IRIS Visual Planning + Design

Wagga Wagga Solar Farm South

Visual Amenity Assessment

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1. Introduction

The purpose of this study is to provide a visual impact assessment of the proposed Wagga Wagga Solar Farm South to be located on 157 Windmill Road, Bomen.

This report identifies and categorises the significance of potential visual impacts from:

- the public realm
- private residences, and
- glare risk.

2. Project description

The Wagga Wagga Solar Farm South would occupy approximately 55-hectars of the host site and would comprise the following elements:

- Dark grey solar panels on galvanised tracker frames and posts (panel array) to a maximum height of 2.8 metres
- Inverter stations of a shipping container size (approx. 2.5 metres high)
- Gravel internal maintenance access tracks and vehicle turnaround areas
- Chainwire site perimeter fencing (up to 2.4 metre-high)

Minor cut and filling would be undertaken to create suitable platforms for the panel arrays.

Approximately nine living trees and four dead trees would be removed from within the site (refer also NGH Environmental Ecological Assessment). The existing north south aligned corridors of planted trees would be retained.

There would be additional vegetation provided as a part of the project. Details of this planting is provided in section 8 of this report, Landscape plan and mitigation measures.

Each Photovoltaic (PV) panel would be comprised of silicon solar cells, treated with an anti-reflective coating, overlayed by tempered glass.

3. Planning context

The following review identifies key documents which provide relevant planning context for the visual assessment of the proposed solar farm. This should be read in conjunction with the Statement of Environmental Effects.

3.1. Wagga Wagga Local Environment Plan 2010

The site is located on land zoned RU1 – Primary Production under the Wagga Wagga Local Environmental Plan (LEP). A key objective of this zone is to '*maintain the rural landscape character of the land'* (Land Use Table Zone RU1).

Land to the north and west of the site is zoned IN1 - General Industrial and is part of Bomen Business Park (refer section 3.3 also *Bomen Strategic Master Plan*). The types of development permitted in this zone include depots; freight transport facilities; general industries; industrial training facilities; light industries, warehousing and distribution centres.

Items of historic and cultural importance which contribute to the visual character of the surrounding landscape include Bomen Railway Station to the west of the site (state heritage listed), and Hareenyha Slab Shed, Kurrajong Woolshed and Shearers' Quarters to the north of the site at 47 Shepherds Sidings Road, Eunonoreenya. None of these are within view of the site.

3.2. Wagga Wagga Development Control Plan 2010

The Wagga Wagga Development Control Plan (DCP) supports the Wagga Wagga LEP by providing additional objectives and controls for administering development.

The Wagga Wagga City DCP (2010) recognises the visual quality of the rural landscape, stating that any development in rural areas should be…' *compatible with the character of the locality in terms of buildings, structures and the nature of operations*' (s.8.1).

It also states that adequate … *'buffer areas and setbacks should be used to minimise potential conflicts with adjoining lawful land uses*' and landscaping and other screening options should be used to … *'help integrate new uses and developments into the rural landscape*'. It also suggests that … *'new buildings should be kept away from ridgelines and visually prominent locations'* using materials that '*…complement the landscape*' (s.8.1).

Land to the north and west of the site is within the Bomen Urban Release Area (refer Figure 3-1). Key objectives for this precinct include:

- *'To require new development to respond to site features including ridgelines and slopes, significant vegetation and creek lines.*
- *To avoid adverse impact upon land which contributes significantly to the overall visual quality of the landscape*.'

Part E of the DCP 2010, Section 13 - Bomen Urban Release Area, identifies East Bomen Road as a '*Major Arterial'* route. The DCP includes an indicative cross section for a '*Major Arterial'* route as having an overall width of 36 metres, with two 7.5m wide carriageways, a central median and street trees. Two '*Secondary Local*' roads would extend north from East Bomen Road. The indicative cross section for the *'Secondary Local'* road also shows a 36m overall corridor width with a 9m wide carriageway. (DCP, 2010 Part E, Section 13, page 16 and 17) These roads would be trafficked by vehicles accessing the industrial areas.

Other key relevant development controls for this precinct include the retention of vegetation, including along creek lines and roads, and the protection of ridgelines as visual features, ensuring they are not adversely affected by development. It further states that '*roads and pathways should generally run along the contours of the land*' (clause 13.4).

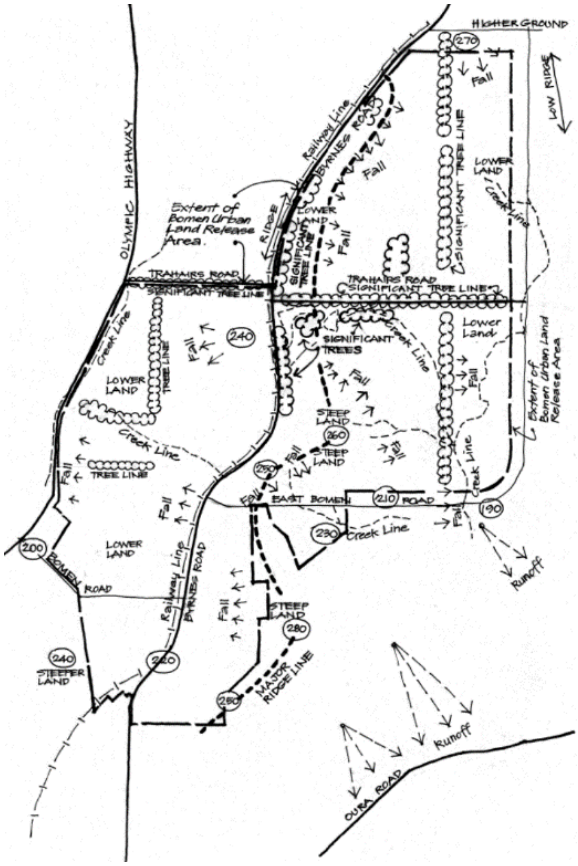

Figure 3-1 Bomen Urban Release Area – Site topography and landscape character (clause 13.4, Figure 4)

3.3. Bomen Strategic Master Plan, 2012

Wagga Wagga City Council commissioned this study to assist the preparation of planning policy and re-zoning for Bomen that is responsive to such challenges as increased urban development pressure and non-agricultural pursuits.

Figure 3-2 is the Character Precinct Map. It identifies an area of light industry bordering the site to the north west and south west (lilac), an area of recreation (green) to the west of the light industry, with heavy industry (blue) and rail uses (orange) along Byrnes Road to the west.

In this plan East Bomen Road is identified as a Major Arterial Road. This document envisions an upgrade to this road to a 36m width with tree and median street trees.

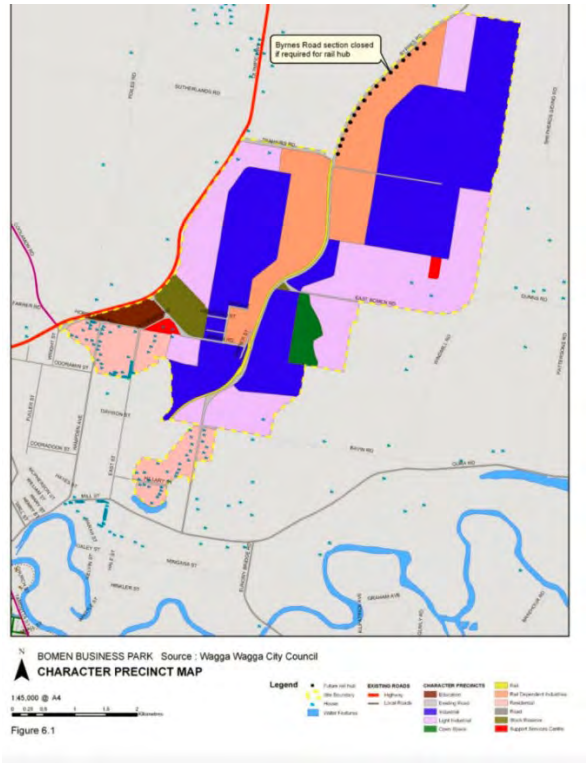

Figure 3-2 Character precinct map (WWCC, 2012, p.49)

The varying topography, creek lines and vegetation are identified in this plan as important elements of the local landscape, which should be preserved and reflected in the form of proposed development.

A key outcome for land use planning is to preserve the '*amenity of adjoining land use and activities*' (clause 8.4.c).

3.1. Wagga Wagga Activation Precinct, 2019

The Bomen area was identified as a 'Special Activation Precinct' by the State Government in 2019. The intention of these precincts is to create jobs, attract investors, and fuel economic development.

4. Existing environment

4.1. Site location and context

The site is located on the eastern outskirts of Bomen, approximately five kilometres to the northeast of Wagga Wagga, north of the Murrumbidgee River.

Bomen is an expanding industrial hub located on the Olympic Highway and the main southern freight rail line between Sydney and Albury, now part of the Inland Rail Project.

In the centre of Bomen, the historic Bomen Railway Station (station group and residence) are State heritage listed and described as … '*focal buildings in the small township of Bomen*' (NSWOEH, 2000).

Surrounding the heavy industrial areas of Bomen the landscape is predominantly rural with a mix of grazing and cropping uses.

The landscape character of the areas surrounding Bomen are changing as areas of land zoned General Industrial (IN1) are being transformed from a rural landscape to general industrial development.

This area has recently been identified as a *Special Activation Precinct* by the NSW Government Department of Planning, Industry & Environment. The intention of these precincts is to create jobs, attract investors, and fuel economic development.

4.1. Topography

The Eunony valley is located between Bomen in the west and the Euranoreenya Hills and Oura in the east. The valley is generally aligned north to south, and the site is located on the eastern slopes of the valley.

From the highpoint north of Bavin Road, several spurs lead down from the ridgeline, to the south and east, including a small ridge which forms the northern boundary of the site. There is a second ridgeline, which is located to the south of the southern boundary of the site.

These ridges create an undulating landscape which create smaller enclosed visual catchments between the spurs and flattens out towards the valley floor in the vicinity of Windmill Road, east of the site.

Refer to Figure 4-1 Topography.

Bomen Railway Station

Overhead transmission lines in the Eunony Valley

4.1. Site features

The site is largely cleared and currently used for sheep grazing. There are some scattered trees across the north and south eastern fields. There are three north south oriented corridors of planted trees within the southern areas of the site. The western most corridor also extends north along the western site boundary.

Existing fields

There is a private driveway which extends west from Windmill Road and is aligned generally parallel with the southern site boundary.

There is an existing transmission line which crosses the site, from the northeast to the west of the site.

Existing planted corridors of trees within the site

Overhead transmission lines crossing the site

4.1. Surrounding landscape character

Areas to the north and west of the site are an existing and emerging industrial landscape with a mix of transport and manufacturing activities intermixed with energy production and transmission.

The Transgrid Bomen substation is located to the west of the site on the outskirts of Bomen. Several overhead transmission lines converge on this substation from the north, east, and south reducing the amenity of this rural landscape.

The approved Wagga Wagga Solar Farm at 157 Windmill Road, adjoins the northern boundary of the proposal site. This approved electricity generating works has an approved footprint of 70-hectares including solar arrays, inverters and a transmission line connection with the Bomen Substation.

Further to the north, East Bomen Road provides east west access to the industrial areas of Bomen. Accordingly, East Bomen Road has been identified as a '*Major Arterial*' route in Part E of the DCP 2010, Section 13 - Bomen Urban Release Area. The road provides access to the future industrial areas to the north, and will be widened.

The Bomen Solar Farm project, located on Trahirs Road, north of the site, is under construction and has introduced the character elements of a solar farm to the study area. This project is located on a 274-hectare site and will include solar arrays, inverters, battery storage, and a transmission line connection to the Bomen Substation crossing East Bomen Road and extending south, to the west of the proposal site. (GHD 2018, page 7 and 8)

There are several large-scale industrial developments on the industrial land to the west of the Bomen Solar Farm, including Riverina Oils & Bio Energy and Renewed Metal Technologies Processing Plant at 177 Trahairs Road. These developments include large scale buildings, tanks and silos.

Industrial development in Bomen

To the west and southwest of the site on the western slopes of the ridgeline (Bomen), there is a further area of dense industrial development including the Wagga Livestock Marketing Centre, oil refining, meat processing and manufacturing businesses. This area of Bomen includes large sheds and industrial buildings, large-scale roads and rail infrastructure.

The surrounding area to the northeast, east and southeast of the site is predominantly rural with scattered rural buildings and residential properties accessed by small driveways and tracks. The valley includes a mix of cattle and sheep grazing, agricultural crops and vineyards.

The study area is not an intact rural landscape with several visual intrusions associated with the location of the study area on the eastern fringe of the Bomen industrial precinct. These intrusions include several overhead transmission lines which cross the study area and converge on the substation.

The industrial areas of Bomen can be seen in views from areas of the Eunony Valley including views from East Bomen, Dunns, Trahairs and Shepherds Siding roads to the north and north east of the site, Windmill Road and Pattersons Road to the east of the site, and from Oura Road to the south.

There are two rural residences and associated buildings located near to the eastern site boundary, accessed via Windmill Road. There are also several rural residences that are located at around one to two kilometres from the site including properties on Dunns Road to the north east, on Pattersons Road to the east, on Oura and Wantabadgery Roads in the southeast, and on Bavin Road to the south.

Beyond this, at a distance of four to five kilometres there are several properties elevated on the eastern hills of the valley.

5. Visual impact assessment

5.1. Methodology

A range of guidance is available for the assessment of landscape and visual impact. In New South Wales the following are typically referred to:

- *EIA-N04 Guidelines for Landscape Character and Visual Impact Assessment*, Roads and Maritime Services, 2018
- *Guidance Note for Landscape and Visual Assessment* (GNLVA), Australian Institute of Landscape Architects Queensland, 2018.

The methodology used for this project is described below and is consistent with the direction offered by these documents.

Refer to Attachment A for key principles found in these guidelines and examples of the visibility of built solar farms.

5.1.1. Zone of visual influence

This assessment begins with the identification of a **Zone of visual influence (ZVI).** This establishes the theoretical area from which the proposal may be visible. This diagram is based on multiple reference points at a height above the solar farm site. The analysis uses a digital terrain model to identify the areas from which views to the site may be possible using a model with a 5-metre accuracy. It does not include the filtering effect of trees and buildings.

5.1.2. Visual absorption capacity

The **Visual absorption capacity (VAC)** of the landscape surrounding the site and across the ZVI area is then determined. Visual absorption capacity is '*the ability for a landscape to accommodate change without the loss of its valued attributes*'. (AILA, 2018) The visual absorption capacity of the landscape surrounding the proposal site has been described and the valued attributes identified.

5.1.3. Photomontages

Three photomontages have been prepared to illustrate the expected changes to views as a result of the project. Photomontages are created using a combination of 3D modelling and photo editing techniques.

The site photographs were undertaken on in September 2019. Details of the photography are as follows:

- Photographs were taken on a Canon EOS 100D with a Canon EFS 18-55mm f3.5-5.6 IS STM lens
- Where possible a 50mm equivalent focal length was used for site photography
- One photograph was used to minimise distortion

The process used to prepare these images was as follows:

- At each photograph location the GPS coordinates are recorded by a Cannon GPS Receiver GP-E2
- A terrain model was prepared using contours with 5 metre intervals
- Cameras were positioned in the model using the photograph GPS data for each image
- A minimum of three points were identified in each view, from the terrain model, and used to align the view
- The proposed solar panels and associated infrastructure were modelled in 3D and materials assigned to the model
- The solar panels and infrastructure were laid out according to the site plan.

These modelled views were then edited in photoshop to insert the model into the photograph.

The viewpoints used to create these photomontages were chosen to represent a range of viewing locations, and from a distance and orientation where the project would be most visible. The photomontages were also chosen to illustrate views from the north, east and southeast of the site.

Distant views were not selected as the detail of the model would not be evident and the extent of change in the photograph would be less.

In the photomontage views where the approved Wagga Wagga Solar Farm project would be visible, it has been shown to represent the future view. The 3D model for this solar farm is from the development application (2018) for this site.

5.1.4. Assessment of representative viewpoints

Views have been selected to represent the range of locations from which the project would be seen. These viewing positions have prioritised locations where there would be a larger number of potential viewers, designated viewing locations and scenic routes, arrival points, and views to particular landscape features such as ridgelines and rocky outcrops.

An assessment of each view has been undertaken in the following steps:

- Identify the **sensitivity** of the viewer (refer Table 5-1)
- Identify the **magnitude of change** created by the proposal (refer Table 5-2)
- Combine these characteristics to assign a level of **likely visual impact** (refer Table 5-3).

Sensitivity refers to the … *'qualities of an area, the number and type of receivers and how sensitive the existing character of the setting is to the proposed nature of change.'* (RMS, 2018)

Locations where there are higher numbers of potential viewers, where views would be seen for a longer duration, and views to areas of higher visual amenity, can be regarded as having a higher visual sensitivity.

Views and visual features recognised by local, State or Commonwealth planning regulations would, by nature of their recognition in these documents, have a higher sensitivity. In particular, the LEP and DCP would reflect the wider community values in relation to visual amenity and identifies areas for protection and planned future desired character.

Each view has been assigned a sensitivity level from low through to high. (refer Table 5-1). These levels consider the following three factors:

- the likely catchment of people who value the view
- if it identified as important in the planning provisions (LEP, DCP or other strategic plan)
- The quality and coherence of the view.

Table 5-1 Visual sensitivity levels

Visual sensitivity level	Description
Low	Views from a small number of receptors, and / or views not including features identified in the planning provisions as having value to the wider community, and / or views which have a lower or fragmented quality and lacks coherence. These may be views seen from local roads, briefly glimpsed views to landscape features, and views from small groups of residences. These views are likely to be common within the landscape.
Low-Medium	Views from a moderate number of receptors, and / or views including local features which are identified in the planning provisions as having value to the local community, and / or views with a minor to moderate level of visual amenity and visual coherence. These may be views seen from the entry to a place, a local collector road, a view sith some landscape features, and views from larger groups of residences.
Medium	Views experienced by a concentration of residents and/or local recreational users, views identified in the planning provisions as having value to the wider community, and / or views with moderate level of visual amenity and visual coherence. These may be a gateway view, view from an identified scenic route and/or large numbers of road or rail users, and or/ views to important visual features. These views are less common within the landscape.
High	Heavily experienced view to a feature or landscape that is iconic to a major portion of a city or a non-metropolitan region, or a designated view in a natural area to a landscape of high visual amenity. It may be a view from of regional open space or designated viewpoint for example. These views are generally unique or uncommon within the regional landscape.

Magnitude of change refers to the extent of change that would be experienced by receptors. This change can be adverse or beneficial.

Magnitude of change considers the characteristics of the project, such as the size, scale, form, line and alignment, and the characteristics of the view, such as distance, landform, backdrop, and visual enclosure.

A high magnitude of change would result if the project contrasts strongly with the existing landscape and has visual characteristics that are not compatible with the view. A low magnitude of change occurs if the view has a higher capacity to absorb the type of change proposed and there would be a high level of integration of form, line, shape, pattern, colour and/ or texture between the development and the surrounding landscape.

Each view has been assigned a magnitude of change level from low through to high. (refer Table 5-2).

Table 5-2 Visual magnitude levels

Visual magnitude level	Description
Negligible	The proposal is not visible, is not visually prominent in the view and / or is compatible with the character of the view. It would result in no perceived change in the amenity of the view.
Low	The proposal is not visually prominent and / or is visually compatible with the character of the view. It would result in a slight change in the amenity of the view.
Medium	The proposal is somewhat prominent and / or is not compatible with the character of the view. It would result in a noticeable change in the amenity of the view.
High	The proposal is visually prominent, and / or contrasts with the character of the view. It would result in a considerable change in the amenity of the view.
Very high	The proposal is visually dominant and / or contrasts substantially with the character of the view. It would result in a substantial change in the amenity of the view.

Visual impact is the combined result of sensitivity together with the magnitude of the change. The visual impact may be adverse or beneficial and at a level of very high through to negligible. (refer table 5-3)

Table 5-3 Visual impact levels

		Sensitivity		
		Low	Medium	High
Modification	Very high	Moderate - high adverse	High adverse	Very high adverse
	High	Moderate adverse	Moderate - high adverse	High adverse
	Medium	Minor adverse	Moderate adverse	Moderate - high adverse
	Low	Negligible	Minor adverse	Moderate adverse
	Negligible	Negligible	Negligible	Negligible
	Improvement	Minor benefit	Moderate benefit	High benefit

5.1.5. Impact significance

The significance of any identified visual impact is determined by a range of factors including the likely duration of the impact, whether the impact is permanent or reversible, and whether the impact is reasonable. A project, for example, which is in accordance with planning intentions is considered to be more reasonable than one which is in conflict with planning intentions.

While this is a judgement for approval authorities, this assessment provides a conclusion which considers these factors.

5.2. Zone of visual influence

A Zone of Visual Influence (ZVI) has been used to establish the theoretical area from which the solar farm may be visible. It is created using topographic data and the height of the proposed project elements and does not include the screening effect of buildings or vegetation.

A series of points have been placed across the proposed solar array area and the likely potential visibility of the site graded from low through to high based on the number of points on the solar arrays that would theoretically be visible. This analysis does not take into consideration factors such as viewing distance, the angle of view (effect of foreshortening) or intervening elements in the view.

The analysis shows the Zone of Visual Influence for the site extending to the north, east and south across the valley. Views to the site are contained to the west by the ridgeline which extends generally north to south between East Bomen Road in the north and Oura Road in the south.

To the north, the ZVI extends across East Bomen Road and to the eastern areas of Trahairs Road, and fields surrounding Shepherds Siding Road. In views from these areas the project visibility would be low and low-moderate i.e. only a small area of the project would potentially be seen.

The hills to the east of the site contain views from the adjacent residential fields and homes on Windmill Road. However, beyond this the ZVI extends across Dunns and Shepherds Siding Road in the north east. From these locations there would theoretically be a low-moderate potential visibility of the project.

The ZVI includes areas further to the east of the site across Pattersons Roads, ending at a local ridgeline to east of east of Pattersons Road near Wheel of Fortune Creek. From these areas there would be a moderate and moderate-high potential visibility of the solar arrays.

To the south, the ZVI extends to properties along Windmill, Bavin and Oura Roads and to the Murrumbidgee River. There would be the greatest potential for visibility in views from Oura Road where the view is orientated along the valley and into the site.

This area formed the basis of field investigations. Refer to Figure 5-1 Zone of visual influence and viewpoint plan.

5.3. Visual absorption capacity

Visual absorption is the ability of a landscape to accommodate change without the loss of its valued attributes. The valued attributes of this landscape are the:

- undulating hills, patches of vegetation and rocky outcrops
- views to the middle-distance ridgelines to the east and west
- distant views across the Murrumbidgee River floodplain to distant ranges in the south.

Scattered trees and blocks of vegetation within the fields, along field boundaries and roads, and on the ridgelines contain and break-up views to and from the site.

At elevated locations within and around the site to the north, east and south east, the views are open and multilayered, extending across open undulating pasture and arable fields in low lying areas. A mountainous horizon is visible in the distance to the east, containing views beyond Pattersons Road. This layering allows for development to sit within the landscape without detracting from the horizon features.

The site and surrounding landscape include a mix of built form with small clusters of farm buildings and homesteads accessed by gravel and sealed roads. The land use transitions into light industrial development on the outskirts of Bomen, along Byrnes Road and west. This includes large industrial sheds, large roads and heavy vehicle activity. The light industry, including a substation to the west of the site, and associated transmission towers and poles further detract from the rural character in areas to the west of the site.

The visual capacity of the landscape to absorb development such as the proposal is substantially increased by this changing landscape character which would neighbour the site to the north and west. The visual compatibility of the proposal with the future development of solar farms and large-scale industry,

as expected in the areas zoned general industrial, would also be increased.

5.4. Assessment of representative viewpoints

The following viewing locations were selected as representative of the range of views to the proposal:

1. View south from East Bomen Road
2. View southwest from Dunns Road
3. View west from Pattersons Road
4. View north from Oura Road
5. View northwest from Bavin Road
6. View west from Windmill Road

Refer to Figure 5-1 Zone of visual influence and viewpoint plan.

The following assessment identifies the visual impact from each viewpoint.

5.4.1. Viewpoint 1: View south from East Bomen Road

Viewpoint 1 – View south from East Bomen Road

Existing view: This view towards the site includes an open field, extending south to a ridgeline in the background (right of view). The site of the approved Wagga Wagga Solar Farm can be seen in the middle ground (left of view), also continuing to the ridgeline in the background of this view.

The approved solar farm site includes some vegetation including a vegetation on the lower slopes (centre of this view) and a block of trees on the ridgeline (centre left of view). There will be native screening vegetation installed along the northern boundary of the approved solar farm site which will establish over time, partly screening views to the approved solar farm.

In the far background, there are distant views to the mountains to the south of Wagga Wagga.

Sensitivity: East Bomen Road provides access to the industrial areas of Bomen. With the proposed future upgrade and future development of the Bomen industrial area this road would have increased use by heavy vehicles. The view from this location is of **low visual sensitivity.**

Magnitude of change: The project site is located on the southern side of the ridgeline and would be out of view. This would result in no perceived change in the amenity of this view and a **negligible magnitude of change**.

Visual impact level: **Negligible visual impact**

5.4.2. Viewpoint 2: View southwest from Dunns Road

Viewpoint 2 – View southwest from Dunns Road, existing view

Viewpoint 2 – View southwest from Dunns Road, photomontage showing approved Wagga Wagga Solar Farm

Viewpoint 2 – View southwest from Dunns Road, photomontage showing the approved Wagga Wagga Solar Farm and proposed Wagga Wagga Solar Farm South

Existing conditions: Cultivated fields are visible in the fore and middle ground of this view. These fields are slightly elevated so that Windmill Road is not visible due to the intervening landform.

To the west there are undulating hills which rise to form a ridgeline that encloses the view. This ridge is partly cleared with several blocks of vegetation. These upper fields include scattered rocky outcrops within the pasture grasses which are a local visual feature.

Water tanks, the Bomen substation and several transmission poles and lines are visible on the ridge and rise above the horizon. There are also transmission lines crossing the intervening fields in the middle ground, and the site in the background of this view. These built features detract from the rural character of this view.

The western areas of the approved Wagga Wagga Solar Farm will be visible on the field to the north of the site (right of view). located on the lower slopes. The fields along the upper ridge and skyline would remain.

Sensitivity: Dunns Road is an unsurfaced road leading east from Bomen. There is a small cluster of rural residences to the north of this road. The view from this location is of **low visual sensitivity.**

Magnitude of change: The site is visible to the south of the approved solar farm (left of view), mostly screened by intervening landform. The solar farm would be located below and not obstruct views to the ridgeline in the background. The upper fields and rocky outcrops, which are a local visual feature, would continue to be seen.

The panel arrays have a low-profile and would generally follow the levels of the site.

The panel arrays would be grouped into blocks so that the entire site area would not be covered. From this angle the panel arrays would appear to overlap and the individual panels would not be differentiated so that they visually merge into blocks. These blocks would be have a similar pattern to other agricultural uses within the valley. The existing vegetation would further break up the view to the blocks of panel arrays and provide some localised screening.

There would be several inverters scattered across the site. These would be of a smaller scale than other agricultural buildings on the adjacent fields and not prominent in the view.

Due to the intervening landform, distance and the low profile of the panel arrays and inverters, which would not rise to the ridgeline in the background, the project would not be visually prominent. The character of the development would be compatible with the character of the view. This would result in a slight reduction in the amenity of this view and a **low magnitude of change**.

Visual impact: **Negligible visual impact**

5.4.3. Viewpoint 3: View west from Pattersons Road

Viewpoint 3 – View west from Pattersons Road

Viewpoint 3 – View west from Pattersons Road, photomontage showing approved Wagga Wagga solar farm

Viewpoint 3 – View west from Pattersons Road, photomontage showing the approved Wagga Wagga and proposed Wagga Wagga Solar Farm South

Existing conditions: This view west across the gently undulating pastures of the valley floor, includes the project site in the middle to background on the rising slopes, in front and set down from the ridgeline which provides a backdrop to this view. This ridge is partly cleared with scattered rocky outcrops and several blocks of vegetation.

Water tanks, the substation and several transmission poles and lines are visible on the ridge and rising above the horizon. There are also several transmission lines crossing the view and the site, which are more prominent in the foreground as they cross the adjacent fields and converge on the substation in the background of the view. These built features detract from the rural character of this view.

While the northern areas of the site are partly screened by intervening vegetation, the upper slopes of the site can be seen in this view, set below the ridgeline in the background.

The western areas of the approved Wagga Wagga Solar Farm will be visible on the adjacent field. Due to the angle of the panel arrays they will be seen overlapping and visually merge in most areas. The approved solar farm would be located on the lower fields and the fields along the ridgeline would remain.

Sensitivity: Pattersons Road is a rural road providing access to several rural properties in the valley to the east of the site. The view from this location is of **low visual sensitivity**.

Magnitude of change: The site is visible to the south of the approved solar farm. The northern areas of the proposed solar farm would be screened by intervening landform, however, the panel arrays on the southern areas of the site would be visible on the east facing slopes, below the ridgeline and rocky outcrops.

While there would be several fields of panel arrays visible, the panel arrays would be grouped into blocks with large patches of undeveloped pasture that would break up the development, assisting in its visual integration into the surrounding landscape.

Due to the distance and orientation, the individual panel arrays would be seen overlapping, they would also visually merge at this distance so that the individual panel arrays would not be discernible.

The panel arrays have a low-profile and would generally follow the contours of the site. The existing vegetation would further break up the view to the blocks of panel arrays and provide some screening.

There would be several inverters scattered across the site. If visible these would be smaller in scale than other agricultural buildings on the adjacent fields and not prominent in the view.

While the project would be visible on several east facing fields, the open patches of field within the site, existing trees, low profile of the inverters and panel arrays, and distance would result in the project not being visually prominent.

The character of the development would be compatible with the character of the wider view. This would result in a noticeable change in the amenity of this view and a **medium magnitude of change**.

Visual impact: **Minor adverse visual impact**

5.4.5. Viewpoint 4: View northwest from Oura Road

Viewpoint 4 – View northwest from Oura Road

Viewpoint 4 – View northwest from Oura Road, photomontage showing the proposed Wagga Wagga Solar Farm South

Existing conditions: This northwest view from the valley floor includes the vineyard and agricultural

buildings of the Eunonyhareenyha Winery in the foreground. The buildings, vineyards and scattered trees obstruct views across the surrounding fields.

In the background of the view there are undulating hills that rise to a ridgeline which encloses the view to the west. This ridge is partly cleared with scattered rocky outcrops within pasture grasses, and intermittent blocks of vegetation. Water tanks, a substation and several transmission poles and lines are visible on the ridge and rise above the horizon. There are also several transmission lines crossing the view and the site, which are less visually prominent at this distance. These built features detract from the rural character of this view.

The western areas of the approved Wagga Wagga Solar Farm will be located on the north and northeast facing fields to the north and out of view.

Sensitivity: This section of Oura Road provides access to the Eunonyhareenyha Winery, Camp Kurrajong, and several rural properties. The views from this location are of **low visual sensitivity**.

Magnitude of change: The site is visible in the middle to background of this view and would extend across the middle slopes of the undulating fields. The solar farm would be located below and not obstruct views to the ridgeline in the background. The upper fields and rocky outcrops, which are a local visual feature, would continue to be seen.

From this angle the panel arrays would appear to overlap and the individual panel arrays would not be differentiated so that they visually merge into blocks. These blocks would be similar in character to other agricultural uses within the valley. The existing vegetation on the site and on intervening fields would further break up the view to the blocks of panel arrays and provide some localised screening.

There would be several inverters scattered across the site. These would be small have a scale similar to other agricultural buildings on the adjacent fields and not prominent in the view at this distance.

While the solar farm would extend across the view, due to the distance, intervening landform, screening vegetation, and low profile of the panel arrays and inverters, the project would not be visually prominent. The character of the development would be generally compatible with the character of this view. The project would result in a noticeable reduction in the amenity of this view and a **medium magnitude of change**.

Visual impact: **Minor adverse visual impact**

5.4.7. Viewpoint 5: View northwest from Bavin Road

Viewpoint 5 – View northwest from Bavin Road

Viewpoint 5 – View northwest from Bavin Road, site location highlighted

Viewpoint 5 – View northwest from Bavin Road, site location highlighted (Detail view)

Existing view: This view towards the site includes open fields in the foreground, with a ridgeline in the background rising to a local high point to the west (left of view). This ridgeline is partly cleared with some blocks of vegetation and pastures with rocky outcrops. There is a large water tank, residence and several transmission poles and wires visible, rising above the ridgeline.

The approved Wagga Wagga Solar Farm will be north of this location (to the right and out of view).

Sensitivity: In this area Bavin Road is a track traversing the fields and blocked in several locations with gates. It provides access to the several rural properties. The view from this location is therefore of **low visual sensitivity.**

Magnitude of change: The site is mainly to the north of the intervening ridge and out of view. There would be a small area of the solar arrays visible on the upper field, in the south western corner of the site. These panel arrays would have a low profile and not rise above the ridgeline in the background.

The solar farm would extend across a small portion of the view and be seen at a distance, the panel arrays would have a low profile and sit below the ridgeline.

Overall, the project would not be visually prominent. The character of the development would be difficult to distinguish as a solar farm and generally compatible with the character of this view. The project would result in no perceived change in the amenity of this view and a **negligible magnitude of change**.

Visual impact level: **Negligible visual impact**

5.4.8. Viewpoint 6: View west from Windmill Road

Viewpoint 6 – View southwest from Windmill Road

Viewpoint 6 – View southwest from Windmill Road, site location highlighted

Existing conditions: This view includes rural properties in the foreground with open fields on the lower slopes of the valley, a tree lined driveway and several residential and rural buildings.

The landform rises in the middle ground of the view to a ridgeline in the background (left of view), and a locally prominent hill to the north (right of view). These hills are partly cleared with scattered rocky outcrops and some intermittent blocks of vegetation. Several transmission lines, a substation and concrete water tanks are visible on the ridgeline and rising above the horizon. There are also transmission lines crossing the view and the site. These built features detract from the rural character of this view.

The approved Wagga Wagga Solar Farm will be to the north and out of view.

Sensitivity: Windmill Road is an unsurfaced, rural road connecting Oura Road in the south with East Bomen Road in the north and providing access for local residents to several rural properties. The view from this location is of **low visual sensitivity**.

Magnitude of change: While the northern areas of the site are partly screened by intervening landform, the southern areas would be seen on the east facing slopes, glimpsed through intervening vegetation. The solar farm would be set below the ridgeline so that there would continue to be a continuous green ridge in the background.

The panel arrays would be grouped into blocks with large patches of undeveloped pasture which would break up the development, assisting in its integration into the surrounding landscape.

The existing vegetation on the site would further break up the view to the blocks of panel arrays and provide some localised screening.

There would be several inverters scattered across the site, however if visible these would be smaller in scale to other agricultural buildings on the adjacent fields and not prominent in the view.

Only a small portion of the project would be visible due to the screening effect of the existing trees, and intervening landform so that the project would not be visually prominent.

The solar arrays and inverters would have a low profile and the character of the development would be compatible with the features of the wider view. This would create in a slight reduction in the amenity of this view and a **low magnitude of change**.

Visual impact: **Negligible visual impact**

5.4.9. Viewpoint 7: View southwest from Windmill Road

Viewpoint 7 – View southwest from Windmill Road

Viewpoint 7 – View southwest from Windmill Road, site location highlighted

Viewpoint 7 – View southwest from Windmill Road, site location highlighted (Detail view)

Existing conditions: This view includes rural properties in the foreground with open fields on the lower slopes of the valley. A tree lined driveway and scattered trees obstruct views to the lower fields. There are several residential and rural buildings in the view including a residence located on small rise in the middle ground of the view.

The landform becomes undulating in the background of the view rising to a ridgeline in the background (left of view), and a prominent hill to the north (right of view). These hills are partly cleared with scattered rocky outcrops and some intermittent blocks of vegetation. Several transmission lines, a substation and concrete water tanks are visible on the ridgeline and rise above the horizon in some locations.

The approved Wagga Wagga North solar farm will not be visible in this view.

Sensitivity: Windmill Road is an unsurfaced, rural road leading north from Oura Road in the south to East Bomen Road in the north and providing access for local residents to several rural properties. This view from this location is of **low visual sensitivity**.

Magnitude of change: The northern areas of the site would be screened by intervening landform, however, the southern areas would be visible on the east facing slopes, glimpsed through intervening vegetation. The solar farm would be set below the ridgeline so that there would continue to be a continuous green ridge in the background.

Only a small portion of the project would be visible due to the screening effect of the existing trees, and intervening landform so that the project would not be visually prominent.

The solar arrays and inverters would have a low profile and the character of the development would be compatible with the features of the wider view. This would create in a slight reduction in the amenity of this view and a **low magnitude of change**.

Visual impact: **Negligible visual impact**

5.5. Summary of visual impact

The following table summarises the findings of the representative viewpoint assessment (refer Table 7-1).

Table 7.1 Summary of visual impact

Viewing location	Sensitivity	Magnitude of change	Impact
1. View south from East Bomen Road	Low	Negligible	Negligible
2. View southwest from Dunns Road	Low	Low	Negligible
3. View west from Pattersons Road	Low	Medium	Minor adverse
4. View northwest from Oura Road	Low	Medium	Minor adverse
5. View northwest from Bavin Road	Low	Negligible	Negligible
6. View west from Windmill Road	Low	Low	Negligible
7. View southwest from Windmill Road	Low	Low	Negligible

5.5.1. Visual impacts during operation of the project

There would be a **negligible visual impact** in views from East Bomen Road in the north (refer viewpoint 1) the solar farm would be screened by intervening landform and out of view.

There would be a **negligible visual impact** in views from Dunns Road in the north east (refer viewpoint 2) as the solar farm would be mostly screened by intervening landform. Where it is visible, it would not be visually prominent.

In views from the east (refer viewpoint 3, 6 and 7) there would be **negligible visual impacts** from mid-range locations, such as from Windmill Road (viewpoints 6 and 7) due to intervening landform and vegetation which reduces the visibility of the proposed solar farm. Further east, such as in views from Pattersons Road (Viewpoint 3), the site becomes visible in the middle to background of views. There would be **minor adverse visual impacts** in these views as the proposed solar farm would be more visible as the viewing location is slightly higher and the project would comprise a slightly larger area of the background of the view.

From the south, such as from Bavin Road (refer viewpoint 5), there would be a **negligible visual impact** as the intervening landform would screen much of the proposed solar farm infrastructure and any visible areas would be consistent with and visually absorbed into the character of the view.

There would be **minor adverse visual impacts** in views from the south east, in locations at around two kilometres from the site where the view opens up views to the site. (refer viewpoint 4). From these locations the upper slopes of the proposed solar farm would be seen on the east facing slopes of the site, partly screened by vegetation and landform.

In summary, there are several factors which contribute to the **negligible to minor overall visual impact** of the project, these include:

- Intervening landform screens views from the north and south almost entirely, and northern areas of the solar farm in most views.
- Northern areas of the project would be screened by intervening landform.
- The existing corridors of vegetation extending through the southern and western areas of the site would be retained on the site and would provide some localised screening.
- Some scattered trees would be removed from within the site, however, these trees are not prominent in views from the surrounding areas as they are located mainly on the lower slopes of the site.
- The low-profile development form, visual merging of the panel arrays into blocks, and

patches of field being retained. would assist in the visual integration of the project infrastructure.

- The upper fields and rocky outcrops, which are a local visual feature, would continue to be visible.

5.5.2. Visual impacts during construction of the project

The visibility of construction works would also be largely contained by intervening landform and vegetation. The earthworks and equipment required to construct the solar farm would be seen in from locations to the northeast, east and southeast. During this time the site would be more visually prominent and there may be a slightly higher potential for visual impact. However, this would be a temporary and short-term impact.

5.5.3. Visual impacts at night

There would be minimal lighting associated with the solar farm project. Any minor security lighting would be consistent with lighting from the surrounding residences and not result in a noticeable reduction in the amenity of views to the site.

5.5.4. Significance of visual impact

Overall, the duration of any construction impacts being short term and the operational impacts would be medium term. Due to the nature of the solar farm, the minor adverse visual impacts identified are reversible with the decommissioning of the solar farm at the end of the project life.

The proposal is reasonable from a visual amenity perspective due to the surrounding context of industry, transmission and solar farms. Furthermore, electricity generating works are permitted with consent in the RU1 zone via the Wagga Wagga Local Environmental Plan 2010. There are also a range of potentially visually prominent development types that would be permissible on land zoned RU1 Primary Production land use zone with and without consent.

6. Visual impact on private residential properties

6.1. Methodology

6.1.1. Approach

The assessment of visual impact on views from private residential properties is guided by the planning principles for 'view sharing' provided in the judgement of the NSW Planning Environment court in the *Tenacity Consulting V Warringah Council* [2004}, NSWLEC 140.

View sharing is when a property … *'enjoys existing views and a proposed development would share that view by taking some of it away*.' (NSWLEC 140, 2004)

6.1.2. Identifying receptors

The judgement indicates that the most affected properties should be considered only. For the purposes of this assessment, all receptors within one kilometre have been identified and assessed. Beyond this, the zone of visual influence plan, prepared for the visual assessment (refer section 6.1 of this report), has been used to identify residences which may have a view to the project.

In this zone, where there is a group of properties and where the site may be seen, a house has been selected and assessed as representative of views from this group. Beyond this, where there has been a concern raised by a resident during community consultation activities an assessment has been undertaken.

Generally, at views up to 100 metres, details of colour texture and structures can be identified and changes in landform and built form are more pronounced. At distances between 100m and around 1 kilometre elements appear less distinctive. Some detail can be seen, however increasingly colour and texture variation becomes grouped into mass elements. At these distances the individual panels would not be discernible at most angles. In views at beyond this, while a solar farm may be visible, the eye will mainly detect colour and shape. Shape may remain evident if it is inconsistent with other landscape forms. Refer to Attachment A for photographic examples of solar farms at a range of viewing distances.

6.1.3. Assessment steps

To determine whether or not view sharing is reasonable the judgement suggests the following four-step assessment be undertaken.

Step 1: Assess views to be affected, noting:

- water views are valued more highly than land views
- iconic views are valued more highly than views without icons
- whole views are valued more highly than partial views.

Step 2: Consider from what part of the property the views are obtained, noting:

- the protection of views across side boundaries is more difficult than the protection of views from front and rear boundaries.
- whether the view is enjoyed from a standing or sitting position may also be relevant. Sitting views are more difficult to protect than standing views.
- the expectation to retain side views and sitting views is often unrealistic.

Step 3: Assess the extent of the impact, noting:

- this should be undertaken from the whole of the property (residence), not just for the view that is affected
- the impact on views from living areas is more significant than from bedrooms or services areas;
- views from kitchens are highly valued because people spend so much time in them.

Step 4: Assess the reasonableness of the proposal that is causing the impact, noting that:

- a development that complies with all planning controls would be considered more reasonable than on that breaches them,
- with a complying proposal, the question should be asked whether a more skillful design could provide the applicant with the same development potential and amenity and reduce the impact on the views of neighbours. If the answer to that question is no, then the view impact of a complying development would probably be considered acceptable and the view sharing reasonable.

To identify the extent of impact (step 3) viewshed diagrams and cross sections have been prepared. The viewsheds are based on a 3D digital terrain model and does not include the screening effect of vegetation and other buildings. It therefore shows the worst-case scenario for visibility based on landform. The cross sections are also based on this landform data and show potential lines of sight to the proposed Wagga Wagga Solar Farm South. Both the viewshed diagrams and cross sections show the existing vegetation within the site boundary and do not include the proposed screen planting.

6.2. Assessment of residential receptors

The following table, refer Figure 6-1, includes an assessment of the private residences. Each residential property has been considered in line with the principles of view sharing.

6.1. Summary of residential visual impact

From adjoining properties to the east, on Windmill Road (R1 and R2), there would be no view to the project due to the intervening landform. (Refer figure 6-2 and 6-3) This would result in a **negligible visual impact**.

In views from the north, such as from residences on East Bomen Road (R4), the project would also be out of view due to the intervening landform. (Refer figure 6-4) This would result in a **negligible visual impact**.

In views from Bavin Road in the south (R6 and R7) and also areas of Oura Road (R8), there would be no view to the project or, where visible, the small visible area would result in a **negligible visual impact**. (Refer figure 6-5, 6-6 and 6-7)

Further east along Oura Road, there would be a greater visibility of the project from some residences east of Windmill Lane (refer to R9). From this location there would be a **minor - moderate visual impact** as, while there is a greater visibility of the project from these properties, the project is set down below the ridgeline and upper fields, which would remain visible.

From properties to the northeast, there would be some views from properties on Dunns Road (such as R13). These properties would experience a change to a small part of their view, at approximately three kilometres. (Refer figure 6-9) This would result in a **negligible visual impact**.

Further to the east, the existing intervening vegetation would limit views from the residence and gardens at 172 Pattersons Road (R17), however, there would be views towards the project from other areas of the rural property. These views include the attractive ridgeline east of Bomen and the undulating hills, but also include other built elements. (Refer figure 6-10 and 6-11) This would result in a **negligible-low visual impact**.

At a distance of over five kilometres there are views to the site from several elevated properties on the eastern side of the Eunony valley, including 494 Pattersons Road (R26) (Refer figure 6-13). These properties have panoramic westerly views which are multilayered and include gardens in the foreground, with undulating fields sloping to the valley floor in the middle ground. Beyond this the view includes undulating landform in the background which rises to Bomen, it is in this area that the project would be located. In this layer of the view, there are existing industrial uses visible, including several prominent industrial buildings and silos to the north west. The Bomen Solar Farm (which is under construction) is visible to the north of this panorama, with the panel arrays indistinguishable at this distance and forming a block of colour in the background of this view.

Due to the ongoing nature of the construction of the Bomen Solar Farm, at the time of viewing, part of this solar farm included the array support posts only, while another section included the installed panels. The solar farm appeared grey in colour, which receded and was well absorbed into the surrounding view. In the far background there is a mountainous backdrop including the hills of Mt Pleasant, which form a visual feature within this view.

There would be a **negligible visual impact** in views from this and similarly located properties as a result of the Project as it would comprise a small element in the background of these broad views and be seen a s block of colour, well integrated into the surrounding landscape.

Overall, due to the visual enclosure of the site there are few receptors that would have views to the project. Where a view is possible, the development type is considered to be reasonable in relation to visual compatibility and development expectations of the land uses in the area.

Table 8.1 Visual impact on private residential receptors

Ref. No.	Property address	Step 1: Assess views to be affected.	Step 2: From what part of the property are the views obtained.	Step 3: Assess the extent of the impact			Step 4: Assess the reasonableness of the proposal that is causing the impact
				Distance to visible area	Viewshed description	Level of effect	
R1	181 Windmill Road	There would be no affected views from this property.	N/A	N/A	Project not visible	**Negligible**	This project is reasonable as electricity generating works are permitted with consent in the RU1 zone via the Wagga Wagga Local Environmental Plan 2010. Furthermore, the solar farm is located in the vicinity of other solar farms, industrial development and a substation, and has a character consistent with this transitional area of Bomen.
R2	159 Windmill Road	There would be no affected views from this property.	N/A	N/A	Project not visible	**Negligible**	
R4	66 East Bomen Road	A view across the rural landscape (zoned IN1 General Industrial), with some developed elements such as transmission poles and wires and the approved Wagga Wagga Solar Farm. The view includes foreground and middle ground elements, a backdrop of undulating hills and distant mountains to the east of the view.	House and gardens and surrounding fields	1.5 km	Small area of the south western corner of the site would be visible. This would be a minor change to view if perceived at all.	**Negligible**	
R6	77 Bavin Road	There would be no affected views from this property.	N/A	N/A	Project not visible	**Negligible**	
R7	309 Bavin Road	A view across the rural landscape, including foreground and middle ground elements, undulating hills and ridgeline. There would be some developed elements such as transmission poles and wires, substation and water tanks in the view.	House and gardens and surrounding fields	1.4 km	A small area in the south western corner and north eastern corner of the site would be visible.	**Negligible**	

Ref. No.	Property address	Step 1: Assess views to be affected.	Step 2: From what part of the property are the views obtained.	Step 3: Assess the extent of the impact			Step 4: Assess the reasonableness of the proposal that is causing the impact
				Distance to visible area	Viewshed description	Level of effect	
R8	550 Oura Road	A view across the rural landscape, including foreground and middle ground elements, undulating hills and ridgeline. This view would include some developed elements such as transmission poles and wires, substation and water tanks.	House and gardens and surrounding fields	1.5 km	Small area of the site in the centre of the northern site boundary, and a small area on the south western corner of the site would be visible.	**Negligible**	This project is reasonable as electricity generating works are permitted with consent in the RU1 zone via the Wagga Wagga Local Environmental Plan 2010. Furthermore, the solar farm is located in the vicinity of other solar farms, industrial development and a substation, and has a character consistent with this transitional area of Bomen.
R9	673 Oura Road	A view of the rural landscape including foreground and middle ground elements, undulating hills and ridgeline. View includes some built elements including transmission poles and towers, solar farm and industrial development. There are no icons in the view.	House, gardens and surrounding fields	1.6km	Most of the site would be visible from this location. There would be some areas to the northeast of the site and central south of the site that would be out of view due to the intervening landform.	**Low-Moderate**	
R13	757 Dunns Road	A view of the rural landscape, including foreground fields and a background of undulating hills and local ridgeline. This view includes some built elements including transmission poles and wires, water tanks and other solar farms.	House, gardens and surrounding fields	3 km	Areas of south western corner of the site, and along the southern boundary of the site would be visible.	**Negligible**	
R16	161 Pattersons Road	View of the rural landscape in the foreground, ridgeline with rocky outcrops in the background. Several developed elements including transmission poles and lines, other	House, gardens and surrounding fields	2.3 km	The south half of the site and a small area on the northern site boundary would be visible.	**Negligible - Low**	This project is reasonable as electricity generating works are permitted with consent in the RU1 zone via the Wagga Wagga Local Environmental Plan 2010.

Ref. No.	Property address	Step 1: Assess views to be affected.	Step 2: From what part of the property are the views obtained.	Step 3: Assess the extent of the impact			Step 4: Assess the reasonableness of the proposal that is causing the impact
				Distance to visible area	Viewshed description	Level of effect	
		solar farms and industrial areas are visible.					Furthermore, the solar farm is located in the vicinity of other solar farms, industrial development and a substation, and has a character consistent with this transitional area of Bomen.
R17	172 Pattersons Road	View of the rural landscape in the foreground, ridgeline with rocky outcrops in the background. Several developed elements in the fore, middle and background of the view intrude upon the rural character. There are no icons in the view.	No view from the residence. Views available from fields to the north of the residence in the vicinity of the transmission line.	2.4 km	The south half of the site and a small area on the northern site boundary would be visible.	**Negligible - Low**	
R19	181 Bavin Road	No change	No impact	N/A	Project not visible	**Negligible**	
R31	494 Pattersons Road	Broad panoramic view across the rural landscape with areas of industry. The view includes undulating hills and a local ridgeline in the middle ground with some built elements including transmission poles and wires, several industrial developments and a solarfarm. The view has a backdrop of mountains.	Elevated property. View available from verandah which wraps around the living area and bedrooms.	5.5 km	About half of the site would be visible including the southern areas of the site, upper slopes along the western fields and some areas along the northern boundary. Of this visible area the developed footprint would be about half of seen areas with the remainder open fields and retained vegetation.	**Negligible**	

View south from property on East Bomen Road (R4)

Panoramic view west from 494 Pattersons Road (R26) (September 2019)

View from 494 Pattersons Road to the Bomen Solar Farm which is under construction - 50mm(50mm focal length)

View from 494 Pattersons Road (R26), detail image (50mm focal length)

View from 494 Pattersons Road (R26), detail image (with site highlighted in orange)

View from a field at 172 Pattersons Road, west of the residence

View from a field at 172 Pattersons Road, west of the residence

7. Glare risk assessment

7.1. Methodology

7.1.1. Key concepts and terms

Solar glare

Solar glare is a visual sensation caused by reflected light which causes annoyance, discomfort or loss in visual performance.

Reflected light can be divided into two subtypes, specular reflection and diffuse reflection. Specular reflection is the mirror-like reflection of light from a smooth surface and diffuse reflection is the dispersed reflection from a rough surface.

The law of reflection is that an angle of incidence (entrance angle of the sun's ray) is equal to the angle of reflection (exit angle of the potential glare). Assuming specular reflection (excluding all other factors), the geometric possibility of glare can be accurately predicted.

Ocular impacts

An ocular impact is an impact on the eye or on vision. Ocular impact from solar glare is a function of retinal irradiance (power of electromagnetic radiation produced by the sun) and the subtended source angle (size and distance) of the glare source. (Ho, 2011)

The ocular impact of solar glare can be quantified into three categories (Ho, 2011):

- Green - low potential to cause after-image
- Yellow - potential to cause temporary after-image (flash blindness)
- Red - potential to cause retinal burn (permanent eye damage)

These categories assume a typical blink response in the observer. (Forge Solar, 2019)

Flash blindness is a temporary loss of vision, it is … 'produced when retinal light-sensitive pigments are bleached by light more intense than that to which the retina is physiologically adapted at that moment.' (Farlex Partner Medical Dictionary, 2012) Flash blindness would be experienced, for example, when the flash on a camera is used to take a photograph. Flash blindness would not cause permanent damage in the levels identified for green glare.

An afterimage is an image that continues to appear in a person's vision after the exposure to the original image has ceased. It is caused by a brief exposure to a bright stimulus when the surrounding conditions are darker. Glancing at the sun or bright headlights at night are commonly experienced situations when an after-image may be experienced. An afterimage distracts but does not cause harm. This is a commonly experienced phenomenon, which is usually brief.

Retinal burn is permanent damage to the eye caused by prolonged exposure to solar radiation or other bright light. Lasers and welding torches can cause retinal burn, for example. Photovoltaic modules do not focus reflected sunlight, therefore, it is not possible for photovoltaic modules to produce retinal burn (red glare). (ForgeSolar, 2019).

It is important to note that the yellow and green glare categories are risk ratings, and identify a potential for glare, rather than an actual glare effect. There are a range of atmospheric conditions that influence the potential for glare, including clouds, dust, smoke, rain etc. The intensity of a reflection also generally decreases with distance. Solar Glare Hazard Analysis

To identify the risk of glare effects from the project the Solar Glare Hazard Analysis Tool (SGHAT 3.0) 'GlareGauge' has been used. This is a glare impact assessment model specifically designed to identify the risk of glare caused by solar farms.

The proposed panel areas and the location of observer points are entered into a model, which applies vector calculations based on the geographic location of the site, sun position, the photovoltaic module orientation, reflectance environment and ocular factors.

If potential glare is identified by the model, the tool calculates the retinal irradiance and subtended angle (size/distance) of the glare source to predict potential ocular hazards according to the glare the intensity categories red, yellow and green.

The GlareGauge analysis tool, however, has several limitations, which include:

- The model does not rigorously represent the detailed geometry of the solar farm, features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. The PV array is simulated as a footprint filled with infinitesimally small panels reflecting sunlight in the trajectory of the tilt and orientation. The actual surface area of the solar farm would not be a continuous reflective plane. The Ground Coverage Ratio (GCR) of the solar panel blocks (i.e. ratio of panel to field area when the panels are flat) is 42%, GlareGauge assumes a GCR of 100%.
- The model assumes specular reflection i.e. assumes there is no factors that may diffuse the light reflecting from the panel surface, such as dust.
- The model does not account for 'backtracking' a phase of operation when the sun is low in the sky which maximises the absorption of sunlight. (Refer Attachment C)
- The model does not account for atmospheric conditions such as cloud cover, dust in the air and haze which will impact light reflection. For example, GlareGauge assumes sun with no cloud cover every day of the year.
- Intervening landform, buildings and vegetation between the sun and the site and also between the site and the receptor are not accounted for by the software.

This model shows a scenario which exaggerates the potential for glare. This software is therefore likely to predict solar reflections over a larger area and for a greater length of time than would be experienced in reality.

7.1.2. Identifying receptors

The Zone of visual influence prepared for the visual impact assessment (refer section 5.2 of this report) was used to identify areas from which the project may be visible from private residential properties. All residences located within one kilometre of the site and also within the potential Zone of Visual Influence (ZVI) area have been assessed for a glare impact. Beyond this, residences have been selected to represent groups of properties located within the ZVI area, including properties to the north, northeast, east and southeast, at angles where there is the potential for glare.

Locations along roads to the north, east and southeast of the site, and within the ZVI, have also been assessed. These points were selected to include a range of angles and distances and have been located at intersections and decision points where possible.

7.2. Glare assessment

7.2.1. Solar Glare Hazard Analysis

A glare assessment was undertaken using the Solar Glare Hazard Analysis Tool (SGHAT 3.0) 'GlareGauge'. The assessment is based on the following parameters, which were entered into the model. (Refer Table 7-1)

Table 7-1 Input data for SGHAT Analysis

Parameter	Value
Time zone	UTC +10
Axis Tracking	Single
Tilt of tracking axis	0
Orientation of tracking axis	0
Offset angle of module	0
Module surface material	Smooth glass with an anti-reflective coating (ARC)
Maximum tracking angle	60°
Resting angle	60°
Reflectivity	Vary with sun
Height of panel array above ground	2.8 m maximum height to tip of panels 0.3 m minimum height to bottom of panels

7.3. Summary of glare impact

The following table summarises the results of the GlareGauge analysis. (refer Table 7-2) These represent the risk of glare from the project during operation.

Table 7-2. Input data for SGHAT Analysis

Receptor code	Address	Glare identified
R1	181 Windmill Road	Nil
R2	159 Windmill Road	Nil
R7	309 Bavin Road	Nil
R8	550 Oura Road	Nil
R9	673 Oura Road	Nil
R13	757 Dunns Road	Nil
R16	161 Pattersons Road	Nil
R26	494 Pattersons Road	Nil
R27	381 Shepherds Siding Road	Nil
EBR	East Bomen Road	Nil
WR	Windmill Road	Nil
PR	Pattersons Road	Nil
OR	Oura Road	Nil
DR	Dunns Road	Nil

7.3.1. Glare risk during operation

The Glaregauge analysis has not identified any potential glare risk on the selected residential receptors, or locations along surrounding roads, during operation of the project.

As the 'GlareGauge' software does not accurately model 'backtracking' there is theoretically a potential risk of glare during this phase of operation. However, because the site is well enclosed by intervening landform and vegetation, which obstruct views to the site, the glare risk during this phase of operation is slight. Furthermore, any glare effect would be seen mostly in views at distances of 2km or greater, where the intensity of the glare would be less. Backtracking occurs for a short duration, so any glare effect would pass quickly.

Overall, the glare risk from the project during operation of the project is **negligible**.

7.3.2. Glare risk during construction

There would be some potential for a temporary glare impact during construction. This would include a glare risk when the galvanised posts are installed upon the site, an effect that would be slight and temporary. The array support posts would be mostly shaded and screened by the Photovoltaic modules as they are installed. The impact from the galvanised posts would therefore only be experienced for the duration between installation of the array posts, and installation of the panels. Due to the limited visibility of the site there would be a low risk of this effect, and due to the distance of receivers, any glare effect would be slight.

There is the potential for a further glare risk during construction of the solar farm when the panels are installed and stowed in a fixed position if oriented towards a receptor. The glare from these fixed panels (i.e. before they are tracking the sun) would be a temporary effect, if at all. Due to the limited visibility of this site there would be a low risk of this glare impact during construction.

Overall, any glare experienced during construction would be temporary and be experienced for a short duration. This would result in a **negligible** visual impact.

8. Landscape plan and mitigation measures

A landscape plan has been prepared for the site. It proposes the following additional vegetation types for the site:

- Supplementary planting – additional trees and shrubs within the corridors of existing trees where gaps exist
- Native revegetation - 10-metre wide corridor with a mix of locally native trees and shrubs which provide habitat for native wildlife, along the eastern, and western site boundaries
- Native revegetation - blocks of locally native trees and shrubs which provide habitat for native wildlife, on the northern site boundary, along the dry creek, and around the dam.
- Native screen planting, 10-metre wide corridor with a mix of trees and shrubs (up to 5 metres tall) along the southern site boundary.

The location and width of the screen planting has been determined by the potential visibility of the site.

Native screen planting has been proposed for the northern site boundary as this boundary adjoins the approved Wagga Wagga Solar Farm and the landform visually encloses the Wagga Wagga Solar Farm South site from sensitive receptors in the north.

Refer Figure 8-1 Existing Conditions and Landscape Strategy, 8-2 Landscape Strategy and Notes, 8-3 Landscape Plan, Figure 8-4 Existing trees with supplementary planting, Figure 8-5 Native revegetation areas, Figure 8-6 Native screen planting.

The assessment identified the possible risk of a temporary glare impact during construction.

It is therefore proposed that if a glare effect is experienced, the panels be stowed so that they face west and away from the receivers. This may assist in minimising any potential glare effect.

9. Cumulative impacts

9.1. Approach

Cumulative impacts are impacts that, when considered together, have a different or greater impact than a single impact on its own. Cumulative impacts can result from the incremental and/or combined effects of a project when added to other projects.

The extent to which another project could interact with the construction and/or operation of the project would depend on its scale, location and the timing of construction or operation. Generally, cumulative impacts would be expected to occur in situations where multiple long-duration construction activities are undertaken close to, and over a similar timescale.

Generally, cumulative impacts during the operation of a project are more difficult to assess as often changes to visual amenity are associated with intended land use change. Good planning practices generally group like development types together and separate these from incompatible activities. When a development type is not located purely by land use designation, such as power generation and transmission projects, the reasonableness of the project is more relevant.

Cumulative visual effects are those that would …*'give rise to changes in the landscape character of the study area so as to result in significant effects on its key characteristics and even, in some cases, to transform it into a different landscape type.' (GLVIA3, 2013)* This transformation should not be envisaged by the planning designations.

In relation to cumulative visual impact on private residential properties, most technical guidance in this area suggests that cumulative impact assessment not be undertaken for private receptors. Rather, the surrounding existing and approved development should be considered as a part of the baseline for the assessment. (Residential Visual Amenity Assessment, Technical Guidance Note, 2019)

However, as this issue was raised by the community in relation to the Eunony Valley, the following discussion will consider the potential visual impact of the solar farm projects in the Eunony Valley in combination.

The following section describes the potential cumulative visual impact on the public realm, private residential receptors and glare risk.

9.2. Cumulative visual impact on the public realm

It is unlikely that there will be an overlap in the program for construction of the Bomen Solar Farm (currently under construction), the approved Wagga Wagga Solar Farm, and the Wagga Wagga Solar Farm South project due to the timing of the approvals. The visual impact would therefore be sequential not cumulative. Any sequential visual impacts are temporary and short term.

In the context of the potential construction activity that may occur on the land zoned IN1 General Industrial, the construction of these solar farms is minor in scale and would not create a significant visual impact.

During operation, however, there are potential cumulative visual impacts from the Bomen Solar Farm, the approved Wagga Wagga Solar Farm and the proposed Wagga Wagga Solar Farm South.

There are several locations where the project and other existing and approved solar farms would be visible in the same view. This includes views from East Bomen Road and Dunns Road where there would be views to the approved Wagga Wagga Solar Farm as well as a glimpsed view to the project. Due to the minor change in these views, there would not be a cumulative visual impact from these locations.

In northerly views from Oura Road in the south, the orientation and angle of the view is such that there would be a view to the project, the Wagga Wagga Solar Farm in the middle ground and the Bomen Solar Farm in the background of the view. While there would be multiple solar farms visible, each is somewhat screened by intervening landform and vegetation and well absorbed into the view so that the solar farms would not be visually dominant. For this reason there would not be a cumulative visual impact from this location.

9.3. Cumulative visual impact on private residential properties

There are several locations where the project and other existing and approved solar farms could be visible from private residences. This includes views at a range of distances and angles.

In views from properties to the north of the site (R4) and north east (R13) there would be views to the approved Wagga Wagga Solar Farm as well as glimpses to the proposed Wagga Wagga Solar Farm South project. Similarly, in views from properties to the west of Pattersons Road there would be views to both the approved Wagga Wagga Solar Farm and the Wagga Wagga Solar Farm South project. The Bomen Solar Farm may also be seen from these locations, but this would not be in a view with the same orientation, but in a view oriented to the north. These views have the capacity to absorb this visual change and would not be visually dominated by solar farm development. Therefore, there would not be a cumulative visual impact.

In views from the elevated properties to the east of the site, on Pattersons Road, there are panoramic views that would include the Bomen Solar Farm, approved Wagga Wagga Solar Farm and proposed Wagga Wagga Solar Farm South project. In these views, both the Bomen Solar Farm and approved Wagga Wagga Solar Farm will be well absorbed into the view due to distance and the low profile of the solar arrays. The Wagga Wagga Solar Farm South project would form a small additional area of solar farm development in this view, which would be well absorbed by the diverse character of this outlook. There would not be a cumulative visual impact from these locations.

9.4. Cumulative glare impact

Glare is a natural part of the landscape i.e. glare can be generated by water, the foliage on trees etc. It can also be caused by built elements in the landscape such as houses, sheds, cars using roads etc. This assessment will focus on the glare risk associated with the solar farm projects approved and under construction within the eastern slopes of Bomen.

The Environmental Impact Statement for the Bomen Solar Farm, Statement of Environmental Effects for the Wagga Wagga Solar Farm, and the analysis for the proposed Wagga Wagga Solar Farm South (refer chapter 7 of this report) have each identified no glare impact or a negligible glare impact during the operation of these solar farms.

There is therefore expected to be no cumulative glare impact during operation of the Wagga Wagga Solar Farm South project.

There would be some limited and temporary glare potentially experienced from these solar projects during construction. This effect would be successive, short term and temporary. As any glare would be a result of the particular angle of incidence of the sun towards the panel arrays, and directed towards a particular receptor, it is unlikely that there would be multiple glare impacts experienced from one location at any one time. The timing of construction, and aging of the galvanised finish on each successive solar farm would further reduce the potential for there to be a residual visual impact on one of the approved solar farms while the Wagga Wagga Solar Farm South project is under construction.

It is therefore reasonable to assume that there would not be a cumulative glare impact during construction of any significance.

10. Conclusions

10.1. Visual impact

The site is well enclosed by landform and existing vegetation and as a result has a relatively low potential visibility from most areas within the potential zone of visual influence (ZVI) of the project. Furthermore, the landscape has a high visual capacity to absorb views to development of this type due to the undulating landform, existing corridors of vegetation, existing built elements such as overhead power lines and poles, the substation and concrete water tanks in the vicinity of the site. Furthermore, the existing industrial development, which characterise areas to the north of the site, detract from the rural character of westerly views towards Bomen.

There would be mainly **negligible visual impacts** from publicly accessible locations surrounding the site as the project is well visually contained by landform and existing vegetation and the project would not obstruct views to the upper fields, ridgeline and rocky outcrops which are a local visual feature.

There would be a **minor adverse visual impact** experienced in views from Pattersons and Oura roads. While the project would be more visible and comprise a greater area of the view, the character of the solar farm would not contrast with the surrounding landscape.

These visual impacts are not considered to be significant as the development type is consistent with planning intentions for this area of Wagga Wagga. These impacts are also expected to be experienced over the medium term and are reversable.

While the Wagga Wagga Solar Farm South would be visible within view of the approved Wagga Wagga Solar Farm and Bomen Solar Farm, there was no cumulative visual impact identified from public realm locations.

10.2. Visual impact on private residential properties

The extent of impact on private residences surrounding the site is mainly **negligible**. However, there would be **negligible-minor visual impact** expected on properties to the west of Pattersons Road. There would also be a **minor -moderate visual impact** on a small number of properties to the south east of the site on Oura Road.

These impacts are reasonable as electricity generating works are permitted with consent in the RU1 Zone via the Wagga Wagga Local Environmental Plan 2010. The solar farm is located in the vicinity of other solar farms, industrial development and a substation, and has a character consistent with this transitioning area of Bomen.

The addition of the Wagga Wagga Solar Farm South to views of the approved Wagga Wagga Solar Farm and Bomen Solar Farm would not result in solar farm development visually dominating or transforming the character of this landscape in a way that is not in-line with the planning intentions of the area. This change does not reach a threshold which would result in a cumulative visual impact that is unreasonable.

10.3. Glare risk

Glare is often experienced in both urban and natural landscapes, with all surfaces having some reflectivity potential. The setting of the Wagga Wagga Solar Farm South site has mixed scenic quality, with some existing built elements likely to produce some level of glare in the landscape.

The proposed Wagga Wagga Solar Farm South is a photovoltaic system, which is designed to absorb sunlight. The farm would use a single axis tracking system, which tracks the sun for most of the day and has a lower glare risk than a fixed frame photovoltaic system.

The analysis identified that there was no potential for glare during operation of the project. While a glare effect during backtracking is possible, this risk is slight and unlikely to have an effect of any significance due to intervening elements, distance and the short duration of this phase of operation.

Overall, there would be a **negligible** glare risk during project operation.

While there would be some risk of glare during construction, this impact would be temporary and experienced for a short period of time. Overall, this potential risk of glare would have a **negligible** impact on the amenity of surrounding residents.

It is proposed that if there is a glare effect experienced during construction, the solar panels be stowed facing away from the receivers to minimise this temporary effect.

The glare assessments for the proposed Wagga Wagga Solar Farm South, approved Wagga Wagga Solar Farm, and Bomen Solar Farm each have not identified a glare risk during operation of the project. Therefore, it can be assumed that there is no cumulative glare risk during operation of the project.

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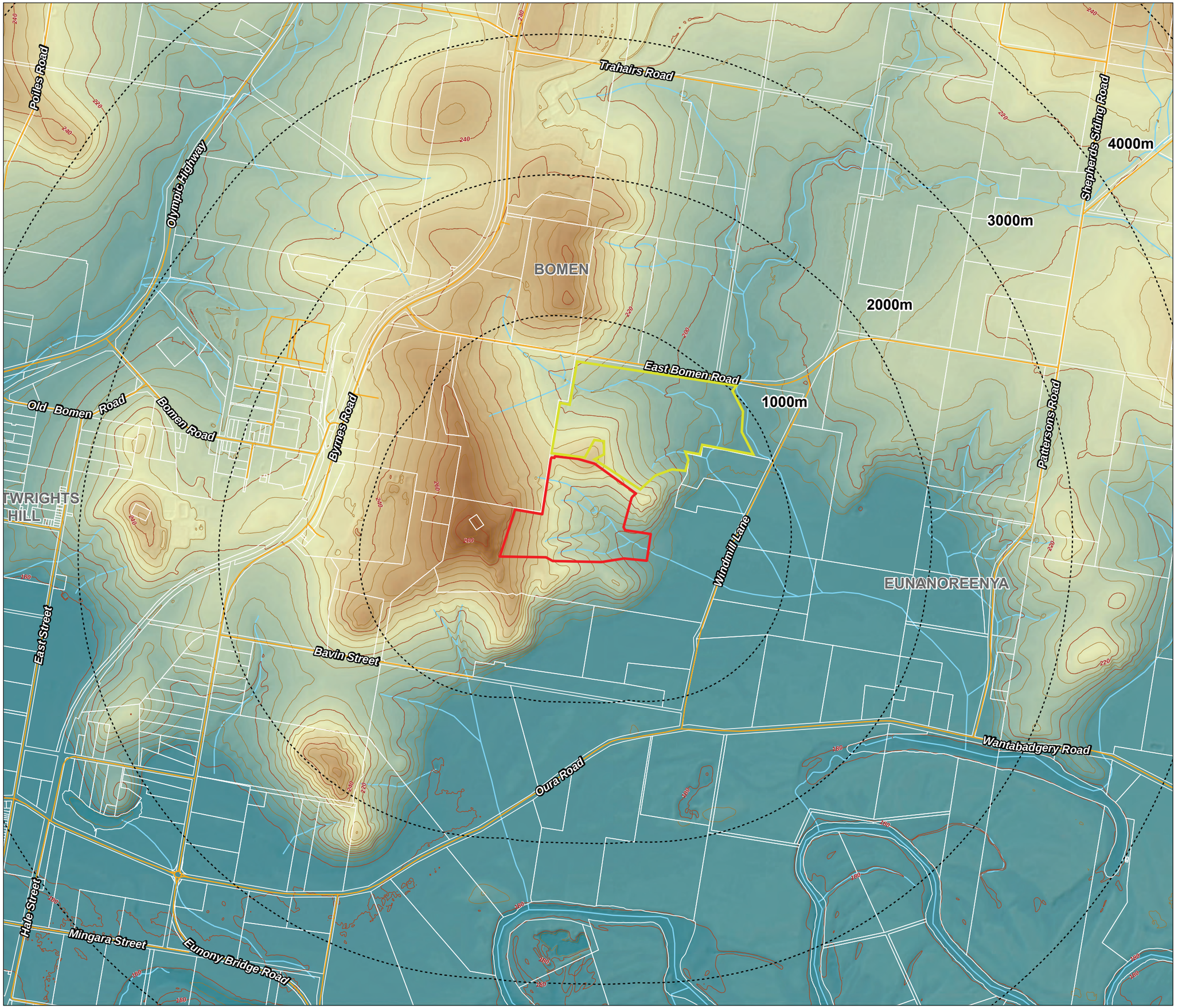

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FIGURE 4-1: Topography

- Watercourse
- Contour (20m)
- Contour (5m)
- Distance from the site

Elevation

- High: 310m
- Low: 172m

- Wagga Wagga Solar Farm (approved)
- Wagga Wagga Solar Farm South

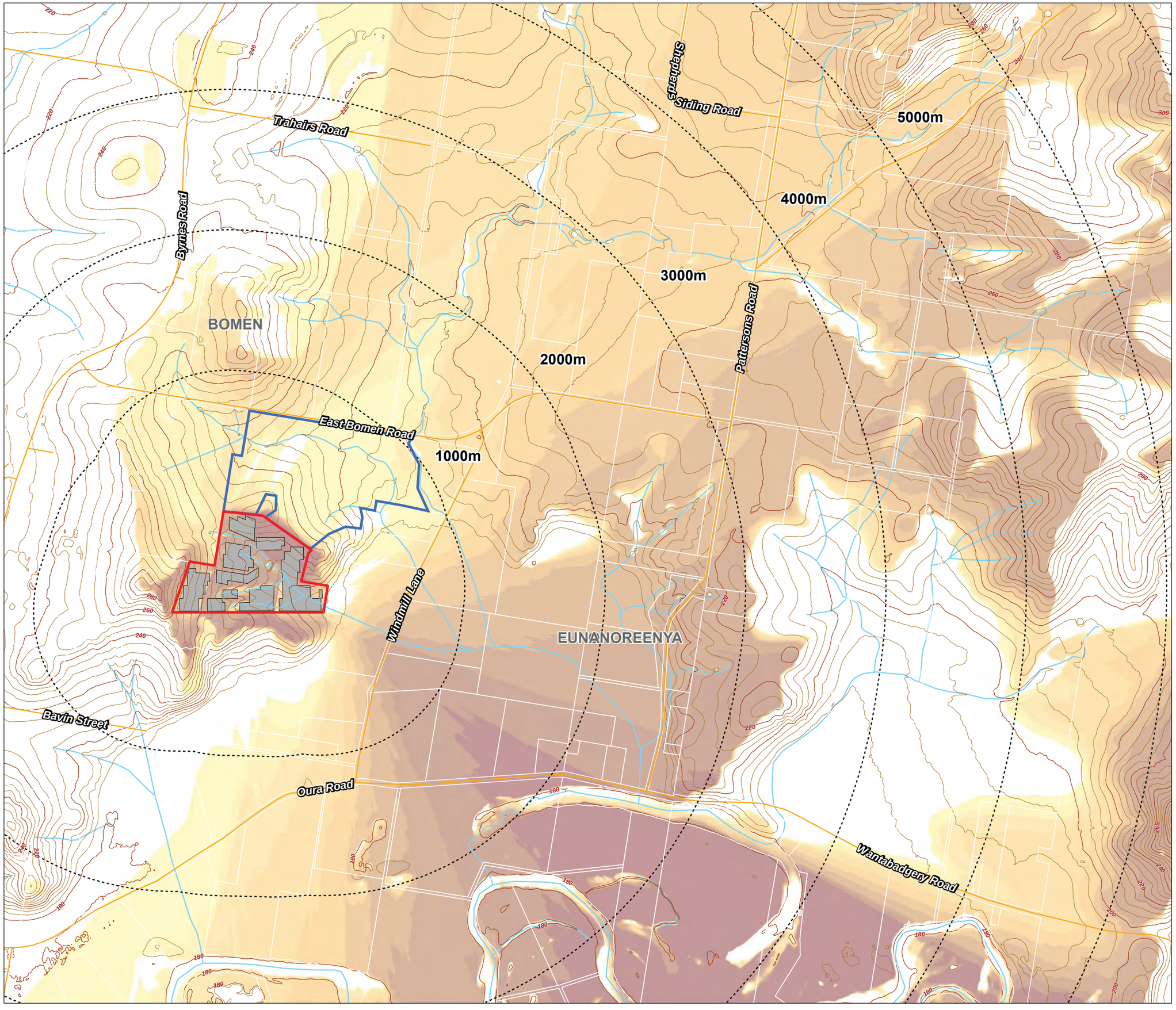
SOURCE:
Surface analysis: Derived from TARCUTTA and WAGGA WAGGA 2kmx2km 5 metre Resolution Digital Elevation Model 2014
Cadastre: NSW Land and Property Information 2018
Watercourse: GeoScience Australia 2015

N W E S

0 0.25 0.5 0.75 1 1.25
Kilometers

A3 Scale: 1:25,000

File:WaggaWaggaStage2_FIG3_Topography_190321 Date: 3/21/2019



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Wagga Wagga Solar Farm South 157 Windmill Road

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FIGURE 5-1: Zone of Visual Influence

- Wagga Wagga Solar Farm (approved)
- Wagga Wagga Solar Farm South
- Watercourse
- Contour (20m)
- Contour (5m)
- Distance from the site
- Solar arrays

Potential visibility

- Not visible
- Low
- Low-moderate
- Moderate
- Moderate- high
- High

SOURCE:
Surface analysis: Derived from TARCUTTA and WAGGA WAGGA 2kmx2km 5 metre Resolution Digital Elevation Model 2014
Cadastre: NSW Land and Property Information 2018
Watercourse: GeoScience Australia 2015

N W E S

0 0.25 0.5 0.75 1 1.25

Kilometres

A3 Scale: 1:25,000

Date: 15/11/2019

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FIGURE 5-2: Viewpoint Plan

- Wagga Wagga Solar Farm (approved)
- Wagga Wagga Solar Farm South
- Watercourse
- Contour (20m)
- Contour (5m)
- Distance from the site
- Area where solar panels may be visible
- Viewpoint location

SOURCE:
Surface analysis: Derived from TARCUTTA and WAGGA WAGGA 2kmx2km 5 metre Resolution Digital Elevation Model 2014
Cadastre: NSW Land and Property Information 2018
Watercourse: GeoScience Australia 2015

0 0.25 0.5 0.75 1 1.25
Kilometres

A3 Scale: 1:25,000

Date: 26/07/2019

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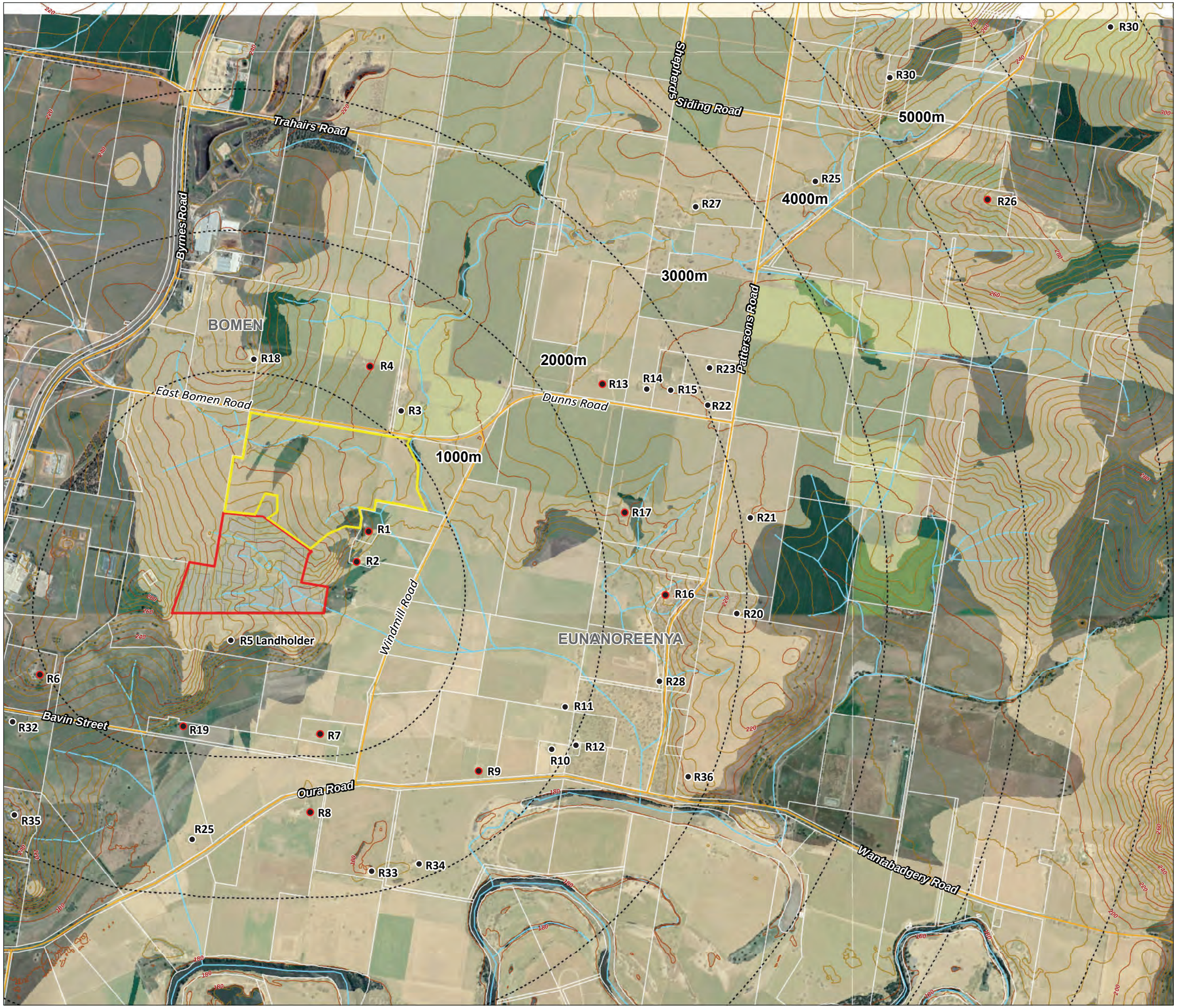

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FIGURE 6-1: Private residential receptors

- Wagga Wagga Solar Farm (approved)
- Wagga Wagga Solar Farm South
- Watercourse
- Contour (20m)
- Contour (5m)
- Distance from the site
- Solar array footprint
- Potential Zone of Visual Influence based on landform
- Residence
- Residence (assessed)

SOURCE:
Surface analysis: Derived from TARCUTTA and WAGGA WAGGA 2kmx2km 5 metre Resolution Digital Elevation Model 2014
Cadastre: NSW Land and Property Information 2018
Watercourse: GeoScience Australia 2015

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Kilometres

A3 Scale: 1:25,000

Date: 11/11/2019

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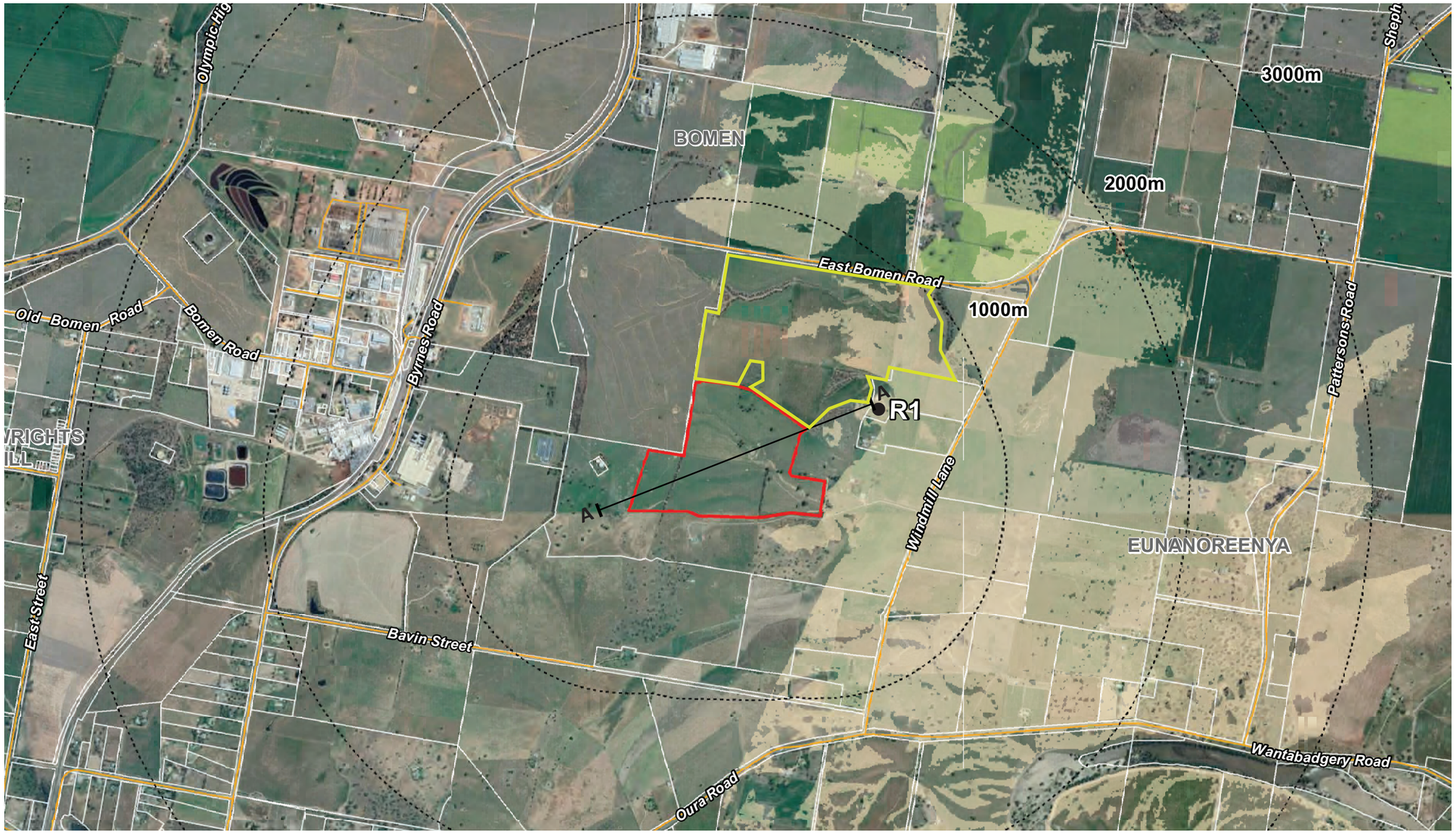

A-A Cross section from Receptor 1

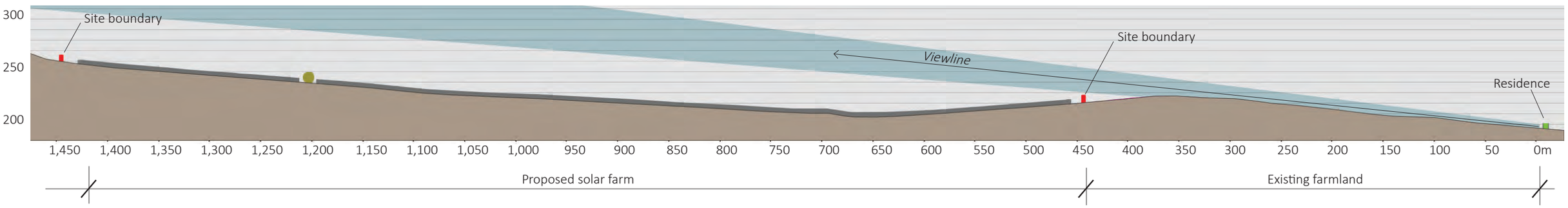

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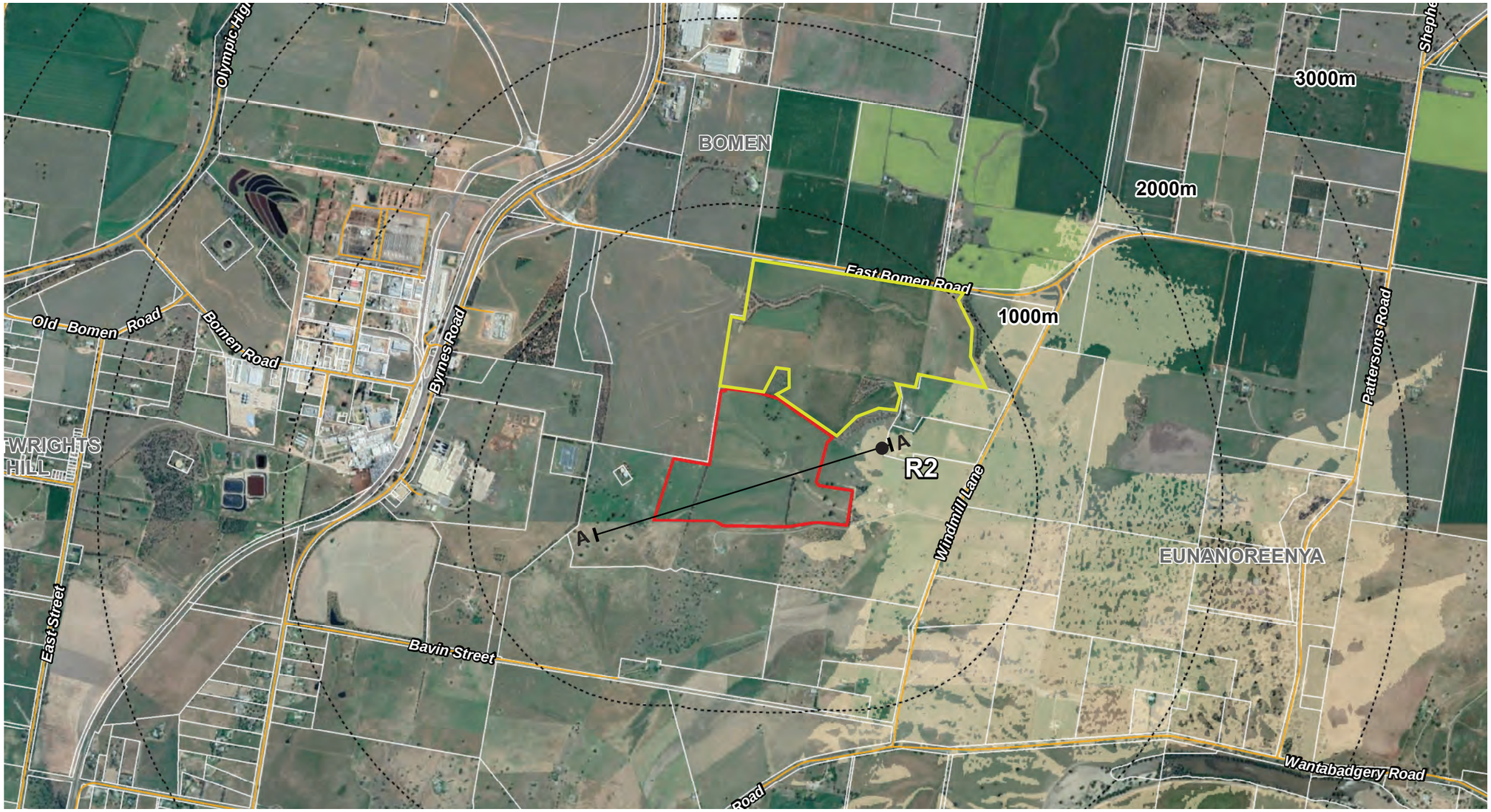
FIGURE 6-2:
Viewshed and cross section from Receptor 1 (R1)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed from house

Distance from site

A-A Cross section from Receptor 2

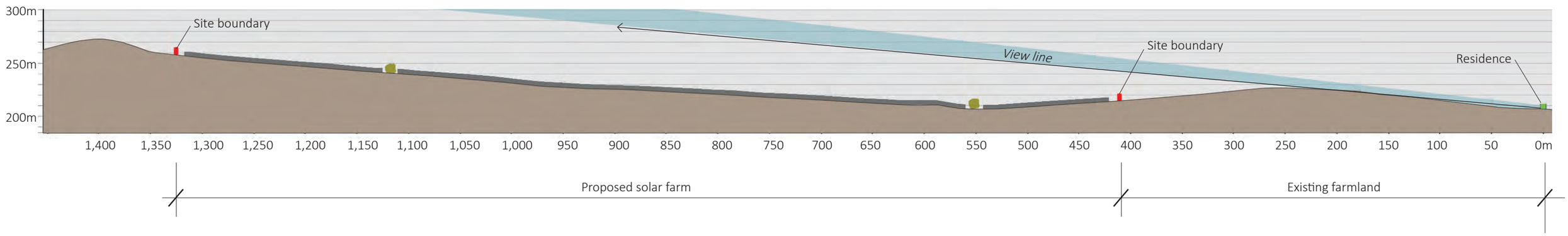


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FIGURE 6-3:
Viewshed and cross section from Receptor 2 (R2)

Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed from house

Distance from site

Cross section from Receptor 4

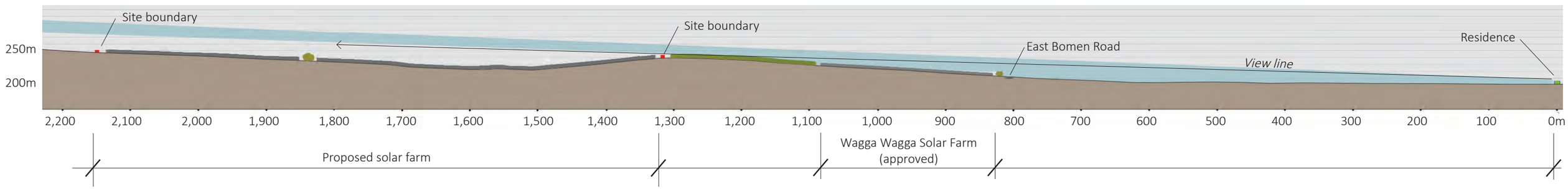

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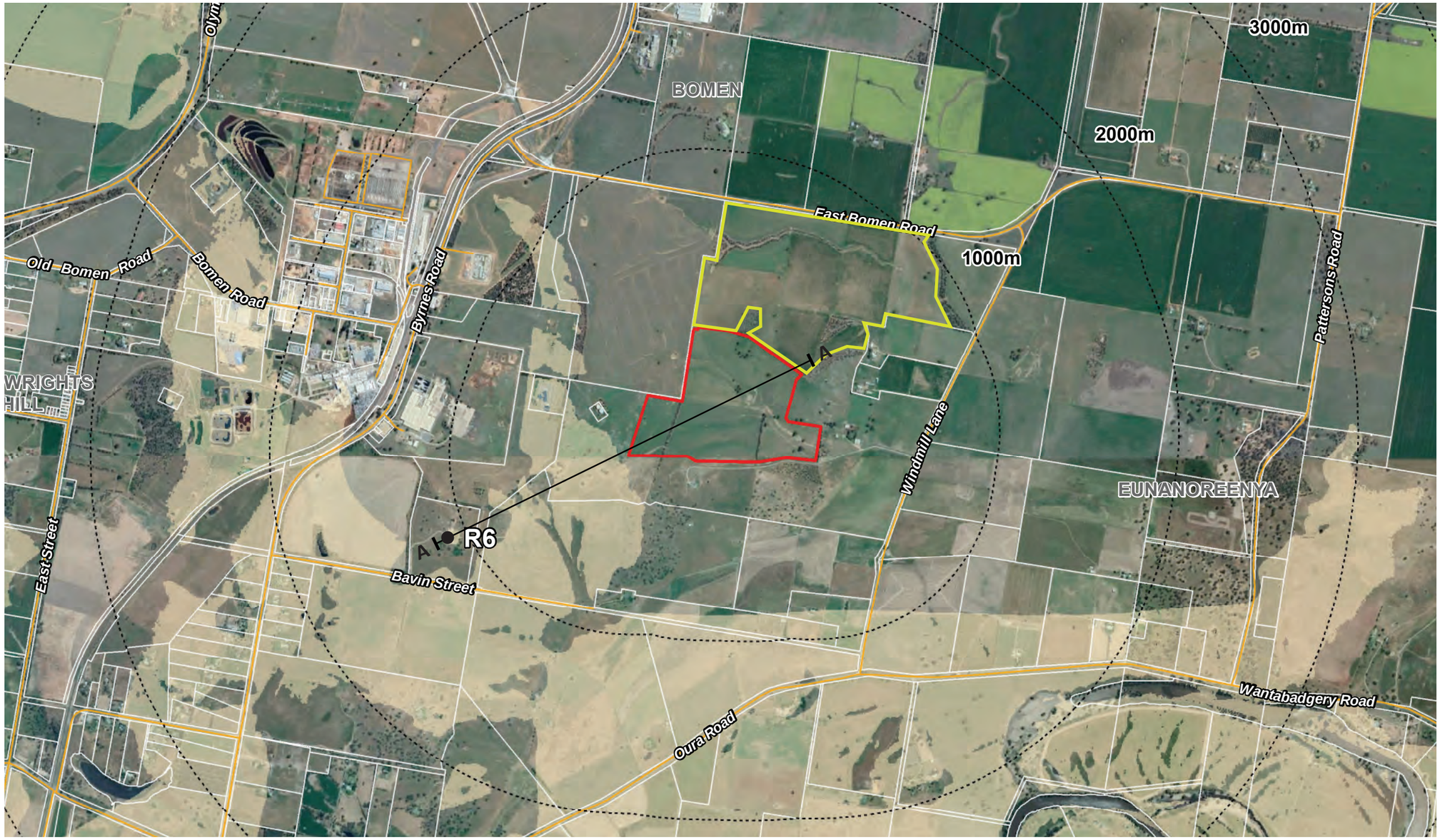
FIGURE 6-4:
Viewshed and cross section from Receptor 4 (R4)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed from house

Distance from site

A-A Cross section from Receptor 6

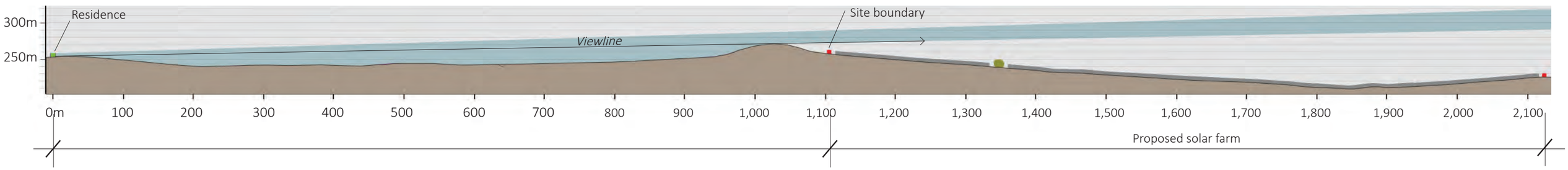


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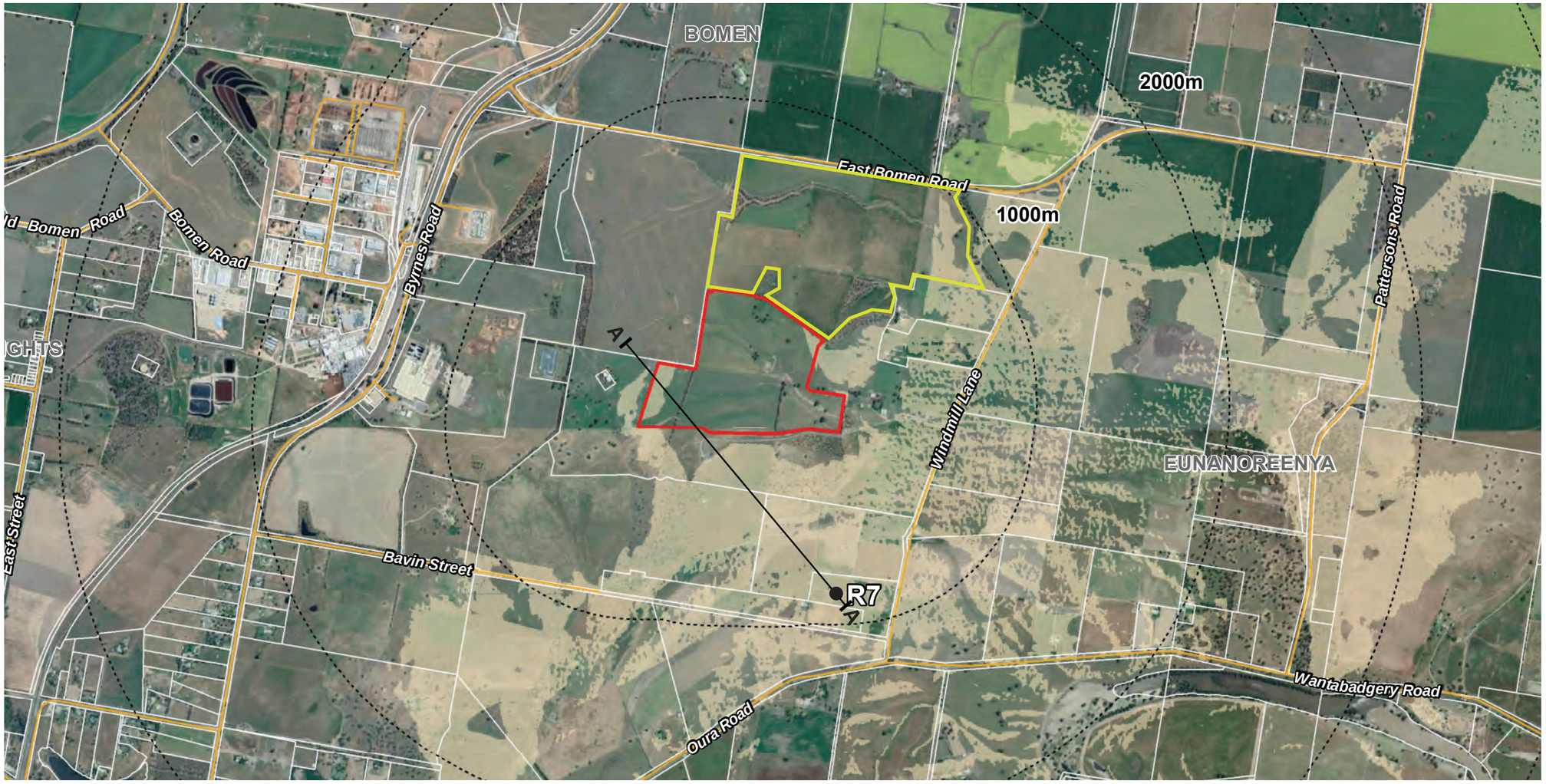
FIGURE 6-5:
Viewshed and cross section from Receptor 6 (R6)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed from house

Distance from site

A-A Cross section from Receptor 7

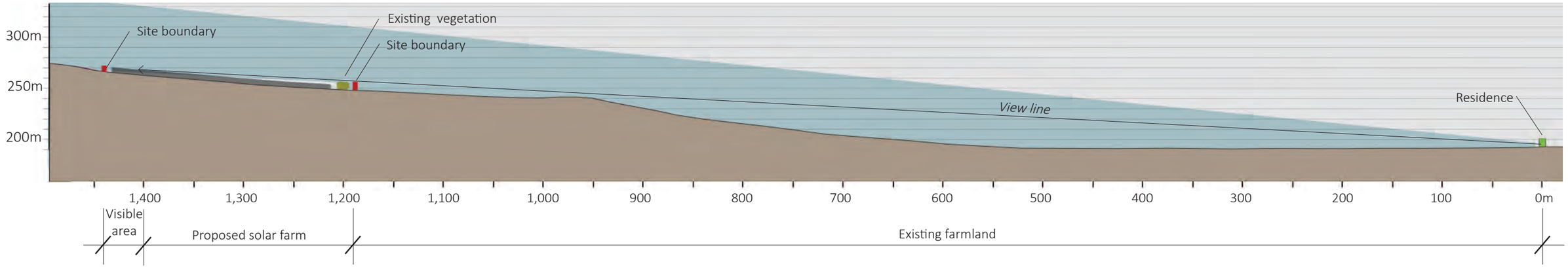


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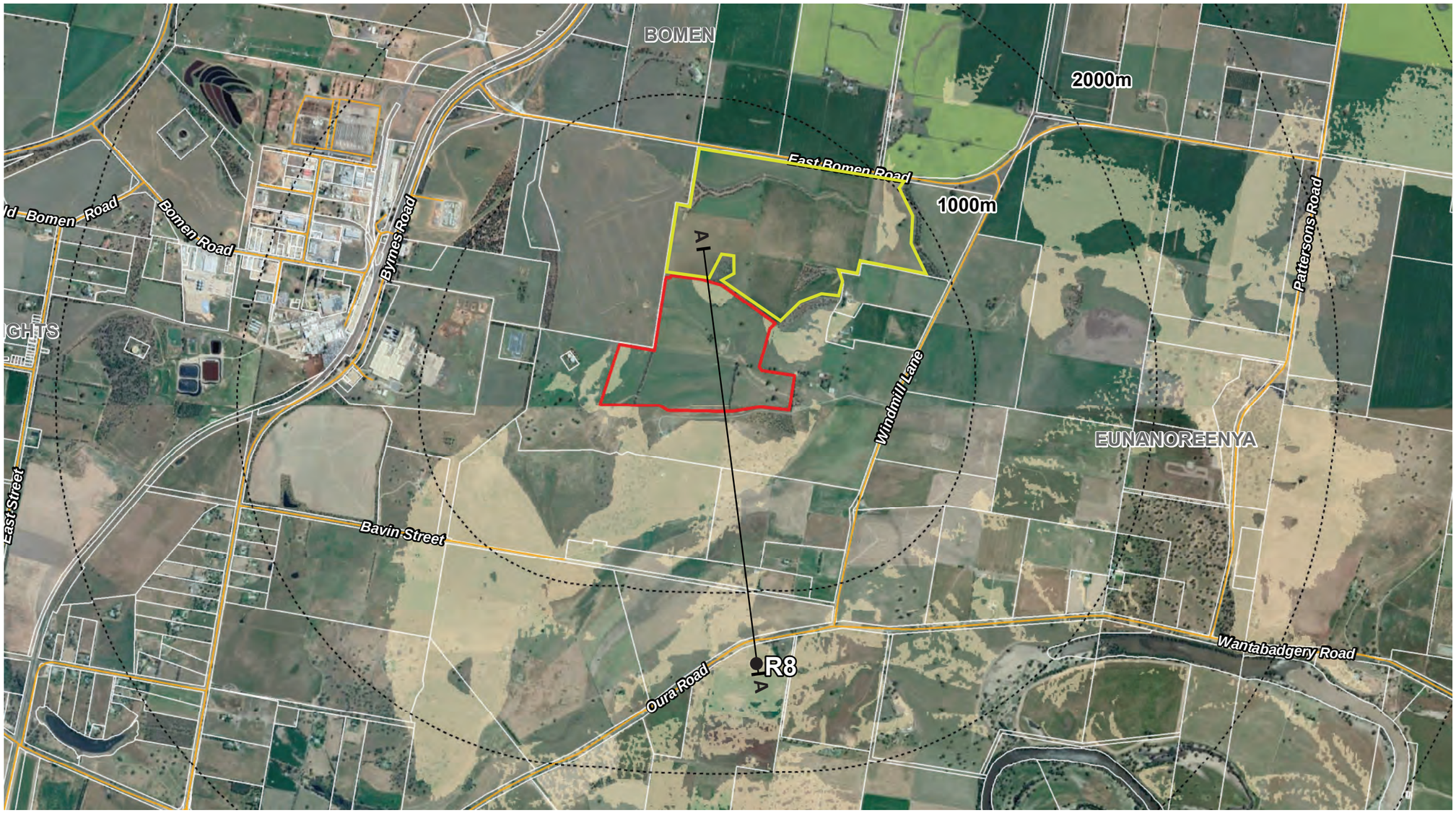
FIGURE 6-6:
Viewshed and cross section from Receptor 7 (R7)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed from house

Distance from site

A-A Cross section from Receptor 8

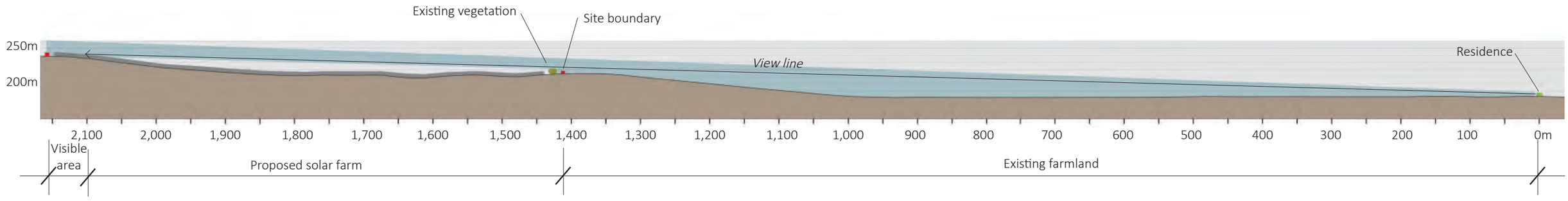


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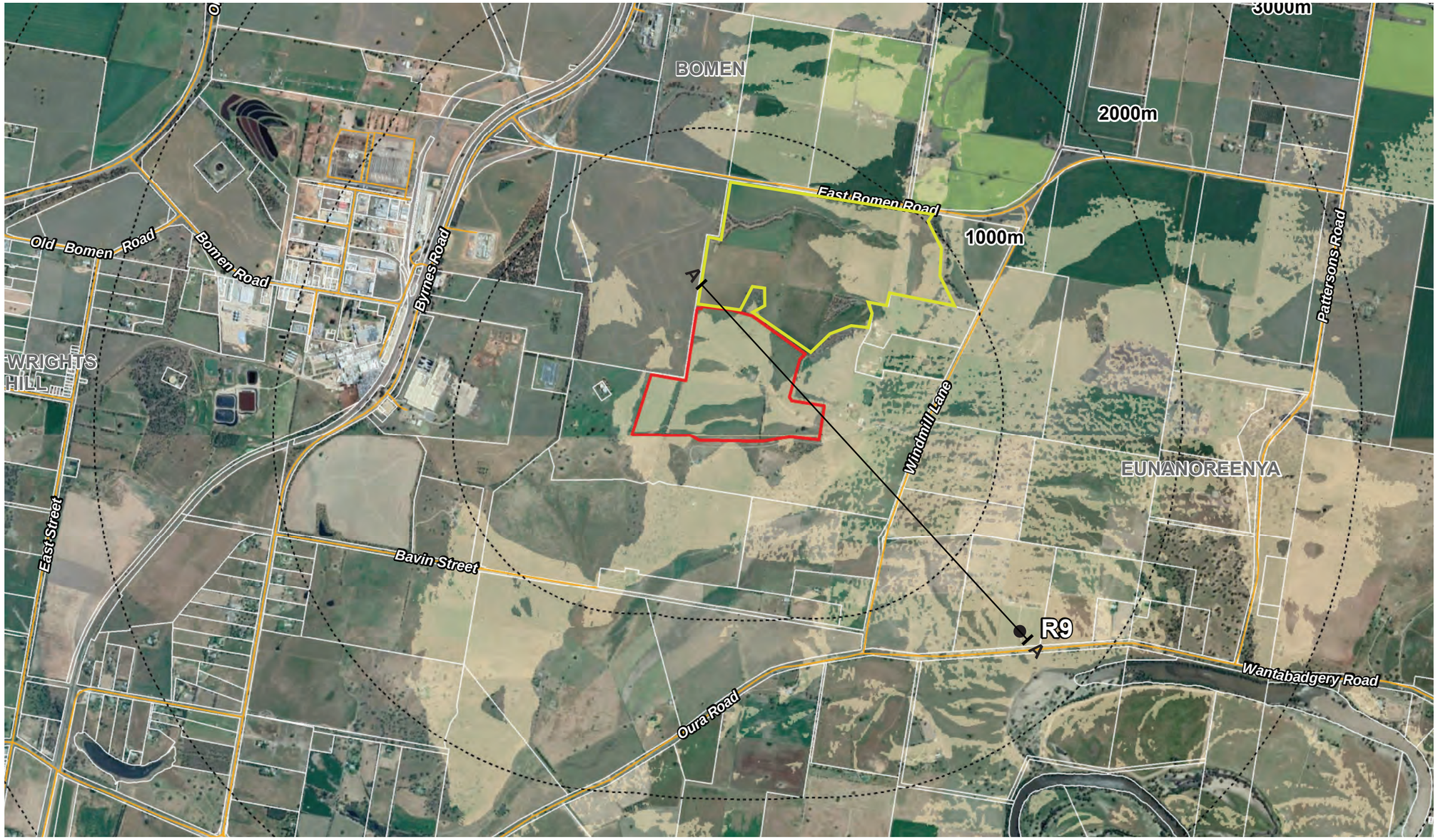
FIGURE 6-7:
Viewshed and cross section from Receptor 8 (R8)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed from house

Distance from site

A-A Cross section from Receptor 9

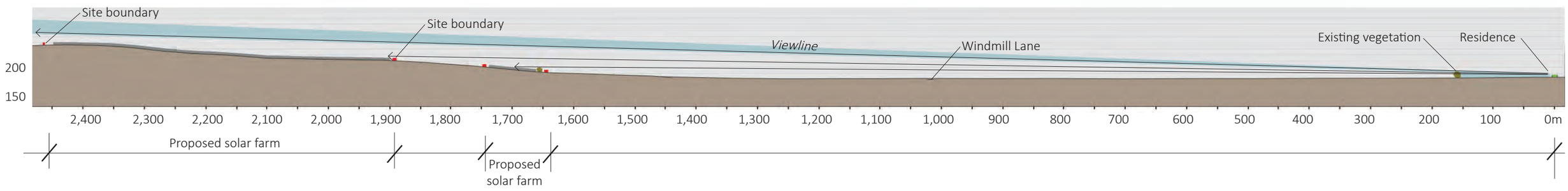


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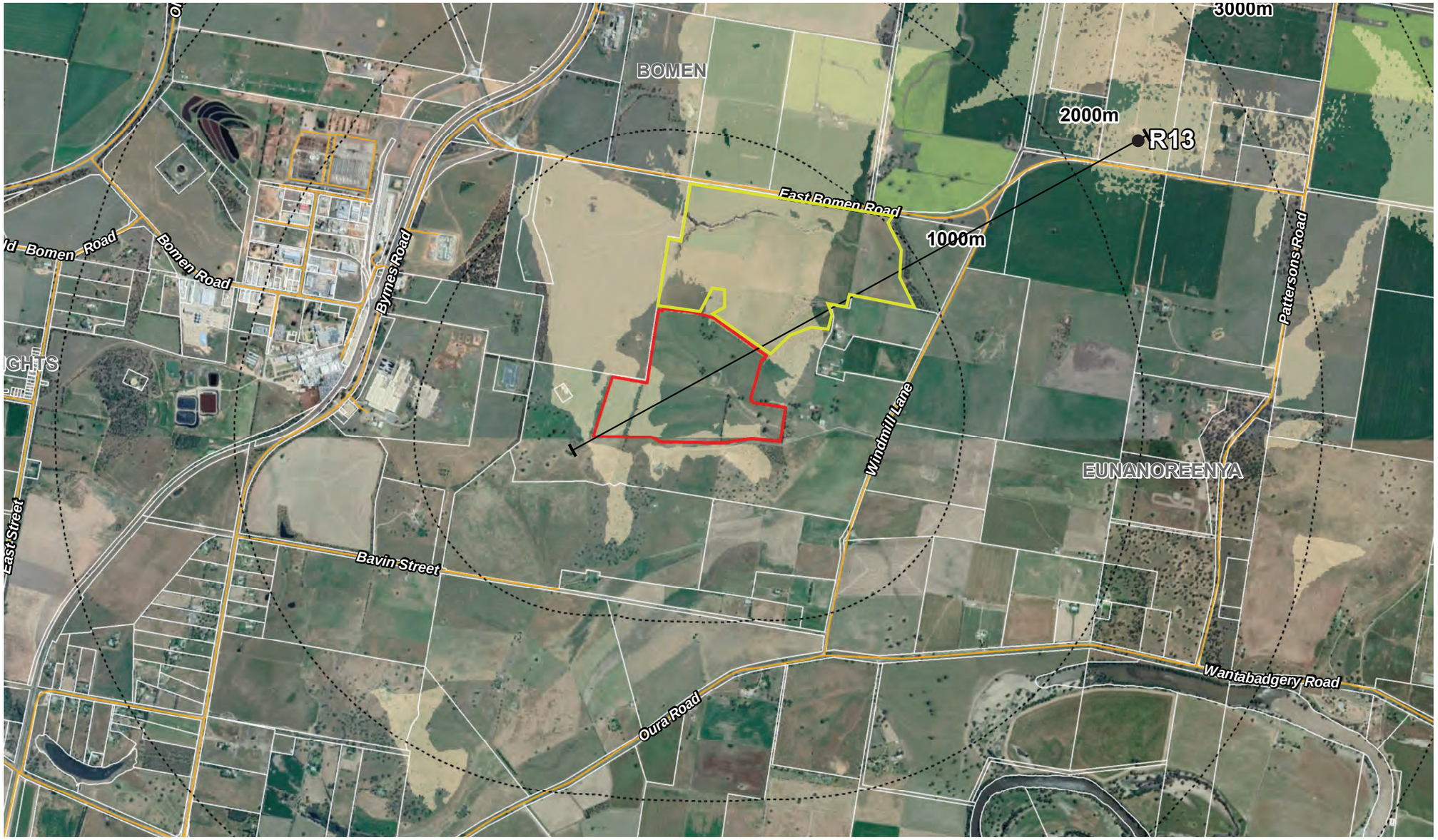
FIGURE 6-8:
Viewshed and cross section from Receptor 9 (R9)



A-A Cross section from Receptor 13

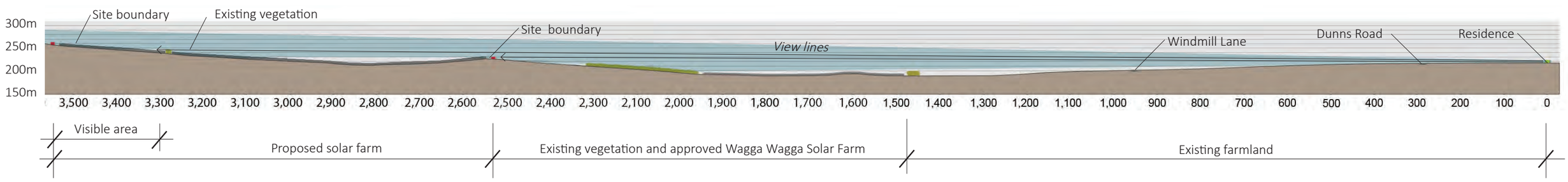


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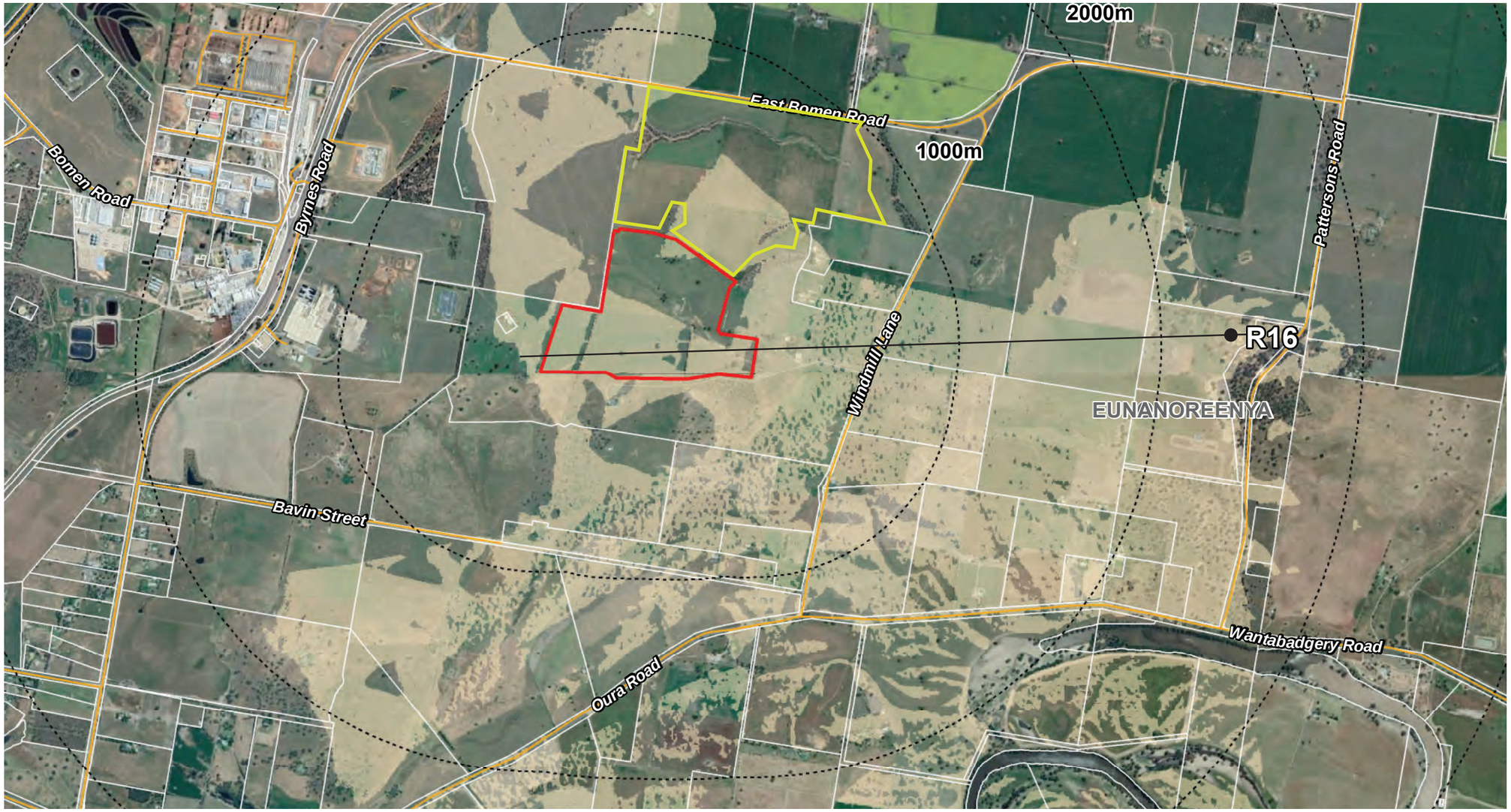
FIGURE 6-9:
Viewshed and cross section from Receptor 13 (R13)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed

Distance from site

A-A Cross section from Receptor 16

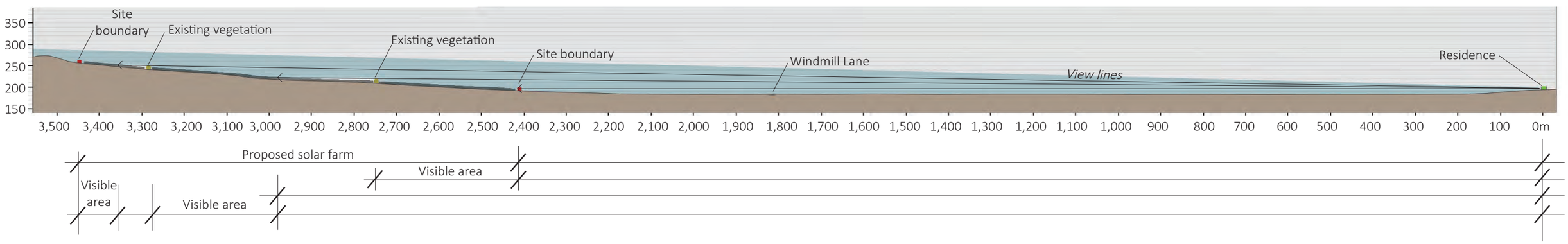


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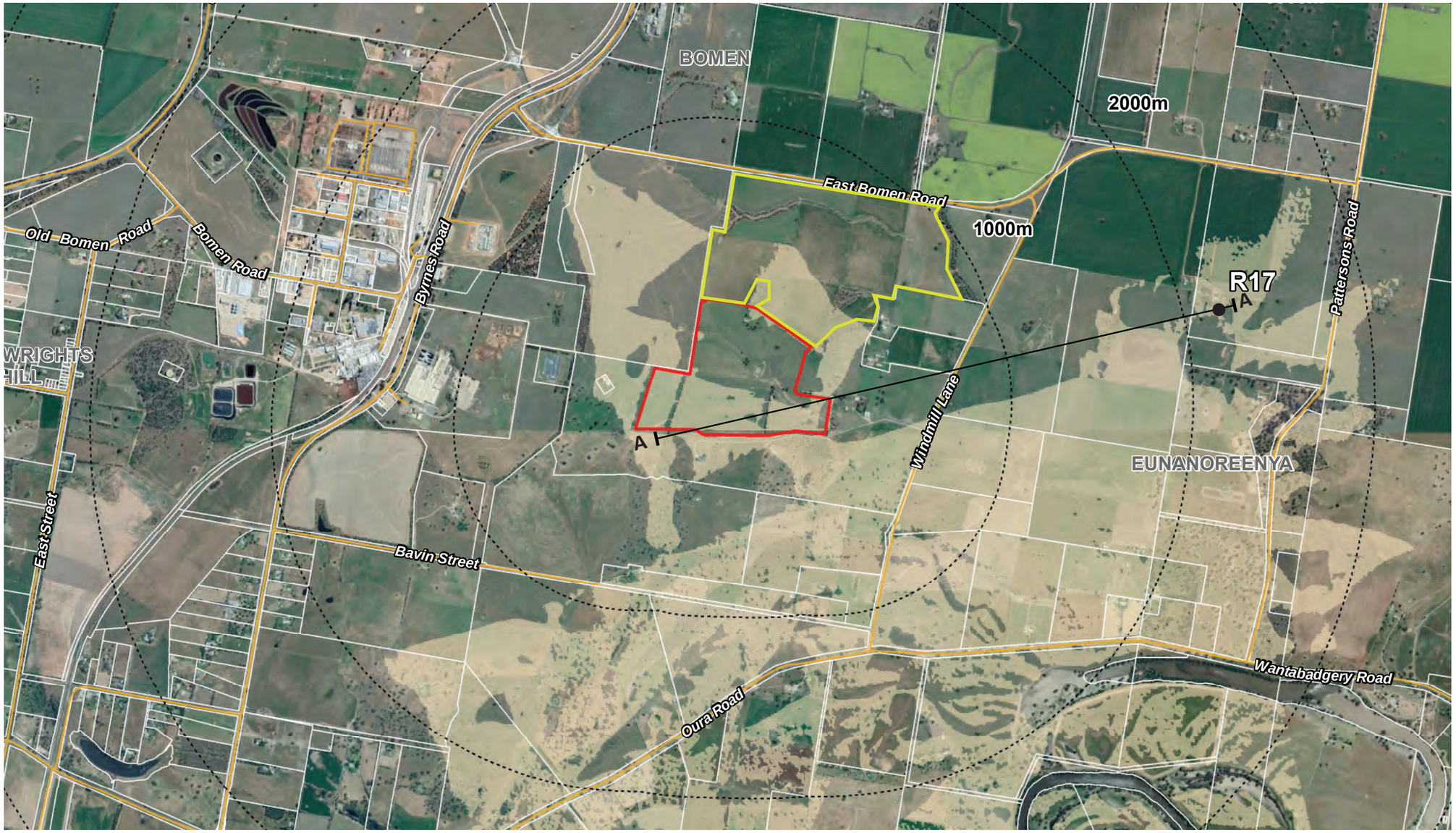
FIGURE 6-10:
Viewshed and cross section from Receptor 16 (R16)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed

Distance from site

A-A Cross section from Receptor 17

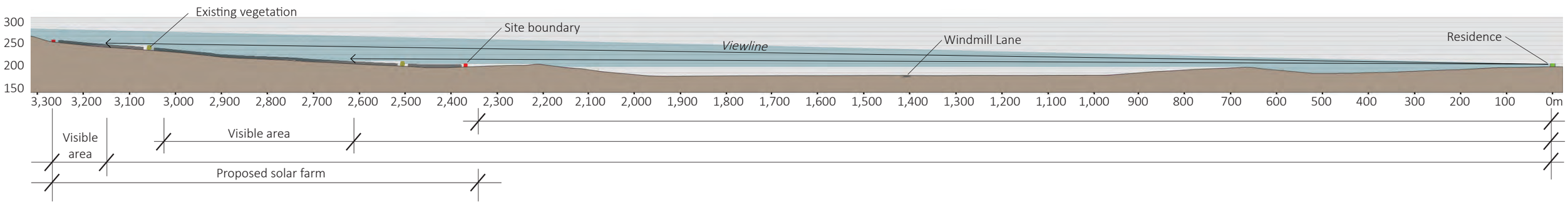


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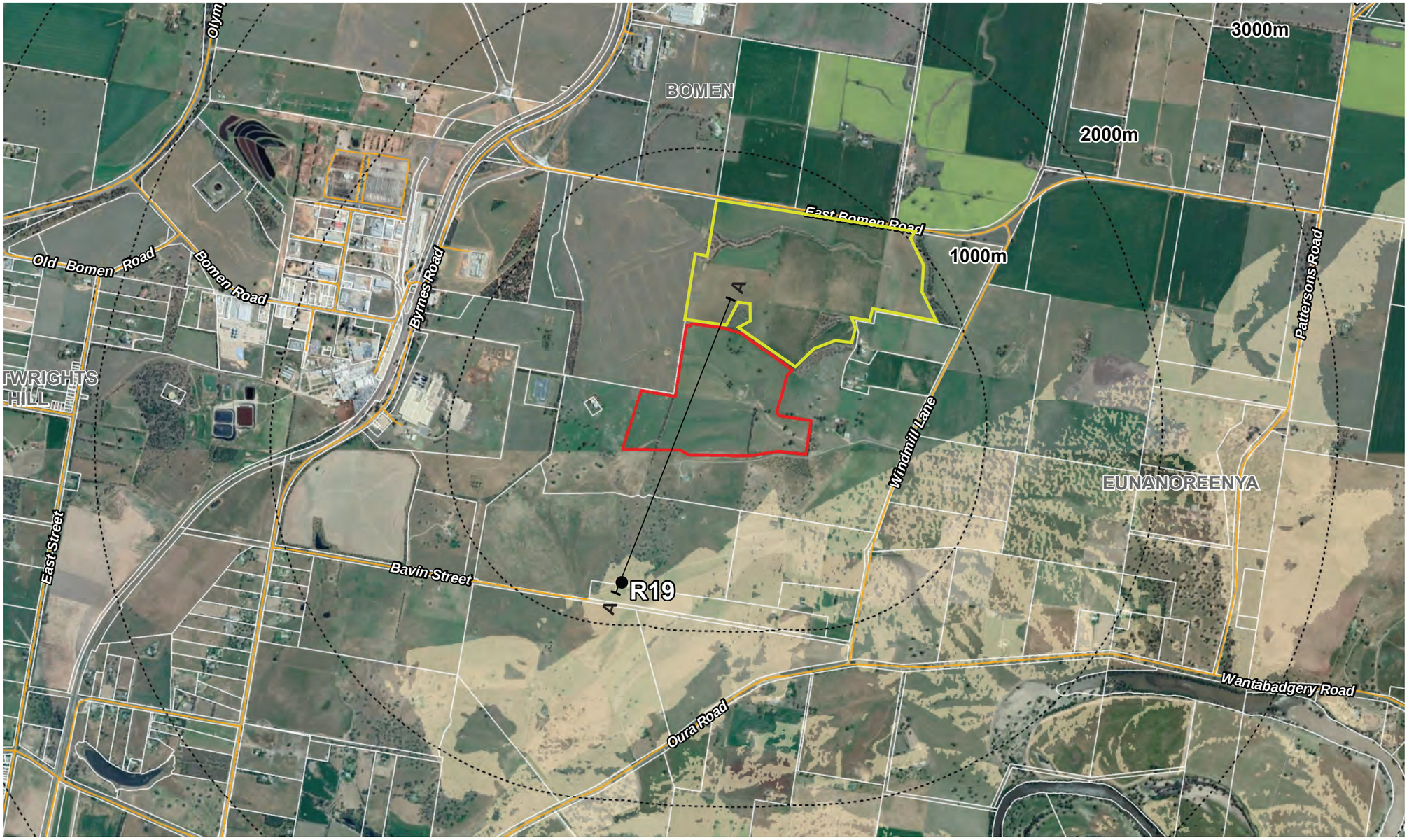
FIGURE 6-11:
Viewshed and cross section from Receptor 17 (R17)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed

Distance from site

A-A Cross section from Receptor 19

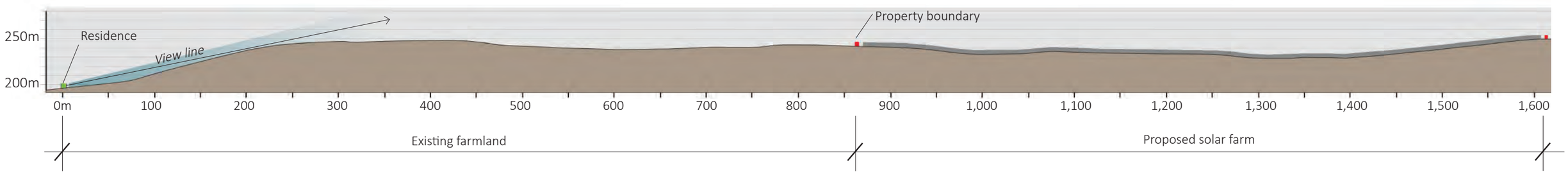


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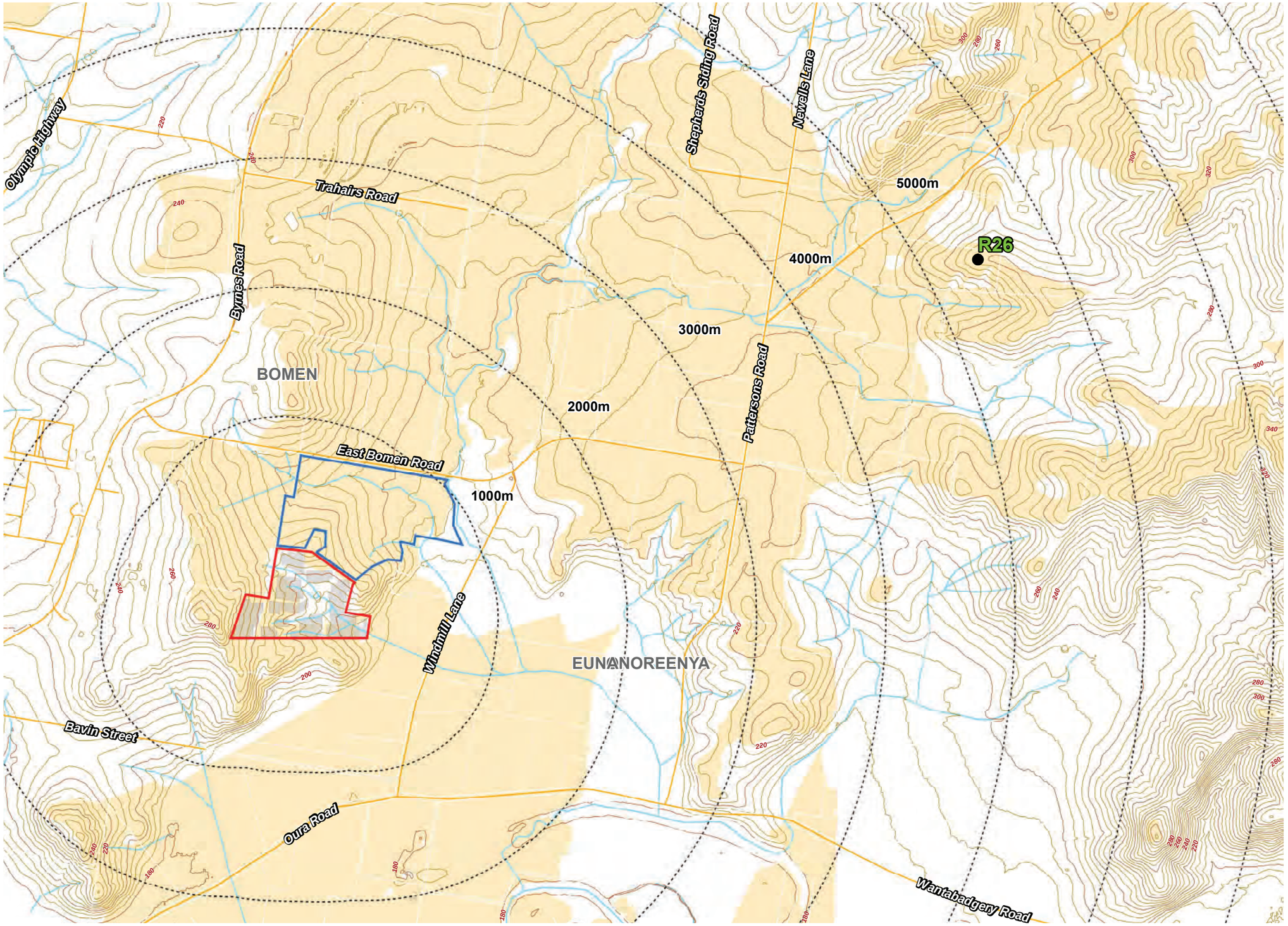
FIGURE 6-12:
Viewshed and cross section from Receptor 19 (R19)



Wagga Wagga Solar Farm (approved)

Wagga Wagga Solar Farm South

Viewpoint location

Viewshed

Distance from site

DRAFT

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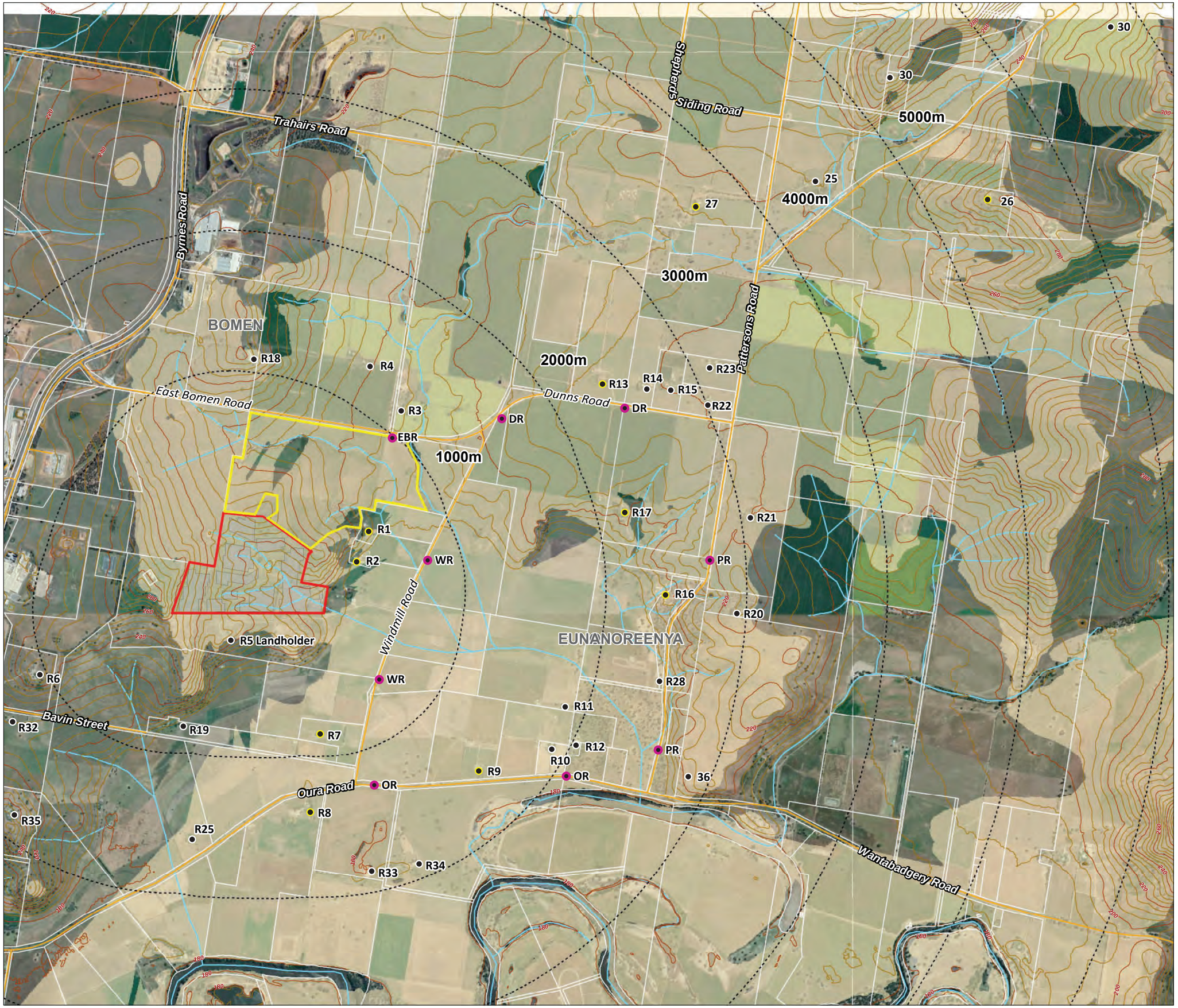
FIGURE 6-13:
Viewshed from Receptor 26 (R26)



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DRAFT

Wagga Wagga Solar Farm South 157 Windmill Road, Bomen

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FIGURE 7-1: Glare Receptor Locations

- Wagga Wagga Solar Farm (approved)
- Wagga Wagga Solar Farm South
- Watercourse
- Contour (20m)
- Contour (5m)
- Distance from the site
- Solar array footprint
- Potential Zone of Visual Influence based on landform
- Residence
- Residence (assessed)
- Road location (assessed)

SOURCE:
Surface analysis: Derived from TARCUTTA and WAGGA WAGGA 2kmx2km 5 metre Resolution Digital Elevation Model 2014
Cadastre: NSW Land and Property Information 2018
Watercourse: GeoScience Australia 2015

N W E S

0 0.25 0.5 0.75 1 1.25
Kilometres

A3 Scale: 1:25,000

Date: 11/11/2019

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EXISTING CONDITIONS:

Plant community types

According to the NSW BioNet Vegetation Map Collection there are two existing Plant Community Types (PCTs) present in the vicinity of the site. These are:

Plant Community Type (PCT)	Dominant species
Blakelys Red Gum- Yellow Box grassy tall woodland of the NSW South-western Slopes Bioregion (277)	*Eucalyptus blakelyi - Eucalyptus melliodora - Eucalyptus bridgesiana / Acacia dealbata / Themeda australis - Poa sieberiana - Bothriochloa macra - Aristida ramosa sens. lat*
White Box- Blakelys Red Gum- White Cypress Pine shrubby woodland on metamorphic hills in the Wagga Wagga- Cootamundra region of the NSW South Western Slopes Bioregion (346)	*Eucalyptus albens - Eucalyptus blakelyi - Callitris glaucophylla - Eucalyptus microcarpa / Dillwynia sericea - Acacia pycnantha - Acacia decora - Acacia verniciflua / Gonocarpus elatus - Cheilanthes sieberi subsp. sieberi - Austrostipa densiflora - Xerochrysum viscosum*

Screening vegetation with a mix of acacias, allocasuarina and eucalypt species provides screening effect.

Existing vegetation

There are existing scattered trees on the site and some corridors of trees which have been planted along field boundaries. These include the following locally native shrubs and tree species:

Acacia doratoxylon, Currawang
Acacia buxifolia, Box-leaved wattle
Callistemon spp.
Dodonaea viscosa, Sticky hop-bush
Eucalyptus blakelyi, Blakely's red gum
Eucalyptus melliodora, Yellow box
Eucalyptus microcarpa, Western grey box
Eucalyptus populnea subsp. bimbil, Bimble box

Screening effect of acacia species

Scattered mature trees on south western field

Planted field boundary trees showing dense form and screening effect

Acacia doratoxylon, Currawang

Mature trees with signs of dieback and rocky outcrops

Planted field boundary trees showing dense form and screening effect

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FIGURE 8-1: EXISTING CONDITIONS

Date: January 2020 Drawn: SR
Job Number: 2018-108 Issue: Rev2

LANDSCAPE STRATEGY:

The landscape plan identifies trees to be retained and removed, and proposes three landscape treatments for the site. These are:

1. Native screen planting
2. Native revegetation
3. Existing trees with supplementary planting.

These landscape treatments are shown on the landscape plan, refer Figure 2-3.

To ensure the suitability of planting for the local conditions, the plant species proposed for these landscape treatments have been selected from the:

- Landscape Guidelines, Recommended Plant Species for the Wagga Wagga Area, Locally Native Trees and Shrubs, Wagga Wagga City Council
- The Flora of Wagga Wagga, A Guide For Revegetation and Restoration, (Waggaflora.com), Charles Sturt University, City of Wagga Wagga Council and NSW Environmental Trust
- Wagga Wagga Native Vegetation Map, ADS-40 Edition 2, Plant Community Types, NSW Office of Environment and Heritage.
- locally native species identified on the site and which appear to be in good health.

Planted trees on the northwestern field boundary

View from driveway northwest across the south eastern field of the site

Track through planted trees on the western site boundary

View east to the site from the adjacent field showing corridors of existing planted trees

LANDSCAPE NOTES:

The following notes provide further detail to support the landscape plan.

Existing vegetation and site preparation

- A star picket or durable temporary fence is to be erected around the perimeter of the drip line of retained trees in accordance with AS4970 Protection of trees on development sites.
- Soil testing and amelioration to be undertaken in accordance with relevant Australian Standards.

Set-out

- All plants to be set out in accordance with the corresponding plant set-out matrix with planting densities as shown.
- Shrubs to be set back a minimum of 1 metre from the property boundary or solar farm fence.
- Trees to be set back 2 metres from the property boundary and a minimum of 12 metres from any solar panel.
- Setbacks are to be maintained from services as shown on the engineering plans.

Planting

- Planting is to be installed at the first feasible planting season i.e. any time outside extreme weather conditions which may include drought, extreme heat and frost.
- All plant stock to be minimum 50 x 50 x 120mm tubes. Plants are to be healthy and well formed with no rootbound stock.
- Individual plants should be planted so the base of the plant is level with the surrounding ground and with a shallow basin around each plant to retain water.
- Install proprietary tree guard sleeves and stakes for each tree and shrub. Install as per manufacturer's specification.
- Install 1 x slow release fertiliser tablet (12 month feeding) per plant as per manufacturers specification.
- All planting areas to have 75mm depth of well composted forest blend / straw mulch.
- Mulch shall be free from deleterious material, including rocks, plastic and any material toxic to plant growth. Mulch shall comply with the requirements of AS 4454 2012: Composts, soil conditioners and mulches.

Establishment and maintenance

- The plant Establishment Period is to be 13 weeks commencing from the completion of the landscape area. This will be followed by a Monitoring Period. The combined length of the Establishment and Monitoring Period will be 24 months.
- Establishment period activities are to include watering, weeding, and replacement of failed or damaged treatments.
- Tree guard sleeves and stakes are to be removed when guarding is deemed to be no longer required by revegetation contractor.

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FIGURE 8-2: LANDSCAPE STRATEGY & LANDSCAPE NOTES

Date: January 2020
Job Number: 2018-108
Drawn: SR
Issue: Rev2

Key:

- **1.** Existing trees with supplementary planting
- **2.** Native revegetation (10 metres wide)
- **2.** Native revegetation
- **3.** Native screen planting (10 metres wide)
- Trees to be retained
- Trees to be removed (dead)
- Trees to be retained (dead)
- Trees to be removed
- Site boundary
- Solar farm fence

N

0m 50m 100m 150m

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FIGURE 8-3: LANDSCAPE PLAN

Date: January 2020
Job Number: 2018-108
Drawn: SR
Issue: Rev2

1. EXISTING TREES WITH SUPPLEMENTARY PLANTING

Where gaps exist in the existing planted areas, supplementary native tree and shrub planting is proposed. This supplementary planting would be a mix of native trees and shrubs.

Plant list:

	Mature height	*Mature spread*	*Flowering*
Trees			
Acacia dealbata, Silver wattle'*	*6-12m*	*8-10m*	*Winter - spring*
Acacia implexa, Hickory Wattle'*	*5-8m*	*5m*	*Summer - autumn*
Acacia pycnantha , Golden wattle'*	*5-8m*	*5-8m*	*Summer - autumn*
Banksia marginata, Silver banksia'*	*5-10m*	*2-5m*	*Autumn - winter*
Shrubs			
Acacia acinacea, Gold Dust Wattle'*	*2m*	*1.5m*	*Winter - spring*
Acacia decora, Western Silver Wattle'*	*2-5m*	*2-5m*	*Winter - spring*
Acacia hakeoides, Hakea Wattle'*	*1.4m*	*3m*	*Winter - spring*
Acacia verniciflua, Varnish Wattle'*	*1-4m*	*2-4m*	*Winter - spring*
Bursaria spinosa, Blackthorn'*	*2-4m*	*2-4m*	*Summer*
Dodonaea viscosa subsp.cuneata, Hop bush'*	*2-3m*	*2-3m*	*Winter - spring*
*Eremophila deserti, Turkey Bush**	*2-4m*	*2-4m*	*Winter - summer*

** from the Wagga Wagga City Council Landscape Guidelines, Locally native trees and shrubs suitable for planting under DCP 2010 Section 5.3, plant list p12-15*

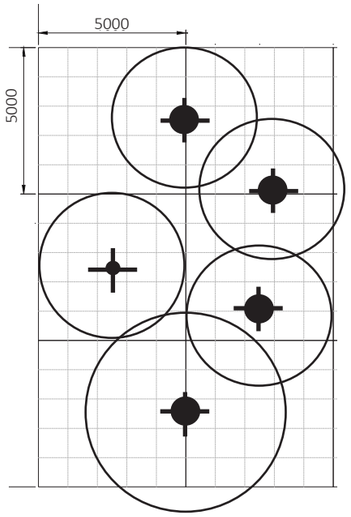
' from www.Waggaflora.com (based on the flora of the Graham Centre Biodiversity Nursery, Charles Sturt University, 2019)

Plant set-out matrix

Additional plants to be installed where there is a 5x5 metre gap in the canopy of existing planted area and a visual break is apparent.

Specification notes

- Individual planting holes to be excavated, backfilled with ameliorated site soil and mulch to be applied across disturbed area.
- New plants to achieve an overall ratio of 80% shrubs and 20% trees.



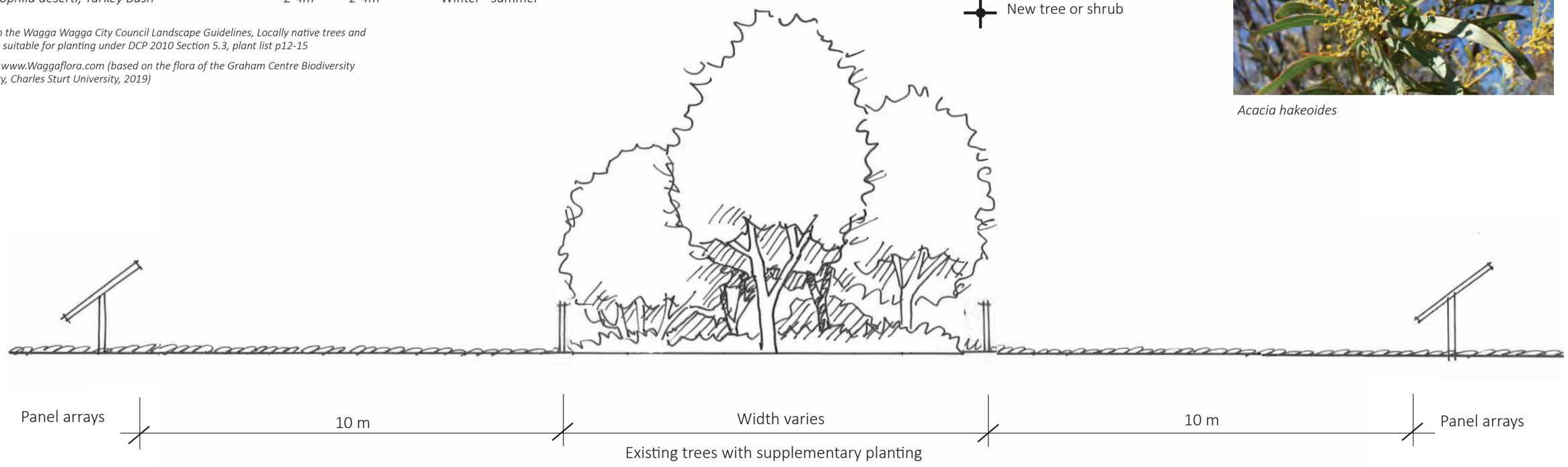
KEY

Existing tree or shrub

New tree or shrub

Acacia doratoxylon, Currawang

Acacia hakeoides



A - A Indicative cross section - Existing trees with supplementary planting

Scale: 0m 1 2 5m

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FIGURE 8-4: EXISTING TREES WITH SUPPLEMENTARY PLANTING

Date: January 2020 Drawn: SR
Job Number: 2018-108 Issue: Rev2

2. NATIVE REVEGETATION AREAS

Revegetation areas will include a mix of locally native trees and shrubs including species to provide habitat for native wildlife. This mix of trees will create a framework for natural regeneration.

Plant list:

	Mature height	*Mature spread*	*Flowering*
Trees			
Acacia dealbata, Silver wattle'*	*6-12m*	*8-10m*	*Winter - spring*
Acacia doratoxylon, Currawang'*	*8-10m*	*5-8m*	*Winter - spring*
Acacia pycnantha , Golden wattle'*	*5-8m*	*5-8m*	*Summer - autumn*
Banksia marginata, Silver banksia'*	*5-10m*	*2-5m*	*Autumn - winter*
*Eucalyptus albens, White box**	*20-15m*	*10-20m*	*Spring - summer*
*Eucalyptus blakelyi, Blakey's red gum**	*20-15m*	*10-20m*	*Spring - summer*
*Eucalpytus polyanthemos, Red box**	*15-25m*	*5-15m*	*Summer - spring*
Shrubs			
Acacia acinacea, Gold Dust Wattle'*	*2m*	*1.5m*	*Winter - spring*
Acacia decora, Western Silver Wattle'*	*2-5m*	*2-5m*	*Winter - spring*
Acacia hakeoides, Hakea Wattle'*	*1.4m*	*3m*	*Winter - spring*
Acacia verniciflua, Varnish Wattle'*	*1-4m*	*2-4m*	*Winter - spring*
Bursaria spinosa, Blackthorn'*	*2-4m*	*2-4m*	*Summer*
Dodonaea viscosa subsp.cuneata, Hop bush'*	*2-3m*	*2-3m*	*Winter - spring*
*Eremophila deserti, Turkey Bush**	*2-4m*	*2-4m*	*Winter - summer*
Groundcovers			
Lomandra multiflora, Many-flowered mat-rush	*0.3m*	*0.3m*	*Winter-spring*
Dianella revoluta, Spreading flax-lily	*0.3m*	*0.3-0.5m*	*Winter-spring*

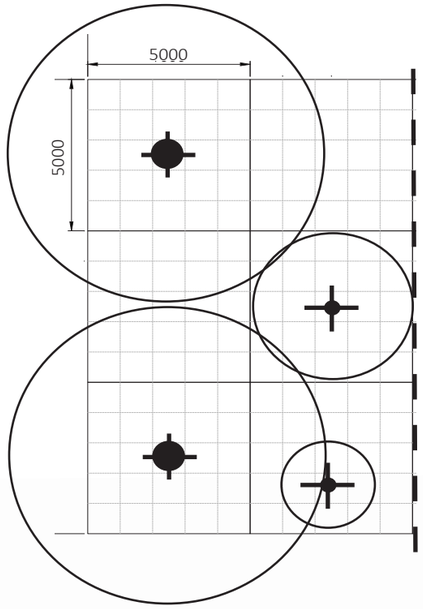
** from the Wagga Wagga City Council Landscape Guidelines, Locally native trees and shrubs suitable for planting under DCP 2010 Section 5.3, plant list p12-15*

' from www.Waggaflora.com (based on the flora of the Graham Centre Biodiversity Nursery, Charles Sturt University, 2019)

Eucalyptus albens, White box

Plant set-out matrix

The setout will intermix trees and shrubs in an informal layout. Larger trees to be setback from the solar farm fence.



Banksia marginata, Silver banksia

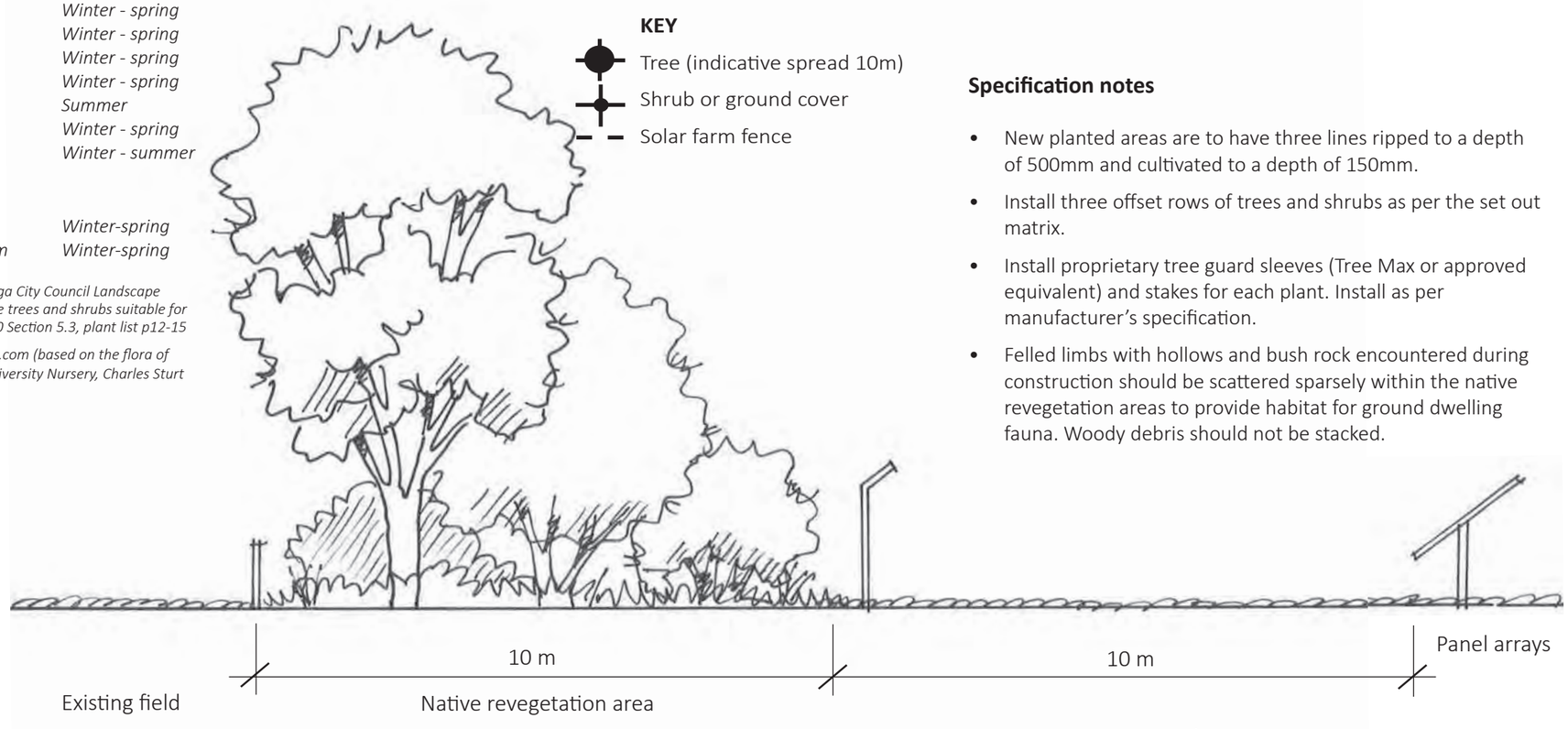
Eremophila deserti, Turkey bush

KEY

- Tree (indicative spread 10m)
- Shrub or ground cover
- Solar farm fence

Specification notes

- New planted areas are to have three lines ripped to a depth of 500mm and cultivated to a depth of 150mm.
- Install three offset rows of trees and shrubs as per the set out matrix.
- Install proprietary tree guard sleeves (Tree Max or approved equivalent) and stakes for each plant. Install as per manufacturer's specification.
- Felled limbs with hollows and bush rock encountered during construction should be scattered sparsely within the native revegetation areas to provide habitat for ground dwelling fauna. Woody debris should not be stacked.



B - B Indicative cross section - Native revegetation areas

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FIGURE 8-5: NATIVE REVEGETATION AREAS

Date: January 2020 Drawn: SR
Job Number: 2018-108 Issue: Rev2

3. NATIVE SCREEN PLANTING

A mix of native trees and shrubs with a dense and compact habbit have been selected to provide a maximum screening effect.

The following plant list includes a number of 'pioneer species' which should establish quickly and form an effective visual screen in the short term.

While some of these species are relatively short lived (7-12 years), they will disperse seed and new plants will regenerate so that a self-sustaining vegetation screen is maintained in the long term.

Plant list:	*Mature height*	*Mature spread*	*Flowering*
Trees			
Acacia dealbata, Silver wattle'*	*6-12m*	*8-10m*	*Winter - spring*
Acacia doratoxylon, Currawang'*	*8-10m*	*5-8m*	*Winter - spring*
Acacia implexa, Hickory Wattle'*	*5-8m*	*5m*	*Summer - autumn*
*Acacia leucoclada, Northern silver wattle **	*5-8m*	*5m*	*WInter - spring*
Acacia pycnantha , Golden wattle'*	*5-8m*	*5-8m*	*Summer - autumn*
Allocasuarina verticalla, Drooping she-oak	*3-7m*	*3-7m*	*Winter - spring*
Banksia marginata, Silver banksia'*	*5-10m*	*2-5m*	*Autumn - winter*
Shrubs			
Acacia acinacea, Gold Dust Wattle'*	*2m*	*1.5m*	*Winter - spring*
Acacia hakeoides, Hakea Wattle'*	*1.4m*	*3m*	*Winter - spring*
Acacia verniciflua, Varnish Wattle'*	*1-4m*	*2-4m*	*Winter - spring*
Bursaria spinosa, Blackthorn'*	*2-4m*	*2-4m*	*Summer*
Dodonaea viscosa subsp.cuneata, Hop bush'*	*2-3m*	*2-3m*	*Winter - spring*
*Eremophila deserti, Turkey Bush**	*2-4m*	*2-4m*	*Winter - summer*

Bursaria spinosa, Blackthorn

** from the Wagga Wagga City Council Landscape Guidelines, Locally native trees and shrubs suitable for planting under DCP 2010 Section 5.3, plant list p12-15*

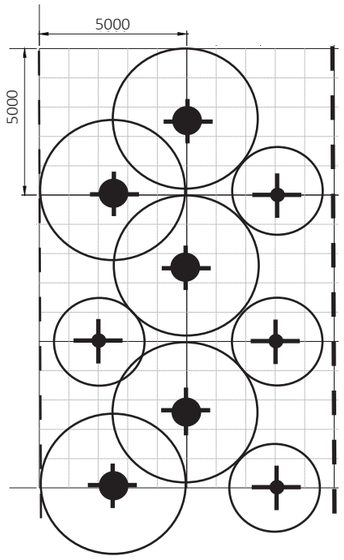
' from www.Waggaflora.com (based on the flora of the Graham Centre Biodiversity Nursery, Charles Sturt University, 2019)

Plant set-out matrix

Trees and shrubs will be staggered to maximise the screening effect of the proposed planting.

Specification notes

- New planted areas are to have three lines ripped to a depth of 500mm and cultivated to a depth of 150mm.
- Install three offset rows of trees and shrubs as per the set out matrix.
- Install proprietary tree guard sleeves (Tree Max or approved equivalent) and stakes for each plant. Install as per manufacturer's specification.

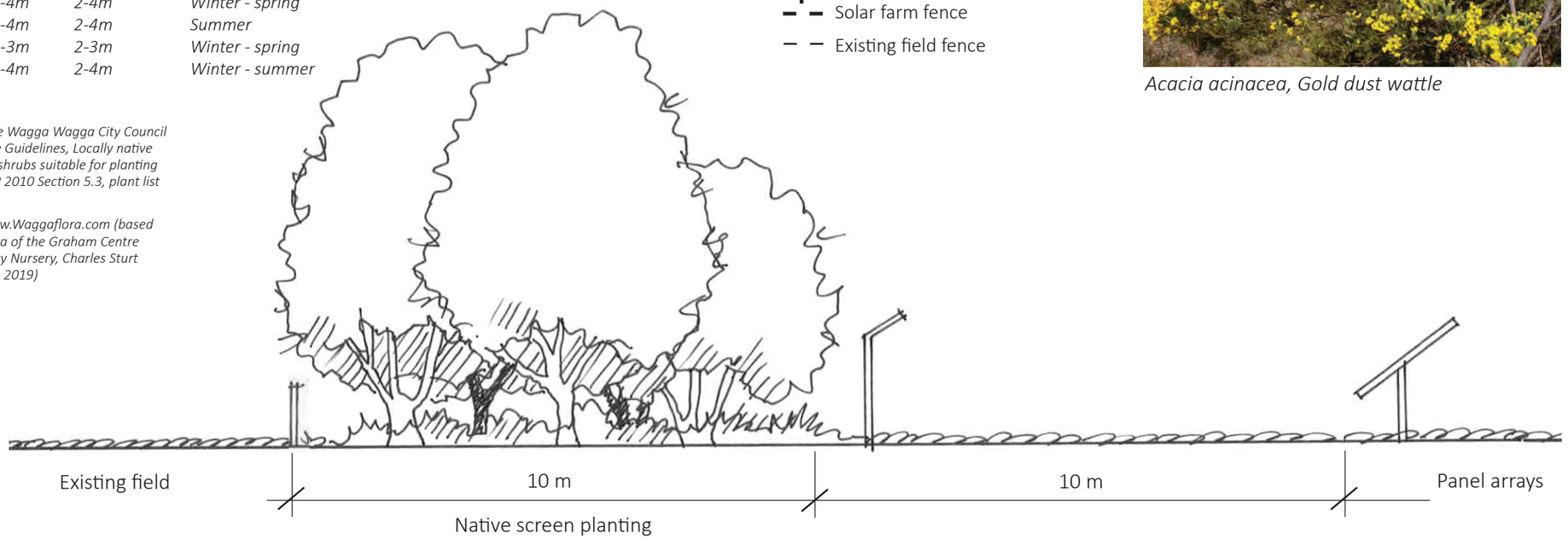


KEY

- Tree (indicative spread 5m)
- Shrub (indicative spread 2.5m)
- Solar farm fence
- Existing field fence

Allocasuarina sp.

Acacia acinacea, Gold dust wattle



C - C Indicative cross section, Native screen planting

Scale: 0m 1 2 5m

FIGURE 8-6: NATIVE SCREEN PLANTING

Date: January 2020 Drawn: SR
Job Number: 2018-108 Issue: Rev2

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Attachment A – Principles of visual impact

The following principles generally apply the consideration of visual impacts:

- In general, scenic preference studies indicate that views to water and natural elements are preferred over urban scenes, mountains and hills are preferred over flat land.
- Views with a high proportion of attractive features (such as the ocean or mountains) are considered to have higher scenic quality and are more important to protect.
- Views with attractive skyline features and views which include focal points are preferred.
- Views which have structure and legibility (foreground, midground, background, focal points, etc.) are preferred over poorly structured views.
- views that include diversity and a range of visual interests are preferred over simple outlooks.
- Ridgelines, which enclose views, and are typically more visually prominent warrant greater protection
- There is less visual impact when the element: does not rise above the skyline, is viewed against a backdrop, is viewed at a greater distance, and / or has similar visual characteristics (line, shape, form, texture, colour) as other elements within the view.
- Panoramic views with a number of distinctive elements are more attractive and desirable than narrow view corridors or views of single elements.
- Wider views are typically more diverse and can consequently accommodate more change. It is not reasonable to protect all areas of a panoramic view.
- Viewing distances are an important factor affecting the magnitude of change – the greater the distance from the viewpoint, the smaller an object appears, the greater the field of view, and the less discernible is the detail (colours, textures, etc).
- Viewpoints typically have primary views in one direction (e.g. to an attractive or distinctive feature) and secondary views in other directions. Primary views are typically of greater value than secondary views.
- Views from public spaces (streets, lookouts, parks etc.) assume greater importance than private residential views. As a general principle, nobody has a 'right' to a view.
- Diversity is generally preferred over uniformity, and heritage over modernity, but these need to be balanced with preferences for consistency and coherence of built elements, which are also valued.
- Discordant elements which contrast with their otherwise-attractive settings are often regarded as having a detrimental impact on amenity.

Attachment B – Viewing distances and solar farms

*View from Trahairs Road to Bomen Solar Farm, 50mm at 1 km (under construction, November 2019)**

View from Trahairs Road to Bomen Solar Farm, at 1 km zoomed detail (under construction, November 2019)

11.1. Short and mid-range views

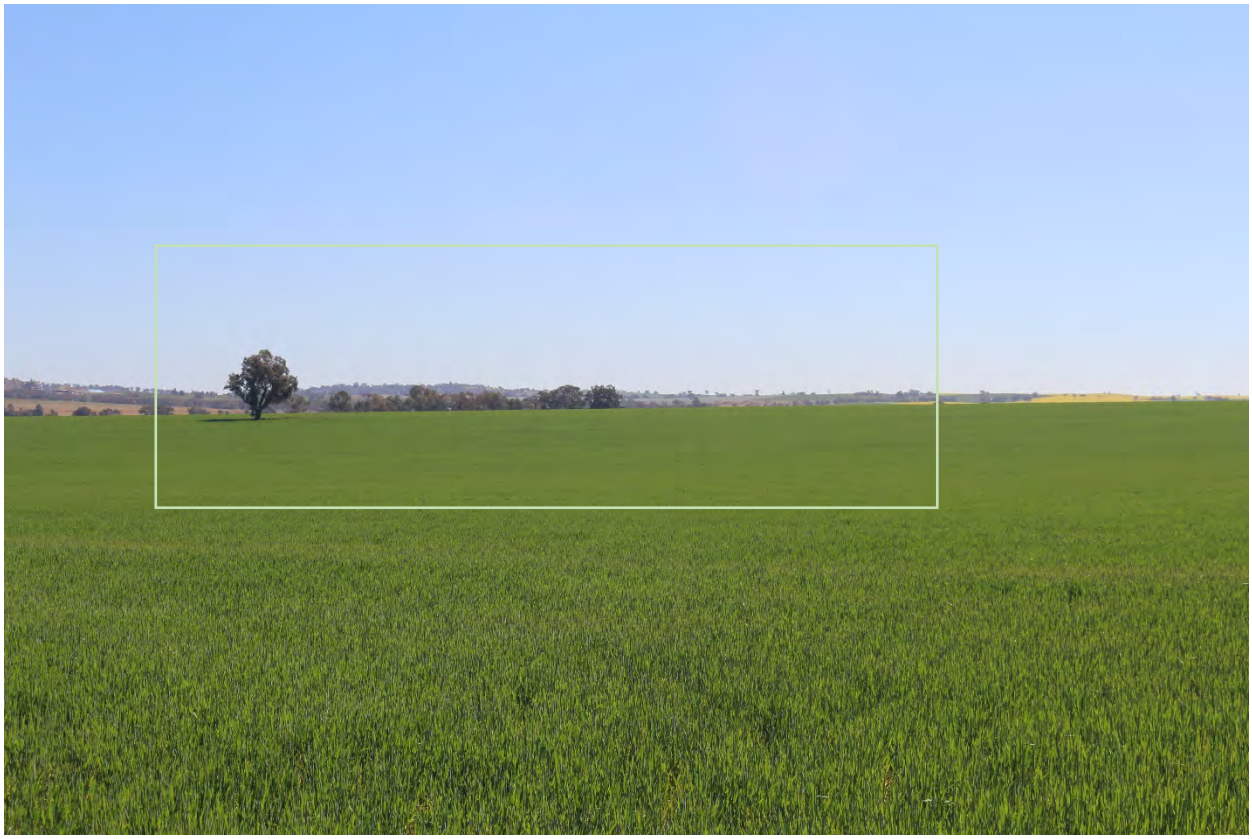
These views include both constructed and partially constructed sections of the solar farm viewed at a distance of one kilometre. These photographs demonstrate that the individual panels cannot be differentiated at this distance, and the solar farm appears as a block of colour.

View from East Bomen Road to Bomen Solar Farm, 50mm at 1.5 km (under construction, November 2019)

View from East Bomen Road to Bomen Solar Farm, zoomed detail (under construction, November 2019)

These views include both constructed and partially constructed sections of the solar farm viewed at a distance of approximately 1.5 kilometres. These photographs demonstrate that the individual panels cannot be differentiated at this distance, and the solar farm appears as a block of colour.

The constructed part of the solar farm is in the distance and has a dark grey colour. The under-construction area of the site is located in the middle ground and appears lighter grey as the posts have been installed but the panels have not been installed on the trackers.



View from 172 Pattersons Road to Bomen Solar Farm, 50mm at 2.5 km (under construction, September 2019)

View from 172 Pattersons Road to Bomen Solar Farm, zoomed detail (under construction, September 2019)

This view includes both constructed and partially constructed sections of the solar farm viewed at a distance of approximately 2.5 kilometres. This photograph illustrates that the individual panels cannot be differentiated at this distance, and the solar farm appears as a block of colour.

11.2. Distant views

View from 494 Pattersons Road to Bomen Solar Farm, 50mm at 3 km (under construction, September 2019)

View from 494 Pattersons Road to Bomen Solar Farm, zoomed detail (under construction, September 2019)

View from Oura Road to Bomen Solar Farm, 50mm at 4-5 km (under construction, November 2019)

View from Oura Road to Bomen Solar Farm, zoomed detail (under construction, November 2019)

These views include both constructed and partially constructed sections of the solar farm at a distance of about 3 - 5 kilometres. They demonstrate that the panels cannot be differentiated at this distance, and the solar farm appears as a block of colour, which recedes into the background of the view. As the form of the solar farm does not contrast with the surrounding landscape, it is difficult to identify in the landscape.

View from Byrnes Road to Bomen Solar Farm (November 2019)

View from Byrnes Road to Bomen Solar Farm (November 2019)

These images to the northern edge of the Bomen Solar Farm, illustrates the overlapping of panel arrays at short range.

Attachment C – Solar farms and glare

11.3. Types of solar farms

There are currently two types of solar technology used in solar farms, photovoltaic and thermal. Whilst solar thermal technology harnesses heat using lenses and reflectors to heat fluid which drives a turbine, photovoltaic technology converts sunlight directly into electricity. Photovoltaic cells are designed to absorb not reflect sunlight.

Photovoltaic solar panels can be supported on a fixed frame or have a tracking system. The use of a tracking system, which moves the panels so that they follow the trajectory of the sun, reduces the potential for an incidence angle which can cause a glare effect. The proposed solar farm is a single axis tracking system.

Common misconceptions about the glare potential of solar farms may stem from an unfamiliarity with the difference between thermal technology, fixed frame photovoltaic and tracking photovoltaic systems.

11.4. Solar farms and glare

The amount of light reflected from a Photovoltaic module depends on the amount of sunlight hitting the surface, as well as the surface reflectivity. The amount of sunlight interacting with the Photovoltaic module will vary based on geographic location, time of year, cloud cover, and Photovoltaic module orientation.

The proposed Photovoltaic modules would comprise a silicon solar cell overlayed by tempered glass and held in an anodised aluminium alloy frame. For glass, reflection is mainly specular whereas metals often combine specular reflection with diffuse reflection (City of London, 2017). Glare caused by photovoltaic modules are therefore generally a result of specular reflection from the glass surface of the panel.

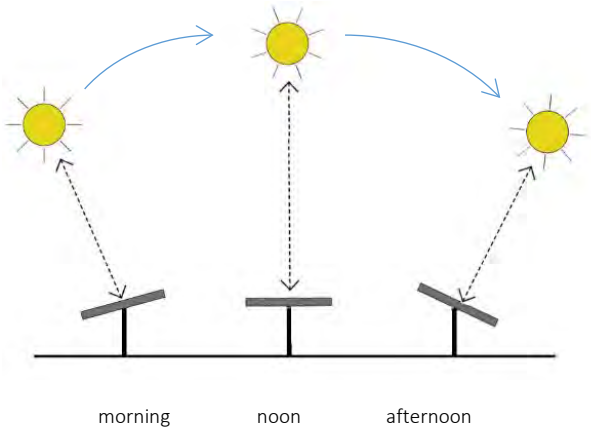
The sun changes its east-west orientation throughout the day, and the sun's north-south position in the sky changes throughout the year. The sun reaches its highest position at noon on the Summer Solstice (21 December in the Southern Hemisphere) and its lowest position at sunrise and sunset on the Winter Solstice (21 June in the Southern Hemisphere).

Due to this constant movement, the area of the solar farm reflecting at any one time would move throughout the year, as would the time and duration.

Photovoltaic modules (solar panels) are positioned on galvanised trackers. While galvanised materials can initially be reflective, and may cause a slight glare effect, the galvanised finish will develop a zinc patina over the course of approximately six months in external conditions and will become dull and not have a further risk of glare.

11.5. Photovoltaic module tracking

The project proposes a single axis tracking system. The horizontal single axis tracking system rotates the PV panels across an east to west arc, following the sun's trajectory across the sky. The purpose of the tracking system is to optimise solar energy collection by orienting the photovoltaic module towards the sun as it moves.



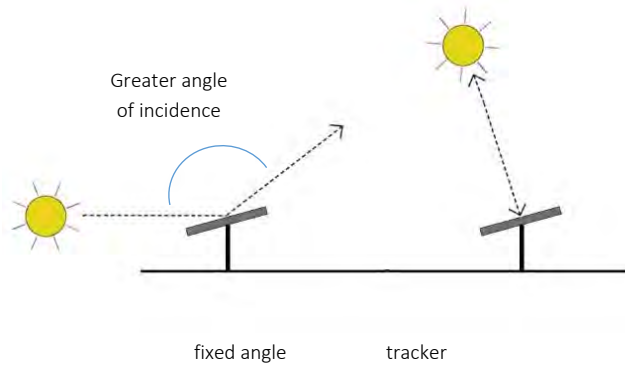
Single axis tracking system

Throughout the day, as the panels rotate to follow the sun, the angle of incidence (angle of solar rays) is such that any reflection is directed towards the sky.

However, a tracking system has a maximum angle of rotation. Once the tracking mechanism reaches its maximum angle, the systems will begin 'backtracking'.

During the 'backtracking' procedure the tracking system begins to rotate away from the sun to reduce shadow cast on adjacent PV panels. This phase occurs for a short duration that varies throughout the year.

While ‘backtracking’ the angle of incidence increases. This creates the potential for a temporary, short duration, glare effect. To achieve a glare effect on a receptor it must be located in line with this angle of incidence (angle of the solar ray on the panel).



Backtracking

Before the solar farm is operational, the panel arrays are stowed in a fixed position. During this time there will also be higher angles of incidence (angle of the solar ray on the panel). This creates the potential for a temporary glare effect. The effect will only occur if the angle of incidence angles the suns rays towards the receptor.

Attachment D – Glare Gauge results

ForgeSolar
PV planning & glare analysis

GlareGauge Glare Analysis Results

Site Configuration: WWSFS - Arrays 1 - 4 1_2m 60deg resting

Project site configuration details and results.

Created **Dec. 12, 2019 9:24 p.m.**
Updated **Dec. 13, 2019 12:09 a.m.**
DNI **varies** and peaks at **1,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC10**
Site Configuration ID: 34279.4392

Summary of Results No glare predicted!

PV name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	0	0	-
PV array 2	SA tracking	SA tracking	0	0	-
PV array 3	SA tracking	SA tracking	0	0	-
PV array 4	SA tracking	SA tracking	0	0	-

Component Data

PV Array(s)

Name: PV array 1
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.077131	147.428554	257.13	1.20	258.33
2	-35.077714	147.428571	255.62	1.20	256.82
3	-35.077705	147.428321	258.05	1.20	259.25
4	-35.078652	147.428280	257.06	1.20	258.26
5	-35.078641	147.427953	261.40	1.20	262.60
6	-35.079532	147.427932	258.58	1.20	259.78
7	-35.079549	147.429573	242.78	1.20	243.98
8	-35.078658	147.429611	243.41	1.20	244.61
9	-35.078642	147.429815	241.60	1.20	242.80
10	-35.078346	147.429811	242.01	1.20	243.21
11	-35.078340	147.430118	239.11	1.20	240.31
12	-35.077688	147.430094	240.41	1.20	241.61
13	-35.077666	147.430421	237.21	1.20	238.41
14	-35.077117	147.430410	238.64	1.20	239.84
15	-35.077122	147.429278	250.33	1.20	251.53
16	-35.076836	147.429230	251.65	1.20	252.85
17	-35.076867	147.428667	256.84	1.20	258.04
18	-35.077133	147.428629	256.43	1.20	257.63

Name: PV array 2
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.079560	147.430364	237.25	1.20	238.45
2	-35.078744	147.430364	236.97	1.20	238.17
3	-35.078744	147.431287	228.94	1.20	230.14
4	-35.078292	147.431262	228.99	1.20	230.19
5	-35.078292	147.432549	221.15	1.20	222.35
6	-35.078836	147.432560	221.41	1.20	222.61
7	-35.078845	147.431294	229.19	1.20	230.39
8	-35.078994	147.431294	229.58	1.20	230.78
9	-35.079064	147.431745	226.61	1.20	227.81
10	-35.079556	147.431766	228.21	1.20	229.41

Name: PV array 3
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.076783	147.434612	212.10	1.20	213.30
2	-35.077292	147.433529	217.07	1.20	218.27
3	-35.076932	147.431147	231.95	1.20	233.15
4	-35.077222	147.431125	232.13	1.20	233.33
5	-35.077678	147.431104	231.24	1.20	232.44
6	-35.077801	147.431930	224.49	1.20	225.69
7	-35.077573	147.431930	225.06	1.20	226.26
8	-35.077845	147.433604	215.34	1.20	216.54
9	-35.077388	147.434580	211.36	1.20	212.56

Name: PV array 4
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.075106	147.431694	230.32	1.20	231.52
2	-35.075325	147.433432	220.13	1.20	221.33
3	-35.076089	147.433475	218.23	1.20	219.43
4	-35.076142	147.433733	217.49	1.20	218.69
5	-35.076625	147.433711	218.23	1.20	219.43
6	-35.076572	147.433464	219.32	1.20	220.52
7	-35.076879	147.433475	218.48	1.20	219.68
8	-35.076598	147.431437	229.42	1.20	230.62
9	-35.075808	147.431431	229.47	1.20	230.67
10	-35.075861	147.431694	227.42	1.20	228.62

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	-35.087310	147.438944	182.31	1.60	183.91
OP 2	-35.091916	147.438193	183.51	1.60	185.11
OP 3	-35.089370	147.451479	183.60	1.60	185.20
OP 4	-35.077881	147.465224	194.17	1.60	195.77
OP 5	-35.073050	147.462607	203.98	1.60	205.58
OP 6	-35.064620	147.461098	216.35	1.60	217.95
OP 7	-35.090542	147.442688	182.00	1.60	183.60
OP 8	-35.089910	147.458224	184.75	1.60	186.35
OP 9	-35.088716	147.465476	187.34	1.60	188.94
OP 10	-35.075582	147.469618	217.33	1.60	218.93
OP 11	-35.066168	147.462687	218.02	1.60	219.62
OP 12	-35.066853	147.452902	203.70	1.60	205.30
OP 13	-35.067960	147.444491	193.56	1.60	195.16
OP 14	-35.074594	147.442538	194.88	1.60	196.48
OP 15	-35.076447	147.441905	186.82	1.60	188.42
OP 16	-35.053456	147.468241	215.83	1.60	217.43
OP 17	-35.055078	147.494985	276.71	1.60	278.31
OP 18	-35.084569	147.443203	182.45	1.60	184.05
OP 19	-35.075683	147.447495	183.34	1.60	184.94

PV Array Results

PV array 1

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0

PV array 2

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0

PV array 3

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0

PV array 4

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fo large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for assumptions and limitations not listed here.

ForgeSolar
PV planning & glare analysis

GlareGauge Glare Analysis Results

Site Configuration: WWSFS - Arrays 5 - 8 1_2m 60deg resting

Project site configuration details and results.

Created **Dec. 12, 2019 11:34 p.m.**
Updated **Dec. 13, 2019 12:29 a.m.**
DNI **varies** and peaks at **1,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC10**
Site Configuration ID: 34282.4392

Summary of Results No glare predicted!

PV name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 5	SA tracking	SA tracking	0	0	-
PV array 6	SA tracking	SA tracking	0	0	-
PV array 7	SA tracking	SA tracking	0	0	-
PV array 8	SA tracking	SA tracking	0	0	-

Component Data

PV Array(s)

Name: PV array 5
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.073438	147.433285	232.18	1.20	233.38
2	-35.073728	147.433328	231.88	1.20	233.08
3	-35.073535	147.432663	231.14	1.20	232.34
4	-35.073728	147.432663	230.66	1.20	231.86
5	-35.073500	147.431976	231.63	1.20	232.83
6	-35.074255	147.431955	230.35	1.20	231.55
7	-35.074896	147.433972	223.32	1.20	224.52
8	-35.074246	147.433977	229.65	1.20	230.85
9	-35.074281	147.434034	229.40	1.20	230.60
10	-35.073684	147.434004	233.58	1.20	234.78

Name: PV array 6
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.075353	147.436386	218.72	1.20	219.92
2	-35.075326	147.436086	218.46	1.20	219.66
3	-35.075634	147.436075	215.81	1.20	217.01
4	-35.075598	147.434251	217.99	1.20	219.19
5	-35.074738	147.434240	224.95	1.20	226.15
6	-35.074773	147.436343	222.08	1.20	223.28

Name: PV array 7
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.079570	147.436032	209.43	1.20	210.63
2	-35.078710	147.435968	207.36	1.20	208.56
3	-35.078710	147.436311	205.34	1.20	206.54
4	-35.076963	147.436193	207.93	1.20	209.13
5	-35.076912	147.436049	208.27	1.20	209.47
6	-35.076198	147.436018	211.48	1.20	212.68
7	-35.076201	147.436400	211.80	1.20	213.00
8	-35.075770	147.436437	215.12	1.20	216.32
9	-35.075790	147.436989	217.42	1.20	218.62
10	-35.075463	147.436976	219.30	1.20	220.50
11	-35.075476	147.437713	221.16	1.20	222.36
12	-35.076310	147.437717	216.61	1.20	217.81
13	-35.076269	147.437364	215.12	1.20	216.32
14	-35.077159	147.437429	207.94	1.20	209.14
15	-35.077176	147.437284	207.09	1.20	208.29
16	-35.077946	147.437295	203.11	1.20	204.31
17	-35.077914	147.438346	203.61	1.20	204.81
18	-35.078741	147.438362	198.13	1.20	199.33
19	-35.078742	147.438982	195.39	1.20	196.59
20	-35.078150	147.438937	200.40	1.20	201.60
21	-35.078170	147.439307	198.84	1.20	200.04
22	-35.078752	147.439333	193.49	1.20	194.69
23	-35.078755	147.439151	194.32	1.20	195.52
24	-35.079513	147.439183	191.45	1.20	192.65

Name: PV array 8
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	-35.079082	147.432785	220.71	1.20	221.91
2	-35.079073	147.433665	216.66	1.20	217.86
3	-35.078309	147.433665	215.04	1.20	216.24
4	-35.078309	147.434459	211.51	1.20	212.71
5	-35.077923	147.434416	211.27	1.20	212.47
6	-35.077958	147.435553	208.42	1.20	209.62
7	-35.078783	147.435553	209.19	1.20	210.39
8	-35.078783	147.435435	209.51	1.20	210.71
9	-35.079556	147.435371	211.77	1.20	212.97
10	-35.079538	147.432764	221.87	1.20	223.07

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	-35.087310	147.438944	182.31	1.60	183.91
OP 2	-35.091916	147.438193	183.51	1.60	185.11
OP 3	-35.089370	147.451479	183.60	1.60	185.20
OP 4	-35.077881	147.465224	194.17	1.60	195.77
OP 5	-35.073050	147.462607	203.98	1.60	205.58
OP 6	-35.064620	147.461098	216.35	1.60	217.95
OP 7	-35.090542	147.442688	182.00	1.60	183.60
OP 8	-35.089910	147.458224	184.75	1.60	186.35
OP 9	-35.088716	147.465476	187.34	1.60	188.94
OP 10	-35.075582	147.469618	217.33	1.60	218.93
OP 11	-35.066168	147.462687	218.02	1.60	219.62
OP 12	-35.066853	147.452902	203.70	1.60	205.30
OP 13	-35.067960	147.444491	193.56	1.60	195.16
OP 14	-35.074594	147.442538	194.88	1.60	196.48
OP 15	-35.076447	147.441905	186.82	1.60	188.42
OP 16	-35.053456	147.468241	215.83	1.60	217.43
OP 17	-35.055078	147.494985	276.71	1.60	278.31
OP 18	-35.084569	147.443203	182.45	1.60	184.05
OP 19	-35.075683	147.447495	183.34	1.60	184.94

PV Array Results

PV array 5

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0

PV array 6

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0

PV array 7

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0

PV array 8

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
OP: OP 10	0	0
OP: OP 11	0	0
OP: OP 12	0	0
OP: OP 13	0	0
OP: OP 14	0	0
OP: OP 15	0	0
OP: OP 16	0	0
OP: OP 17	0	0
OP: OP 18	0	0
OP: OP 19	0	0

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fo large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for assumptions and limitations not listed here.