

Crookwell 3 Wind Farm



Proposed view south from the Crookwell Goulburn Road toward the Crookwell 3 South wind farm turbines

LANDSCAPE & VISUAL IMPACT ASSESSMENT

Prepared for:



CROOKWELL DEVELOPMENT PTY LTD

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Prepared by:

GREEN BEAN DESIGN

landscape architects

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Green Bean Design – Capability Statement

Green Bean Design is an experienced landscape architectural consultancy specialising in landscape and visual impact assessment. As an independent consultant Green Bean Design provide professional advice to a range of Clients involved in large infrastructure project development.

Green Bean Design Principal Landscape Architect Andrew Homewood is a Registered Landscape Architect with over 20 years continuous employment in landscape consultancy and has completed numerous landscape and visual impact assessments for a variety of large scale electrical infrastructure and renewable energy projects, including wind energy and solar power developments.

Green Bean Design has participated in fifteen wind energy projects across New South Wales and Victoria including assessments for:

• Silvertown Wind Farm	• Boco Rock Wind Farm	• Collector Wind Farm
• Crookwell 3 Wind Farm	• Sapphire Wind Farm	• Willatook Wind Farm
• Eden Wind Farm	• Birrema Wind Farm	• White Rock Wind Farm
• Paling Yards Wind Farm	• Port Kembla Wind Farm	• Rye Park Wind Farm
• Deepwater Wind Farm		

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Green Bean Design (GBD) was commissioned by Crookwell Development Pty Ltd (the Proponent) to undertake a Landscape and Visual Impact Assessment (LVIA) for the Crookwell 3 wind farm and associated development infrastructure.

The Proponent is considering a number of alternative wind turbine models and therefore, this LVIA has adopted a theoretical wind turbine 'tip' height of 157m in order to assess a 'hybrid' design that incorporates the maximum dimensions from each turbine model. This LVIA should be considered conservative in nature as the actual wind turbine 'tip' height is likely to be lower than that assessed in this LVIA.

This LVIA involved a desk top study and field inspections to collect and analyse information to describe and define landscape characteristics of the area in which the Crookwell 3 wind farm would be constructed. This LVIA has determined that the landscape surrounding the Crookwell 3 wind farm has an overall medium sensitivity to accommodate change, and represents a landscape that is reasonably typical of landscape character areas that are commonly found in the surrounding regional area of the New South Wales Southern Tablelands and the NSW/ACT Border Region Renewable Energy Precinct.

As a landscape with an overall medium sensitivity to accommodate change, some intrinsic characteristics of the landscape are likely to be altered by the wind farm; however, the landscape will have some capability to accommodate change. This LVIA has determined that the Crookwell 3 wind farm would not be an unacceptable development within the NSW/ACT Border Region Renewable Energy Precinct.

The overall visibility of the Crookwell 3 wind farm turbines was determined within a 10km radius of the wind farm and illustrated by a series of panoramic photographs and 6 Zone of Visual Influence (ZVI) diagrams. The ZVI diagrams demonstrate the influence of topography on visibility and identify areas from which the wind farm would, and would not be visible. The ZVI diagrams, together with the photomontages, also illustrate the extent of intervisibility between the Crookwell 3 wind farm turbines and turbines within other existing and approved wind farms within the surrounding landscape.

This LVIA assessed the potential visual impact of the Crookwell 3 wind farm for the majority of residential view locations within the Crookwell 3 10km viewshed as well as impacts for motorists travelling along highways and local roads surrounding the wind farm. A number of criteria were considered and assessed to determine levels of visual impact.

This LVIA determined that the Crookwell 3 East site would have a potential High or Moderate to High visual impact on 19 residential view locations within the Crookwell 3 wind farm 5km viewshed, and that the South site would have a potential High or Moderate to High visual impact on 10 residential view locations within the Crookwell 3 wind farm 5km viewshed. The majority of residential view locations between the Crookwell 3 wind farm 5km and 10km viewshed would experience a Nil to Low visual impact.

A cumulative visual assessment identified 3 additional current and approved wind farms within the locality of the Crookwell 3 wind farm. This LVIA determined that there would be some intervisibility between the Crookwell 3 wind farm, and other wind farm turbines within the Crookwell 3 wind farm 10km viewshed.

Whilst there are opportunities for 'direct' and 'indirect' views from residential dwellings, and 'sequential' views from some surrounding road corridors between Crookwell 3 wind farm and other wind farms, there is unlikely to be a significant increase in visual impact arising from cumulative impacts.

Night time obstacle lighting would have the potential to create a visual impact for a small number of residential view locations surrounding the Crookwell 3 wind farm, including an increased cumulative impact where views extend toward lit turbines within the approved Crookwell 2 wind farm. This LVIA notes that further to the withdrawal of the CASA Advisory Circular there are no guidelines by which to define criteria for wind farm night time obstacle lighting, and that night time obstacle lighting has been determined as not required for the Gullen Range wind farm, and has recently been removed from the Cullerin wind farm adjoining the Hume Highway to the west of Yass.

Although some mitigation measures are considered appropriate to minimise the visual effects for a number of the elements associated with the Crookwell 3 wind farm, it is acknowledged that the degree to which the wind turbines may be visually mitigated is limited by their scale and position within the landscape relative to surrounding view locations.

1.1 Introduction

This LVIA addresses one of the key requirements of the Crookwell 3 wind farm Environmental Assessment (EA) to be submitted and assessed under Part 3A of the Environmental Planning & Assessment Act 1979 (EP&A Act).

This LVIA methodology adopted by GBD has been applied to a number of similar LVIA for large scale infrastructure projects prepared by GBD, which have been assessed and approved by the New South Wales Department of Planning & Infrastructure (DoP&I) under Part 3A of the EP&A Act.

This LVIA addresses and responds to the Director General's Requirements (DGR's) dated 8th April 2010, for the assessment of potential landscape and visual impacts of the project. **Table 1** outlines the relevant landscape and visual impact assessment requirements of the DGR's and the corresponding section in which they are addressed within this LVIA.

Table 1 - Director General's Requirements

DGR's	Report Reference
<ul style="list-style-type: none"> provide a comprehensive assessment of the landscape character and values and any scenic or significant vistas of the area potentially affected by the project. This should describe community and stakeholder values of the local and regional visual amenity and quality, and perceptions of the project based on surveys and consultation; 	Refer LVIA Sections 4, 5 and 6.
<ul style="list-style-type: none"> assess the impact of shadow "flicker", blade "glint" and night lighting from the wind farm; 	Refer LVIA Sections 12,13 and Appendix A.
<ul style="list-style-type: none"> identify the zone of visual influence (no less than 10 kilometres) and assess the visual impact of all project components on this landscape; 	Refer LVIA Section 7 and Figures 3 and 4.
<ul style="list-style-type: none"> include photomontages of the project taken from potentially affected residences (including approved but not yet developed dwellings or subdivisions with residential rights), settlements and significant public view points, and provide a clear description of proposed visual amenity mitigation and management measures; 	Refer LVIA Section 11 and Figures 26 to 70.
<ul style="list-style-type: none"> provide an assessment of the feasibility, effectiveness and reliability of proposed mitigation measures and any residual impacts after these measures have been implemented. 	Refer LVIA Section 16.

Although not directly applicable to the Crookwell 3 EA, GBD has also reviewed the Goulburn Mulwaree and Upper Lachlan Shire Council's Development Control Plans (DCP) for Wind Power Generation and GBD confirm that this LVIA addresses a number of key DCP requirements with regard to consideration of visual assessment, including provision for:

- The assessment of visual impact and scenic value;
- The assessment of cumulative impact;
- Shadow Flicker Assessment;
- Viewshed mapping; and
- Photomontages.

GBD is not aware of any landscape areas within the Crookwell 3 wind farm 10km viewshed that may be subject to any Local, State or Federal statutory designations for high landscape values or scenic quality and/or scenic protection.

GBD is cognisant of the Australian Wind Energy Association and Australian Council of National Trust's publication *Wind Farms and Landscape Values National Assessment Framework*, June 2007, and encompasses the general assessment framework outlined in the National Assessment Framework. In addition to the National Assessment Framework, the preparation of this LVIA has also included a review of the National Wind Farm Development Guidelines (Public Consultation Draft V2.4 July 2010).

This LVIA involved a comprehensive evaluation of the landscape character in which the Crookwell 3 wind farm and ancillary structures would be located, and an assessment of the potential landscape and visual impacts that may result from the construction and operation of the wind farm, taking into account appropriate mitigation measures. This LVIA is based on technical and design information provided by the Proponent to GBD.

The Proponent is considering a number of potential turbine models to install within the Crookwell 3 wind farm. As each turbine model differs in tower height and rotor diameter the landscape and visual assessment process has selected the maximum dimensions from each turbine model to create a 'hybrid' turbine model. The 'hybrid' model is expected to exceed the dimensions of the final model

selected for installation, and as such, presents a worst case scenario for the visual impact assessment. The dimensions of the 'hybrid' model have been used in the production of both ZVI diagrams and the photomontages.

1.2 National Assessment Framework

GBD is cognisant of the Australian Wind Energy Association and Australian Council of National Trust's publication Wind Farms and Landscape Values National Assessment Framework (NAF), June 2007, and have encompassed the general assessment framework outlined in the NAF within the LVIA methodology. In addition to the NAF, the preparation of this LVIA has also included a review of the National Wind Farm Development Guidelines (Public Consultation Draft V2.4 July 2010).

Table 2 outlines the relevant requirements of the NAF and the corresponding section in which they are addressed within this LVIA report.

Table 2 NAF Requirements

NAF Tasks (through Steps 1 to 4)	LVIA Reference/Response
<p>Step 1 Assess the Landscape Values</p> <p>1A Preliminary Landscape Assessment</p> <ul style="list-style-type: none"> • 1A.1 Desktop Review • 1A.2 Seek information from Local Authority • 1A.3 Identify potential community and stakeholder interests • 1A.4 Site survey • 1A.5 Preliminary assessment of landscape values <p>1B Full Landscape Assessment</p> <ul style="list-style-type: none"> • 1B.1 Define the study area for assessment, including the zone of visual influence • 1B.2 Landscape Character Analysis • 1B.3 Natural and cultural values analysis • 1B.4 Involve communities and stakeholders in identifying landscape values • 1B.5 Document values and analyse significance 	<p>This LVIA has been prepared through a comparable methodology to that outlined in the NAF and has included a desktop review (pre site inspection) to determine potential view locations as well as establishing the extent and types of landscape characteristics within the 10km viewshed.</p> <p>Early telephone discussions with the relevant Local Authorities determined that no additional wind farm developments were current other than those notified on the DoP&I website: (http://majorprojects.planning.nsw.gov.au/page/project-sectors/transport--communications--energy---water/generation-of-electricity-or-heat-or-co-generation/)</p> <p>Community and stakeholder interests have been identified by an ongoing process of direct consultation between the Proponent and relevant stakeholders. The results of the consultative process are included in this LVIA as well as other relevant sections of the EA.</p> <p>Site survey and preliminary assessment work has been undertaken and incorporated into this LVIA. The preparation of a separate preliminary assessment of landscape values is not a requirement under the NSW DoP&I DGR's.</p> <p>This LVIA addresses the requirements of Step 1B and</p>

NAF Tasks (through Steps 1 to 4)	LVIA Reference/Response
	presents an analysis of key considerations included in the NAF.
<p>Step 2 Describe and Model the Wind Farm in the Landscape</p> <ul style="list-style-type: none"> • 2.1 Describe the development • 2.2 Model the development • 2.3 Prepare a visual assessment report 	This LVIA has described and modelled the Crookwell 3 wind farm development and selected view points from a range of view locations including non associated residential dwellings and road corridors within the 10km viewshed.
<p>Step 3 Assess the Impacts of the Wind Farm on Landscape Values</p> <ul style="list-style-type: none"> • 3.1 Seek community input to potential impacts • 3.2 Identify and describe impacts • 3.3 Identify potential cumulative impacts • 3.4 Identify other relevant factors • 3.5 Evaluate impacts 	<p>Community and stakeholder interests have been identified by an ongoing process of direct consultation between the Proponent and relevant stakeholders. The results of the consultative process are outlined and included in this LVIA as well as other relevant sections of the EA.</p> <p>This LVIA has identified and described potential landscape and visual impacts associated with the Crookwell 3 wind farm development as well as potential cumulative impacts resulting from other wind farm projects within the NSW/ACT Border Region Renewable Energy Precinct.</p>
<p>Step 4 Respond to Impacts</p> <ul style="list-style-type: none"> • 4.1 Changes to location or siting of the wind farm or ancillary infrastructure • 4.2 Layout and design considerations • 4.3 Minor changes and mitigation measures • 4.4 Recommend changes to the development 	<p>The development of the Crookwell 3 wind farm turbine layout has been reviewed and adjusted throughout the preparation of this LVIA. Changes to the layout have occurred as a result of stakeholder consultation and specific concerns directed toward the visual impact of the wind farm from surrounding view locations.</p> <p>Significant changes have occurred throughout the development of the preferred design layouts including the removal and repositioning of turbines within site boundary.</p>

The NAF is noted by its authors as a framework document and does not set out a detailed or prescribed method to undertake an assessment of landscape values. This LVIA has; however, followed the majority of techniques and has tested and determined outcomes for the principal issues that have been raised in the NAF.

1.3 Draft NSW Planning Guidelines Wind Farms (December 2011)

The NSW DoP&I issued the Draft Planning Guidelines Wind Farms in December 2011, which provide guidance and information for wind farm applicants, consent authorities as well as communities and stakeholder groups. The draft guidelines set out key considerations for the upfront assessment of

landscape and visual impact for residential dwellings within a 2km radius of proposed wind turbines (through the Gateway Process and Site Compatibility Certification) and specific assessment requirements that may be set out in the NSW DoP&I Director Generals Requirements on a project by project basis. The draft guidelines also set out a comprehensive framework for the assessment of landscape and visual impacts including residential dwellings within 2 km proximity of proposed wind turbines.

The draft guidelines were placed on public exhibition between December 2011 and March 2012; however, by the completion of this LVIA the draft guidelines had not been finalised or formally adopted by the DoP&I. This LVIA has been prepared with regard to the draft guidelines and included the preparation of photomontages from the all of the non associated residential dwellings located within 2 km of the proposed Crookwell 3 wind turbines, apart from 4 residential dwellings where the occupants were not interested in the production of a photomontage.

1.4 Draft National Wind Farm Development Guidelines (July 2010)

The Draft National Wind Farm Development Guidelines, originally issued October 2009, have been revised following a first round of public consultation and comment. The revised Guidelines were re-issued in July 2010 for a second round of comments. The Guidelines aim to offer best practice advice and are not a mandatory requirement for wind farm developments within Australia.

The Guidelines adopt a staged approach to the assessment of landscape values and impacts. A Preliminary Stage is summarised by the following activities:

- Defining the scope and policy context;
- Preliminary landscape character and significance analysis;
- Preliminary view analysis;
- Preliminary community values analysis; and
- Identification of possible cumulative impacts.

1.5 Auswind Best Practice Guidelines (December 2006)

The Auswind Best Practice Guidelines were developed to assist wind farm proponents to implement best practice in regards to the location and siting of wind energy facilities and to conduct wind farm investigations and impact assessments. The guidelines have been subject to revisions following technical reviews and consultation with both industry and broader stakeholder input.

The Guidelines, developed between (the former) Auswind and the National Trust, provide a landscape assessment approach to describe, assess and evaluate the potential landscape and visual impact of a proposed wind energy project. A summary of the approach includes:

- Consultation with experts in the analysis of the environments visual characteristics e.g. Landscape Architects;
- Preparation of 'Zone of Visual Influence' or 'Seen Area Diagrams';
- Preparation of photomontages (also referred to as Visual Simulations);
- Determination of cumulative impact from existing wind energy projects;
- Investigation of impacts with associated infrastructure elements, including substation, service roads and power lines; and
- Assessment of Shadow Flicker.

The Auswind Best Practice Guidelines offer best practice advice and are not a mandatory requirement for wind farm developments within Australia.

1.6 Methodology

This LVIA methodology included the following activities:

- Desktop study addressing visual character and identification of residential and public view locations within the surrounding area;
- Fieldwork and photography;
- Preparation of ZVI diagrams;
- Assessment and determination of landscape sensitivity;
- Assessment and determination of visual impact;
- Preparation of photomontages and illustrative figures;
- Preparation of shadow flicker assessment.

1.7 Desktop study

A desktop study was carried out to identify an indicative viewshed for the Crookwell 3 wind farm. This was carried out by reference to 1:25,000 scale topographic maps as well as aerial photographs and satellite images of the project area and surrounding landscape. A preliminary ZVI diagram was also produced prior to the commencement of fieldwork in order to inform the likely extent and nature of areas within the nominated viewshed of the proposed wind farm.

Topographic maps and aerial photographs were also used to identify the locations and categories of potential views that could be verified during the fieldwork component of the assessment. The desktop study also outlined the visual character of the surrounding landscape including features such as landform, elevation, landcover and the distribution of settlements.

1.8 Preparation of ZVI Diagrams

GL-Garrad Hassan Pacific Pty Ltd (GL-GH) prepared ZVI Diagrams to illustrate the potential visibility of the wind turbines within the Project 10km viewshed. ZVI Diagrams included visibility from tip of blade and rotor face and are illustrated in **Figures 3, 4, and 21 to 24** and detailed in **Section 4** of this LVIA.

1.9 Fieldwork and Photography

The fieldwork involved:

- A total of 5 days of site inspections (over three separate visits) to determine and confirm the potential extent of visibility of the Crookwell 3 wind farm and ancillary structures and to obtain suitable photographs for report illustrations and photomontages;
- Determination and confirmation of the various view categories and locations from which the Crookwell 3 wind farm and ancillary structures could potentially be visible; and
- Preparation of a record for each view location inspected and assessed.

1.10 Assessment of Landscape Sensitivity

The potential impact of the Crookwell 3 wind farm on the sensitivity of the landscape surrounding the wind farm would result primarily from the capability of the wind farm to integrate with the landscape, and the degree to which the landscape would accommodate the wind farm.

The capability of the landscape to accommodate the wind farm would result primarily from the nature and degree of perceptual factors that can influence interpretation and appreciation of the landscape, including landform, scale, topographic features, landcover and human influence or modifications.

1.11 Assessment of Visual Impact

The visual impact of the wind farm on surrounding view locations would result from the visibility of the wind turbines and the characteristics of the landscape between, and surrounding, the view

location and the wind farm. The potential degree of visibility and resultant visual impact may be partly determined by a combination of factors including:

- The category and type of situation from which people may view the wind farm (examples of categories include residents or motorists);
- The visual sensitivity of view locations surrounding the wind farm;
- The potential number of people with a view toward the proposed wind farm from any one view location;
- The viewing distance between the view location and the wind farm; and
- The duration of time people may view the wind farm from any particular static or dynamic view location.

An underpinning rationale for this LVIA is that if people are not normally present at a particular location, such as agricultural pasture areas, or views are screened by landform or vegetation, then there is likely to be a nil visual impact at that location.

If, on the other hand, a small number of people are present for a short period of time at a particular location then there is likely to be a low visual impact at that location, and conversely if a large number of people are present then the visual impact is likely to be higher.

Although this rationale can be applied at a broad scale, this LVIA also considers, and has determined, the potential visual impact for individual view locations that have a higher degree of sensitivity to the wind farm, including the potential impact on individual residential dwellings situated in the surrounding landscape. The determination of a visual impact is also subject to a number of other factors which are considered in more detail in this LVIA.

Whilst this LVIA addresses a number of static elements associated with the Crookwell 3 wind farm, the assessment acknowledges and has considered the potential visual impact associated with the movement of the wind turbine rotors.

1.12 Photomontages

GL-GH prepared photomontages from twenty one view locations to illustrate the potential visibility of the Crookwell 3 wind farm within the 10km viewshed. The Crookwell 3 photomontages have also modelled and illustrate wind turbines within other wind farm developments where visible from the selected view locations.

The view locations selected for the preparation of photomontage included adjoining and non associated residential dwellings and surrounding road corridors. The photomontage locations are illustrated in **Figure 25** and the photomontages in **Figures 26 to 70**.

1.13 Shadow Flicker & Blade Glint

GL-GH prepared a Shadow Flicker assessment and report for the Crookwell 3 wind farm. The results of the shadow flicker assessment are summarised in this LVIA report, with a copy of the detailed Shadow Flicker report for the Crookwell 3 wind farm is included in full in this LVIA **Appendix A**.

2.1 Location

The Crookwell 3 wind farm would be located in the NSW/ACT Border Region Renewable Energy Precinct and the Upper Lachlan Shire Local Government Area. The wind farm would be constructed on two separate land parcels known as Crookwell 3 East (within an area of 1100 ha) and Crookwell 3 South (within an area of 400 ha). The location of the Crookwell 3 wind farm is illustrated in **Figure 1**.

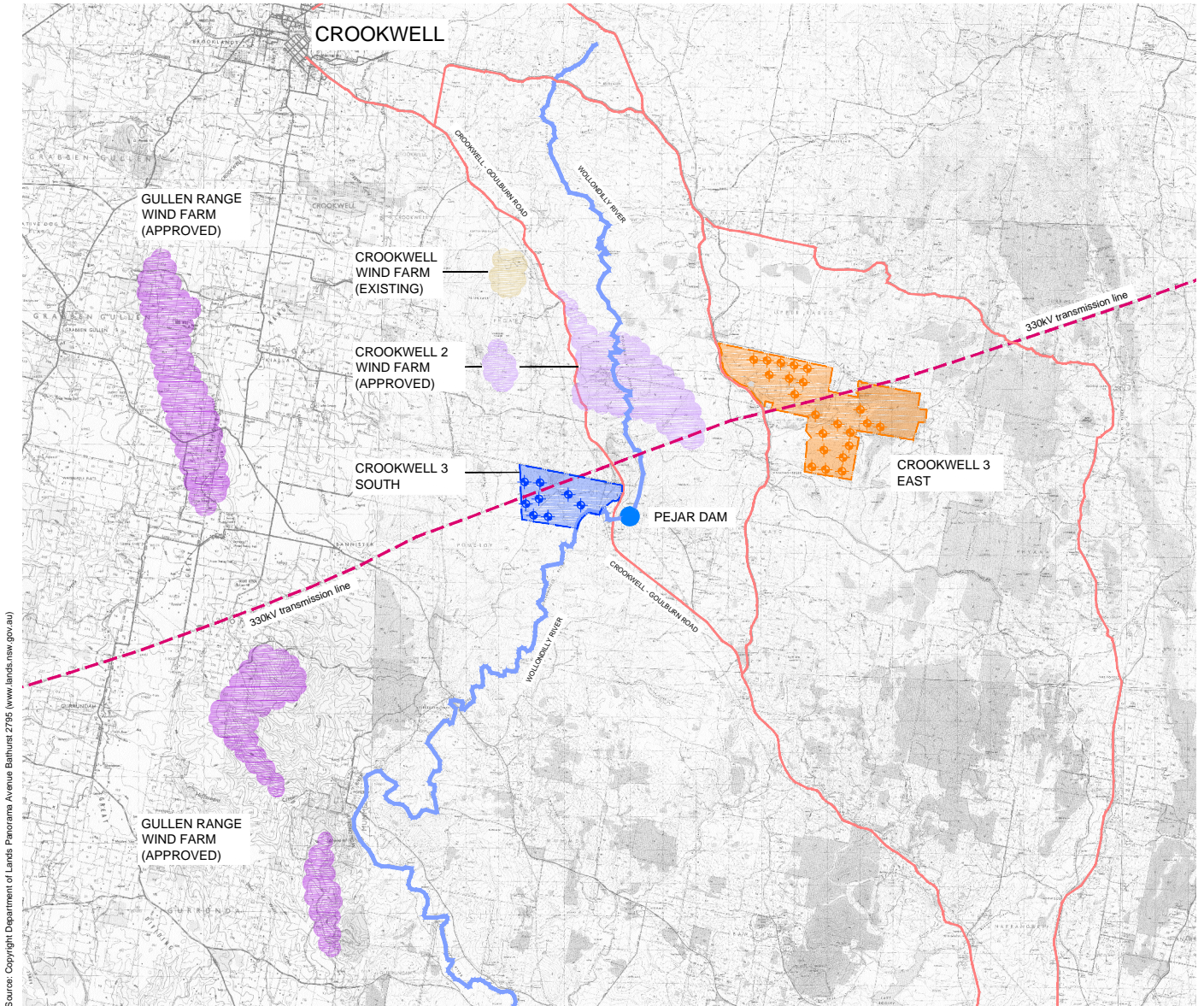
The Crookwell 3 East site is bounded by Bolton's Lane to the north, Woodhouselee Road to the west and the Upper Lachlan Shire / Goulburn-Mulwaree Council border to the south east. Accordingly, the Crookwell 3 East site adjoins the Goulburn-Mulwaree Local Government Area.

The Crookwell 3 South site is bounded by Crookwell Road to the east and property boundaries to the north, south and west. The Wollondilly River flows south west through the lower portion of the Crookwell 3 South site.

The closest Crookwell 3 South and East turbines are around 7 km apart, with the existing Crookwell 1 turbines around 6km north of the Crookwell 3 South site. The approved Crookwell 2 wind farm turbines extend north west of Pigmans Hill toward and beyond the Wollondilly River and Crookwell Goulburn Road. The closest Crookwell 3 and Crookwell 2 turbines are around 2 to 3km apart.

The Crookwell Township is around 15km to the north west of the Crookwell 3 wind farm and the regional centre of Goulburn 25km to the south.

The disused branch railway line between Goulburn and Crookwell was closed to passengers in 1974 and to goods traffic in 1984.



Source: Copyright Department of Lands Panorama Avenue Bathurst 2795 (www.lands.nsw.gov.au)

CROOKWELL 3 WIND FARM LOCATION PLAN, LOCAL CONTEXT



CROOKWELL 3 WIND FARM - LOCATION PLAN, STATE CONTEXT (Not to scale)



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GREEN BEAN DESIGN
landscape architects

3.1 Project description

The key visual components of the Crookwell 3 wind farm would comprise:

- Up to thirty wind turbines (up to twenty two within Crookwell 3 East and up to eight within Crookwell 3 South);
- Up to thirty individual 33kV kiosk transformers and switchgear with associated control systems to be located in the vicinity of the wind turbine towers (in some turbine models transformer equipment will be integrated within the tower or nacelle);
- Underground electrical and communication cable network linking turbines to each other within the South and East site boundaries. (An underground or overhead connection between the Crookwell 3 site boundaries and the Crookwell 2 site boundary to reach the substation approved as part of the Crookwell 2 wind farm);
- Up to three wind monitoring masts;
- On site access tracks for construction, operation and ongoing maintenance; and
- Crookwell 3 wind farm signage.

Temporary works associated with the construction of the wind farm that may be visible during construction and operational phases include:

- Crane hardstand areas; and
- Mobile concrete batching plant and rock crushing facilities.

Table 3 outlines the main design parameters for the proposed Crookwell South and East sites:

Table 3 – Crookwell 3 South and East design parameters:

Element	Description
Tower height	Maximum of 105m
Rotor Diameter	Maximum of 104m

Overall height from ground level to tip of blade	Maximum of 157m
Crookwell 3 South	Maximum of 8 turbines
Crookwell 3 East	Maximum of 22 turbines
Proposed number of Crookwell 3 wind turbines	Maximum of 30 turbines

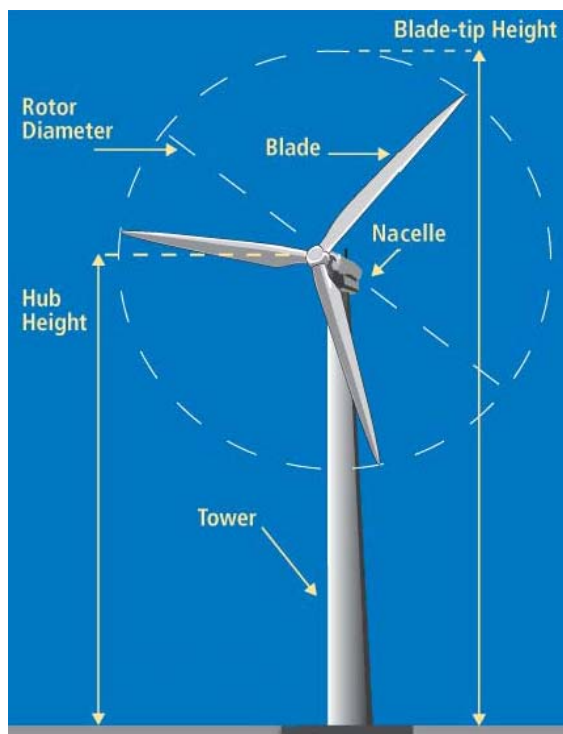
The Crookwell 3 wind farm layout is illustrated in **Figure 2**.

3.2 Wind turbines

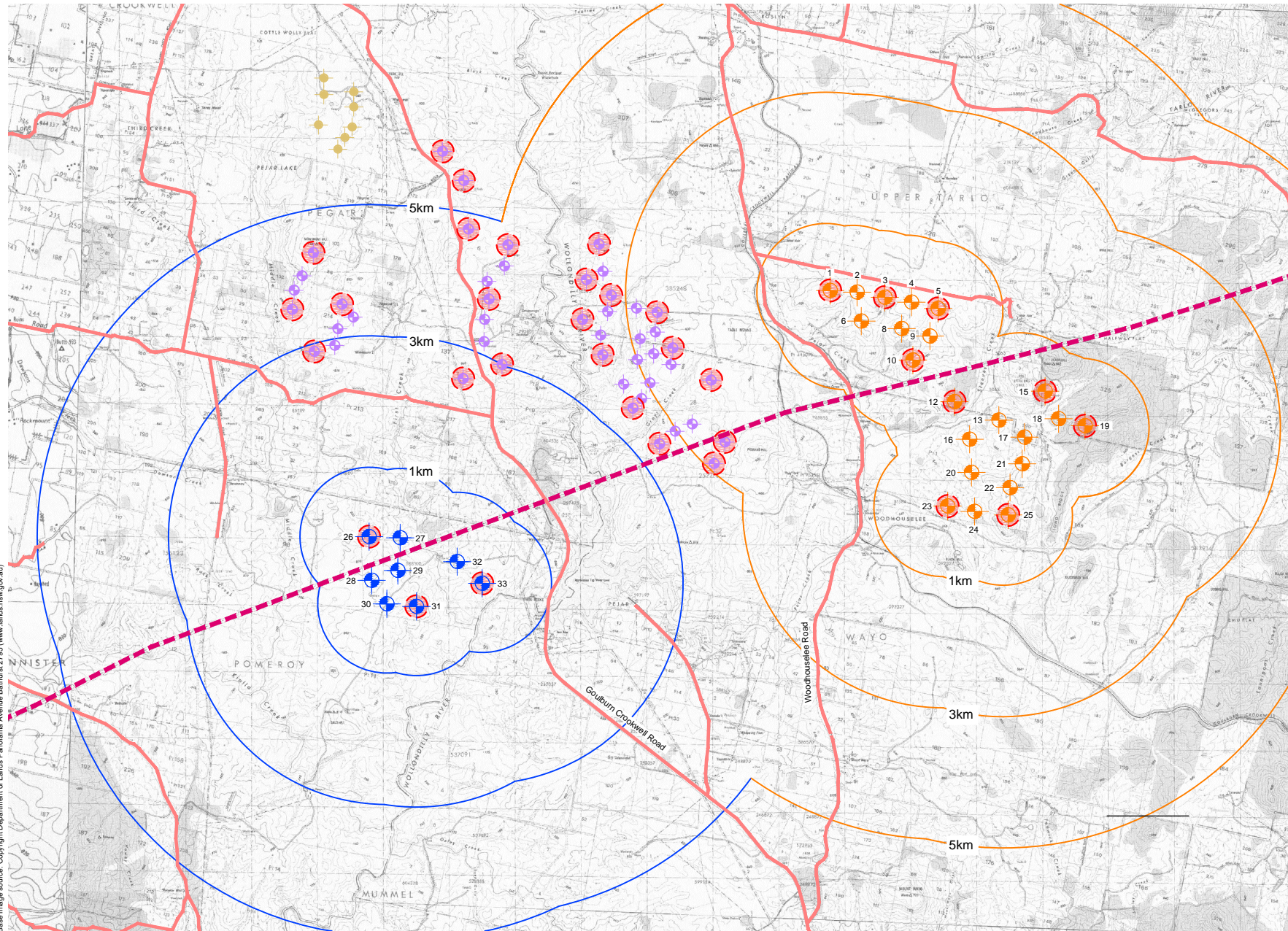
The specific elements of the wind turbines comprise:

- Concrete foundations;
- Tubular tapering steel towers;
- Nacelles at the top of the tower housing the gearbox and electrical generator;
- Rotors comprising a hub (attached to the nacelle) with three blades; and
- Three fibreglass blades attached to each hub.

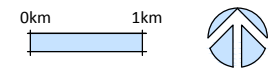
The following diagram identifies the main components of a typical wind turbine:



Configuration and components of a typical wind turbine



- Legend**
- Proposed Crookwell 3 East Turbine
 - Proposed Crookwell 3 South Turbine
 - Approved Crookwell 2 Turbine
 - Existing Crookwell Turbine
 - Turbine with obstacle lighting (Crookwell 2 and Crookwell 3)
 - Distance from proposed Crookwell 3 South turbine
 - Distance from proposed Crookwell 3 East turbine
 - Road
 - Existing 330kV transmission line



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3.3 Wind Monitoring Masts

Up to three wind monitoring masts would be installed on-site, extending up to 105m in height. The wind monitoring masts would be of a guyed, narrow lattice or tubular steel design.

The wind monitoring masts would be unlikely to create a significant visual impact, and are similar in scale, or smaller than a number of surrounding communication masts visible in the landscape surrounding the wind farm project area.

3.4 On-site access tracks

On-site access tracks would be constructed to provide access to turbine locations across the site during construction and operation. During construction the majority of access tracks would be approximately 10m wide to allow for vehicle manoeuvring, and reduced to 5m wide to facilitate access for maintenance vehicles during the operational phase.

The final access track design would be developed on a number of environmental grounds, including minimising the potential for visual impact by considering:

- the overall length and extent;
- the use of existing farm track route and laneways;
- the need for clearing vegetation;
- the potential for erosion;
- the extent of cut and fill; and
- the potential to maximise rehabilitation at the completion of the construction phase.

3.5 Electrical cabling

The majority of cabling works, including the installation of control cables linking the turbines to the control building would be installed underground. For safety and access issues some cabling may be required to be installed on medium voltage overhead transmission lines supported by single concrete poles. This is more likely to occur at locations where the cables exit the Crookwell 3 wind farm and enter the Crookwell 2 wind farm.

Grid connection would be achieved via a connection to the 330kV transmission line which crosses the site. The project would utilise and be connected to the single substation, control room and facilities for the grid connection approved as part of the Crookwell 2 wind farm.

4.1 Introduction

A key component of this LVIA is defined by the description, assessment and determination of the viewshed, zone of visual influence and visibility associated with the wind farm. It is a combination of these issues that sets out the framework for determining the significance and magnitude of potential visual impact of the wind farm on view locations within the landscape.

In order to clarify and explain this component of this LVIA, the relationship between viewshed, zone of visual influence and visibility is outlined and defined in **Table 4**.

Table 4 – Definitions

	Definition	Relationship
Viewshed	An area of land surrounding and beyond the project area which may be potentially affected by the wind farm.	Identifies the majority of this LVIA study area that incorporates view locations that may be subject to a degree of visual impact.
Zone of Visual Influence (ZVI)	A theoretical area of landscape from which the wind farm structures may be visible.	Determines areas within a viewshed from which the wind turbines may be visible.
Visibility	A relative determination at which a wind turbine or group of wind turbines can be clearly discerned and described.	Describes the likely number and relative scale of wind turbines visible from a view location.

An overview of viewshed, zone of visual influence and visibility is discussed in the following sections.

4.2 Viewshed

For the purpose of this LVIA viewshed is defined as the area of land surrounding and beyond the project area which may be potentially affected by the wind farm. In essence, the viewshed defines this LVIA study area. The viewshed for the Crookwell 3 wind farm has been illustrated as a series of concentric bands (illustrated at 2km, 3km, 5km and 10km distance offsets) extending across the landscape up to 10km from the wind turbines. The distance of the viewshed can vary between wind farm projects, and may be influenced and informed by a number of criteria including the height of the wind turbines together with the nature, location and height of landform that may limit visibility.

It is important to note that the wind turbines would be visible from some areas of the landscape beyond the 10km viewshed; however, within the general parameters of normal human vision, a wind

turbine at a maximum height of 157m to the tip of the rotor blade would occupy a relatively small proportion of a person’s field of view from distances in excess of 10km. The viewshed is used as a framework and guide for visibility assessment, as the degree of visual impacts will tend to be graduated with distance although there are unlikely to be any distinct or abrupt noticeable changes between the nominated distance bands. For the purpose of this LVIA, the viewshed assumptions for the Crookwell 3 wind farm are outlined in **Table 5**.

Table 5 – Viewshed Descriptors

Distance from turbine	Potential Viewshed Descriptors
>20km	Wind turbines become indistinct with increasing distance. Some blade movement visible but are usually not discernable. Turbines may be discernable but generally indistinct within viewshed resulting in Low level visibility and Nil where influenced or screened by surrounding topography and vegetation.
10km – 20km	Wind turbines noticeable but tending to become less distinct with increasing distance. Blade movement visible but less discernable with increasing distance. Discernable but generally less distinct within viewshed (potentially resulting in Low level visibility).
5km – 10km	Wind turbines visible but tending to become less distinct depending on the overall extent of view available from the potential view location. Movement of blades may be discernable where visible against the skyline. Potentially noticeable within viewshed (potentially resulting in Low to Moderate level visibility).
3 – 5km	Wind turbines clearly visible in the landscape but tending to become less dominant with increasing distance. Movement of blades discernable. Noticeable but less dominant within viewshed (potentially resulting in Moderate level visibility).
1 – 3km	Wind turbines would generally dominate the landscape in which the wind turbine is situated. Potential for high visibility depending on the category of view location, their location, sensitivity and subject to other visibility factors. Potentially dominant within viewshed (potentially resulting in Moderate to High level visibility).
<1km	Wind turbines would dominate the landscape in which they are situated due to large scale, movement and proximity. Dominant and significant within viewshed (potentially resulting in High level visibility).

4.3 Zone of Visual Influence (ZVI)

The ZVI diagrams are used to identify theoretical areas of the landscape from which wind turbines, or portions of turbines, may be visible within the viewshed. They are useful for providing an overview as to the extent to which the Crookwell 3 wind farm may be visible from surrounding areas within the viewshed.

Six ZVI diagrams have been prepared by GL-GH including:

- Diagram 1, Crookwell 3 ZVI from tip of blade;
- Diagram 2, Crookwell 3 ZVI from full face of rotor;
- Diagram 3, Crookwell 3 and Crookwell 1 ZVI cumulative tip of blade;
- Diagram 4, Crookwell 3 and Crookwell 2 ZVI cumulative tip of blade;
- Diagram 5, Crookwell 3 and Gullen Range ZVI cumulative tip of blade; and
- Diagram 6, Crookwell 1, 2, 3 and Gullen Range ZVI cumulative tip of blade.

The ZVI diagrams are illustrated in **Figures 3** and **4**. The cumulative ZVI diagrams are illustrated in **Figures 21** to **24**.

4.4 ZVI Methodology

The methodology adopted by GL-GH is a purely geometric assessment where the visibility of the proposed Crookwell 3 wind farm is determined from carrying out calculations based on a digital terrain model of the site and the surrounding terrain.

Calculations have been made to determine the visibility of the wind turbines:

- blade tips (essentially a view toward any part of the wind turbine rotor, including views toward the tips of blades above ridgelines);
- rotor face (essentially a view toward the entire swept path of the wind turbine blades).

The calculations also take into account the terrain relief and earth curvature.

This assessment methodology is conservative as:

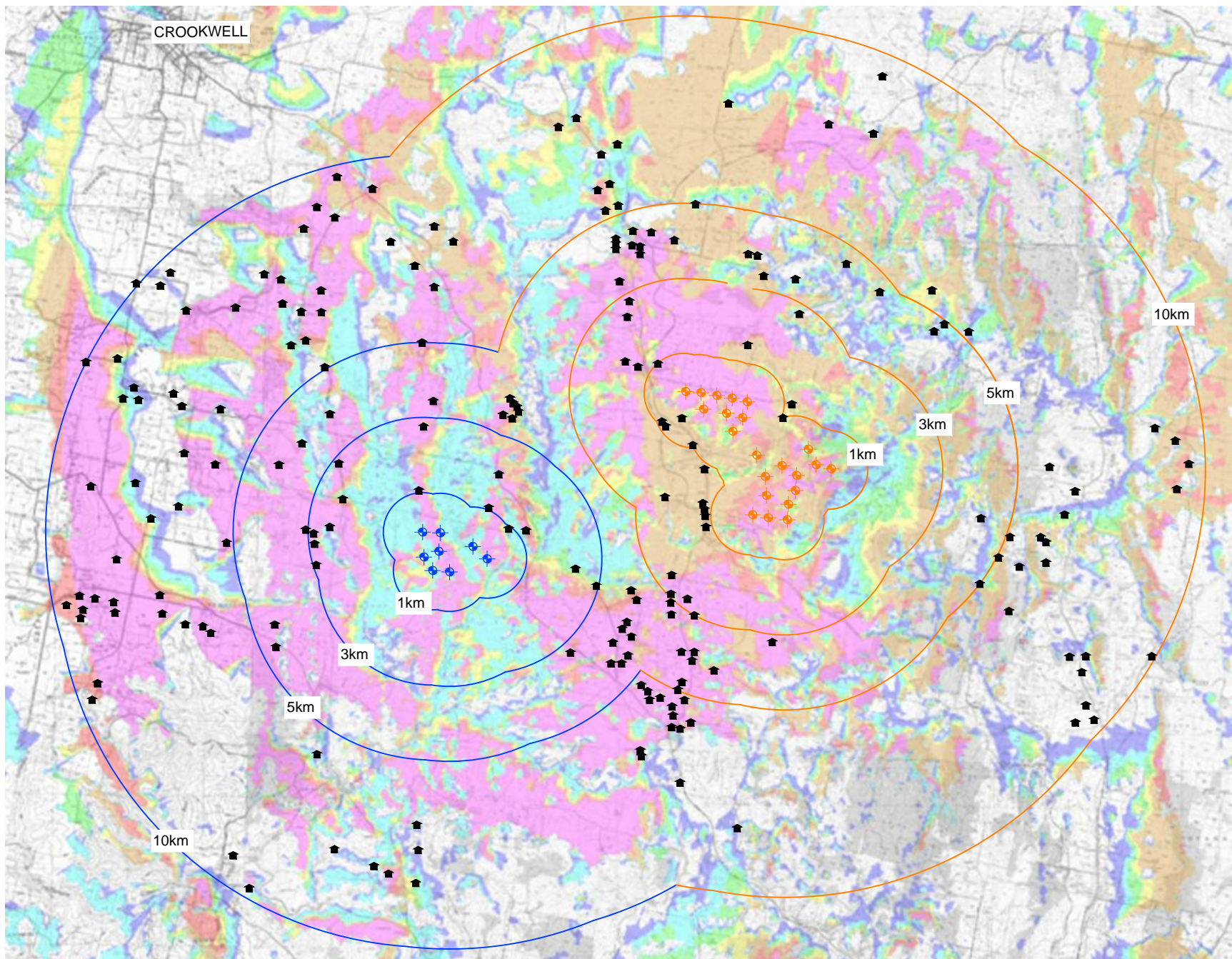







Figure 3 ZVI Diagram 1
Crookwell 3 - Tip of blade

Legend

-  Proposed Crookwell 3 East Turbine
-  Proposed Crookwell 3 South Turbine
-  Distance from proposed Crookwell 3 South turbine
-  Distance from proposed Crookwell 3 East turbine
-  Residential dwelling

Legend (ZVI Tips visible)

-  0 - 4
-  5 - 9
-  10 - 14
-  15 - 19
-  20 - 24
-  25 - 29
-  30



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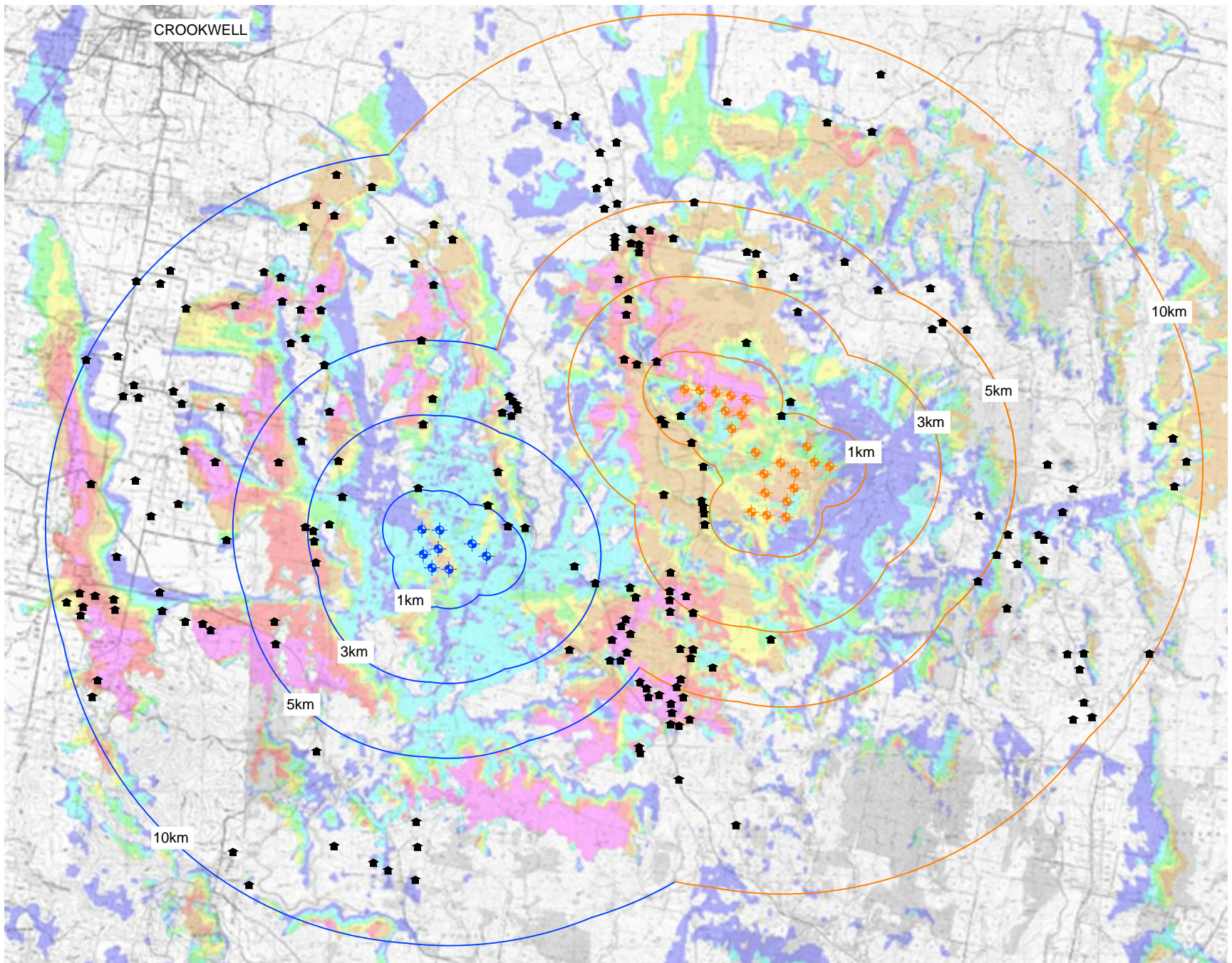







Figure 4 ZVI Diagram 2
Crookwell 3 - Rotor face

Legend

-  Proposed Crookwell 3 East Turbine
-  Proposed Crookwell 3 South Turbine
-  Distance from proposed Crookwell 3 South turbine
-  Distance from proposed Crookwell 3 East turbine
-  Residence

Legend (ZVI Rotors visible)

-  0 - 4
-  5 - 9
-  10 - 14
-  15 - 19
-  20 - 24
-  25 - 29
-  30



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- The screening effects of any structures and vegetation above ground level are not considered in any way. Therefore the wind farm may not be visible at many of the locations indicated on the ZVI diagrams due to the local presence of trees or other screening materials.
- Additionally, the number of turbines visible is also affected by the weather conditions at the time. Inclement or cloudy weather tends to mask the visibility of the proposed wind project.

Accordingly, while the ZVI diagrams are a useful visualisation tool, they are very conservative in nature.

4.5 Visibility

The level of wind turbine visibility within the Crookwell 3 viewshed can result from a number of factors including, but not limited to:

Distance

With an increase in distance the proportion of a person's horizontal and vertical view cone occupied by a visible turbine structure, or group of turbine structures, would decline.

As the view distance increases so do the atmospheric effects resulting from dust particles and moisture in the atmosphere, which makes the turbines appear to be grey thus potentially reducing the contrast between the wind turbines and the background against which they are viewed.

Whilst the distance between a view location and the wind turbines is a primary factor to consider when determining potential visibility, there are other issues which may also affect the degree of visibility.

Movement

The visibility of the wind turbines would vary between the categories of static and dynamic view locations. In the case of static views the relationship between a wind turbine and the landscape would not tend to vary greatly. The extent of vision may be relatively wide as a person would tend to scan back and forth across the landscape where panoramic views are available.

In contrast views from a moving vehicle are dynamic as the visual relationship between wind turbines is constantly changing as well as the visual relationship between the wind turbines and the landscape

in which they are seen. The extent of vision can be partially constrained by the available view from within a vehicle at proximate distances.

Relative position

In situations where the view location is at a lower elevation than the wind turbine structure most of it would be viewed against the sky. The degree of visual contrast between a white coloured turbine and the sky would depend on the presence of background clouds and their colour. Dark grey clouds would contrast more strongly with white turbines than a background of white clouds.

The level of contrast is also influenced by the position of the sun relative to the individual wind turbines and the view location. Where the sun is located in front of the viewer, the visible portion of the wind turbine would be seen in shadow. Where the background to the wind turbine is dark toned the visual contrast would be reduced.

Where the sun is located behind the view location then the visible portion of the wind turbine would be in full sun. If the background is also light toned, such as white clouds, then the contrast is less when compared to a dark background.