MEMORANDUM

Winu Ecohydrology Assessment — Interim Findings

To:	Gerhard Berger, Worley
From:	Stuart Richardson, Richardson Consulting
Date:	29 June 2026
Subject:	Winu Ecohydrology Assessment — Initial Findings (Interim Memorandum)

Introduction

Richardson Consulting has been engaged to undertake a Stage 1 ecohydrological assessment for the Winu project, in accordance with the requirements of the GDE Toolbox (Richardson et al., 2011). This memorandum presents the interim findings of that assessment. A full report is being prepared.

Setting and potential water sources

The Rimfire area sits at an elevation of between 250 and 290 m AHD, with the lowest elevations in the south-east of the site, within the inferred boundary of the Percival Palaeovalley system. The palaeochannel is approximately 3 to 4 km wide and forms a local topographic low, sitting 5 to 10 m below the surrounding land.

Analysis by Worley (2024) identified a potential drainage pathway that coincides with the Percival Palaeovalley. Given the dune-dominated topography of the Rimfire area and aeolian sand cover extending to a depth of 20 mbgl, there are no clearly defined surface water paths. Rainfall is more likely to accumulate within the palaeochannel, where it may pool or flood, recharging the unsaturated zone and providing a potential water source for vegetation.

Groundwater is relatively shallow within the palaeochannel. Figure 1 shows the monitoring bore locations and key vegetation units, and Figure 2 presents the time-series groundwater depth data. Recent gauging data (2024–2025) record groundwater at depths of 3.5 mbgl (WINU1446) to 6.7 mbgl (WINU1445) in the north, and 9.5 mbgl (WINU1454) to 12 mbgl (WINU1453) in the south. Two further bores (WINU1451 and WINU1452), mapped within the south-western extent of the P23c vegetation zone but outside the palaeochannel, also record shallow groundwater (5.6–5.7 mbgl).

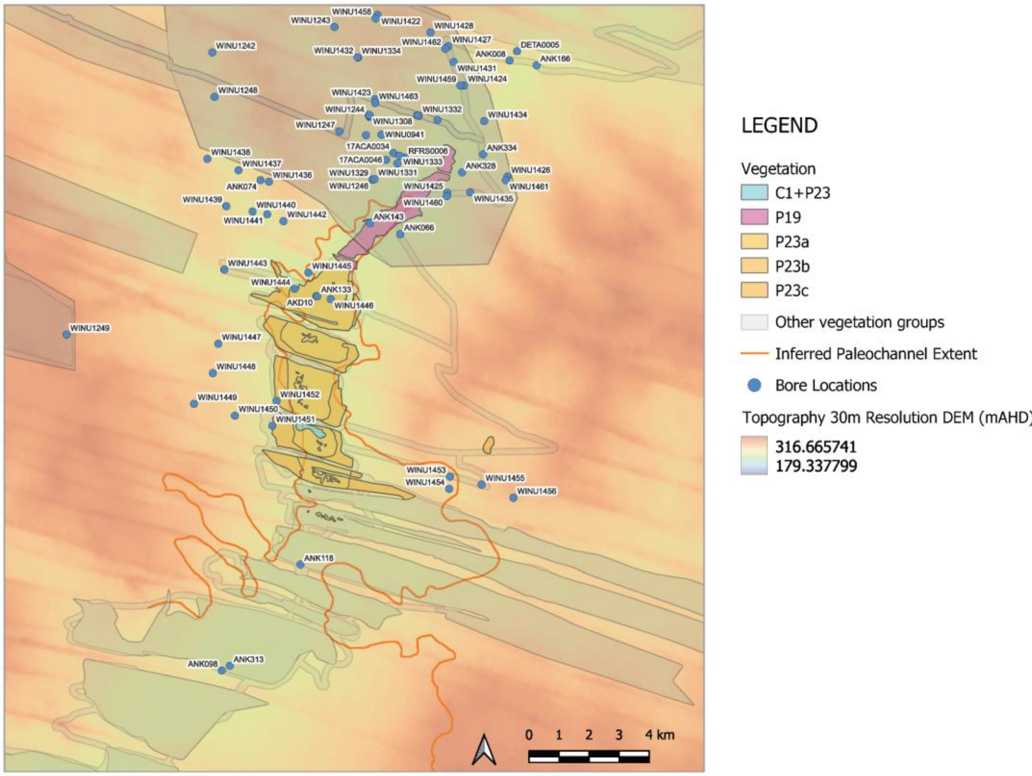

Figure 1. Groundwater monitoring bore locations and key vegetation units.

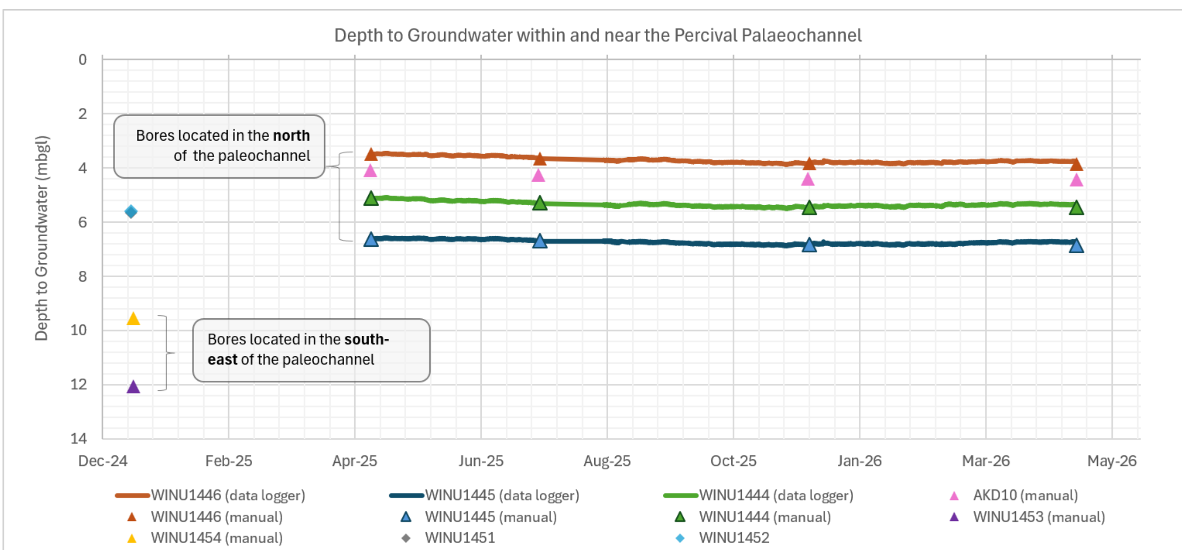

Figure 2. Time-series groundwater depth values.

The electrical conductivity (EC) of groundwater in the palaeochannel bores is approximately twice that recorded elsewhere. This may reflect evapoconcentration where groundwater is shallow, differences in host-rock chemistry, slower groundwater movement and longer residence times, or the presence of a different aquifer system or water source.

Vegetation units and potential for groundwater dependency

Recent botanical surveys of the Winu Project area (Western Botanical, 2025) found a strong spatial correlation between the palaeochannel and the occurrence of the following key vegetation communities:

- P23a – Melaleuca lasiandra, Melaleuca glomerata (Eucalyptus victrix, Acacia colei var. colei) open shrubland over Triodia basedowii (Acacia stellaticeps);
- P23b – Melaleuca lasiandra (Hakea lorea, Melaleuca glomerata) open shrubland over Triodia epactia (Euploca glandulifera, Ptilotus axillaris);
- P23c – Interzone – Melaleuca lasiandra, Melaleuca glomerata, Acacia ancistrocarpa (Acacia drepanocarpa, Acacia monticola) open shrubland over Triodia schinzii;
- P23d – Melaleuca glomerata scattered low shrubs over Trianthema turgidifolium (Triodia basedowii);
- C8 – Clay-pan (Eragrostis cumingii) with scattered herbs and grasses; and
- C1+P23 – Mosaic Eucalyptus victrix open woodland + Melaleuca spp. open shrubland.

A degree of correlation was also observed between the P19 association and the palaeochannel, with 50% of mapped P19 occurring within it. Other patches of P19 occur further north and west of the palaeochannel, where depth to water exceeds 40 mbgl:

- P19 – Low open shrubland of Melaleuca lasiandra, Acacia drepanocarpa subsp. latifolia, Acacia sericophylla, Acacia monticola, Acacia tumida var. kulparn and Gyrostemon tepperi over a low open shrubland of Gompholobium simplicifolium, Seringia exastia, Bonamia erecta, Dicrastylis cordifolia, Corchorus sidoides subsp. sidoides, Acacia melleodora, Hibiscus leptocladus, Ptilotus calostachyus, Sida sp. Pindan and Tribulopis marliesiae (P3).

The distinctive occurrence of these communities, combined with the potential presence of shallow groundwater, may indicate some level of groundwater dependence. Melaleuca species (M. lasiandra and M. glomerata), together with E. victrix, can use groundwater but may not depend on it entirely, instead drawing on water stores within the unsaturated zone when available. M. glomerata in particular is recognised as an obligate GDE (e.g. Brim Box et al., 2022), implying it is entirely dependent on groundwater for survival. While dependence is plausible, there is little direct evidence that groundwater is the only water source at this location. Whether M. glomerata would survive declining groundwater levels can only be resolved through ongoing ecohydrological monitoring.

E. victrix can potentially access groundwater but is also able to draw on other sources, such as unsaturated-zone water stores. Fan et al. (2017) report a mean rooting depth of 8.71 m for E. victrix, based on 45 rooting-depth observations across the Pilbara, and the species can reach rooting depths of 15–20 m where deeper water tables exist. Its rooting depth can be inferred from long-term water-table elevations because it demonstrates 'opportunistic physiognomy in using water' — extending roots to the water table when shallow soil stores are depleted and the table has declined. Other studies in the eastern Pilbara indicate that E. victrix is not dependent on groundwater where geological barriers limit root development, or where groundwater is deeper than 10 m.

A spatial correlation between vegetation and the palaeochannel may also arise from environmental conditions other than groundwater, including:

- **Local change in soil type —** the palaeochannel's distinctive shallow geology may produce a different regolith or soil type that is favourable, or unfavourable, to particular ecological communities. Such differences in soil composition and chemistry may not be visually evident; and
- **Local change in topography —** the palaeochannel occupies a topographic low (5 to 10 m below the surrounding land) that is likely to retain surface run-off for longer than the adjacent land.

Remote sensing

Overview of approach

The core hypothesis is that vegetation communities relying on groundwater will maintain comparatively higher greenness through the dry season, while non-groundwater-dependent vegetation will show a pronounced seasonal decline. The analysis therefore focuses on dry-season greenness retention as a proxy for the persistent availability of water, including groundwater.

Two high-resolution satellite image acquisitions bracket the wet and dry seasons. The wet-season imagery was acquired by Pleiades Neo (PNEO):

Scene	Sensor	Date	Native MS Resolution	PAN Resolution
PNEO4	Pleiades Neo 4	17 August 2025	1.2 m	0.3 m
PNEO3	Pleiades Neo 3	9 July 2025	1.2 m	0.3 m

The dry-season imagery was acquired by Pleiades 1 (PHR):

Scene	Sensor	Date	Native MS Resolution	Notes
PHR1A	Pleiades 1A	13 November 2024	2 m	Primary dry reference
PHR1B	Pleiades 1B	10 March 2025	2 m	Gap-fill (transitional / fairly wet)

Two vegetation indices were computed for both seasons from the imagery:

- **MSAVI (Modified Soil-Adjusted Vegetation Index) — primary index.** MSAVI adaptively accounts for soil brightness, making it more suitable than NDVI for sparse vegetation over bright laterite and sandy soils. In this environment, bare-soil reflectance varies strongly across rock, sand and duricrust substrates, and NDVI can produce spuriously high values over bright soils. MSAVI suppresses this effect and provides more consistent vegetation detection across heterogeneous backgrounds. It is used as the primary index for segmentation masking and persistence ranking.

- **NDVI (Normalised Difference Vegetation Index) — secondary index.** NDVI is retained for comparison and for compatibility with standard industry interpretation. Using only the Red and NIR bands, it is directly comparable across scenes after IR-MAD correction.

Persistence

Vegetation that remains green throughout the dry season is considered a candidate for groundwater dependence. However, applying a fixed, absolute MSAVI or NDVI threshold to identify ‘persistently green’ vegetation is unreliable in arid landscapes: bare-soil reflectance varies widely across the scene, and species composition differs between geomorphic units (dune, swale, palaeochannel). A relative persistence approach is therefore used, ranking objects (canopy) against the local scene distribution rather than against a fixed threshold. Qualifying objects are assigned to tiers based on their persistence score:

Tier	Criterion	Interpretation
P1	Score ≥ 75th percentile	Strongest dry-season greenness retention — highest-priority GDE candidates
P2	Score ≥ 50th percentile	Moderate dry-season retention — secondary GDE candidates
P3	Score < 50th percentile	Low dry-season retention — unlikely to be groundwater dependent
Background	Did not meet wet-season qualifier	Outside the analysis domain

Together, P1 and P2 form the candidate GDE layer delivered to the client, with P1 the recommended priority tier for field verification.

Output

The remote sensing results for the P1 tier (Figure 3) indicate potential for groundwater dependence across a range of vegetation types within the palaeochannel. This is consistent with the known presence of shallow groundwater and the vegetation species associated with potential groundwater use.

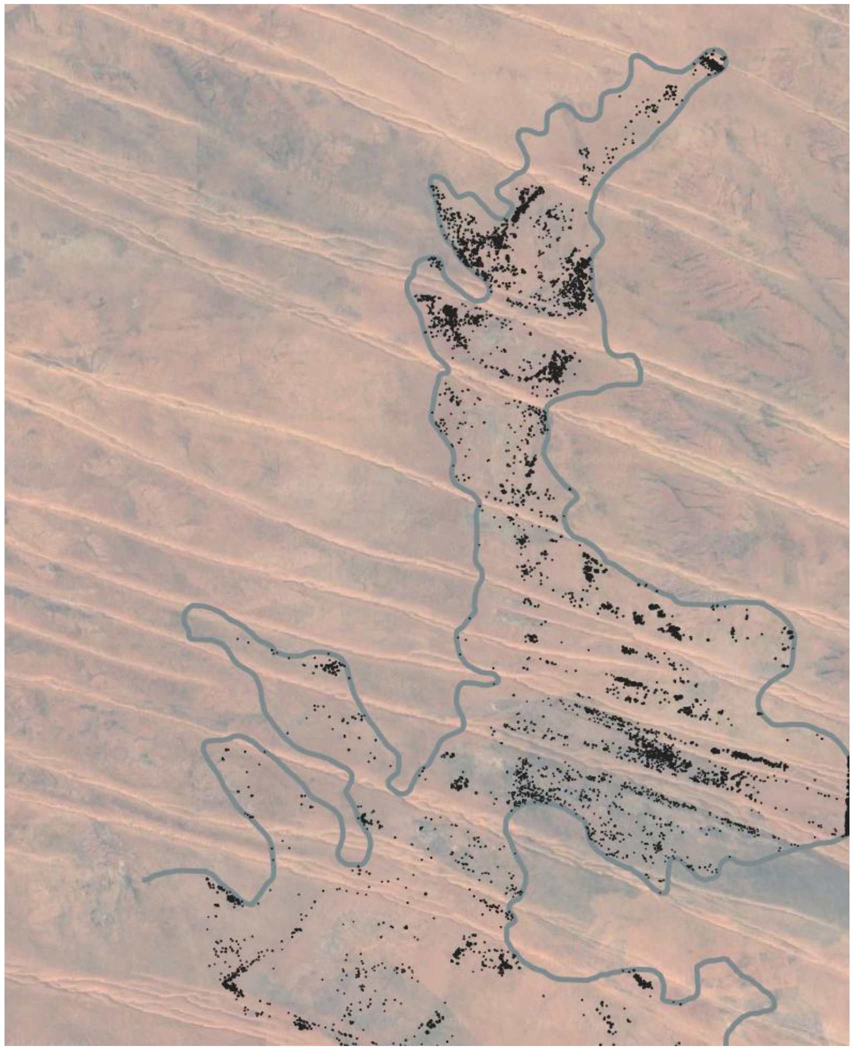

Figure 3. P1 (75th percentile) tier of MSAVI persistence, inferring areas of potential groundwater-dependent vegetation.

Important caveats and further analysis

- **Relative, not absolute, persistence.** The persistence score is relative to the scene. A P1 object in a stressed landscape may have a lower absolute MSAVI than a P3 object in a more productive landscape. The score is a within-scene ranking, not a universal measure of greenness.
- **Maximum object-size cap.** Objects larger than 5,000 m² (~80 m diameter) were excluded from the OBIA output. Large connected patches, such as dense Melaleuca stands, may be candidates for manual delineation or polygon splitting.
- **Single wet season.** The analysis compares a single wet-season acquisition (August 2025) against a single dry-season composite, so inter-annual variability is not captured.
- **Alternative water sources.** Persistence is used to infer potential groundwater use, but sufficient moisture retained in the unsaturated zone through the dry season could also sustain greenness.

- **Further analysis.** Sentinel-2 imagery will be added to provide a multi-year analysis of wet–dry season comparisons, albeit at a coarser 10 m pixel size.

This remote sensing analysis provides a single line of evidence to support inferences about potential groundwater use by vegetation. Further field-based investigation and ongoing monitoring — focused on the P1 tier — are required to confirm vegetation's reliance on groundwater.

Potential effects of drawdown in groundwater levels

The following commentary on impacts is based on the estimated drawdown in groundwater levels at the end of mine life (EOM) under the P90 scenario, for the vegetation units within the palaeochannel:

- **E. victrix open woodland (C1+P23).** This area lies south of the one-metre drawdown contour, indicating that no impact on groundwater availability is expected.
- **M. glomerata and M. lasiandra open shrubland (P23a, P23c).** This area has a depth to groundwater of three to seven mbgl, with drawdown estimated at one to two metres at EOM. Under current conditions, M. glomerata and M. lasiandra may access groundwater during dry periods, and a decline of one to two metres could affect water availability. However, the modelling indicates this drawdown would occur gradually over 15 to 20 years, providing an opportunity for vegetation to adapt and extend root systems as groundwater levels fall.
- **M. lasiandra low open shrubland (P19).** This area, at the northern end of the palaeochannel, has an estimated drawdown of two to five metres at EOM, which could affect water availability. As above, the modelled drawdown is expected to occur gradually over 15 to 20 years, allowing time for vegetation to adapt and extend root systems. There is no groundwater-depth measurement in this area, although the modelled water table rises north of the palaeochannel, suggesting reduced potential for groundwater dependency.

Monitoring and management with triggers

The proposed approach of using groundwater trigger values is supported. Management of potential changes in groundwater conditions and associated impacts will be guided by a monitoring, trigger-level and management-response framework. The framework is hierarchical, so the scope of the management response is commensurate with the degree of change relative to the triggers. For example, exceeding the 'early response' trigger requires additional monitoring effort to confirm trends, while exceeding criteria level 2 — where drawdown approaches or exceeds natural fluctuations and the P90 modelled predictions for two consecutive monitoring periods — requires reduction or suspension of borefield operations to limit further drawdown and allow recovery.

- **Location of monitoring.** Groundwater monitoring should occur where potential groundwater-dependent vegetation is present, with sites chosen across a range of baseline groundwater depths and vegetation species.
- **Add vegetation monitoring.** The groundwater trigger framework should be expanded to include vegetation condition and water-use monitoring, using both remote sensing and on-ground surveys (e.g. understorey and canopy condition, and leaf water potential). This would establish an ecohydrological framework that links changes in groundwater conditions to changes in vegetation condition.
- **Monitor control sites.** The proposed monitoring sites all lie within the area of estimated drawdown. The monitoring should be expanded to include control sites that measure natural, climate-driven fluctuations in groundwater and vegetation conditions.
- **Adjust over time.** The management approach should allow triggers to be revised as more is learned about the relationship between groundwater and vegetation condition. For example, ongoing monitoring will confirm the degree of vegetation dependence on groundwater, which in turn informs trigger values.

Preliminary findings

- Groundwater is shallow in the area of the palaeochannel and is likely a source of water for vegetation, alongside unsaturated-zone water stores that accumulate in the low-lying palaeochannel.
- The species M. lasiandra, M. glomerata and E. victrix are present within the palaeochannel. These species can access groundwater where root systems extend to the water table, but may also be able to use other sources, such as unsaturated-zone stores, when available.
- Preliminary remote sensing analysis of vegetation persistence suggests that vegetation in this area was persistently using water during the dry season, inferring possible use of groundwater (further multi-year analysis is underway).
- Modelled drawdown in groundwater levels is very gradual, allowing time for root systems to adapt.
- This preliminary assessment is based on limited data. Observations on the potential for groundwater dependency and response to change are preliminary only, but will be confirmed through targeted field investigation and ongoing monitoring under a trigger-based management regime.
- The proposed trigger-based management approach is supported as a mechanism to limit impacts, but should be integrated with vegetation monitoring to provide a better understanding of hydrological-ecological relationships. Add monitoring at control sites.

Next steps

- Complete the remote sensing analysis of vegetation persistence with multi-year Sentinel-2 data.
- Prepare an ecohydrological conceptual model.

- Prepare a report, including recommendations for further investigations to support this ecohydrological assessment.

References

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