Uungula Wind Farm

Appendix E

Eco Logical Australia:

Bushfire

September 2020

CWP Renewables Pty Ltd
(02) 4013 4640

P.O. Box 1708 Newcastle NSW 2300
cwprenewables.com

Uungula Wind Farm Bush Fire Risk Assessment

CWP Renewables

ecological AUSTRALIA
A TETRA TECH COMPANY

1300 646 131
www.ecoaus.com.au

DOCUMENT TRACKING

Project Name	Uungula Wind Farm Bush Fire Risk Assessment
Project Number	19ARM_13867
Project Manager	Robert Cawley
Prepared by	Letara Judd
Reviewed by	Mick George
Approved by	Mick George
Status	**Final**
Version Number	**v4**
Last saved on	**21 September 2020**

This report should be cited as 'Eco Logical Australia. 2020 Uungula Wind Farm Bush Fire Risk Assessment. Prepared for CWP Renewables.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from CWP Renewables

Template 2.8.1

Contents

List of Figures

List of Tables

Glossary of Terms

Term	Description
Assets	Anything valued by people which includes houses, crops, forests and, in many cases, the environment.
Bushfire	Unplanned vegetation fire. A generic term which includes grass fires, forest fires and scrub fires both with and without a suppression objective.
Bushfire Attack Level (BAL)	A means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact, using increments of radiant heat expressed in kilowatts per metre squared, which is the basis for establishing the requirements for construction to improve protection of building elements from attack by bushfire.
Contained	The status of a bushfire suppression action signifying that a control line has been completed around the fire, and any associated spot fires, which can reasonably be expected to stop the fire's spread.
Fire management	All activities associated with the management of fire prone land, including the use of fire to meet land management goals and objectives.
Fuel hazard	Fine fuels in bushland that burn in the continuous flaming zone at the fire's edge. These fuels contribute the most to the fire's rate of spread, flame height and intensity. Typically, they are dead plant material, such as leaves, grass, bark and twigs thinner than 6 mm thick, and live plant material thinner than 3 mm thick.
Head fire	The part of the fire where the rate of spread, flame height and intensity are greatest, usually when burning downwind or upslope.
Intensity	The rate of energy release per unit length of fire front usually expressed in kilowatts per metre (Kw/m).
Residence time	The time required for the flaming zone of a fire to pass a stationary point; the width of the flaming zone divided by the rate of spread of the fire.
Spotting	Behaviour of a fire producing sparks or embers that are carried by the wind and start new fires beyond the zone of direct ignition by the main fire.

*Most terms are taken from the Bushfire Glossary prepared by the Australasian Fire and Emergency Service Authorities Council Limited (AFAC).

Abbreviations

Abbreviation	Description
APZ	Asset Protection Zone
BAL	Bushfire Attack Level
ERP	Emergency Response Plan
FDR	Fire Danger rating
FFDI	Forest Fire Danger Index
GFDI	Grassland Fire Danger Index
RFS	New South Wales Rural Fire Service

1. Introduction

1.1 Background

The Uungula Wind Farm (the project) is a proposed renewable energy project located in the Central-West Renewable Energy Zone, approximately 14 km east of Wellington, 25 km west of Mudgee and 82 km south east of Dubbo, within the Dubbo Regional Council local government area (see **Figure 1**).

The project consists of the installation, operation, maintenance and decommissioning:

- Up to 97 Wind Turbine Generators (WTGs) up to 250 m in height with a nameplate capacity of approximately 4 megawatts or greater;
- An Energy Storage Facility (ESF) compound;
- Ancillary Infrastructure:
  - Hardstands;
  - Substations;
  - Operations and Maintenance (O&M) Compounds; and
  - Overhead transmission lines (high voltage);
  - Overhead transmission lines (medium to low voltage);
- Project Components and Infrastructure:
  - Permanent Meteorological Masts (concrete footings for mast and guy wires); and
  - Underground transmission lines (medium to low voltage);
- Temporary Facilities:
  - Concrete (or asphalt) batching plants;
  - Earthworks;
  - Rock crushing facilities;
  - Site compound and office; and
  - Temporary Meteorological Masts.

The project is estimated to have an installed generating capacity of approximately 400 MW The descriptions provided here relate specifically to the fire environment and risks. The development will occupy only a small part of each property, and the existing land use will be preserved.

1.2 Aims and Objectives

This Bush Fire Risk Assessment has the following aims:

- Address the requirements identified in the revised SEARs (SSD 6687) dated 11/11/2019 the Key Issue of Hazards/Risks for Bushfire:

  'identify potential hazards and risks associated with bushfire/ use of bushfire prone land, including the risks that a wind farm would cause bush fire and any potential impacts on the aerial fighting of bush fires and demonstrate compliance with Planning for Bushfire Protection 2006 (if located on bushfire prone land).

- Identify risks and mitigation actions (PBP 2019) to:
  - Protect fire-fighters in the event of a fire within the site
  - Reduce the likelihood of a bushfire impacting the site or spreading from the site
  - Identify measures to prevent or mitigate fires igniting
  - Identify work that should not be carried out during total fire bans
  - Assess availability of fire-suppression equipment, access and water
  - Recommend storage and maintenance of fuels and other flammable materials
  - Guide notification of the local NSW RFS Fire Control Centre for any works that have the potential to ignite surrounding vegetation, proposed to be carried out during a bush-fire fire danger period to ensure weather conditions are appropriate
  - Incorporate appropriate bush fire emergency management planning

2. Bushfire risk assessment

2.1 Bushfire Prone Land

The subject land of the proposed development includes land classified as bushfire prone on Dubbo Regional Council's bush fire prone land map[1]. As required under the SEARS, the Bush fire prone land mapping triggers the requirement to identify potential hazards and risks as well as demonstrating compliance with PBP.

2.2 Fire Climate

Fire climate strongly influences the likelihood of ignitions and how often, here expressed as the average number of days per year, fires will be uncontrollable without mitigation measures. While the predominant vegetation where the turbines and infrastructure will be located is grassland, patches of woodland and forest occur across the site (See Figure 4), as such the bushfire risk assessment for the site has been undertaken using the Grass Fire Danger Index (GFDI) and Forest Fire Danger Index (FFDI) Data from the Bureau of Meteorology weather station at Wellington (site 065034 D&J Rural), which is 22 km from the wind farm site, indicate the frequency of occurrence of fire weather for both forests and grasslands (**Table 1**). An FDR Very High fire danger occurs on average 1.0 days per year for grassland and 7.9 days per year for forest, while days of FDR severe and above for both grassland and forest are very rare – three Severe/Extreme for GFDI and 16 days for FFDI recorded in 38 years. GFDI could not be calculated for 18.4% and FFDI for 45.5% of the 3 pm records, because of incomplete data. A proportional adjustment of missing records was undertaken as reflected in **Table 1** below, resulting in significant increases in the average days per year of low-moderate FDR for both GFDI and FFDI.

Table 1: Average number of days per year of daily Fire Danger Rating and GFDI and FFDI categories at 3 pm at Wellington (D&J Rural)

Fire Danger Rating	GFDI	FFDI	Average Days per Year		Adjusted Average Days per Year	
			GFDI	FFDI	GFDI	FFDI
Catastrophic	150+	100+	0.0	0.0	0.0	0.0
Extreme	100 – 149	75 – 99	0.0	0.0	0.0	0.0
Severe	50 – 99	50 – 74	0.1	0.4	0.1	0.7
Very High	25 – 49	25 – 49	1.1	8.1	1.3	14.9
High	12 – 24	12 – 24	4.5	35.6	5.5	65.5
Low-Moderate	0 - 11	0 - 11	292.7	155.0	358.6	284.4
Incomplete			67.1	166.3	-	-
Total			365.5	365.5	365.5	365.5

Daily records at 3 pm from 1980 to 2017.

[1] https://www.planningportal.nsw.gov.au/spatialvie wer/#/find-a-property/address

High fire danger conditions or worse for grass fires occur in the months of December, January, February and March and rarely, if at all, in the other months (**Table 2**). For forest fire danger, high fire danger days have been recorded in all months of the year, with October – April having the highest amount (**Table 3**).

Table 2: Number of days in each month of daily Fire Danger Rating and GFDI categories at 3 pm at Wellington (D&J Rural)

	Incomplete	Low-Moderate (0-11)	High (12-24)	Very High (25-49)	Severe (50-99)	Extreme (100-149)	Catastrophic (150+)
January	284	821	65	17	0	0	0
February	194	843	31	5	1	0	0
March	257	872	38	9	1	1	0
April	200	940	0	0	0	0	0
May	174	1004	0	0	0	0	0
June	144	996	0	0	0	0	0
July	121	1057	0	0	0	0	0
August	266	912	0	0	0	0	0
September	194	946	0	0	0	0	0
October	239	939	0	0	0	0	0
November	202	938	0	0	0	0	0
December	277	855	37	9	0	0	0
Totals	2552	11123	171	40	2	1	0

Daily records at 3 pm from 1980 to 2017.

Table 3: Number of days in each month of daily Fire Danger Rating and FFDI categories at 3 pm at Wellington (D&J Rural)

	Incomplete	Low-Moderate (0-11)	High (12-24)	Very High (25-49)	Severe (50-74)	Extreme (75-100)	Catastrophic (100+)
January	563	307	235	79	3	0	0
February	494	352	186	41	1	0	0
March	569	419	171	18	1	0	0
April	516	501	117	6	0	0	0
May	506	643	28	1	0	0	0
June	487	649	4	0	0	0	0
July	507	659	12	0	0	0	0
August	539	611	28	0	0	0	0
September	525	558	52	5	0	0	0
October	543	467	138	28	1	0	0
November	522	382	173	58	4	1	0
December	550	341	209	73	5	0	0
Totals	6321	5889	1353	309	15	1	0

Daily records at 3 pm from 1980 to 2017.

The wind directions associated with Very High or worse grassland or forest fire danger are predominantly west but significant fire weather from all other wind directions can occur (**Table 4**).

Table 4: Number of days in eight wind direction categories with significant grass fire weather at 3 pm at Wellington (D&J Rural)

Wind Direction	Total	Total No. of days GFDI >=25	Avg. No. days per year GFDI > =25	Total No. of days GFDI >=50	Avg. No. days per year GFDI > =50	Total No. of days FFDI >=25	Avg. No. days per year FFDI > =25	Total No. of days FFDI >=50	Avg. No. days per year FFDI > =50
N	3420	5	0.13	0	0.00	61	1.61	2	0.05
NE	771	1	0.03	0	0.00	7	0.18	0	0.00
E	785	2	0.05	0	0.00	15	0.39	0	0.00
SE	649	1	0.03	0	0.00	8	0.21	0	0.00
S	912	2	0.05	0	0.00	21	0.55	1	0.03
SW	2502	5	0.13	0	0.00	48	1.26	1	0.03
W	1683	19	0.49	3	0.08	113	2.97	7	0.18
NW	1377	7	0.18	0	0.00	52	1.37	5	0.18
Incomplete	1790								
Totals	13889	42	1.08	3	0.077	325	8.55	16	0.42

Daily records at 3 pm from 1980 to 2017.

2.3 Fuel hazard

The area surrounding the site is modified agricultural land utilised primarily for cattle, sheep and goat grazing, cropping for stock feed and sheep studs. The landscape is predominately modified grassland with scattered trees and woodland as well as more extensive forest areas in closer proximity to some proposed infrastructure (**Figure 3**).

Materials for the turbines are steel or concrete/steel hybrids for the main sections and the blades are a fibreglass. The potential for fire of wind turbines is inherently low (CFS 2016). The CFA (2015) identified a risk of fire as a result of electronics and combustible oils and hydraulic fluids in the same enclosure.

It is intended that the vegetation fuel around the turbine hardstand, overhead transmission lines and access roads will be maintained in a low fuel state by mechanical, manual and chemical clearing methods prior to construction activities commencing and as part of ongoing maintenance activities for the duration of the Project. A fire could still spread in this fuel under severe fire weather conditions.

The likelihood of a fire spreading within the area as a result of the proposed wind turbines is uncertain, because a case history (i.e. previous fire records from fire agencies and wind farm sites) and experiments are required for similar environments, climate and wind farm components, ideally from within Australia is not available to enable assessment with more confidence. However, this assessment considers fire behaviour potential and ignition sources for the site to provide an understanding of the likelihood of a fire spreading if ignition occurs. CFA (2015) note that wind turbines manufactured today are required to meet accepted quality and safety standards. CFA (2015) also identified a number of measures that can be put in place to reduce the likelihood of a fire occurring. These include:

- Lightning protection
- Non-combustible hydraulic and lubricant oils
- Heat barriers to protect combustible elements
- Heat and/or smoke detection systems, for early notification of fires
- Suppression systems, either water of foam that can contain a fire.

2.4 Topography

The topography of the land is undulating, varying from approximately 360 m to 660 m in elevation across the site. Given the large expanse of the site it is expected some of the 97 sites would be exposed to slopes varying from upslope to >20 degrees downslope.

2.5 Fire behaviour potential

2.5.1 Grassland areas

Crops and pasture surround the site on the north and east and make up the predominant fuel for bushfires along with Forest and Grassland vegetation throughout the site (**Figure 3**). There will be periods when these pasture lands will be non-flammable because they are either fallow, too green to burn or are recently planted. There will also be periods when some crops are cured and highly flammable.

It should be assumed that, under the most extreme weather, a fire would spread even in heavily grazed grass and embers may breach any APZ. The rate of spread and fire intensity values for ‘eaten out pastures’ and while the rates of spread are considerably lower compared to ‘cut/grazed pastures’, significant fires can still develop. The residence time for flames in heavily grazed pasture are likely to be

very short, probably less than five seconds (Cheney and Sullivan 2008), so the wind farm components will have a similarly short time of exposure to flame contact and high radiant heat.

Previous studies on predicting bushfire behaviour potential for the grassland at similar locations (ELA, 2018) found fires in cured pasture and crops can be very fast moving and intense; and direct attack on such a grass fire will usually fail at GFDI >49 (Cheney and Sullivan 2008). An ignition point takes some time to build to a quasi-steady state rate of spread, however, under extreme weather conditions a grass fire can be expected to reach maximum rate of spread within 30 minutes or even less (Cheney and Sullivan 2008), by which time the fire is probably uncontrollable.

APZs can be effective at stopping grass fires, however, at wind speeds greater than 25 km/h even very wide APZs (fire breaks) can fail (Cheney and Sullivan 2008). Under the worst weather conditions that could be expected, an APZ of even 40 m width may fail to stop a grass head fire (Cheney and Sullivan 2008). Any trees within 20 m of APZ would significantly increase the spotting potential.

The likelihood of a fire ignition at a point where the pattern of existing crops can carry a fire to or from the site under the wind and weather conditions investigated has not been calculated. However, it is expected to be a low probability and the ignition risk discussed below seem to support this assumption.

2.5.2 Woodland and forest areas

There are patches of woodland and forest vegetation on the site (**Figure 3**) that will influence fire behaviour in those parts of the site.

The forest vegetation type for the site is classified as Upper Riverina Dry Sclerophyll Forest & Western Slopes Dry Sclerophyll Forests (Keith 2004). These classes of vegetation form an open eucalypt forest or woodland up to 20 m tall with open sclerophyllous shrub stratum and a patchy groundcover of grasses and open eucalypt forest or woodland 10-25 m tall, dominated by ironbark eucalypts and cypress pines with an open sclerophyllous shrub stratum and sparse to moderate grassy groundcover respectively.

The woodland vegetation predominately on the site boundaries is Western Slopes Grassy Woodland (Keith 2004). The tree canopy is typically up to 20 m tall with well-spaced crowns. Tussock grasses dominate the understory. Fuel loads contributing to rate of spread for grassy woodlands are typically 10 t/ha, and total fuel loads that contribute to intensity are 15t/ha (PBP Table A2.1, RFS 2006).

Previous studies on predicting bushfire behaviour potential for the ‘forest and woodland’ (Nobel *et al* 1980) at similar locations (ELA, 2018) found rate of spread and fire intensity values in indicate that fires in woodland and fire vegetation can be intense; and direct attack on such a fire will usually fail at FFDI >49 (**Table 5** from Cary, 2011).

Table 5: Suppression capabilities at increasing fire line intensities

Fireline Intensity (kW/m)	Suppression
<350	Head/flank attack using hand tools Hand constructed breaks should hold
350 - 2000	Too intense for hand attack Dozers and tankers with retardant effective on flanks and possibly head Fires may jump dozer breaks
2000 - 5000	Fires represent serious control problem May be crowning and long-distance spotting Head fire attack will fail and will endanger lives of fire fighters
> 5000	Crowning, long distance spotting, whirlwinds and highly erratic fire behaviour Control efforts at the head of fire will fail Mass spotting and erratic fire behaviour can endanger fire fighters many kilometres ahead of the main fire front

2.6 Fire ignition

Bushfires occur in most years in this district, typically started by accidents such as escaped burns, machinery and hot works (e.g. welding). Lightning fires are uncommon. There are no ignition occurrence records for the site or nearby that provide statistical validity or a guide to likelihood of nearby ignition.

Earth moving equipment, power tools (e.g. welders, grinders), mowers and slashers are well known for starting bushfires under conditions of high temperature, low humidity and high wind. Therefore, construction and ongoing maintenance of the wind farm will be a potential source of ignitions from December to March.

A technical report into the financial and market impacts of wind turbine fires (Sharma 2015) found that turbine fires are relatively infrequent, with approximately around 50 each year out of 300,000 wind turbines internationally (a rate of 1:6000).

It is conceivable that arcs or melted components resulting from a fault could ignite grass fuels under or surrounding installations and start a bushfire. However, the level of risk from faults cannot be assessed at this stage because there is no case history available and it is not possible to compare the ignition risk from farm operations (e.g. crop harvesting) relative to wind farm operation (see also **Section 1.1**).

2.7 Fire history

Mapped fire records of the Rural Fire Service from 2001 to 2019 were examined and indicate that there were 7 grass or bush fires within 30 km of the site over this period, ranging in size from 0.3 to 2742 ha. Two of these occurred within the windfarm footprint, one in 2009 (218 ha) and one in 2017 (2742 ha).

2.8 Assets at risk

The following assets are located on site or within 2 km of the proposed wind farm:

- various agricultural crops
- stock (sheep and cattle)
- fences
- residences

The town of Wellington is located approximately 10 km to the west.

All of these assets, including the WTG, wind monitoring masts and operational and maintenance components of the wind farm, are at risk from a bushfire that may propagate within the wind farm, or from an external fire threat.

2.9 Fire fighter and public safety

The usage of the general area surrounding the site is mostly limited to landowners, who are farmers, and the operators of the wind farm site.

The fire-fighters likely to respond to a bushfire in this area would be volunteers from the Rural Fire Service and or individual property owners. If the wind farm is designated by Fire & Rescue NSW as major infrastructure, then brigades from Wellington town could respond.

The risks to fire-fighter safety associated with a fire burning the turbines and associated equipment include inhalation of potentially toxic fumes and smoke from any plastic components such as cables (although the main structure of the WTG will be steel or concrete/steel hybrid) or other decomposed products (Allianz Risk Consulting 2012).

Any fire-fighters from the Rural Fire Service or neighbouring farms attending bushfires in this area will not be equipped with breathing apparatus and are unlikely to be trained in structural and electrical firefighting.

2.10 Bushfire scenarios

Two worst case bushfire scenarios have been considered for the purpose of understanding risk based on the fire climate, fuels, fire behaviour potential and fire history; they assume no risk mitigation strategies for the site:

1. A large, landscape scale bushfire occurs on a day with FDR of 49 or similar, west wind direction and at a time when crops adjacent to the wind farm are cured. The fire started well to the west and the wind farm boundary on the approach side is impacted by head fire. The likelihood of such a fire occurrence is low, given the fire history of the area, but it is still possible given the fire climate and fire behaviour potential. A substantial or complete fire encroachment on all equipment could be expected. The impact of this relatively short (but potentially intense) fire exposure on the WTG, ESF and ancillary infrastructure is not known.

2. An electrical fault ignites grass under a WTG, a fault at the ESF, or site work or machinery, on a day with FDR of 49 or similar, west wind direction and at a time when crops adjacent to the wind farm are cured. The fire spreads to the east for several kilometres destroying many crops, stock and fences. Liability for losses and potentially suppression costs are potentially sought from those responsible for the ignition cause e.g. as occurs with electricity distribution companies. As for the first scenario, the likelihood of such a fire is low.

A risk of a major fire spreading from the wind farm in the direction of Wellington is low, based on the wind direction associated with significant fire weather, but still possible (**Table 4**).

3. Mitigation Strategies

3.1 Overview

Mitigation strategies are guided by knowledge of the factors that contribute to bushfire risk:

- Fuels, weather, topography, predicted fire behaviour;
- Spatial patterns and frequency of unplanned ignitions;
- Suppression capability: resources (air and ground), access (roads, tracks) and water; and
- Values and assets: people, buildings, commerce, industry, services and the natural environment.

Mitigation strategies are also guided by evidence of efficacy of available treatment options. Mitigation must be a combination of complementary strategies, all of which are required to provide the best possible protection outcome for the wind farm and the community.

3.2 Asset Protection Zone

An Asset Protection Zone (APZ) is typically designed to separate a vulnerable asset from the bushfire hazard (vegetation/fuel). An APZ is either a lower fuel hazard such as mown or heavily grazed grass or a fire break of ploughed or fallow ground. APZs do not eliminate the fire risk but may lower it to an extent where fire control is more feasible or damage to the asset is reduced or eliminated.

Understanding the value and limitations of APZ is important, and as is the understanding that bushfires attack built assets by either flame contact, radiant heat or burning debris. An APZ can be used to lower or eliminate the bushfire attack from flame contact and radiant heat around the perimeter of the WTG and operational and maintenance facilities, but under winds of >25 kph burning debris can result in a fire breaching an APZ to ignite grassy fuel within other parts of the site. A fire emanating from the WTG may also jump an APZ by burning debris under similar conditions. An APZ will significantly reduce the likelihood of a bushfire spreading into the facility. APZ are to be established and maintained as Inner Protection Areas (IPA).

Despite the limitations of any APZ, as specified in PBP 2019 a minimum:

- 10 m APZ is to be established around each WTG and wind monitoring masts, and the compound for the operation and maintenance facilities including battery storage and substations (PBP, 2019);
- 20 m APZ will be incorporated into the final design layout if battery-based storage technology is used;
- No APZ is required for road access, power, other services or fencing.

When establishing and maintaining an IPA the following requirements apply (PBP, 2019):

Trees:

- canopy cover should be less than 15% (at maturity)
- trees (at maturity) should not touch or overhang the any infrastructure buildings;
- lower limbs should be removed up to a height of 2m above ground;
- canopies should be separated by 2 to 5m;
- preference should be given to smooth barked and evergreen trees.

Shrubs:

- create large discontinuities or gaps in the vegetation to slow down or break the progress of fire towards buildings;
- shrubs should not be located under trees;
- shrubs should not form more than 10% ground cover;
- clumps of shrubs should be separated from exposed windows and doors by a distance of at least twice the height of the vegetation.

Grass:

- should be kept mown (as a guide grass should be kept to no more than 100mm in height) leaves and vegetation debris should be removed.

3.3 Wind farm construction

3.3.1 Seasonal Construction

Should construction of the wind farm take place between 1 December and 31 March (see **Table 2** for data on seasonal occurrence of fire weather), the following measures are recommended to control the risk of grass fire ignitions:

- APZ is constructed as the first stage of development for each WTG, ESF or the operations and maintenance facility;
- all plant, vehicles and earth moving machinery are cleaned of any accumulated flammable material (e.g. soil and vegetation);
- a suitable fire appliance is present on site with at least two personnel trained in bushfire fighting;
- on days when Very High fire danger or worse is forecast for Wellington, the 'fires near me' app is to be checked hourly for the occurrence of any fires likely to threaten the site; and
- all operations involving earth moving equipment, vehicles, slashers and hot works (e.g. grinders, welders) cease while the GFDI is or forecast to be 35 or greater (Rural Fire Service 2018).

3.3.2 Construction Standard

The proposed towers include the following construction:

- Slab on ground and potential rock anchor foundations;
- The supporting tower structure of a WTG is typically comprised of a reducing cylindrical tower made out of either a welded steel shell or a concrete steel hybrid, fitted with an internal ladder and lift.
- The nacelle is the housing constructed of steel and fibreglass, mounted on top of the tower. It encloses the gearbox, generator, transformers, motors, brakes, electronic components, wiring and hydraulic and lubricating oil systems.
- WTG blades are typically made from glass fibre reinforced with epoxy or plastic attached to a steel hub and include lightning rods for the entire length of the blade.

Essential equipment should be designed and housed in such a way as to minimise the impact of bush fires on the capabilities of the infrastructure during bush fire emergencies. It should also be designed and maintained so that it will not serve as a bush fire risk to surrounding bush.

The following construction should be considered in the design of supporting infrastructure:

- Designed to mitigate the risk of fuel build up (i.e. leaf material), flame damage, ember attack and radiant heat;

- To be constructed from non-combustible materials;
- Include ember protection measures including:
  - Vents, penetrations and weepholes in external walls, shall be screened with a mesh made of corrosion-resistant steel or bronze;
  - The roof/wall junctions are to be sealed/screened with aluminium, steel or bronze mesh with a minimum aperture size of 2 mm; and
  - The base of any side-hung external doors shall be fitted with draught excluders/draught seals/weather strips.

Flexibility is required within the Development Consent to enable the Proponent to install the most contemporary and cost-effective models available at construction, thereby ensuring that the Project can deliver the lowest possible levelised cost of energy. New WTGs are continually entering the market and it is possible that variations to these conventional designs could occur prior to final WTG selection.

3.4 Wind farm ongoing operations

Fuel management within wind farm

It is assumed that a fire may start and spread within the footprint of the windfarm (see **Section 2**); ignitions could include lightning fires, human error or electrical faults. For this reason, it is recommended that vegetation fuels throughout the wind farm are maintained in a minimal condition by grazing, with additional slashing or mowing if required. This will minimise the radiant heat exposure to wind farm components and reduce the risk of a fire spreading beyond the wind farm. If grazing or slashing is not possible under the WTG other lower risk ground cover should be considered e.g. gravel or a non-curing ground cover and/or a very low above ground biomass.

Days of Very High or worse fire danger

To minimise the risk of fire ignitions, all operations on the site involving earth moving equipment, vehicles, slashers and hot works (e.g. grinders, welders) should cease while the GFDI is or forecast to be 35 or greater. This will require establishing an operational procedure for onsite recording of temperature, relative humidity and wind speed, as well as associated training.

Fire-fighter safety

A fire incident at Waterloo (South Australia) in January 2017 provides recent and real experience to test existing (practices, plans and protocols (Butler 2017). A number of lessons from the incident can be applied by the wind farm owner, and the industry as whole. An important takeaway is the aerial-friendly identification and markings for meteorological (“met”) masts and guy wires at wind farm locations.

It is also important to review and update emergency management plans and protocols – particularly for fire events – with a focus on:

- communications practices including advising state air-desk (who control aerial firefighting assets)
- on site asset management/operations centre control procedures to pause, brake and ‘lock’ individual turbines

- best practice approaches to support aerial and ground-based responses
- water storage point signage, access track markings and site mapping.

The safety hazards for fire-fighters from WTG (**Section 2**) and local fire-fighting capability are such that fire suppression within the footprint of the wind farm cannot be expected or relied upon. The only exception to this would be aerial water bombing that is compliant with air operations safety procedures; however, these resources may not be available at short notice for a fire that could spread several kilometres within an hour**.** Fire suppression is most likely only to be feasible from the APZ or internal access that could be utilised for firefighting.

It is recommended that fire-fighting equipment for fire-fighters be located permanently on site for rapid initial response should a fire occur. This could be a fire-fighting trailer or slip-on unit with a minimum 1,000 litre water capacity. Staff should be appropriately trained (i.e. basic firefighter level) and equipped with personal protection equipment (PPE).

An Emergency Response Plan (ERP) should be developed prior to construction commencing at the site and provide the following:

- addresses foreseeable on-site and off-site fire events
- activation of water spray systems and any other response/protection measures
- clearly states work health safety risks and procedures to be followed by fire-fighters, including
    - personal protective clothing
    - minimum level of respiratory protection
    - minimum evacuation zone distances
    - a safe method of shutting down and isolating the turbines
    - any other risk control measures required to be followed by fire-fighters
- evacuation triggers and protocols
- suppression response strategies and tactics, including aerial suppression options/management

Two copies of the ERP should be permanently stored in a prominent 'Emergency Information Cabinet' to be located at the main entrance point to the wind farm and the operations and maintenance facility, external to any security fence or locked gate, and a copy provided to local emergency responders (**Figure 2**).

Once constructed and prior to operation, contact should be made by the site operator with the Local Emergency Management Committee to establish emergency management procedures with relevant authorities for the safety hazards presented by the site. The operator of the wind farm should brief the local volunteer fire brigades and neighbouring farmers at appropriate intervals, for example, at annual pre-season fire meetings, on safety issues and procedures.

3.5 Energy Storage Facility

An ESF forms part of the Project which would consist of infrastructure designed to store and discharge energy. The ESF will consist of buildings, shipping containers, or other infrastructure and will connect to the WTGs, Collector Substation and Switching Station via underground and/or overhead cables. A 20 m asset protection zone (APZ) will be incorporated into the final design layout if battery-based storage technology is used, a larger APZ is proposed than that required for this type of development (10m) to lower the risk to the adjoining bush land.

It is recommended that the ESF will have a fire detection and suppression system based on Novec 1230 or equivalent. This is considered appropriate for the ESF as the Novec 1230 system is suitable for suppressing fires in occupied spaces, in areas where an electrically non-conductive medium is required, where electronic systems cannot be shut down in an emergency and where clean-up of other agents poses a problem. Additionally, independent toxicity studies have established that the agent is low in both acute and chronic toxicity with high safety margins between its normal use concentrations and the No Observable Adverse Effect Level (NOAEL).

3.6 Water storage

Whilst the likelihood of a damaging fire impacting the wind farm is considered low, the consequence could be significant e.g. large number of WTG, ESF and/or ancillary infrastructure damaged.

The risk of a fire starting from the wind farm and spreading to surrounding areas is also considered low. Water supply should be designed to provide filling points for fire tanker units near the wind farm entrance and at the O&M Compounds. A combined storage of 50,000 litres is recommended for the site, based on refilling an approximate of six tanker units (4,000 litres) twice each.

3.7 Total Fire Bans

Under Section 63 of the *Rural Fires Act 1997* it is the responsibility of the landowner to limit the ignition and prevent the spread of fires from the property. On days declared Total Fire Ban you cannot light, maintain or use a fire in the open, or carry out any activity in the open that has the potential for a fire to develop. General purpose hot works (such as welding, grinding or gas cutting or any activity that produces a spark or flame) are not to be done in the open.

The NSW RFS strongly recommends the landowner reconsider activities such as such using a tractor or slashing, to help reduce the chance of a fire starting on the property.

Fire permits are also suspended on days of total fire ban. Permits may resume after the total fire ban is lifted, as long as the permit hasn't expired. The NSW RFS Commissioner is responsible for exemptions to Total Fire Bans. These exemptions are detailed in the NSW Government Gazette each time a Total Fire Ban is declared under the *Rural Fires Act 1997* Section 99.

The local NSW RFS Fire Control Centre (Wuuluman Rural District) should be notified of any works that have the potential to ignite surrounding vegetation, proposed to be carried out during a bush-fire fire danger period to ensure weather conditions are appropriate.

3.8 Access

The Project Site will be accessed from the public road network at the following locations during construction and operation:

1. Primary Project Site entry off Twelve Mile Road, approximately 17 km east of Wellington. This will be the sole access point for OSOM Vehicles and the main access point for Heavy and Light Vehicles; and,
2. Secondary intersections and cross-over locations along Uungula and Ilgingery Roads. These secondary access points will facilitate the routes of internal roads throughout the Project Site required for construction and operational vehicles.

The proposed development does not include additional public roads and upgrades of internal access have been assessed in accordance with property access requirements show in Table 6**.**

The internal property access is a road network of approximately 100 kms. The existing farm tracks will be upgraded to be a width of 6 m to accommodate the construction traffic loads, as well as for maintenance purposes during operation. Access to the Project Site on Project roads would be restricted from public access.

Table 6: Property access requirements (adapted from table 5.3b of PBP)

Performance Criteria	Acceptable Solutions	Compliance notes
The intent may be achieved where:		
Firefighting vehicles can access the dwelling and exit the property safely.	There are no specific access requirements in an urban area where an unobstructed path (no greater than 70m) is provided between the most distant external part of the proposed dwelling and the nearest part of the public access road (where the road speed limit is not greater than 70kph) that supports the operational use of emergency firefighting vehicles. In circumstances where this cannot occur, the following requirements apply:	Not applicable
	Minimum 4m carriageway width;	Complies. Approximate trafficable width of 6m for all internal access.
	In forest, woodland and heath situations, rural property access roads have passing bays every 200m that are 20m long by 2m wide, making a minimum trafficable width of 6m at the passing bay;	Complies. Approximate trafficable width of 6m for all internal access.
	A minimum vertical clearance of 4m to any overhanging obstructions, including tree branches;	To comply
	Provide a suitable turning area in accordance with Appendix 3;	To comply
	Curves have a minimum inner radius of 6m and are minimal in number to allow for rapid access and egress;	Can comply The advice of a relevant authority or suitably qualified professional should be sought, for certification of design and installation in accordance with relevant legislation, Australian Standards and table 5.3b of PBP.
	The minimum distance between inner and outer curves is 6m;	
	The crossfall is not more than 10 degrees;	
	Maximum grades for sealed roads do not exceed 15 degrees and not more than 10 degrees for unsealed roads;	
	A development comprising more than three dwellings has access by dedication of a road and not by right of way.	Not Applicable
	Note: Some short constrictions in the access may be accepted where they are not less than the minimum (3.5m),	Not Applicable

Performance Criteria	Acceptable Solutions	Compliance notes
	extend for no more than 30m and where the obstruction cannot be reasonably avoided or removed. the gradients applicable to public roads also apply to community style development property access roads in addition to the above.	

3.9 Emergency Management

A Bush Fire Emergency Management and Operations Plan should identify all relevant risks and mitigation measures associated with the construction and operation of the wind or solar farm. This should include:

- detailed measures to prevent or mitigate fires igniting;
- work that should not be carried out during total fire bans;
- availability of fire-suppression equipment, access and water;
- storage and maintenance of fuels and other flammable materials;
- notification of the local NSW RFS Fire Control Centre for any works that have the potential to ignite surrounding vegetation, proposed to be carried out during a bush-fire fire danger period to ensure weather conditions are appropriate; and
- appropriate bush fire emergency management planning.

3.10 Summary of recommended mitigation strategies

Table 7 summarises the bushfire mitigation strategies and recommendations made in this document.

Table 7: Summary of recommended mitigation strategies and actions

Mitigation Strategy	Section of Plan	Action
Asset Protection Zone (APZ)	3.2	Despite the limitations of any APZ, as specified in PBP 2019 a minimum: 10 m APZ is to be established around each WTG and wind monitoring masts, and the compound for the operation and maintenance facilities including battery storage and substations (PBP, 2019); 20 m APZ will be incorporated into the final design layout if battery-based storage technology is used; No APZ is required for road access, power, other services or fencing.
Operation and Maintenance (O&M) facility	3.3	APZ to be maintained to IPA standard.
Wind farm construction	3.4	If construction occurs from December to March: APZ constructed first, fire appliance on site and earth moving equipment, vehicles, slashers and hot works (e.g. grinders, welders) suspended when GFDI >=35. The following construction should be considered in the design of supporting infrastructure: Designed to mitigate the risk of fuel build up (i.e. leaf material), flame damage, ember attack and radiant heat; To be constructed from non-combustible materials; Include ember protection measures including:

Mitigation Strategy	Section of Plan	Action
		Vents, penetrations and weepholes in external walls, shall be screened with a mesh made of corrosion-resistant steel or bronze; The roof/wall junctions are to be sealed/screened with aluminium, steel or bronze mesh with a minimum aperture size of 2 mm.
Wind farm ongoing operations	3.4	Maintain minimal fuel load by grazing, slashing or mowing. Under WTG fuels minimised. No vegetation within the O&M facility. Suspend site maintenance operations involving earth moving equipment, vehicles, slashers and hot works (e.g. grinders, welders) when GFDI >=35.
Fire-fighter safety	3.4	Emergency Response Plan to be prepared and stored at 'Emergency Information Cabinet' at main entrance to wind farm and provided to local emergency responders. Include aerial suppression options/management.
Initial response capabilities	3.4	A rapid response unit (slip on or fire trailer) with minimum 1000 L water capacity be maintained on site, with appropriately trained and equipped (PPE) staff able to operate.
Water storage	3.5	Designed to supply fire tanker units (combined minimum 50,000 L storage) near wind farm entrance and O&M Compounds.
Access	3.8	Proposed internal access upgrades can comply with Property Access requirements. The project includes a Primary and Secondary access to public roads. The internal access roads do not provide public access.
Emergency Management	3.9	A Bush Fire Emergency Management and Operations Plan should identify all relevant risks and mitigation measures associated with the construction and operation of the wind or solar farm. ESF to have a fire detection and suppression system based on Novec 1230 or equivalent

Letara Judd
Bushfire Consultant

Mick George
Principal Consultant

4. References

Butler, T. 2017. *In case of fire.* http://www.ecogeneration.com.au/in-case-of-fire/

Cary, G (2011) ENVS6204 Lecture 3.2 Fire Regime, Australian National University.

Cheney N.P., Gould J.S. Catchpole W.R. 1998. *Prediction of Fire Spread in Grasslands*. International Journal of Wildland Fire 8, 1-13.

Cheney N.P., Sullivan, A.L. 2008. *Grassfires: Fuel weather and fire behaviour*. CSIRO Publishing 2nd Edition, Collingwood, Vic.

Country Fire Service (SA). 2016. *Guidelines for wind farms.* Government of South Australia.

Cruz, M.G., Gould, J.S., Alexander, M.E., Sullivan, A.L., McCaw, W.L. and Matthews, S. 2015. *A Guide to Rate of Fire Spread Models for Australian Vegetation*. CSIRO Land and Water, Canberra ACT and AFAC, Melbourne, Vic, 125 pp.

Ecological Australia (ELA). 2018. *Bodangora Wind Farm Bushfire Risk Assessment*

NSW Rural Fire Service (2018). *Harvest fires.* https://www.rfs.nsw.gov.au/plan-and-prepare/farm-fire-safety/grain-harvesting-guide accessed 9/02/2018.

NSW Rural Fire Service (2019). *Planning for Bushfire Protection, a guide for councils, planners, fire authorities and developers*

Sharma, J. 2015. *WTGing inferno: Global trends in wind turbine downtime events.* GCube Underwriting Limited.

Wilson, A.A.G. 1988. *Width of firebreak that is necessary to stop grassfires: some field experiments.* Canadian Journal of Forest Research 18, 682–687.

Appendix A: Maps

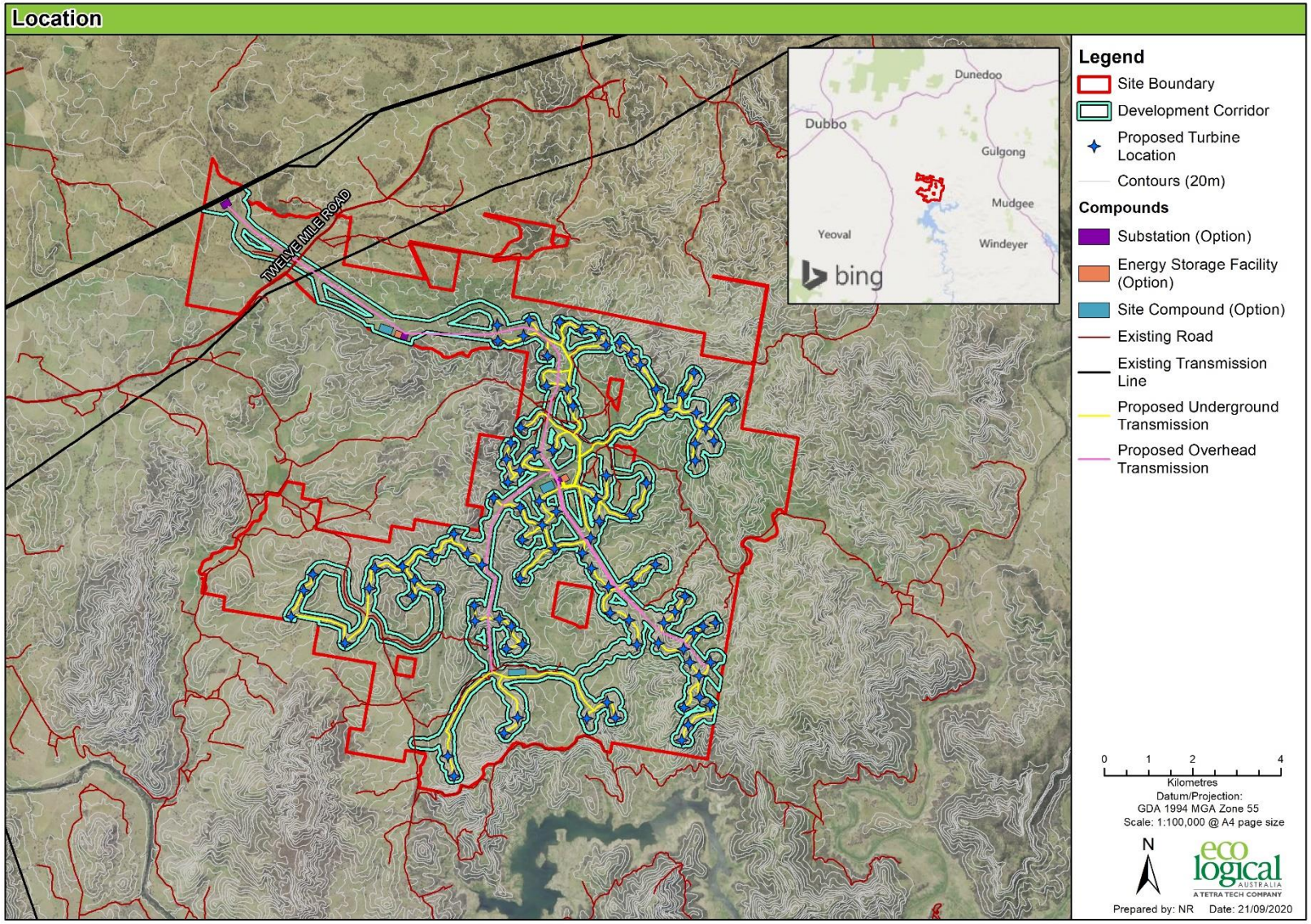

Figure 1: Site Context and layout

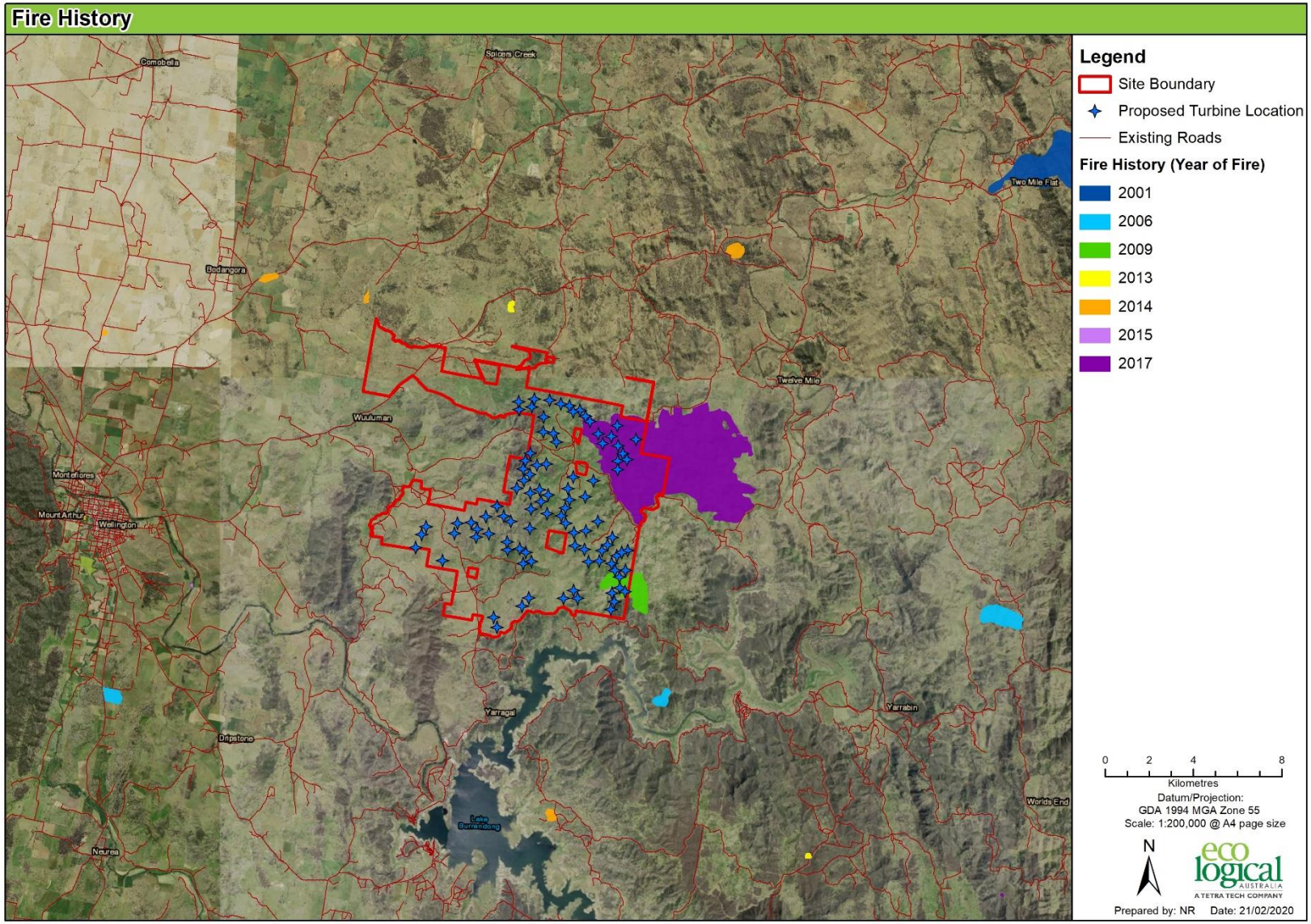

Figure 2: Fire History

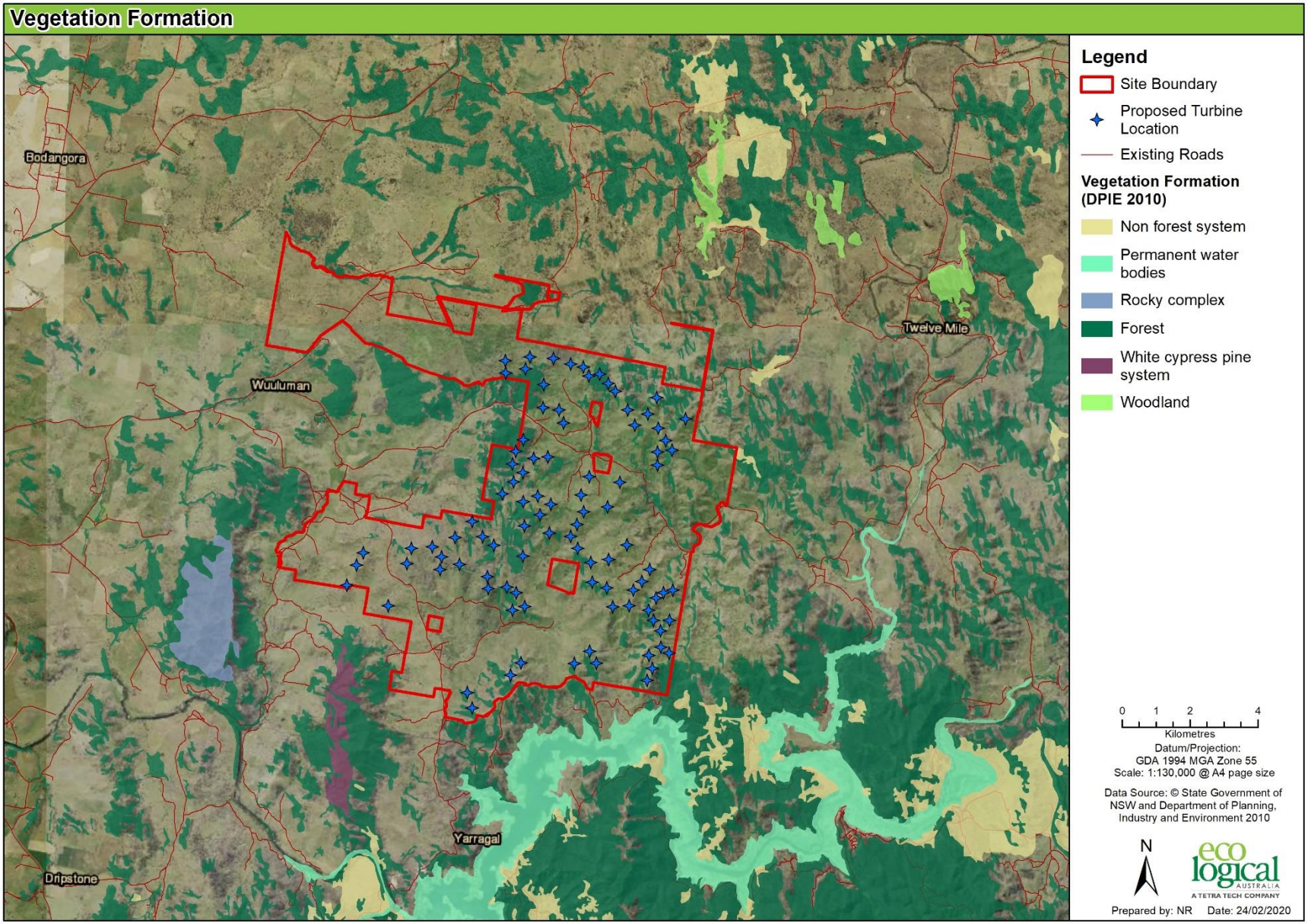

Figure 3: Vegetation

eco logical AUSTRALIA
A TETRA TECH COMPANY

1300 646 131
www.ecoaus.com.au