Australasian Groundwater & Environmental Consultants

Report on

GS26 Lower Macquarie Alluvium Stage 5

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GS26 – Lower Macquarie Alluvium

Stage 5 – Assessment through multiple lines of evidence

The Lower Macquarie Alluvium (GS26) is located within the Macquarie catchment in central-western New South Wales and comprises an alluvial aquifer system associated with the Macquarie and Bogan rivers floodplain (Figure 1). The aquifer system comprises a deep alluvial paleochannel towards the southeast between Narromine and Dandaloo (MDBA, 2020). Groundwater entitlements are concentrated along the main alluvial plain between Macquarie and Bogan rivers, particularly downstream of Narromine in the south and southeastern sections of GS26, between Narromine and Dandaloo (Figure 1). GS26 spans 1,202 km², with a Sustainable Diversion Limit (SDL) of 70.70 GL/year and a long-term average recharge estimate of 62.80 GL/year (Table 1). Between 2013 and 2023, average annual groundwater extraction was 33.27 GL/year, representing 53% of estimated recharge and 47% of the SDL (Figure 2). Groundwater supplements the surface water supply in years of below-average rainfall, supporting irrigation, stock and domestic use, and providing a critical reserve for local water utilities in Narromine (Figure 1 and Figure 2). Rainfall patterns show cycles of below- and above-average conditions, followed by substantial rainfall recovery post-2020 (Figure 3).

The aquifer is generally shallow towards the east, proximal to the Macquarie River, with water levels within 10 m to 15 m of the ground surface (Figure 4a). Further south and southeast, water levels deepen to a value in the range 50 m to 60 m below the ground surface. Groundwater flows from east to west along the main floodplain. A localised depression zone is observed southwest in the centre of GS26 (Figure 4b). The long-term (1974–2024) and short-term (2012–2024) groundwater level surfaces are broadly consistent, with an observed depression around the southern paleochannel and a well-defined multi-decadal fluctuation zone ranging from 3 m to 20 m differences in water levels (Figure 5). In some areas of the paleochannel, water levels at the bottom of the groundwater fluctuation zone are aligned with recent short-term water levels, indicating that current water levels are close to the deepest observed since 1974 (Figure 5). Water quality is generally fresh, with salinity below 2,239 µS/cm (1,500 mg/L), and freshest near Narromine (Figure 6). Previous studies show that salinity is lowest closest to the Macquarie River and increases further west, proximal to the Bogan River, thus creating a freshwater pocket controlled by the potential recharge from the Macquarie River leakage (MDBA, 2020; NSW DPIE, 2019; Rojas et al., 2022). Most hydrographs show increasing trends up to the mid-1990s, and declining trends thereafter, whereas a minority of bores have wholly stable trends (Figure 7). Across some bores with longer records, a substantial recovery is observed post-2020, driven by above-average rainfall patterns for the period. Spatially, long-term water level trends show mostly declining conditions (26 bores, or 74% of bores with sufficient data), mainly around Narromine, and nine bores show no statistically significant trend, or stable/improving trends (Figure 9; Table 1). In the short-term (2012-2024), a slight shift towards better conditions is observed (61% of bores with sufficient data show declining trends), whereas a substantial number of bores (10) remain with no statistically significant trend (Figure 10). Salinity trend analysis is constrained by poor data availability (Figure 8).

Recharge for GS26 is estimated at 62.80 GL/year (MDBA, 2020). This estimate was derived from a groundwater model covering the SDL surface, which includes diffuse recharge, irrigation, river leakage and lateral flows. A recent reassessment for the MD-SY2 project by Crosbie et al. (2025) estimated diffuse recharge alone at 47.25 GL/year for GS26, which is aligned with the estimate provided by MDBA (2020), considering additional recharge sources. Table 1 shows a storage-to-recharge ratio (S/R) above 333 using the WERP estimate of storage (Rojas et al., 2022). This suggests high buffering capacity and low vulnerability to short-term climate variability ("low responsiveness" threshold[1] defined in Rojas et al., 2022). Both the extraction-to-recharge (E/R = 0.53) and SDL-to-recharge (SDL/R = 1.13) ratios remain above the critical value of 0.5, indicating high pressure on the productive base.

The productive base shows significant signs of stress. Long-term (1974-2024) groundwater level trends indicate statistically significant (α = 0.05) declines spread over GS26 (one bore reaching a rate >0.5 m/year), with higher rates of decrease around Narromine. Elsewhere, long-term water level trends are stable or slightly fluctuating or showing no statistically significant trends in a minority of bores (Figure 9). In contrast, short-term (2012-2024) water levels show no statistically significant trend (α = 0.05) at 10 bores, and a reduced number of bores (19, down from 26) with a slightly declining trend (Figure 10; Table 1). Stable or slightly fluctuating trends are located proximal to the Macquarie River in the short-term, and therefore, the impacts on surface water connectivity are expected to be moderate. Crosbie et al. (2023) have classified the reaches of the Macquarie and Bogan rivers in GS26 as 'always losing' for the period 2000-2019, thus highlighting the connectivity between river and aquifer.

Stage 4 of this BPR technical groundwater review provided a quantitative assessment of resource condition indicators (RCIs) within a 5 km buffer around extraction points (asset area). The analysis reveals that 54% of the productive base asset area, 53% of the river connectivity asset area, and 49% of the GDE asset area exhibit long-term declining trends (Table 2). Short-term trends are more favourable, with all ESLT asset areas showing between 44% and 23% of declining trends. In the short-term, between 28% and 35% of the ESLT asset areas showed stable or improving conditions (Table 2). Figure 11 illustrates this improvement as a horizontal displacement from the deteriorating trend zone to the variable trend zone, with some increase in the uncertainty (represented by the vertical displacement). Salinity data availability remains a significant limitation, resulting in the salinity ESLT area being fully classified as 'insufficient data' in the short-term analysis (2012-2024).

The NSW state-based risk assessment (NSW DPE, 2022) assigns variable risk ratings across ESLT values in GS26. Productive base risks are variable, rated from low to high for aquifer structural integrity, medium to high for local drawdown reducing access to groundwater users, and low to medium for reductions in recharge due to improved irrigation efficiencies and water conveyance. River connectivity risks are predominantly low for the impacts of groundwater use on (surface) water users and for impacts on instream ecological values. This is aligned with the observed river connectivity behaviour (always losing) and the historical depth-to-water values observed proximal to the Macquarie River. Risks to GDEs related to groundwater extraction are rated low to medium. Other risks such as climate change reducing groundwater availability for GDEs and the risk of poor water quality impacting GDEs are rated low/medium. The NSW state-based risk assessment rated water quality risks as medium to high, primarily associated with groundwater extraction, which can induce connections with poor-quality groundwater. The residual risk to water quality remains medium to high but is classified as tolerable (NSW DPE, 2022). Overall, water level data coverage is good; however, salinity monitoring remains limited in both the long- and short-term, contributing to substantial residual uncertainty in water quality risk assessment.

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

Projections from the MD-SY2 project suggest that while diffuse recharge may increase by up to 11% due to intense rainfall events, overbank and in-stream recharge are likely to decline by 8% to 18% by 2050 (Crosbie et al., 2025). These changes are expected to reduce episodic recharge and groundwater replenishment during dry years, while these opposing trends introduce uncertainty regarding net future recharge in GS26. Stage 6 of this BPR review shows that the median future area of influence (AoI[2]) exceeds the current AoI, and deteriorating areas are projected to expand under future climate scenarios (Figure 12). Despite the uncertainty surrounding net future recharge, overbank and in-stream recharge are likely the dominant recharge processes for GS26, and thus, the SDL/R ratio is likely to marginally increase under future climate conditions. The Stage 6 assessment classifies climate change pressure on GS26 as high based on long-term trends, and moderate for short-term trends.

In summary, GS26 shows slight improvement or stabilisation of water levels in the short-term (2012–2024), particularly near rivers and following the post-2020 rainfall recovery. However, long-term trends indicate localised declines and legacy drawdown around Narromine, with declines persisting into the short-term that may still affect the productive base. Salinity trends cannot be robustly evaluated due to the limited data available, and this remains a critical information gap. Current extraction is below both the SDL and recharge estimates, but the SDL exceeds recharge, and thus future increases in take could place the productive base under additional stress. Risk assessments highlight high risks to the productive base, and low to moderate risks for river connectivity and GDEs, which reflects the variable connectivity of the aquifer with the Macquarie River in GS26. Water quality risks are rated high, which, in combination with limited spatial and temporal data coverage, highlights the issue of future vulnerability of water quality given reduced in-stream and floodplain recharges. Climate projections suggest an increasing risk of localised decline due to changes in episodic recharge patterns. Collectively, the analysis indicates high pressure on the productive base of GS26, and high pressure from climate variability, with current conditions showing persisting declines in key areas, and future risks emerging under full SDL use.

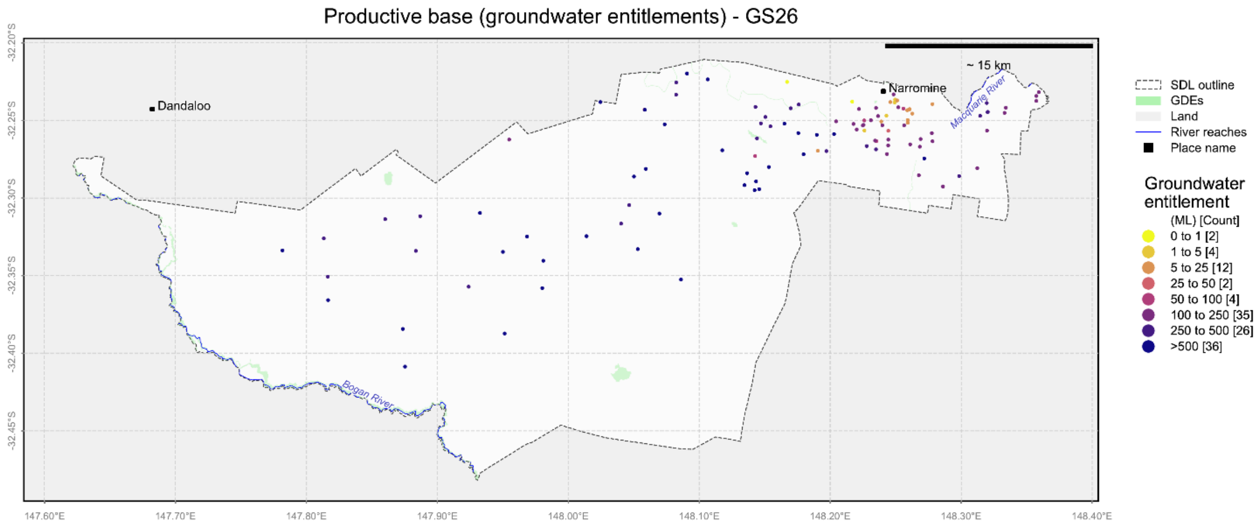


Figure 1 Productive base (groundwater entitlements)

[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.

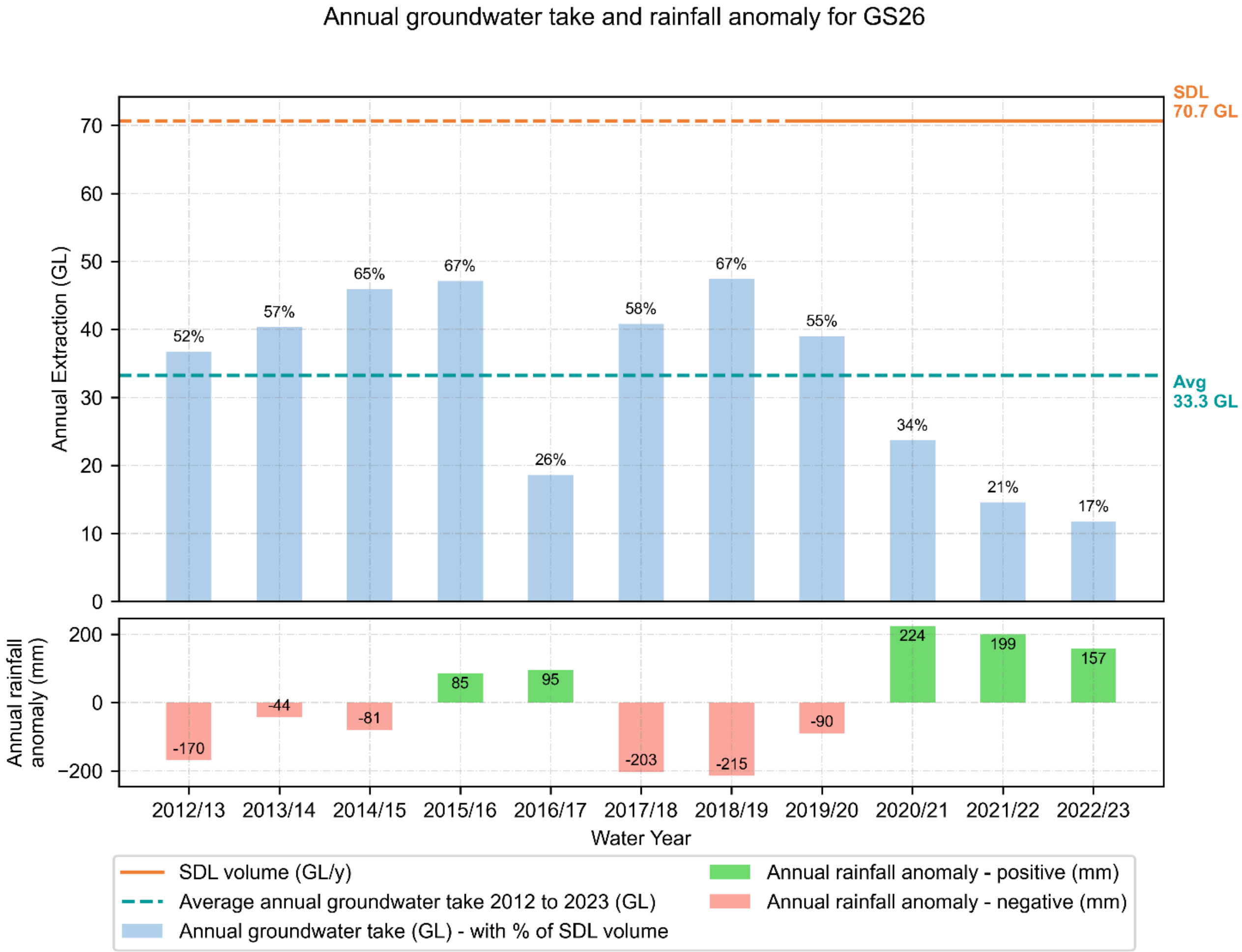


Figure 2 Groundwater take in the SDL since 2012

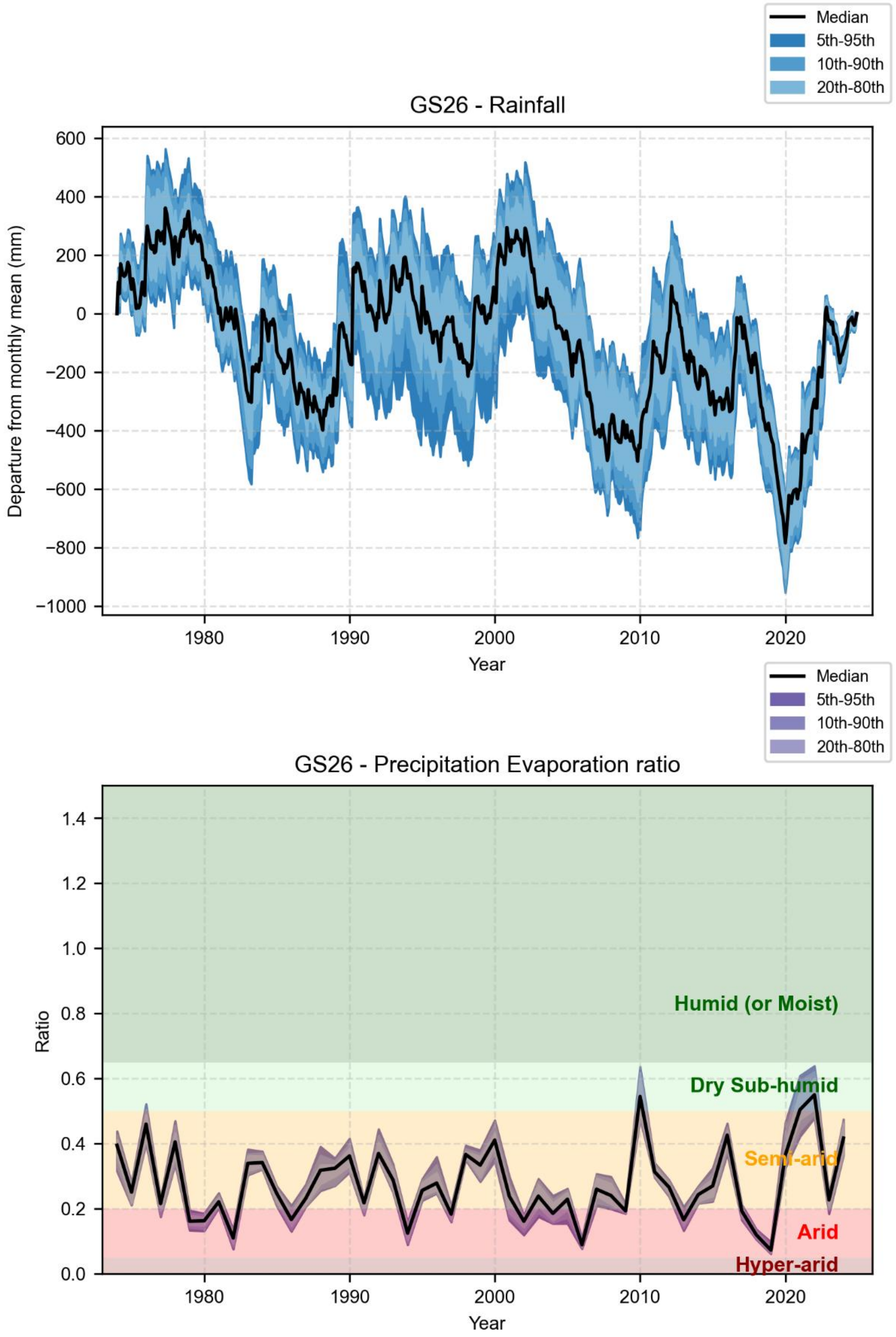
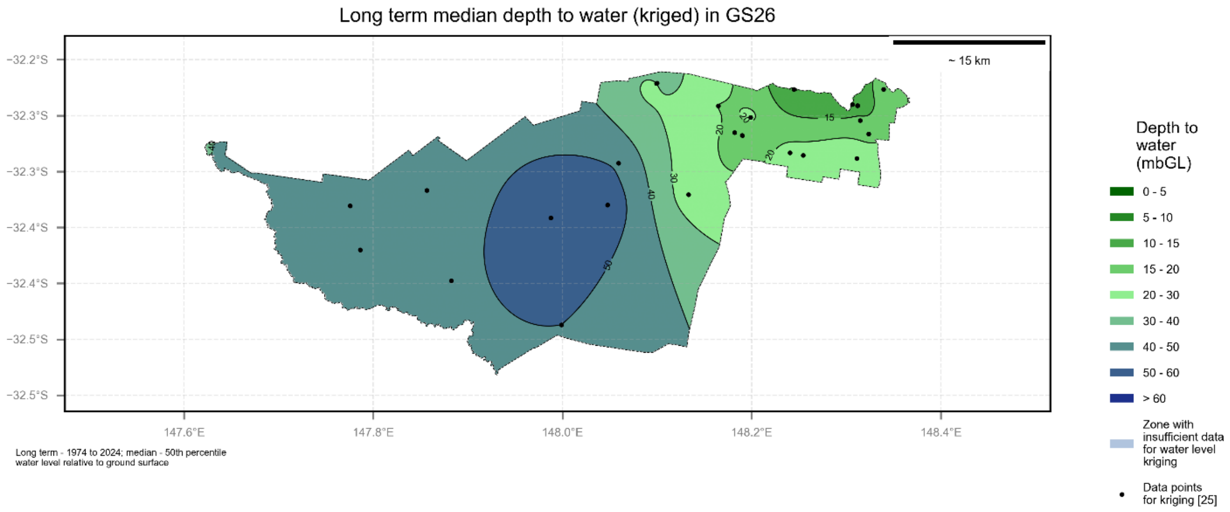
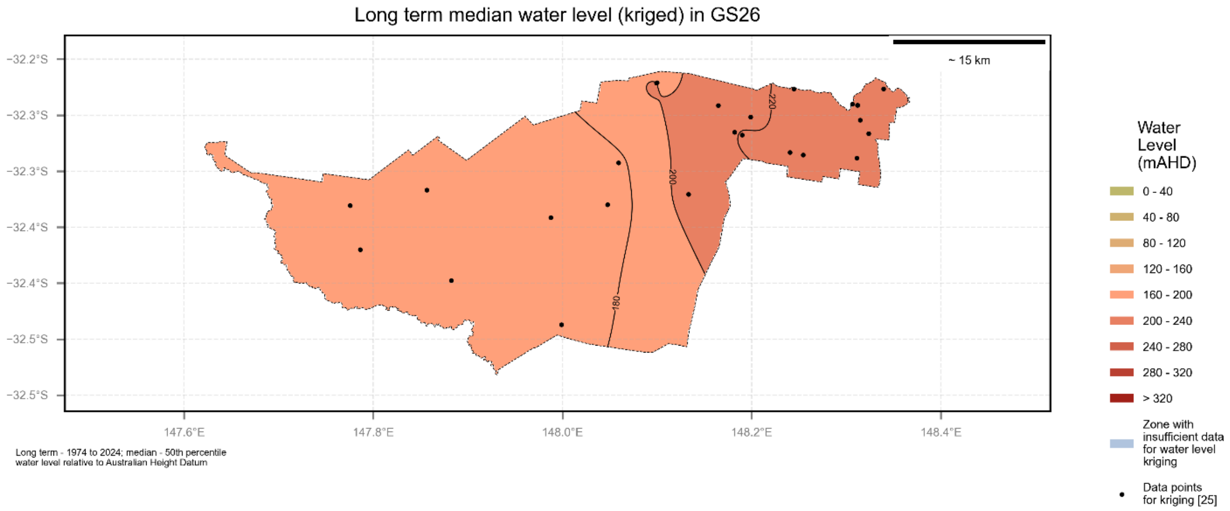


Figure 3 Historical climate trends

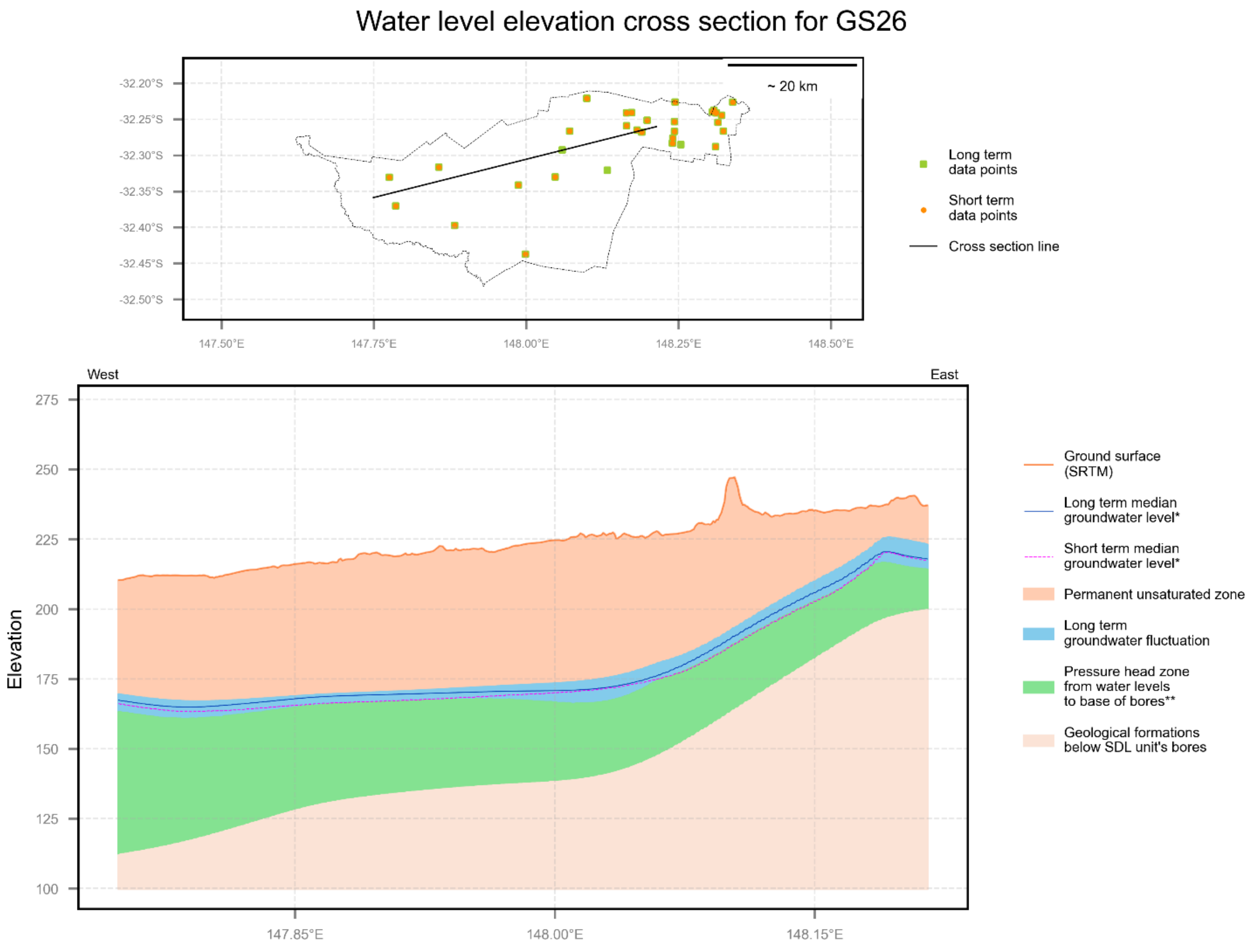


a)



b)

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

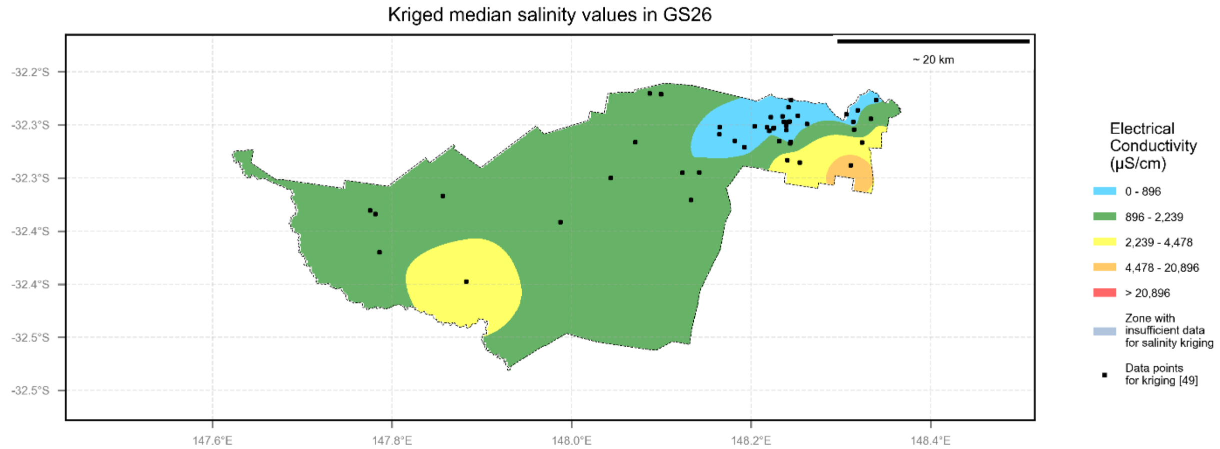


Figure 6 Groundwater salinity distribution

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	-	-	70.70
SDL resource unit area	km²	-	-	4,145
Average annual take (2013 to 2023)	GL/y	-	-	33.27
Number of groundwater entitlement bores	-	-	-	203
SDL resource unit storage estimate*	GL	-	-	66,643
Recharge estimate (SY1)	GL/y	-	-	62.80
Recharge estimate (Stage 2)	GL/y	-	-	62.80
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	47.25
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.47
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	1.13
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	1.13
Storage/Stage 2 Recharge (S/R)	-	-	-	1,061
Storage/SY2 or modelled Recharge (S/R)	-	-	-	1,061
Number of bores in the SDL unit	-	571	571	-
Number of bores for water level trend analysis	-	35	32	-
Number of bores for water level trend with sufficient data	-	35	31	-
Number of bores with decreasing water level trend	-	26	19	-
Number of bores with increasing water level trend	-	4	2	-
Number of bores with no statistically significant water level trend	-	5	10	-
Mean water level trend magnitude	m/y	-0.13	-0.23	-
Minimum water level trend magnitude	m/y	-0.56	-0.91	-
5%ile water level trend magnitude	m/y	-0.44	-0.8	-
10%ile water level trend magnitude	m/y	-0.33	-0.56	-
50%ile water level trend magnitude	m/y	-0.12	-0.16	-
90%ile water level trend magnitude	m/y	0.02	0.05	-
95%ile water level trend magnitude	m/y	0.07	0.07	-
Maximum water level trend magnitude	m/y	0.15	0.15	-
Number of bores for salinity trend analysis	-	51	4	-
Number of bores for salinity trend with sufficient data	-	2	0	-
Number of bores with decreasing salinity trend	-	0	0	-
Number of bores with increasing salinity trend	-	0	0	-
Number of bores with no statistically significant salinity trend	-	2	0	-
Mean salinity trend magnitude	µS/cm/y	-54	N/A	-
Minimum salinity trend magnitude	µS/cm/y	-73	N/A	-
5%ile salinity trend magnitude	µS/cm/y	-71	N/A	-
10%ile salinity trend magnitude	µS/cm/y	-69	N/A	-
50%ile salinity trend magnitude	µS/cm/y	-54	N/A	-
90%ile salinity trend magnitude	µS/cm/y	-39	N/A	-
95%ile salinity trend magnitude	µS/cm/y	-37	N/A	-
Maximum salinity trend magnitude	µS/cm/y	-35	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	1,103,997,967	23%	54%	23%	Deteriorating trends	28%	44%	28%	Variable trends
GDEs	361,114,409	10%	49%	41%	Variable trends	34%	25%	41%	Variable trends
River connectivity	336,154,898	5%	53%	42%	Deteriorating trends	35%	23%	42%	Variable trends
Water quality	988,621,708	14%	0%	86%	Insufficient data	0%	0%	100%	Insufficient data

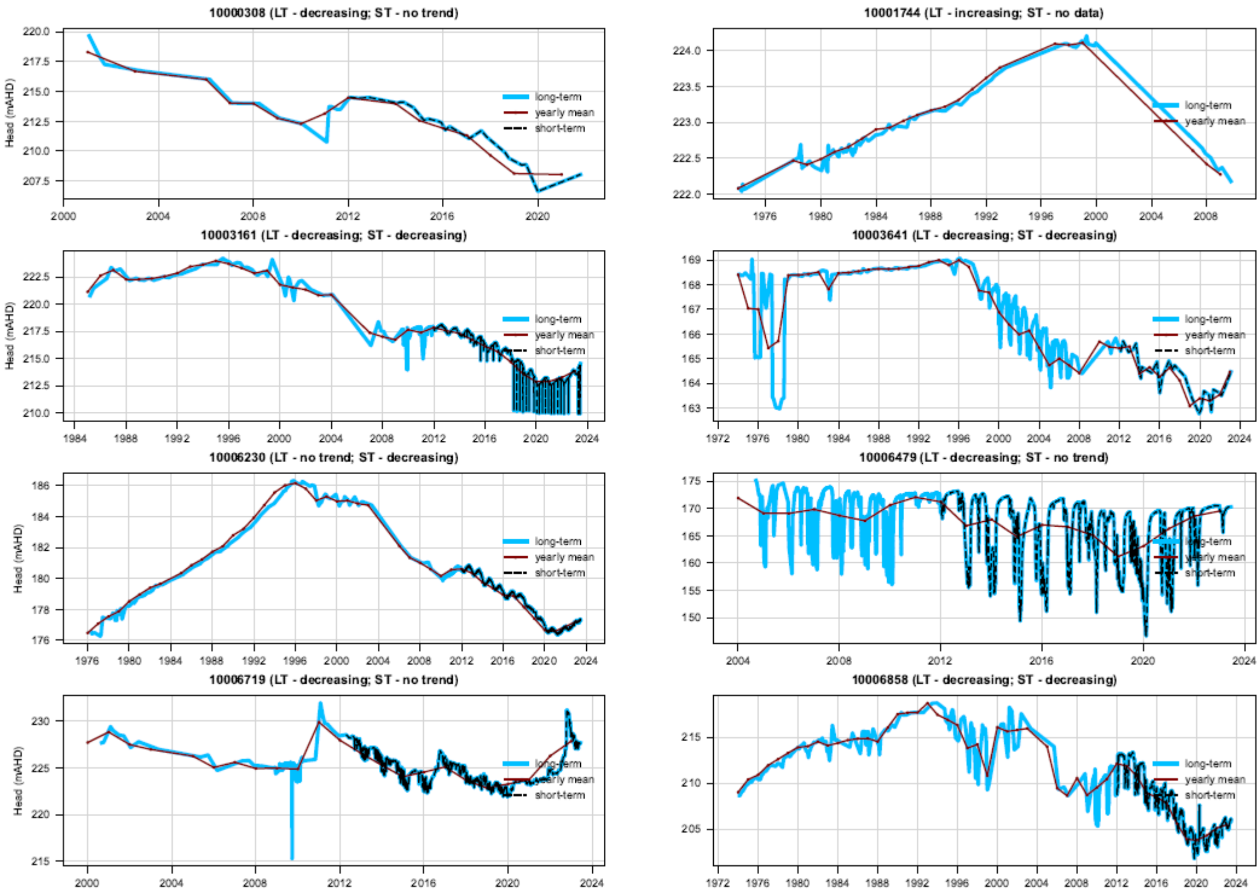


Figure 7 Representative groundwater hydrographs for the SDL resource unit

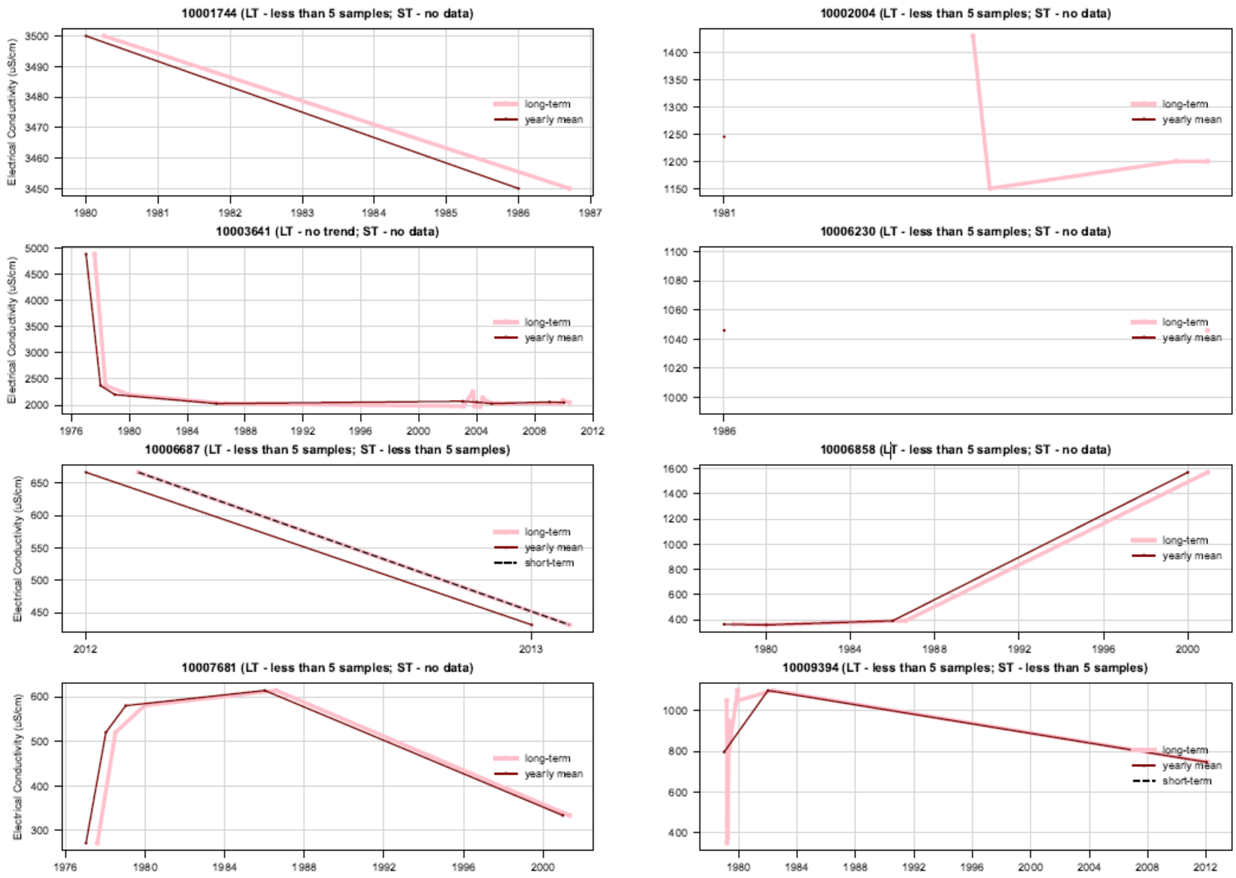
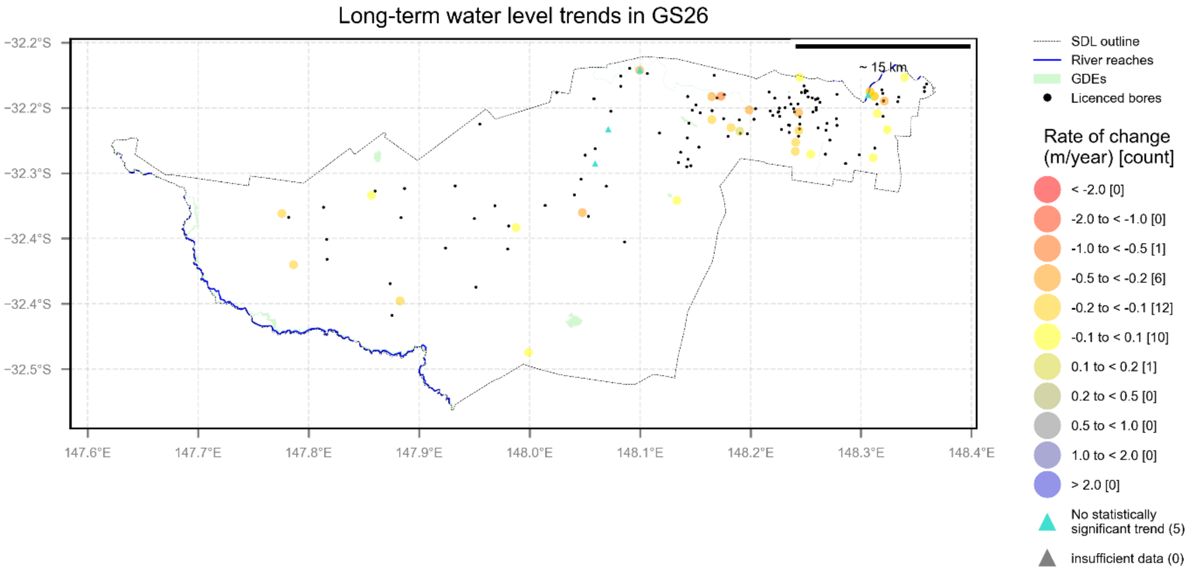


Figure 8 Representative groundwater salinity time series for the SDL resource unit



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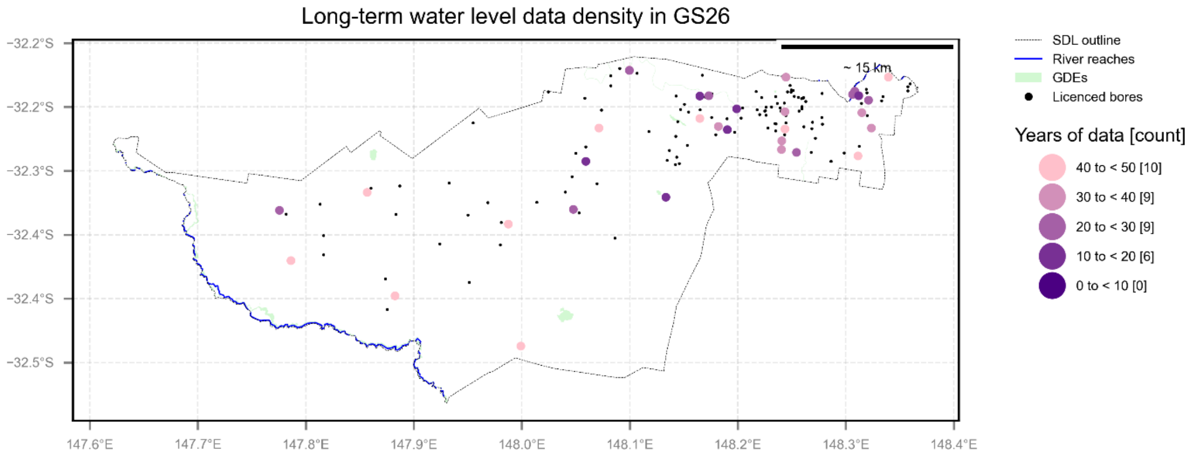

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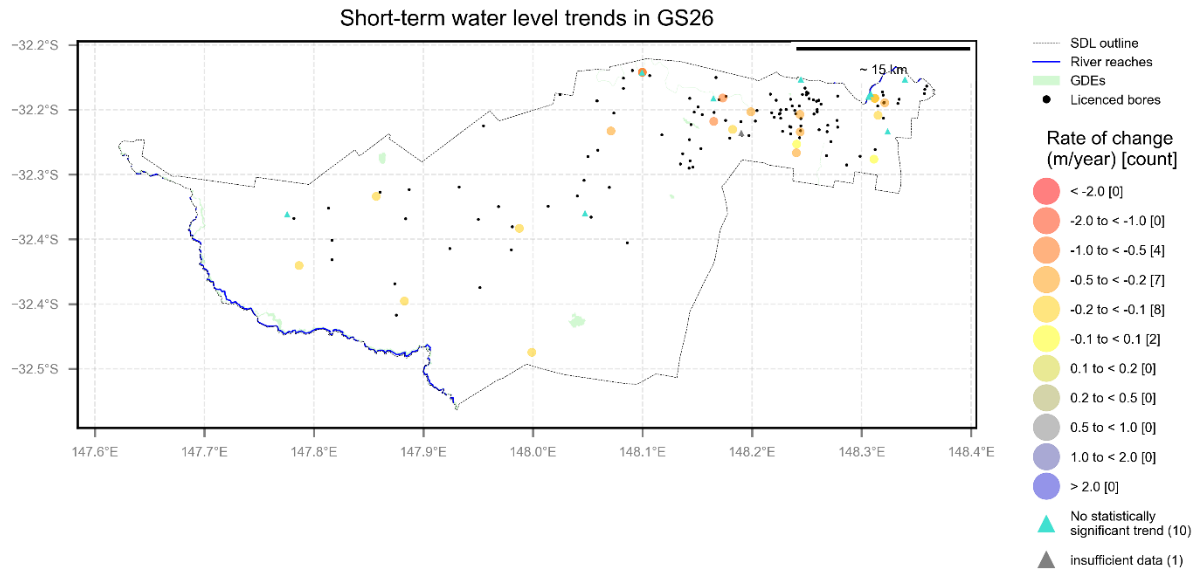
Figure 9 Long-term (1974 to 2024) (a) groundwater level trends and (b) data availability



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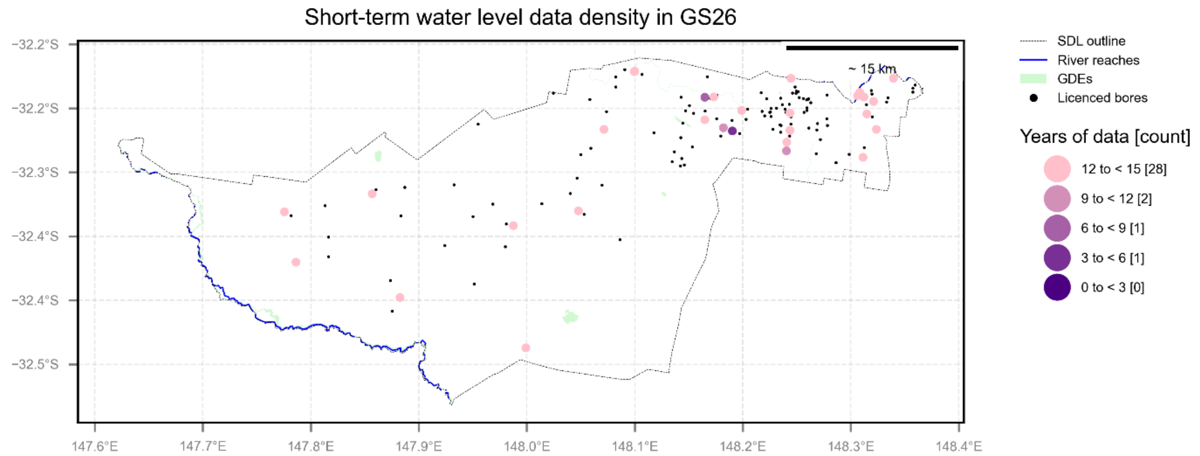

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Figure 10 Short-term (2012 to 2024) (a) groundwater level trends and (b) data availability

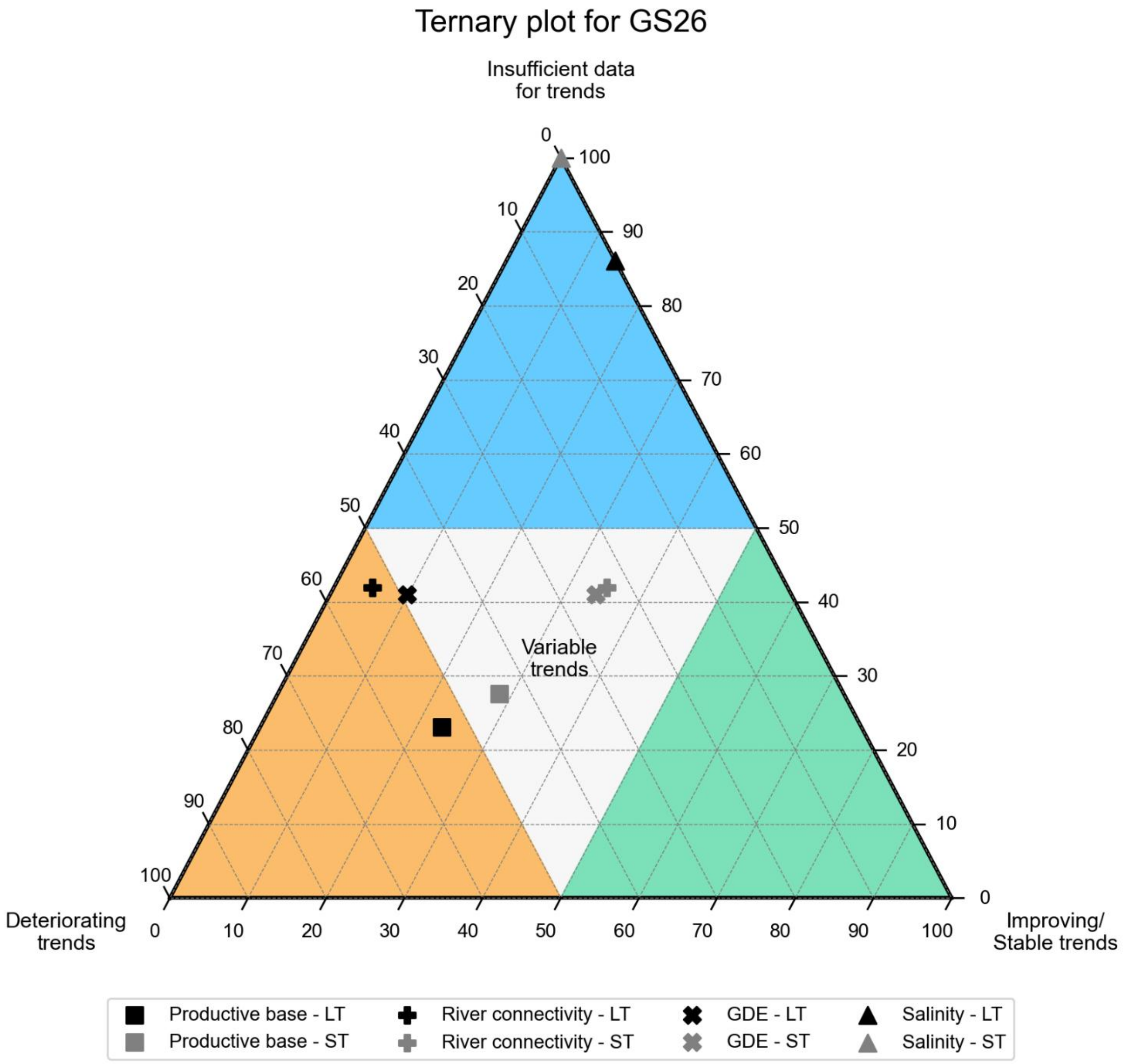

Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

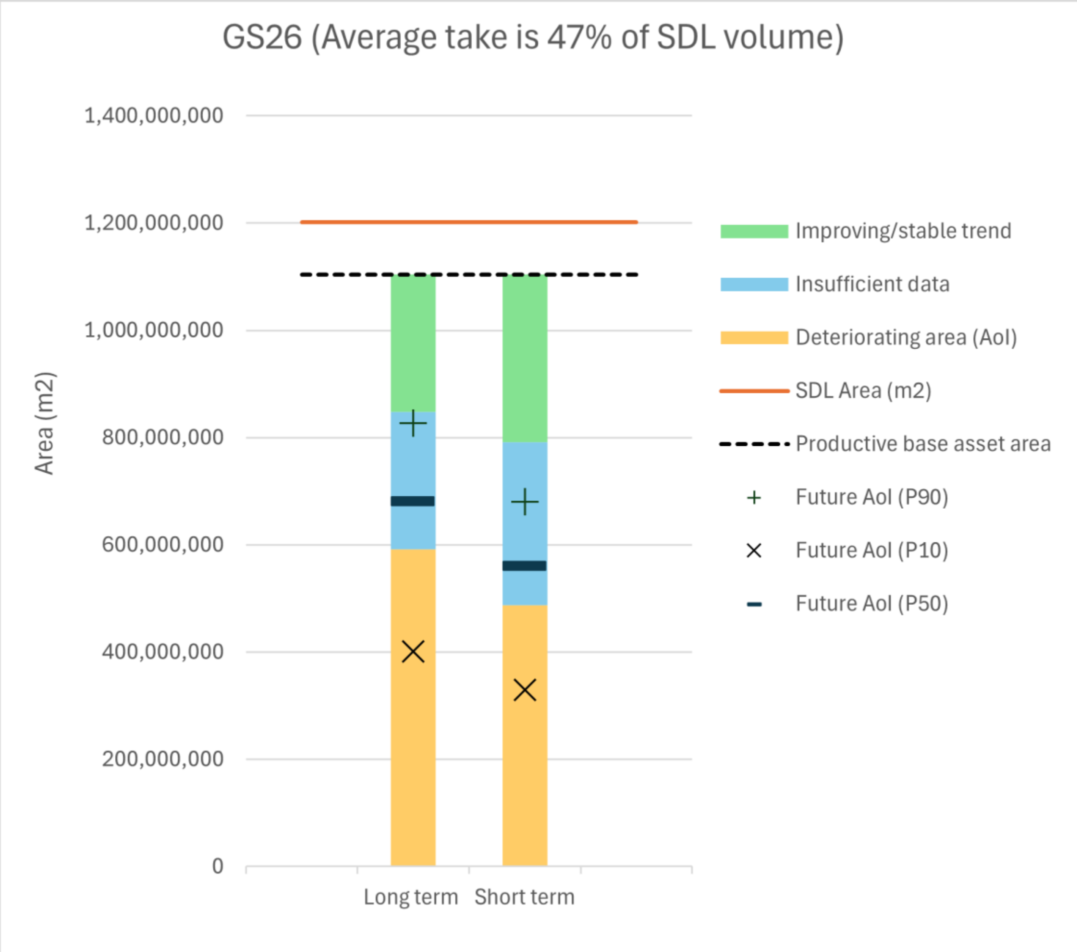

Figure 12 Estimates for change in area of influence (AoI) due to climate change

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