Australasian Groundwater & Environmental Consultants

Report on

# GS46 Upper Murray Alluvium Stage 5

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ABN 64 080 238 642

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Australasian Groundwater and Environmental Consultants Pty Ltd

Brisbane Head Office
Level 2, 15 Mallon Street
Bowen Hills QLD 4006
t: (07) 3257 2055

Newcastle
4 Hudson Street
Hamilton NSW 2303
t: (02) 4962 2091

Perth
46B Angove Street
North Perth WA 6006
t: (08) 6383 9970

Townsville
Unit 1, 60 Ingham Road
West End QLD 4810
t: (07) 4413 2020

ageconsultants.com.au | linkedin.com/company/ageconsultants

# GS46 – Upper Murray Alluvium

## Stage 5 – Assessment through multiple lines of evidence

The Upper Murray Alluvium (GS46) is located within the Upper Murray floodplain in southeastern New South Wales. It stretches from downstream of the Hume Dam near Albury in the east to Hopefield in the west, covering the northern floodplain of the River Murray (Figure 1). GS46 consists of unconsolidated sediments from the Shepparton (up to 40 m) and Lachlan (up to 100 m) Formations, arranged as a shallow unconfined or semi-confined aquifer and a deeper semi-confined aquifer, both of which are hydraulically linked to the River Murray (NSW DPIE, 2019; Crosbie et al., 2023). Groundwater entitlements are evenly distributed across GS46, with larger allocations in the northwest (Figure 1), and basic landholder rights are mainly located around Howlong. GS46 spans approximately 490 km², with a Sustainable Diversion Limit (SDL) of 14.10 GL/year and a long-term average recharge of 3.73 GL/year (Table 1; other estimates of recharge vary). From 2013 to 2023, the average annual groundwater extraction was 11.51 GL/year, which is approximately three times the estimated recharge and 82% of the SDL (Figure 2). Groundwater use supports intensive irrigation along with stock and domestic needs on the main alluvial floodplain, helping to supplement surface water during years with below-average rainfall (Figure 1, Figure 2). Long-term climate records indicate a period of predominantly below-average rainfall from 2000 to 2010, followed by a recovery and stable conditions until 2017. Since 2020, rainfall has increased notably (Figure 2). GS46 is mainly characterised by semi-arid conditions, based on the precipitation-to-evaporation ratio (Figure 3).

The water table typically lies within 10 m of the ground surface (Figure 4a). However, some areas away from the River Murray, towards the northwest of GS46, exceed 15 m or 20 m deep, and other areas closer to the river within a 5 m depth. Groundwater flows from the east to the west along the main alluvial floodplain (Figure 4b). Long-term (1974-2024) and short-term (2012-2024) median groundwater levels show consistent spatial patterns. They are contained within a well-defined multi-decadal fluctuation zone up to 5 m thick (Figure 5). In several parts of GS46, the base of the fluctuation zone aligns with recent (short-term) water levels, suggesting that current levels are near the deepest recorded since 1974. Water quality is generally fresh, with salinity below 1,500 mg/L (equivalent to 2,239 µS/cm) (Figure 6), although some areas towards the northwest of GS46 show higher salinity levels (MDBA, 2020; DPIE, 2019). Water level trends indicate that most bores with data have a long-term trend that is between -0.1 m/year and 0.1 m/year (1974–2024) (Figure 7, Figure 9), while short-term declines are more noticeable (Figure 10; -0.2 m/year to -0.1 m/year). Despite this, though some bores demonstrating recovery after 2020 (Figure 7). Understanding of temporal salinity patterns remains limited due to sparse data (Figure 8).

MDBA (2020) previously reported recharge at 19.70 GL/year for GS46, which includes only diffuse recharge (MD-SY1 WAVES modelling). A review of diffuse recharge rates for the MD-SY2 project (Crosbie et al., 2025) estimated diffuse recharge for GS46 as 8.91 GL/year. Both of these estimates are higher than the Stage 2 long-term estimate of 3.73 GL/year, which is based on chloride mass balance data from Lee et al. (2024). Table 1 shows a storage-to-recharge ratio (S/R) of 328 based on the MD-SY2 recharge estimate and the WERP storage estimate (Rojas et al., 2022), indicating moderate buffering capacity and vulnerability to short-term climate variability (S/R sits within “medium responsiveness” bracket[1] defined in Rojas et al., 2022). The high extraction-to-recharge (E/R) and SDL-to-recharge (SDL/R) ratios (Table 1) imply moderate to high pressure on the productive base.

[1] S/R ratio: High responsiveness: 29 to 111.
Medium responsiveness: 11 to 333.
Low responsiveness: >333.

The productive base shows signs of stress, as most monitoring bores with sufficient data (12 of 14) show declining long-term water level trends (Table 1; Figure 9). Statistically significant declines (α = 0.05) have been recorded since 1974 along the floodplain in 12 of the 14 eligible monitoring bores (Table 1; central and west regions of GS46, rates typically less than 0.2 m/year). Short-term trends (Figure 10) indicate an increase in the severity of declining trends (e.g. up to 0.5 m/year in 42% of the bores with data), and a decrease in the number of bores showing stable or slightly fluctuating trends (Figure 10). However, the short-term data also indicates a decrease in the proportion of the asset area that shows deteriorating trends (Table 2). Together, these observations may indicate localised areas of risk. The short-term period (2012-2024) was characterised mainly by average rainfall until 2017, followed by a notable decrease before 2020 and a sharp increase after 2020 (Figure 3). A significant drop in annual groundwater extraction after 2020 correlates with the positive annual rainfall anomaly (Figure 2). Groundwater declines likely affect surface water connectivity, as all reaches with flow data were classified as 'mostly not losing' upstream of Albury and 'mostly losing' downstream from 2000 to 2019, per Crosbie et al. (2023). Groundwater-dependent ecosystems (GDEs), such as riparian and floodplain vegetation, may also be impacted if water levels fall below critical ecological thresholds.

Stage 4 of this BPR technical groundwater review provided a quantitative assessment of resource condition indicators within a 5 km buffer around extraction points (asset area). Long-term groundwater level declines were observed in 40% of the productive base asset area, 35% of the river connectivity asset area, and 36% of the GDE asset area (Table 2). In the short term, these percentages decreased modestly to 32%, 27%, and 26%, respectively (Table 2). Areas showing improving water level conditions slightly increased in the short-term across all ESLT values (except water quality) (Table 2), indicating limited recovery or stabilisation (Figure 11). Levels of uncertainty, indicated by areas with insufficient data to determine temporal trends, rose slightly from long-term to short-term periods (minimal vertical displacement of points in Figure 11). The exception is the water quality (salinity) ESLT value, where recent data gaps have grown, resulting in the short-term asset area being fully classified as having 'insufficient data' to assess temporal trends.

The NSW state-based risk assessment (NSW DoI, 2019) assigns varying risk ratings across ESLT values. For the productive base, most risk factors are rated as medium. However, high risks of potential local drawdowns reducing groundwater access and the growth of basic landholder rights decreasing groundwater availability are identified in GS46. Risks to river connectivity are rated as low for GS46, while risks to GDEs range from low to medium, with higher risks linked to groundwater extraction causing local drawdown near identified GDEs. These risks align with the spatial variability in observed water level trends (Figure 10) and mapped GDEs, which are proximal to the River Murray (Figure 1). Water quality risks are assessed as medium, primarily due to the potential for groundwater extraction to lead to connections with poor-quality groundwater. Limited water level and salinity data contribute to residual uncertainty in the overall risk profile.

Future projections from the MD-SY2 project suggest that diffuse recharge in GS46 may increase by 2050 due to more intense rainfall events (Crosbie et al., 2025). In contrast, overbank flood recharge is forecast to decline by 33% compared to current conditions (Crosbie et al., 2025), potentially reducing localised episodic recharge and groundwater availability during dry periods. These opposing trends introduce uncertainty about the net future recharge in GS46. Stage 6 of this BPR technical groundwater review found that the future area of drawdown (Area of Influence, AoI[2]) is expected to remain largely unchanged under climate change scenarios, with the median future AoI (P50) only slightly higher than the current AoI (Figure 12). The SDL/R ratio is expected to increase in future, given the projected decline in floodplain recharge, indicating that the rate of resource replenishment may vary in the future. The Stage 6 assessment classified the pressure from future climate change on GS46 groundwater resources as high, based on both long- and short-term water level evidence.

[2] Area of influence is defined as the area impacted by drawdown caused by groundwater extraction. For the quantitative assessment of Stage 4, this is equivalent to the percentage asset area showing a deteriorating resource condition, which is a statistically significant declining trend in groundwater level.

Overall, short-term groundwater trends (2012–2024) show slightly worsening conditions across ESLT values, but only in local zones of GS46, while the level of uncertainty has marginally increased compared to the long-term assessment (1974–2024). Uncertainty about salinity trends has grown significantly, with 100% of the short-term asset area now classified as lacking enough data to determine temporal trends. Current extraction remains below the SDL and is sensitive to annual rainfall; however, the average extraction of 11.51 GL/year exceeds the most recent estimate of recharge (8.91 GL/year). Similarly, the SDL exceeds this recharge estimate, and the effects of full SDL use have not yet been observed. The state-based risk assessment supports this concern, indicating medium risks across most ESLT values and high risks to the productive base due to groundwater extraction. Climate projections suggest reduced episodic (localised) recharge from floodplain processes in the future for this alluvial resource unit. Collectively, the analysis indicates that there is moderate to high pressure on the productive base of GS46, and high pressure from future climatic change.

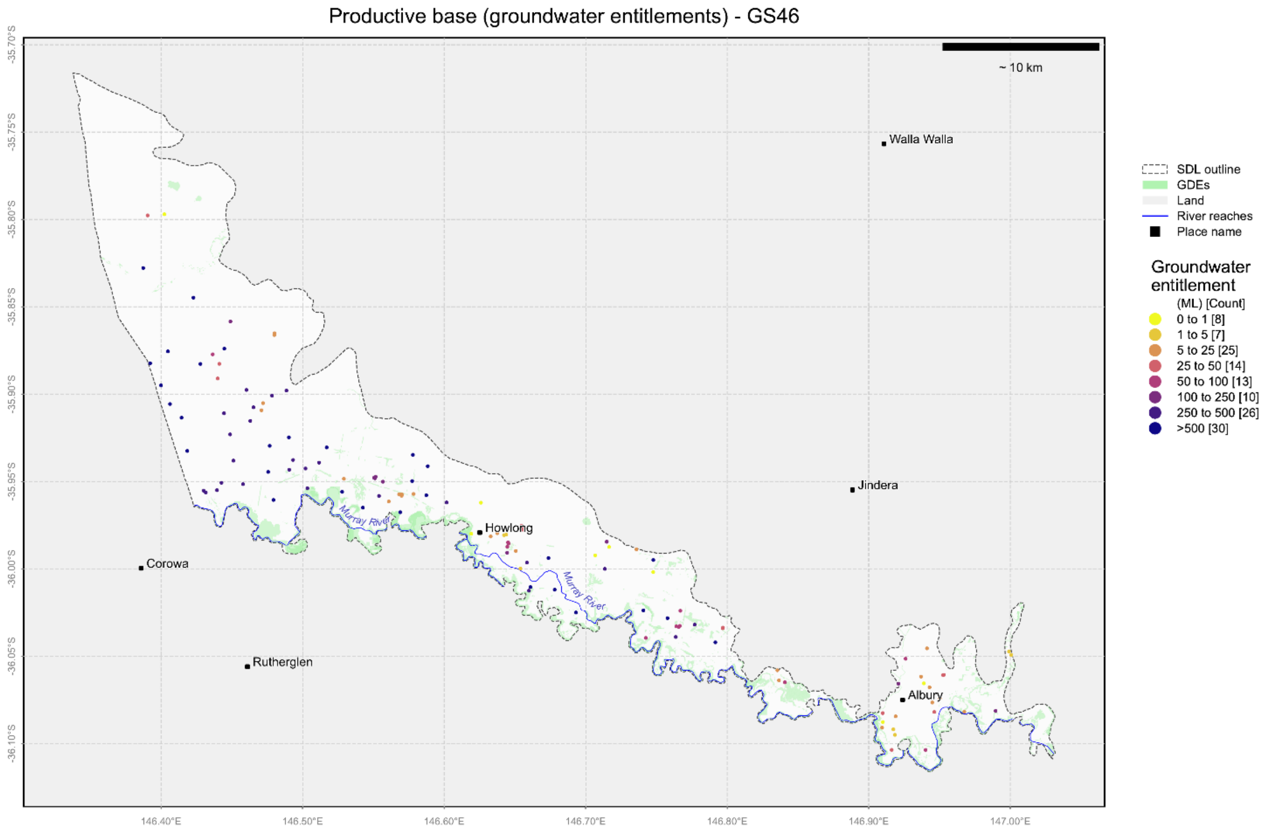



Figure 1 Productive base (groundwater entitlements)

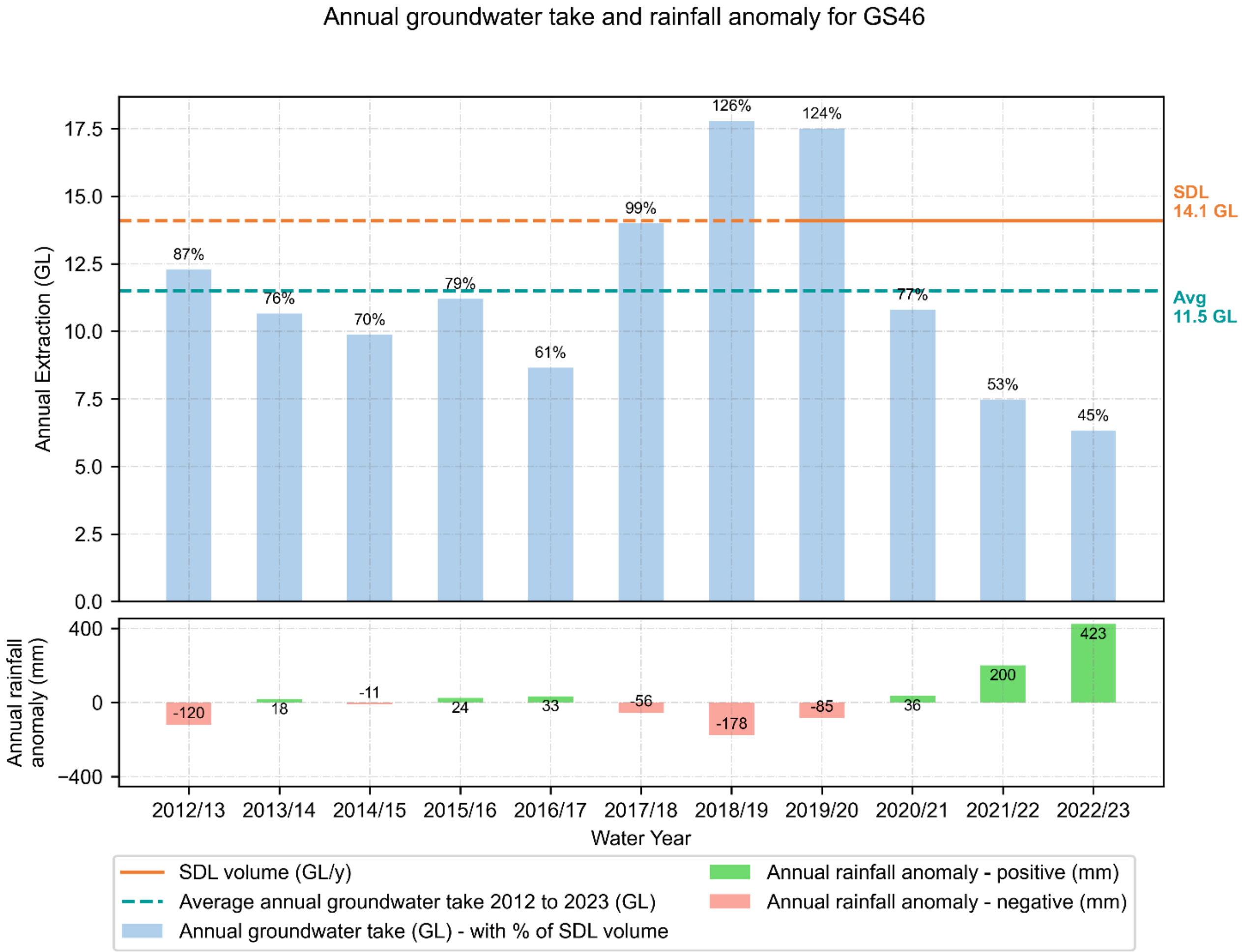



Figure 2 Groundwater take in the SDL since 2012

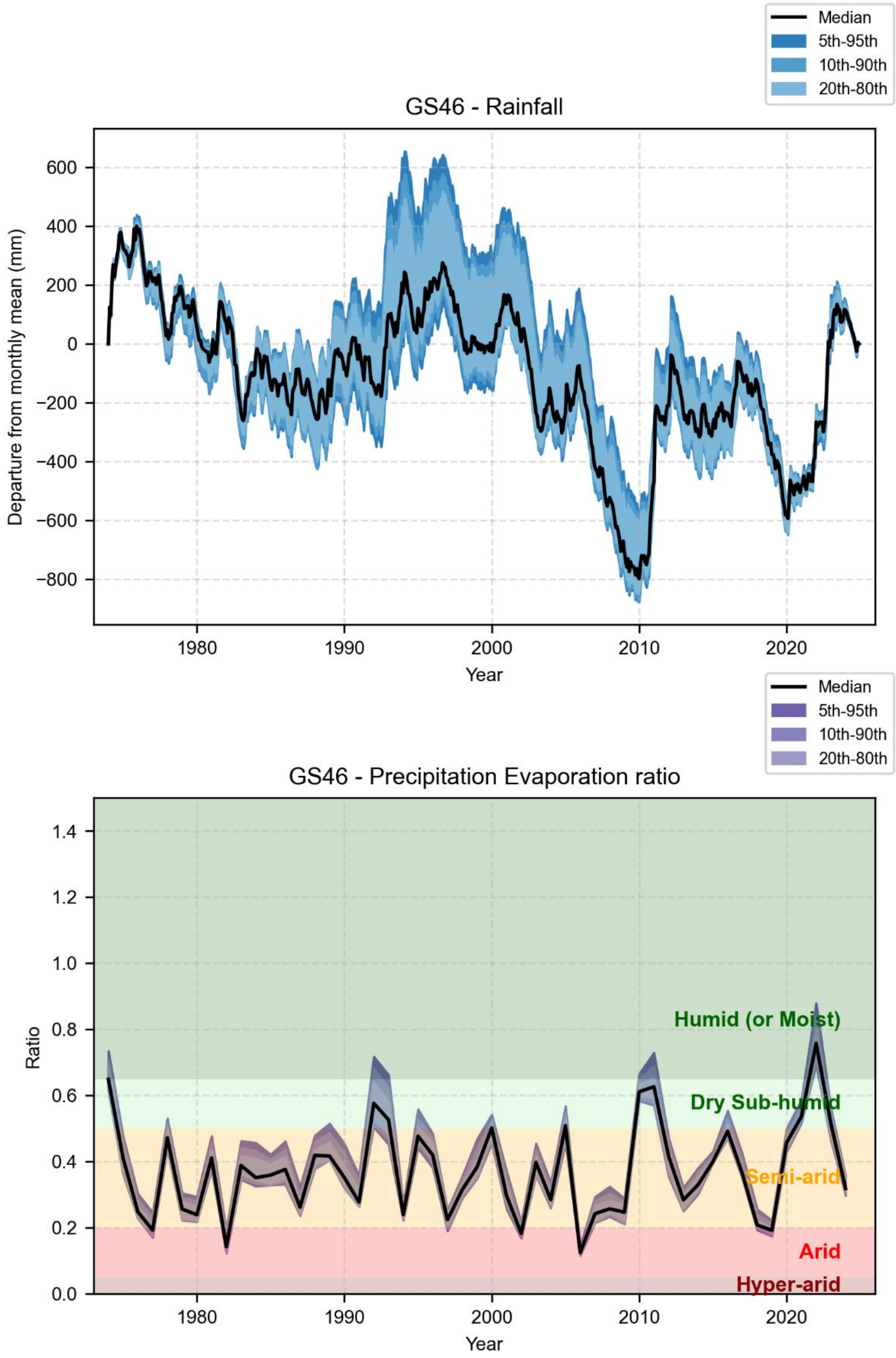



Figure 3 Historical climate trends

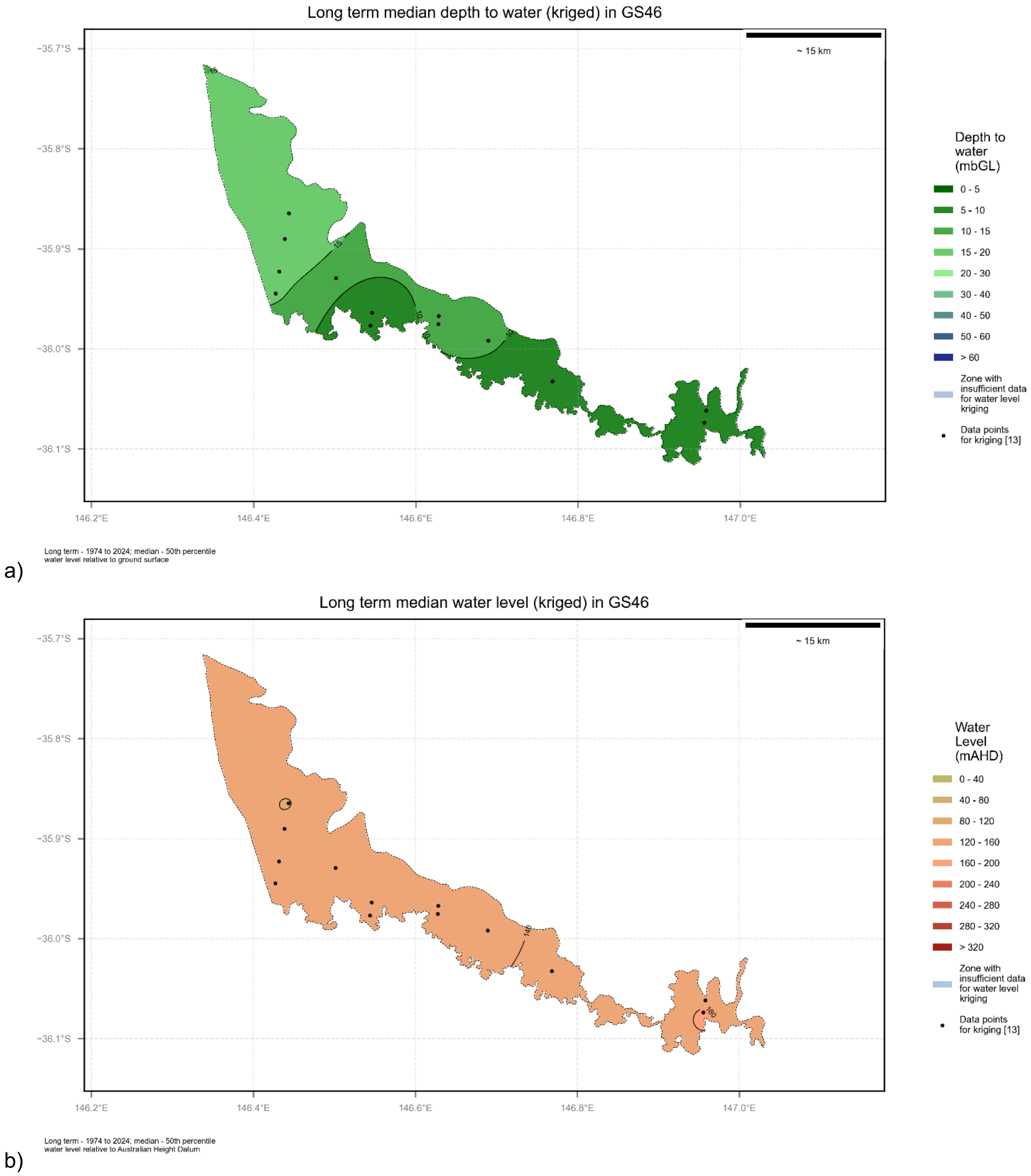
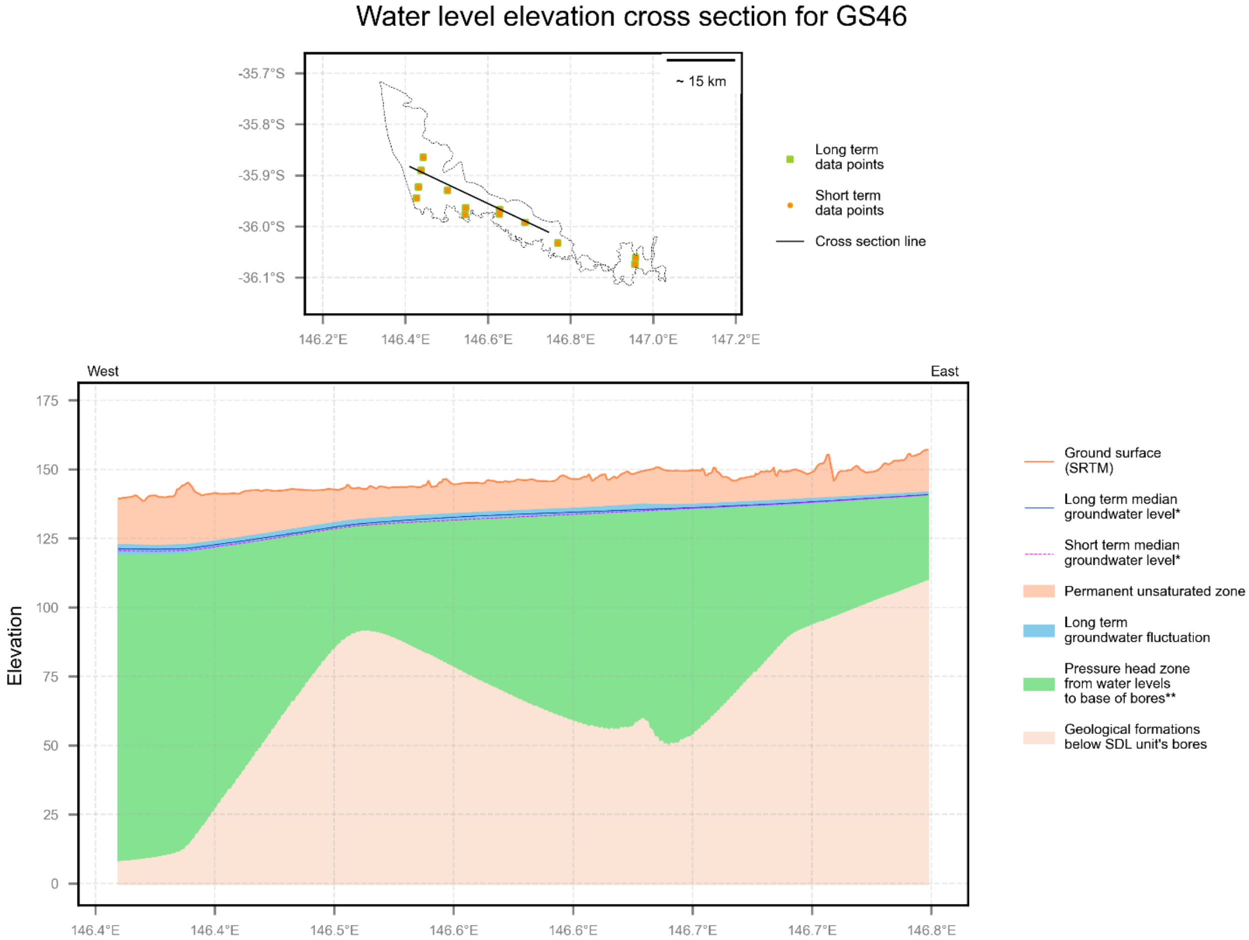



Figure 4 Long-term median (a) depth to water and (b) water level elevation




*Long term - 1974 to 2024; Short term - 2012 to 2024; median - 50th percentile

***This cross-section is a scaled representation of bore data specific to the SDL resource unit.*
*The data are temporally and spatially aggregated, resulting in some smoothing of the representation of water levels and aquifer formations that is different from the detail of reality.*
*The blue zone represents the long term fluctuation in groundwater levels, as indicated by the 5th and 95th percentiles of groundwater levels from 1974 to 2024.*
*The green pressure head zone may be representative of the total available drawdown (TAD), as it shows the water column in bores of the SDL resource unit (measured as the difference between the long-term 5th percentile groundwater level and the base of the bores of the SDL resource unit).*
*This cross-section is for interpretation purposes only and should not be used for planning or compliance purposes.*

Figure 5 West to east distribution of water levels in the SDL resource unit

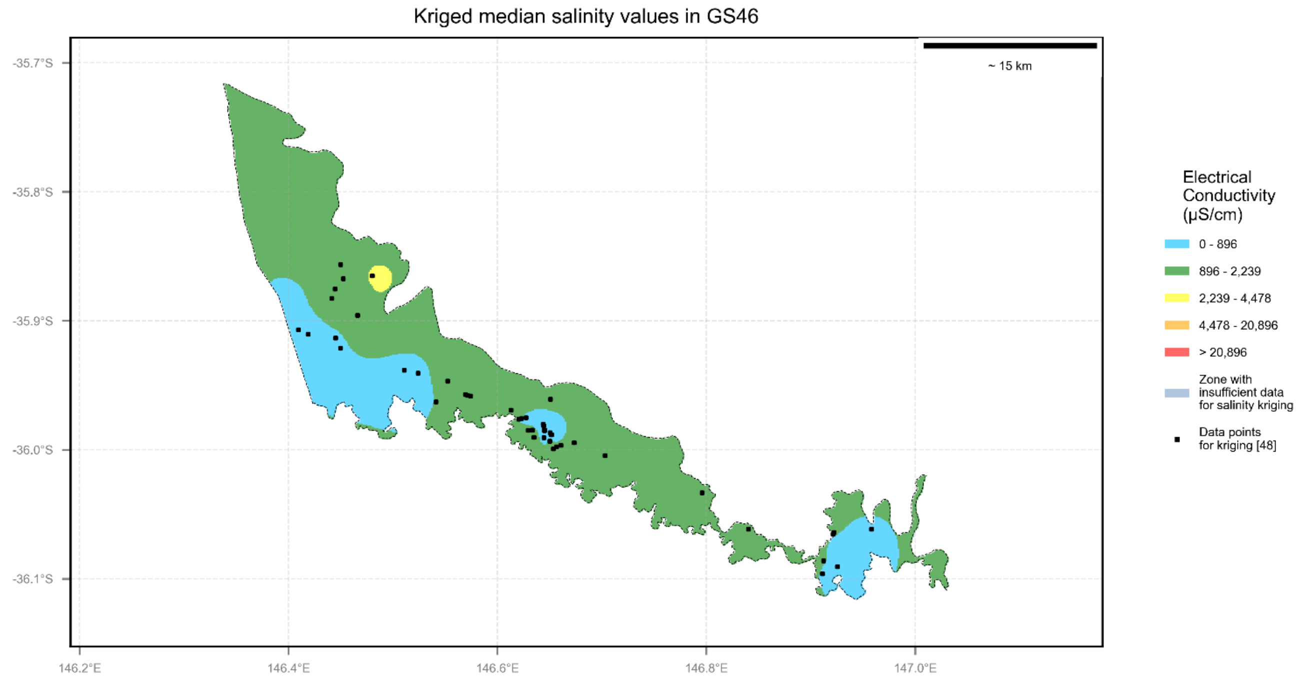



Figure 6 Groundwater salinity distribution

Table 1 Table of groundwater metadata for the SDL resource unit

| Parameter | Unit | Long-term (1974 to 2024) | Short-term (2012 to 2024) | SDL resource unit data |
|---|---|---|---|---|
| SDL volume | GL/y | - | - | 14.10 |
| SDL resource unit area | km² | - | - | 490 |
| Average annual take (2013 to 2023) | GL/y | - | - | 11.51 |
| Number of groundwater entitlement bores | - | - | - | 133 |
| SDL resource unit storage estimate* | GL | - | - | 2,920 |
| Recharge estimate (SY1) | GL/y | - | - | 19.70 |
| Recharge estimate (Stage 2) | GL/y | - | - | 3.73 |
| Diffuse recharge estimate (SY2 - WAVES) | GL/y | - | - | 8.91 |
| Extraction/SDL (E/SDL) (Stage 2 result) | - | - | - | 0.82 |
| SDL/Recharge (SDL/R) (Stage 2 result) | - | - | - | 3.78 |
| SDL/Recharge (SDL/R) (SY2 or modelled recharge) | - | - | - | 1.58 |
| Storage/Stage 2 Recharge (S/R) | - | - | - | 783 |
| Storage/SY2 or modelled Recharge (S/R) | - | - | - | 328 |
| Number of bores in the SDL unit | - | 955 | 955 | - |
| Number of bores for water level trend analysis | - | 14 | 13 | - |
| Number of bores for water level trend with sufficient data | - | 14 | 12 | - |
| Number of bores with decreasing water level trend | - | 12 | 9 | - |
| Number of bores with increasing water level trend | - | 1 | 0 | - |
| Number of bores with no statistically significant water level trend | - | 1 | 3 | - |
| Mean water level trend magnitude | m/y | -0.05 | -0.09 | - |
| Minimum water level trend magnitude | m/y | -0.17 | -0.37 | - |
| 5%ile water level trend magnitude | m/y | -0.14 | -0.24 | - |
| 10%ile water level trend magnitude | m/y | -0.12 | -0.14 | - |
| 50%ile water level trend magnitude | m/y | -0.04 | -0.07 | - |
| 90%ile water level trend magnitude | m/y | 0.01 | 0.01 | - |
| 95%ile water level trend magnitude | m/y | 0.06 | 0.03 | - |
| Maximum water level trend magnitude | m/y | 0.13 | 0.05 | - |
| Number of bores for salinity trend analysis | - | 50 | N/A | - |
| Number of bores for salinity trend with sufficient data | - | 2 | N/A | - |
| Number of bores with decreasing salinity trend | - | 0 | N/A | - |
| Number of bores with increasing salinity trend | - | 0 | N/A | - |
| Number of bores with no statistically significant salinity trend | - | 2 | N/A | - |
| Mean salinity trend magnitude | µS/cm/y | -1,802 | N/A | - |
| Minimum salinity trend magnitude | µS/cm/y | -3,549 | N/A | - |
| 5%ile salinity trend magnitude | µS/cm/y | -3,374 | N/A | - |
| 10%ile salinity trend magnitude | µS/cm/y | -3,199 | N/A | - |
| 50%ile salinity trend magnitude | µS/cm/y | -1,802 | N/A | - |
| 90%ile salinity trend magnitude | µS/cm/y | -404 | N/A | - |
| 95%ile salinity trend magnitude | µS/cm/y | -230 | N/A | - |
| Maximum salinity trend magnitude | µS/cm/y | -55 | N/A | - |

**Note:** *Groundwater resource storage estimate source: WERP (RQ8b).

Table 2 Table of results from spatial analysis of RCI trends in ESLT asset areas

| ESLT Value | Asset area (m2) | Long-term | | | | Short term | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Proportion of asset area with improving/ stable RCI trends | Proportion of asset area with deteriorating RCI trends | Proportion of asset area with uncertain RCI trends | Trend grouping | Proportion of asset area with improving/ stable RCI trends | Proportion of asset area with deteriorating RCI trends | Proportion of asset area with uncertain RCI trends | Trend grouping |
| Productive base | 1,036,772,293 | 15% | 40% | 45% | Variable trends | 20% | 32% | 48% | Variable trends |
| GDEs | 907,112,309 | 17% | 36% | 47% | Variable trends | 23% | 26% | 51% | Insufficient data |
| River connectivity | 767,926,277 | 20% | 35% | 45% | Variable trends | 25% | 27% | 48% | Variable trends |
| Water quality | 956,080,028 | 16% | 0% | 84% | Insufficient data | 0% | 0% | 100% | Insufficient data |

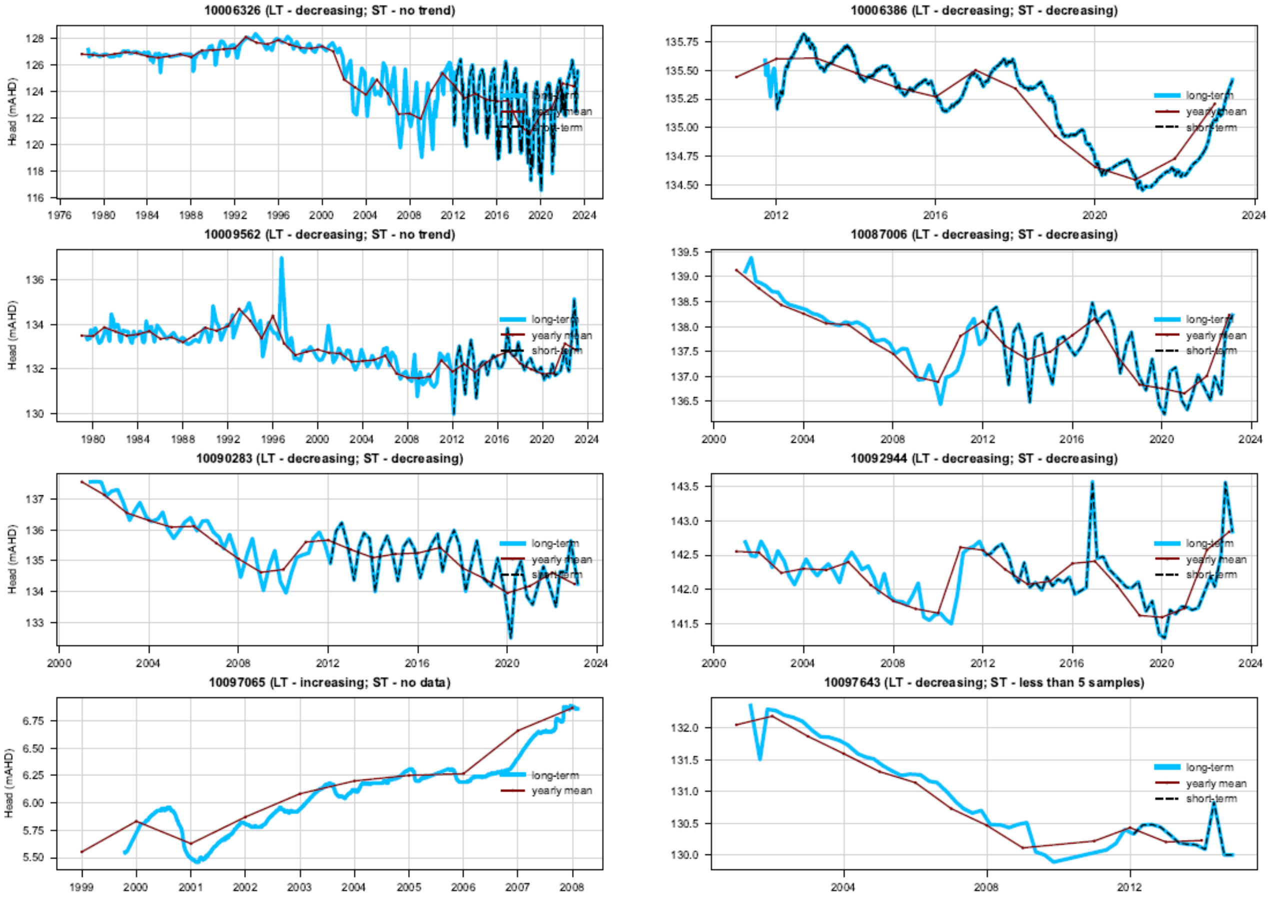



Figure 7 Representative groundwater hydrographs for the SDL resource unit

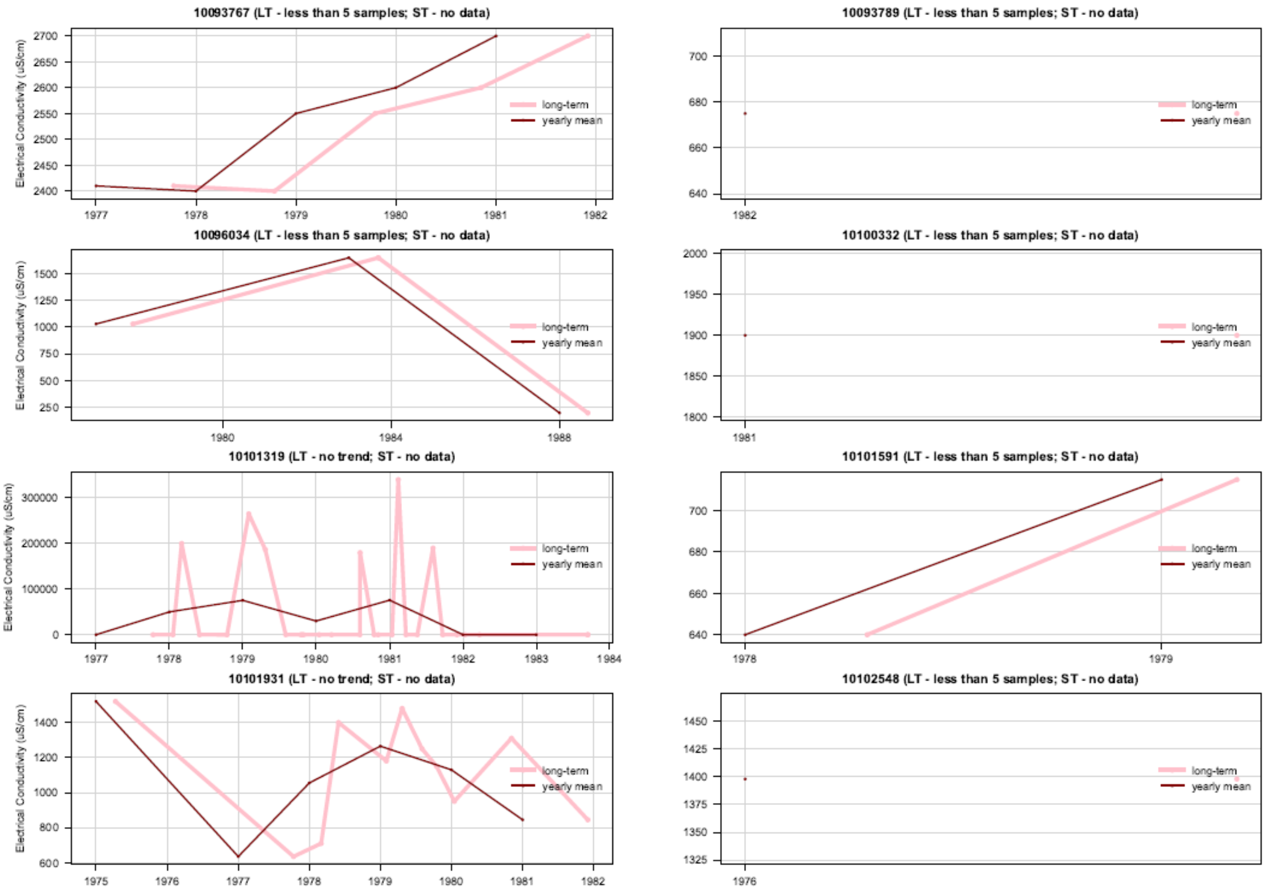



Figure 8 Representative groundwater salinity time series for the SDL resource unit

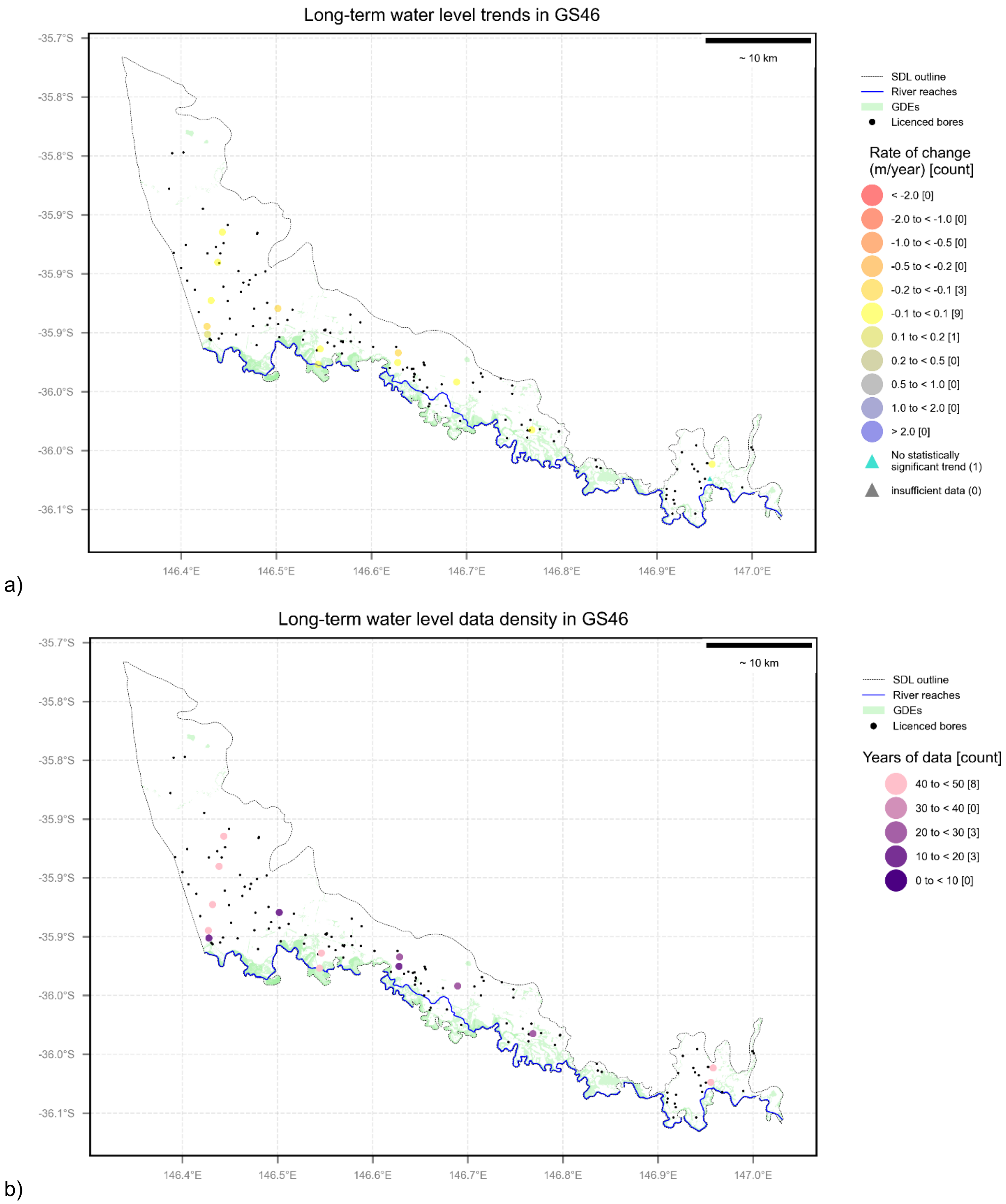
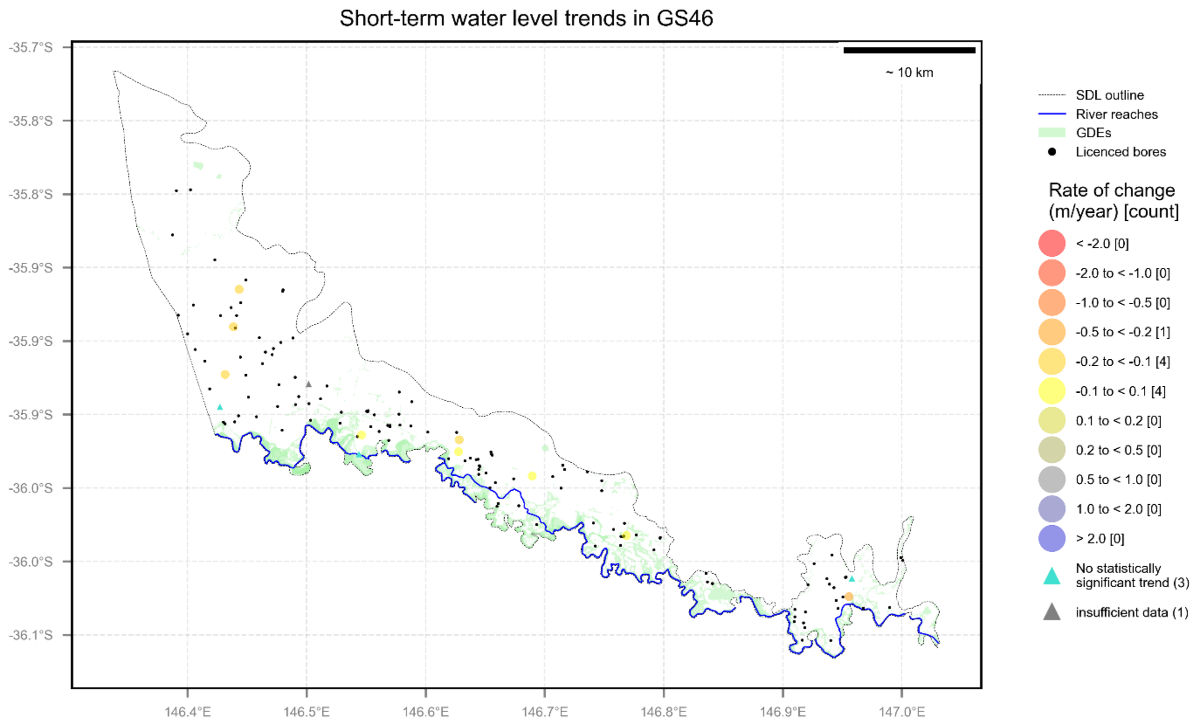
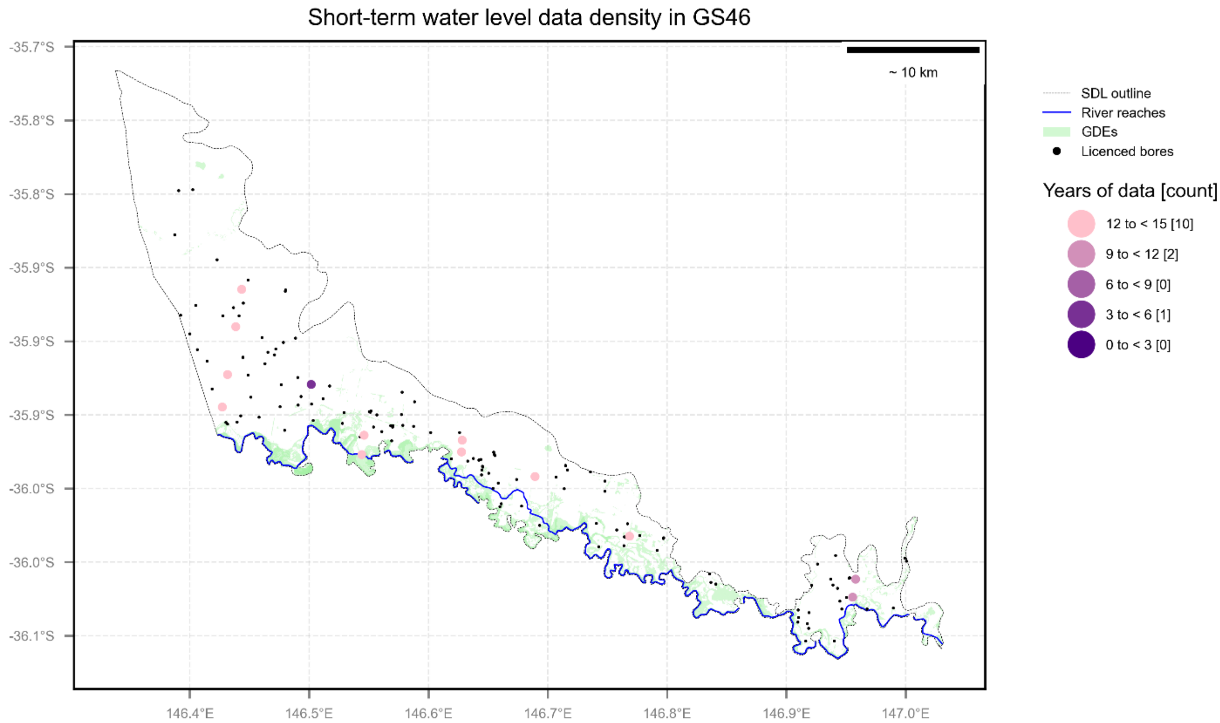



Figure 9 Long-term (1974 to 2024) groundwater level trends (a) and data availability (b)




a)




b)

Figure 10 Short-term (2012 to 2024) groundwater level trends (a) and data availability (b)

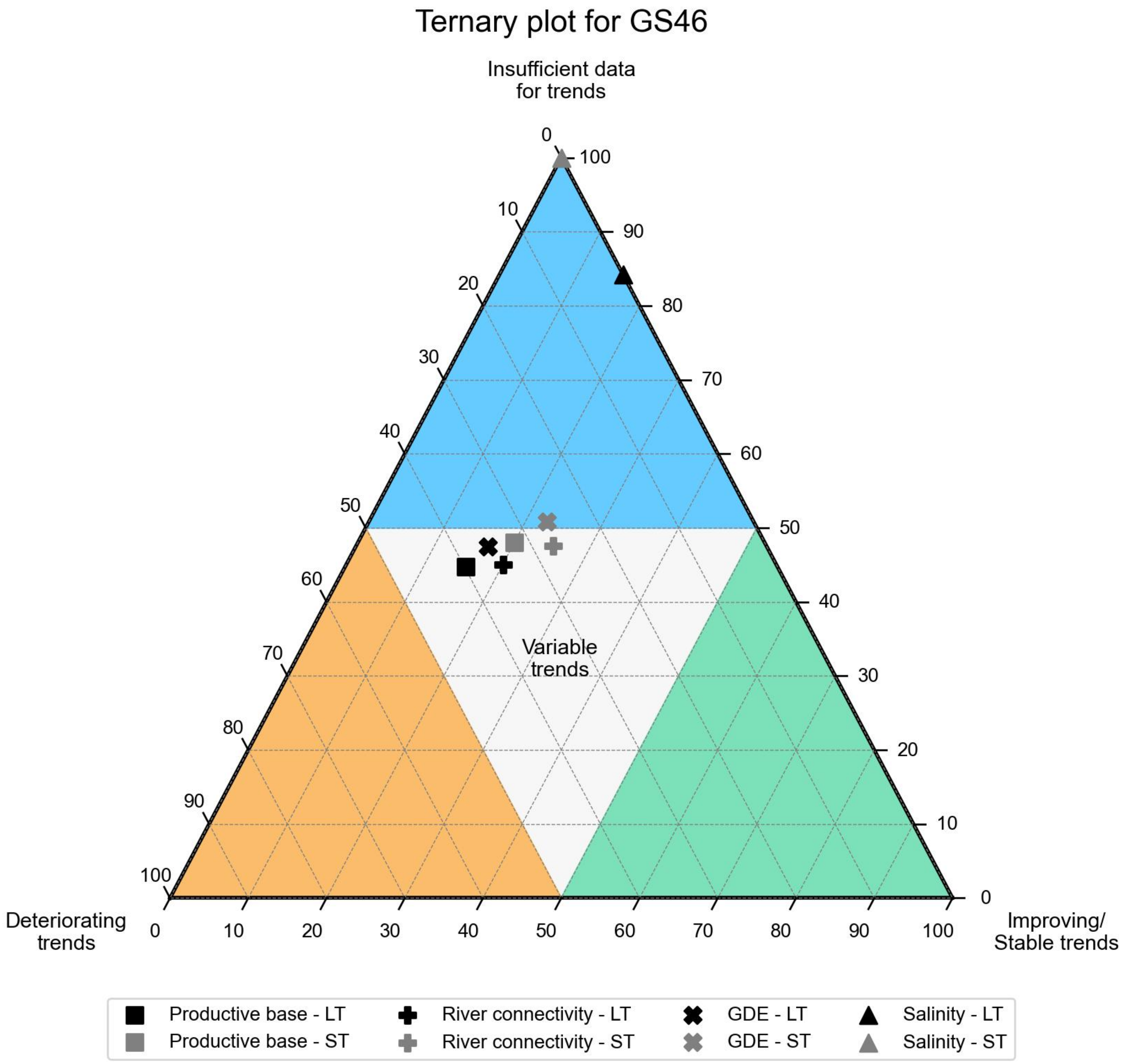



Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

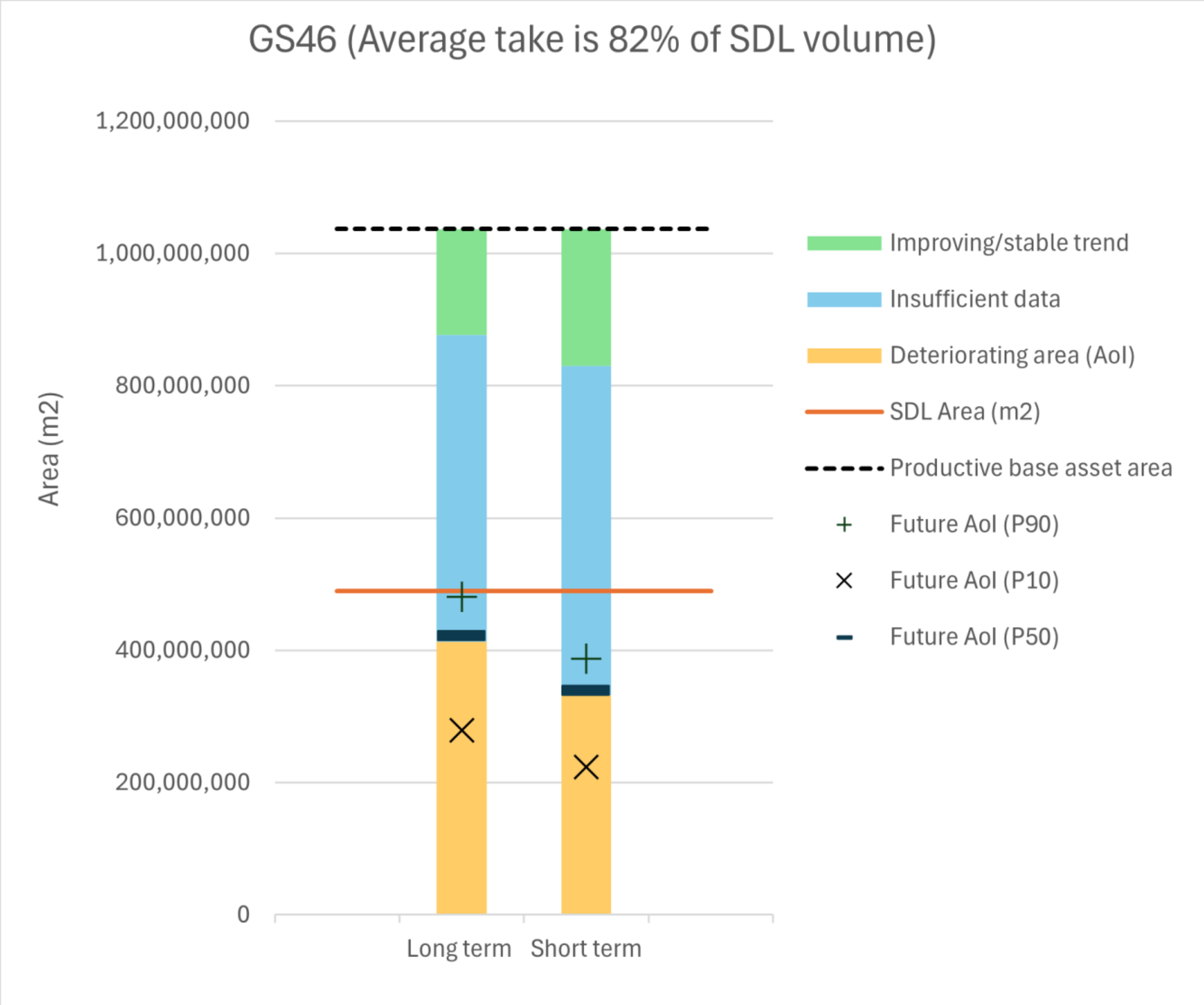



Figure 12 Estimates for change in area of influence (AoI) due to climate change

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