Shadow Flicker Assessment Summary

SECTION 11

11.1 Introduction

Due to their height, wind turbines can cast shadows on surrounding areas at a significant distance from the base of the wind turbine tower. Coupled with this, the moving blades create moving shadows. When viewed from a stationary position, the moving shadows appear as a flicker giving rise to the phenomenon of 'shadow flicker'. When the sun is low in the sky the length of the shadows increases, increasing the shadow flicker affected area around the wind turbine.

A shadow flicker assessment has been prepared by Garrad Hassan Pacific Pty Ltd to determine and illustrate the potential impact of shadow flicker on surrounding receptor locations. Shadow flicker assessments were prepared for both the '125' and '107' design layouts; however, the LVIA has only incorporated the detailed shadow flicker assessment for the '107' design layout, as the slightly larger '107' rotor diameter presents the worse case scenario. The results of the '125' and '107' design layout shadow flicker assessments are summarised in this section of the LVIA. The detailed shadow flicker assessment for the '107' design layout is included at **Appendix A**.

A shadow flicker assessment can over estimate the actual number of annual hours of shadow flicker at a particular location due to a number of reasons including:

- The probability that the wind turbines will not face into or away from the sun all of the time;
- The occurrence of cloud cover;
- The amount of particulate matter in the atmosphere (moisture, dust, smoke etc…) which may diffuse sunlight;
- The presence of vegetation; and
- Periods where the wind turbine may not be in operation due to low winds, or high winds or for operational or maintenance reasons.

11.2 Residents

As there are no guidelines by which to assess the impact of shadow flicker in New South Wales, the shadow flicker assessment prepared by Garrad Hassan has adopted the Victorian Planning Guidelines that state:

"*The shadow flicker experienced at any dwelling in the surrounding area must not exceed 30 hours per year as a result of the operation of the wind energy facility*".

The results of the shadow flicker assessment for the '107' design layout determined that five residential receptors surrounding the wind farm may be subject to varying levels of shadow flicker. The five residential receptors include 'Yandra', 'Rockybah', 'Benbullen', 'Avonlake' and 'Coopers Hill'. Each of these five residential receptors is an associated landowner. A summary of the shadow flicker results are outlined in the **Tables 20** and **21** below:

Table 20- Flicker Assessment Summary for the '107' design layout

Residential Receptor	Theoretical maximum (hours per year)	Adjusted for rotor orientation (hours per year)	Reduction %
'Benbullen'	47	30	36
'Yandra'	20	11	44
'Rockybah'	11	6	48
'Coopers Hill'	13	9	34
'Avonlake'	20	11	44

One of the associated residences, Benbullen, has been identified as having potential exposure to a maximum theoretical duration of shadow flicker greater than 30 hours per year; however, the residence is located to the east of a substantial vegetated wind break, with additional tree planting around the residence effectively blocking all views from the residence toward any of the surrounding wind turbines. As there are unlikely to be any views toward wind turbines from the residence, it is anticipated that Benbullen will not experience the level of shadow flicker determined in the assessment.

Table 21- Flicker Assessment Summary for the '125' design layout

Residential Receptor	Theoretical maximum (hours per year)	Adjusted for rotor orientation (hours per year)	Reduction %
'Benbullen'	26	17	35
'Yandra'	16	9	46
'Rockybah'	19	11	41
'Coopers Hill'	10	7	35
'Avonlake'	0	0	-

None of the surrounding residential receptors was determined to have the potential to exceed a maximum theoretical duration of shadow flicker greater than 30 hours per year for the '125' design layout.

The 'adjusted for rotor orientation hours' combines the probability of shadow flicker with the occurrence of various wind directions, rather than assuming the worse case assumption of the turbine always facing the sun.

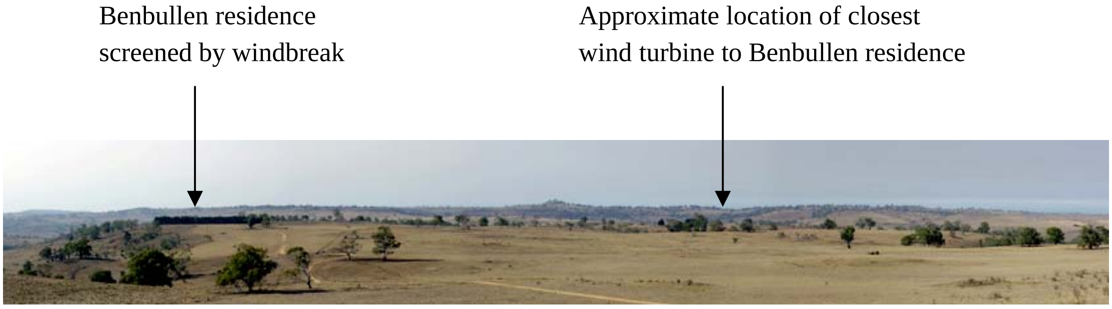

Plate 17. *View south from Benbullen access gate illustrating windbreak screen between residence and closest turbine.*

11.3 Photosensitive Epilepsy

The Canadian Epilepsy Alliance (http://www.epilepsymatters.com) defines photosensitivity as '*a sensitivity to flashing or flickering lights, usually of high intensity, which are pulsating in a regular pattern – and people with photosensitive epilepsy can be triggered into seizures by them'*. Both the Canadian Epilepsy Alliance and Epilepsy Action Australia (http://www.epilepsy.org.au) estimate that less than 5% of people with epilepsy are photosensitive.

Epileptic seizures may be triggered by a range of electronic devices including material broadcast by televisions, computer screens or strobing and flashing lights in nightclubs. Seizures may also be triggered by natural light shining off water, through tree leaves or by flickering caused by travelling past railings. Not all flashing or flickering light will trigger a seizure in people with photosensitive epilepsy, and the potential to trigger a seizure may also be dependant on the frequency of flashing or flicker, the duration and intensity of light.

Epilepsy Action Australia suggest that the frequency of flashing or flickering light most likely to trigger seizures occurs between 8 to 30Hz (or flashes/flickers per second), although this may vary between individuals. It also suggests that 96% of people with photosensitive epilepsy are sensitive to flicker between 15 to 20Hz.

The majority of three bladed wind turbines are unlikely to create a flicker frequency greater than 1Hz (or 1 flicker per second). The flicker frequency for a three blade wind turbine can be calculated by multiplying the hub rotation frequency (in meters per second) by the number of blades. As the maximum rotational speed for the Boco Rock wind turbines would be around

20 revolutions per minute (rpm), the hub rotation frequency would be 20rpm divided by 60 seconds resulting in 0.3 meters per second. Multiplying 0.3 meters per second by three blades equals around 1Hz (or 1 flicker per second).

Given the low flicker frequency associated with the Boco Rock wind turbines, which falls below the range suggested by Epilepsy Action Australia as a potential trigger for photosensitive epileptic seizures, it is unlikely that the Boco Rock wind turbines would present a risk to people with photosensitive epilepsy.

11.4 Motorists

The shadow flicker diagram indicates two local road traverse areas subject to potential shadow flicker, and includes portions of the Avonlake Road and the Snowy River Way.

Motorists can experience shadow flicker sensations whilst driving as a result of shadows cast on the road from roadside or overhead objects such as trees, poles or buildings. Under certain conditions the sensation of shadow flicker may cause annoyance and may impact on a driver's ability to operate a motor vehicle safely.

The photograph in **Plate 18** illustrates a typical situation where shadow flicker may be experienced whilst driving along a road where trees cast shadows.

Plate 18. *Potential shadow flicker created by trees filtering sunlight across road.*

There are no specific guidelines to address the potential impact of shadow flicker on motorists cast by wind turbines across roads, although there are lighting standards that can be applied to minimise the adverse effects of flicker caused by roadside or overhead objects. These standards include AS 1158:5:2007 (Lighting for roads and public spaces – Part 5: Tunnels and underpasses), section 3.3.8 and CIE 88:2004 (Guide for lighting of roads tunnels and underpasses, 2nd ed.), section 6.14. The standards suggest that the flicker effect will be noticeable and possibly cause annoyance between 2.5 and 15Hz (2.5 to 15 flickers per second), and that a flicker effect between 4 and 11Hz should be avoided for longer than 20 seconds.

As the potential flicker frequency for the Boco Rock wind turbines is likely to be around 1Hz, it is unlikely that the flicker effect will cause annoyance or impact on a driver's ability to operate a motor vehicle safely whilst travelling along local roads surrounding the wind farm.

11.5 Blade Glint

Blade glint can occur with the reflection of sun off rotating turbine blades which may be visible from surrounding receptor locations. Glint may be noticeable for some distance, but usually results in a low impact.

The surfaces of the wind turbines, including the towers and blades, are largely convex, which will tend to result in the divergence of light reflected from the surfaces, rather than convergence toward a particular point.

Blade glint can also be mitigated through the use of matt coatings which, if applied correctly, will generally mitigate potential visual impacts caused by glint.

Night Time Lighting

SECTION 12

12.1 Introduction

The Boco Rock wind farm may require obstacle marking and lighting at night time and during periods of reduced visibility. The requirement for lighting would be subject to the advice and endorsement of the Civil Aviation Safety Authority (CASA). CASA is currently undertaking a safety study into the risk to aviation posed by wind farms and may develop a new set of guidelines to replace the Advisory Circular with regard to lighting for wind turbines that was withdrawn by CASA in mid 2008.

In accordance with the CASA Advisory Circular two red medium intensity obstacle lights were required on specified turbines at a distance not exceeding 900m and all lights were to flash synchronously. To minimise visual impact some shielding of the obstacle lights below the horizontal plane was permitted.

Lighting for aviation safety may also be required prior to and during the construction period, including lighting for large equipment such as cranes.

Potential visual impacts associated with obstacle marking and lighting at night time have not been extensively researched or tested in New South Wales, although some site investigations have been carried out at existing wind farms in Victoria. Investigations have generally concluded that although night time lighting mounted on wind turbines may be visible for a number of kilometres from the wind farm project area, the actual intensity of the lighting appears no greater than other sources of night time lighting, including vehicle head and tail lights.

Previous investigations have also suggested that replacing the more conventional incandescent lights with light emitting diodes (LED) may help to minimise the potential visual impact of the wind turbine lights (Epuron 2008).

12.2 Existing light sources

A small number of existing night time light sources occur in the vicinity of the Boco Rock wind farm, and includes residential and general lighting around Nimmitabel.

Localised lighting is associated with a small number of dispersed homesteads located within the project boundary, but lighting is unlikely to be visually prominent and does not emit any significant illumination beyond immediate areas surrounding residential and agricultural buildings.

Lights from occasional vehicles travelling along the local roads provide dynamic and temporary sources of light.

12.3 Potential light sources

The main potential light sources associated with the Boco Rock wind farm would include:

- Control and auxiliary buildings;
- Substation; and
- Wind turbines.

In addition to the standard level of lighting required for normal security and safety, lighting may also be required for scheduled or emergency maintenance around the control building, substation and wind turbine areas.

As the visibility of the substation and control room would be largely contained by surrounding landform, it is unlikely that light spill from these sources would be visible from the majority of surrounding receptor locations including surrounding residences.

12.4 Potential receptors and impact

The categories of potential receptors that may be impacted by night time lighting generally include residents and motorists.

Irrespective of the total number of visible lights, safety lighting is more likely to be noticeable from exterior areas surrounding residences rather than from within residences where at night time room lights tend to reflect and mirror internal views in windows, or curtains and blinds tend to be drawn.

Whilst safety lighting would be visible to motorists travelling along the local roads, the duration of visibility would tend to be very short and partially screened by undulating landform along some sections of local road corridors.

Night time lighting associated with the wind farm is unlikely to have a significant visual impact on the majority of receptor locations, including residential receptor locations in areas surrounding the proposed wind farm, and would be negligible for most receptor locations.

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Pre-construction and construction

13.1 Potential visual impacts

There are potential visual impacts that may occur during both pre-construction and construction phases of the project. The wind farm construction phase is likely to occur over a period of around 18 to 24 months, although the extent and nature of pre-construction and construction activities will vary at different locations within the project area.

Plate 19. *Illustrating general construction activities at the Capital Hill wind farm site, including views toward cranes, partial construction of towers and laydown areas.*

The key pre-construction and construction activities that may be visible from areas surrounding the proposed wind farm include:

- Ongoing detailed site assessment including sub surface geotechnical investigations;
- Various civil works to upgrade local roads and access point;
- Construction facilities, including portable structures and laydown areas;
- Various construction and directional signage;
- Mobilisation of rock crushing and concrete batching plant (if required);
- Excavation and earthworks; and
- Various construction activities including erection of wind turbines, monitoring masts and substation with associated electrical infrastructure works.

The majority of pre-construction and construction activities, some of which would result in physical changes to the landscape (which have been assessed elsewhere in the LVIA report), are generally temporary in nature and for the most restricted to various discrete areas within or beyond the immediate wind farm project area. The majority of pre-construction and construction activities would be unlikely to result in an unacceptable level of visual impact for their duration and temporary nature.

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Perception and Public Consultation

14.1 Perception

People's perception of wind farms is an important issue to consider as the attitude or opinion of individual receptors adds significant weight to the level of potential visual impact.

The opinions and perception of individuals from the local community and broader area were sought and provided through a range of consultation activities. These included:

- Door knocking;
- Leaflet drops and local media presentations;
- Dedicated project web site including feedback provisions;
- Public open day;
- Public Opinion Surveys; and
- Individual stakeholder meetings.

The attitudes or opinions of individuals toward wind farms can be shaped or formed through a multitude of complex social and cultural values. Whilst some people may accept and support wind farms in response to global or local environmental issues, others may find the concept of wind farms completely unacceptable. Some may support the environmental ideals of wind farm development as part of a broader renewable energy strategy but do not consider them appropriate for their regional or local area. It is unlikely that wind farm projects will ever conform or be acceptable to all points of view; however, research within Australia as well as overseas consistently suggests that the majority of people who have been canvassed do support the development of wind farms.

Wind farms are generally easy to recognise in the landscape and to take advantage of available wind resources are more often located in elevated and exposed locations. The geometrical form of a wind turbine is a relatively simple one and can be visible for some distance beyond a wind farm, and the level of visibility may be accentuated by the repetitive or repeating pattern of multiple wind turbines within a local area. Wind farms do have a significant potential to alter the physical appearance of the landscape, as well as change existing landscape values.

14.2 Public Consultation

The final '125' and '107' design layouts are the culmination of several meetings with residents in the local community, and have taken into account a number of issues and concerns relating to potential visual impacts from individual receptor locations.

The Proponent held a number of meetings with stakeholders in the area surrounding the windfarm, including individual meetings with adjoining landowners potentially impacted by the wind farm development.

A public consultation 'open day' was held on the 26th March 2009 at the Nimmitabel Country Club, and was attended by around 100 visitors. During the open day visitors had the opportunity to review plans of the Boco Rock wind farm development together with a number of photomontages prepared from surrounding locations. Visitors also had the opportunity to complete a landscape values questionnaire prepared for the open day. In addition to the landscape values questionnaire, the Proponent also conducted a Public Opinion Survey during the course of 2008/09. A brief summary of the feedback received from the community is presented below:

From a total of 20 Public Opinion Surveys received by the Proponent:

- *15 respondents supported the Boco Rock wind farm development*
- *3 respondents did not support the Boco Rock wind farm development; and*
- *2 respondents were undecided.*

The three respondents who did not support the wind farm development cited issues with views, spoiling the landscape/wildlife issues and spoiling the scenery.

From a total of 22 Landscape Values Questionnaires received by the Proponent:

- *13 of the respondents considered that the Boco Rock wind farm development would have a negative impact on the landscape; and*
- *9 of the respondents considered that the Boco Rock wind farm development would have either a neutral or positive impact on the landscape.*

Whilst the number of returned surveys and questionnaires are statistically too small to determine any trend in overall positive or negative support for the wind farm development amongst the wider community, they do provide a 'snap shot' into local community attitudes.

An informal straw poll was carried out by the on-line version of the Cooma-Monaro Express (11th October 2007), which posed the question:

'Should Monaro have wind farms?'

From a total of 119 respondents 75% agreed that the Monaro should have wind farms, 23% of respondents disagreed and 2% were undecided. The poll was not scientific and only expressed the views of on-line viewers who chose to participate in the poll.

14.3 Quantitative Research

Whilst published Australian research into the potential landscape and visual impacts of wind farms is limited, there are general corresponding results between the limited number that have been carried out when compared with those carried out overseas.

One of the most recent studies to have been carried out to establish community perception toward wind farms was commissioned by Epuron for the Gullen Range wind farm and was completed in August 2007. The proposed Gullen Range wind farm site is located in the Southern Tablelands region of New South Wales, where a small number of wind farms are operating or have been approved for construction, with an additional number currently planned.

The study targeted people living in a number of small urban and rural communities located in the area immediately surrounding the proposed Gullen Range wind farm as well as other communities surrounding potential future wind farm development sites. The results of the survey suggested that almost 89% of respondents were in favour of wind farms being developed in the Southern Tablelands, with around 71% of respondents accepting the development of a wind farm within one kilometre from their residential dwelling.

These general levels of support for wind farm developments have also been recorded for a number of wind farm developments around Australia as well as overseas.

Auspoll research carried out in February 2002 on behalf of a wind farm developer for a wind farm project in Victoria included just over 200 respondents. The results indicated that:

- *Over 92% of respondents agreed that wind farms can make a difference in reducing greenhouse emissions and mitigating the effects of global warming.*
- *Over 88% disagreed with the statement that wind farms are ugly.*
- *Over 93% of respondents identified 'interesting' as a good way to describe wind farms, over 73% nominating 'graceful' and over 55% selecting attractive.*
- *Over 79% of respondents thought that the wind farm would have a good impact on tourism, with 15% of respondents believing that the wind farm would make no difference.*
- *Over 40% of respondents believed that the impact of the wind farm on the visual amenity of the area would be good, with 40% believing that it would make no difference.*

A September 2002 MORI poll of 307 tourists conducted in Argyll (United Kingdom) indicated that:

- *43% maintained that the presence of wind farms had a positive impression of Argyll as a place to visit.*

- *43% maintained that the presence of wind farms had an equally positive or negative effect.*
- *Less than 8% maintained it had a negative effect.*
- *91% of tourists maintained that the presence of wind farms in Argyll made no difference to the likelihood of them visiting the area.*

There is no published Australian research on community attitudes to the impact of wind farms on landscape and visual issues before and after construction. However, overseas research in the United Kingdom conducted by MORI in 2003 indicated that:

- *Prior to construction 27% of people polled thought problems may arise from wind farm impact on the landscape*
- *Following construction the number of people who thought the landscape has been spoiled was 12%.*

The majority of research carried out to date has focussed on public attitudes to wind farms and does not provide any indication for acceptable or agreed thresholds in relation to numbers and heights of turbines, and the potential impact of distance between turbines and receptors.

14.4 The Broader Public Good

Whilst visual perceptions and attitudes of local communities toward wind farm developments are an important issue, and need to be assessed locally in terms of potential landscape and visual impacts, there is also an issue of the greater potential public benefit provided by renewable energy production. Wind farms are expected to make a contribution toward meeting the Government's commitment that 20% of Australia's electricity supply comes from renewable energy sources by 2020.

In the 2006 Land and Environment Court decision to confirm, on an amended basis, consent for the construction of a wind farm at Taralga, Chief Judge Justice Preston said in his prologue to the judgement:

"The insertion of wind turbines into a non-industrial landscape is perceived by many as a radical change which confronts their present reality. However, those perceptions come in different hues. To residents, such as members of the Taralga Landscape Guardians Inc. (the Guardians), the change is stark and negative. It would represent a blight and the confrontation is with their enjoyment of their rural setting".

"To others; however, the change is positive. It would represent an opportunity to shift from societal dependence on high emission fossil fuels to renewable energy sources. For them, the

confrontation is beneficial – being one much needed step in the policy settings confronting carbon emission and global warming".

"Resolving this conundrum – the conflict between the geographically narrower concerns of the guardians and the broader public good of increasing the supply of renewable energy – has not been easy. However, I have concluded that, on balance, the broader public good must prevail".

Whilst the exact circumstances between the Taralga wind farm and the proposed Boco Rock wind farm may differ, the comments provided by the Chief Judge clearly state the need for the broader public good to be put before the potential negative impacts on some members of the local community.

15.1 Mitigation Measures

The purpose of mitigation is to avoid, reduce, or where possible remedy or offset any significant negative impact arising from the Boco Rock wind farm development. In general mitigation measures may reduce the potential visual impact of the Boco Rock wind farm in two ways:

- Firstly, by reducing the visual prominence of the wind turbines and associated structures by minimising the visual contrast between the wind turbines and the landscape in which they are viewed; and
- Secondly, by screening views toward the wind turbines from specific receptor locations.

In relation to the first form of mitigation, the design of the turbine structures has been highly refined over a number of years to maximise their efficiency. The height of the supporting towers and dimensions of the rotors are defined by engineering efficiency and design criteria. Consequently, modification of the turbine design to mitigate potential visual impacts is not considered a realistic option.

Colour is one aspect of the wind turbine design that does provide an opportunity to reduce visual contrast between the turbine structures and the background against which they are viewed. The white colour that is used on a majority of turbine structures provides the maximum level of visual contrast with the background. This maximum level of visual contrast could be reduced through the use of an appropriate off white or grey colour for the turbines where the visual contrast would be reduced when portions of the turbine were viewed against the sky as well as for those portions viewed against a background of landscape. The final colour selection may, however, be subject to the availability of turbine models on the market at the time of ordering.

The potential visual impact of the Boco Rock wind farm from specific receptor locations could be mitigated by planting vegetation close to the receptor locations. For instance, tree or large shrub planting close to a residence can screen potential views to individual or groups of turbines. Similarly roadside tree planting can screen potential views of turbines from particular sections of road provided the turbine is not located some distance from the road.

The location and design of screen planting used as a mitigation measure is very site specific and requires detailed analysis of potential views and consultation with receptors. Planting vegetation may not provide effective mitigation in all circumstances and can reduce the extent of existing views available from residences or other receptor locations.

There is greater potential to mitigate the visual prominence for some of the ancillary structures and built elements associated with the wind farm, including the substation, control room and facilities buildings, through the appropriate selection of materials and colours, together with consideration of their reflective properties.

The potential visual impacts of vehicular tracks providing access for construction and maintenance can be mitigated by minimising the extent of cut and fill in the track construction. Re-vegetating disturbed soil areas immediately after completion of construction works and using local materials as much as possible in track construction to minimise colour contrasts also assist in mitigating potential impacts. The proposed substation and control room to be constructed in association with the wind turbines would be relatively limited in size. Potential visual impacts would be mitigated by careful location away from direct views from major roads and residences.

15.2 Summary of Mitigation Measures

Table 22 Visual Assessment: Summary of Mitigation Measures

Safeguard	Implementation			
	Design	**Site Preparation**	**Construction**	**Operation**
Consider options for use of colour to reduce visual contrast between turbine structures and background, e.g. use of off white rather than white, and use matt finish to avoid reflected sunlight.	✓			
Avoid use of advertising, signs or logos mounted on turbine structures, except those required for safety purposes.			✓	✓
If necessary, design and construct site control building and facilities building sympathetically with nature of locality.	✓		✓	
If necessary, locate substations away from direct views from roads and residences, to minimise additional line needed, and to ‘blend in’ with existing transmission infrastructure.	✓		✓	
Enforce safeguards to control and minimise fugitive dust emissions.		✓	✓	
Restrict the height of stockpiles to minimise visibility from outside the site.		✓	✓	
Minimise activities that may require night time lighting, and if necessary use low lux (intensity) lighting designed to be mounted			✓	✓

Safeguard	Implementation			
	Design	Site Preparation	Construction	Operation
with the light projecting inwards to the site to minimise glare at night.				
Minimise cut and fill for site tracks and revegetate disturbed soils as soon as possible after construction.		✓	✓	
Maximise revegetation of disturbed areas to ensure effective cover is achieved.				✓
Consider options for planting screening vegetation in vicinity of nearby residences and along roadsides to screen potential views of turbines. Such works to be considered in consultation with local residents and authorities.	✓	✓		
Undertake revegetation and off-set planting at areas around the site in consultation and agreement with landholders.	✓	✓	✓	

Cumulative Visual Impact Assessment

16.1 Summary

'Direct' cumulative visual impacts may occur where two or more winds farms have been constructed within the same locality, and may be viewed from the same receptor location either simultaneously, or within the same overall viewshed.

'Indirect' cumulative visual impacts may also arise as a result of multiple wind farms being observed at different locations during the course of a journey (e.g. from a vehicle travelling along a highway or from a network of local roads), which may form an impression of greater magnitude within the construct of short term memory.

There are no additional wind farms that have been constructed, or that are currently being assessed for planning approval, that occur within the nominated viewshed of the Boco Rock wind farm. Therefore there are unlikely to be any 'direct' cumulative impacts that result from views toward multiple wind farms from the receptor locations identified in the LVIA.

The Capital Hill wind farm is the nearest existing wind farm (currently under construction) in New South Wales located north of Bungendore. The Capital Hill wind farm is approximately 165km north east of the Boco Rock wind farm site and will host up to 63 turbines.

The Snowy Plains wind farm is the closest approved wind farm to the Boco Rock wind farm. This wind farm will be located approximately 30km north west of Berridale, and around 65km north west of the Boco Rock wind farm. The Snowy Plains wind farm will host up to 16 turbines. Approved in 2005, construction of the Snowy Plains wind farm is yet to commence.

The closest proposed wind farm is at Shannon's Flat located to the north of Cooma. This proposal, currently subject to feasibility studies, would be for up to 20 wind turbines and approximately 70km north, and beyond the viewshed, of the Boco Rock wind farm.

The majority of wind farms within New South Wales, currently constructed, approved or under consideration by the New South Wales Department of Planning, are located within the general regional area of the New South Wales Southern Tablelands, including sites in the locality of Crookwell, Goulburn, and Yass.

An online ABC News report dated 26th August 2009, suggested that the New South Wales Government planned to fast-track renewable energy projects (including wind farms) in the state's south-east, including the far South Coast and Monaro. It is therefore likely that additional wind farm projects will be proposed within the region and potentially contribute to potential cumulative visual impact.

Wind farm proponents may be required to undertake cumulative impact assessments to determine potential impacts on a project by project basis. The LVIA determined that the Boco Rock wind farm is unlikely to result in either a direct, or indirect, cumulative visual impact (including potential cumulative impact associated with night time obstacle lighting), in association with any known existing or proposed wind farm in New South Wales.

Conclusions

17.1 Summary

In summary, the LVIA has determined that the Boco Rock wind farm, based on either the '125' or '107' design layout, would have an overall **Low** to **Moderate** visual impact on the majority of non-associated residential receptors as well as receptors at public locations, including the main highways and local road networks identified in the LVIA.

The LVIA determined that the Boco Rock wind farm would have a potential **High** visual impact on 12 of the 94 residential receptors. The 12 residential receptors are all associated landowners hosting wind turbines on their property. Each associated landowner has been in close consultation with the Proponent during the planning process, including the positioning of individual wind turbines within respective property boundaries. It is understood that none of the associated landowners has expressed concerns with regard to the potential visual impact of the proposed wind farm, including the potential visibility of wind turbines from within, or immediately surrounding their residential dwellings.

The LVIA determined the overall landscape character sensitivity to be **Medium** with some characteristics of the landscape likely to be altered by the wind farm development, although the landscape may have some capability to accommodate change. This capability is largely derived from the large scale and open landscape character identified in this part of the Monaro, together with the relatively low density of potential receptors located within the immediate and surrounding area of the wind farm viewshed.

The LVIA determined that the construction of either the '125' or the alternative '107' design layout would result in no significant difference in the overall level of landscape or visual impact.

The majority of residential dwellings surrounding the wind farm are strategically situated within the landscape to mitigate exposure to inclement weather, or have adopted measures to reduce these impacts by planting and maintaining windbreaks around dwellings. The extent of windbreak planting reduces the potential visibility of the windfarm from a number of residential receptor locations surrounding the wind farm area.

The LVIA identified and assessed 25 selected public receptor locations, the majority from road corridors. The LVIA determined that the proposed wind farm would not have a High impact on views from any of the selected public receptor locations. The LVIA determined that the wind farm would have a Moderate impact on 7 of the selected public receptor locations, generally due to the proximity of the wind turbines relative to the receptor. The majority of the selected public receptor locations are dynamic view locations (motorists travelling along local roads) and include contextual views that will potentially change in reasonably quick succession within the spatial qualities of the surrounding landscape.

It is acknowledged that the wind farm may have the potential to impact people engaged in predominantly farming or recreational activities, where views toward wind turbines occur from surrounding and non-associated agricultural areas. Ultimately the level of impact would depend on the type of activities engaged in as well as the location of the activities together with the degree of screening provided by local landform or vegetation within individual properties. Whilst views toward the turbines will occur from a wide area of surrounding rural agricultural land, the LVIA has determined that the sensitivity of visual impacts is less for those employed or carrying out work in rural areas compared to potential views from residential dwellings.

The LVIA has determined that the large majority of non-associated landowners adjoining the wind farm project area are unlikely to have views toward the wind farm from their residential dwellings.

Views toward the proposed collector substation, located to the north of Coal Pit Gully, would be largely contained by surrounding topography and unlikely to be visible from surrounding residential or public receptor locations. Similarly the internal overhead 33kV electrical lines are unlikely to be visible from the majority of receptor locations identified in the LVIA.

The Landscape Character Areas identified and described in the LVIA are generally well represented throughout the Bombala Council and Cooma-Monaro Shire Council areas and more generally within other sub-regions of temperate grassland across the New South Wales Southern Tablelands. The LVIA has determined that the landscape surrounding the Boco Rock wind farm may have the ability to accommodate the physical changes associated with the wind farm and its associated structures. Wind farm developments have been previously approved in the New South Wales Southern Tablelands region and in similar areas of landscape character, including the wind farms located at Crookwell, the Cullerin Range and Capital Hill north of Bungendore.

The shadow flicker assessment, prepared by Garrad Hassan Pty Ltd, concluded that the wind farm would potentially impact one residential receptor (an associated landowner) by exceeding a cumulative 30 hours of shadow flicker per year. Views toward the wind turbines from this residential receptor location are significantly screened by windbreak planting, as well as tree planting surrounding the residence. As there are effectively no views toward the turbines, it is unlikely that shadow flicker would be experienced within or surrounding the curtilage of the residence.

It is unlikely that potential wind turbine shadow flicker effects would have any significant adverse impacts on people with photosensitive epilepsy or upon motorists travelling along local roads surrounding the wind farm.

The potential impact associated with night time obstacle lighting, if required by CASA, is unlikely to be significant.

The Boco Rock wind farm would not have a significant impact on the character of the Nimmitabel Township, where views toward the wind farm from the majority of residential receptors would be screened by adjoining residences or tree cover. A small number of residences located on elevated sections east of Nimmitabel may have potential distant views toward a small number of turbines within the eastern portion of the wind farm project area, although views toward these turbines are likely to be partially screened in some circumstances by landform and vegetation.

The Boco Rock wind farm would not be significantly visible from the major roads within the general locality of the wind farm, including the Monaro Highway and Snowy Mountains Highway. The wind farm would be visible from a number of local roads, including the Snowy River Way; however, the local roads carry a relatively low volume of daily traffic. The Boco Rock wind farm is not considered to have a significant impact on distant views toward the Snowy Mountain Range from any of the receptor locations assessed in this LVIA.

The construction of the Boco Rock wind farm would not result in a cumulative landscape or visual impact when considered against any known existing or proposed wind farm developments, including the Snowy Plains and Capital Hill wind farm projects.

Both pre-construction and construction activities are unlikely to result in an unacceptable level of visual impact due to the temporary nature of these activities together with proposed restoration and rehabilitation strategies. The preferred location for some of the construction activities, including the on-site concrete batch plant and rock crusher, would generally be located away from publicly accessible areas, with the closest residential receptors generally comprising associated landowners.

Although some mitigation measures may be considered appropriate to minimise the visual effects for a number of the elements associated with the 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 receptor locations. Despite this, the Proponent has engaged in ongoing consultation with local residents and made a number of adjustments to the location of individual turbines to minimise visual impacts where possible.

Subject to Department of Planning determination, and any conditions of approval, the proponent would consider implementing landscape treatments to screen and mitigate the potential visual impact of the wind farm for individual neighbouring properties within an appropriate and agreed distance from the wind farm project area, subject to consultation and agreement with individual property owners.

Appendix A – Garrad Hassan Flicker Assessment

SHADOW FLICKER ASSESSMENT FOR THE BOCO ROCK WIND FARM, NEW SOUTH WALES

Client	**Green Bean Design Pty Ltd**
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Document No	45067/PR/08
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2. This report has been produced from information relating to dates and periods referred to in this report. The report does not imply that any information is not subject to change.

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CONTENTS

1 EXECUTIVE SUMMARY

Garrad Hassan Pacific Pty Ltd (GH) has been commissioned by Green Bean Design Pty Ltd (GBD) to carry out an independent assessment of the shadow flicker durations for sites around the Boco Rock Wind Farm, based on a 107 wind turbine layout. The results of the work are reported here.

Conditions of consent applied to projects in NSW have been consistent with the Victorian guidelines [1] in relation to shadow flicker. Within these guidelines, the issue of shadow flicker is specifically addressed and it is stated that:

"The shadow flicker experienced at any dwelling in the surrounding area must not exceed 30 hours per year as a result of the operation of the wind energy facility."

It is generally proposed that shadow flicker from wind turbines does not cause annoyance beyond a distance equivalent to approximately 10 rotor diameters.

Determining the annual duration of shadow flicker is far from straightforward. The simplest method to calculate shadow flicker examines the quantity of shadow flicker from a purely geometrical standpoint. Such a style of calculation is the simplest, but tends to over-estimate the number of hours of shadow flicker experienced at a dwelling [1,2]

There are a number of reasons why the theoretical duration of shadow flicker provides a conservative assessment. Calculation of the theoretical duration of shadow flicker is usually undertaken based on simplifying assumptions regarding operation of the turbines;

- The modelled shadow flicker hours assumes that the wind turbine is constantly yawed to the worst case position of facing into or away from the sun, and hence in the worst-case orientation for casting shadows;
- Periods where the wind turbine is not rotating due to low winds are not considered.

There are also local environmental factors which can reduce the incidence of shadow flicker relative to the theoretical values;

- Periods when there are clouds between the sun and observer;
- The modelling process does not take into account any reduction due to the effect of any vegetation or other shielding effects.

Independent analysis of duration of shadow flicker has been conducted for dwellings neighbouring the proposed Boco Rock Wind Farm by means of a simple geometric analysis, together with an assessment of the probable degree of conservatism attached to the assessment. The modelling shows that there are four buildings that may be subject to some level of shadow flicker.

An assessment has also been conducted to estimate the potential degree of conservatism due to the yaw direction of the turbine. This supplementary analysis suggests a significantly lower amount of shadow flicker to be expected at the surrounding buildings.

Note that the modelling process does not take into account any further reduction due to the effects of vegetation or other shielding effects around each house, cloud cover or turbine shutdown in calculating the number of shadow flicker hours, and therefore the adjusted values may still be regarded as a conservative assessment.

Should problems occur, potential mitigation measures exist to reduce the incidence of shadow flicker. The simplest management technique is a physical screen between the wind turbines and any sensitive location. This is most easily accomplished by means of additional trees or other vegetation.

It is also noted that the times for which there is the potential for shadow flicker to occur can be determined in advance. Modern wind turbines are controlled by sophisticated computer systems, and the potential exists to manage operation of the proposed wind farm to turn off individual turbines to avoid shadow flicker incidence at such times.

2 DESCRIPTION OF THE PROPOSED WIND FARM SITE

Site description

The Boco Rock site is located in southeastern New South Wales, approximately 5 km west of Nimmitabel and approximately 30 km south of Cooma, as shown in Figure 2.1.

The site is mainly cleared land, consisting of a ridgeline running approximately north-south on the western edge of a valley and two elevated areas to the northeast of the valley.

House locations

A list of co-ordinates of buildings, within and surrounding the site, has been provided by GBD [3]. Co-ordinates of receptors (ie. buildings) within 1.5 km of the wind farm are shown in Table 2.1.

The co-ordinates presented in this report are in UTM Zone 55 of the MGA94 coordinate system.

Proposed Wind Farm layout

GBD has advised that the proposed turbine model for the project may have a rotor diameter of 104 m and a proposed hub height of 100 m.

A list of co-ordinates of proposed turbine locations has been provided by GBD [4]. These co-ordinates are shown in Note 1 The co-ordinates presented in this report are in MGA 94, Zone 55.
Table 2.2.

Figure 2.2 shows a more detailed map of the site with the proposed turbine layout and surrounding house locations.

3 BLADE GLINT

Blade glint is the regular reflection of sun off rotating turbine blades. Its occurrence depends on a combination of circumstances arising from the orientation of the nacelle, angle of the blade, and the angle of the sun [5]. The reflectiveness of the surface of the blades is also important. The effect can be noticed over considerable distances, but is usually very minor.

Blade glint can be effectively and cost effectively managed through the use of matt coatings on the turbine blades and, if so done, is not considered to have a significant visual impact [1]. Blade glint is therefore not expected to be a problem with the proposed Boco Rock wind farm if appropriate matt finish is specified for the turbine blades.

4 SHADOW FLICKER ASSESSMENT METHODOLOGY

Due to their height, wind turbines and their blades can cast shadows on surrounding areas at a significant distance from the base of the tower. Coupled with this, the moving blades create moving shadows. When viewed from a stationary position, the moving shadows appear as a flicker giving rise to the phenomenon of 'shadow flicker'. When the sun is low in the sky the length of the shadows increases, increasing the shadow flicker affected area around the wind turbine.

The number of annual hours of shadow flicker at a given location can be calculated using geometrical models incorporating data such as the sun path, the topographic variation over the wind farm site, and wind turbine details such as rotor diameter and hub height. In such models, the wind turbine rotor is modelled as a disc and is assumed to be in the worst case position, pointing towards the sun. Furthermore, the sun is assumed to be a point light source.

To illustrate typical results, an indicative theoretical shadow flicker map, for a flat area, is shown in Figure 3.1. The geometry of the shadow flicker map can be characterised as a butterfly shape, with the four protruding lobes corresponding to slowing of solar north-south travel around the summer and winter solstices for morning and evening. The lobes to the north of the indicative turbine location result from the summer solstice and conversely the lobes to the south result from the winter solstice. The lobes to the west result from morning sun while the lobes to the east result from evening sun.

Shadow flicker calculated in this manner overestimates the number of annual hours of shadow flicker experienced at a specified location due to several reasons.

1. The probability of wind turbines consistently yawing to the 'worst case' scenario where the wind turbine is facing into or away from the sun-turbine vector is less than 1 (i.e. less than 100% of the time).

   It is noted that the diagram shown in Figure 3.1 has been generated assuming that the indicative turbine is always pointing towards or away from the sun. Wind direction data at the site has been provided by the client and the site wind rose is shown overlaid on the indicative shadow flicker map, in the form of a site wind rose binned into 30 degree direction bins.

   Orientation of the rotor other than directly pointing at the sun will reduce the projected shadow, and hence the incidences of shadow flicker.

2. The occurrence of cloud cover has the potential to significantly reduce the number of hours of shadow flicker.

3. The amount of aerosols (moisture, dust, smoke, etc.) in the atmosphere has the ability to influence shadows cast.

   Firstly, the distance away from a wind turbine that shadows can be cast is dependent on the degree that direct sunlight is diffused, which is in turn dependent on the amount of dispersants (humidity, smoke and other aerosols) in the path of light between the light source (sun) and the receiver [2].

   Secondly, the quantity of aerosols in the air is known to vary with time and thereby affecting the refraction of light. This in turn affects the intensity of the direct light and consequently, the resulting shadows.

4. The modelling of the wind turbine blades as discs to determine shadow path overestimates the shadow flicker effect.

   The blades are of non-uniform width with the thickest viewable blade width (maximum chord) occurring closer to the hub and the thinnest being located at the tip of the blade. As outlined in point 3 above, the direct sunlight is diffused resulting in a maximum distance from the wind turbine that a shadow can be cast. This maximum distance is dependent on the human threshold for which variation in light intensity can be perceived [2]. When the blade tip causes shadow, the diffusion of direct sunlight means that the light variation threshold occurs closer to the wind turbine than when a shadow is caused by the maximum chord. That is, the maximum shadow length cast by the blade tip is less than by the blade root or maximum chord.

5. Modelling the sun as a point light source rather than a disc has an effect similar to that of point 4 above.

   Firstly, situations arise where the light rays from different portions of the sun disc superimpose around a shadow resulting in light intensity variations less than human perception.

   Secondly, when the sun is positioned directly behind the wind turbine hub, there is no variation in light intensity at the receiver location and therefore no shadow flicker.

6. The presence of vegetation can locally shield incidences of shadow flicker.

7. Periods where the wind turbine is not in operation due to low winds, high winds or operational and maintenance reasons. This is specific to the operational control of particular turbine types.

The modelling of shadow flicker has been conducted using simple geometric analysis. The wind turbine has been modelled assuming all wind turbines are disc objects positioned in the worst case with respect to shadow flicker. The sun has been assumed to be a point light source.

Due to points 3 and 4 above, an approximation for the maximum length of shadow flicker which may result in annoyance has been used. Guidance from the South Australian Government recommends that this distance is 500 m [6]. Other guidelines suggest a limit of up to 10 rotor diameters. Considering local and international industry experience, GH generally assumes that the maximum distance to which shadow flicker should be considered is the greater of 1 km [7] or 10 rotor diameters. For the layout assessed here, it has been assumed that shadow flicker may result in annoyance out to a maximum distance of 10 rotor diameters from each turbine, being 1040 m.

No attempt has been made to account for the effects of cloud cover, or to identify any vegetation or other shielding effects around each house, in calculating the number of shadow flicker hours presented in Section 4.

Due to these effects, and those described above, it is probable that the results presented here overestimate the actual amount of shadow flicker that will be experienced.

5 RESULTS OF THE ANALYSIS

The results of the assessment of shadow flicker for the Boco Rock Wind Farm are presented in the form of a shadow flicker map in Figure 4.1. The shadow flicker results for each receptor within 1.5 km of the wind farm are listed in Table 4.1.

The assessment shows that there are four buildings that may be subject to some level of shadow flicker. These are identified as the Yandra, Rockybah, Benbullen and Coopers Hill residences. One of these, Benbullen, has shown potential to have a maximum theoretical duration of shadow flicker greater than 30 hours per annum. The other three are predicted to have maximum theoretical shadow flicker durations of less than 30 hours per annum. The information provided to GH states that all four are participating landowners' residences.

Analysis has been conducted to assess the effect of the site wind regime in determining the turbine orientation, rather than using the worst case assumption of the turbine always facing the sun. By combining the probability of occurrence of various wind directions, with the reduction in shadow flicker resulting from orientation of turbines to these wind directions, a second set of shadow flicker results have been determined. These calculations have been completed based on 30 degree direction bins.

The results of this supplementary analysis have shown a significantly reduced amount of shadow flicker to be expected at the surrounding buildings. These results are also presented in Table 4.1.

Note that the modelling process does not take into account any reduction due to the effects of vegetation or other shielding effects around each house, cloud cover or turbine shutdown in calculating the number of shadow flicker hours and therefore, the supplementary analysis may still yield conservative results.

Should problems occur, potential mitigation measures exist to reduce the incidence of shadow flicker. The simplest management technique is a physical screen between the wind turbines and any sensitive location. This is most easily accomplished by means of additional trees or other vegetation.

It is also noted that the times for which there is the potential for shadow flicker to occur can be determined in advance. Modern wind turbines are controlled by sophisticated computer systems, and the potential exists to manage operation of the proposed wind farm to turn off individual turbines to avoid shadow flicker incidence at such times.

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5 Energy-Wise Renewables "Guidelines for Renewable Energy Developments - Wind Energy", Energy Efficiency and Conservation Authority New Zealand, June 1995.

6 Planning SA, Planning Bulletin "Wind Farms, Draft for Consultation", South Australian Government, 2002.

7 http://www.windpower.org/en/tour/env/shadow/shadow2.htm

LIST OF TABLES

LIST OF FIGURES

House Identifier	Easting [m] [1]	Northing [m] [1]	Name	Active Landowner
1	696387	5954178	Yandra	Yes
2	691826	5955463	Roselea	Yes
3	693247	5953985	Rockybah	Yes
4	699314	5951354	Benbullen	Yes
5	684531	5940643	Coopers Hill	Yes
6	698804	5955622	Glenfinnan	Yes
7	688537	5951337	Nestlebrae	Yes
8	684924	5947624	Avonlake	Yes

Note 1 The co-ordinates presented in this report are in MGA 94, Zone 55.

Table 2.1 House locations within 1.5 km of the Boco Rock Wind Farm turbines.

Turbine ID	Easting [m] [1]	Northing [m] [1]	Turbine ID	Easting [m] [1]	Northing [m] [1]
1	697079	5947458	38	690021	5952945
2	687735	5949793	39	690269	5953865
3	689060	5948990	40	690378	5954117
4	686429	5949123	41	691064	5953898
5	685314	5942019	42	690882	5953523
6	685239	5941774	43	691404	5954122
7	685391	5942261	44	692762	5952598
8	685471	5943164	45	692760	5952311
9	685544	5942813	46	691378	5951957
10	685548	5943443	47	691478	5951394
11	696481	5948045	48	691168	5951077
12	686480	5948025	49	695888	5951937
13	688607	5949577	50	697108	5950831
14	693737	5948912	51	697385	5951300
15	685924	5946234	52	696773	5952291
16	688177	5950155	53	696828	5952868
17	689264	5949903	54	697727	5953359
18	687305	5947553	55	697254	5953921
19	685086	5941303	56	697222	5953441
20	685462	5946852	57	698530	5953698
21	685950	5945309	58	698582	5954018
22	688582	5950428	59	698490	5954502
23	696428	5949201	60	696503	5948774
24	695344	5949857	61	695808	5949311
25	694743	5949566	62	692153	5953783
26	694588	5948950	63	692349	5954226
27	692960	5948576	64	696897	5951793
28	686184	5947607	65	698556	5951837
29	696452	5948431	66	698243	5950882
30	693291	5948764	67	698114	5953399
31	687965	5949062	68	694594	5954992
32	685387	5941027	69	695268	5954084
33	685651	5940690	70	694917	5954701
34	686437	5949679	71	695166	5953796
35	686725	5949239	72	695722	5953341
36	689544	5952531	73	685998	5944387
37	689720	5952714	74	688370	5949329

Note 1 The co-ordinates presented in this report are in MGA 94, Zone 55.

Table 2.2 Proposed turbine layout for the Boco Rock Wind Farm site. (Cont.)

Turbine ID	Easting [m] [1]	Northing [m] [1]	Turbine ID	Easting [m] [1]	Northing [m] [1]
75	689417	5952335	92	686019	5945675
76	686630	5946509	93	685510	5942510
77	696029	5952768	94	685145	5941548
78	698084	5951461	95	685929	5947130
79	698787	5954759	96	685973	5944698
80	690216	5953133	97	695350	5949014
81	691905	5953488	98	695325	5948274
82	691890	5952113	99	695761	5948324
83	691759	5953070	100	694221	5948752
84	685987	5943787	101	695453	5952686
85	693350	5949564	102	694890	5952608
86	694775	5951867	103	693244	5950271
87	685982	5944993	104	693662	5950592
88	686073	5944069	105	694217	5950185
89	698542	5950987	106	686627	5947073
90	686647	5948528	107	693904	5949660
91	687282	5946971			

Note 1 The co-ordinates presented in this report are in MGA 94, Zone 55.

Table 2.3 Proposed turbine layout for the Boco Rock Wind Farm site. (Concl.)

House	Name	Active Landowner	Theoretical Maximum Hours per Year	Adjusted for rotor orientation Hours per Year	Adjusted for rotor orientation Reduction [%]
1	Yandra	Yes	20	11	44%
2	Roselea	Yes	0	0	
3	Rockybah	Yes	11	6	48%
4	Benbullen	Yes	47	30	36%
5	Coopers Hill	Yes	13	9	34%
6	Glenfinnan	Yes	0	0	
7	Nestlebrae	Yes	0	0	
8	Avonlake	Yes	20	11	44%

Table 4.1 Modelled shadow flicker durations for receptors in the vicinity of the proposed Boco Rock Wind Farm site.

Figure 2.1 Location of the proposed Boco Rock Wind Farm site.

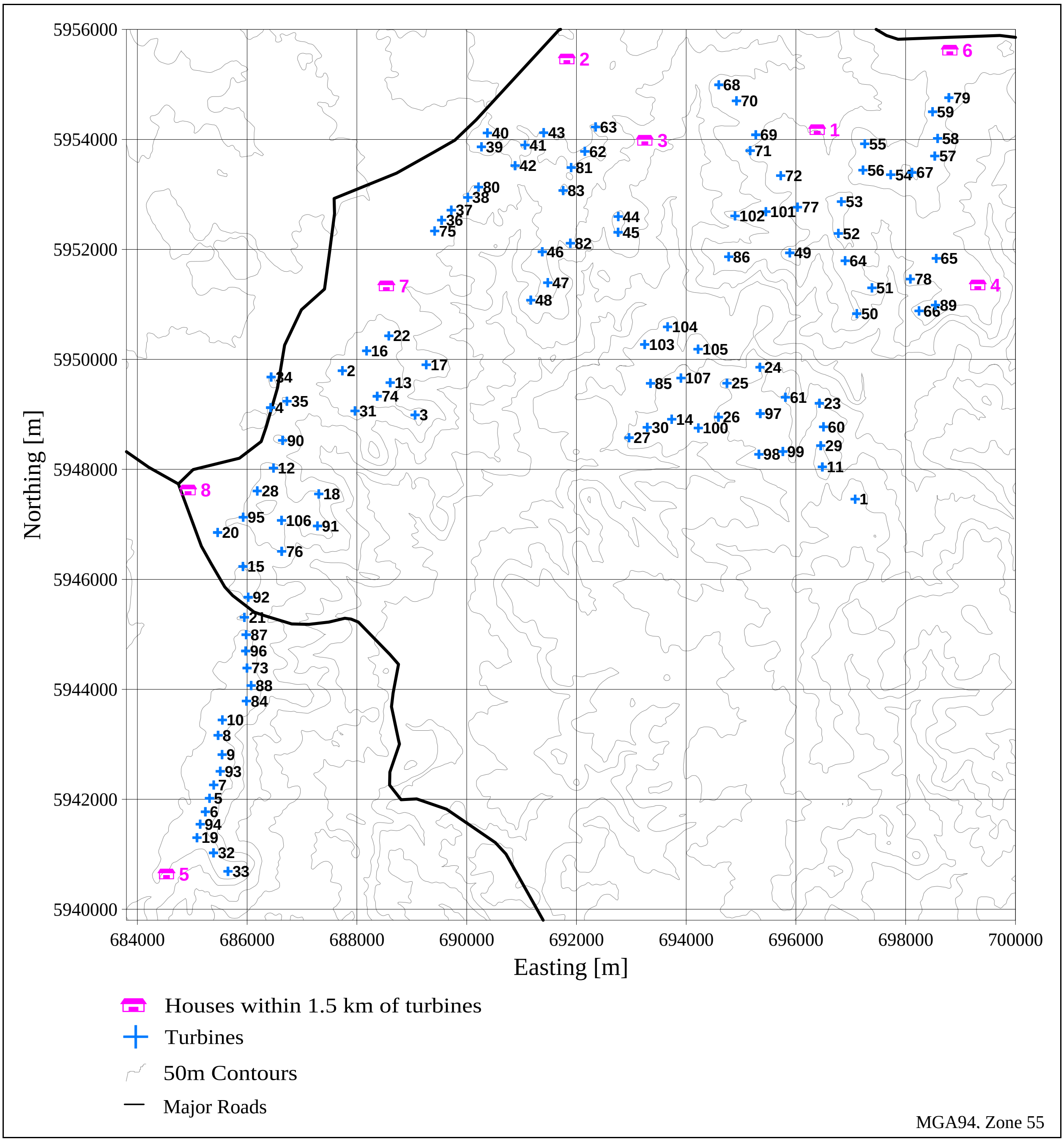


Figure 2.2 Proposed Boco Rock wind farm showing houses within 1.5 km of the turbines.

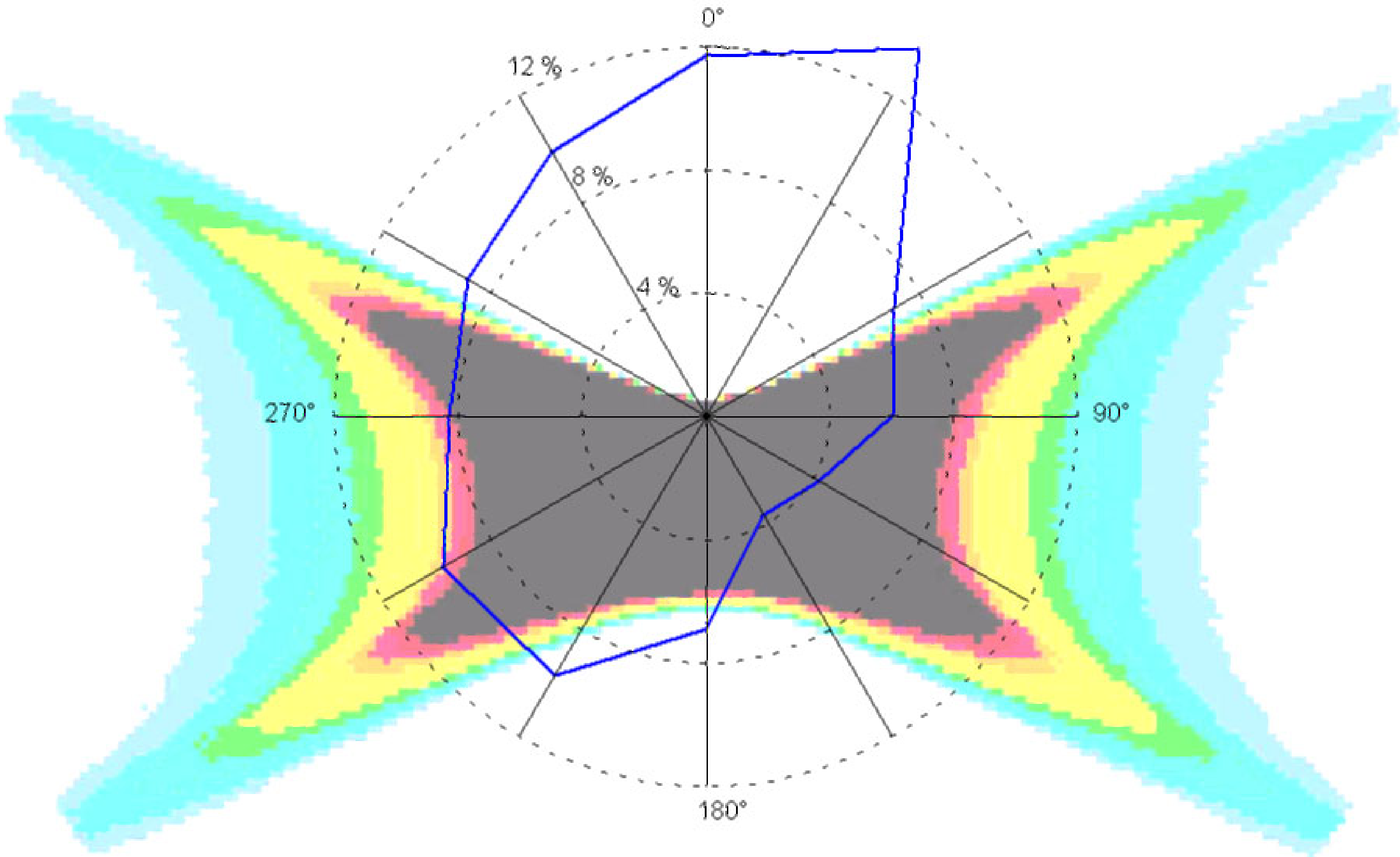


Figure 3.1 Indicative shadow flicker map with wind direction frequency overlain

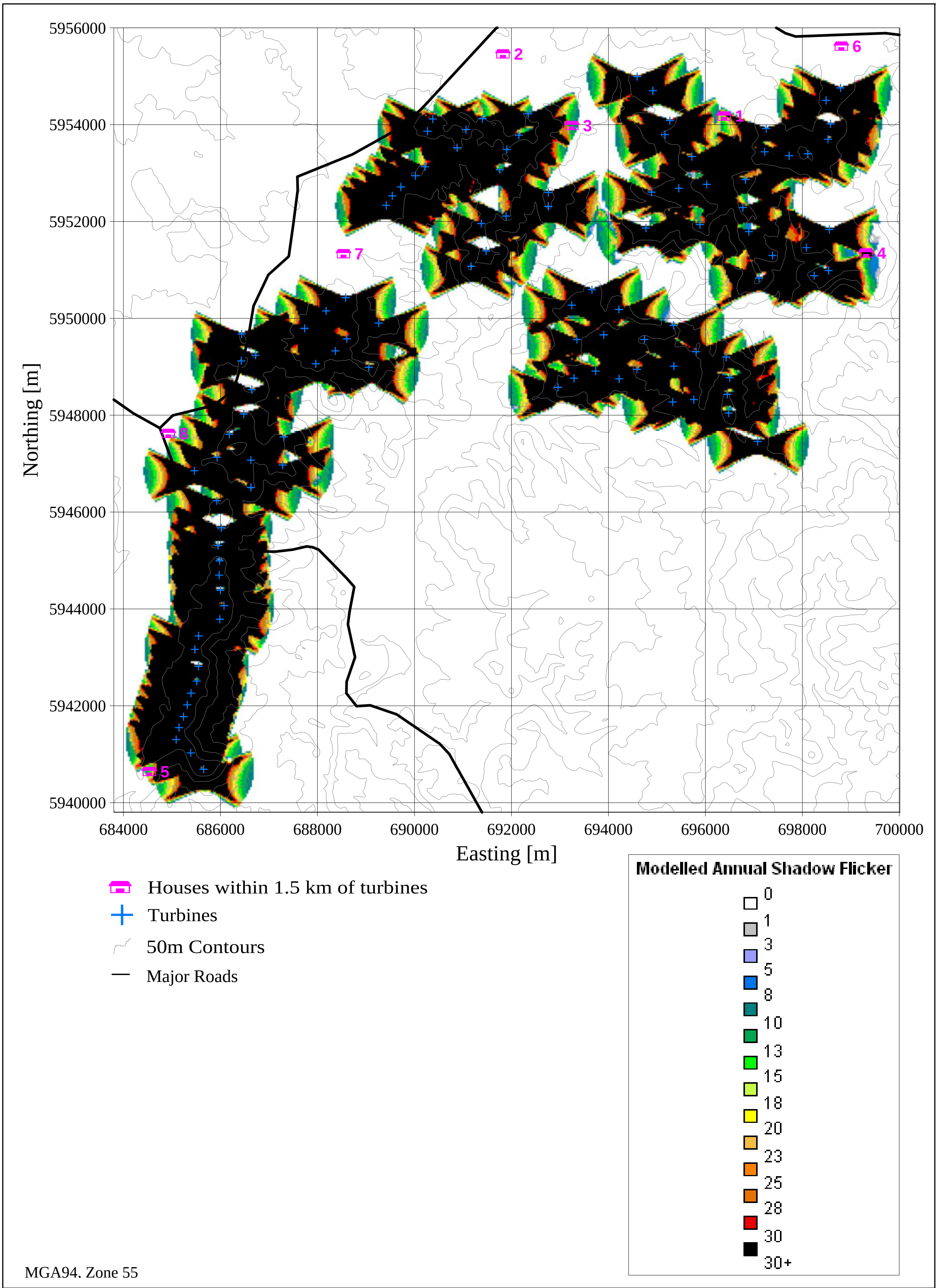


Figure 4.1 Modelled hours of theoretical shadow flicker at the Boco Rock Wind Farm.

Appendix B – Capital Hill wind farm, bench mark study

B.1 Introduction

The bench mark study was originally prepared for the **superseded '127'** design layout which included wind turbines mounted on 80m high towers, and was compared to the wind turbines constructed at the Capital Hill wind farm also mounted on 80m high towers. There are currently no known constructed wind turbines mounted on 100m high towers in New South Wales, and as such there is limited opportunity to update the bench mark study; however, the bench mark study is considered to provide a relative comparison of the process used to create the photomontages and is therefore considered appropriate to verify the procedure used to generate the photomontages for the current wind turbine design layouts.

The photomontages were prepared with the industry standard software package 'GH Windfarmer', specifically designed and applicable to the development of wind farms.

Whilst modern computer software packages produce relatively accurate images to illustrate the location and scale of wind turbines in the landscape, there are opportunities for unintentional errors to occur during the production of photomontage. To verify the scale of the wind turbine structures within the photomontage it can be beneficial, although not always necessary, to undertake a bench mark study against an existing wind farm development.

There are few readily available opportunities to undertake direct visual comparisons between proposed and existing wind farms in New South Wales, largely due to the small number of operational wind farms, as well as differences in tower and rotor dimensions between those previously constructed and the larger dimensions of more advanced and efficient wind turbine models. There was, however, an opportunity to undertake a bench mark study between the superseded Boco Rock wind farm '127' design layout and Capital Hill wind farm that is currently being constructed to the north east of Canberra. The Capital Hill wind farm, approved by the NSW Department of Planning in 2006, allows for the construction of up to sixty three wind turbines and is due for completion in 2009.

The suitability of the Capital Hill wind farm for the bench mark study was determined by similarities in the overall and general characteristics of the landscape and landuse surrounding the wind farm together with the similar wind turbine design parameters. The Capital Hill wind farm turbines include 80m high towers, the same height as the superseded '127' design layout at Boco Rock. The 88m diameter blades at the Capital Hill wind farm are 4m shorter than the 92m diameter blades proposed for the Boco Rock wind farm; however, the variance between rotor diameters was considered to be an acceptable level for the bench mark study over the distances considered.

The bench mark study was applied to the Boco Rock wind farm photomontage locations A, B, C and D, which are illustrated in **Figures 24** to **27**.

A portion of each photomontage with a view toward a proposed turbine was extracted from the panoramic image to represent the original extent of the site photograph taken with a 50mm camera lens. The extracted photograph was then placed next to a photograph (taken with the same camera and 50mm lens) toward the turbines constructed at the Capital Hill wind farm at the same or similar distances.

The bench mark study demonstrated that the wind turbines modelled and incorporated into the LVIA for the **superseded '127' design layout** are comparable in scale to those constructed and photographed at the Capital Hill wind farm.

Detail A (approximate 50mm field of view)

Receptor Location B7 - Springfield Road, view west to south west (127 wind turbine layout)
Distance to closest turbine 1km

Detail A - Proposed Boco Rock windfarm
Distance to closest turbine 1km
Extract replicating 50mm camera lens field of view

Capital Hill Windfarm (as constructed)
Distance to closest turbine 1km
Single frame with a 50mm camera lens

Proposed Boco Rock windfarm - full rotor swept path (red) at 1km

Existing Capital Hill windfarm - full rotor swept path (blue) at 1km

Detail B (approximate 50mm field of view)

Receptor Location B72 - Snowy River Way, view south west to north east (127 wind turbine layout)
Distance to closest turbine 4.6km

Detail B - Proposed Boco Rock windfarm
Distance to closest turbine 4.6km
Extract replicating 50mm camera lens field of view

Capital Hill Windfarm (as constructed)
Distance to closest turbine 4km
Single frame with a 50mm camera lens

Proposed Boco Rock windfarm - full rotor swept path (red) at 4.6km

Existing Capital Hill windfarm - full rotor swept path (blue) at 4km

Photomontage Bench Mark Test

The Boco Rock Windfarm photomontages have been prepared with the technically advanced computer software program GH Windfarmer, specifically designed for windfarm development.

A bench mark test was also carried out to compare the scale of the proposed wind turbines illustrated in the photomontage against the scale of wind turbines within a constructed windfarm.

The Capital Hill windfarm, located north of Bungendore in NSW, was selected for the bench mark test due to similarities in landform characteristics as well as almost identical tower and rotor dimensions to those proposed for the 127 wind turbine layout at Boco Rock.

The bench mark test, and images as illustrated, demonstrate that the scale of the proposed wind turbines in the photomontage are relative and comparable with those at the existing Capital Hill windfarm.

BOCO ROCK WINDFARM

Fig 33 - Bench Mark Study Sheet 1

Garrad Hassan Pacific Pty Ltd

GREEN BEAN DESIGN landscape architects

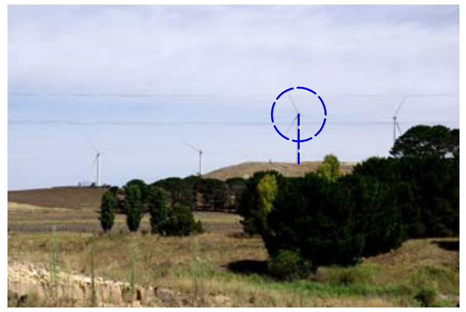
Detail C (approximate 50mm field of view)

Photomontage Location C - Snowy River Way, view north east to south
Distance to closest turbine 1.5km

Proposed Boco Rock windfarm - full rotor swept path (red) at 1.5km

Existing Capital Hill windfarm - full rotor swept path (blue) at 1.5km

Detail C - Proposed Boco Rock windfarm
Distance to closest turbine 1.5km
Extract replicating 50mm camera lens field of view



Capital Hill windfarm (as constructed)
Distance to closest turbine 1.5km
Single frame with 50mm camera lens

Detail D (approximate 50mm field of view)

Photomontage Location D - Ironmungy Road, view north east to south east.
Distance to closest turbine 4.6km

Proposed Boco Rock windfarm - full rotor swept path (red) at 4.5km

Existing Capital Hill windfarm - full rotor swept path (blue) at 4km

Detail D - Proposed Boco Rock windfarm
Distance to closest turbine 4.5km
Extract replicating 50mm camera lens field of view

Capital Hill windfarm (as constructed)
Distance to closest turbine 4km
Single frame with 50mm camera lens

Photomontage Bench Mark Test

The Boco Rock Windfarm photomontages have been prepared with the technically advanced computer software program GH Windfarmer, specifically designed for windfarm development.

A bench mark test was also carried out to compare the scale of the proposed wind turbines illustrated in the photomontage against the scale of wind turbines within a constructed windfarm.

The Capital Hill windfarm, located north of Bungendore in NSW, was selected for the bench mark test due to similarities in landform characteristics as well as almost identical tower and rotor dimensions to those proposed for the 127 wind turbine layout at Boco Rock.

The bench mark test, and images as illustrated, demonstrate that the scale of the proposed wind turbines in the photomontage are relative and comparable with those at the existing Capital Hill windfarm.

BOCO ROCK WINDFARM

Fig 34 - Bench Mark Study Sheet 2

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Limitations

Green Bean Design has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Wind Prospect CWP Pty Ltd and only those third parties who have been authorised in writing by Green Bean Design to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Green Bean Design Proposal dated 12th November 2008.

The methodology adopted and sources of information used are outlined in this report. Green Bean Design has made no independent verification of this information beyond the agreed scope of works and Green Bean Design assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to Green Bean Design was false.

This report was prepared between January and August 2009 and is based on the conditions encountered and information reviewed at the time of preparation. Green Bean Design disclaims responsibility for any changes that may have occurred after this time.

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