HADOUKEN PTY LTD

Environmental Assessment Report

Collie Solar Farm

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TERMINOLOGY, ABBREVIATIONS AND DEFINITIONS

Term	Definition
AS	Australian Standard
AS/NZS	Australian Standard/New Zealand Standard
AS/NZS ISO 31000: 2009	Principles and guidelines standard for risk management
AS/NZS ISO 19011: 2003	Principles and guidelines standard for quality and/or environmental management systems auditing
CMP	Construction Management Plan
Critically Endangered	A species that has undergone, is suspected to have undergone or is likely to undergo a very severe reduction in numbers in the immediate future:
Cwlth	Commonwealth of Australia
DBCA	Western Australian Department for Biodiversity Conservation and Attractions (formerly Department of Parks and Wildlife)
DEE	Australian Government Department of the Environment and Energy (formerly Department of Sustainability, Environment, Water, Population and Communities)
DRF	Declared Rare Flora
DWER	Western Australian Department of Water and Environmental Regulation
Ecological Community	Refers to all the interacting organisms living together in a specific habitat
EMP	Environmental Management Plan
EMS	Environmental Management System
Endangered	A species that has undergone, is suspected to have undergone or is likely to undergo a severe reduction in numbers in the immediate future:
Environment	Living things, their physical, biological and social surroundings and interactions between all of these (WA OEPA definition)
EP Act	Western Australian *Environmental Protection Act 1986* and its associated regulations
EPA	Western Australian Environmental Protection Authority
EPBC Act	Australian Government *Environment Protection and Biodiversity Conservation Act 1999* and its associated regulations
ha	Hectare (10,000 m^2)
HSE	Health, Safety and Environment
IMS	Integrated Management System
ISO	International Organization for Standardization
km	Kilometre
m	Metre, the SI unit of distance

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m^3	Cubic metre, the SI unit of volume
Migratory Species	Species listed as migratory under section 209 of the EPBC Act (Cwlth)
mm	Millimetre
MW	Megawatt: electrical power measurement, equal to one million (106) watts
MNES	Matters of National Environmental Significance
NZS	New Zealand Standard
P1	Priority 1 on the Priority Fauna or Priority Flora lists for a species that is poorly known from one or a few locations which are potentially at risk.
P2	Priority 2 on the Priority Fauna or Priority Flora lists for a species that is poorly known from one or a few locations some of which are on lands managed primarily for nature conservation with secure tenure being managed for nature conservation.
P3	Priority 3 on the Priority Fauna or Priority Flora lists for a species that is poorly known from several locations and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat not under imminent threat.
P4	Priority 4 on the Priority Fauna or Priority Flora lists for a species that is rare and considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are not currently threatened or in need of special protection.
P5	Priority 5 on the Priority Fauna or Priority Flora lists for a species that is not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.
Risk Assessment	The development of quantitative estimates of risk based upon engineering evaluation and mathematical techniques that combine estimates of accident consequences and frequencies
SDS	Safety Data Sheet (formerly Material Safety Data Sheet). A widely-used system for cataloguing information on substances, such as chemicals, chemical compounds, and chemical mixtures and may include instructions for the safe use and potential hazards associated with a particular material or product
TEC	Threatened Ecological Community listed as critically endangered, endangered or vulnerable under section 181 of the EPBC Act
TEMP	Terrestrial Environmental Management Plan
Threatened Species	Species listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent under section 178 of the EPBC Act
Vulnerable	A species that has undergone, is suspected to have undergone or is likely to undergo a substantial reduction in numbers in the immediate future:
WA	Western Australia

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1. INTRODUCTION

Hadouken Pty Ltd (Hadouken) proposes to develop a 20 MW (maximum designed output) photo-voltaic (PV) solar farm with a battery storage system on the outskirts of Collie in Western Australia. The site is located on the southern half of Lot 2977 which lies between Patstone Road and Harris River Road as shown in Figure 1. The southern half of Lot 2977 covers an area of approximately 34 ha. Hadouken has contracted Matters of Environment Pty Ltd (MoE) to conduct an environmental desk study and site survey, followed by an environmental risk and impact assessment.

This report provides a description of the proposed development and its location, especially in regard to the construction or operational activities that could or will have an impact on the environment. It describes the environmental aspects known or likely to occur on or around Lot 2977, with particular focus on features that may be impacted by a solar farm and battery development. The report also contains suggested management and mitigation measures designed to limit the potential risks and impacts to a level deemed to be acceptable.

Figure 1. Site Location Plan with the site boundary shown in red to the north of Collie town centre.

1.1 Regulatory Approvals

This report has been written to support a planning application for the proposed development under the *Planning and Development Act 2005*.

A referral under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) will also be submitted to assess the potential impacts on matters of national environmental significance and is currently scheduled for submission in late January 2018.

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A referral under Western Australia's *Environmental Protection Act 1986* (EP Act) and relevant associated regulations is not deemed necessary on advice received from the Western Australian Office of the Environmental Protection Authority (OEPA). This advice was received in an email which is provided for reference in Appendix 1.

A native vegetation clearing permit will be applied for under section 51E of the Western Australian *Environmental Protection Act 1986* to seek approval to remove native vegetation in preparing the site for development.

1.2 Description of the Proposed Development

The proposed development is for a power generation plant that converts sunlight into electrical energy through upward-facing panels that hold a large number of PV cells. The Collie Solar Farm will have a designed electricity generating output of 10 MW AC. The electrical energy will either be exported to the South West Interconnecting System (SWIS) via a local distribution line or used to charge a future battery storage system installed on site. The capacity of the battery storage system will depend on available componentry at the time of procurement. The energy stored in the battery storage system will be used to feed into the SWIS when on site generating potential is low, e.g. at night, or when demand for electricity is high. An indicative layout of the solar farm can be seen in Figure 2 but is subject to final design.

The solar farm, battery storage and control systems will comprise of:

- approximately 69,000 solar panels mounted on fixed frames with a footprint of around 18 ha
- the frames will be fastened to small diameter driven or screwed piles of approximately 1.5 m length
- panels will be set at a height of approximately 0.9 m above finished ground level
- buried cables connecting the PV panels together and to the five inverters and battery storage
- Li-ion batteries held within 5-10 shipping containers (depending on technology and supplier)
- Switchgear installed between the inverters and grid connection to the north-east corner of the site
- above-ground export cable from the control system to 22 kV transmission line located on the eastern boundary of the site.

The design and arrangement of the panels has been optimised to maximise electricity generation from the smallest parcel of land. The PV panels are aligned approximately north to south and in a fixed-tilt arrangement holding the panels rigidly in place without tracking the sun. Each line of panels is angled at 8° from horizontal east to west and each line of panels oppose adjacent lines in a shallow saw-tooth arrangement. This arrangement avoids the potential of panels overshadowing each other and minimises the land area for the generating capacity. This arrangement is shown schematically in Figure 3.

Lot 2977 already has suitable vehicular access for installation and operation of the solar farm via Harris River Road on the eastern boundary. For safety reasons it is possible that an alternative access point will be required via Patstone Road on the site's western boundary.

The Site will be partially levelled using a cut and fill approach to provide a more level surface for installing the panels and equipment and to ensure the incident light falls on the PV panels within required tolerances for solar generation. Based on the existing differences in levels across the site, the maximum heights of the cut and fill is likely to be a maximum of approximately 1.5 m each. The cut and fill material will all be contained on site. The perimeter of the excavated areas will be battered at natural angles for the geology type. Fill material will require compacting to prevent subsidence of the land and the installed panels and infrastructure. Similarly, natural slope angles will be formed at the edges of the fill. Once level, the ground under the panels will be surfaced with chippings or compacted aggregate to prevent weed and plant growth and to manage fire risk. An existing track that follows the pipeline along the northern boundary will be used to access the western half of the site.

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Figure 2. Site Layout Plan showing the creek through the centre of the site and isolated trees on the western half.

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1.2.1 Construction

Construction of the proposed development will include the following activities that are to be addressed by this environmental impact assessment:

- Removal of trees from within the array footprint and wider site in accordance with vegetation clearing permit
- Designation of a drop-off site on the grassed paddock near Patstone Road for temporary storage of installation equipment
- Harris River Road will be used for the delivery of construction plant and installation equipment.
- Levelling of the ground surface within the solar farm footprint by excavation of the higher ground and deposition of the soil on the lower ground
- Any landscaping that may be required for visual screening or environmental purposes
- Lay compacted aggregate over the surface of the solar farm footprint or seed with low growing grass
- Installation of small (75-125 mm diameter) driven or screwed foundation piles
- Trenching and laying of interconnecting cables between the PV panels and the inverters, and from the inverters to the control equipment
- Trenching and laying of an earthing system within trenches
- Fixing of panel frames to the installed piles and PV panels to the frames
- Placement of the five inverters
- Placement of the battery storage containers
- Connection and commissioning of the cables and earthing systems with the panels, inverters, battery and control systems
- Installation of a 1.8 m high, chain-link perimeter fence topped with three barbed-wire strands
- Connection with the grid via a 22 kV transmission line on the eastern boundary of the proposed array.

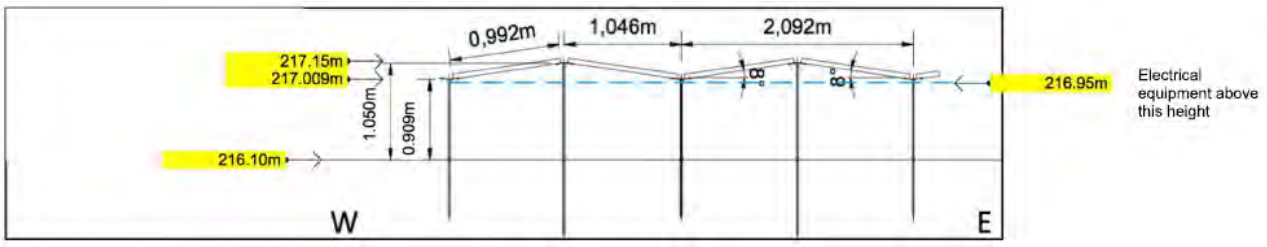

Figure 3. Schematic of the arrangement of PV panels showing the shallow saw-tooth arrangement that maximises electricity generation. The cross section is from east to west through the site and is looking north.

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1.2.2 Schedule

Construction is currently scheduled to start in Q2 - Q3 2018, and is expected to take between three and six months. The solar array will be operational for an intended period of 25 years.

1.2.3 Operation

The solar farm will require little maintenance and is monitored remotely (Perth) for generating output and performance. It will generate electricity when the ambient light falling on the panels is adequate and will store and discharge electricity as required through the future battery storage system. Public will not be permitted on the site due to safety concerns as normal on an electricity power generation plant.

Site activities will be limited to routine maintenance and inspection programs twice a week and further ad-hoc maintenance will be conducted as required. Maintenance activities are expected to be low through the selection of materials and equipment that are designed to maximise reliability of output. The PV panels will need cleaning periodically when electricity generation is affected by build-up of dust and other dirt and is anticipated to be quarterly. Cleaning will generally be conducted during cool weather or early in the day to reduce the risk of thermal stress damaging the panels when cool cleaning liquids contact the hot glass surfaces. Water is used to clean the panels and doesn't require chemicals.

Vegetation will be routinely controlled on site and around the perimeter to prevent fuel build up and overshadowing the panels.

Maintenance vehicles will be parked on site near where works are required and access through a gated entrance on the north-eastern corner of the solar farm.

1.3 Site Description

The chosen site of the proposed solar farm, lies approximately 2.1 km north of Collie town centre as shown in Figures 1 and 2, and has a development footprint of around 18 ha. The proposed development site is designated jointly as 'Rural' and "Development Investigation Area" in the Shire of Collie's *Local Planning Strategy* (2009). It is understood that the latter designation is to anticipate expansion of an industrial area to the south of the Site.

The land slopes towards a creek running north to south down the middle of the site. Elevation lies between 221 m on the north west to 207 m near the southern end of the creek and a difference in elevation across the site of 13 m. The corresponding fall on the eastern half of the site is 10 m from near the site entrance to the southern end of the creek. The fall along the creek is approximately 3.5 m from north to south.

The Site is surrounded by a mix of grazed paddock (cattle) and woodland, with some very large stands of woodland on the opposite side of Patstone Road to the west and 0.7 km north. The larger components of these woodlands are managed by the Western Australia Department of Biodiversity, Conservation and Attractions (BCA) as Regional Parks and State Forest. Smaller stands of woodland also occur within the paddocks in the wider area.

An industrial estate lies beyond the woodland immediately south of the Site, where new development is in progress on the west side of the southern boundary.

The nearest other developments are domestic dwellings on the west side of Patstone Road and on the opposite side of Harris River Road to the east as shown in Figure 2.

1.4 Project Environmental Consultant

MoE is an independent environmental consultancy formed in 2016. It is run by Dr Barry Shepherd who has been an ecologist and independent consultant for more than 24 years. Ten of these years have been spent in Western Australia servicing various industries in support of many developments including renewable

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energy (wave, wind and solar), housing, marinas and, oil and gas. Barry Shepherd has a Ph.D. in Ecology and B.Sc. (hons) in Environmental Biology.

The conclusions and recommendations contained in this document reflect the professional opinion of MoE, using the data, information and records acquired. MoE has used reasonable care and professional judgment in its interpretation and analysis of the data.

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2. DESK STUDY AND SITE SURVEY

2.1 Method

GIS data were acquired from Western Australia's Department of Parks and Wildlife for threatened and protected flora, fauna, communities, reserves and environmentally sensitive areas. In addition, a search was conducted for the area on the Department of Energy and Environment's (DEE) Protected Matter Search Engine, the results of which are provided in Appendix 1. The buffer areas used for these searches was 10 km. Additional information on flora and fauna was acquired through the Atlas of Living Australia (https://www.ala.org.au/) and Florabase (https://florabase.dpaw.wa.gov.au/).

The AHIS database was queried to identify if any sites of Aboriginal Heritage are located on or near the Site. In addition, the Aboriginal Heritage Places Dataset was downloaded from the Department of Aboriginal Affairs (DAA) website. Information on European cultural heritage was obtained using the Australian Places Inventory (http://www.environment.gov.au/heritage/places/wa/index.html).

Other information such as wind erosion, weeds, managed lands, and bush fire prone areas was obtained using spatial information available from the Western Australian Government's data portal located at: data.wa.gov.au.

All data can be made available on request.

A Level 1 Site Survey was conducted by Dr Shepherd on 23 December 2017 and a follow up survey on 29 December 2017 to identify the environmental values on the Site and adjacent areas. Habitats were inspected to identify the broad vegetation types present and the potential or actual use by protected fauna. Topography and amenity values were also considered. Sightings of fauna or their signs (scats, tracks, diggings or burrows) were also recorded where found.

Prior to the site survey, aerial imagery was inspected that indicated the presence of large trees. Collie falls within "Southern Jarrah Forest" Sub-region of the Interim Biogeographic Regionalisation for Australia (IBRA) (DEE, 2016). This bioregion is known to be important for three species of black-cockatoos listed as Threatened under the EPBC Act. For this reason, a Level 2 black-cockatoo habitat assessment was also conducted during the site survey in accordance with the Revised draft referral guidelines for three threatened black cockatoo species (DEE, 2017). Woodland habitats adjacent to the site were inspected for the potential or actual use by black-cockatoos, and all trees and habitats within the development footprint were inspected for foraging, roosting or nesting potential and all information gained was used to generate a "foraging habitat score" for the three types of black-cockatoos.

All eucalypt trees within the development footprint or that may be impacted by the proposed development were measured. If the trunk diameter was greater than 500 mm at breast height (DBH), the tree's position was recorded in GPS (Garmin GPSMAP64s) and the tree assessed in accordance with DEE (2017). In addition to the DBH, each record included the species, whether the tree was alive or dead and a rating to indicate whether the tree contained hollows suitable for black-cockatoos or not. Each tree was rated between 5 where no hollows are present to 1 where black-cockatoo nesting is confirmed. Hollows were inspected for the opening size, height above ground level, position on the branch or trunk, and whether signs of chewing or scratch marks were present.

A further survey was conducted on 29 December 2017 to survey additional trees that had been identified to cause potential shadow on the PV panels after the array layout had been adjusted.

2.2 Desk Study Findings

Data acquired from the protected matters search engine are presented in Appendix 1 and show that no World Heritage Properties, National Heritage Places, Wetlands of International Importance (Ramsar Wetlands), or Threatened Ecological Communities (TECs) are known to exist on or within 10 km of the Site. For the sake of clarity, marine values are ignored due to the site being 44 km from the ocean and any marine species that occur inland are unlikely to use a site with characteristics such as those found on Lot 2977.

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2.2.1 Flora and Fauna

Fourteen Threatened species of flora and fauna and eight Migratory species of fauna can potentially be found on or within 10 km of the site and these are listed in Table 1.

Table 1. Records acquired during the search for MNES of threatened or migratory species that may be found on or within 10 km of the site.

Species	EPBC Act Status	Likelihood of occurrence on Site	Justification
Birds			
Actitis hypoleucos Common Sandpiper	Migratory	Low	No preferential habitat on site. May transit across site or even stop at ponds temporarily.
Apus pacificus Fork-tailed swift	Migratory	Low	No preferential habitat on site. May transit across site and feed on insects flying over.
Botaurus poiciloptilus Australasian Bittern	Endangered	Low	No preferential habitat on site. May transit across site or even stop at ponds temporarily.
Calidris acuminata Sharp-tailed Sandpiper	Migratory	Low	No preferential habitat on site. May transit across site or even stop at ponds temporarily.
Calidris ferruginea Curlew Sandpiper	Critically Endangered, Migratory	Low	No preferential habitat on site. May transit across site or even stop at ponds temporarily.
Calidris melanotos Pectoral Sandpiper	Migratory	Low	No preferential habitat on site. May transit across site or even stop at ponds temporarily.
Calyptorhynchus banksii naso Forest Red-tailed Black-cockatoo	Vulnerable	High	This species is known to be common in the Collie area (DEE, 2018a) and its preferred breeding habitat can be found nearby.
Calyptorhynchus baudinii Baudin's Black-cockatoo	Vulnerable	High	This species is known to be common and breeds in the Collie area (DEE, 2018b).
Calyptorhynchus latirostris Carnaby's Black-cockatoo	Endangered	Moderate	Not known to frequent the area and unlikely to breed west of Collie.
Leipoa ocellata Malleefowl	Vulnerable	Low	No preferential habitat of mallee and wattle shrublands or low woodlands (DEH, 2007) on or near site.
Motacilla cinereal Grey Wagtail	Migratory	Low	May occur in low numbers in the area as it is a non-breeding summer visitor mostly to northern Australia (Pizzey and Knight, 2007).
Numenius madagascariensis Eastern Curlew	Critically Endangered, Migratory	Low	No preferential habitat on site. May transit across site or even stop at ponds temporarily.
Pandion haliaetus Osprey	Migratory	Low	No preferential habitat on site. May transit across site.

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Fish			
Nannatherina balstoni Balston's Pygmy Perch	Vulnerable	Low	No tannin-stained pools or running streams on site and >30 km from the coast as described in DEWHA (2008b).
Mammals			
Bettongia penicillata Brush-tailed Bettong or Woylie	Endangered	Low	No preferential habitat on site but may utilise woodland adjacent to the site for occasional sheltering and foraging. Foxes and cats are common in the area and will reduce the potential of this species occurring. They may transit across the paddock to move between woodland stands (DEC, 2012b).
Dasyurus geoffroii Chuditch	Vulnerable	Low	No preferential habitat on site and adjacent stands of woodland are too small to support this species. May transit across site to access surrounding woodlands in their large home range (DEC, 2012a).
Pseudocheirus occidentalis Western Ringtail Possum	Vulnerable	Low	No preferential habitat of coastal peppermint on site. Collie is generally outside the more coastal regions in which this species is known to occur (DE, 2013).
Setonix brachyurus Quokka	Vulnerable	Low	No preferential habitat on site but may occur in the larger woodland stands in the wider landscape where it is normally found (DEC, 2013a).
Plants			
Diuris micrantha Dwarf Bee-orchid	Vulnerable	Low	Unlikely to be found on site due to the extensive period of grazing that has occurred including within the creek where it is most likely to be found (DEWHA, 2008).
Grevillea rara Rare Grevillea	Endangered	Low	Not recorded on site and no creeklines within Jarrah forest present where it is known to occur (DEC, 2008).

Records held within the state flora and fauna databases were inspected and those species with some potential of occurring on the site are listed in Table 2. Threatened, declared rare, and priority plant species are not expected to be present on the site due to the years of grazing by cattle through the pasture, rush and woodland.

Table 2. Fauna species listed under Western Australia legislation previously recorded within the 10 km data search area. Species listed in Table 1 that were also listed under state legislation have been ignored for the sake of clarity.

Species	Conservation Status	Likelihood of presence on site	Justification
Falco peregrinus Peregrine Falcon	Special Protection	Moderate	May occasionally hunt prey bird species over the site and use trees and woodland to rest and feed.
Merops ornatus	Migratory	High	Likely to hunt insects over site and may breed in sandy soils in clearings

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Rainbow Bee-eater			or along edges of shrub or woodlands.
Macropus eugenii derbianus Tammar Wallaby	P4	Low	While Tammar Wallabies, will venture onto open pastureland, it does so from its preferred habitat of dense, low vegetation (DEC, 2012c) which is absent on or immediately adjacent to the site.
Macropus irma Western Brush Wallaby	P4	Low	While this species is found in open woodlands it prefers habitats that contain thickets for shelter and does not venture onto open paddocks (Morris and Christensen, 2008).
Hydromys chrysogaster Rakali (Water Rat)	P4	Moderate	Dams and a pond are present on site which could be visited when individuals roam widely over terrestrial terrain (Olsen, 2008).
Falsistrellus mackenziei Western Falsistrelle	P4	Moderate	This species is known to frequent old forest which is absent but has been found in adjacent habitats (Kitchener et al., 2008).

Of the species listed in Table 1 and Table 2, five are considered to have a moderate or higher chance of being present and use habitats on site that may be impacted by the development. These species were the focus of the field surveys and detailed in the relevant section below.

2.2.2 Weather

Collie has a Mediterranean climate type with hot, dry summers and cool wet winters. Temperatures can reach the low-40s in summer and occasionally drops below zero on winter mornings. The Collie area receives an average of 928.5 mm rainfall annually with most of that falling in June and July (BOM, 2018). It lies within the wetter south-western extremity of WA with dryer areas to the north and east.

2.2.3 Soils and Geology

Collie lies within the Collie Basin which is a valley system within the Darling Plateau and is the only coal producing area in WA (Varma, 2002). It is underlain by Archaean crystalline rocks which is covered by sediment formations forming the Collie and Stockton groups. Surface geology is formed from laterite alluvium and colluvium which in turn overlay the Nakine Formation. Surficial sediments are up to 4 m thick and were formed by Tertiary and Recent deposits. The laterite over sedimentary rock is mostly sandy with alluvium and colluvium in and around valleys and depressions (Varma, 2002).

2.3 Site Survey Results

The area proposed for development is comprised of a grassed paddock with a creek running from north to south down the centre of the site. A small dam exists on the northern end of the creek which was full of water at the time of survey. Another dam lies some 30 m within the paddock to the north. Seven mature Marri (*Corymbia calophylla*) and one mature Jarrah (*Eucalyptus marginata*) fall within the footprint of the solar farm, with other individual and small groups within the paddock to the north and west. Small stands of Eucalypt

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woodland lie on the northern, eastern and southern boundaries and mature eucalypts line Patstone Road to the west. These features are illustrated in Figure 5 and described in detail in the following sections.

2.3.1 Vegetation

The proposed solar farm is located in a paddock sown with grass as shown in Plate 1. The Site has been used to graze cattle for at least 20 years (P. Piavanini pers. comm.). The weeds flatweed *Hypochaeris radicata* and dock *Rumex* spp are very common throughout the grassland. Weed species such as wild radish or wild geranium that are known to provide seeds to black-cockatoo were not found in the grassland. The eastern half of the paddock contained 21 mature or semi-mature Marri and Jarrah. The paddock to the north also contained further semi-isolated Marri and Jarrah. Remains of fallen trees could be seen across the paddock indicating it had more trees in the past. All eucalypts are susceptible to nutrient enriched soils and will die prematurely. Fertilizers have been applied annually (P. Piavanini, pers. comm.) across Lot 2977 and several trees have been removed for risk of dropping branches or being blown over.

The paddock slopes gently down towards its centre from the north west and north east, to a creek that bisects the paddock from north to south. The creek is seasonally wet (P. Piavanini pers. comm.) and, for part of its length, supports rushes (*Juncus* spp) and several weed species including a Birdsfoot Trefoil (*Lotus* spp) and a dock (*Rumex* spp) that are also found within the pastoral grassland. The presence of rushes indicates that the water table is close to the surface throughout the year along the line of the creek. Isolated clumps of rushes are also found in diminishing densities away from the creek especially to the east where groundwater lies close to the surface. A typical view of the paddock and reed/rush community is provided in Plate 2. Two decrepit Swamp Paperbarks (*Melaleuca rhaphiophylla*) are present next to the dam at the northern end of the ditch.

Stands of secondary-growth eucalypt woodland comprised mostly of Marri and Jarrah, lie on the eastern edge of the paddock (1.7 ha), along the centre of the southern boundary (3 ha) and eastern half of the northern boundary (1.5 ha). These stands are shown in Figure 4. The stands of woodland contain some large trees of both species but most trees within each stand are of relatively young secondary growth. Tree heights estimated from measured vertical angles and distances from a single tree in two of the woodlands, show them to be around 21 m high along the northern boundary and 24 m high on the eastern boundary. The sparse understorey is formed of recently recruited Marri and Jarrah, and the ground flora is comprised mostly of agricultural grasses (oats and barley) and weeds similar to those in the paddock. A few saplings were recorded in the woodlands including of Woody Pear *Xylomenium occidentale* and a *Grevillea* spp. Typical views of these woodlands can be seen in Plate 3 and Plate 4.

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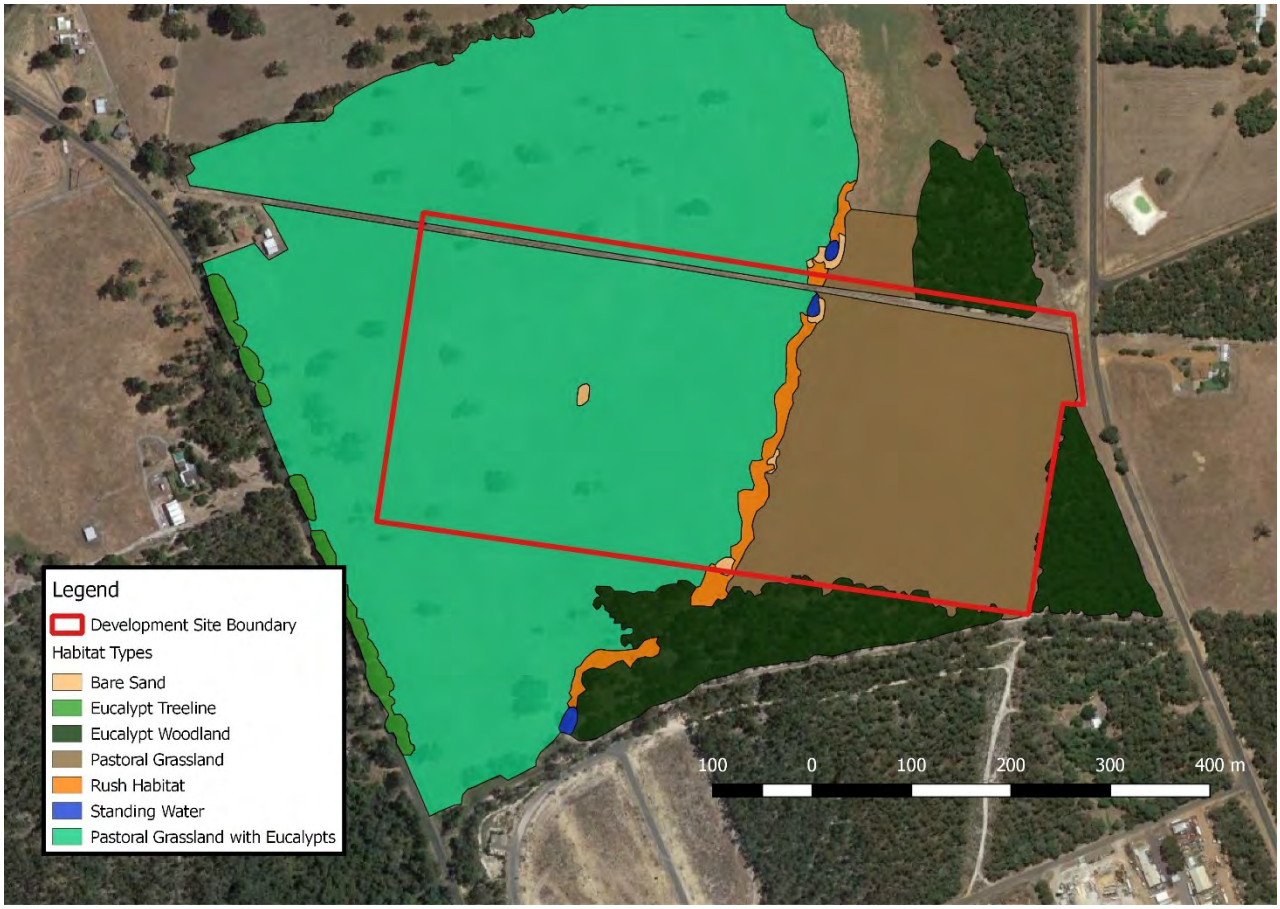

Figure 4. Habitat types present on and around the proposed solar farm development.

The western half of the site contained 32 isolated, mostly large Marri and Jarrah trees. These had various growth habits whereby some were broad and spreading and others tall with a distinct crown. This suggests that many other trees were present in the past and this is supported by information received from the landowner. Evidence of dead fallen trees could also be found extensively across the Site. It is known that many eucalypt species do not tolerate raised nutrient levels and can die. Of the 32 trees recorded in the paddock, only seven lie within the development footprint (see Figure 4), but a number of other trees may cast shadows over the proposed array.

The western boundary of the site with Patstone Road is formed by a line of Marri and Jarrah trees.

2.3.2 Standing Water

Two small dams have been formed at the northern end of the creek, with one each side of the pipeline that runs east to west along the northern boundary. Both dams contained water at the time of survey and was poached by cattle around part of their margins. Both hold water all through the year as advised by the landowner. The creek contains flowing water after rainfall. A view of the dam is shown in Plate 5.

A large pond is located adjacent the southern end of Lot 2977 and outside the development footprint. This pond is permanently wet. It is filled seasonally by the creek but throughout the year by sub-surface waters (P. Piavanini pers. comm.). The margins of this pond is also heavily poached by cattle and has very little marginal vegetation as seen in Plate 6.

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2.3.3 Fauna

The use of the grassland paddock as a wildlife habitat will be limited to a few common species of insects, frogs, reptiles, birds and small mammals. Some were evident during survey and included observation of grasshoppers, dragonflies and other insects. Common bird species were also observed in and around the paddock including Australian Ravens (*Corvus coronoides*), Australian Magpies (*Gymnorhina tibicen*), Magpie Larks (*Grallina cyanoleuca*), Willie Wagtails (*Rhipidura leucophrys*) and Common Bronzewings (*Phaps chalcoptera*). Australasian Pipits (*Anthus novaeseelandiae*) were observed within the grassland of the paddock adjacent the northern boundary and may form one or two breeding pairs. Striated Pardalotes (*Pardalotus striatus*) Australian Ringnecks (*Barnardius zonarius*) and Red Wattlebirds (*Anthocaera carunculata*) were observed and heard within the woodlands on the edges of the paddock. A Nankeen Kestrel (*Falco cenchroides*) was observed in one of the isolated Marris that also contained a nest typical of Kestrels. A Pallid Cuckoo (*Cacomantis pallidus*) and three Dusky Woodswallows (*Artamus cyanopterus*) were observed feeding on insects from overhead wires on the western half of the Site. Tree Martins (*Hirundo nigricans*) were observed overhead and Brown Honeyeaters (*Lichmera indistincta*) and Weebills (*Smicrornis brevirostris*) were heard through the day. A White-faced Heron (*Egretta novaehollandiae*) and several Straw-necked Ibis (*Threskiornis spinicollis*) were observed flying over the Site.

Rainbow Bee-eaters (*Merops ornatus*) were heard calling occasionally from the site on both survey visits but were not observed. This migratory species breeds from August to January in burrows it excavates in sandy soils within cleared and semi-cleared habitats including farmland (DEE, 2018). Although it was not observed, there is a chance it was breeding on site due to the habitats present.

Scats which appeared consistent with Western Grey Kangaroos (*Macropus fuliginosus*) were found at several locations across the site, and a group of three kangaroos were observed on an adjacent property. This species is likely to be regular visitors to the site. Several scats of European Foxes (*Vulpes vulpes*) were also recorded and the landowner advised that cats were frequently seen (P. Piavanini pers. comm.). Both foxes and cats are feral species and are voracious predators of native wildlife. No other signs of fauna were recorded on the day of survey.

The trees in the woodland offer foraging, nesting and roosting sites for other species of fauna including small mammals, birds and bats. Similarly, the isolated trees would also offer hollows and cavities for nesting and roosting birds and bats, but it is unlikely that arboreal mammals would venture into the open pasture and use these trees. One bat of note that has been previously recorded in the area is the Western Falsistrelle (*Falsistrellus mackenziei*) which is endemic to Western Australia and a Priority 4 species. This bat species is normally associated with wet sclerophyll forest, or wetter areas of Karri and Tuart dry forests (Kitchener et al., 2008), but can also be found in habitats adjacent to such forest. It roosts in tree hollows and cavities.

It is possible that other listed fauna such as Chuditch, Brush Wallabies, Woylies or Rakali may traverse the site on occasion if transiting between stands of other more suitable habitat. It is considered unlikely that individuals of these species would rely on the habitats on or immediately adjacent to the site for any length of time as their habitat requirements are not found here.

2.3.4 Black-cockatoo Habitat Survey

A group of three Baudin's Black-cockatoo (*Calyptorhynchus baudinii*) were observed feeding on Marri nuts within the woodland on the southern edge of the site and were occasionally heard during the first survey in November. None were observed or heard calling on the second visit in late December. Forest Red-Tailed Black-cockatoo (*Calyptorhynchus banksii naso*) were frequently seen and heard throughout the two survey visits.

Baudin's Black-cockatoos breed between August and December within large hollows in Karri (*E. diversicolor*), Marri, Jarrah and other eucalypts (DBCA, 2017a). Incubation last for around 29 days and nesting continues for another 40-50 days. Forest Red-tail breeds throughout the year but with peaks between April and June and August and October (DBCA, 2017c). Incubation last for around 29-31 days and nesting continues for another 40-50 days. Nesting sites are generally large hollows in mature eucalypts in proximity to freshwater

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and food sources, in particular Marri. Outside of the breeding season, both species require roost sites at which they congregate at night and which is selected to be close to standing freshwater and food resources. These features are present on site and are common in the area surrounding Collie.

The eucalypt woodlands along the eastern and southern boundaries and adjacent to Patstone Road were inspected for black-cockatoo activity and the trees on the northern and eastern stands of woodland nearest to the solar farm were surveyed. A full black-cockatoo tree survey was not conducted within the woodlands due to time constraints. Nesting hollows were found in trees in the paddock and woodland and therefore the site was deemed to provide high quality foraging habitat for black-cockatoos. Each of the 32 isolated trees within the eastern paddock and 13 trees in the paddock to the north were surveyed for their suitability for black-cockatoo nesting, roosting and foraging. The scoring of the site for black-cockatoos is summarised in Appendix 2.

One dam is present within the development footprint, and another lies just outside the development area to the north. A permanent pond is located just outside the southern boundary of the site. These permanent stands of freshwater are of value to black-cockatoos which offers freshwater throughout the year. Black-cockatoos require local access to standing freshwater to maintain the viability of feeding, roosting and nesting sites in the wider area.

The isolated trees inspected for nesting and roosting potential are mapped in Figure 5 and results are listed in Table 3. All 32 trees within the paddocks had a trunk or trunks with diameter at breast height (DBH) greater than 500 mm. DBH ranged from 600 to 2400 mm. One tree with a DBH of 650 could not be thoroughly inspected and there was doubt that it had no hollows so was given a category of 4. Three trees whose DBH were 950 mm and 1250 mm contained hollows of suitable size but with no chew or scratch marks were seen and were classified 3 accordingly. One of these hollows contained a feral honeybee nest and the other was approximately 70 mm diameter and currently too small for black-cockatoos. One of these hollows was at the top of a broken upright branch and looked very suitable but had no marks on its edges (see Plate 7). Two rough and untidy birds nests were located near the entrance to this hollow. One tree of DBH 1100, had a hollow with chew and/or scratch marks around the entrance and of suitable size for black-cockatoos. This was on a horizontal limb and may not have been suitable for black-cockatoos. There were no clear signs that black-cockatoos had used any hollows in the site for nesting and no black-cockatoos were observed within the trees at the time of survey.

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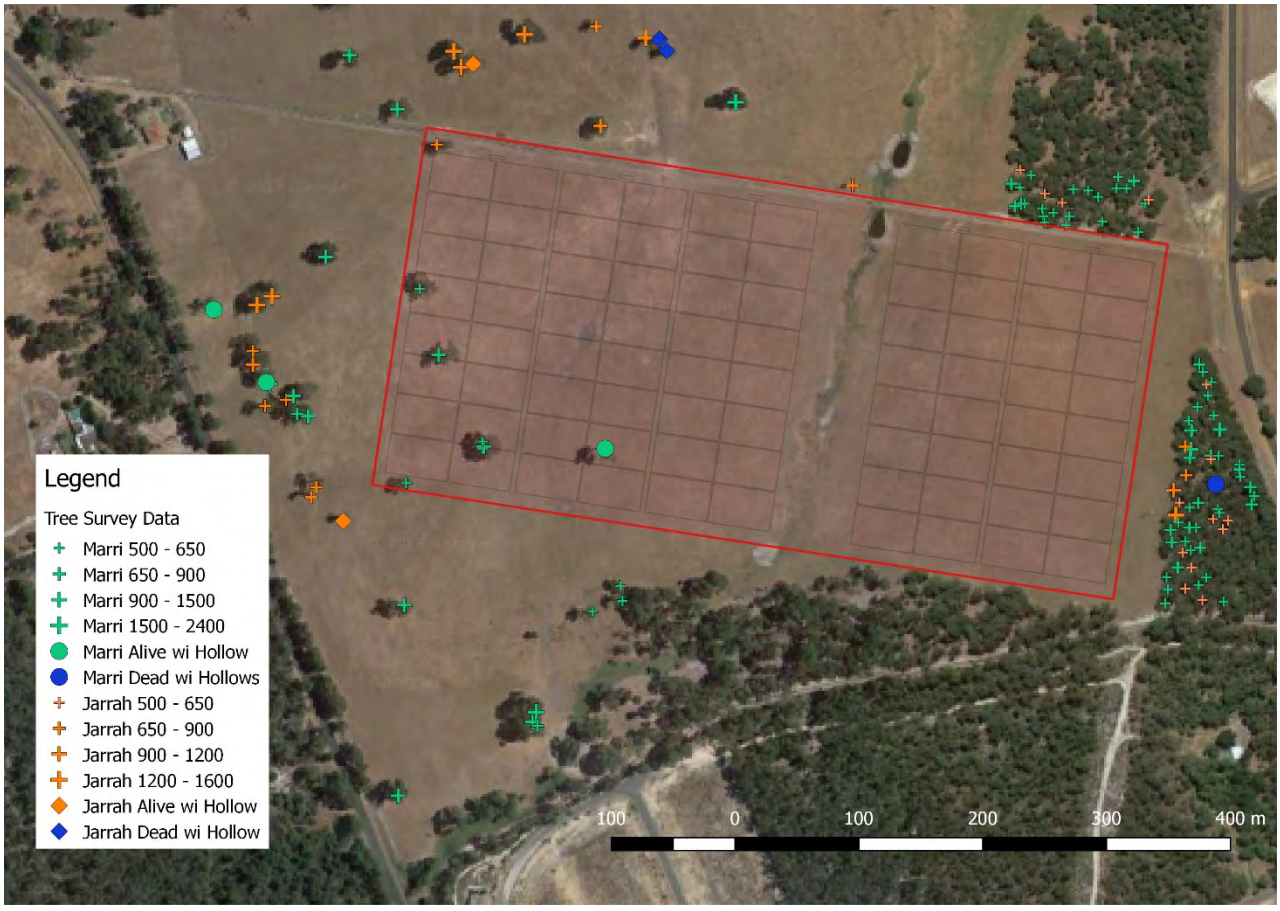

Figure 5. Results of black-cockatoo foraging habitat survey.

Table 3. Results of the black-cockatoo habitat survey of the isolated trees in the paddock on the western half of Lot 2977.

Category	Jarrah	Marri
1	-	-
2	1	1
3	3 (2 dead)	2
4	1	2
5	15	20

Feeding remains from Baudin's and Forest Red-tailed black-cockatoos were found underneath nine of the 45 isolated trees.

All three stands of woodland along the boundaries of the site to the east contained very large Marri and Jarrah trees of suitable size to contain nesting hollows (DBH >500 mm). Foraging signs for both Baudin's and Forest Red-tailed black-cockatoos were common under trees regardless of their size. Marri nuts were of varying ages including old and new. Examples of the chewed Marri nuts from this site are shown in Plate 8 and Plate 9. Despite a thorough search, no Marri nuts were found that had characteristic chew marks from Carnaby's Black-cockatoo. However, it does not discount Carnaby's Black-cockatoo from using the Site at other times

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of the year. Some chewed Jarrah nuts were also recorded but could not be attributed to a particular bird species.

It is likely that Baudin's use the site for foraging, roosting and potentially nesting at certain times of the year. Forest Red-tailed black-cockatoos are likely to use the site throughout the year for foraging, roosting and potentially nesting. The essential resources that would enable this site to be used by these two species such as nesting hollows, food and standing water, are present on Lot 2977. It is also possible that Carnaby's Black-cockatoo may use the site at times through the year but only for foraging or roosting. Carnaby's Black-cockatoo normally nest within Wandoo (*Eucalyptus wandoo*) and Salmon Gum (*Eucalyptus salmonophloia*) (DBCA, 2017b) not found on or around the site.

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3. ENVIRONMENTAL ASSESSMENT

The construction of the solar farm, associated infrastructure, battery storage system, site access and export cable will occur on a single grassland paddock as indicated in Figure 3. This will result in the loss of 18 ha of pasture grassland, half of which has some semi-isolated mature trees. The layout of the solar farm has been adjusted to avoid impacts on the creek and dams at the northern end of the creek.

Up to eight mature eucalypt trees will be cleared to allow the solar farm to be installed or to prevent overshadowing of the array from trees during operation. The trees are classed as native vegetation and will be the subject of a vegetation clearing permit (VCP) under section 51E of Western Australia's EP Act. The loss of the trees also has the potential to indirectly impact on the two species of black-cockatoo known to use the Site. For this reason, approval will also be sought from the DEE through referral under Part IV of the EPBC Act.

As part of the site selection process, Hadouken considered over ten other sites in south-western WA but found them to be less suitable for use as a solar farm due to less than ideal geotechnical characteristics, zonation, topography, the lack of suitable connection points to the SWIS, or a combination of these criteria.

The potential risks and impacts on the environmental values described in Section 2 have been identified and are discussed in the following.

3.1 Social Impacts

3.1.1 Heritage

There are no aboriginal or European cultural features on the site or surrounding area that will be impacted by the solar farm. Heritage has been assessed by Brad Goode & Associates Pty Ltd and supported by the Western Australian Department of Planning, Lands and Heritage (DPLH) as confirmed in information provided in Appendix 4.

3.1.2 Reflection and Glare

There is potential for the solar farm (specifically the PV panels in the array) to have a visual impact on people living nearby and on drivers using Harris River Road. Glare is unlikely to occur on Patstone Road because people using this road will either be below the level of the panel surfaces or behind the rise in landscape to the west of the solar farm. This assessment only considers the issue of glare on people's visual impact and does not address the potential for impacting visual amenity and landscape. Concern has also been raised for the potential for the effects of glare on pilots overhead.

Glare is defined as a prolonged source of light that is a nuisance or hazard to people, processes, or animals (Rea, 2000). Sources of glare can be directly from a light source or indirectly via reflected light. Glare is generally caused when a source or sources of light are substantially brighter than the surrounding scene. Glare interferes with vision by impairing sight, and extreme cases of glare can cause discomfort or even pain (Rea 2000). Sensitivity is a function of the intensity of the glare and the individual's perception of that glare. Sensitivity to glare is subjective and varies widely between individuals and states of health within the individual. Age-related eye degradation also makes older individuals more sensitive to glare.

Glint is a similar reflection of light but momentary in nature and is not considered a hazard for activities around PV arrays. Because glint is temporary it does not generally obscure vision long enough to be considered a nuisance. However, the description of glare in this section is equally applicable to glint.

Since PV panels do not generate light, it is light from the sun, reflected off the glass panels that causes most concern amongst people living or working in proximity to a PV array. Only PV panels are expected to have potential for glare; the other components such as the inverters and battery containers do not have reflective surfaces.

Creation of glare is a function of the following four basic components:

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- angles involved between source of light, reflective surface, and position of the receiver
- intensity of the light
- reflectivity and absorptive capacity of the surface
- ambient light conditions.

A number of studies have described the physics of light reflection from PV panels including Sunpower (2011), Spaven Consulting (2011), GHD (2014) and provide a good account of how light is reflected off PV panels. The angles at which the source of light hits a reflective surface and then reflects off or is transmitted or absorbed is critical to understanding reflection off PV panels and is repeated here for clarity.

Light is reflected off flat and smooth (specular) surfaces at the same angle that it strikes the reflective plane as shown in Figure 6.

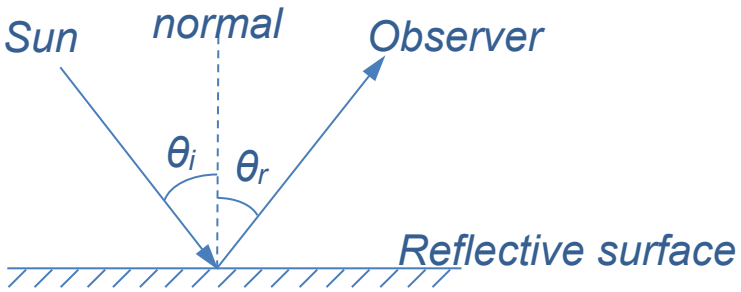

Figure 6. Angle of reflection off a flat, smooth surface. Angles *θi* and *θr* are always equal (Protogeropoulos and Zachariou, 2010).

High values of *θi* shown in Figure 6 will result in higher levels of reflectance regardless of the surface (Protogeropoulos and Zachariou, 2010). Figure 6 is a simplification of most real-world examples and assumes 100% of the light is reflected and none is lost to absorption or transmission. It also assumes all light arrives from the same direction. Most surfaces absorb some of the light incident on them, and transparent surfaces allow light to pass through (transmitted). Light falling on the Earth's surface also arrives by many pathways and not just from the direction of the sun as inferred in Figure 6. Angle of reflection and low reflectivity influence the risks of glare from PV at ground level and from the air and are explained more fully below.

PV Panel Design and Reflectivity

PV cells create electricity by light particles (photons) passing through a layer of electrically charged silica which frees electrons and induces an electric current. PV cells are fragile and need protecting usually with a sheet of glass. In the interests of efficiency, designers of PV panels select glass that allow as much light transmission as possible with the lowest amount of reflection (Protogeropoulos and Zachariou, 2010).

PV glass reflects between 2 and 10% of the light hitting the surface (Protogeropoulos and Zachariou, 2010, Spaven Consulting, 2011). General glazing reflects between 6 and 20% of the incident light (Meister Consultant Group 2014, Pilkington, 2010) and glass used on windscreens of vehicles reflects approximately 45% light (Protogeropoulos and Zachariou, 2010). Glazing used on office blocks known to be a cause of glare reflects between 20% and 50% of the light hitting the outside of the glass (Pilkington, 2010). Reflectivity of smooth water has been reported to be between 4-5% (GMI Energy, 2015) with rippled water reflecting substantially more.

In addition to low reflectivity, glass used on PV panels has textured surfaces to aid absorption but also traps the small amount of light reflected off the aluminium elements of the PV cells by aiding internal reflection (Sunpower, 2011). A close-up photograph of a PV panel can be seen in Plate 10. Typical reflection off a PV

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panel is shown next to the reflection off a glazing panel in Plate 11, demonstrating clear difference in intensities.

Because the panel strips of most PV arrays are at or near horizontal, winter sun will have relatively large incident angles towards the south and reflect more light than if the panels were tilted towards north. An incidental advantage of textured glass is that the small amount of light that is reflected will be diffuse and reduce the effects of glare.

PV panels are orientated to minimise the incident angles with the sun and maximise absorption of photons. To achieve this, panels can be fixed in position or can track the sun in one or two planes which helps minimise the incident angle through the day and maximises absorption of light particles. When fixed, most panels are laid flat and any reflection is naturally upwards even when the sun is very low in the sky. When panels are flat, reflection can only be seen from the air or from land that is at a higher elevation than the PV array. The selected strategy will depend on the physical constraints of each site.

Potential for Reflectivity from the Collie Solar Farm

For the Collie Solar Farm, Hadouken has selected strips of PV panels arranged in an approximately north-south direction. Each strip of panels will abut each other, with each panel fixed at an angle of 8° from horizontal. Each row of panels will alternate between an east and west inclination as shown previously in Figure 3. This arrangement ensures panels do not over-shadow adjacent ones and allows the largest number of panels to be placed in the smallest area of land.

There is potential that up to eight residences will be able to see the solar farm. Of these, only those that lie to the east, south or west have potential of being affected by solar reflection or glare due to the path of the sun. The nearest residence is within a woodland approximately 145 m to the south east of the site as shown in . Views from this location will be heavily screened by the woodland surrounding this property. A single residence is located on the opposite side of Harris River Road and lies 153 m east of the development boundary. Elevation levels are such that the residence will overlook the solar farm. A single residence lies 206 m west of the western boundary but there is little likelihood of any views of the development site at this location due to the rise in land elevation levels between the house and the development boundary. One residence is located 220 m to the west on the opposite side of Patstone Road. There would be no views of the solar farm from this residence as it sits below the rise in land on the western boundary of the development.

Harris River Road runs north to south of the eastern boundary and drivers either immediately east of the site or those approaching from the south east will be able to see the array. Similarly, drivers approaching the south-western corner of the array from the south on Patstone Road may also be able to see the array but will be lower than the array. People and drivers within Collie Light Industrial Area to the south of the development site are unlikely to be affected by glare given the woodlands in between and relatively high elevation of the sun which would only be high in the sky when it is in-line with the PV panels and industrial area.

Having the panels set at angles facing slightly east or west, reflection could occur horizontally or even downward when the sun is very low in the sky. The potential of a horizontal or even downward reflection is shown in Figure 8 and occurs when the sun is at least 9° above the horizon. When the sun is above a certain elevation, all light will be reflected above the eye level of nearby observers depending on the elevation of the surrounding land relative to the PV panels. When the solar elevation angle is lower than 9°, no light would fall on the east-inclined panels.

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Figure 7. Location of solar farm and nearest residences. Distances to nearest four residences are provided.

Drivers on Harris River Road and residents opposite the main entrance to the solar farm will be somewhere between 3.2 and 4.0 m or so above the surface of the PV panels. They may see reflected light for a period of time in the late afternoon or early evening. Light falling on the west-inclined panels at this elevation would be reflected upwards and above the eye-height of observers on Harris River Road.

However, there are various factors that will limit the potential for glare as follows:

1. Final profile of the land and in particular a slope towards both sides of the creek. Panel lines east of the creek will be sloping towards the west and therefore observers on Harris River Road will only see the side profile of the panels.
2. Alternate inclination of the panels will interfere with the amount of light reflected off that can be seen at low elevations; west-inclined panels will be partially in the way of light reflected off the adjacent east inclined panel.
3. Tall trees and woodland of up to 24 m surround the site which raises the level of the effective horizon. When the sun is setting in the west, the trees will cause it to fall beneath the horizon sooner than if the trees weren't there.
4. Positions of observers that would be in the line of reflection along Harris River Road would only be in line with reflected sunlight when the bearing to the sun is between 315° and due west partially because of the existing shielding of woodland which rise to 21 m and more. For most of this time the sun will be too high in the sky for the reflections to be received at ground level.

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All above values vary substantially depending on the position of the onlooker relative to the panels and the sun. Reflection, and thus glare, will only occur when the panels lie immediately between the onlooker and the sun and eye-level of the onlooker must be at the same level and the panels or higher. There is only a limited period during each day when this can occur due to the juxtaposition of the road and the solar farm.

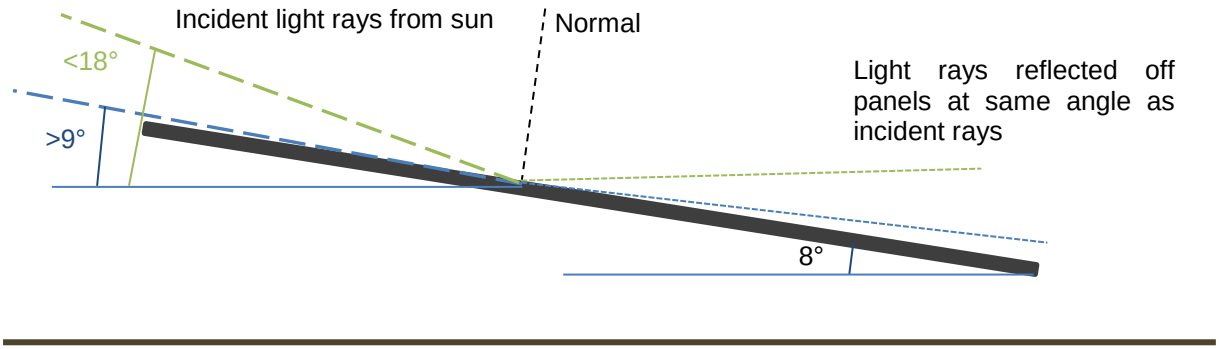

Figure 8. Angle of reflection off a panel inclined east with incident light from the sun at 9°. Green lines depicting incident light rays reflected above horizontal are at approximately 18°.

In Collie, WA, the sun is at its highest in the sky at midday on the summer solstice (18 December) and will rise to 80.5° above the horizon. It sets from a near vertical position in the sky in the summer and therefore is more westerly from mid-afternoon to sunset. On the winter solstice (18 June), the sun reaches a maximum of 33.3° from horizon. Therefore, it sets from a low position in the sky and its bearing varies much more than during the summer. In early May the sun will fall below 18° from 16:00 and from a bearing of 302° which can form a line with the sun, the panels and observers on Harris River Road. As spring and winter progresses the sun will be at this elevation earlier in the day and further to the west.

It is therefore concluded that the PV panels could possibly be a source of reflection for residents and drivers along Harris River Road for a short period at the end of some sunny days in autumn, winter and spring when the angles between the sun, panels and observer align.

To overcome the potential for the possible reflection to cause distraction or impact on the vision of passing drivers and residents on Harris River Road, a vegetation screen will be planted along the eastern paddock boundary between the woodland to the north of the site and woodland to the east. Furthermore, planting will also be carried out within the woodland on the eastern boundary to increase the density of the vegetation and reduce risk of reflection passing through the trees.

Collie Airport lies 5.1 km south-east of the proposed solar farm and concerns have been raised in the past that solar panels can be a source of glare severe enough to affect the vision of pilots. However, this is extremely unlikely because the glass covering the PV cells are selected for low reflectance to maximise absorption of photons and maximise electricity generation (Spaven Consulting, 2011). Instead they are visible generally as dark grey panels that have less reflectance that a grassy field or water body (Spaven Consulting, 2011).

The Federal Aviation Administration (FAA) in the United States acknowledges solar PV arrays are compatible with airports because they are designed to absorb sunlight and minimize potential for glare (FAA, 2010). The reasons why this is so are discussed below.

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Other Potential Sources of Glare

Site lighting may be required during installation for security purposes during construction, but these will be nominal and have downward reflectors to minimise light spill. While site lighting may be visible at night during the installation period, other urban lighting along roads and residences in the area is likely to dominate.

There are no plans to use site lighting for operations but some lighting may be required during emergency maintenance.

3.1.3 Other Electromagnetic Emissions

PV arrays generate electricity and will therefore generate electromagnetic fields (EMFs). EMFs occur around all electrical equipment and cabling, naturally around organisms, during electrical storms and around magnetic anomalies (WHO, 2012). While the World Health Organisation and Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) advise there are no known threats to human health from EMFs, both agencies agree on prudent avoidance of extremely low frequency (ELF) EMF with frequencies less than 2 kHz (WHO, 2012). This includes the 50 Hz power line transmission in Australia.

Chang and Jennings (1994) measured EMF at commercial PV arrays in the US and found them to be lower than around domestic applications and were indistinguishable from background levels at the boundary of the PV array. Similarly, NRPB (2004) measured EMF at a number of electrical substations in the UK and reported that EMF from the substations could not be detected above background within five metres.

Electrical standards require all components and installations to meet electromagnetic compliance (EMC) which includes shielding and other controls that prevent interference with other electrical appliances and communications. Collie Solar Farm will adhere to applicable Australian electrical standards. All components of the solar farm will be contained within the site fencing including the export cable which runs up to the existing overhead 22 kV distribution lines owned and operated by Western Power. Due to the exclusion fencing, engineered controls for EMFs and very short range for remaining EMFs, it is highly unlikely that EMFs would present a hazard to the public.

3.1.4 Heat Generation

PV panels necessarily absorb the visible wavelengths of the solar spectrum but incidentally also absorb the thermal wavelengths and can be expected to heat up when sunlight falls on them. Although the same amount of solar radiation would fall on the agricultural land before a PV array is installed, the thermal inertia of the surfaces on which sunlight falls are different. A small amount of internal heating will also occur due to electron movement within the cells and connecting cables, but this is considered insignificant compared with solar heating. There is public concern that PV arrays may increase the ambient temperature surrounding the PV array (Barron-Gafford et al., 2016). Numerous studies have investigated the effects of urban heat islands (UHI) which are similar to the concerns investigated by Barron-Gafford et al. (2016). Findings on UHI are varied and depend on a wide range of factors (dos Santos Cardoso et al. (2017) including in particular:

- vegetation within the urban area and its surrounds
- wind characteristics
- landform.

There is only one study of the heating effect of PV Arrays so this must be treated with some caution as the effect may not occur elsewhere.

PV panels operate most efficiently at 25°C (Ike, 2013). Above this, the electricity produced drops by up to 5% for temperatures of 28°C above the optimum in free standing and well-cooled PV panels (Nordmann and Clavadetscher, undated). For this reason, materials making up the PV panels are selected so heat is dissipated instead of stored (Barron-Gafford et al., 2016).

Modelling studies conducted for heatwave conditions in the US (Los Angeles) and France (Paris) suggest the presence of PV panels reduce the temperature in cities and lower the effects of heat islands (Masson et al.,

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2014). However, empirical evidence gathered by Barron-Gafford et al. (2016), indicated that a PV array installed over bare ground had ambient temperatures 2-4.8°C higher that urban areas and arid, natural vegetation in the same region and similar to that of central Western Australia. They concluded that the heat island was influenced primarily by the lack of vegetation at the PV site and release of the heat energy to the air instead of absorption to the ground. Vegetation helps reduce ambient air temperature by shading the ground and the evaporative cooling effects of transpiration (release of water vapour through leaf pores) (Myeong, 2010).

It is possible the presence of the PV panels may cause the ambient air temperatures within the solar farm to rise during warmer conditions by up to four degrees. Convection currents caused by the warmer air over the panels will cause most of the warmer air to rise which consequently won't be felt at ground level. It is possible a slight amount of radiant heat will be transferred horizontally and felt in the surrounds at ground level. This increase in temperature over the site and surrounding area will be influenced by the following factors:

- the distances to the dwellings (minimum 140 m)
- mixing of air over the site and surrounds through wind and convection currents
- effects of evapotranspiration from vegetation in the area including the woodland to the north, east and south of the solar farm, and larger stands of woodland in the wider landscape
- effects of the existing heat island from Collie town centre and the surrounding built up areas.

Studies on heat islands have been conducted but few have measured the temperature gradient across the urban/rural fringe. Zhang et al. (2004) and Zhou et al. (2015) found that heat islands could influence vegetation growth through the year by up to 10 km into the surrounding areas but did not report temperature gradients across the urban/rural boundary. Other factors besides temperature may have influenced vegetative growth. Myeong (2010), detected that vegetated parkland areas cooled surrounding urban areas in Seoul, South Korea by up to 4°C over distances between 240 and 360 m. Rosenzweig (2007) found that cooling effects of parkland were detectable by between 15 and 60 m into the urban environment in New York, United States depending on the size of the park. Hart and Sailor (2008) identified that vegetation cover in the urban environment was the largest single feature influencing cooling in the urban environment. Conversely, it was the absence of vegetation that had the greatest influence on temperature increases in urban environments. These results suggest that the cooling effects of woodland vegetation around the solar farm in the area will be the dominant influence on temperature in the surrounds rather than the heat dissipated by the PV panels.

In conclusion, it is unlikely that residents will detect any change in temperature due to the heat island effect of the solar farm due to the dominant influence of the surrounding environment.

3.1.5 Noise

Noise levels of deliveries to the site and construction activities are likely to be heard in the surrounding environment and may have the potential to cause nuisance to nearby residents. Some electrical generating and distribution equipment generates noise and could be a nuisance to people living nearby. PV panels are not known to create audible noise but during operation inverters and control equipment may generate humming sounds or sudden sounds as solenoid switches are triggered.

The Western Australian Environmental Protection (Noise) Regulations 1997 (the Noise Regulations) prescribe restrictions on noise outputs for equipment located in new residential developments or rural premises. The values contained in Table 4 are assigned noise limitations for activities that may be heard outside residential premises.

Table 4. Assigned levels of noise for various times of day for residential premises.

Time of Day	Assigned Level		
	dB $L_{A\ 10}$	dB $L_{A\ 1}$	dB $L_{A\ max}$

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0700–1900 hrs Monday to Saturday	45	55	65
0900–1900 hrs Sunday and public holidays	40	50	65
1900-2200 hrs all days	40	50	55
2200 hrs to 0700 hrs Monday to Saturday and 2200 to 0900 hrs Sunday and public holidays	35	45	55

$L_{A\,10}$: assigned level not to be exceeded for more than 10% of period
$L_{A\,1}$: assigned level not to be exceeded for more than 1% of period
$L_{A\,max}$: assigned level not to be exceeded at any time.

According to Western Power (2014), distribution transformer noise is limited to 30 dB(A) outside residential properties and levels over this attract penalties. Transformers are deemed to comply with the Noise Regulations if 1000 kVA transformers are greater than 7 m from residential lot boundaries or 5.5 m or more for transformers less than 630 kVA. This suggests that the transformers and inverters proposed for the Collie Solar Farm will be compliant since they are all located at least 140 m from the nearest residence. However, the following predicts whether any noise from the solar farm will be audible at the nearby residences.

Additional considerations or 'influencing factors' for traffic are also included in the Noise Regulations and increase the assigned levels. These influencing factors will however, be ignored for this assessment.

Existing Sources of Noise

Although the proposed solar farm is located in a semi-rural setting, the nearby residents are exposed to noise from existing traffic using Harris River Road and Patstone Road. Other sources may be present such as agricultural machinery in paddocks, but these are considered to be infrequent and won't contribute a significant amount of noise in the area.

The nearest residence in the woodland to the south is partially shielded from traffic noise by the woodland and distance from the road. It will therefore have lower existing levels of ambient noise than the residence opposite the site entrance. However, it will not be as close to the vehicles delivering equipment to site or be as close to the inverters which are located along the north of the site. For this reason, the residence on Harris River Road will be used as the model for assessing impacts of noise on nearby residents.

Harris River Road is a single carriageway between Collie to the south-east and Harris Dam to the north. Harris River Road also joins with Mornington Road to the north leading to the town of Mornington. Harris River Road and Mornington Road is used as an alternative route to Perth from Collie (P. Piavanini pers. comm.) and carries passenger vehicles, work vehicles and heavy freight. Traffic volume of Mornington Road was monitored by Main Roads WA in 2014 (Main Roads Traffic Map, accessed 5 January 2018) and was recorded with a daily average of 594 vehicle movements through the week which reduces to an average of 435 during weekends. The majority of traffic flow is between 05:00 and 18:00 hrs with peaks at 06:00 and 16:00 hrs. No traffic data are available for Harris River Road or Patstone Road. Traffic volume using Mornington Road is seen as a good indicator of the minimum levels of traffic bi-passing the site of the proposed solar farm.

The speed limit along Harris River Road observed to be 80 kph and Patstone Road is 80-90 kph. Typically, source levels for cars travelling between 60 and 100 kph are between 101 and 107 dB(A)@ 1 m (Schreurs et al., 2011). Source levels from trucks were reported to be between 104 and 118 dB(A)@ 1 m depending on whether they were articulated or not and accelerating or at a constant speed (Schreurs et al., 2011).

In the simplest form, sound levels reduce by approximately half (6 dB) every doubling of distance in accordance with the inverse-square law. This relatively simple model is considered adequate to demonstrate likely noise levels at nearby residences. Using the inverse square law, Table 5 provides predictions for levels of noise perceived at the residences nearest to the above features.

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Table 5. Predicted levels of noise at closest residence from existing sources of traffic along Harris River Road.

Existing source	Distance to dwelling (m)	Frequency	Source level dB(A)	Estimate at nearest residence dB(A)
Harris River Road - Cars	91	Throughout day and night	101-107	61-68
Harris River Road - Trucks	91	Mostly through day	104-118	64-79

Predictions made in Table 5 do not account for wind direction, reflection or screening and instead relies on uninterrupted spreading on the sound wave. Trees, buildings and other structures will affect the transmission of sound and energy losses. Wind direction is predominantly from the east in the morning and from the west in the afternoon (BOM, 2018b) and therefore helps carry the noise from the road to the residence only later in the day.

Noise Sources from Installation of the Proposed Solar Farm

During installation, construction noise will be generated but, due to the relatively simple construction methods, these noises will not be as intrusive as typical construction activities. Work will be restricted to daytime hours of 07:00 to 18:00 Monday to Friday and 08:00 to 13:00 on Saturdays. Except for emergency work, activities will not take place outside standard hours without prior notification of local residents. Construction will span up to six months and noise will typically occur from the activities and equipment listed below and in Table 3.

- Construction traffic
- Excavation plant for levelling the site
- Tree felling equipment
- Small diameter piles for PV frames
- Laying chippings or covering under the PV panels, access tracks and parking areas
- Excavation for cable and earthing trenches and backfilling
- Installation of inverters and switchgear
- Installation of fencing around the site perimeter.

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Table 6. Sources of noise used in construction and typical source levels of plant and equipment. (from Schreurs et al. 2011 and Atkins Acoustics, 2013). Note that the results below represent the higher noise levels received at the residences and most operations on site will be farther away than the distances quoted and few of the noise sources will be constant.

Item	Noise Source Level dB(A)	Pattern of use	Typical distance to nearest residence (m)	Estimated Sound Level at nearest residence dB(A)
Harris River Road				
Large haulage truck	114	Sporadic, up to six per day	91	75
Concrete truck	112	Occasional	91	73
Flatbed truck	106	Sporadic, up to six per day	91	67
Mobile crane	110	Sporadic for positioning inverters (4 No.) and control container	91	71
On Site				
Large haulage truck	114	Sporadic, up to six per day	250	66
Excavator plant	114	Period of four weeks during site-levelling activities	250	66
Concrete truck	112	Occasional	250	64
Flatbed truck	106	Sporadic, up to six per day	250	58
Mobile crane	110	Sporadic for positioning inverters (4 No.) and control container	250	62
Hand tools	105	Occasional	250	57
Chainsaw	110	For several days when felling trees	172	65
Wheeled loader (Bobcat)	105	Frequent to grade soil, lay limestone and backfill trenches	250	57
Excavator	114	Occasional when excavating cable trenches	250	66
Bored piling rig	110	Frequent when installing foundation piles for PV frames	250	62
Generator	104	As required for hand tools	250	56

Data in Table 6 show that the highest source of noise during construction for the residents on Harris River Road will be around 75 dB(A) from delivery vehicles arriving on site and would be similar or less than existing traffic due to the slower speed involved in manoeuvring a junction. The extra six or so vehicle movements per week-day over the existing traffic volume of 594 daily average are unlikely to add significant noise loadings to the residents situated on Harris River Road. Therefore, it is concluded that noise audible to the residents on Harris River Road will not be noticeably greater than current traffic levels or result in higher levels of disturbance during working hours only.

Site construction activities are predicted to be heard at the nearest residence on Harris River Road during the day throughout the construction period. Estimated noise levels at this residence from construction activities have been calculated from a central position in the eastern half of the site as a typical source of noise. Most activities will be farther away than this and less frequently they will be closer. Noise levels potentially heard

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from this residence may occasionally rise to, or slightly exceed, the highest predicted value of 66 dB(A) during vehicle deliveries, site re-profiling and trenching. The residence on Harris River Road is partially screened by shrubs to the front from noise emanating from the site. These shrubs will help dissipate some of the noise. Sound transmittance to the residence will also be affected by the drop in level of the site, especially as excavation progresses. Short periods of chainsaw use may also rise to 65 dB(A) at the residence on the western half of the site. However, noise from chainsaws will only be at this level while cutting occurs which is generally only a small portion of the time it takes to remove a tree. Noise levels for all other tree felling activities will drop due to greater distances between the trees and the residence. Chainsaw activity will also be within the noise levels of traffic on Patstone Road at this residence and partially masked when traffic is passing by.

All other residences are farther away from construction activities than the two residences included in the above assessment and are therefore unlikely to receive noise levels higher than the stipulated thresholds from the Noise Regulations stated in Table 4. Furthermore, the solar farm site is screened from most other residences by trees and woodland and noise levels are likely to be reduced by these features.

No construction is planned to occur outside normal working hours.

Operations of the Proposed Solar Farm

Noise during operations can be divided into the continuous noise emitted by the solar farm equipment and the sporadic noise created by site activities (personnel and vehicles). Site visits by operational staff are anticipated to be once every two weeks as the solar farm will be controlled remotely. Most site activities will be limited to inspections and minor maintenance matters which are not likely to generate noise of the level found during construction. In the unlikely event of major maintenance, similar levels of noise may be generated as for construction but for shorter periods of time.

All potential sources of noise from electrical generation are listed in Table 7 with estimates of received levels at nearest residence. Noise from electricity generation and transmission will only occur during daylight hours and when solar radiation is strong enough to generate electricity. Noise generation at night from the solar farm will be limited to occasional switchgear noise when supplies from the batteries are being utilised. No other sources of noise will occur at night.

Table 7. Sources of noise from equipment proposed for use in Collie Solar Farm. Source levels are taken from manufacturers specifications.

Component	No. Units	Noise Source Level dB(A)	Distance to nearest residence (m)	Estimated noise level at nearest residence dB(A)
Photovoltaic panels	36,000	None detectable	162	None
Control Switchgear	1	None detectable	150	None
Inverter	5	79	200	33

Results presented in Table 7 show that the highest levels of noise from the power generating plant will come from the five inverters located across the northern boundary of the site. Assuming the sound from the inverters is not reflected or absorbed, according to the inverse square law, noise levels from the inverters will be at or below 33 dB approximately 200 m of the source and below rural background levels or that of a quiet bedroom at night (NOSHC, 2004). This is within the stipulated noise levels laid out in Table 4 for residential premises and is likely to be inaudible during the day due to the masking of traffic noise.

Furthermore, planted screening for the sake of visual obtrusion, will also help absorb noise from equipment on the solar farm.

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The local inhabitants are not likely to experience any level of disturbance from noise emanating from the operating solar farm.

3.2 Vegetation

The installation of the solar farm will require the removal of approximately 18 ha of pasture grassland, some of which contains semi-isolated mature eucalypts. Clearance of the site to install the solar farm will involve the removal of eight semi-isolated trees including seven Marri and one Jarrah. Two Swamp Paperbarks that lie next to the dam at the north of the creek will also need removing to reduce shadow over the surrounding array. This is a combined total of approximately 0.17 ha of isolated tree habitat based on the dripline of each tree.

The eucalypts and paperbarks are not intrinsically ecologically important features and their loss will not cause a significant impact in isolation. They form native vegetation however, and will be the subject of a vegetation clearing permit under section 51E of the Western Australia EP Act. All commitments and conditions agreed under that permit will be complied with in full. Management and mitigation conditions placed on the vegetation clearing permit are not anticipated due to the relatively low intrinsic value of the trees and large number remaining in the surrounding paddocks.

The loss of mature eucalypts may have a secondary impact on fauna and that is discussed in the next section.

Excavation of the higher ground on the north-eastern corner may cause a change to the groundwater regime below the woodlands adjacent to the site. This could quicken water drainage away from the woodland and stress the trees within it. Excavation work will be 15 m or so from the trunks of any tree in the northern woodland and 35 m from the trees in the eastern woodland. The presence of wetland flora along the creek and to the middle of the eastern half of the paddock demonstrates the water table is close to the surface at least for most of the year. Relatively shallow excavation in the north-eastern corner may cause a localised lowering of the water table across the excavated area, but is likely to remain around natural levels within a few metres north and east of the excavation. The loss of the grassland vegetation across the paddock will remove the process of transpiration in this area and thus more water will be retained within the soil. The two stands of woodland are comprised mostly of Marri which are generally deep rooted on the higher areas (Beard, 1990) and unlikely to be susceptible to a minor and temporary drop in the water table.

The array layout has been adjusted to avoid direct impacts on the creek along the centre of the site. This feature will be maintained to preserve surface water flows and water levels in dams to the north and pond to the south. While direct impacts on the creek are avoided, the excavation and reprofiling of the site may lead to indirect impacts through changes in hydrology, sediment runoff and deposition.

Made-up ground (fill) will be predominantly in the southern half of the site and greatest adjacent to the creek. The edges of the fill will be compacted, profiled and stabilised to prevent erosion of the fill material. The battered slope of the fill material will be allowed to vegetate and help stabilise over time. The fill material will be covered in gravel aggregate and remain porous to water. The resultant fill will therefore allow water to creek vertically and horizontally to the undisturbed ground underlying the fill. No changes in groundwater regimes that would significantly affect the vegetation lining the creek are therefore anticipated. It is unlikely to affect drainage to, or levels within, the dams on the north end of the creek or the pond to the south as these are fed by a much larger catchment area around the site.

To protect the creek from sediments carried by runoff or erosion, it is recommended that the battered sides of fill material are either consolidated with geofabric or by planting suitable native flora as ground cover, or both.

3.3 Fauna

The use of pastoral land around Collie by native fauna is limited to low-density use by a number of common bird species such as magpies, ravens, Magpie Larks, kestrels, pipits and pigeons among others, that take advantage of seeds, invertebrates and small vertebrates such as reptiles, frogs and rodent pests that occur

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in or over the pasture. The loss of 18 ha of pastoral grassland is unlikely to have a significant effect on these common species. A large amount of similar habitat occurs in the Collie region and the few animals that currently utilise the site will be dispersed into the surrounding landscape.

On completion of the development, some fauna species will forage within the solar farm for insects, seeds and other food items that are blown into the area or seek shelter among the panels and in the gravel. The creek will be maintained and offer continued habitat for fauna.

No significant impacts are expected to occur on these common species.

Other fauna species including threatened Chuditch or Woylie, or the Priority 4 Rakali, Tammar or Brush Wallaby may, on occasion, transit through the site between preferred habitat types. Care should be taken during construction to ensure that mammalian fauna do not get trapped in excavations and trenching and suffer injury or undue stress. It is unlikely these species will be impacted at all during operation of the solar farm and if they pass across the area, they will skirt the perimeter fence.

There is a potential that Rainbow Bee-eaters could breed in the sandy substrates on site and would be at risk of injury or abandonment of the nest during the breeding period of August to January. Nest burrows can be re-used in subsequent years, but adults are more likely to excavate new burrows each year (DEE, 2018). Construction of the solar farm is currently scheduled to occur after all fledglings will have left nests and therefore unlikely to impact this species. If however, the schedule changes and construction coincides with the breeding period of this species, the site should be searched by a competent scientist before site activities to ensure the risk is negligible.

Western Falsistrelle bats (Priority 4) may roost in hollows or cavities within the trees across the site or adjacent woodland although this is not very likely as they generally inhabit other woodland types. The loss of one or two potential roost sites from within the 18 or so trees to be felled are unlikely to impact this species significantly. Any individuals that may use this site will be displaced to other roost sites within the extensive stands of woodland elsewhere in the region. If present, their movements and foraging behaviour are unlikely to be affected by a solar farm at this location. Common species of bat that are likely to forage over the site or roost within tree hollows and cavities will likewise be displaced and forced to find other roosting sites. Common species of bat have less specific requirements of a habitat which are likely to be plentiful as their roosting requirements are relatively generic.

As with all fauna that may roost or shelter in the trees, bats could be injured if present when the trees are felled. Prior to lopping tree limbs, hollows will be inspected for bats and other vertebrate fauna. Where bats are found the limb will be left in situ while work continues around it. If bats are still present, the limb will either be left until the following day or be cut below the location of the bat roost and lowered to the ground to allow for bats to vacate.

3.3.1 Black-cockatoos

Baudin's and Forest Red-tailed black-cockatoos are present on the site and potentially breed. The loss of 8 mature trees that offer foraging potential in the Collie area is not considered to be a significant impact as there are a large number of mature, semi mature and recruit Marri and Jarrah on which both these species have been seen to feed.

Roosting and breeding sites of the two black-cockatoo species known to frequent the site, are valuable resources in the Collie area and therefore the success of these two species may be impacted by the loss of these semi-isolated trees. For this reason, the Collie Solar Farm is to be referred to the Commonwealth Department of Environment and Energy under section IV of the EPBC Act. All commitments made during that application process and any conditions placed on the approval will be complied with in full. Because the loss of one potential black-cockatoo nesting hollow has been identified on two species listed as vulnerable under the EPBC Act, a number of management and mitigation measures will be written into the EPBC Act referral. The following will be considered and depending on the outcome of the referral, committed to as required:

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1. Felling will take place outside the breeding seasons for these two species where possible.
2. If felling cannot be conducted outside breeding seasons, trees with hollows will be monitored by a suitably competent ecologist prior to felling. Males tend to the females incubating eggs and nests are easily monitored by watching for returning males.
3. Monitoring will be conducted from a distance that will not disturb birds in the hollows.
4. If black-cockatoos are found to be nesting in any one tree, the tree will be left in-situ until the black-cockatoos have naturally vacated the nest.
5. Installation of two artificial nests or "cockatubes" in adjacent woodland.
6. Adjacent woodland habitat to be augmented by planting local proteaceous (e.g. *Banksia*, *Hakea*) and Casuarina (e.g. *Allocasuarina*) species known to be used as a food source by Baudin's and Red-tailed black-cockatoos.

3.4 Soils

The solar farm site lies in an area of moderate to high wind erosion risk with a code of M1 (10-30% high to extreme) either side of the creek. Land along the eastern and western boundaries has a code of High (30-50% of map unit has a high to extreme wind erosion risk) according to the Department of Agriculture's (DAFWA) wind erosion mapping. PV panels and frames have the potential to alter the micro-conditions close to the ground and raise the risk of wind erosion if susceptible soil is left exposed (Yuan Fang et al., 2016). Vegetation around the solar farm will remain in situ and land under the panels will be covered in gravel. Gravel will not be susceptible to wind erosion and will help consolidate and protect the subsoil.

Rainfall draining off the panels has the potential to cause localised ponding and subsequent erosion through the creation of runnels and gulleys across the site. Runnels and gulleys will lead to sediment deposition in the creek and potentially silt up the southern pond. The gravel surfacing will help stabilise the ground surface and dissipate the energy of rainfall draining off the PV panels. To ensure surface water erosion does not occur, ground surface under the panels will be monitored. If erosion starts to occur, preventative measures will be sought which will consider the following:

- Placement of larger aggregates at locations of concentrated runoff to absorb the energy
- Releveling of panels to eliminate points of concentrated runoff
- Consolidation of the surface aggregates using spray or fabric
- Drip control mechanisms.

Erosion through either wind or surface water runoff is not considered to be a significant risk on the Collie Solar Farm.

3.5 Soil and River Pollution

One component of each of the five inverters will be a transformer. Each transformer will contain approximately 1400 L of transformer oil to help cool and insulate the transformer componentry. Each transformer will be located within a steel housing and 40' container and protected from physical damage. In the remote possibility of a leak occurring, any leaks will be contained within the container which will have more than the capacity to retain all 1400 L. Frequent inspections of the site and remote monitoring will also identify that leaks have occurred so that appropriate action can be carried out.

No other oils or noxious chemicals will be used in the solar farm with the potential of causing pollution events in soils or rivers.

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3.6 Bushfire

Construction and operation of the solar farm could increase the risk of bush fire on or adjacent to the Site. Bush fire could be caused by:

- Carelessly discarded cigarettes
- Hot work
- Use of petrol powered tools and vehicles
- Mechanical equipment and plant
- Electrical faults or risk of shorts through proximity of vegetation to live overhead cables
- Storage of flammable liquids and combustible solids
- Lightning strike.

Although the pastoral grassland itself has not been mapped as an area prone to bush fire, the woodland habitats to the north, east and south are (Department of Fire and Emergency Services, 2018). Some installation and operation activities could therefore elevate fire risk. A fire on the site could spread to adjacent woodland and threaten flora, fauna and properties in the area.

The otherwise low risk of fire is likely to be highest through installation and maintenance activities and therefore management measures are considered in Section 4.

To minimise the risk of electrical faults, expensive downtime and potential fire, reliability has been uppermost in the design strategy and selection of materials used in manufacturing the solar farm and associated equipment. Similarly, lightning strike mitigation will also be incorporated through the design and installation.

It is therefore concluded that the operation of the solar farm will pose little risk of causing bush fire.

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4. SUGGESTED MANAGEMENT MEASURES

The above assessment indicates that the proposed solar farm will generally have low impacts on the environmental features on and around the site. With appropriate management and mitigation measures, the removal of trees from the paddock will not result in any direct impacts on black-cockatoos, bats or other significantly protected fauna using them.

Together with the reduction in carbon emissions due to the generation of electricity from solar power, the overall impact of the development can be considered negligible to low.

Despite the relatively low level of impact of the development, several management measures are proposed to be implemented in order to ensure identified impacts do not exceed those predicted.

- Maintain and enhance creek and allow more diverse vegetation to generate.
- Maintain and enhance woodland on eastern perimeter of solar farm to screen local residents and vehicle drivers from potential glare and visual intrusion.
- Species used in perimeter landscape planting to be of local species and known to be a foodplant of black-cockatoos. Planting scheme would also provide other native fauna with shelter in moving across the landscape
- Encourage regeneration of woodland floor by excluding grazing. Encourage new growth of Jarrah and Marri in areas surrounding the site that will not hinder electricity generation of the solar farm e.g. around the southern perimeter of the development area.
- Encourage revegetation of battered sides of excavation and fill areas to stabilize soils and reduce risk of erosion.
- Vegetation control during operations should be conducted using mechanical means and not chemicals. If however, chemicals are the only option, they should be used sparingly and in discrete applications not broadscale.
- Erosion of fill material to be monitored and corrective action taking if signs are found.
- Vegetation along the access track will occasionally be trimmed back but not removed.
- Vehicles for construction will be maintained to manufacturers recommendations to reduce the risk of hydrocarbon spill.
- Bush fire risk is considered a potential threat to surrounding habitats, fauna and property if management measures are not identified and adopted ahead of construction. A suite of fire management measures should be adopted to reduce the risk of bush fires. These measures should include consideration of the following:
    - selection, maintenance and operation of plant, vehicles and tools
    - reduction of fuel loads and volume of combustible materials on the site
    - control of vegetation under overhead export cables in accordance with state requirements
    - control of hot work considering ambient conditions and fire risk
    - control of flammable liquids and combustible materials stored on site
    - remote monitoring of switchgear and loading
    - fire fighting equipment appropriate to the most credible fire risks on site
    - awareness and training of site staff in minimizing fire risk and fire response actions.

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In addition, all measures agreed in the process of acquiring EPBC Act and native vegetation clearing permit will be committed to and monitored as required by the respective designated authorities. These are likely to include, but may not be limited to the following:

- Provision of artificial nest hollows “cockatubes” in woodland adjacent to the site.
- Felling of trees to be conducted outside the breeding or peak seasons where possible. If cockatoos may be breeding, trees with hollows are to be monitored prior to felling by a competent ecologist to ensure no black-cockatoos are nesting.
- If black-cockatoos are found to be nesting in any tree, the tree must be left in situ to allow the birds to vacate naturally.
- Planting schemes for screening to use native flora of local source, and selected from the list of food plants preferred by Baudin’s and Forest Red-tailed black-cockatoos e.g. *Banksia* spp., *Hakea* spp. and *Allocasuarina* spp. (sheoak).

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5. CONCLUSIONS

Using a number of key management measures, the environmental impacts identified for this proposal are likely to be low and therefore acceptable. No impacts on features of cultural heritage or social values have been identified. Notwithstanding agreement and implementation of the environmental management measures resulting from the planning application submission (supported by this document), the EPBC Act referral and application for the native vegetation clearing permit, no further environmental or cultural heritage actions are considered necessary.

The information provided in this assessment show that reflected light off the PV panels on Collie Solar Farm may possibly be seen by the local residents and drivers on Harris River Road. To overcome this potential occurrence, it is proposed to plant a vegetated screen along the eastern boundary of the paddock and within the woodland on the eastern side of the site. This will help prevent reflection causing potential risks of glare.

Aircraft pilots in the air are likely to see some reflection off the PV panels when the position between the pilot-PV panels and sun allows, but this is unlikely to cause nuisance or a hazard. The reflection will be subdued and diffused due to the characteristics of the materials used in the panels.

Noise from construction and major maintenance are expected to comply most of the time with the requirements of the Noise Regulations for all residences near the proposed solar farm. Occasional work along the eastern boundary for excavation, trenching and truck manoeuvres may rise slightly above the permitted levels of 65 dB(A) by up to 2 dB(A). This assumes no absorption or screening has occurred in the sound path and does not account for the masking that will occur from the effects of around 590 vehicles transiting this location every week day. It is concluded that due to the screening and absorption factors of the ground cover that the permitted levels will not be breached at all during construction.

It has been shown that noise from electrical generating equipment will not be audible to residents adjacent to the solar farm and therefore will no impacts will occur.

EMF generated by the operation of the solar farm will be shielded and controlled through compliance with Australian electrical requirements and will not pose a hazard to the public or interfere with electrical appliances or communications.

The PV panels may possibly heat the air around the site and cause a minor rise in ambient temperatures. However, this is unlikely to be felt by residents in the area due to the greater influence of the cooling effects of vegetation surrounding the Site. Other factors are also likely to minimise this risk including the mixing of air by wind and convection currents, and distance to the nearby residences.

Seven mature Marri and one Jarrah will need to be cleared from the grassed paddock on the west half of the site. This has the potential to impact on the available resources for Baudin's Black-cockatoo and Forest Red-tailed Black-cockatoo. Loss of eight trees in the Collie area is not likely to limit food resources for these two species. One tree has a hollow and all are mature with some potential as roosting trees. All lie within close proximity to standing water and other food plants. The loss of one potential breeding hollow and eight roosting trees is not considered significant on these two species but has been acknowledged by the proponent and it has committed to providing two artificial nesting "Cockatubes" in adjacent woodland. A planting scheme required to screen Harris River Road from the solar farm will be comprised of local native species that provide food for the two species of black-cockatoo known to use this area.

It is concluded that Carnaby's Black-cockatoo is unlikely to breed in the area but may be seen on occasion.

Hadouken has been advised that the likely impacts from the solar farm will not be significant on state interests and therefore a referral under Western Australia's EP Act is deemed not necessary. Approval to remove the trees in the eastern paddock will be sought from the DWER under a native vegetation clearing permit and the secondary impacts on two species of black-cockatoo that may be impacted will be referred to the Commonwealth DEE. Management measures and mitigation agreed through these two regulatory approval processes will ensure the impacts are acceptable.

All other potential impacts on native species are considered negligible to low providing some simple management measures are acted upon, in particular the inspection of trees for bats.

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The proposed Collie Solar Farm will be submitted for planning approval under planning legislation and supported by this environmental assessment.

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PLATES (ALL PHOTOGRAPHS TAKEN BY B. SHEPHERD)

Plate 1. Typical view of Lot 2977 looking west over the grassed paddock. Above ground water pipeline can be seen on the right of the view and the central ditch can be seen in the middle of the photograph.

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Plate 2. View of the seasonally wet ditch looking from the southern end north. Water pipeline along northern boundary can be seen in background.

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Plate 3. Eucalypt woodland of Marri (*Corymbia calophylla*) and Jarrah (*Eucalyptus marginata*) adjoining eastern boundary of the Site. Note mixture of large trees, intermediate age and recruits. Ground flora comprised of agricultural grasses.

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Plate 4. Typical view of Eucalypt woodland along southern boundary with mix of Jarrah and Marri.

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Plate 5. View of field dam at northern end of the creek. Note decrepit Swamp Paperbarks on far bank.

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Plate 6. View of pond beyond the southern boundary of the site. Such ponds are considered essential in the support of black-cockatoos around roosting and breeding sites. This pond will not be affected by the planned proposal.

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Plate 7. Large hollow in Marri in western paddock. Note two nests. A Nankeen Kestrel was observed in this tree in November but not on the nest.

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Plate 8. Marri nuts chewed by Baudin's Black-cockatoo (*Calyptorhyncus baudinii*). These nuts were picked off the ground from under a feeding individual. Note the nut is virtually intact compared with nuts chewed by Forest Red-tailed Black-cockatoo shown in Plate 9.

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Plate 9. Marri nuts chewed by Forest Red-tailed Black-cockatoo (*Calyptorhyncus banksii naso*). Note the large cut marks and high level of damage.

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Plate 10. Close-up photograph of a PV panel showing the textured surface of the protective glass layer.

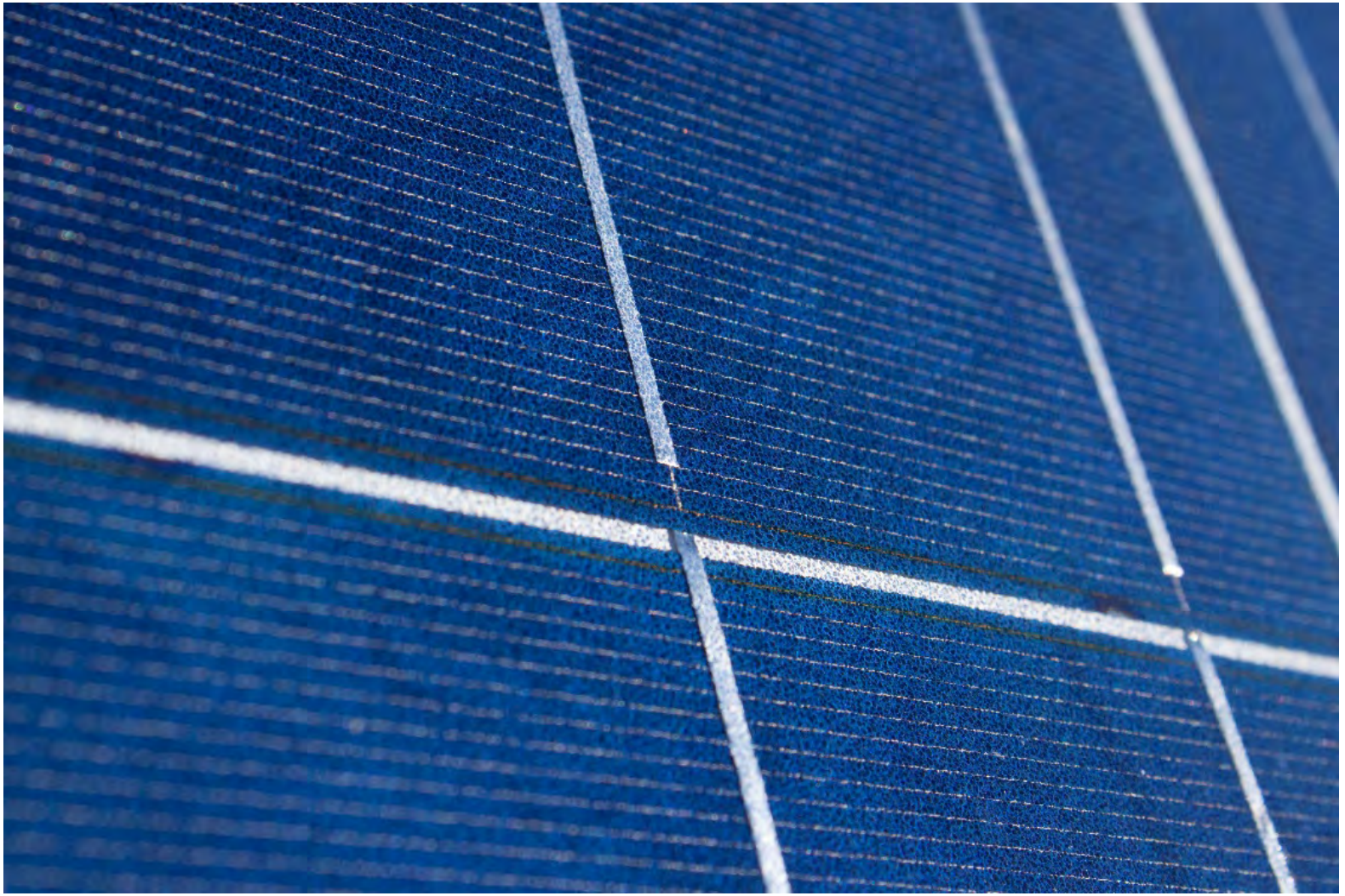

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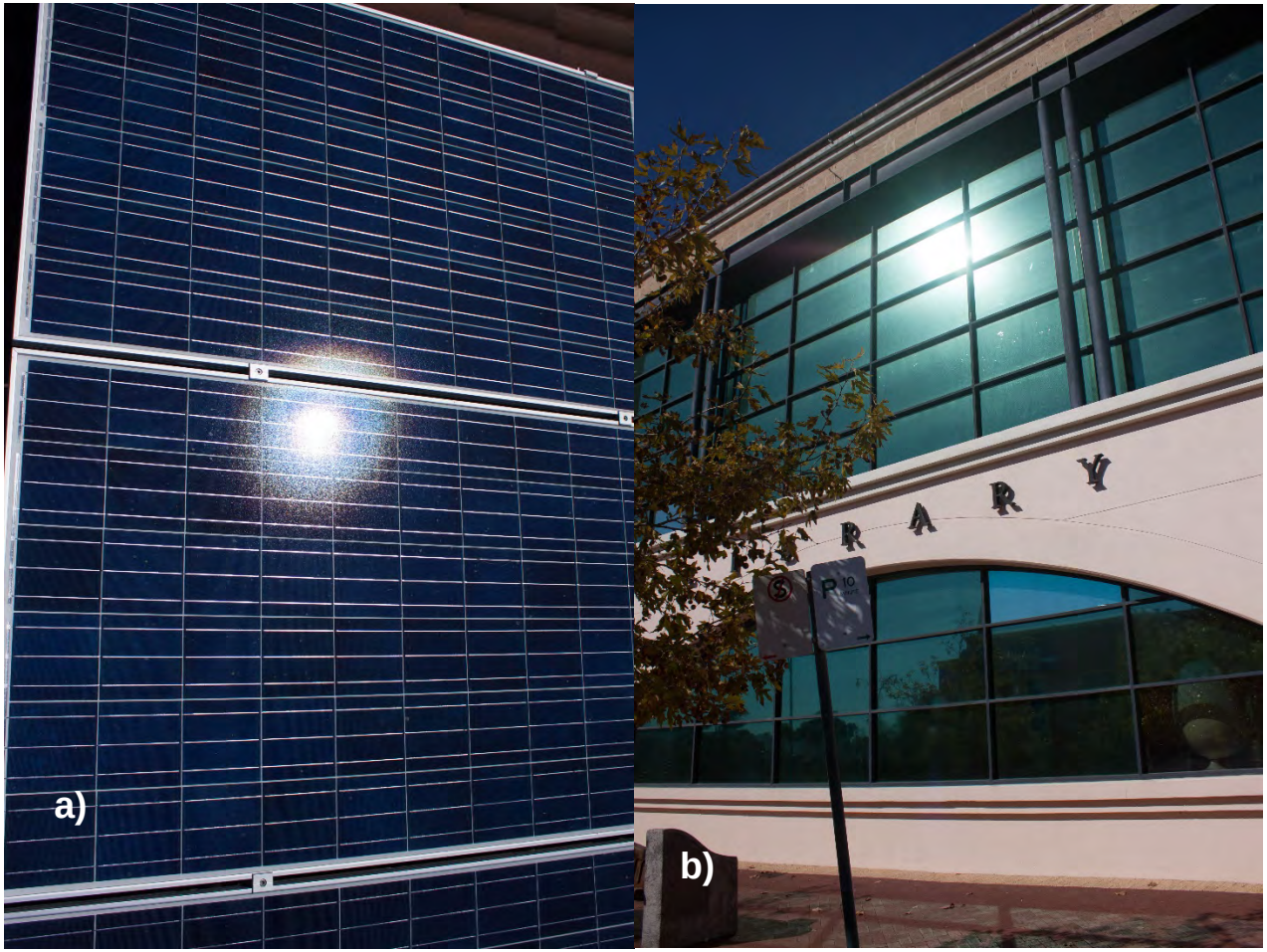
Plate 11. Photo of reflection from full sun on a) household photovoltaic panel and b) glazing. Glare from the PV panel is distinctly lower in intensity and diffuse “softened” compared with the intense glare off glazed panels of a public library. The photographs were taken in full sun around noon on 28 April 2017.



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APPENDIX 1: EMAIL RESPONSE FROM THE OEPA

From: "Hans Jacob" <hans.jacob@dwer.wa.gov.au>
Date: 13 Dec 2017 10:41 am
Subject: RE: Collie Solar Farm - Memo to OEPA
To: "Ben Tan" <ben.tan@hadouken.com.au>
Cc:

Ben

Thanks for the memo.

If the only potentially significant environmental impact as a result of the proposal is from the clearing of large trees (i.e. there no other potentially significant env impacts expected from operating the proposal) then I recommend that you apply for a clearing permit under the Part V of the Environmental Protection Act 1986. Forms can be found on the DWER website. https://www.der.wa.gov.au/our-work/clearing-permits. This process can consider offsets and mitigation of impacts associated with clearing.

If you are after technical advice on mitigating impacts on the three species of black cockatoos then you may wish to consult with the regional office of Department of Biodiversity conservation and Attractions (or WA Museum) about installation of 'cockatubes'.

Hope this helps.

Thanks

Hans

Hans Jacob

Manager

Infrastructure Assessment Branch

EPA Services

Department of Water and Environmental Regulation

The Atrium, Level 4, 168 St Georges Terrace, Perth

Locked Bag 33, Cloisters Square, Perth WA 6850

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APPENDIX 2: RESULTS OF THE EPBC ACT PROTECTED MATTERS SEARCH

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APPENDIX 3: RESULTS OF THE BLACK-COCKATOO FORAGING HABITAT SCORING ASSESSMENT

	Carnaby's Black-cockatoo		Baudin's Black-cockatoo		Forest Red-tailed Black-cockatoo	
Feature	Entire Site	Development Footprint	Entire Site	Development Footprint	Entire Site	Development Footprint
Woodland containing foraging species, native eucalypts, Marri and Jarrah.	7	-	7	-	7	-
Individual foraging plants	-	1	-	1	-	1
Contains trees with suitable nest hollows	3	3	3	3	3	3
Primarily comprises Marri	2	-	2	-		-
Contains tree with potential to be used for breeding	2	2	2	2	2	2
Is within the known foraging area	-	-	3	3	-	-
Jarrah and/or Marri show good recruitment	-	-	-	-	3	-
Primarily contains Marri/Jarrah	-	-	-	-	2	-
Habitat Score:	14	6	17	9	17	6
Final Score (accounts for recorded nesting hollow)	>10	<10	>10	<10	>10	<10

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APPENDIX 4: ASSESSMENT OF ABORIGINAL AND EUROPEAN CULTURAL HERITAGE

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