Australasian Groundwater & Environmental Consultants

Report on

GS42 Upper Darling Alluvium Stage 5

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GS42 – Upper Darling Alluvium

Stage 5 – Assessment through multiple lines of evidence

The Upper Darling Alluvium (GS42) lies within the northern Basin and includes the alluvial sediments along the Darling River upstream of the Menindee Lakes (Figure 1; Crosbie et al., 2023). The aquifer system is unconfined to semi-confined, comprising unconsolidated valley-fill sediments that are hydraulically connected to the Darling River. Groundwater entitlements are concentrated southwest of Bourke and around Wilcannia, with most basic landholder rights distributed along the main alluvial corridor of the Darling River and in the Paroo valley. GS42 spans approximately 9,073 km², with a sustainable diversion limit (SDL) of 6.59 GL/year and a long-term average recharge of 10.05 GL/year (recharge estimates vary, refer to Table 1 for details). There are salinity interception schemes (SIS) located in GS42 to prevent saline groundwater discharging to the Darling River, which are allocated 3.3 GL/year for extraction (50% of the SDL). Average extraction between 2013 and 2023 was 3.61 GL/year, representing 36% of estimated recharge and 55% of the SDL volume (Figure 2). Groundwater use supports stock, domestic, and limited irrigation needs, with extraction concentrated near Bourke and other river-adjacent areas (Figure 1). Long-term climate observations within GS42 show a relatively persistent below-average rainfall signal for the 2000–2010 period, with a partial recovery early 2011 and another substantial period of below-average rainfall between 2011 and 2021, interrupted by a short recovery in 2016 (Figure 3). GS42 has had a mostly arid climate since at least the 1980s based on the precipitation-evaporation ratio (Figure 3). The short-term period (2012–2024) is characterised by a persistent below-average rainfall pattern prior to 2020 (Figure 3) and a modest recovery in rainfall post 2021 (Figure 2).

The long-term water table is generally within 10 m to 15 m from the ground surface, though some areas reach values deeper than 15 m (Figure 4a). Close to the Darling River, water levels are within 10 m and possibly influenced by the river head. Groundwater flows from northeast to southwest along the main alluvial valley (Figure 4b). Long-term (1974–2024) and short-term (2012–2024) median groundwater levels show a low spatial variability across GS42 when defining the long-term groundwater fluctuation zone (Figure 5). In the downstream section of GS42, the bottom of the groundwater fluctuation zone is aligned with recent (short-term) water levels, indicating that current levels are close to the deepest observed since 1974. Salinity data is sparse, but is concentrated around south-west of Bourke and shows values mainly in the range 4,480–20,900 µS/cm (equivalent to 3,000–14,000 mg/L) (Figure 6), with a few isolated areas of similar salinity levels. Pockets of freshwater are reported along the Darling River, with low salinity ranging up to 3000 mg/L (MDBA, 2020). Water level trends show widespread declining trends over the long- and short-term periods (Figure 7; Figure 9; Figure 10), with localised marginal declining trends along the Darling River (usually less than 0.1 m/year). The understanding of temporal salinity trends is limited due to poor data availability (Figure 8).

MDBA (2020) previously reported diffuse recharge at 14.30 GL/year for GS42, based on WAVES modelling. Recent WAVES modelling has revised this estimate to 8.00 GL/year in the MD-SY2 project (Crosbie et al., 2025). Both of these estimates compare favourably with the Stage 2 estimate of 10.05 GL/year, which is based on chloride mass balance data (Lee et al., 2024). Table 1 shows a storage-to-recharge ratio (S/R) of 1,629, using the recharge estimate of Stage 2 and the storage estimate from RRAM, suggesting high buffering capacity and limited vulnerability to short-term climate variability (S/R is above the "low responsiveness" threshold[1] defined in Rojas et al., 2022). The low extraction-to-recharge (E/R) ratio (0.36) and moderately high SDL-to-recharge (SDL/R) ratio of 0.66 (Table 1) suggest potential future pressure on the productive base if the full SDL value materialises.

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

The productive base shows signs of stress, with widespread drawdown, albeit of gentle magnitude (Table 1; Figure 9; Figure 10). Connectivity with the Darling River is acknowledged to be a losing classification, where in stream and flood waters may infiltrate to groundwater, although it is likely episodic and restricted to shallow areas or periods of high flow. Groundwater-dependent ecosystems (GDEs) occur along riparian margins and ephemeral floodplains and may benefit from shallow water tables during recharge events. Statistically significant (α=0.05) declines have occurred since 1974 in 31 of the 50 monitoring bores with suitable data (Table 1), particularly south-west of Bourke (upstream of Darling River) and east of Wilcannia (downstream of Darling River). Short-term trends (Figure 10) show similar conditions with statistically significant declining trends south-west of Bourke and in the south of the unit. One bore, north of Bourke Airport has shown a statistically significant increasing trend since 1974. River reaches for GS42 are classified 'always losing' and 'mostly losing' in the upstream Darling River to 'some losing' in the downstream Darling River during the 2000-2019 period (Crosbie et al., 2023). Groundwater-dependent ecosystems (GDEs) within GS42, such as riparian and floodplain vegetation, may also be impacted in locations proximal to the Darling River if water levels drop below ecologically relevant 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 69% of the productive base asset area, 59% of the river connectivity asset area, and 71% of the GDE asset area (Table 2). In the short-term, these percentages decreased to 26%, 19%, and 26%, respectively (Table 2). About 24% of the productive base asset area and 25% of the river connectivity asset areas showed improving water level conditions in the short-term (Table 2), suggesting more favourable conditions in terms of stabilisation in recent years (Figure 11). For the water quality (salinity) ESLT, the asset area classified as having 'insufficient data to determine temporal trends' represents 100% in both the short- and long-term.

The state-based risk assessment assigns all assessed risks except one as having nil or low risk ratings across all ESLT values in GS42 (NSW DPE, 2023). This includes risks such as: aquifer compaction, growth in groundwater extraction, land management change, change in recharge due to climate change, changes in irrigation efficiency, growth in mining, and salinisation from pumping induced mixing. The only exception is the risk from local drawdown reducing groundwater access for consumptive users, which is assigned as a low to medium risk level. The risk from climate change had a low likelihood due to the S/R ratio of GS42 mentioned above.

Future projections from the MD-SY2 project suggest that diffuse recharge in GS42 may remain unchanged by 2050 (Crosbie et al., 2025). In contrast, overbank flood and instream recharge are projected to decline by 20% and 11.6% relative to current conditions, respectively (Crosbie et al., 2025), potentially reducing (localised) episodic recharge and groundwater availability during dry periods. Stage 6 of this BPR technical groundwater review found that the future area of drawdown (Area of Influence, AoI[2]) is projected to remain practically unchanged under climate change scenarios (Figure 12). However, given that diffuse and floodplain recharge are projected to decrease, there is evidence suggesting that the SDL/R ratio is projected to increase, indicating that the rate of replenishment for the resource may change in the future. In contrast to the state assessment of risk, the Stage 6 assessment classified the pressure from future climate change on GS42 groundwater resources as very high based on water level trend evidence (long- and short-term), current indicators of stress, and projected changes to recharge.

[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) indicate an improvement in water resource condition compared to the long-term (1974–2024) for the productive base and in zones near the Darling River. Although declining trends are detected, they are mild (typically less than 0.1 m/year) and coexist with some stable trends (or no statistically significant trend). Uncertainty around assessing water quality exists in both short- and long-term due to insufficient temporal density of salinity data. Water level trends show stable or not statistically significant patterns across some bores, with marginal declines near Bourke and Wilcannia, where allocations are focussed for town supply and agriculture. Current extraction remains well below the SDL and recharge, with take naturally limited by poor water quality. Extraction levels in GS42 reached a maximum of 64% of SDL and averaged at around 54% of SDL within the short-term. However, the SDL/R ratio is 0.66 and climate change could reduce influx to the aquifer, indicating that the rate of replenishment may change in the future. The health of water-dependent ecosystems and river ecologies in GS42 appears more reliant on low-salinity influxes from surface water than on groundwater influxes. Moreover, the groundwater level declines observed may be linked to declining river discharge, driven by climate change and stream regulation. The state-based risk assessment rates all ESLT risks between nil and medium. However, climate projections suggest reduced episodic (localised) recharge from floodplain processes. Collectively, the analysis suggests that there is moderate to high pressure on the productive base for GS42, with very high pressure from drying of the climate; however, the future groundwater fluxes depend more on delivery of fresh water from rainfall and runoff than on limiting take from the aquifer, which contains mainly saline water.

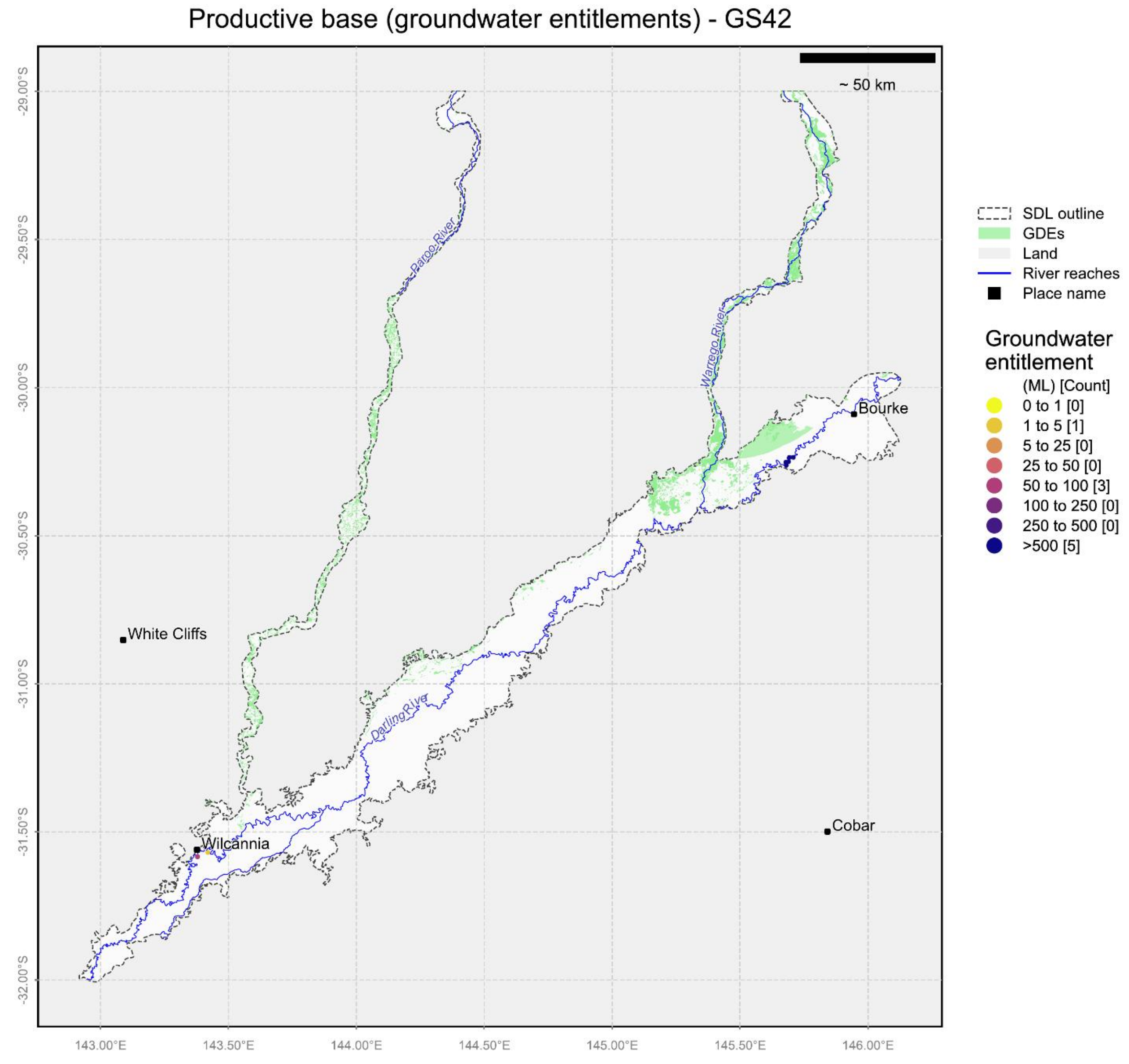


Figure 1 Productive base (groundwater entitlements)

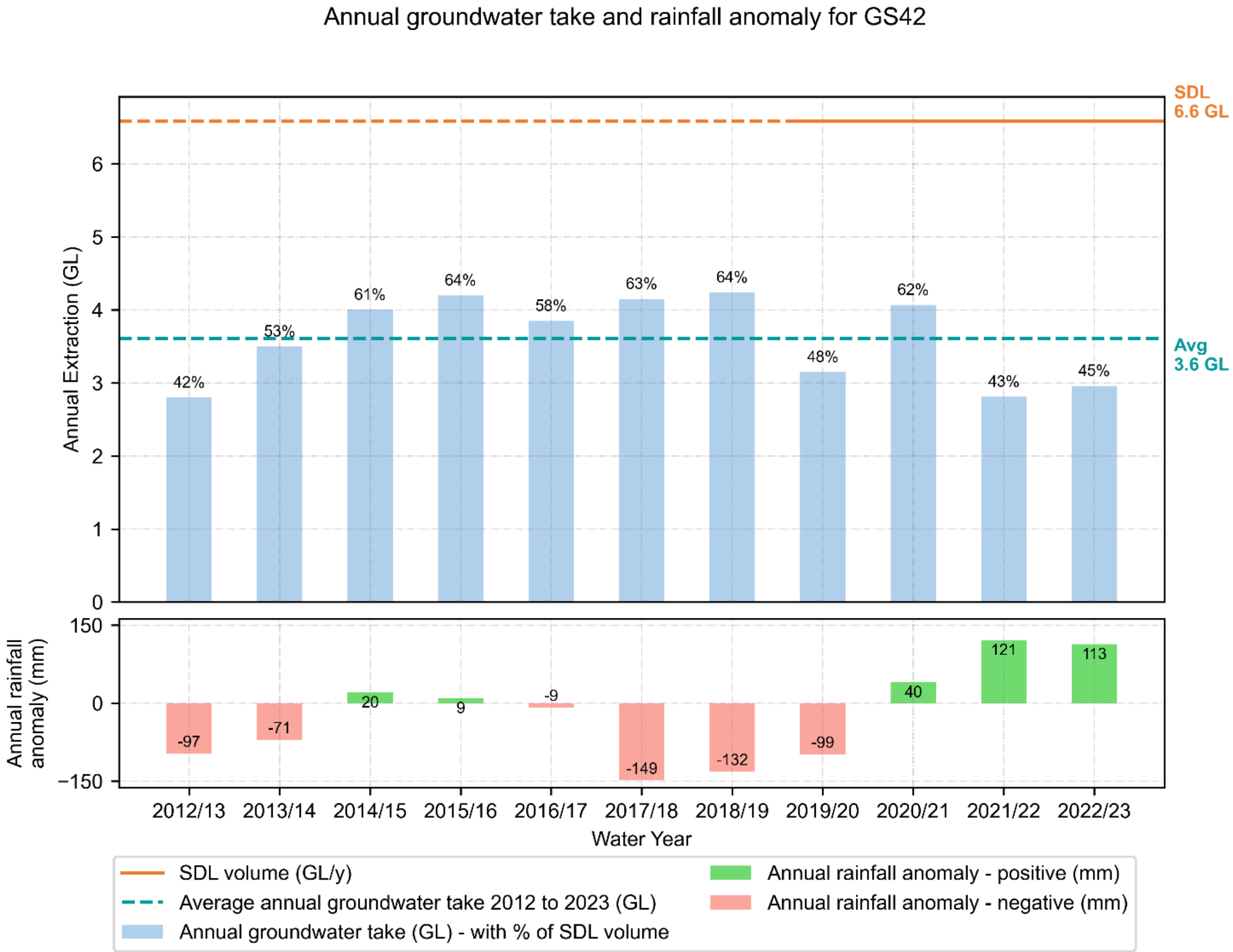


Figure 2 Groundwater take in the SDL since 2012

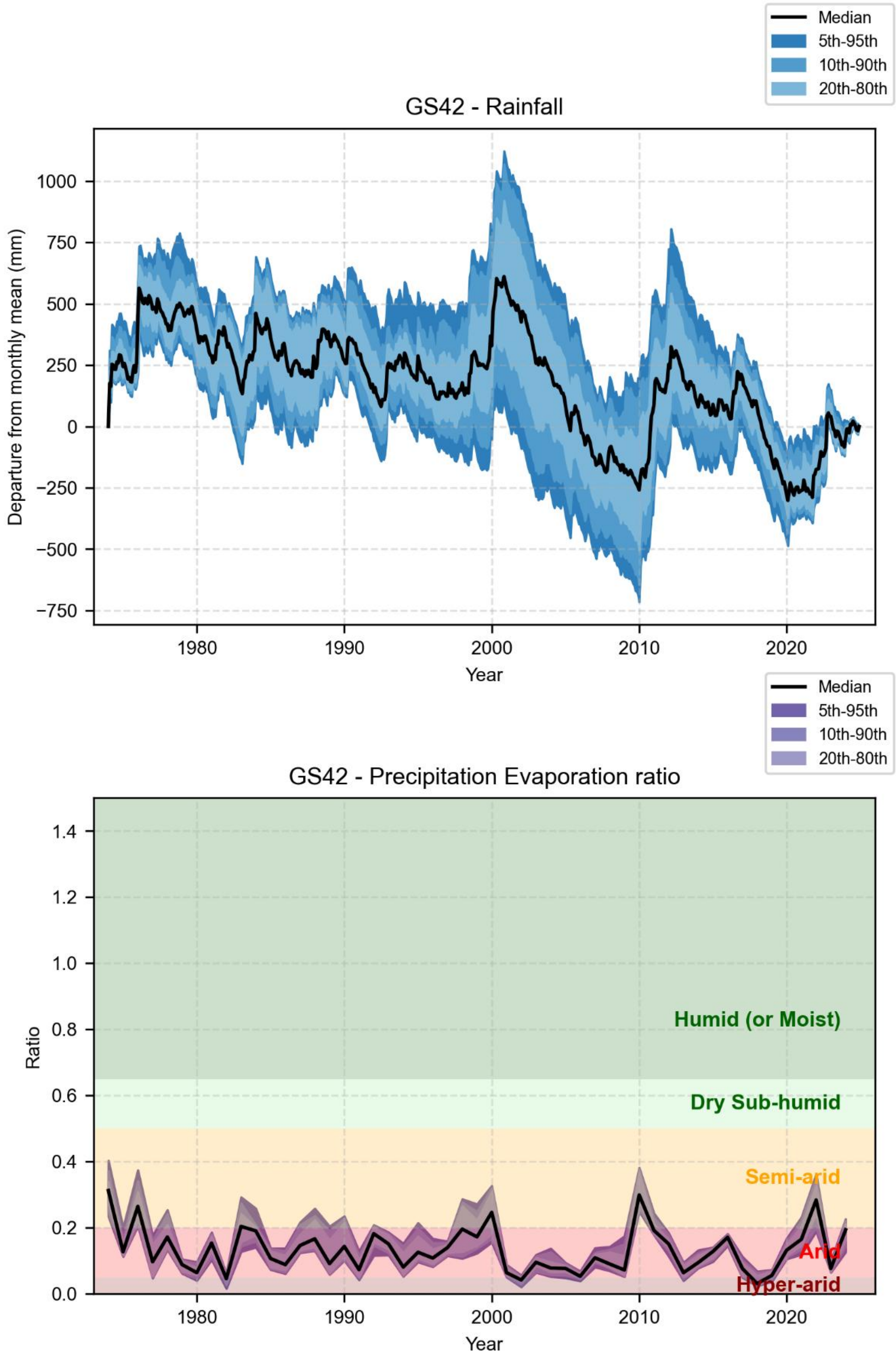
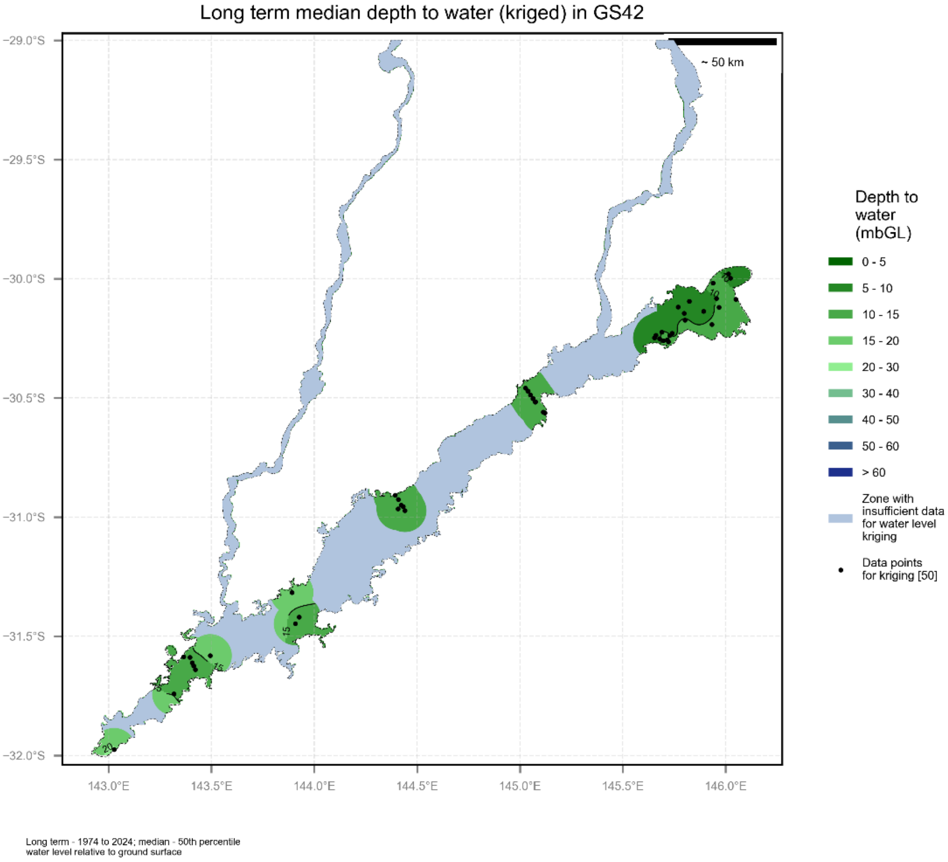
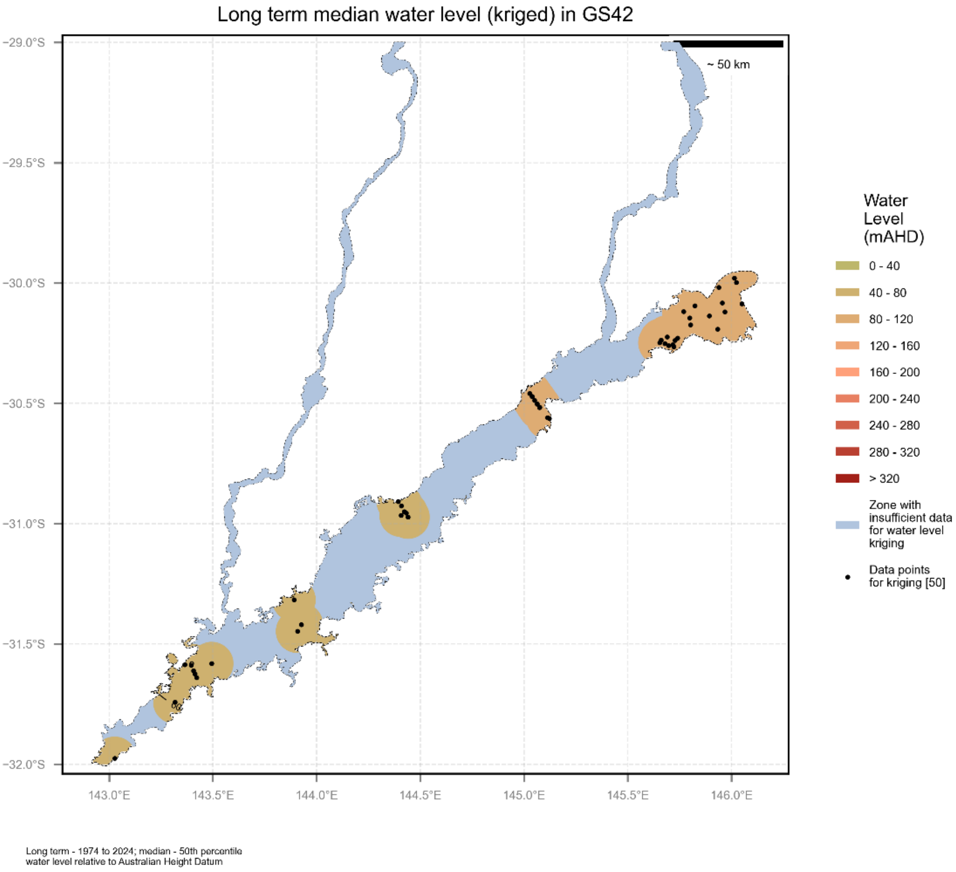


Figure 3 Historical climate trends



a)



b)

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

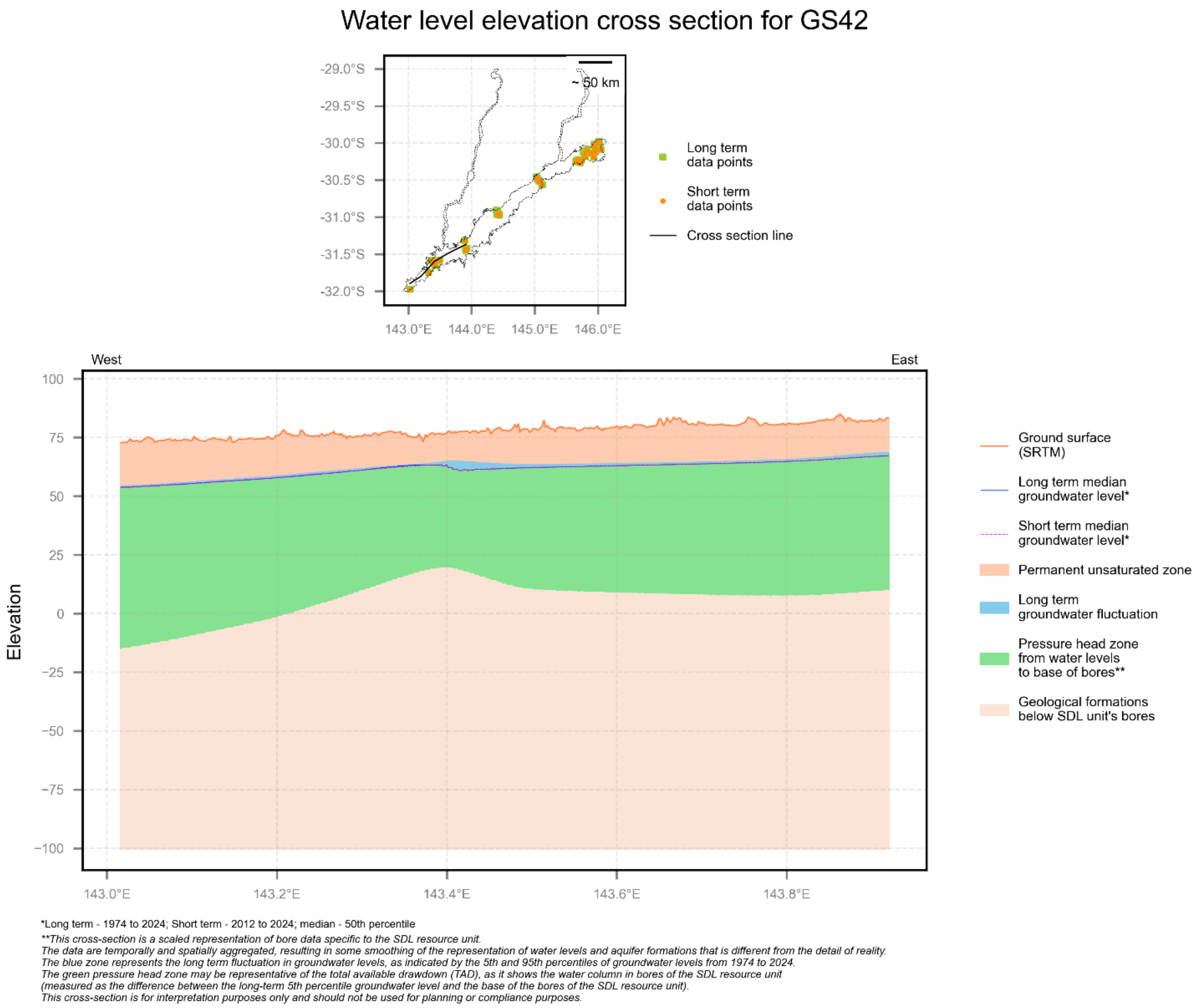


Figure 5 West to east distribution of water levels in the SDL resource unit

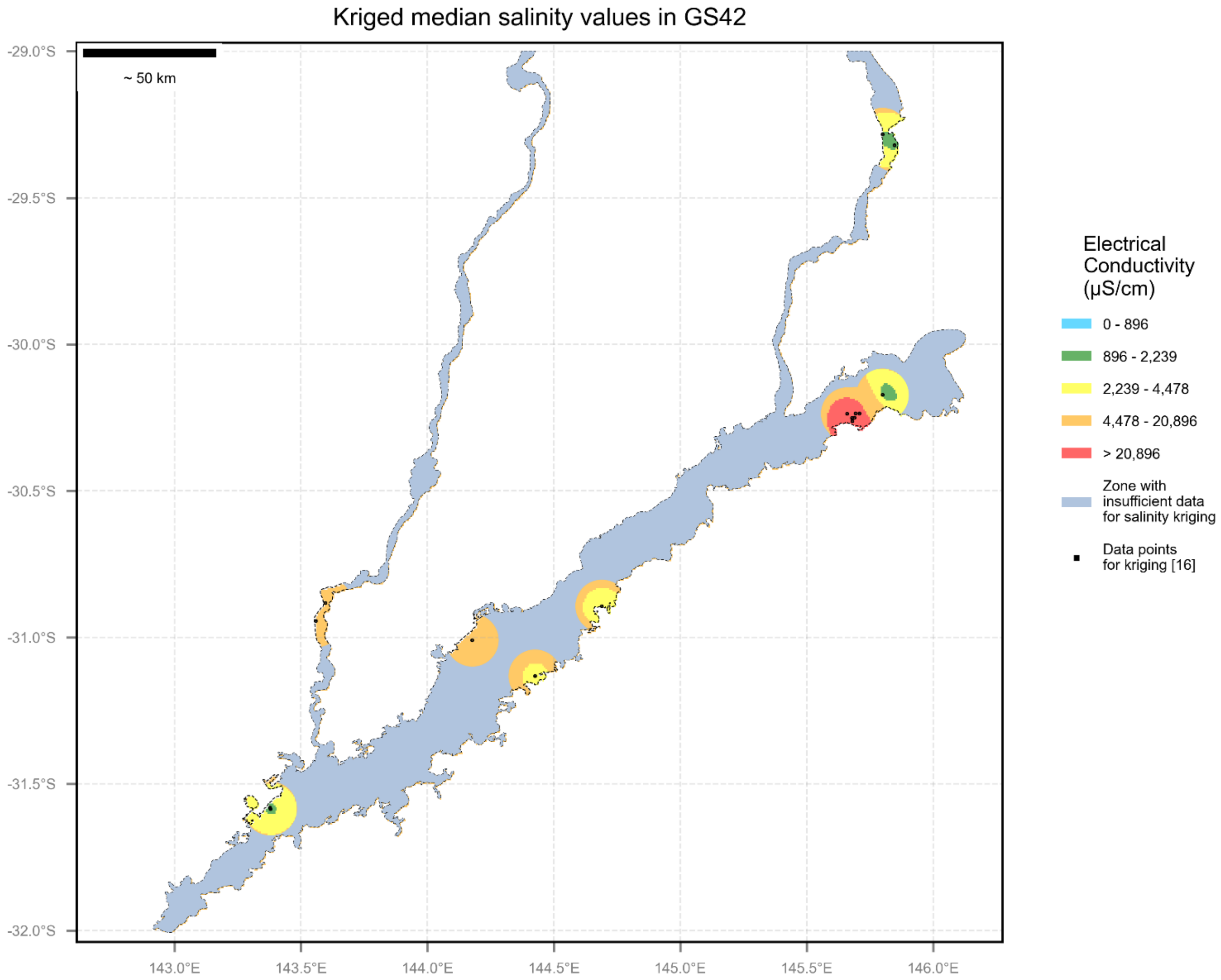


Figure 6 Groundwater salinity distribution

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	-	-	6.59
SDL resource unit area	km²	-	-	9,073
Average annual take (2013 to 2023)	GL/y	-	-	3.61
Number of groundwater entitlement bores	-	-	-	9
SDL resource unit storage estimate*	GL	-	-	13,189
Recharge estimate (SY1)	GL/y	-	-	14.30
Recharge estimate (Stage 2)	GL/y	-	-	10.05
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	8.00
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.55
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.66
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	0.82
Storage/Stage 2 Recharge (S/R)	-	-	-	1,312
Storage/SY2 or modelled Recharge (S/R)	-	-	-	1,648
Number of bores in the SDL unit	-	263	263	-
Number of bores for water level trend analysis	-	52	41	-
Number of bores for water level trend with sufficient data	-	50	27	-
Number of bores with decreasing water level trend	-	31	16	-
Number of bores with increasing water level trend	-	7	2	-
Number of bores with no statistically significant water level trend	-	12	9	-
Mean water level trend magnitude	m/y	-0.01	-0.02	-
Minimum water level trend magnitude	m/y	-0.37	-0.21	-
5%ile water level trend magnitude	m/y	-0.12	-0.15	-
10%ile water level trend magnitude	m/y	-0.03	-0.1	-
50%ile water level trend magnitude	m/y	-0.01	-0.02	-
90%ile water level trend magnitude	m/y	0.04	0.02	-
95%ile water level trend magnitude	m/y	0.09	0.06	-
Maximum water level trend magnitude	m/y	0.15	0.33	-
Number of bores for salinity trend analysis	-	18	6	-
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: RRAM.

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	241,563,011	17%	69%	14%	Deteriorating trends	24%	26%	50%	Insufficient data
GDEs	47,847,372	15%	71%	14%	Deteriorating trends	23%	26%	51%	Deteriorating trends
River connectivity	518,534,991	9%	59%	32%	Deteriorating trends	25%	19%	56%	Insufficient data
Water quality	120,390,042	0%	0%	100%	Insufficient data	0%	0%	100%	Insufficient data

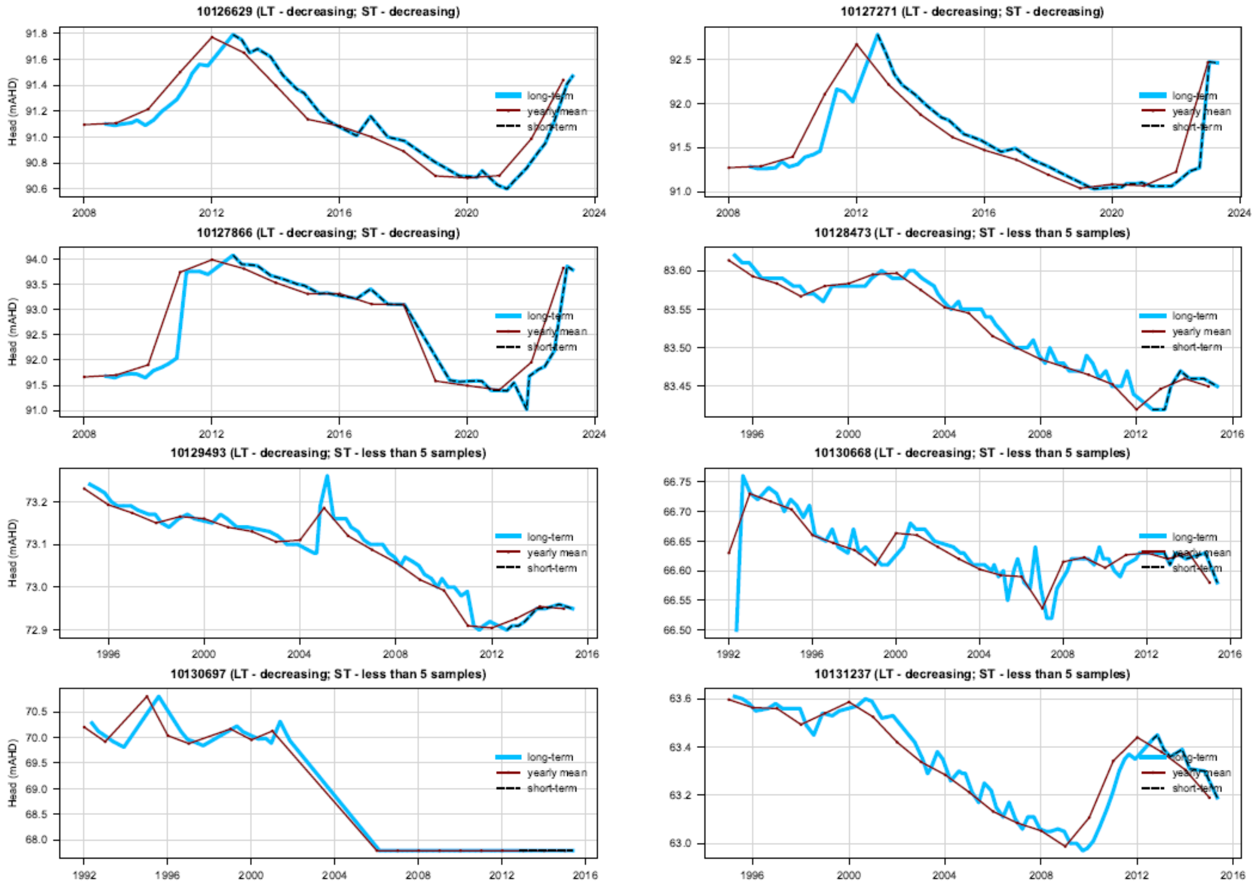


Figure 7 Representative groundwater hydrographs for the SDL resource unit

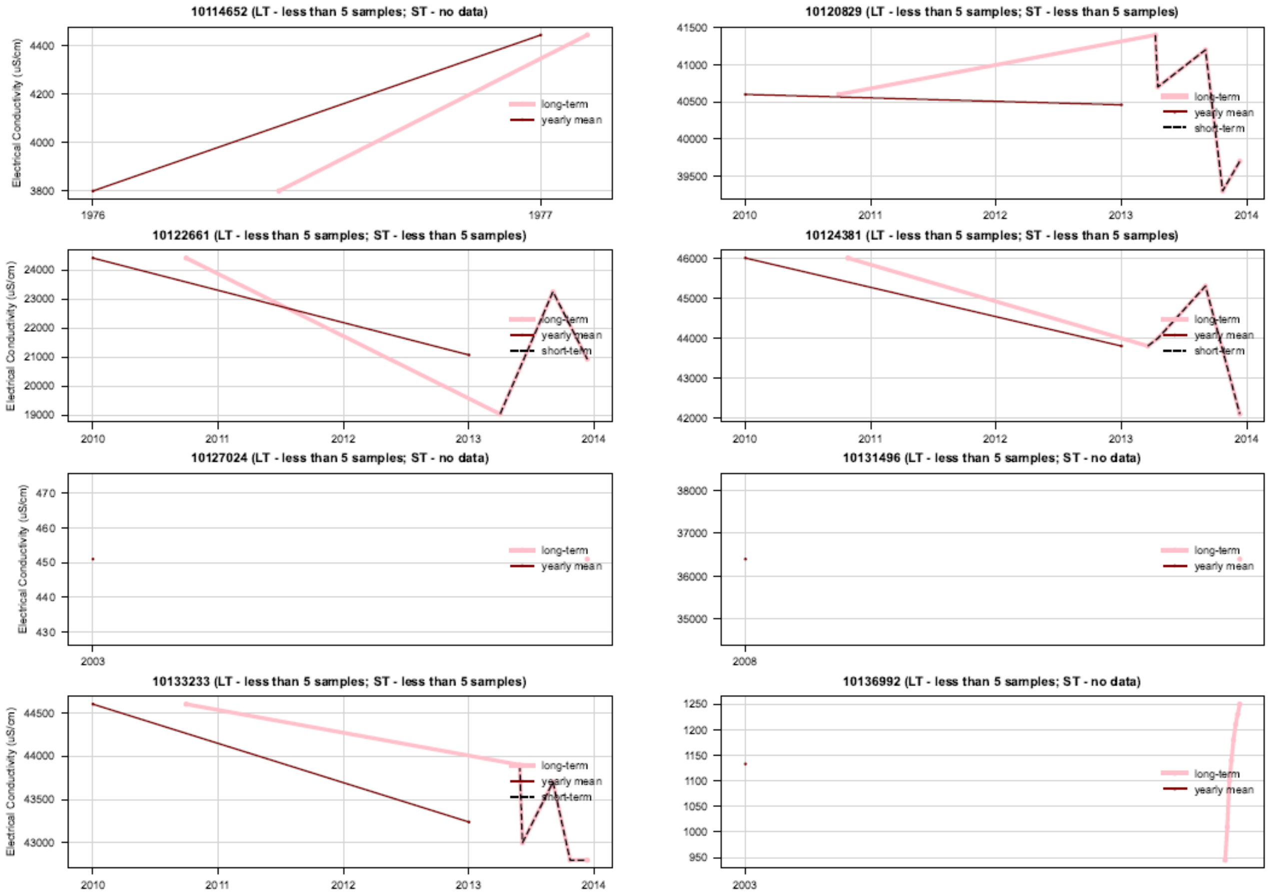


Figure 8 Representative groundwater salinity time series for the SDL resource unit

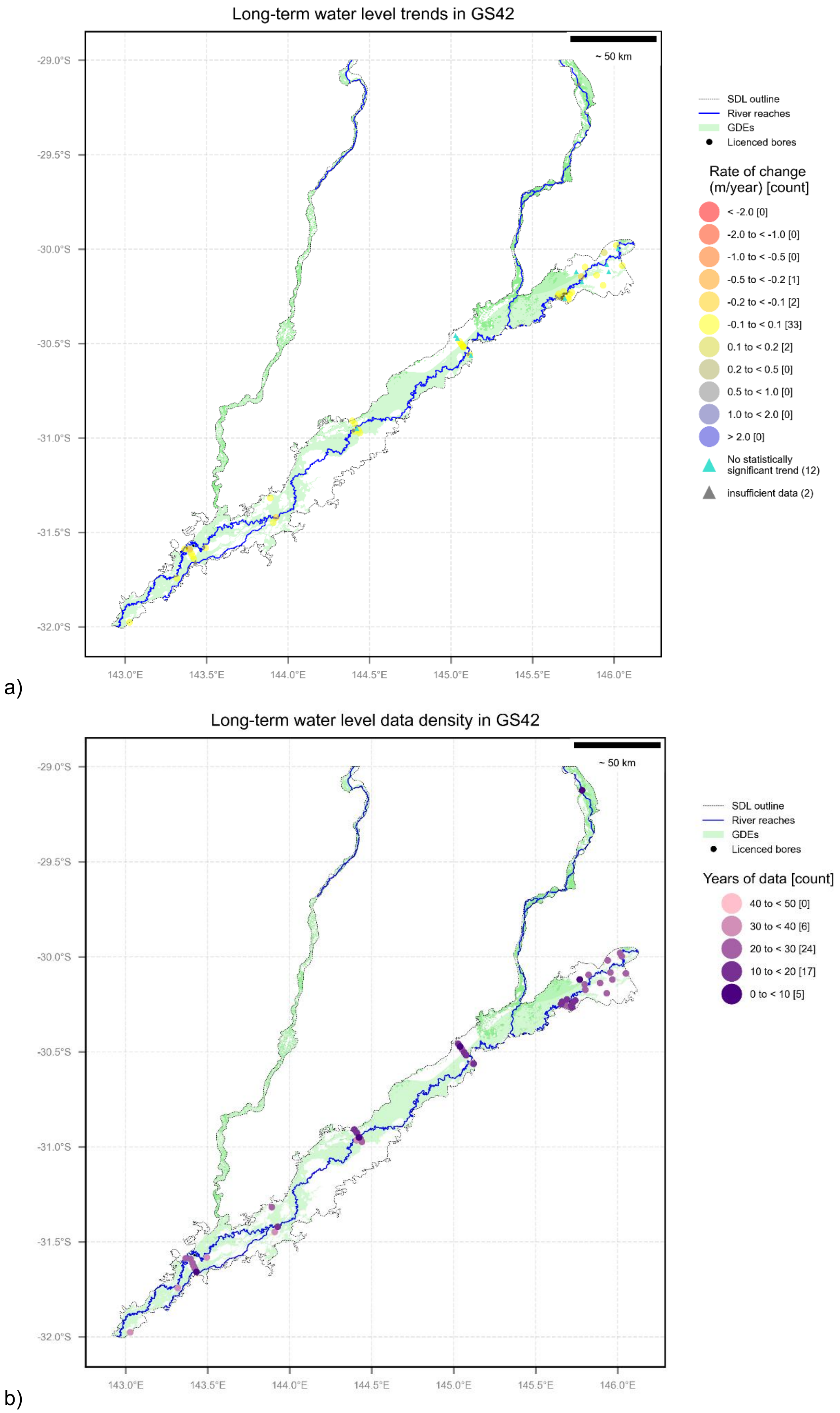
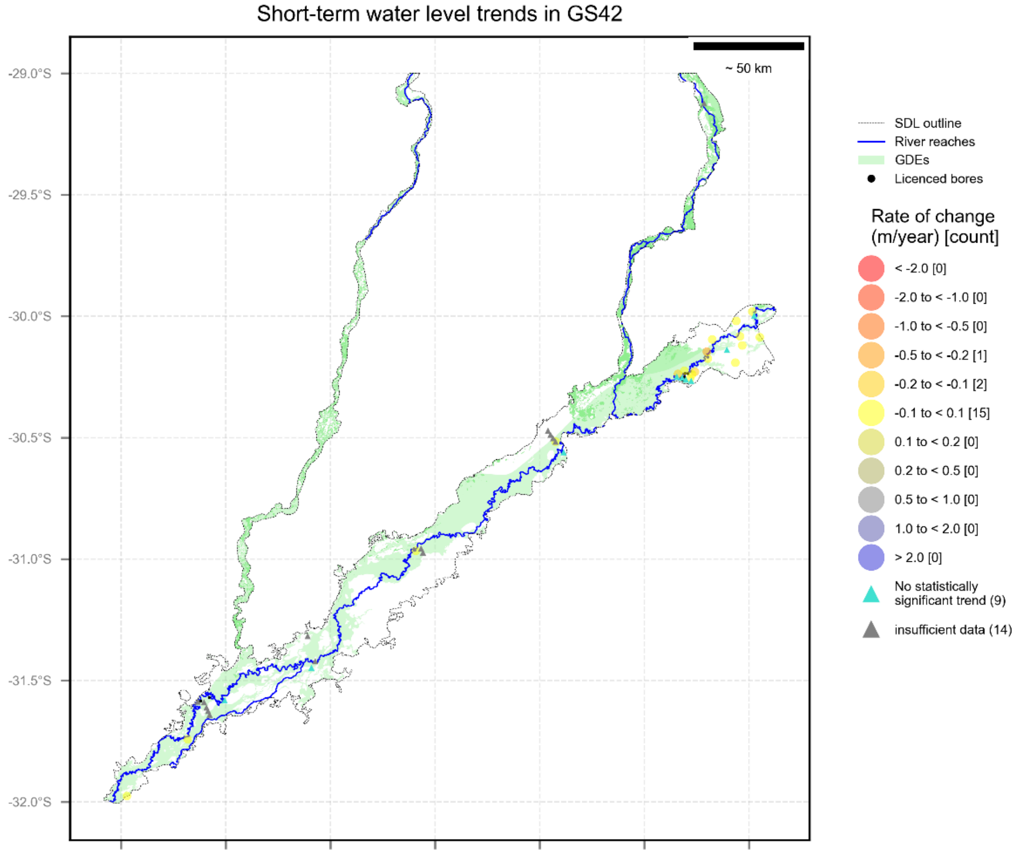
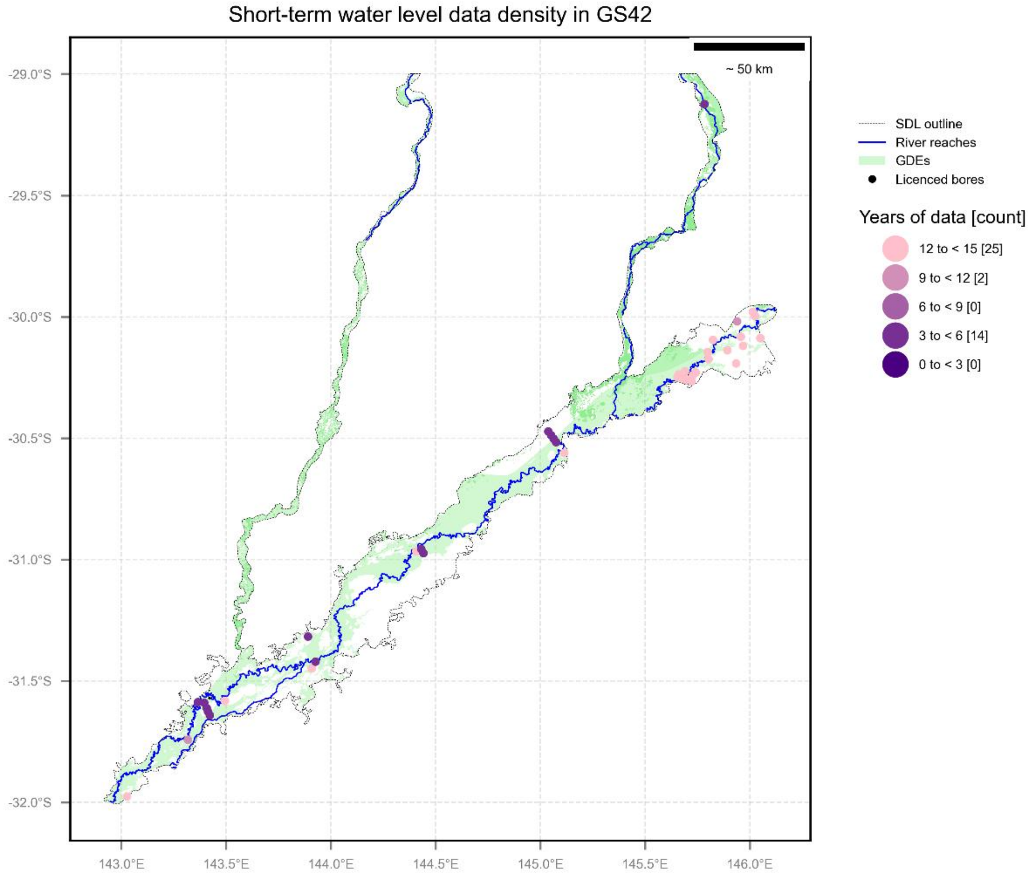


Figure 9 Long-term (1974 to 2024) groundwater level trends (a) and data availability (b)



a)



b)

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

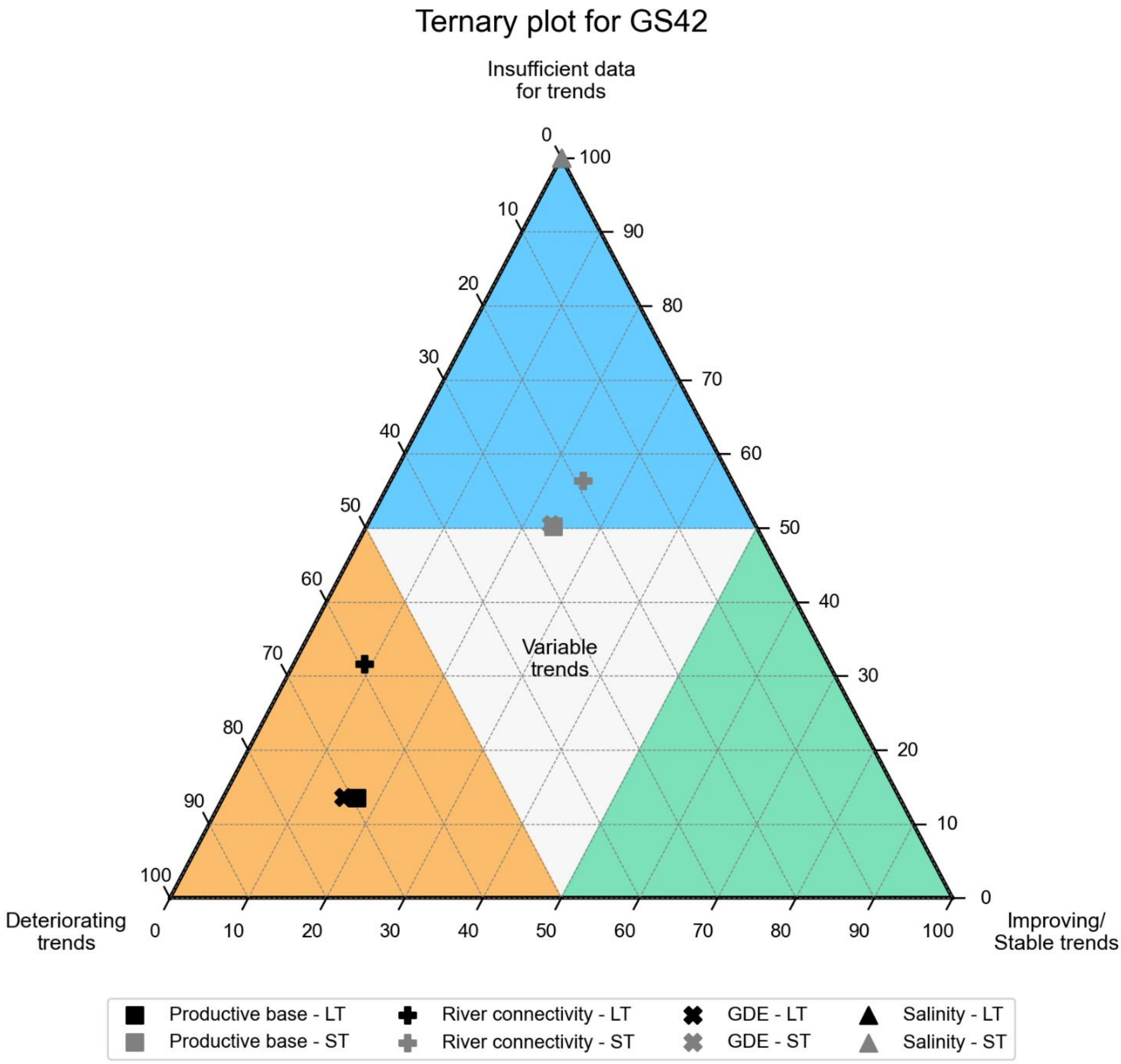
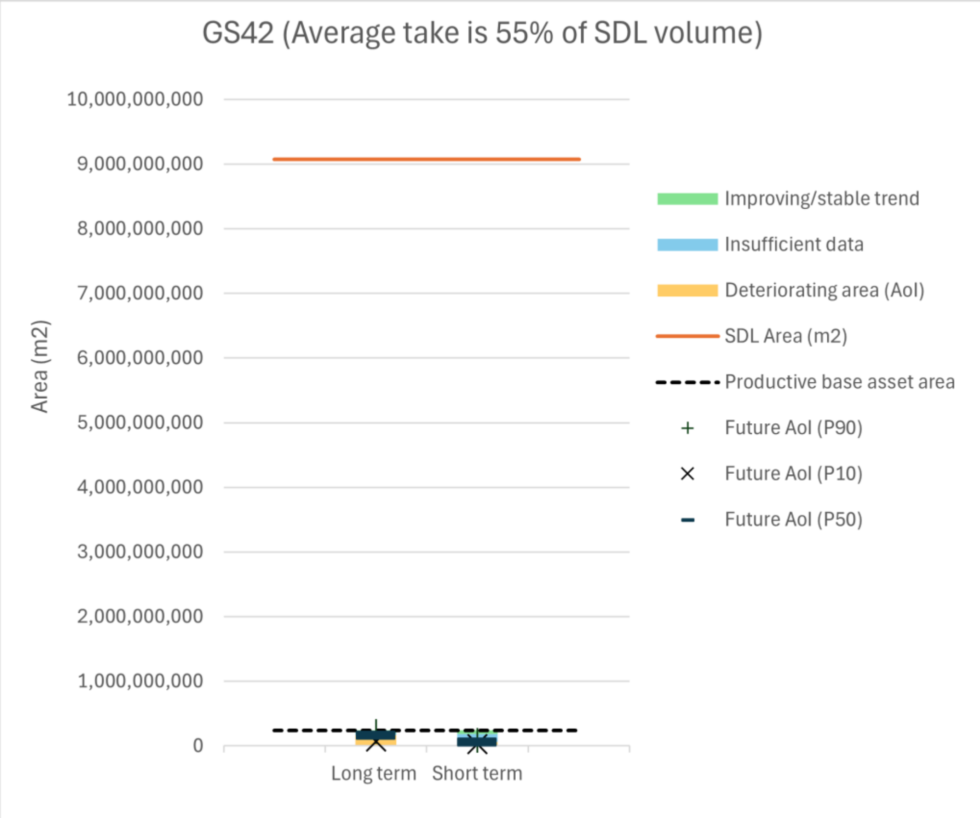


Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values



a)

b)

Figure 12 Estimates for change in area of influence (AoI) due to climate change (a) including, and (b) excluding a scale with the SDL area

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