ARK ENERGY

Attexo

Chalumbin Wind Farm

Elevation

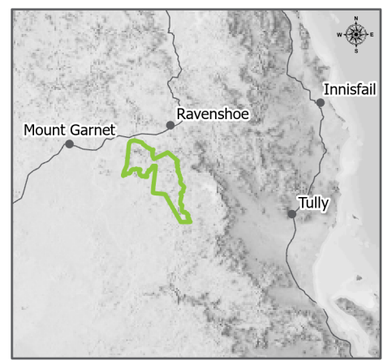
Figure 4.6 Sheet 2 of 4

- Project Area Boundary
- Turbine
- Met-mast

Clearance Envelope
- Stage 1
- Stage 2
- Watercourse
- Lot Boundary
- Easement

Elevation (mAHD)
- <200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700
- 700 - 800
- 800 - 900
- 900 - 1,000
- 1,100 - 1,100
- 1,100 - 1,200

Date: 15/10/2022 Author: TOD
Project: EPU-004 Reviewed: NOD



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Scale: 1:50,000@A3

Data Source(s):
Digital Cadastral Database - Department of Resources (2022)
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ARK ENERGY

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Chalumbin Wind Farm

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Figure 4.6 Sheet 3 of 4

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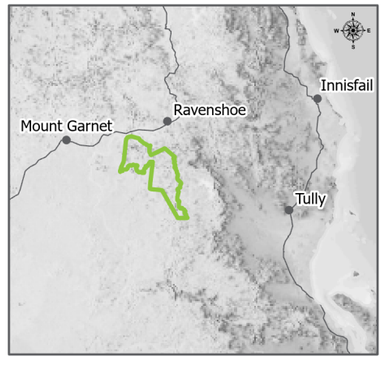

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Data Source(s):
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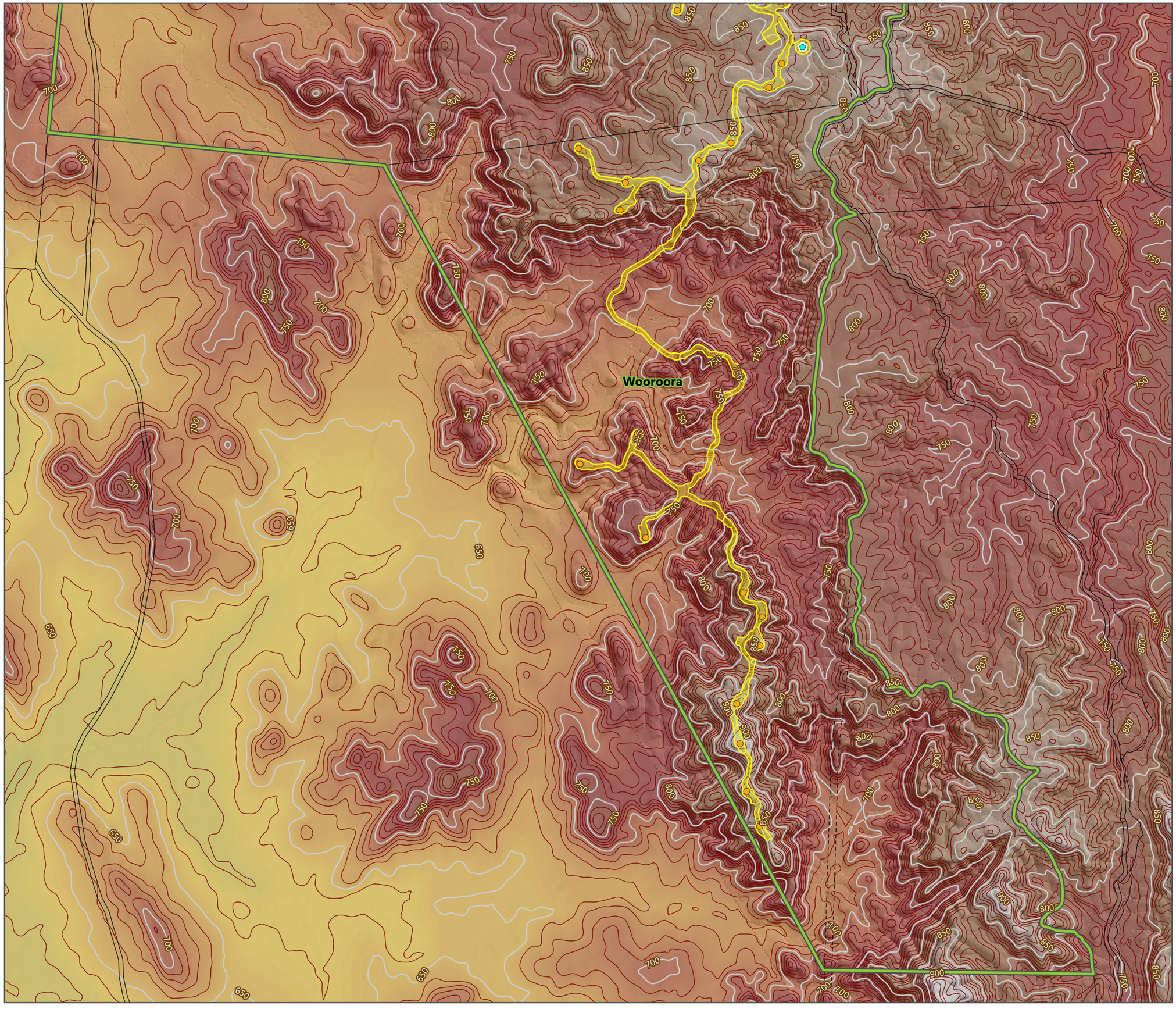

ARK ENERGY

Attexo

Chalumbin Wind Farm

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Figure 4.6 Sheet 4 of 4

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Date: 15/10/2022 Author: TOD
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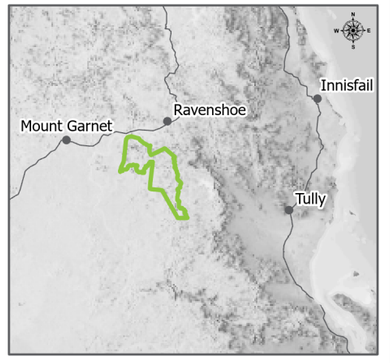

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4.1.10 Climate and Climate Change

4.1.10.1 Climate

The Project area is located on the western edge of the Wet Tropics of Queensland and the dominant rainfall pattern is monsoonal. Alternating wet and dry seasons typically last for four to eight months although this can vary considerably, depending on the severity of the El Nino / Southern Oscillation.

Wind data compiled for the period 2017 to 2022 at the South Johnstone weather station shows that predominant winds are highly variable over the course of the year but overall are from the south (12.45 %), followed by the west (10.12 %) and south-southeast (8.84 %) (Willy Weather 2022).

Table 4-2 provides a summary of temperature and rainfall data relevant to the Project area, with rainfall measurements taken from the BoM Woodleigh Station (weather station 031119), and two Queensland Government Water Monitoring Information Portal stations (Blunder Creek at Wooroora (site #116015A) and Chalumbin Standalone Pluvio (site #1160P001). The locations of these stations are shown in Figure 2-3 within the Sediment and Erosion Management Plan (**Appendix J**), which also shows the variability in rainfall across the Project area. **Table 4-2** also provides temperature readings measured at the Walkamin Research Station during the period 1969 to 2021 (weather station 31108, approximately 70 km from the Project area).

Mean annual rainfall across the weather stations ranges from 894 mm to 1,719 mm[11], with the wettest month being February, and the driest month being September. The majority of rain (approximately 73 % to 82 %) falls within the months December to April.

Seasonally, temperatures are hottest from October to February. The mean maximum daily temperature in summer was 30.8°C in December, with a winter minimum of 13.1°C in July.

The highest aspects of the site are approximately 990 m above sea level (asl), which are considerably higher in elevation than the Walkamin Research Station at 594 m asl. The change in temperature as a function of elevation is typically between 0.6°C and 1°C but this can vary significantly with the influence of factors such as wind speed and moisture.

[11] This is consistently lower than coastal parts of the Wet Tropics such as Cairns (1,998 mm, 1943-2021), Innisfail (3,548 mm, 1881-2019) and Tully (4,086 mm, 1925-2021)

Table 4-2 Summary of Climate Data (BoM, Queensland Government Water Monitoring Information Portal)

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Woodleigh Station (BoM Weather Station 031119)													
Mean rainfall (mm)	192.5	214.3	160.5	42	24.5	19.6	8.7	8.3	7.7	27.5	69.2	119.1	893.9
Blunder Creek at Wooroora (Qld Government Site #116015A)													
Mean rainfall (mm)	181	249.3	173.2	98.1	60.1	46.7	34.2	23	14.5	36.6	57.1	114	1,087.8
Chalumbin Standalone Pluvio (Qld Government Site #1160P001)													
Mean rainfall (mm)	263.2	333.1	286.2	191.1	128.7	87.1	67.7	45.2	34.9	53.4	84	159.1	1,733.7
Walkamin Research Station (BoM Weather Station 31108)													
Mean maximum temperature (°C)	30.1	29.3	28.2	26.7	25.1	23.7	23.4	24.9	27.2	29.4	30.6	30.8	27.4
Mean minimum temperature (°C)	20.3	20.5	19.6	18.1	16.2	14	13.1	13.3	14.8	16.7	18.5	19.8	17.1

4.1.10.2 Climate Change

CSIRO has recently released climate change projections for Australia based on the results from 23 global climate models (DES 2019). Projections for the Far North Queensland region have been extracted from this dataset for the Queensland Climate Change Centre of Excellence (QCCCE). The projections presented here are relative to the base period of 1980–1999.

- 2030 (medium emissions scenario):
  - **Annual and seasonal temperature**: annual mean temperature (the average of all daily temperatures within a given year) is projected to increase by 0.9°C. There is little variation in projections across the seasons.
  - **Annual and seasonal rainfall**: annual rainfall (the total rainfall received within a given year) is projected to decrease by one per cent (-13 mm). The largest seasonal decrease of five per cent (-7 mm) is projected for spring.
  - **Annual and seasonal potential evaporation**: across all seasons the annual 'best estimate' increase is projected to be around three per cent (60 mm), with some models projecting up to a five per cent increase in autumn (21 mm), summer (27 mm) and winter (20 mm).
- 2050 (low and high emissions scenarios):
  - **Annual and seasonal temperature**: annual temperature will increase by 1.1°C and 1.8°C under the low and high emissions scenarios respectively. There is little variation in projections across the seasons.
  - **Annual and seasonal rainfall**: annual rainfall is projected to decrease by one per cent (-13 mm) and two per cent (-25 mm) under the low and high emissions scenarios respectively. The largest seasonal decrease of 10 per cent (-13 mm) under the high emissions scenario is projected for spring.
  - **Annual and seasonal potential evaporation**: under a high emissions scenario an increase in annual potential evaporation of up to nine per cent (180 mm) is projected with the best estimate being six per cent (120 mm). Summer is projected to have the greatest increase of up to 11 per cent (58 mm).
- 2070 (low and high emissions scenarios):
  - **Annual and seasonal temperature**: annual temperature is projected to increase by 1.5°C and 2.8°C under the low and high emissions scenarios respectively. There is little variation in projections across the seasons.
  - **Annual and seasonal rainfall**: annual rainfall is projected to decrease by two per cent (-25 mm) and three per cent (-38 mm) under the low and high emissions scenarios respectively. The largest seasonal decrease under a high emissions scenario of 16 per cent (-21 mm) is projected for spring.
  - **Annual and seasonal potential evaporation**: under a high emissions scenario, annual potential evaporation is projected to increase by as much as 15 per cent (300 mm). Autumn, summer and winter are projected to be the seasons most impacted with increases up to 17 per cent (73 mm, 90 mm and 67 mm respectively) in some models.

The Far North Queensland region is predicted to experience higher temperatures, greater frequency and duration of extreme temperatures (heatwave), more intense rainfall but with increased variability, and more intense tropical cyclones but at a lower frequency (DES 2019a). There is an additional risk of increased bushfire intensity, although these predictions are less robust due to the synergistic relationship with rainfall, fuel-load and potential for increased fuel loads from increased CO_2 concentrations (Weber et al 2021).

Biodiversity is globally predicted to disperse to higher altitudes or to the higher latitudes to remain within its preferred climatic envelope (Chen et al 2011). Within the context of the WTQ World Heritage Area, there are considerable barriers for dispersal of species from existing protected areas due to limited habitat connectivity at a landscape scale. Dispersal in the region is therefore expected to occur most frequently within the existing protected area network including the WTQ World Heritage Area which offers greatest opportunity to reach the more suitable climates at higher elevations relative to the coastal lowlands (Van Der Wal et al 2012).

It is predicted that seven frog species, five mammal species, three bird species and three skink species would lose over half their present habitat with only a 1°C temperature increase (Williams et al. 1995). The cumulative impacts of habitat fragmentation leave wildlife susceptible to competition, disease and predation from invasive pests and weeds (Tng et al. 2018) which ultimately reduces their capacity to adapt to change, particularly in isolated areas, thus increasing their exposure to extinction (Tng et al. 2018).

4.2 Assessment Methodology

4.2.1 Desktop Assessment

A desktop assessment was undertaken to develop an understanding of the environmental values, landscape features, vegetation communities and threatened species that were known or had the potential to occur within the Project area and the surrounding landscape. The Project area was defined as the extent of the host lots that is outside the Wet Tropics of Queensland World Heritage Area, encompassing proposed wind turbine locations and all support infrastructure. The study area was defined as the Project area with a 10 km buffer. The following data sources were reviewed:

- Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) Protected Matters Search Tool (PMST) to identify potential MNES. Search results from March 2022 are included in **Appendix B**.
- DCCEEW's Species Profiles and Threats database (SPRAT);
- Queensland Department of Environment and Science (DES) WildNet database to identify previously recorded flora and fauna species, including non-native species. Search results from March 2022 are included in **Appendix B**.
- DES mapping for essential habitat, protected plants trigger areas, wetlands, watercourses and drainage features;
- Queensland Department of Resources (DoR) regulated vegetation mapping (including remnant, high-value regrowth and non-remnant vegetation);
- Atlas of Living Australia (ALA) database;
- High-resolution satellite imagery;
- Published ecological information on threatened flora and fauna species where available; and
- Information provided through consultation with acknowledged species experts, Action Groups, academics, etc.

Initial desktop searches were undertaken in September 2020 to inform field survey requirements; the desktop searches were repeated as part of the EPBC Referral and again during the PER preparation, in order to account for potential updates to government datasets and recent threatened species observations.

4.2.2 Field Assessment

4.2.2.1 Survey Teams, Timing and Weather Conditions

There has been an extensive program of ecological surveys undertaken for the Project. The majority of these surveys were undertaken to help to inform the PER, with some surveys undertaken for the purposes of secondary permits and approvals or management plans (the results of such surveys have still informed the PER where appropriate). A summary of the surveys undertaken to date, including the timing of the surveys and the team members involved, is presented in **Table 4-3**. A program of detailed habitat quality assessments is also underway across the Project's impact areas and proposed offset areas to inform the future Offset Area Management Plan for the Project.

Table 4-3 Summary of Survey Timing and Teams

Survey	Timing	Survey Team	Years of Experience
Protected plants survey at proposed meteorological monitoring mast location	23 September 2020	Dr Paul Williams	> 25 years
Spring vegetation surveys	20-29 October 2020	Dr Paul Williams	> 25 years
		Darren Maxwell	> 25 years
		Nicholas Heard	8 years
		Corey Callahan	8 years
Fauna reconnaissance survey	20-21 October 2020	Terry Reis	> 25 years
		Nikki O'Donnell	> 20 years
Wet season fauna surveys	19-31 January 2021	Terry Reis	> 25 years
		Dr Bruce Thomson	> 30 years
		Ben Nottidge	> 15 years
		Rhys Sharry	3 years
		Janelle VanderBeek	3 years
		Alex Wright	1 years
Additional protected plants surveys in new areas of Project footprint	16-19 March 2021	Dr Paul Williams	> 25 years
		Selina Carruthers	1 year
Supplemental wet season fauna surveys	23-31 March 2021	Ben Nottidge	> 15 years
		Nikki O'Donnell	> 20 years
		Rhys Sharry	3 years
Protected plants surveys at additional two meteorological monitoring masts	30 March 2021	Darren Maxwell	> 25 years

Survey	Timing	Survey Team	Years of Experience
Dry season fauna surveys	19-28 June 2021	Dr Bruce Thomson	> 30 years
		Ben Nottidge	> 15 years
		Janelle VanderBeek	3 years
		Wise Lum	3 years
Early dry season bird utilisation surveys	19-28 June 2021	Mervyn Mason	> 25 years
		Rhys Sharry	3 years
Protected plants surveys at additional sites within the Project footprint	23 June 2021	Ben Nottidge	> 15 years
Additional (late dry season) bird utilisation surveys	5-17 October 2021	Mervyn Mason	> 25 years
		Janelle VanderBeek	3 years
Greater glider habitat assessment	9-15 December 2021	Mervyn Mason	> 25 years
		Sonny Royal	2 years
Targeted magnificent brood frog surveys	7-11 December 2021, 12-16 January 2022, 25-27 January 2023	Janelle VanderBeek	3 years
		Rhys Sharry	3 years
Additional (early wet season) bird utilisation surveys	18-27 January 2022	Mervyn Mason	> 25 years
		Janelle VanderBeek	3 years
Targeted surveys for the North Queensland Lace (*Aponogeton bullosus*)	3-9 February 2022	Darren Maxwell	> 25 years
		Selina Carruthers	1 year
Additional (late wet season) bird utilisation surveys	6-14 April 2022	Mervyn Mason	> 25 years
		Sonny Royal	2 years
Additional (early dry season) bird utilisation surveys	9-17 August 2022	Mervyn Mason	> 25 years
		Selina Carruthers	2 years
Additional (early wet season) bird utilisation surveys	15-26 November 2022	Mervyn Mason	> 25 years
		Braden McDonald	2 years
Protected plants surveys within High-Risk Trigger Mapping areas associated with Stage 1	12-20 December 2022	Bruce McLennan	> 25 years
		Abraham Floyd	2 years
Nesting surveys for the red goshawk	11-14 October 2021, 18-22 December 2022	Mervyn Mason	> 25 years
		Janelle VanderBeek	3 years

Survey	Timing	Survey Team	Years of Experience
		Jason Richard	> 25 years
		Matthew Whitehouse	11 years

Weather conditions leading up to and during these surveys are summarised in **Table 4-4**. Rainfall was measured at the Ravenshoe Alert gauge (weather station 31200) approximately 10 km from the Project area while temperature was measured at the Walkamin Research Station (weather station 31108) approximately 70 km from the Project area.

The Project area received significant rainfall in the weeks immediately prior to the start of the wet season fauna surveys, associated with Tropical Cyclone Imogen. Heavy rainfall also occurred leading up to the supplemental wet season fauna surveys in March 2021, with the result that both survey events can be considered as indicative of wet season conditions. Rainfall in the two months prior to the dry season surveys was lower than the 1968-2021 average and can therefore be considered as indicative of dry season conditions.

Table 4-4 Weather Conditions Indicative of the Project Area Prior to Surveys (BOM, 2022)

	Sep 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021	May 2021	June 2021	July 2021	August 2021	Sept 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022
Rainfall (mm)	35 (22.1)	19 (46.6)	22 (52.8)	75 (138.4)	43[12] (255)	293 (281)	143 (272.4)	183 (121.9)	54 (64.8)	35 (58)	32 (45.2)	26 (27.3)	44 (23.1)	41 (46.3)	164 (57.8)	159 (139.3)	289 (255)
Mean minimum temperature (ºC)	16 (14.8)	16.7 (16.7)	18.2 (18.5)	20.5 (19.8)	20.7 (20.3)	20.6 (20.5)	19.5 (19.6)	18.8 (18.1)	16.1 (16.2)	15.4 (14)	15.2 (13.1)	15.3 (13.3)	15.5 (14.8)	17.9 (16.7)	19.7 (18.5)	19.8 (19.8)	20.5 (20.3)
Mean maximum temperature (ºC)	26.6 (27.2)	29.6 (29.3)	31.2 (30.6)	31.6 (30.8)	28.9 (30.1)	29.2 (29.3)	29 (28.2)	27 (26.7)	25.1 (25.1)	25.2 (23.7)	26.1 (23.4)	25.1 (24.7)	26 (27.2)	32.1 (29.4)	30.9 (30.6)	31.1 (30.8)	30.6 (30.1)

Numbers in brackets represent the relevant meteorological averages between years 1968 and 2021.

[12] The volume of rainfall recorded at Ravenshoe Alert station for January 2021 appears to have been incorrectly recorded as it would not suggest the cyclonic conditions experienced on site, nor is it comparable with rainfall data recorded over the same period at nearby weather stations: Innot Hot Springs to the west (363.4 mm), Woodleigh Station to the west (381.6 mm), Greenhaven to the northeast (653.8 mm) and Sutties Creek to the east (653 mm)

4.2.2.2 Flora Surveys

Vegetation Community Surveys

Indicative flora survey sites were selected across the Project area based on the results of the desktop assessment. Site selection was determined using high-quality satellite imagery, regional ecosystem (RE) mapping (remnant and non-remnant vegetation) and the proposed Project footprint at the time. The purpose of these surveys was to assess the location, extent and condition of vegetation across the Project area taking into consideration the diagnostic criteria for TECs listed under the EPBC Act where applicable, and to identify preferred habitat types for threatened flora species.

Vegetation surveys were undertaken on foot, with quaternary sites undertaken in accordance with the Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland version 5.1 (Neldner et al 2020). Quaternary sites are intended to provide a rapid means of assessing vegetation structure, floristic composition and status, with the following information collected for each site:

- vegetation structure (height range, median height, estimated cover for each stratum) and floristic composition (dominant and common native species within each stratum);
- vegetation status, i.e. remnant or regrowth and the RE classification;
- brief condition assessment, including assessment of disturbance factors;
- potential habitat and likely presence of protected plants;
- recorded fauna habitat and other ecological features and signs of fauna presence;
- presence of weed species; and
- geology and landscape attributes.

Surveys also included an assessment of the diagnostic characteristics for TECs where these were highlighted in the desktop assessment as potentially occurring. Subsequent to the field surveys, vegetation mapping was undertaken based on the results of the vegetation surveys and interpretation of high-resolution orthophotos. Vegetation mapping was undertaken by Dave Stanton, who has published vegetation mapping of the Wet Tropics World Heritage Area on behalf of the Australian Government which formed the core of the Queensland Herbarium's RE mapping for the Wet Tropic Bioregion and contiguous areas of the Einasleigh Uplands; and Dr Paul williams, who has extensive experience undertaking vegetation surveys and research focusing on northern QLD including RE mapping and BioCondition surveys for the Australian Government, Bush Heritage and numerous private proponents in the Wet Tropics bioregion.

Flora surveys were undertaken throughout the Project area, as mapped in **Figure 4-7**.