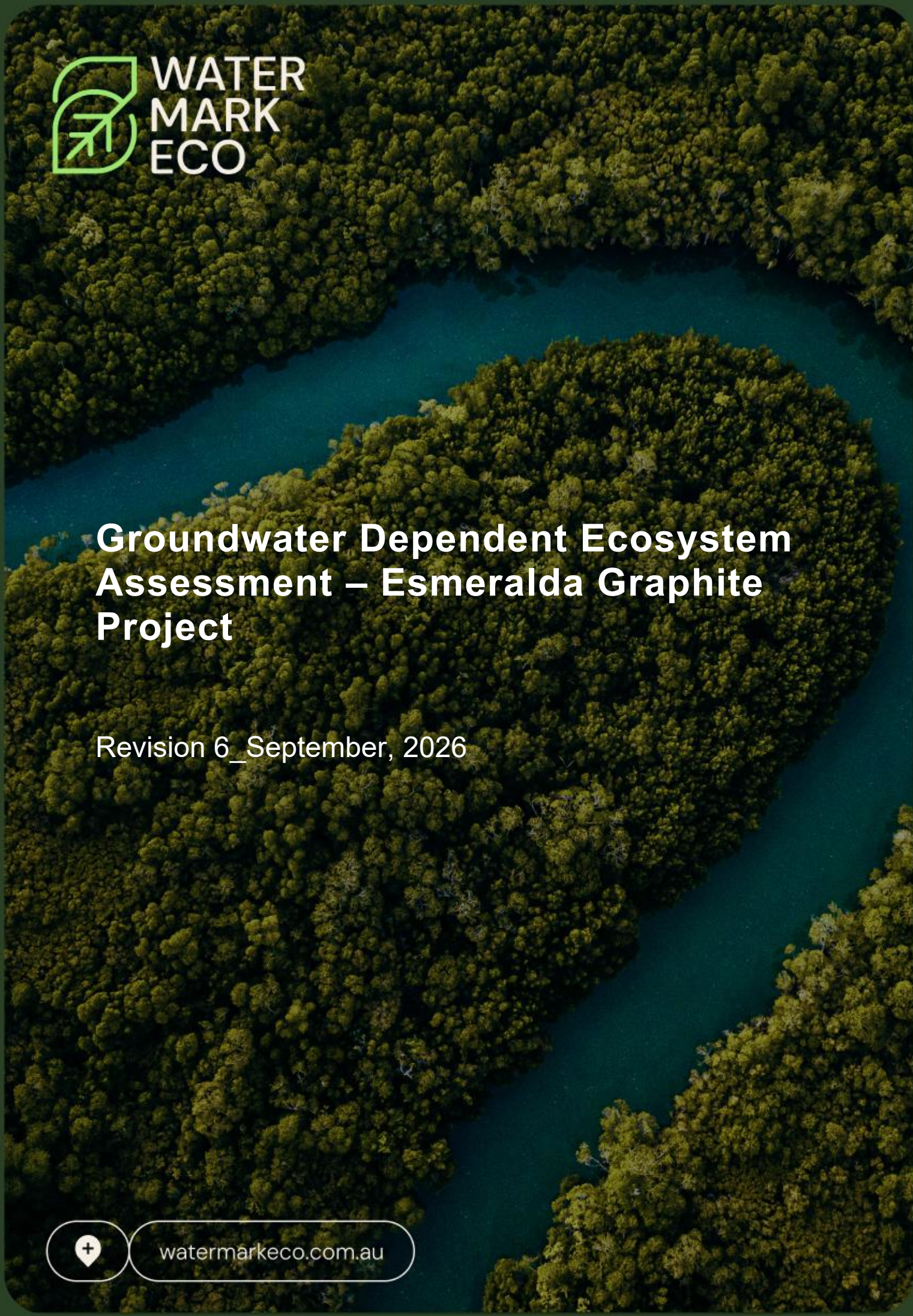
Graphinex – Esmeralda Graphite Project

Environmental Impact Statement

Appendix G – Groundwater Dependent Ecosystem Assessment

GRAPHINEX



Groundwater Dependent Ecosystem Assessment – Esmeralda Graphite Project

Revision 6_September, 2026

watermarkeco.com.au

Project No. 2025_19

Project Manager: David Stanton

Client: Graphinex Pty Ltd / AARC Environmental Solutions Pty Ltd

Purpose: Groundwater Dependent Ecosystem Assessment for the Esmeralda Graphite Project.

Report	Revision	Date Issued	Issued By.	Purpose
GDE Impact Assessment	REV 1	17 December 2025	David Stanton	First revision GDE assessment prior to inclusion of stable isotope results
	REV 2	11 February 2026	David Stanton	Updated report following client comments
	REV 3	11 April 2026	David Stanton	Inclusion of stable isotope results and impact assessment.
	REV 4	27 April 2026	David Stanton	Updates to regional ecosystem mapping included
	REV 5	26 May 2026	David Stanton	Final report following comments from OCG
	REV 6	23 Sept 2026	David Stanton	Updated report following further comments from OCG

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Please contact me if further information is required concerning any aspect of this document

Yours Sincerely,



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Executive Summary

Watermark Ecohydrology was engaged by AARC Environmental Solutions, on behalf of Graphinex Pty Ltd, to undertake a groundwater-dependent ecosystem assessment to support an application to mine the graphite resources associated with the Esmerelda Granite through an open-cut mining operation. \The study utilised multiple lines of evidence, as recommended in federal GDE assessment guidelines, including measurement of leaf water potential and soil moisture potential to identify the occurrence and ecohydrological function of any GDEs within the Project site.

The dry-season assessment, conducted under optimal seasonal conditions for assessing groundwater dependence, confirmed the following ecohydrological relationships.

- The dry-season moisture required to support transpiration in woody vegetation is supplied entirely within the vadose zone across all habitats sampled.
- Swamp wetland depressions (RE2.3.55d) and ephemeral flood channel habitats (RE2.3.26c) retain moisture into the dry season by capturing surface flows and facilitating moisture infiltration, with moisture availability declining as seasons dry.
- In swamp wetland depressions, there may be some ephemeral zones of saturation as ponded surface water infiltrates into the wetland soil profile and infiltration is retarded by clay soil horizons. This saturation would be fleeting and not consistent with the definition of groundwater.
- Wet-season recharge of fluvial sands in ephemeral drainage lines facilitates the perching of shallow groundwater, hosted in channel sand deposits, on impermeable basement rock. Woody vegetation usage of this perched groundwater suggests that these watercourses represent GDEs when perched groundwater is present. Perched groundwater, however, rapidly diminishes as the climate dries, and riparian woodlands become solely reliant on soil moisture.

The recent installation of groundwater monitoring bores indicates that groundwater hosted in the Gilbert River Sandstone is under sub-artesian pressure, with a potentiometric surface at ~7 metres below ground level. However, the biophysical assessment does not indicate that this deeper groundwater interacts with the woody vegetation's rooting zone. Overall, the data indicate low moisture availability across most, if not all, terrestrial habitats, suggesting that the potential for groundwater reliance is extremely low within the proposed MLA and its surrounding landscape.

While modelling indicates project-related groundwater drawdown in the aquifer at the base of the Gilbert River Formation, this groundwater does not support either terrestrial or aquatic GDEs, and project-related GDE impacts are not predicted.

Glossary

Alluvial aquifer	An aquifer comprising unconsolidated sediments deposited by flowing water usually occurring beneath or adjacent to the channel of a river.
Aquifer	A geological formation or structure that stores or transmits water to wells or springs. Aquifers typically supply economic volumes of groundwater
Aquatic GDE	Vegetation supported by surface expression of groundwater (e.g., spring fed watercourses and associated fringing vegetation).
Base flow	Streamflow derived from groundwater seepage into a stream.
Capillary fringe	The unsaturated zone above the water table containing water in direct contact with the water table though at pressures that are less than atmospheric. Water is usually held by soil pores against gravity by capillary tension.
Confined aquifer	A layer of soil or rock below the land surface that is saturated with water with impermeable material above and below providing confining layers with the water in the aquifer under pressure.
Evapotranspiration	The movement of water from the landscape to the atmosphere including the sum of evaporation from the lands surface and transpiration from vegetation through stomata
Facultative phreatophyte	A plant that occasionally or seasonally utilises groundwater to maintain high transpiration rates, usually when other water sources aren't available.
Fractured rock aquifer	An aquifer in which water flows through and is stored in fractures in the rock caused by folding and faulting.
Fluvial	Relating to processes produced by or found in rivers
Groundwater	Those areas in the sub-surface where all soil or rock interstitial porosity is saturated with water. Includes the saturated zone and the capillary fringe.
Groundwater dependent ecosystems (GDE)	An ecosystem that depends, either wholly or partially, on groundwater to meet their moisture requirements to maintain ecological processes.
Infiltration	Passage of water into the soil by forces of gravity and capillarity, dependent on the properties of the soil and moisture content.
Leaf water potential (LWP)	The total potential for water in a leaf, consisting of the balance between osmotic potential (exerted from solutes), turgor pressure (hydrostatic pressure) and matric potential (the pressure exerted by the walls of capillaries and colloids in the cell wall).
Leaf area index (LAI)	The ratio of total one-sided area of leaves on a plant divided by the area of the canopy when projected vertically on to the ground.
Obligate phreatophyte	A plant that is completed dependent on access to groundwater for survival
Percolation	The downward movement of water through the soil due to gravity and hydraulic forces.
Permeability	A materials ability to allow a substance to pass through it, such as the ability of soil or rocks to conduct water under the influence of gravity and hydraulic forces.
Permanent wilting point	The water content of the soil at which a plant can no longer extract water and leaves will wilt and die. Usually 1.5 Mpa (-217 psi). Generally applied to crops although Australian flora typically have much larger stress thresholds.
Phreatic zone	The zone of sub-surface saturation separated from the unsaturated zone in unconfined aquifers by the water table.
Soil water potential	A measure of the difference between the free energy state of soil water and that of pure water. Essentially a measure of the energy required to extract moisture from soil.
Stable isotope	An isotope that does not undergo radioactive decay.
Standard Wilting Point	The minimum LWP or corresponding soil moisture potential that can be tolerated before a plant wilts in response to negative water supply. This is accepted at -15 bars or -1.5 MPa (or -217.55 PSI).

Specific Yield	The ratio of the volume of water that a saturated rock or soil will yield by gravity to the total volume of the rock or soil.
Surface water	Movement of water above the earths' surface as runoff or capture in streams and closed depressions.
Transpiration	The process of water loss from leaves, through stomata, to the atmosphere.
Terrestrial GDE	Terrestrial vegetation supported by sub-surface expression of groundwater (i.e., tree has roots in the capillary fringe of groundwater table).
Unconfined aquifer	An aquifer whose upper surface is at atmospheric pressure, producing a water table, which can rise and fall in response to recharge by rainfall
Vadophyte	Flora species relying solely on moisture from the vadose zone to drive transpiration.
Vadose zone	The unsaturated zone, above the water table in unconfined aquifers
Water Potential	The free energy potential of water as applied to soils, leaves plants and the atmosphere.
Wetting front	The boundary of soil wet by water from rainfall and dry soil as the water moves downward in the unsaturated zone.

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1.0 Introduction

AARC Environmental Solutions Pty Ltd (AARC), on behalf of Graphinex Pty Ltd (Graphinex), engaged Watermark Ecohydrology to undertake a groundwater-dependent ecosystem (GDE) assessment to provide information necessary to manage the proposed mining of the Esmeralda Graphite Project (the Project). The Project site (the Site) is located approximately 70km south of the Croydon township, 400 kilometres (km) west of Cairns in far north Queensland (**Figure 1**).

The objective of this study is to identify the occurrence and ecohydrological function of any GDEs within the Project site and surrounds, so that the potential risks posed by the mining operation can be adequately assessed. The assessment includes both field and desktop components.

1.1 Project Description

The Project proposes to mine the graphite resources associated with Esmerelda Granite, supporting an open-cut mining operation. Mining will occur within the proposed MLA to produce ~ 3.5 million tonnes per annum (Mtpa) of Run-of-Mine (ROM) for an operational life of approximately 53 years. The operation will involve:

- Construction of an open-cut graphite mine using trucks and excavators to a depth of ~ 250m below ground level.
- Deposition of excavated overburden and non-ore-bearing material in waste dumps adjacent to the open pit.
- Delivering graphite ore to the mineral processing plant, processing of graphite ore and transfer of flotation tailings to storage facilities.
- Establishment of operational infrastructure to support the project.
- Progressive mine rehabilitation of waste dump and tailings cell areas.
- Back fill the void and undertake post-mining rehabilitation.

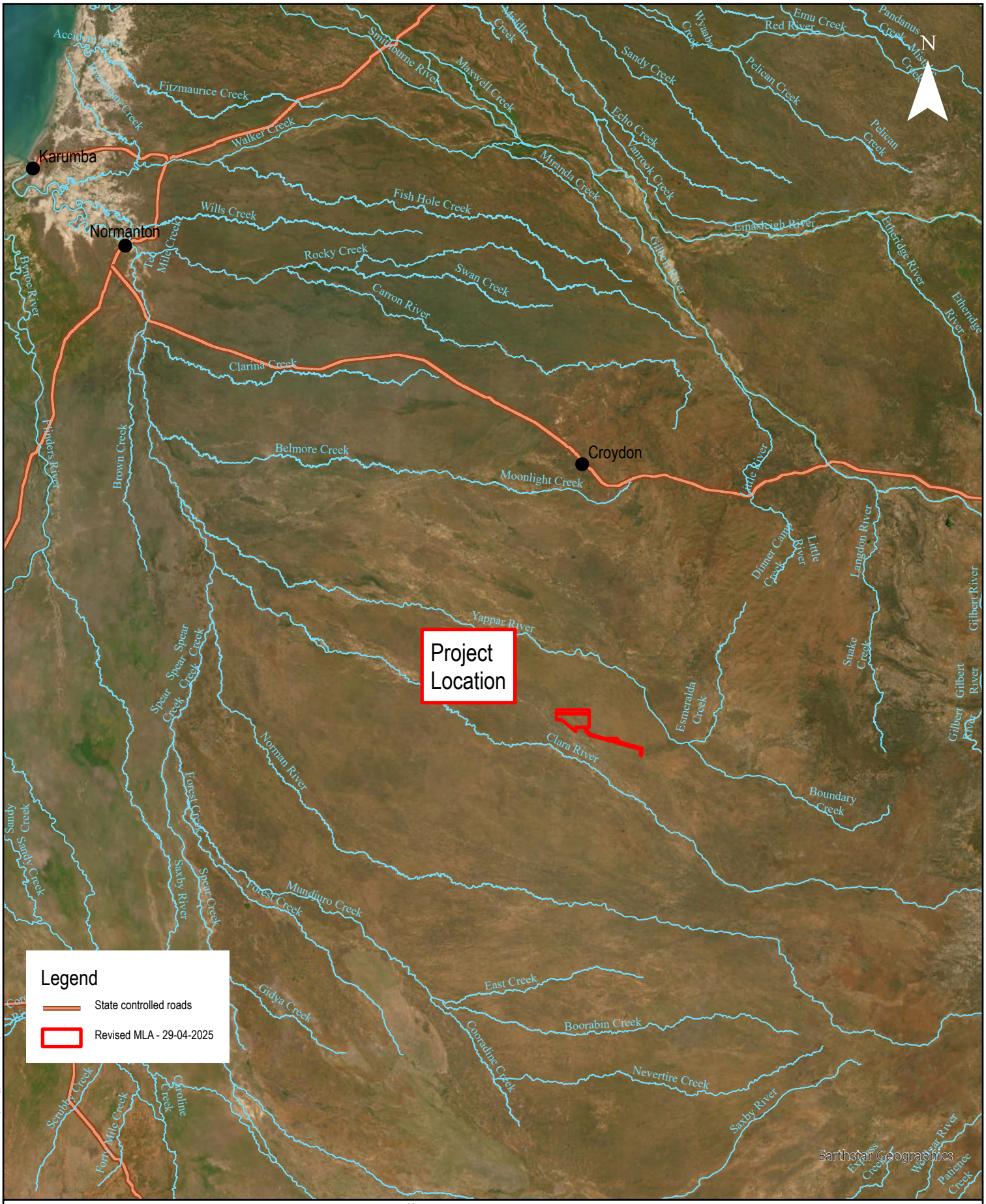
A general overview of the Project components, taken from the IAS (AARC 2025) is shown in **Figure 2**.

1.2 Project objectives

The objective of this study is to provide a field-based investigation to assess the presence and nature of GDEs within and surrounding the Project area, which may be subject to an impact due to groundwater changes (e.g. drawdown) resulting from the proposed mining activities. Completion of the field-based assessment included:

- General field traverse of mapped terrestrial GDE areas to identify any areas of groundwater seepage and assist in targeting field-based assessment sites.
- Biophysical assessments to characterise the physical interactions of potentially groundwater dependent trees with their edaphic controls.
- Stable isotope investigations to identify the source, or sources of moisture utilised by areas currently mapped as GDEs.

These field investigations aim to determine the presence, extent and ecohydrological function of GDEs within and surrounding the Project area, to allow a robust assessment of the impact of the Project to groundwater-dependent assets. While radiogenic isotope (222RN) analysis of surface and groundwater was proposed as a component of the initial assessment, the general lack of surface water (excluding a farm dam) meant that the proposed sampling was impractical.



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Scale: @A4 0 35 70 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Figure 1. Esmerelda Project Location

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Scale: 1:1,335,727

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 10/12/2025

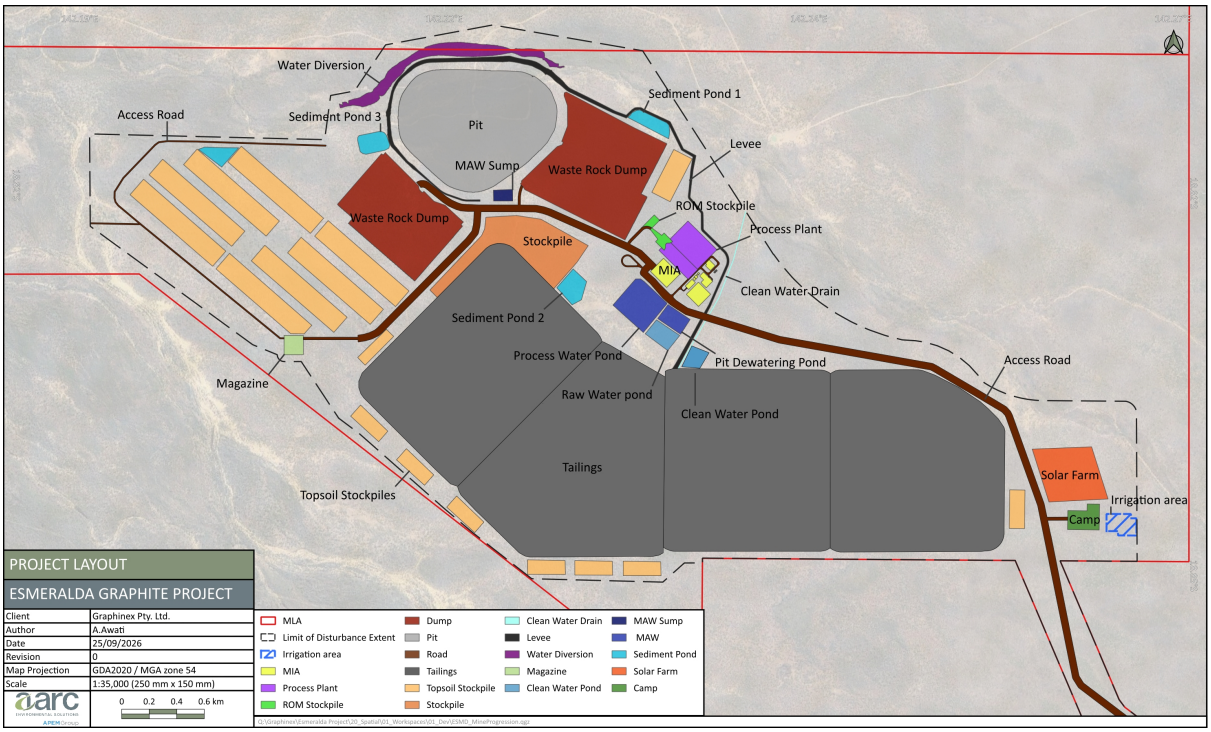


Figure 2. The proposed Project layout.

2.0 Survey Timing, Rainfall and Climate

The climate of Croydon and the broader area associated with the Gulf of Carpentaria is tropical monsoonal with a distinctive dry season from May to October and wet season from November to April, associated with tropical storms, cyclones and monsoon lows. Completion of the field assessment occurred between the 25th of August and the 4th of September 2025, with the timing consistent with a dry-season assessment.

The average annual rainfall for the Project area, taken from gridded climate data at Prospect Station (-18.92, 142.25, 7.5 km south of the proposed MLA) over 35-year period is 669.54 mm (SILO, 2025) with ~85% occurring from November to April. In contrast, the average annual pan-evaporation over the same period is 2619.92 mm (**Figure 3**), peaking in October to November. The significant offset between rainfall and pan-evaporation means that vegetation growth is strongly limited by rainfall. Tropical cyclones are often associated with the most intense rainfall events. The mean daily maximum temperature on site is reportedly 31.3 °C in the cooler months (May to September) and 35.6 °C in the hotter summer months (October to April). Conditions in the 3-month leadup to the assessment were dry with 37.3 mm on the 29th of June being the most significant rainfall event in the 3-month period reported at Croydon Township (BOM Station 029012), and no rainfall was recorded in two months prior to the field assessment at the Croydon (**Figure 4**).

The region has experienced several significant drought events, which are likely to have affected both surface flows and the recharge of groundwater systems. **Figure 5** demonstrates the primary climatic cycles in terms of Cumulative Rainfall Departure (CRD) (Weber & Stewart, 2004), representing a cumulative departure of monthly rainfall from the long-term mean monthly rainfall between January 1990 to September 2025 (SILO, 2025). A strongly decreasing rainfall trend between 1990 to 1997, 2002 to 2006, 2012 to 2015, and

2020 to 2023 represent significant drought periods. The most pronounced wetting trend in the previous 34 years occurred between 2007 and 2012. From 2018 to present has been more stable, with a weak drying trend from 2018 to 2022, followed by a sharp spike in CRD values in January 2023, and a general drying trend from this point to the start of the field survey. The analysis of cumulative rainfall departure is relevant to this assessment as shallow water tables generally follow similar trends, with rising water tables and increased occupation of surface waters coincident with increasing trends in the CRD curve.

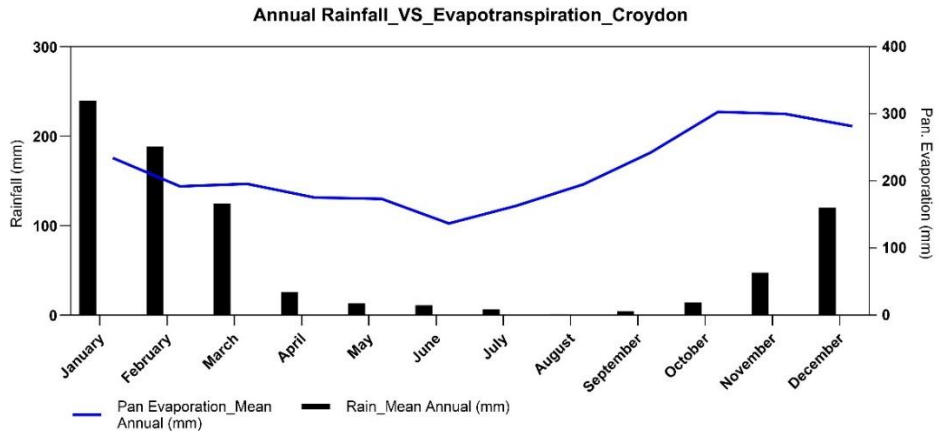


Figure 3. Annual mean rainfall compared to pan evaporation for the Project area, from SILO (2025).

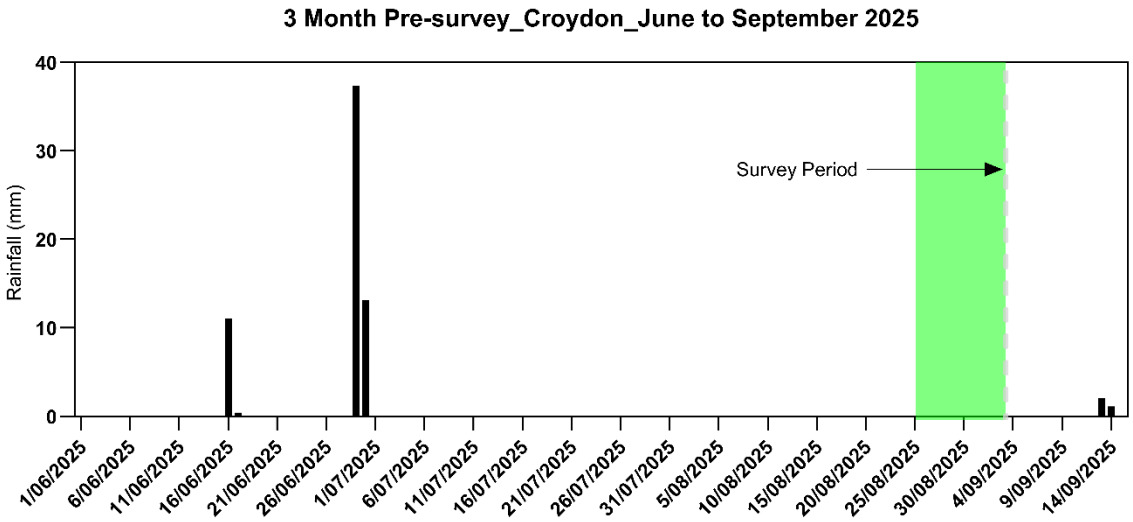


Figure 4. Daily rainfall for 3 months prior to field survey showing 37.3 mm falling on the 29th June, and no rainfall recorded in the 2-months prior to the assessment.

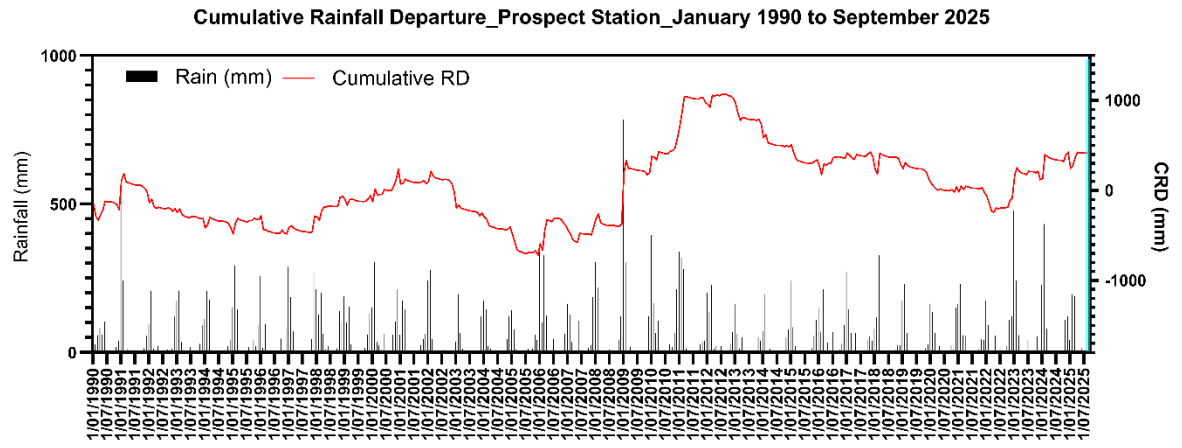


Figure 5. Cumulative rainfall departure (CRD) over a 35-year period from 1990 to 2025, for the Project area (Prospect Station from SILO, 2025), demonstrating a declining rainfall trend from 2012 to 2022, after which rainfall volumes increased abruptly January 2023, followed by relatively stable rainfall volumes up to commencement of the survey.

2.1 Topography, Geology and Drainage

The site lies on the western margin of the Carpentaria Basin, which the Millungera Basin and deeper granitoid lithologies underlie. At the Project site, the Esmerelda Granite sub-crops into sediments of the Carpentaria Basin, specifically the Tertiary age Claraville Beds. Within the Project site, the braided sandy channels Warrigal Creek and Borer River pass immediately south of the proposed ML, and a minor unnamed tributary of Warrigal Creek passes through the proposed ML's central area. These braided watercourses are part of a much larger system of rivers and streams that dissect the surface deposits of the Carpentaria Basin, flowing east to west as they enter the Norman River and ultimately flow into the Gulf of Carpentaria. The subdued landscape of the Carpentaria basin consists of flat plains, gently dipping east to west, with elevations ranging between 120 m and 140 m Australian Height Datum (AHD).

2.2 Hydrogeology

The hydrogeology of the Project area is described in detail in the Groundwater Impact Assessment Report (Hydrogeologist 2026). In summary, the Project site lies within the northern extent of the Great Artesian Basin hydrostratigraphic units are recognised based on their capacity to host groundwater, consistent with the classification applied in the Great Artesian Basin Water Resources Assessment (GABWRA) (CSIRO, 2012). The groundwater hosting units are described as:

1. **Cainozoic cover:** The Carpentaria Basin strata are overlain by a covering of unconsolidated Quaternary alluvium, and by the semi-consolidated Tertiary sediments of the Claraville Beds. The Quaternary alluvium is described as a clay, silt, sand, and gravel deposits that form active flood plain alluvium deposits associated with the braided channel of Warrigal Creek, plus an un-named tributary extends through the project mining area. The thickness of the Tertiary sediments, including

the Claraville Beds, is approximately 10m across the Project area (AARC, 2025), and is thought to be largely unsaturated.

2. **Gilbert River Formation:** Lying underneath the Claraville Beds, though not outcropping at the surface, the Gilbert River Formation is considered a moderate to high permeability formation and a regional aquifer. Recently installed monitoring bores targeting the Gilbert River Formation (installed in September 2025) indicate that the water table is sub-artesian, with a potentiometric surface that lies between ~ 6.6 to 12.5 mbgl, with salinity values ranging from 854 to 1130 uS/cm. Artesian conditions exist approximately 4 km west of the Project site, where RN107981 (constructed in 1946) expresses groundwater at surface, supporting permanent surface water infrastructure.
3. **Bedrock:** The ore hosting Croydon Volcanics and Esmerelda granite likely forms a low transmissivity and low hydraulic conductivity fractured rock aquifer, and there are no connected aquifers known to be associated with this geological formation.

The location of the groundwater supply and monitoring bores in relation to the Project area is shown in **Figure 6**.

Bores construction logs (Hydrogeologist, 2026) show that the shallow Tertiary sediments are monitored at 7–11.5 mbgl, the Gilbert River Formation at 46–55 mbgl, and the Proterozoic basement at 78–84 mbgl. Groundwater in the deeper units rises well above the screened intervals but remains below ground level, consistent with sub-artesian conditions.

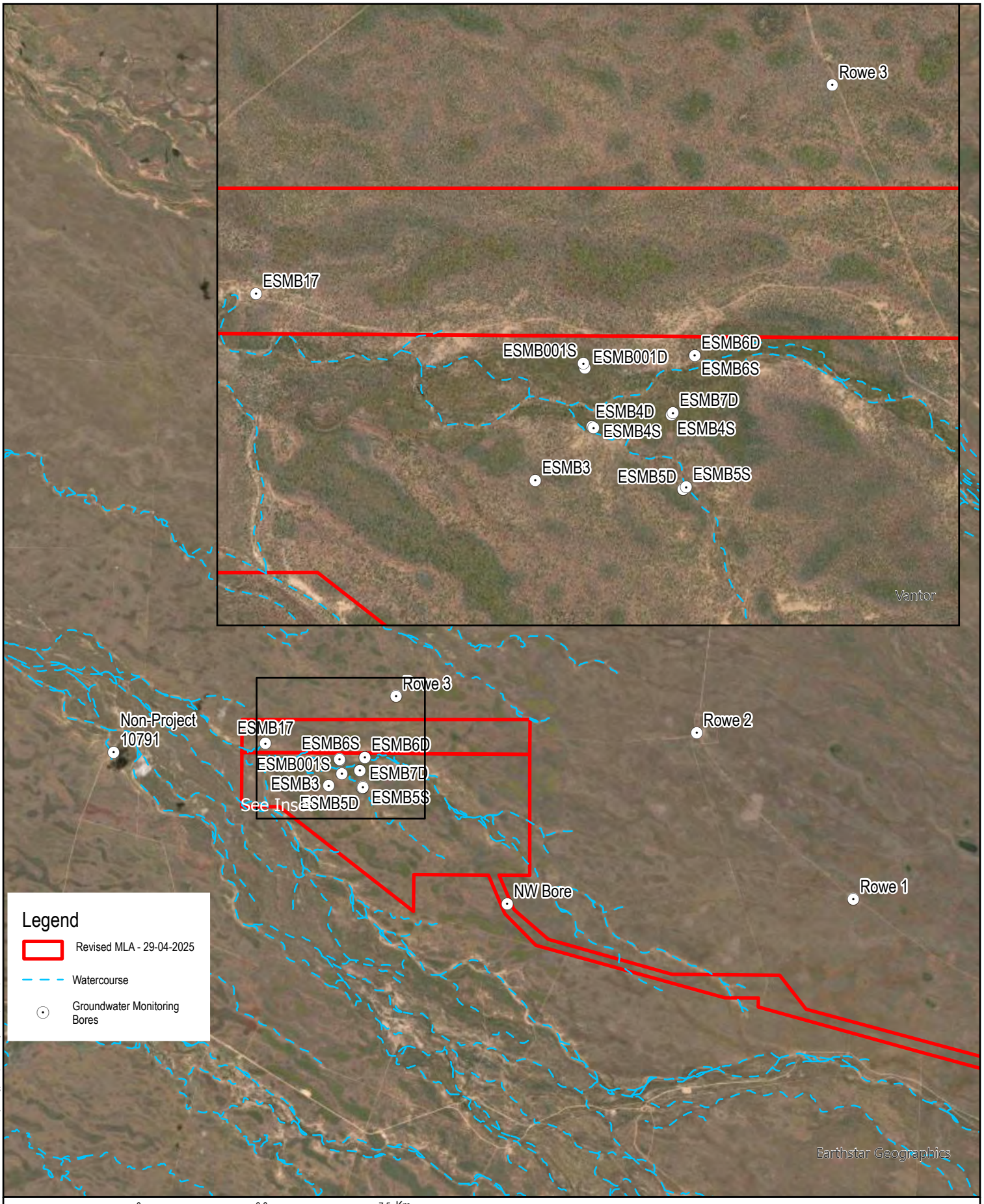
- Tertiary sediments: Screen intervals are 8.5–11.5 mbgl in ESMB01S, and 7–10 mbgl in ESMB02S, ESMB03, ESMB04S, ESMB05S and ESMB06S. Subsequent monitoring indicates these bores are dry, with no persistent SWL. Construction logs record initial water levels in ESMB03 and ESMB05S, which should not be interpreted as evidence of a sustained shallow aquifer.
- Gilbert River Formation: Screen intervals are 49–55 mbgl in ESMB01D and ESMB02D; 46–49 mbgl in ESMB04D and ESMB17; 49–52 mbgl in ESMB05D; and 47–50 mbgl in ESMB06D and ESMB07S. Construction-log water levels range from approximately 6.64–15.16 mbgl, substantially above the screens, supporting the sub-artesian interpretation. Subsequent monitored groundwater elevations generally range from 112.6–114.5 mAHD, with 108.0–113.2 mAHD reported for ESMB17.
- Proterozoic basement: ESMB07D is screened at 78–84 mbgl within brecciated granite. Its construction log records a water level of 56.10 mbgl, already above the screen. Subsequent monitoring reports elevations of 113.6–114.2 mAHD, equivalent to approximately 7.1–7.7 mbgl using the logged ground elevation of 121.3 mAHD. These later levels indicate substantial pressure recovery; slow recovery following sampling suggests low permeability.

In summary, the shallower unconfined Tertiary unit is consistently dry, with no evidence for a permanent or sustained groundwater unit. Bores installed in the Gilbert River Formation intersect aquifers at considerable depth, and SWLs in these bores represent potentiometric surfaces rising from confined aquifers rather than actual groundwater levels that would be within the rooting depth of terrestrial vegetation.

Table 1. Summary of SWLs and ECs from relevant groundwater monitoring bores screened within the Tertiary and Gilbert River formations.

RN	Project ID	Construction Date	Y	X	SWL (mbgl)	Total depth (m)	EC (µS/cm)	Aquifer	Aquifer Geology
208360	ESMB001D	25/07/2024	-18.81716	142.2129	Unknown	60	987	Gilbert River Formation	Sandstone with water fractures
208359	ESMB001S	24/07/2024	-18.81689	142.2128	Unknown	55	995	Gilbert River Formation	Sandstone with water fractures
157437	ESMB17	17/11/2025	-18.81267	142.1913	15	49	1450	Gilbert River Formation	Sandstone with water fractures
211853	ESMB3	14/09/2025	-18.82422	142.2097	Dry	10	Dry	Tertiary - Claraville Beds	Clay -sand
211966	ESMB4D	9/09/2025	-18.82081	142.2134	-6.64	51.1	854	Gilbert River Formation	Sandstone with water fractures
211953	ESMB4S	13/09/2025	-18.82005	142.2186	-7.78	54	1130	Gilbert River Formation	Sandstone with water fractures
211953	ESMB4S	11/09/2025	-18.82092	142.2135	Dry	10	ry	Tertiary - Claraville Beds	Clay -sand
211854	ESMB5D	14/09/2025	-18.82471	142.2194	Dry	10	Dry	Tertiary - Claraville Beds	Clay -sand
211954	ESMB5S	14/09/2025	-18.82457	142.2196	-7.8	41	1104	Gilbert River Formation	Clay with siltstone
NA	ESMB6D	NA	-18.81634	142.2201	NA	NA	1280	NA	NA
NA	ESMB6S	NA	-18.81634	142.2201	NA	NA	NA	NA	NA
211946	ESMB7D	11/09/2025	-18.81994	142.2187					
10791	Non-Project 10791	8/12/1946	-18.81538	142.1474	Artesian	190.8	680-700	Gilbert River Formation	Sandstone with water fractures
NA	NW Bore	NA	-188,564	142.2616	NA	NA		NA	NA
NA	Pelican Bore	NA	-18.897	142.421	NA	NA	2520	NA	NA
171489	Rowe 1	13/09/2016	-18.85438	142.3618	20	57	3150	Gilbert River Formation	Sandstone with water fractures
109343	Rowe 2	13/11/2002	-18.80888	142.3161	17	46.9	1970	Gilbert River Formation	Sandstone with water fractures
157196	Rowe 3	24/09/2013	-18.79938	142.229	12.5	59	NA	Gilbert River Formation	Sandstone with water fractures

RN = Registered Bore ID; NA = Not Available or Unknown



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Scale: @A4 0 3.8 7.5 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Figure 6. The location of registered groundwater monitoring bores

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2.3 Terrestrial Vegetation

AARC (2025) verified that thirteen REs (15 RE sub-types) occur within the proposed MLA boundary, comprising a mix of eucalyptus, melaleuca and acacia species. **Table 2** provides a summary of REs confirmed within the Project area based on field-based investigations (AARC, 2025), which was certified in the map amendment process by the Queensland Herbarium in April 2026. **Figure 7** shows the certified RE mapping relative to the proposed MLA. Significant canopy species occurring within the Project area are listed in **Table 3.**

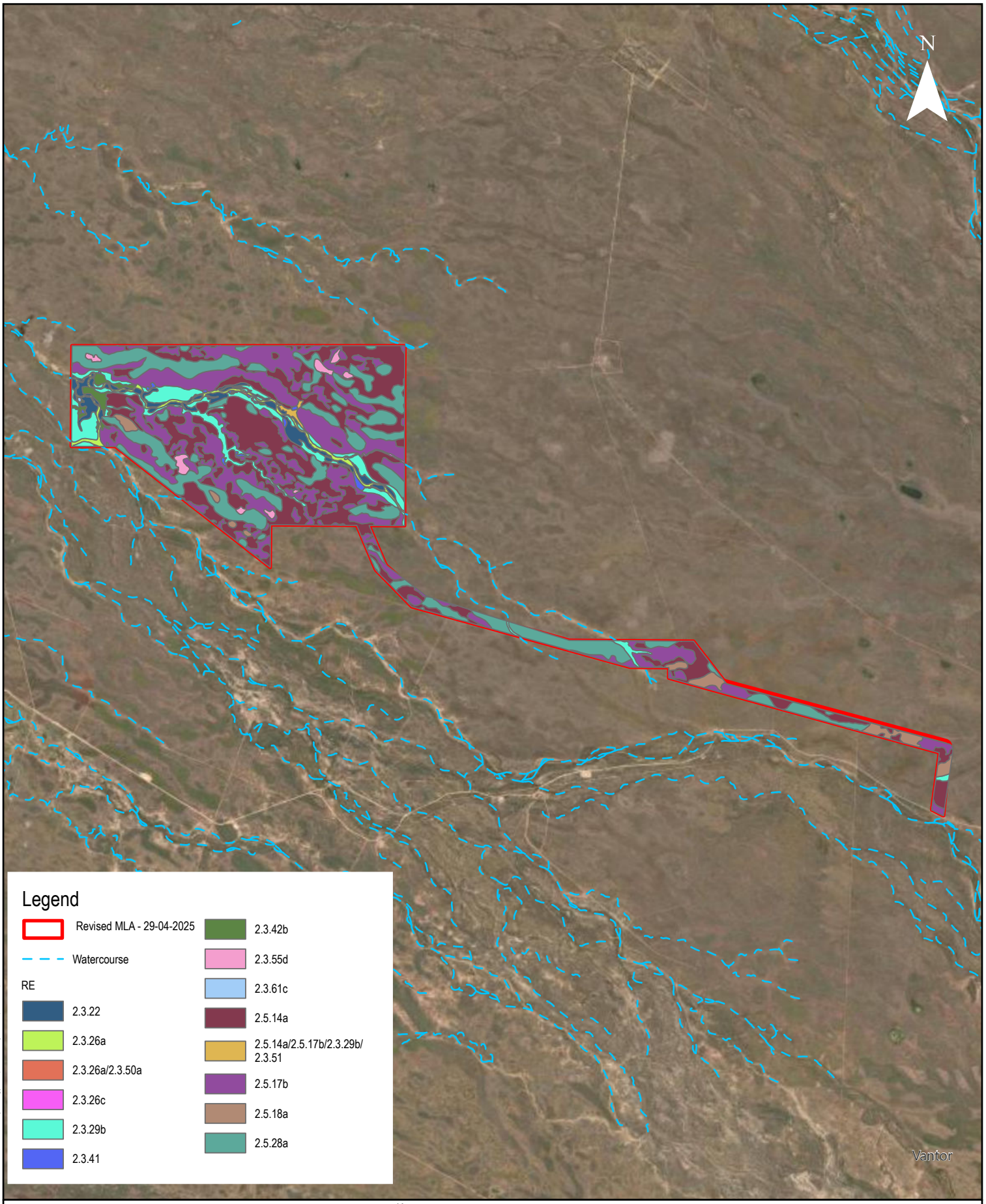
Table 2. Regional ecosystems occurring within the proposed MLA and surrounding areas.

Regional Ecosystem	RE descriptions (Certified RE Mapping)
2.3.22	*Corymbia polycarpa* and *Melaleuca spp.* woodland on sandy channels and levees.
2.3.26b	*Eucalyptus camaldulensis* woodland to low woodland, commonly with Melaleuca spp. Occasional canopy species include *Lophostemon grandiflorus, Grevillea pteridifolia, Corymbia polycarpa* and *Erythrophleum chlorostachys.*
2.3.26c	*Eucalyptus camaldulensis* low woodland, usually with *Melaleuca viridiflora.* Occasional canopy species include *M. citrolens, M. nervosa, M. fluviatilis* and *Pandanus sp.*
2.3.29a	*Melaleuca* spp. low open woodland to low woodland, occasionally with *Eucalyptus microtheca*. Occurs on active Quaternary alluvial plains and drainage depressions on Tertiary surfaces in the south-east of the bioregion. Sandy and silty clay soils.
2.3.29b[1]	*Melaleuca viridiflora* low woodland to low open woodland, occasionally with *M. citrolens, M. stenostachya. M. acacioides, Grevillea striata* and *Terminalia spp.* may occur in the canopy.
2.3.41	*Aristida dominii, Eriachne spp., Chloris lobata +/- Eragrostis basedowii, Iseilema sp.* tussock grassland on active Quaternary alluvial plains of major watercourses
2.3.42b[1]	*Eucalyptus microtheca* low open woodland to woodland, commonly with *Excoecaria parvifolia* and *Lysiphyllum cunninghamii.*
2.3.50a	Bare sand and rock with scattered shrubs and patches of grasses, forbs and sedges. Occurs in the channels of major watercourses. Riverine.
2.3.51[1]	Seasonal swamps. *Eucalyptus camaldulensis +/- Melaleuca viridiflora* open woodland in closed depressions on Tertiary sand sheets.
2.3.55d	Seasonal swamps (wooded). *Melaleuca viridiflora* low woodland, occasionally with *Excoecaria parvifolia* and *M. citrolens.* Occurs in closed depressions on Tertiary to Quaternary deposits in the north of the bioregion.
2.3.61c	Seasonal swamps (wooded). *Eucalyptus microtheca* woodland, occasionally with *Melaleuca viridiflora* and *M. citrolens.*

Regional Ecosystem	RE descriptions (Certified RE Mapping)
2.5.14a[1]	*Melaleuca viridiflora* low open woodland to low woodland. Occurs on broad, gently undulating Tertiary sand sheets in the south-east of the bioregion. Sands, yellow podzolics and yellow earths.
2.5.17b[1]	*Melaleuca citrolens* low open woodland to low woodland, commonly with *M. viridiflora*, *Eucalyptus microneura* and *Terminalia platyptera*. Occurs on broad, gently undulating Tertiary sand sheets in the south-east of the bioregion. Yellow to brown sands and loams.
2.5.18a	*Corymbia setosa* low open woodland to woodland, commonly with *Erythrophleum chlorostachys*. Occurs on broad, gently undulating, Tertiary sand sheets in the south-east of the bioregion. Brown sands and sandy loams.
2.5.28a[1]	*Corymbia polycarpa* woodland, commonly with *C. confertiflora*, *Erythrophleum chlorostachys* and *C. grandifolia*. Occurs on reworked sand deposits on broad plains (Claraville Plains subregion). Brown sands and sandy loams.

Table 3. Major canopy species within the MLA and surrounds.

Eucalyptus species (species / common name)
Corymbia grandifolia (large-leaf cabbage gum), *Eucalyptus camaldulensis* (river red gum), *Eucalyptus microtheca* (coolibah), *Corymbia polycarpa* (long-fruited bloodwood), *Corymbia setosa* (rough-leaved bloodwood)
Melaleuca species (including other Myrtaceae genera shrubs)
Melaleuca viridiflora (Broad-leaved tea tree), *Melaleuca fluviatilis* (weeping paperbark), *Melaleuca citrolens* (gulbarn), *Astermyrtus symphiocarpa* (liniment bush)
Acacia species and other species
Acacia holosericea (silver-leaved wattle), *Acacia leptocarpa* (slender-fruited wattle), *Acacia platycarpa* (ghost wattle), *Acacia torulosa* (Torulosa wattle), *Erythrophloeum chlorostachys* (Cooktown ironwood), *Grevillea striata* (beefwood)



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Scale: @A4 0 3.3 6.5 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Figure 7. Field verified regional ecosystems (certified April 2026).

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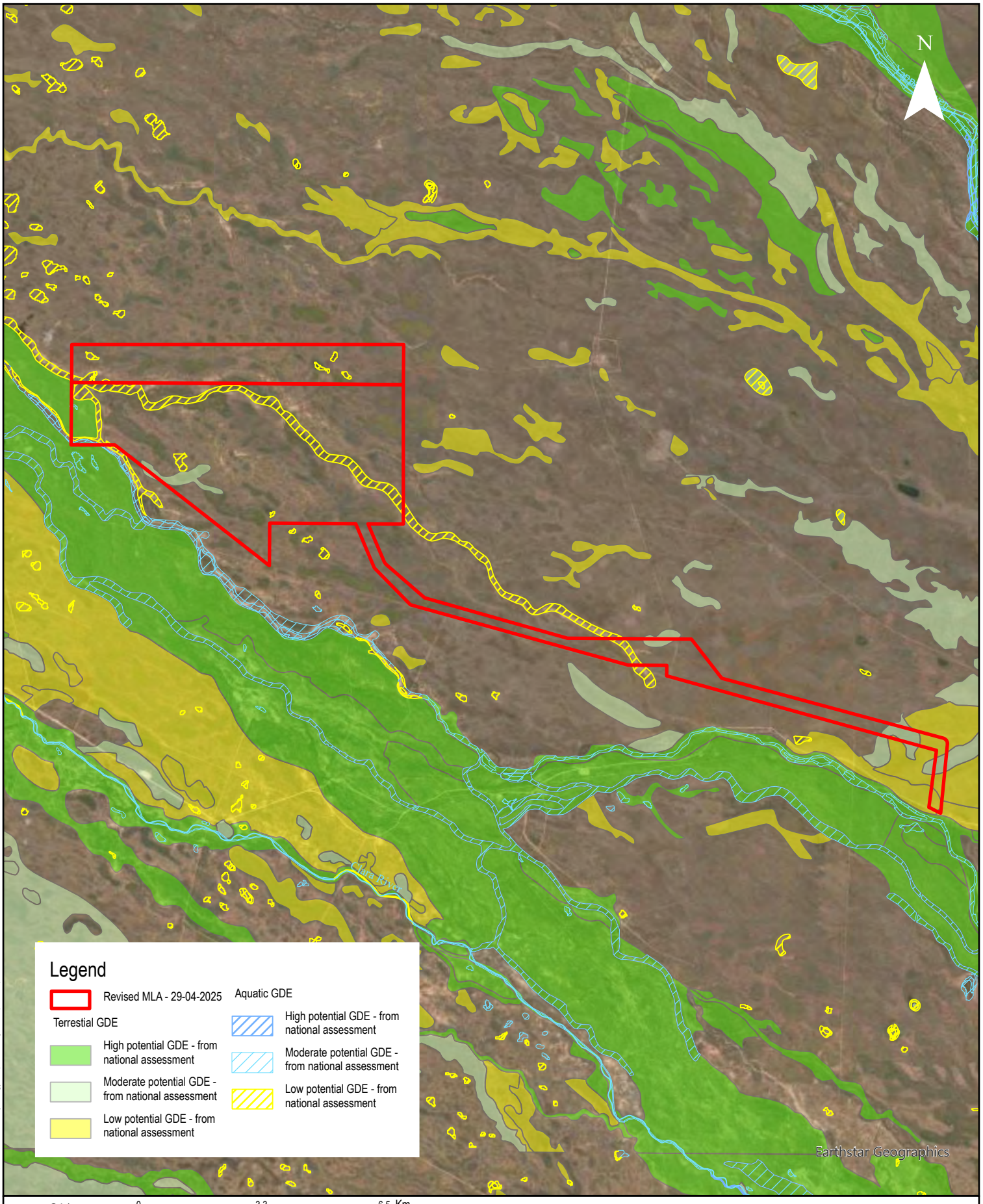
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2.4 Groundwater Dependent Ecosystems

The Bureau of Meteorology GDE Atlas (BOM, 2025) classifies the riparian corridors of Warrigal Creek, Borer River to the south, and the unnamed tributary (all occupied by RE2.3.26a) as 'Moderate Potential' aquatic GDEs. Several circular wetland features scattered throughout the proposed MLA, identified as RE2.3.55d and a patch of RE2.3.61, are also classified as 'Low Potential' aquatic GDEs. Terrestrial GDEs are mapped largely to the south of Warrigal Creek, with scattered occurrences throughout the proposed MLA, represented as a mix of "High", "Moderate", and "Low" potential GDEs (see **Figure 8**). The nearest Spring is at the 'Ancient' complex, approximately 18 km to the north-east of the proposed MLA (DCCEEW, 2023), with a much broader spread of springs occurring approximately 50 km to the south (**Figure 9**). The risk of impact to these springs are considered minimal due to their distance from the Project area.

2.5 Ecohydrological Function of Major Canopy Tree Species

There is minimal information on the ecohydrological function of woodland trees and shrubs in the Project area. General knowledge of the woodland and riparian flora across savannah woodlands suggests that the soil moisture, derived from rainfall and stream bank recharge in the case of riparian vegetation, is the dominant source of moisture driving evapotranspiration. Woodland/riparian trees are, at most, facultative phreatophytes, and water use strategies largely depend on landscape position (Cook & O'Grady, 2006). The amount of groundwater used is usually a function of position in the landscape. Trees closer to a watercourse at lower elevations use more groundwater than trees higher on the levees (Cook & O'Grady, 2006). Comprehensive studies across the Ti Tree basin, 180 north of Alice Springs in the Northern Territory, limited any significant groundwater use to groundwater <12 mbgl (Cook & Eamus, 2018), and O'Grady (2010) established vegetation groundwater use is restricted to water table depths at <10 mbgl, consistent with Doody et al. (2019). The ecohydrological function of the dominant tree canopy species (i.e., those with the deepest rooting potential), based on available desktop resources, is discussed in the following section.



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Coordinate System: GDA 2020 MGA Zone 54 A4

Source: BOM GDE Atlas (2020).

Figure 8. Mapped groundwater dependent ecosystems from the BOM GDE Atlas.

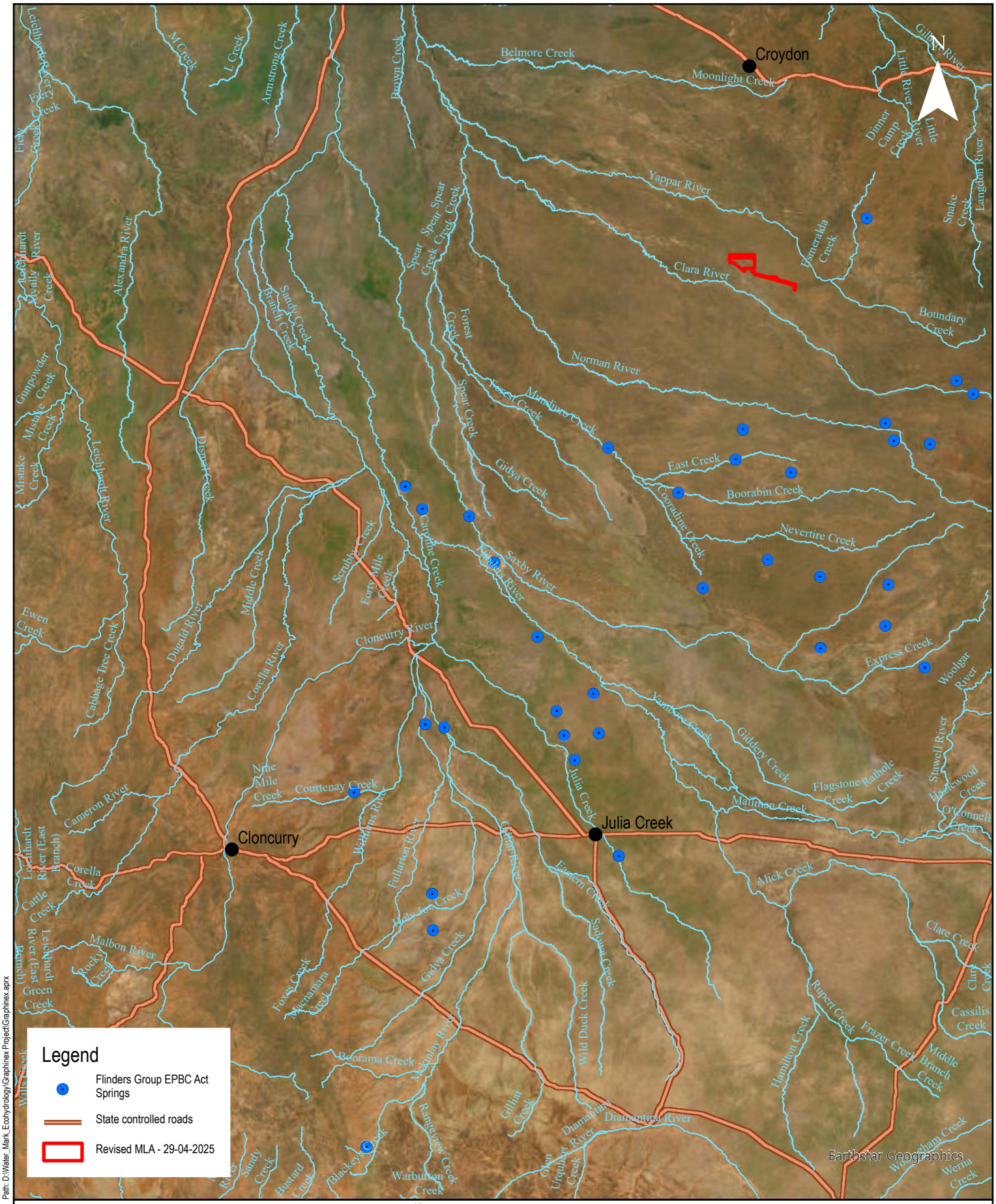
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Figure 9. The location of EPBC Act listed Springs relative to the Project Area

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Eucalypts: The area within the MLA and surrounding area are characterised by the presence of savannah woodland comprising a mix of bloodwood and eucalypt genera species, with eucalypts within the assessment area. Eucalypt species occurring within the MLA are detailed in **Table 2** and **3**, with discussion provided for these species included in the following sections.

River red gum (*Eucalyptus camaldulensis),* a recognised facultative phreatophyte was recorded within riparian vegetation associated with Warrigal Creek, and larger tributaries. River red gum is a well-studied species with deep sinker roots, hypothesised to grow down towards zones of higher water supply (Bren et al., 1986). The water requirements of river red gum are obtained from three primary sources: groundwater, rainfall, and river flooding. Flooding enables the species to survive in semi-arid areas (ANBG 2004). Stands of river red gum are intimately associated with the surface-flooding regime of associated watercourses and related groundwater flow. The high-water use of river red gums contributes to maintaining water tables at depth (Mensforth et al., 1994; Lamontagne et al., 2005). River red gum is considered partially opportunistic in its water use. It is regarded as a facultative phreatophyte, shifting between a combination of surface soil moisture and groundwater during periods of high rainfall and then shifting to exclusive use of groundwater during drier periods. They are likely to achieve this shift by inactivating surface roots during drier periods with increased reliance on deeper tap roots when surface water is unavailable. The maximum potential rooting depth of river red gum is subject to considerable conjecture in current literature. However, it is widely accepted that the species has the capacity to access deep groundwater sources (Eamus et al., 2006a). Horner et al. (2009) found rooting depths at 12–15 mbgl based on observed mortality in plantation river red gum forests on the Murray River Floodplain, and Jones et al. (2020) found maximum rooting depths of 8.1m in river red gum in a broad study area in the Great Artesian Basin.

For other eucalypt species, O'Grady et al. (2006) concluded the following in a study on groundwater usage of trees on a tropical floodplain savannah:

1. Clarkson's bloodwood (*Corymbia clarksoniana)* was demonstrated to utilise groundwater when the water table was at 10 mbgl indicating the potential for development of a deep sinker root. Other bloodwood species occurring within the MLA, including the closely related long-fruited bloodwood (*Corymbia polycarpa)*, are similarly likely to be facultative phreatophytes.
2. Based on studies of O'Grady et al., (2006), Moreton Bay ash (*Corymbia tessellaris)* demonstrated groundwater usage when the water table was at 4mbgl, although it is not known whether the species has the capacity to utilise deeper groundwater sources. Related species in the study area, including broad-leaved carbeen (*Corymbia grandifolia)* is attributed as having similar ecohydrological function

3. The studies completed on coolabah concern the southern species *Eucalyptus coolabah*, although the northern species *Eucalyptus microtheca*, as relevant to this assessment, is likely to possess similar ecological characteristics and edaphic requirements, favouring sites with heavier clay soils, typically close to drainage lines, and requires flooding for regeneration (Roberts, 1993). Costelloe et al. (2008) suggest that coolabah avoids using saline groundwater by growing at sites that maximise the frequency of soil moisture replenishment, possessing an extremely low transpiration rate, and having a strong capacity to extract moisture from soils with

extremely low osmotic/matrix potentials. Coolabah will favour the use of low salinity soil moisture in the vadose zone above the groundwater table over saline groundwater, though it can however continue to extract moisture at Cl concentrations up to 30 000 mg/L (~27 800 µS/cm) in soils where matric potential in the upper soil profile is extremely low due to a combination of extreme drying coupled with a clayey substrate. The heavy clay soils that support coolabah-dominant communities (RE2.3.42a) place a physical limitation on tree root penetration. Clay substrates are unsuitable media for the development of a deep taproot system that would be necessary to reach the groundwater table (Dupuy et al., 2005), and soils with low hydraulic conductivities, such as clays, significantly limit the ability of trees to utilise groundwater (Feikema et al., 2010). Hence, coolabah is unlikely to have the same capacity to develop deeper tap roots, and its maximum rooting depth would most likely be considerably less than 10m.

Melaleuca species: There is limited information on the water use strategies of the larger paperbark species in the literature. Two studies (O'Grady et al, 2006; O'Grady et al, 2005) indicate *Melaleuca argentea* and *Melaleuca leucadendra* directly utilise surface water, although their capacity to utilise water from deeper aquifers when surface water is not available is unknown. Based on observations of matted tree roots concentrated in wet sands within river channel deposits, it is expected that weeping tea-tree (*Melaleuca fluviatlilis),* which is associated with the larger drainage features within the MLA, will utilise mostly surface water, with the capacity to utilise residual moisture in river channel deposits as surface water recedes. There is no evidence for the development of deeper sinker roots in weeping tea tree with significant investment in spreading lateral roots adapted to utilising shallow moisture sources.

For broad-leaved paperbark (*Melaleuca viridiflora*) as occurs within the MLA, and similar species, including rough-barked paperbark, O'Grady et al (2006) suggest a capacity to utilize moisture from the upper 0.5m of the soil profile plus deeper usage of moisture below 7m, likely to represent groundwater. O'Grady et al. (2006) demonstrated that broad-leaved paperback could utilize groundwater from a water table at 10mbgl, which suggests considerable species adaptability with a dimorphic root system capable of utilizing moisture from multiple sources and depths dependent on seasonal availability.

Liniment bush*:* Liniment bush (*Asteromyrtus symphiocarpa)*, which is associated with RE2.3.55d within the MLA, is a native of northern Australia and Papua New Guinea, adapted to infertile, acidic, and waterlogged soils. The species typically ranges in height from 4 – 10 m and tends to grow in drainage-impeded areas in association with *Melaleuca viridiflora.* The rooting depth is assumed to be like that of *Melaleuca viridiflora,* for which it shares a common habitat association.

Cooktown ironwood: Cooktown ironwood (*Erythrophloeum chlorostachys),* which is common within the MLA, can occupy a range of habitats, including rocky slopes and loamy plains. While the rooting depth of Cooktown ironwood is unknown, it is, at most, a facultative phreatophyte. **Table 4** indicates the likelihood of groundwater usage, based on knowledge of tree rooting depth, for canopy species found within the Site and surrounds.

Table 4. Potential rooting and groundwater threshold depth for the dominant canopy species in the Project area.

RE	Species	Common name	Deep sinker roots	Threshold Groundwater Depth
2.3.26a/ 2.3.26c	*Eucalyptus camaldulensis*	River red gum	Known	>10m / <15m
2.3.22 2.3.26a/2 .3.26c	*Melaleuca fluviatilis*	Weeping paperbark	Known	<10m
2.3.26a 2.3.26c 2.3.29b 2.3.51 2.3.55d 2.3.61c 2.5.14a 2.5.17b	*Melaleuca viridiflora*	Broad leaved paperbark	Known	<10m
2.3.22 2.5.28a	*Corymbia polycarpa*	Long-fruited bloodwood	Likely	<10m
2.5.28a	*Corymbia grandifolia*		Likely	<10m
2.5.18a	*Corymbia setosa subsp. pedicellaris*		Likely	<10m
2.3.29a 2.3.42b 2.3.61c	*Eucalyptus microtheca*	Coolabah	Possible	~5 to <10m
2.3.55d	*Asteromyrtus symphyocarpa*	Liniment bush	Possible	~5 to <10m
2.5.29b	*Melaleuca citrolens*	Gulbarn	Possible	~5 to <10m
2.3.26a 2.5.18a 2.5.28a	*Erythrophleum chlorostachys*	Cooktown ironwood	Unlikely	<5m

**Recorded during field assessment

3.0 Field Assessment Methods

The following section provides a summary of methods that were employed during the field investigation to determine the likely moisture sources utilised by terrestrial vegetation, including both biophysical and hydro-chemical assessments. The study follows methods recommended in the GDE Toolbox (Richardson et al., 2011) and Doody et al. (2019), completed in an optimal sampling window, to provide a suitable basis for impact assessment.

3.1 Site Selection

Field survey focused on those areas that were identified as either aquatic or Terrestrial GDEs within the GDE Atlas (BOM, 2025). Identification of the surface expression of groundwater is fundamental to the assessment of aquatic GDEs, and where aquatic GDEs are mapped in association with deep-rooted woody vegetation, terrestrial GDEs could also be expected to occur. **Figure 10** shows sampling localities relative to mapped GDEs with **Table 5** providing a summary of the purpose of individual GDE assessment sites. The field assessment targeted representative habitats mapped as terrestrial and aquatic GDEs within and adjacent to the MLA, concentrating on areas where Project-related groundwater drawdown is predicted to be greatest. Most sampling sites were located in riparian and wetland ecosystems because these habitats commonly support facultative phreatophytes, including river red gum and weeping paperbark. Seasonal inundation may also recharge shallow or perched groundwater systems that are disconnected from the regional aquifer and provide temporary water sources for vegetation.

Site selection therefore captured habitats with potential dependence on either regional groundwater or locally recharged shallow groundwater. Given the regional extent of the Gilbert River Formation aquifer and the recurrence of similar regional ecosystems across the landscape, the selected sites are considered representative of the principal habitat types and potential groundwater-use settings that may be affected by the Project.

Table 5. The location of GDE assessment sites and sampling purpose.

GDE Assessment Area	Landform	Purpose	Targeted RE
1, 2, 4, 9	Sandy braided drainage channel / watercourse associated with Warrigal Creek and Tributaries	Sampling of Low Potential Aquatic / Terrestrial GDEs associated with riparian woodland and open forest,	2.3.26a/2.3.26c
3	Residual clay to sandy clay soils associated with floodplain woodland and associated floodplain overflow wetland (modified)	Sampling of Low Potential Aquatic and Terrestrial GDE associated with the Warrigal Creek floodplain.	2.3.42b
5	Flat to gently undulating residual plain.	Assessment of a Moderate Potential Terrestrial GDE associated with a eucalypt woodland.	2.5.28
6	Open drainage depression / drainage line formed on a residual plain.	Assessment of Low Potential Aquatic and Terrestrial GDE associated with seasonal drainage feature / depression.	2.3.29b

GDE Assessment Area	Landform	Purpose	Targeted RE
7, 8, 10	Closed wetland depression on residual soils.	Investigation of a Low Potential Aquatic GDE within a closed wetland depression on an undulating residual plain.	2.3.55d



Photograph 1. Braided drainage channel on a tributary of Warrigal Creek at GDE Assessment Area 2 (RE2.3.26a).



Photograph 2. Closed seasonal wetland depression with Corymbia polycarpa and Asteromyrtus symphiocarpa (RE2.3.55d) at GDE Assesment Area 7.



Photograph 3. Woodland of Eucalyptus microtheca fringing a floodplain wetland at GDE Assessment Area 3. The surface water body is formed on drainage feature that has been historically modified to support water storage for grazing purposes.

3.2 Leaf Water Potential

Leaf Water Potential (LWP) defines the work required per unit quantity of water to transport it from the moisture held in the soil to leaf stomata. LWP balances osmotic potential, turgor pressure, and matric potential. It is a function of soil water availability, evaporative demand, and soil conductivity. LWP was measured pre-dawn (before sunrise) as per standard protocol. Due to a lack of transpiration, LWP will equilibrate with the wettest portion of the soil, which contains a significant amount of root material. LWP will shift to a lower status pre-dawn as the soil dries out seasonally (Eamus 2006a). Measurement of LWP pre-dawn thus indicates the water availability to trees at each assessment site and whether trees are tapping saturated zones of the soil profile where water is freely accessible or utilising moisture that is more tightly bound to soil particles.

Survey localities were sampled pre-dawn (first light to pre-sunrise), and leaves were collected from three to five mature canopy trees with a 9 m extension pole fitted with a lopping head. Sampling focused on both brigalow (*Acacia harpophylla)*, and other eucalypt species with potential to be a facultative phreatophyte. Collected branches were double bagged in black plastic to avoid moisture loss and sun exposure, and LWP was measured on-site within half an hour of harvest. Leaf material was trimmed with a fine blade and inserted into an appropriate grommet for sealing within a Model 3115 Plant Water Status Console (Soil Moisture Equipment Corp, 2007). The chamber was sealed and gradually pressurised with nitrogen until the first drop of leaf water emerged from the petiole with values represented in millipascals (MPa) for direct comparison to Soil Moisture Potential (SMP) measurements. In total, 32 trees were assessed for LWP across the fifteen assessment sites, with the location of these trees detailed in Section 4.2. The following categories were applied as a measure of relative water availability:

- Extremely High: LWP >-0.276 MPa
- Very High: LWP -0.276 to -0.580 MPa
- High: LWP <-0.580 to -0.896 MPa
- Moderate: LWP <-0.896 to -1.21 MPa

- Low: LWP <-1.21 to -1.72 MPa
- Very Low: LWP <-1.72 to -2.21 MPa
- Extremely Low: LWP <-2.21 MPa

While the defining values of these categories are arbitrary, they indicate the likely degree and nature of groundwater dependence or interaction. The 'Extremely High' category would indicate the potential for interaction with a highly fresh groundwater source, with the degree of groundwater interaction decreasing to the 'Moderate' category, which may indicate either utilisation of soil moisture from the vadose zone or interaction with saline groundwater. Categories of 'Low' to 'Extremely Low' are considered unlikely to utilise groundwater to any degree, regardless of salinity. It should also be noted that soil moisture in the 'Extremely High' category can be supplied directly from unsaturated portions of the soil profile depending on moisture availability, which can be assessed by measuring SMP.

3.3 Soil Moisture Potential

A hand auger was utilised to collect shallow soil samples at regular depths down the soil profile at selected sites and opportunistic sampling of groundwater where intersected. Selection of sites for auger placement considered:

1. Whether LWP measurements indicated a higher degree of water availability in the soil profile than other assessment localities, suggesting that shallow groundwater or a soil zone of higher matric potential exists at depth (i.e. a sand lens may be present in the soil profile).
2. The representativeness of a particular chosen site as a means to provide information that applies to other assessment localities.

At each site chosen for auger sampling, the aim was to collect soil samples to the maximum depth of the auger of penetration, with penetration often arrested by coarse gravel / cobble substrates, large tree roots, or refusal at relatively shallow depths in the soil profile due to a high density of root material. Observations taken for each auger hole included:

1. Soil structure, colour, and texture.
2. Presence of root matter.
3. Soil moisture/water and areas of saturation.

Soil sampling was undertaken at regular intervals down the soil profile for analysis of stable isotopes of oxygen ($\delta^{18}O$) and deuterium ($\delta^{2}H$), and duplicate samples were retained for analysis of SMP.

Sample collection was generally spaced at 0.5 m down the auger profile, with additional samples taken where changes in soil structure/texture, moisture content, or zones of tree roots were intersected. Samples were sealed in airtight plastic vials and placed on ice for later measurement of SMP.

SMP, which includes the matric (water availability) and osmotic (saltiness) potential, measures the energy required to extract moisture from the soil. Water can only move down a hydraulic gradient from soil to root (Gardner, 1960). Areas in the soil profile with a less negative SMP than measured pre-dawn LWP will be accessible as a source of moisture. Large, mature trees are unable to extract moisture from regions in the soil profile where the total SMP is significantly below LWP measured in pre-dawn leaf material (Feikema et al., 2010; Lamontagne et al., 2005; Thorburn et al., 1994; Mensforth et al., 1994; Holland et al., 2009 and Doody et al., 2015). The maximum suction roots for crops can apply to soil/rock

before a plant wilts due to a negative water supply is approximately -15 bars or -1.5 MPa (or -217.55 psi). This wilting point is relatively consistent between all plant species. However, many Australian plants have adapted to conditions of low water availability and can persist strongly in soil conditions where moisture potential is below standard wilting point (Eamus, 2006a). As a general measure, however, where measured LWP is below the standard wilting point, it indicates plant water deficit, and the tree is unlikely to be supported by a saturated water source regardless of groundwater salinity.

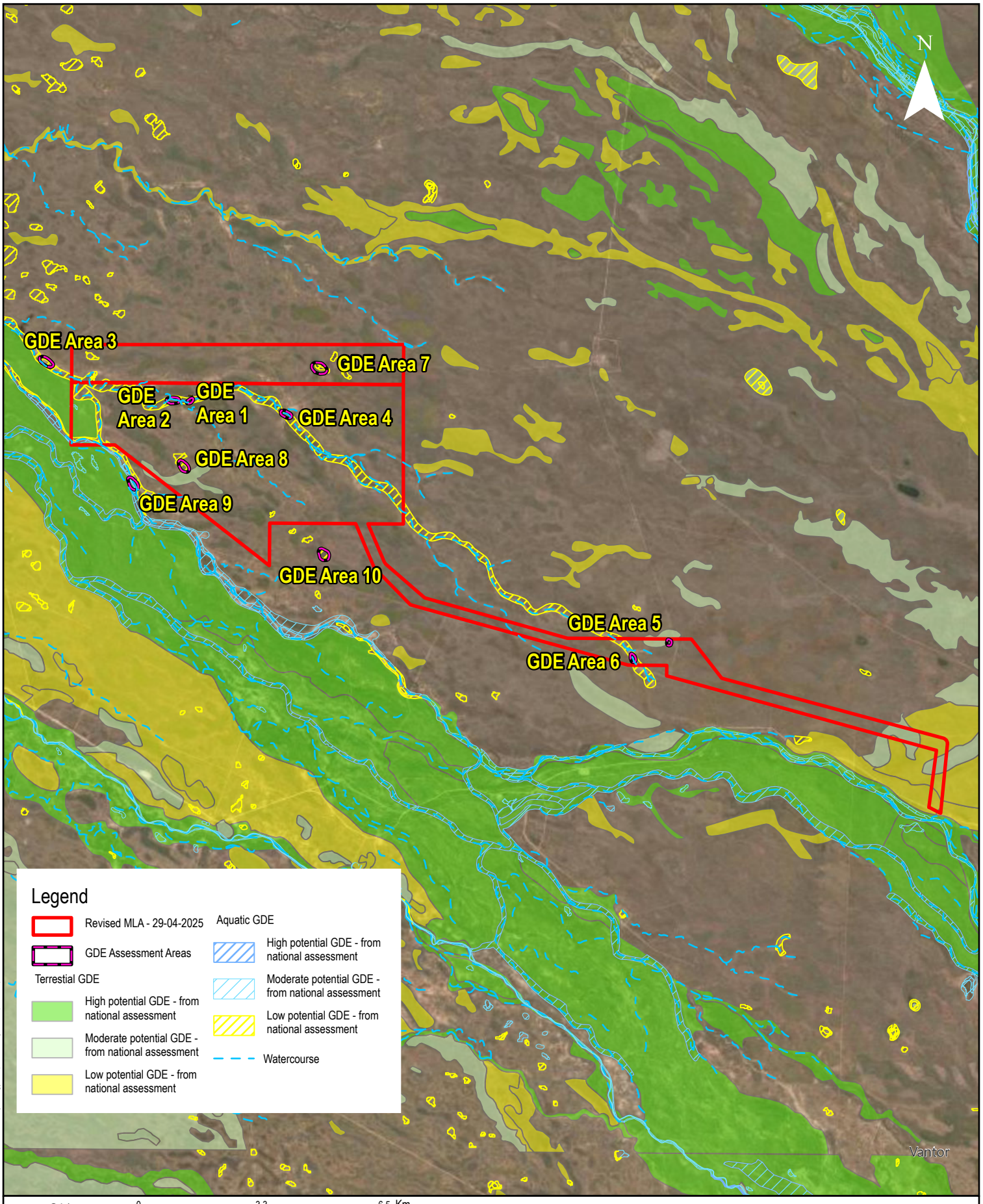
Soils were sampled at regular intervals down a soil profile for measurement of SMP, with sampling intervals dependent on the degree of structural and lithological heterogeneity. The measurement of SMP was completed in the laboratory with a portable Dew Point Potentiometer (WP4C) (Meter et al., 2021). The WP4C meter uses the chilled mirror dew point technique with the sample equilibrated within the headspace of a sealed chamber that contains a mirror and a means of detecting condensation on the mirror. Soil moisture potential samples were measured in millipascals (mPa). A 7 ml soil sample was inserted into the WP4C meter using a stainless-steel measuring tray.

3.4 Stable Isotope Sampling and Analyses

Trees may utilise water from various sources including the phreatic zone (saturated zone), the vadose zone (unsaturated zone) and surface water. The stable isotopes of water, oxygen 18 ($\delta^{18}O$), and deuterium ($\delta^{2}H$) are valuable tools to help define terrestrial vegetation's predominant water source. The method relies on a comparison between the stable isotope ratios of water contained in plant xylem (from a twig or xylem core) with stable isotope ratios found in the various sources of water, including a shallow groundwater table, potential sub-artesian aquifer water sources or shallow soil moisture. Methods used to assess stable isotopes are detailed below.

3.4.1 Soil Moisture Isotopes

Sampling was undertaken regularly in auger holes to capture isotopic signatures from a range of potential plant moisture sources from the upper soil surface to the top of the phreatic zone in shallow water tables. The sampling intervals for soil moisture isotope analyses depended on auger yield and soil variation. In general, the initial soil sample was taken within the top 0.2 m of the soil profile, and subsequent samples were taken at 0.5 m intervals down the soil profile to the end of the hole, mirroring the interval for SMP. Approximately 200 milligrams (mg) of soil was collected for isotope analysis, sealed in airtight plastic sampling containers, double-sleeved in click-seal plastic bags, and placed on ice for storage prior to dispatch to the Australian National University (ANU) Stable Isotope Laboratory for analysis where they were snap frozen until analysis was complete. Soil intervals selected for stable isotope analysis include where tree roots were recorded, exceptionally moist intervals, or at the base of the auger hole where high soil moisture/groundwater was recorded. In most cases, isotopic sampling of complete profiles was undertaken to aid data interpretation.



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Scale: @A4 0 3.3 6.5 Km Coordinate System: GDA 2020 MGA Zone 54 A4

Source: BOM GDE Atlas (2020).

Figure 10. The location of GDE Assessment Areas Areas relative to of BOM mapped GDEs

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Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 11/12/2025

3.4.2 Xylem Water Isotopes

Twigs were collected from the outer canopy branches of target trees used to sample LWP. The following sampling procedure was applied:

1. Harvesting of outer branches of trees of the target tree at the GDE assessment site was completed, with two duplicate samples prepared from each branch for analysis.
2. The position of trees subject to assessment was marked with a GPS, and structural measurements, including height and diameter at breast height (dbh), were recorded.
3. Outer branches from each tree were harvested with an extendable aluminium pole.
4. Stem material approximately 5 cm in length was sourced with secateurs.
5. The bark was immediately removed, and stems were sealed in wide-mouth sample containers with leakproof polypropylene closures (approx. 125 ml volume). They were immediately labelled with the tree number and placed in an iced storage vessel prior to dispatch to the ANU Stable Isotope Laboratory.
6. Upon receipt of samples at the ANU Stable Isotope Laboratory, samples were snap-frozen (-18 degrees Celsius) until analysis.
7. Samples were taken from the xylem to be as close to the centre of the twig as possible. Extracted water was analysed using a Picarro L2140i cavity ring-down spectrometer for both xylem and soil samples.

The collection of twig samples occurred from multiple trees at each assessment site, consistent with trees assessed for LWP. Sampled portions of branches with a minimum diameter of 1 cm were debarked and then trimmed to approximately 5 cm in length. The debarked sections were sealed in 2.5 x 5 cm clip-sealed bags, then individually placed into airtight 30 ml polypropylene sample containers, on ice, and frozen within 2 hours of collection. Freezing prevented water dispersal between the xylem and the phloem during storage, thus eliminating a potential source of error resulting from considerable partitioning of isotope ratios across a twig cross-section. There is also potential for fractionation of stable isotope values, particularly δ^2H, during movement of water through the xylem from roots to leaves (Evaristo et al, 2017; Petit & Froend, 2018). As fractionation will likely result in isotopic enrichment rather than depletion, the least enriched sample from each tree is considered most likely to be representative of the soil moisture or groundwater source (Hilary Stuart-Williams – ANU Farquhar Laboratory personal communication, July 25, 2019).

3.4.3 Water Sampling

Very little surface water was present in watercourses or wetlands during the assessment. Creeks were consistently dry, with the only surface water sample collected from a modified overflow wetland feature at GDE Assessment Area 3. In addition, at the time of assessment, groundwater monitoring bores had not been installed, and sampling of groundwater for water quality and stable isotope composition could not be completed.

3.5 Data Reconciliation and Interpretation

Data interpretation followed a structured approach by filtering multiple lines of evidence to assess groundwater dependence. The biophysical measurement of LWP formed the primary assessment, followed by the adjunct comparison with SMP, with stable isotope data used to provide supplementary evidence where ambiguity remained. In addition, an overview of the depth of the groundwater table and groundwater salinity was completed as a final filter to

determine the accessibility of groundwater and suitability as a source of moisture to support transpiration at each assessment locality.

Step 1. LWP: An initial comparison of individual trees' LWP values within the expected range for known terrestrial GDEs subject to various salinity regimes, assuming complete saturation of sediments in the groundwater table and minimal influence of soil matric potential, is applied. This data is derived from a range of published sources, including Jones et al. (2020), Holland et al., (2009), and Mensforth et al., (1994):

- Expected LWP for trees in equilibrium with a fresh to brackish saturated source of moisture (EC<1500 µS/cm) = >-0.2MPa.
- Expected LWP for trees in equilibrium with a moderately saline soil moisture source (EC>1500 to 10 000 µS /cm) =-0.2MPa to -0.55MPa.
- Expected LWP for trees in equilibrium with a saline soil moisture source (EC>10 000 to 30 000 µS /cm) = -0.55MPa to -1.5MPa.

Where groundwater regimes exhibit varying salinity regimes, this greatly increases the complexity and uncertainty of LWP assessments, meaning much greater reliance on other analytical tools, such as stable isotopes. However, trees that demonstrate LWP values that are considerably more negative than expected ranges for the local groundwater salinity regimes are assumed not to exhibit any significant degree of groundwater dependence. From the range of groundwater salinities recorded from monitoring bores, sites with average LWP <-1.5 MPa (standard wilting point) were not subject to further scrutiny other than for comparative purposes. Groundwater with salinity > 30 000 µS /cm is considered an unsuitable source of moisture for most trees and unlikely to be utilised by deep rooted vegetation.

Step 2. Soil Augering and SMP: Soil augering is helpful for a) direct observation of soil physical properties including depth to bedrock; b) physical observation of distribution of tree roots down within the soil profile; c) identification and sampling of shallow groundwater tables; and d) measurement of soil biophysical properties including SMP. For trees where LWP was within the expected range of values for GDEs, soil augering allowed the direct observation of the physical features of the soil profile, as well as facilitated measurement of SMP to identify the likelihood that moisture for transpiration was being supplied from the upper soil profile, or whether deeper sources of moisture may exist. As described in **Section 3.3**, water can only move down a hydraulic gradient from soil to root, meaning that only those portions of the soil profile with an SMP that is less negative than measured pre-dawn LWP will be accessible as a source of moisture (Gardner, 1960). This does not provide an absolute assessment of groundwater dependence, though identifies potential moisture sources, as context to the stable isotopes assessment (Step 3).

Step 3. Stable Isotope Signatures: For trees that demonstrate potential groundwater dependence from LWP measurements, stable isotope signatures from the xylem samples were compared to signatures from groundwater, surface water from residual and permanent pools, and soil moisture (where this data was available) to provide a fingerprint for the source of moisture being utilised. Where three lines of evidence indicated utilisation of a groundwater source, the tree was generally accepted as being groundwater dependent. Where ambiguity remained in the assessment, additional features were considered, including site-specific geology, geomorphology, soil physical properties, groundwater salinity, and depth to the water table at the location to inform the final assessment of groundwater dependence for any tree or site.

3.6 Limitations and Other Information Relevant to the Assessment

This assessment evaluates ecohydrological processes at each of the 10 GDE assessment sites. The survey timing is optimal for identifying ecosystems sustained by groundwater, being conducted under dry seasonal conditions with limited preceding rainfall. However, perched ephemeral groundwater systems are likely to form following extended periods of wetting, which may contribute to the moisture requirements of some habitats. Where such exceptions occur, the presence of seasonal groundwater has been conceptualised to capture the moisture requirements of habitats under a broader range of seasonal conditions.

4.0 Results

4.1. Leaf Water Potential

Figure 11 shows the average LWP values for the ten GDE assessment sites, **Figure 12** represents the LWP values for individual trees, and **Figure 13** provides a spatial representation of average values. The data identifies the following trends:

- Only three sites present average LWP values that are 'High', being ES2 (-0.6 MPa) and ES9 (-0.625) sampled within riparian habitats (RE2.3.26a/2.3.26c), and a single site, ES7 (-0.635 MPa), sampled from a wetland depression (RE2.3.55d). LWP values for individual trees at these sites are relatively consistent (**Figure 12**), except for a single river red gum at ES2, which has a 'Very High' LWP value of -0.25 MPa. This data indicates that trees at these sites have access to a highly available moisture source.
- Assessment site ES1, located on a riparian habitat (RE2.3.26a) has 'Moderate' moisture availability (-1.05 MPa) suggesting either that vegetation is using a saline groundwater source, or that soil moisture is being derived from the vadose zone.
- All other assessment sites present 'Low' to 'Extremely Low' LWP values, suggesting that the edaphic conditions supporting vegetation at these sites is very dry, with limited potential for groundwater usage.
- At sites with mixed canopy species, particularly site ES5, *Corymbia polycarpa* tends to have higher moisture availability than *Melaleuca viridiflora* (**Figure 12**). The consistent difference in LWP values suggests that the taproot system of *Corymbia polycarpa* is deeper than that of *Melaleuca viridiflora*, with the capacity to access more available moisture at greater soil depths. For other species, including *Melaleuca fluviatilis, Eucalyptus camaldulensis*, and *Eucalyptus coolabah*, patterns of moisture availability are less obvious, and LWP values are most likely controlled by both rooting depth and localised variations in soil moisture availability. The most negative individual LWP values are reported for *Eucalyptus coolabah* (-3.6 MPa). *Erythrophleum chlorostachys* (-3.35 MPa), and *Melaleuca viridiflora* (-3.35 MPa) indicating high tolerance for extremely dry edaphic conditions. The highest individual LWP values is reported for *Eucalyptus camaldulensis* (-0.25 MPa) at site ES2, suggesting relatively high water availability at this location.

Overall, the data indicates low moisture availability across most, if not all, habitats, suggesting that the potential for groundwater reliance is extremely low across the proposed MLA and in the equivalent surrounding landscape.

Table 6 provides an initial assessment of the likelihood of groundwater utilisation for all sites at the time of assessment. The potential for those trees with LWP values <-0.55 to utilise groundwater becomes increasingly unlikely as LWP values become more negative. Based on this data, there indication of possible groundwater usage for site associated with RE2.3.26a and RE2.3.55d, though groundwater usage in habitats outside these riparian and swamp woodland ecosystems is extremely unlikely. **Appendix A** provides a structural summary of all trees assessed for LWP.

4.2 Soil Auger Sampling

The survey program included the sampling of five soil auger holes, focusing specifically on riparian (RE2.3.26c) and swamp woodland (RE2.3.55d) habitats where moisture availability is highest. **Table 7** summarises auger location, target ecosystem, target geology, and depth, with auger logs representing the significant elements of the soil profile, including soil intervals, and the presence of tree roots. Collection of soil samples occurred at each significant change in soil texture/moisture to measure SMP and assess stable isotope composition. Soil moisture potential (SMP) was measured for each soil sample, and the results of these analyses were plotted directly on the auger logs. **Appendix B** shows the location of auger holes relative to sampled trees at each GDE assessment site. **Appendix C** provides a summary of SMP values.

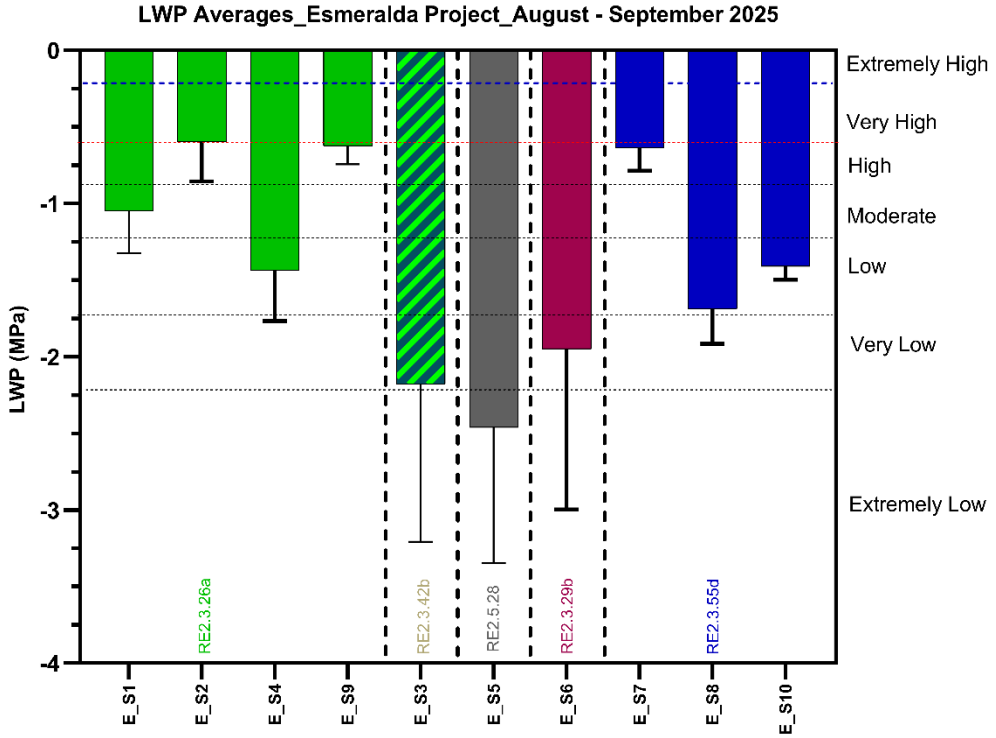


Figure 11. Average LWP values for all assessment sites with categories of moisture availability indicated.

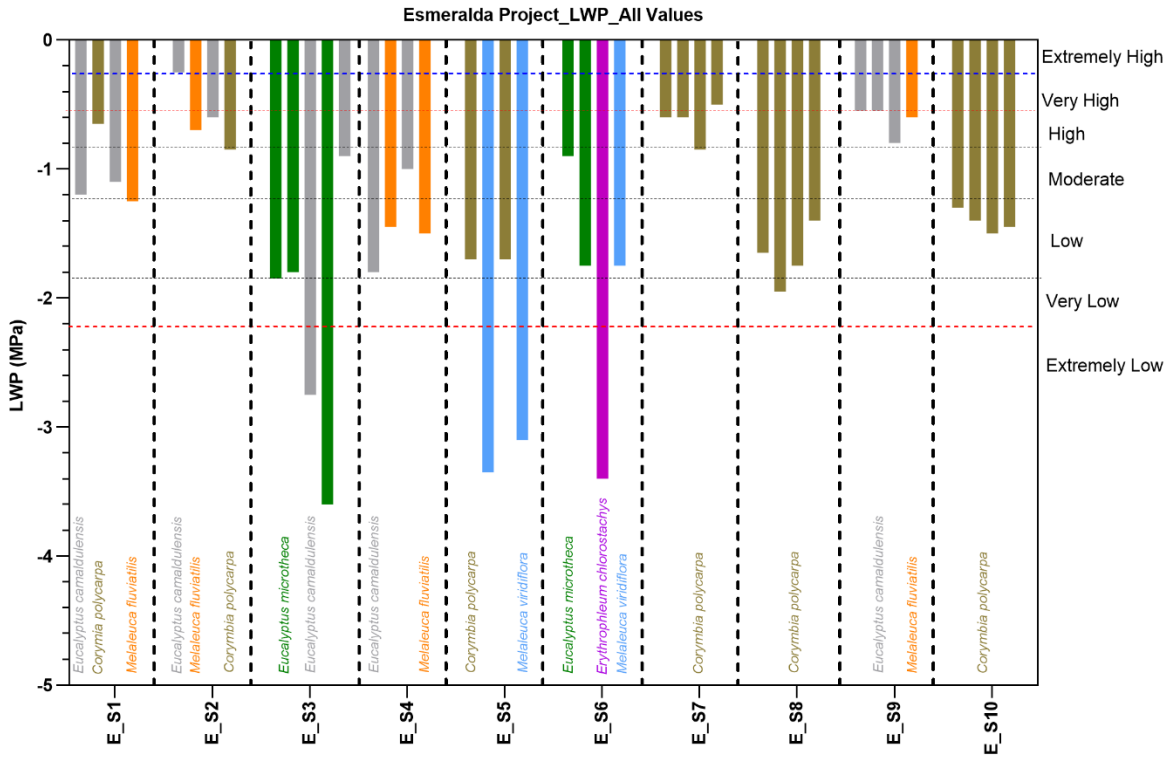
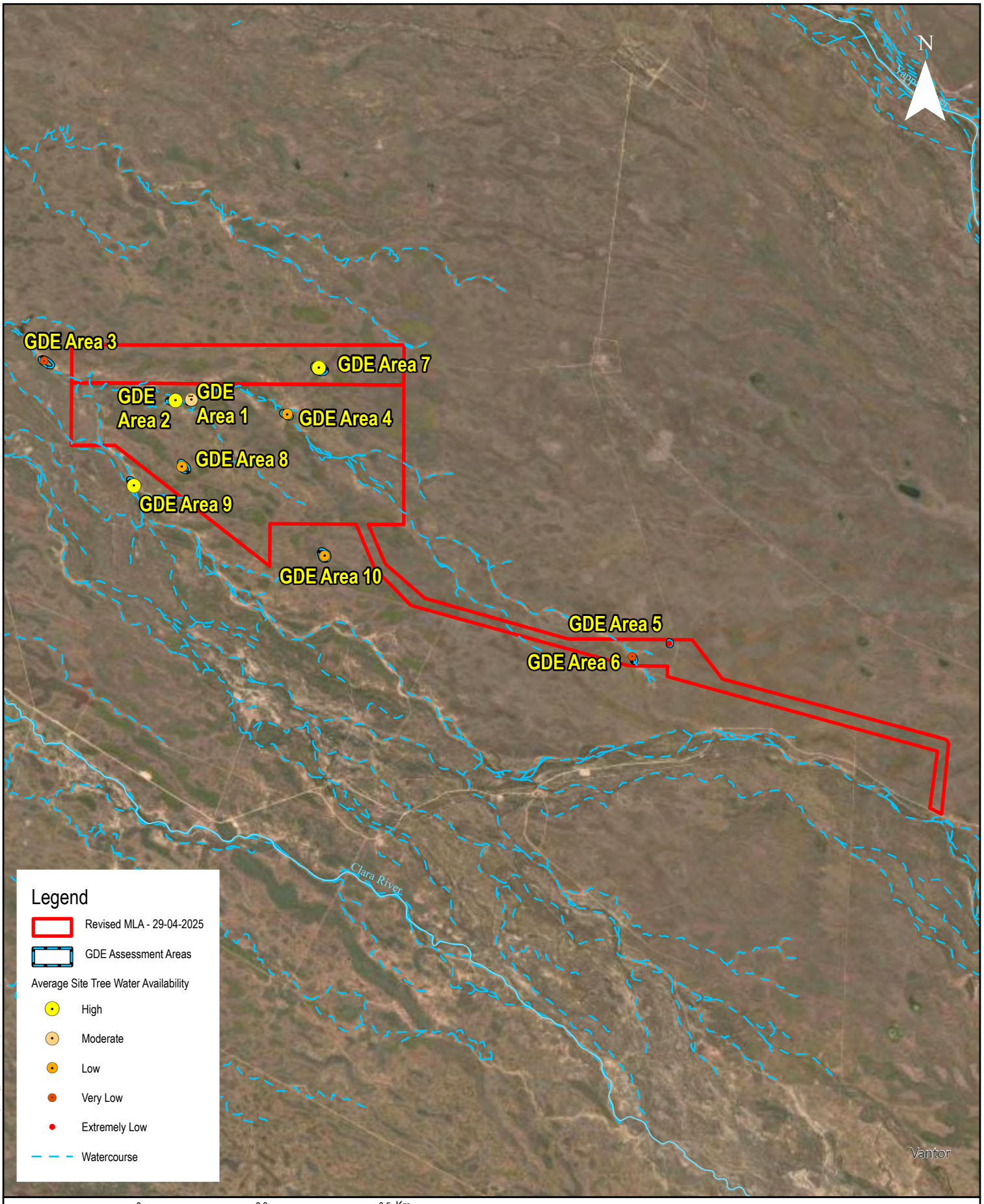


Figure 12. LWP values for individual trees across all assessment sites with categories of moisture availability indicated.



Path: D:\Water_Mark_E.cohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 3.3 6.5 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Figure 13. Average Leaf Water Potentials for all assessment areas.

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:130,030

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 11/12/2025

Table 6. Summary details and results of LWP assessment for GDE assessment sites.

Site	Average LWP (MPa)	Water Availability	Comments
RE2.3.26a/2.3.26c– *Eucalyptus camaldulensis* & *Melaleuca fluviatilis*			
ES1 ES2 ES4 ES9	-0.6 to -1.43 MPa	High to Low	The highest LWP value (-0.6MPa) suggests low potential for groundwater usage, though there is a high degree of variability between sites and sites with the more negative LWP values are unlikely to be utilising groundwater to any significant degree. As groundwater salinity recorded in monitoring wells is relatively fresh (generally <1500 µS/cm), it is most likely that LWP variability is controlled by moisture content in the vadose zone, rather than variable usage of a saline groundwater source.
RE2.3.55d – *Corymbia polycarpa*			
Site ES7 ES8 ES10	-0,64 to -1.69 MPa	High to Low	The highest LWP value at site ES7 (-0.64MPa) indicates high moisture availability and low potential for groundwater usage. However, LWP values for site ES8 and ES10 are substantially more negative (and -1.69 MPa and -1.41 respectively) indicating limited potential for groundwater usage at these sites.
RE2.3.42b – *Eucalyptus microtheca*			
Site ES3.	-2.18 MPa	Very Low	The extremely negative LWP values at this site indicates limited potential for groundwater utilisation at the time of the assessment.
RE2.5.28 – *Corymbia polycarpa & Melaleuca viridiflora*			
Site ES5	-2.46MPa	Extremely Low	The extremely negative LWP values at this site indicates limited potential for groundwater utilisation at the time of the assessment.
RE2.3.29b – *Melaleuca viridiflora*			
Site ES6	-1.95 MPa	Very Low	While the average LWP value at site ES6 is very low, there is considerable variation between trees and species. *Eucalyptus microtheca* (ES6T1) presents a LWP value of -0.9 MPa indicating moderate water availability while *Erythrophleum chlorostachys* has extremely low moisture availability (-3.4 MPa). Overall, there is limited potential for woody vegetation at site ES6 to be utilising groundwater, though variation in the source and depth of soil moisture uptake likely occurs between individual trees.

Table 7. The location, depth and target of shallow auger holes sampled during the assessment.

Auger Hole	Y	X	Ecosystem Sampled (RE)	Auger Target	Total Auger Depth (m)
ES1_AU1	-18.819018	142.214559	2.3.26a	Weathered sedimentary rocks at the base of creek channel / fluvial sediments	1.5
ES3_AU1	-18.8096949	142.17698	2.3.26a	Weathered sedimentary rocks at the base of creek channel / fluvial sediments.	2.5
ES4_AU1	-18.822287	142.23874	2.3.26a	Weathered sedimentary rocks at the base of creek channel / fluvial sediments.	1.6
ES4_AU2	-18.822306	142.23859	2.3.26a	Weathered bedrock at the base of fluvial channel sands.	0.3
ES7_AU1	-18.811176	142.24606	2.3.55d	Base of weathered sediments below the central portion of the wetland depression.	6.6

4.2.1 RE2.3.26a (Auger ES1_AU1)

Auger ES1_AU1 was placed into the lower alluvial floodplain terrace of the tributary stream. The auger intersected sandy sediments, variably mixed with silt and clay, above weathered sedimentary basement rock. The profile was extremely dry down to 0.75 m, with SMP values as low as -20.0 MPa at the surface, and moistened below this depth, with a substantial overlap between SMP and LWP values from 0.75 mbgl to the base of the profile at 1.5 mbgl, where the penetration was arrested on sedimentary basement (**Figure 14**).

4.2.2 RE2.3.26a (Auger ES3_AU1)

Like Auger ES1_AU1, Auger ES3_AU1 was placed into the lower alluvial floodplain terrace of the tributary stream, intersecting sandy sediments, variably mixed with silt and clay. The alluvial profile, however, was considerably deeper, intersecting sedimentary basement rock at 2.5 mbgl (**Figure 15**). The entire profile was extremely dry, with SMP values universally <2.0 MPa, though there was overlap between SMP and LWP at 1.1 and 2.3 mbgl, consistent with the presence of coarse tree roots, suggesting that riparian vegetation moisture sources derive from unsaturated soil regions.

4.2.3 RE2.3.26a (Auger ES4_AU1)

Auger ES4_AU1 was placed into the lower alluvial floodplain terrace of the tributary stream, intersecting sandy sediments, variably mixed with silt and clay, above weathered sedimentary basement rock, intersected at 1.6 mbgl. The profile was extremely dry from the surface (-56.0 MPa), with soil moisture availability increasing with depth. There was no intersection between SMP and LWP in the profile, despite increasing moisture availability at depth, suggesting that riparian vegetation is utilising residual moisture held in bedrock fractures, rather than moisture in the alluvial soils (**Figure 16**).

4.2.4 RE2.3.55d (Auger ES7_AU1)

Auger ES7_AU1 penetrated a deep soil profile with variable mixtures of sand, silty sand, and occasional clayey sand horizons. The upper 0.5 m of the soil profile was extremely dry (<2.0 MPa), with another extremely dry interval between 1.5 and 2.0 mbgl, where SMP values plunge as low as -4.0 MPa. Substantial intersection between LWP and SMP occurs between 0.5 and 1.5 mbgl, 3.0 and 5.5 mbgl, and at the base of the profile (6.6 mbgl), The substantial intersection between SMP and LWP suggests that LWP values reported at the site can be accounted for by moisture in the vadose zone, supported by the presence of coarse tree roots at 5.25 and 6.35 mbgl. Auger ES7_AU1 did not intersect groundwater, and the soil profile remained dry to full depth.

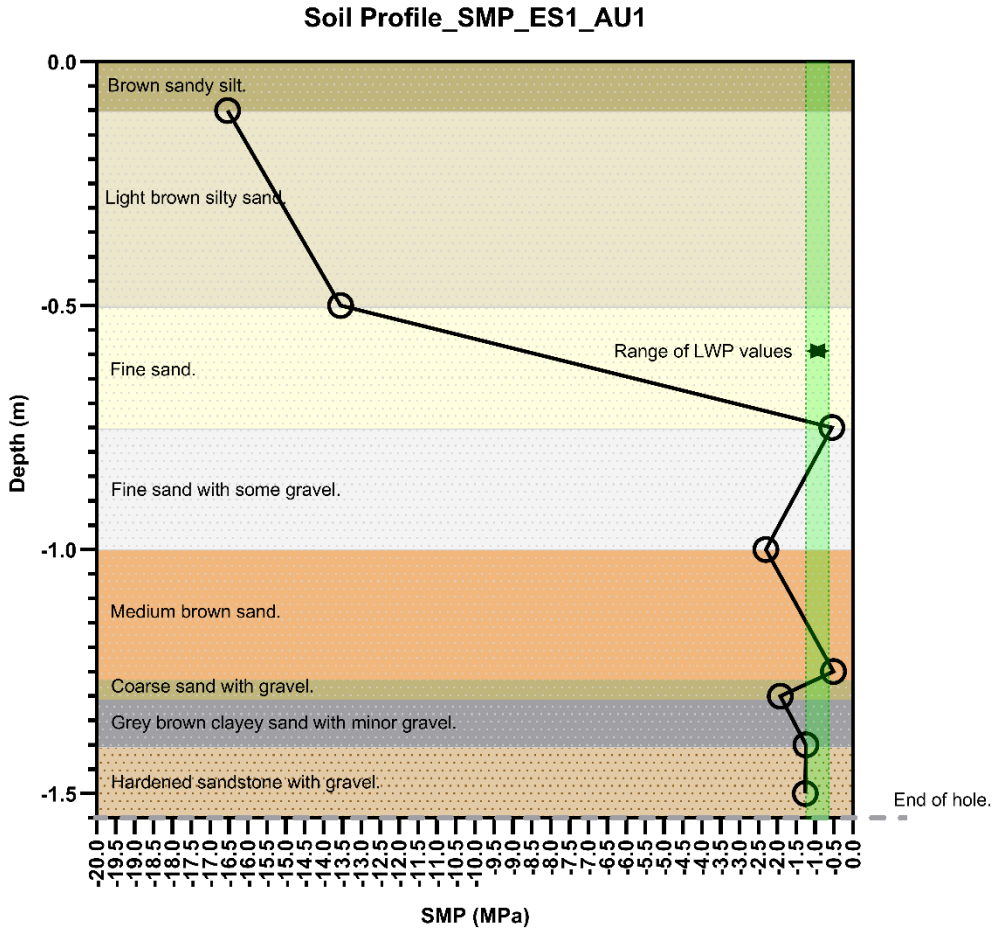


Figure 14. Profile for auger ES1_AU1 showing intersection between SMP and LWP below 0.75 mbgl.

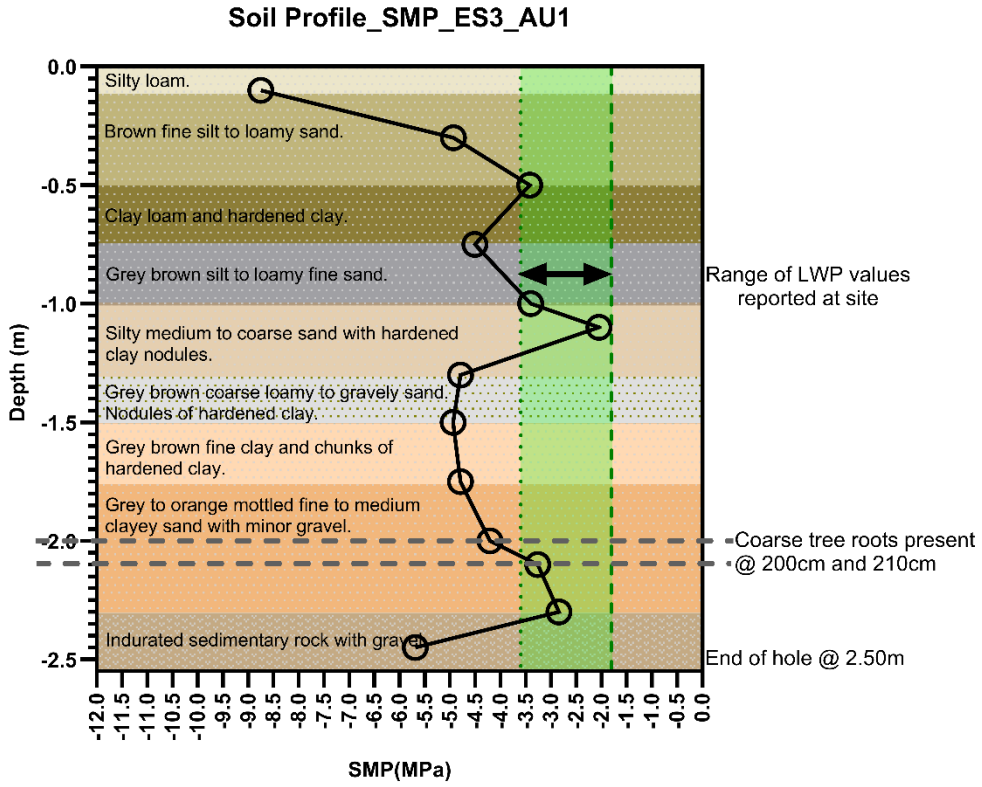


Figure 15. Auger profile for site ES3_AU1 demonstrating the intersection of LWP and SMP values at 1.2 mbgl, and between 2.0 and 2.3 mbgl, consistent with the presence of coarse tree roots.

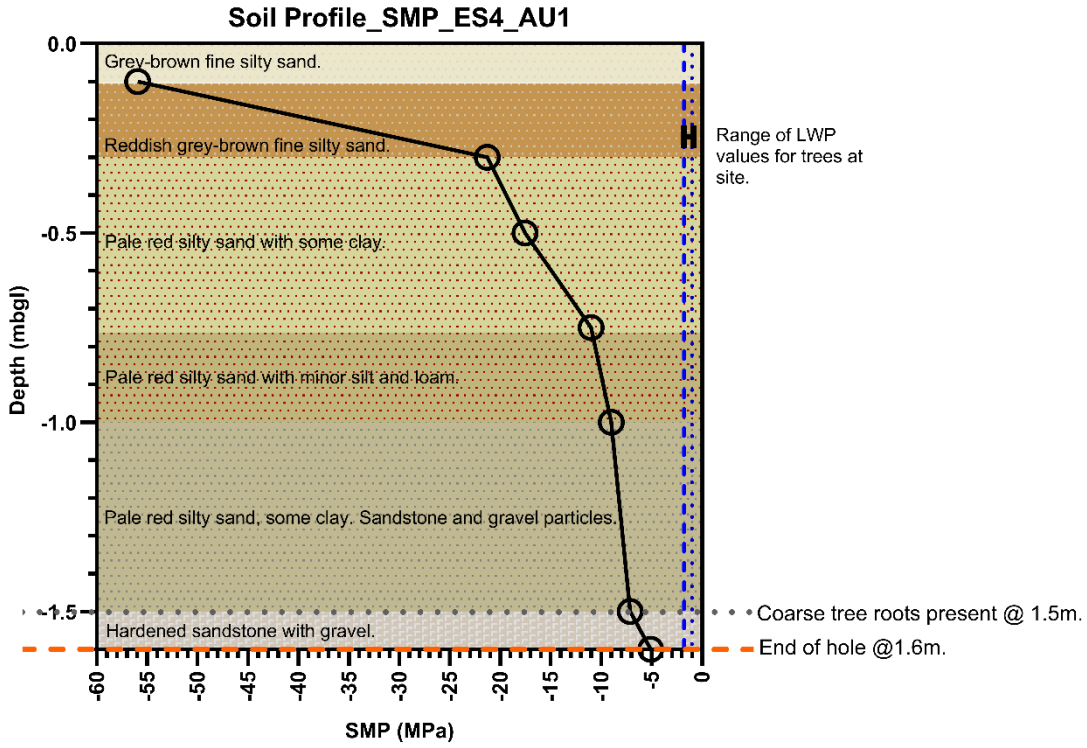


Figure 16. Auger profile for site ES4_AU1 demonstrating an extremely dry soil profile with increasing soil moisture availability with depth.

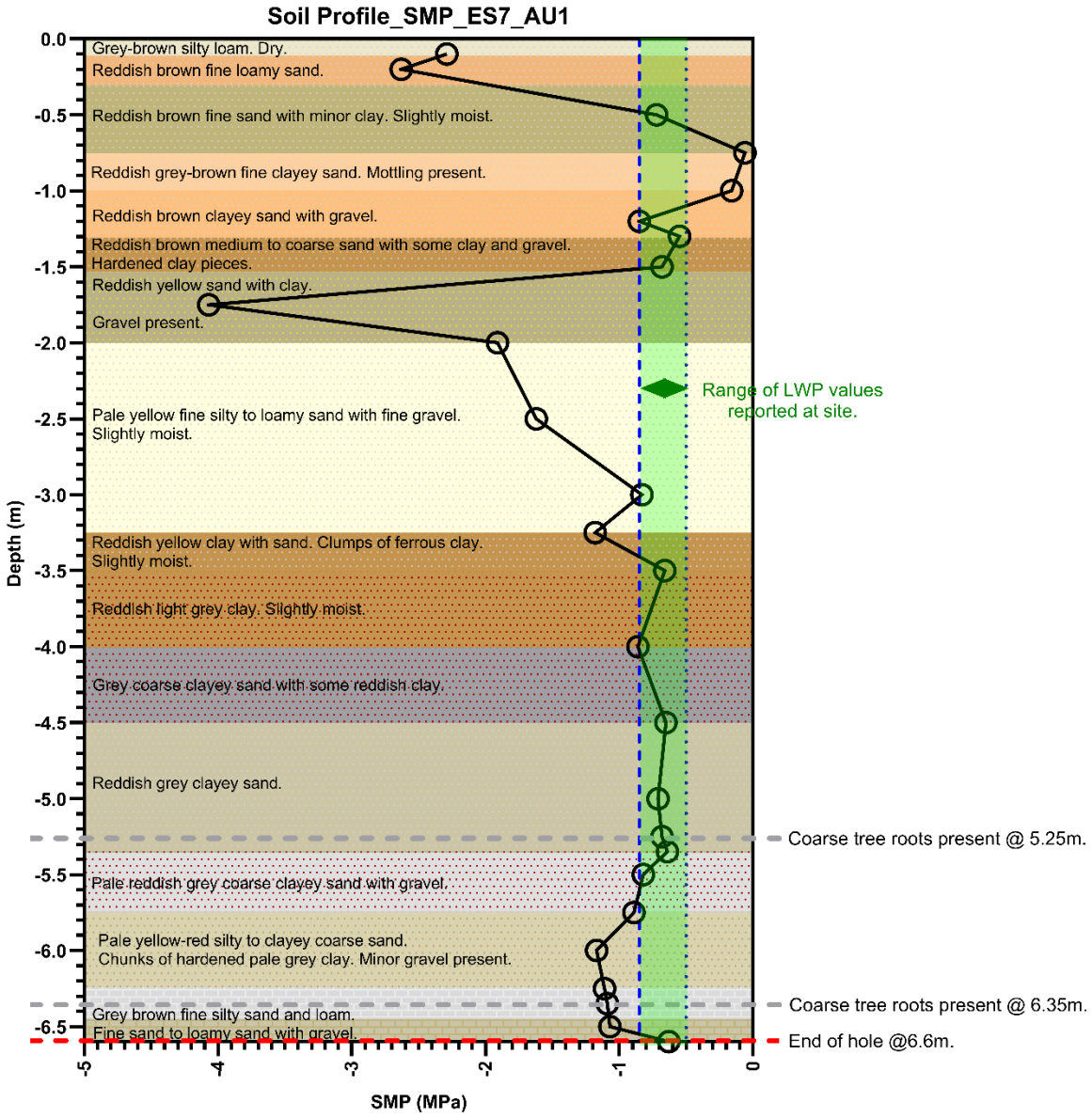


Figure 17. Auger profile for ES7_AU1 demonstrating the intersection of LWP and SMP values from 0.5 to 1.5 mbgl, and also from 3.5 mbgl to the base of the auger profile.

4.3 Stable Isotope Sampling and Analyses

Section 4.3 presents an analysis of stable isotope data collected from soils, twig xylem and surface water during the assessment, applied as an additional line of evidence to support biophysical measurements. As there was no sampling of groundwater completed during the field assessment, the range of GAB water isotopic compositions was sourced from relevant literature and applied as a proxy for locally collected groundwater isotope compositions, recognising the geological disjunct between groundwater sources at the Project site and proxy groundwater values sourced from the Galilee Basin (Keegan-Treloar et al., 2024).

To assist data interpretation, the local meteoric water line (LMWL) for Mt Isa (Y = 9.220*X + 7.100), as developed by Crosbie et al., (2012), and located 400 km south-west of the Project was applied in the absence of local rainfall data.

Stable isotopes ratios of oxygen and hydrogen ($\delta^{18}O$ and $\delta^{2}H$) extracted from water found within the xylem of sampled twigs, soil, surface water and groundwater are represented in **Figure 19** to **Figure 20**, with **Figure 21** providing a downhole isotope profile for Site E7 (RE2.3.55d). Raw data from the laboratory analysis is provided in **Appendix D**. The isotope data demonstrates the following trends:

- ***Riparian Sites (Assessment Areas 1, 2, 4, 9* - RE2.3.26a**): **Figure 18** demonstrates stable isotope data from assessment sites on the riparian channels of Warrigal Creek and its tributaries, including soil samples from site ES7, to provide context for the isotopic composition of soils in deeper regions of the soil profile. The data demonstrates relatively consistent overlap between the clusters of soil and xylem samples suggesting a common linkage. Additionally, twig xylem and soil samples have considerably more depleted/lighter isotopic compositions than the range of values reported for GAB aquifers (Keegan-Treloar et al., 2024), suggesting that groundwater does not contribute in any significant manner to the moisture sources of riparian vegetation.
- ***Wetland Sites (Assessment Areas 7, 8 and 10* - RE2.3.55d**): **Figure 19** demonstrates stable isotope data from assessment sites located in wetland depressions associated with RE2.3.55d. As in RE2.3.26c, the data demonstrate continuous overlap between the soil and xylem clusters; twig xylem is slightly offset below the LMWL, while soil samples cluster along it. The offset of twig xylem values is consistent with small degrees of evaporative enrichment that occur as moisture passes from soils to leaves (Evaristo et al., 2017; Petit & Froend, 2018). Twig xylem samples also show a large spread of values, with endpoints both strongly enriched and strongly depleted, compared to groundwater samples from GAB aquifers (Keegan-Treloar et al., 2024). The data suggest that groundwater does not contribute significantly to the moisture sources of deep-rooted vegetation associated with wetland depressions. In addition, the downhole isotope profile for site ES7 (**Figure 20**) indicates strong overlap between site twig xylem and soil moisture $\delta^{18}O$ values down the entire soil profile, indicating that soil moisture drives transpiration at this site.
- **Sites with mixed species associated with older alluvial and residual plains (ES3, 5 and 6 - RE2.3.42b_RE2.5.28_2.3.29b)**: **Figure 21** demonstrates stable isotope data from assessment sites on the residual plains, though includes soil samples from site ES7, to provide context for the isotopic composition of soils in deeper regions of the soil profile. The data demonstrates twig xylem is strongly enriched above soil samples and does not overlap significantly with the range of GAB

groundwater samples. A lack of overlap between twig xylem and soil samples demonstrates the complexities of moisture uptake in a drying soil profile. In this case, the gas vapour fraction of the soil profile may have had a significant influence on the isotopic results (Tetzlaff et al., 2020), which has ultimately confounded the relationship between soil and twig xylem values. Regardless, there is no evidence that groundwater has been a significant source of moisture supporting terrestrial vegetation on residual landforms.

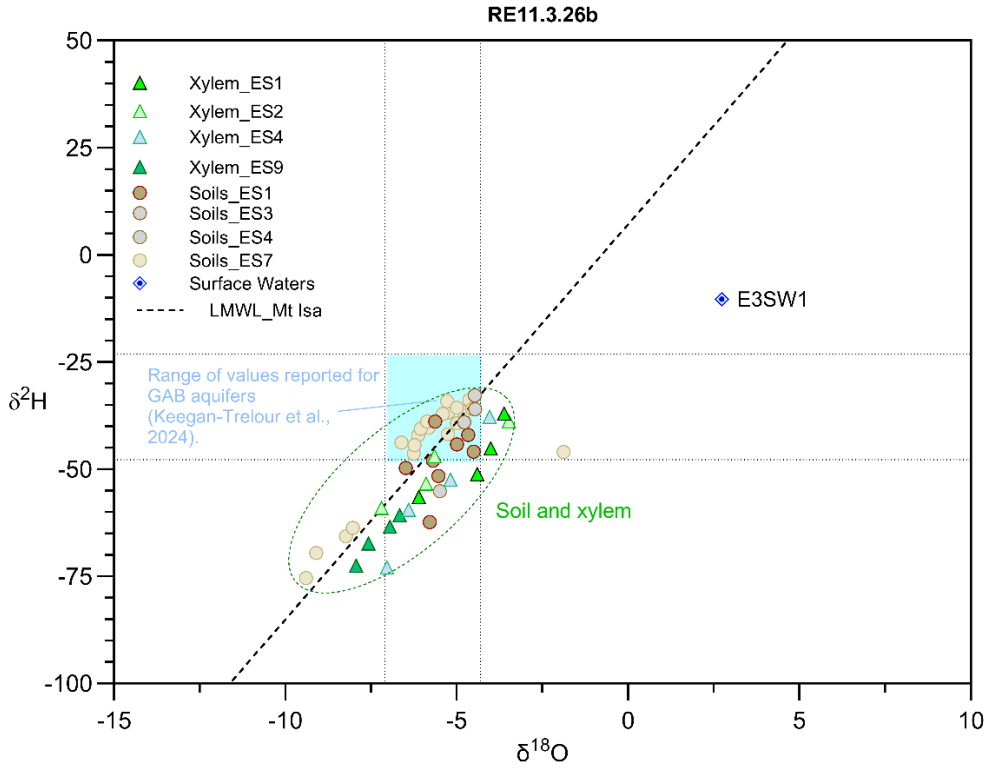


Figure 18. Stable isotope biplot for sites associated with riparian landforms of Warrigal Creek and tributaries showing a defined cluster of overlapping twig xylem and soils samples.

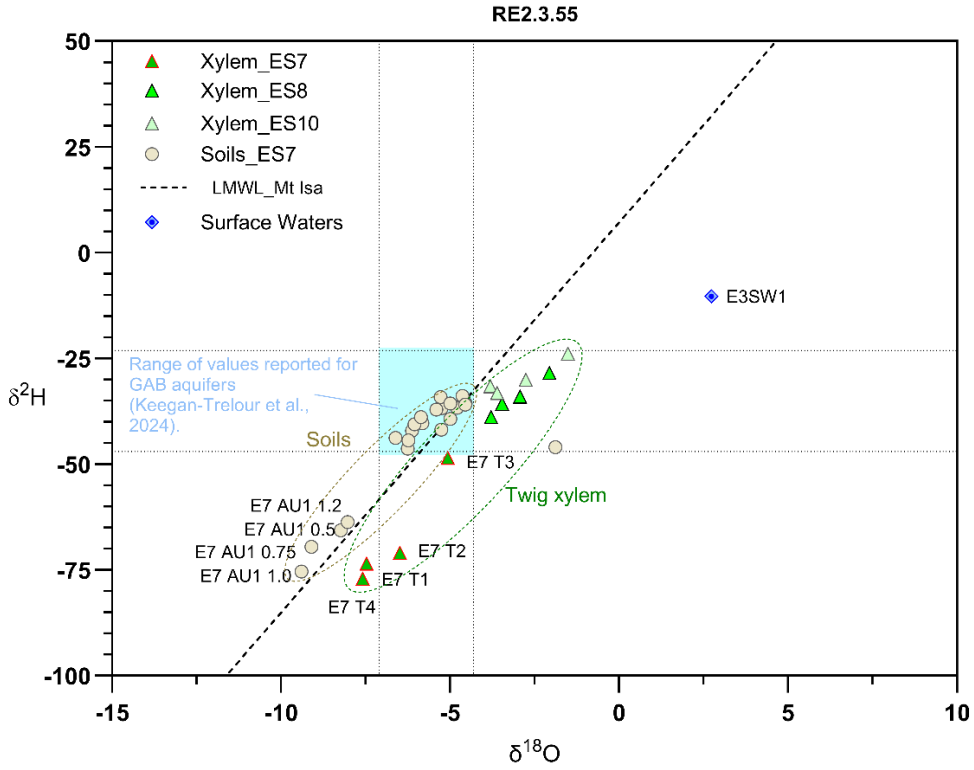
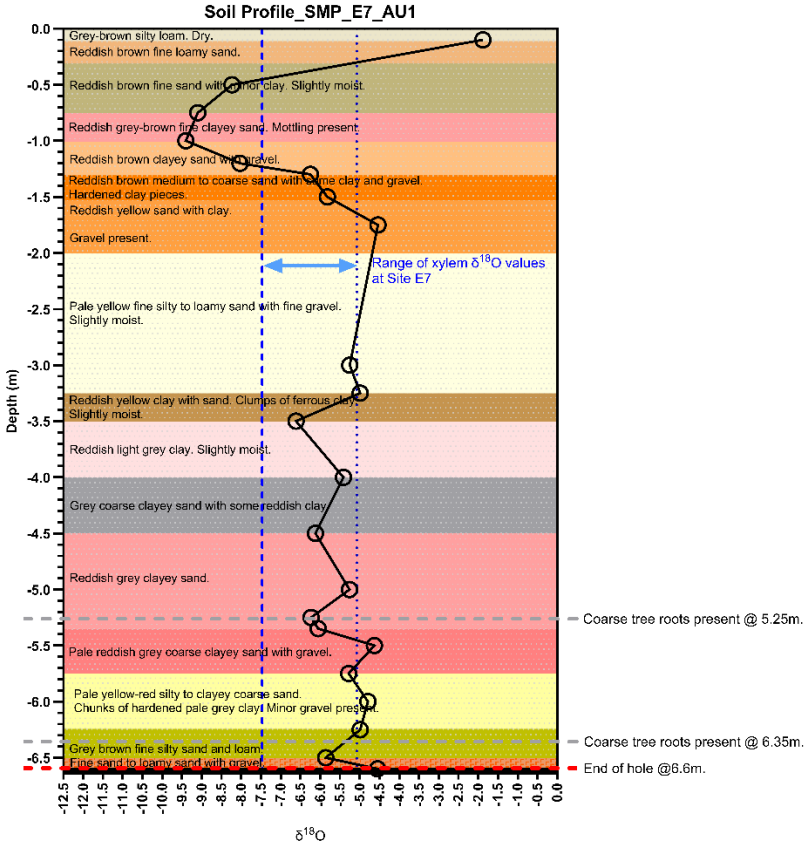


Figure 19. Stable isotope biplot for sites associated with wetland sites ES7, ES8 and ES10, showing the offset of twig xylem values below the LMWL.



a

Figure 20. Downhole $\delta^{18}O$ profile for auger ES7 within wetland depression habitat (RE2.3.55) showing consistent overlap between twig xylem and soil samples.

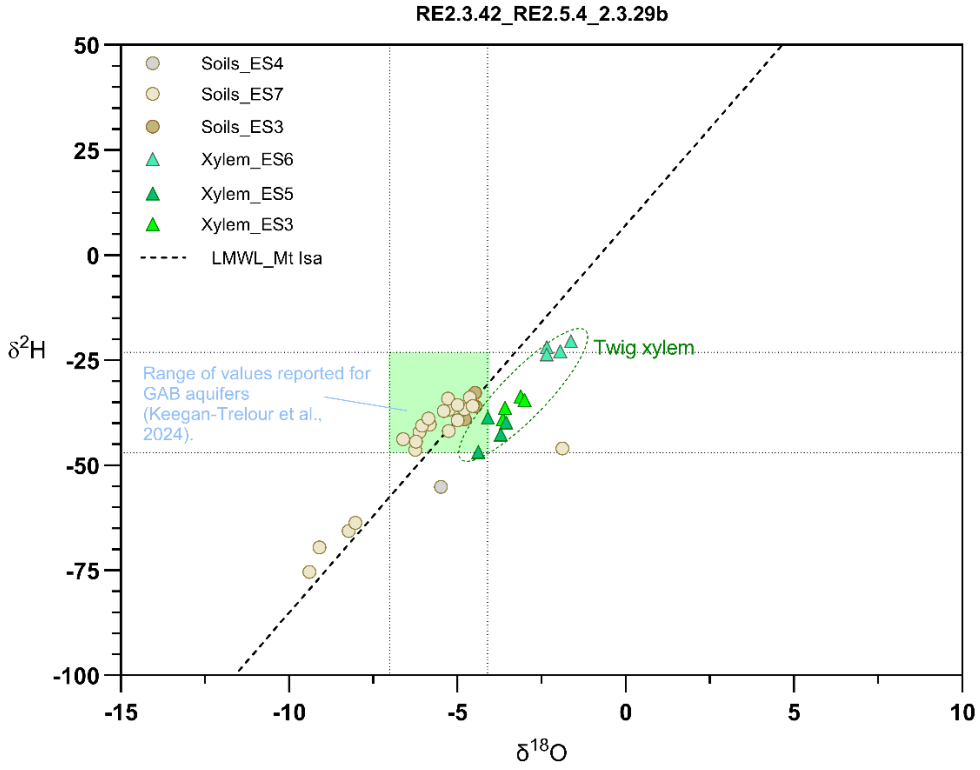


Figure 21. Stable isotope biplot for sites on residual landforms showing the substantial enrichment of twig xylem over soil samples.

4.4 Summary of Data

Table 8 summarises the evidence for groundwater dependence and the likely water sources at each of the ten assessment sites. The reported Gilbert River Formation potentiometric levels, approximately 6.6–12.5 m below ground, represent the levels to which groundwater rises under pressure within bores, rather than the depth of a shallow water table accessible to roots. Seasonal perched groundwater in channel sands represents a separate potential water source, conceptualised in **Section 5.0**, and should be distinguished from residual moisture retained in unsaturated sediments or weathered rock fractures.

An Extremely High LWP value indicates readily available moisture but does not identify its source. Following surface flows, moisture retained in localised wetter portions of the fluvial sediments may support high LWP values without requiring groundwater uptake. Stable isotope comparisons provide an additional line of evidence when interpreted alongside LWP, SMP and the hydrogeological setting. However, the published GAB groundwater isotope values are a regional proxy rather than locally sampled groundwater signatures, so isotopic differences cannot conclusively exclude local groundwater contributions. TabTaken together, the depth of the monitored Gilbert River Formation aquifer, the absence of a demonstrated connection to the root zone, soil–xylem isotope overlap at some sites, and SMP–LWP overlap within selected auger profiles favour soil moisture as the principal water source during the assessment. This interpretation is less certain at ES4, where the sampled SMP profile does not overlap LWP, and at sites without local soil profiles. Overall, substantial use of Gilbert River Formation groundwater is unlikely on the available evidence, while seasonal use of shallow perched groundwater in riparian habitats remains plausible

Table 8. Summary of data sources at individual GDE assessment sites.

Habitat / assessment site	Possible groundwater interactions	LWP and SMP results	Stable isotope results	Likely water sources and uncertainties
Riparian woodland **ES1** RE 2.3.26a/2.3.26c	Potential seasonal perched water in channel sands over weathered Claraville Beds. Deeper Gilbert River Formation groundwater use is not demonstrated.	Mean LWP -1.05 MPa (Moderate). ES1_AU1 shows SMP–LWP overlap at intervals from about 0.75 to 1.5 m, consistent with accessible soil moisture.	Riparian xylem and soil-water clusters overlap (**Fig. 18**). Much of the xylem is depleted relative to the published GAB comparison range; this is not a local groundwater endmember.	**Most likely:** moisture stored in unsaturated alluvium. Seasonal use of perched channel water is plausible following flow but was not confirmed at sampling.
Riparian woodland **ES2** RE 2.3.26a/2.3.26c	Potential seasonal perched water in channel sands over weathered Claraville Beds. Deeper Gilbert River Formation groundwater use is not demonstrated.	Mean LWP -0.60 MPa (High); one tree at -0.25 MPa (Extremely High under the report's thresholds). No site-specific SMP profile is presented.	Included in the overlapping riparian soil–xylem clusters (**Fig. 18**). Comparison soils come from other sites; source attribution is not specific to ES2.	**Most likely:** accessible soil moisture and residual stream-recharged storage. Recent or seasonal perched channel groundwater remains plausible; high LWP alone does not establish groundwater use.
Riparian woodland **ES4** RE 2.3.26a/2.3.26c	Potential seasonal perched water in channel sands over weathered Claraville Beds. Deeper Gilbert River Formation groundwater use is not demonstrated.	Mean LWP about -1.43 MPa (Low). ES4_AU1 remains too dry to overlap LWP down to 1.6 m; SMP is about -56 MPa near the surface.	Included in the riparian soil–xylem cluster (Fig. 18), but habitat-level overlap does not resolve the mismatch with the local SMP profile.	**Most likely**: residual water in weathered bedrock fractures or unsampled wetter pockets, as inferred in Section 4.2.3. Whether fracture water is unsaturated storage or locally perched water is unresolved. Seasonal channel-water use remains plausible.
Riparian woodland **ES9** RE 2.3.26a/2.3.26c	Potential seasonal perched water in channel sands over weathered Claraville Beds. Deeper Gilbert River Formation groundwater use is not demonstrated.	Mean LWP -0.625 MPa (High). No site-specific SMP profile is presented.	Included in the overlapping riparian soil–xylem clusters (**Fig. 18**); the comparison includes soils from other sites. No local groundwater isotope sample was available.	**Most likely:** relatively available soil moisture and residual stream-recharged storage. Seasonal perched groundwater is plausible following channel flow; current use and contribution cannot be quantified.

Habitat / assessment site	Possible groundwater interactions	LWP and SMP results	Stable isotope results	Likely water sources and uncertainties
Seasonal swamp woodland **ES7** RE 2.3.55d	Gilbert River Formation regional aquifer: no demonstrated root-zone connection. Claraville Beds are generally unsaturated.	Mean LWP about -0.64 MPa (High). SMP supports uptake at intervals around 0.5–1.5 m and deeper intervals to 6.6 m. Roots occur at 5.25 and 6.35 m; no groundwater was intersected.	Soil and xylem $\delta^{18}O$ overlap at multiple depths (**Fig. 20**). The wetland biplot shows a broad xylem spread and an offset from soil water (**Fig. 19**); these do not uniquely identify an aquifer.	**Most likely:** rainfall/runoff-derived water retained in the deep unsaturated soil profile, particularly finer horizons. Strong combined support for soil-water use. The report interprets wet-season saturation as transient infiltration, not a persistent groundwater supply.
Seasonal swamp woodland **ES8** RE 2.3.55d	Gilbert River Formation regional aquifer: no demonstrated root-zone connection. Claraville Beds are generally unsaturated.	Mean LWP -1.69 MPa (Low), indicating lower water availability than ES7. No site-specific SMP profile is presented.	Wetland xylem overlaps the broader ES7 soil-water comparison but varies widely (**Fig. 19**). This is not a direct match to an ES8 soil profile.	**Most likely:** stored rainfall/runoff-derived soil moisture. Significant regional groundwater use is not supported by the combined assessment. Uptake depth and source remain less certain than at ES7.
Seasonal swamp woodland **ES10** RE 2.3.55d	Gilbert River Formation regional aquifer: no demonstrated root-zone connection. Claraville Beds are generally unsaturated.	Mean LWP -1.41 MPa (Low). No site-specific SMP profile is presented.	Included in the wetland isotope comparison (**Fig. 19**), using soil water sampled at ES7. No site-specific soil–xylem depth comparison is available.	**Most likely:** stored rainfall/runoff-derived soil moisture. Regional groundwater support is not demonstrated; seasonal recharge and uptake depth are inferred from the habitat model rather than measured locally. [1, 3]
Floodplain woodland and modified overflow wetland **ES3** RE 2.3.42b	Gilbert River Formation regional aquifer: no demonstrated root-zone connection. Claraville Beds are generally unsaturated.	Mean LWP -2.18 MPa (Very Low). ES3_AU1 contains dry soils with SMP–LWP overlap at selected depths around 1.0–1.2 and 2.0–2.3 m. Roots are recorded near 2.0–2.1 m.	In the older-alluvial/residual-site comparison, xylem is generally enriched relative to comparison soils (**Fig. 21**). Soil–xylem offsets prevent a definitive source match.	**Most likely:** moisture retained in the unsaturated soil profile. Groundwater use is not supported by the combined evidence.

Habitat / assessment site	Possible groundwater interactions	LWP and SMP results	Stable isotope results	Likely water sources and uncertainties
Woodland on residual plain **ES5** RE 2.5.28	Gilbert River Formation regional aquifer: no demonstrated root-zone connection. Claraville Beds are generally unsaturated.	Mean LWP -2.46 MPa (Extremely Low). Corymbia polycarpa has less negative LWP than Melaleuca viridiflora. No site-specific SMP profile is presented.	Xylem is enriched relative to comparison soils and does not substantially overlap the published GAB range (**Fig. 21**). Soil samples are from other sites.	**Most likely:** tightly held residual soil water, with species differences in uptake depth or availability. Substantial groundwater use is unlikely; the proposed vapour/fractionation explanation for the isotope offset remains unconfirmed.
Woodland adjoining drainage depression **ES6** RE 2.3.29b	Gilbert River Formation regional aquifer: no demonstrated root-zone connection. Claraville Beds are generally unsaturated.	Mean LWP -1.95 MPa (Very Low); individual trees range from -0.90 to -3.40 MPa. No site-specific SMP profile is presented.	Included in the enriched residual-site xylem cluster, offset from comparison soils (**Fig. 21**). No local soil profile or groundwater endmember confirms the source.	**Most likely:** heterogeneous soil-water stores at different depths, consistent with variable tree LWP. Substantial groundwater use is unlikely; exact uptake depths and sources remain unresolved.

5.0 Conceptualisation of Tree Moisture Sources

With reference to **Section 4.1**, based on measured pre-dawn LWPs, only a limited number of survey localities have the potential to be groundwater-supported, which includes RE2.3.26a at site ES2 and ES9, as well as RE2.3.55d at site ES7. There are, however, several factors suggesting that the vadose zone rather than groundwater supports the moisture requirements of vegetation at these sites, and more broadly across the landscape, including:

- LWP values for many trees sampled from a range of habitats, including both riparian and eucalypt woodlands, are consistently strongly negative, suggesting that woody vegetation is reliant on soil moisture from unsaturated portions of the soil profile.
- There is a consistent overlap between LWP and SMP for all augers sampled, including the deeper auger profile at ES7_AU1. The consistent overlap between LWP and SMP indicates that soil moisture in the unsaturated regions of the soil profile, supported transpiration at the time of sampling.
- Groundwater monitoring bores installed into the Claraville Beds are consistently unsaturated to depths below 10 mbgl. Groundwater was intersected in deeper aquifers of the Gilbert River Formation, rising to ~7 mbgl under sub-artesian pressure. There was, however, no physical or biophysical evidence from LWP and SMP that this sub-artesian groundwater was being expressed at the surface or interacting with the tree root zone to any degree.
- Stable isotope values at all sites and across all landforms suggests that terrestrial vegetation is using soil moisture to support transpiration. There is no isotopic or biophysical evidence that groundwater is supporting vegetation across the site to any degree.

Ecohydrological models have been developed for riparian ecosystems (RE2.3.26a) and wetland depressions (RE2.3.55d), which conceptualise the sources of moisture for woody vegetation on a seasonal basis. **Figure 22** presents the model for the wetland depression, and **Figure 23** presents the riparian ecosystem.

The Auger profile ES7_AU1, constructed in the swamp wetland depression, indicates a deep soil profile down to 6.6m, including intervals of clayey and silt-sand. During the wet season (**Figure 22a**) following significant precipitation, surface water fills the wetland depression, infiltrating the wetland surface through mechanisms of both ‘preferential’ (rapid infiltration along fractures) and ‘piston’ (slow uniform seepage through soil pores) flow. During this process, the infiltrating surface water may be impeded by clay-rich layers, potentially forming ephemeral zones of saturation wherever these layers occur in the soil profile. Because moisture infiltration is slowed rather than captured, these ephemeral zones of saturation do not represent groundwater, and these wetland features are unlikely to be GDEs. During drier periods (**Figure 22b**), the clay-rich horizons sustain elevated soil moisture content longer than the sandier intervals, extending the availability of soil moisture to support transpiration as the climate dries.

The representation of the GAB aquifer hosted in the Gilbert River Formation (quartz sandstone) in **Figures 22a** and **22b** is conceptual, based on data from recently constructed groundwater monitoring bores. While the inference is that this aquifer is under sub-artesian pressure with a potentiometric surface at ~seven mbgl, there is no evidence from deep

auger profiling that groundwater is rising into the root zone of woody vegetation at any of the sample locations, nor is there evidence of groundwater discharge into drainage channels.

Braided channels are often prominent in ephemeral drainage systems, with the channel defined by a shallow mantle of coarse fluvial sand that rests upon weathered sedimentary basement (Claraville beds). A narrow and discontinuous low alluvial terrace fringes the sandy channel, confined by weathered basement on the outer margins of the terrace. The fluvial sand may have small islands stabilised by *Melaleuca fluviatilis*, a dominant riparian species on the stream banks and channels, interspersed with scattered *Eucalyptus camaldulensis*.

During wet season flows, these fluvial sands are fully saturated, with surface water receding into the sand as surface flows diminish, perched on the weathered basement rock (**Figure 23a**). There is likely to be some minor infiltration into basement rock fracture zones and areas of more intense weathering. Because of the conceptualised perched layer, riparian vegetation utilising groundwater in the channel sands would be consistent with the definition of a terrestrial GDE. Groundwater use, however, occurs on a seasonal basis following surface flows and attenuates as the climate dries and shallow groundwater volumes diminish through evapotranspiration (**Figure 23b**).

- LWP data collected during the assessment indicate that moisture availability is variable along the riparian fringe in drier periods and likely depends on several factors, including:
- The duration and volume of surface flows.
- The depth of the fluvial sand influences the volume of perched groundwater.
- The intensity of weathering and fracturing in the sedimentary basement below the fluvial sand influences the degree to which moisture can infiltrate along fracture zones.
- Whether a flood event is associated with overbank flow, which influences bank storage within alluvial terraces.

Evidence from the field survey indicates that perching of water in the fluvial sand is ephemeral, lasting only for a few days or weeks following recharge. Hence, any groundwater use is likely to be similarly fleeting, with moisture use rapidly transitioning to utilisation of residual moisture within rock fractures and wet sand grains, which persist as shallow groundwater diminishes. There is no evidence that suggests riparian vegetation interacts with deeper groundwater systems associated with the GAB, which are not connected to the perched groundwater systems associated with ephemeral watercourses.

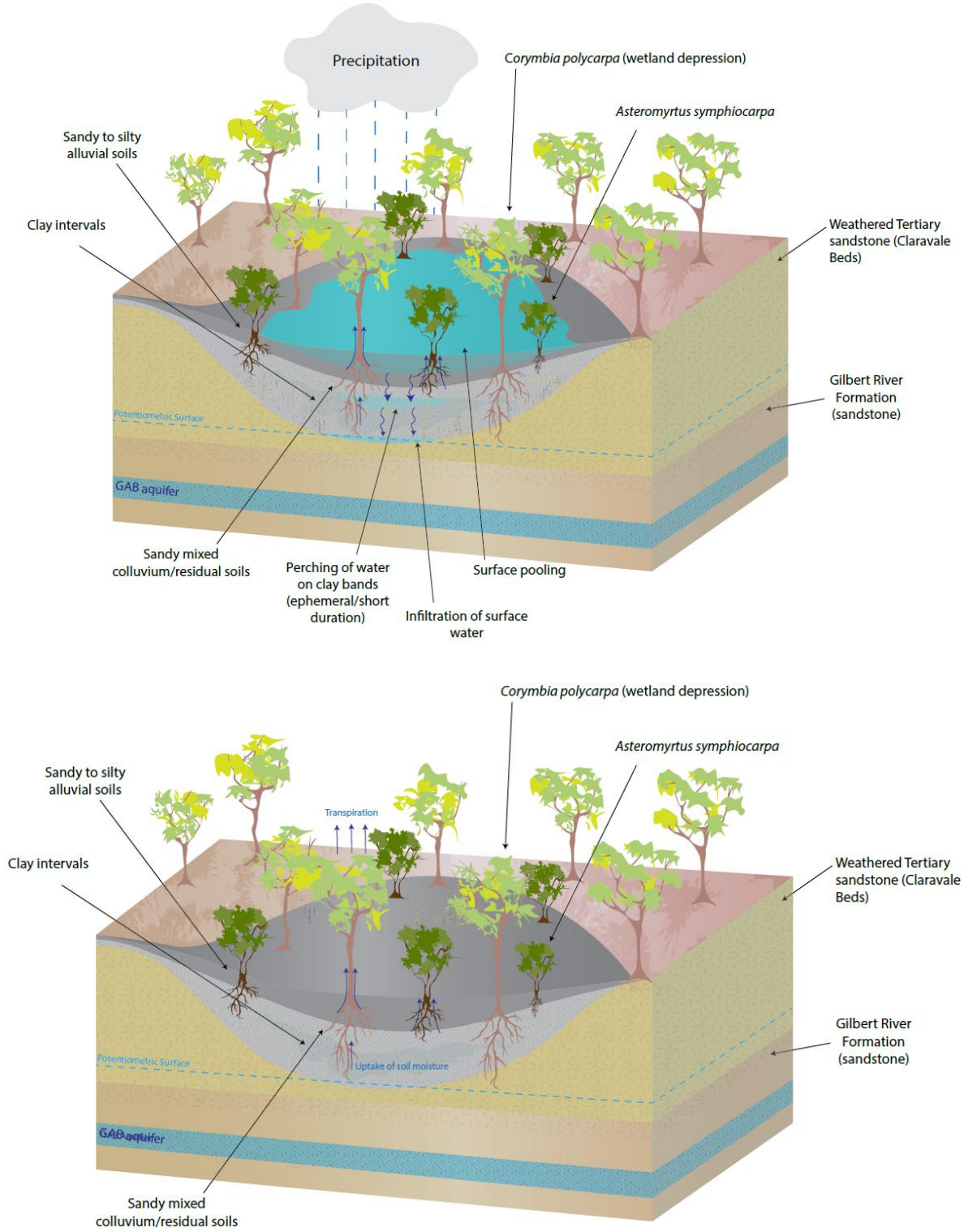


Figure 22. Ecohydrological conceptualisation of a swamp wetland depression (RE2.3.55d) during the wet season (**Figure 22a** above), and dry season (**Figure 22b** below).

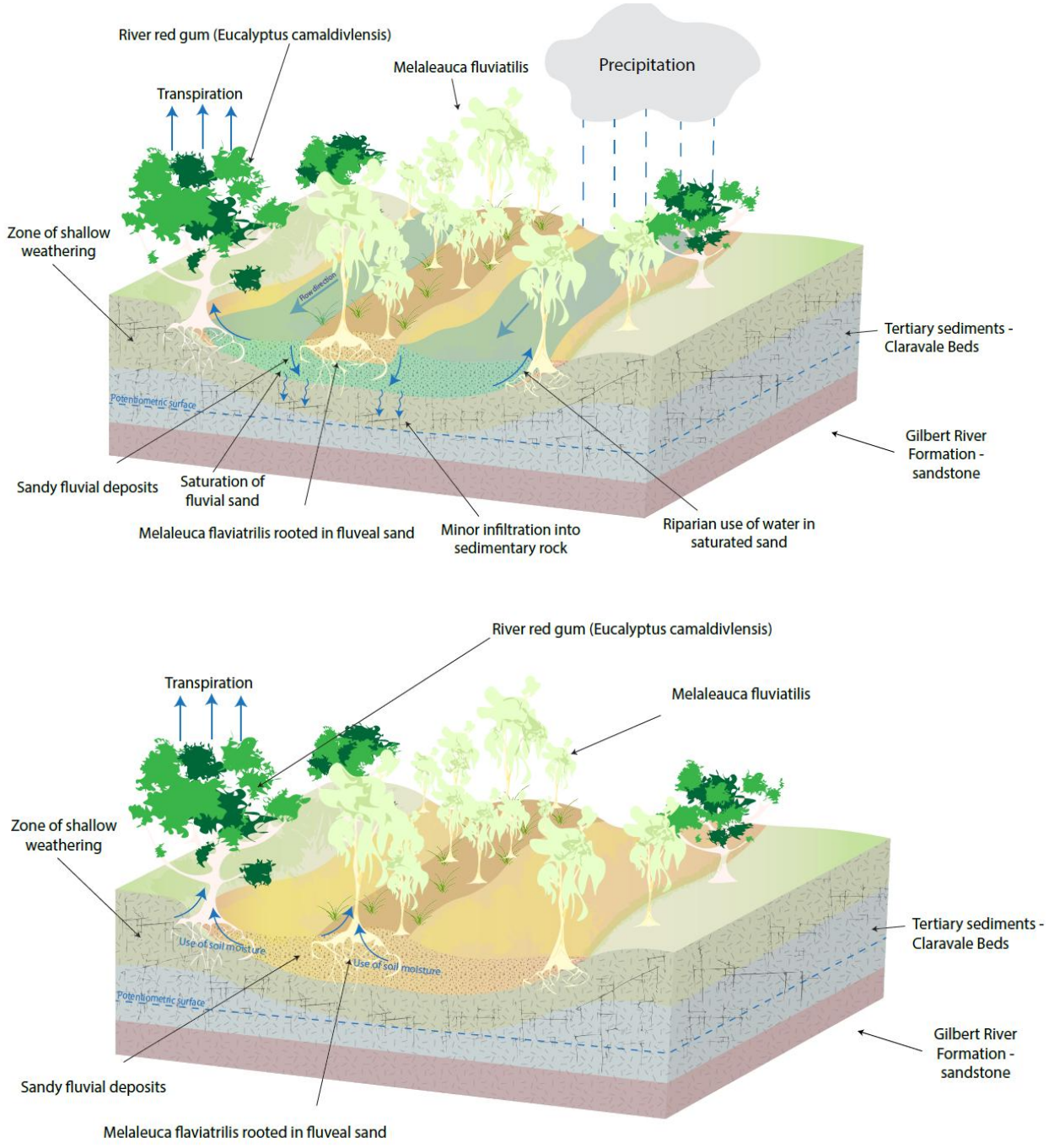


Figure 23. Ecohydrological conceptualisation of an ephemeral flood channel system (RE2.3.26a) during the wet season with saturation of the channel sand (**Figure 23a** above), and dry season where moisture usage is restricted to residual moisture in fluvial sand and rock fractures (**Figure 23b** below).

6.0 Impact Assessment

Richardson (2011) identifies several pathways that will result in impacts to the health and ecological function of a GDE which may include:

1. Direct clearing of a GDE
2. A total or partial loss or reduction in the volume or pressure of the aquifer being utilised by GDEs.
3. A change in the magnitude and timing of volume fluctuations in the aquifer being utilised by GDEs.
4. Changes to the interaction between surface flows and aquifers being utilised by a GDE.
5. Change in chemical composition of an aquifer detrimentally impacting the health of a GDE.

Importantly, while groundwater modelling for the Project completed for the Groundwater Impact Assessment (Hydrogeologist, 2026) indicates up to 50 m groundwater drawdown in the central portion of the MLA, this affects the confined aquifer within the Gilbert River Formation, a 40 m thick geological unit with an upper surface intersected at a depth >10 mbgl (Hydrogeologist, 2026), beyond the rooting depth of terrestrial vegetation, which is consistent with the findings of this study, that terrestrial vegetation was not using groundwater at the time of assessment. The only potential for groundwater dependence in terrestrial vegetation is seasonal and associated with small amounts of perched groundwater that might occur at the base of channel sands on Warrigal Creek following wet-season surface flows. Given the limited potential for groundwater dependence within the assessment area, a risk assessment has been completed to assess the likelihood of impacts on GDEs associated with the Esmeralda Project, which are described below:

- ***High significance:*** Complete destruction of a GDE in terms of complete loss of keystone species and conversion to an alternate degraded ecological state. Impacts are irreversible and the only feasible option for mitigation is an environmental offset under relevant environmental policy.
- ***Moderate significance:*** Degradation of a GDE to an extent such that 25% or more keystone species are affected by the action. Impacts will be reversible only with mitigation.
- ***Low significance:*** Impacts are short in duration and reversible without mitigation required.
- ***Insignificant:*** Impacts are undetectable when assessed against a relevant ecological baseline.

Table 9 shows the ranking applied to the likelihood assessment, including the descriptor; **Table 10** shows descriptions of impact magnitude; and **Table 11** shows the derived risk matrix. **Table 12** presents the constructed risk assessment with a residual risk score. The following assessment presents unmitigated risk, with no specific management actions or mitigations applied.

Based on the risk assessment outcomes in **Table 12**, unmitigated risk to GDEs identified in this assessment are classified as '*Insignificant*'.

Table 9. Descriptors and ranking for the likelihood of impact occurring.

Rank	Likelihood	Description
1	Highly unlikely	There is no precedent for this event in the industry and similar events have not previously occurred.
2	Unlikely	Impacts have been associated with previous industry actions although similar impact pathways are not identified for the Project.
3	Possible	Impact pathways are not clearly understood and impacts have been previously associated with a similar industry action
4	Likely	Impacts have previously been associated with the industry and a clear impact pathway exists.
5	Highly likely	A common event that is consistently associated with a similar industry action/ of an action that is proposed to occur.

Table 10. Descriptors of Impact Magnitude applied in the risk assessment.

Magnitude	Description
Negligible	No impact identifiable above baseline ecological conditions
Low	Plant stress linked to mining development that results in the reduction in volume and duration of groundwater supporting a GDE system that does not result in more than 5% dieback of 'mature canopy trees'*. Impact localised and reversible with mitigation.
Moderate	Plant stress linked to mining development that results in the reduction in volume and duration of groundwater supporting a GDE system that does not result in more than 25% dieback of mature canopy trees (defined as a canopy tree with DBH >60cm). Impact is reversible with mitigation.
High	Significant harm (loss of 25 to 50% of mature canopy trees). Impact is reversible although a significant lag in return to pre-disturbance condition occurs (lag>20yrs). Vegetation is converted from remnant to non-remnant status and significant impacts to habitat for protected fauna species occurs. Biodiversity offsets may be required.
Severe	Irreversible impact to > 50% 'mature canopy trees'* that cannot be mitigated. Vegetation is converted from remnant to non-remnant status and significant impacts to habitat for protected fauna species occurs. Biodiversity offsets will be required.

*A 'mature canopy tree' is defined for the purpose of this risk assessment as a tree that forms a component of the undisturbed canopy (T1 or upper structural layer) of a remnant vegetation community.

Table 11. Matrix applied in the risk assessment.

		Likelihood				
		Highly Unlikely (1)	**Unlikely (2)**	**Possible (3)**	**Likely (4)**	**Highly Likely (5)**
Consequence	**Severe**	Insignificant	Low	High	High	High
	High	Insignificant	Low	Moderate	High	High
	Moderate	Insignificant	Low	Moderate	Moderate	Moderate
	Low	Insignificant	Low	Low	Low	Low
	Negligible	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant

Table 12. Risk assessment for potential impacts and risk scores based on unmitigated[1] project development.

Impact Pathway	Comments	Pre-mitigated Risk		
		Likelihood	Consequence	Risk
1. Direct clearing of a GDE	No direct clearing of GDEs proposed.	1	Severe	Insignificant
2. A total or partial loss or reduction in the volume or pressure of the aquifer being utilised by TGDEs.	There is no hydraulic connection between the ephemeral perched groundwater unit seasonally hosted in the channel sands of Warrigal Creek and the sub-artesian groundwater unit at the base of the Gilbert Formation, that is subject to groundwater drawdown impacts (Hydrogeologist 2026).	1	Moderate	Insignificant
3. A change in the magnitude and timing of volume fluctuations in the aquifer being utilised by GDEs.	Perched groundwater will occur at the base of the sandy river channel on Warrigal Creek and in restricted pockets on the unnamed tributary. Seasonal surface flows recharge perched groundwater, and residual groundwater attenuates rapidly during the dry season. Diversion of an unnamed tributary of Warrigal Creek around the proposed mining void will ensure that the duration and volume of wet-season surface flows in larger ephemeral watercourses will not be impacted by the Project.	1	Moderate	Insignificant
4. Changes to the interactions between surface flows and aquifers being utilised by a GDE.	There is no mechanism for the Project to impact the interaction between surface flows and the groundwater at the base of the Gilbert River Formation that is subject to groundwater drawdown impact.	1	Moderate	Insignificant
5. Change in chemical composition of an aquifer detrimentally impacting the health of a GDE[1].	The Project will not result in changes to the chemical composition of surface flows in ephemeral watercourses within the Project area	1	Moderate	Insignificant

[1]Assumes all necessary site environmental management plans and procedures are in place to contain potential sources of environmental contamination to the quarry for on-site treatment and management.

7.0 Conclusions

The major conclusions drawn from this assessment are:

- During a dry season assessment under optimal seasonal conditions, there is no evidence that woody vegetation is reliant on groundwater to any degree to support transpiration.
- The dry-season moisture required to support transpiration in woody vegetation is supplied entirely within the vadose zone across all habitats sampled. Some habitats, including swamp wetland depressions (RE2.3.55d) and ephemeral flood channel habitats (RE2.3.26a), retain moisture for longer into the dry season by capturing surface flows and facilitating moisture infiltration. Moisture availability in these habitats declines as soil moisture reserves diminish under drier climate conditions.
- The wet-season ponding of surface water in swamp wetland depressions facilitates deep infiltration into the soil profile. Ephemeral zones of saturation may occur when infiltrating surface water is intercepted by clay soil horizons, though the saturation is fleeting and does not meet the definition of groundwater. The ecohydrological function of these swamp wetlands does not align with the definition of a GDE.
- In ephemeral drainage lines, wet-season recharge of fluvial sands facilitates the perching of shallow groundwater, hosted in channel sand deposits, on impermeable basement rock. Woody vegetation usage of this perched groundwater suggests that these watercourses represent GDEs when perched groundwater is present. Perched groundwater rapidly diminishes as the climate dries, and riparian woodlands become solely reliant on soil moisture held in the vadose zone.
- The recent installation of groundwater monitoring bores indicates a deeper groundwater zone, hosted in the Gilbert River Sandstones, inferred to be a GAB aquifer. This groundwater is under sub-artesian pressure, with a potentiometric surface at ~7 mbgl. There is no indication from biophysical assessment that this deeper groundwater interacts with the rooting zone of woody vegetation.

While modelling predicts project-related groundwater drawdown in the aquifer at the base of the Gilbert River Formation, this groundwater does not support either terrestrial or aquatic GDEs, and project-related GDE impacts are not predicted.

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9.0 Appendix

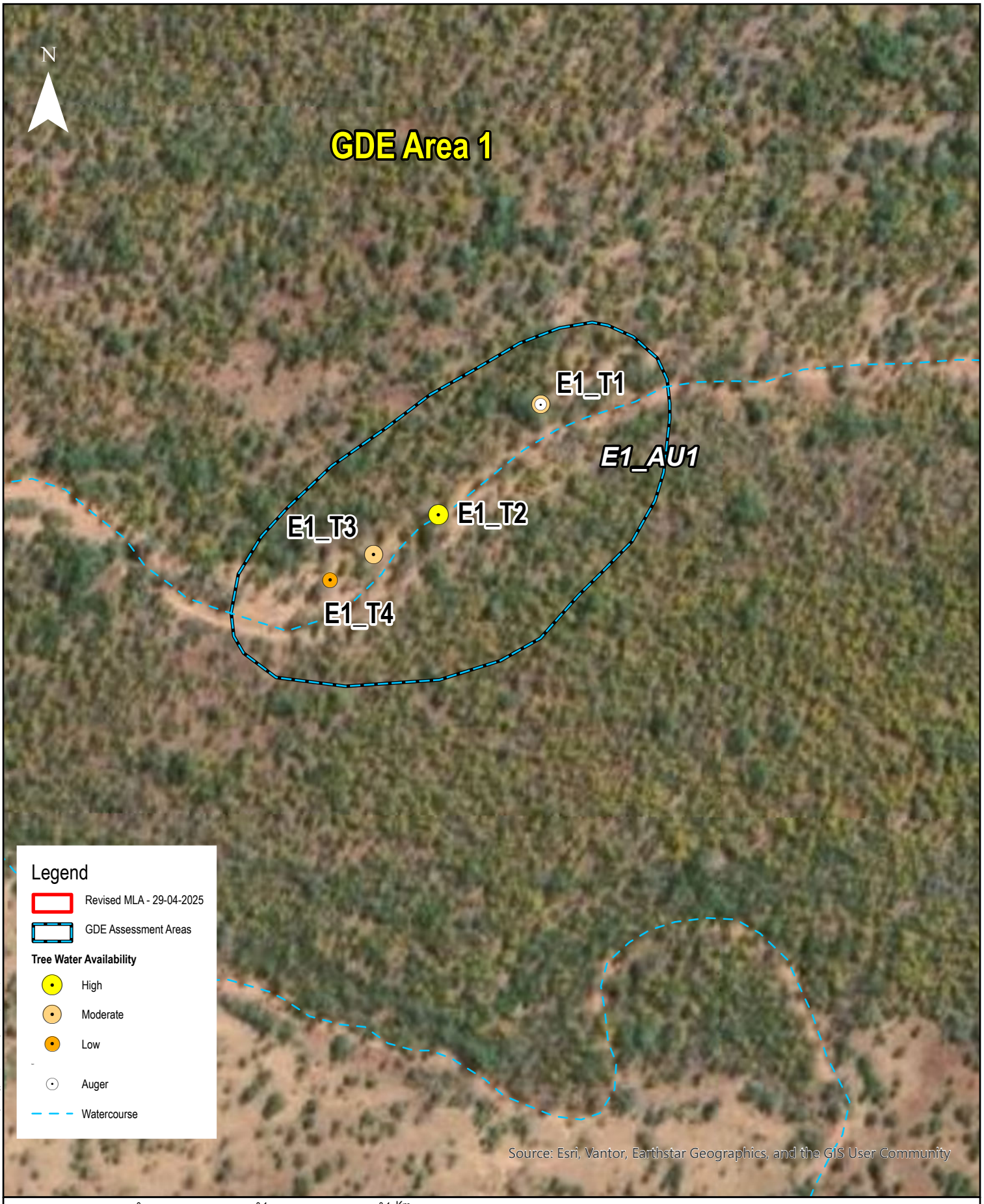
Appendix A: Tree Structural Details and Water Potentials

Esmeralda Trees	Y	X	Tree Sample Point	Species	DBH (mm)	Height (m)	LWP	Tree Water Availability	Grouping
E1	-18.819017	142.214559	E1_T1	*Eucalyptus camaldulensis*	29	13	-1.2	Moderate	RE2.3.26a Watercourse riparian vegetation
E1	-18.819425	142.214167	E1_T2	*Corymbia polycarpa*	45	15	-0.65	High	RE2.3.26a Watercourse riparian vegetation
E1	-18.819573	142.213918	E1_T3	*Eucalyptus camaldulensis*	46	12	-1.1	Moderate	RE2.3.26a Watercourse riparian vegetation
E1	-18.819668	142.213751	E1_T4	*Melaleuca fluviatilis*	41	10	-1.25	Low	RE2.3.26a Watercourse riparian vegetation
E2	-18.81922	142.210595	E2_T1	*Eucalyptus camaldulensis*	48	13	-0.25	Extremely High	RE2.3.26a Watercourse riparian vegetation
E2	-18.819065	142.210227	E2_T2	*Melaleuca fluviatilis*	39	12	-0.7	High	RE2.3.26a Watercourse riparian vegetation
E2	-18.819209	142.209915	E2_T3	*Eucalyptus camaldulensis*	48	12	-0.6	High	RE2.3.26a Watercourse riparian vegetation
E2	-18.819201	142.209443	E2_T4	*Corymbia polycarpa*	32	13	-0.85	High	RE2.3.26a Watercourse riparian vegetation
E3	-18.809998	142.177581	E3_T1	*Eucalyptus microtheca*	42	10	-1.85	Very Low	2.3.42b Floodplain adjoining watercourse
E3	-18.809861	142.177256	E3_T2	*Eucalyptus microtheca*	48	12	-1.8	Very Low	2.3.42b Floodplain adjoining watercourse
E3	-18.809953	142.177085	E3_T3	*Eucalyptus microtheca*	40	15	-2.75	Extremely Low	2.3.42b Floodplain adjoining watercourse
E3	-18.809685	142.176978	E3_T4	*Eucalyptus microtheca*	45	11	-3.6	Extremely Low	2.3.42b Floodplain adjoining watercourse
E3	-18.809336	142.177188	E3_T5	*Eucalyptus camaldulensis*	40	7	-0.9	Moderate	2.3.42b Floodplain adjoining watercourse
E4	-18.822349	142.238639	E4_T1	*Eucalyptus camaldulensis*	33	9	-1.8	Very Low	RE2.3.26a Watercourse riparian vegetation
E4	-18.822401	142.238488	E4_T2	*Melaleuca fluviatilis*	37	14	-1.45	Low	RE2.3.26a Watercourse riparian vegetation
E4	-18.82239	142.237989	E4_T3	*Eucalyptus camaldulensis*	31	10	-1	Moderate	RE2.3.26a Watercourse riparian vegetation
E4	-18.822267	142.237624	E4_T4	*Melaleuca fluviatilis*	60	16	-1.5	Low	RE2.3.26a Watercourse riparian vegetation
E5	-18.876039	142.334909	E5_T1	*Corymbia polycarpa*	33	16	-1.7	Low	RE2.5.28 Low woodland on plain
E5	-18.87629	142.335035	E5_T2	*Melaleuca viridiflora*	28	8	-3.35	Extremely Low	RE2.5.28 Low woodland on plain
E5	-18.876529	142.334925	E5_T3	*Corymbia polycarpa*	30	9	-1.7	Low	RE2.5.28 Low woodland on plain

Esmeralda Trees	Y	X	Tree Sample Point	Species	DBH (mm)	Height (m)	LWP	Tree Water Availability	Grouping
E5	-18.876314	142.334847	E5_T4	*Melaleuca viridiflora*	29	8	-3.1	Extremely Low	RE2.5.28 Low woodland on plain
E6	-18.879629	142.325624	E6_T1	*Eucalyptus microtheca*	24	8	-0.9	Moderate	RE2.3.29b Low woodland adjoining drainage feature
E6	-18.879801	142.325843	E6_T2	*Eucalyptus microtheca*	46	9	-1.75	Very Low	RE2.3.29b Low woodland adjoining drainage feature
E6	-18.880032	142.325934	E6_T3	*Erythrophleum chlorostachys*	33	7	-3.4	Extremely Low	RE2.3.29b Low woodland adjoining drainage feature
E6	-18.880364	142.325959	E6_T4	*Melaleuca viridiflora*	25	7	-1.75	Very Low	RE2.3.29b Low woodland adjoining drainage feature
E7	-18.811184	142.246473	E7_T1	*Corymbia polycarpa*	60	20	-0.6	High	RE2.3.55d Seasonal swamp woodland
E7	-18.811493	142.246265	E7_T2	*Corymbia polycarpa*	70	21	-0.6	High	RE2.3.55d Seasonal swamp woodland
E7	-18.811418	142.245761	E7_T3	*Corymbia polycarpa*	75	18	-0.85	High	RE2.3.55d Seasonal swamp woodland
E7	-18.810891	142.245766	E7_T4	*Corymbia polycarpa*	85	21	-0.5	Very High	RE2.3.55d Seasonal swamp woodland
E8	-18.835	142.212294	E8_T1	*Corymbia polycarpa*	60	17	-1.65	Low	RE2.3.55d Seasonal swamp woodland
E8	-18.835066	142.212637	E8_T2	*Corymbia polycarpa*	62	14	-1.95	Very Low	RE2.3.55d Seasonal swamp woodland
E8	-18.834787	142.212506	E8_T3	*Corymbia polycarpa*	40	15	-1.75	Very Low	RE2.3.55d Seasonal swamp woodland
E8	-18.834381	142.212045	E8_T4	*Corymbia polycarpa*	60	15	-1.4	Low	RE2.3.55d Seasonal swamp woodland
E9	-18.839642	142.200291	E9_T1	*Eucalyptus camaldulensis*	45	12	-0.55	Very High	RE2.3.26a Watercourse riparian vegetation
E9	-18.839255	142.1997	E9_T2	*Eucalyptus camaldulensis*	44	7	-0.55	Very High	RE2.3.26a Watercourse riparian vegetation
E9	-18.838626	142.199608	E9_T3	*Eucalyptus camaldulensis*	37	8	-0.8	High	RE2.3.26a Watercourse riparian vegetation
E9	-18.834706	142.212595	E9_T4	*Melaleuca fluviatilis*	28	7	-0.6	High	RE2.3.26a Watercourse riparian vegetation
E10	-18.856064	142.248267	E10_T1	*Corymbia polycarpa*	60	14	-1.3	Low	RE2.3.55d Seasonal swamp woodland
E10	-18.856153	142.247864	E10_T2	*Corymbia polycarpa*	71	18	-1.4	Low	RE2.3.55d Seasonal swamp woodland
E10	-18.855959	142.247404	E10_T3	*Corymbia polycarpa*	35	15	-1.5	Low	RE2.3.55d Seasonal swamp woodland

Esmeralda Trees	Y	X	Tree Sample Point	Species	DBH (mm)	Height (m)	LWP	Tree Water Availability	Grouping
E10	-18.856603	142.248028	E10_T4	*Corymbia polycarpa*	36	16	-1.45	Low	RE2.3.55d Seasonal swamp woodland

Appendix B: Sampling Spatial Details



Path: D:\Water_Mark_Ecohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A1. Sampling detail at GDE Assessment Area 1

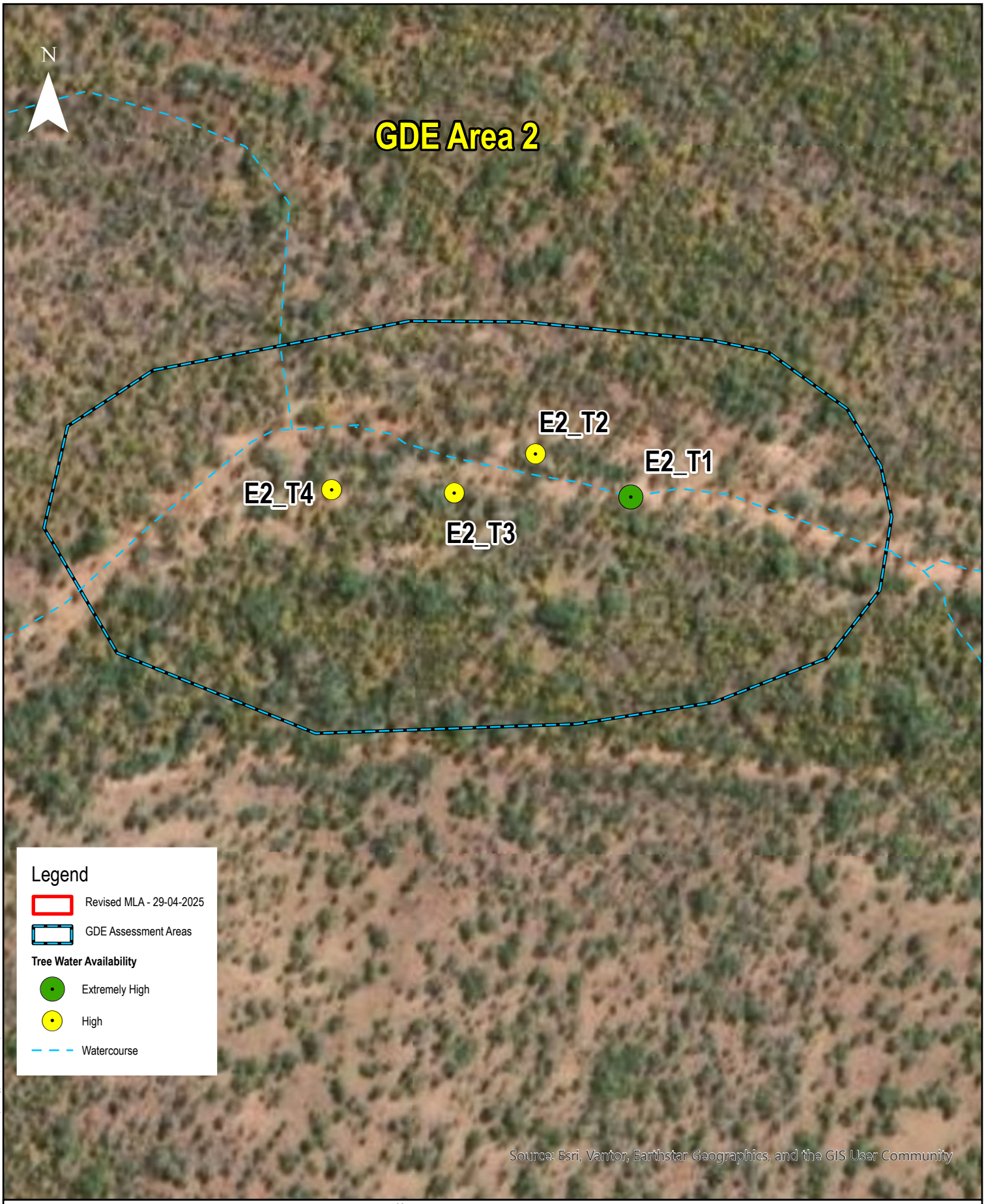
WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water...Mark...E:cohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A2. Sampling detail at GDE Assessment Area 2

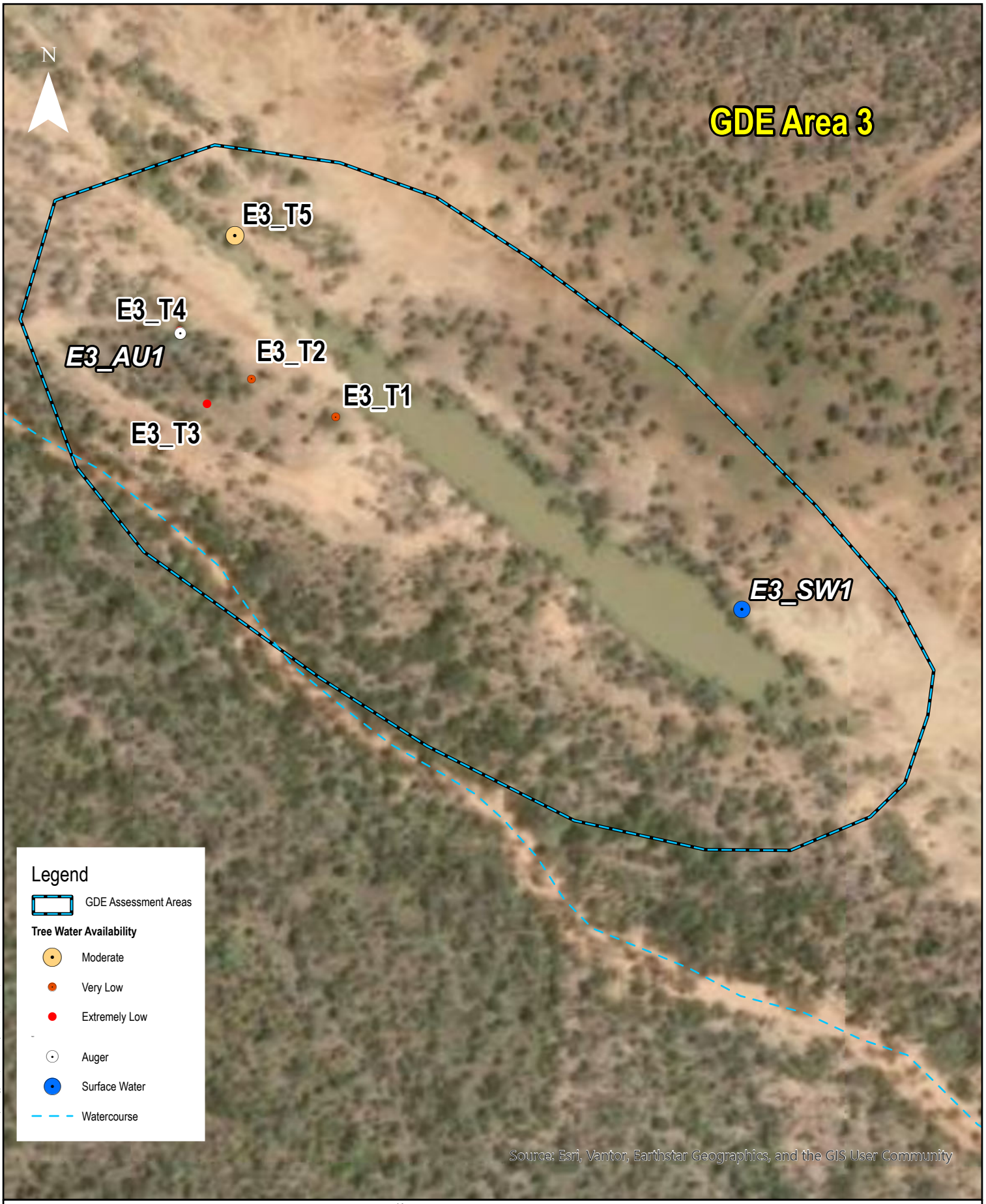
WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water_Mark_Ecohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A3. Sampling detail at GDE Assessment Area 3

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water_Mark_Ecohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A4. Sampling detail at GDE Assessment Area 4

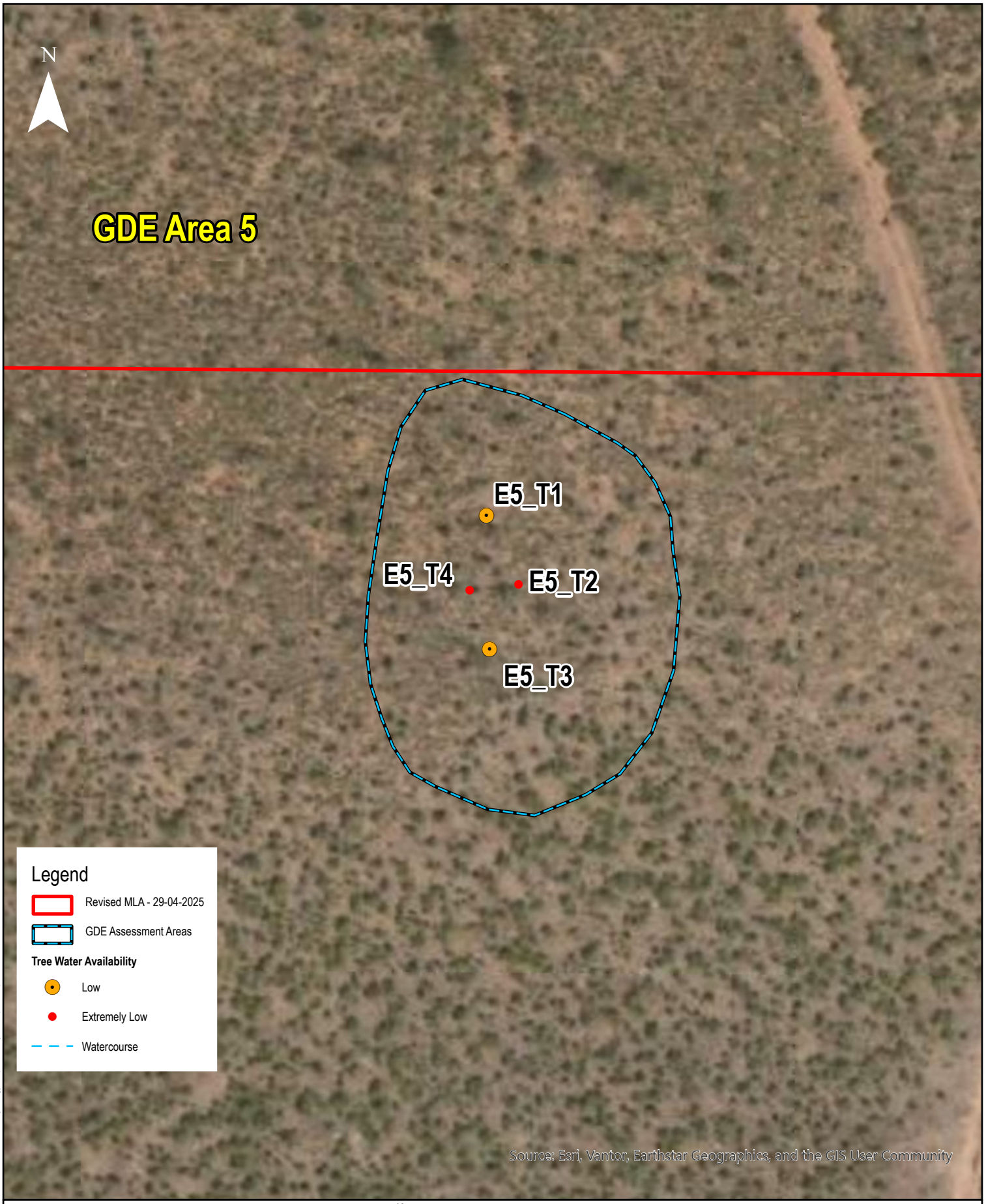
WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water_Mark_Ecohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A5. Sampling detail at GDE Assessment Area 5

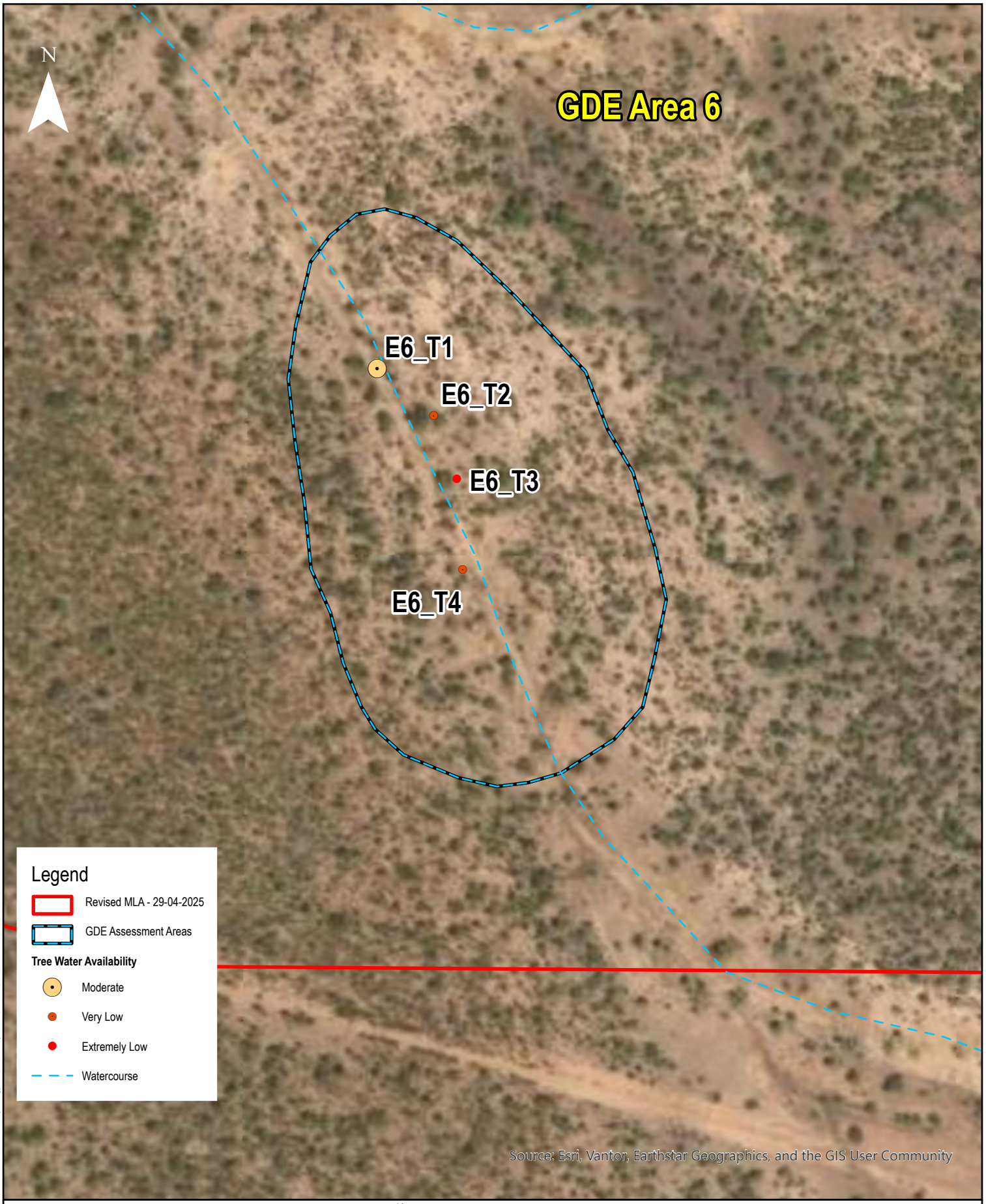
WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water...Mark...E\ochydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A6. Sampling detail at GDE Assessment Area 6

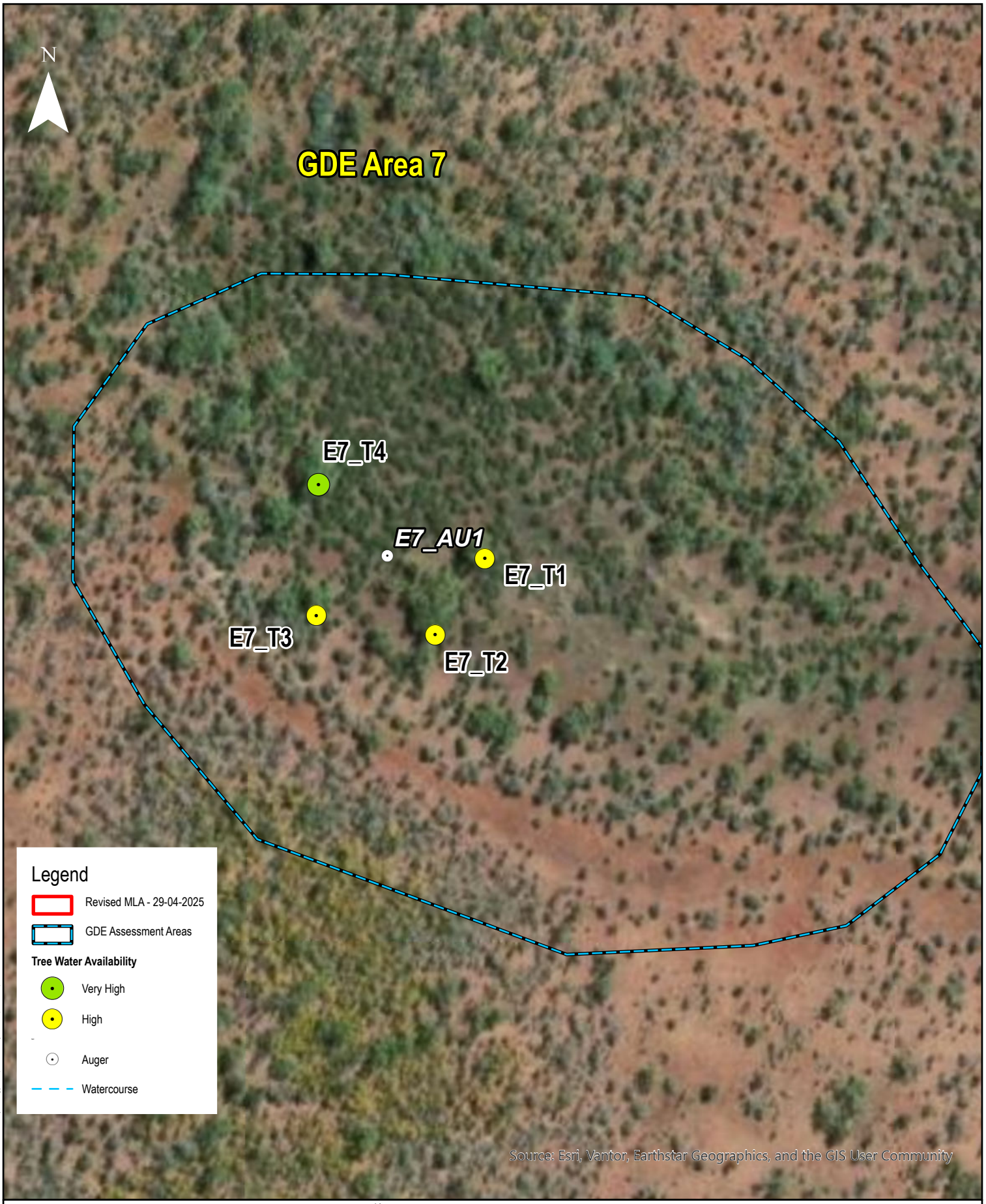
WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water_Mark_Ecohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A7. Sampling detail at GDE Assessment Area 7

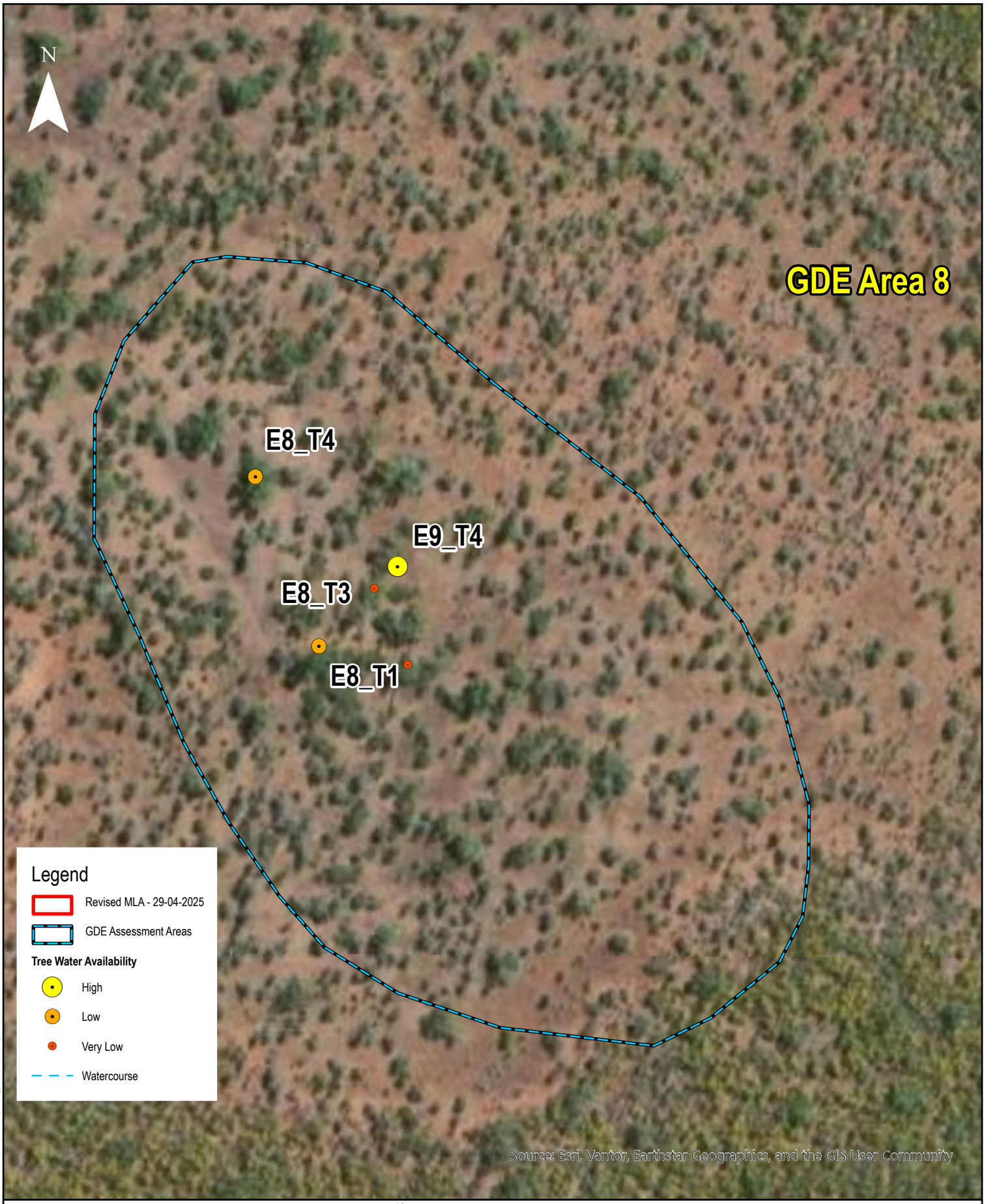
WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,200

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water_Mark_E.cohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A8. Sampling detail at GDE Assessment Area 8

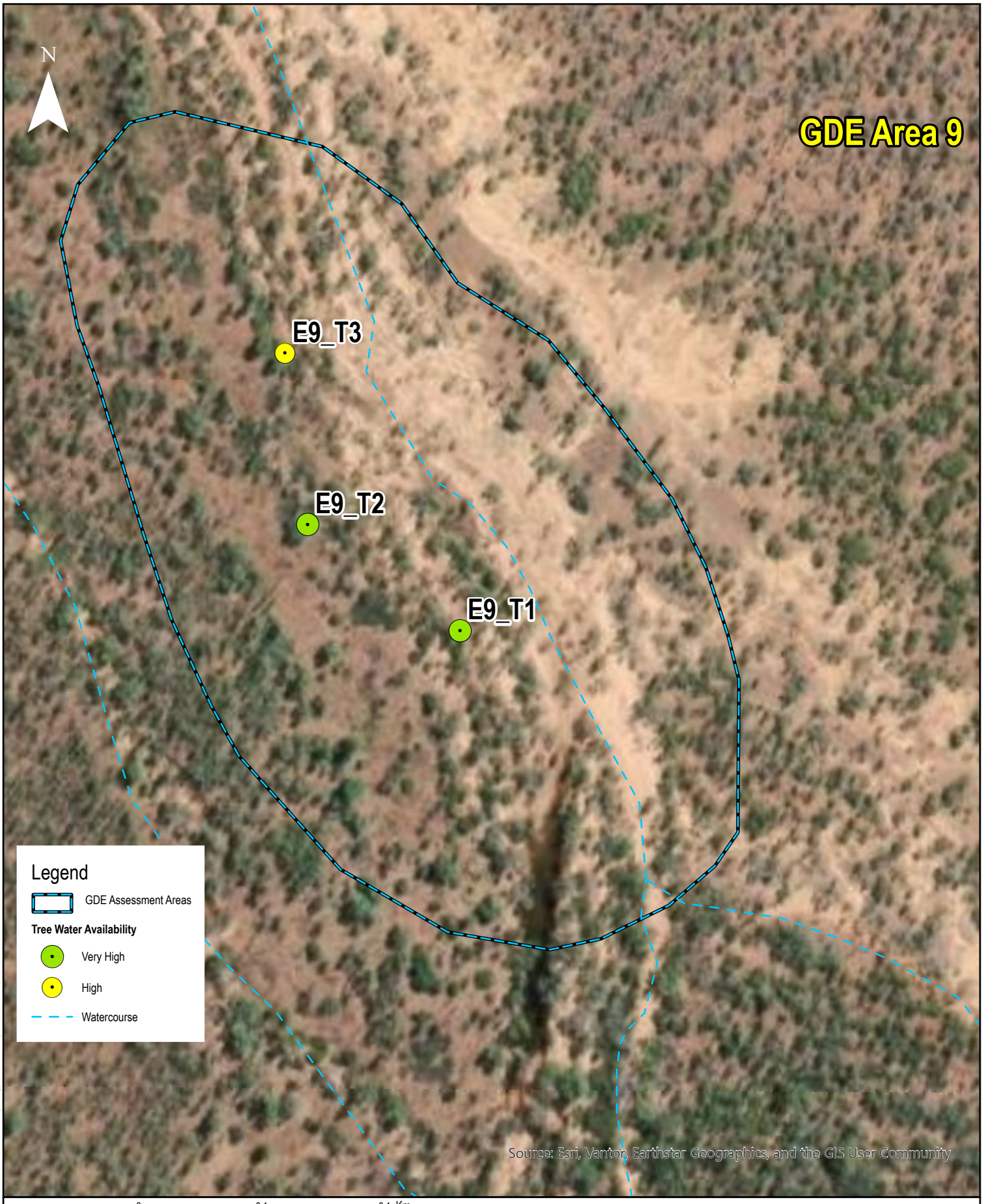
WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water...Mark_E.cohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A9. Sampling detail at GDE Assessment Area 9

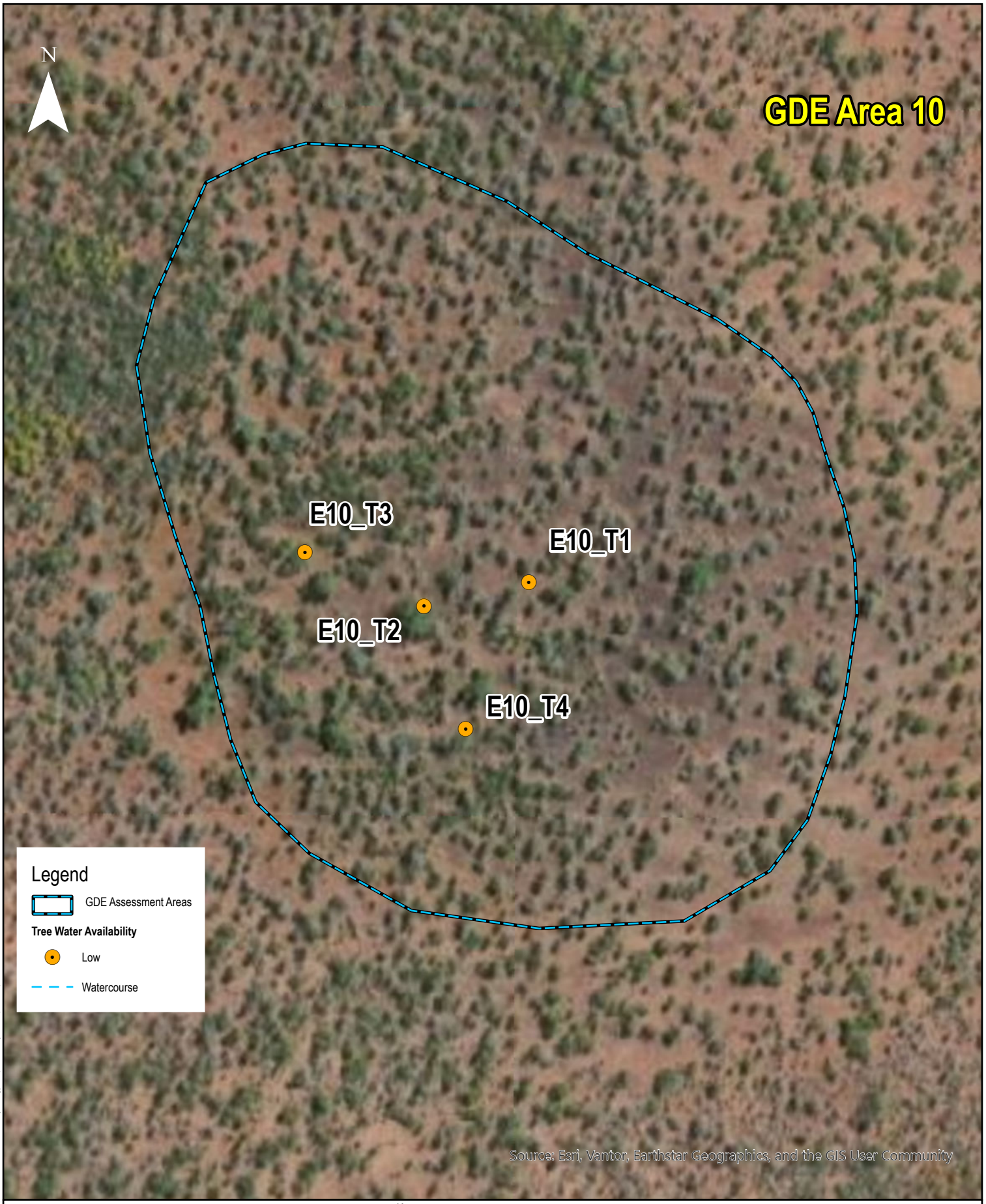
WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025



Path: D:\Water_Mark_E.cohydrology\Graphinex Project\Graphinex.aprx

Scale: @A4 0 0.1 0.1 Km

Coordinate System: GDA 2020 MGA Zone 54 A4

Appendix A10. Sampling detail at GDE Assessment Area 10

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
watermarkeco.com.au

Scale: 1:2,000

Client :

Project: Graphinex Esmerelda Project.

Drawn By D.G. Checked D.S. Date: 8/12/2025

Appendix C: Soil Sampling and Moisture Potentials

Sample	Type	Project	Date Sampled		SMP Measurements
E7_AU1_0.1	Soil	Esmeralda	29/08/2025	Grey-brown silty loam. Dry.	-2.29
E7_AU1_0.3	Soil	Esmeralda	29/08/2025	Reddish brown fine loamy sand. Slightly moist. Fine tree roots present.	-2.63
E7_AU1_0.5	Soil	Esmeralda	29/08/2025	Reddish brown fine sand with minor clay. Slightly moist.	-0.72
E7_AU1_0.75	Soil	Esmeralda	29/08/2025	Reddish brown fine sand with some clay.Slightly moist.	-0.06
E7_AU1_1.0	Soil	Esmeralda	29/08/2025	Reddish grey-brown fine clayey sand. Mottling present.	-0.16
E7_AU1_1.2	Soil	Esmeralda	29/08/2025	Reddish grey-brown clayey sand with gravel.	-0.85
E7_AU1_1.3	Soil	Esmeralda	29/08/2025	Reddish brown clay sand with gravel	-0.55
E7_AU1_1.5	Soil	Esmeralda	29/08/2025	Reddish brown medium to coarse sand with some clay and gravel. Hardened clay pieces.	-0.68
E7_AU1_1.75	Soil	Esmeralda	29/08/2025	Reddish yellow fine loamy sand with gravel.	-4.07
E7_AU1_2.0	Soil	Esmeralda	29/08/2025	Reddish yellow fine silty sand with minor clay with gravel.	-1.91
E7_AU1_2.5	Soil	Esmeralda	29/08/2025	Pale yellow fine silt clay with gravel.	-1.62
E7_AU1_3.0	Soil	Esmeralda	29/08/2025	Pale yellow fine silty fine sand with minor clay with fine gravel. Slightly moist.	-0.83
E7_AU1_3.25	Soil	Esmeralda	29/08/2025	Pale yellow fine silty to loamy sand with fine gravel. Slightly moist.	-1.18
E7_AU1_3.5	Soil	Esmeralda	29/08/2025	Reddish yellow clay with sand. Clumps of ferrous clay. Slightly moist.	-0.66
E7_AU1_4.0	Soil	Esmeralda	29/08/2025	Reddish light grey clay. Slightly moist.	-0.86
E7_AU1_4.5m	Soil	Esmeralda	29/08/2025	Grey coarse clayey sand with some reddish clay.	-0.65
E7_AU1_5.0	Soil	Esmeralda	29/08/2025	Reddish grey medium to coarse clayey sand.	-0.71
E7_AU1_5.25	Soil	Esmeralda	29/08/2025	Reddish grey clayey sand to sandy clay. Tree roots present.	-0.68
E7_AU1_5.35	Soil	Esmeralda	29/08/2025	Reddish grey clayey sand.	-0.64

Sample	Type	Project	Date Sampled		SMP Measurements
E7_AU1_5.5 m	Soil	Esmeralda	29/08/2025	Pale grey reddish clayey sand. Red gravel and particles present	-0.82
E7_AU1_5.7 5	Soil	Esmeralda	29/08/2025	Pale reddish grey coarse clayey sand with gravel.	-0.89
E7_AU1_6.0	Soil	Esmeralda	29/08/2025	Reddish yellow fine sandy silt clay	-1.17
E7_AU1_6.2 5	Soil	Esmeralda	29/08/2025	Pale yellow-red silty to clayey coarse sand. Chunks of hardened pale grey clay. Minor gravel present	-1.11
E7_AU1_6.3 5	Soil	Esmeralda	29/08/2025	Tree roots present.	-1.09
E7_AU1_6.5	Soil	Esmeralda	29/08/2025	Grey brown fine silty sand and loam.	-1.07
E7_AU1_6.6	Soil	Esmeralda	29/08/2025	Find sand to loamy sand with minor gravel. End of hole.	-0.63
E1_AU1_0.1	Soil	Esmeralda	27/08/2025	Brown sandy silt.	-16.54
E1_AU1_0.5	Soil	Esmeralda	27/08/2025	Fine light brown silty sand.	-13.55
E1_AU1_0.7 5	Soil	Esmeralda	27/08/2025	Fine sand	-0.56
E1_AU1_1.0	Soil	Esmeralda	27/08/2025	Fine sand with some gravel.	-2.31
E1_AU1_1.2 5	Soil	Esmeralda	27/08/2025	Medium brown sand.	-0.52
E1_AU1_1.3	Soil	Esmeralda	27/08/2025	Coarse sand with gravel.	-1.93
E1_AU1_1.4	Soil	Esmeralda	27/08/2025	Grey brown clayey sand with minor gravel.	-1.25
E1_AU1_1.5	Soil	Esmeralda	27/08/2025	Hardened sandstone with gravel. End of hole.	-1.27
E3_AU_0.1	Soil	Esmeralda	27/08/2025	Silty loam.	-8.75
E3_AU_0.3	Soil	Esmeralda	27/08/2025	Brown fine silty to loamy sand.	-4.93
E3_AU_0.5	Soil	Esmeralda	27/08/2025	Brown fine silty to loamy sand.	-3.42
E3_AU_0.75	Soil	Esmeralda	27/08/2025	Clay loam and hardened clay.	-4.51
E3_AU_1.0	Soil	Esmeralda	27/08/2025	Grey brown silty to loamy fine sand.	-3.4
E3_AU_1.1	Soil	Esmeralda	27/08/2025	Silty medium to coarse sand with hardened clay nodules	-2.05
E3_AU_1.3	Soil	Esmeralda	27/08/2025	Silty medium to coarse sand with hardened clay nodules	-4.79

Sample	Type	Project	Date Sampled		SMP Measurements
E3_AU_1.5	Soil	Esmeralda	27/08/2025	Grey brown coarse loamy to gravely sand. Nodules of hardened clay.	-4.94
E3_AU_1.75	Soil	Esmeralda	27/08/2025	Grey brown fine clay and chunks of hardened clay.	-4.79
E3_AU_2.0	Soil	Esmeralda	27/08/2025	Grey to orange mottled fine to medium clayey sand with minor gravel. Tree roots present.	-4.21
E3_AU_2.1	Soil	Esmeralda	27/08/2025	Grey to orange mottled fine to medium clayey sand with minor gravel. Tree roots present.	-3.26
E3_AU_2.3	Soil	Esmeralda	27/08/2025	Grey to orange medium clayey sand with gravel.	-2.84
E3_AU_2.45	Soil	Esmeralda	27/08/2025	Indurated granite with gravel. End of hole.	-5.69
E4_AU1_0.1	Soil	Esmeralda	2/09/2025	Grey-brown fine silty sand.	-55.96
E4_AU1_0.3	Soil	Esmeralda	2/09/2025	Reddish grey-brown fine silty sand.	-21.3
E4_AU1_0.5	Soil	Esmeralda	2/09/2025	Pale red silty sand with some clay.	-17.55
E4_AU1_0.75	Soil	Esmeralda	2/09/2025	Pale red silty sand with some clay.	-11.01
E4_AU1_1.0	Soil	Esmeralda	2/09/2025	Pale red silty sand with minor silt and loam.	-8.99
E4_AU1_1.5	Soil	Esmeralda	2/09/2025	Pale red silty sand with some clay. Sandstone and gravel particles. Tree roots present.	-7.13
E4_AU1_1.6	Soil	Esmeralda	2/09/2025	Hardened sandstone with gravel. End of hole.	-5.11
E4_AU2_0.1	Soil	Esmeralda	2/09/2025	Sand.	-47
E4_AU2_0.2	Soil	Esmeralda	2/09/2025	Sand with gravel	-29.13
E4_AU2_0.3	Soil	Esmeralda	2/09/2025	Gravel with sand. End of hole	-8.58

Appendix D: Stable Isotope Results (when available)

Sample	Type	$\delta^{18}O$ VSMOW	$\delta^{2}H$ VSMOW
E1 AU1 0.3	Soil	-5.79	-62.34
E1 AU1 0.75	Soil	-4.51	-45.96
E1 AU1 1.0	Soil	-5.69	-48.07
E1 AU1 1.1	Soil	-5.53	-51.56
E1 AU1 1.25	Soil	-4.66	-41.99
E1 AU1 1.3	Soil	-4.99	-44.22
E1 AU1 1.4	Soil	-6.49	-49.69
E1 AU1 2.5	Soil	-5.63	-38.89
E3 AU1 1.5	Soil	-4.46	-35.98
E3 AU1 2.1	Soil	-4.78	-39.02
E3 AU1 2.3	Soil	-4.47	-32.81
E4 AU1 1.5	Soil	-5.49	-55.17
E7 AU1 0.1	Soil	-1.88	-46.01
E7 AU1 0.5	Soil	-8.23	-65.65
E7 AU1 0.75	Soil	-9.1	-69.57
E7 AU1 1.0	Soil	-9.4	-75.42
E7 AU1 1.2	Soil	-8.03	-63.72
E7 AU1 1.3	Soil	-6.25	-46.35
E7 AU1 1.5	Soil	-5.82	-40.35
E7 AU1 1.75	Soil	-4.54	-35.63
E7 AU1 3.0	Soil	-5.25	-36.77
E7 AU1 3.25	Soil	-4.99	-39.34
E7 AU1 3.5	Soil	-6.61	-43.82
E7 AU1 4.0	Soil	-5.41	-37.14
E7 AU1 4.5	Soil	-6.12	-42.14
E7 AU1 5.0	Soil	-5.26	-41.87
E7 AU1 5.25	Soil	-6.23	-44.42
E7 AU1 5.35	Soil	-6.05	-40.56
E7 AU1 5.5	Soil	-4.63	-33.92
E7 AU1 5.75	Soil	-5.28	-34.15
E7 AU1 6.0	Soil	-4.79	-36.73
E7 AU1 6.25	Soil	-4.99	-35.64
E7 AU1 6.5	Soil	-5.86	-38.86
E7 AU1 6.6	Soil	-4.55	-35.92
E1 T1	Twigs	-3.62	-37.03
E1 T2	Twigs	-4.01	-45.12
E1 T3	Twigs	-4.4	-51.17
E1 T4	Twigs	-6.1	-56.47
E10 T1	Twigs	-2.76	-30.09
E10 T2	Twigs	-3.81	-31.57
E10 T3	Twigs	-1.51	-23.94
E10 T4	Twigs	-3.61	-33.25
E2 T1	Twigs	-7.19	-59.04

Sample	Type	$\delta^{18}O$ VSMOW	$\delta^{2}H$ VSMOW
E2 T2	Twigs	-5.89	-53.4
E2 T3	Twigs	-5.65	-46.9
E2 T4	Twigs	-3.48	-38.84
E3 T1	Twigs	-3.12	-33.63
E3 T2	Twigs	-3.65	-39.08
E3 T3	Twigs	-3	-34.52
E3 T4	Twigs	-3.58	-36.33
E3 T5	Twigs	4.65	1.89
E4 T1	Twigs	-4.04	-37.79
E4 T2	Twigs	-6.4	-59.45
E4 T3	Twigs	-5.18	-52.46
E4 T4	Twigs	-7.04	-72.91
E5 T1	Twigs	-4.38	-46.87
E5 T2	Twigs	-3.55	-39.78
E5 T3	Twigs	-3.71	-42.74
E5 T4	Twigs	-4.09	-38.74
E6 T1	Twigs	-2.35	-21.96
E6 T2	Twigs	-1.94	-22.87
E6 T3	Twigs	-2.35	-23.68
E6 T4	Twigs	-1.63	-20.49
E7 T1	Twigs	-7.47	-73.52
E7 T2	Twigs	-6.48	-70.98
E7 T3	Twigs	-5.07	-48.55
E7 T4	Twigs	-7.59	-77.07
E8 T1	Twigs	-2.06	-28.44
E8 T2	Twigs	-3.79	-38.91
E8 T3	Twigs	-2.93	-34.09
E8 T4	Twigs	-3.46	-35.72
E9 T1	Twigs	-6.67	-60.74
E9 T2	Twigs	-6.95	-63.46
E9 T3	Twigs	-7.93	-72.49
E9 T4	Twigs	-7.58	-67.31
E3_SW	Surface Water	2.73	-10.37