Australasian Groundwater & Environmental Consultants

Report on

GS25 Lower Lachlan Alluvium Stage 5

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Australasian Groundwater and Environmental Consultants Pty Ltd

GS25 – Lower Lachlan Alluvium

Stage 5 – Assessment through multiple lines of evidence

The Lower Lachlan Alluvium (GS25) is located within the Lachlan catchment in central New South Wales between Lake Cargelligo in the east, to 20-30 km west of Ivanhoe in the north and Oxley in the south (Figure 1). GS25 comprises a large alluvial fan hosting a shallow unconfined/semiconfined aquifer within the Calivil Formation and a deeper semiconfined/confined aquifer within the Renmark Group sediments (NSW DPE, 2019). GS25 is hydraulically connected to the Lachlan River (Crosbie et al., 2023), but given the deeper water levels, river leakage is not influenced by groundwater pumping. Groundwater entitlements are concentrated around Hillston and tend to align with the Lachlan River on the south and Willandra Creek on the north (Figure 1). GS25 spans approximately 26,120 km², with a Sustainable Diversion Limit (SDL) of 117.00 GL/year and a long-term average recharge estimate of 120.00 GL/year (Table 1). Between 2013 and 2023, average annual groundwater extraction was 100.52 GL/year, representing 84% of estimated recharge and 86% of the SDL (Figure 2). Groundwater use supports intensive irrigation, industry, stock and domestic, and local water utilities, supplementing surface water supply during years of below-average rainfall (Figure 2). Long-term climate observations show a relatively persistent below-average rainfall signal for the 2000–2010 period, with two cycles of above- and below-average rainfall between 2010 and 2020, and a sustained above-average rainfall period post-2020 (Figure 3). GS25 is characterised as mostly arid/semiarid conditions based on the precipitation-to-evaporation ratio.

The water table fluctuates from less than 10 m below the ground surface in the eastern section of GS25 proximal to the Lachlan River, to over 20-30 m below ground level in the central area around Hillston, and more than 40 m in a localised northeast sector (Figure 4a). Groundwater flows from east to west along the main alluvial fan, with a depression zone observed southwest of Hillston (Figure 4b). Long-term (1974-2024) and short-term (2012-2024) median groundwater levels show spatial agreement and are contained within a well-defined multi-decadal fluctuation zone of up to 10 m (Figure 5). Across GS25, the base of the groundwater fluctuation zone aligns with recent (short-term) water levels, indicating that current levels are close to the deepest observed since 1974, with concentrated declines around Hillston. A well-defined freshwater pocket around Hillston with salinity below 2,239 µS/cm (equivalent to 1,500 mg/L) is observed in Figure 6. Outside this freshwater lens, groundwater quickly transitions to brackish and saline conditions around the Booligal wetlands and northwest of GS25 (MDBA, 2020). Water level trends vary spatially but show decreases over the long-term (since the 1970s and 1980s), with multi-decadal variability (Figure 7; Figure 9; Figure 10) linked to extraction pressure around Hillston (between Lachlan River and Willandra Creek). Short-term decreasing trends are slightly more widespread further west, with some bores showing stabilisation or recovery post-2020. The understanding of temporal salinity trends is limited due to poor data availability (Figure 8).

MDBA (2020) previously reported recharge at 120.00 GL/year for GS25, which incorporates diffuse, irrigation, in-stream and lateral flow recharge derived from a calibrated groundwater model. MD-SY2 project estimated diffuse recharge alone at 57.21 GL/year (Crosbie et al., 2025). Based on this, the estimate by MDBA (2020) (120.00 GL/year) has been used for this assessment. Table 1 shows a high storage-to-recharge ratio (S/R) using this estimate of recharge and the WERP estimate of storage (Rojas et al., 2022), suggesting high buffering capacity and limited vulnerability to short-term climate variability (above the "low responsiveness" threshold[1] defined in Rojas et al., 2022). However, the high extraction-to-recharge (E/R) and SDL-to-recharge (SDL/R) ratios (Table 1) suggest moderate to high pressure on the productive base, particularly in low-transmissivity zones or areas showing delayed recovery and legacy decreasing trends in water levels.

The productive base shows signs of stress, with a long-term decreasing trend in water level affecting the freshwater lens area around Hillston (Table 1; Figure 9; Figure 10). Statistically significant (α=0.05) declines

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

of up to 0.5 m/year have occurred since 1974 along the central area of GS25, whereas in the Great Cumbung Swamp a localised long-term increase in water levels is evident. Statistically significant trends for the short-term show a slight shift towards less extreme trends (declines of up to 0.2 m/year) but a wider spread towards the west. Localised recovery trends are also observed in the short-term in two bores located proximal to the Lachlan River (Figure 10). The short-term period (2012-2024) is characterised by a mixed below- and above-average rainfall signal prior to 2020 and a positive annual rainfall anomaly post-2020 (Figure 3), and a substantial reduction in annual groundwater take post-2018 (Figure 2). This suggests that short-term declining trends in the west may be attributable to legacy declines, given the consistent reduction in groundwater extraction observed since 2018 and the recovery in the rainfall anomaly post-2020. Persisting groundwater declines are unlikely to affect surface water connectivity given groundwater level depths at GS25 proximal to the rivers and creeks, with the Lachlan River and Willandra Creek classified as 'always losing' during 2000-2019 by Crosbie et al. (2023). This same study was unable to classify the lower reaches of the Lachlan River downstream Booligal due to data limitations. This adds uncertainty to potential impacts on groundwater-dependent ecosystems (GDEs) listed as DIWA/Ramsar Wetlands in NSW DPE (2019), identified downstream of Booligal.

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 41% of the productive base asset area, 48% of the river connectivity asset area, and 18% of the GDE asset area (Table 2). In the short-term, these percentages decreased to 32%, 29% and 2%, respectively (Table 2). In terms of asset areas showing improving or stable trends, long-term estimates of less than 6% of the ESLT asset areas show improved values in the short-term (14%-25%), thus indicating partial recovery or stabilisation (Table 2). The proportion of the asset area with uncertain trends in the short-term is close to 50% for productive base and river connectivity asset areas, and 82% for GDEs. Furthermore, the level of uncertainty has remained essentially unchanged between the long- and short-term periods for most ESLTs (minimal vertical displacement of points in Figure 11). The exception is the water quality (salinity) ESLT, where recent data gaps have increased, with the short-term asset area fully classified as having 'insufficient data' to determine temporal trends.

The NSW state-based risk assessment (NSW DPE, 2019) assigns variable risk ratings across ESLT values of GS25. For the productive base, risks are rated low to high. Risks to the structural integrity of aquifer systems, as well as risks of growth in water utilities and basic landholder rights (BLR), reducing groundwater availability are rated medium. Local drawdown reducing groundwater access by consumptive users is rated as high risk, with a high tolerable residual risk. River connectivity risks are rated nil, which is aligned with the observed groundwater depths and the disconnected-losing classification of the Lachlan River and main creeks in GS25. Risks to GDEs range from low to high depending on category: risks of groundwater extraction causing local drawdown impacting GDEs are rated high, with a high and tolerable residual risk; risks of climate change reducing groundwater availability to GDEs, and poor water quality to GDEs are rated low. Finally, the risk of groundwater extraction inducing a connection to poor quality groundwater is rated as high, with a high and tolerable residual risk. Data availability is moderate for water levels but substantially more limited for salinity and river reaches downstream of Booligal wetlands, contributing to residual uncertainty in the risk profile for water quality and GDEs.

Future projections from the MD-SY2 project suggest that diffuse recharge in GS25 may marginally increase by 2050 due to more intense rainfall events (Crosbie et al., 2025). In contrast, overbank flood recharge and in-stream recharge are projected to decline by 30% and 15% relative to current conditions, respectively (Crosbie et al., 2025), potentially reducing (localised) episodic recharge and groundwater availability during dry periods. These opposing trends introduce uncertainty regarding the net change in future recharge in GS25. Stage 6 of this BPR technical groundwater review found that the future area of drawdown (Area of Influence, AoI[2]) is projected to expand under climate change scenarios, with the median future AoI (P50) exceeding the present AoI, indicating likely increases in deteriorating areas (Figure 12). Based on the recharge estimates, more than half of the total recharge is expected to come from sources other than diffuse recharge from rainfall. Therefore, the SDL/R ratio is also projected to increase, indicating that the rate of replenishment for the resource may change in the future. The Stage 6 assessment classified the pressure from future climate change on GS25 groundwater resources as very high (based on 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, long-term (1974-2024) and short-term (2012–2024) groundwater trends suggest conditions for ESLT values in GS25 have remained unchanged with a slight shift towards improving/stable conditions, while uncertainty levels are largely unchanged from the long-term assessment (1974–2024). Some areas, most notably in the freshwater pocket around Hillston, continue to experience persistent declines in water levels, amid above-average rainfall and reduced groundwater extraction. These trends could indicate that legacy impacts from pumping in this area are persistent. In contrast, uncertainty in salinity trends has substantially increased, with 100% of the short-term asset area now classified as having insufficient data to inform temporal trends. Current groundwater extraction remains below, but close to, both the SDL and recharge volumes. The state-based risk assessment supports this concern, highlighting medium to high risks for water quality and local drawdowns. Climate projections indicate reduced episodic (localised) recharge from floodplain processes in this alluvial resource unit. Collectively, the analysis suggests there is moderate to high pressure on the productive base of GS25, with very high pressure from future climatic variability.

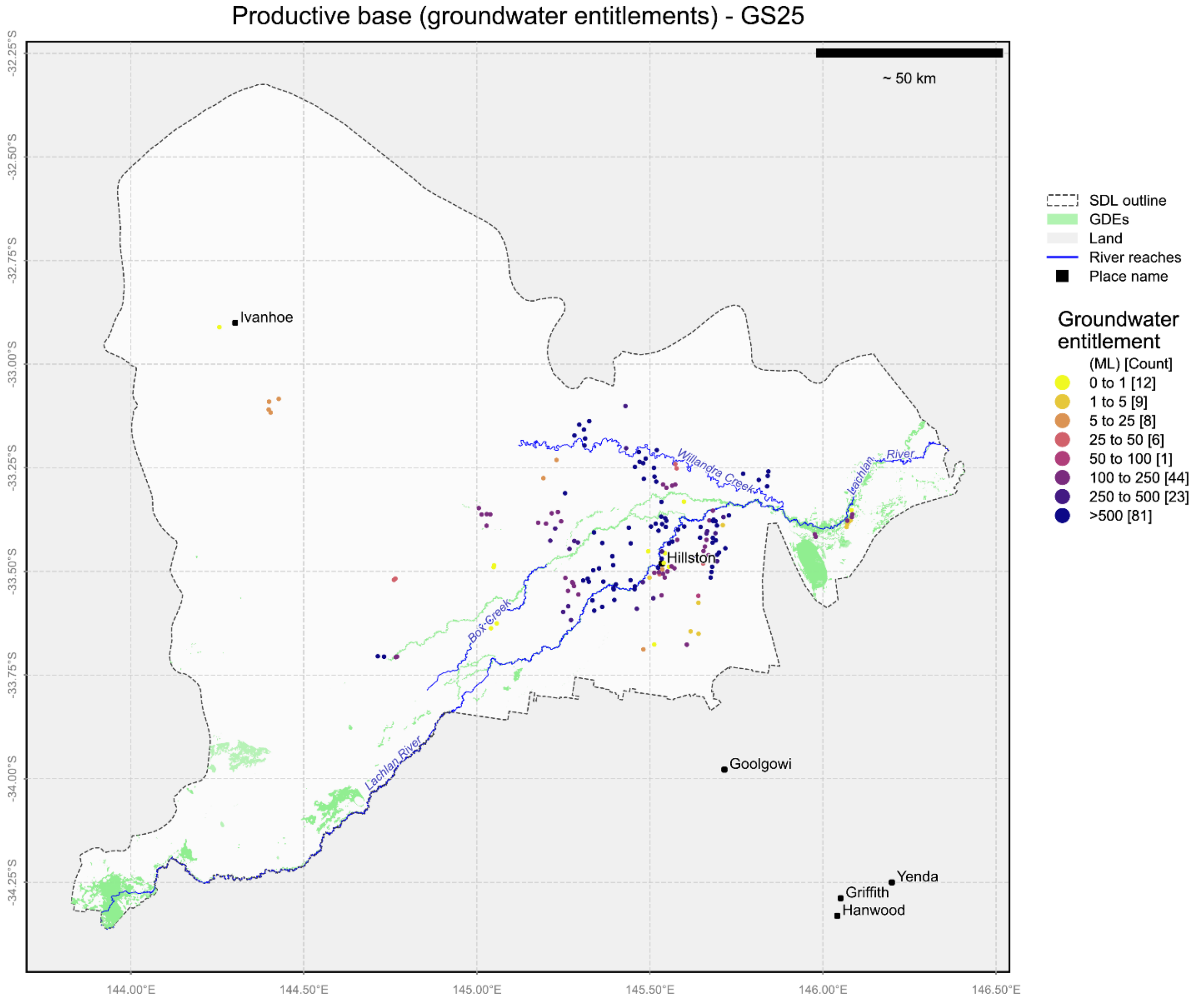


Figure 1 Productive base (groundwater entitlements)

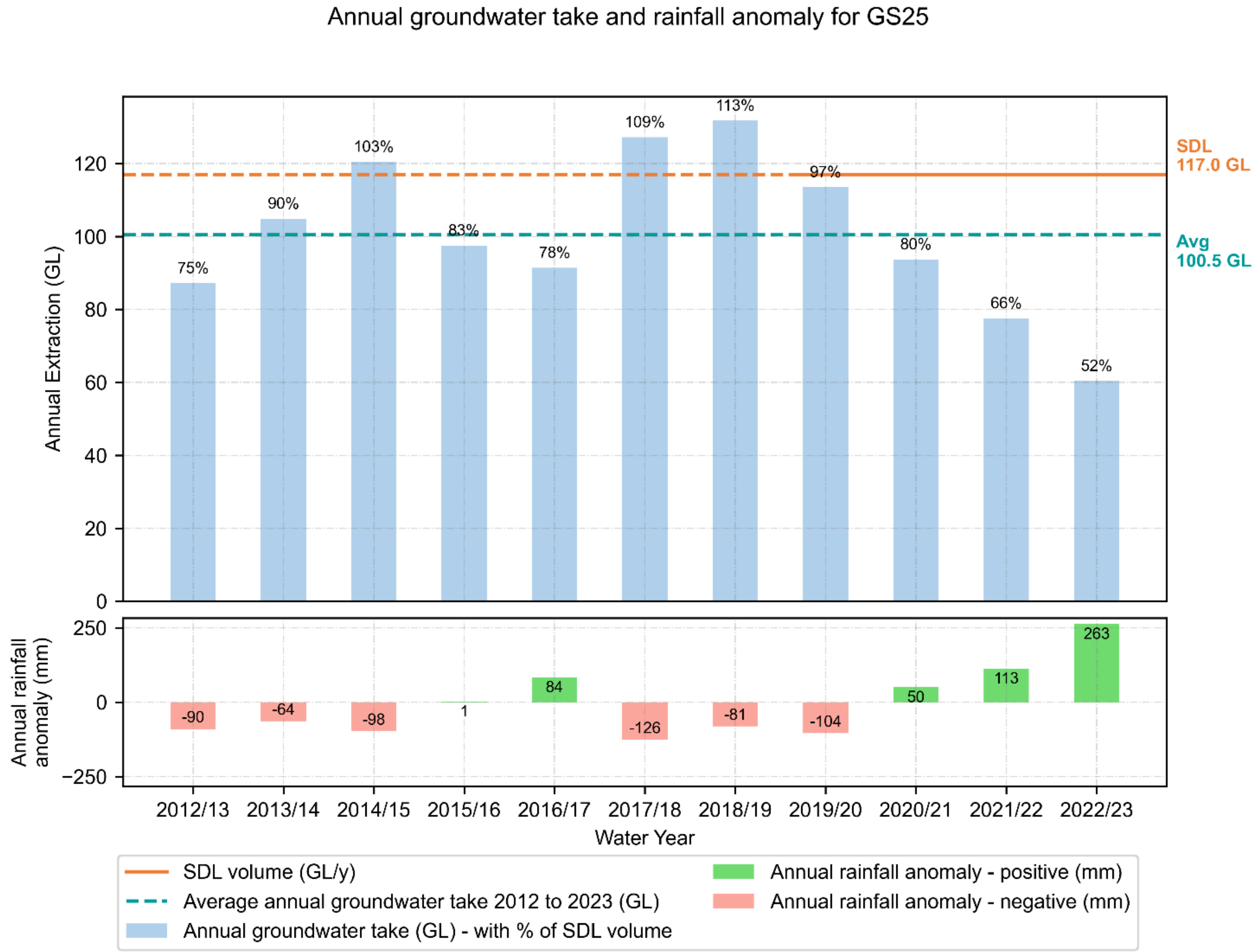


Figure 2 Groundwater take in the SDL since 2012

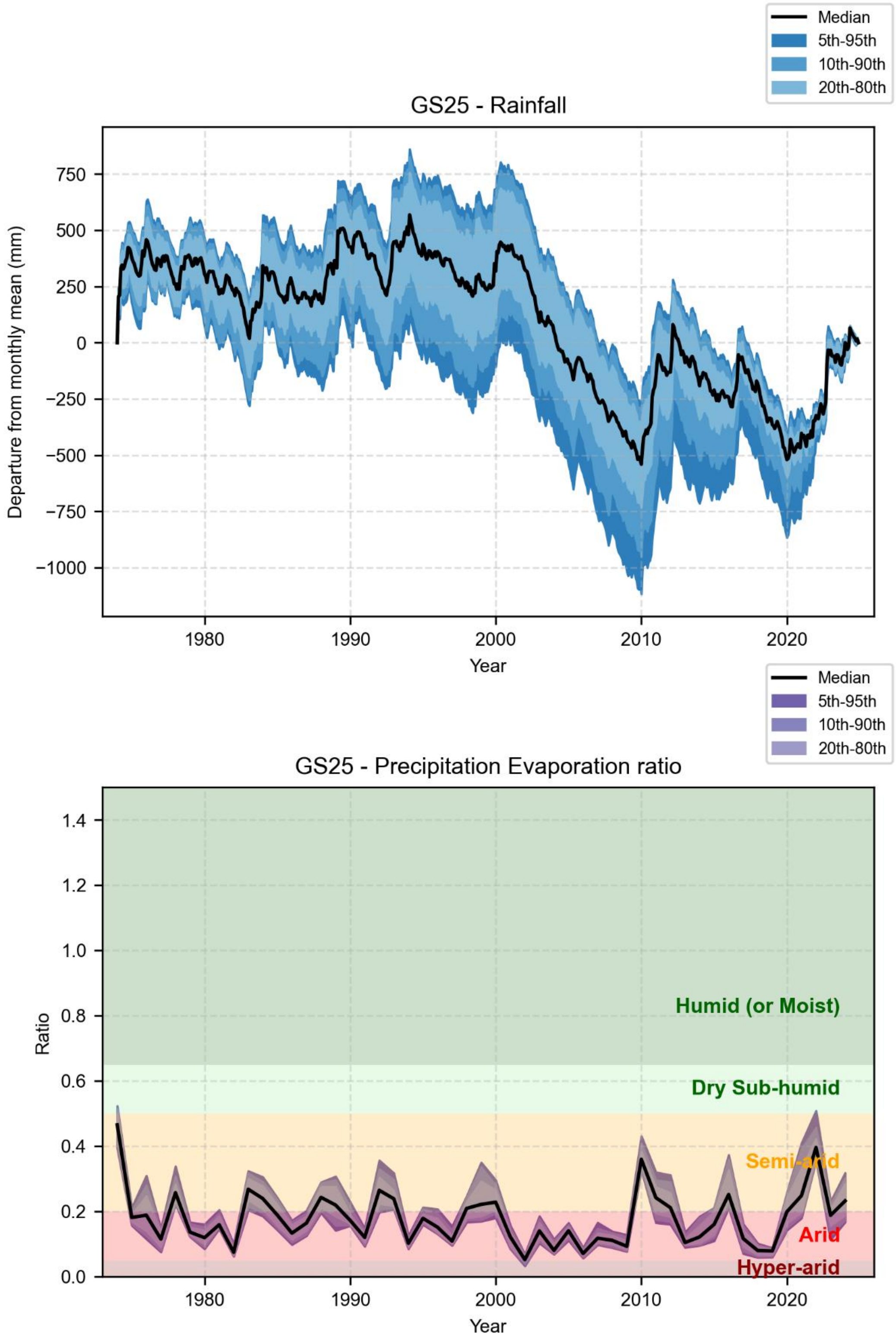
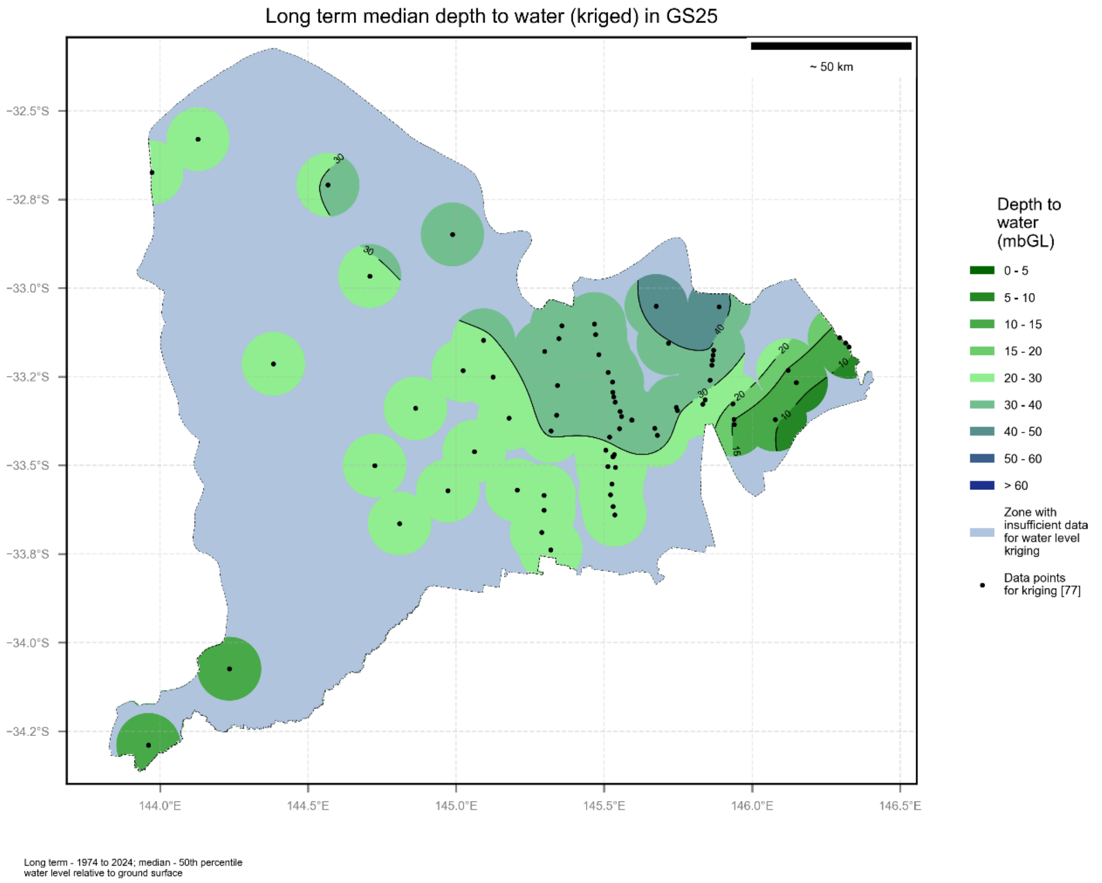
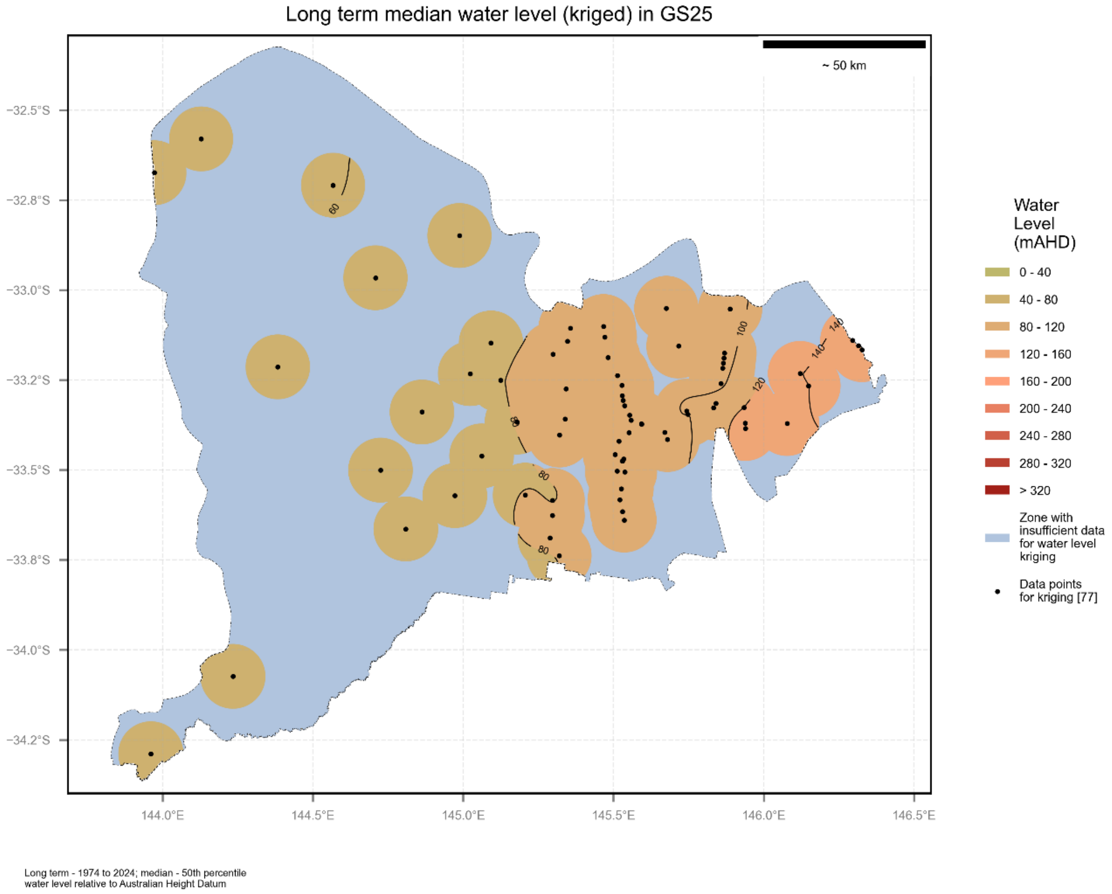


Figure 3 Historical climate trends



(a)



(b)

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

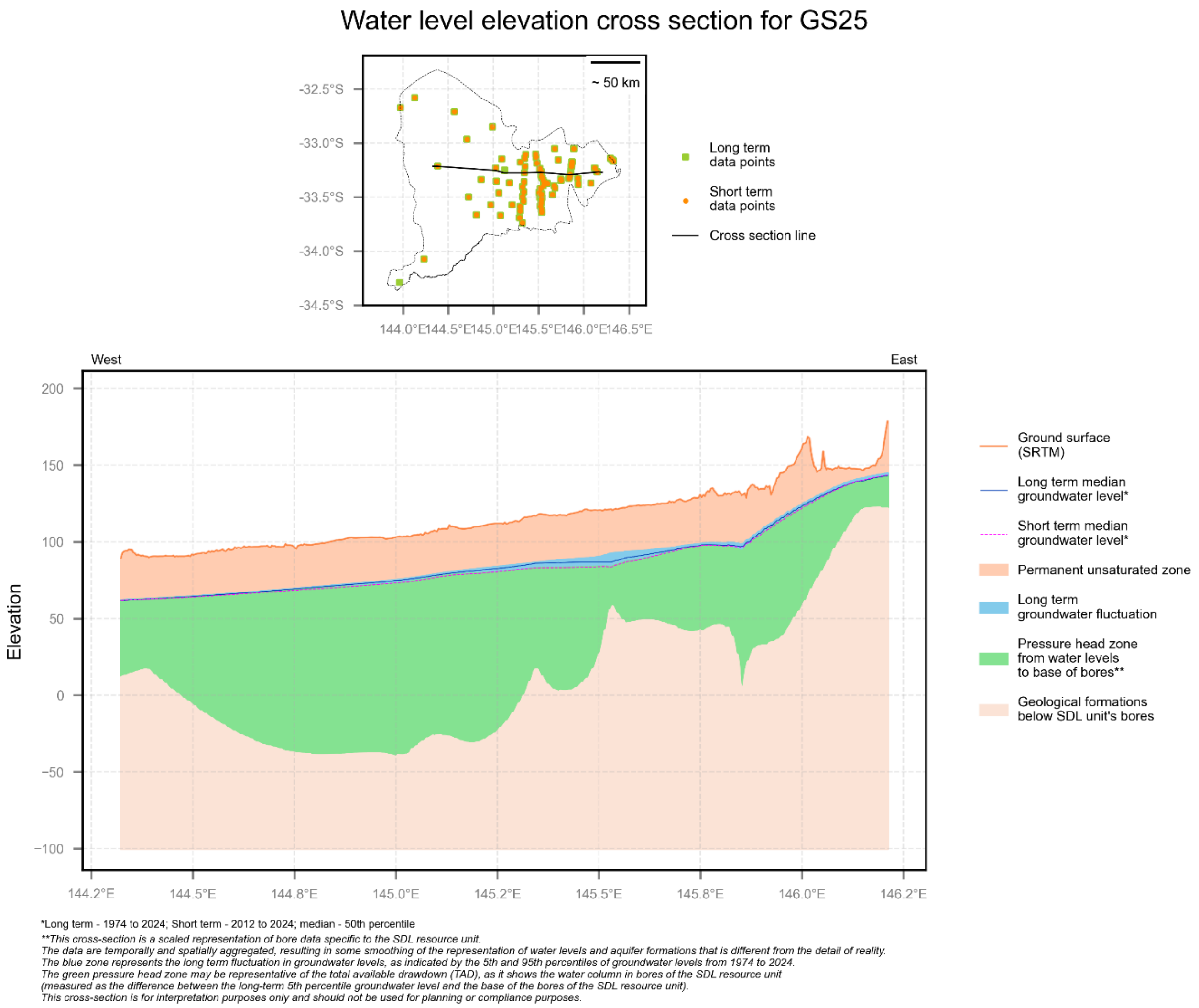


Figure 5 West to east distribution of water levels in the SDL resource unit

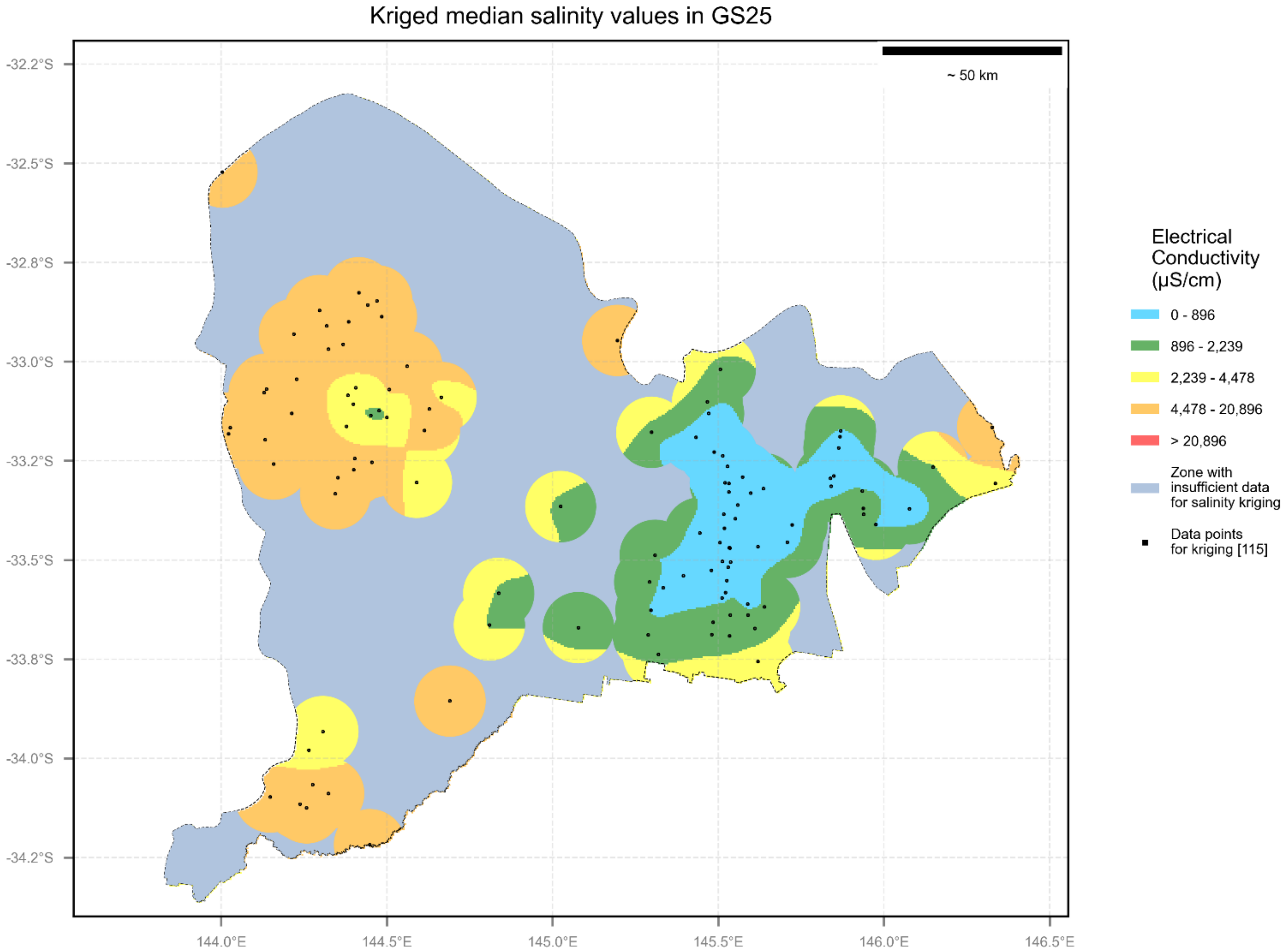


Figure 6 Groundwater salinity distribution

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	-	-	117.00
SDL resource unit area	km²	-	-	26,120
Average annual take (2013 to 2023)	GL/y	-	-	100.52
Number of groundwater entitlement bores	-	-	-	184
SDL resource unit storage estimate*	GL	-	-	353,905
Recharge estimate (SY1)	GL/y	-	-	120.00
Recharge estimate (Stage 2)	GL/yr	-	-	120.00
Diffuse recharge estimate (SY2 - WAVES)	GL/yr	-	-	57.21
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.86
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.98
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	0.98
Storage/Stage 2 Recharge (S/R)	-	-	-	2,949
Storage/SY2 or modelled Recharge (S/R)	-	-	-	2,949
Number of bores in the SDL unit	-	1,838	1,838	-
Number of bores for water level trend analysis	-	87	83	-
Number of bores for water level trend with sufficient data	-	87	79	-
Number of bores with decreasing water level trend	-	62	51	-
Number of bores with increasing water level trend	-	9	6	-
Number of bores with no statistically significant water level trend	-	16	22	-
Mean water level trend magnitude	m/y	-0.09	-0.06	-
Minimum water level trend magnitude	m/y	-0.39	-0.34	-
5%ile water level trend magnitude	m/y	-0.32	-0.3	-
10%ile water level trend magnitude	m/y	-0.29	-0.28	-
50%ile water level trend magnitude	m/y	-0.06	-0.07	-
90%ile water level trend magnitude	m/y	0.01	0.09	-
95%ile water level trend magnitude	m/y	0.02	0.14	-
Maximum water level trend magnitude	m/y	0.57	0.8	-
Number of bores for salinity trend analysis	-	121	N/A	-
Number of bores for salinity trend with sufficient data	-	7	N/A	-
Number of bores with decreasing salinity trend	-	0	N/A	-
Number of bores with increasing salinity trend	-	2	N/A	-
Number of bores with no statistically significant salinity trend	-	5	N/A	-
Mean salinity trend magnitude	µS/cm/y	6	N/A	-
Minimum salinity trend magnitude	µS/cm/y	-2	N/A	-
5%ile salinity trend magnitude	µS/cm/y	-2	N/A	-
10%ile salinity trend magnitude	µS/cm/y	-2	N/A	-
50%ile salinity trend magnitude	µS/cm/y	2	N/A	-
90%ile salinity trend magnitude	µS/cm/y	17	N/A	-
95%ile salinity trend magnitude	µS/cm/y	17	N/A	-
Maximum salinity trend magnitude	µS/cm/y	18	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	3,782,933,432	6%	41%	53%	Insufficient data	14%	32%	54%	Insufficient data
GDEs	1,424,706,707	0%	18%	82%	Insufficient data	15%	2%	82%	Insufficient data
River connectivity	2,047,811,961	6%	48%	46%	Variable trends	25%	29%	46%	Variable trends
Water quality	3,760,654,244	10%	4%	86%	Insufficient data	0%	0%	100%	Insufficient data

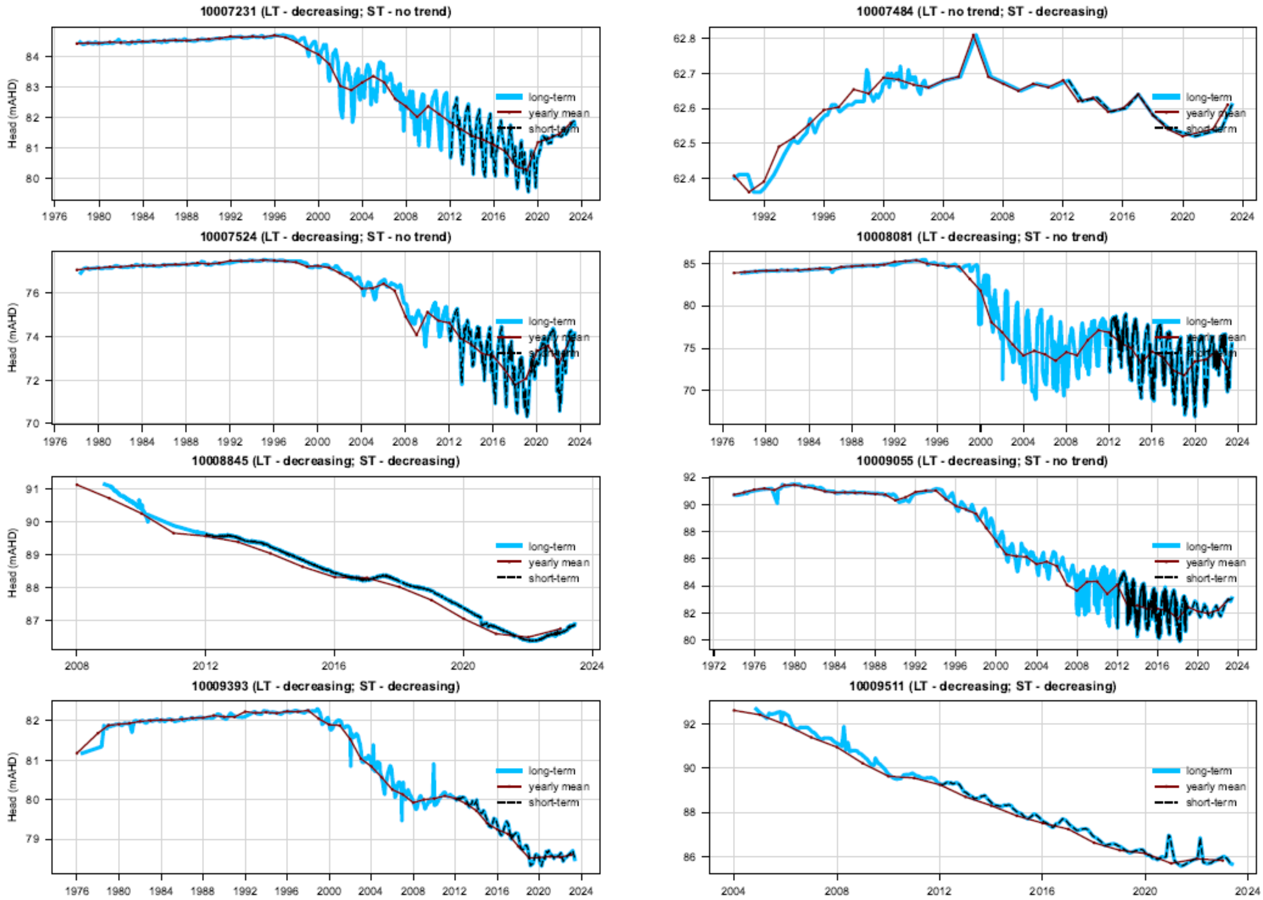


Figure 7 Representative groundwater hydrographs for the SDL resource unit

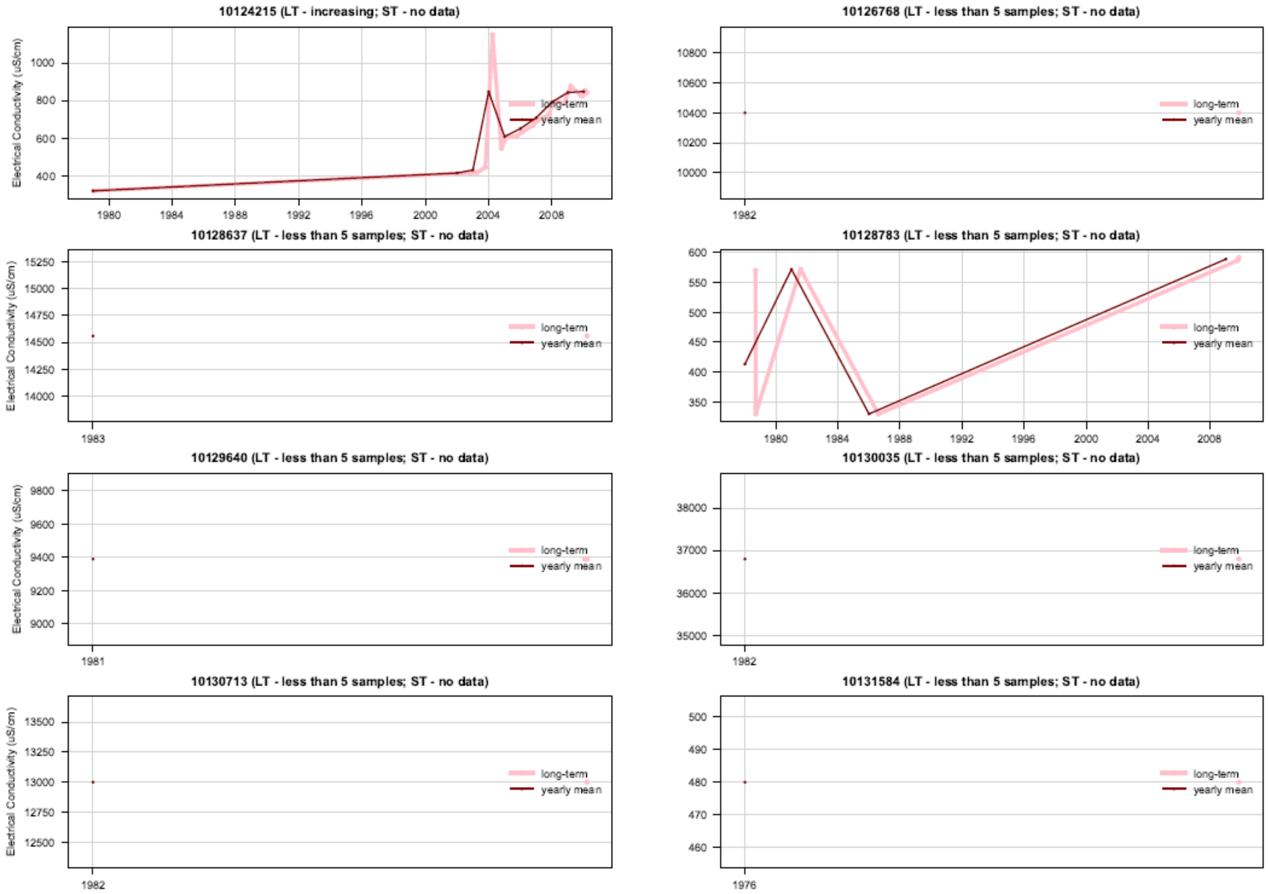
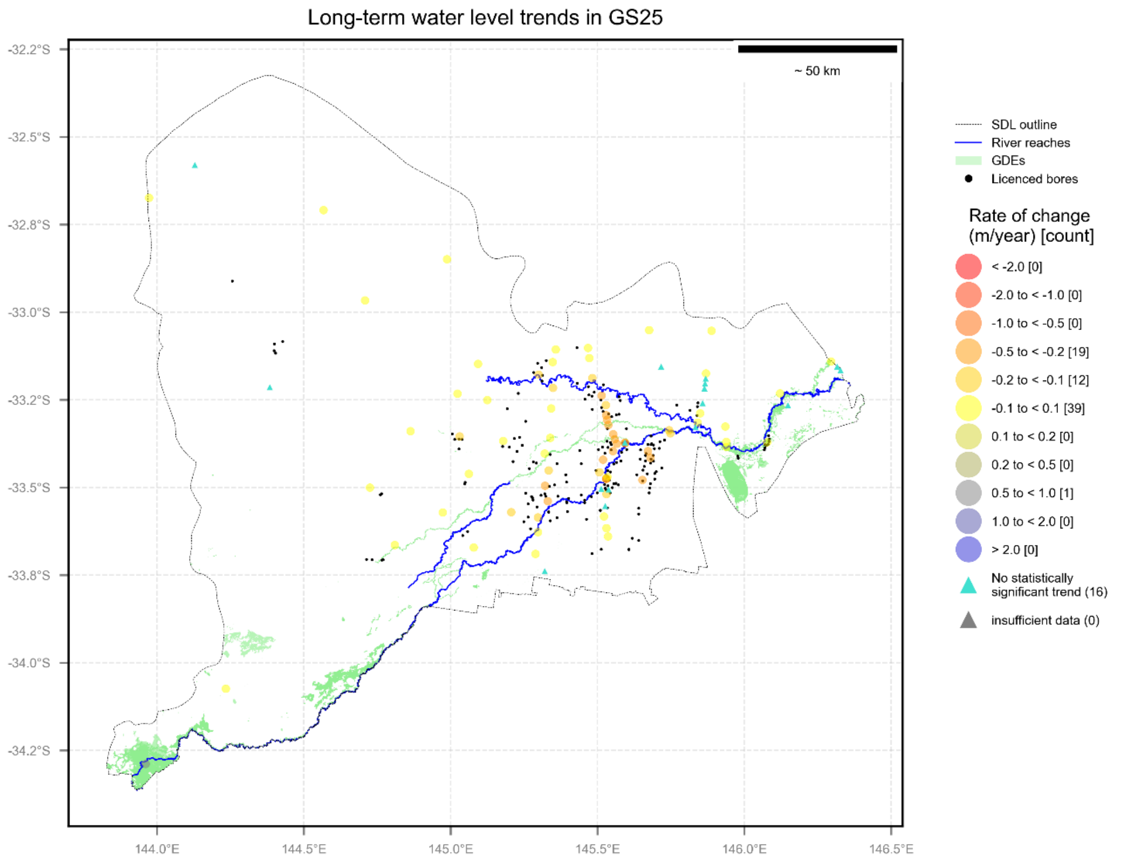
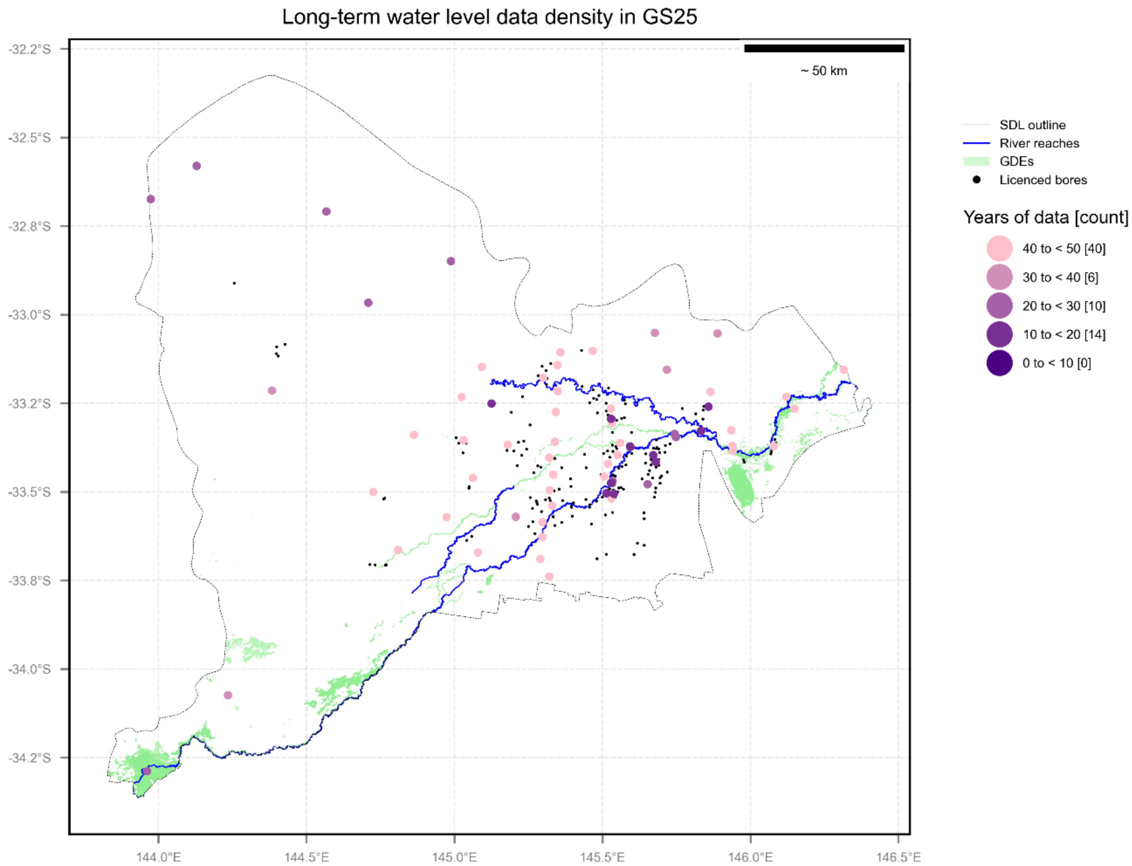


Figure 8 Representative groundwater salinity time series for the SDL resource unit

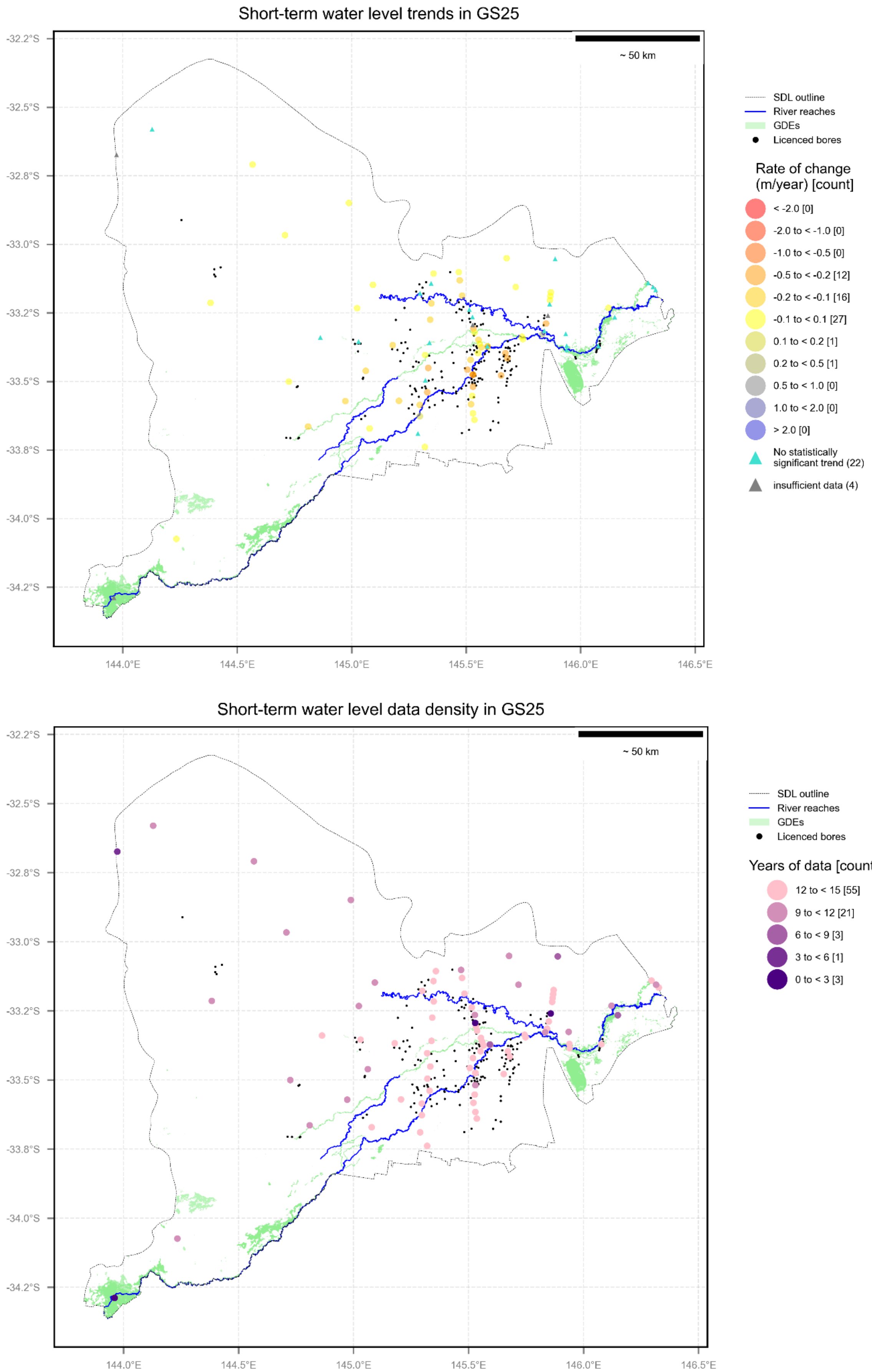


a)



b)

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)

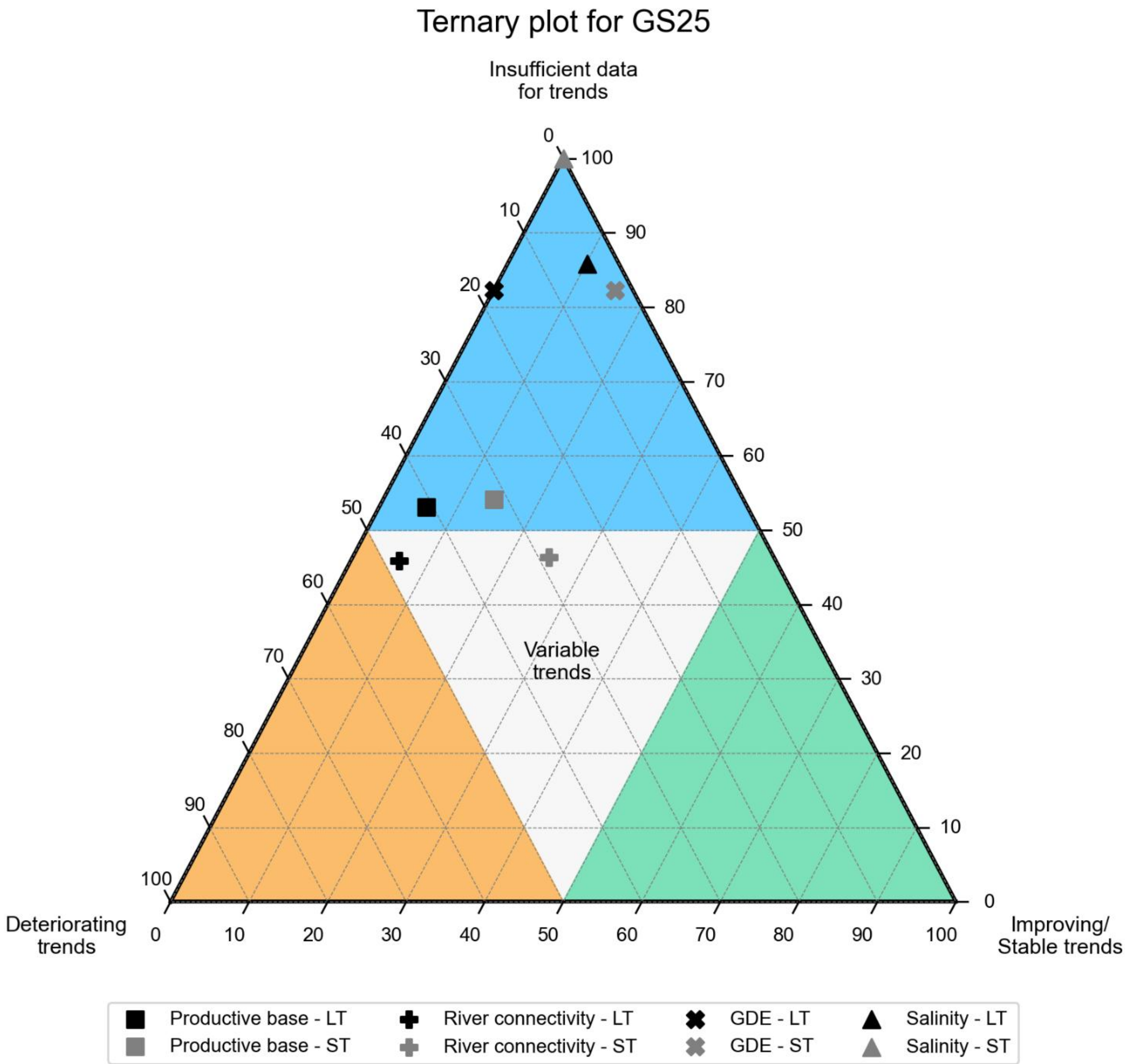


Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

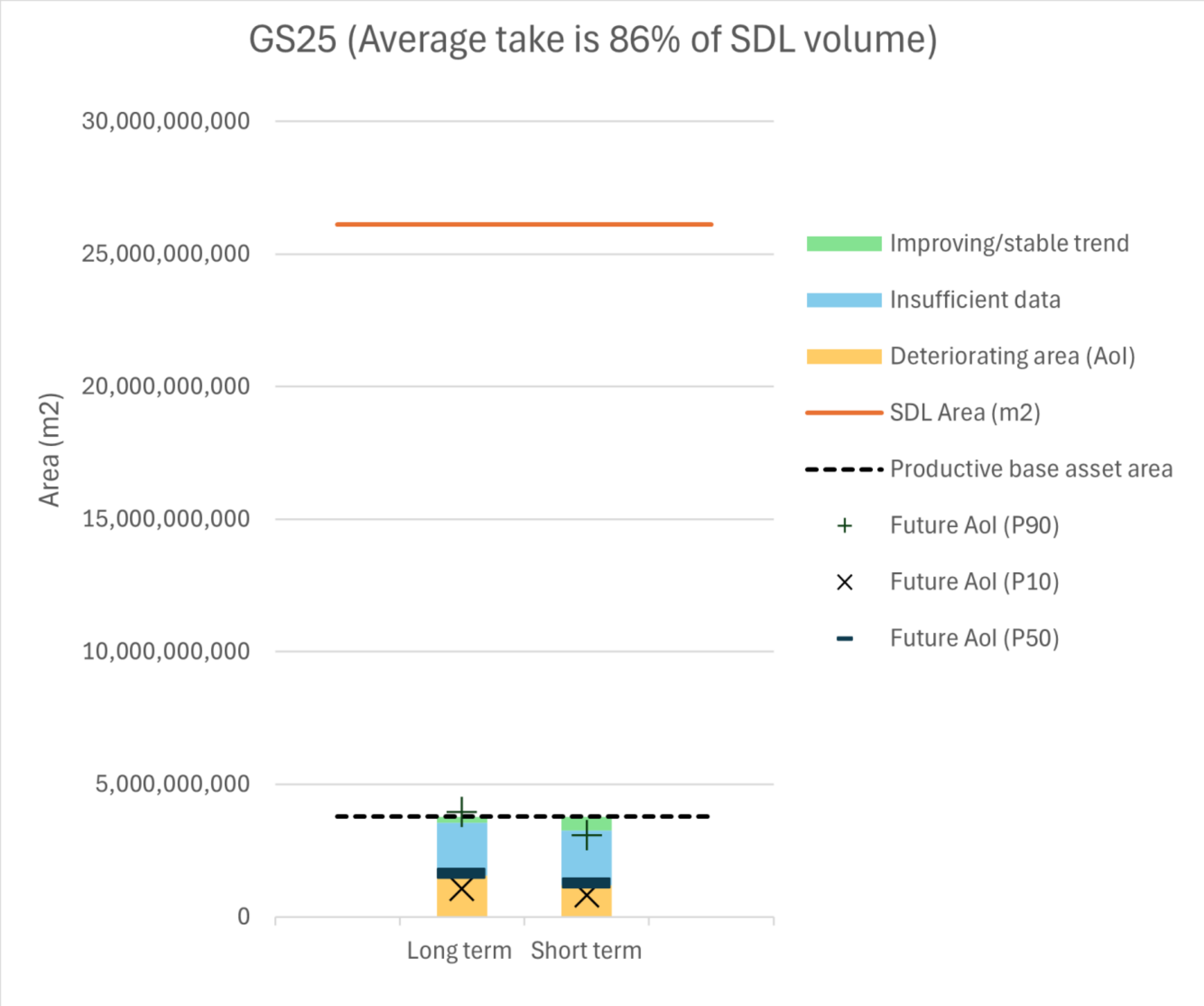


Figure 12 Estimates for change in area of influence (AoI) due to climate change

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