TECHNICAL REPORT

NON-PRESCRIBED GROUNDWATER RESOURCES ASSESSMENT – KANGAROO ISLAND NATURAL RESOURCES MANAGEMENT REGION

PHASE 1 – LITERATURE AND DATA REVIEW

2012/02

Government of South Australia
Department for Water

NON-PRESCRIBED GROUNDWATER RESOURCES ASSESSMENT – KANGAROO ISLAND NATURAL RESOURCES MANAGEMENT REGION

PHASE 1 – LITERATURE AND DATA REVIEW

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FOREWORD

South Australia's Department for Water leads the management of our most valuable resource—water.

Water is fundamental to our health, our way of life and our environment. It underpins growth in population and our economy—and these are critical to South Australia's future prosperity.

High quality science and monitoring of our State's natural water resources is central to the work that we do. This will ensure we have a better understanding of our surface and groundwater resources so that there is sustainable allocation of water between communities, industry and the environment.

Department for Water scientific and technical staff continue to expand their knowledge of our water resources through undertaking investigations, technical reviews and resource modelling.

Scott Ashby
CHIEF EXECUTIVE
DEPARTMENT FOR WATER

CONTENTS

CONTENTS

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

In its *Water for Good* plan, the Government of South Australia (2009) states that resources assessment, monitoring and management of non-prescribed groundwater resources are crucial and necessary elements which will assist in achieving sustainable use of the resource. The Department for Water has lead agency responsibility for ensuring the sustainable management of groundwater resources of the state of South Australia (the State) and has developed the *Groundwater Program* to fulfil responsibilities under the *Natural Resources Management Act 2004* and in response to water security issues facing the State. This report presents findings of the sub-program *Non-prescribed groundwater resources assessment – Kangaroo Island Natural Resources Management Region*.

In an environment where water resources are increasingly scarce, a better understanding of both potable and non-potable water resources capacity and a more proactive approach to management is required. *Water for Good* identifies that the State's non-prescribed water resources require monitoring and management to enhance sustainable development opportunities and avoid them being over exploited. *Water for Good* supports this through an action to expand monitoring networks and increase the regularity of assessments and reporting.

There is only limited understanding of groundwater resources in most non-prescribed regions across the State. Current knowledge gaps regarding the occurrence, storage and quality of groundwater resources present significant barriers to the management and future development of many groundwater systems. Addressing these gaps is especially important due to anticipated increases in demand for water, changes in land use and potential impacts associated with a changing climate.

The pressure to access new water resources will also increase. The water-related impacts of land use change, such as mining and energy operations, may go undetected unless suitable monitoring and assessment is in place (Government of South Australia 2009). New pressures are likely to be realised for non-potable resources that traditionally have not been utilised or managed. Baseline information is important to both stimulate economic growth and allow appropriate planning to avoid unsustainable extraction and detrimental resource decline.

Through the Department for Water's *Groundwater Program*, an opportunity exists to deliver an improved understanding of the State's groundwater resources and to better understand the potential for further groundwater development. Benefits to stakeholders include a better understanding of the potential for groundwater to support South Australia's social and economic development and the identification of resources that require a strong focus on detailed scientific investigation and effective monitoring.

1.1. OBJECTIVES

The objective of this project is to improve the understanding of non-prescribed groundwater resources in the Kangaroo Island Natural Resources Management (KINRM) Region. Water resources are important for sustaining agriculture, industry, mining and townships, but non-prescribed regions have traditionally been poorly understood due to limited monitoring and investigation programs. A better understanding of the potential for groundwater development will benefit a broad range of stakeholders and assist to identify regions that require further investigation and effective monitoring.

The aim of this report is to integrate and describe the existing data and knowledge about the groundwater resources of the KINRM Region. This assessment aims to compile geological and hydrogeological data, giving particular attention to the identification of major hydrogeological units and related groundwater information. Based on the available information, discussions on groundwater salinity, level and yield are supported by a selection of map products. This report identifies further steps required to identify priority areas for further assessment and to address the knowledge gaps that may exist.

2. KANGAROO ISLAND NATURAL RESOURCES MANAGEMENT REGION

Kangaroo Island (KI) spans an area of around 4400 km^2 (440 000 ha) and is Australia's third-largest island after Tasmania and Melville Island. The major population centres are Kingscote, American River, Penneshaw and Parndana (Fig. 1). KI sustains a base population of over 4250 people (ABS 2008) which is forecast to slowly increase above 4660 by 2016 (KINRMB 2009). Around 40% of KI's ratepayers are not permanent residents. In the 2007-08 financial year, around 175 000 tourists visited KI (equating to around 586 000 visitor nights) (Access Economics 2009).

Low-salinity groundwater is in short supply on KI. Occurrences of good quality groundwater are limited and localised, however groundwater provides baseflow in the upper reaches of the Cygnet and Rocky Rivers (Shand et al. 2007; Banks 2010) and supports permanent pools which are important in preserving KI's aquatic biodiversity assets. Most groundwater is brackish to saline (> 2000 mg/L) and wells are generally low yielding (< 1 L/s) (Barnett & Dodds 2000).

Two Water Supply Systems (WSSs) owned and operated by SA Water, the Middle River and Penneshaw WSSs, service KI's demand for potable water. Water for the Middle River WSS is sourced from Middle River Reservoir and water for Penneshaw WSS is sourced from the Penneshaw Seawater Desalination Plant.

2.1. CLIMATE

The climate of KI is of Mediterranean-type: temperate with dry and warm summers and cool wet winters. Monthly mean maximum temperature in February is 21.8 °C and in July is 14.1 °C (BoM 2011). Summer daily maxima rarely exceed 35 °C and winter daily maxima rarely fall below 13 °C—each showing less fluctuation than the nearby mainland—most likely due to the moderating effect of the surrounding ocean. Rainfall is winter dominant. Around 65% of KI's annual rainfall falls between May and September (BoM 2011). Rainfall is spatially variable across KI (Fig. 2) ranging from 540 mm/y at Cape Willoughby in the east up to 800 mm/y toward the western coast (BoM 2011). Class A Pan evaporation is around 1400 mm/y (Banks 2010).

2.2. TOPOGRAPHY

The topography of KI is a dissected high lateritic plateau, incised by rivers and streams toward its northern and southern flanks (Twidale & Bourne 2002). The plateau is terminated by high, near-vertical cliffs along the north coast. The highest relief across KI is approximately 300 mAHD.

The southern and western coastal areas comprise mainly scrub covered calcarenite dunal systems with occasional exposures of sheet limestone. The Nepean Plain—the flood plain of the Cygnet River—is a low lying area located around Kingscote which spans an area of approximately 200 km^2 (Barnett 1977).

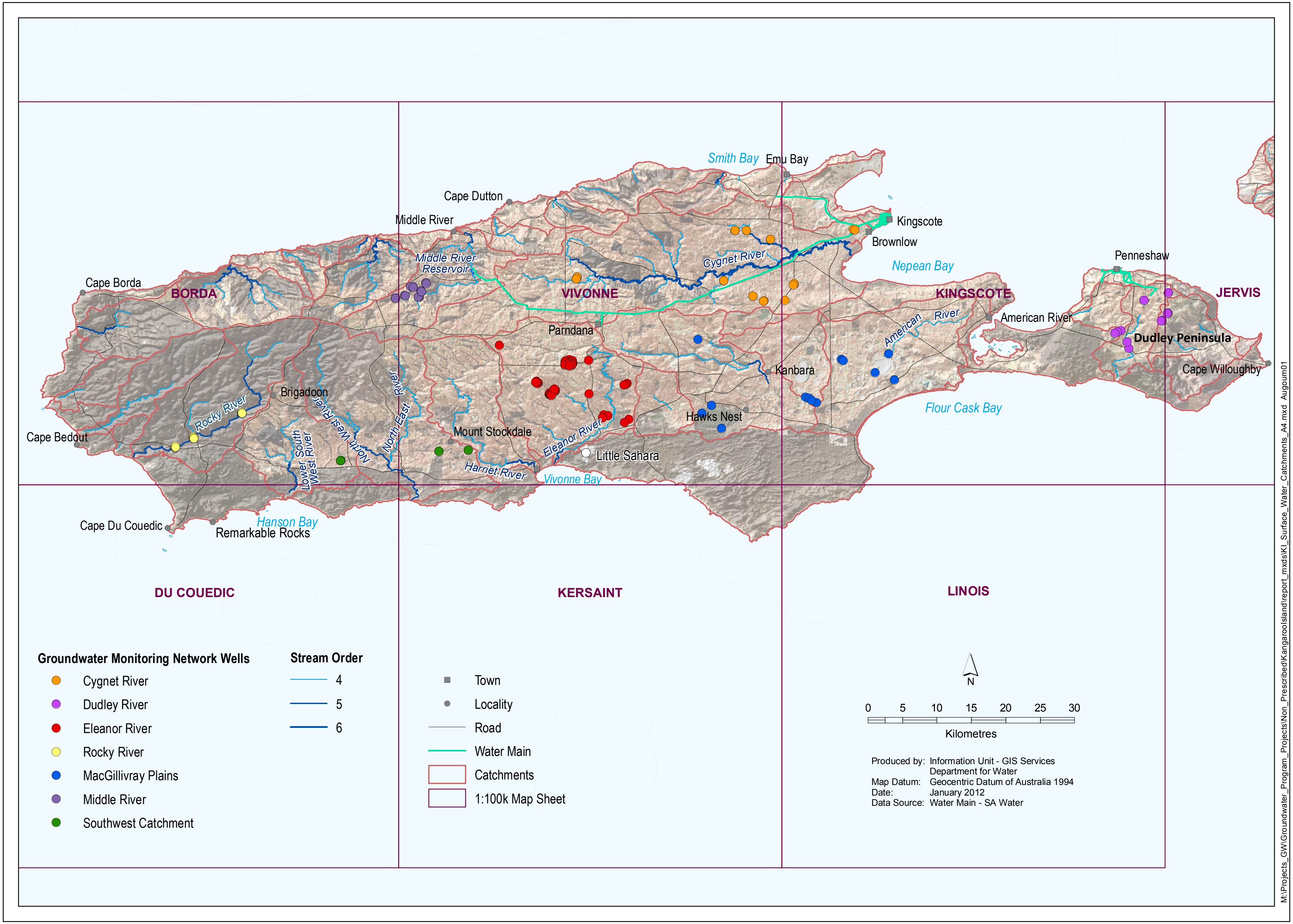


Figure 1. Kangaroo Island's surface water catchments, main watercourses and groundwater monitoring networks

2.3. LAND USE

KI's economy is underpinned by primary production and tourism. Together these sectors account for around 90% of the region's gross regional product (Econsearch 2005). Fisheries, agriculture and forestry are KI's largest employers followed by the retail and hospitality industries.

The predominant land uses across the KINRM Region are grazing and conservation (Table 1 and Fig. 2). Sheep meat and wool industries remain the greatest contributors to KI's agricultural revenues. Landholders have historically placed an emphasis on wool production but the focus is progressively shifting towards prime lamb production. Significant growth in cropping has occurred, increasing from 8000 ha in 1990 to greater than 23 000 ha in 2003 (KINRMB 2009). Plantation forestry has seen growth from 3200 ha in 2000 to 20 000 ha in 2008. Orchards, viticulture, olives and seed potatoes are emerging primary industries. Rapid changes in land use may impact upon components of KI's water balance and generate increased demand for new water resources.

Across the southern coastal region, sheet limestone and sand dunes have inhibited development. Consequently, this region comprises a large proportion of KI's conservation areas. KI's four main conservation areas are Flinders Chase National Park, Kelly Hill Conservation Park, Seal Bay Conservation Park and Cape Willoughby Conservation Park (Fig 2). These areas are pivotal to the region's tourism industry.

Table 1. Land use classified by number of land parcels and total area of land parcels

Land use	Number of parcels	% of parcels	Area (ha)	% of area
Grazing - modified pasture	607	9.9%	153 180	35.3%
Conservation	226	3.7%	143 480	33.1%
Residual native cover	2890	47.3%	75 708	17.5%
Cropping	374	6.1%	24 111	5.6%
Forestry	142	2.3%	23 587	5.4%
Agriculture	207	3.4%	5247	1.2%
Water body	936	15.3%	4357	1.0%
Residential	406	6.6%	1555	0.4%
No defined use	26	0.4%	911	0.2%
Minor land use	233	3.8%	871	0.2%
Degraded land	65	1.1%	687	0.2%
Total	**6112**	**100**	**433 700**	**100**

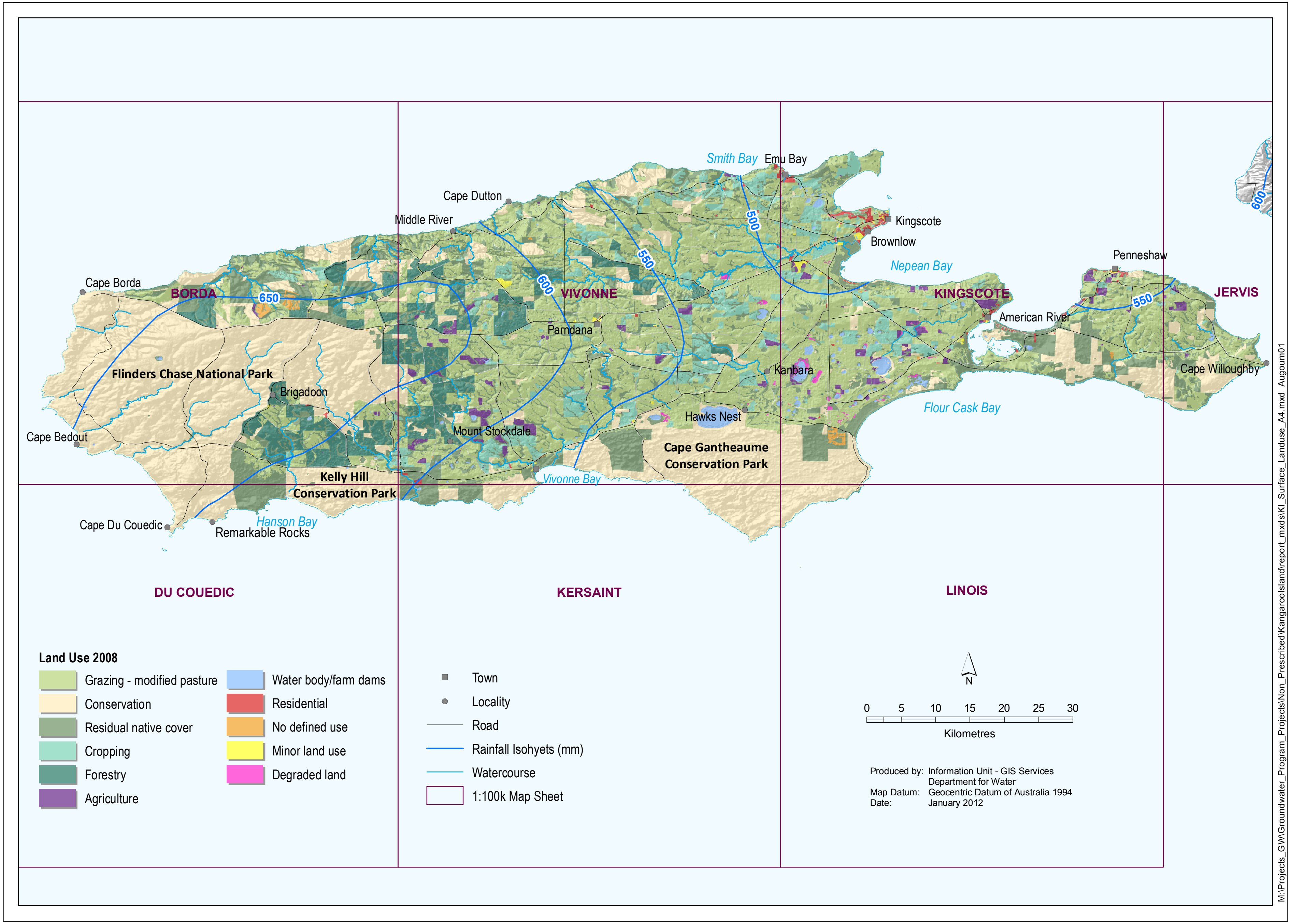


Figure 2. Aggregated land use categories

2.4. WATER RESOURCES

Despite good rainfall, the groundwater resources on KI are limited in quantity and quality. Good quality groundwater is available only in small supplies. Rain water and surface water are the main sources of water.

There are over 3000 km of surface drainage on KI with most rivers draining the elevated regions of the western plateau to the coast. Stream flows are highly seasonal. Maximum monthly discharge occurs in the winter months, whilst in summer many rivers become semi-permanent creeks or waterholes (Wen 2005). Surface water flows have previously been estimated at 16 GL/y, of which less than 1 GL/y is utilised by the South Australian Water Corporation (SA Water) systems (Wen 2005).

Surface water catchments have historically supplied residents of KI with potable water. Prior to 1938, residents relied on rainwater tanks supplemented by a 200 kL tank fed by a small catchment (SA Water 2009). The township of Kingscote was supplied by the Cygnet River Scheme from 1938 to 1968, when the Middle River Reservoir was commissioned (SA Water 2009). SA Water currently services the demand for potable water via the operation of the Penneshaw and Middle River WSSs. However, many households on KI, including residents of American River and Emu Bay, are not connected to SA Water WSSs. These households rely mainly on rainwater tanks and farm dams for potable and non-potable supply.

Uncleared areas of KI, which are encompassed predominantly by Flinders Chase National Park, represent the only catchment-scale regions of South Australia which remain in pristine condition (e.g. Rocky River and Breakneck River catchments). Watercourses that have been listed as 'Rivers of National Significance' in the Australian Directory of Important Wetlands are the Lower Cygnet River, the Lower Chapman River, Flinders Chase River and Lower South West River (Fig. 1) (Environment Australia 2001). Nilsen (2006) identifies many other watercourses of considerable ecological value, due to the degree of undisturbed riparian vegetation and stream flows and absence of erosion-related issues.

With the exception of Breakneck and Rocky River Catchments, all other KI catchments are effected by considerable farm dam development, which intercept and store surface water flow for domestic, stock and irrigation purposes (Wen 2005). On-stream dams can create problems for downstream users and ecosystems and have little flexibility for management (Wen 2005).

2.4.1. SURFACE WATER–GROUNDWATER INTERACTIONS

The Rocky River catchment has been the focus of two recent groundwater–surface water interaction studies (Shand et al. 2007; Banks 2010). Shand et al. (2007) reported that there are significant differences in watercourse salinity between catchments in KI. Shand et al. (2007) concluded that the role groundwater plays in governing watercourse salinity and stream flow generation is poorly understood. Furthermore, sustainable management of water resources on KI is contingent on a thorough understanding of the available water resources and of the impact land clearance has had on water quality and water availability.

Banks (2010) proposed refinements to Shand et al. (2007) conceptual model of the Rocky River catchment by investigating the variable nature of groundwater–surface water connectivity at the catchment scale. Banks' (2010) study highlighted the importance of winter rainfall recharge of shallow sedimentary perched aquifers located in the catchment headwaters. Results of his study suggested that these aquifers gradually drain into the tributaries of Rocky River and in some cases provide continuous baseflow during summer months. Groundwater-reliant permanent pools have been identified as providing important summer refuge for various aquatic fauna along some river reaches.

2.4.2. PUBLIC WATER SUPPLY

SA Water has prepared a long-term plan for KI (SA Water 2009) establishing a framework to ensure that the residents of KI have a secure water supply to meet forecast increases in demand for a 25 year period (2007–2033). It identifies initiatives that complement a continued emphasis on water conservation and reducing water use, while enabling KI to grow and develop within sustainable limits (Government of South Australia 2009). Current and projected potable water demand and supply have been considered. The state and condition of water resources from which potable supply is sourced and options to ensure demand can be met have been evaluated.

2.4.2.1. Surface Water Resources

SA Water commissioned the Middle River Reservoir WSS in 1968 to an original design capacity of 470 ML. In 2007 the reservoir capacity was increased to 540ML by the installation of a 'fuse' raising the spillway level (SA Water 2009). Located 50 km west of Kingscote, the system supplies potable water to the townships of Kingscote, Brownlow and Parndana and adjacent rural regions (Fig 1).

Based on historical rainfall data and current catchment conditions, SA Water (2009) assessed the current reliability and estimated the safe yield for the Middle River Reservoir to be (a) 560 ML/y for a reservoir design capacity of 470 ML; and (b) 630 ML/y for an increased capacity of 540 ML. The Middle River Reservoir has spilled during winter months every year since its construction. However, the period and volume of spill are reduced in drought years.

Jolly et al. (2000), in a risk assessment study of dryland salinity on South Australia's surface water resources, rated the Middle River Reservoir at extreme risk of increasing salinity. Barnett (2000) reported that although there is insufficient data to evaluate salinity trends of streams which supply Middle River Reservoir, the need for salinity management by winter flushing is clear evidence of the adverse impacts resulting from the effects of dryland salinity. SA Water (2009) state that inflows into the Middle River Reservoir are likely to decrease as a result of reducing rainfall due to impacts of climate change as well as from impacts of increasing areas of forestry development.

2.4.2.2. Seawater Desalination

SA Water commissioned the Penneshaw WSS in 2003. This system is supplied from the Penneshaw Desalination Plant which sources seawater from Backstairs Passage; a supply of seawater which is effectively unlimited (SA Water, 2009). The desalination plant has a capacity of 300 kL/day (110 ML/y) and supplies potable water to Penneshaw and surrounding rural areas in addition to feeding a 32 ML treated water storage. SA Water (2009) projects that by 2030–31 the demand from the Penneshaw WSS is likely to be around 95 ML/y and forecasts that the current capacity of the Penneshaw Desalination Plant along with balancing storages is sufficient to meet the projected demand.

2.5. DEMAND AND SUPPLY

A key commitment in *Water for Good* is the development of Regional Demand and Supply Statements to ensure that long-term water security solutions for each region are based on a thorough understanding of the state of all local water resources, the demand for these resources and likely future pressures (e.g. DFW 2011; DFW 2012).

The Demand and Supply Statements provide demand and supply projections for the scenarios of high and low population growth and high and low greenhouse gas emissions. Two projection sets address the demand and supply for (1) drinking quality water only; and (2) for all water sources and human demands.

Water resources of the KINRM Region support a variety of dependencies including aquatic ecosystems, dryland and irrigated agriculture, aquaculture, potable water supplies and industrial and urban rural domestic use. Forestry has also emerged as a significant industry on KI. Plantation forestry can intercept more rainfall than traditional agricultural land uses, potentially reducing a catchment's water yields by impacting on stream flow and groundwater recharge. These changes, together with potential climate variability and increased water allocation, may have significant consequence to existing users, including the environment, with alteration of baseflow and flow regimes.

3. HYDROGEOLOGY

3.1. *GEOLOGICAL SETTING*

KI forms an extension of the Neoproterozoic to Early Cambrian Adelaide Geosyncline and Delamerian fold belt, congruent with the Fleurieu Peninsula and eastern Mount Lofty Ranges on the South Australian mainland (Flottmann et al. 1995). A large number of significant geological sites attest KI's long and varied geological history. These landforms and landscapes constitute popular tourist attractions and include Remarkable Rocks, Kelly Hill Caves, Little Sahara and Cape du Couedic (Fig. 1).

From north to south, the geology of KI comprises the southern extent of the Archean to Mesoproterozoic Gawler Craton and is overlain by Cambrian platformal sediments of the Kangaroo Island Group, which have been collectively juxtaposed against basinal equivalents of the Cambrian Kanmantoo Group during the Cambro–Ordovician Delamerian Orogeny (Fairclough 2007). Kanmantoo Group sediments are widespread across KI and comprise metamorphosed, argillaceous sandstones and quartzites, quartz-mica schists and phyllitic siltstones (Barnett 1977). These basement rocks were subsequently intruded by Ordovician granites, basic intrusives (of unknown age) and tourmaline pegmatites. There is some Neoproterozoic Adelaidean outcrop mapped along the north-eastern coastline of Dudley Peninsula (Fairclough 2007), although its occurrence is minor and consequently it will not be considered further in this report.

Basement rocks show major faulting (Cygnet Fault) across the north-east corner of KI (Fig. 3). The fault separates unmetamorphosed Cambrian to the north from metasediments occurring elsewhere (Gravestock & Gatehouse 1995). Basement materials were subject to widespread deep chemical weathering resulting in the formation of iron oxide gravels which overlie mottled clays up to several tens of metres thick (Barnett and Dodds 2000). Near Kingscote, basement rocks are overlain by Jurassic basalts and Permian till.

Tertiary fossiliferous limestone and sands deposited under marine conditions over wide areas of eastern KI (Barnett & Dodds 2000) and subsequent weathering remain evident near Kingscote, Cape Willoughby and Flour Cask Bay (Shepherd 1978).

Quaternary sediments are widespread on the island, but are generally thin with the exception of the south coast and the region between the Cygnet River and Cygnet Fault. Consolidated aeolian dune sediments of the Quaternary Bridgewater Formation are common along the southern and western coasts. Other Quaternary deposits include unconsolidated sand dunes, beach sands, estuarine sediments, alluvium and considerable thickness of outwash clay to the north of the Cygnet Fault (Barnett & Dodds 2000).

3.1.1. GEOLOGICAL OCCURRENCE

There are 1702 drillholes on KI, including 923 water wells, 706 mineral drillholes and 33 stratigraphic drillholes. In total, 1009 drillholes have either stratigraphic or hydrostratigraphic interpretations reported in the State's database. This information is used to develop geological formation distribution figures (Fig. 5 and Fig. 6). Across KI, there are an additional 213 drillholes that do not have stratigraphic information, but do have either a driller's log or geologist lithological logs (Fig. 5a). Validation of these data would increase the density of stratigraphic data points and aid local and regional hydrogeological interpretation.

From available stratigraphic interpretations, information for specific formations or groups of formations can be extracted, including spatial distribution, formation thickness or depth of occurrence below ground level. A selection of Quaternary, Tertiary, Permian and Cambrian material is presented in Figure 5 and Figure 6. The information differentiates between drillhole intersections that fully intersect a formation and those which do not. A drillhole intersection is deemed to have fully intersected a formation if a deeper unit has been identified in the same drillhole log. Fully intersecting occurrences are indicated on the figure by a black dot in the centre of the map symbol.

3.1.1.1. Quaternary

Stratigraphic interpretations are available for the Quaternary Bridgewater Formation, Saint Kilda Formation and Hindmarsh Clay (Fig. 5b). Each plotted symbol size indicates the thickness of the occurrence, which in the case of Quaternary material commences from the ground surface.

Intersections of the Bridgewater Formation are common along much of the southern and eastern coastal regions and has been logged to a maximum thickness of 66 m. Thick occurrences have been identified near Flour Cask Bay and between Kingscote and the Cygnet Fault. The thicknesses of large expanses of Bridgewater Formation along the southern and western coastlines are uncertain due to a paucity of data.

The Hindmarsh Clay and Saint Kilda Formation have been logged in only a limited number of drillholes in the east of KI. These two formations have a mean thickness of 5 m and 8 m respectively, and have been logged to a maximum thickness of 34 m and 44 m respectively. The surface geology map (Fig. 3) indicates a greater distribution of the Saint Kilda Formation along the south coast but formation thicknesses are unknown.

Undifferentiated Quaternary alluvial and fluvial material is identified across much of the island. It is generally thinly deposited (mean thickness of 3 m) over Cambrian material, but occurrences of up to 30 m thickness have been observed. The greatest thicknesses are found on the Nepean Floodplain between the Cygnet River and the Cygnet Fault.

3.1.1.2. Tertiary

Undifferentiated Tertiary to Quaternary sediments have been commonly logged on the Island (Fig. 5c). These clays, sands and gravels have a mean thickness of 7 m up to a maximum thickness of 30 m below ground surface.

The Tertiary Hallett Cove Sandstone and Kingscote Limestone have been logged mostly between Kingscote, the Cygnet River and the Cygnet Fault (Fig. 5c). The Hallett Cove Sandstone underlies Quaternary material at a mean depth of 13 m and has a mean thickness of 17 m. The Kingscote Limestone occurs at a mean depth of 15 m and has a mean thickness of 14 m.

3.1.1.3. Permian

Permian sediments are restricted mostly to the north-east of the Island and have been identified as either undifferentiated Permian glacial sediments or the Carboniferous to Permian Cape Jervis Formation. The Cape Jervis Formation occurs north of the Cygnet Fault between Smith Bay and the Cygnet River (Fig 6a), mostly at or near ground surface (mean depth of 2 m) with a mean thickness of 13 m. The undifferentiated Permian material, consisting of clay and fine sand (occasional coarse sand), occurs near ground surface (mean depth of 2 m) and has a mean thickness of 11 m.

3.1.1.4. Cambrian

Cambrian basement rocks are ubiquitous across KI (Fig 6b). Basement rocks have been identified as the Kangaroo Island Group and the Kanmantoo Group and their occurrences are demarcated by the Cygnet Fault. Other Cambrian materials include the Cambrian to Ordovician Normanville Group and the Summerfield Intrusive Suite. Older Neoproterozoic material of the Adelaide Geosyncline has been identified near Penneshaw.

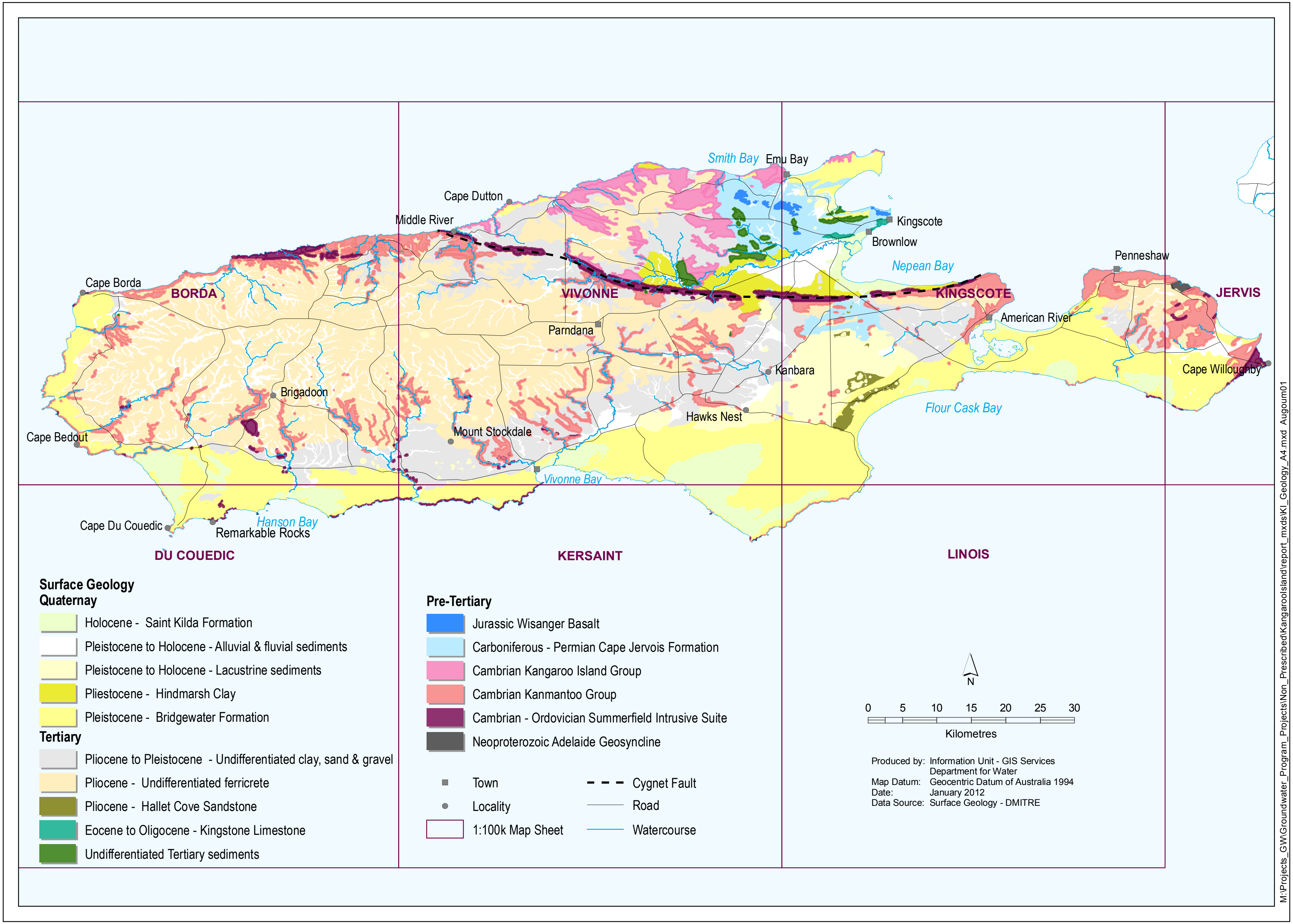


Figure 3. Surface geology

As basement material is often drilled to only a limited extent, Figure 6b provides the depth from surface at which Cambrian material is intersected (depth to top of basement). The depth to Cambrian basement on KI is quite shallow with at a mean depth of less than five metres. The maximum depth to basement is 89 m.

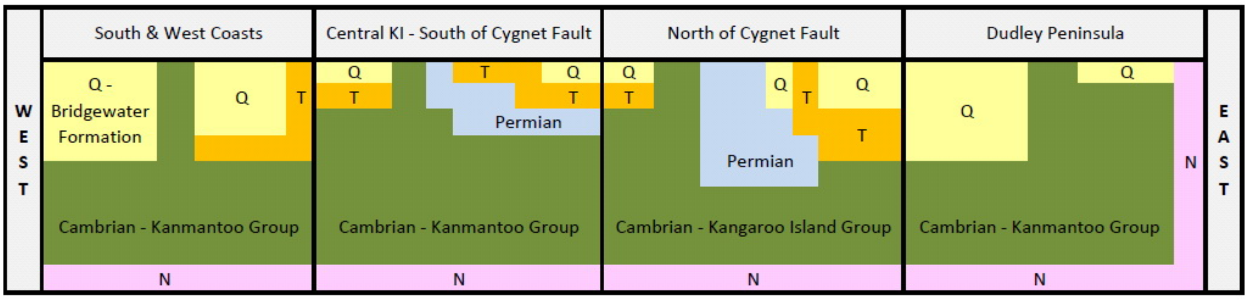
The thickness of combined Quaternary, Tertiary and Permian sediments is illustrated in Figure 6c. Figure 6b and Figure 6c highlight the limited thickness of sedimentary cover throughout the central island region, whereas thicker occurrences of sediment (deeper basement) are found around Flour Cask Bay and on the Nepean Floodplain, as well a few other isolated locations.

3.2. HYDROGEOLOGY

The occurrence of underground water on the island is strongly controlled by its geology (Barnett & Dodds 2000). Groundwater resources across KI are known to reside within Cambrian fractured rock aquifers, Permian glacial sediments, Tertiary limestone and sandstone, consolidated Quaternary aeolianite and river alluvium. The regional hydrogeology of KI has been discussed in previous reports (e.g. Barnett (1977); Shepherd (1978); and Barnett and Dodds (2000)), which detail groundwater occurrences and quality across KI.

KI's fractured rock aquifers comprise metasediments of the Early Cambrian Kanmantoo Group and Early Cambrian Kangaroo Island Group, intruded in places by Palaeozoic granitoids. The Tertiary Kingscote Limestone aquifers occur between Kingscote and the Cygnet Fault. Aeolian sediments of the Quaternary Bridgewater Formation are common along the southern and western coasts.

Permian glacial tills found near Kingscote are not regarded as a significant aquifer. A simplified distribution of Quaternary, Tertiary, Permian and Cambrian stratigraphic units across KI is presented in Figure 4. A more detailed discussion of groundwater resources is presented in Section 5.



N = Neoproterozoic; Q = Quaternary; T = Tertiary

Figure 4. Schematic stratigraphic framework across Kangaroo Island

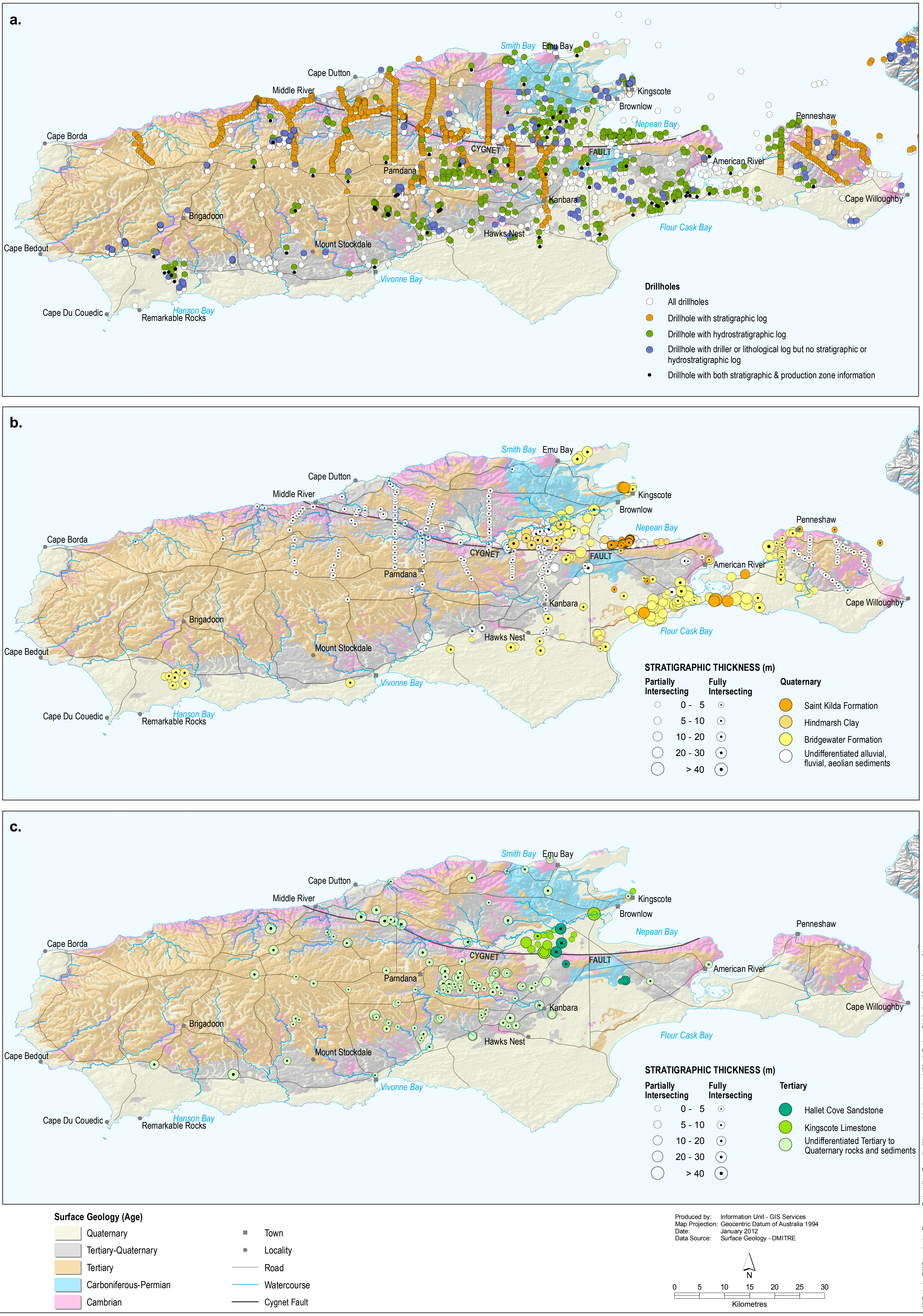


Figure 5. Distribution of drillholes and stratigraphic intersections

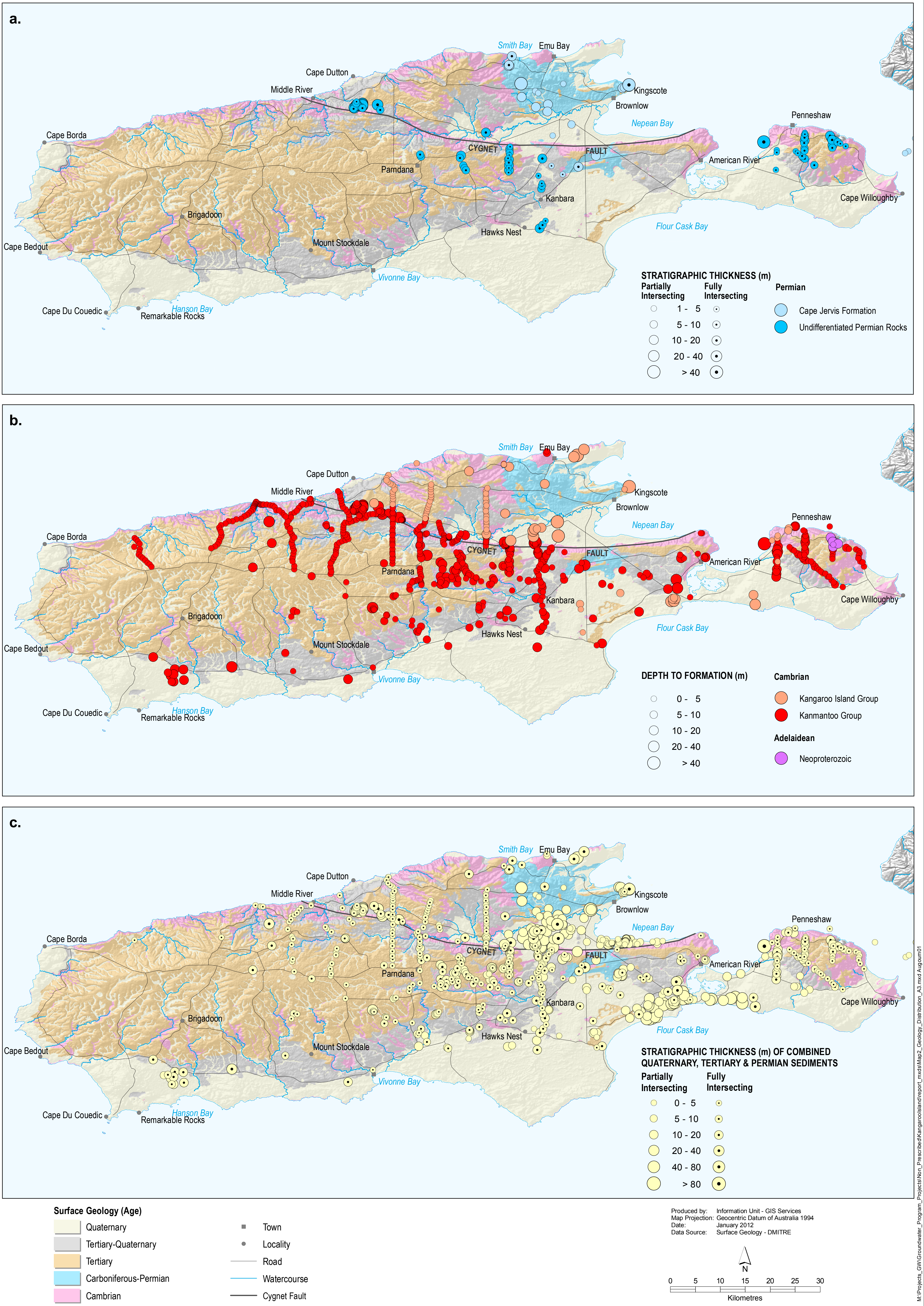


Figure 6. Distribution of stratigraphic intersections

4. GROUNDWATER DATA

4.1. GROUNDWATER DATA SUMMARY - REGIONAL

Data used in the production of this report have been sourced principally from South Australia's hydrogeological database (SA Geodata) which is administered by the Department for Water (DFW) and the Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE). Whilst every effort is made to present information from the database as accurately as possible, there will be limitations on data accuracy in relation to data being up-to-date, validated or complete. Other sources of information accessed in support of these assessments include available literature and publicly available state and national geoservers – namely, DMITRE's South Australian Resources Information Geoserver (SARIG) and Geoscience Australia's geoserver.

Of the 923 water wells, 661 wells have salinity measurements, 629 wells have SWL measurements and 236 wells have well yield measurements. Recent water level and salinity data are available for current active groundwater observation networks. These data can be accessed via the groundwater information database (*Obswell*) on the South Australian Government's *WaterConnect* website. In areas that are not currently monitored, it is common to find that only a few groundwater parameters (e.g. salinity and water level) have been sporadically recorded since 1999. Table 2 highlights the availability of recent (2000–10) groundwater data, which represents only 25% and 37% of the 'latest' salinity and water level observations, respectively. A large proportion of data for both parameters pre-dates 1980. Most wells have only a single water salinity and/or level observation collected at the time of drilling.

Table 2. Summary of latest groundwater data age for the non-prescribed Kangaroo Island Natural Resources Management Region.

Period	Salinity		Standing water level		Well yield	
	Drillholes	%	Drillholes	%	Drillholes	%
No date recorded	74	11	3	1	4	2
Pre-1960	78	12	51	8	38	16
1960–70	148	22	155	25	102	43
1970–80	14	2	2	0	11	5
1980–90	132	20	160	26	27	11
1990–2000	52	8	27	4	26	11
2000–10	163	25	231	37	28	12
Total	**661**		**629**		**236**	

Exploration for new groundwater resources suitable for domestic and stock purposes is often focused in regions where salinity is known to be low. For this reason, drillhole data and knowledge of aquifers is likely to be clustered around these areas. Information regarding relatively saline groundwater is likely to be sparse, as demand for this resource has traditionally been low.

Although there can be a great number of wells for which water quality data exists, a common constraint is the lack of associated well construction and production zone details. This limits the ability to assign groundwater observations to a specific hydrogeological formation. Of the 923 water wells on KI, 366 have stratigraphic information, but only 2 have an 'aquifer monitored' assigned – i.e. identification of which aquifer(s) a well is screened within for the purpose of groundwater abstraction or monitoring. To build on this very limited knowledge, a desktop assessment identified wells that have both stratigraphic information and production zone information. For KI, this assessment identified 123 water wells that have suitable information to identify or infer the aquifer that is monitored, significantly aiding in the ability to provide discussion around groundwater resources.

This report has compiled groundwater data available from within the SA Geodata database for the KINRM Region. Information on groundwater salinity, standing water level, yields and data age are tabulated by 1:100 000 map sheets and where applicable, information on associated water cuts and maximum well depth are included.

For consistency, the reference to map sheet areas will follow a consistent naming convention. For example, the Vivonne 1:100 000 Map Sheet will be referred to in this report as *Vivonne*.

4.1.1. GROUNDWATER SALINITY

Across the KINRM Region, there are 1702 drillholes, 923 of which are identified as water wells. Of these, 661 water well have measurements of groundwater salinity (Table 3). The spatial density of groundwater salinity data is greatest across the eastern half of the KINRM Region (Fig. 7). Salinity measurements are fewer toward the west and very few measurements are available within the boundaries of KI's national parks.

Of 661 wells, 163 (25%) have salinity data recorded within the past 10 years and 226 wells (34%) have salinity data recorded prior to 1970. Across the KINRM Region, only 143 wells (22%) have salinity less than 1500 mg/L and 302 wells (46%) have salinity greater than 4999 mg/L. At the regional scale, Barnett & Dodds (2000) attribute high groundwater salinities to unfavourable geology (Section 5).

Table 3. Summary of salinity, standing water level and yield data and associated median values (with number of data points in brackets) for the Kangaroo Island Natural Resources Management Region

Associated median well data	Total number of wells	Salinity (mg/L)						
		<1000	1000–1499	1500–2999	3000–4999	5000–9999	10 000–19 999	≥20 000
%	(661)	14.7 (97)	7 (46)	16 (106)	16.6 (110)	19.8 (131)	16.2 (107)	9.7 (64)
Max well depth (m)	(579)	5.5 (87)	5.6 (38)	6 (93)	7 (91)	7.9 (111)	14.4 (100)	13.7 (59)
Yield (L/s)	(219)	0.32 (23)	0.15 (7)	0.45 (37)	0.66 (32)	0.4 (41)	0.38 (56)	0.91 (23)
SWL (m)	(535)	2.1 (78)	2.4 (37)	2.6 (85)	2.3 (88)	2.8 (100)	4.9 (94)	7.8 (53)
Water cut (m)	(282)	9 (22)	3 (12)	12.2 (41)	10.9 (36)	10.2 (48)	10 (78)	13.7 (45)
Observation year		1990	1986	1986	1986	1986	1962	1962

Associated median well data	Total number of wells	Standing Water Level (metres below ground)						
		<5	5–9.99	10–19.99	20–29.99	30–49.99	50–99.99	≥100
%	(627)	63.5 (398)	20.9 (131)	10 (63)	3 (19)	1.9 (12)	0.6 (4)	0 (0)
Max well depth (m)	(622)	5.1 (393)	13 (131)	21.3 (63)	33.5 (19)	47.6 (12)	77 (4)	0 (0)
Water cut (m)	(317)	4 (141)	10.4 (93)	16.8 (51)	27.4 (19)	42 (9)	59 (4)	0 (0)
Observation year		1986	1985	1985	1968	1961	1979	0

Associated median well data	Total number of wells	Yield (L/s)				
		<1	1–2.99	3–4.99	5–9.99	≥10
%	(236)	72.5 (171)	19.1 (45)	3.4 (8)	1.7 (4)	3.4 (8)
Max well depth (m)	(235)	15.5 (170)	21.3 (45)	24.2 (8)	18 (4)	48 (8)
Water cut (m)	(215)	10 (154)	14 (43)	16.4 (8)	12.8 (3)	36.6 (7)
Observation year		1962	1989	1989	1994	1971

4.1.2. STANDING WATER LEVEL

Of the 1702 drillholes within the KINRM Region, 627 water wells have records detailing depth to groundwater. The distribution of data is similar to that of the salinity data (Fig. 8), as wells observed for one parameter are likely to be observed for the other.

While 231 of 627 wells (37%) have a standing water level recorded within the past 10 years, 317 wells (51%) have standing water level measurements recorded between 1960–90 (Table 3). Across KI, groundwater is typically encountered less than 5 m below ground surface, with 398 wells (64%) having standing water levels of less than 5 m. A cluster of standing water levels of greater depths are located between American River and Flour Cask Bay, a region where the combined Quaternary and Tertiary sediments are relatively thick.

4.1.3. WELL YIELD

Of 1702 drillholes that are known to exist across the KINRM Region, records for well yield are available from 236 wells. Typically, well yield is recorded at the time of drilling. Consequently, well yield data from 140 of 236 wells (59%) have been recorded prior to 1970, while only 28 wells (11%) have well yield recorded within the past ten years.

Across the region, well yields are low. Around 90% of wells have yields of less than 1 L/s (Fig. 9). The majority of water wells have been drilled for stock or domestic use and have generally been of sufficient quantity and quality for these purposes. Only a few wells have been drilled for irrigation or industrial purposes. Higher yielding wells are located near Cygnet River and within aeolianites toward KI’s southern coast, but these are few in number.

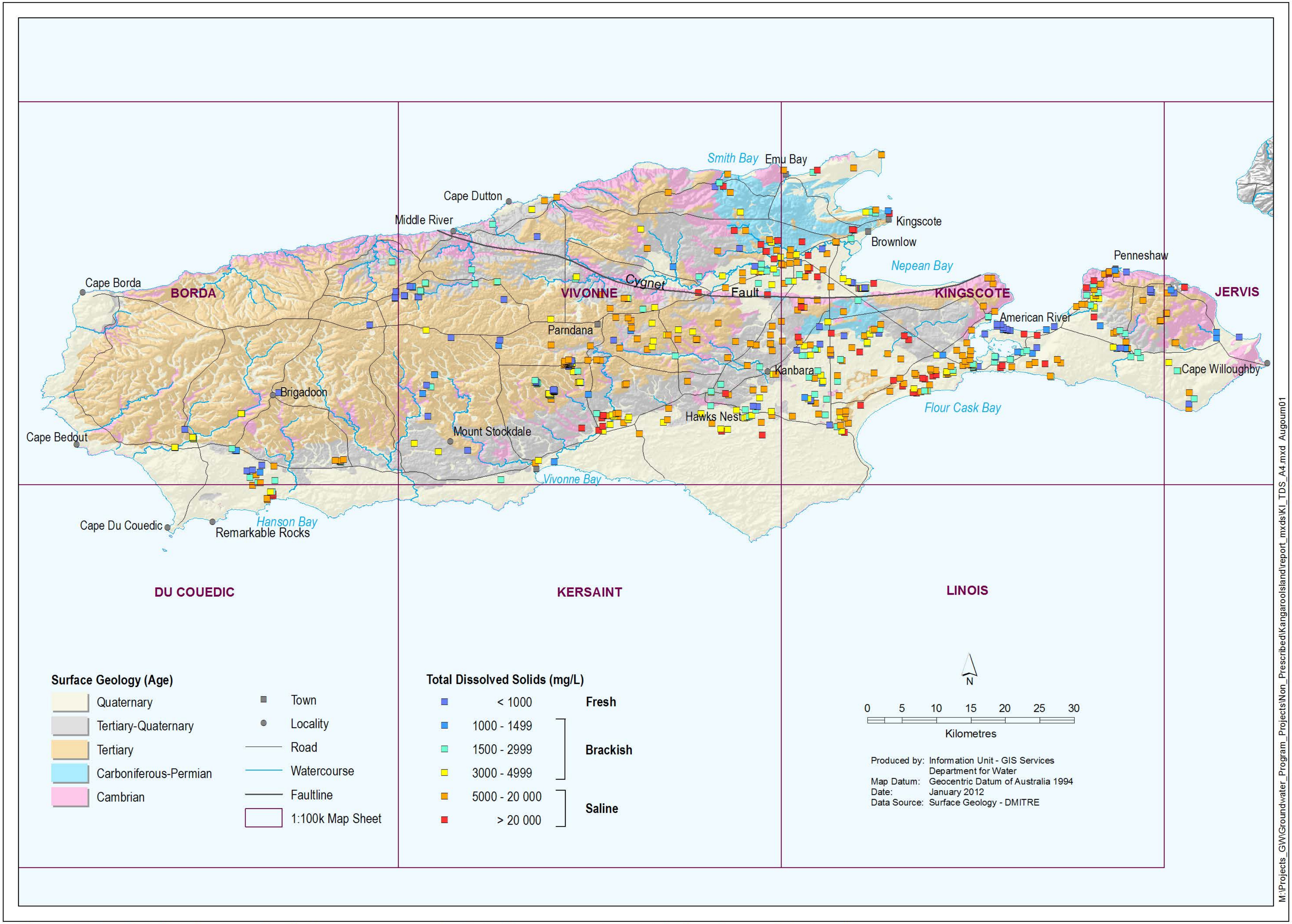


Figure 7. Spatial distribution of salinity measurements. Salinity measured as total dissolved solids (mg/L)

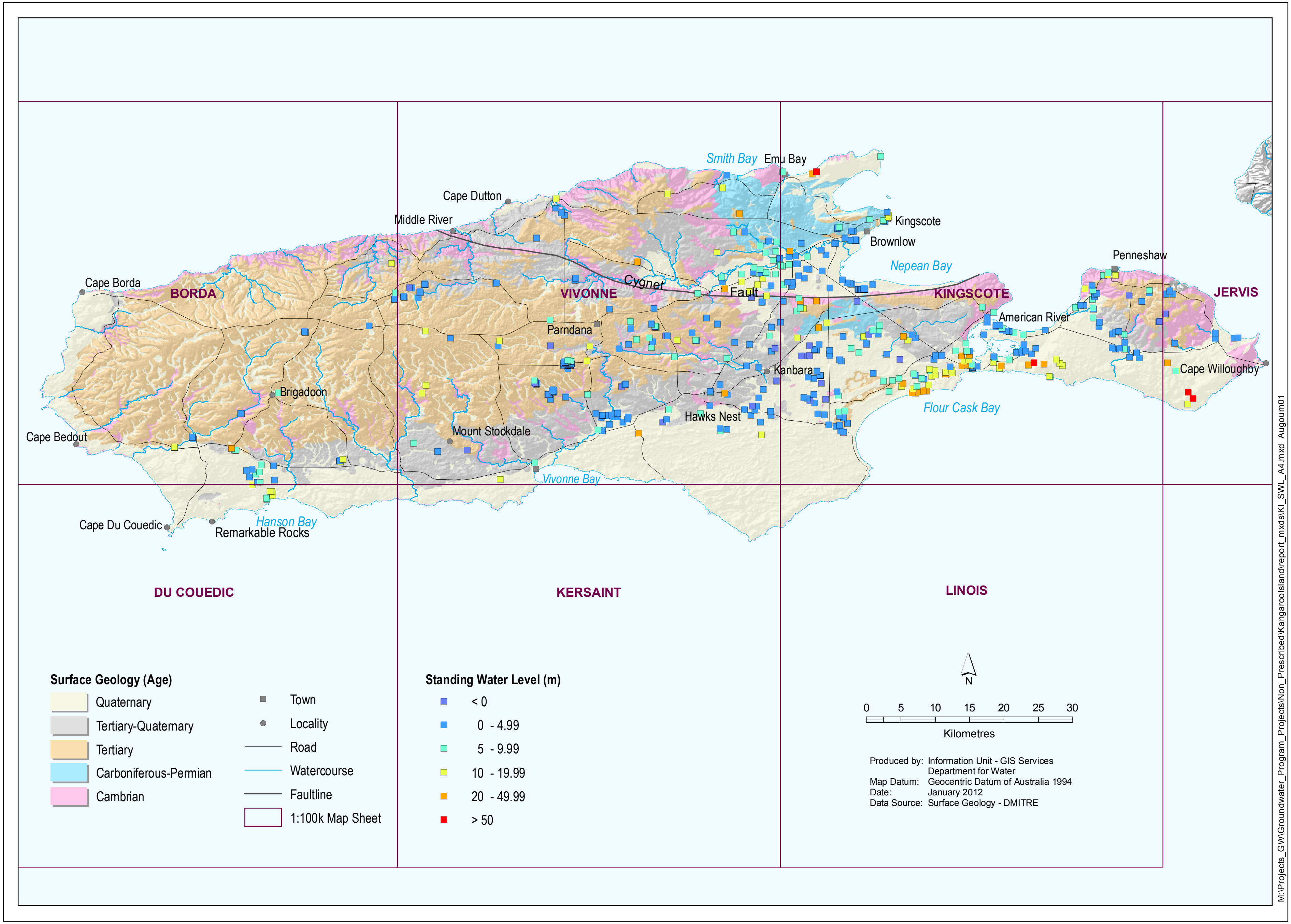


Figure 8. Spatial distribution of standing water level (SWL) measurements. SWL measured as metres below ground surface

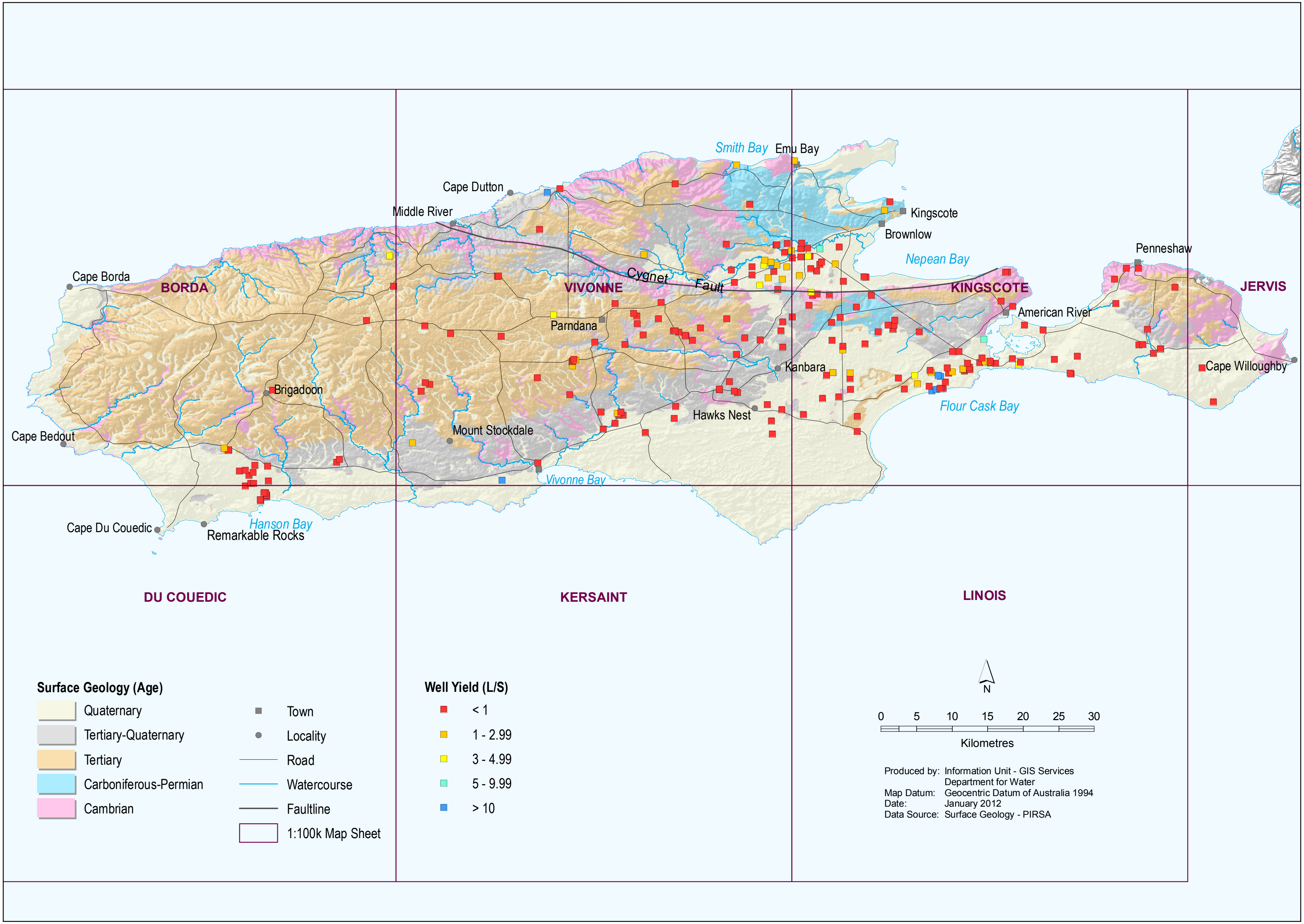


Figure 9. Spatial distribution of well yield measurements. Yield measured as litres per second (L/s)

4.2. MONITORING NETWORKS

The Cygnet River and Eleanor River networks have monitored groundwater levels in their respective catchments since around 1990, albeit at irregular intervals. From 2006, KI's groundwater level and salinity monitoring networks were augmented by the Dudley Peninsula, Rocky River, MacGillivray Plains, Middle River and Southwest Catchment monitoring networks (Fig. 1 and Table 4). These current groundwater networks aim to monitor seasonal fluctuation and long-term trends in groundwater level to aid in the evaluation of changes in groundwater storage and the risk of dryland salinity.

The Rocky River monitoring network is the only network designed to assess the processes of surface water–groundwater interactions (Banks 2010), with several Rocky River monitoring sites equipped with surface water and groundwater level loggers.

A review of the KINRM Region monitoring networks was conducted by DWLBC (Wen 2005), covering information on six themes: resource data, surface water quantity, surface water quality, groundwater quantity, groundwater quality, aquatic ecosystems and catchment characteristics. Wen (2005) recommended that the drafting of a coordinated plan for an integrated monitoring strategy be prioritised, in addition to improving lines of communication and exchange of data between the main monitoring organisations.

In 2010, DFW commissioned a review of groundwater, surface water and soil condition monitoring sites for several of South Australia's NRM regions. The scope of works for the statewide review included a review of monitoring networks across the KINRM Region (AGT 2010). The KINRM monitoring review has mainly focused on:

- Drivers and objectives of monitoring
- A summary of current monitoring infrastructure, period of record and frequency of monitoring (Table 4)
- Recommendations for the establishment and maintenance of a robust water resources monitoring network across the KINRM Region, such that DFW can reliably report on the state and condition of groundwater and surface water resources.

Table 4. Groundwater monitoring networks, showing the number of current and historical sites, monitoring frequency and the main formations monitored

Groundwater Networks	Total Sites	Historical Sites		Current Sites		Monitoring Frequency		Comment	
		SWL	Salinity	SWL	Salinity	SWL	Salinity	Formations Monitored	Purpose for Monitoring
Cygnet River	22	0	0	22	0	Random	N/A	Undefined	Dryland salinity
Dudley Peninsula	15	0	0	15	0	Random	N/A	Undefined	Dryland salinity
Eleanor River	62	9	0	53	0	Six-monthly	N/A	Undefined	Dryland salinity
Rocky River	32	0	0	32	32	Monthly manual & selected continuous logging	Continuous logging	Undefined	Groundwater–surface water interaction
MacGillivray Plains	9	0	0	9	0	Six-monthly	N/A	Undefined	Dryland salinity
Southwest Catchments	8	0	0	8	0	Random	N/A	Undefined	Dryland salinity
Middle River	24	0	0	24	0	Continuous logging	N/A	Undefined	Groundwater–surface water interaction

4.3. GROUNDWATER DATA SUMMARIES – LOCAL

4.3.1. WEST KANGAROO ISLAND – BORDA (6226) & DU COUEDIC (6225) 1:100 000 MAP SHEETS

4.3.1.1. Geology

The surface geology around the interior of *Borda* and *Du Couedic* is dominated by Tertiary (Pliocene) – Quaternary (Holocene) material, which includes undifferentiated alluvial and fluvial sediments, ferricrete, clay, claystone, sand and sandstone (Fig. 3). Outcrop of sandstone and siltstone of the Early Cambrian Kanmantoo Group (Bollaparudda Subgroup) is common between Cape Bedout and Mount Stockdale (on *Vivonne*), along the western coast of KI to Cape Bedout and is ubiquitous along KI's northern coastline. Kanmantoo Group Formations include the Tunkilla Formation, Tapanappa Formation, Petal Cove Formation, Middleton Sandstone and the Balquhidder Formation.

Outcrop of the Summerfield Intrusive Suite of Cambrian–Ordovician age occur as the Flinders Chase Granite, Remarkable (Rocks) Granite and Stun Sail Boom Granite. These are mostly exposed along the southern coast but notable occurrences are found further inland.

Calcarenites of the Quaternary (Pleistocene) Bridgewater Formation are common as surface expressions along the western and southern coastal fringes and are interspersed by occurrences of the Semaphore and Gantheaume Sand Members of the Quaternary (Holocene) Saint Kilda Formation. The Bridgewater Formation has been logged in a cluster of nine drillholes (eight fully intersecting) in the south of *Borda* to a depth up to 18 m and with a mean thickness of 11 m (Fig. 5b and Table 5).

Further inland, undifferentiated Quaternary sediments range in thickness between 0.1 and 0.4 m (mean 0.2 m, from six drillholes) and undifferentiated Pliocene to Pleistocene material range in thickness between 14 and 30 m (mean 20 m from 5 drillholes). The combined thickness of Quaternary and Tertiary sediments from all drillholes on *Borda* ranges between 0.1 to 30 m (mean 10 m).

On *Borda,* 76 drillholes intersect the Cambrian Kanmantoo Group, which includes the Middleton Sandstone. The mean depth to this material is 3 m. There are no drillholes which intersect the entire thickness of the Kanmantoo Group, but there are intersections up to 60 m. Information on Kanmantoo lithology is available in a group of drillholes on the south of *Borda*, north of Hanson Bay and in an exploration drillhole transect in the north of *Borda*.

Table 5. Summary of main geological formations on *Borda*

Unique formation or geological time scales	Number of intersecting drillholes*	Minimum Thickness (m)#	Maximum Thickness (m)	Mean Thickness (m)	Mean Depth From (m)	Mean Depth To (m)
Quaternary Sediments	15 (14)	0.1	17.7	6.9	0.0	6.9
Bridgewater Formation	9 (8)	5.5	17.7	11.4	0.0	11.4
Combined Quaternary & Tertiary Sediments	20 (19)	0.1	30.0	10.3	0.0	10.3
Unique formation or geological time scales	**Number of intersecting drillholes***	**Min Depth From (m)**	**Max Depth From (m)**	**Mean Depth From (m)**	**Max Depth To (m)**	**Mean Intersected Thickness^**
Cambrian *(Kanmantoo Group)*	76 (0)	0.0	30.0	2.6	90.0	12.2

* Bracketed numbers represent the number drillholes from the set which are determined to fully intersect the formation. # Minimum formation thickness calculated from only fully intersected occurrences of formation. ^ Will not be representative of full formation thickness, only the extent to which the formation(s) have been drilled.

4.3.1.2. Groundwater Data

The availability of drillholes across western KI is restricted largely to the southern and northern extents of *Borda*. Drillholes are scarce throughout the central and western extent of *Borda* (Fig. 5a). Water wells and the availability of groundwater data are limited mostly to the south of *Borda*, north of Hanson Bay and south-west of Brigadoon along Rocky River (Fig. 7, Fig. 8 and Fig. 9).

Salinities vary between 145 and 25 000 mg/L (median 3164 mg/L) across *Borda* and *De Couedic.* Of the 67 wells with salinity records, 35 wells (52%) have salinities greater than 3000 mg/L (Table 6). Salinities from wells known to be screened in the Quaternary Bridgewater Formation range between 450 and 5000 mg/L (mean 2800 mg/L, from four drillholes). Salinities of wells open to Early Cambrian fractured rock aquifers range between 1000 and 35 500 mg/L (mean 29 000 mg/L from eight drillholes) and have a mean depth to formation of 16 m.

Wells located around the southern coastal township of Hanson Bay have low-salinity groundwater of 740 mg/L in one well open to the Quaternary Bridgewater Formation, and 450 mg/L in one well open to both the Quaternary Bridgewater Formation (up to 10 m depth below ground surface) and Early Cambrian Middleton Sandstone fractured rock aquifers. Good quality groundwater (around 1000 mg/L) is also evident from one well open to the Early Cambrian Kanmantoo Group. Good quality groundwater (less than 1500 mg/L) has been encountered around 10 km north of Hanson Bay (near Kangaroo Island Wilderness Retreat, Flinders Chase National Park) – this well is open to undifferentiated Pliocene to Pleistocene regolith and colluvial sediments (up to 17 m depth below ground surface) and also to the Early Cambrian Kanmantoo Group. Groundwater salinity of 400 mg/L is evident from one well located toward the centre of *Borda* near the township of Brigadoon. This well is screened within an unidentified Tertiary sand aquifer at between 18–28 m depth. Toward the north-west, three wells open to Early Cambrian Kanmantoo Group fractured rock aquifers have low salinities. These wells have salinities of 300, 450 and 2100 mg/L and their production zones are between 21–30, 14–18 and 39–90 m depth, respectively.

Most wells across *Borda* and *Du Couedic* have shallow standing water levels, with 38 of 66 wells (58%) having standing water levels of less than 5 m. Wells completed within fractured rock aquifers commonly have water cuts at greater depth than the standing water level, indicating that groundwater may be under pressure at these locations. However, artesian conditions have not been reported. Well yields are generally low, with 21 of 28 wells (75%) having yields of less than 1 L/s and 27 of 28 wells (96%) having yields of less than 3 L/s. Most salinity and water level data were recorded around 2007–08 and the median period where well yield data were collected is 1958.

Table 6. Summary of salinity, standing water level and yield data and associated median values (with number of data points in brackets) for *Borda* and *Du Couedic*

Associated median well data	Total number of wells	Salinity (mg/L)						
		<1000	1000–1499	1500–2999	3000–4999	5000–9999	10 000–19 999	≥20 000
%	(67)	25.4 (17)	9 (6)	13.4 (9)	20.9 (14)	20.9 (14)	7.5 (5)	3 (2)
Max well depth (m)	(66)	7.3 (16)	15.5 (6)	19.8 (9)	12.5 (14)	15 (14)	20.6 (5)	32.8 (2)
Yield (L/s)	(27)	0.31 (6)	0.15 (3)	0.32 (7)	0.76 (1)	0.41 (4)	0.66 (4)	0.88 (2)
SWL (m)	(61)	2.9 (14)	3.8 (6)	12.8 (9)	3.9 (14)	4.7 (12)	9.3 (4)	12.6 (2)
Water cut (m)	(25)	13.3 (6)	13.4 (3)	20 (7)	0 (0)	12.8 (4)	14 (3)	16.2 (2)
Observation year		2007	2005	1992	2007	2007	2007	2009
Associated median well data	**Total number of wells**	**Standing Water Level (metres below ground)**						
		<5	**5–9.99**	**10–19.99**	**20–29.99**	**30–49.99**	**50–99.99**	**≥100**
%	(66)	57.6 (38)	24.2 (16)	16.7 (11)	1.5 (1)	0 (0)	0 (0)	0 (0)
Max well depth (m)	(66)	7 (38)	24 (16)	35 (11)	39.6 (1)	0 (0)	0 (0)	0 (0)
Water cut (m)	(26)	3.7 (7)	13.4 (12)	28.5 (6)	31 (1)	0 (0)	0 (0)	0 (0)
Observation year		2008	2003	1999	1989	0	0	0

Associated median well data	Total number of wells	Yield (L/s)				
		<1	1–2.99	3–4.99	5–9.99	≥10
%	(28)	75 (21)	21.4 (6)	3.6 (1)	0 (0)	0 (0)
Max well depth (m)	(28)	21.3 (21)	31.5 (6)	90 (1)	0 (0)	0 (0)
Water cut (m)	(25)	13.7 (18)	19 (6)	42 (1)	0 (0)	0 (0)
Observation year		1958	2005	1997	0	0

4.3.2. CENTRAL KANGAROO ISLAND – VIVONNE (6326) 1:100 000 MAP SHEET

4.3.2.1. Geology

The surficial geology of *Vivonne* is dominated by Tertiary (Pliocene) to Quaternary (Holocene) material, which includes undifferentiated alluvial and fluvial sediments, ferricrete, clay, claystone, sand and sandstone (Fig. 3). Undifferentiated Pleistocene–Holocene alluvial and fluvial sediments are more common toward the north of the map sheet with older Tertiary (Eocene–Miocene) marine limestone also described (undifferentiated Pata Formation Limestone of the Murray Group). Undifferentiated lacustrine and playa sediments are common toward the south. Surface expression of the Quaternary (Pleistocene) Bridgewater Formation is ubiquitous along the southern coastal fringe, extending onto *Kersaint* and is interspersed by occurrences of the Semaphore and Gantheaume Sand Members of the Quaternary (Holocene) Saint Kilda Formation.

The Cygnet Fault is the demarcation between the Kangaroo Island and Kanmantoo Groups and is characterised by outcrop of Cambrian to Ordovician igneous rocks of the Summerfield Intrusive Suite. Outcropping of the Early Cambrian Kanmantoo Group is common south of the Cygnet Fault, around the centre of *Vivonne*. Outcropping sequences include the Balquhidder Formation, Middleton Sandstone, Petal Cove Formation, Tapanappa Formation and Tunkalilla Formation of the Bollaparudda Subgroup. Outcropping of Middle-Jurassic Wisanger Basalt and sandstone and shale of the Early Cambrian Kangaroo Island Group are common north of the Cygnet Fault between the fault zone and the northern-coastline. Carboniferous to Permian material, which in places has been identified as the Cape Jervis Formation (Table 7), outcrops at the north-east terrestrial extent of *Vivonne*. Hindmarsh Clay and Kingscote Limestone have been interpreted north of the Cygnet Fault in a small band extending onto *Kingscote* between the Cygnet River, Kingscote and American River (Fig. 3 and Fig. 5c).

The mean depth to Cambrian basement (fractured rock aquifers) is similar for the Kanmantoo Group (3.7 m) and Kangaroo Island Group (4.2 m), which are found south and north of the Cygnet Fault respectively. Cambrian rocks are generally intercepted at shallow depth but may underlie thicker occurrences of Quaternary, Tertiary and Permian sediments in places (Fig. 6a and Fig. 6b).

Table 7. Summary of main geological formations on *Vivonne*

Unique formation or geological time scales	Number of intersecting drillholes*	Minimum Thickness (m)#	Maximum Thickness (m)	Mean Thickness (m)	Mean Depth From (m)	Mean Depth To (m)
Quaternary Sediments	251 (235)	0.1	34.1	3.2	0.0	3.2
Bridgewater Formation	10 (6)	5.2	16.2	8.8	0.1	9.0
Hindmarsh Clay	8 (5)	13.1	34.1	18.3	0.0	18.3
Combined Quaternary & Tertiary Sediments	388 (340)	0.1	46.6	5.3	0.0	5.4
Kingscote Limestone	10 (1)	5.5	45.7	12.8	15.1	27.9
Combined Carboniferous to Quaternary Sediments	402 (345)	0.1	56.1	6.8	0.0	6.8
Permian (includes Cape Jervis Formation)	54 (45)	2.0	45.4	12.3	0.9	13.2
Unique formation or geological time scales	**Number of intersecting drillholes***	**Min Depth From (m)**	**Max Depth From (m)**	**Mean Depth From (m)**	**Max Depth To (m)**	**Mean Intersected Thickness^**
Cambrian	522 (0)	0.0	46.5	3.8	979	15.9
Kanmantoo Group	453 (0)	0.0	46.5	3.7	116	14.2
Kangaroo Island Group	64 (0)	0.0	34.1	4.2	979	29.0

* Bracketed numbers represent the number drillholes from the set which are determined to fully intersect the formation. # Minimum formation thickness calculated from only fully intersection occurrences of formation. ^ Will not be representative of full formation thickness, only the extent to which the formation(s) have been drilled.

4.3.2.2. Groundwater Data

Salinities across *Vivonne* range between 60 and 34 000 mg/L (median 4204 mg/L). Of 277 wells, 117 (42%) have salinities greater than 5000 mg/L while only 61 wells (22%) have salinities less than 1500 mg/L (Table 8). Most wells with production zone information available indicate that they are open to Tertiary sediments or Cambrian fractured rock aquifers. Wells open to undifferentiated Pliocene to Pleistocene regolith and colluvial sediments have salinities ranging between 400 and 16 000 mg/L (mean 4900 mg/L, from 34 drillholes) with a mean formation thickness of 6 m. Wells open to the Early

Cambrian Kanmantoo Group have salinities ranging between 400 and 24 000 mg/L (mean 7800 mg/L, from six drillholes) with a mean depth to formation of 8 m. A further 20 wells have been identified as being open to the Early Cambrian Tapanappa Formation (Kanmantoo Group). Salinities of these wells range between 400 and 9000 mg/L (mean 4300 mg/L) with a mean depth to formation of 5 m.

In general, good quality groundwater occurrence is limited to three areas: (1) toward the east between Mount Stockdale and Cape Dutton, where four wells are open to fractured rock aquifers (Table 9); (2) Near Hawks Nest, eight wells have salinities of less than 3000 mg/L (but production zone information is not available); and (3) toward the north-east near Cygnet River where eight wells have salinities of less than 2500 mg/L (one well is open to undifferentiated alluvial and fluvial sediments of 16 m thickness and a second well is open to the Eocene–Oligocene Kingscote Limestone of 3 m thickness, while the remaining wells do not have production zone information available).

Depth to groundwater is generally shallow. Of 238 wells, 168 (71%) have standing water levels of less than 5 m below ground surface. In many instances depth to water cut is greater than standing water level, indicating groundwater may be under pressure. Well yields are typically low, with 67 of 93 wells (72%) having yields of less than 1 L/s, while only five wells (8%) have yields of greater than 3 L/s. The median period standing water level data were collected is 2004 and the median period yield data were collected is 1963.

Table 8. Summary of salinity, standing water level and yield data and associated median values (with number of data points in brackets) for *Vivonne*

Associated median well data	Total number of wells	Salinity (mg/L)						
		<1000	1000–1499	1500–2999	3000–4999	5000–9999	10 000–19 999	≥20 000
%	(277)	16.2 (45)	5.8 (16)	14.8 (41)	20.9 (58)	21.3 (59)	13 (36)	7.9 (22)
Max well depth (m)	(223)	5.2 (40)	6.8 (12)	9 (31)	6.6 (44)	7.9 (45)	12.8 (31)	10.5 (20)
Yield (L/s)	(83)	0.4 (6)	1 (1)	0.8 (11)	0.51 (21)	0.4 (16)	0.25 (21)	0.38 (7)
SWL (m)	(202)	1.4 (35)	1.7 (9)	1.9 (26)	2.1 (41)	1.5 (43)	4.5 (29)	7 (19)
Water cut (m)	(91)	11.1 (6)	34 (1)	16.8 (11)	11.4 (21)	9 (17)	10.2 (24)	12.5 (11)
Observation year		2005	1993	1988	1986	2005	1966	1963
Associated median well data	**Total number of wells**	**Standing Water Level (metres below ground)**						
		<5	**5–9.99**	**10–19.99**	**20–29.99**	**30–49.99**	**50–99.99**	**≥100**
%	(238)	70.6 (168)	19.3 (46)	8 (19)	1.7 (4)	0.4 (1)	0 (0)	0 (0)
Max well depth (m)	(237)	5.5 (167)	14.2 (46)	24 (19)	46.2 (4)	84 (1)	0 (0)	0 (0)
Water cut (m)	(100)	6.9 (44)	12.2 (33)	16.4 (18)	35.8 (4)	42 (1)	0 (0)	0 (0)
Observation year		2009	1962	1993	1966	2007	0	0

Associated median well data	Total number of wells	Yield (L/s)				
		<1	1–2.99	3–4.99	5–9.99	≥10
%	(93)	72 (67)	20.4 (19)	2.2 (2)	1.1 (1)	4.3 (4)
Max well depth (m)	(93)	17.7 (67)	23.5 (19)	22.5 (2)	18 (1)	48 (4)
Water cut (m)	(91)	8.9 (66)	16 (18)	17.7 (2)	12.8 (1)	41 (4)
Observation year		1962	1990	1989	2007	2000

Table 9. Groundwater salinities between Mount Stockdale and Cape Dutton, Kangaroo Island.

Unit Number	Production zone (m below ground surface)	Salinity (mg/L)	Aquifer monitored
6326 00054	8–24	380	Kanmantoo Group
6326 00823	9–18	418	Tapanappa Formation
6326 00836	11–23	264	Unnamed sandy gravel/black slate
6326 00302	12.1–12.6	1400	Kanmantoo Group

4.3.3. EAST KANGAROO ISLAND – KINGSCOTE (6426) & JERVIS (6526) 1:100 000 MAP SHEETS

4.3.3.1. Geology

The surficial geology of *Kingscote* and *Jervis* is demarcated by the Cygnet Fault (Fig. 3). North of the fault, coastal areas are dominated by the Quaternary Bridgewater Formation and Saint Kilda Formation, with minor occurrences of the recent Glanville Formation. Undifferentiated alluvial and fluvial sediments of Holocene–Pleistocene age are common across the Nepean Floodplain between Cygnet River and the Cygnet Fault, while the Hindmarsh Clay abuts the Cygnet Fault to the north. The Holocene Semaphore Sand Member has been described between the Cygnet Fault and the Nepean Bay coastline. Outcrop of the Middle Jurassic Wisanger Basalt occurs between Cygnet River and the northern coastline and also immediately north of Kingscote.

The southern coastline is dominated by the Quaternary Bridgewater Formation. Undifferentiated lacustrine and playa sediments are common east of Kanbara while Early Permian glacial till deposition is common between these lacustrine sediments and the Cygnet Fault. The Holocene to Late-Pliocene Glanville Formation has been described south-east of American River.

The Quaternary (Pleistocene) Bridgewater Formation, which is interspersed by the more recent Holocene Saint Kilda Formation (Semaphore and Gantheaume Sand Members) has a mean thickness of 17 m (from 128 drillholes). It is generally of greatest thickness around Flour Cask Bay and on the Nepean Floodplain around Cygnet River (Fig. 5b).

Surface exposures of Tertiary materials are limited north of the Cygnet Fault, but include a minor expression of the Palaeogene Kingscote Limestone between Kingscote and Brownlow. The Kingscote Limestone occurs under the Nepean Floodplain at a mean depth of 15 m with a mean thickness of 15 m and has been logged to a thickness greater than 80 m. Extensive outcrop of Tertiary (Pliocene) ferricrete, clay and sand has been identified south of Cygnet Fault and also on northern Dudley Peninsula. The Hallett Cove Sandstone has mean depth and thickness similar to the Kingscote Limestone (Fig 5c and Table 10,). However, the estimated depths and thicknesses of the Kingscote Limestone and Hallett Cove Sandstone are based on a limited number of drillhole data.

Significant exposures of the Carboniferous to Permian Cape Jervis formation occur both north and south of the Cygnet Fault. The Cape Jervis Formation and other Permian sediments have a mean thickness on *Kingscote* and *Jervis* of 10 m, but have been logged to thicknesses greater than 70 m. Outcropping is evident south of Nepean Bay and between Kingscote and Smith Bay, but also occurs at depth around Penneshaw (Fig. 6a).

Outcrop of Cambrian to Ordovician Delamerian igneous rocks of the Summerfield Intrusive Suite mark the location of Cygnet Fault and represent the northern boundary of the Early-Cambrian Kanmantoo Group, which outcrop immediately south of the Cygnet Fault scarp and along the northern coastal cliffs of the Dudley Peninsula. Other minor exposures occur along the southern coastline and in the Island's interior. The Kanmantoo Group, which includes the Tapanappa Formation occurs at a mean depth of 6 m (from 109 drillholes).

The Kangaroo Island Group, which includes the Stokes Bay Sandstone and Smith Bay Shale occurs at a mean depth of 22 m (from 25 drillholes) (Fig. 6b and Table 10). One well, located just inland from Emu Bay, intersects the Palaeoproterozoic Lincoln Complex at 313 m and is the only drillhole to fully intersect the Kangaroo Island Group (177 m in thickness) as well as a limestone unit of the Normanville Group. Two other intersections of the Normanville Group have been logged east of Penneshaw at depths between 5 m and 20 m. Surface expressions of the Kangaroo Island Group (Boxing Day Formation, White Point Conglomerate and Emu Bay Shale) occur only on the northern coastline.

Depth to Cambrian basement is generally quite shallow across KI, but is deepest in the east of the island where considerable thicknesses of overlying sedimentary material have been observed. Sedimentary formations are thickest on the flanks of the Cygnet River (between the Cygnet Fault, Smith Bay and Kingscote) and inland from Flour Cask Bay (Fig. 6c).

Table 10. Summary of main geological formations on *Kingscote* and *Jervis*

Unique formation or geological time scales	Number of intersecting drillholes*	Minimum Thickness (m)#	Maximum Thickness (m)	Mean Thickness (m)	Mean Depth From (m)	Mean Depth To (m)
Quaternary Sediments	305 (130)	0.3	65.8	11.1	0.0	11.1
Bridgewater Formation	128 (52)	0.9	65.8	17.3	0.1	17.3
Hindmarsh Clay	48 (7)	1.8	13.3	2.3	6.1	8.4
Saint Kilda Formation	75 (41)	0.6	44.0	7.6	0.4	7.9
Combined Quaternary & Tertiary Sediments	314 (126)	0.1	106.7	11.7	0.1	11.6
Kingscote Limestone	6 (0)	-	80.7	15.0	15.7	30.7
Hallett Cove Sandstone	7 (4)	5.5	39.3	16.5	12.7	29.2
Combined Carboniferous to Quaternary Sediments	329 (131)	0.3	106.7	12.4	0.1	12.4
Permian (includes Cape Jervis Formation)	42 (32)	2.0	71.1	10.1	2.8	12.9
Unique formation or geological time scales	**Number of intersecting drillholes***	**Min Depth From (m)**	**Max Depth From (m)**	**Mean Depth From (m)**	**Max Depth To (m)**	**Mean Intersected Thickness^**
Cambrian	139 (1)	0.0	89.0	8.4	334	15.3
Kanmantoo Group	109 (0)	0.0	89.0	6.4	293	12.7
Kangaroo Island Group	26 (1)	0.0	77.1	17.3	334	22.9

* Bracketed numbers represent the number drillholes from the set which are determined to fully intersect the formation. # Minimum formation thickness calculated from only fully intersection occurrences of formation. ^ Will not be representative of full formation thickness, only the extent to which the formation(s) have been drilled.

4.3.3.2. Groundwater Data

Salinities across *Kingscote* and *Jervis* are generally high, with 164 of 317 wells (52%) having salinities greater than 5000 mg/L (Table 11). Only 59 wells (19%) have salinities less than 1500 mg/L. Most wells with production zone information available show them to be open to the Quaternary Bridgewater Formation. Salinities of these wells ranges between 500 and 105 000 mg/L (mean 19 000 mg/L, from 17 drillholes).

Good quality groundwater (less than 3000 mg/L) has been encountered in three localities:

(1) north-east of Kanbara, where one well intercepts stratified sands and silts at between 4 m and 7 m depth; a second well intercepts the Early Permian–Late Carboniferous Cape Jervis and Early Cambrian Tapanappa Formations at between 6 and 31 m depth;

(2) along the north-west coast of Dudley Peninsula (opposite American River), where eight low-salinity wells are screened up to 32 m depth (although supporting stratigraphic information is available for only one well, which is open to the Quaternary Bridgewater Formation at greater than 7 m thickness); and

(3) along the north-east coast of Dudley Peninsula, where five low-salinity wells are drilled up to 16 m depth (stratigraphic information is not available) while one low-salinity well intercepts Quaternary Bridgewater Formation at 2 m thickness and Early Cambrian Kanmantoo Group at between 2 and 9 m depth.

Depth to groundwater is generally shallow. Of 323 wells, 261 (81%) have standing water levels of less than 10 m below ground surface. The depth to water cut is greater than standing water level for many wells located inland, indicating groundwater may be under pressure. Well yields are typically low with 83 of 115 wells (72%) having yields of less than 1 L/s, while only 8 wells (7%) have yields of greater than 3 L/s. The median period most standing water level data were collected is early-1980s and the median period yield data were collected is mid-1960s.

Table 11. Summary of salinity, standing water level and yield data and associated median values (with number of data points in brackets) for *Kingscote* and *Jervis*

Associated median well data	Total number of wells	Salinity (mg/L)						
		<1000	1000–1499	1500–2999	3000–4999	5000–9999	10 000–19 999	≥20 000
%	(317)	11 (35)	7.6 (24)	17.7 (56)	12 (38)	18.3 (58)	20.8 (66)	12.6 (40)
Max Well depth (m)	(290)	5.5 (31)	4.1 (20)	4.6 (53)	6 (33)	7.2 (52)	14 (64)	17.1 (37)
Yield (L/s)	(109)	0.38 (11)	0.08 (3)	0.44 (19)	0.95 (10)	0.38 (21)	0.51 (31)	1.07 (14)
SWL (m)	(272)	2.5 (29)	2.4 (22)	2.7 (50)	2.4 (33)	5 (45)	4.7 (61)	9.1 (32)
Water cut (m)	(166)	4 (10)	2.4 (8)	5.5 (23)	7.6 (15)	10.4 (27)	9.8 (51)	13.9 (32)
Observation year		1985	1985	1985	1986	1962	1962	1962
Associated median well data	**Total number of wells**	**Standing Water Level (metres below ground)**						
		<5	**5–9.99**	**10–19.99**	**20–29.99**	**30–49.99**	**50–99.99**	**≥100**
%	(323)	60.4 (195)	20.4 (66)	10.8 (35)	3.7 (12)	3.4 (11)	1.2 (4)	0 (0)
Max well depth (m)	(319)	4.5 (191)	10 (66)	18.9 (35)	30.5 (12)	47.6 (11)	77 (4)	0 (0)
Water cut (m)	(191)	3.1 (93)	9.5 (45)	16.5 (29)	26.8 (12)	42.1 (8)	59 (4)	0 (0)
Observation year		1986	1977	1967	1962	1961	1979	0

Associated median well data	Total number of wells	Yield (L/s)				
		<1	1–2.99	3–4.99	5–9.99	≥10
%	(115)	72.2 (83)	17.4 (20)	4.3 (5)	2.6 (3)	3.5 (4)
Max well depth (m)	(114)	13 (82)	17.3 (20)	24 (5)	18 (3)	50.8 (4)
Water cut (m)	(99)	9.9 (70)	14 (19)	14.3 (5)	15.1 (2)	7.6 (3)
Observation year		1962	1982	1980	1980	1961

5. GROUNDWATER RESOURCES

Groundwater resources of the KINRM Region are found within Neoproterozoic to Early Cambrian fractured rock aquifers, Permian glacial sediments, Tertiary limestones and sands, consolidated Quaternary aeolianites and recent river alluviums (Table 12).

A paucity of groundwater data exists across *Borda* and *Du Couedic* and also for a largely inaccessible area of scrub covered dunes to the east of Seal Bay Conservation Park (Fig. 7, Fig. 8 and Fig. 9). Few groundwater data are available within KI's National Parks due to difficulties presented by lack of vehicle access. Where groundwater data does exist, water level and water quality data relating to specific aquifers are often uncertain due to a lack of production zone and/or stratigraphic information.

The use of groundwater in non-prescribed regions can be difficult to quantify without dedicated well metering and monitoring data. Landowner surveys, land use maps and satellite imagery can be used to identify land use practice and estimate the levels of groundwater-dependent irrigation.

5.1. QUATERNARY

KI's main Quaternary aquifers include the Bridgewater Formation calcarenites and equivalents such as the Glanville Formation. Unconsolidated sand members of the Saint Kilda Formation and undifferentiated alluvial and fluvial clays, sands and gravels may also be important potential groundwater sources.

The Quaternary Bridgewater Formation has a high permeability due to the presence of solution features and consequently is considered to be a good aquifer (e.g. Uley South Lens and Polda Basin on Eyre Peninsula and Para Wurlie and Carribie Basins on Yorke Peninsula). Infiltration rates for these calcarenites are typically high and on KI this is indicated by the lack of drainage patterns over large areas underlain by the Bridgewater Formation. Recharge to the unconfined Quaternary aquifer percolates down through solution cavities and can stratify above more dense saline water (Barnett 1977). Low groundwater salinities (500–1500 mg/L) have been recorded from the Bridgewater Formation in a number of areas (Hanson Bay, Flour Cask Bay and Nepean Floodplain). These observations of good quality groundwater are limited in extent often with nearby wells yielding high salinity groundwater. Well yields as high as around 2 L/s have been reported (Barnett & Dodds 2000).

River alluvium aquifers can yield groundwater salinities less than 1000 mg/L which include observations along both Middle River and Cygnet River. Barnett and Dodds (2000) postulated that the recent gravel aquifers of the Cygnet River may occur in a limestone-basal palaeochannel, which may be narrow and difficult to locate. Small storages of low-salinity groundwater (less than 1500 mg/L) have also been discovered in sandy shell beds at between 2–3 m depth. These occur between unconsolidated sand dunes toward the south-western coastal fringe of Nepean Bay.

5.2. TERTIARY

The Tertiary Hallett Cove Sandstone and the Kingscote Limestone have been identified on KI and logged up to thicknesses of 40 and 80 m respectively. Unconfined Tertiary limestone and sand aquifers commonly contain high-salinity groundwater which is likely connate in origin (Barnett 1977; Shepherd 1978). Low-salinity groundwater can occur in good recharge areas around Cygnet River (Shepherd 1978). Kingscote Limestone salinities in this area are between 1500 and 3300 mg/L and yields generally range between 1 and 2 L/s. It is likely that wells showing lower groundwater salinities are spatially correlated with zones of greater rainfall or surface water recharge (Barnett & Dodds 2000), but are likely to be localised with salinities quickly increasing with distance from the recharge area.

Undifferentiated Tertiary to Quaternary clays, sand and gravels have been identified throughout much of KI's interior with some good to moderate quality groundwater observed. These sediments are usually less than 5 m thick but intersections up to 30 m thick have been encountered. Thicker sediments may represent areas of potential for groundwater development. Elsewhere groundwater may be perched and ephemeral but may provide important groundwater discharge which maintains stream flow, pools and aquatic habitats (Banks 2010).

5.3. PERMIAN

Permian glacial sediments primarily occur around the Kingscote–Smith Bay area (Shepherd 1978). These sediments are poor aquifers due to the impermeable characteristics of stiff boulder clay which is common throughout (Barnett 1977). Barnett and Dodds (2000) reported low yields from Permian glacial sediments of less than 0.1 L/s and salinities greater than 30 000 mg/L. One well screened within the Cape Jervis Formation and located south of Smith Bay has salinity of less than 5000 mg/L.

5.4. CAMBRIAN (BASEMENT)

Barnett (1977) reported that basement rocks of the Early Cambrian Kanmantoo Group are tight and impermeable. These rocks are often devoid of the open joints and fractures that delineate the fractured rock matrix between which groundwater is ordinarily stored and transmitted. Soluble, clayey weathering products infill the joints and fractures that are present, resulting in groundwater of relatively high salinity (Barnett & Dodds 2000). The clayey weathering products also inhibit rainfall recharge to fractured rock aquifers in the central plateau area, causing waterlogging problems.

Groundwater salinities from wells identified to be open to Cambrian aquifers range between 300 and 23 000 mg/L (mean 4500 mg/L). Lower salinities are more common in the centre and west of the Island, particularly near Hanson Bay and Middle River and a cluster of low-salinity wells around 10 km north of Vivonne Bay. Yields from wells completed within fractured rock aquifers are generally less than 2 L/s. Barnett (1977) noted that high salinities can persist irrespective of high rates of surface runoff suggesting that recharge rates are likely to be low.

Barnett and Dodds (2000) postulated that vertical joints in Wisanger Basalts may act as groundwater conduits to underlying impervious sediments, possibly resulting in lateral flow and the formation of springs around the Gap Hills.

The Normanville Group Limestones can contain solution features and cavities, which on the southern Fleurieu Peninsula has resulted in high well yields and lower salinity through enhanced recharge where they outcrop or subcrop (Barnett & Rix 2006). However, extensive development of these aquifers has been limited due to the unpredictable occurrence of solution features.

5.5. POTENTIAL FOR GROUNDWATER USE

Groundwater is available in most locations but is highly variable in quality, quantity and accessibility (well yield and location). Groundwater salinities across KI are generally high (mean of 7800 mg/L), despite rainfall rates of 540–800 mm/y (BoM 2011). Generally high salinities are a result of the regional geology. The nature of the deep clayey weathering zones of the Kanmantoo basement rocks acts as a barrier to recharge and mineral dissolution contributes to these higher salinities (Barnett & Dodds 2000).

Groundwater of low salinity has been observed in wells scattered across KI, but are considered to be limited in extent with limited spatial correlation to hydrostratigraphic formations. Low-salinity groundwater is most apparent around southwest KI between Hanson Bay, Brigadoon and Cape Bedout and central KI between Mount Stockdale, Parndana and Middle River. In KI’s east, on Dudley Peninsula as well as between Flour Cask Bay (south coast) and Smith Bay (north coast), low salinity observations do occur but are scattered amongst numerous high salinity records.

Water wells throughout the study region have yields that are predominately less than 1 L/s, which is not likely to accommodate the needs of high-volume groundwater users. Users requiring supplies of over 3–5 L/s might consider targeting high-yielding brackish or saline aquifers (if available) and employ desalination technologies as required (Barnett & Dodds 2000).

Barnett and Dodds (2000) reported that despite having similar rainfall and basement lithology to the Mt Lofty Ranges, the fractured rock aquifers for KI are poor with low development potential. As sedimentary cover across much of KI is thin or absent, fractured rock aquifers represent as the only option for groundwater in many areas

In some places, recent deposits would be favoured for groundwater development opportunities, optimally where Quaternary and Tertiary sediment thickness is greatest. These sediments may contain good quality groundwater where adequate recharge occurs. Rapid recharge into the Bridgewater Formation aquifers, as occurs in the Eyre and Yorke Peninsulas, results in large storages of good quality groundwater. Significant thicknesses of the Bridgewater Formation have been logged along the southern coastal margin, particularly around Flour Cask Bay. Additionally, the Nepean Floodplain between Cygnet River and the Cygnet Fault contains notable thicknesses of Quaternary and Tertiary deposits. The Bridgewater Formation is widespread along KI’s southern, eastern and western coastal margins, but is largely coincident with conservation areas, which may impede attempts to investigate and access this resource. Furthermore, care should be taken in abstracting these resources as over-pumping may promote incursion of underlying saline groundwater into the well.

To understand the prospects for groundwater extraction, estimates of resource potential and volumetric capacity could be made based on revised and more detailed knowledge of aquifer formations, their hydrogeological properties and associated water levels.

Information of Quaternary and Tertiary sedimentary sequences, such as mean thickness and range of occurrence, can be calculated for a defined geological region or spatial extent (e.g. 1:100 000 map sheet). As a preliminary assumption, locations of greater sedimentary thickness may have a potential for larger volumes of groundwater storage. However, groundwater levels needs to be considered in tandem with sedimentary thickness to enable estimation of saturated thickness. By assuming a value for the porosity of the matrix, groundwater storage can be estimated from the saturated thickness.

Fractured rock aquifers are far more complex than sedimentary sequences and consequently estimating the capacity of groundwater resources in fractured rock environments requires many simplifying assumptions about the degree of and depth to which water-bearing fractures extend and about the porosity of the system.

5.5.1. GROUNDWATER RECHARGE

In determining the water balance, rainfall recharge is the most difficult parameter to estimate as it is dependent on variables including rainfall intensity and duration and the nature of the land cover and soils. Across the KINRM area, rainfall recharge is likely governed by climatic processes and by the permeability of soils and underlying geology.

Aeolian sediments, including the Bridgewater Formation, have been identified along much of KI's coastal margins. Where recharge rates are high, infiltration of rainfall may occur readily through highly permeable sediments, consistent with the observed lack of surface drainage along KI's southern coastal region.

Groundwater recharge to fractured rock aquifers is considered to be localised and irregular. Although the dynamics of fractured rock aquifer hydrology is more uncertain than sedimentary systems, the volume of recharge is generally considered to be governed by the underlying fracturing (permeability) of the rock, while groundwater quality may be determined by the location of the well with respect to local recharge zones.

On KI, clayey weathering products often infill joints and fractures which can inhibit recharge and promote surface runoff (streams). These clayey products may also dissolve contributing salinity to the groundwater. Recharge to fractured rock systems across the KINRM Region is not well understood, but recharge may occur where basement material outcrops and sub-crops, as well as via vertical and lateral leakage from adjacent aquifers. Furthermore, vertical cracks and joints in the Wisanger Basalts may facilitate preferential flow of rainfall to impermeable sediments underlying them, possibly resulting in the formation of springs around the perimeter of the Gap Hills (Barnett & Dodds 2000).

5.5.2. POTENTIAL CLIMATE CHANGE IMPACTS

Regional climate change scenarios for the KINRM Region have been developed, based on statewide climate modelling conducted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in 2003. Suppiah et al. (2006) reported on the impacts of three different emission scenarios (1) no policies to reduce emissions, (2) greenhouse gas emissions stabilise at 450 ppm by 2100 and (3) emissions stabilise at 550 ppm by 2150. The authors concluded that:

- by 2030, annual temperature will likely increase between 0.3–1.0 °C
- by 2070, annual temperature will likely increase between 0.6–3.0 °C
- annual rainfall will likely decrease by 1–11% by 2030 and by 3–30% by 2070.

Forecasts of impacts to the hydrology of the KINRM Region due to climate change include a considerable reduction in the volume and increased variability of surface water run-off. Furthermore, groundwater recharge events are projected to become less predictable and more episodic. The consequential impacts on dryland salinity are unknown. Reductions in rainfall, runoff and groundwater recharge would likely result in increased pressure on water resources, necessitating increasing groundwater well depths and increasing dam storages. Changes in the dynamics of surface water-groundwater interaction are possible and risks due to a lack of capacity for adaptation need to be considered.

SA Water has considered potential changes in demand for water across the region. SA Water (2009) cites an increase in demand by up to 10% by 2018. This estimate is based on CSIRO investigations undertaken on other water supply systems, considering assessments of temperature, evaporation and rainfall projections under different CO_2 emission scenarios across South Australia.

GROUNDWATER RESOURCES

DFW is undertaking assessments of groundwater resources which are vulnerable to the impacts of climate change through the *Impacts of Climate Change on Water Resources* (ICCWR) project. Detailed modelling of groundwater resources under various CO_2 emission scenarios is currently being conducted and forecasts made of potential climate change impacts on the rate of rainfall recharge. The scope of the ICCWR project is currently limited to mainly Prescribed Wells Areas and Prescribed Water Resources Areas. However, the non-prescribed KINRM Region falls within the scope of the ICCWR project.

Table 12. Summary of main geological units and their hydrogeological significance (Barnett 1977; Shepherd 1978; Barnett & Dodds 2000; Geoscience Australia 2011)

Age			Unit	Lithology	Occurrence and Hydrogeology
Quaternary	Holocene		Saint Kilda Formation	Shallow marine deposits; includes shell beds, sands and clays. *Semaphore Sand Member* – Unconsolidated white to pale grey bioclastic quartz-carbonate sand of modern beaches and transgressive dune fields. *Gantheaume Sand Member* – Unconsolidated aeolian cliff top dunes and sand spreads from reworking of Bridgewater Formation.	Occurs commonly along southern and western coastline and coastal fringes of Nepean Bay; unconfined aquifer; salinity generally at or greater than sea water. Semaphore Sand Member occurrences is limited to near-coastal areas between the Cygnet Fault and the Nepean Bay coastline. Small storages of good quality groundwater can been found 2–3 m below ground surface between unconsolidated sand dunes toward the south-western corner of Nepean Bay.
Quaternary	Pleistocene	Late	Glanville Formation	Soft, white to cream-fawn richly fossiliferous shelly sand and clay and calcreted shell beds	In general, groundwater is highly saline; occurs south-east of American River
Quaternary	Pleistocene	Middle	Bridgewater Formation	Calcareous sands; broken, rounded shell fragments and limestone	Unconfined aquifer; widespread along the southern and western coastlines; salinities are variable, but as low as 500 mg/L and yields up to 2 L/s. Good quality groundwater residing within the Bridgewater Formation appears to be correlated with rainfall – The lowest salinity groundwater occur mainly in the south-western part of KI where rainfall is highest.
Tertiary	Pliocene		Hallett Cove Sandstone	Marine fossiliferous sandy limestone and calcareous sandstone. Transgressive, shallow marginal marine.	Identified in the east of KI, as surface exposure inland of Flour Cask Bay. Further north is has been logged at mean depth of 13 m and mean thickness of 17 m. Salinities associated with three wells known to intersect this formation are variable (550-17 000 mg/L), but screen intervals are unknown.
Tertiary	Eocene – Oligocene		Kingscote Limestone	Fossiliferous limestone and sandy limestone. Echinoid, bryozoan and molluscan in the lower part, cross bedded calcarenite in the upper part.	Found mainly around Kingscote, Cape Willoughby and Flour Cask Bay; good quality groundwater correlated with higher recharge areas near Cygnet River; salinities can be extremely variable (1000–14 000 mg/L) over distances of only 500 m
Jurassic			Wisanger Basalt	Dark, fine-grained basalt containing pillows, columnar jointing and quartz-filled vesicles	Identified occurrence towards the north coast, east of Kingscote. The basalt may play an important role in groundwater recharge but no groundwater information is available.
Carboniferous – Early Permian			Cape Jervis Formation	Permian glacial sediments. Poorly sorted, unconsolidated yellow-green siltstone, sandstone, sandy limestone, tills, fossiliferous shales and grit with rounded pebbles and boulders.	Occurs mainly in the Kingscote–Smith Bay area with minor occurrences near Penneshaw; poor aquifer due to the impermeable nature of the clay; groundwater generally of high salinity and yields of less than 0.1 L/s. Good quality groundwater has been reported north-east of the township of Kanbara.

Age		Unit	Lithology	Occurrence and Hydrogeology
Cambrian	Early – Late	Kanmantoo Group	Metamorphosed, argillaceous sandstones and quartzites, quartz-mica schists and phyllitic siltstones	Includes Middleton Sandstone, Petrel Cove Formation, Tapanappa Formation, Tunkalilla Formation; occurs across all of KI except the Stokes Bay–Nepean area; generally tight and impermeable with few open fractures and joints; soluble products subsequently dissolve resulting in high-salinity groundwater. Some fresh groundwater observations have been made e.g. toward the north-west of *Borda*; near the southern coastal township of Hanson Bay; toward the east of *Vivonne* (between Mount Stockdale and Cape Dutton) and along the north-east coast of Dudley Peninsula.
Cambrian	Early – Middle	Kangaroo Island Group	Shallow marine mudstone, shale, sandstone and conglomerate	Includes Smith Bay Shale and Stokes Bay Sandstone. Occurrence is north of the Cygnet Fault. Similarly to the Kanmantoo Group the Kangaroo Island Formation is generally tight and impermeable with few open fractures and joints; soluble products subsequently dissolve resulting in high-salinity groundwater.
Cambrian	Early	Normanville Group & Equivalents	Marine shelf to basinal carbonate. Limestone; sandstone; shale; volcanics. e.g. Parara Limestone – Blue–grey nodular limestone; can be interbedded dark grey to black; minor mottled argillaceous limestone and thin calcareous shale.	The Parara Limestone, Winulta Formation (sandstone, conglomerate) and the Wangkonda Formation (limestone) have been logged beneath Kangaroo Island Group material at Emu Bay. Surface expression occurs between Penneshaw and Cape Willoughby; groundwater observations are not available.
Neo-protero zoic		Adelaidean	Sequence of quartzites, sandstones, limestones, siltstones and shales	Occurrences are limited to a narrow zone between Newland Bay and Cape Forbin; likely to contain only saline groundwater

6. RECOMMENDATIONS AND FURTHER INVESTIGATIONS

This initial investigation has collated groundwater information for the KINRM Region and presents a regional description of the non-prescribed groundwater resources. Geological and hydrogeological data have been compiled with particular attention given to the identification of major hydrogeological units and related groundwater information.

Additional assessment of non-prescribed groundwater resources will be addressed in a prioritised manner and structured to allow stakeholders an opportunity to provide feedback on their priority needs for groundwater resources. The 'Phase 2' assessments will be developed to advance the understanding of groundwater resources of South Australia deemed to have a greater short term need for improved knowledge. Areas for further and more detailed assessments in Phase 2 will be defined based on criteria including importance of and proximity to, proposed and projected development activities (e.g. mining or other industrial economic developments), as well as population development needs. It is anticipated that Phase 2 assessments will involve more detailed desktop analysis of the available information but may need to be supported by targeted field activities to fill information gaps.

The following recommendations are made with a view to guide project planning for future non-prescribed groundwater assessments. Identified key knowledge gaps include groundwater storage, sustainable yield, rates and volumes of groundwater abstraction and processes of groundwater recharge. Better knowledge of these parameters is fundamental to formulating strategies for sustainable water use.

6.1. DATA CAPTURE AND DATA VALIDATION – SA GEODATA

It is recommended that greater attention be focused on groundwater data capture and validation and ensuring that all available historical groundwater data (e.g. microfiche and exploration files) are available via the State geodatabase, SA Geodata. Salinity or water level data which are many decades old may be valuable for analyses of trends in the condition of the groundwater resource. Also, lengthy time series are useful in calibrating and validating numerical groundwater models. Importantly, archived data not yet entered into SA Geodata may include well construction details, which is invaluable as it enables a more robust assessment of groundwater resources through identifying the specific aquifer(s) from which groundwater samples have been taken.

6.2. MONITORING NETWORKS

Groundwater levels provide important information on the relationships between recharge, discharge, storage and flow directions of groundwater systems. Long term monitoring is essential in the development of groundwater models and to design, implement and monitor the effectiveness of groundwater management programs (Wen 2005).

A number of groundwater monitoring networks are established across the study region. A detailed report covering all prescribed and non-prescribed monitoring networks was prepared for DFW (AGT 2010). This report provides dialogue on groundwater observation networks that are recognised in the State's observation well database (*Obswell*) and recommended:

- The Rocky River network should be reviewed to determine its future viability to monitor the state and condition of the resource

- The Rocky River network could be rationalised from 32 monitoring sites to 12
- New groundwater monitoring sites should be established adjacent to wetlands that are representative of the type of wetlands found on KI
- Groundwater level monitoring should be conducted at least quarterly.

The adoption of groundwater loggers at representative sites of interest, which are equipped with telemetry for remote monitoring would reducing the need for quarterly visits and therefore the required monitoring investment in the long term.

There is no apparent groundwater water quality monitoring undertaken on KI (presumably due to high salinity) other than the Rocky River network. Selected wells should be periodically sampled in other areas/networks provided stratigraphy, well construction and aquifer monitored is known. Monitoring in most areas of the State is focussed on water levels (quantity of resource) yet in some areas both protection and potential use/sustainability of the resource is in some cases, more dependant on management of water quality.

There may be private groups across the region that manage networks or groups of wells that actively observe groundwater, but are not under a formal arrangement to have data included into the State database. Known custodians of privately monitored groundwater networks and data should also be approached to share groundwater data that can be accessed through the State database.

Outside of the established monitoring networks, available regional water well data for most areas (i.e. water level, salinity and yield) are several decades old. The lack of recent groundwater information does not allow an accurate appraisal of the current groundwater condition and hampers the assessment of the resource potential. Historically, the establishment of groundwater monitoring networks has been to manage potable resources and dryland salinity. However, emergence of non-potable groundwater use highlights the importance of understanding and monitoring these resources so that they can be managed for all potential users.

It is recommended that a regional monitoring program be developed, particularly for non-prescribed areas with a high probability of future development, to enable review of the status of both potable and non-potable groundwater resources. A suitable approach may target a broad network of operational wells for which stratigraphic and production zone information exists.

Recommendations and activities that relate to groundwater monitoring and associated infrastructure requirements will be closely linked with the *Groundwater Program's* Statewide Groundwater and Water Monitoring System project. This is a project that aims to deliver a reliable 'fit for purpose' State groundwater monitoring network that is under regular review with respect to current suitability and future needs.

6.2.1. MONITORED AQUIFERS

As part of this project, the occurrence of individual stratigraphic units of hydrogeological significance were examined and used to develop a hydrogeological discussion around the available groundwater data. For a limited number of suitable wells, available well production zone information was correlated with the associated stratigraphic intervals to indicate the geological interval(s) to which the well is open. A significant knowledge gap exists with respect to aquifers being monitored across all of KI's monitoring networks. Details of the aquifers that the observation wells are open to are absent for all wells assigned to these networks.

Knowledge of the open aquifer interval would allow for a more robust analysis of the available groundwater data. Further interpretation of lithological logs to hydrostratigraphic intervals coupled with validation of well production zones would allow an aquifer monitored description to be linked to a greater amount of groundwater observations.

6.3. AQUIFER EXTENT

To determine volumetric estimates of groundwater storages, better definition of the vertical and areal extents of hydrostratigraphic units is required. Refined estimates of aquifer extent would aid in 3-D mapping of groundwater systems (Section 6.8.1). Furthermore, refining the hydrogeological significance of various geological units could be achieved via interpretation of stratigraphic logs from existing lithological logs. However, large areas can be devoid of drillhole information and drilling programs would best define the likely areal extent of groundwater resources. Drilling programs are extremely resource intensive and geophysical methods may be favoured where budgetary constraints restrict drilling programs.

6.4. GEOPHYSICAL DATA

Geophysical datasets often provide valuable interpretation that could not otherwise be obtained without expensive conventional groundwater investigations. Where paucity of data presents barriers to defining aquifer extent, geophysical methods (e.g. gravity, electromagnetic, shallow seismic) may be the most cost-effective option for filling data gaps. Airborne geophysical techniques can acquire vast amounts of data within a short time frame over complex terrain.

Magnetic Resonance Sounding provides a qualitative evaluation of sub-surface water content and, although in the early stages of application in Australia, this approach promises to be a valuable geophysical tool to aid in groundwater status assessments.

6.5. AQUIFER HYDRAULIC PROPERTIES

Hydraulic properties of an aquifer such as transmissivity and storage (specific yield or specific storage) can be determined by conducting aquifer tests. Tests targeted at specific hydrostratigraphic units would result in a more robust understanding of groundwater conditions across the KINRM Region. Aquifer testing could be focused on areas where demand for groundwater is likely to be greatest. However, it should be noted that good quality data from aquifer tests are contingent on meeting numerous assumptions, two of which are: (1) the aquifer of interest is the only aquifer that is pumped/monitored and (2) the well(s) from which data are collected are screened across the entire thickness of the aquifer. Appropriately constructed wells can indicate the capacity of a groundwater system to supply water in the long term and in a sustainable manner.

6.6. FRACTURED ROCK AQUIFERS

Due to the high variability and generally poor prospects identified for fractured rock (basement) aquifers, they are utilised in only a few areas across the KINRM Region. They are considered to be of low importance to the overall low salinity groundwater resource capacity of the region but a large knowledge gap exists with regard to their volumetric potential. Limited reliable data are available for fractured rock aquifers. Investigations targeting fractured rock formations would aid in defining the potential of these resources.

6.6.1. DEPTH TO BASEMENT INTERPRETATION

A regional definition of depth to basement is a valuable product in the estimation of sedimentary sequence thicknesses and groundwater storage volumes. A basement map based on geophysical data including shallow seismic, regional gravity and magnetic data is recommended for the development of accurate resources assessments.

A valuable related product would be a map of saturated sedimentary thickness. Such a spatial product could be coupled with a distribution map of salinity and a well capacity rating, based on the knowledge of the formation type and well yields. Such a product would require detailed well and groundwater data validation and a program of aquifer testing.

6.7. GROUNDWATER RECHARGE

Recharge to the groundwater system is an important component to the water budget and estimates of recharge are essential to define a resource’s capacity to sustain supply over a given time period. Further investigation is required to better understand the magnitude and processes of natural groundwater recharge in non-prescribed areas.

In order to better estimate recharge to unconfined aquifers, the feasibility of regional modelling of recharge using such packages as the WAVES model as used in Murray-Darling Basin modelling projects (e.g. Crosbie et al. 2008) should be investigated. Estimating rates of rainfall recharge within fractured rock environments is especially challenging. Numerical modelling and/or water balance studies may aid in constraining estimated ranges of recharge to fractured rock aquifers.

CSIRO and Geoscience Australia have recently developed a framework for a nationally consistent approach to estimating recharge and discharge in data poor areas (CSIRO 2011). To generate estimates of recharge, two stand-alone tools required users to populate key inputs fields including rainfall, soil and regolith texture, bedrock type and vegetation. The tools are in the Microsoft Excel® spreadsheet format and recharge and discharge estimates are based on simple approximations with data that are readily available or accessible.

Extending the scope of DFW’s ICCWR project may aid in estimating future recharge rates of the non-prescribed groundwater resources across the KINRM Region, in addition to facilitating the evaluation of climate change impacts on recharge into the future.

6.8. PRODUCTS

To enable easier interpretation of groundwater data, a number of map products have been generated during this study. These map products have been designed to improve accessibility to groundwater information for key stakeholders and the public. Additional map products have been identified which would complement the products developed here. Optimal technologies by which they might be delivered have been explored.

6.8.1. 3-D MAPPING

The petroleum and mining industries are well advanced in using 3-D mapping and visualisation techniques to aid in the assessment of potential reserves of oil or ore. Hydrogeologists in Australia are beginning to take advantage of these technologies to aid in the development of conceptual hydrogeologic models within a virtual 3-D environment. Manipulating and evaluating data within a 3-D environment enables volumetric assessment (e.g. groundwater storage) of the resource in addition to state-of-the-art static visualisation and animation.

6.8.1.1. ArcHydro ®

ArcHydro® is a geodatabase design and incorporates a suite of accompanying tools tailored for support of water resource assessment applications within ESRI’s ArcGIS® (Geographic Information System, or

GIS) environment. ArcHydro® is compatible with Microsoft Access® and ArcGIS® thereby providing an interface between the State's stratigraphic database and GIS software. It is expected that the main benefits will be improvements in the way that groundwater data are queried, superior reporting products, 3-D visualisation and capabilities including the calculation of stratigraphic Geo-volumes, which can be used to develop estimates of groundwater storage.

6.8.2. ONLINE PDF MAPS

The most recent available datasets of groundwater and aquifer formations could be arranged and presented (for download) as high quality Portable Document Format (PDF) map products. These would deliver the functional advantages of spatial software through a layered information structure. Users (such as industry and community) would be able to toggle layers and annotations on and off, zoom in and out and query groundwater related layers and labels. Such a product could be delivered to the wider audience via the internet and current freeware (Adobe Reader). Any new data or knowledge generated and incorporated into the database can be updated to the PDF products in subsequent iterations of data map production.

7. CONCLUSION

In an environment where water resources are increasingly scarce, the *Water for Good* plan states that resource assessment, monitoring and management of non-prescribed groundwater resources are crucial and necessary elements which will assist in achieving sustainable use of the resource. In response to water security issues facing the State, the DFW through the *Groundwater Program*, is striving to develop a better understanding of both potable and non-potable water resources capacity and a more proactive approach to groundwater management. These actions will benefit potential industry users of groundwater and improve the ability to manage the resource. To consolidate on current knowledge, this assessment report has collated data on hydrogeological formations and their groundwater, identified knowledge gaps and defined the need for further investigations to improve the ability to advise on groundwater development opportunities.

Groundwater is available in most locations but is highly variable in quality, quantity and accessibility. Groundwater resources of the KINRM Region are found within consolidated Quaternary aeolianites and recent river alluvium, Tertiary limestone and sandstone, Permian glacial sediments and Cambrian fractured rock aquifers. In some places, KI's recent deposits could be favourable for groundwater development opportunities, primarily where Quaternary and Tertiary sediment thicknesses are greatest. Fractured rock aquifers have generally low development potential.

A paucity of groundwater data exists in KI's west and few groundwater data are available within KI's National Parks due to difficulties of vehicle access. Where groundwater data does exist, water level and water quality data relating to specific aquifers are often uncertain due to a lack of production zone and/or stratigraphic information.

Well yields are predominately less than 1 L/s, which is not likely to accommodate the needs of high-volume groundwater users. Groundwater salinity across KI is generally high, as a result of the regional geology. Groundwater of low salinity has been observed in wells scattered across KI, but are considered to be limited in extent. The most apparent locations of low salinity groundwater are south-western KI between Hanson Bay, Brigadoon and Cape Bedout and Central KI between Mount Stockdale, Parndana and Middle River. In KI's east, on Dudley Peninsula as well as between Flour Cask Bay (south coast) and Smith Bay (north coast), low salinity observations do occur, but are scattered amongst numerous high salinity records.

Rapid recharge into the Bridgewater Formation may result in the potential for larger storages of good quality groundwater. Significant thicknesses of the Bridgewater Formation have been logged along the southern coastal margin, particularly around Flour Cask Bay. Additionally, the Nepean Floodplain between Cygnet River and the Cygnet fault contains notable thicknesses of the Quaternary and Tertiary deposits. However, care should be taken in abstracting these resources as over-pumping may promote incursion of underlying saline groundwater into the well.

Drivers of increasing groundwater demand include increasing tourism, irrigation and livestock numbers and forestry impacts on groundwater resources should be assessed. Changes in supply of groundwater are likely to be influenced by changes in climate. Based on modelling conducted by CSIRO, impacts of climate change are likely to include increasing temperature (leading to increasing rates of evaporation and transpiration) and decreasing rates of rainfall.

A good understanding of the impacts of any new groundwater resource development is required to ensure that existing groundwater resources and their users are not adversely affected. The supply potential of groundwater resources in the non-prescribed regions will be assisted by estimates of resource volumes, which will be the focus of subsequent non-prescribed investigations under the Groundwater Program.

Although a discussion of the available groundwater data is presented herein, this body of work does not explicitly identify any new viable resources without further assessment being actioned. The occurrence of individual stratigraphic units of hydrogeological significance are examined and used to develop a hydrogeological discussion around the available groundwater data. However, much of the groundwater data, due to a lack of supporting well construction information, are unable to be confidently allocated to an aquifer formation. An additional limitation which often precludes confident assessment is data age, which is often numerous decades old. The scarcity of available recent information limits the ability to make reliable estimates.

This report has identified key knowledge gaps including groundwater storage, sustainable yield, rates and volumes of groundwater abstraction and processes of groundwater recharge. Better knowledge of these parameters is fundamental to formulating strategies for sustainable water use. Consideration of stakeholders needs for groundwater resources and criteria including importance of and proximity to, proposed and projected development activities will prioritise areas for further assessment.

APPENDICES

APPENDIX A. KANGAROO ISLAND GEOLOGICAL FORMATIONS

This section aims to provide a more detailed description of the most commonly occurring geological formations across the study area. However, the following descriptions of stratigraphic units are not exhaustive. Geological summaries presented here are based on Lindsay and Shepherd (1966), Binks (1970), Shepherd (1978), Drexel, Preiss and Parker (1983), Drexel and Preiss (1995) and Geoscience Australia (2010); the reader is referred to these references for a more detailed discussion on geological formations. The spatial distribution of surface geology (Fig. 3) and geo-chronology of geological formations (Table 12) have been described in the main body of this report.

QUATERNARY

On KI, shallow groundwater is abstracted from coastal aeolianites (Bridgewater Formation) and recent sedimentary deposits. Recent alluvium deposits of Cygnet River have reportedly shown good quality groundwater (less than 1000 mg/L) and good well yields (up to 2.5 L/s). It has been postulated that these gravels may infill palaeochannels which have been eroded into underlying Tertiary limestone, forming aquifers that may be narrow and difficult to locate.

Bridgewater Formation (Qpcb)

Across KI the Quaternary limestone aquifer contains lithology of the Bridgewater Formation, consisting of calcareous sands, broken shell fragments and limestone. The Bridgewater Formation originated as barrier shoreline complexes, but also as transgressive sand dunes and aeolian sand sheets, which morph to thin veneers and can extend well inland. Local calcrete capping which forms at the evaporation front is common. Occurrences of Bridgewater Formation are common along the western and southern coastal fringes up to around 6–13 m thickness, but has been recorded up to 120 m thick in places.

Glanville Formation (Qpcg)

Intertonguing with and laterally equivalent to the Bridgewater Formation is the Glanville Formation. This formation comprises soft, white to cream–fawn richly fossiliferous shelly sand and clay and moderately cemented calcarenite shell beds. It occurs south-east of American River where, on KI, a seaway separated Dudley Peninsula from the rest of the island and was progressively choked by migrating transgressive dunes. Here, richly fossiliferous shelly limestone was deposited, which crops out extensively around the margins of Pelican Lagoon and around the margins of the Nepean Bay. In general, groundwater found within this formation is highly saline.

Saint Kilda Formation (Qhck)

The Saint Kilda Formation refers to all coastal and shelf sediments of Holocene age and comprise various sedimentary facies which were deposited by various marine processes. In general, sediments are calcareous, fossiliferous, shallow marine deposits and consist of shell beds, sands and clays. Sediments also occur as organic, gypseous clay of supratidal flats. It's base is clearly defined, as it disconformably overlies Pleistocene marine continental sediments and It's upper surface can be one of active sedimentation. This formation occurs along coastal fringes of Nepean Bay and is common along KI's southern and western coastlines. In areas other than KI, groundwater salinities within the Saint Kilda Formation are generally at or above the salinity of seawater.

The Semaphore Sand is a member of the Saint Kilda Formation and is limited to near-coastal areas between the Cygnet Fault and the Nepean Bay coastline. It consists of unconsolidated white to pale grey, chiefly calcareous bioclastic quartz-carbonate sand of modern beaches and transgressive dune fields.

TERTIARY

Tertiary sediments across KI bear groundwater of relatively high salinity, with the exception of small localised supplies of good quality groundwater in the Cygnet River region. Lower salinities are likely to correlate with areas of higher recharge. Groundwater salinities generally increase towards the east of Cygnet River which may indicate hydraulic connection between the Tertiary limestone and the ocean.

Hallett Cove Sandstone (Tph)

Little description is available for the Hallett Cove Sandstone with most available commentary derived from occurrences in the St Vincent Basin around the Hallett Cove area. The transgressive, shallow marginal marine formation infills the Troubridge Basin, which extends over eastern KI, southern Fleurieu Peninsula and bisects central Yorke Peninsula. The formation is described as a red-brown calcareous sandstone and siltstone, sandy limestone, oyster-rich bed with gastropods and bivalves. It has been mapped on KI between Flour Cask Bay and Cygnet River.

Kingscote Limestone (Teok)

The Late Eocene to Late Oligocene Kingscote Limestone is a bioclastic limestone with a thin basal bed of pebbly quartzose greensand. The richly fossiliferous yellow to buff limestone is echinoid, bryozoan and molluscan in the lower part and a cross bedded calcarenite in the upper part. The lowest unit of the Kingscote Limestone correlates in part with the Tortachilla Limestone that occurs in the southern part of the St Vincent Basin. On KI, it has been reported at Kingscote, Cygnet River Freestone Creek and Point Reynolds. The unconfined aquifer is reported to host good quality groundwater in higher recharge areas near the Cygnet River. The surrounding groundwater is highly saline and of likely connate origin.

PERMIAN – CARBONIFEROUS

Cape Jervis Formation (CP-j)

The formation consists of Carboniferous to Permian glacio-marine fluvioglacial sediments and residual erratics that are found within the Troubridge Basin. Poorly sorted, unconsolidated yellow–green siltstone, sandstone, sandy limestone, tills, fossiliferous shales and grit with rounded pebbles and boulders. Large granite erratics of the Cambrian Kanmantoo Group and a high concentration of coarser clasts are features of this formation. Pollen and spores are abundant. The uppermost part comprises glacio-marine siltstone with foraminifers. The glacigenic beds comprise five broad units within which there is considerable lithological variation. Clay shale, fissile, scattered boulders; sandstone, gritty, yellow-white, cross bedded, scattered calcareous pebbles, interbedded laminated fissile grey clay; boulder till, with clay-shale and sandy till.

Occurrences are mainly in the Kingscote–Smith Bay area with minor occurrences around Penneshaw. Scattered outcrops occur along the northern coast of KI between Dudley Peninsula and Smith Bay .The Cape Jervis Formation outcrops on KI where it is overlain by either Tertiary sediments or the Jurassic Wisanger Basalt. Glacigenic sediments up to 289 m thick were intersected near Kingscote and sediments around 200 m were intersected west of Kingscote in north–south trending troughs. Areas underlain by the Cape Jervis Formation are susceptible to dryland salinity as a result of poor drainage.

CAMBRIAN BASEMENT

For the purpose of the discussion presented here, weathered basement and hard crystalline basement have not been differentiated. Cambrian sediments within the Stansbury Basin are contained in a triangular region bounded by Yorke and Fleurieu Peninsulas and KI. Groundwater can occur within weathered and non-weathered basement (fractured rock) units. Within fractured rock aquifers, salinities are often high and yields are typically low. However, salinity and yield can be variable – the quality and quantity between wells in the same aquifer and sometimes only hundreds of metres apart can differ substantially.

Kanmantoo Group (Ek)

The formation consists of Early to Middle Cambrian marine metasandstone, phyllite, schist, gneiss, minor calcsilicate and marble; sandstone; siltstone, occasionally sulphidic; metamorphosed. Metamorphosed, argillaceous sandstones and quartzites, quartz-mica schists and phyllitic siltstones, generally tight and impermeable with few open fractures and joints. This group comprises the Tapanappa Formation, Talisker Formation and Middleton Sandstone and occurs across all of KI except the Stokes Bay–Nepean area. Clayey weathering products commonly infill joints and fractures. Soluble products subsequently dissolve which result in high-salinity groundwater. This aquifer is used mainly for small stock supplies, however isolated occurrences of fresher groundwater can be found.

Kangaroo Island Group (Ea)

The formation comprises Early to Middle Cambrian shallow marine mudstone, sandstone, shale and conglomerate. A conformable sequence of strata comprising (in ascending order) the Mount McDonnell Formation, Stokes Bay Sandstone, Smith Bay Shale, White Point Conglomerate, Emu Bay Shale, Boxing Day Formation. The upper sequences down to the basal, sandstone dominated white point conglomerate are correlated to the Kanmantoo Group on Fleurieu Peninsula, but the older sequences are not equivalent and the suggested correlative is the Normanville group. The Kangaroo Island Group is found mostly to the north of the Cygnet Fault.

NEOPROTEROZOIC BASEMENT

Adelaidean (N – undifferentiated Neoproterozoic)

The Adelaidean is a (local) South Australian chronostratigraphic scale which refers to the period during which Proterozoic sedimentation occurred in the Adelaide Geosyncline. Subdivisions of the Adelaidean – viz. Willouran, Torrensian, Sturtian and Marinoan – are based on type sections of strata. The Flinders Ranges and Mount Lofty Ranges host a record of Adelaidean sedimentation which is internationally recognised for its high level of completeness. Formations of Adelaidean age comprise sequences of quartzites, sandstones, limestones, siltstones and shales. Occurrences on KI are limited to narrow zone between Newland Bay and Cape Forbin. These fractured rock aquifers are likely to contain only saline groundwater.

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

GLOSSARY

3-D — Three dimensional
ABS — Australian Bureau of Statistics

Aquifer — An underground layer of rock or sediment that holds water and allows water to percolate through

Aquifer, confined — Aquifer in which the upper surface is impervious (see 'confining layer') and the water is held at greater than atmospheric pressure; water in a penetrating well will rise above the surface of the aquifer

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

Artesian — An aquifer in which the water surface is bounded by an impervious rock formation; the water surface is at greater than atmospheric pressure, and hence rises in any well which penetrates the overlying confining aquifer

AGT – (environmental consultants) Australian Groundwater Technologies

AHD – Australian Height Datum; the geodetic datum for altitude measurement in Australia. In 1971 the mean sea level for 1966–1968 was assigned the value of zero on the Australian Height Datum at thirty tide gauges around the coast of the Australian continent

AWRIS – The Australian Water Resources Information System

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

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

Biodiversity — (1) The number and variety of organisms found within a specified geographic region. (2) The variability among living organisms on the earth, including the variability within and between species and within and between ecosystems

Biological diversity — See 'biodiversity'

BoM — Bureau of Meteorology, Australia

Bore — See 'well'

Catchment — That area of land determined by topographic features within which rainfall will contribute to run-off at a particular point

CMB — Chloride mass balance

CSIRO — Commonwealth Scientific and Industrial Research Organisation

DFW — Department for Water (Government of South Australia)

DMITRE — Department for Manufacture, Innovation, Trade, Resources and Energy

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

Dryland salinity — The process whereby salts stored below the surface of the ground are brought close to the surface by the rising watertable. The accumulation of salt degrades the upper soil profile, with impacts on agriculture, infrastructure and the environment.

DTEI – Department for Transport, Energy and Infrastructure

DWLBC — Department of Water, Land and Biodiversity Conservation (Government of South Australia)

DWR – Department for Water Resources

EC — Electrical conductivity; 1 EC unit = 1 micro-Siemen per centimetre (µS/cm) measured at 25°C; commonly used as a measure of water salinity as it is quicker and easier than measurement by TDS

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

Erratics — Glacier-transported rock fragments that differ from the local bedrock

Fully-penetrating well — In theory this is a wellhole that is screened throughout the full thickness of the target aquifer; in practice, any screen that is open to at least the mid 80% of a confined aquifer is regarded as fully-penetrating

GIS — Geographic Information System; computer software linking 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

Groundwater — Water occurring naturally below ground level or water pumped, diverted and released into a well for storage underground; see also 'underground water'

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

Hydraulic conductivity (K) — A measure of the ease of flow through aquifer material: high K indicates low resistance, or high flow conditions; measured in metres per day

Hydrogeology — The study of groundwater, which includes its occurrence, recharge and discharge processes, and the properties of aquifers; see also 'hydrology'

ICCWR — Impacts of Climate Change on Water Resources

Impact — A change in the chemical, physical, or biological quality or condition of a water body caused by external sources

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

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 mechanical means

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

KI — Kangaroo Island

KINRM — Kangaroo Island Natural Resources Management

KINRMB — Kangaroo Island Natural Resources Management Board

mAHD — Defines elevation in metres (m) according to the Australian Height Datum (AHD)

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

Monitoring — (1) The repeated measurement of parameters to assess the current status and changes over time of the parameters measured (2) Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, animals, and other living things

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

Natural resources — Soil, water resources, geological features and landscapes, native vegetation, native animals and other native organisms, ecosystems

NRM — Natural Resources Management; 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

Observation well — A narrow well or piezometer whose sole function is to permit water level measurements

Obswell — Observation Well Network

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

PDF – Portable Document Format

Penetrating well — See 'fully-penetrating well'

Permeability — A measure of the ease with which water flows through an aquifer or aquitard, measured in m^2/d

PIRSA — Primary Industries and Resources South Australia (Government of South Australia)

Population — (1) For the purposes of natural resources planning, the set of individuals of the same species that occurs within the natural resource of interest. (2) An aggregate of interbreeding individuals of a biological species within a specified location

Potable water — Water suitable for human consumption such as drinking or cooking water

Prescribed water resource — A water resource declared by the Governor 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 well — A well declared to be a prescribed well under the Act

PWRA — Prescribed Water Resources Area

QA – Quality Assurance

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

Reticulated water — Water supplied through a piped distribution system

Riparian — Of, pertaining to, or situated or dwelling on the bank of a river or other water body

Riparian areas — Geographically delineable areas with distinctive resource values and characteristics that comprise the aquatic and riparian ecosystems

Riparian habitat — The transition zone between aquatic and upland habitat. These habitats are related to and influenced by surface or subsurface waters, especially the margins of streams, lakes, ponds, wetlands, seeps, and ditches

Riverine habitat — All wetlands and deep-water habitats within a channel, with two exceptions — wetlands dominated by trees, shrubs, persistent emergent mosses or lichens, and habitats with water that contains ocean-derived salt in excess of 0.5 parts per thousand

SA Geodata — A collection of linked databases storing geological and hydrogeological data, which the public can access through the offices of PIRSA. Custodianship of data related to minerals and petroleum, and groundwater, is vested in PIRSA and DWLBC, respectively. DWLBC should be contacted for database extracts related to groundwater

SARIG — (DMITRE's) South Australian Resources Information Geoserver

SATC – South Australian Tourism Commission

SA Water — South Australian Water Corporation (Government of South Australia)

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

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

Sustainability — The ability of an ecosystem to maintain ecological processes and functions, biological diversity, and productivity over time

T — Transmissivity; a parameter indicating the ease of groundwater flow through a metre width of aquifer section (taken perpendicular to the direction of flow), measured in m^2/d

TDS — Total dissolved solids, measured in milligrams per litre (mg/L); a measure of water salinity

Tertiary aquifer — A term used to describe a water-bearing rock formation deposited in the Tertiary geological period (1–70 million years ago)

Transmissivity (T) — A parameter indicating the ease of groundwater flow through a metre width of aquifer section

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

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; a lake through which water flows; a channel (but not a channel declared by regulation to be excluded from the this definition) into which the water of a watercourse has been diverted; and part of a watercourse

Water quality data — Chemical, biological, and physical measurements or observations of the characteristics of surface and groundwaters, atmospheric deposition, potable water, treated effluents, and wastewater, and of the immediate environment in which the water exists

Water quality information — Derived through analysis, interpretation, and presentation of water quality and ancillary data

Water quality monitoring — An integrated activity for evaluating the physical, chemical, and biological character of water in relation to human health, ecological conditions, and designated water uses

Well — (1) An opening in the ground excavated for the purpose of obtaining access to underground water. (2) An opening in the ground excavated for some other purpose but that gives access to underground water. (3) 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 to 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 tides does not exceed six metres.

WSS —Water supply system

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