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GS27a – Lower Murray Shallow Alluvium

Stage 5 – Assessment through multiple lines of evidence

The Lower Murray Shallow Alluvium (GS27a) is located within the Murray catchment in southern New South Wales, with the Victorian Murray units GS8a and GS8c along the southern edge, and Billabong Creek forming the northern border of the unit. The alluvium is associated with the Murray and Edward rivers, and Billabong Creek (Figure 1), with a deep and shallow component (GS27b and GS27a, respectively). GS27a is defined as the uppermost 20 m of the alluvial profile (MDBA, 2020), mainly consisting of the Shepparton Formation sediments, although that formation can reach a thickness of 70 m (NSW DPIE, 2019). GS27a lies between Corowa in the east and Swan Hill in the west, with Deniliquin located in the centre of the SDL resource unit. Groundwater entitlements are concentrated in the Berriquin Irrigation District (near Wakool), where water quality is suitable for irrigation, and the Murray Irrigation District (around Finley and Deniliquin; Figure 1). Although individual bores in shallow GS27a are licenced for take over 500 ML, the deeper resource (GS27b) is the more widely used groundwater for irrigation of broadacre crops, including rice and cereals, as the yields and quality are generally better. GS27a spans 17,915 km², with a Sustainable Diversion Limit (SDL) of 81.90 GL/year and a long-term average recharge estimate of 337.00 GL/year (Table 1). Between 2013 and 2023, average annual groundwater extraction was 6.10 GL/year, representing just 2% of estimated recharge (using the long-term estimate) and only 7% of the SDL (Figure 2). Groundwater supplements the surface water supply in years of below-average rainfall, supporting mainly stock and domestic use, although irrigation take also occurs (Figure 1 and Figure 2). As most take from GS27a relates to basic landholder rights, the majority is not metered (NSW DPIE, 2019). Rainfall patterns show most years having below-average conditions prior to 2021, followed by substantial rainfall recovery post-2021 (Figure 3).

The aquifer is just 20 m thick, and water levels are within 10 m of the ground surface for much of the SDL resource unit (Figure 4a). In the upgradient areas in the east of GS27a, depth to groundwater can increase up to more than 15 m. Groundwater flows from east to west along the main floodplain of the River Murray. Discharge occurs as lateral flow to the west (where hydraulic gradients were upward prior to development), and a small component as saline baseflow to surface water in the western area of the SDL resource unit. The median long-term (1974–2024) groundwater level surfaces are different in the east and the west, due to diverse processes acting on the aquifer (Figure 5). In the east, there are rising groundwater levels, which have occurred due to irrigation (mostly by surface water) since the 1970s (NSW DPIE, 2019). In the west, the long-term median water level is closer to the base of the long-term fluctuation zone (Figure 5), indicating residual drawdown from groundwater take in GS27a and leakage to the underlying GS27b. Residual drawdown in both GS27a and GS27b is most substantial near Deniliquin, where the hydraulic gradient has always been downward (NSW DPIE, 2019), and it is likely that some of the drawdown in GS27a could be due to take from GS27b.

Recharge for GS27a is estimated at 337.00 GL/year (MDBA, 2020), which was derived from a groundwater model that included 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 138.51 GL/year for GS27a, which is only 41% of the estimate provided by modelling (Table 1). Table 1 shows that the storage-to-recharge ratio (S/R) is estimated as 128 using the WERP storage estimate (Rojas et al., 2022) and the modelled recharge estimate. This suggests moderate buffering capacity and intermediate vulnerability to short-term climate variability (“medium responsiveness” bracket¹ is defined in Rojas et al., 2022 as 11 to 333). In addition, the extraction-to-recharge (E/R = 0.02), SDL-to-recharge (SDL/R = 0.24), and extraction-to-SDL (E/SDL = 0.07) ratios are all low or very low, indicating limited pressure on the productive base.

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

Water quality is generally brackish, with salinity above 2,239 $\mu\text{S}/\text{cm}$ (1,500 mg/L) in some areas and very saline in the west (Figure 6). However, salinity is sufficiently low for irrigation in selected areas of the shallow alluvium, which are typically associated with the location of ancient streams (NSW DPIE, 2019). Although groundwater salinisation has historically been an issue in GS27a, salinity trend analysis is constrained by poor data availability (Figure 8). There was a salinity sampling campaign in the Murray Irrigation District in 2009 and 2011, which showed rising salinity in some locations, but no change in the beneficial use class for the shallow aquifer (NSW DPIE, 2019). Causes of salinisation were found to be diverse, including the movement of saline water from soils, the River Murray, or other groundwater units (DPE, 2015). The saline shallow groundwater poses a threat to high-value GDEs and surface water, as saline baseflow can occur in the west of GS27a (NSW DPIE, 2019). A salt interception scheme (SIS) has operated west of Wakool since approximately 1990 to extract highly saline water from the shallow unit (the Wakool–Tullakool Subsurface Drainage Scheme; NSW DPIE, 2019).

Long-term (1974-2024) and short-term (2012-2024) groundwater level trends indicate signs of stress on the productive base, as statistically significant ($\alpha = 0.05$) declines and increases are present across GS27a (rates up to ± 0.5 m/year). There are two main types of water level trend (Figure 7) in GS27a: linear increases and fluctuating trends. Most bores that show fluctuating trends are also recording statistically significant declines, and the overprinting inter-decadal undulations are due to climate variability. Data records for the short-term are largely absent (Figure 7), and responses to the post-2020 above-average rainfall patterns are not known (Figure 2). Spatially, the two types of trends are distributed differently, with rising trends common in the centre and northeast, and declining trends present in the west and south (Figure 9a). Rising trends are known to be linked to long-term irrigation (mainly with surface water) between Berrigan and Jerilderie (Figure 1). Although groundwater extraction from GS27a was encouraged in the 1990s to abate this trend (NSW DPIE, 2019), there remain very few GS27a entitlements in that area, and recent monitoring data is scarce (Figure 10a). The areas with declining water levels in GS27a partly occur along the alignment of the River Murray, where no groundwater take occurs from GS27a (Figure 9a, Figure 10a) or GS27b. This could mean that: the SIS is largely responsible for these trends; or recharge is decreasing in those areas; or that leakage of groundwater from GS27a occurs in response to distal take from surrounding or underlying groundwater sources. It is not clear if the rate of decline has slowed significantly between the long-term and the short-term, as sufficient data are not available (compare Table 1, Figure 9a, Figure 10a). However, the shallow groundwater beneath the River Murray is saline and poses a risk to GDEs, and there is not a large residual drawdown compared to pre-development levels in GS27a (rates of decline are moderate). In summary, the declining trends pose a risk to all ESLT values, but rising trends would also be problematic, due to risks from groundwater salinity potentially impacting productive base, rivers, and GDEs.

There are also declining trends in GS27a that are located proximal to the wetlands and GDEs near the River Murray and Edwards River, especially near Mathoura (compare Figure 1 with Figure 9a). Crosbie et al. (2023) have classified the reaches of these rivers in GS27a as ‘always losing’ and ‘mostly losing’ for the period 2000-2019 if they are upstream of Moulamein or Swan Hill (Figure 1). Downstream of these locations, the streams are classified as ‘mostly not losing’ or ‘never losing’ (Crosbie et al., 2023). Although the rivers are connected to the alluvium, there is a lag in response to recharge and extraction, and the resources are managed separately. The potential GDEs (including wetlands and terrestrial GDEs) present in GS27a are mainly classified as very high, high, and medium ecological value (NSW DPIE, 2019), and some are associated with Ramsar- and DIWA-listed wetlands. These communities typically host endangered and threatened species and form extensive connected riparian corridors dominated by basin target species such as black box, lignum, and river red gums (NSW DPIE, 2019). Groundwater monitoring near Mathoura indicates that in 1995, due to drawdown, the vertical hydraulic gradient reversed from upward (pre-development) to downward (post-development) (NSW DPIE, 2019). This change in the direction of the vertical hydraulic gradient is likely to have a material impact on the GDEs, as upward gradients indicate potential for groundwater discharge to the surface (i.e. that was likely occurring in the past), whereas downward gradients and a declining trend indicate discharge is likely to diminish and/or cease.

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). The analysis reveals that 32% of the productive base asset area, 22% of the river connectivity asset area, and 32% of the GDE asset area exhibit long-term declining trends (Table 2). Short-term trends were not assessed due to lack of temporal data (Table 2). Figure 11 illustrates these differences, with most assets shifting from improving / stable trends in the long-term to insufficient data in the short-term. The insufficiency is largely due to monitoring in this catchment being focussed on the deeper alluvium (GS28b). Salinity data availability also remains an important limitation, resulting in the salinity ESLT being fully classified as 'insufficient data' in both the long-term and short-term analyses (2012-2024).

The NSW state-based risk assessment (NSW DPE, 2022) assigns variable risk ratings across ESLT values in GS27a. Productive base risks are variable, rated medium for aquifer structural integrity, high for local drawdown reducing access to groundwater users, and low for reductions in recharge due to climate change. River connectivity and GDE risks from groundwater drawdown are high, but low regarding climate change impacts on recharge. The risk of poor water quality impacting the productive base due to drawdown-induced mixing is high, indicating the variable water quality in the unit is problematic. Overall, water level data coverage is good for the long-term, but there is a critical gap in the monitoring of bores less than 20 m deep for the short-term, especially in the Berriquin Irrigation District. Salinity monitoring remains limited in both the long- and short-term, contributing to substantial residual uncertainty in water quality risk assessment.

Projections from the MD-SY2 project suggest that, while diffuse recharge may increase with climate change by up to 9% due to intense rainfall events, the overbank and in-stream recharge are likely to decline by 44% and 15% by 2050, respectively (Crosbie et al., 2025). Despite the uncertainty surrounding net future recharge, overbank and in-stream recharge are likely the dominant recharge processes for GS27a, and thus, recharge is expected to marginally decrease, and the SDL/R ratio is likely to slightly increase under future climate conditions. As SDL/R for GS27a is currently low (0.24), a small increase poses low risk. Stage 6 of this BPR review shows that the median future area of influence (Aoi²) marginally exceeds the current Aoi, and deteriorating areas are projected to expand slightly under future climate scenarios (Figure 12). Stage 6 of this assessment classifies climate change pressure on GS27a as low for both long- and short-term timeframes based on mixed trends and low E/SDL and SDL/R ratios, which is aligned to state-based risk assessment for climate change impact to recharge.

In summary, GS27a shows a mixture of declining and increasing trends in water level resource condition indicators, with: a) problematic rising trends related to irrigation impacts acting more strongly on GS27a than GS27b; and b) declining trends resulting from groundwater take acting more strongly on GS27b than GS27a. Increasing water levels in GS27a have been a significant issue since the 1970s and pose a risk through potential salinisation. It is not known if the rising trends persist in the short-term (2012–2024). Conversely, the high use areas, such as around Deniliquin, experience drawdown in the long-term, and trends have rates up to -0.5 m/year near Mathoura, an area of high ecological value GDEs. Reflecting this, risk assessments highlight high risks to the ESLT values from groundwater take and salinity impacts. There is also a critical gap in monitoring bores less than 20 m deep for short-term monitoring. The aquifer has low vulnerability to short-term climate variability, and the E/R (0.02), SDL/R (0.24), and E/SDL (0.07) ratios are all low or very low, moderate pressure on the productive base from groundwater extraction. Climate projections suggest an increasing risk of localised decline due to changes in episodic recharge patterns, but overall, the pressure from climate change is classed as low, in line with state risk assessments. Collectively, GS27a is considered moderately sensitive to long-term extraction and practices of land use (e.g. irrigation) or climate drying (e.g. reduced localised recharge). Current trends are not known, and require ongoing management to avoid impacts to ESLT values.

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.

Productive base (groundwater entitlements) - GS27a

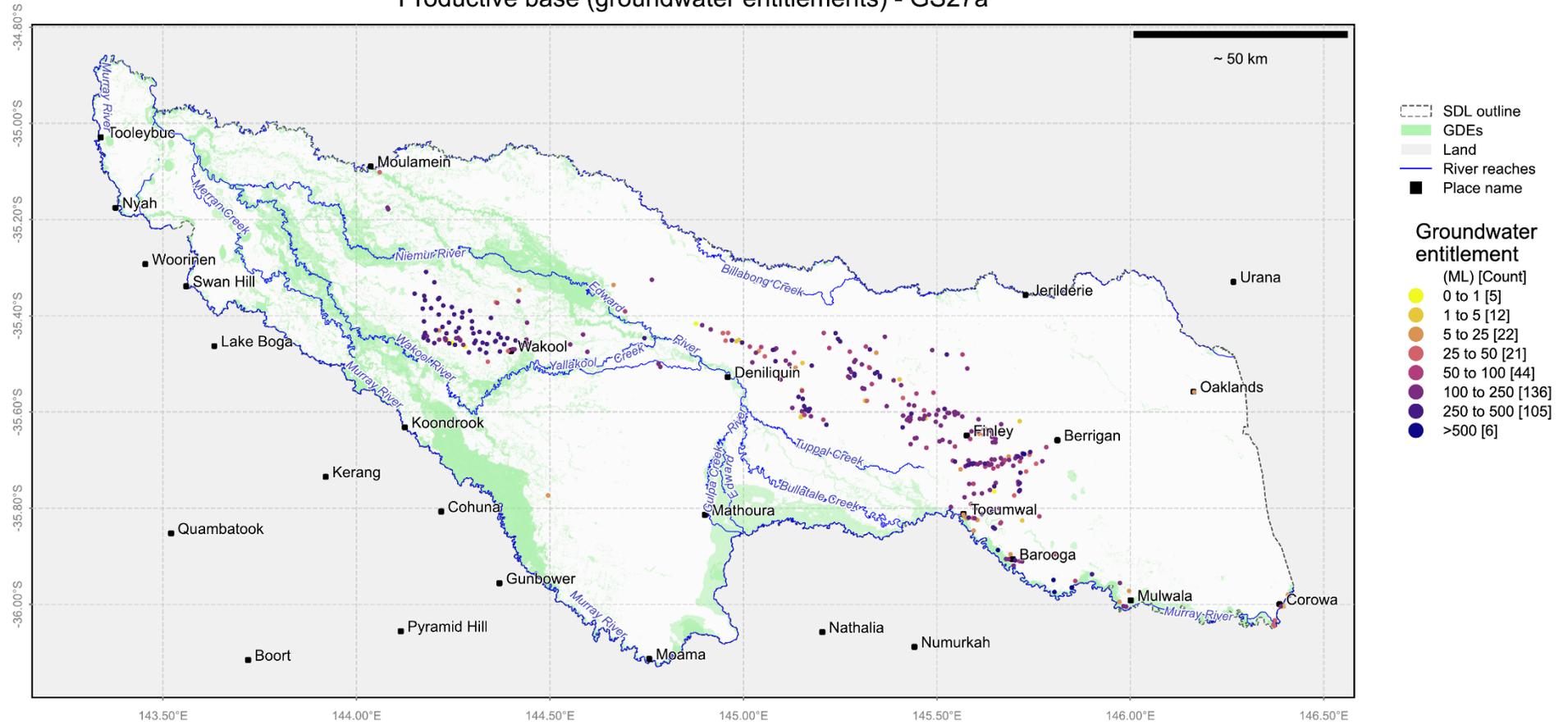


Figure 1 Productive base (groundwater entitlements)

Annual groundwater take and rainfall anomaly for GS27a



Figure 2 Groundwater take in the SDL since 2012

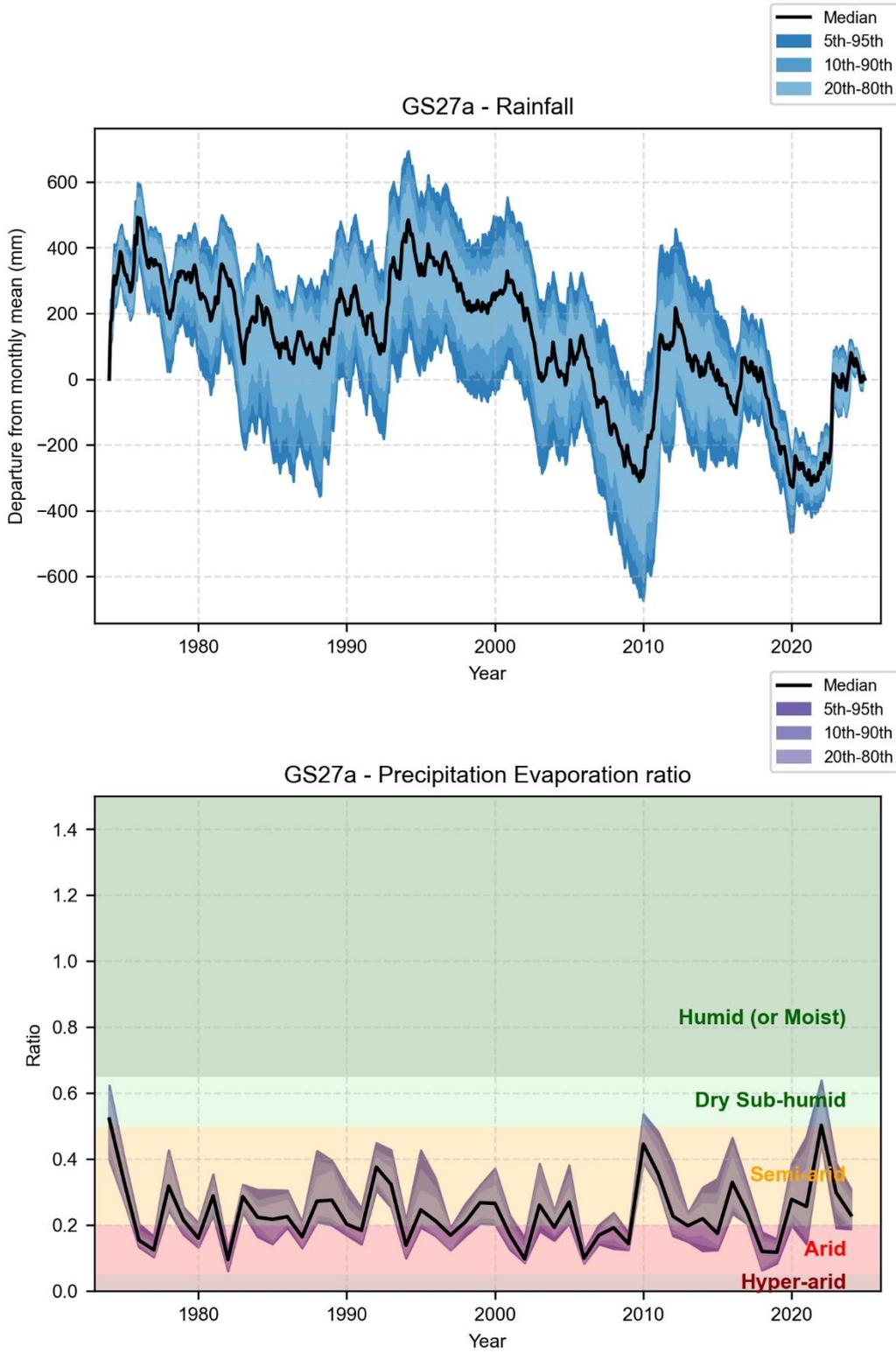


Figure 3 Historical climate trends

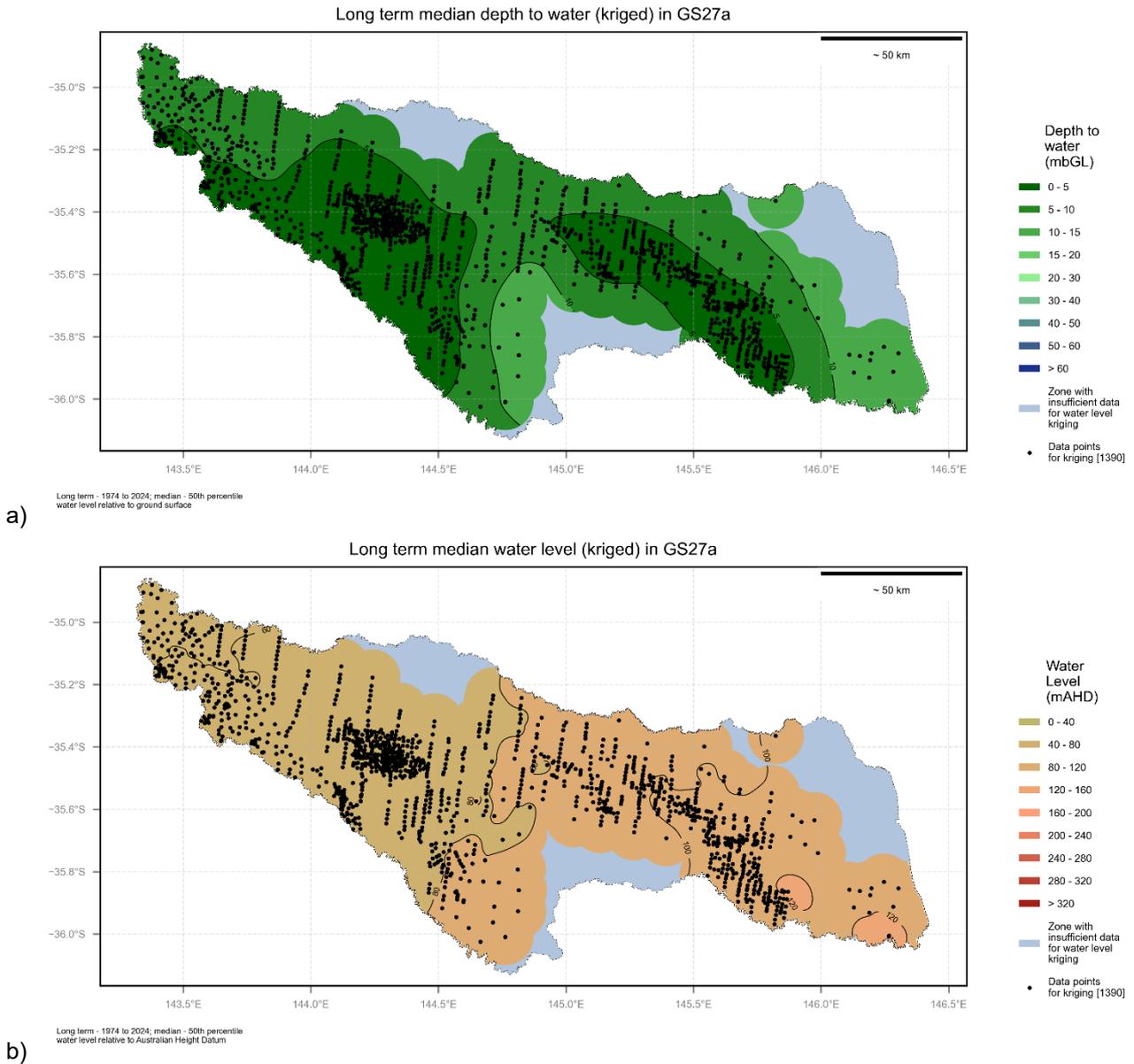
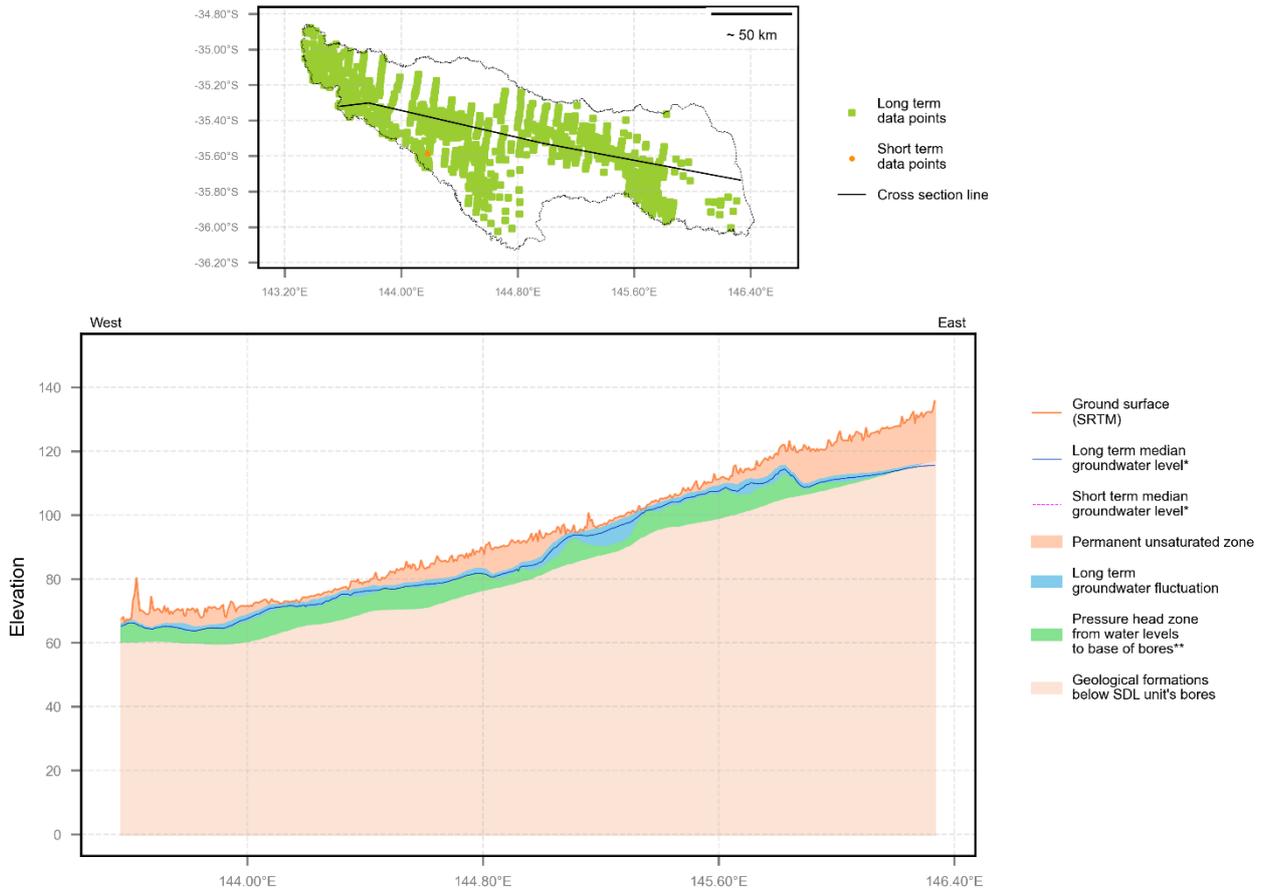


Figure 4 Long-term median (a) depth to water and (b) water level elevation

Water level elevation cross section for GS27a



*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.

Note: there is insufficient data to draw a short-term median water level for GS27a.

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

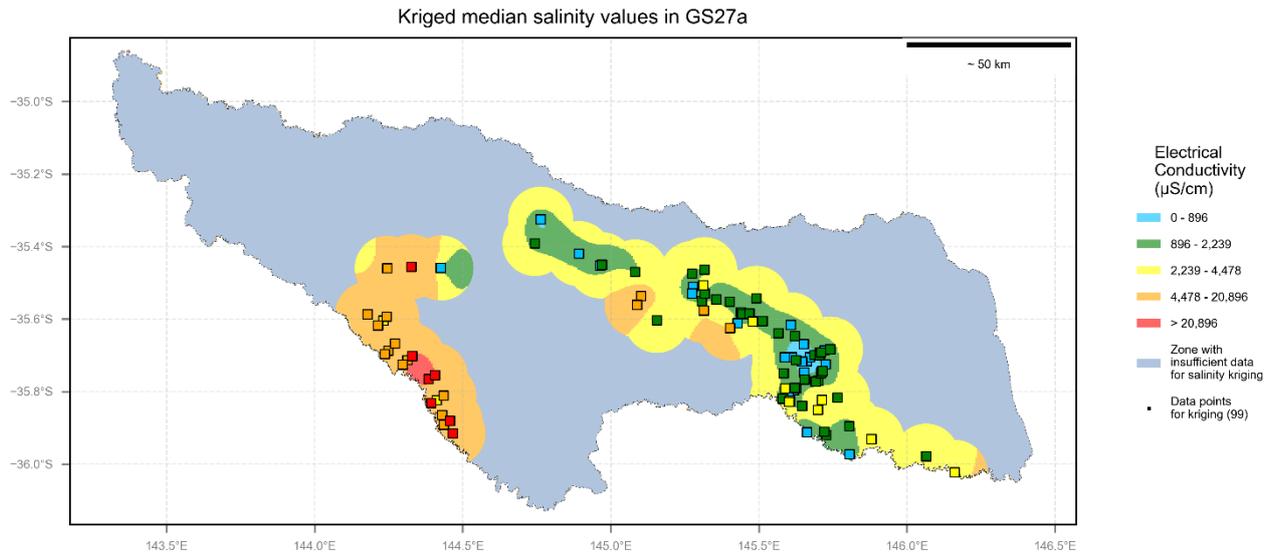


Figure 6 Groundwater salinity distribution

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	-	-	81.90
SDL resource unit area	km ²	-	-	17,915
Average annual take (2013 to 2023)	GL/y	-	-	6.10
Number of groundwater entitlement bores	-	-	-	726
SDL resource unit storage estimate*	GL	-	-	42,982
Recharge estimate (SY1)	GL/y	-	-	337.00
Recharge estimate (Stage 2)	GL/y	-	-	337.00
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	138.51
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.07
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.24
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	=	=	=	0.24
Storage/Stage 2 Recharge (S/R)	-	-	-	128
Storage/SY2 or modelled Recharge (S/R)	=	=	=	128
Number of bores in the SDL unit	-	6,062	6,062	-
Number of bores for water level trend analysis	-	1,438	9	-
Number of bores for water level trend with sufficient data	-	1,390	1	-
Number of bores with decreasing water level trend	-	739	0	-
Number of bores with increasing water level trend	-	315	0	-
Number of bores with no statistically significant water level trend	-	336	1	-
Mean water level trend magnitude	m/y	-0.03	-0.10	-
Minimum water level trend magnitude	m/y	-0.38	-0.10	-
5%ile water level trend magnitude	m/y	-0.17	-0.10	-
10%ile water level trend magnitude	m/y	-0.12	-0.10	-
50%ile water level trend magnitude	m/y	-0.04	-0.10	-
90%ile water level trend magnitude	m/y	0.10	-0.10	-
95%ile water level trend magnitude	m/y	0.17	-0.10	-
Maximum water level trend magnitude	m/y	0.68	-0.10	-
Number of bores for salinity trend analysis	-	105	23	-
Number of bores for salinity trend with sufficient data	-	0	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	-	0	0	-
Mean salinity trend magnitude	µS/cm/y	N/A	N/A	-
Minimum salinity trend magnitude	µS/cm/y	N/A	N/A	-
5%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
10%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
50%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
90%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
95%ile salinity trend magnitude	µS/cm/y	N/A	N/A	-
Maximum salinity trend magnitude	µS/cm/y	N/A	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	4,570,000,000	54%	32%	14%	Improving / stable trends	0%	0%	100%	Insufficient data
GDEs	3,960,000,000	52%	32%	16%	Improving / stable trends	0%	0%	100%	Insufficient data
River connectivity	2,590,000,000	42%	22%	36%	Variable trends	0%	0%	100%	Insufficient data
Water quality	4,430,000,000	0%	2%	98%	Insufficient data	0%	0%	100%	Insufficient data



Figure 7 Representative groundwater hydrographs for the SDL resource unit

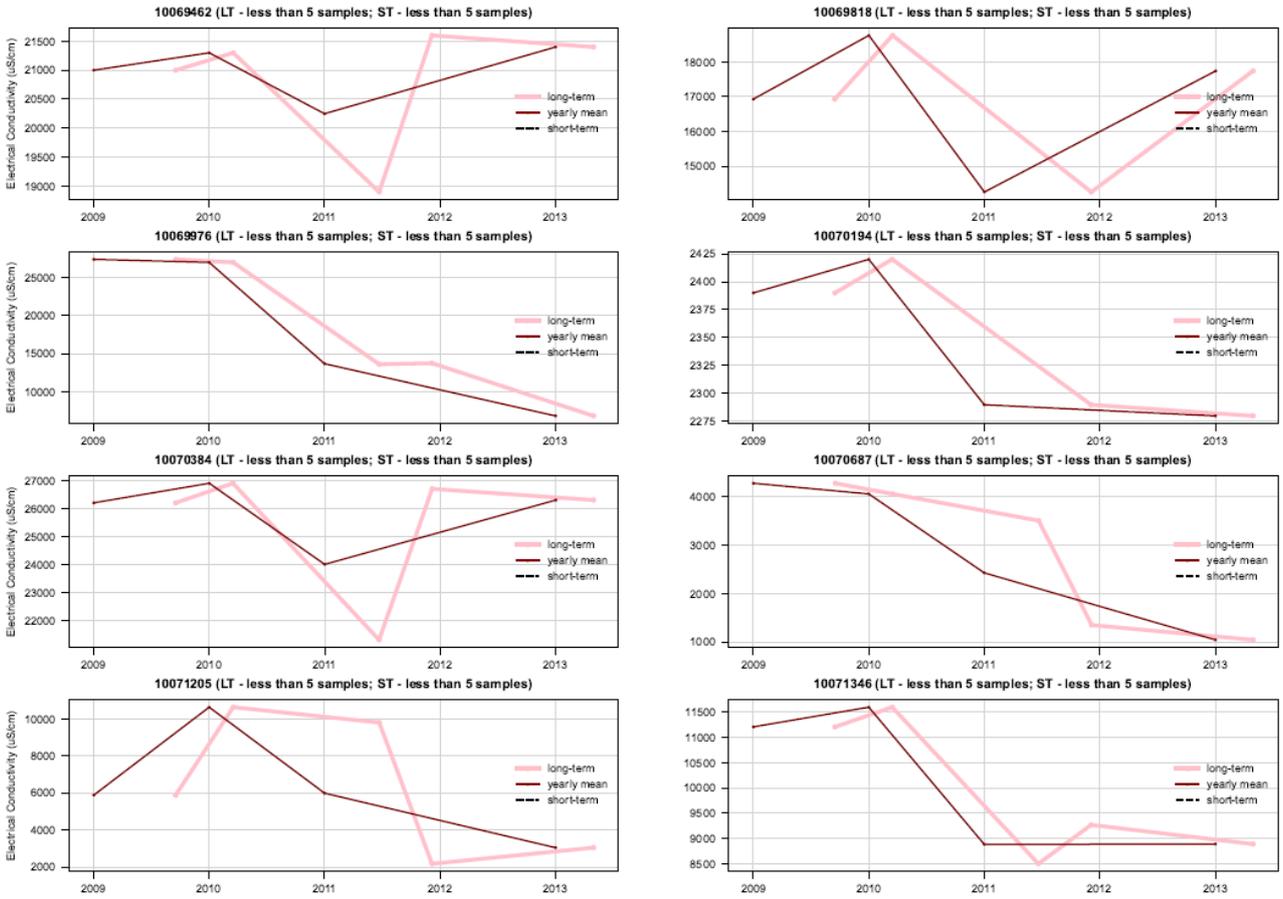


Figure 8 Representative groundwater salinity time series for the SDL resource unit

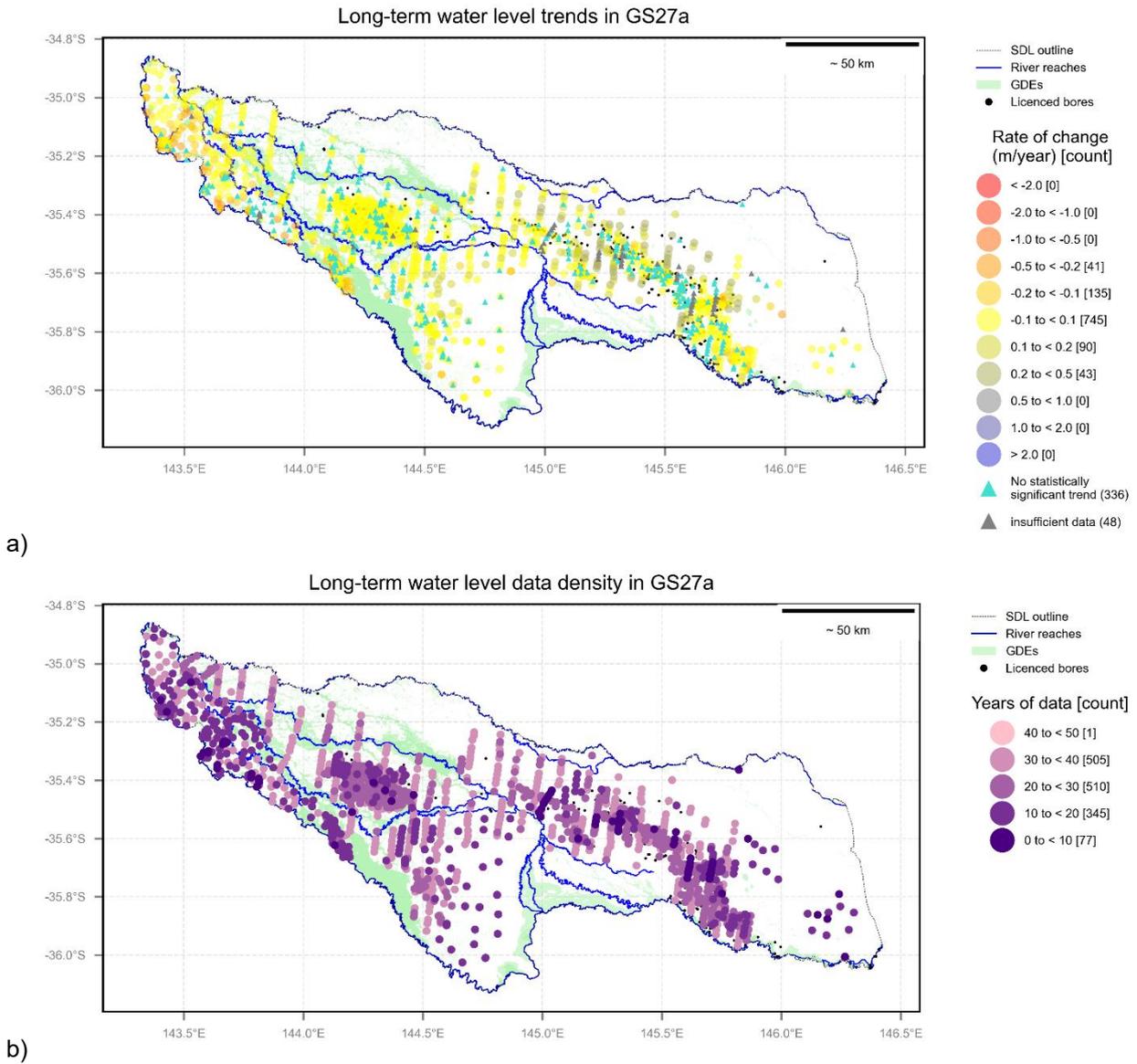


Figure 9 Long-term (1974 to 2024) (a) groundwater level trends and (b) data availability

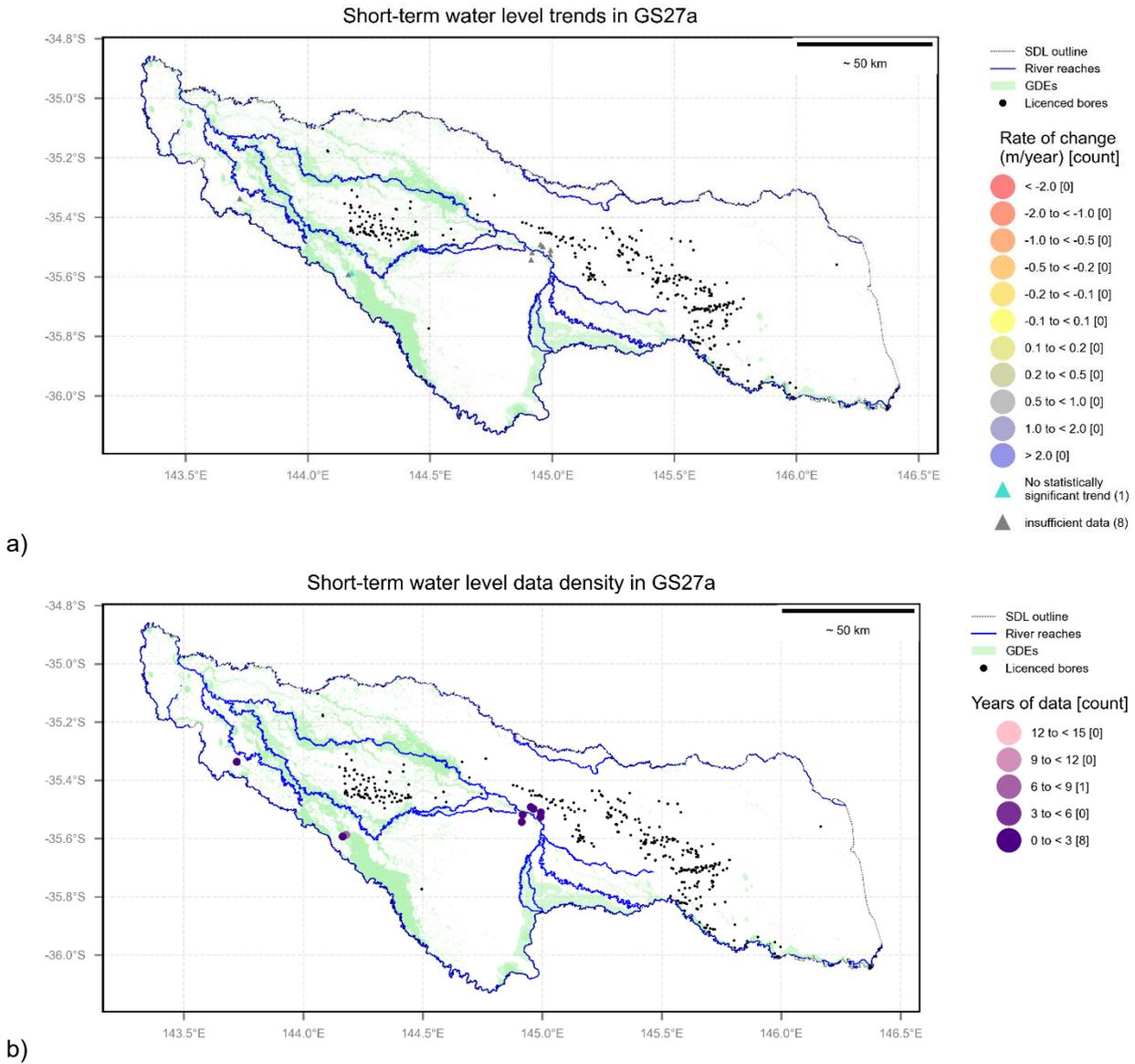


Figure 10 Short-term (2012 to 2024) (a) groundwater level trends and (b) data availability

Ternary plot for GS27a

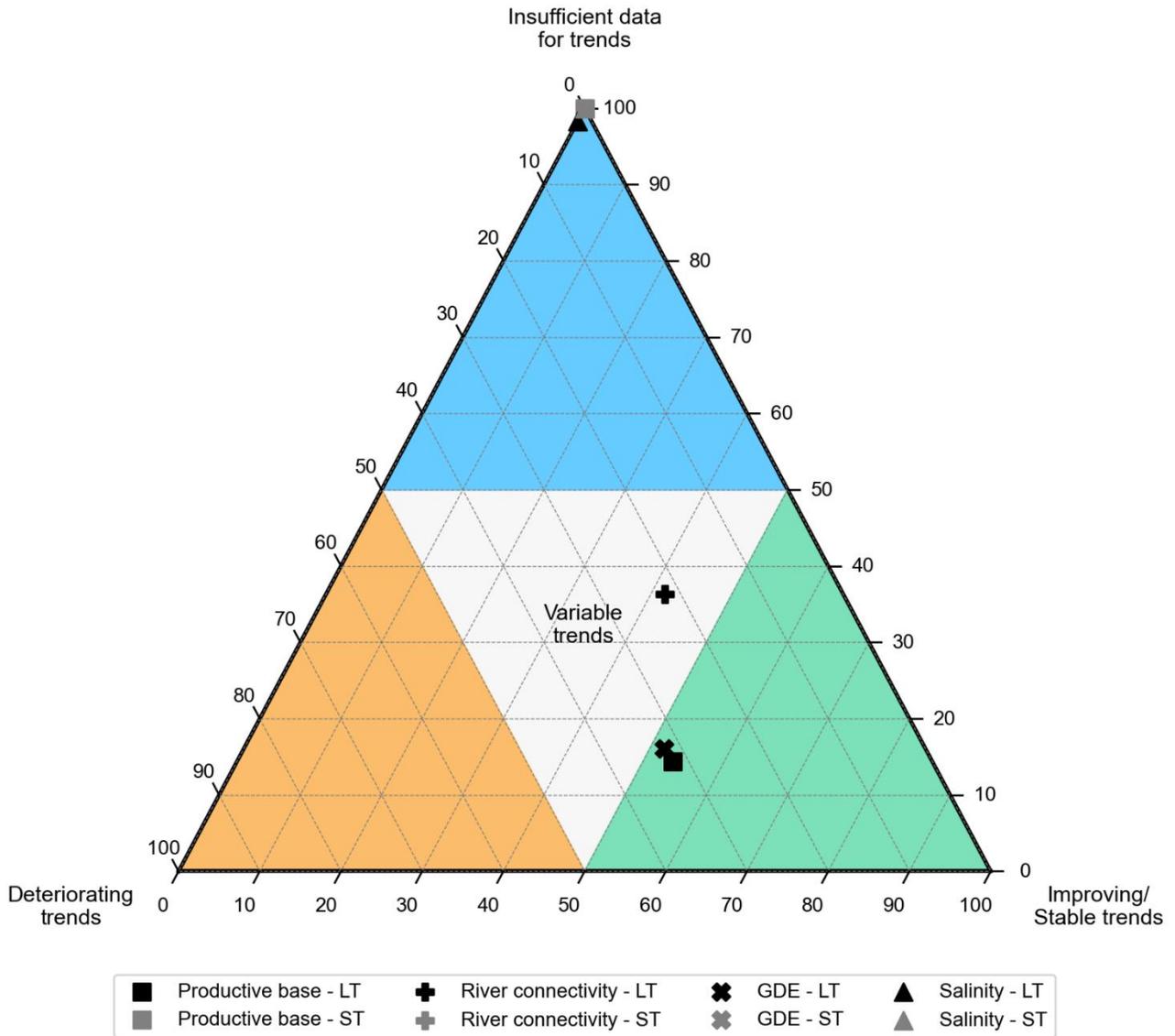


Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

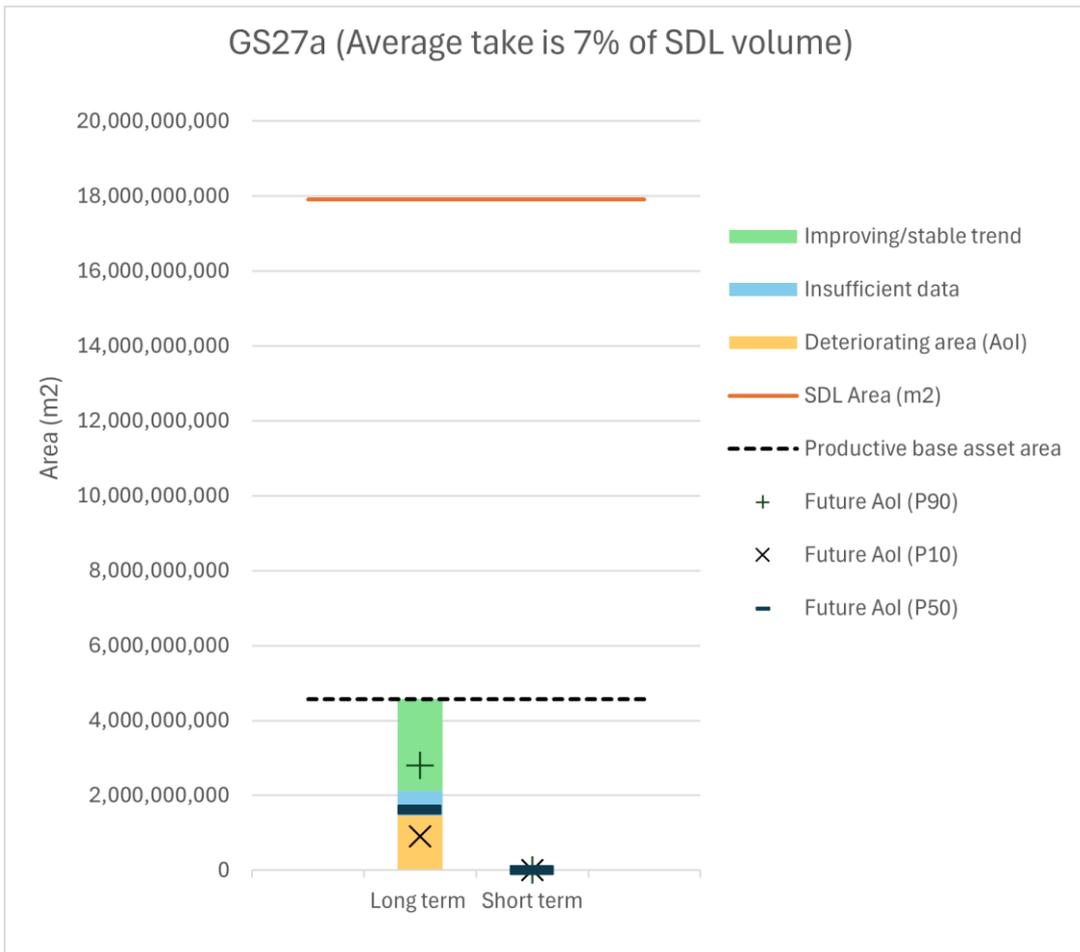


Figure 12 Estimates for change in area of influence (Aol) due to climate change

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