Surface Water Technical Advice Memo

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1. Purpose

The Northern and Yorke Landscape Board (N&Y Landscape Board) approached the Water Science and Monitoring Branch of DEW to undertake surface water (SW) monitoring and hydro-ecological modelling to support the delivering Environmental and Cultural Flows (ECF) project. For the Barossa surface water monitoring component of the project, key activities include:

- Installation of sensors and loggers to collect water level, water electrical conductivity (EC), and water temperature data at priority permanent pools of high ecological significance.
- Undertake surveys of the pools to characterize pool behaviour under different flow regimes.
- Comparison of pool depth data with streamflow data from nearby gauging stations to provide context for pool behaviour in relation to flow in the relevant stream section.
- Post-processing and analysis of results.
- Reporting of results.

This document presents data collected from the monitoring pools between the commencement of monitoring in September 2023 through to May 2025, and summarises key insights gained from the analysis. The findings aim to provide insight into the behaviour of the permanent pools and their resilience, which can inform the provision of targeted environmental and cultural flows for the Barossa area. This information will support the assessment of effective environmental flow strategies for the Barossa PWRA and inform future flow delivery approaches to help restore and protect both environmental and cultural flows across the catchment.

2. Background

Permanent pools in seasonal (i.e., non-perennial) watercourses are vital ecological features that act as refuge habitat for obligate aquatic flora and fauna during the cease-to-flow period. They are typically sustained by a combination of residual hyporheic flows from previous surface flows and groundwater discharge, particularly from streambed recharge during flow events (Bourke et al., 2023). These pools provide essential refuges for aquatic species, support riparian vegetation, and hold cultural significance for First Nations.

Permanent pools in the Barossa Valley are termed such as they are generally considered to be a permanent in the landscape. Regardless of flow conditions, these pools have persisted throughout recent history, including the Millennium Drought. While there has been no dedicated investigation into the exact source of water sustaining these pools, it is generally considered that the pools are either through-flow (type B – Figure 1) or groundwater gaining pools (type C – Figure 1).

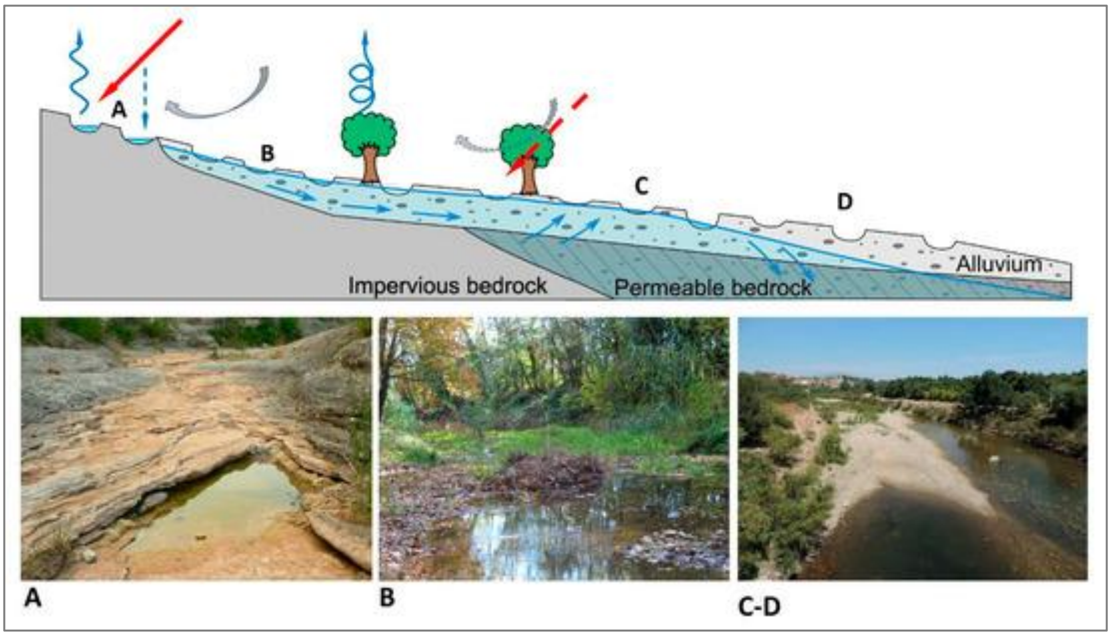

Figure 1. Schematic situation of isolated pools and their relationships with groundwater. (A):"perched" pools. (B): "through- flow" pools. (C):"groundwater gaining" pools. (D) "groundwater losing" pools. (Bonada et al., 2020).

These pools not only retain water but also, serve as an observation point of the near-surface groundwater system that provide water to the pools. As such, they serve as important indicators of broader hydrological conditions. Changes in pool persistence or water levels over time can reflect shifts in groundwater availability, rainfall patterns, or upstream water extraction, such as interception by dams. Monitoring these pools provides valuable insight into their response to changing climate and catchment conditions, while also helping to detect early signs of stress, such as disconnection from groundwater. Hancock et al. (2014) studied interactions between groundwater and surface water systems in the Barossa PWRA and found that the groundwater and surface water systems can generally be classed as highly connected, with a combination of 'gaining' and 'losing' stream conditions depending on the season and location. Understanding these dynamics is essential for informing environmental flow strategies and supporting the long-term resilience of both ecological systems and cultural assets in the Barossa catchment.

Flows in the Barossa catchment have become increasingly intermittent due to climate change (Savadamuthu et al., 2023), low rainfall, and water interception by instream dams, leading to reduced groundwater recharge, declining water quality, and deteriorating ecosystem health. This has particularly impacted permanent pools, fish populations and culturally significant sites. The Barossa Water Security Strategy identified the need for an environmental water plan as a key recommendation to improve watercourse health and cultural flows.

To better understand changes in pool conditions, loggers were installed at 15 key locations across the Barossa catchment in September 2023. Depending on site conditions, some locations were equipped with water level loggers, while others were fitted with multi-parameter loggers capable of measuring both water level and EC. Data has been collected for the period from 24th September 2023 to 29th May 2025.

Considering the historical flow patterns and water availability within the Barossa catchment, the monitoring activities will provide essential data to inform the targeted Environmental Water Plan.

3. Monitoring

3.1 Permanent pool monitoring sites

Based on investigation of aerial imageries, followed by field investigations, key permanent pools were identified. These pools were selected because they are excellent examples of groundwater-dependent pools that have consistently maintained relatively stable water levels over time. Fifteen permanent pools were selected as monitoring sites based on specific site characteristics, as detailed in Table 1 and shown in Figure 2.

Table 1. Selected permanent pools monitoring locations

Site No	Site name	Logger type	Site characteristics
1	Lower Upper Tanunda	WL*	Pool at the base of the cascade from the headwaters of Tanunda Creek. Located just upstream of the gorge at Bethany for Tanunda Creek
2	Mid Tanunda	WL+EC**	Permanent pool on the on the upper part of Tanunda Creek
3	Mid Upper Jacob	WL+EC	Located mid Pewsey Vale in deep valley, downstream of most major tributaries.
4	Upper Lower Jacob	WL+EC	Large permanent pool near the end of the Jacob Creek Gorge
6	Transition Zone	WL	Located near end of Transition zone, logger was installed at this location to see how often flows reach the end of the transition zone.
7	Lower Flaxman	WL+EC	Pool is located upstream of Penrice gauge. Last permanent water pool before the Transition Zone. Located just upstream of the gorge at Penrice for North Para River
8	Lower Flaxman	WL	Located lower third of the Flaxman Valley. Area where baseflow impacts should be detectable as well as key information relating to the permanence of pools.
9	Mid Lower Flaxman	WL	Located approximately halfway down the lower Flaxman Valley. Area of likely impact to baseflows due to recent dry years.
10	Mid Lower Flaxman	WL+EC	Located downstream of weirs, ability to capture both spill and potential release from weir system.
11	Lower Mid Flaxman	WL	Located most downstream of the large weirs that will determine if water is spilled from the weir system into the lower Flaxman Valley
12	Mid Upper Flaxman	WL+EC	Most downstream pool before the long dry reach before the gauge. Will be the most likely to detect major changed due to any potential changes in dam behaviour in the Upper Flaxman Valley
13	Lower Upper Flaxman	WL	Located at the end of the Upper Flaxman Valley and pool lies in close proximity to the gorge at Mt McKenzie for North Para River.
14	Upper Mid Flaxman	WL	Last permanent pool before the confluence between North Para and Stone Chimney Creek
15	Lower Stone Chimney	WL	No permanent pools in this area but should be able to locate a good cease to flow. Is used to get a record of flows coming out of Stone Chimney Creek
16	Mid Flaxman	WL	Last of the permanent pools before the large weir pools. Should provide more accurate indications of flow than using the weir pool itself due the smaller surface area.

*WL- Water level (depth) logger (Rugged TROLL 100)

** WL + EC - multi-parameter logger, measures water level (depth) and Conductivity (Aqua TROLL 200)

The monitoring locations were surveyed and instrumented with staff gauges and water level/WL+EC loggers to monitor pool depth and salinity. This report covers data from 24th September 2023 to 29th May 2025. The loggers were left at the monitoring pools for continuous data collection.

The variation in pool depth and specific conductivity, along with rainfall data and streamflow data from nearby monitoring sites, are discussed in the Results and Observation Section. The cross-sectional and longitudinal profiles of the sites are provided in Appendix 6.1 Cross section and longitudinal section of the monitoring pools). Photographs taken during site visits are presented in Appendix 6.2 Photo.

3.2 Streamflow monitoring sites

Streamflow data from the gauging stations located in the vicinity of the selected pools, where relevant, are used to provide context for the pool depth behaviour in the permanent pools in relation to flow in the creeks. The selected streamflow gauging stations are provided in Table 2 and shown in Figure 2.

Figure 3 illustrates the classification of stream reaches related to surface and groundwater interaction within the PWRA, to support the interpretation of permanent pool behaviour in relation to surface-groundwater interaction dynamics. This classification is based on Hancock et al. (2014), which investigated interactions between groundwater and surface water systems in the Barossa PWRA.

Table 2. Streamflow monitoring sites

Site No	Site name	Streamflow monitoring site
1	Lower Upper Tanunda	A5050535 - Tanunda Creek at Bethany
2	Mid Tanunda	
3	Mid upper Jacob	
4	Upper Lower Jacob	
6	Transition Zone	
7	Lower Flaxman	A5050517 - North Para River at Penrice
8	Lower Flaxman	
9	Mid Lower Flaxman	
10	Mid Lower Flaxman	
11	Lower Mid Flaxman	
12	Mid upper Flaxman	A5050533 - North Para River at Mount McKenzie
13	Lower Upper Flaxman	
14	Upper Mid Flaxman	
15	Lower Stone Chimney	
16	Mid Flaxman	A5050517 - North Para River at Penrice

3.3 Rainfall monitoring sites

Rainfall data was obtained from the closest rainfall station to each monitoring site as mentioned in Table 3 and indicated in the Figure 2.

This information was used to gain an understanding of variation of pool depth and electric conductivity of the permanent pools over time for a longer duration.

Table 3. Selected BoM rainfall stations

Site No	Site name	Closest Rainfall Station (m AHD)
1	Lower Upper Tanunda	23318 (Tanunda)
2	Mid Tanunda	
3	Mid upper Jacob	23313 (Lyndoch)
4	Upper Lower Jacob	23363 (Rowland Flat)
6	Transition Zone	23312 (Nuriootpa)
7	Lower Flaxman	23300 (Angaston)
8	Lower Flaxman	
9	Mid Lower Flaxman	

10	Mid Lower Flaxman	
11	Lower Mid Flaxman	
12	Mid upper Flaxman	23302 (Collingrove)
13	Lower Upper Flaxman	
14	Upper Mid Flaxman	
15	Lower Stone Chimney	
16	Mid Flaxman	

Note:

- Pool depth measurements are relative to the position of the logger within the pool. While reasonable effort was made to place the logger at the lowest point in the pools as practical, accessibility constraints at some monitoring sites prevented placement at the absolute deepest point. However, the data still provides a consistent and reliable indication of relative changes in pool depth over time.
- A full survey (including cross-sectional and longitudinal sections) was conducted only at Sites 2, 3, 6, 9, and 10. The logger location is indicated in the cross section or longitudinal section figure of each site.
- When the logger gets very close to the water surface (gets exposed to air), it records unusually high specific conductivity levels. Therefore, extremely high specific conductivity values with very low pool depth do not accurately represent the water quality in the monitoring pool.

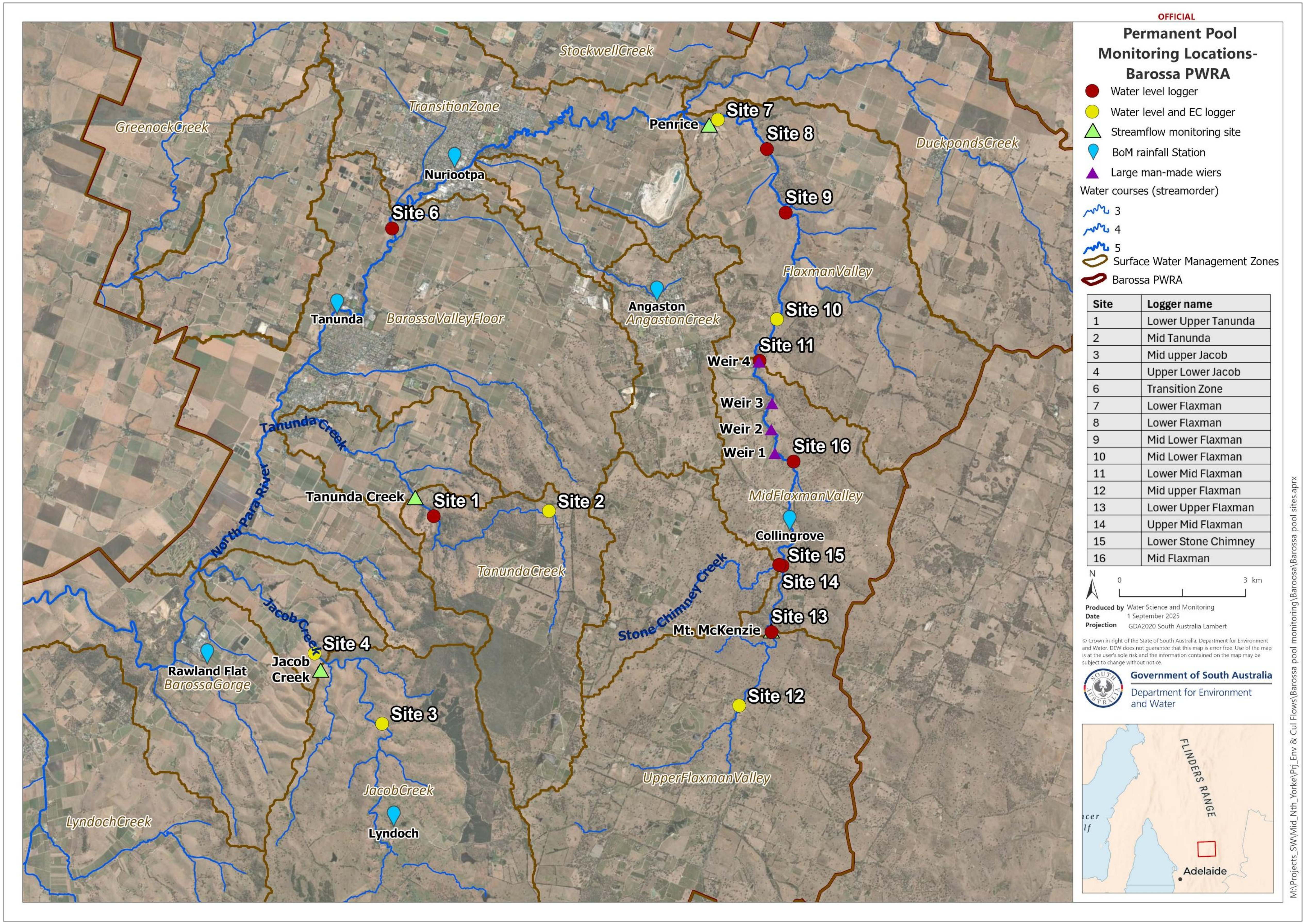

Figure 2. Locations of permanent pool monitoring sites, streamflow gauges, and rainfall stations

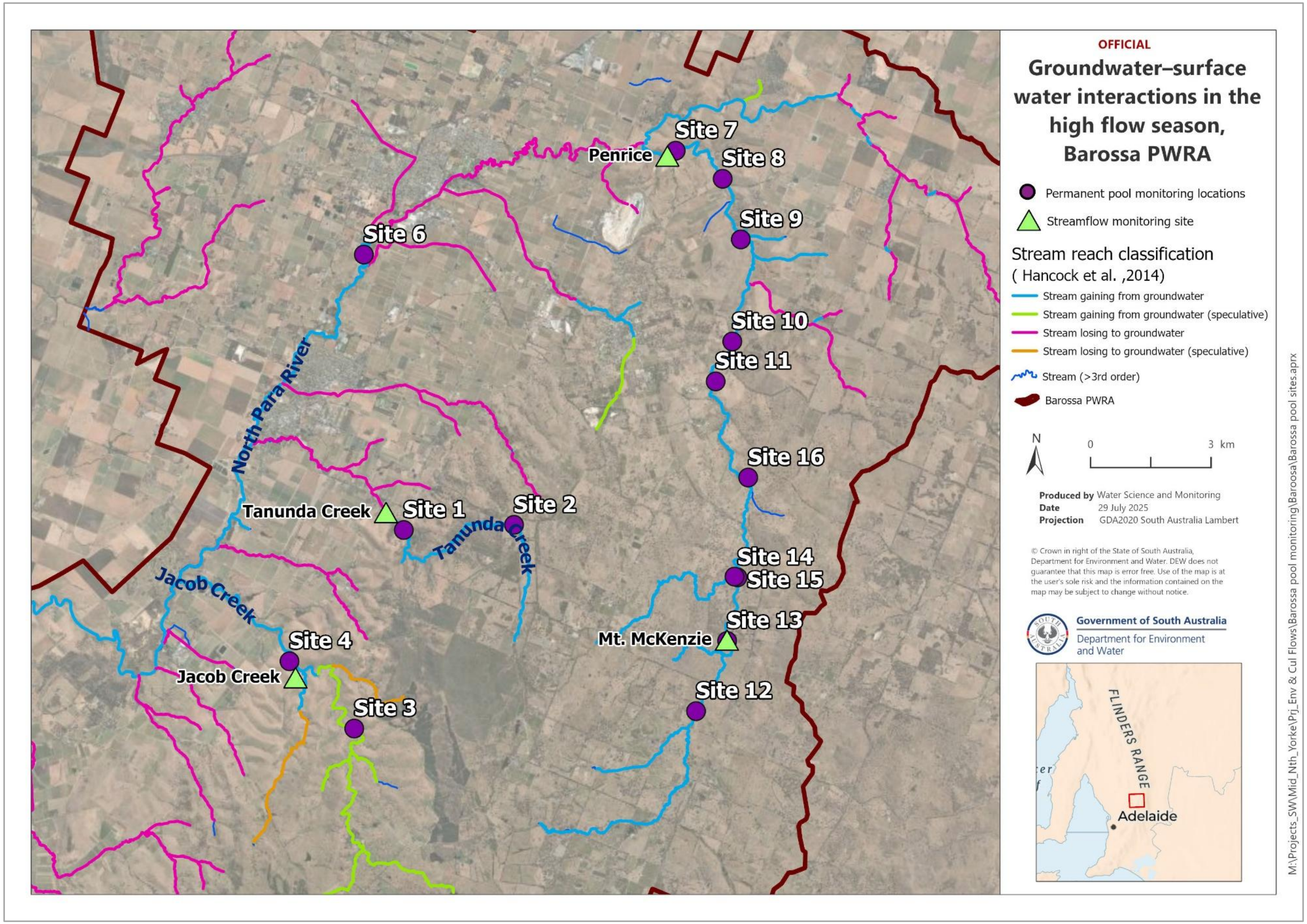

Figure 3. Groundwater – surface water interactions in Barossa PWRA (Hancock et al., 2014)

4. Results and Observations

4.1 Pool Depth Observations

Option 1: Logger installed above the deepest point of the pool (not at the lowest elevation). In this case, the actual pool depth can only be determined at sites where a full survey was conducted (Sites 2, 3, 6,10).
(CTF = Cease to Flow)

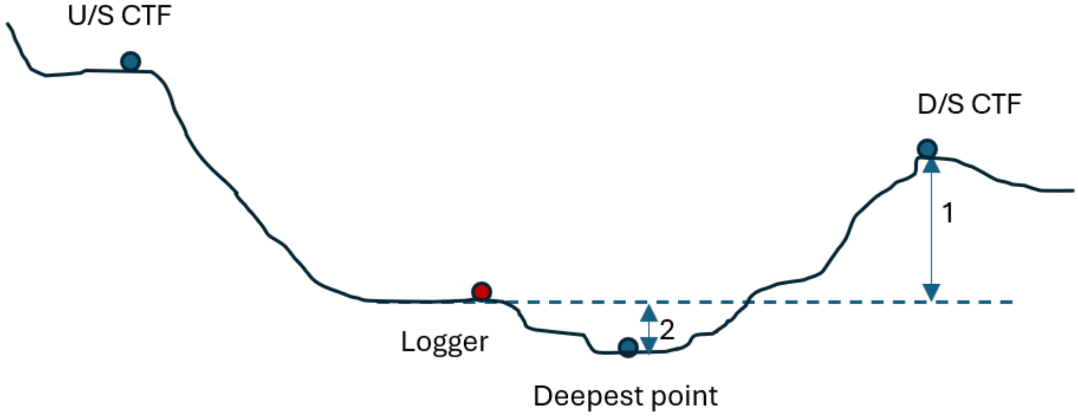

Figure 4. Sketch of the permanent pool - Option 1

Option 2: Logger installed at the deepest point of the pool (lowest elevation of the pool bed) or assumed to be installed at the lowest point (Sites 8 ,9, 11, 12, 14, 15, 16).

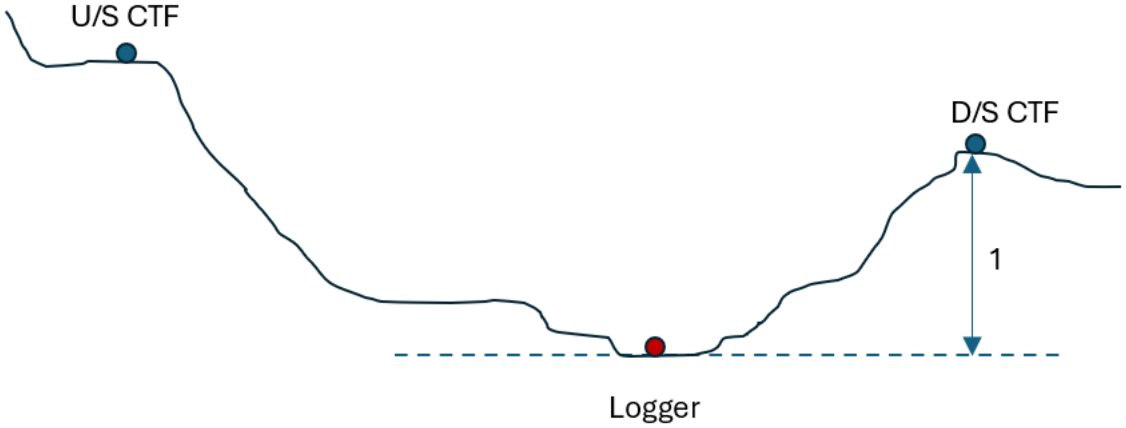

Figure 5. Sketch of the permanent pool - Option 2

The following values are presented relative to the logger level, as shown in Figure 4 and Figure 5. The lowest pool depth is reported only for pools that retained water. Some pools were dry, while in others the logger was out of the water. These instances are noted in the "Notes" column, based on observations during the May site visit (28th and 29th May 2025).

Table 4. Pool depth observations

Site No	Site name	1. Depth from D/S CTF to Logger[1] (m)	2.Depth to Deepest Point[2] (m)	Highest Pool Depth Recorded (m)	Lowest Pool Depth Recorded (m)	Notes (as of May 2025)
1	Lower Upper Tanunda	Survey not conducted		0.48	0.40	Pool holding water
2	Mid Tanunda	0.49	0.16	0.92	-	Pool observed dry
3	Mid Upper Jacob	0.61	0.04	0.89	0.39	Pool holding water
4	Upper Lower Jacob	Survey not conducted		1.26	1.16	Pool holding water
6	Transition Zone	1.88	0.67	1.90	0.85	Pool holding water
7	Lower Flaxman	Survey not conducted		1.43	-	Logger out of water
8	Lower Flaxman	1.17	NA	1.68	-	Pool observed dry
9	Mid Lower Flaxman	1.56	NA	1.63	0.38	Pool holding water
10	Mid Lower Flaxman	1.02	0.41	1.21	-	Pool observed dry
11	Lower Mid Flaxman	1.55	NA	1.47	-	Logger out of water
12	Mid Upper Flaxman	0.32	NA	1.50	-	Logger out of water
13	Lower Upper Flaxman	Survey not conducted		1.31	0.52	Pool holding water
14	Upper Mid Flaxman	1.28	NA	1.36	-	Logger out of water
15	Lower Stone Chimney	0.40	NA	0.42	-	Pool observed dry
16	Mid Flaxman	1.73	NA	1.72	-	Logger out of water

[1] Relative to the logger elevation.

[2] Only available at sites where a full survey was conducted and relative to the logger.

4.2 Tanunda Creek

4.2.1 Comparison with streamflow and rainfall

As detailed in Hancock et al. (2014) and shown in Figure 3, groundwater is likely to flow (gaining stream) into streams in the headwaters of Tanunda Creek, while streams in the lower section are likely to recharge the groundwater system (losing stream). Sites 1 and 2 are located along Tanunda creek, a tributary of the North Para River. The permanent pool at Site 2 is located in the headwaters of Tanunda Creek and Site 1 is located further downstream in close vicinity to the gauge at Bethany (A5050535) on Tanunda Creek (Figure 2).

Figure 6 shows the variation in pool depth at these two permanent pools compared with streamflow recorded at Bethany (A5050535) and rainfall recorded at Tanunda (23318). From February 2024 to mid-June 2024, and again from December 2024 to March 2025, the streamflow level was below the recordable range, indicating no measurable flow. These prolonged low or no-flow periods indicate extended dry conditions and limited catchment runoff.

- The permanent pool at Site 1, being a trickling pool supported by groundwater, was able to maintain its pool depth throughout the period, showing only minor variation in pool depth (approximately 8 cm).
- The pool at Site 2 remained relatively stable during the first dry period (February–May 2024) but dried up from January 2025 onwards.

The early months of 2025 experienced very low rainfall, which is reflected in the streamflow records. Further investigations are required to better understand the variability in pool depth behaviour and the underlying influencing factors.

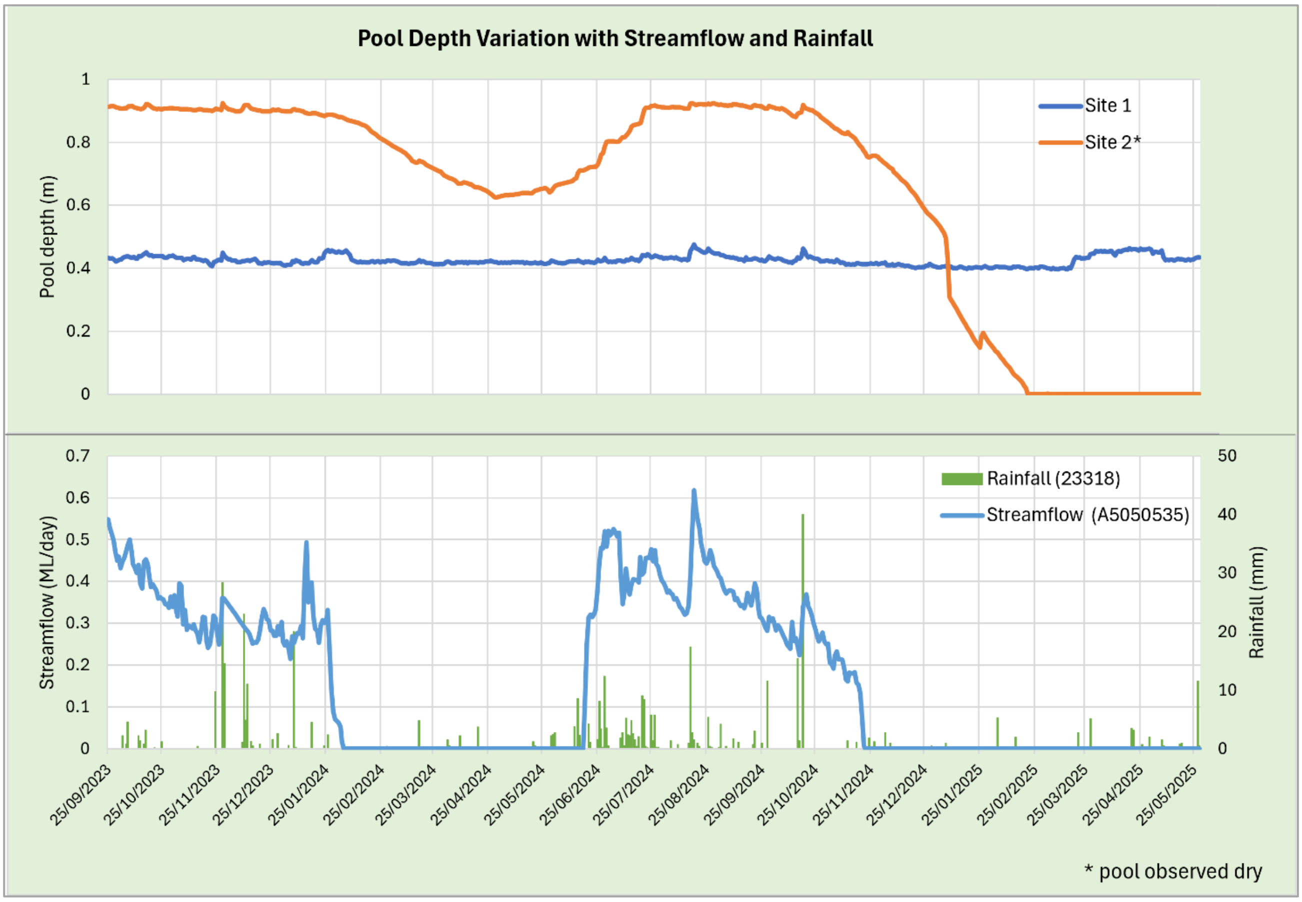

Figure 6. Variation in pool depth at Site 1 and 2 compared with streamflow at Bethany (A5050535) and rainfall at Tanunda (23318)

4.2.2 Pool depth and Specific conductivity variation

Site 2 – Mid Tanunda (u/s of site 1)

Figure 7 presents the temporal variation in pool depth and specific conductivity, compared against rainfall recorded at Station 23318, for the permanent pool.

- Site 2 is located upstream of site of Site 1 in a gaining stream section of the stream. The pool depth remained relatively stable (0.88–0.92 m) until early 2024, after which it showed a gradual decline through to June 2024. This steady decline of pool depth during the dry season (February–May 2024) suggests water loss through evaporation and may reflect a broader reduction in the water level in the surrounding alluvial channel or unconfined aquifer. Following rainfall events in late June and July 2024, a recovery in pool depth was observed, but the pool dried out after the second dry period (November 2024- March 2025).
- The drying of the permanent pool from early March 2025 suggesting that **this pool, typically sustained by shallow groundwater could no longer be supported under very dry conditions due to its likely disconnection from the groundwater table**.
- The maximum conductivity reading of around 28,000 µS/cm is not a true reflection of water quality. This unusually high value is likely due to the logger being exposed to air after pool depth reduced. Conductivity generally increased as water level decreased, indicating concentration of dissolved salts as water volume declined. This indicates limited groundwater inflow.

Site 1 – Lower Upper-Tanunda

Figure 8 shows variation of pool depth compared with rainfall (23318).

- Site 1 is a permanent pool at the base of the cascade from the headwaters of Tanunda Creek (and upstream of Site 2). The monitoring data indicates the presence of a permanent pool with relatively stable pool depth conditions. Pool depth fluctuations during the monitoring period are relatively minor, with pool levels ranging between approximately 0.40 m to 0.48 m, indicating continuous water retention throughout varying climatic conditions.
- During extended periods of low rainfall (February-May 2024 & November 2024 – April 2025), pool depth showed only a small variation (0.4- 0.43 m), confirming that the pool is sustained even without frequent rain. This suggests that **the pool is supported by groundwater, with gradual water loss through evaporation and seepage.**

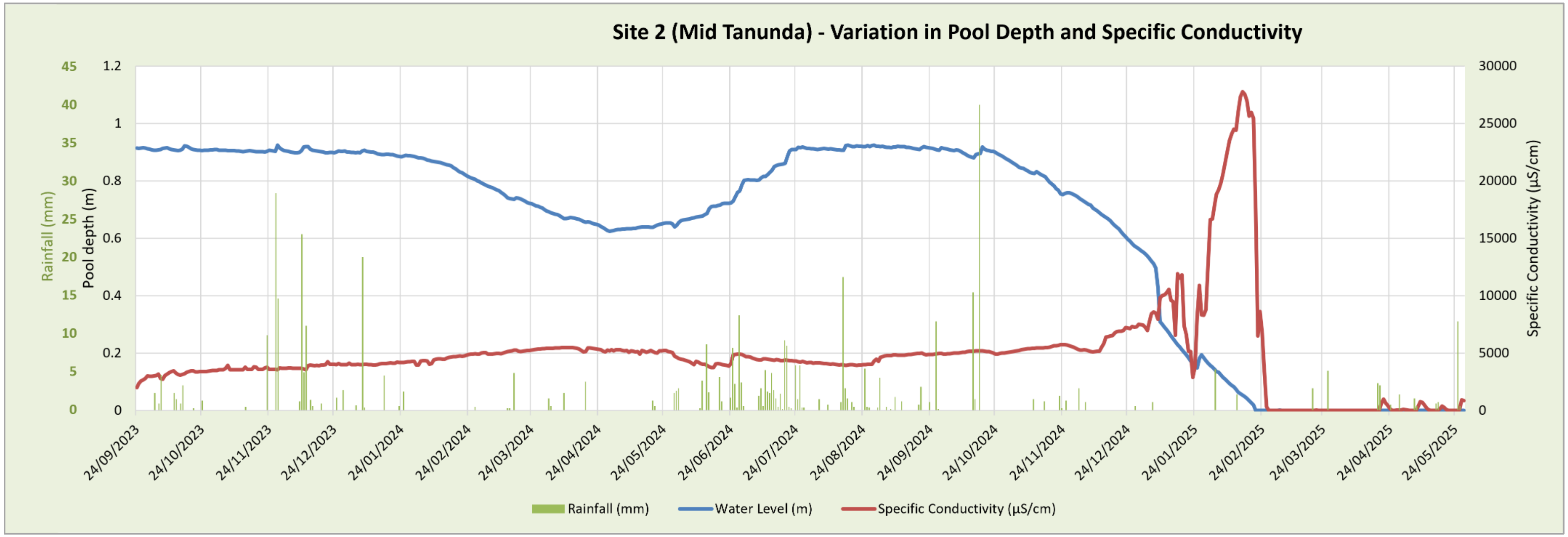

Figure 7. Site 2 - Variation in pool depth and specific conductivity[1]

[1] Pool dried in late February 2025 (around 21/02/2025). Unusually high EC values are likely due to the logger being exposed to air after pool depth reduced.

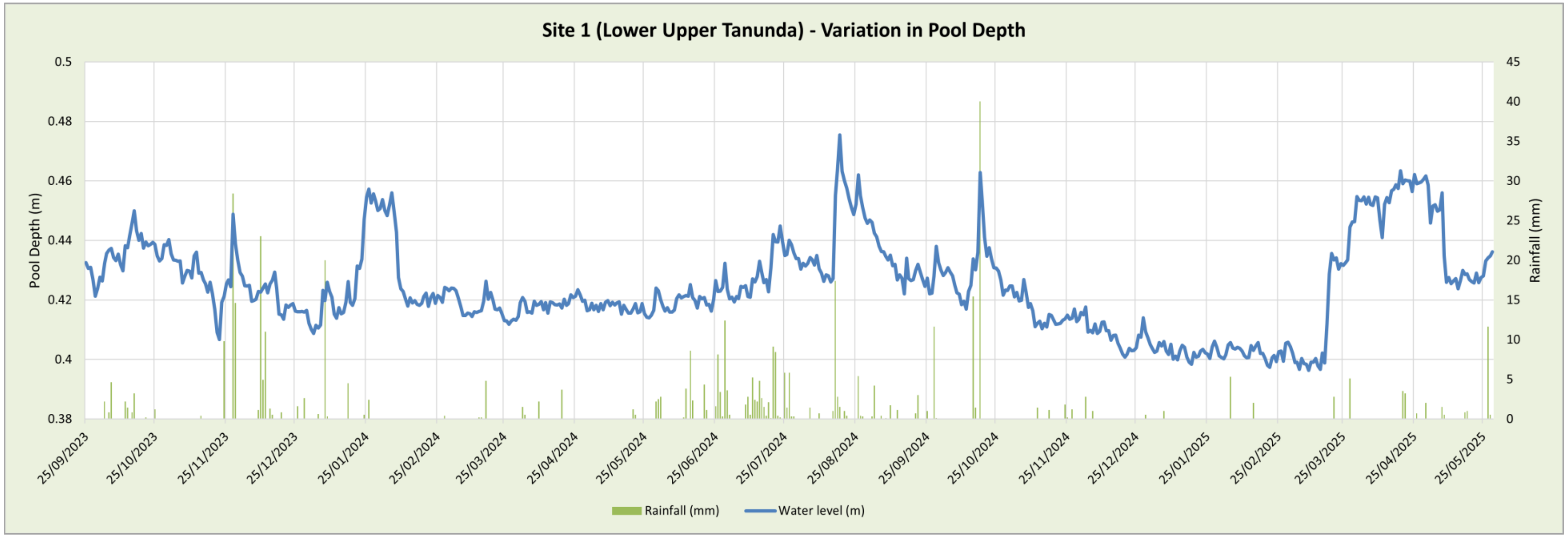

Figure 8. Site 1- Variation in pool depth

4.3 Jacob Creek

Streamflow data for Jacob Creek were not available for the monitoring period. The permanent pools at Sites 3 and 4 are in the headwaters of Jacob Creek, with Site 3 located upstream of Site 4.

As described by Hancock et al. (2014) the headwaters of Jacob Creek are situated within the high-rainfall, fractured rock environment of the Barossa Range. This area has been identified as supporting groundwater-dependent ecosystems, characterised by low water-holding capacity soils, extensive riparian waterlogging, and a series of ponds likely sustained by groundwater inflow.

Both pools maintained water levels throughout the dry periods, consistent with the characteristics outlined above. Detailed monitoring data are provided below, with water level and EC variations at Sites 3 and 4 presented in Figure 9 and Figure 10, respectively.

Site 3 Mid upper Jacob (upstream of Site 4)

- Pool water levels (rise and fall) follow rainfall observations, with pool depth ranging from 0.5 m to 0.89 m during the observation period. However, they remained relative stable (low variation of ~0.4 m) during drier months, indicating **a permanent pool with low seasonal variability and stable water level conditions supported by groundwater inflows (gaining stream section).**
- Specific conductivity values ranged widely from 1040 to 9042 µS/cm, with fluctuations due to changes in pool depth and rainfall events.
- Between June and September 2024, a notable increase in conductivity was observed, peaking at over 9000 µS/cm. This is likely due to inflows of dissolved salts into the pool by catchment runoff generated from high rainfall events (the 'First Flush') generated after a long dry period. However, the limited variation in water depth (0.80 → 0.86 m) was insufficient to reduce the conductivity, resulting in continuous high conductivity values until October 2024.

Site 4 Upper Lower Jacob

- Pool (water level) behaviour at site 4 was similar to that of Site 3 except for the period between late 2024 spring season and autumn of 2025.
- Pool depth ranged from 1.16 m to 1.26 m, with a relatively low variation of around 10 cm. This limited fluctuation suggests the presence of **a permanent pool with low seasonal variability, likely maintained by consistent groundwater inflows.**

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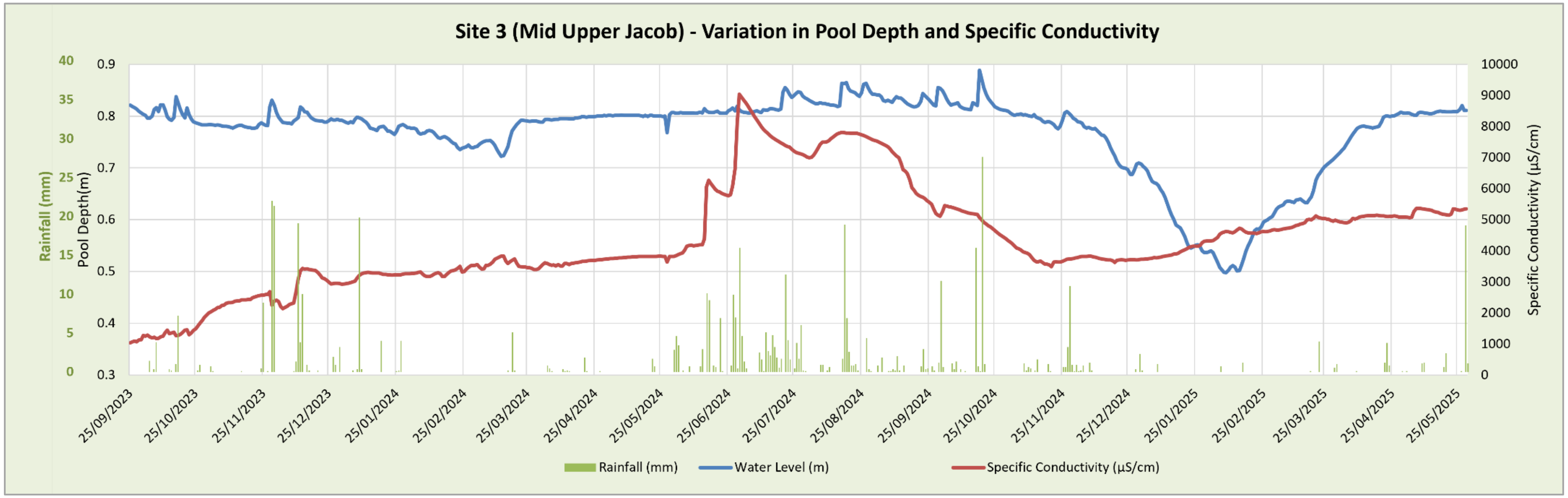

Figure 9. Site 3- Variation in pool depth and specific conductivity

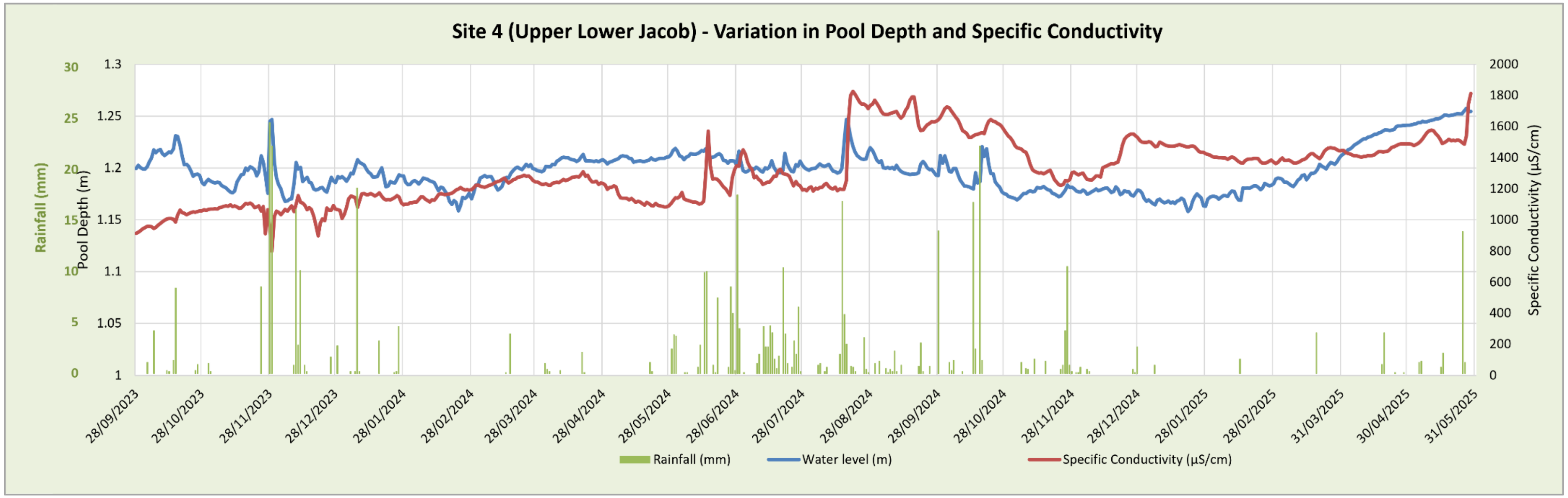

Figure 10. Site 4 – Variation in pool depth and specific conductivity

4.4 Transition Zone

Site 6 Transition Zone

Figure 11 shows the variation in pool depth for the monitoring period.

- Pool depth at Site 6 ranged from 0.85 m to 1.90 m, with a variation of approximately 1m.
- After each rainfall-driven peak, the water level in the pool declined steeply back toward the relatively stable base level (~1.4 m), suggesting these additional surface flows were lost to the surrounding groundwater until the level in the pool matched that of the surrounding groundwater. Pool depth gradually reduced during the second low rainfall period (November 2024 – March 2025).
- The pattern suggests that the monitoring pool at **Site 6 responds quickly to rainfall driven surface inflows but does not retain this additional surface water for long, with relatively rapid losses through seepage and evaporation back to the surrounding shallow groundwater level.**

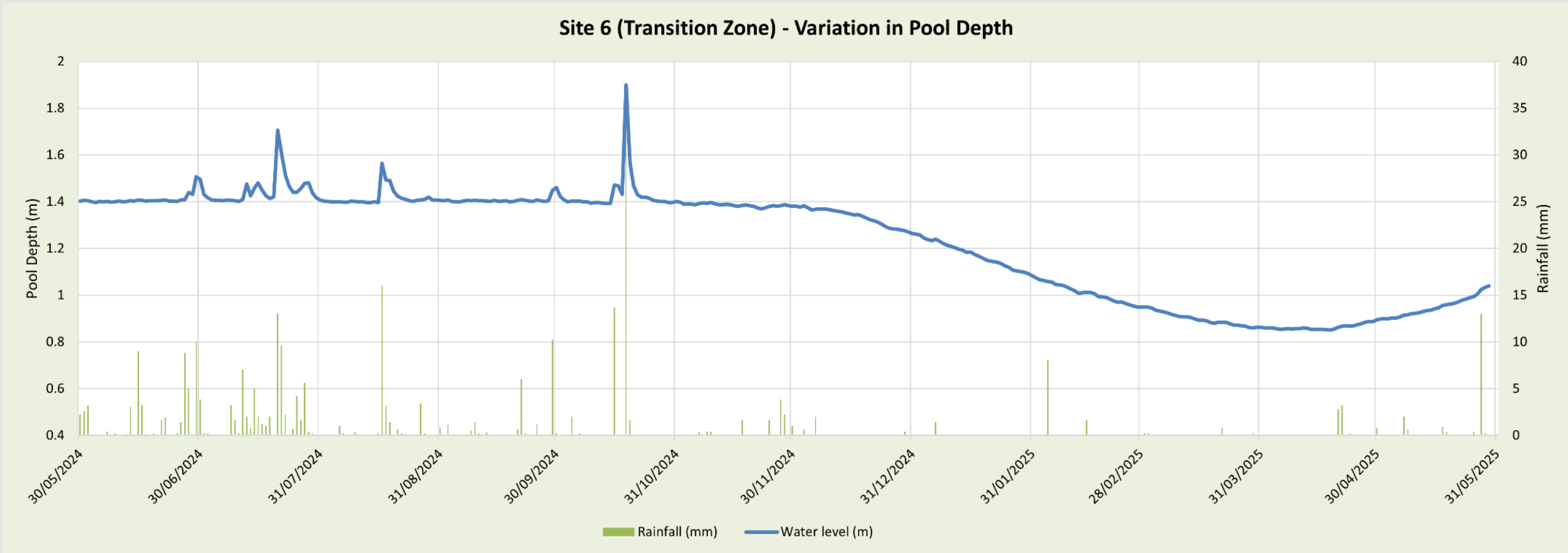

Figure 11. Site 6 – Variation in pool depth

4.5 Lower and Mid Flaxman Valley

There are variable losing/gaining type stream reaches in the Flaxman Valley which are associated with the local and regional fractures and fold structures typical of a fractured rock environment. Overall, the Flaxman Valley contains gaining-type stream reaches (Hancock et al., 2014). As shown in Figure 3, all the permanent pools in the Flaxman Valley selected for this study are located within gaining stream reaches. Flows in this and the entire downstream section of the North Para watercourse are heavily influenced by the presence, and the fill and spill processes, of 4 large impoundments (large man-made weirs) on the main watercourse (Figure 2). These impoundments reduce downstream inflows and limit recharge, which can affect the persistence of permanent pools.

4.5.1 Pool depth and Specific conductivity variation

Data for sites are presented below in an upstream to downstream order, with Site 16 being the most upstream in the mid and lower Flaxman valley section.

Site 16 Mid Flaxman

- Figure 13 shows the variation in pool depth for the monitoring period. From the start of monitoring to mid-November 2024, pool depth at Site 16 remained relatively stable and followed a general seasonal pattern, ranging from 1.72 m to 1.12 m. However, during the subsequent dry period (November 2024 – March 2025), a continual decline in pool depth was observed. While the logger at Site 16 was out of water (from around 11/05/2025), field observations confirmed that the pool retained a considerable water level (Photo 24).
- This water level pattern indicates that **Site 16 is responsive to seasonal rainfall while still maintaining some groundwater connectivity.**

Site 11 Lower Mid Flaxman

- This is one of the 4 large man-made weirs (Figure 2) constructed on the main North Para River in the mid-lower section of the Flaxman valley. This site is primarily monitored to assess conditions in the lower Flaxman Valley by informing when the weir spills.
- Inflows to this weir from upstream are suspected to have been from the spring that feeds the upstream weir.
- The depth pattern at this site is not considered to be an overly accurate reflection of the surrounding groundwater level as there is a significant water extraction from this weir pool.
- Figure 14 shows the variation in pool depth for the monitoring period. Site 11 had high pool depth variability (1.44 m), with levels declining to near-dry (logger out of water) conditions by March 2024, followed by a gradual recovery in the subsequent months and dropping again during the subsequent dry period (November 2024 – March 2025).

Site 10 Mid Lower Flaxman

- This site is located downstream of the fourth watercourse weir (Site 11). Figure 15 shows the variation in pool depth and specific conductivity for the monitoring period. Pool depth ranged from 1.21 m down to completely dry. From September 2023 to May 2024, pool depth declined steadily and became completely dry from mid November 2024 (around 15/11/2024). Winter rainfall (June–August 2024) led to a slight increase (0.2-0.3 m) in pool depth; however, levels declined rapidly again following the reduction in rainfall after October 2024.
- Specific conductivity ranged from 605 to 7704 µS/cm, increasing sharply as depth declined.
- **Given Site 10's location downstream of the weirs, these trends suggest that there were fewer significant spills from the weir system during this period and disconnection from shallow groundwater.**

Site 9 Mid Lower Flaxman

- Figure 16 shows the variation in pool depth for the monitoring period. Site 9 indicated higher pool depth variability (1.2 m), with levels declining to 0.79 m by May 2024 before gradually recovering following winter (June-Aug 2024). During the second low rainfall period (November 2024 – March 2025) the water level at the pool gradually declined but maintained a pool depth of around 0.4 m.
- The gradual recovery and sustained pool depth during extended dry conditions **suggest a strong connection to shallow groundwater, supporting the pool's ability to retain water even in the absence of consistent surface inflow.**

Site 8 Lower Flaxman

- Figure 17 shows the variation in pool depth for the monitoring period. The monitoring data from site 8 indicates higher pool depth variation (1.5m), declining from 1.54 m in September 2023 to low pool depth (0.2m) conditions by May 2024. Despite small water level increase after winter rainfall events (June–August 2024), the pool dried out (around 24/12/2024) indicating its **limited water retention capacity and disconnection from the shallow groundwater.**

Site 7 Lower Flaxman

- Figure 18 shows the variation in pool depth and specific conductivity for the monitoring period. From September 2023 to January 2024, pool depth remained relatively high (~1.4 m) and stable. Following this period, a gradual decline was observed, with levels reaching a minimum of 0.46 m by mid-2024. This indicates significant water loss likely due to evaporation, seepage, and limited surface water inflow. More rapid and sustained decline occurred between November 2024 and March 2025, with the logger coming out of the water by mid-February 2025 (around 12/02/2025).
- Specific conductivity ranged from 4254 to 5846 µS/cm between the beginning of monitoring and October 2024. It steadily increased as pool depth dropped, likely due to the concentration of dissolved salts as water volume decreased.
- While there were some inflow events between June and August 2024, they led to only a short-lived increase in pool depth, suggesting that water was lost through seepage due to the **strong connection to the surrounding alluvial channel aquifer**.

4.5.2 Comparison with streamflow and rainfall

The streamflow gauge at Penrice (A5050517) for the North Para River is located downstream of Site 7 to 11 and 16. As shown in Figure 12 streamflow at this monitoring site indicated sharp peaks in September, reflecting higher flows after the winter runoff period, followed by a rapid decline from early October. From January 2024 until the end of the monitoring period (May 2025), most of the streamflow data remained below the recordable range, indicating no measurable flow. This extended no-flow period suggests prolonged dry conditions and minimal catchment runoff throughout 2024 and 2025.

Pool depth data from all monitoring sites upstream of the Penrice gauge followed a similar drying trend, beginning in late November. The permanent pools at Sites 8 and 10 had dried up completely. Only the permanent pools at Sites 9 and 16 retained water throughout the monitoring period. (Logger at Site 16 was out of the water, resulting in a dry reading. Refer to Photo 24).

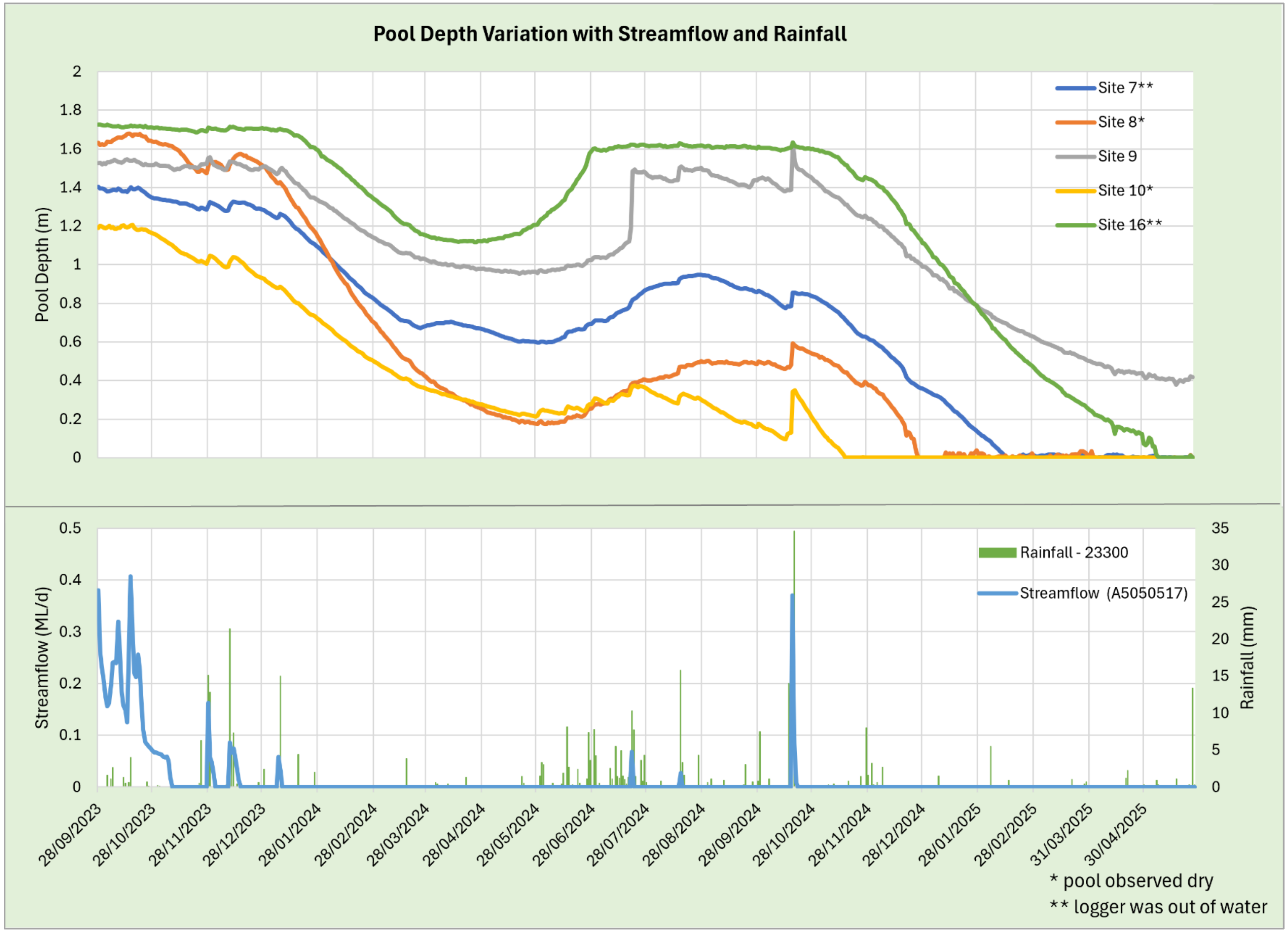

Figure 12. Variation in pool depth at Site 7 to 11 and 16, compared with streamflow at Penrice (A5050517) and rainfall at Angaston (23300)

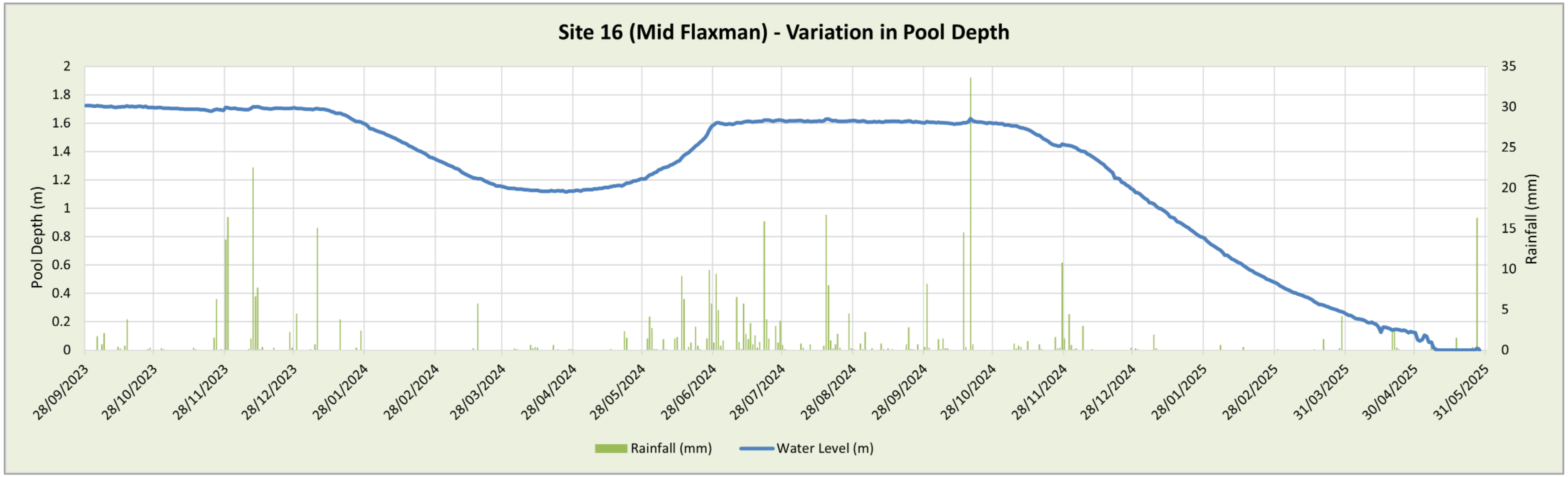

Figure 13. Site 16 – Variation in pool depth[2]

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[2] Logger was out of water from mid-May (around 11/05/2025).

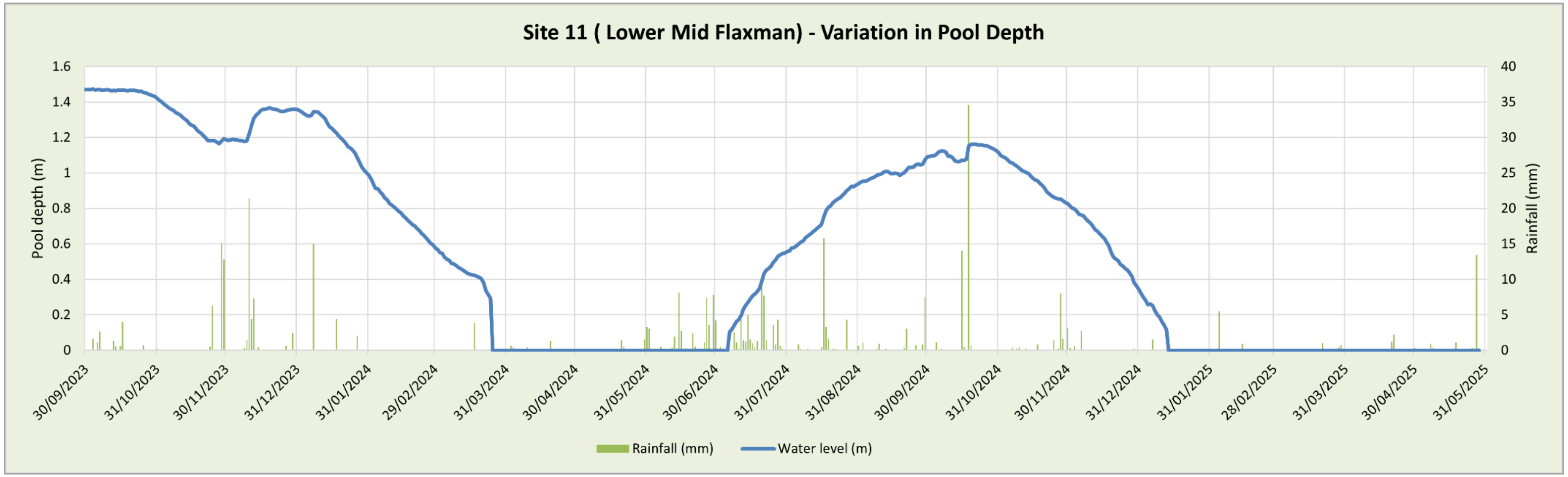

Figure 14. Site 11 – Variation in pool depth[3]

[3] One the weirs on the North Para River, monitored to determine spill occurrence and downstream conditions. Logger was out of water (around 27/03/2024 to 03/07/2024 and 13/01/2025 end of monitoring).

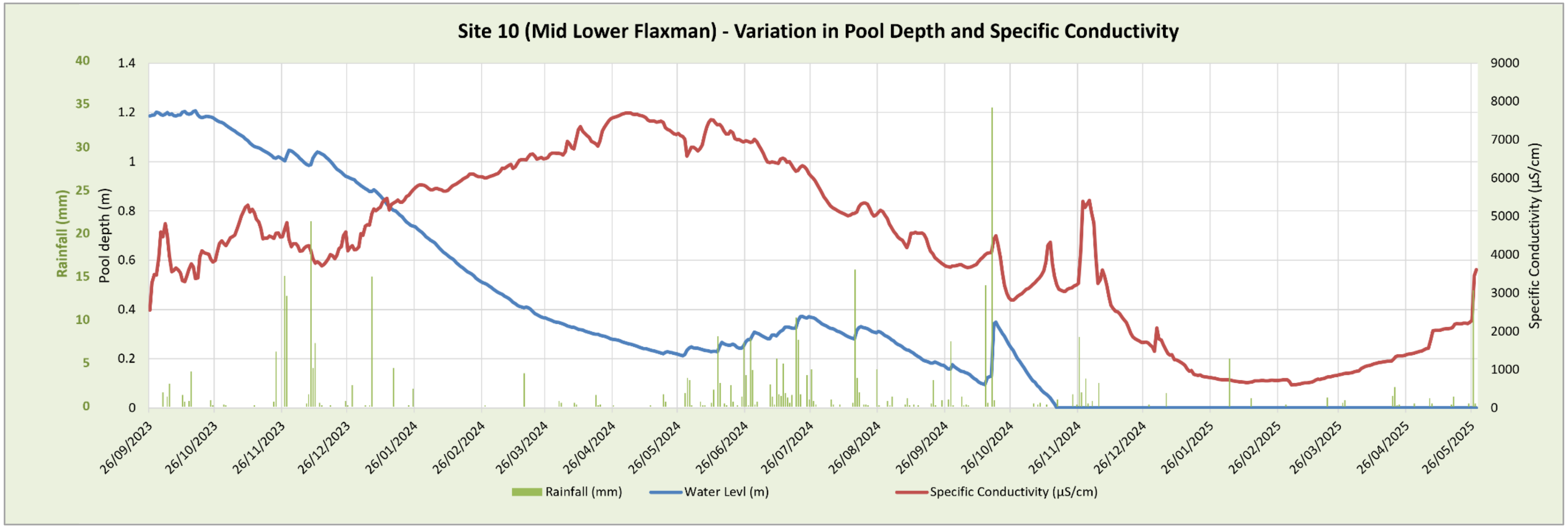

Figure 15. Site 10- Variation in pool depth and specific conductivity[4]

[4] Pool was dry from Mid November 2024 (around 15/11/2024).

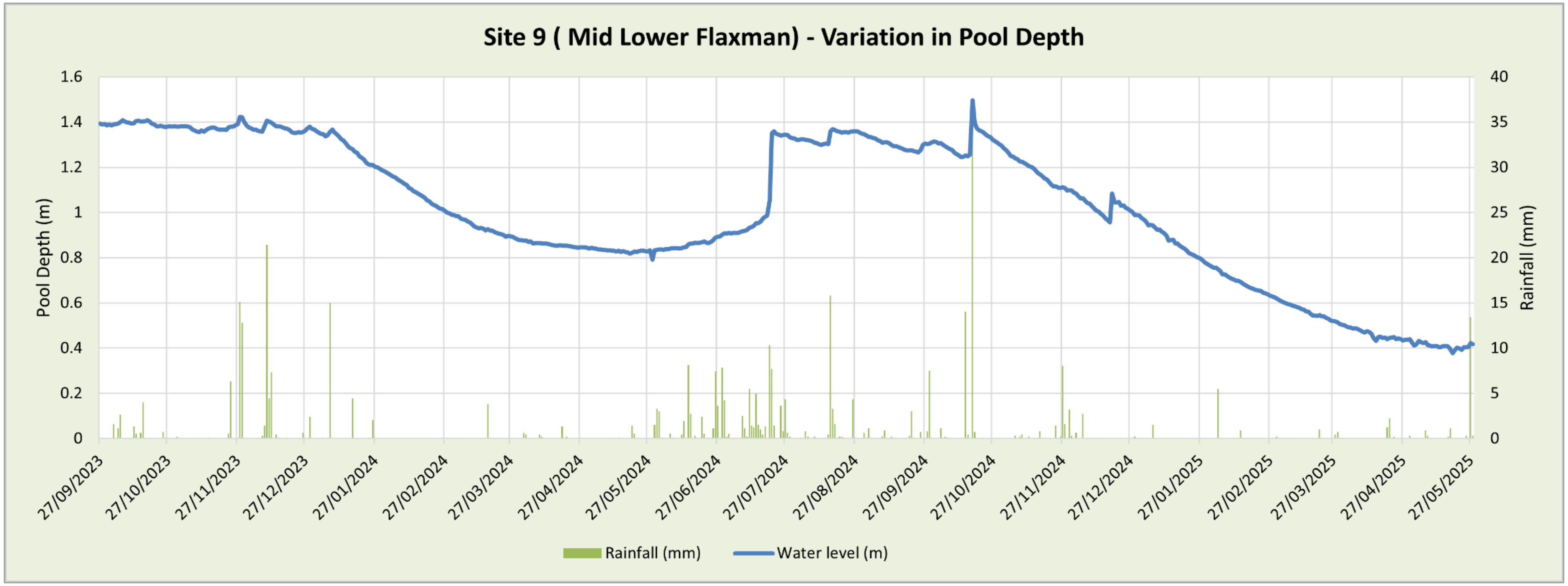

Figure 16. Site 9- Variation in pool depth

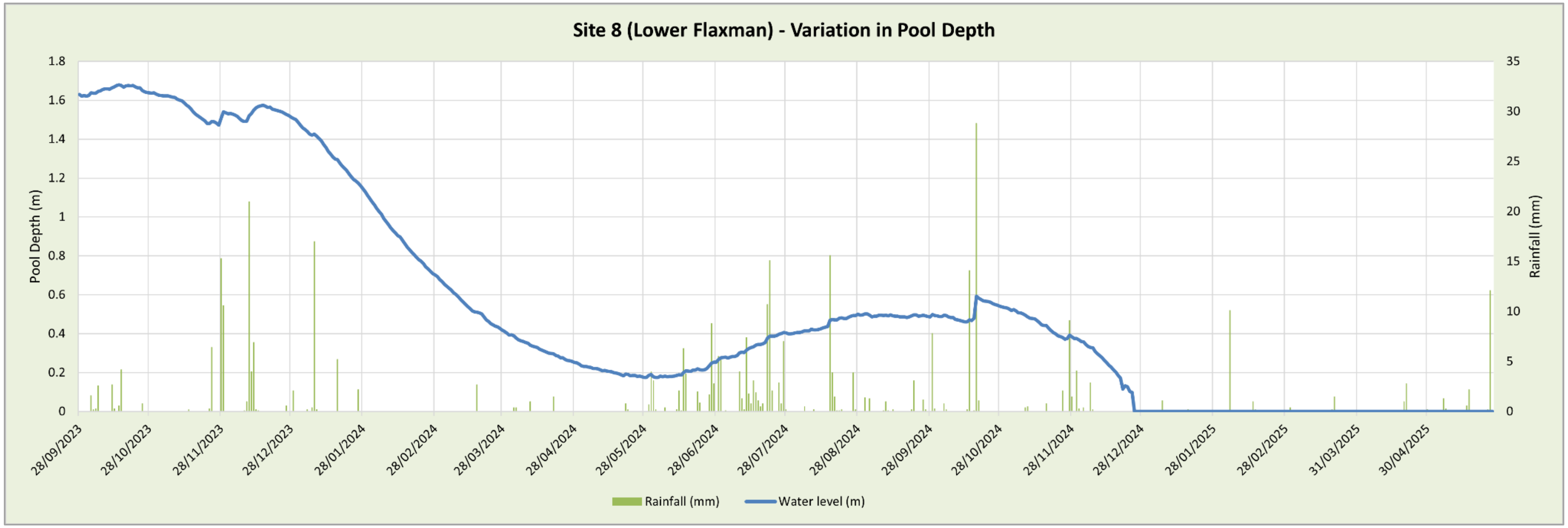

Figure 17. Site 8- Variation in pool depth[5]

[5] Pool was dry from end of December 2024 (around 24/12/2024).

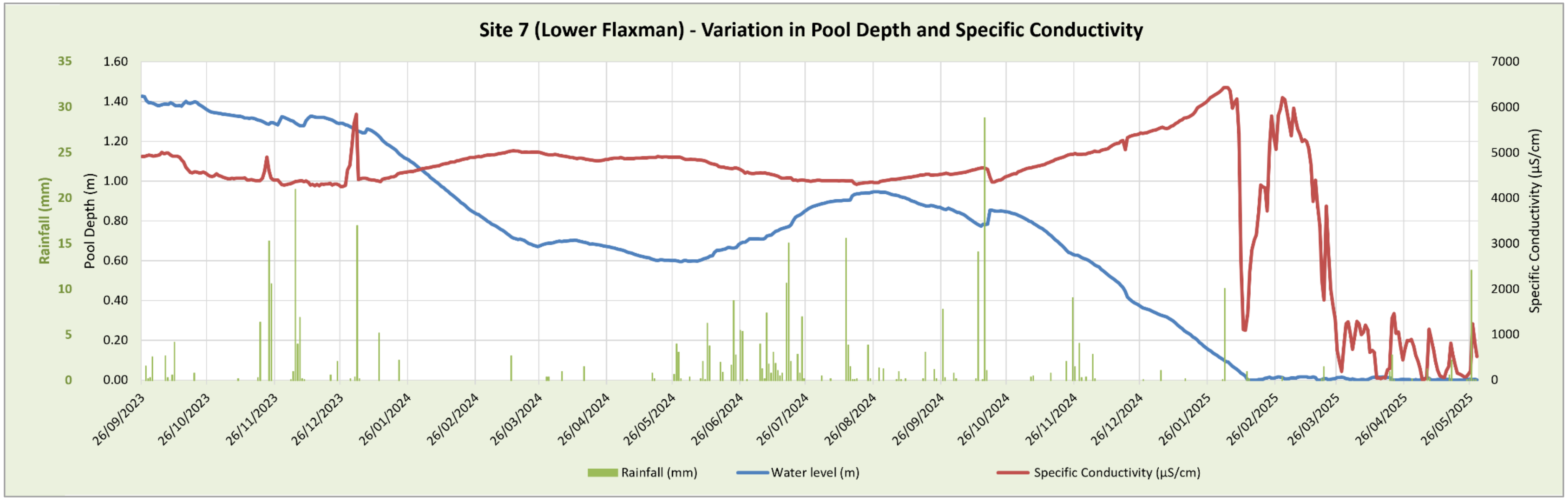

Figure 18. Site 7- Variation in pool depth and specific conductivity[6]

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[6] Logger was out of water from mid-February 2025 (around 12/02/2025). Unusually high EC values are likely due to the logger being exposed to air after pool depth reduced.

4.6 Upper Flaxman Valley

The headwaters of the Flaxman Valley (mid and upper sub catchments) have been identified as containing groundwater dependent ecosystems on low water-holding-capacity soils, associated with a series of ponds that are likely resulting from groundwater flow (Hancock et al., 2014).

4.6.1 Pool depth and Specific conductivity variation

Site 12 Mid upper Flaxman

- This site is most upstream site in the catchment and is located immediately downstream of the headwaters of Flaxman Valley. Figure 20 shows the variation in pool depth and specific conductivity for the monitoring period. The observed pool depth data at Site 12 exhibited very high variation (ranging from approximately 1.5 m down to nearly dry (logger was out of water from around 03/02/2025), demonstrating a significant decline from November 2024 through early 2025.
- Based on observations on 28/05/2025 (Photo 19) the pool was stagnant and discoloured, indicating disconnection from groundwater (In contrast, a groundwater-connected pool would appear as in Photo 24).
- The rapid drop to dry conditions and prolonged dry periods, even with intermittent minor rainfall, suggest that **the local groundwater levels that support this pool have declined significantly resulting in disconnection from the shallow groundwater** for at least part of the monitoring period.
- According to the landholder, this pool usually shows significantly less variation in water level than was observed in the extended dry period from late 2005 to early 2025.

Site 13 Lower Upper Flaxman

- Site 13 (Figure 21) is downstream of Site 12 and it represents a better groundwater connective pool compared with other pools in Flaxman Valley. It displayed a minimal pool depth variation throughout the year until November 2024. Similar to the rest of the pools the pool depth gradually declined during the low rainfall period between November 2024 and March 2025, but maintained a pool depth around 0.6 m.
- This demonstrates the **pool's high groundwater connectivity throughout the whole monitoring period.**

Site 14 Upper Mid Flaxman

- Pool depth at Site 14 (Figure 22) declined from 1.36 m to near-dry conditions (logger was out of the pool) by mid-December 2024.
- Similar to the pool at Site 12, the water in this pool was observed to be stagnant and discoloured (Photo 21).
- As the last permanent pool before the confluence of North Para and Stone Chimney Creek, **its prolonged dry period reflects a lack of sustained inflow and disconnection from the shallow groundwater**.

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4.6.2 Comparison with streamflow and rainfall

The variation in streamflow observed at the Mount McKenzie (A5050533) gauging station during the pool monitoring period (Figure 19) aligns with the trend recorded at the Penrice gauging station. From February 2024 to mid-June 2024, and again from December 2024 to March 2025, the streamflow level was below the recordable range, indicating no measurable flow. Although there was minor flow peaks observed between July and November 2024, these were relatively small (0.02-0.15 ML/day). Overall, the extended low- and no-flow periods indicates persistent dry conditions and limited catchment runoff throughout much of the monitoring period.

The streamflow gauge is located near the permanent pool at Site 13. Site 12 lies in the headwaters, while Site 14 is situated just downstream of the gauge. All permanent pools, except the one at Site 13, exhibited a drying trend that appears to correlate to lower flows as shown in the streamflow records. This decline began at the end of November 2024, with a slight recovery during the winter months, before returning to near-dry conditions by the end of the monitoring period. The early months of 2025 experienced very low rainfall, which is reflected in both the streamflow and the condition of the permanent pools. The pool at Site 13, managed to retain water throughout the monitoring period. At Sites 12 and 14, the loggers were out of the water, and from observations in May 2025, both pools were nearly dry (Photo 19 and Photo 21). Further investigations are required to better understand the variability in pool depth and the factors influencing these patterns.

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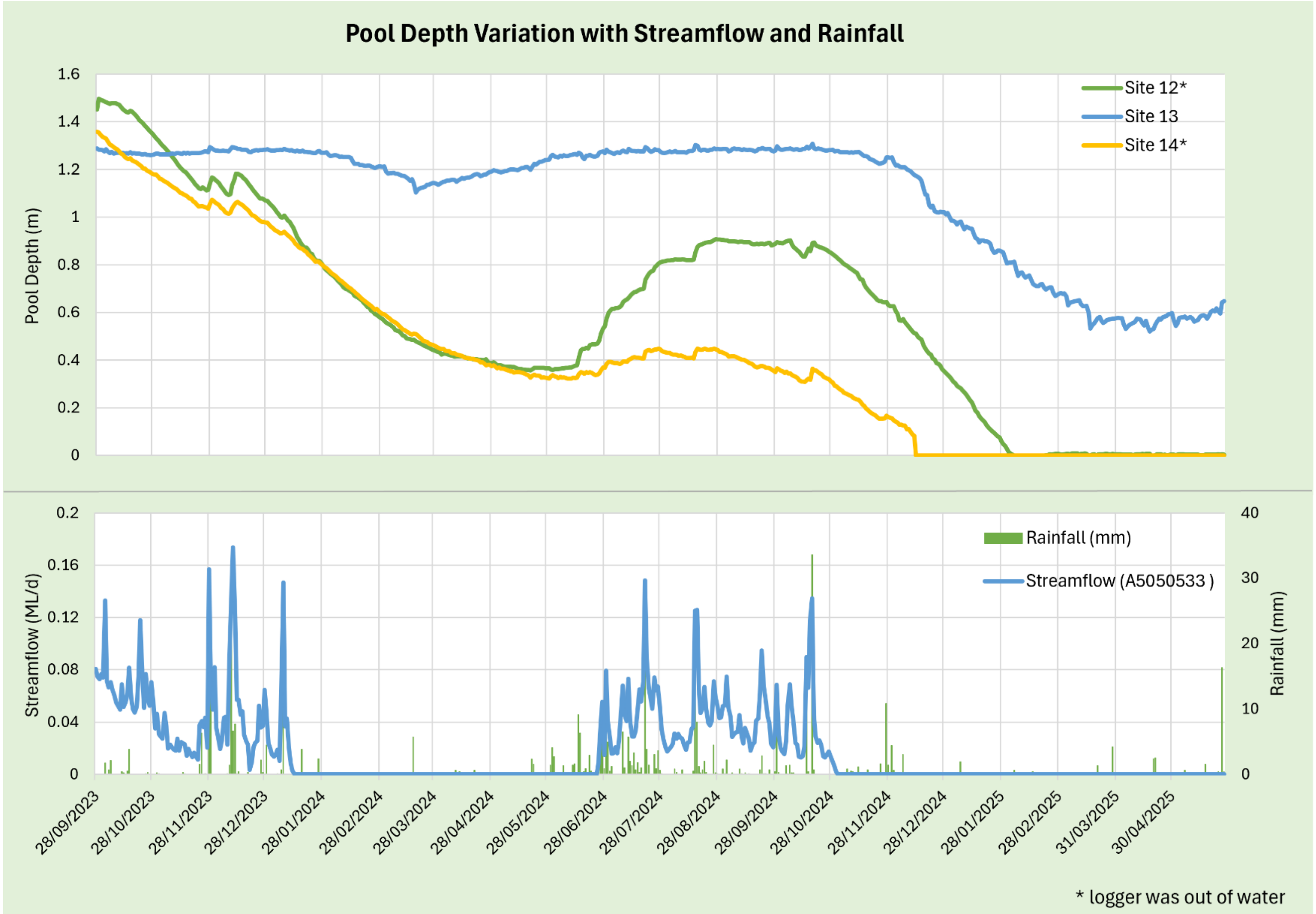

Figure 19. Variation in pool depth at Site 12, 13 and 14, compared with streamflow at Mt.Mckenzie (A5050533) and rainfall at Collingrove (23302)

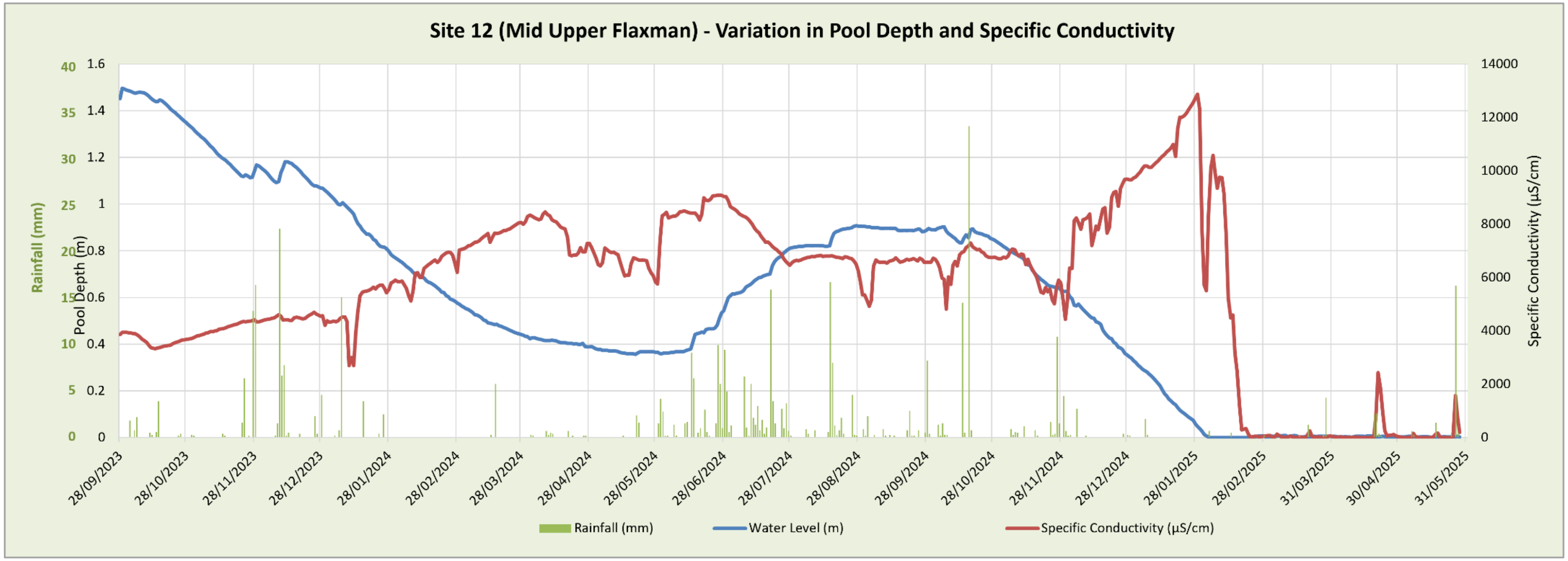

Figure 20. Site 12- Variation in pool depth and specific conductivity[7]

[7]Logger was out of water from early February (around 03/02/2025). Unusually high EC values are likely due to the logger being exposed to air after pool depth reduced

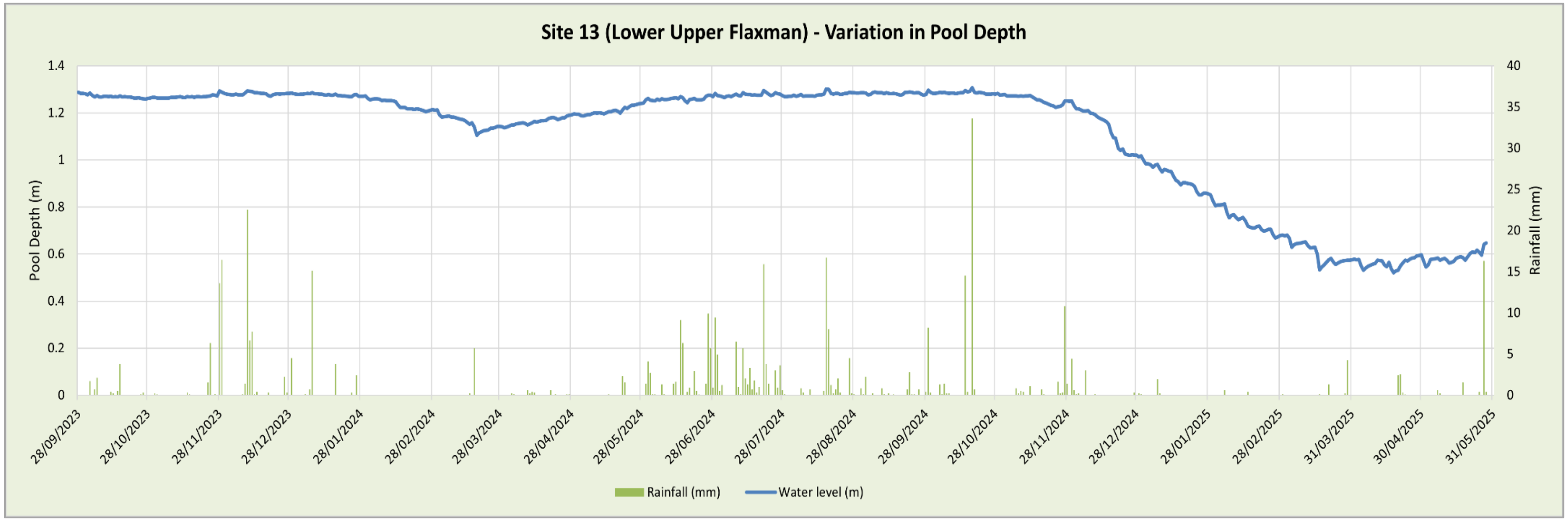

Figure 21. Site 13 - Variation in pool depth

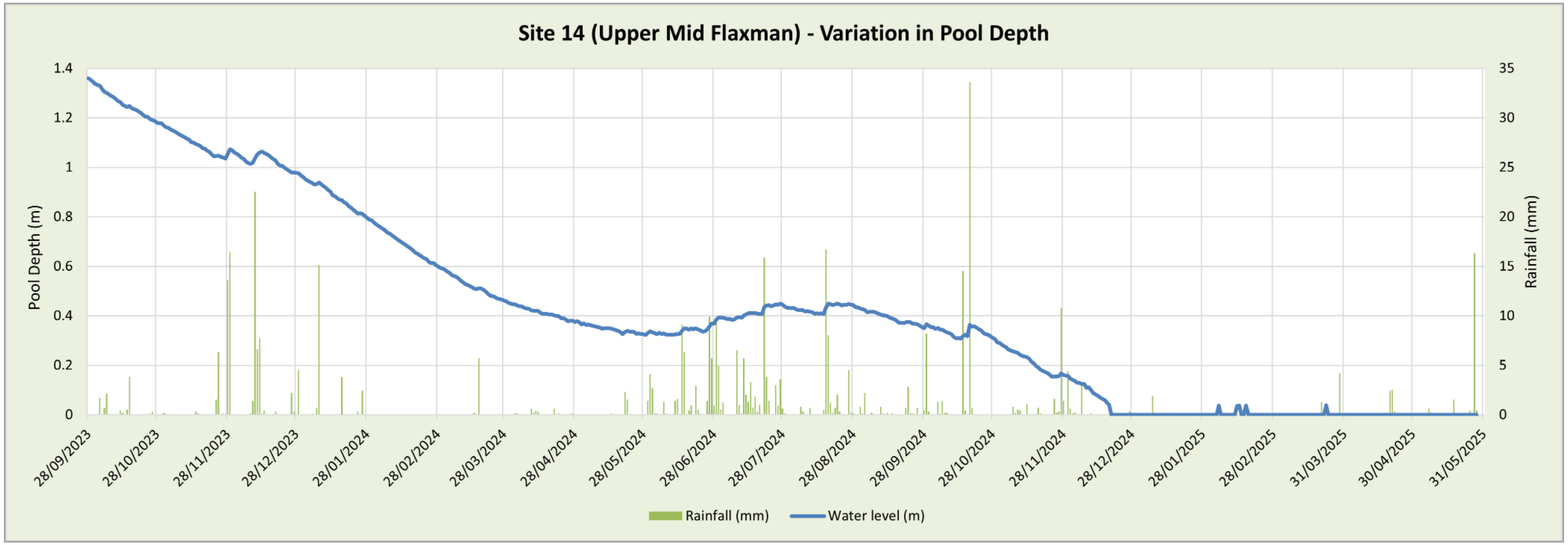

Figure 22. Site 14- Variation in pool depth[8]

[8] Logger was out of water (from around 19/12/2024)

4.7 Stone Chimney Creek

Site 15 Lower Stone Chimney

- This site is located at the outlet of Stone Chimney sub-catchment. Pool depth at Site 15 (Figure 23) ranged from 0.42 m to dry conditions indicating very low water persistence.
- The monitoring site dried rapidly from late September 2023 to mid-November 2023 and remained dry for most of the monitoring period.
- A brief rise in water level was recorded in late August 2024 but declined quickly, highlighting the pool's low capacity to sustain water over time.
- The monitoring site is used to get a record of flows coming out of Stone Chimney Creek. The observed pool depth trends suggest **limited connection to groundwater and poor water retention**. This section of the creek appears highly responsive to surface flow events, with little ability to maintain water levels during extended dry periods.

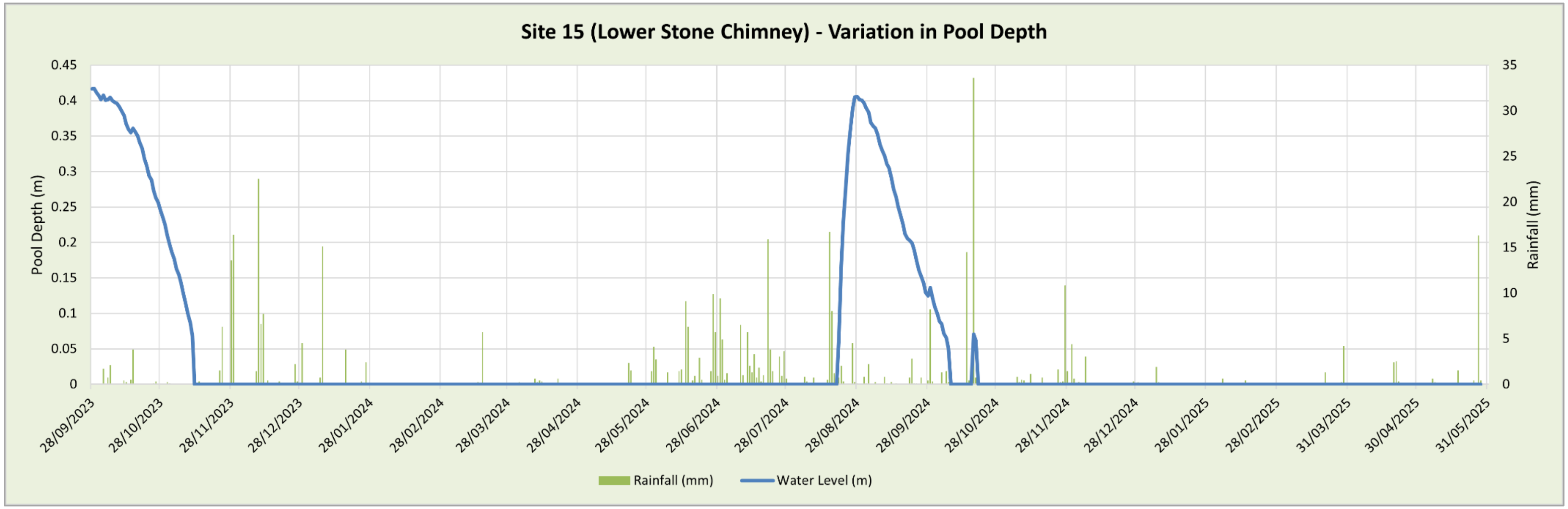

Figure 23. Site 15- Variation in pool depth[9]

[9] Pool was dry (around 11/11/2023 to 20/08/2024 and 22/20/2024 to end of monitoring)

5. Summary

The pools selected for monitoring under this project are considered representative examples of permanent pools within the PWRA. Pools were identified and selected using local knowledge of DEW staff and conversations with landholders. Criteria used for pool selection were their value as groundwater-dependent ecosystems, and evidence that pools were at least partially maintained through groundwater contributions. While this report summarises the data collected for a very short period (September 2023 to May 2025), it provides valuable insight and evidence on the behaviour of pools in the PWRA.

The key observations of monitoring and analysis are summarised below.

- This monitoring was undertaken during a notably dry period in the Barossa study area (September 2023 to May 2025), which provides valuable insight into how permanent pools respond under extended low-flow and low-recharge conditions.
- Monitoring suggests that most selected permanent pools are dependent on near-surface groundwater levels for at least part of the year.
- Most monitoring pools (except for Sites 1, 3, 4, 6, 9, 13 and 16) were reaching nearly dry or fully dry conditions by the end of the monitoring period (May 2025).
- According to Figure 3 and Hancock et al. (2014) the selected permanent pools are located in gaining reaches, where groundwater contributes to surface water. The declines in pool water levels observed since November 2024 indicate signs of stress, most likely linked to a declining trend in local groundwater levels. This is resulting in increased disconnection between pools and groundwater.
- Groundwater levels are declining (DEW, 2023) due to reduced rainfall volumes leading to reductions in recharge through both streambed and across the landscape.
- Measured declines in streamflow (DEW, 2023) due to reduced rainfall and upstream flow interception by large dams is exacerbating reductions in groundwater levels due to reduced opportunities for streambed recharge. Streambed recharge is likely a significant source of aquifer recharge relevant to maintenance of pool levels.
- Measured declines in streamflow is also leading to reduced water delivery to monitored pools, which in turn is leading to reductions in water quality and deteriorating ecosystem health (Savadamuthu et al., 2023).
- Although the monitoring period is relatively short, the behaviour of the pools during this time is concerning, particularly given that recent climate conditions and associated catchment runoff are projected to persist or worsen.

These findings provide important guidance for the strategic planning of Environmental Watering Plan for the Barossa catchment. It achieves this through providing evidence on the persistence of pool water level in the Barossa PWRA and providing insight into the surface and groundwater processes that likely drive and maintain these water levels.

The authors gratefully acknowledge the invaluable the immense contributions of Jennifer Munro and other staff from the Northern and Yorke Landscape Board throughout the entire process leading to the preparation this document.

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6. Appendix

6.1 Cross section and longitudinal section of the monitoring pools

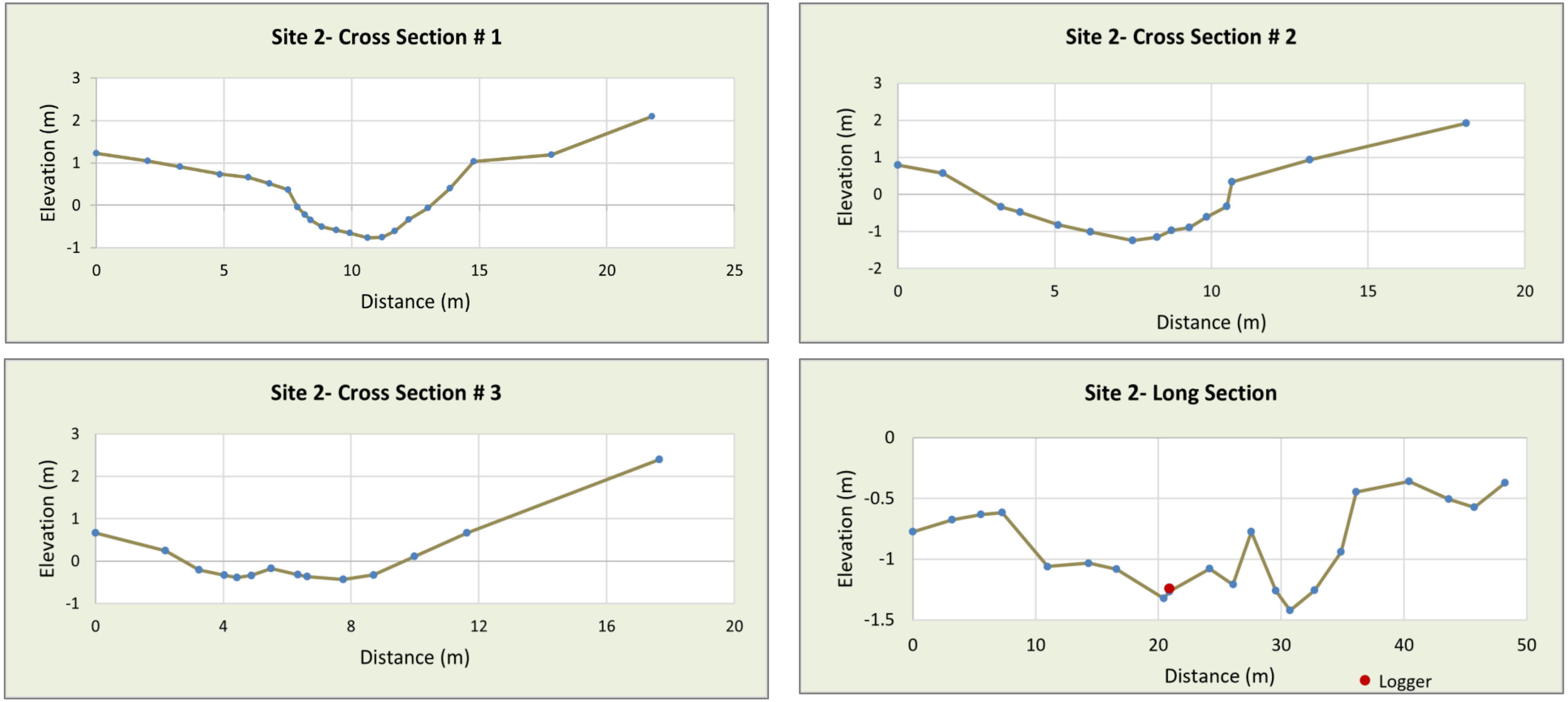

Figure 24. Site 2 - Cross section and longitudinal section

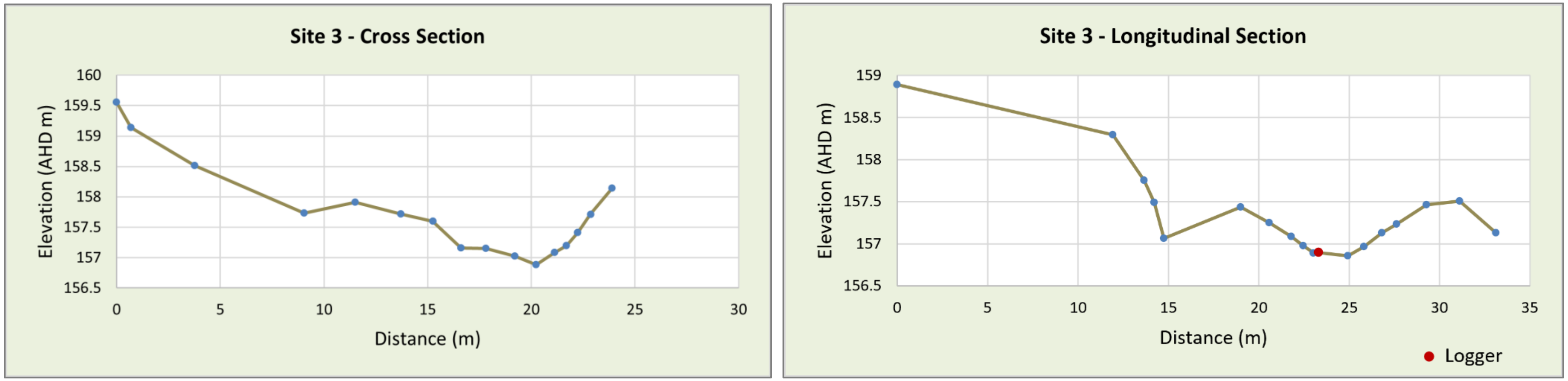

Figure 25. Site 3 - Cross section and longitudinal section

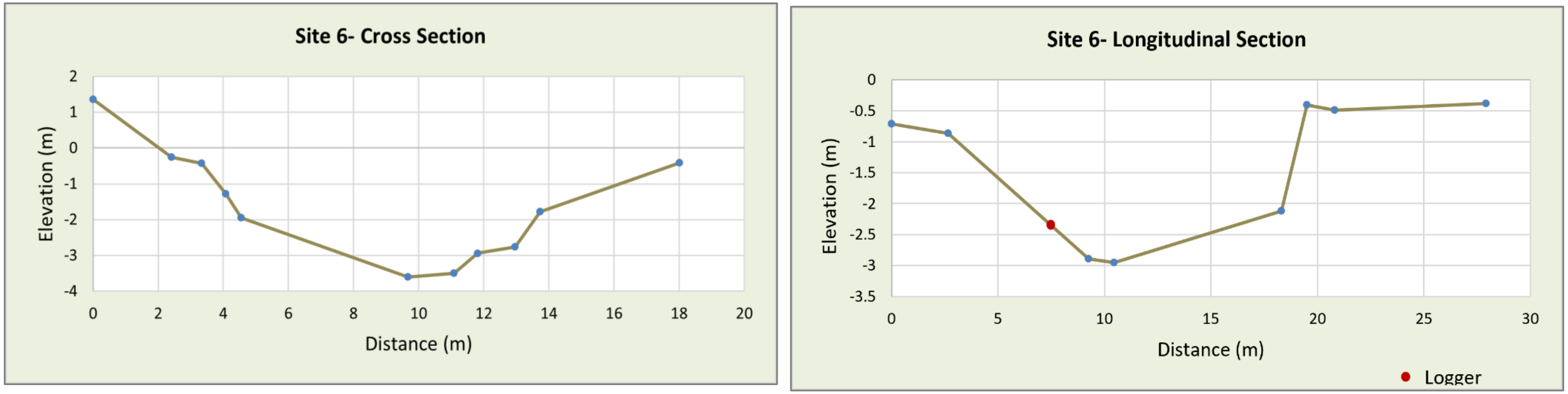

Figure 26. Site 6 - Cross section and longitudinal section

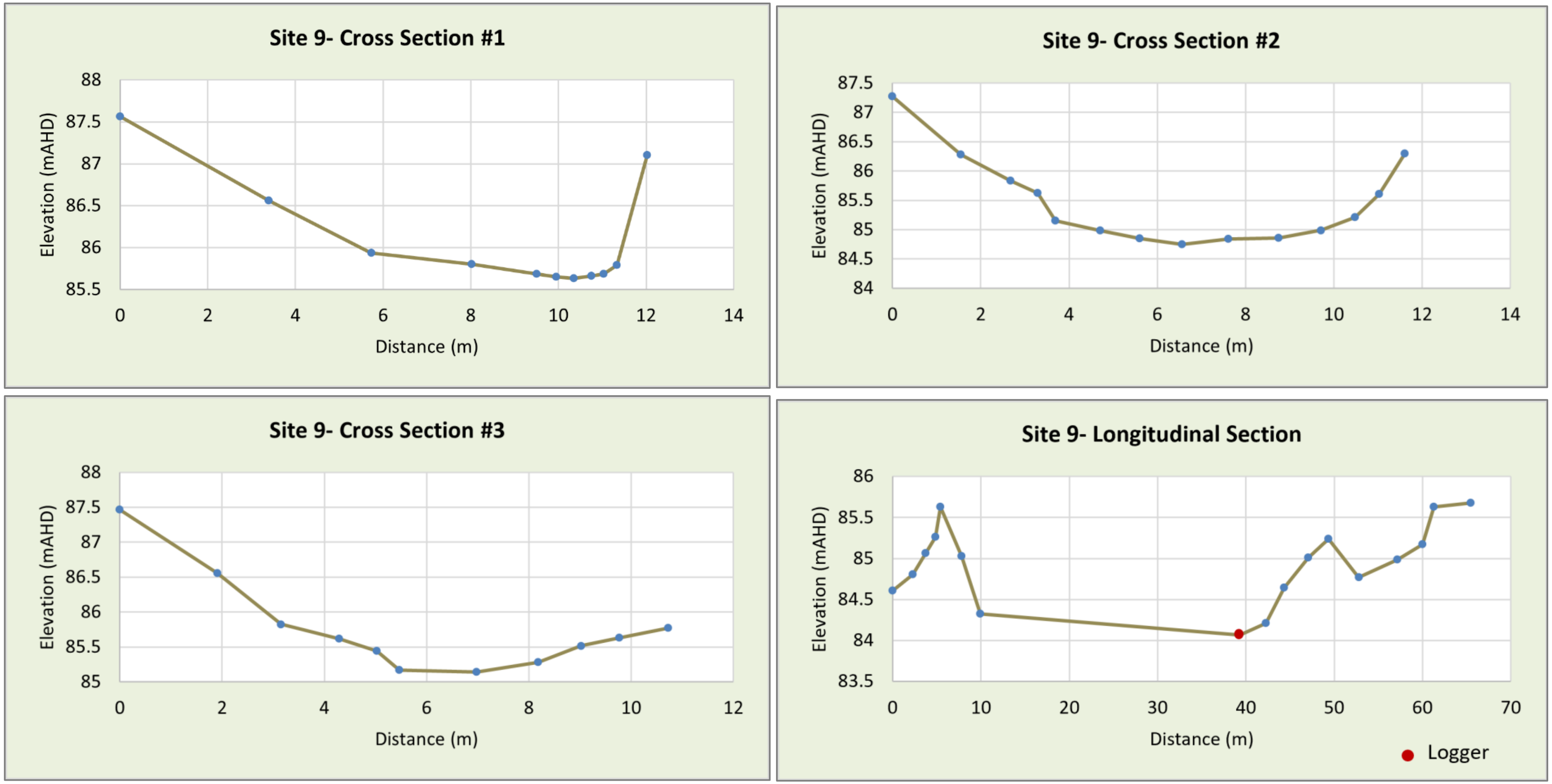

Figure 27. Site 9 - Cross section and longitudinal section

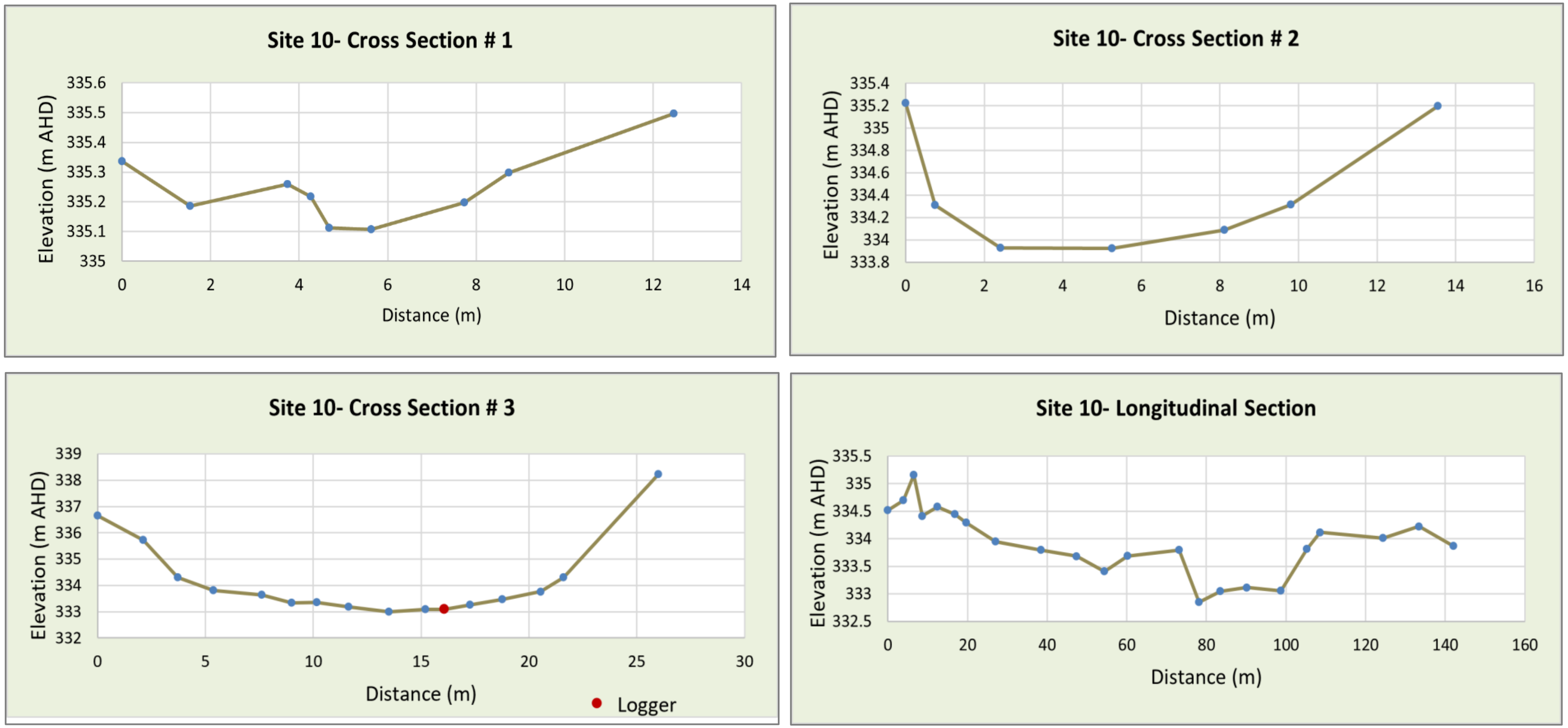

Figure 28. Site 10 - Cross section and longitudinal section

6.2 Photographs

Photo 1. Site 1 – November 2023

Photo 2. Site 2 - May 2025

Photo 3. Site 3- August 2023

Photo 4. Site 3 -May 2024

Photo 5. Site 3 – May 2025

Photo 6. Site 4- November 2023

Photo 7. Site 6 - November 2023

Photo 8. Site 6 – May 2024

Photo 7. Site 6 - May 2025

Photo 8. Site 7 - November 2023

Photo 9. Site 8 - May 2025

Photo 10. Site 9 – November 2023

Photo 11. Site 9 -May 2024

Photo 12. Site 9 – May 2025

Photo 13. Site 10 – November 2023

Photo 14. Site 10 – May 2024

Photo 15. Site 10 – May 2025

Photo 16. Site 11 - May 2024

Photo 17. Site 12 – November 2023

Photo 18. Site 12- May 2024

Photo 19. Site 12- May 2025

Photo 20. Site 13- May 2024

Photo 21. Site 14- May 2025

Photo 22. Site 15 – May 2025

Photo 23. Site 16- May 2024

Photo 24. Site 16- May 2025

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