# Solar Photovoltaic Glint and Glare Study

Prepared for:

**Bookaar Solar Farm Pty Limited**

**Bookaar Solar Farm**

April, 2018

www.pagerpower.com

# ADMINISTRATION PAGE

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# EXECUTIVE SUMMARY

## Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from the proposed Bookaar Solar Farm located in south western Victoria, Australia. This assessment pertains to the possible effects upon surrounding roads and dwellings. The analysis includes modelling of a tracking system that optimises the panel angle throughout the day to maximise electricity generation.

## Pager Power

Pager Power has undertaken over 300 glint and glare assessments in locations such as Australia, India and Europe. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders including airports and aviation regulators.

## Guidance

There is limited glint and glare guidance for the assessment of proposed solar photovoltaic (PV) developments. Pager Power's methodology is based on independent studies, consultation with stakeholders and experience drawn from completion of over 300 glint and glare assessments.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The results show that the reflections produced are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[1].

## Glint and Glare

The definition of glint and glare used by Pager Power is as follows:

- Glint – a momentary flash of bright light;
- Glare – a continuous source of bright light.

### General Effects of Glint and Glare

Glint and glare effects can only ever occur when the weather is clear and sunny. In the scenario where a solar reflection is possible towards a road user or resident in a surrounding dwelling, the individual will also be looking in the general direction of the Sun. This means the Sun and solar reflection will be visible simultaneously. The Sun is a significantly brighter source of light. Lastly, at any one location, only a particular area of solar panels will produce a solar reflection towards it. Not all receptors will experience a solar reflection at the same time.

## Results

### Surrounding Roads

Solar reflections are theoretically possible towards approximately 2.6km of road classified as an arterial road. Road users are expected to be travelling at (up to) 100 km/h with a low density of traffic expected. Any solar reflection could last for up to 20 minutes, however in reality, its duration would depend on the speed of the car travelling through the solar reflection zone. In accordance with the methodology set out in Section 3 and Appendix E, the overall expected impact upon road users with respect to safety is classified as low (at worst) where the reflecting solar panels are visible. Where the solar panels are not visible, there is no impact.

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[1] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

**Surrounding Dwellings**
Solar reflections are possible towards five surrounding dwelling receptors. At these dwellings, views of the proposed solar farm and the reflecting solar panels has not been confirmed. The solar reflections would last for up to 20 minutes per day potentially all year round from windows with a clear view of the reflecting solar panels. The results vary per dwelling therefore see Section 5.3 and Appendix G for the detailed results breakdown for each dwelling. In all cases, a clear view of the reflecting solar panels at the particular time of day when a solar reflection was geometrically possible would be required. In addition, the weather would also have to be clear and sunny. In accordance with the methodology set out in Section 3 and Appendix E, the resulting impact significance is low to moderate at these dwellings. If proposed screening removes the solar panels from view, no impact will be possible.

**Council Viewpoints**
All three viewpoints (Mt Laura, Camperdown Botanic Gardens and Mt Elephant) are beyond 7km from the proposed solar farm and are situated north and south of the panel area. It is Pager Power's methodology to consider receptors within 1km of a solar panel. Furthermore, no solar reflection would be expected at these viewpoints considering the geographic relationship to the proposed solar farm. Considering this, no impact is expected at these viewpoints.

## Mitigation

Four metre high screening will be installed at the site boundary between the dwellings where a solar reflection may be possible. This will likely remove any visibility of the solar panels because the landscape is relatively flat, the distance between receptors and panels is relatively large and the solar panels are 4m tall at their maximum tilt, equal to the screening height. Therefore any predicted impacts at these dwellings, and also the roads, would likely be removed.

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# ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 43 countries within Europe, Africa, America, Asia and Australasia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects;
- Building developments; and
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

# 1 INTRODUCTION

## 1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from the proposed Bookaar Solar Farm located in south western Victoria, Australia.

This assessment pertains to the possible effects upon surrounding roads and dwellings. This report contains the following:

- Solar farm details;
- Explanation of glint and glare;
- Overview of relevant guidance;
- Overview of relevant studies;
- Overview of Sun movement;
- Assessment methodology;
- Identification of receptors;
- Glint and glare assessment for identified receptors;
- Results discussion; and
- Mitigation.

Following this a summary of findings and overall conclusions and recommendations is presented.

## 1.2 Pager Power's Experience

Pager Power has undertaken over 300 Glint and Glare assessments internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground based receptors including roads and dwellings.

## 1.3 Understanding Glint and Glare – General Overview and Definition

When sunlight illuminates an object, an amount of the incident light is reflected. This reflected light, when directed towards the eye of an observer, can become noticeable and cause a distraction or a nuisance. The definition of glint and glare can vary. The definition used by Pager Power is as follows:

- Glint – a momentary flash of bright light.
- Glare – a continuous source of bright light.

In context, glint will be witnessed by moderate to fast moving receptors whilst glare would be encountered by static or slow moving receptors with respect to a solar farm. The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare. Where reflected sunlight may be visible to a receptor, it can be concluded that glint and glare effects are possible.

# 2 PROPOSED SOLAR FARM LOCATION AND DETAILS

## 2.1 Photovoltaic Panel Mounting Arrangements and Orientation

The solar panels will be mounted to the ground and fitted to a single-axis tracking system that tilts the panels from east to west throughout the day. A single-axis tracking system has been modelled in this report however fixed panels are being retained as an option are also being considered.

## 2.2 Tracking System

It is understood that:

- The azimuth angle of the panels will be 90 degrees in the morning and 270 degrees in the evening. During solar noon, when the Sun is directly overhead, the panels will be flat, directed immediately upwards.
- The tilt of the panels throughout the day is programmed, based on the known path of the Sun and shading considerations i.e. the tilt angle is optimised to avoid having one row of panels cast a shadow on another row.
- The range of elevation angles will be ±60°.

The panel details are illustrated in Figures 1 and 2 below.

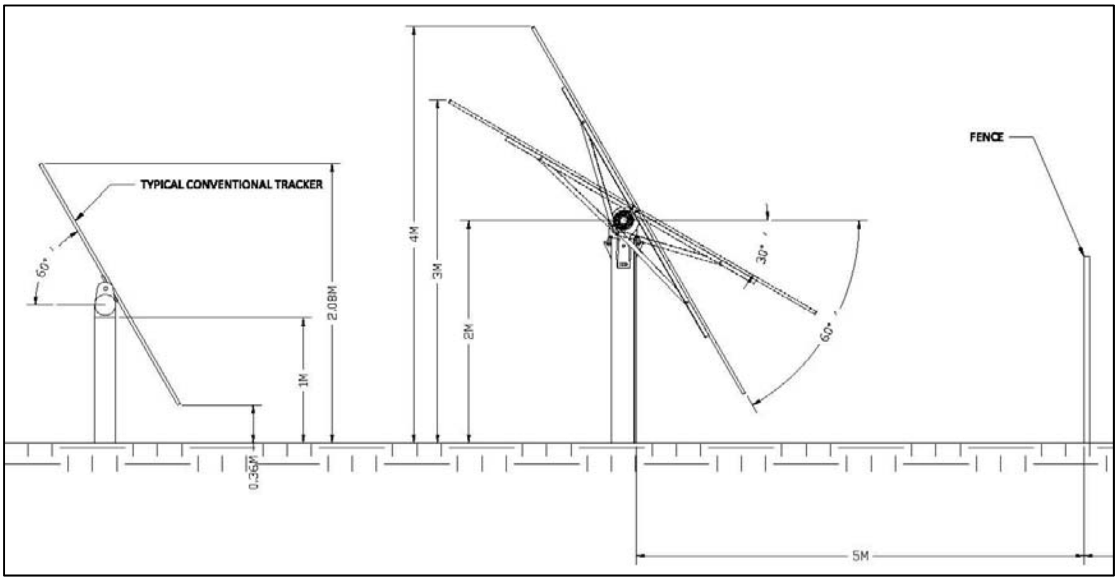


Figure 1 *Panel tracking details – 1*

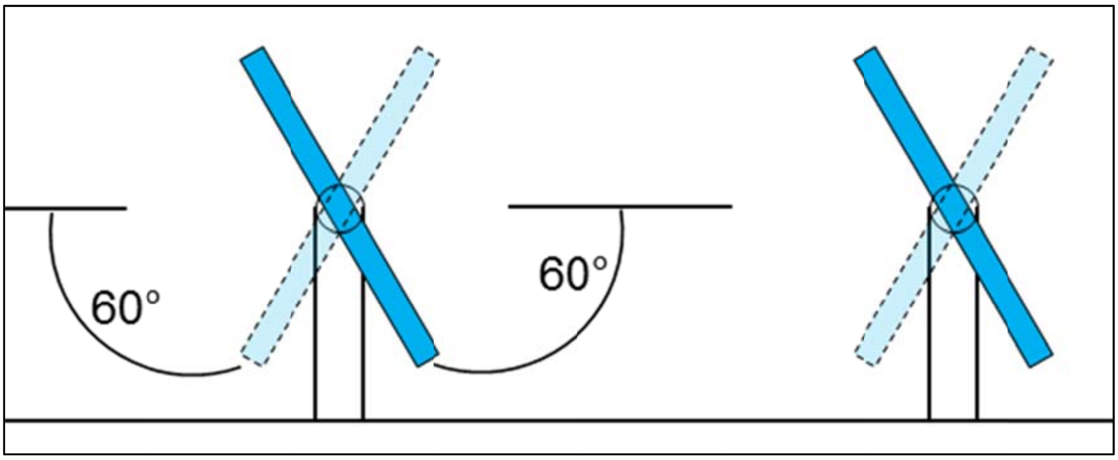


Figure 2 *Panel tracking details – 2*

Shading considerations that dictate the panel tilt. This is affected by:

- The elevation angle of the Sun;
- The vertical tilt of the panels; and
- The spacing between the panel rows.

This means that early in the morning and late in the evening, the panels will not be directed exactly towards the Sun. Figure 3 below illustrates this.

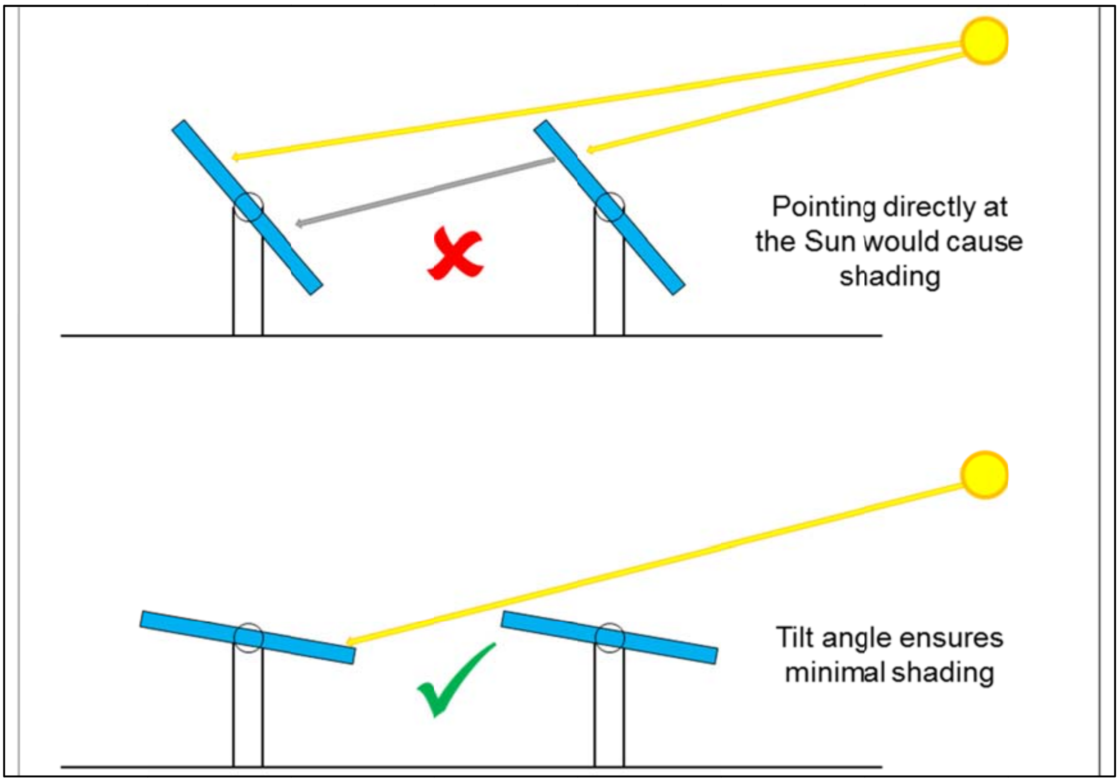


Figure 3 *Shading considerations*

Later on in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 4 below.

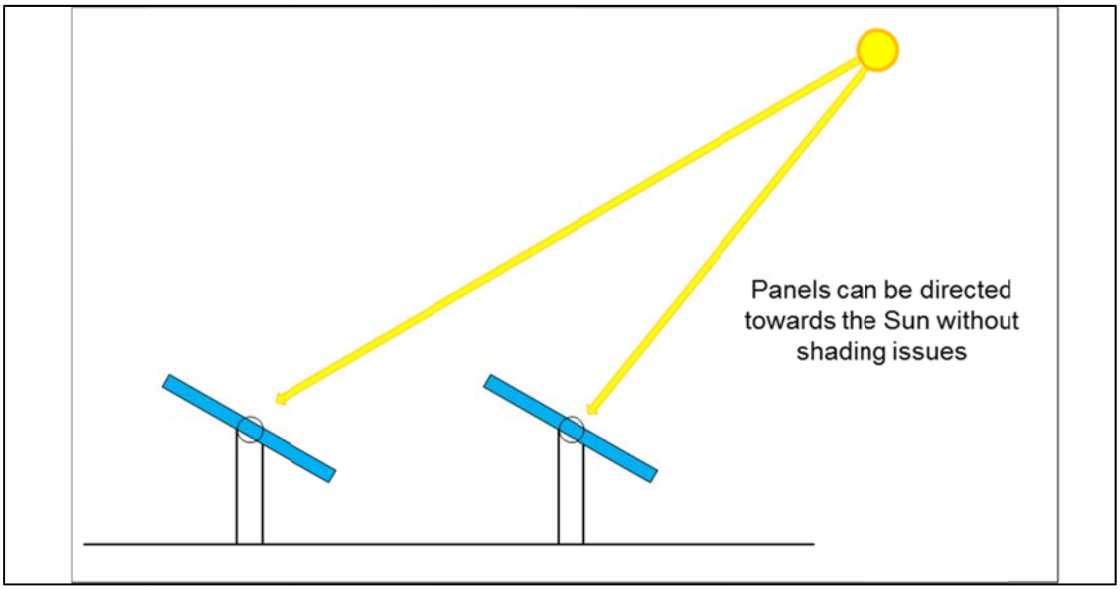


Figure 4 *Panel alignment at high solar angles*

In reality the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The two previous figures are for illustrative purposes only.

## 2.3 Proposed Solar Farm Panel Area

Figure 5[2] below (red line) shows the proposed Solar Farm Development Area. Other constraints are also shown.

[2] Source: © 2018 Google/CNES/Airbus


Figure 5 *Solar Farm Development Area*

# 3 GLINT AND GLARE ASSESSMENT METHODOLOGY

## 3.1 Guideline and Studies Overview

To the author's knowledge, there are no specific guidelines for examining the effect of solar reflections from solar panels with respect to residential amenity or road safety in Australia.

Notwithstanding this, well established guidelines exist in the UK (produced by the CAA[3]) and in the USA (produced by the FAA[4]) with respect to solar developments and aviation activity. Generic advice has also been provided within UK Planning Policy.

The analysis has therefore been informed by the available guidance and Pager Power's assessment experience. The approach is to identify receptors, undertake geometric reflection calculations using Pager Power's own bespoke glint and glare model, and then to compare against available solar panel reflection studies.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The overall conclusions from the available independent studies with regard to glint and glare issues from solar panels are as follows:

- Specular reflections of the Sun from solar panels are possible;
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence; and
- Published guidance shows that the intensity of reflections from solar panels are equal to or less than those from water. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces which are common in an outdoor environment such as those produced from glass and steel[5].

Appendix A and Appendix B present a review of relevant guidance and independent studies.

## 3.2 Background

Details of the Sun's movements and solar reflections are presented in Appendix C.

## 3.3 Methodology

The assessment methodology is based on guidance, studies, previous discussions with stakeholders and Pager Power's practical experience. Information regarding the methodology of the Pager Power glint and glare assessment is presented below:

- Identify receptors in the area surrounding the proposed solar farm;
- Consider direct solar reflections from the proposed solar farm towards the identified receptors by undertaking geometric calculations – accounting for the tracker system;
- Consider the visibility of the panels from the receptor's location. If the panels are not visible from the receptor then no reflection can occur;
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur;
- Consider both the solar reflection from the proposed solar farm and the location of the direct sunlight with respect to the receptor's position;
- Consider the solar reflection with respect to the published studies and guidance; and
- Determine whether a significant detrimental impact is expected.

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[3] Civil Aviation Authority.
[4] Federal Aviation Administration.
[5] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

Within the Pager Power model, representative points within each solar panel area are modelled, as well as the relevant receptor locations. The result is a chart that illustrates whether a reflection can occur and the approximate duration of any effects. Calculations were undertaken at a resolution of 10 day steps with 10 minute intervals within each assessed day.

The full methodology is set out in Appendix E while further technical details relating to the methodology of the geometric calculations can be found in Appendix C.

## 3.4 Assessment Limitations

The list of assumptions and limitations are presented in Appendix D.

# 4 IDENTIFICATION OF RECEPTORS & MODELLING OVERVIEW

## 4.1 Ground Level Receptors – Overview

There is no legal or formal guidance with regard to the maximum distance at which glint and glare should be assessed. There is also no technical limit to the distance at which reflections could occur.

However, the significance of a reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases.

Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances.

A 1km buffer is therefore considered appropriate for glint and glare effects on ground-based receptors. This buffer zone has been determined and deemed appropriate considering existing studies, guidance and Pager Power's assessment experience.

All ground heights have been taken from Pager Power's database, based on interpolated SRTM data.

## 4.2 Modelling Overview

Figure 6[6] below shows the assessed solar panel areas that have been used for modelling purposes. Coordinate data for the boundary points is shown in Appendix F. The maximum theoretical panel areas (constraint free areas within the Solar Farm Development Area) have been combined into one area for modelling purposes. The inclusion of areas where development will not occur will not change the overall results.


Figure 6 *Modelled points within the solar farm*

[6] Source: © 2018 Google/CNES/Airbus.

The representative panel locations are selected for modelling purposes and only solar panels within 1.5km have been modelled for each individual receptor. The number of assessed panel locations is deemed appropriate for providing a reliable result. An increased resolution would not change the overall results significantly.

### 4.3 Road Receptors

Road receptors have been identified within the area surrounding proposed solar farm. The assessed road is Darlington-Camperdown Road. Meningoort Road and Blind Creek Road were reviewed however these are dirt roads where very low density traffic would be expected. Therefore an assessment of these is not recommended based on Pager Power's assessment methodology.

The assessed length of road is shown in Figures 7 and 8[7] on the following pages. Approximately 200m separates each point; the total length of road assessed is approximately 9.4km. The co-ordinates of the assessed roads are presented in the Appendix F.

[7] Source: © 2018 Google/CNES/Airbus.


Figure 7 *Road receptors 1-30*


Figure 8 *Road receptors 19-48*

## 4.4 Dwelling Receptors

Potential dwelling receptors have been identified within the area surrounding proposed solar farm. These dwellings are shown in the Figure 9[8] below.


Figure 9 *Dwelling receptors*

The co-ordinates of the assessed dwellings are presented in the Appendix F.

[8] Source: ©2018 Google/CNES/Airbus.

## 4.5 Elevated Receptors in Wider Region – Viewpoints

An assessment of three viewpoints in the surrounding landscape has been requested. Their locations are shown in Figure 10[9] below.

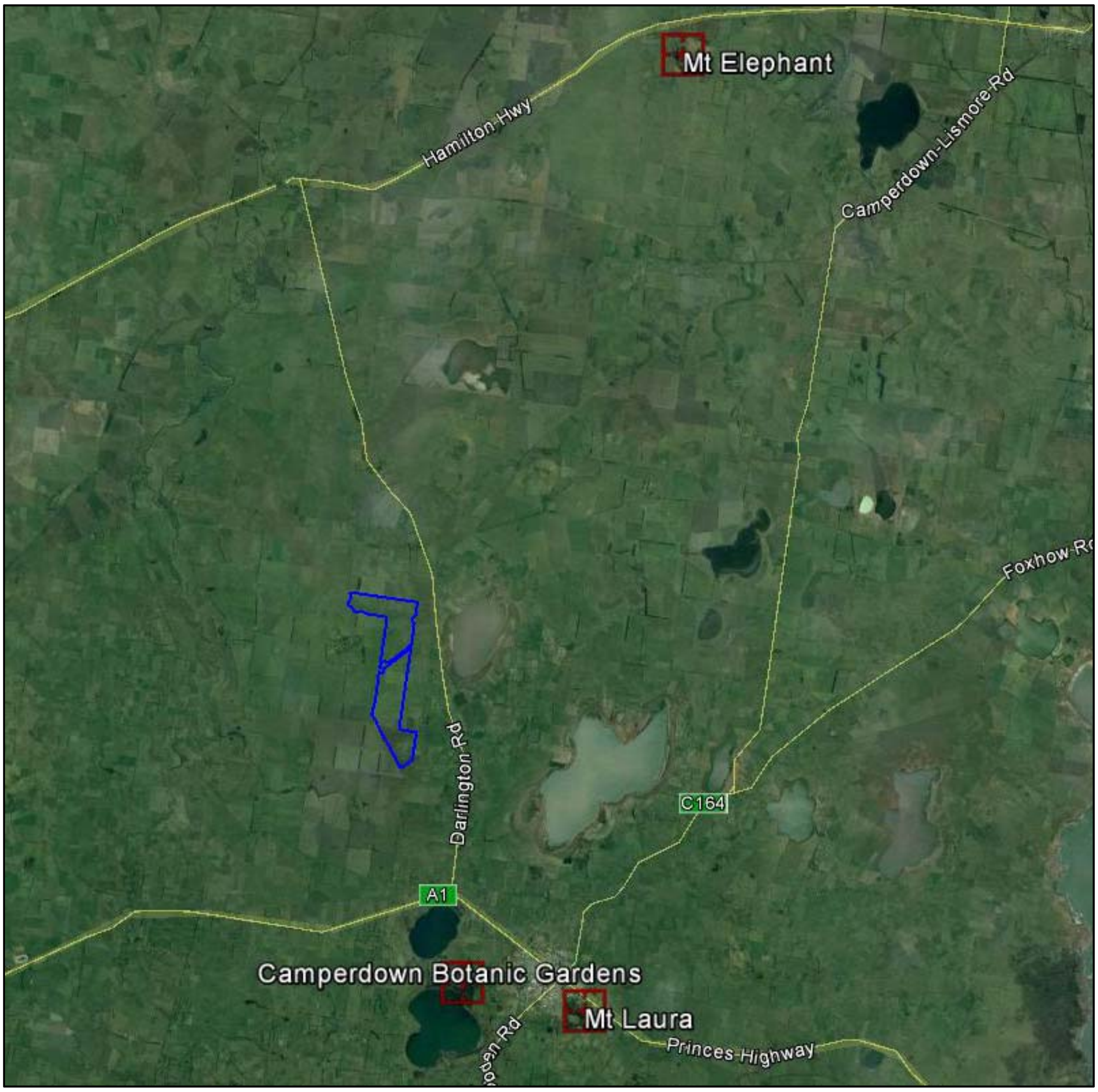


Figure 10 *Viewpoint receptors*

All three viewpoints (Mt Laura, Camperdown Botanic Gardens and Mt Elephant) are beyond 7km from the proposed solar farm and are situated north and south of the panel area. It is Pager Power's methodology to consider receptors within 1km of a solar panel. Furthermore, no solar reflection would be expected at these viewpoints considering the geographic relationship to the proposed solar farm. Considering this, no impact is expected at these viewpoints and these are therefore not discussed further within this report.

The co-ordinates of the assessed dwellings are presented in the Appendix F.

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[9] Source: ©2018 Google/CNES/Airbus.

## 4.6 Conditions for a Reflection

The model calculates the angular separation between a reflection and the line from the observer to the reflecting panel. This is illustrated in Figure 11 below.

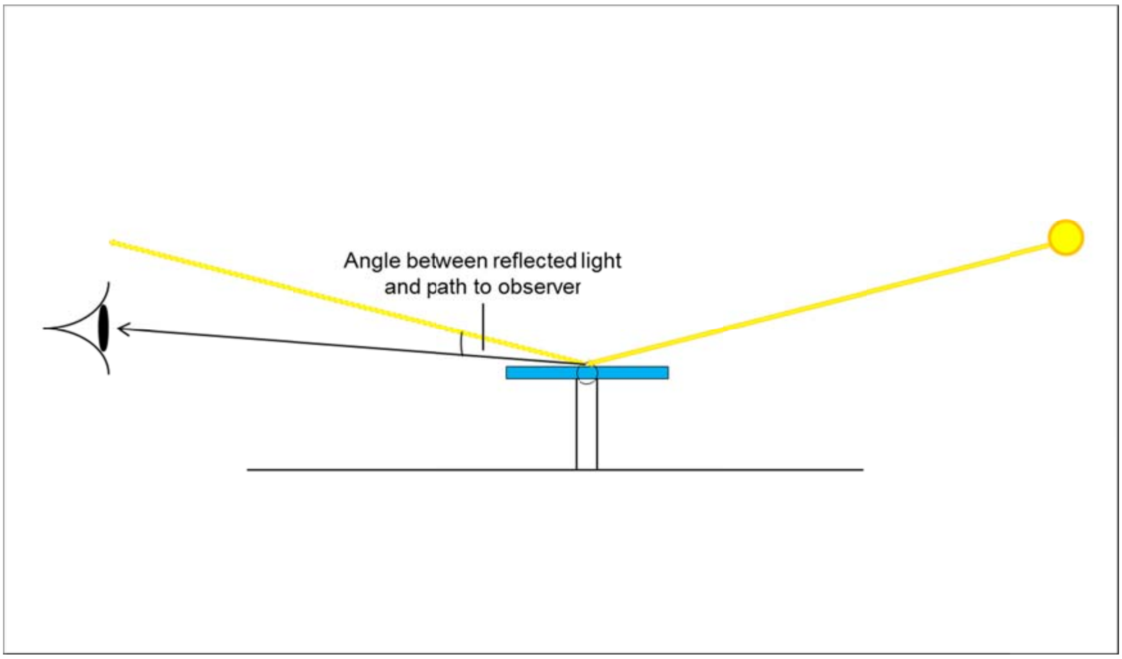


Figure 11 *Calculating reflections*

It can be seen that if the angle is zero, the observer will experience a direct reflection. Angles above zero indicate that the reflection will pass over the observer, and no reflection would be experienced. It is important to remember that:

- The Sun is not a point source, but has an angular size of approximately 0.5 degrees as seen from Earth.
- The receptor height above ground level is based on a typical value (1.5 metres for road users and 1.8 metres for dwellings). In practice this may vary by, typically[10], one or two metres.
- The terrain height above mean sea level is based on a database, and may vary in practice by a few metres.
- The modelling considers the representative panel locations only (approximately 250 metres separation).

To accommodate for the above, the model identifies scenarios where the separation angle illustrated in Figure 11 is up to 10 degrees. This is considered a conservative approach.

[10] e.g. due to an observer on an upper floor.

# 5 GLINT AND GLARE ASSESSMENT

## 5.1 Results

Tables 1 and 2 in the following subsection summarises the months and times during which a solar reflection could be experienced by a receptor.

This does not mean that reflections would occur continuously between the times shown.

The range of times at which reflections are geometrically possible is generally greater than the length of time for any particular day. This is because the times of day at which reflections could start and stop vary throughout the days/months.

Times are in GMT+11 which is the local time in south western Victoria, Australia

Appendix G presents the detailed modelling output in cases where effects are possible.

## 5.2 Modelling Results Overview – Roads

The results of the geometric calculations for the assessed surrounding roads are presented in in Table 1 below.

| Receptor | Results | | Conclusion |
|---|---|---|---|
| | Solar reflection possible? | | |
| | am | pm | |
| R1-R9 | No | No | Road locations beyond 1km from the reflecting solar panels. No significant impact expected. |
| R10 | No | Yes – approximately between 20:20 and 20:40 GMT+11 from late November until late January. | Solar reflection possible if the reflecting solar panels are visible. Discussed further in Section 6.1. |
| R11 | No | Yes – approximately between 19:50 and 20:40 GMT+11 from late October until mid-February. | |
| R12 | No | Yes – approximately between 20:00 and 20:40 GMT+11 from mid-January until early March and again between 19:30 and 20:40 GMT+11 from early October until mid-December. | |
| R13 | No | Yes – approximately between 19:10 and 20:40 GMT+11 from late September until early April. | |
| R14 | No | Yes – approximately between 18:30 and 20:40 GMT+11 from mid-August until early May. | |
| R15 | No | Yes – approximately between 18:10 and 20:40 GMT+11 most of the year. | |

| Receptor | Results | | Conclusion |
|---|---|---|---|
| | Solar reflection possible? | | |
| | am | pm | |
| R16 | No | Yes – approximately between 18:00 and 20:40 GMT+11 most of the year. | Solar reflection possible if the reflecting solar panels are visible. Discussed further in Section 6.1. |
| R17 | No | Yes – approximately between 18:00 and 20:40 GMT+11 most of the year. | |
| R18 | No | Yes – approximately between 18:00 and 20:40 GMT+11 most of the year. | |
| R19 | No | Yes – approximately between 18:00 and 20:40 GMT+11 most of the year. | |
| R20 | No | Yes – approximately between 18:10 and 20:20 GMT+11 from mid-February until late October. | |
| R21 | No | Yes – approximately between 18:00 and 20:00 GMT+11 from early March until early October. | |
| R22 | No | Yes – approximately between 18:20 and 19:30 GMT+11 from late March until mid-May and again between 18:30 and 19:10 GMT+11 from late July until late September. | |

| Receptor | Results | | Conclusion |
|---|---|---|---|
| | Solar reflection possible? | | |
| | am | pm | |
| R23 | No | Yes – approximately between 18:10 and 19:00 GMT+11 from early April until June and again between 18:10 and 18:50 GMT+11 from July until late August. | Solar reflection possible if the reflecting solar panels are visible. Discussed further in Section 6.1. |
| R24-R48 | No | No | Road locations beyond 1km from the reflecting solar panels. No significant impact expected. |

Table 1 *Geometric glint and glare reflection calculation results – roads*

### 5.3 Modelling Results Overview – Dwellings

The results of the geometric calculations for the assessed surrounding dwellings are presented in in Table 2 below.

| Receptor | Results | | Conclusion |
|---|---|---|---|
| | Solar reflection possible? | | |
| | am | pm | |
| B-D | No | No | Dwelling locations beyond 1km from the reflecting solar panels. No significant impact expected. |
| E | No | Yes – approximately between 18:00 and 20:40 GMT+11 all year round. | Solar reflection possible if the reflecting solar panels are visible. Discussed further in Section 6.2. |
| F-H | No | No | Dwelling locations beyond 1km from the reflecting solar panels. No significant impact expected. |
| I | No | Yes – approximately between 18:10 and 19:00 GMT+11 from March until early April until late July. | Solar reflection possible if the reflecting solar panels are visible. Discussed further in Section 6.2. |
| J | No | No | Dwelling location beyond 1km from the reflecting solar panels. No significant impact expected. |
| K | No | Yes – approximately between 18:10 and 20:40 GMT+11 most of the year. | Solar reflection possible if the reflection solar panels are visible. Discussed further in Section 6.2. |
| L | No | Yes – approximately between 19:00 and 20:40 GMT+11 from late September until mid-April. | Solar reflection possible if the reflecting solar panels are visible. Discussed further in Section 6.2. |
| M | No | No | Dwelling location beyond 1km from the reflecting solar panels. No significant impact expected. |

| Receptor | Results | | Conclusion |
| --- | --- | --- | --- |
| | Solar reflection possible? | | |
| | am | pm | |
| N | Yes – approximately between 07:10 and 07:20 GMT+11 from late February until early April and again between 06:30 and 07:30 GMT+11 from late September until late October. | No | Solar reflection possible if the reflecting solar panels are visible. Discussed further in Section 6.2. |
| O-Q | No | No | Dwelling locations beyond 1km from the reflecting solar panels. No significant impact expected. |

Table 2 *Geometric glint and glare reflection calculation results – dwellings*

# 6 RESULTS DISCUSSION

## 6.1 Road Results

Based on a review of the geometric analysis[11], road users located at 14 of the 48 assessed road locations could experience a solar reflection from the proposed solar farm (road receptor locations 10-23).

In general, a solar reflection originates from those solar panels immediately west of the road receptor location.

At the remaining assessed road receptor locations, no solar reflection is geometrically possible or the reflecting solar panels are beyond 1km from the assessed road (1-9 and 24-48).

Figure 11[12] on the following page shows the length of road that could experience a solar reflection. The landscape is very flat with sparse vegetation between the solar panels and length of road. Therefore it is deemed that the entire zone may experience a solar reflection, which is approximately 2.6km in length. The effect of proposed screening has not been considered at this stage.

### 6.1.1 Road Assessment Conclusions

Overall, a solar reflection may only be visible from approximately 2.6km of road.

The Darlington-Camperdown Road where a solar reflection may be visible is classified as an arterial[13] road. Road users on this road would be expected to be travelling at (up to) 100km/h with a low density of traffic expected. Any solar reflection could last for up to 20 minutes, however in reality, its duration would depend on the speed of the car travelling through the solar reflection zone. Note that not all of the zone will receive a solar reflection at the same time.

In accordance with Pager Power's guidance, the impact upon road users with respect to safety is therefore classified as **low** where the reflecting solar panels are visible. Where the solar panels are not visible, **no impact** is expected. There is no requirement for mitigation based on Pager Power's Glint and Glare Guidance.

In the event that a solar reflection is experienced by a road user, further comments regarding the scenario in which a solar reflection would be visible and the intensity of any solar reflection experienced are presented Section 6.3. Mitigation is discussed in Section 6.4.

[11] Considering a 1km boundary.
[12] Source: © 2018 Google/CNES/Airbus.
[13] Local road, as per Pager Power's methodology.


Figure 12 *Sections of road that could experience a solar reflection*

## 6.2 Dwelling Results

Based on a review of the geometric analysis[14], residents located within five of the 16 assessed dwelling receptors could experience a solar reflection from the proposed solar farm (receptor locations E, I, K, L and N).

At the remaining assessed dwelling receptor locations, no solar reflection is geometrically possible or the reflecting solar panels are beyond 1km from the assessed road (B-D, F-H, J, M, O and P).

Figure 12[15] below shows the dwelling receptor locations that could experience a solar reflection. The landscape is very flat with sparse vegetation between the solar panels and the assessed dwellings. Therefore it is deemed that all dwellings within 1km where a solar reflection is geometrically possible would have view of the reflecting solar panels. The effect of proposed screening has not been considered at this stage.

Figure 13 *Dwellings that could experience a solar reflection*

[14] Considering a 1km boundary.
[15] Source: © 2018 Google/CNES/Airbus.

### 6.2.1 Dwelling Assessment Conclusions

Overall, a solar reflection is deemed possible towards five surrounding dwellings considering a bare earth model. Proposed intervening screening would reduce the duration and likelihood of impact and is discussed in Section 6.4.

Unmitigated, solar reflections would last for up to 20 minutes on any one day at any one location and only from windows with a clear view of the reflecting solar panels. Solar reflections would only occur on days when the weather is clear and sunny. See Table 2 and Appendix G for the detailed results breakdown.

The potential reflections would last for more than three months a year but less than 60 minutes per day. In accordance with the methodology set out in Section 3 and Appendix E (for dwellings), the resulting impact significance is **low** to **moderate**. If screening removes the solar panels from view, then there will be **no impact**. There is no requirement for mitigation based on Pager Power's Glint and Glare Guidance however this is considered in Section 6.4.

In the event that a solar reflection is experienced by resident within a surrounding dwelling, further comments are presented in the following sub-section.

For completeness, mitigation options are presented in Section 6.4.

## 6.3 Results Discussion Regarding Reflections from Solar Panels

The geometric solar reflection calculations have determined that glint and glare effects are possible at five dwellings and a length of road totalling approximately 2.6km (worst-case). Overall, low to moderate impact upon residential amenity is expected and a low impact upon road safety is expected. Further comments are presented below regarding the scenario in which a solar reflection could be experienced by surrounding receptors.

In all scenarios where a solar reflection is geometrically possible towards surrounding roads and dwellings, direct sunlight would coincide with the solar reflection. This means that the viewer will likely be able to see the glare from the reflecting solar panels as well as the Sun directly. Therefore, in this similarly assessed scenario, even if a solar reflection from the panel is experienced by a receptor, the direct sunlight will also be experienced. It is important to note that the direct sunlight would be a significantly brighter source of light when compared to the solar reflection. Lastly, at any one location, only a particular area of solar panels will produce a solar reflection towards it. Note that not all receptors will experience a solar reflection at the same time.

A view of a solar reflection from within the assessed dwellings would only occur where there is a clear view of the reflecting solar panels at the particular time of day when a solar reflection was geometrically possible. In addition, the weather would also have to be clear and sunny.

To experience a solar reflection from the road, a road user would need to be located within the reflection zones, and have a clear view of the reflecting solar panels at the particular time of day when a solar reflection was geometrically possible. In addition, the weather would also have to be clear and sunny. In all cases, the driver would then also be looking in the general direction of the Sun.

## 6.4 Mitigation and Recommendations

There is no requirement for mitigation based on the results of the analysis however it should be considered for dwelling receptors E, I, K, L and N where a solar reflection is possible. Visibility of the proposed solar farm for these dwellings has been determined via a site survey[16]. The results are presented in Table 3 on the following page.

[16] Completed by the client

| Dwelling | Expected Visibility |
|---|---|
| E | No visibility as viewed from within site, thought to be unoccupied. |
| I | Good screening from existing shelter belt, may be some views but not conclusive. |
| K | Views of northern half of site from property, potentially from house but not conclusive. |
| L | Screened completely by existing vegetation, views from drive. |
| N | Screened completely by existing vegetation, limited views from extended drive. |

Table 3 *Dwelling visibility site survey results*

In addition 4m screening will be installed at the site boundary between dwellings E, I, K which will likely remove any visibility that remains. This is because the landscape is relatively flat, the distance between receptors and panels is relatively large and the solar panels are 4m tall at their maximum tilt, equal to the screening height. Therefore any predicted impacts at these dwellings, and also the roads, would likely be removed.

# 7 OVERALL CONCLUSIONS

## 7.1 Road Results

Overall, a low impact upon road users (at worst) on the assessed roads is expected. The overall results and reasoning are presented below.

- Solar reflections are theoretically possible towards approximately 2.6km of Darlington Road;
- The road is classified as an arterial road;
- Road users would be expected to be travelling at (up to) 100 km/h with a low density of traffic expected;
- Any solar reflection could last for up to 20 minutes, however in reality, its duration would depend on the speed of the car travelling through the solar reflection zone. Note that not all of the zone will produce a solar reflection towards the road at the same time;
- In accordance with the methodology set out in Section 3 and Appendix E, the overall expected impact upon road users with respect to safety is classified as low where the reflecting solar panels are visible. Proposed screening has not been yet been considered.

## 7.2 Dwelling Results

Overall, a low to moderate impact upon residential amenity is expected (at worst). Where the solar panels are not visible, no impact is expected. The overall results and reasoning are presented below.

- Solar reflections are possible towards five of the assessed dwelling receptors based on the modelling. The visibility of the reflecting solar panels cannot be confirmed based on the available imagery and therefore the conclusions are considered conservative;
- At these five dwellings, the solar reflections would last for up to 20 minutes per day potentially all year round. The results vary per dwelling therefore please see Table 3 and Appendix G for the detailed results breakdown for each dwelling;
- In all cases, a clear view of the reflecting solar panels at the particular time of day when a solar reflection was geometrically possible would be required. In addition, the weather would also have to be clear and sunny;
- In all scenarios where a solar reflection is geometrically possible towards the surrounding dwellings, direct sunlight would coincide with the solar reflection. Direct sunlight is significantly more intense than reflections form solar panels;
- In accordance with the methodology set out in Section 3 and Appendix E (for dwellings), the resulting impact significance is low to moderate. If screening removes the solar panels from view, no impact will be possible.

## 7.3 Council Viewpoints

All three viewpoints (Mt Laura, Camperdown Botanic Gardens and Mt Elephant) are beyond 7km from the proposed solar farm and are situated north and south of the panel area. It is Pager Power's methodology to consider receptors within 1km of a solar panel. Furthermore, no solar reflection would be expected at these viewpoints considering the geographic relationship to the proposed solar farm. Considering this, no impact is expected at these viewpoints.

# APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

This section presents details regarding the relevant guidance and studies with respect to the considerations and effects of solar reflections from solar panels, known as 'Glint and Glare'. Whilst there is little formal guidance with regard to the assessment of this issue, Pager Power has reviewed relevant publications pertaining to glint and glare. Relevant extracts from guidance published in the UK is presented below for reference.

This is not a comprehensive review of the data sources, rather it is intended to give an overview of the important parameters and considerations that have informed this assessment.

## UK Planning Policy

UK National Planning Practice Guidance dictates that in some instances a glint and glare assessment is required however, there is no specific guidance with respect to the methodology for assessing the impact of glint and glare.

The planning policy from the Department for Communities and Local Government (paragraph 27[17]) states:

*'Particular factors a local planning authority will need to consider include… the effect on landscape of glint and glare* and on ***neighbouring uses and aircraft safety****.'*

The National Planning Policy Framework for Renewable and Low Carbon Energy[18] (specifically regarding the consideration of solar farms) states:

***'****What are the particular planning considerations that relate to large scale ground-mounted solar photovoltaic Farms?*

*The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.*

*Particular factors a local planning authority will need to consider include:*

- *the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on* ***neighbouring uses and aircraft safety****;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun;*

*The approach to assessing cumulative landscape and visual impact of large scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero.'*

## Assessment Process

No process for determining and contextualising the effects of glint and glare are, however, provided. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar farm is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant.

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[17] http://planningguidance.planningportal.gov.uk/blog/guidance/renewable-and-low-carbon-energy/

[18] Reference ID: 5-013-20140306, paragraph 13-13,http://planningguidance.planningportal.gov.uk/blog/guidance/renewable-and-low-carbon-energy/particular-planning-considerations-for-hydropower-active-solar-technology-solar-farms-and-wind-turbines/

# APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

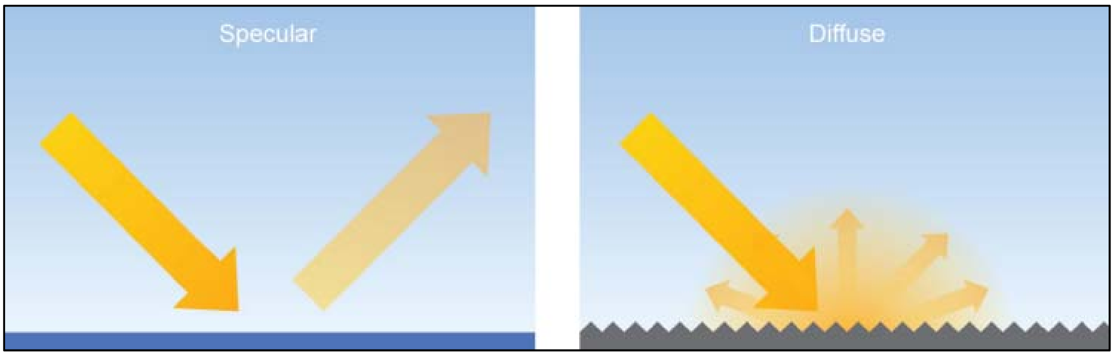
## Overview

Studies have been undertaken assessing the type and intensity of solar reflections from various surfaces including solar panels. An overview of these studies is presented below.

There are no specific studies for determining the effect of reflections from solar panels with respect to dwellings. The guidelines presented are related to aviation safety. The results are applicable for the purpose of this analysis.

## Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below[19], taken from the FAA guidance, illustrates the difference between the two types of reflections. Because solar panels are flat and have a smooth surface most of the light reflected is specular, which means that incident light from a specific direction is reradiated in a specific direction.




*Specular and diffuse reflections*

## Solar Reflection Studies

An overview of content from identified solar panel reflectivity studies is presented in the subsections below.

**Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems"**

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[20]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure on the following page.

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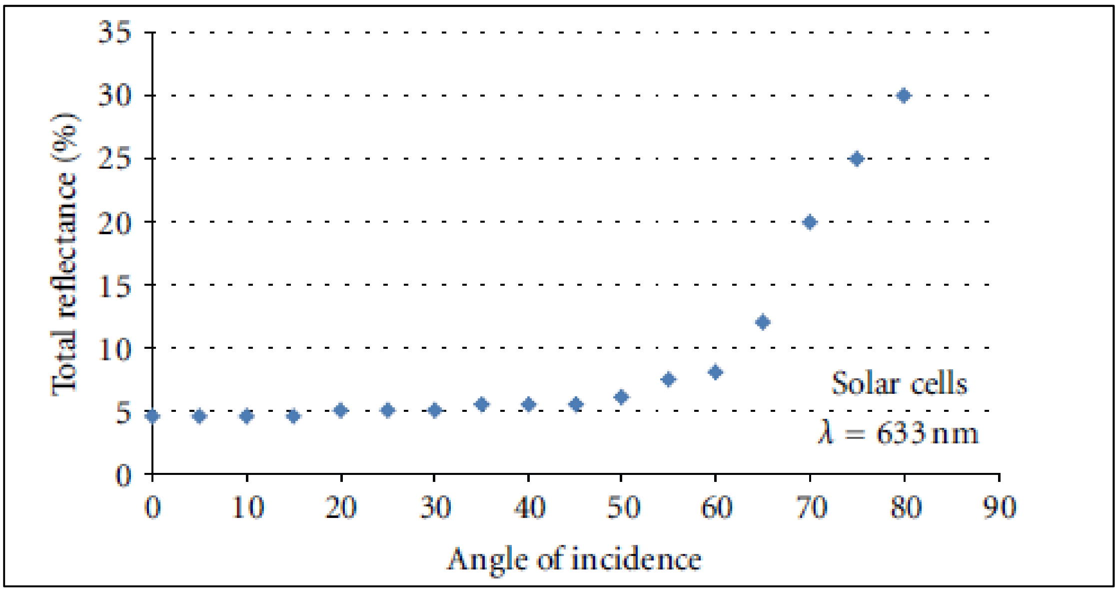
[19] http://www.faa.gov/airports/environmental/policy_guidance/media/airport_solar_guide_print.pdf
[20] Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems," ISRN Renewable Energy, vol. 2011, Article ID 651857, 6 pages, 2011. doi:10.5402/2011/651857



*Total reflectance % when compared to angle of incidence*

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

**FAA Guidance- "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[21]**

The 2010 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure[22] within the FAA guidance, is presented on the following page.

[21] FAA, November (2010): *Technical Guidance for Evaluating Selected Solar Technologies on Airports.*
[22] http://www.faa.gov/airports/environmental/policy_guidance/media/airport_solar_guide_print.pdf

| Surface | Approximate Percentage of Light Reflected[23] |
|---|---|
| Snow | 80 |
| White Concrete | 77 |
| Bare Aluminium | 74 |
| Vegetation | 50 |
| Bare Soil | 30 |
| Wood Shingle | 17 |
| Water | 5 |
| Solar Panels | 5 |
| Black Asphalt | 2 |

*Relative reflectivity of various surfaces*

Note that the data above does not appear to consider the reflection type (specular or diffuse).

An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

**SunPower Technical Notification (2009)**
SunPower published a technical notification[24] to '*increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment'.* The study revealed that the reflectivity of a solar panel is considerably lower than that of '*standard glass and other common reflective surfaces'.* With respect to aviation and solar reflections observed from the air, SunPower has developed several large installations near airports or on Air Force bases. It is stated that these developments have all passed FAA or Air Force standards with all developments considered "No Hazard to Air Navigation". The note suggests that developers discuss any possible concerns with stakeholders near proposed solar farms.

Figures within the document show the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel. The results, similarly to those from Riley and Olsen study (2011) and the FAA (2010), show that solar panels produce a reflection that is less intense than those produced from these surfaces.

[23] Extrapolated data, baseline of 1,000 W/m$^2$ for incoming sunlight.
[24] Technical Support, 2009. SunPower Technical Notification- Solar Module Glare and Reflectance.

## APPENDIX C – PAGER POWER'S REFLECTION CALCULATIONS METHODOLOGY

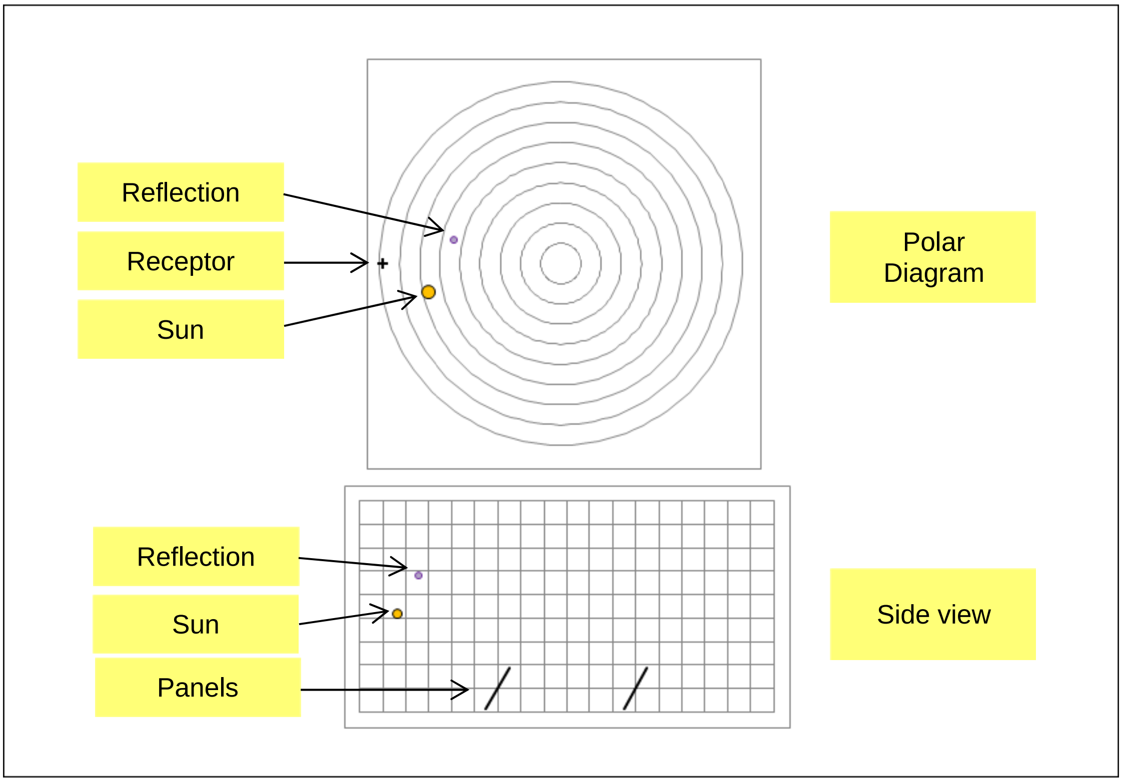
The calculations are three dimensional and complex, accounting for:

- The Earth's orbit around the Sun;
- The Earth's rotation;
- The Earth's orientation;
- The reflector's location;
- The reflector's 3D Orientation – including consideration of the tracking mechanism.

Reflections from a flat reflector are calculated by considering the normal which is an imaginary line that is perpendicular to the reflective surface and originates from it.

A single axis system such as Sun Power rotates panels from east to west so that they face the Sun as it passes through the sky during the day. At very low solar altitudes the panels flatten so that one row of panels does not cast a shadow on the next. Pager Power's computer algorithm determines the amount of panel tilt based on (1) the predicted position of the Sun; (2) how far the panel can actually tilt - determined by the physical characteristics of the tilting mechanism and (3) the shadow that will be cast on the neighbouring row of panels.

The diagram below illustrates one step in the iterative modelling process, showing the position of the Sun, the angle of the panels and the direction of the reflection at a single point in time.



# APPENDIX D – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Calculations have been undertaken for panel locations at each boundary point of the site, and the site centre. In each case, the modelled altitude of the panels is the same across the development. This is an appropriate assumption because the modelled area is relatively flat.

Only a reflection from the face of the panel has been considered. The frame or the reverse of the solar panel has not been considered.

The model assumes that a receptor can view the face of every panel within the proposed solar farm area whilst in reality this, in the majority of cases, will not occur.

Therefore any predicted reflection from the face of a solar panel that is not visible to a receptor will not occur.

A finite number of points within the proposed solar farm are chosen in order to build a comprehensive understanding of the entire solar farm. This determines whether a reflection could ever occur at a chosen receptor. The calculations do not incorporate all of the possible panel locations within the solar farm outline.

A single reflection point on the panel has been chosen for the geometric calculations. This will suitably determine whether a reflection can be experienced at a location and the general time of year and duration of this reflection. Increased accuracy could be achieved by increasing the number of heights assessed however this would only marginally change the results and is not considered significant.

Whilst line of sight to the solar farm from receptors has been considered, only available street view imagery and satellite mapping has been used. In some cases this imagery may not be up to date and may not give the full perspective of the installation from the location of the assessed receptor.

Any screening in the form of trees, buildings etc. that may obstruct the Sun from view of the solar panels is not considered unless stated.

# APPENDIX E – ASSESSMENT METHODOLOGY

## Overview

The significance of glint and glare will vary for different receptors. The following section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

## Impact significance definition

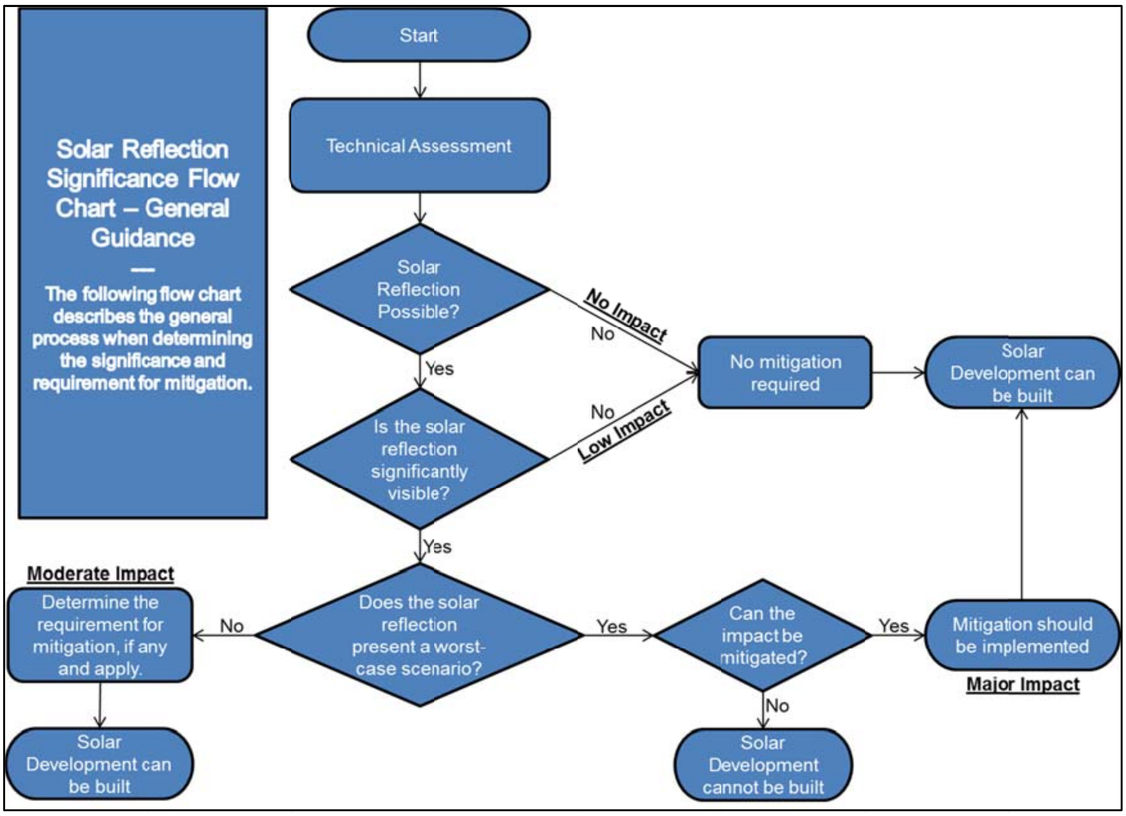
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

| Impact Significance | Definition | Mitigation Requirement |
|---|---|---|
| No Impact | A solar reflection is not geometrically possible or will not be visible from the assessed receptor. | No mitigation required. |
| Low | A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels. | No mitigation required. |
| Moderate | A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case. | Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation. |
| Major | A solar reflection is geometrically possible and visible under conditions that will produce a significant impact.<br>Mitigation and consultation is recommended. | Mitigation will be required if the proposed solar development is to proceed. |

*Impact significance definition*

## Assessment Process – General

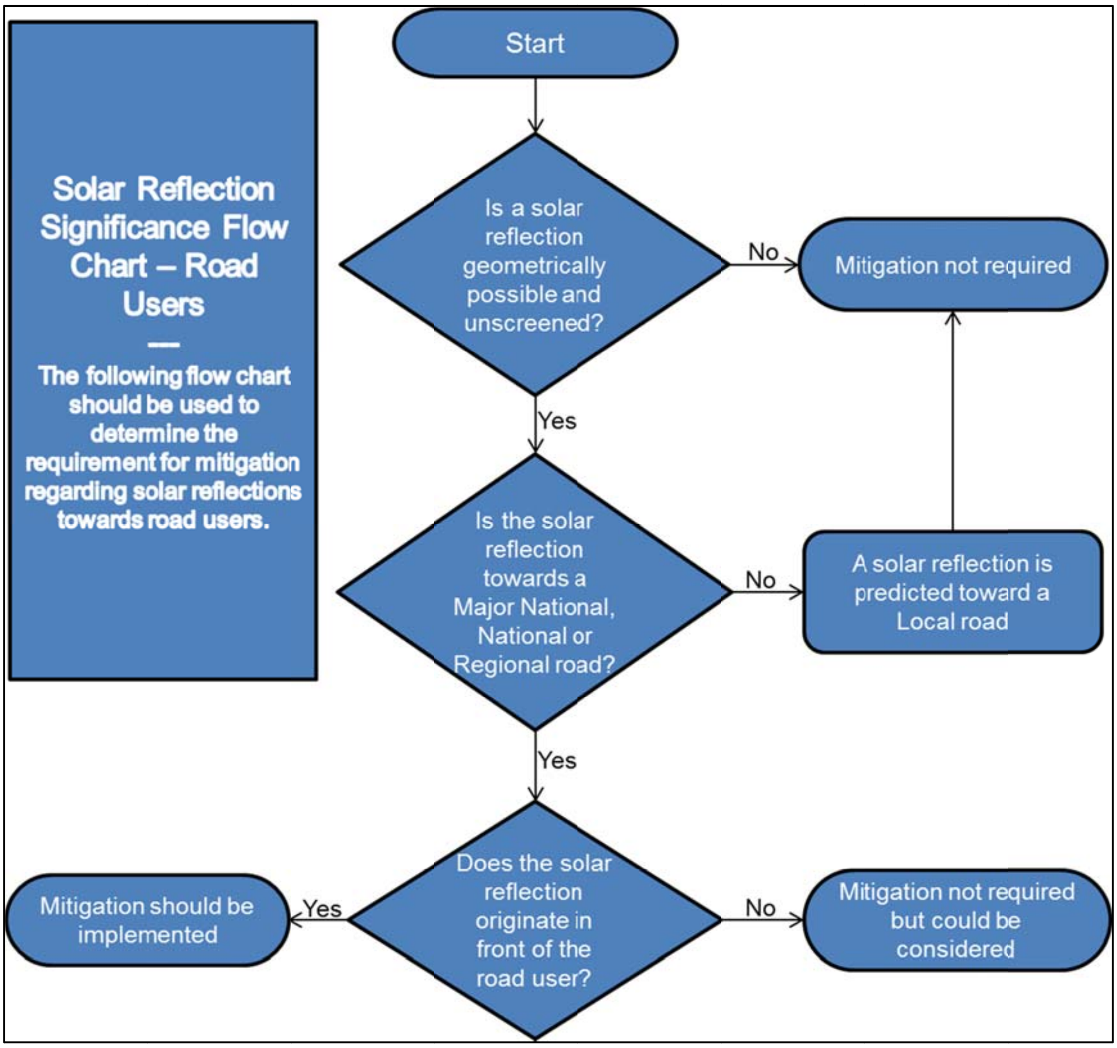
The flow chart presented below shows the general process for establishing a mitigation requirement for a glint and glare impact.




*General mitigation requirement flow chart*

## Assessment process for road receptors

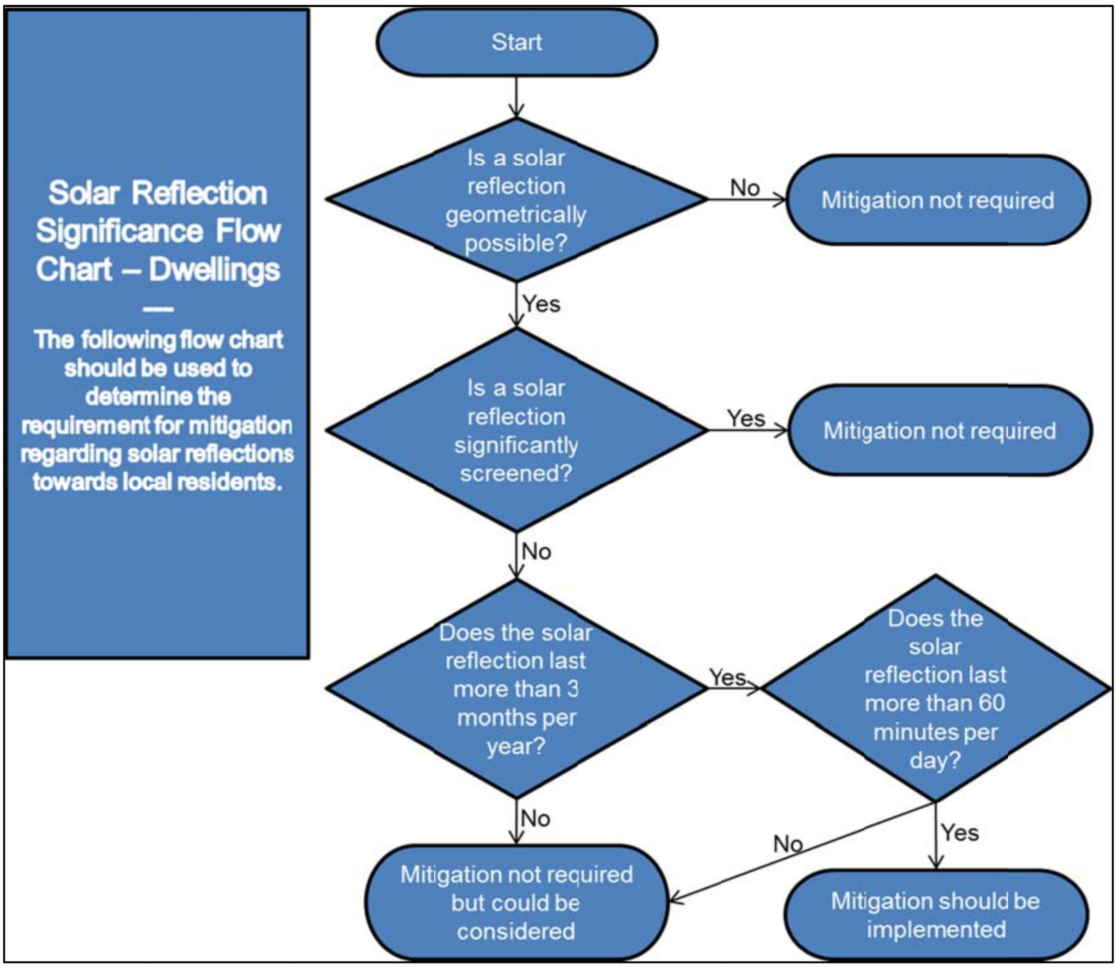
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.




*Road receptor mitigation requirement flow chart*

## Assessment process for dwelling receptors

The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.




*Dwelling receptor mitigation requirement flow chart*

# APPENDIX F – COORDINATE DATA

## Road Receptors

| ID | Long. (°) | Lat. (°) | Z amsl + receptor height (m) | No. | Long. (°) | Lat. (°) | Z amsl + receptor height (m) |
|---|---|---|---|---|---|---|---|
| 01 | 143.097 | -38.1054 | 150.0 | 25 | 143.1055 | -38.1477 | 147.0 |
| 02 | 143.0977 | -38.1071 | 148.5 | 26 | 143.1058 | -38.1495 | 145.9 |
| 03 | 143.0985 | -38.1088 | 147.0 | 27 | 143.1062 | -38.1513 | 145.3 |
| 04 | 143.0993 | -38.1106 | 146.8 | 28 | 143.1066 | -38.1531 | 145.6 |
| 05 | 143.1 | -38.1122 | 145.2 | 29 | 143.107 | -38.1549 | 146.1 |
| 06 | 143.1008 | -38.1139 | 144.3 | 30 | 143.1076 | -38.1567 | 143.8 |
| 07 | 143.1014 | -38.1157 | 143.9 | 31 | 143.1081 | -38.1583 | 143.4 |
| 08 | 143.1018 | -38.1174 | 145.8 | 32 | 143.1088 | -38.16 | 147.1 |
| 09 | 143.102 | -38.1192 | 144.5 | 33 | 143.1098 | -38.1617 | 149.0 |
| 10 | 143.1021 | -38.121 | 145.4 | 34 | 143.1107 | -38.1633 | 146.5 |
| 11 | 143.1022 | -38.1228 | 146.3 | 35 | 143.1115 | -38.165 | 146.6 |
| 12 | 143.1023 | -38.1246 | 147.5 | 36 | 143.1122 | -38.1667 | 147.7 |
| 13 | 143.1023 | -38.1264 | 147.9 | 37 | 143.113 | -38.1684 | 145.5 |
| 14 | 143.1024 | -38.1282 | 145.9 | 38 | 143.1134 | -38.1702 | 147.1 |
| 15 | 143.1025 | -38.13 | 146.9 | 39 | 143.1134 | -38.172 | 148.3 |
| 16 | 143.1027 | -38.1318 | 143.4 | 40 | 143.1132 | -38.1738 | 152.6 |
| 17 | 143.1028 | -38.1336 | 143.4 | 41 | 143.1129 | -38.1756 | 154.0 |
| 18 | 143.103 | -38.1354 | 145.5 | 42 | 143.1127 | -38.1774 | 153.5 |
| 19 | 143.1033 | -38.1372 | 145.7 | 43 | 143.1125 | -38.1792 | 154.4 |
| 20 | 143.1037 | -38.139 | 145.9 | 44 | 143.1124 | -38.1809 | 155.5 |
| 21 | 143.104 | -38.1407 | 146.5 | 45 | 143.1122 | -38.1827 | 155.2 |
| 22 | 143.1044 | -38.1425 | 146.7 | 46 | 143.112 | -38.1845 | 155.2 |
| 23 | 143.1048 | -38.1442 | 148.0 | 47 | 143.1118 | -38.1863 | 154.5 |
| 24 | 143.1051 | -38.146 | 145.9 | 48 | 143.1117 | -38.1883 | 155.1 |

## Dwelling Receptors

| ID | Long. (°) | Lat. (°) |
|---|---|---|
| B | 143.1065 | -38.1687 |
| C | 143.1087 | -38.1696 |
| D | 143.1145 | -38.1673 |

| ID | Long. (°) | Lat. (°) |
|---|---|---|
| E | 143.0981 | -38.1586 |
| F | 143.1061 | -38.1562 |
| G | 143.1048 | -38.1478 |
| H | 143.1067 | -38.1474 |
| I | 143.1024 | -38.1435 |
| J | 143.1074 | -38.1493 |
| K | 143.1017 | -38.1295 |
| L | 143.1035 | -38.1271 |
| M | 143.0686 | -38.1347 |
| N | 143.0725 | -38.1352 |
| O | 143.1031 | -38.1123 |
| P | 143.112 | -38.1773 |
| Q | 143.1068 | -38.1802 |

## Viewpoint Receptors

| ID | Long. (°) | Lat. (°) | Z amsl[25] (m) |
|---|---|---|---|
| Mt Laura | 143.158241 | -38.243711 | 270 |
| Camperdown Botanic Gardens | 143.112309 | -38.235422 | 256 |
| Mt Elephant | 143.195069 | -37.960936 | 368 |

## Panel Area Boundary Co-Ordinates

| ID | Long. (°) | Lat. (°) | ID | Long. (°) | Lat. (°) |
|---|---|---|---|---|---|
| 1 | 143.0697 | -38.1199 | 42 | 143.0815 | -38.1434 |
| 2 | 143.0953 | -38.1229 | 43 | 143.0814 | -38.1441 |
| 3 | 143.0946 | -38.1271 | 44 | 143.0823 | -38.1442 |
| 4 | 143.0945 | -38.1271 | 45 | 143.0825 | -38.1427 |
| 5 | 143.0944 | -38.1271 | 46 | 143.0928 | -38.1366 |
| 6 | 143.094 | -38.1272 | 47 | 143.093 | -38.1356 |
| 7 | 143.094 | -38.1272 | 48 | 143.0839 | -38.141 |
| 8 | 143.0937 | -38.1275 | 49 | 143.0832 | -38.1402 |
| 9 | 143.0935 | -38.1277 | 50 | 143.0817 | -38.1411 |
| 10 | 143.0934 | -38.1278 | 51 | 143.0815 | -38.1424 |

[25] Provided by developer

| ID | Long. (°) | Lat. (°) | ID | Long. (°) | Lat. (°) |
|---|---|---|---|---|---|
| 11 | 143.0935 | -38.1281 | 52 | 143.0811 | -38.1427 |
| 12 | 143.0935 | -38.1286 | 53 | 143.0815 | -38.1406 |
| 13 | 143.094 | -38.1291 | 54 | 143.083 | -38.1325 |
| 14 | 143.0942 | -38.1292 | 55 | 143.0839 | -38.1273 |
| 15 | 143.0929 | -38.1364 | 56 | 143.076 | -38.1263 |
| 16 | 143.0923 | -38.1397 | 57 | 143.075 | -38.1258 |
| 17 | 143.0894 | -38.1554 | 58 | 143.0748 | -38.1257 |
| 18 | 143.0894 | -38.1555 | 59 | 143.0745 | -38.1256 |
| 19 | 143.0884 | -38.1606 | 60 | 143.0742 | -38.1256 |
| 20 | 143.095 | -38.1614 | 61 | 143.0739 | -38.1256 |
| 21 | 143.0933 | -38.1696 | 62 | 143.0733 | -38.1257 |
| 22 | 143.0895 | -38.1719 | 63 | 143.0727 | -38.1259 |
| 23 | 143.0888 | -38.1717 | 64 | 143.0715 | -38.1258 |
| 24 | 143.0871 | -38.1693 | 65 | 143.0712 | -38.1252 |
| 25 | 143.0872 | -38.1686 | 66 | 143.0704 | -38.1243 |
| 26 | 143.0866 | -38.1686 | 67 | 143.0701 | -38.1241 |
| 27 | 143.085 | -38.1663 | 68 | 143.0693 | -38.1237 |
| 28 | 143.0852 | -38.1662 | 69 | 143.0694 | -38.1236 |
| 29 | 143.0845 | -38.165 | 70 | 143.0695 | -38.1234 |
| 30 | 143.0842 | -38.1651 | 71 | 143.0695 | -38.1233 |
| 31 | 143.0799 | -38.1588 | 72 | 143.0694 | -38.1231 |
| 32 | 143.0801 | -38.1587 | 73 | 143.0694 | -38.123 |
| 33 | 143.0785 | -38.1564 | 74 | 143.0693 | -38.1229 |
| 34 | 143.0782 | -38.1565 | 75 | 143.0695 | -38.1228 |
| 35 | 143.0781 | -38.1562 | 76 | 143.0697 | -38.1226 |
| 36 | 143.0782 | -38.1559 | 77 | 143.0698 | -38.1224 |
| 37 | 143.0782 | -38.1558 | 78 | 143.0701 | -38.122 |
| 38 | 143.0785 | -38.1543 | 79 | 143.0702 | -38.1215 |
| 39 | 143.0789 | -38.1543 | 80 | 143.0703 | -38.1212 |
| 40 | 143.08 | -38.1488 | 81 | 143.0702 | -38.1208 |
| 41 | 143.0809 | -38.1437 | 82 | 143.0699 | -38.1202 |

**Panel Area Reflection Reference Points**

| Reflector | Long. (°) | Lat. (°) | Z (ground height + panel height) (m) |
|---|---|---|---|
| R1 | 143.0864 | -38.1674 | 144.4 |

| Reflector | Long. (°) | Lat. (°) | Z (ground height + panel height) (m) |
|---|---|---|---|
| R2 | 143.0922 | -38.1674 | 142.5 |
| R3 | 143.0864 | -38.1629 | 143.0 |
| R4 | 143.0922 | -38.1629 | 142.7 |
| R5 | 143.0807 | -38.1584 | 143.0 |
| R6 | 143.0864 | -38.1584 | 142.6 |
| R7 | 143.0807 | -38.1539 | 142.2 |
| R8 | 143.0864 | -38.1539 | 142.0 |
| R9 | 143.0807 | -38.1494 | 143.3 |
| R10 | 143.0864 | -38.1494 | 143.0 |
| R11 | 143.0864 | -38.1449 | 143.3 |
| R12 | 143.0921 | -38.1404 | 143.6 |
| R13 | 143.0864 | -38.1359 | 144.1 |
| R14 | 143.0921 | -38.1359 | 143.9 |
| R15 | 143.0864 | -38.1314 | 145.2 |
| R16 | 143.0921 | -38.1314 | 143.7 |
| R17 | 143.0807 | -38.1269 | 146.5 |
| R18 | 143.0864 | -38.1269 | 145.3 |
| R19 | 143.0921 | -38.1269 | 144.0 |
| R20 | 143.075 | -38.1224 | 145.8 |
| R21 | 143.0807 | -38.1224 | 143.8 |
| R22 | 143.0864 | -38.1224 | 145.0 |

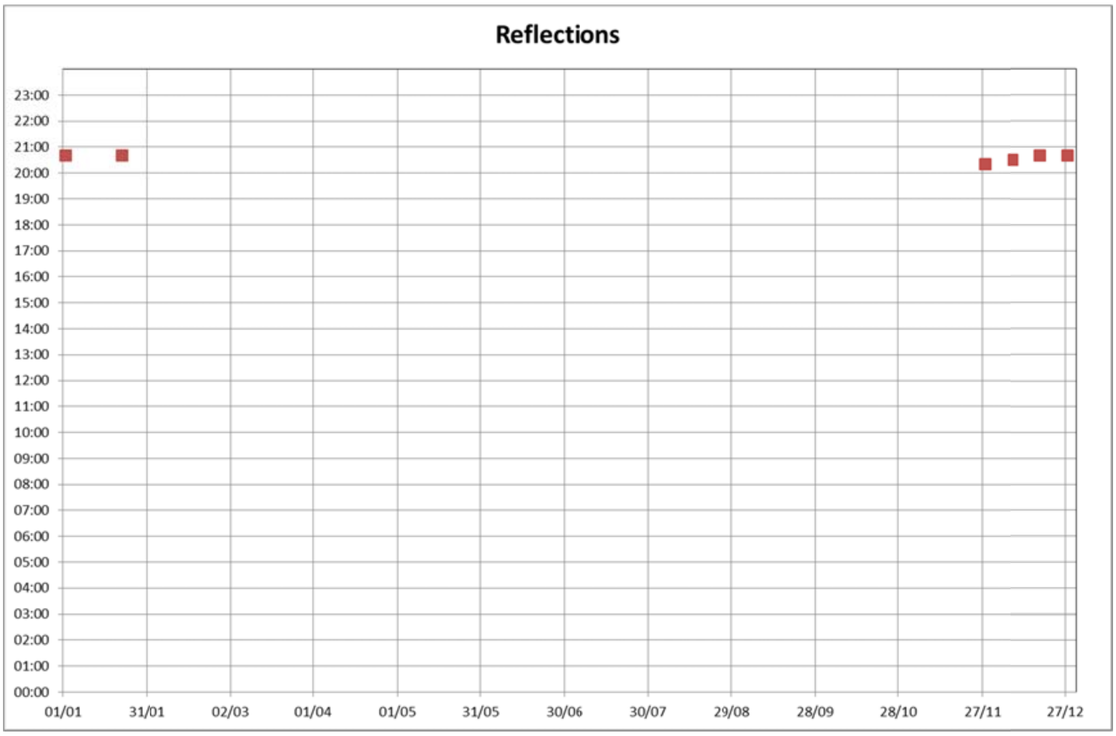
# APPENDIX G – GEOMETRIC CALCULATION RESULTS

The charts for the receptors are shown on the following pages. Each chart shows the reflection date/time graph. The brown icons indicate the dates and times at which geometric reflections are possible. This is based on a 10 degree criteria (discussed in Section 4.5). The results are combined for all assessed points within the proposed solar farm.

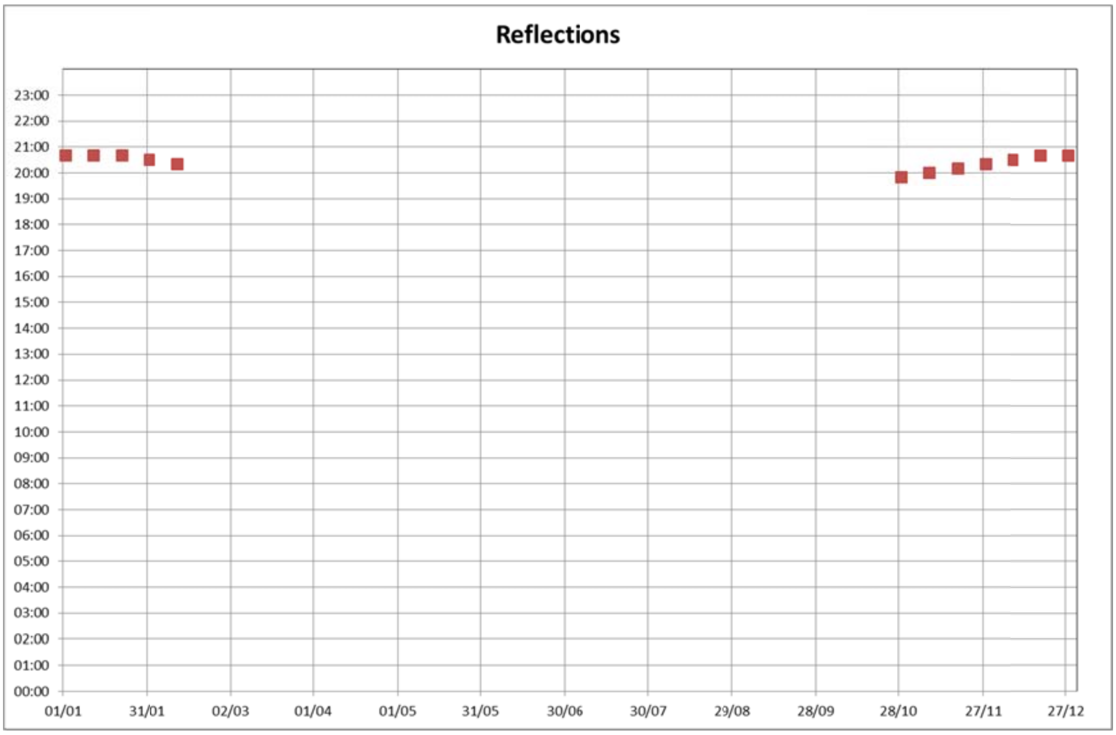
## Road Receptors

The glint and glare charts at the receptors where a solar reflection is geometrically possible, not considering existing screening, are presented below.

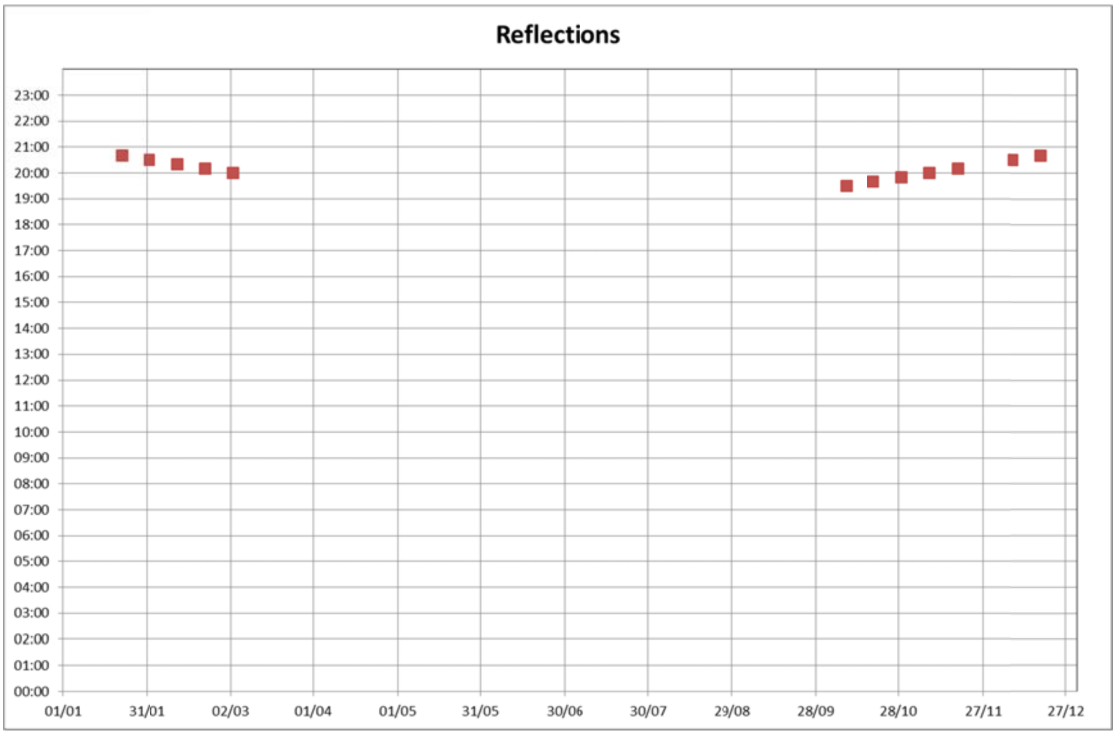
**Road 10**



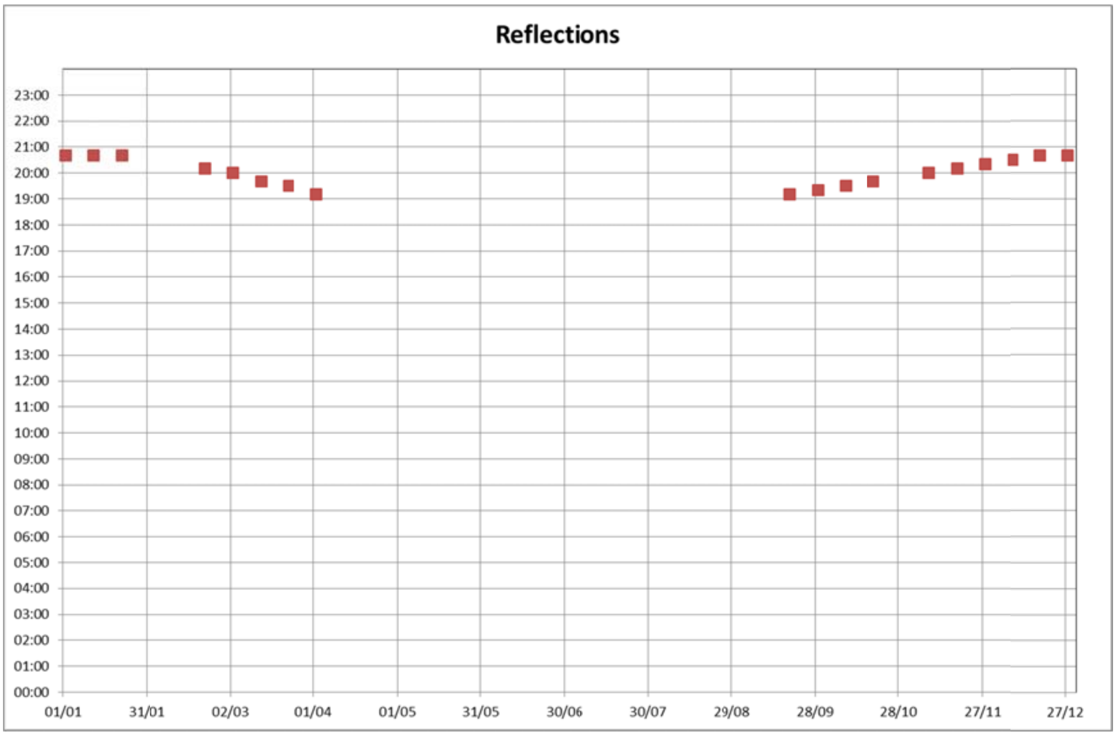
**Road 11**



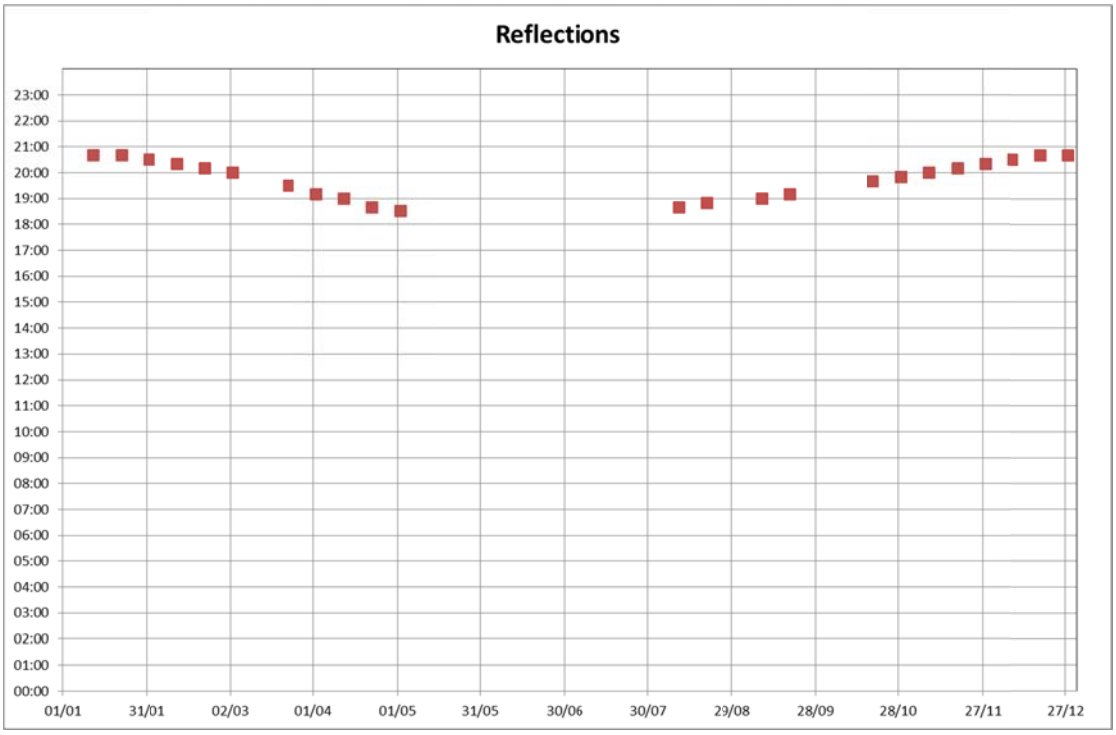

**Road 12**



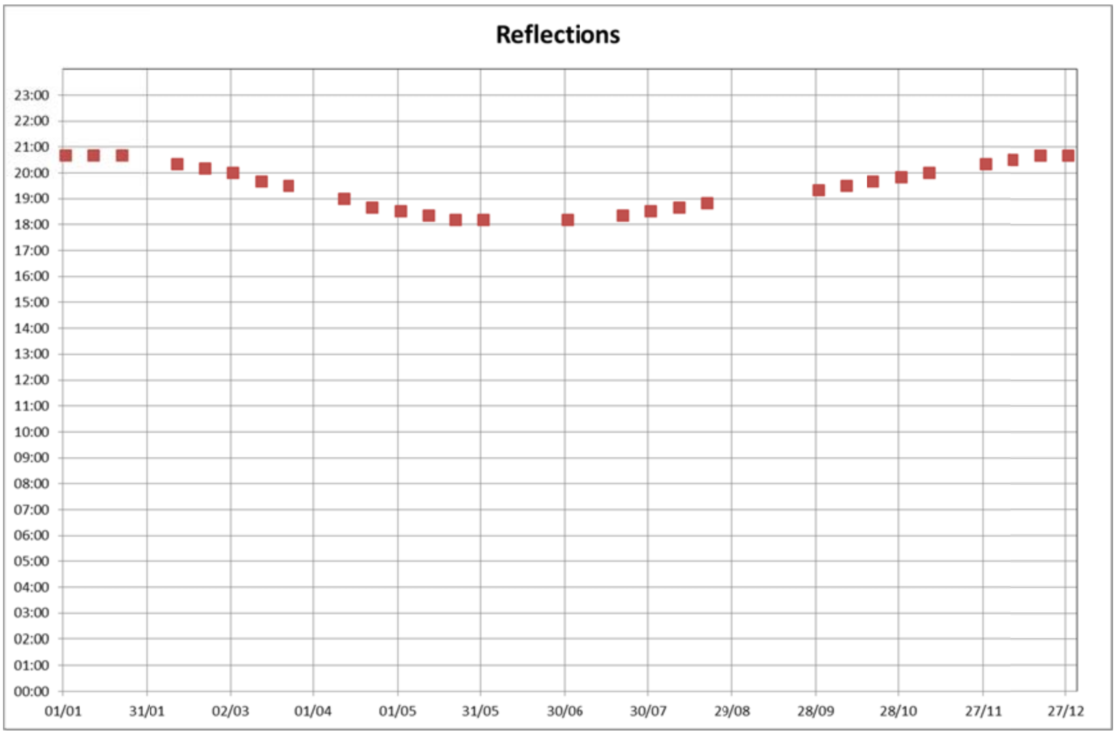
**Road 13**




**Road 14**



**Road 15**

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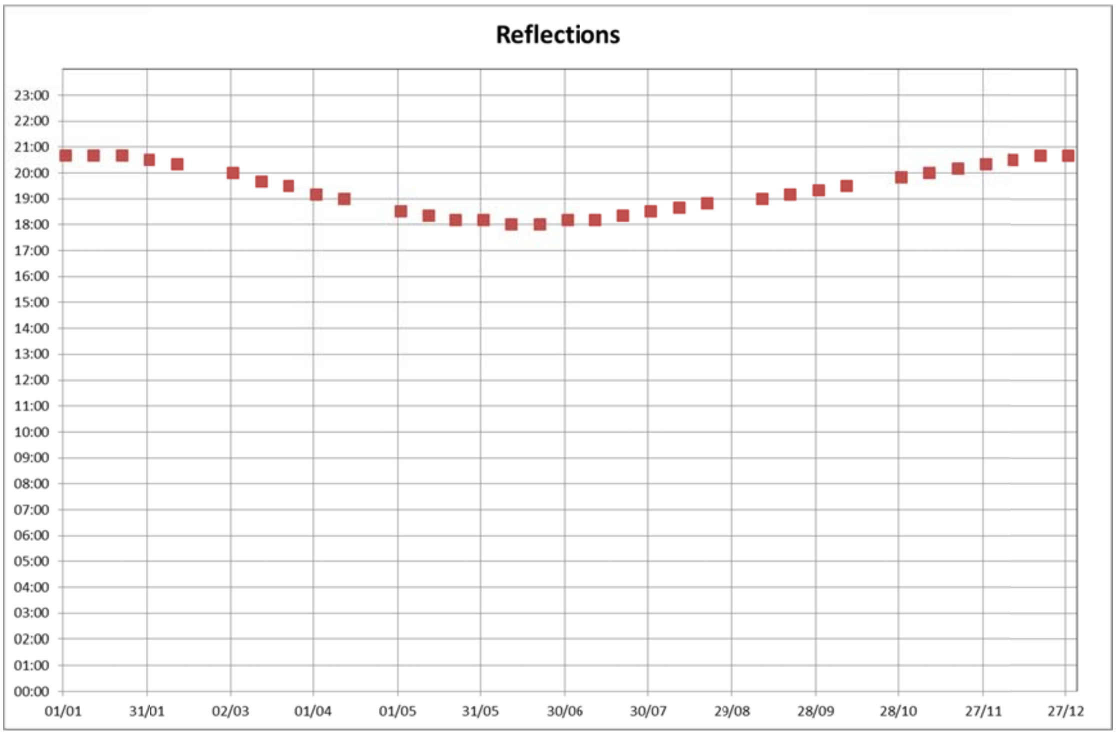

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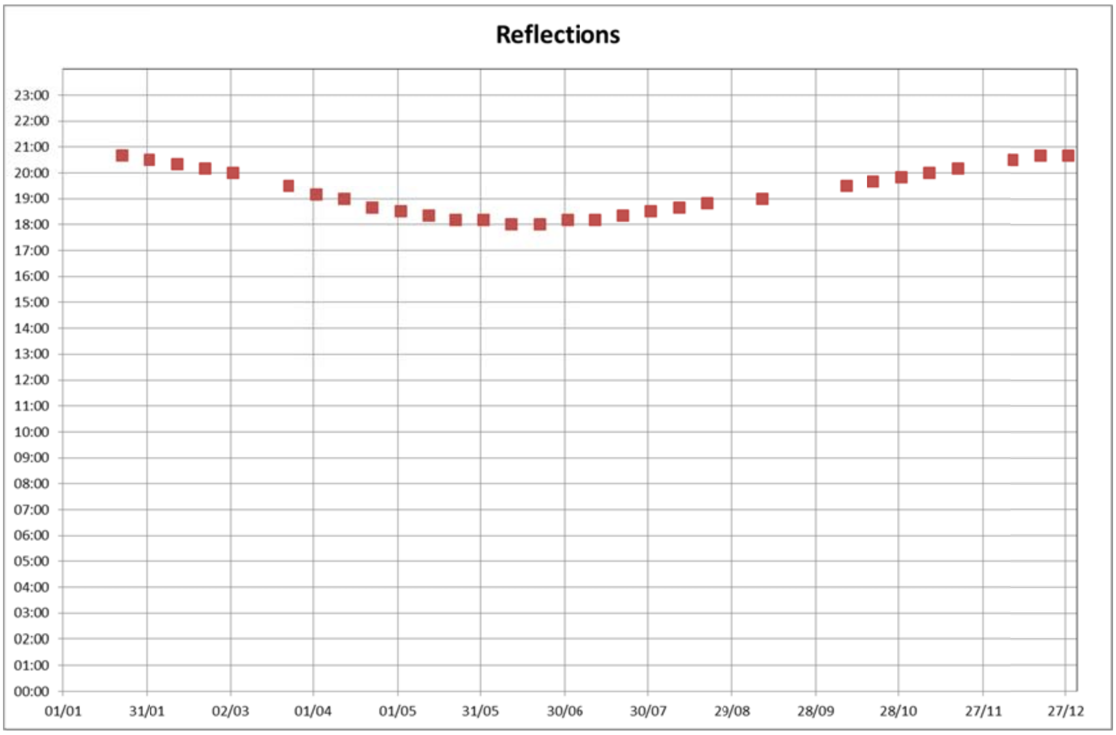


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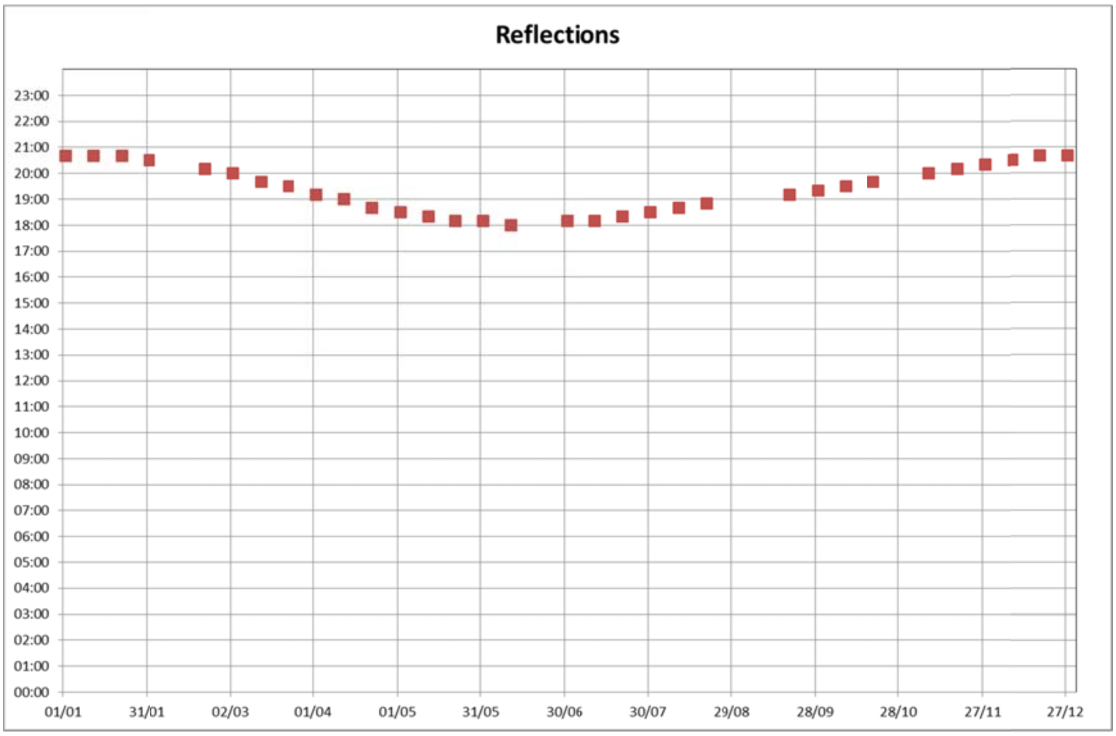
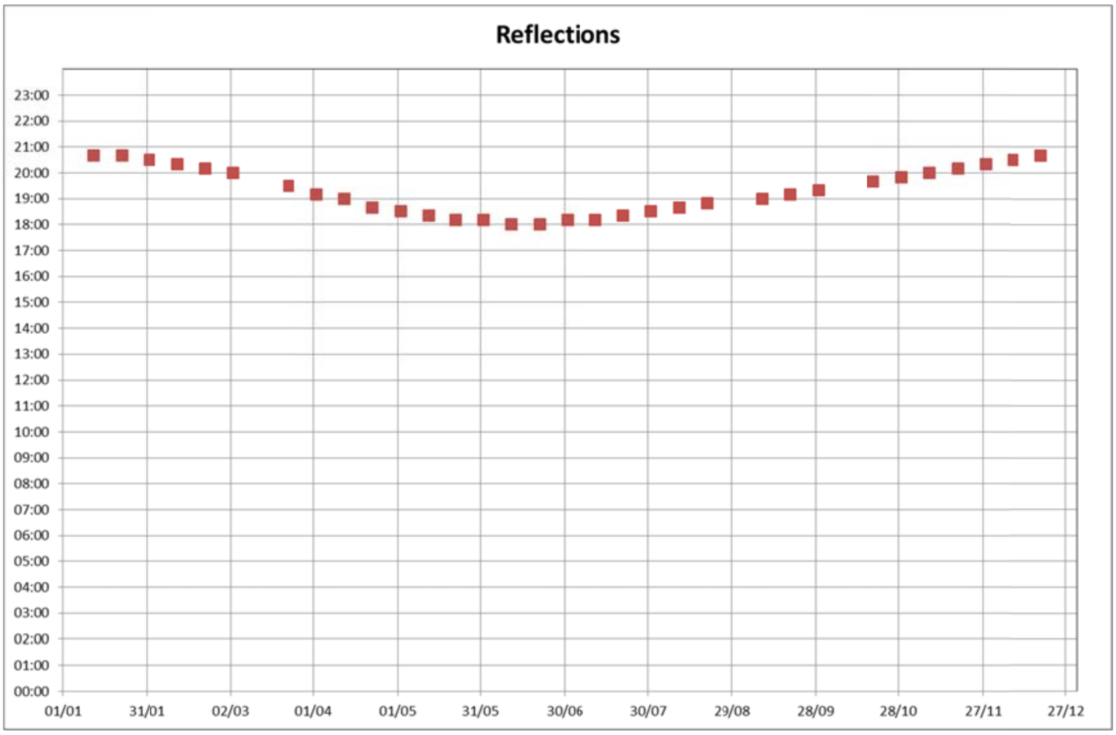
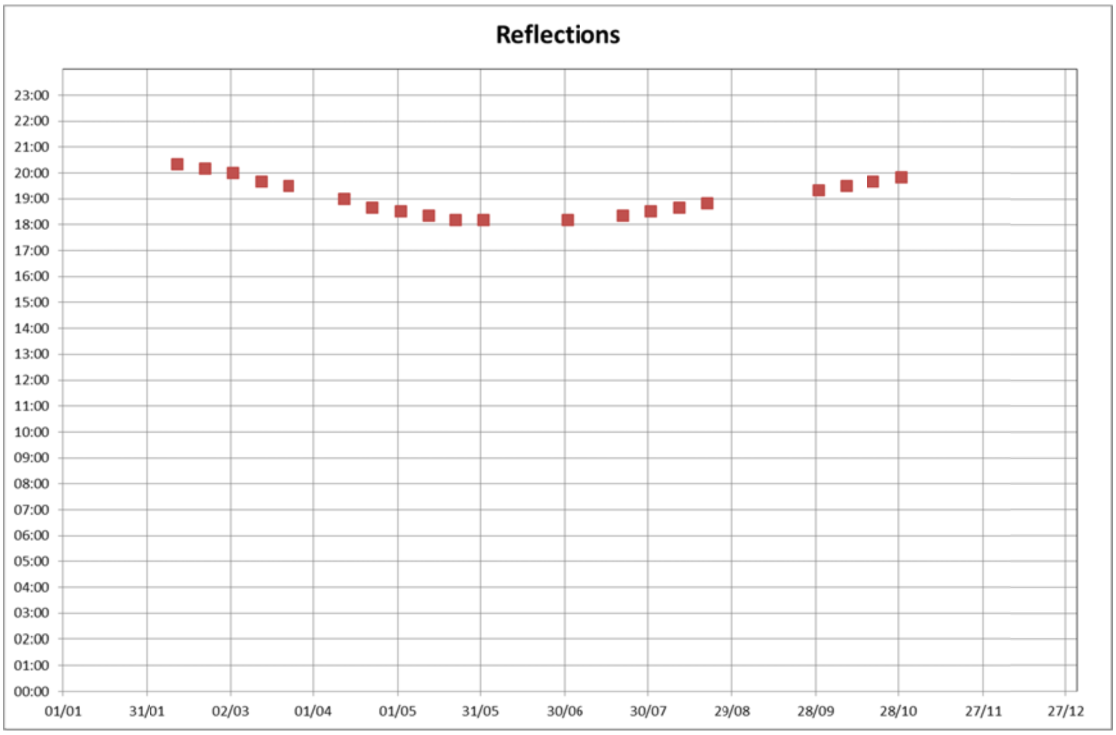


Road 19




Road 20



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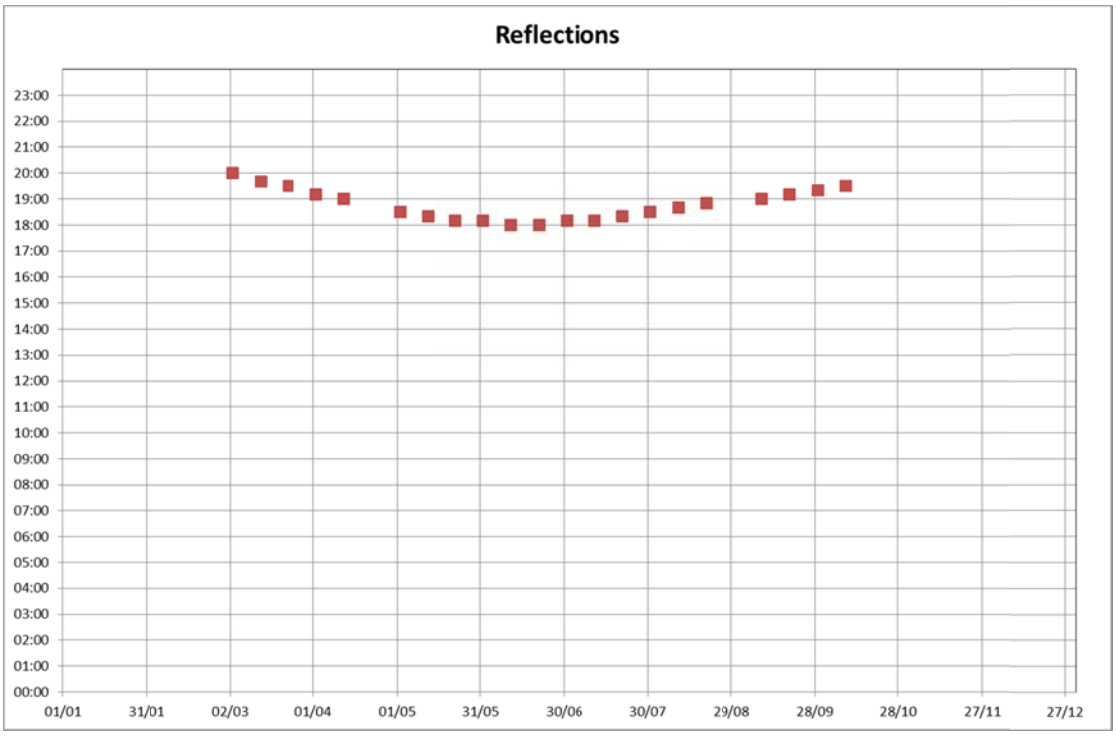


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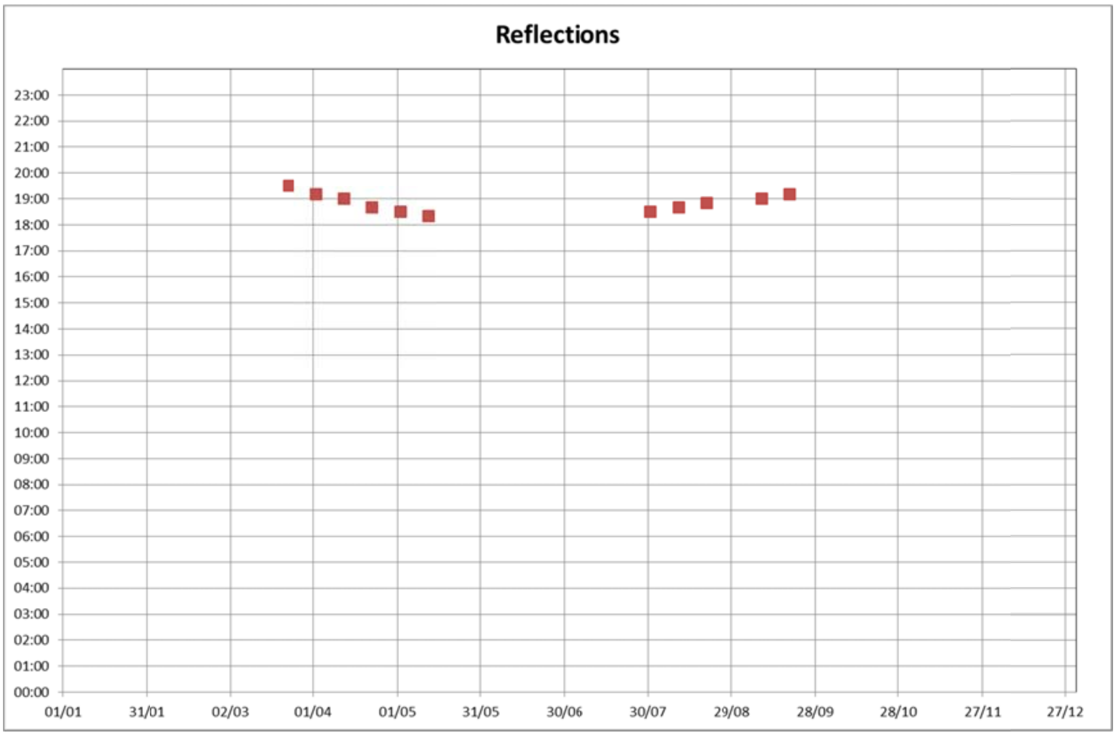

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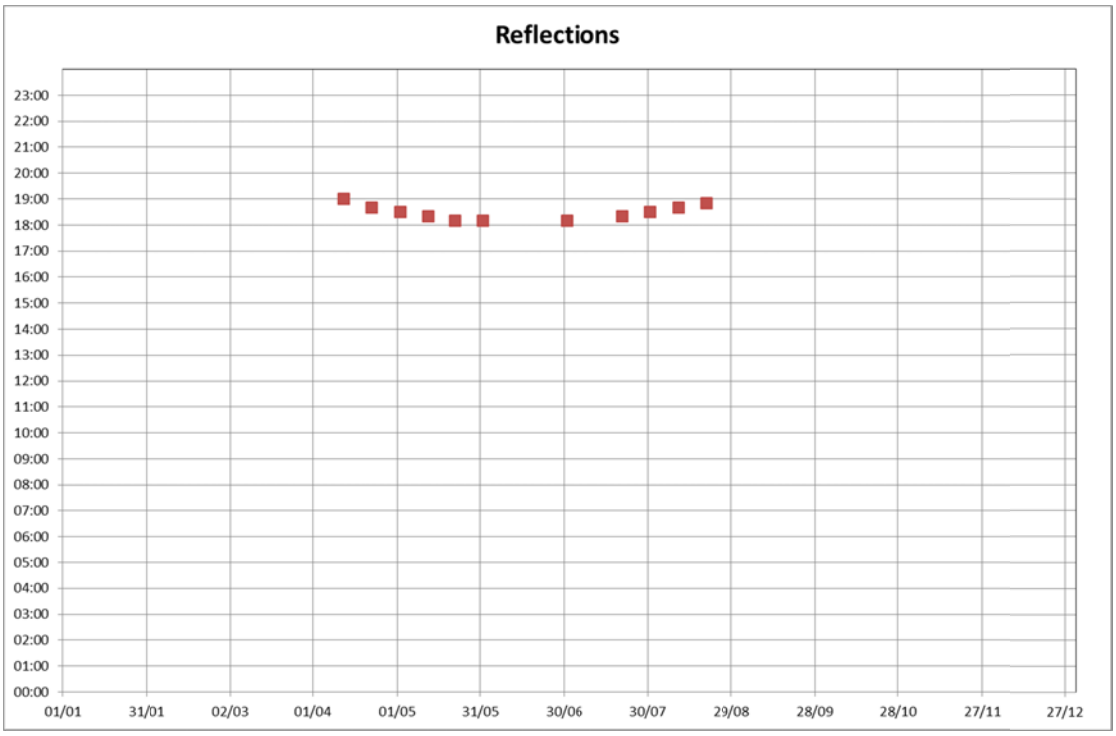

Reflections
23:00
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01/01
31/01
02/03
01/04
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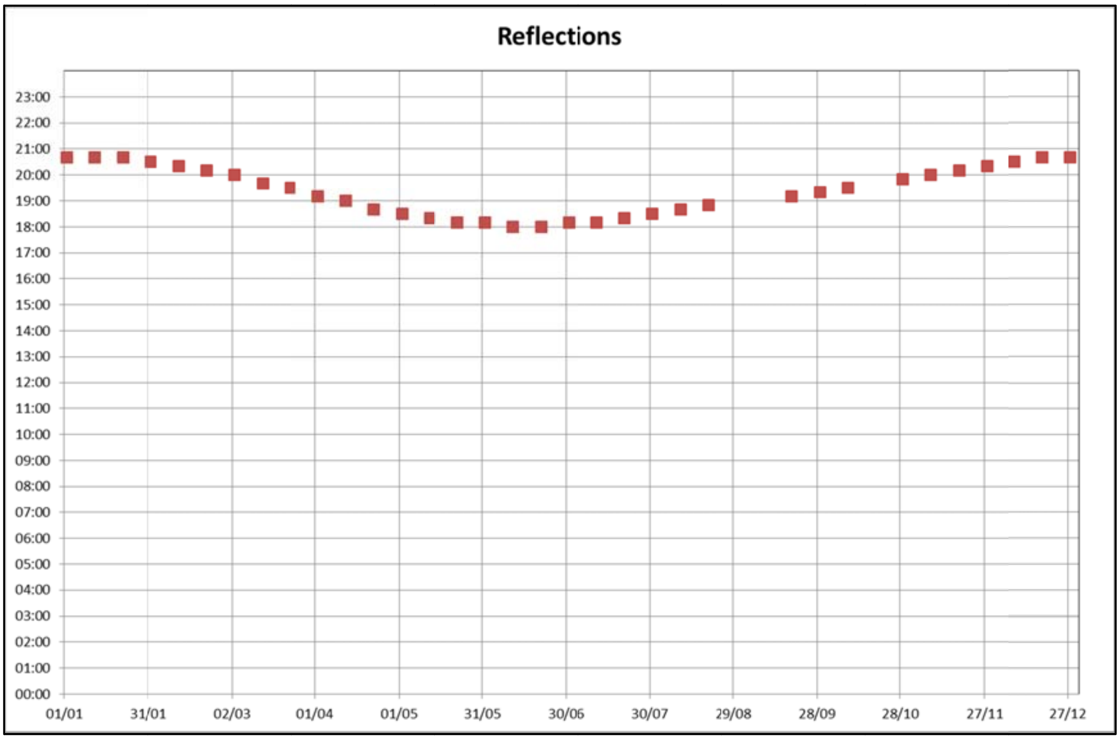
30/06
30/07
29/08
28/09
28/10
27/11
27/12

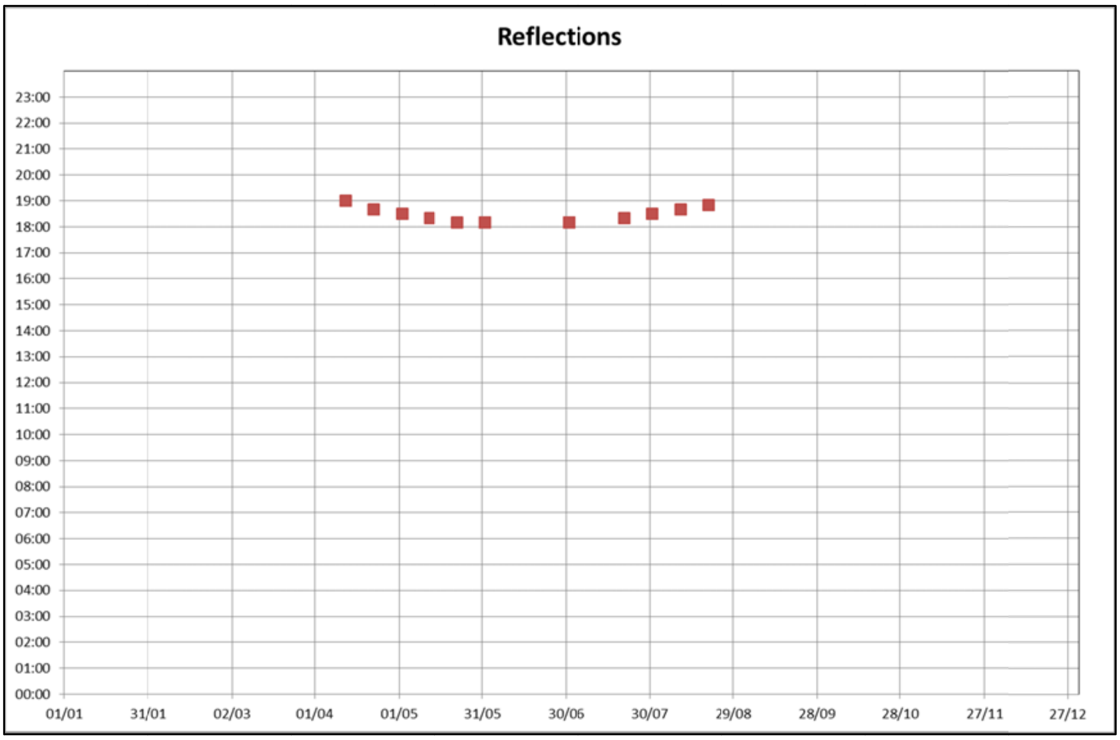
## Dwelling Receptors

The glint and glare charts at the receptors where a solar reflection is geometrically possible, not considering existing screening, are presented below.

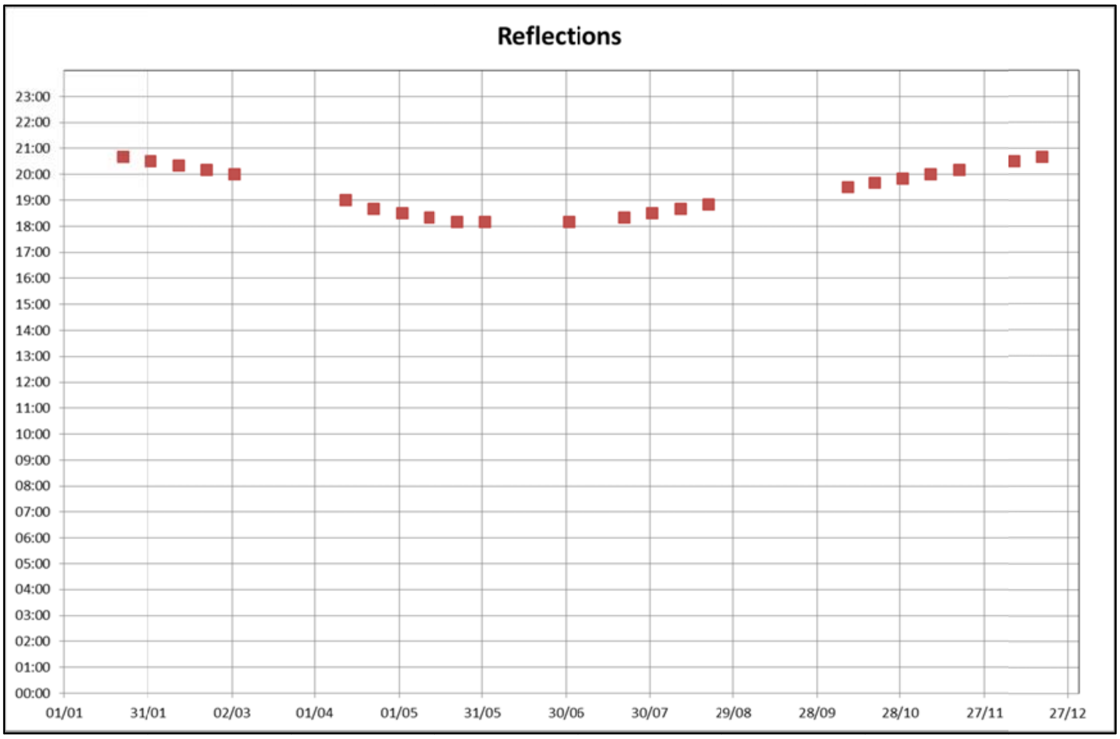
**Dwelling E**



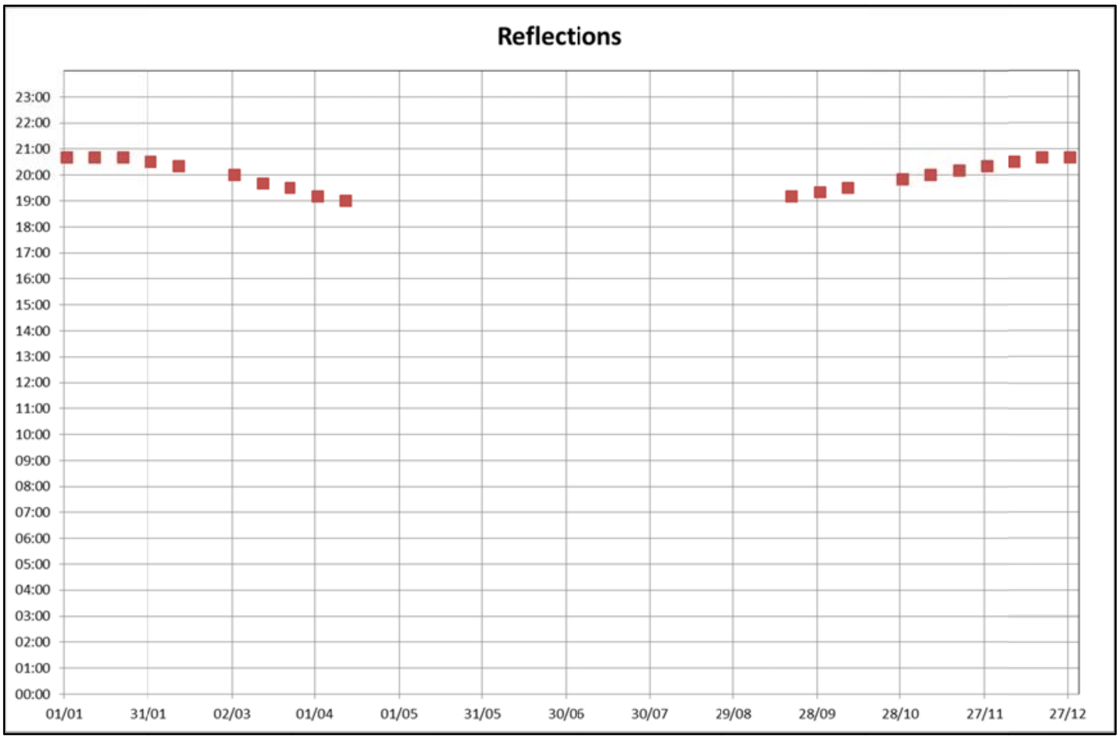

**Dwelling I**



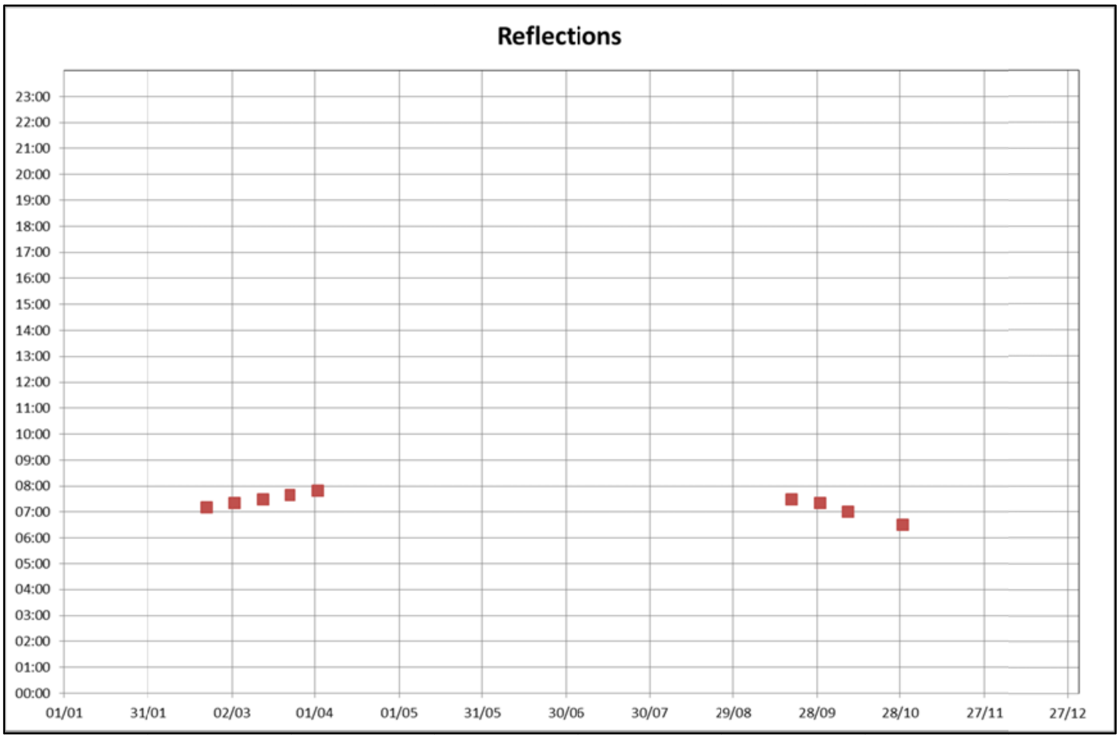
**Dwelling K**




**Dwelling L**



**Dwelling N**



Reflections
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