Groundwater levels and storage capacity of the Southern Basins Prescribed Wells Area – Uley Wanilla and Lincoln South

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Department for Environment and Water
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The Department works in partnership with the First Peoples of South Australia and supports their Nations to take a leading role in caring for their Country.

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Foreword

The Department for Environment and Water (DEW) is responsible for the management of the State's natural resources, ranging from policy leadership to on-ground delivery in consultation with government, industry and communities.

High-quality science and effective monitoring provide the foundation for the successful management of our environment and natural resources. This is achieved through undertaking appropriate research, investigations, assessments, monitoring and evaluation.

DEW's strong partnerships with educational and research institutions, industries, government agencies, Landscape Boards and the community ensures that there is continual capacity building across the sector, and that the best skills and expertise are used to inform decision making.

Ben Bruce
CHIEF EXECUTIVE
DEPARTMENT FOR ENVIRONMENT AND WATER

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1. Summary

The Southern Basins Prescribed Wells Area (PWA) is located within the Eyre Peninsula Landscape Board region. Groundwater is the primary water resource within the area, supporting public water supply (PWS), stock and domestic use, industry and numerous terrestrial and marine groundwater-dependent ecosystems (GDEs). The groundwater resources are divided into management zones (i.e., consumptive pools) under the *Water Allocation Plan for the Southern Basins and Musgrave PWAs* (the WAP) (EPNRMB 2016).

This report presents an assessment of groundwater levels, groundwater salinity and groundwater storage conditions within the Uley Wanilla and Lincoln South consumptive pools. The assessment draws on long-term groundwater monitoring records, groundwater resource condition reporting, groundwater storage assessments and previous hydrogeological investigations undertaken within the Southern Basins PWA.

Groundwater resources across the Eyre Peninsula are experiencing increasing pressure from climatic variability, declining rainfall recharge, and long-term groundwater extraction. Recent groundwater modelling for the adjacent Uley South Consumptive Pool indicates that ongoing extraction at historical rates is likely to result in continued groundwater level decline, reductions in groundwater storage and increasing risks to groundwater quality (DEW 2023b; DEW 2023c).

The groundwater level, groundwater salinity and storage data presented in this report indicate that both Uley Wanilla and Lincoln South consumptive pools are experiencing long-term groundwater level decline and reduced resilience to climatic variability. In the Uley Wanilla Consumptive Pool, groundwater level declines and reductions in storage indicate increasing risks to GDEs that rely on groundwater discharge and shallow groundwater conditions. In the Lincoln South Consumptive Pool, declining groundwater levels have contributed to a reversal in hydraulic gradients, increasing the likelihood of saline-water ingress from the surrounding QL aquifer, the ocean and, potentially, Sleaford Mere.

Multiple lines of evidence indicate that additional groundwater extraction from either resource would increase pressure on groundwater storage and GDEs and may increase risks associated with declining groundwater quality. In the Uley Wanilla Consumptive Pool, any additional extraction would be expected to reduce groundwater discharge and groundwater storage. In Lincoln South Consumptive Pool, additional extraction would be expected to increase vulnerability to induced recharge from adjacent saline-water sources.

The findings of this assessment indicate that both consumptive pools exhibit characteristics of groundwater systems under stress and have limited capacity to accommodate additional extraction without increasing risks to resource condition. Consequently, any future groundwater management decisions relating to these consumptive pools should be considered in the context of the Water Allocation Plan objectives to:

- minimise impacts on GDEs;
- minimise the risk of seawater intrusion;
- minimise the risk of increasing groundwater salinity; and
- support the long-term viability of groundwater resources.

While historical extraction has contributed to groundwater-level decline, the observed trends also reflect prolonged reductions in rainfall recharge across Eyre Peninsula. The relative contribution of climate and extraction differs between consumptive pools; however, available evidence indicates that both factors have reduced groundwater resource resilience over time.

2. Introduction

2.1. Purpose

This report presents an assessment of groundwater levels, groundwater salinity and groundwater storage conditions within the Uley Wanilla and Lincoln South consumptive pools of the Southern Basins PWA (Figure 2-1). The groundwater resources are divided into management zones (i.e., consumptive pools) (Appendix A, Figure 2-1) under the Water Allocation Plan for the Southern Basins and Musgrave PWAs (the WAP) (EPNRMB 2016).

The assessment draws on long-term groundwater monitoring records, groundwater resource condition reporting, groundwater storage assessments and previous hydrogeological investigations undertaken within the Southern Basins PWA. The report summarises the current condition of these groundwater resources and evaluates the implications of continued groundwater extraction in the context of resource sustainability, GDEs and the objectives of the WAP.

2.2. Background

Groundwater is the primary water resource within the Southern Basins PWA, supporting PWS, industry, stock and domestic users, and numerous GDEs. The Uley South Basin remains the principal source of drinking water for the Lower Eyre Peninsula, in particular Port Lincoln, while the smaller Uley Wanilla and Lincoln South consumptive pools have historically been used to supplement supply during periods of high demand.

Groundwater resources across the Eyre Peninsula have experienced increasing pressure over recent decades from a combination of groundwater extraction and declining rainfall recharge. Long-term monitoring indicates that many groundwater systems are exhibiting declining groundwater levels, reduced groundwater storage and increasing groundwater salinity. These trends have been particularly evident within the Uley Wanilla and Lincoln South consumptive pools (DEW 2024).

Historically, the Uley Wanilla and Lincoln South consumptive pools have been used to supplement public water supplies from the larger Uley South Basin during periods of peak demand. Long-term declines in rainfall and related recharge across the Eyre Peninsula have persisted beyond the Millennium Drought (DEW 2020b) and have contributed to declining groundwater levels and groundwater storage throughout the region (DEW 2020b; DEW 2024). Recharge estimates derived from groundwater level records at a number of representative monitoring wells using the Water Table Fluctuation (WTF) method indicate a sustained reduction in recharge over recent decades (Figure 2-2).

Recent investigations undertaken for the Uley South groundwater model have demonstrated that continued extraction at historical rates is likely to contribute to ongoing groundwater level decline, reductions in groundwater storage and increasing risks of saline-water intrusion (DEW 2023b; DEW 2023c). These findings highlight the importance of understanding the condition and future capacity of neighbouring groundwater resources, including Uley Wanilla and Lincoln South consumptive pools.

In the context of potential future demand for PWS from these groundwater resources, it is important to consider not only the volume of groundwater available within storage but also the hydrogeological processes that sustain the longer-term viability of the resource. Groundwater extraction may be supplied through a combination of reduced groundwater storage, reduced natural groundwater discharge and induced recharge from adjacent water sources. The relative contribution of these processes has important implications for groundwater resource condition and GDEs.

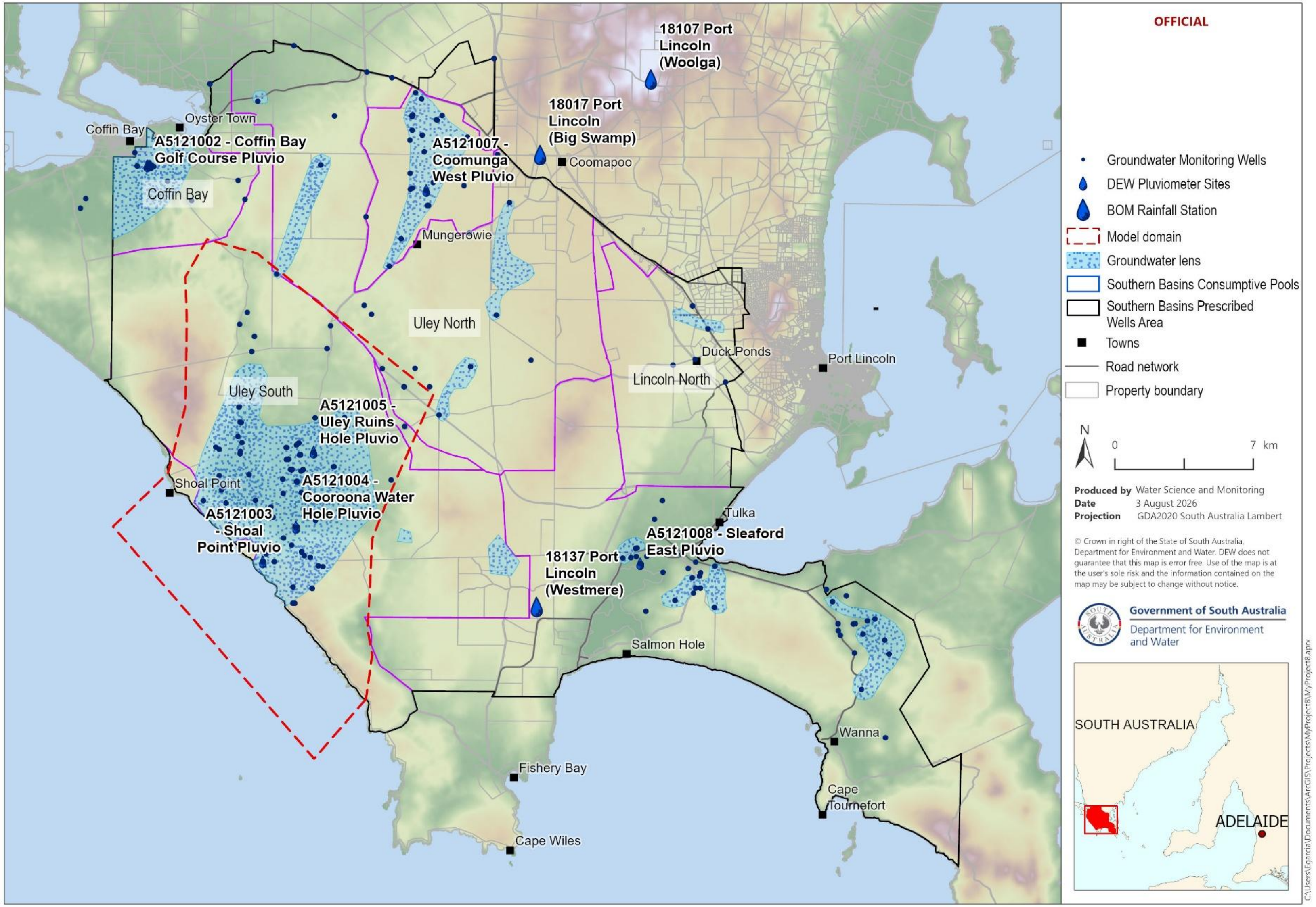


Figure 2-1 Southern Basins PWA, including Uley Wanilla and Lincoln South consumptive pools as outlined in purple, and fresh groundwater lenses of the area are shadded light blue

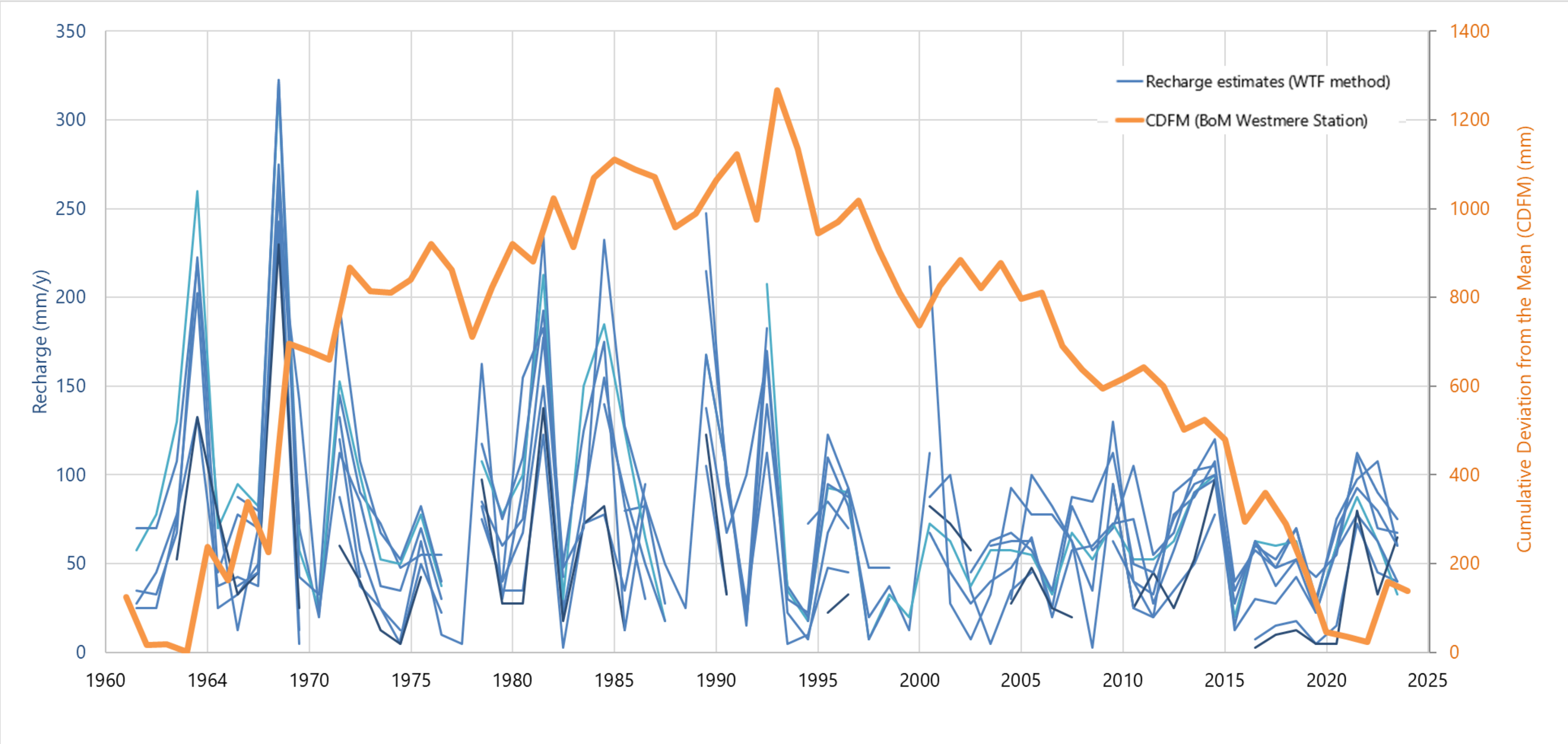


Figure 2-2 Long-term trends in rainfall (cumulative deviation from mean rainfall) and recharge for the Uley South Basin. Recharge was estimated from groundwater level records at selected monitoring wells using the Water Table Fluctuation (WTF) method (adapted from DEW 2020b).

3. Study area

3.1. Southern Basins Prescribed Wells Area

The Southern Basins PWA is located in the southern Eyre Peninsula Landscape region. The climate of the region is Mediterranean, characterised by cool wet winters and warm dry summers.

Groundwater is the primary water resource within the PWA and supports PWS, stock and domestic requirements, industry and GDEs (including wetlands; Figure 3-1). Water resources are managed through a series of consumptive pools established under the WAP for the Southern Basins and Musgrave PWAs. The Uley Wanilla and Lincoln South consumptive pools are the focus of this assessment (Figure 2-1).

Groundwater resources occur predominantly as a series of discrete and semi-discrete lenses within the Quaternary Limestone (QL) aquifer. Maps of the QL aquifer watertable elevations indicate two predominant groundwater flow directions within the Southern Basins PWA: a west to north-westerly trend and a west to south-westerly trend (Figure 3-2). Groundwater ultimately discharges to the sea. Hydrochemical evidence indicates that groundwater in the QL aquifer in the Uley South Basin is less than 30 years old (Love et al., 1994). While similar dating has not been performed for Uley Wanilla of Lincoln South, groundwater age is expected to be similar.

The size, geometry and hydraulic connectivity of these lenses vary considerably throughout the PWA and influence their vulnerability to groundwater-level decline and salinity impacts. Groundwater recharge is derived primarily from local rainfall, making groundwater resources particularly sensitive to variability in rainfall and long-term climatic trends.

3.2. Uley Wanilla Consumptive Pool

The Uley Wanilla Consumptive Pool comprises a discrete freshwater lens within the QL aquifer. Historically, the resource has been used to supplement PWS from the neighbouring Uley South Basin during periods of high demand.

The areal extent of the groundwater lens is constrained by the underlying geology. Consequently, opportunities for induced recharge from adjacent groundwater systems are limited. Recharge is derived primarily from direct rainfall infiltration.

The resource also provides environmental value through its contribution to GDEs, including river red gum woodland communities within the Wanilla area and to the near-shore environment.

3.3. Lincoln South Consumptive Pool

The Lincoln South Consumptive Pool comprises a series of coastal freshwater lenses (Lincoln A, Lincoln B and Lincoln C) occurring within the QL aquifer that are hydraulically connected to a surrounding brackish groundwater system which is itself connected to the ocean. There is evidence which strongly suggests that the brackish groundwater system is also directly connected to the saline lake, Sleaford Mere (EPNRMB 2016). The position and extent of the freshwater lenses are maintained through the density contrast between fresh and saline groundwater.

Historically, the resource has supplemented PWS for the Lower Eyre Peninsula. The resource also supports environmental values associated with GDEs, including the Sleaford Wetland Group, the Pillie Wetland Group and the near-shore marine environment.

Because these freshwater lenses occur within a coastal hydrogeological setting, they are potentially vulnerable to groundwater-level decline, saline-water ingress and groundwater-quality deterioration.

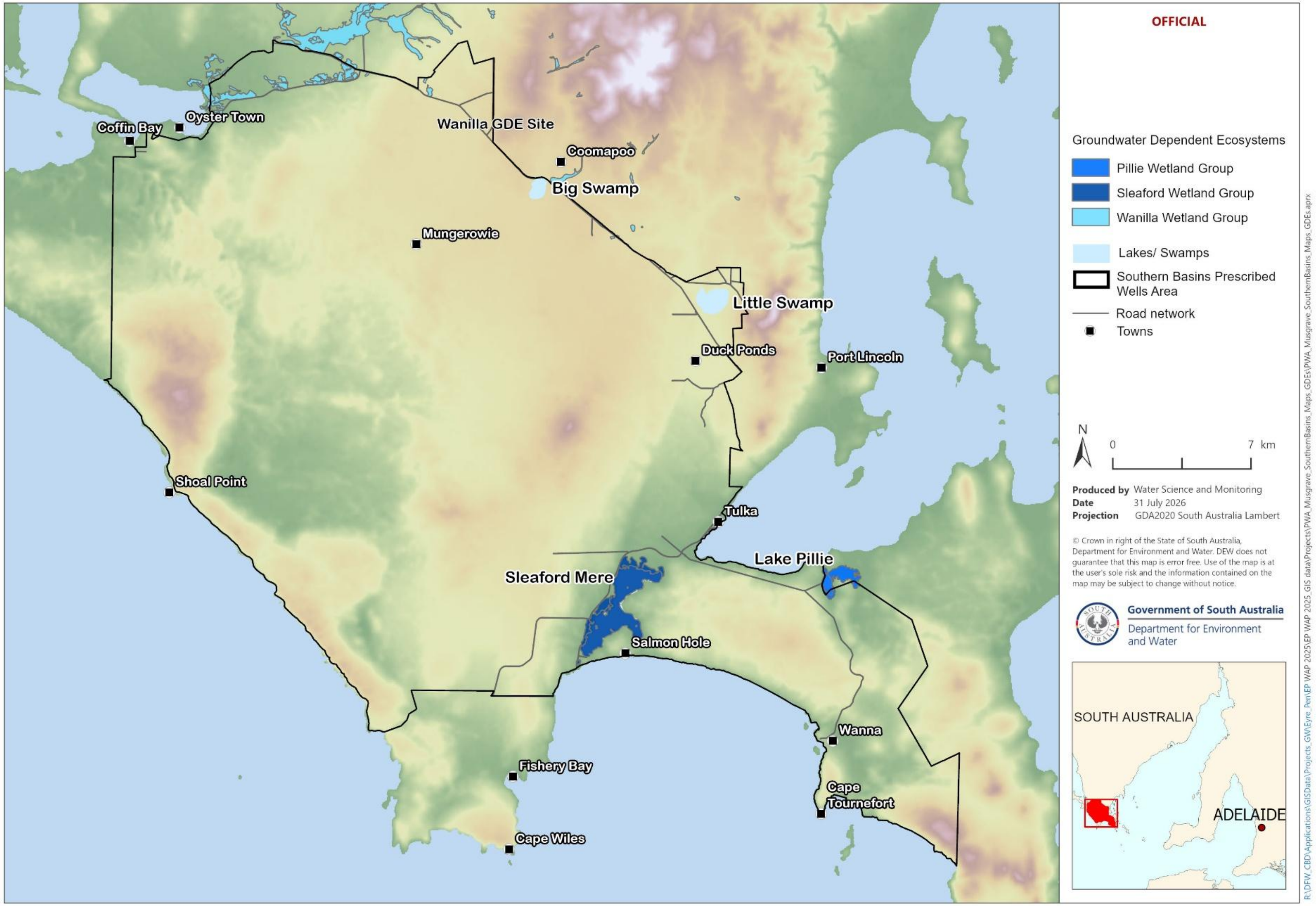


Figure 3-1 Wetland groundwater-dependent ecosystems (GDEs) of the Southern Basins PWA.

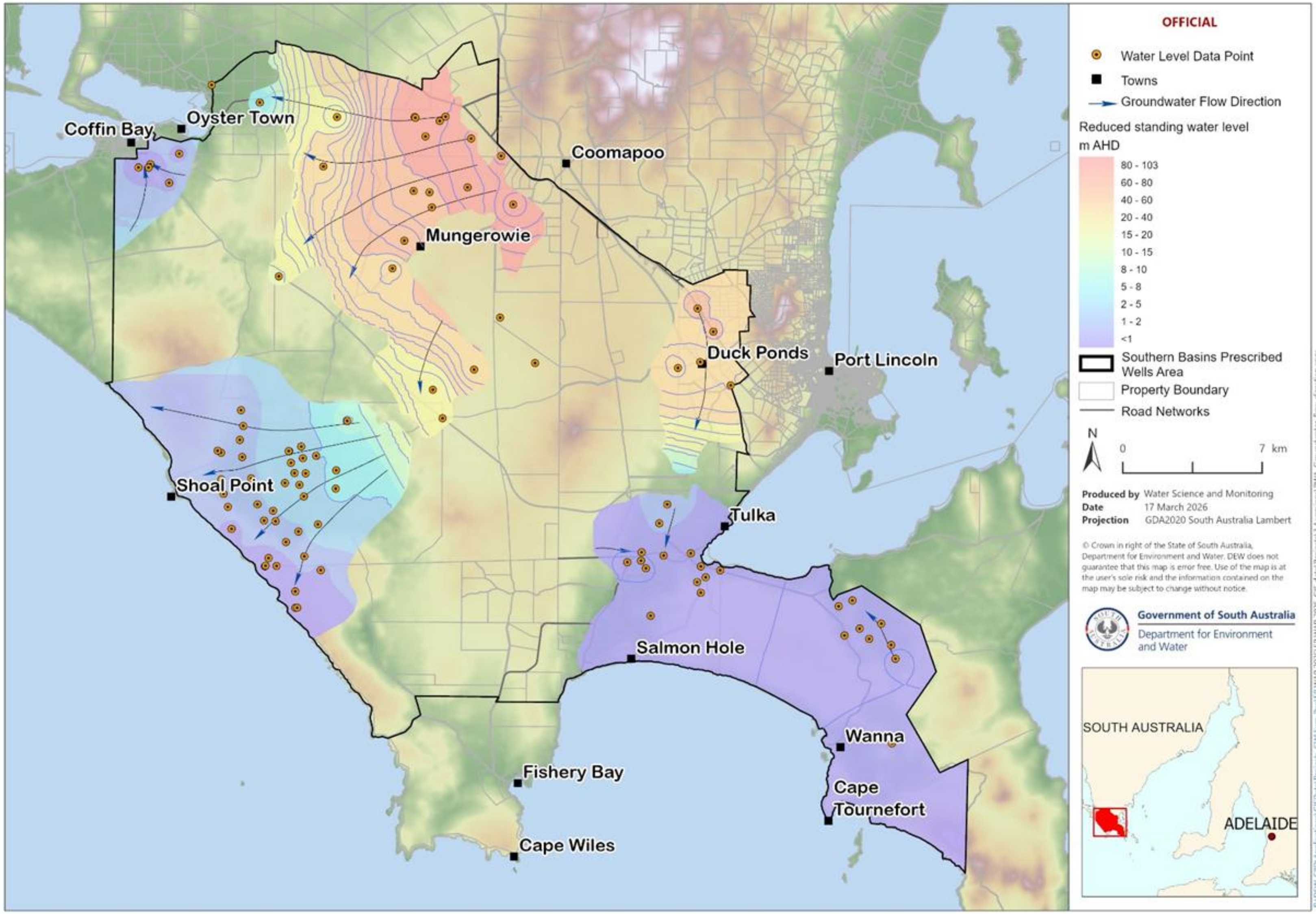


Figure 3-2 Indicative groundwater flow directions for the QL aquifer in the Southern Basins PWA.

4. Groundwater condition assessment

4.1. Uley Wanilla Consumptive Pool

4.1.1. Groundwater levels

Representative monitoring wells indicate long-term declines in groundwater levels across the Uley Wanilla Consumptive Pool (Figure 4-1 and Figure 4-2). Groundwater levels responded positively to above-average rainfall between 2010 and 2016 and generally declined during the drier period between 2017 and 2019.

Although annual rainfall in 2020 and 2022 was above average, corresponding recovery in groundwater levels was limited. Groundwater-level responses since 2020 have been weaker than would be expected based solely on rainfall. This may indicate changes in recharge processes, including changes in rainfall timing and rainfall intensity. Further investigation would be required to assess these factors.

Monitoring wells with long-term records, including ULE007 and ULE034, show groundwater-level declines of approximately 8 m since monitoring commenced. The median status of groundwater levels within the Uley Wanilla Consumptive Pool monitoring network was classified as *Lowest on record* for four consecutive years between 2018 and 2021 (DEW 2020a; DEW 2021; DEW 2022; DEW 2023a).

Groundwater-level declines observed in Uley Wanilla Consumptive Pool are similar to those recorded in the adjacent Uley South Basin. By means of analogy, in a study using a highly parameterised numerical groundwater model of Uley South, Knowling et al. (2015) showed that between 1978 and 2012, groundwater extraction contributed to aquifer depletion at 1.4 to 2.9 times that of climate (maximum-in-time and time-averaged, respectively), in terms of the basin-scale water budget. These results were broadly replicated in modelling conducted by DEW (2020b). It is very likely that historical groundwater extractions have also been the dominant driver in groundwater level decline in nearby Uley Wanilla given the similarity in the nature of the two karstic limestone groundwater systems and their shared climatic and physiographic environment.

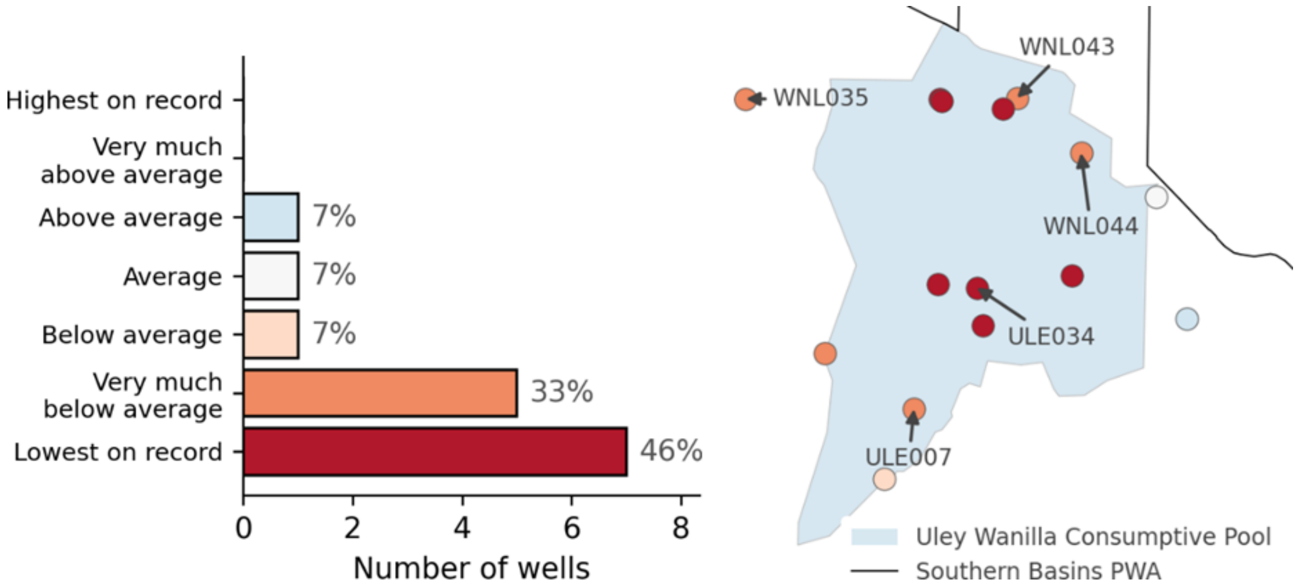


Figure 4-1 2023 winter-recovered water levels for monitoring wells across the Uley Wanilla Consumptive Pool.

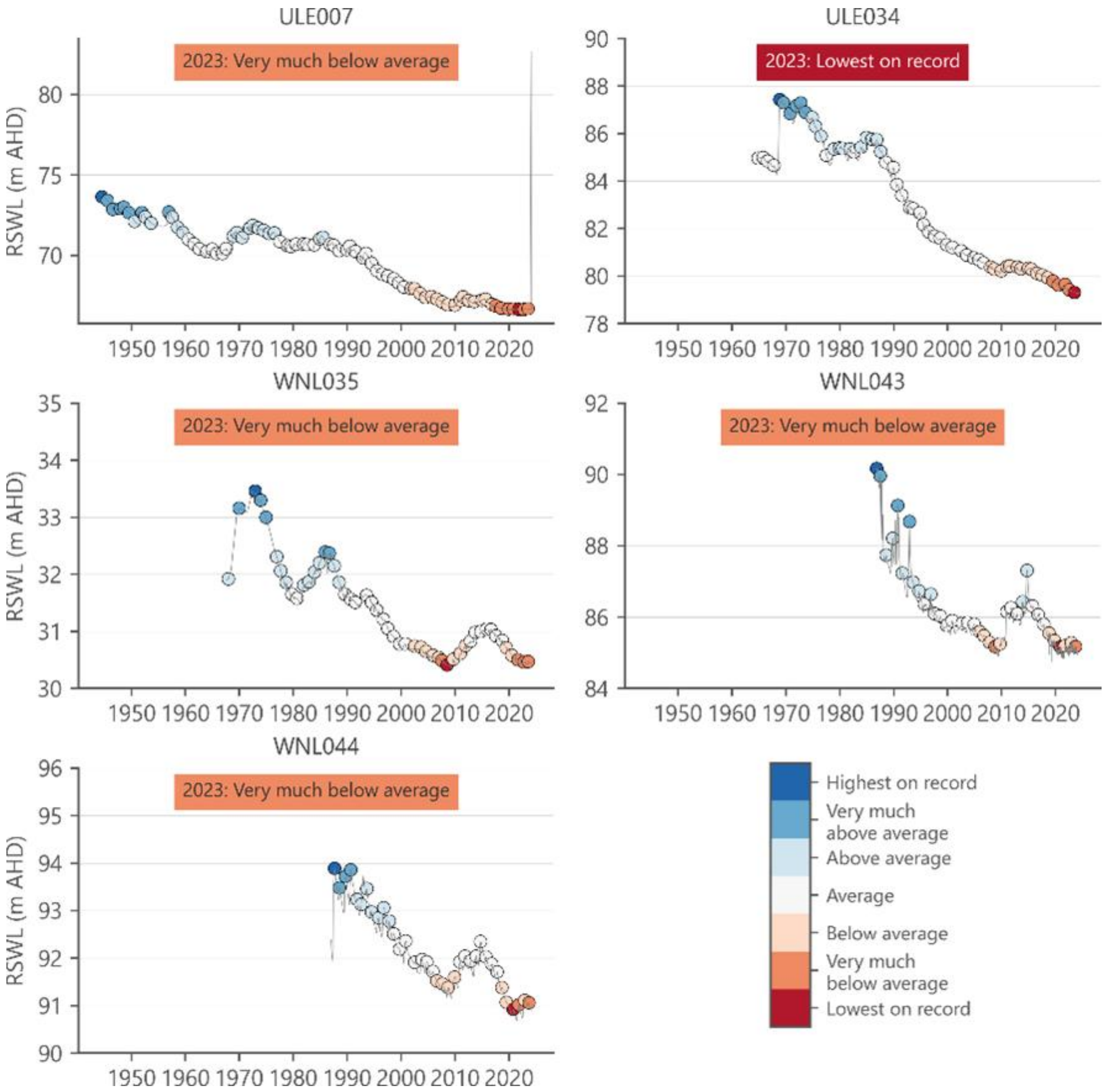


Figure 4-2 Groundwater level hydrographs for representative monitoring wells across the Uley Wanilla Consumptive Pool.

4.1.2. Groundwater salinity

Groundwater salinity remains relatively low compared with many groundwater resources across Eyre Peninsula; however, increasing trends are evident in several PWS production wells.(Figure 4-3 and Figure 4-4).

Although salinity remains within an acceptable range for PWS, increasing trends indicate a gradual reduction in groundwater quality and suggest the resource may be becoming increasingly sensitive to groundwater-level decline.

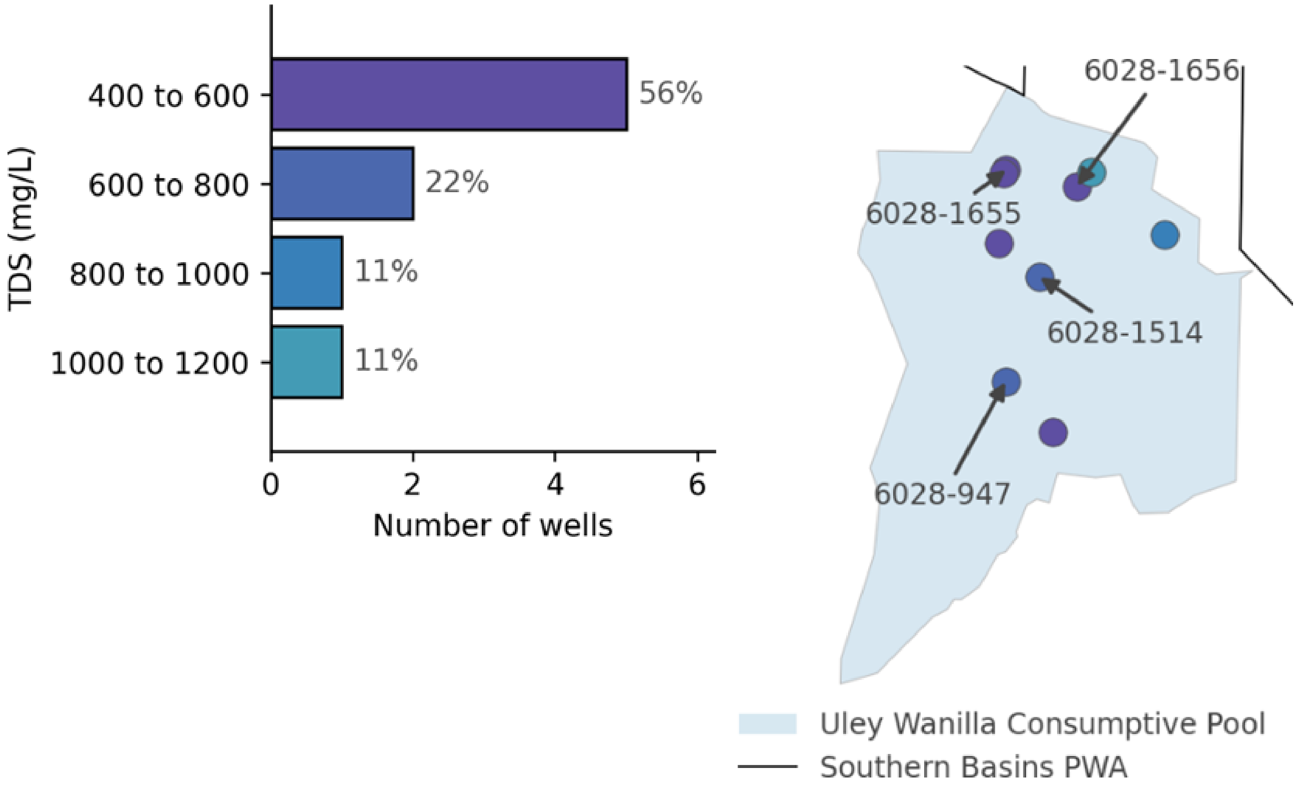


Figure 4-3 2023 salinity observations for monitoring wells across the Uley Wanilla Consumptive Pool.

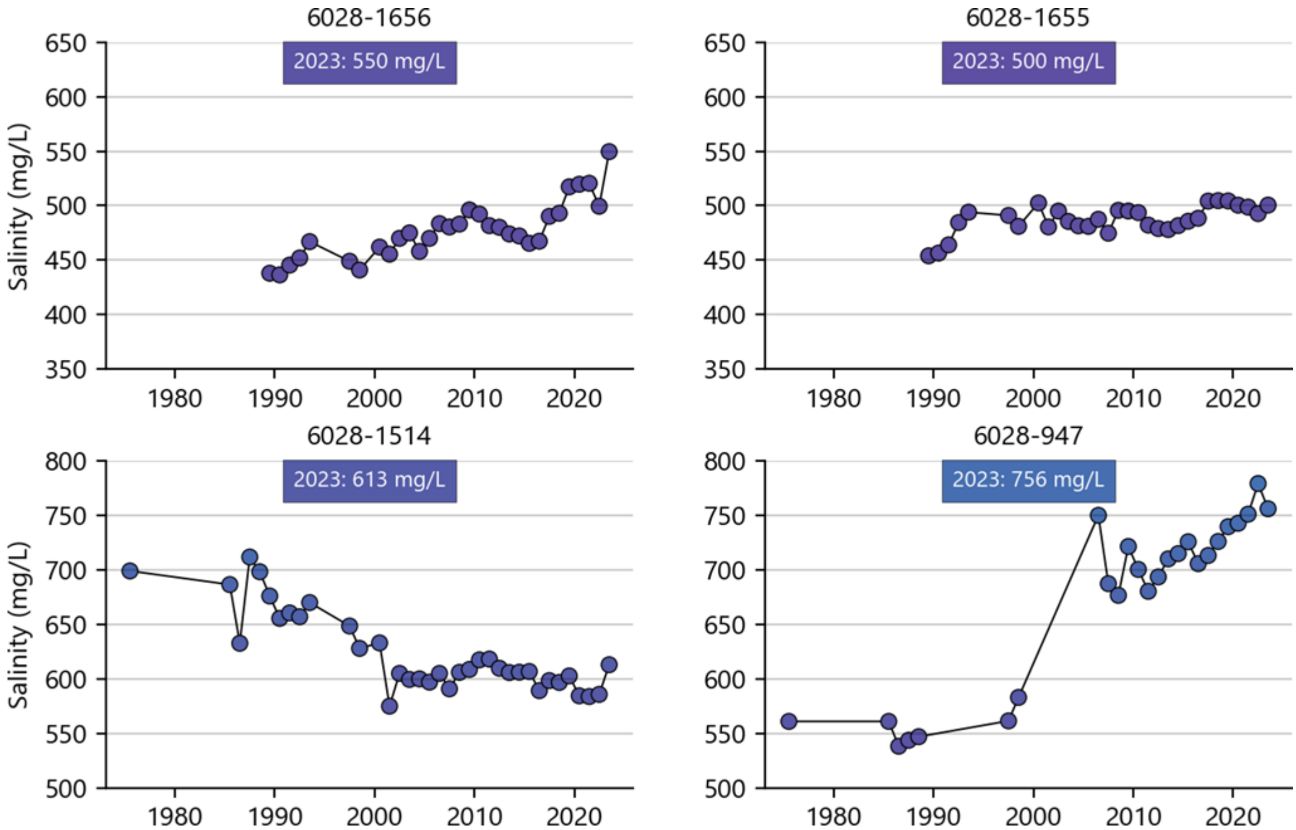


Figure 4-4 Groundwater salinity graphs for representative monitoring wells across the Uley Wanilla Consumptive Pool.

4.1.3. Resource storage and condition

Changes in aquifer storage in any given water-use year are used to determine the volumes of groundwater available for take from the variable consumptive pools of each PWA that are allocated in the following water-use year (EPNRMB 2016). The level of storage is compared to baseline storage calculated in 1993 and expressed as a percentage, where the 1993 storage has been benchmarked as 100%. At the time of adoption of the WAP in 2016, the level of storage in Uley Wanilla Consumptive Pool was 87.6%. By 2022, the level of storage had fallen to 78.9%, indicating an 8.7% decrease in the capacity of the resource to meet both consumptive and non-consumptive uses of water.

The estimated resource capacity of the Uley Wanilla Consumptive Pool comprises approximately 294 ML of freshwater and 576 ML of brackish groundwater (EPNRMB 2016). Current water access entitlements total approximately 230 ML and are sourced predominantly from the freshwater lens, representing approximately 78% of the estimated freshwater resource capacity. Collectively, groundwater level, salinity and storage data indicate declining freshwater resource condition and reduced capacity to support both consumptive and non-consumptive water use demands.

4.2. Lincoln South Consumptive Pool

4.2.1. Groundwater levels

Since the 1960s, long-term declines in groundwater levels are evident in all representative wells for Lincoln South (Figure 4-5). While rates of groundwater extraction were high in the 1960s and 1970s, extraction was negligible between 2012–13 and 2018–19, before regular extraction resumed in the past few years (at a rate of ~500 ML/y).

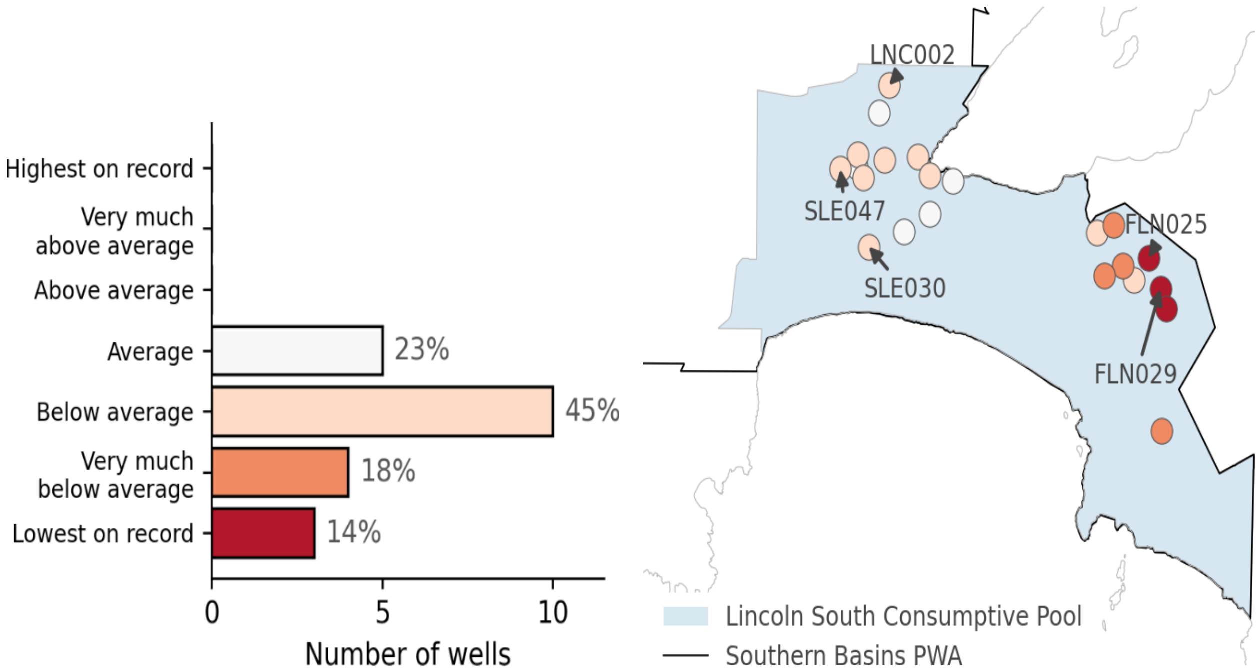


Figure 4-5 2023 winter-recovered water levels for wells across the Lincoln South Consumptive Pool.

In 2022–23, groundwater levels (measured at their post-winter maximum) in 77% of Lincoln South monitoring wells were classified as 'Below average' or lower. Some wells (for example, SLE047, FLN029, FLN025) are showing groundwater levels near, or below, mean sea level, despite above-average rainfall in 2020 and 2022 (Figure 4-6). Monitoring well LNC002, located further inland, historically recorded groundwater levels were as high as 5 m AHD, but these have declined to approximately 2 m AHD over the past 50 years.

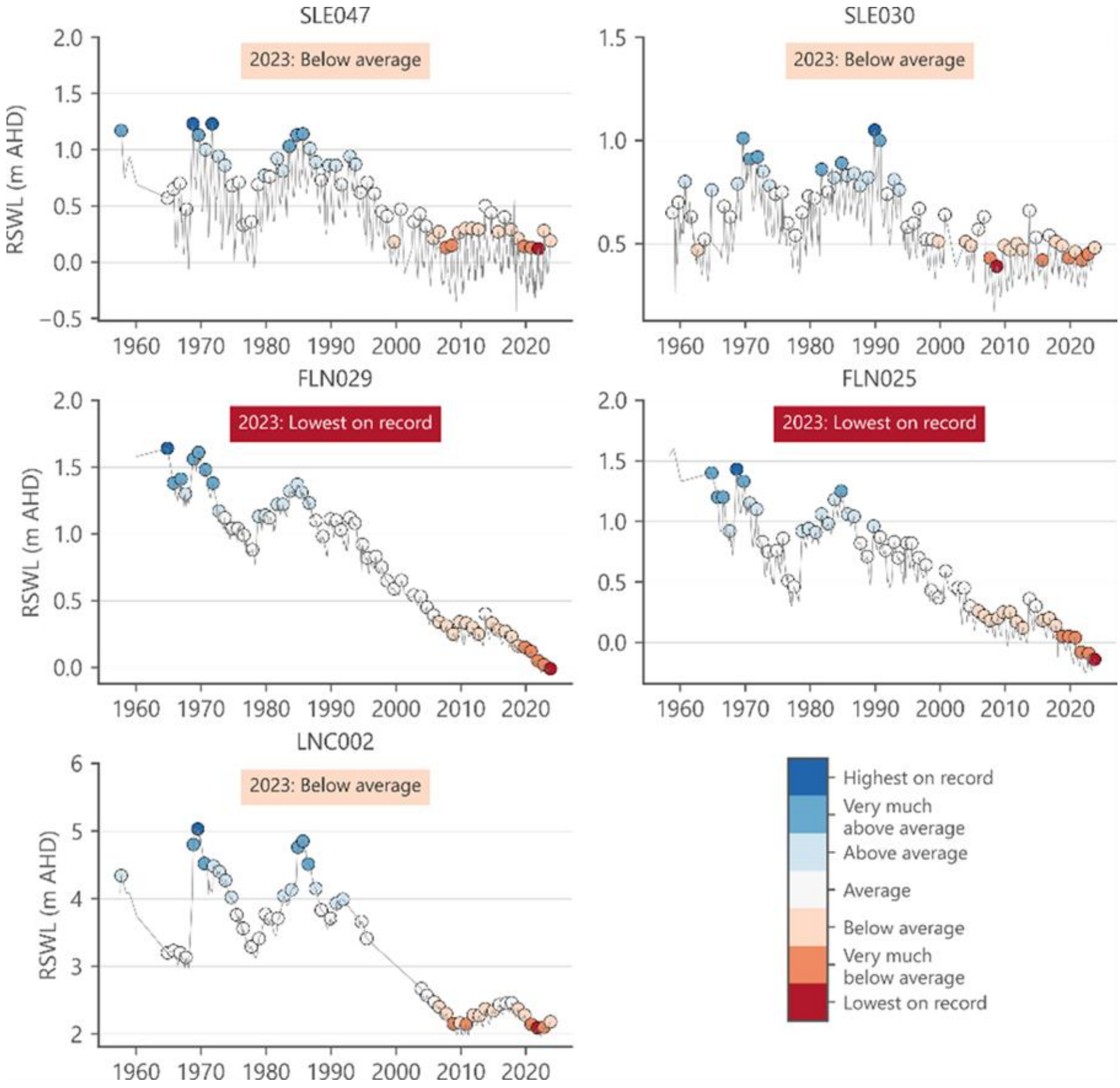


Figure 4-6 Groundwater level hydrographs for representative monitoring wells across Lincoln South Consumptive Pool.

4.2.2. Groundwater salinity

Groundwater salinity generally increased between the mid-1980s and 2010 despite relatively stable extraction rates over much of this period. (DEW 2024). In the 10 years to 2023, 8 of 9 wells show trends of increasing salinity (at a median rate of 0.4% increase per year; Figure 4-7 and Figure 4-8). These trends indicate that an ingress of saline groundwater has been occurring which is likely to be a result of declining groundwater levels and a reversal of the hydraulic gradient from discharge towards the ocean (and towards Sleaford Mere) to induced recharge flowing from the ocean (and very likely Sleaford Mere) back into the freshwater lenses (DEW 2010). Declining groundwater levels also increase the likelihood of up-coning of high-salinity groundwater that lies beneath the freshwater lenses, which is a known risk in Lincoln South (EPNRMB 2016).

4.2.3. Resource storage and condition

As discussed above, annual changes in aquifer storage are used to determine the volumes of groundwater available for take from variable consumptive pools in the following water-use year. Since changes in Lincoln South groundwater levels are buffered by the surrounding seawater, and the robustness of the freshwater lenses is relatively low, the WAP's adaptive-management approach in this environment has shown shortcomings in managing this resource. The measured level of storage has remained above 95% since the current WAP was adopted in 2016 and; consequently, full allocation has been issued each year despite groundwater declining to levels near, or below, sea level and increasing groundwater salinity, which has had a deleterious impact on the resource.

Somaratne and Ashman (2018) assessed recharge to the Lincoln South freshwater lenses (Lincoln A, B, and C) using two standard methodologies: water-table fluctuation; and chloride mass balance. This study concluded that extraction from Lincoln South resources during the period 1961–77 resulted in mining of the groundwater storage (that is, rates of extraction that exceeded rates of groundwater replenishment). The authors concluded that extraction for PWS has resulted in seawater intrusion, up-coning of high-salinity groundwater from below the freshwater lenses, and lateral flow of brackish water into PWS wellfield areas.

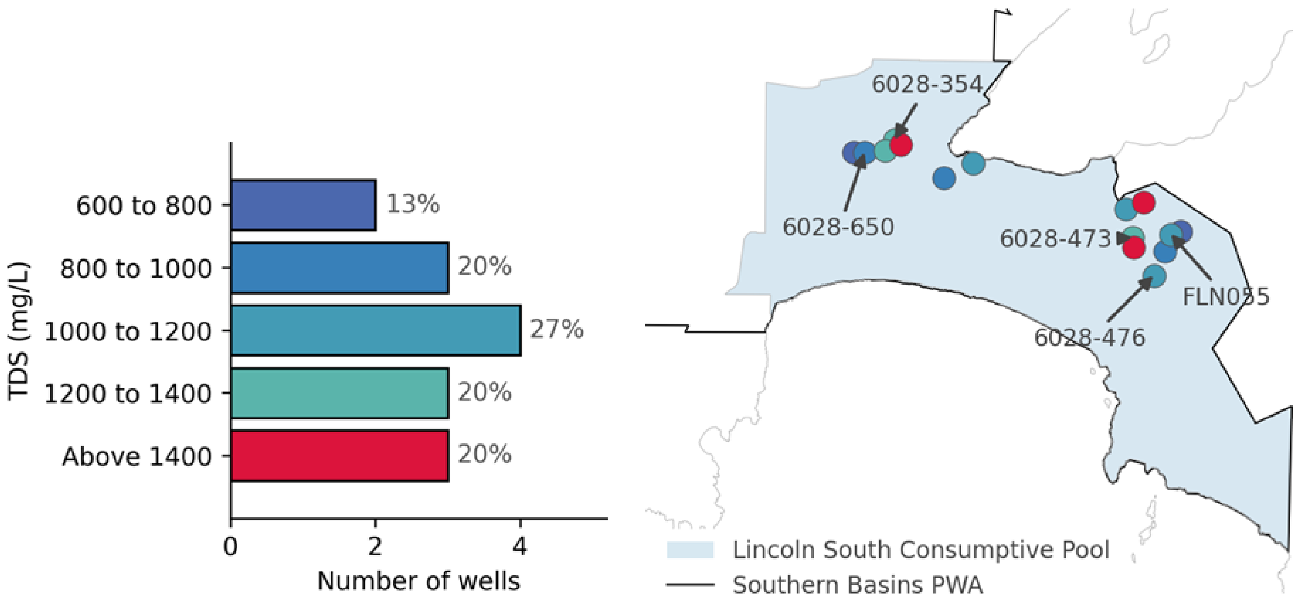


Figure 4-7 2023 salinity observations from monitoring wells across the Lincoln South Consumptive Pool.

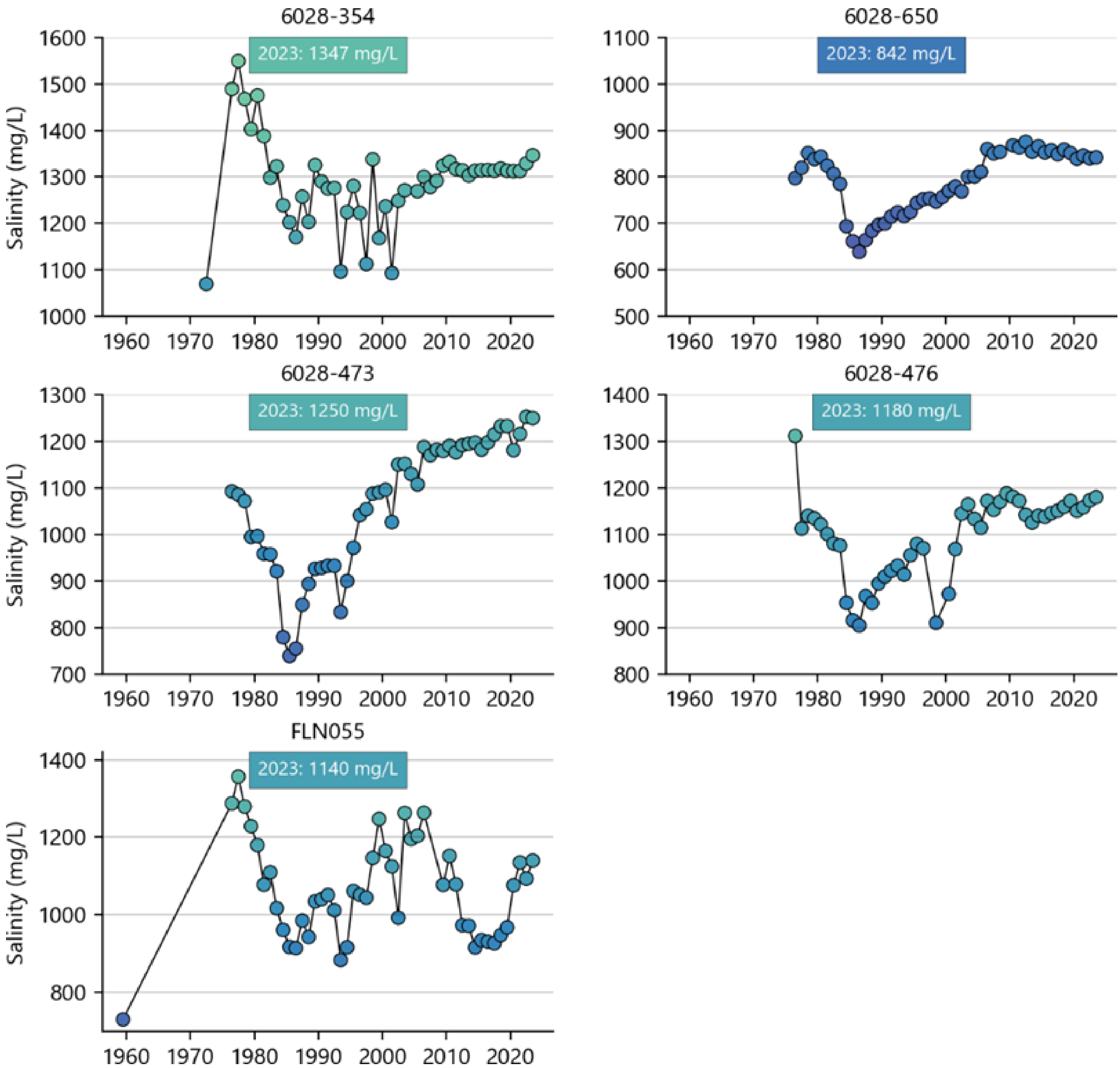


Figure 4-8 Groundwater salinity graphs for representative monitoring wells across Lincoln South Consumptive Pool.

Multiple lines of evidence indicate that groundwater-level decline has contributed to a reversal in hydraulic gradients within parts of the Lincoln South freshwater lens system. These changes are consistent with increasing risks of saline-water ingress from adjacent groundwater systems and surrounding saline-water bodies.

5. Hydrogeological interpretation

5.1. Implications of groundwater extraction

The notion that the rate of recharge to a groundwater system is the parameter most important in determining a sustainable rate of extraction from that system was first debunked by Theis (1940) in a paper entitled *The Source of Water Derived from Wells: Essential Factors Controlling the Response of an Aquifer to Development*. In this paper, Theis demonstrated that groundwater systems prior to development are in a state of equilibrium whereby inflows (for example rainfall recharge) are approximately equal to outflows (for example discharge to surface water bodies, the ocean and GDEs). Following the development of a groundwater system, groundwater extracted by wells is a new discharge that is superimposed on a previously stable system that must be balanced by an increase in recharge (contemporaneously termed 'induced recharge'), a decrease in natural discharge, a loss in groundwater storage or a combination of these.

Subsequent to this seminal paper, many authors have sought to reinforce the principle that the magnitude of sustainable groundwater development is governed by the quantum of discharge from any given groundwater system that can be 'captured' by the development (for example Brown (1963); Bredehoeft et al. (1982); Sophocleous (2000); Bredehoeft (2002)). This principle has been clearly demonstrated by Bredehoeft (2002) in applying simple algebra to the water balance equation of a theoretical aquifer situated on a circular island in a freshwater lake that is being developed by pumping.

This same rationale, demonstrated by Bredehoeft (2002), has been applied to the Uley Wanilla and Lincoln South consumptive pools of the Southern Basins PWA in this analysis.

5.2. Uley Wanilla Consumptive Pool

The Uley Wanilla Consumptive Pool is a discrete groundwater lens, where the areal extent of the lens is constrained by the underlying geology. Although a larger volume of brackish groundwater exists within the surrounding groundwater system, hydraulic connectivity between the freshwater lens and adjacent brackish groundwater is limited. Consequently, if it is assumed that rainfall recharge is constant, groundwater extraction from Uley Wanilla will be met from decreased natural discharge that would otherwise have supported the health of nearby GDEs (Figure 2-2), in combination with a small loss in aquifer storage.

The estimated freshwater resource capacity is approximately 294 ML (EPNRMB 2016), while current water access entitlements under the current WAP total approximately 230 ML. As consumptive demand is sourced predominantly from the freshwater lens, water access entitlements represent 78% of the available freshwater resource.

Under these hydrogeological conditions, groundwater extraction can only be balanced through reductions in natural groundwater discharge, reductions in groundwater storage, or a combination of both. Given the limited potential for induced recharge, extraction is expected to reduce groundwater available to support GDEs and so contributes to declining groundwater levels.

The compounding factor in these systems is the very short groundwater residence times of around 30 years. This means that any perturbations to the system, such as groundwater pumping, will result in dynamic changes in groundwater levels and a new, in this case unfavourable, equilibrium will be reached very rapidly as will any decrease in natural discharge (or increase in induced recharge).

The Eyre Peninsula Landscape Board (the Board) has been monitoring the health of select stands of red gums within the Musgrave and Southern Basins PWAs since adoption of the first WAP in 2016, as identified in the WAP's Monitoring, Evaluation, Reporting and Improvement Plan (EPLSB 2024). The Board publishes GDE monitoring report cards annually which provide a summary of the monitoring data and include high-level data interpretation; this reporting commenced in 2018 (Appendix B and Appendix C).

River red gum woodland communities occur in the northern part of the Uley Wanilla Consumptive Pool. A wide range of stakeholders across Eyre Peninsula identified red gums communities as high-value GDEs during the community consultation phase, prior to the adoption of the 2016 WAP. The typical water-use requirements of red gums are greater than that provided by average annual rainfall on Eyre Peninsula and thus their survival is dependent on access to groundwater. As groundwater levels decrease, particularly if groundwater levels decline more rapidly than the trees can adapt to, they will likely begin showing signs of stress (dieback); if conditions do not improve, they may perish altogether (EPNRMB 2016).

At the conclusion of the 2022 GDE monitoring period, and in the context of Uley Wanilla groundwater status being classified 'Lowest on record' between 2018 and 2021, analyses undertaken by the Board of red gum community monitoring data across all sites (Graph 1, Appendix B) indicated that:

- absolute condition scores for Wanilla red gums between 2020 and 2022 are the lowest of all sites (and this was not the case between 2016 and 2019);
- the rate of increasing red gum health for the Wanilla site between 2018 and 2021 is the lowest of all sites; and
- the rate of decline for the Wanilla site over the 12-month period 2021-22 is the greatest of all sites.

Further, the GDE monitoring data analyses show that the absolute condition scores for the Wanilla experimental red gum community sites are markedly lower than the Coulta control site (Graph 1, Appendix C).

Long-term groundwater-level decline, declining storage, limited recovery following above-average rainfall, and worsening red gum condition collectively indicate that the freshwater lens is experiencing reduced resilience. Storage declined from 87.6% of baseline conditions at adoption of the WAP to 78.9% by 2022 despite adaptive management arrangements designed to reduce allocations during periods of declining storage. This suggests that current management settings may have slowed the rate of decline but have not facilitated recovery of the resource.

No information is available on the impact of declining groundwater on dependent ecosystems in the near-shore environment.

5.3. Lincoln South Consumptive Pool

The Lincoln South freshwater resources (that is Lincoln A, Lincoln B and Lincoln C lenses) are continuous with the surrounding brackish QL aquifer and exist in the landscape due to the difference in density between the fresh and brackish groundwater. The brackish aquifer is itself directly connected to the ocean and evidence strongly suggests it is also directly connected to the saline lake, Sleaford Mere (EPNRMB 2016). Groundwater levels measured at many of the monitoring wells located within Lincoln South are now at, or below, mean sea level. Consequently, instead of these resources discharging to the ocean or Sleaford Mere, as would have occurred prior to development of the natural system, a reversal in hydraulic gradient has occurred and recharge is now being induced from the ocean, and very likely also induced from the saline water that comprises Sleaford Mere, combined with a small loss in aquifer storage.

Current water access entitlements total approximately 929 ML and are sourced from the freshwater lenses, despite the majority of the estimated 4,584 ML resource capacity occurring as brackish groundwater. Consequently, pressure is concentrated on the freshwater component of the resource.

Sleaford Mere (Kuyabidni) is located within the Sleaford Mere Conservation Park (IUCN Category III Protected Area) and is associated with the Barngarla and Nauo peoples. It is listed as a Nationally Important Wetland (DCCEEW, 2024) and is one of a very small number of permanent salt lakes protected within South Australia's reserve system. Sleaford Mere is a permanently inundated, shallow saline lake water body that appears to be primarily dependent on direct rainfall but is understood to be also partly supported via its connection to the surrounding QL aquifer (that is Lincoln South). This site is of national and international importance for migratory shorebirds (providing habitat) and supporting amphibious plant species and aquatic plants. Sleaford Mere also has Stromatolites of heritage significance. Sleaford Mere is part of the Sleaford Group, along with Little Sleaford Mere – an ephemeral lake.

Permanent freshwater soaks occur at the northern end of Sleaford Mere and are likely to be impacted by any local groundwater level decline. Doeg et al (2012) determined environmental requirements for the Sleaford Wetland Group (Appendix A), which included: "For the entire year, the groundwater level needs to be in direct contact with the sources of the freshwater soaks." Anthropogenic perturbations to the local hydrology (for example a reduction or loss of soaks) is likely to impact on endemic flora species (for example the regionally threatened *Gyrostemon thesioides* (Broom Wheel-fruit), Hibbertia sp. A (Port Lincoln Guinea-flower) and *Pultenaea vestita* (Feather Bush-pea)) and fauna species (for example JAMBA and CAMBA listed birds including the Caspian tern, Common greenshank, Crested tern, Curlew sandpiper and Sharp-tailed sandpiper; DCCEEW 2024). Continued groundwater-level decline may therefore increase the risk of reduced freshwater soak discharge and associated impacts on groundwater-dependent vegetation communities and habitat values.

Similarly, the Pillie Wetland group (consisting of a number of small elongate dampland basins on the southeastern tip of the Southern Basins PWA) also appears to be dependent on direct rainfall and groundwater recharge from the supporting QL aquifer (Lincoln resultsSouth; EPNRMB 2016). The risks to the Pillie Wetland, and any associated biota, from falling local groundwater levels are almost certainly analogous to those risks faced by the Sleaford Wetland Group.

Recovery from these processes is likely to occur over very long timescales and may not be achievable within management-relevant timeframes. Further, extraction of groundwater will likely increase the rate at which these processes are occurring which will likely result in increased salinity within the freshwater lenses and increasing risk to GDEs.

No information is available on the impact of declining groundwater on dependent ecosystems in the near-shore environment.

6. Conclusions

6.1. Uley Wanilla Consumptive Pool

In the Uley Wanilla Consumptive Pool, observation wells with long-term records show very large groundwater level declines of around 8 m which strongly suggests the risk of detrimental impacts to local GDEs (e.g., Wanilla river red gum communities) has been increasing with time. The status of the Uley Wanilla Consumptive Pool has been classified 'Lowest on record' for four consecutive years over the period 2018–21. Evidence suggests that it is very likely that historical groundwater extractions have been the dominant driver in groundwater level decline. Given recharge is sourced only from incident rainfall, any groundwater that is extracted from the aquifer will be met by a commensurate reduction in natural discharge and a small loss in storage (i.e., decrease in groundwater levels). Consequently, should further extraction occur, there will be deleterious impacts on any GDEs that are reliant on that discharge or storage for their health and/or survival. Available evidence indicates that current management arrangements have reduced, but not reversed, resource decline.

6.2. Lincoln South Consumptive Pool

In the Lincoln South Consumptive Pool, groundwater levels in 2022–23 (measured at their post-winter maximum) in 77% of observation wells were classified 'Below average' or lower. Some wells are showing groundwater levels near, or below, mean sea level despite above-average rainfall in 2020 and 2022. Multiple lines of evidence demonstrate that a reversal in hydraulic gradient has occurred, and seawater ingress is now being induced from the ocean and very likely also induced from the saline water that comprises Sleaford Mere. Consequently, available evidence suggests that continuing extracted from Lincoln South, would likely be met by a small loss in groundwater storage with the balance being met by induced ingress from the ocean and saline water from Sleaford Mere. This volume of seawater and high salinity groundwater being entrained into the fragile Lincoln South lens will have deleterious impacts on the health and/or survival of any ecosystems that are dependent on fresh groundwater.

The principal risk to Lincoln South is the ongoing degradation of freshwater quality through saline-water ingress and up-coning processes. Recovery from these processes is likely to occur over very long timescales and may not be achievable within management-relevant timeframes. Continued extraction is expected to increase the likelihood of further salinity increases within the freshwater lenses and associated impacts on GDEs.

6.3. Overall

Both resources exhibit declining resilience under current climatic and extraction conditions; however, the dominant hydrogeological risks differ. Compounding these risks is the very short groundwater residence times of around 30 years. This means that any perturbations to the system, such as groundwater pumping, will result in dynamic changes in groundwater levels and/or a decrease in natural discharge (or increase in induced recharge via ingress from the ocean), and a new, in this case unfavourable, equilibrium will be reached very rapidly. The deleterious impacts of reduced natural groundwater discharge and increased induced recharge from high-salinity sources are likely to increase where groundwater-dependent ecosystems rely on the Uley Wanilla and Lincoln South freshwater lenses. Collectively, the available evidence indicates that future management arrangements should focus on recovery of freshwater resource condition, protection of terrestrial and marine GDEs and reduction of long-term risks associated with groundwater extraction.

7. Appendices

A. Environmental water requirements of the Sleaford Wetland Group

Description: The Sleaford Group is located on the south-eastern tip of the Eyre Peninsula and consists of two basins, Sleaford Mere and Little Sleaford Mere. Sleaford Mere is a permanently inundated, shallow saline lake, while Little Sleaford Mere is ephemeral.

Hydrology: Recharge appears to be via direct rainfall and groundwater recharge. At the northern end of Sleaford Mere, permanent freshwater soaks can be located.

Vegetation: Sleaford Mere displays the typical fringing zonation of *Gahnia trifida* or *G. filum*, *Melaleuca halmaturorum, M. lanceolata*, *M. cassytha* and *Baumea*. On the damp littoral edges of the lake, a diverse community includes *Wilsonia*. The permanent freshwater soaks provide habitat for a number of restricted plant taxa including *Hydrocotyle* and *Triglochin striatum*.

Other significant environmental values: Sleaford Mere is a site of national and international importance for shorebirds and is nationally important through its inclusion in the Directory of Important Wetlands in Australia (Environment Australia 2001). Sleaford Mere provides important habitat for a wide range of waders, shorebirds and other waterbirds.

Environmental Water Requirement: Based on the presence of different vegetation components and persistence of water, the EWR for Sleaford Mere can be described as:

- For the entire year, the groundwater level needs to be in direct contact with the sources of the freshwater soaks.
- The groundwater table needs to maintain the surface water to a depth of 100–200 mm throughout the year.
- For at least three months of the year (at any time), the groundwater table needs to be maintained within 1 m of the *Baumea* zone.
- For at least three months of the year (at any time), the groundwater table needs to be maintained within 2–3 m of the *Melaleuca* zone.
- For at least two months of the year (at any time), the groundwater table needs to be maintained within 3–4 m of the *Gahnia* zone.
- For at least three months of the year over spring (one in three years) the groundwater table needs to be maintained within 250 mm of the *Baumea* zone.
- For at least three months of the year over spring (one in 10 years) the groundwater table needs to be maintained within 250 mm of the *Melaleuc* zone.

(Excerpt from Doeg *et al.* (2012))

B. 2022 Report Card: Eyre Peninsula Groundwater-Dependent Ecosystem monitoring site

2022 Eyre Peninsula Groundwater Dependent Ecosystem Report Cards

Overview and Red Gum GDE Condition Summary

Why are we checking on the health of Groundwater Dependent Ecosystems?

One of the objectives of the *Water Allocation Plan (WAP) for the Southern Basins and Musgrave Prescribed Wells Areas (PWAs) (2016)* is to minimise the impact of the licensed take of groundwater on ecosystems that depend on the prescribed groundwater resource, collectively known as Groundwater Dependent Ecosystems (GDEs). The WAP aims to reduce the risk of licensed groundwater extraction having negative impacts on GDE condition, location and extent. To ensure this aim is achieved, the Eyre Peninsula Landscape Board has developed a program to monitor changes in flora condition and/or extent, as well as groundwater levels, at a group of GDEs within the Southern Basins and Musgrave PWAs. Changes are measured against a 2016 baseline, and results are interpreted to identify possible causes of changes observed in GDEs since 2016.

What are Groundwater Dependent Ecosystems?

GDEs rely on groundwater to meet all or some of their water requirements to sustain the diverse communities of plants, animals, fungi and microbes which live in them. Groundwater provides a vital and reliable source of water to all GDEs, whether they are entirely dependent on groundwater, or only need groundwater seasonally or episodically (irregular or occasional water). This is particularly true on the Eyre Peninsula because of the generally low rainfall environment and the lack of surface watercourses in the region.

A number of studies (found here) have identified two types of representative GDEs as priority for monitoring on the EP. The first, Red Gum (*Eucalyptus camaldulensis*) woodlands, are entirely or partially reliant on groundwater. Red Gums are deep rooted plants that are able to switch between water sources depending on availability. They use surface or soil water during wet conditions and can be entirely dependent on groundwater during drought conditions. The second type of priority GDE is wetlands. These receive seasonal, intermittent or continuous groundwater contribution and are often dominated by plants such as Tea-Trees (*Melaleuca spp.*) and reeds. These ecosystems are both relatively well understood, and there are established methods for monitoring them.

What affects GDE health?

Changes in groundwater quantity (e.g. depth, extent, duration) and quality (e.g. salinity) affect the condition and survival of GDEs. The GDE monitoring program therefore aims to relate the condition of GDE vegetation to groundwater levels and quality. Changes in groundwater can be caused by factors we cannot control, such as changes in rainfall and temperature, but also by factors we can control, such as the extraction of groundwater. In the PWA, groundwater extraction is controlled through implementing the WAP. The WAP sets out the principles governing how groundwater should be shared fairly to benefit communities, GDEs and economic development. To make sure the WAP is working, it is reviewed every five years. The results of the GDE monitoring program are one factor taken into account during these reviews. If we find the extraction of groundwater is negatively impacting the GDEs, then the rules governing extraction could be modified.

Selection of monitoring sites

Location of GDE monitoring sites

The GDE monitoring program has been designed so that the effects of factors we can control (water extraction) can be distinguished from those we cannot (climate variability). We therefore monitor licensed extraction sites, located in the areas that can be influenced by water extraction activities, and also monitor control sites. Control sites are located where conditions are similar to those at the licensed extraction sites, except they are located outside the areas that can be influenced by water extraction. We can identify the effects of uncontrollable influences at the control sites. Then, comparing the control sites to the licensed extraction sites, we can distinguish any additional effects that are caused by water extraction. Five Red Gum GDE sites (three licensed extraction and two control) and two wetland GDE sites (one licensed extraction and one control) have been selected for monitoring.

How is Red Gum GDE condition measured?

To monitor the condition of Red Gum GDEs, the condition of individual Red Gum trees is measured using a method developed by Nick Souter (2018). For each tree, characteristics such as leaf extent, leaf density, leaf die off, growth at branch tips, and the presence of flowers and seeds, are assessed visually and given a score using a standard system. The characteristic scores are used to calculate a Red Gum Condition Index (RCI) score for each tree. At each site 50 trees are assessed, and the average RCI score is calculated for the site. The same 50 trees are assessed annually at each site, and the average RCI score for the site is compared to that from previous years. We can thus determine whether there has been a change in the average Red Gum condition at the site over time.

Groundwater and climate data

At both wetland and Red Gum GDE sites, monitoring wells with data loggers and rainfall gauges have been installed. These are used to monitor groundwater levels and rainfall amount and intensity at the sites. Regional climate data such as maximum daily temperatures and historic rainfall data from nearby weather stations is also analysed.

What do we do with the monitoring data?

For each of the GDE sites, report cards are produced annually and published on the Eyre Peninsula Landscape Board website. These report cards present the results of the GDE monitoring program, evaluating any changes and trends in GDE vegetation condition, groundwater level and rainfall at the site. The Red Gum GDE report cards presenting the results of monitoring are published annually. Report cards for the wetland GDEs are under development and will be published soon.

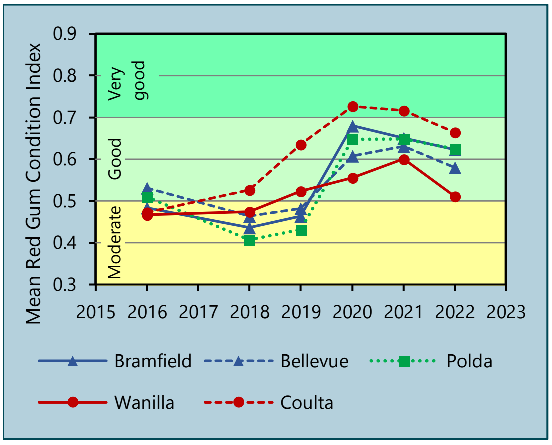
The findings from the monitoring program are interpreted to determine the likely causes of any changes in GDE condition. If it is found that there is a decline in groundwater levels and a decline in GDE condition at the licensed extraction sites, but not at the control sites, then it is possible the decline is caused by extraction of groundwater. If this occurs, then this will trigger further investigation, a review and possible amendment of the WAP to ensure the objective to maintain the health of GDEs is achieved.

Summary results of 2022 Red Gum GDE monitoring

Monitoring results show that in the Musgrave PWA there has been no negative impact of licensed groundwater extraction on the Red Gum GDEs between October 2016 and October 2022. Following a net improvement in Red Gum condition between 2016 and 2020 at both the extraction sites (Bramfield and Polda) and the control site (Bellevue), Red Gum condition has remained stable and good during 2021 and 2022 (see table and Graph 1).

Red Gum condition at Wanilla improved every year from 2016 to 2021, and then declined in 2022, although it still remained good. The net improvement in Red Gum condition at Wanilla for the 2016 to 2022 period is however 10% lower than at Coulta (control site for Wanilla) (see table and Graph 1). A longer data set is however required to determine whether these differences are statistically significant, and what may be causing them if they are.

The maintenance of good and very good Red Gum condition in 2022 at all Red Gum GDE sites has been supported by higher than average total annual rainfall in the Musgrave and Southern Basins PWAs. At Wanilla and Coulta the total annual rainfall was 34% higher than the mean annual rainfall, resulting in good groundwater recharge, and groundwater levels in December 2022 being higher than they were in December 2021. With the exception of Coulta, groundwater levels at all sites do however, still remain lower than levels in June 2018, when automatic data loggers were installed at bores at all sites.



Graph 1 Change in Red Gum Condition Index, 2016 to 2022, at all monitored Red Gum GDE sites

Monitoring into the future

Tree condition and groundwater level monitoring will continue on a yearly basis. A study is also going to be undertaken in 2022-2023 to confirm definitively whether the Wanilla and Coulta Red Gums are using local groundwater. This will be done by looking at stable chemical isotopes that occur in the local groundwater, and which are a "signature" for a groundwater source, and comparing these to the isotopes occurring in tree sap.

Overview of monitoring results at Red Gum GDEs

		Red Gum Condition				Groundwater levels[3]	
Site	**Type of Site**	**RCI Score 2022**	**Condition 2022**	**Change 2021-22**	**Trend 2016-22**	**Change (m) Jun 2018 to Dec 2022**	**Change (m) Dec 2021 to Dec 2022**
Musgrave PWA							
Bramfield	Licensed extraction	0.62	Good[2]	-3%	+14%	-0.67	-0.37
Bellevue	Control for Bramfield[1]	0.58	Good[2]	-5%	+5%	-0.29	-0.04
Polda	Licensed extraction	0.62	Good[2]	-2%	+11%	-0.57	-0.12
Southern Basins PWA							
Wanilla	Licensed extraction	0.51	Good[2]	-9%	+4%	-0.19	+0.16
Coulta	Control for Wanilla[1]	0.66	Good[2]	-5%	+14%	+1.35	+0.74

[1] No licensed extraction [2] Good - RCI of 0.50 to 0.69 [3] Changes at one representative +well at each site

For more information

Follow the links below to access other key documents:

- *Water Allocation Plan for the Southern Basins and Musgrave Prescribed Wells Areas*
- *A Guide to the Water Allocation Plan. Southern Basins and Musgrave Prescribed Wells Areas, Eyre Peninsula*
- *Monitoring, Evaluation and Improvement Plan for the Southern Basins and Musgrave Prescribed Wells Areas Water Allocation Plan*
- Access the 2022 site specific Red Gum GDE report cards here
- Access the full report on assessment of Red Gum condition in 2018 here:
  Muller K. L., N.J. Souter and Australian Water Technology (2019). *Eyre Peninsula Groundwater Dependent Ecosystem Data Analysis: Red Gum tree condition data (five sites)*. A report for Natural Resources Eyre Peninsula, Department for Environment and Water, Port Lincoln, South Australia.

Links to other supporting scientific reports can be found here

DEW (2021). *Musgrave and Southern Basins Prescribed Wells Areas. 2019-20 water resources assessment*, DEW Technical Note 2021/15

DEW (2021). *Musgrave Prescribed Wells Area. 2019-20 groundwater status overview*

DEW (2021). *Southern Basins Prescribed Wells Area. 2019-20 groundwater status overview*

Contact: Eyre Peninsula Landscape Board, **Senior Water Resources Officer** P (08) 8688 3200

C. 2022 Report Card: Wanilla Eyre Peninsula Groundwater-Dependent Ecosystem monitoring site

Wanilla

Eyre Peninsula Groundwater Dependent Ecosystems monitoring site

2022 Report Card

Summary

Type of site: Licensed extraction monitoring site

Status: **Orange**, improving trends in the short term (2016 to 2022). Declining condition (2021-2022) likely due to medium term low groundwater levels.

Red Gums:

Condition	Annual change (2021-2022)	Short term trend (2016 to 2022)	Long term trend
Good	**Declining** ↙	**Improving** ↗	**More data required** ?

Groundwater levels: Annual change (2021-2022) **Improving** ↗

Climate: Below average maximum summer temperatures and above average May to July rainfall, with good recharge events.

This Report Card should be read in conjunction with the *Overview and Red Gum GDE Condition Summary*, which provides information about Groundwater Dependent Ecosystem (GDE) monitoring and summary information for all monitored Red Gum GDE sites.

Adult Red Gum at Wanilla assessed as in 'moderate' condition in Oct 2022.

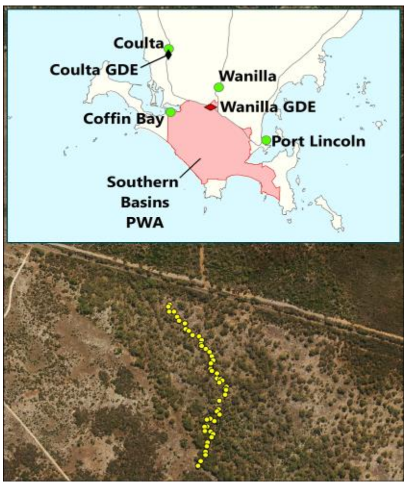
The **Wanilla** Groundwater Dependent Ecosystem (GDE) monitoring site is situated four kilometres east of the Coffin Bay road turn off on Flinders Highway. The site is part of a large remnant patch of Red Gum (*Eucalyptus camaldulensis)* Woodland. Amongst the Red Gum overstorey and midstorey grows native apricot (*Pittosporum sp.*), coast beard-heath (*Leucopogon sp.*), hop-bush (*Dodonaea sp.*) and sheoak (*Allocasuarina spp.*).

The Wanilla GDE site is monitored to assess the impacts of licensed water extraction from the Uley-Wanilla groundwater lens in the Southern Basins Prescribed Wells Area. There are a number of users (including SA Water) who hold licenses to extract water for town water supply, domestic use, and other private commercial purposes. Licensed water extraction from the Uley-Wanilla lens has however been declining, going from 164 ML in 2017-2018 to 33.8 ML in 2021-2022.

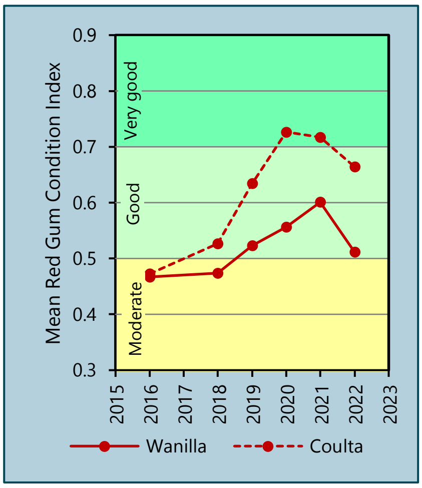
While there is unlicensed extraction of water for stock and domestic purposes, this is assumed to be low compared to extraction for licensed consumptive purposes at other sites, and there is a low likelihood of it having any impact on the GDE.

Red Gum condition

Tree condition monitoring is carried out in late October to early November. In 2016, when the monitoring commenced, the Red Gum condition was moderate, with an average Red Gum Condition Index (RCI) score of 0.47. There was a steady improvement in Red Gum condition until 2021 (average RCI score of 0.60) totalling 13%. However condition has declined in 2022 by 9% (average RCI score of 0.51). This decline in RCI can be attributed to decline in health indicators factors that are assessed to determine the RCI. Most specifically it can be attributed to increased cracking of bark, and increased leaf die-off, indicating decline in tree health. The dataset is too short to enable determination of any long term trends.



Wanilla site map
(yellow dots represent 50 surveyed trees)



Graph 1 Change in Red Gum Condition Index at Wanilla and Coulta (control site for Wanilla) from 2016 to 2022

Groundwater and climate assessment

Red Gum condition declined significantly through 2022, with trees supported by stable groundwater levels, higher than average rainfall, and cooler than average maximum daily temperatures.

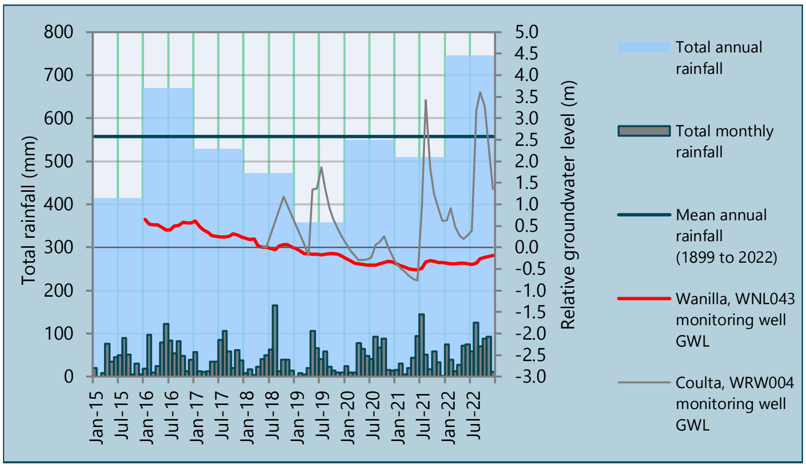
As detailed below, Graphs 2 and 3 shows climatic factors contributing to groundwater medium term decline, and associated Red Gum condition short term decline:

- Total annual rainfall increased from 510 mm in 2021 to 746 mm in 2022, 189 mm above the long term[1] mean annual rainfall (557 mm) (Graph 2).
- Through the summer months of 2022, levels in monitoring well WNL043 continued to fall. This decline was, however, followed by recharge of groundwater from August to the end of December, caused by the higher than average rainfall during these months.
- Temperatures were cooler than usual, with the monthly average of the daily maximum temperature 0.5°C below the long term[1] mean (Graph 3). These cooler temperatures could result in improved groundwater recharge, with less evaporation occurring after rainfall events. The impact of cooler temperatures on Red Gum condition is possibly mixed. They can also contribute to improved Red Gum condition, with the trees being impacted less by heat stress, but could also result in less vigour in the trees, and might have contributed to a small degree to the decline in Red Gum RCI during 2022.

Red Gum condition at Wanilla had improved every year since 2016, with a net 13% improvement in conditions from 2016 to 2021 (Graph 1). However condition has declined in 2022 by 9% resulting in a net improvement of 4%. The net improvement in Red Gum condition at Coulta (control site for Wanilla) for the same period is, however, much higher (14%). A longer data set is however required to determine whether these differences are statistically significant, and what may be causing them if they are.

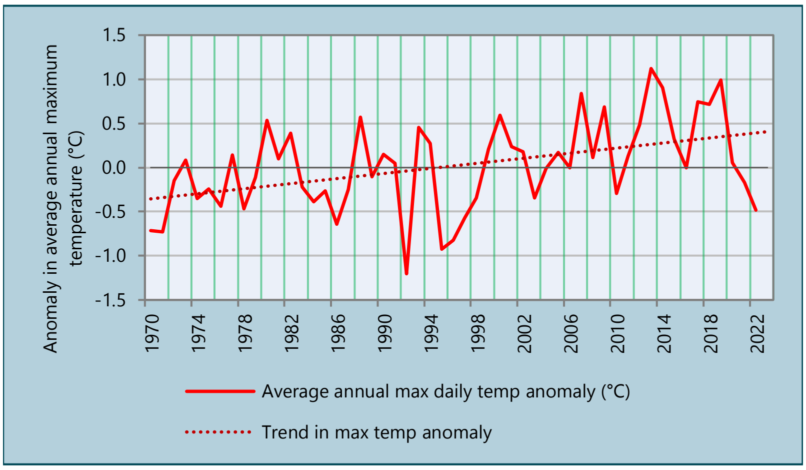
Monitoring into the future

Tree condition and groundwater level monitoring will continue on a yearly basis. A study is also going to be undertaken in 2022-2023 to confirm definitively whether the Wanilla and Coulta Red Gums are using local groundwater. This will be done by looking at stable chemical isotopes that occur in the local groundwater, and which are a "signature" for a groundwater source, and comparing these to the isotopes occurring in tree sap.



Graph 2 Total annual and total monthly rainfall^^, and change in groundwater level** at monitoring wells at Wanilla, WNL043 (6028-1605), and at Coulta, WRW004 (5929-0737).

Notes:
^^Rainfall data for 2016 to 2018, June 2020 to June 2021, and June 2022 to January 2023 is patched SILO data for the Bureau of Meteorology station, Port Lincoln (Big Swamp) (number 18017). All other rainfall data for 2019 to 2022 is site specific data obtained from the rainfall gauge installed at the Wanilla GDE site.
**For all monitoring wells the groundwater levels shown are relative to the groundwater levels in that well at June 2018, which are shown as zero.



Graph 3 Anomaly in annual average of daily maximum temperature^ from 1970 to 2022

Note:
^ This is the difference between the annual average of the daily maximum temperature for any one year and the long term[1] mean of the annual average of the daily maximum temperature. Maximum daily temperature is measured at the Bureau of Meteorology station, Big Swamp (number 18017).

[1]All long term averages are for the period 1 Jan 1899 to 31 Dec 2022.

For more information

Access the full report on assessment of Red Gum condition in 2018 here:
Muller K. L., N.J. Souter and Australian Water Technology (2019). *Eyre Peninsula Groundwater Dependent Ecosystem Data Analysis: Red Gum tree condition data (five sites)*. A report for Natural Resources Eyre Peninsula, Department for Environment and Water (DEW), Port Lincoln, South Australia.

Access the 2022 *Overview and Red Gum GDE Condition Summary* and other specific site (Coulta, Bramfield, Bellevue, and Polda) report cards here.

For groundwater status and long term water extraction information:
DEW (2021). *Musgrave and Southern Basins Prescribed Wells Areas. 2019-20 water resources assessment*. DEW Technical Note 2021/15.
DEW (2021). *Southern Basins Prescribed Wells Area. 2019-20 groundwater status overview*.

Contact: Eyre Peninsula Landscape Board, **Senior Water Resources Officer** P (08) 8688 3200

8. Units of measurement

11.2 Shortened forms

DEW	Department of Environment and Water
DFW	Department for Water
EPNRMB	Eyre Peninsula Natural Resources Management Board
PWA	Prescribed wells area
PWS	Public Water Supply
QL	Quaternary Limestone
SA Water	South Australian Water Corporation
WAP	Water allocation plan

9. Glossary

Act (the) — In this document, refers to the *Natural Resources Management (SA) Act 2004,* which supersedes the *Water Resources (SA) Act 1997.*

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 and the water is held at greater than atmospheric pressure; water in a penetrating well will rise above the surface of the aquifer.

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

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.

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

Hydrogeology — The study of groundwater, which includes its occurrence, recharge and discharge processes, and the properties of aquifers.

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

Australian Height Datum (mAHD) — Defines elevation in metres (m) according to the Australian Height Datum (AHD); 0 mAHD is approximately mean sea level.

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 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.

Production well — The pumped well in an aquifer test, as opposed to a monitoring well; a wide-hole well, fully developed and screened for water supply, drilled on the basis of previous exploration wells.

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

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

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

Water allocation — (a) In respect of a water licence, the quantity of water that the licensee is entitled to take and use pursuant to the licence. (b) In respect of water taken pursuant to an authorisation under section 11 of the Act, the maximum quantity of water that may be taken and used pursuant to that authorisation.

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

Water Allocation Plan (WAP) — A plan prepared by a Catchment Water Management Board or water resources planning committee and adopted by the Minister in accordance with the Act.

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

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.

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