread out, and often not easily identified or managed.

District Plan. (District Soil Conservation Plan) An approved soil conservation plan under the repealed *Soil Conservation Act 1989*. These plans are taken to form part of the relevant regional NRM plans under the transitional provisions of the *Natural Resources Management Act 2004* (Schedule 4 – subclause 53[4] until regional NRM plans are prepared under Chapter 4, Part 2 of the Act.

Domestic purpose. The taking of water for ordinary household purposes and includes the watering of land in conjunction with a dwelling not exceeding 0.4 hectares.

Domestic wastewater. Water used in the disposal of human waste, for personal washing, washing clothes or dishes, and swimming pools.

DSS (decision support system). A system of logic or a set of rules derived from experts, to assist decision making. Typically they are constructed as computer programs.

DSS. Dissolved suspended solids.

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

EC. Abbreviation for electrical conductivity. 1 EC unit = 1 micro-Siemen per centimetre (µS/cm) measured at 25 degrees Celsius. Commonly used to indicate the salinity of water.

Ecological processes. All biological, physical or chemical processes that maintain an ecosystem.

Ecological values. The habitats, the natural ecological processes and the biodiversity of ecosystems.

Ecologically sustainable development (ESD). Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.

Ecology. The study of the relationships between living organisms and their environment.

Ecosystem. Any system in which there is an interdependence upon and interaction between living organisms and their immediate physical, chemical and biological environment.

Ecosystem Services. All biological, physical or chemical processes that maintain ecosystems and biodiversity and provide inputs and waste treatment services that support human activities.

Effluent. Domestic wastewater and industrial wastewater.

EIP. Environment improvement program.

EMLR. Eastern Mount Lofty Ranges.

Entitlement flows. Minimum monthly River Murray flows to South Australia agreed in the Murray-Darling Basin Agreement 1992.

Environmental values. The uses of the environment that are recognised as of value to the community. This concept is used in setting water quality objectives under the Environment Protection (Water Quality) Policy, which recognises five environmental values — protection of aquatic ecosystems, recreational water use and aesthetics, potable (drinking water) use, agricultural and aquaculture use, and industrial use. It is not the same as ecological values, which are about the elements and functions of ecosystems.

Environmental water provisions. Those parts of environmental water requirements that can be met, at any given time. This is what can be provided at that time with consideration of existing users' rights, social and economic impacts.

Environmental water requirements. The water regimes needed to sustain the ecological values of aquatic ecosystems, including their processes and biological diversity, at a low level of risk.

EP. Eyre Peninsula.

EPA. Environment Protection Agency.

Ephemeral streams/wetlands. Those streams or wetlands that usually contain water only on an occasional basis after rainfall events. Many arid zone streams and wetlands are ephemeral.

Erosion. Natural breakdown and movement of soil and rock by water, wind or ice. The process may be accelerated by human activities.

ESD. Ecologically sustainable development *(see above for definition)*.

Estuaries. Semi-enclosed waterbodies at the lower end of a freshwater stream that are subject to marine, freshwater and terrestrial influences and experience periodic fluctuations and gradients in salinity.

Eutrophication. Degradation of water quality due to enrichment by nutrients (primarily nitrogen and phosphorus), causing excessive plant growth and decay. *(See algal bloom).*

Evapotranspiration. The total loss of water as a result of transpiration from plants and evaporation from land, and surface waterbodies.

Fishway. A generic term describing all mechanisms that allow the passage of fish along a waterway. Specific structures include fish ladders (gentle sloping channels with baffles that reduce the velocity of water and provide resting places for fish as they 'climb' over a weir) and fishlifts (chambers, rather like lift-wells, that are flooded and emptied to enable fish to move across a barrier).

Floodplain. Of a watercourse means: (a) the floodplain (if any) of the watercourse identified in a catchment water management plan or a local water management plan; adopted under Part 7 of the Water Resources Act 1997; or (b) where paragraph (a) does not apply — the floodplain (if any) of the watercourse identified in a development plan under the Development Act 1993, or (c) where neither paragraph (a) nor paragraph (b) applies — the land adjoining the watercourse that is periodically subject to flooding from the watercourse.

Flow bands. Flows of different frequency, volume and duration.

GAB. Great Artesian Basin.

Gigalitre (GL). One thousand million litres (1 000 000 000).

GIS (geographic information system). Computer software allows for the linking of geographic data (for example land parcels) to textual data (soil type, land value, ownership). It allows for a range of features, from simple map production to complex data analysis.

GL. *See gigalitre.*

Greenhouse effect. The balance of incoming and outgoing solar radiation which regulates our climate. Changes to the composition of the atmosphere such as the addition of carbon dioxide through human activities, have the potential to alter the radiation balance and to effect changes to the climate. Scientists suggest that changes would include global warming, a rise in sea level and shifts in rainfall patterns.

Geological features. Include geological monuments, landscape amenity and the substrate of land systems and ecosystems.

Greywater. Household wastewater excluding sewage effluent. Wastewater from kitchen, laundry and bathroom.

Groundwater. *See underground water.*

Habitat. The natural place or type of site in which an animal or plant, or communities of plants and animals, lives.

Heavy metal. Any metal with a high atomic weight (usually, although not exclusively, greater than 100), for example mercury, lead and chromium. Heavy metals have a widespread industrial use, and many are released into the biosphere via air, water and solids pollution. Usually these metals are toxic at low concentrations to most plant and animal life.

Hydrogeology. The study of groundwater, which includes its occurrence, recharge and discharge processes and the properties of aquifers. *(See hydrology.)*

Hydrography. The discipline related to the measurement and recording of parameters associated with the hydrological cycle, both historic and real time.

Hydrology. The study of the characteristics, occurrence, movement and utilisation of water on and below the earth's surface and within its atmosphere. *(See hydrogeology.)*

Hyporheic zone. The wetted zone among sediments below and alongside rivers. It is a refuge for some aquatic fauna.

Indigenous species. A species that occurs naturally in a region.

Industrial wastewater. Water (not being domestic wastewater) that has been used in the course of carrying on a business (including water used in the watering of irrigation of plants) that has been allowed to run to waste or has been disposed of or has been collected for disposal.

Infrastructure. Artificial lakes; or dams or reservoirs; or embankments, walls, channels or other works; or buildings or structures; or pipes, machinery or other equipment.

Integrated catchment management. Natural resources management that considers, in an integrated manner, the total long-term effect of land and water management practices on a catchment basis, from production and environmental viewpoints.

Intensive farming. A method of keeping animals, in the course of carrying on the business of primary production, in which the animals are confined to a small space or area and are usually fed by hand or by mechanical means.

Irrigation. Watering land by any means for the purpose of growing plants.

Irrigation season. The period in which major irrigation diversions occur, usually starting in August–September and ending in April–May.

Lake. A natural lake, pond, lagoon, wetland or spring (whether modified or not) and includes: part of a lake; and a body of water declared by regulation to be a lake; a reference to a lake is a reference to either the bed, banks and shores of the lake or the water for the time being held by the bed, banks and shores of the lake, or both, depending on the context.

Land. Whether under water or not and includes an interest in land and any building or structure fixed to the land.

Land capability. The ability of the land to accept a type and intensity of use without sustaining long-term damage.

Leaching. Removal of material in solution such as minerals, nutrients and salts through soil.

Licence. A licence to take water in accordance with the Water Resources Act 1997. *(See water licence.)*

Licensee. A person who holds a water licence.

Local water management plan. A plan prepared by a council and adopted by the Minister in accordance with Part 7, Division 4 of the Act.

Macro-invertebrates. Animals without backbones that are typically of a size that is visible to the naked eye. They are a major component of aquatic ecosystem biodiversity and fundamental in food webs.

mAHD. The elevation in metres, relative to the Australian Height Datum.

MDBC. Murray-Darling Basin Commission.

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

ML. *See megalitre.*

MLR. Mount Lofty Ranges.

Model. A conceptual or mathematical means of understanding elements of the real world which allows for predictions of outcomes given certain conditions. Examples include estimating storm runoff, assessing the impacts of dams or predicting ecological response to environmental change.

Mount Lofty Ranges Watershed. The area prescribed by Schedule 1 of the regulations.

Natural recharge. The infiltration of water into an aquifer from the surface (rainfall, streamflow, irrigation etc.) *(See recharge area, artificial recharge.)*

NHMRC. National Health and Medical Research Council.

NHT. Natural Heritage Trust.

Natural Resources. Soil; water resources; geological features and landscapes; native vegetation, native animals and other native organisms; ecosystems.

Natural Resources Management (NRM). All activities that involve the use or development of natural resources and/or that impact on the state and condition of natural resources, whether positively or negatively.

Obswell. Observation Well Network. The Obswell facility provides on-line access to South Australia's observation bore monitoring data (https://info.pir.sa.gov.au/obswell/sys/aboutObswell.html).

Occupier of land. A person who has, or is entitled to, possession or control of the land.

Owner of land. In relation to land alienated from the Crown by grant in fee simple — the holder of the fee simple; in relation to dedicated land within the meaning of the *Crown Lands Act 1929* that has not been granted in fee simple but which is under the care, control and management of a Minister, body or other person — the Minister, body or other person; in relation to land held under Crown lease or licence — the lessee or licensee; in relation to land held under an agreement to purchase from the Crown — the person entitled to the benefit of the agreement; in relation to any other land — the

Minister who is responsible for the care, control and management of the land or, if no Minister is responsible for the land, the Minister for Environment and Heritage.

Palaeochannels. Ancient buried river channels in arid areas of the state. Aquifers in palaeochannels can yield useful quantities of groundwater or be suitable for ASR.

Pasture. Grassland used for the production of grazing animals such as sheep and cattle.

Percentile. A way of describing sets of data by ranking the data set and establishing the value for each percentage of the total number of data records. The 90th percentile of the distribution is the value such that 90% of the observations fall at or below it.

Permeability. A measure of the ease with which water flows through an aquifer or aquitard.

Personal property. All forms of property other than real property. For example, shares or a water licence.

Phreaphytic vegetation. Vegetation that exists in a climate more arid than its normal range by virtue of its access to groundwater.

Phytoplankton. The plant constituent of organisms inhabiting the surface layer of a lake; mainly single-cell algae.

PIRSA. (Department of) Primary Industries and Resources South Australia.

Pollution, diffuse source. Pollution from sources that are spread out and not easily identified or managed (e.g. an eroding paddock, urban or suburban lands and forests).

Pollution, point source. A localised source of pollution.

Potable water. Water suitable for human consumption.

Potentiometric head. The potentiometric head or surface is the level to which water rises in a well due to water pressure in the aquifer.

Precautionary principle. Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

Prescribed area, surface water. Part of the State declared to be a surface water prescribed area under the Water Resources Act 1997.

Prescribed lake. A lake declared to be a prescribed lake under the Water Resources Act 1997.

Prescribed water resource. A water resource declared by the Minister to be prescribed under the Act, and includes underground water to which access is obtained by prescribed wells. Prescription of a water resource requires that future management of the resource be regulated via a licensing system.

Prescribed watercourse. A watercourse declared to be a prescribed watercourse under the Water Resources Act 1997.

Prescribed well. A well declared to be a prescribed well under the Water Resources Act 1997.

Property right. A right of ownership or some other right to property, whether real property or personal property.

Proponent. The person or persons (who may be a body corporate) seeking approval to take water from prescribed water.

PWA. Prescribed Wells Area.

PWCA. Prescribed Watercourse Area.

PWRA. Prescribed Water Resources Area.

Ramsar Convention. This is an international treaty on wetlands titled The Convention on Wetlands of International Importance Especially as Waterfowl Habitat. It is administered by the International Union for Conservation of Nature and Natural Resources. It was signed in the town of Ramsar, Iran in 1971, hence its common name. The Convention includes a list of wetlands of international importance and protocols regarding the management of these wetlands. Australia became a signatory in 1974.

Recharge area. The area of land from which water from the surface (rainfall, streamflow, irrigation, etc.) infiltrates into an aquifer. *(See artificial recharge, natural recharge.)*

Reclaimed water. Treated effluent of a quality suitable for the designated purpose.

Rehabilitation (of waterbodies). Actions that improve the ecological health of a waterbody by reinstating important elements of the environment that existed prior to European settlement.

Remediation (of waterbodies). Actions that improve the ecological condition of a waterbody without necessarily reinstating elements of the environment that existed prior to European settlement.

Restoration (of waterbodies). Actions that reinstate the pre-European condition of a waterbody.

Reticulated water. Water supplied through a piped distribution system.

Riffles. Shallow stream section with fast and turbulent flow.

Riparian landholder. A person whose property abuts a watercourse or through whose property a watercourse runs.

Riparian rights. These were old common law rights of access to, and use of water. These common law rights were abolished with the enactment of the Water Resources Act 1997, which now includes similar rights under s. 7. Riparian rights are therefore now statutory rights under the Act. Where the resource is not prescribed (Water Resources Act 1997, s. 8) or subject to restrictions (Water Resources Act 1997, s. 16), riparian landholders may take any amount of water from watercourses, lakes or wells without consideration to downstream landholders, if it is to be used for stock or domestic purposes. If the capture of water from watercourses and groundwater is to be used for any other purpose then the right of downstream landholders must be protected. Landholders may take any amount of surface water for any purpose without regard to other landholders, unless the surface water is prescribed or subject to restrictions.

Riparian zone. That part of the landscape adjacent to a water body, that influences and is influenced by watercourse processes. This can include landform, hydrological or vegetation definitions. It is commonly used to include the in-stream habitats, bed, banks and sometimes floodplains of watercourses.

Seasonal watercourses or wetlands. Those watercourses and wetlands that contain water on a seasonal basis, usually over the winter/spring period, although there may be some flow or standing water at other times.

State water plan. The plan prepared by the Minister under Part 7, Division 1, s. 90 of the Act.

Stock Use. The taking of water to provide drinking water for stock other than stock subject to intensive farming (as defined by the Act).

Stormwater. Runoff in an urban area.

Surface water. (a) water flowing over land (except in a watercourse), (i) after having fallen as rain or hail or having precipitated in any another manner, (ii) or after rising to the surface naturally from underground; (b) water of the kind referred to in paragraph (a) that has been collected in a dam or reservoir.

Taxa. General term for a group identified by taxonomy — which is the science of describing, naming and classifying organisms.

To take water. From a water resource includes (a) to take water by pumping or syphoning the water; (b) to stop, impede or divert the flow of water over land (whether in a watercourse or not) for the purpose of collecting the water; (c) to divert the flow of water in a watercourse from the watercourse; (d) to release water from a lake; (e) to permit water to flow under natural pressure from a well; (f) to permit stock to drink from a watercourse, a natural or artificial lake, a dam or reservoir.

Total kjeldhal nitrogen (TKN). The sum of aqueous ammonia and organic nitrogen. Used as a measure of probable sewage pollution.

Transfer. A transfer of a licence (including its water allocation) to another person, or the whole or part of the water allocation of a licence to another licensee or the Minister under Part 5, Division 3, s. 38 of the Act. The transfer may be absolute or for a limited period.

Underground water (groundwater). Water occurring naturally below ground level or water pumped, diverted or released into a well for storage underground.

Volumetric allocation. An allocation of water expressed on a water licence as a volume (e.g. kilolitres) to be used over a specified period of time, usually per water use year (as distinct from any other sort of allocation).

Wastewater. *See domestic wastewater, industrial wastewater.*

Water affecting activities. Activities referred to in Part 4, Division 1, s. 9 of the Act.

Water allocation. (a) in respect of a water licence means the quantity of water that the licensee is entitled to take and use pursuant to the licence; (b) in respect of water taken pursuant to an authorisation under s. 11 means the maximum quantity of water that can be taken and used pursuant to the authorisation.

Water allocation, area based. An allocation of water that entitles the licensee to irrigate a specified area of land for a specified period of time usually per water use year.

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

Water licence. A licence granted under the Act entitling the holder to take water from a prescribed watercourse, lake or well or to take surface water from a surface water prescribed area. This grants the licensee a right to take an allocation of water specified on the licence, which may also include conditions on the taking and use of that water. A water licence confers a property right on the holder of the licence and this right is separate from land title.

Water plans. The State Water Plan, catchment water management plans, water allocation plans and local water management plans prepared under Part 7 of the Act.

Water service provider. A person or corporate body that supplies water for domestic, industrial or irrigation purposes or manages wastewater.

Waterbody. Waterbodies include watercourses, riparian zones, floodplains, wetlands, estuaries, lakes and groundwater aquifers.

Watercourse. A river, creek or other natural watercourse (whether modified or not) and includes: a dam or reservoir that collects water flowing in a watercourse; and a lake through which water flows; and a channel (but not a channel declared by regulation to be excluded from this definition) into which the water of a watercourse has been diverted; and part of a watercourse.

Water-dependent ecosystems. Those parts of the environment, the species composition and natural ecological processes, which are determined by the permanent or temporary presence of flowing or standing water, above or below ground. The in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains, estuaries and lakes are all water-dependent ecosystems.

Water-use year. The period between 1 July in any given calendar year and 30 June the following calendar year. This is also called a licensing year.

Well. (a) an opening in the ground excavated for the purpose of obtaining access to underground water; (b) an opening in the ground excavated for some other purpose but that gives access to underground water; (c) a natural opening in the ground that gives access to underground water.

Wetlands. Defined by the Act as a swamp or marsh and includes any land that is seasonally inundated with water. This definition encompasses a number of concepts that are more specifically described in the definition used in the Ramsar Convention on Wetlands of International Importance. This describes wetlands as areas of permanent or periodic/intermittent inundation, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres.

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