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Report on

GS31

Mid-Murrumbidgee Alluvium

Stage 5

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GS31 – Mid–Murrumbidgee Alluvium

Stage 5 – Assessment through multiple lines of evidence

The Mid-Murrumbidgee Alluvium (GS31) is located within the Murrumbidgee catchment in central New South Wales, between Jugiong and Narrandera (Figure 1). It consists of a shallow unconfined aquifer of the Cowra Formation (up to 40 m) and a deeper semi-confined aquifer of the Lachlan Formation (up to 90 m), both hydraulically connected to the Murrumbidgee River (Figure 1; Crosbie et al., 2023). Groundwater entitlements are mainly concentrated around Wagga Wagga, Collingullie, and Ladysmith (Figure 1). From a management perspective, GS31 covers approximately 1,492 km² and includes four groundwater sources: Gundagai, Kyeamba, Wagga Wagga, and Zone 3. GS31 has a Sustainable Diversion Limit (SDL) of 53.50 GL/year and an estimated long-term average recharge of 73.20 GL/year (Table 1). Between 2013 and 2023, average annual groundwater extraction was 35.98 GL/year, representing 49% of the estimated recharge and 67% of the SDL (Figure 2). Groundwater extraction helps supplement surface water supplies during years of below-average rainfall (Figure 2) and supports intensive irrigation, stock and domestic use, and town water supply in the main alluvial corridor downstream of Wagga Wagga. Long-term climate data show a consistent below-average rainfall trend from 2000 to 2010, two cycles of above- and below-average rainfall between 2010 and 2020, a sustained period of above-average rainfall following 2020, and a very recent trend of below-average rainfall (Figure 3). GS31 is mainly classified as semiarid, with some years shifting into dry sub-humid conditions based on the precipitation to evaporation ratio (Figure 3).

In the main alluvial corridor of GS31, the water table is usually within 10 m of the ground surface, with some areas having shallow levels (< 5 m) (Figure 4a), and areas exceeding 15 m around Wagga Wagga (NSW DPE, 2023). Groundwater flows east to west along the main corridor, and from southeast to northwest upstream of Narrandera (Figure 4b). Long-term (1974-2024) and short-term (2012-2024) median groundwater levels generally align within a well-defined multi-decadal fluctuation zone, ranging from 5 m to 15 m (Figure 5). In several parts of GS31, especially near historical extraction sites like Wagga Wagga, the bottom of the fluctuation zone matches recent (short-term) water levels, indicating current levels are near the deepest observed since 1974. Water quality is mostly fresh to brackish, with salinity levels below 1,500 mg/L (equivalent to 2,239 µS/cm) (Figure 6), with a few isolated pockets of brackish water towards the edges of GS31 (MDBA, 2020; Rojas et al., 2023). Water level trends vary across GS31 but show long-term declines (since the 1970s and 1980s) in the Wagga Wagga and Zone 3 management zones. These declines are linked to extraction rates, climate, and recovery conditions after 2020, displaying multi-decadal variability (Figure 7; Figure 9). Short-term trends are less consistent, with many bores showing a marked recovery after 2020, resulting in more bores with no statistically significant trends during that period (Figure 10). The understanding of how salinity changes over time is limited due to sparse data (Figure 8).

MDBA (2020) previously reported recharge at 73.20 GL/year for GS31, which includes diffuse, irrigation, floodplain, and in-stream recharge derived from a calibrated groundwater model. A recent review for the MD-SY2 project (Crosbie et al., 2025) revised the estimate of diffuse recharge to 23.30 GL/year. Table 1 shows a storage-to-recharge ratio (S/R) of 226 using the estimate of recharge from the numerical model, and the WERP estimate of storage (Rojas et al., 2022), suggesting moderate buffering capacity and some vulnerability to short-term climate variability (S/R sits in the “medium responsiveness” bracket¹ defined in Rojas et al., 2022). However, the high extraction-to-SDL (E/SDL) and SDL-to-recharge (SDL/R) ratios (Table 1) suggest some pressure on the productive base, particularly in areas such as Zone 3 and Wagga Wagga, where most of the extraction is concentrated.

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

The productive base shows significant signs of stress, with long-term water level declines affecting specific areas of GS31 (Zone 3 and Wagga Wagga) (Table 1; Figure 9; Figure 10). Statistically significant ($\alpha = 0.05$) declines have occurred since 1974 along the alluvial corridor downstream of Wagga Wagga, with trend magnitudes ranging from 0.2 m/year to 0.5 m/year. In the long term, many bores also fall into the slightly fluctuating category (-0.1 m/year to 0.1 m/year). In contrast, short-term trends are lower in absolute magnitude (Figure 10) and many bores show no statistically significant trends. Overall, both timeframes reveal a similar proportion of bores (about 75%) with either mildly fluctuating or no statistically significant trends. The short-term period (2012-2024) is characterised by below-average rainfall prior to 2020 (Figure 3) and a significant reduction in annual extraction after 2020, driven by a positive annual rainfall anomaly (Figure 2). Connectivity to surface water during 2000-2019 varies from 'mostly losing' conditions upstream of the Murrumbidgee River at Berembed Weir to 'always losing' conditions downstream (Crosbie et al., 2023). Groundwater-dependent ecosystems (GDEs), such as riparian and floodplain vegetation, may also be impacted if water levels fall below ecologically critical thresholds in areas of high extraction, a risk in Zone 3.

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, 36% of the river connectivity asset area, and 41% of the GDE asset area (Table 2). In the short term, these percentages decreased to 25%, 21%, and 23%, respectively (Table 2). A moderate increase in the asset areas showing improving/stable water level trends in the short term was observed (Table 2), suggesting partial recovery or stabilisation (Figure 11). Levels of uncertainty, as indicated by areas with insufficient data to inform temporal trends, have marginally increased between the long and short term (minimal vertical displacement of points in Figure 11). The water quality (salinity) ESLT remains the most uncertain in the assessment, with around 73% of the asset area classified as having 'insufficient data' to determine temporal trends.

The NSW state-based risk assessment (NSW DPE, 2023) assigns varying risk ratings across ESLT values. For the productive base, medium to high risks to aquifer structural integrity, potential local drawdowns affecting groundwater access, and increases in irrigation efficiency impacting recharge are identified in Wagga Wagga, Zone 3, and Gundagai. Risks of growth in basic landholder rights reducing groundwater availability are ranked as high for Wagga Wagga, Gundagai, and Zone 3, and medium for Kyeamba. River connectivity risks are generally rated low, but zones such as Gundagai (Jugiong) and Zone 3 are rated medium to high, respectively. Risks to GDEs from groundwater extraction leading to drawdown range from medium (Gundagai-Jugiong and Wagga Wagga) to high (Zone 3). Water quality risks are assessed as medium in Wagga Wagga and Zone 3, as groundwater extraction can alter hydraulic gradients and induce mixing with saline water. While data on water levels is extensive, salinity data is more limited, leading to residual uncertainty in the risk profile.

Future projections from the MD-SY2 project suggest that diffuse recharge in GS31 may rise by 2050 due to more intense rainfall events (Crosbie et al., 2025). Conversely, overbank flood recharge and in-stream recharge are expected to decline by 42% and 14%, respectively (Crosbie et al., 2025). These conflicting trends create uncertainty about the overall future net recharge in GS31. Stage 6 of this BPR technical groundwater review found that the future area of drawdown (Area of Influence, Aol²) is likely to expand under climate change scenarios, with the median future Aol (P50) surpassing the current Aol, indicating probable increases in degraded regions (Figure 12). The SDL/R ratio is also expected to rise, suggesting that the rate of resource replenishment may change in the future. The Stage 6 assessment classified the impact of future climate change on GS31 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) indicate slightly improving or stable conditions across ESLT values in GS31, while uncertainty levels remain largely unchanged from the long-term assessment (1974–2024). Some areas, most notably Wagga Wagga and Zone 3, continue to experience legacy declines in water levels, despite a positive rainfall anomaly and reduced groundwater extraction in recent years. Uncertainty in salinity trends has remained steady (73% of asset area), but there are no areas with confirmed increasing salinity trends in the short-term. Current groundwater extraction is below the SDL and near the average of the different recharge estimates. The statewide risk assessment highlighted zones such as Wagga Wagga, Zone 3, and Gundagai across different aspects of the risk profile, especially regarding local drawdowns, impacts on GDEs, and water quality. Climate projections suggest reduced episodic (localised) recharge from floodplain processes, and overall, the pressure from climate change is assessed as high. Taken together, the analysis indicates high pressure on the ESLT values due to local extraction pressure and future climatic variability in GS31.

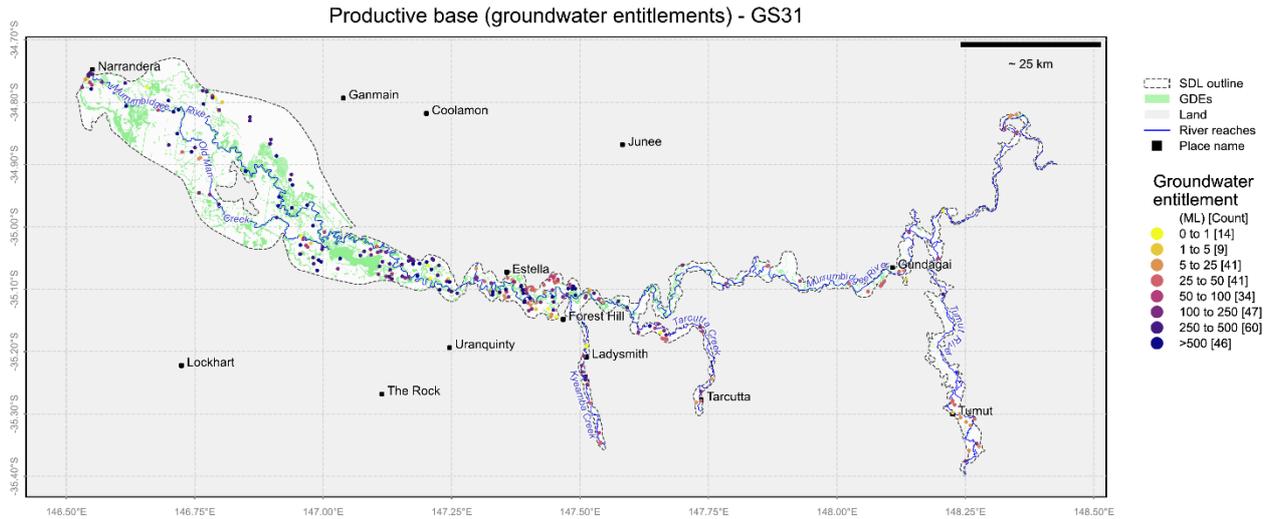


Figure 1 Productive base (groundwater entitlements)

Annual groundwater take and rainfall anomaly for GS31

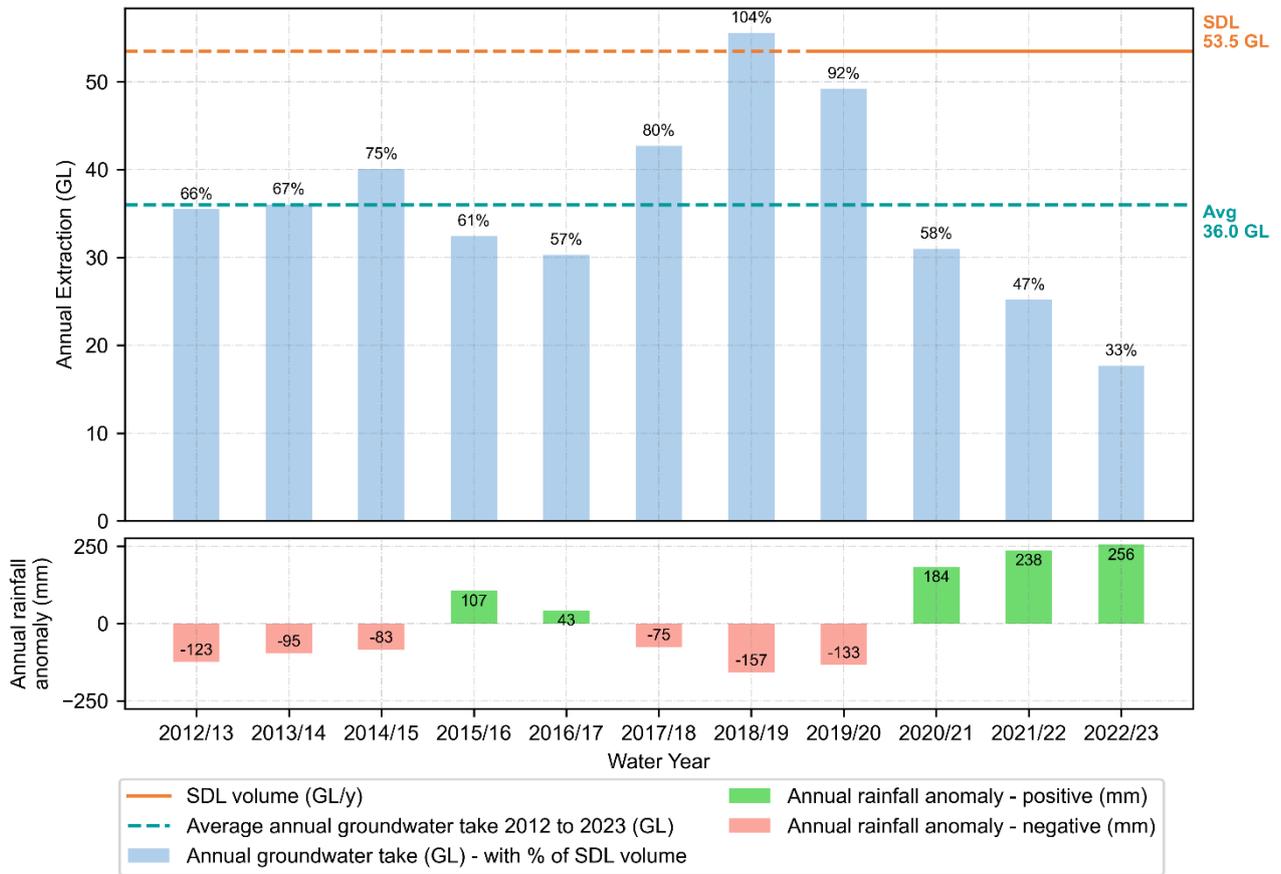


Figure 2 Groundwater take in the SDL since 2012

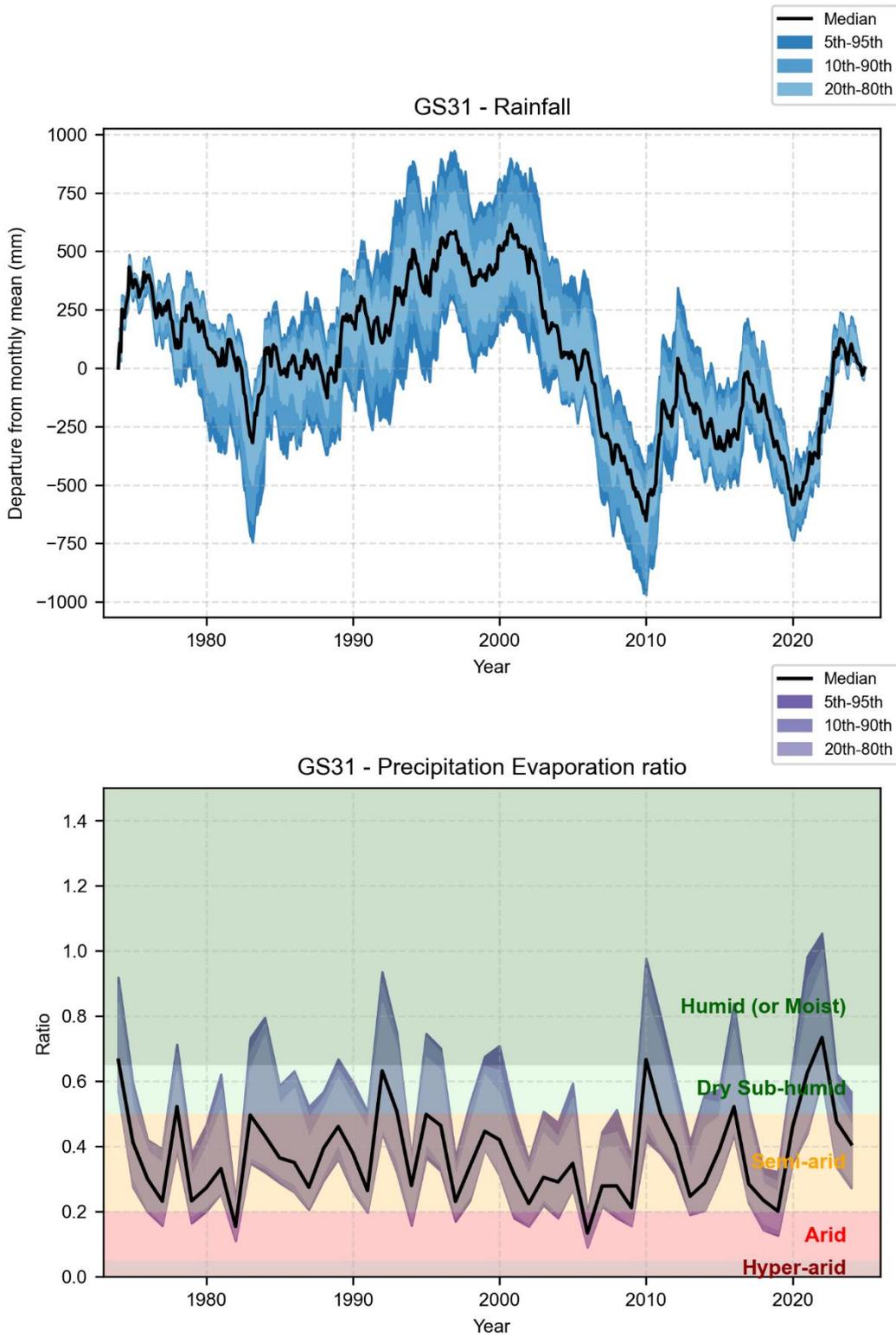


Figure 3 Historical climate trends

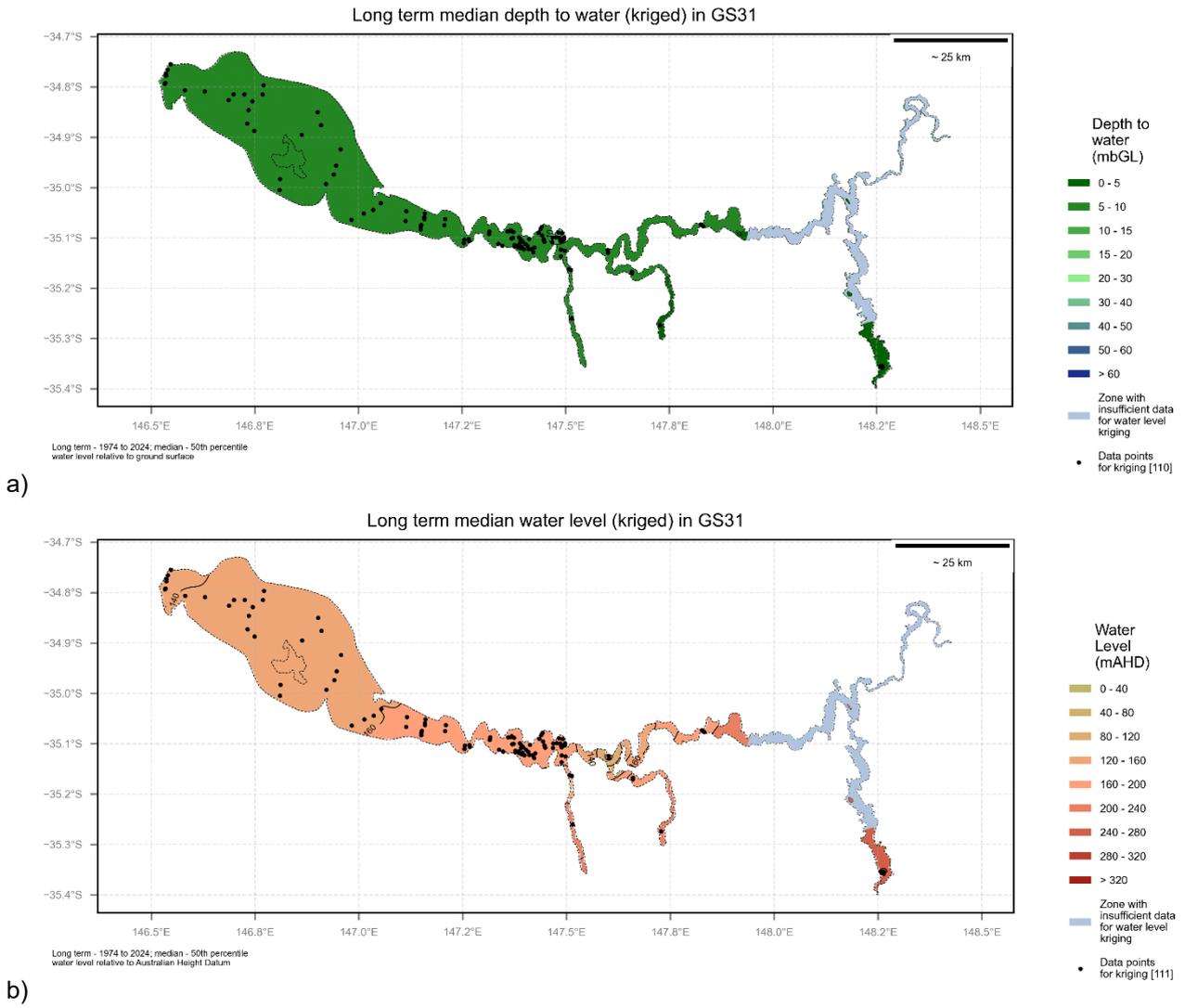
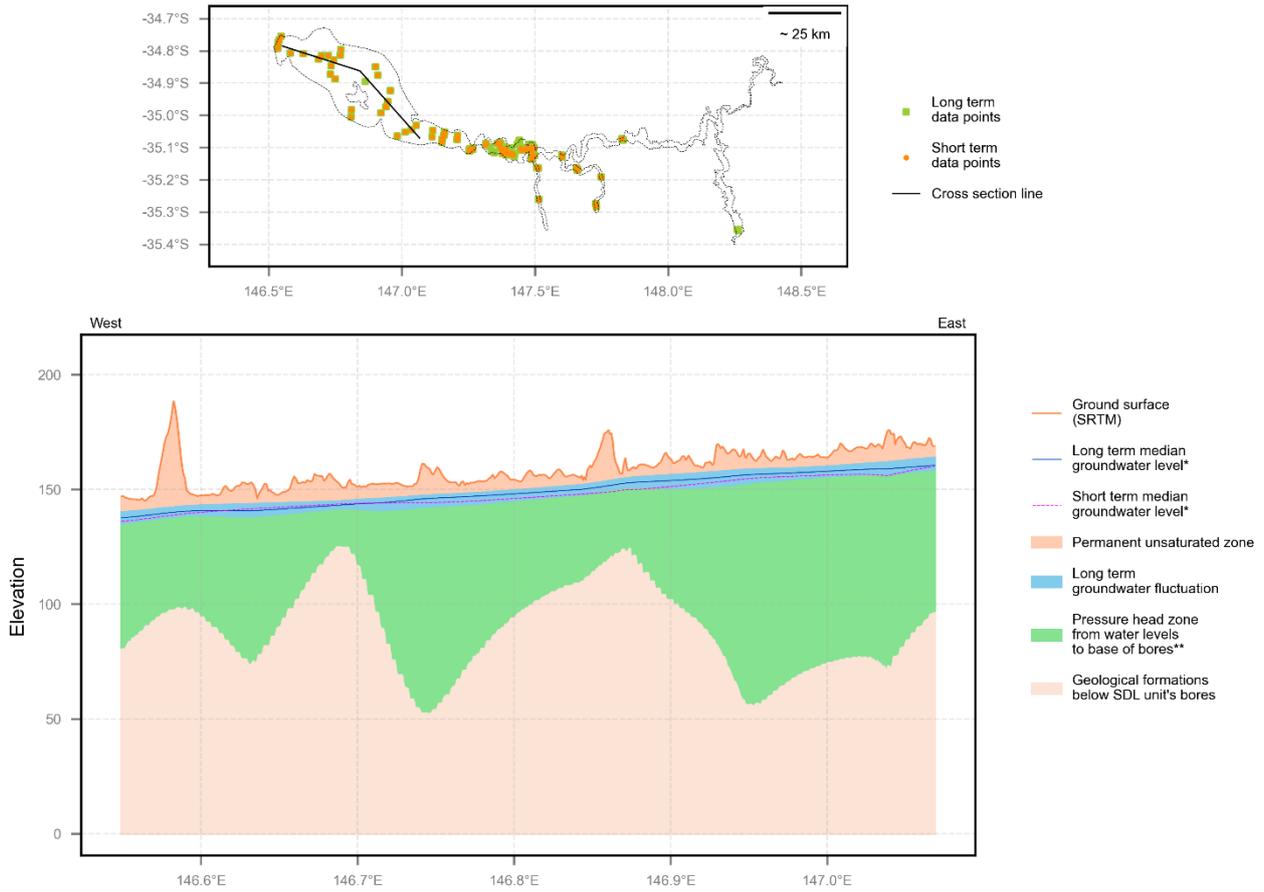


Figure 4 Long-term median (a) depth to water and (b) water level elevation

Water level elevation cross section for GS31



*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

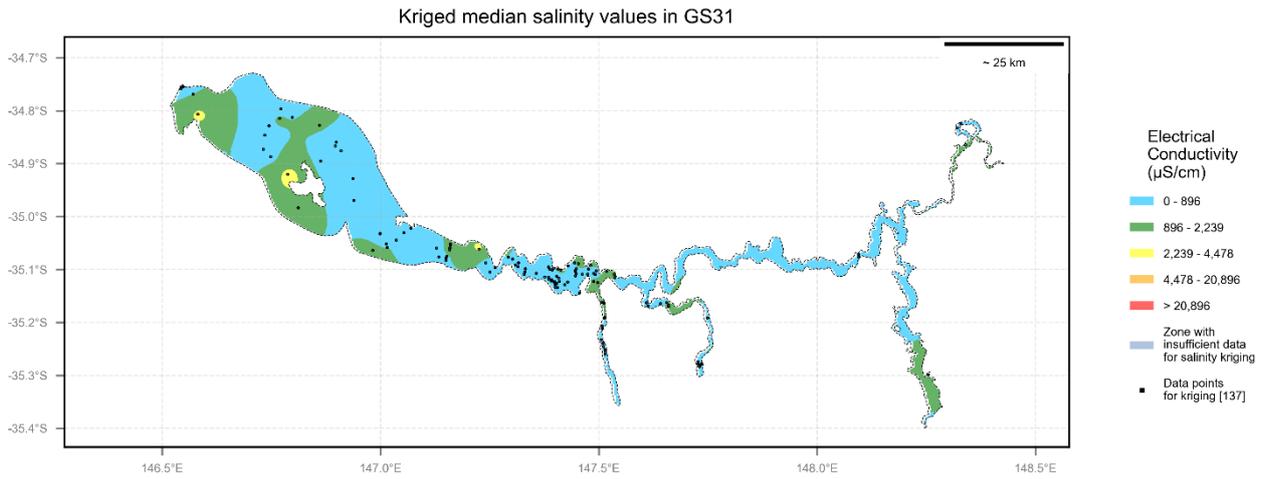


Figure 6 Groundwater salinity distribution

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	-	-	53.50
SDL resource unit area	km ²	-	-	1,492
Average annual take (2013 to 2023)	GL/y	-	-	35.98
Number of groundwater entitlement bores	-	-	-	292
SDL resource unit storage estimate*	GL	-	-	16,532
Recharge estimate (SY1)	GL/y	-	-	73.20
Recharge estimate (Stage 2)	GL/y	-	-	73.20
Diffuse recharge estimate (SY2 - WAVES)	GL/y	-	-	23.30
Extraction/SDL (E/SDL) (Stage 2 result)	-	-	-	0.67
SDL/Recharge (SDL/R) (Stage 2 result)	-	-	-	0.73
SDL/Recharge (SDL/R) (SY2 or modelled recharge)	-	-	-	0.73
Storage/Stage 2 Recharge (S/R)	-	-	-	226
Storage/SY2 or modelled Recharge (S/R)	-	-	-	226
Number of bores in the SDL unit	-	1,510	1,510	-
Number of bores for water level trend analysis	-	119	89	-
Number of bores for water level trend with sufficient data	-	117	87	-
Number of bores with decreasing water level trend	-	94	44	-
Number of bores with increasing water level trend	-	1	0	-
Number of bores with no statistically significant water level trend	-	22	43	-
Mean water level trend magnitude	m/y	0.2	-0.06	-
Minimum water level trend magnitude	m/y	-0.4	-1.03	-
5%ile water level trend magnitude	m/y	-0.26	-0.3	-
10%ile water level trend magnitude	m/y	-0.23	-0.16	-
50%ile water level trend magnitude	m/y	-0.07	-0.03	-
90%ile water level trend magnitude	m/y	0.04	0.07	-
95%ile water level trend magnitude	m/y	0.2	0.08	-
Maximum water level trend magnitude	m/y	12.17	0.29	-
Number of bores for salinity trend analysis	-	145	34	-
Number of bores for salinity trend with sufficient data	-	33	32	-
Number of bores with decreasing salinity trend	-	2	0	-
Number of bores with increasing salinity trend	-	2	0	-
Number of bores with no statistically significant salinity trend	-	29	32	-
Mean salinity trend magnitude	µS/cm/y	-315	-20	-
Minimum salinity trend magnitude	µS/cm/y	-6,114	-167	-
5%ile salinity trend magnitude	µS/cm/y	-1,742	-113	-
10%ile salinity trend magnitude	µS/cm/y	-73	-80	-
50%ile salinity trend magnitude	µS/cm/y	-3	-7	-
90%ile salinity trend magnitude	µS/cm/y	30	19	-
95%ile salinity trend magnitude	µS/cm/y	46	30	-
Maximum salinity trend magnitude	µS/cm/y	91	70	-

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	3,372,739,775	18%	41%	41%	Variable trends	29%	25%	46%	Variable trends
GDEs	3,277,742,402	18%	41%	42%	Variable trends	30%	23%	47%	Variable trends
River connectivity	3,621,000,944	15%	36%	48%	Variable trends	26%	21%	53%	Insufficient data
Water quality	3,307,144,110	25%	3%	72%	Insufficient data	27%	0%	73%	Insufficient data

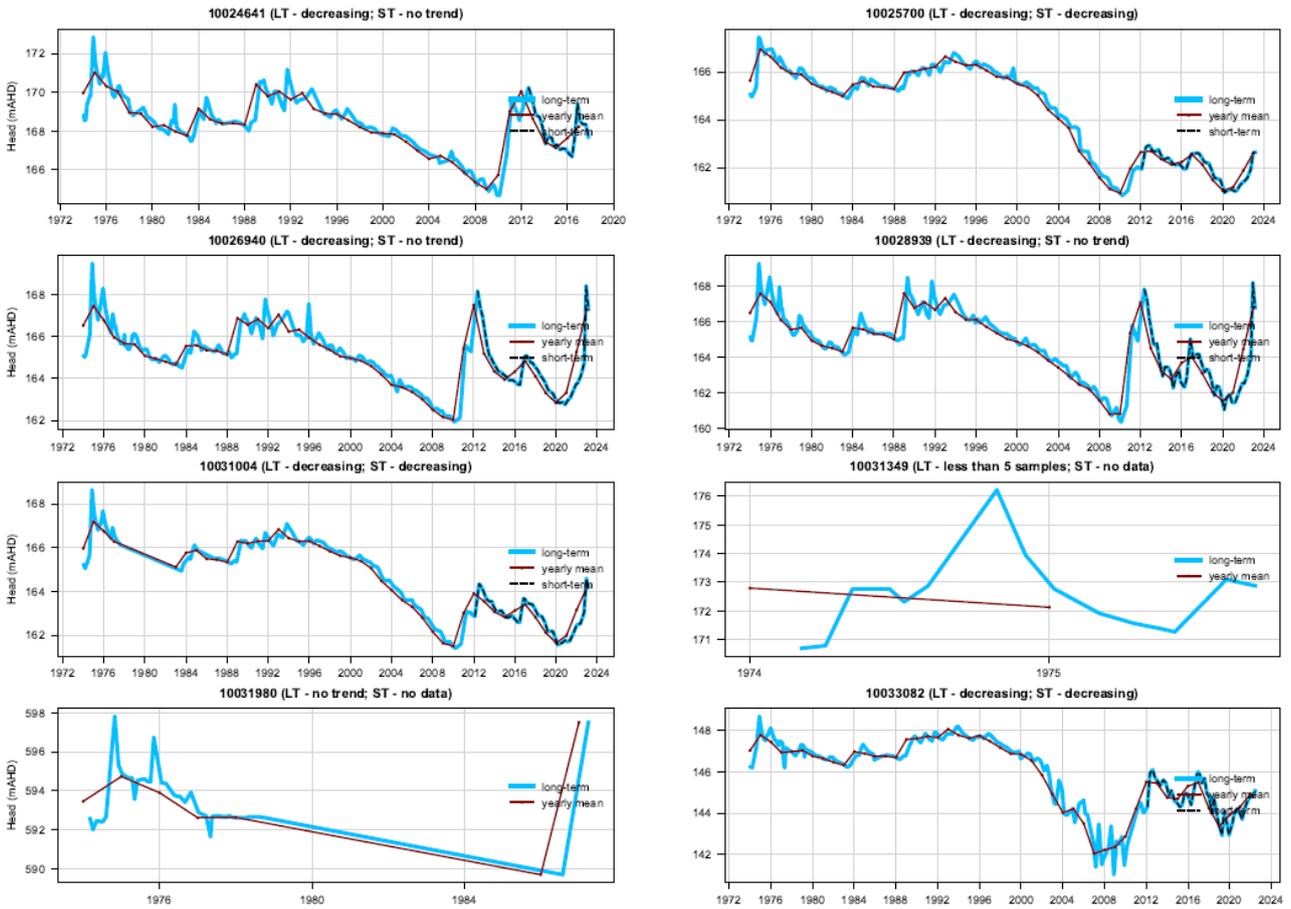


Figure 7 Representative groundwater hydrographs for the SDL resource unit

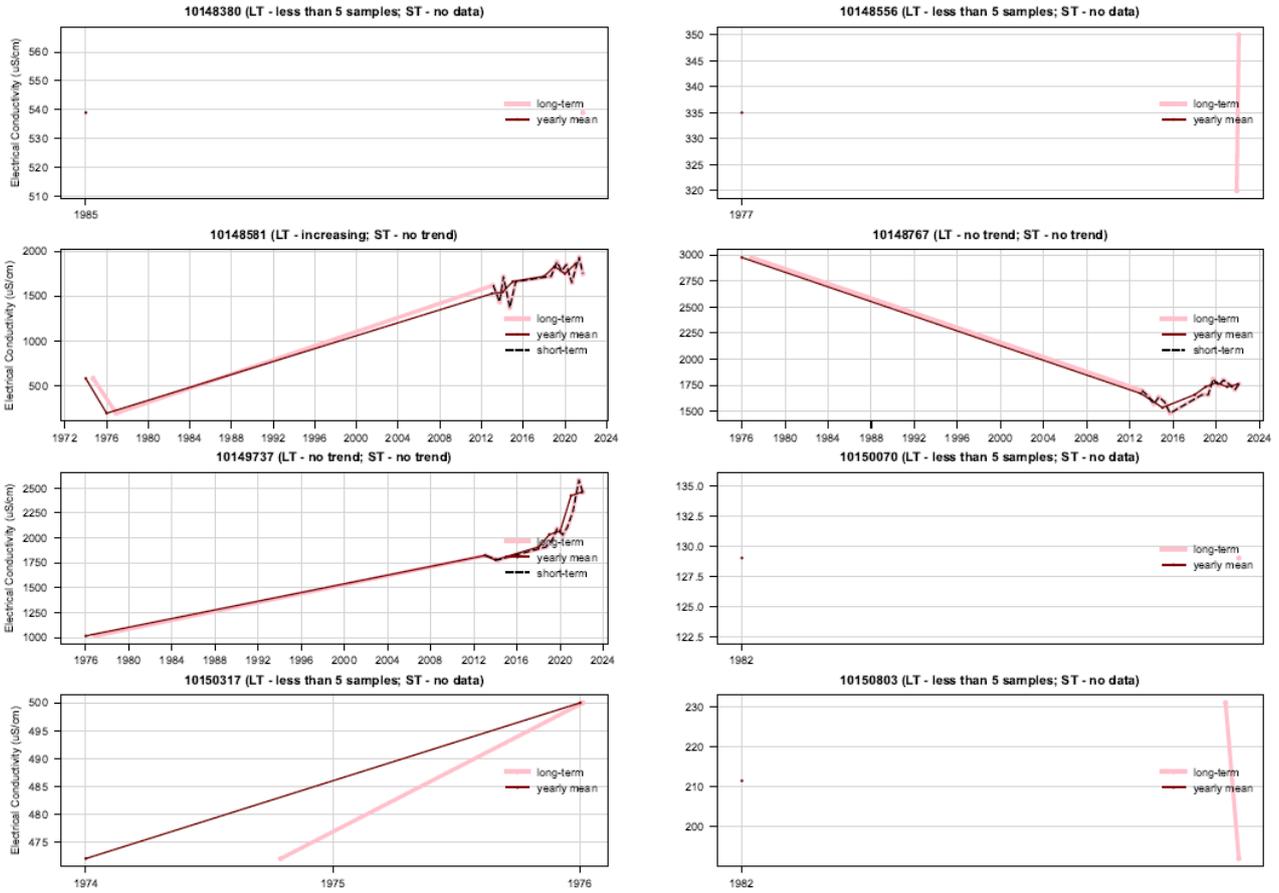


Figure 8 Representative groundwater salinity time series for the SDL resource unit

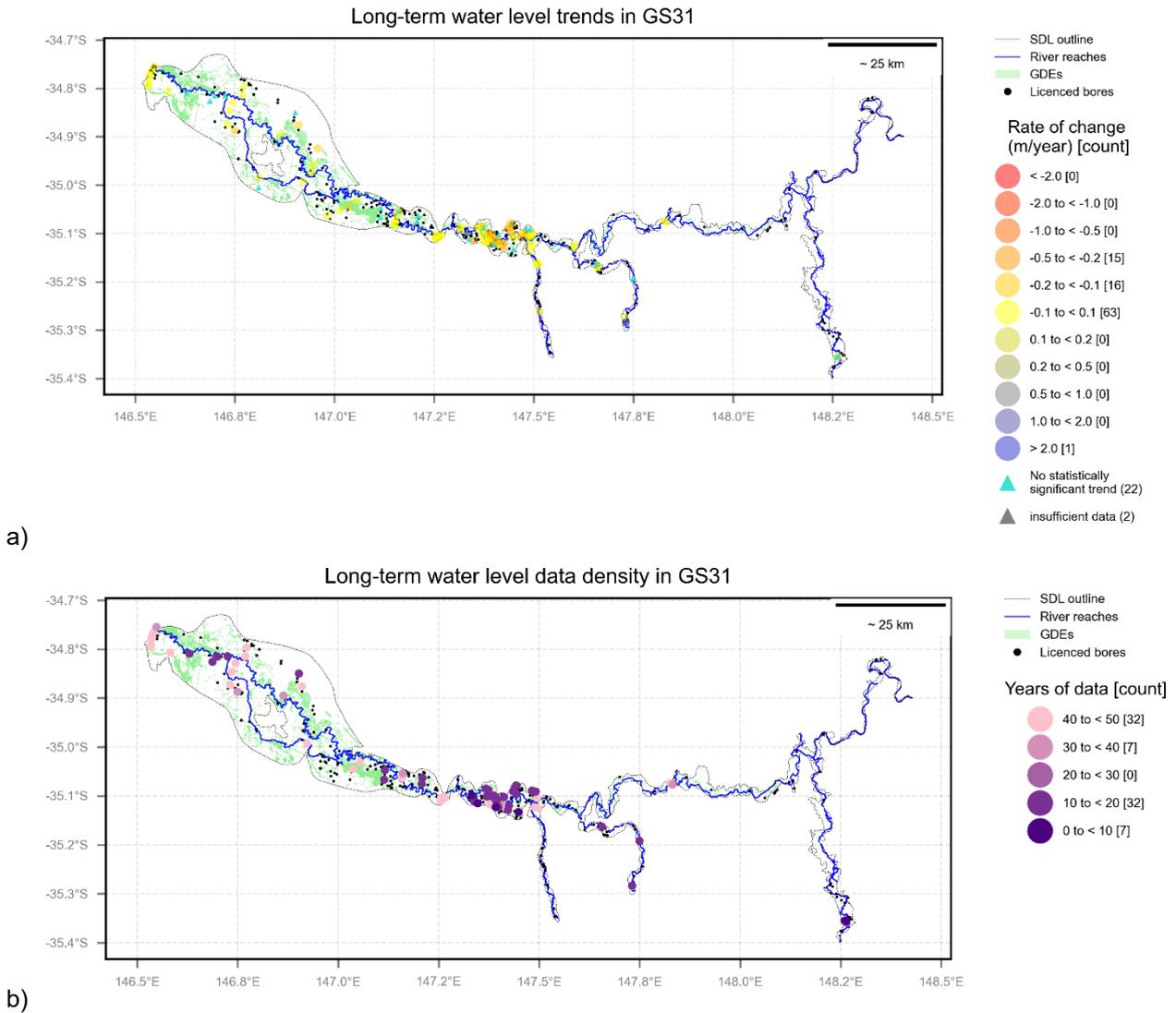


Figure 9 Long-term (1974 to 2024) groundwater level trends (a) and data availability (b)

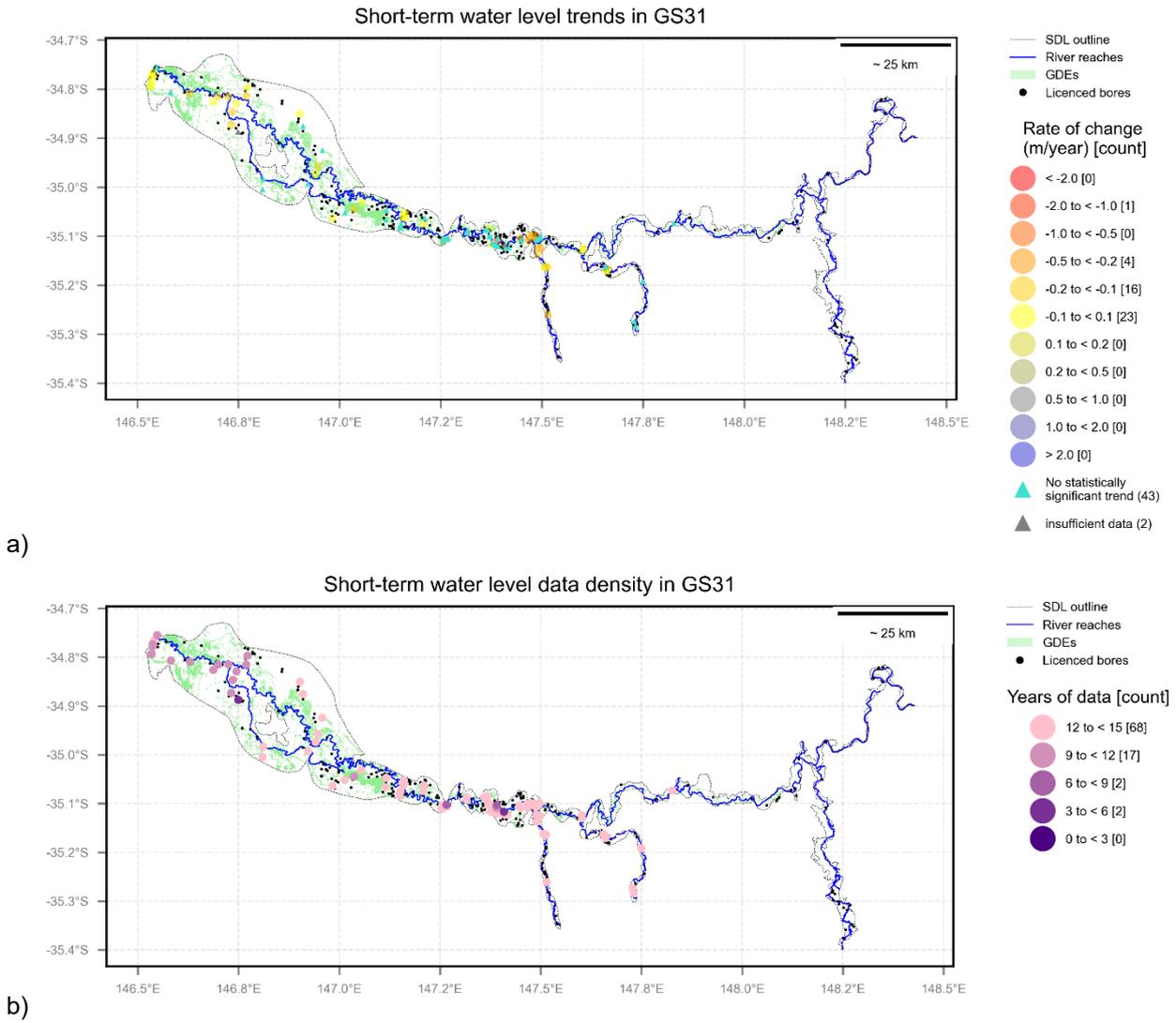


Figure 10 Short-term (2012 to 2024) groundwater level trends (a) and data availability (b)

Ternary plot for GS31

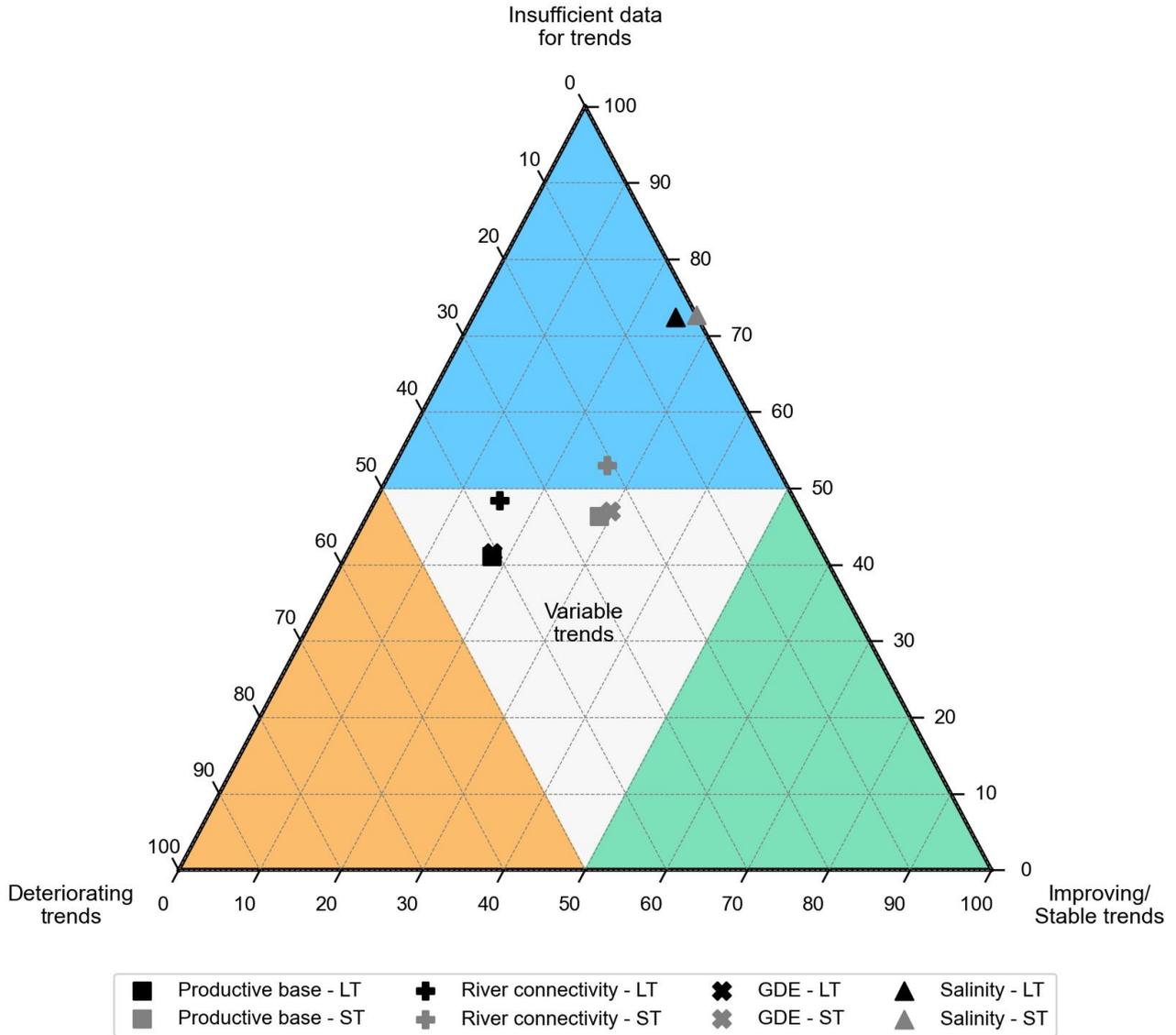


Figure 11 Stage 4 assessment outcome: trends in resource condition indicators for ESLT values

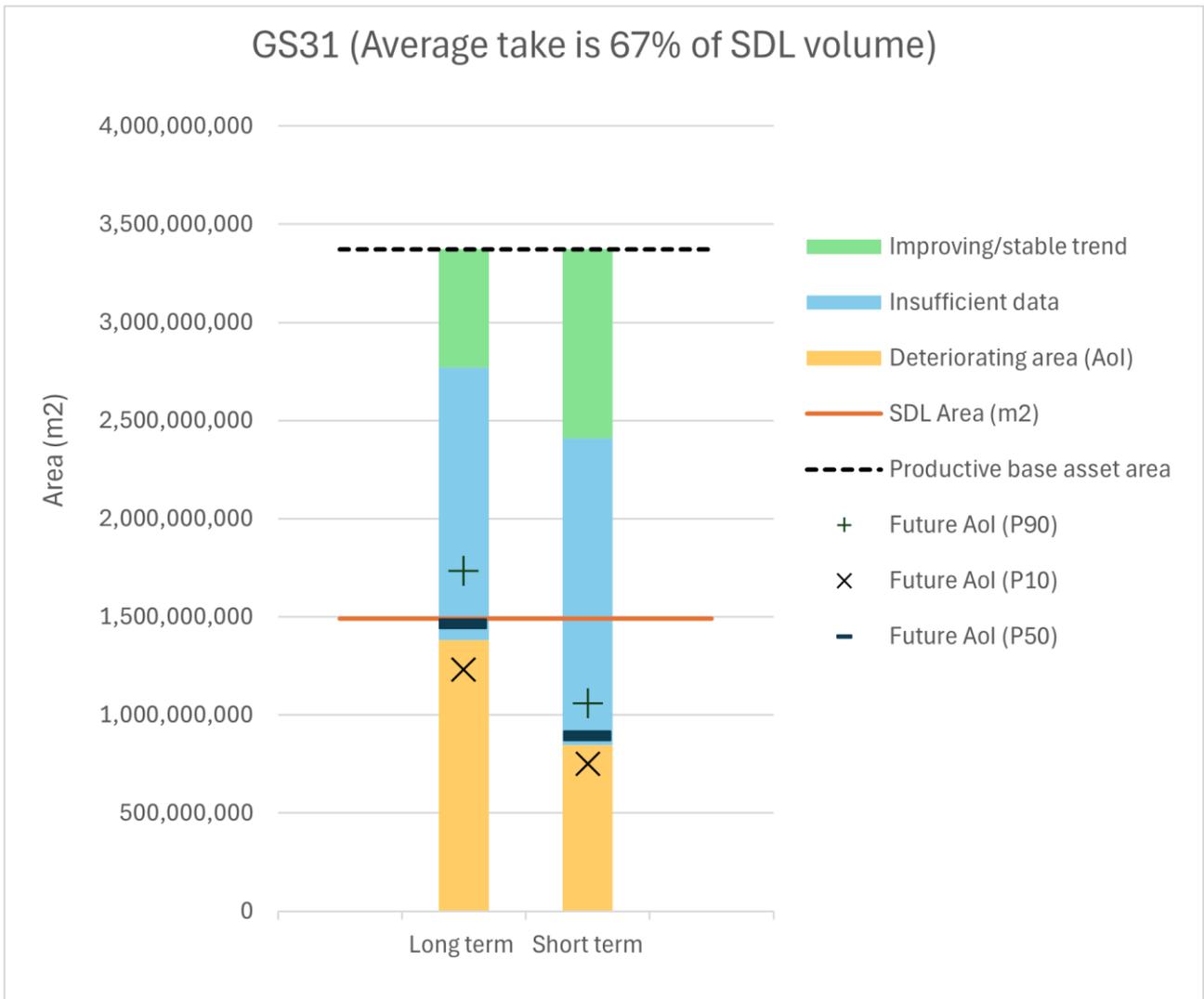


Figure 12 Estimates for change in area of influence (Aol) due to climate change

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