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OSD Detailed SSD DA - Reflectivity Analysis

Victoria Cross Over Station Development

Document No: SMCSWSVO-LLC-SVC-EM-REP-000003

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Prepared For – Lendlease Building Pty Limited | ABN 97 000 098 162

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Victoria Cross Over Station Development

Client:

Lendlease Building Pty Limited

Level 14, Tower Three, International Towers Sydney, Exchange Place, 300 Barangaroo Avenue, Barangaroo NSW 2000

ABN: 97 000 098 162

Prepared by:

Arcadis Australia Pacific Pty Ltd and Mott MacDonald Australia Pty Limited (ARCMAC Joint Venture)

Level 16, 580 George Street Sydney NSW 2000

ABN: 794 7393 1704

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Changes made to this document since its last revision, which affect its scope or sense, are marked in the right margin by a vertical bar (|).

Date	Rev	Amendment Description	By
07/06/2019	A	Issued For Information	N.Mackenzie
05/07/2019	B	Updated for Submission	S.Canty
23/08/2019	C	Sydney Metro comments Incoporated	N.Mackenzie

Contents

1. Introduction

This report has been prepared to accompany a detailed State Significant Development (SSD) development application (DA) for a commercial mixed-use Over Station Development (OSD) above the new Sydney Metro Victoria Cross Station. The detailed SSD DA is consistent with the Concept Approval (SSD 17_8874) granted for the maximum building envelope on the site, as proposed to be modified.

The Minister for Planning, or their delegate, is the consent authority for the SSD DA and this application is lodged with the NSW Department of Planning, Industry and Environment (NSW DPE) for assessment.

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 6 May 2019. Specifically, this report has been prepared to respond to the following SEARs:

10: Amenity

The EIS shall:

- *provide a reflectivity analysis identifying possible adverse glare conditions affecting users of the public domain and occupants of neighbouring buildings.*

The detailed SSD DA seeks development consent for:

- Construction of a new commercial office tower with a maximum building height of RL 230 or 168 metres (approximately 42 storeys).
- The commercial tower includes a maximum GFA of approximately 61,500sqm, excluding floor space approved in the CSSI
- Integration with the approved CSSI proposal including though not limited to:
  - Structures, mechanical and electronic systems, and services; and
  - Vertical transfers;
- Use of spaces within the CSSI 'metro box' building envelope for the purposes of:
  - Retail tenancies;
  - Commercial office lobbies and space;
  - 161 car parking spaces within the basement for the purposes of the commercial office and retail use;
  - End of trip facilities; and
  - Loading and services access.
- Utilities and services provision.
- Signage locations (building identification signs).
- Stratum subdivision (staged).

1.1 The Site

The site is generally described as 155-167 Miller Street, 181 Miller Street, 187-189 Miller Street, and part of 65 Berry Street, North Sydney (the site). The site occupies various addresses/allotments and is legally described as follows:

- 155-167 Miller Street (SP 35644) (which incorporates lots 40 and 41 of Strata Plan 81092 and lots 37, 38 and 39 of Strata Plan 79612)
- 181 Miller Street (Lot 15/DP 69345, Lot 1 & 2/DP 123056, Lot 10/DP 70667)
- 187 Miller Street (Lot A/DP 160018)
- 189 Miller Street (Lot 1/DP 633088)
- Formerly part 65 Berry Street (Lot 1/DP 1230458)

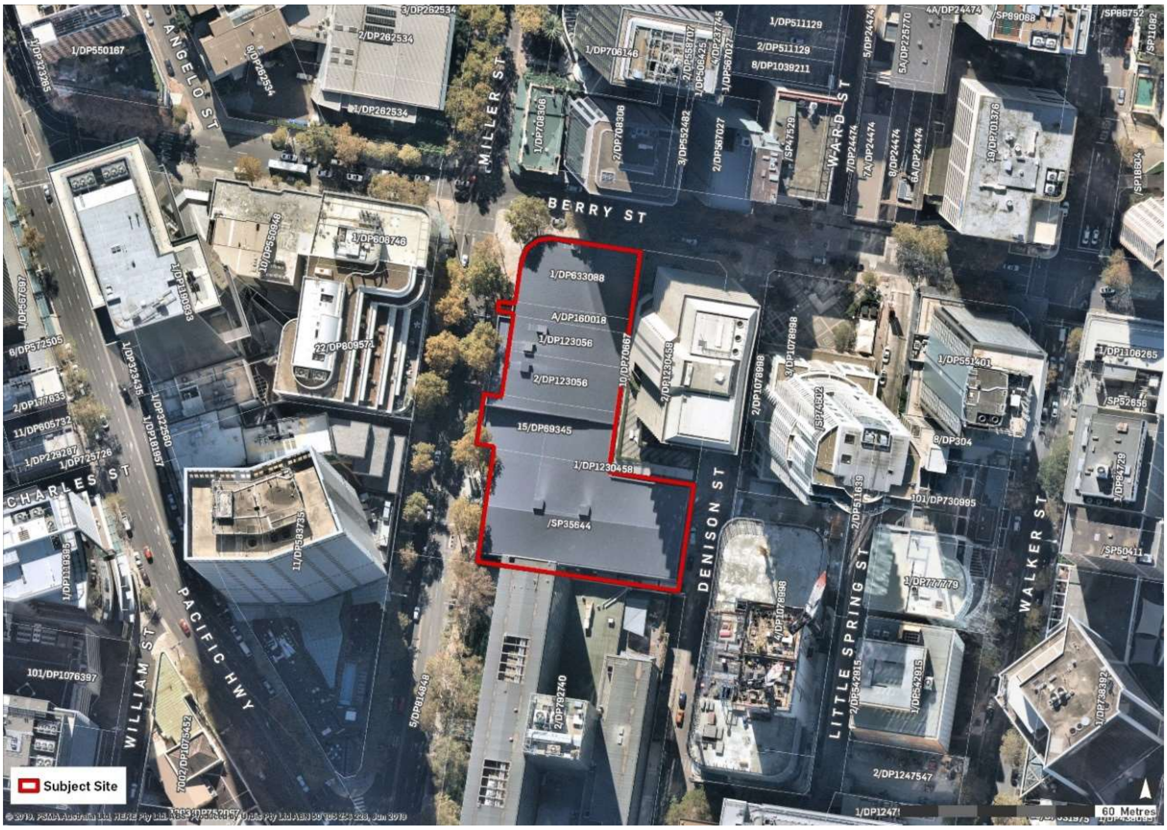


Figure 1: Site aerial

1.2 Sydney Metro Description

Sydney Metro is Australia's biggest public transport project. Services started in May 2019 in the city's North West with a train every four minutes in the peak. Metro rail will be extended into the CBD and beyond to Bankstown in 2024. There will be new metro railway stations underground at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and new metro platforms under Central.

In 2024, Sydney will have 31 metro railway stations and a 66 km standalone metro railway system – the biggest urban rail project in Australian history. There will be ultimate capacity for a metro train every two minutes in each direction under the Sydney city centre. The Sydney Metro project is illustrated in the Figure below.

On 9 January 2017, the Minister for Planning approved the Sydney Metro City & Southwest - Chatswood to Sydenham project as a Critical State Significant Infrastructure project (reference SSI 15_7400) (CSSI Approval). The terms of the CSSI Approval includes all works required to construct the Sydney Metro Victoria Cross Station, including the demolition of existing buildings and structures on both sites. The CSSI Approval also includes construction of below and above ground improvements with the metro station structure for appropriate integration with the OSD.

With regards to CSSI related works, any changes to the “metro box envelope” and public domain will be pursued in satisfaction of the CSSI conditions of approval and do not form part of the scope of the detailed SSD DA for the OSD.

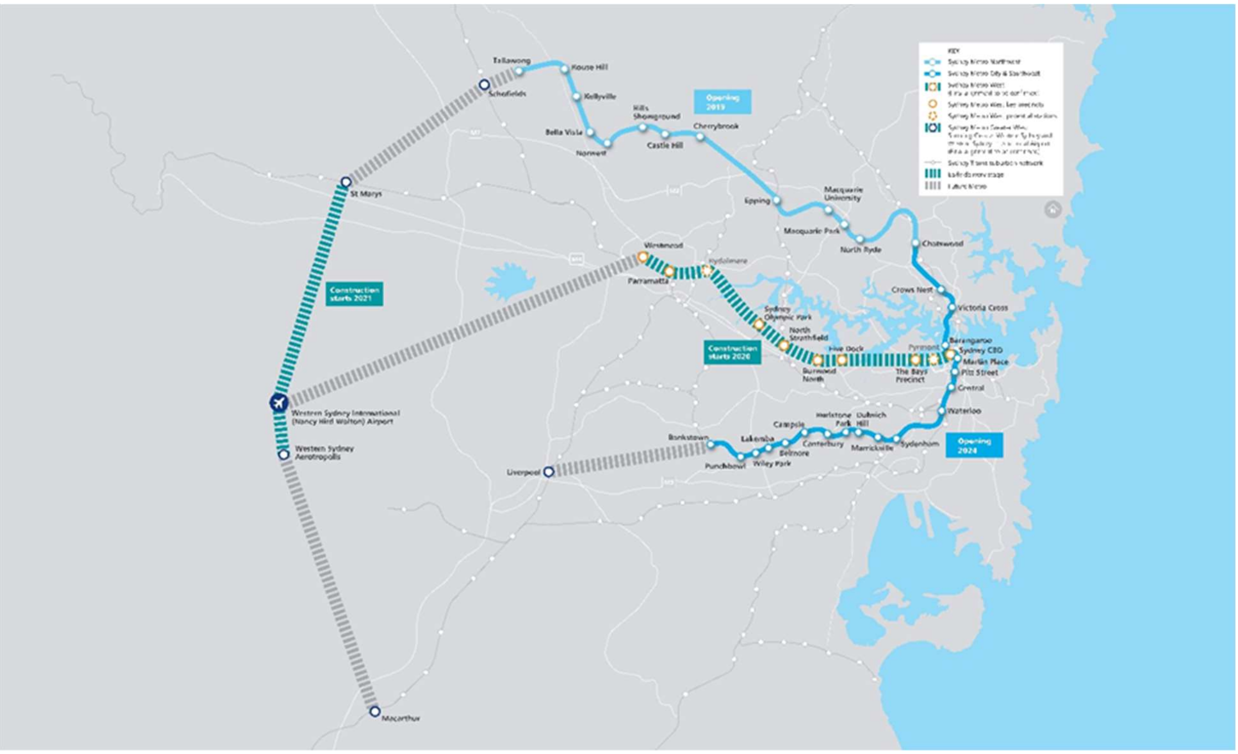


Figure 2: Sydney Metro alignment map (Source: Sydney Metro)

1.3 Scope

The façade of the development is primarily made up of glazing, which is prone to reflecting and causing glare. This resultant glare can be very dangerous when it obstructs the vision of pedestrians and drivers alike. This analysis has been conducted to ensure the development does not interfere with the safety of those travelling around it.

This reflectivity analysis is conducted using the technique published by Hassall (1991) which identifies a limiting veiling luminance of 500 cd/m2 to be appropriate for the comfort of motorists. It is assumed if the conditions for motorists are met, as will the conditions for pedestrians. Worst-case glare scenarios are identified using solar charts, and then for points of concerns in-depth studies using Grasshopper are conducted.

2. Legislation

The North Sydney Development Control Plan (2013) under section 2 – “Commercial and Mixed Use Development’) provides no specific limits with regard to façade reflectance, refer to Figure 3 below. Thus this report acknowledges the requirements outlined in the December 2012 City of Sydney DCP, which states:

Table 1: Legislative requirements

3.2.7	Reflectivity
Objectives	
(a)	Minimise the reflection of sunlight from buildings to surrounding areas and buildings.
(b)	Ensure that building materials do not lead to hazardous, undesirable or uncomfortable glare to pedestrians, motorists or occupants of surrounding buildings.
Provisions	
(1)	A Reflectivity Report that analyses potential solar glare from the proposed building design may be required for tall buildings.
(2)	Generally, light reflectivity from building materials used on facades must not exceed 20%.
(3)	For buildings in the vicinity of arterial roads/major roads and Sydney Airport, proof of light reflectivity is required and is to demonstrate that light reflectivity does not exceed 20%.

While acknowledging the Sydney City requirements, it is assumed that the limit refers to reflected light at normal incidence to the glass.

2.3.4 Reflectivity

Objectives

O1 To minimise the impacts by reflected light and solar reflectivity from buildings on pedestrians and motorists.

Provisions

P1 Buildings should provide a greater proportion of solid to void on all facades and use non-reflective materials.

P2 Buildings should use non-reflective glass and / or recess glass behind balconies.

P3 Sun shields, such as awnings, canopies and pergolas should be provided to glazed areas.

P4 Council may require the submission of a Reflectivity Study prepared by a suitably qualified consultant.

Figure 3: Extract from NS Council DCP

3. Analysis

3.1 Overview

This section outlines the approach to the reflectivity analysis, including key data, assumptions and a description of the Hassall (1991) method.

3.2 Façade Composition

The analysis assumes the building to be rectangular and surface details are negligible. The reflectivity of the glazing changes with the angle of incidence as shown in Table 2, to keep results conservative the facades are assumed to be entirely glass.

Table 2: Assumed reflectivity of glazed surfaces with angle of incidence

Angle of incidence, I	<60	60	70	80	90
Reflectivity	0.1	0.1	0.24	0.48	1

Source: Hassall, 1991

3.3 Methodology

The method of analysis is as follows:

- Identify appropriate study points
- Use solar charts to identify times of interest
- Calculate veiling luminance
- Verify exceedances with Grasshopper

All angles mentioned throughout this report are referenced with respect to North. To produce conservative results the effects of surrounding buildings are not initially considered.

3.4 Study Points

Figure 4 shows the site location and critical aspects (perpendicular to building face) of the development. For ease of reference the building faces were labelled North, East, South and West, please be aware the development's orientation is offset by +8°. Drivers along Berry Street, Miller Street and Warringah Freeway (noting however that 1 Denison Street and 100 Mount Street developments provide shielding) were identified to be at risk of glare. Hence, study points were located along these streets as seen in Figure 5. Table 3 further describes these study points and their orientations.

Figure 4: Critical Aspects of the Development

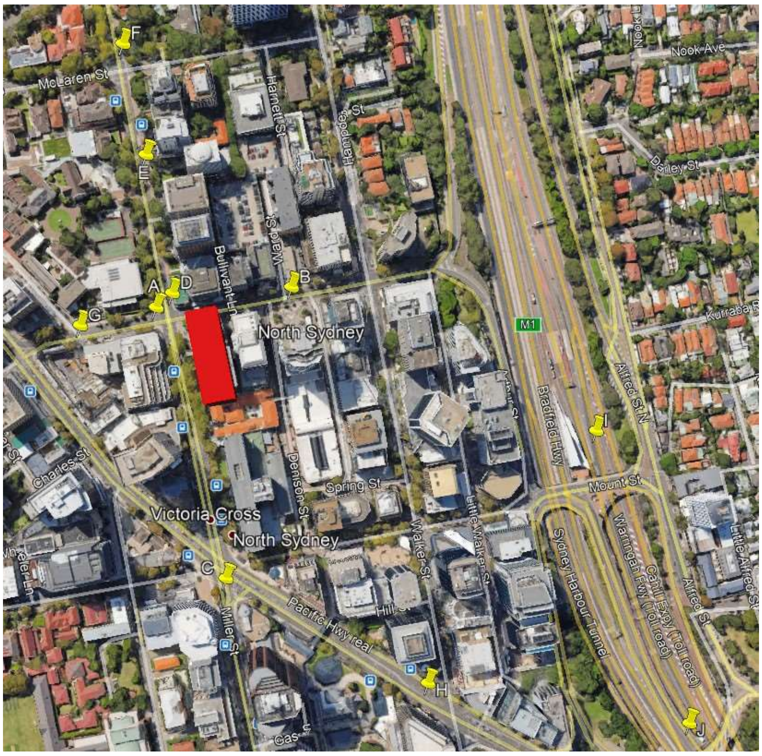


Figure 5: Study point locations & viewing direction

Table 3 Study Point Details

Study Point	Location	Viewpoint		Relevant Aspects
A	Berry Street	East	99°	North & West
B	Berry Street	West	279°	North & East
C	Miller Street	North	9°	West & South
D	Miller Street	South	172°	North & West
E	Miller Street	South	172°	North & West
F	Miller Street	South	172°	North & West
G	Berry Street	East	99°	North & West
H	Pacific Hwy	North	Varies	South & East
I	Warringah Fwy	North	Varies	South & East
J	Warringah Fwy	North	Varies	South & East

3.5 Solar Charts

“Check zones” were identified for each “Study Point” by finding the angles from the point of interest to the base corners of the façade of interest and plotting them onto the solar chart - Figure 6 shows this process clearly. Following the Hassall (1991) method, solar charts were then developed using the building aspect, with the “check zones” overlaid to determine time periods of concern. If the solar chart coincided with the check zones there is the potential for glare effects to occur occurring during the periods identified on the chart (time of year and time of day), otherwise glare will not occur from the façade of interest. The veiling luminance is then calculated for the worst case day and time. Please see the Appendix for the solar charts for all points and faces assessed.

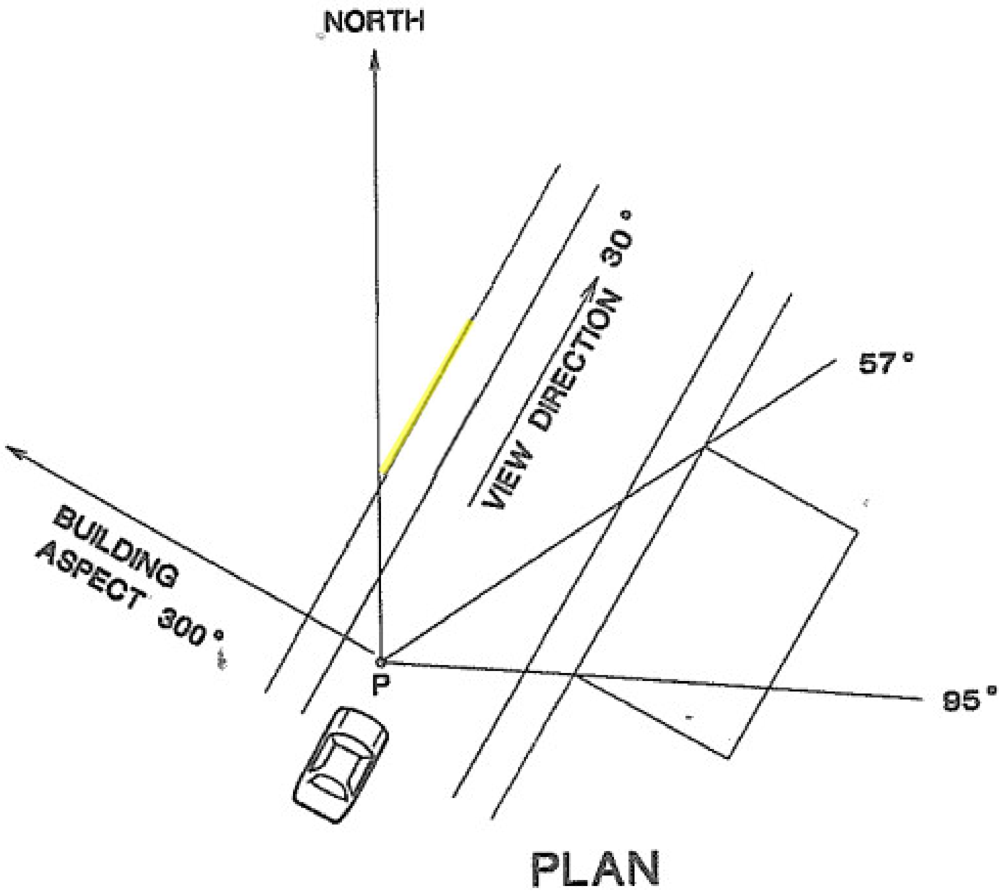


Figure 6: Identifying vertical reflective façade

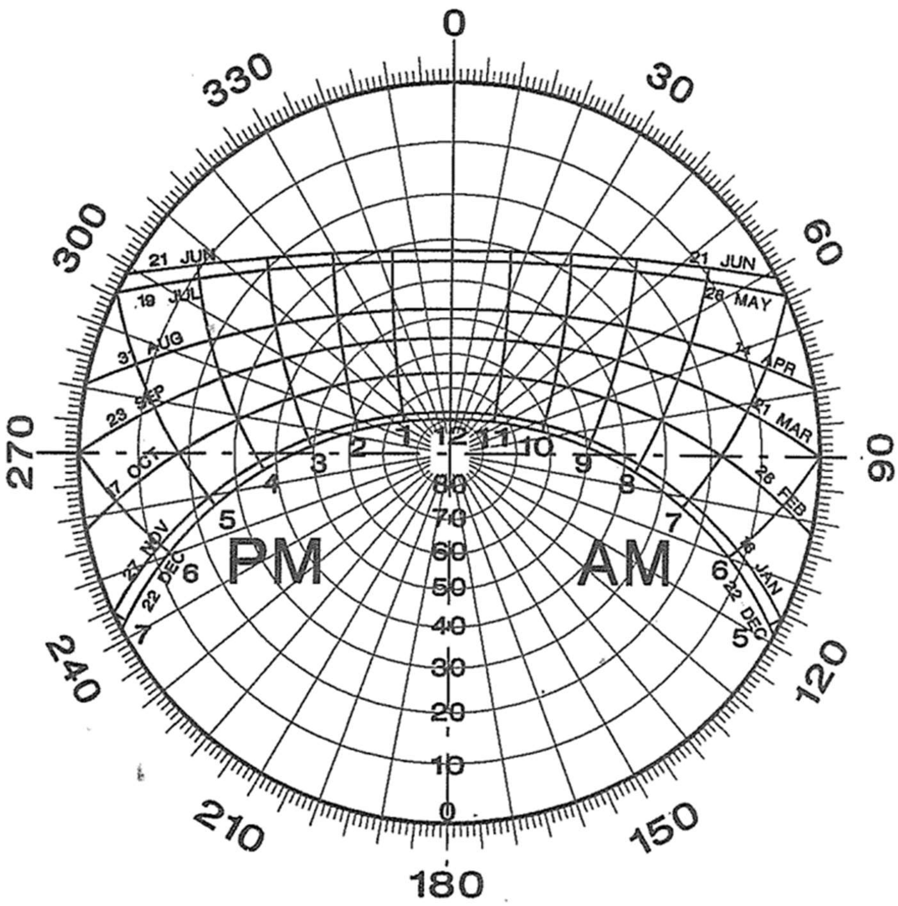


Figure 7: General Solar Chart (Hassall, 1991)

3.6 Calculating veiling luminance

Veiling luminance is a parameter used to estimate the reduction in visibility due to light scatter in the eye (Van Derlofske, n.d.). Hassall (1991) identified a veiling luminance of 500 cd/m2 to be the maximum amount of solar glare to which a driver may be exposed.

From review of the solar charts, some scenarios were found to have no effects due to glare, and hence we do not need to calculate veiling luminance. For those which the check zones coincided with the solar charts the veiling luminance is to be calculated to ensure the glare occurring is not at a dangerously high level.

The procedure to calculate this value is clearly outlined by Hassall (1991) in Section 5.4. The necessary data required is the sun's position at the specified date and time; this is found from Geoscience Australia (2015) Astronomical Information. As well as the observer's viewing direction (Table 3) and building face aspect (Figure 4).

3.7 Parametric Modelling

If the veiling luminance exceeds the limit, parametric modelling (Grasshopper and Ladybug within Rhino) is utilised to perform an in-depth analysis to how the sun reflects off the building surface. This approach considers the shielding effects of surrounding buildings, and hence provides a more realistic approach.

Grasshopper is a visual programming language and environment that runs within the Rhinoceros 3D computer-aided design (CAD) application. Ladybug imports standard EnergyPlus Weather files (.EPW) into Grasshopper. It provides a variety of 2D and 3D interactive climate graphics that support the decision-making process during the early stages of design. Ladybug also supports the evaluation of initial design options through solar radiation studies, view analyses, sunlight-hours modeling, and more. Integration with visual programming environments allows instantaneous feedback on design modifications and a high degree of customization.

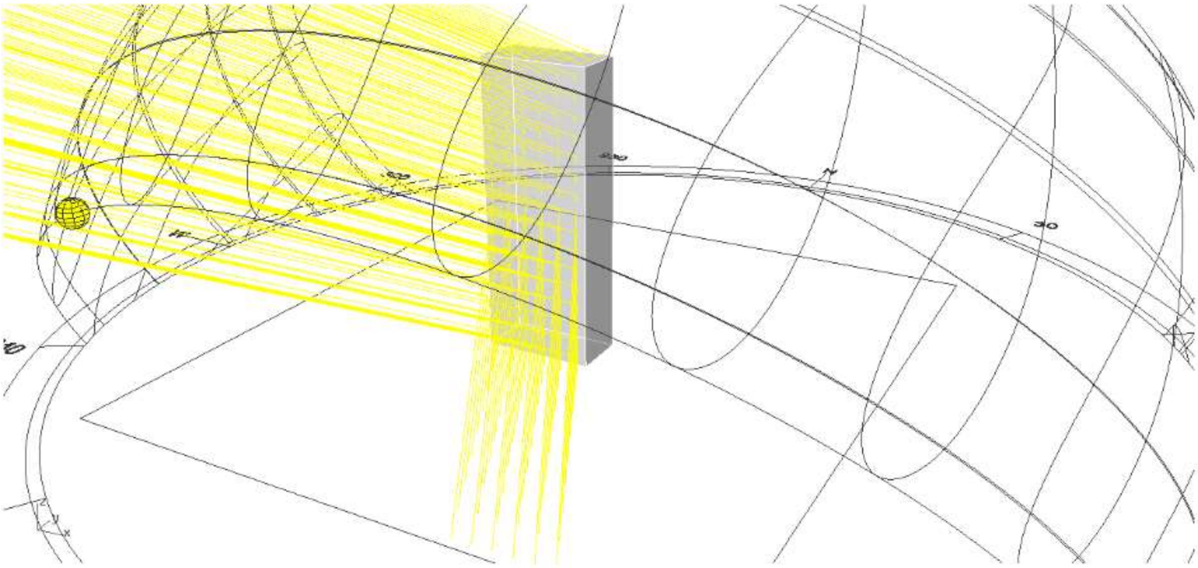


Figure 8: Ray tracing within Rhino using Grasshopper/Ladybug Tools

4. Impact on Drivers and Pedestrians

The veiling luminance is calculated to identify the severity of glare. The results and intermediate results are presented in Table 4.

Table 4: Calculating Veiling Luminance using Hassall (1991) method

Location												
Point location	A	B	B	C	D	E	F	G	G	H	I	J
Building Face	N	N	E	W	N	N	N	N	W	E	E	E
Date	17 May	31 Aug	22 Dec	21 Jun	14 Apr	21 Jun	21 Jun	9 Mar	22 Dec	21 Jun	31 Aug	21 Jun
Time	06:50	17:00	19:00	11:00	07:20	10:20	10:30	07:00	06:00	13.30	16.30	16.30
Results												
Veiling luminance, LV (cd/m^2)	4	1600	60	580	25	110	100	4300	23	2.8	1.57	0.94
< 500 cd/m^2	*Accept*	*Reject*	*Accept*	*Reject*	*Accept*	*Accept*	*Accept*	*Reject*	*Accept*	*Accept*	*Accept*	*Accept*

4.1 Drivers heading South along Miller Street (Points D, E and F)

- The relevant solar charts identified possible times of glare for drivers travelling south along Miller Street. However, the calculation of veiling luminance proved these to be acceptable.
- Points D, E and F experience no dangerous levels of glare when travelling south along Miller Street due to the North and West faces of the development.
- Figure 22, Figure 24 and Figure 26 shows the West face produces no glare.
- The calculations in Table 4 demonstrate the coincident check zones in Figure 21, Figure 23, and Figure 25 do not exceed the limit of 500 cd/m2.

4.2 Drivers heading North along Miller Street (Point C)

- At Point C drivers will experience some adverse levels of glare from the west façade as the veiling luminance exceeds 500 cd/m2 during late mornings in winter for approximately half an hour, as shown on the solar chart in Figure 19.
- Otherwise Figure 20 shows that the south façade produces no glare.
- Given the exceedance, this aspect was assessed further using parametric modelling as shown below in Figure 9. A glancing reflection is clearly apparent from the west façade, however it is anticipated that given the elevation of the sun at midday, that sun-visors will provide control. Additionally the west façade also includes vertical fins which will further mitigate glancing reflections from the façade as shown in Figure 10.

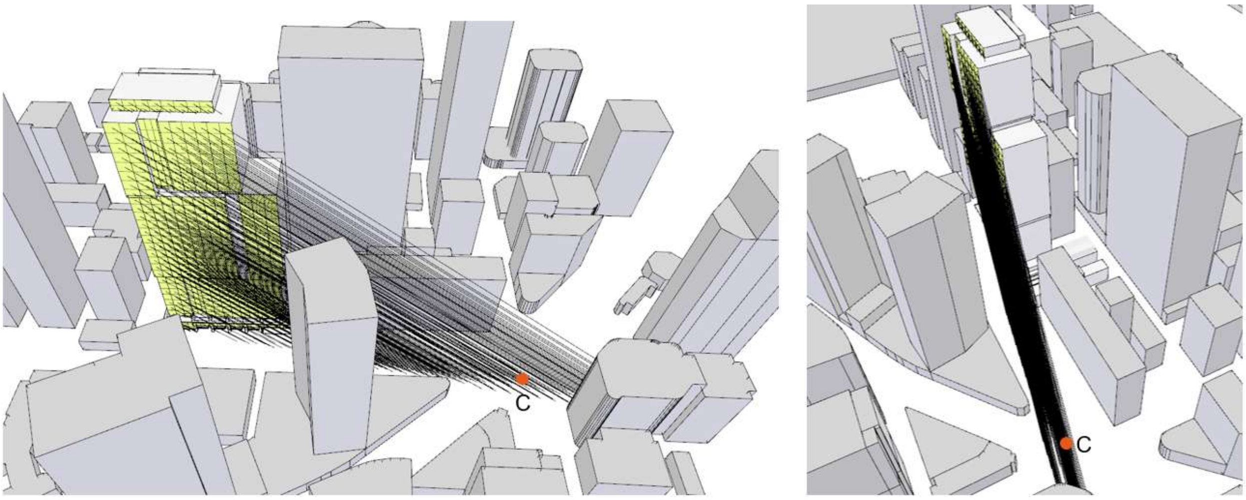


Figure 9 Glancing reflection from the west façade impacting drivers heading north

Figure 10: South and west façade – proposed form

4.3 Drivers heading East along Berry Street (Point A and G)

- Point A located at the intersection of Berry and Miller registers no adverse levels of glare, due to its proximity to the building. The calculation in Table 4 demonstrates the coincidence check zone in Figure 15 does not exceed the limit of 500 cd/m2. Figure 16 shows the driver experiences no glare due to the West face.

- However, Point G shows a high level of over 4000 cd/m2 due to the North face. This occurs in mid-May in the early morning for an hour. Figure 27 shows this occurs only for a short period of time. Figure 28 demonstrates the West face has no glare effects.
- Given the exceedance, this aspect was assessed further using parametric modelling as shown below in Figure 10. A glancing reflection is clearly apparent from the north façade, with surrounding buildings offering limited shielding. It should be noted however that drivers will be heading into the sun at that time of day. Notwithstanding that, the north façade has external fins which will significantly mitigate glancing reflections as shown in Figure 11, therefore the vertical fins completely block glancing reflections ensuring compliance with the criterion.

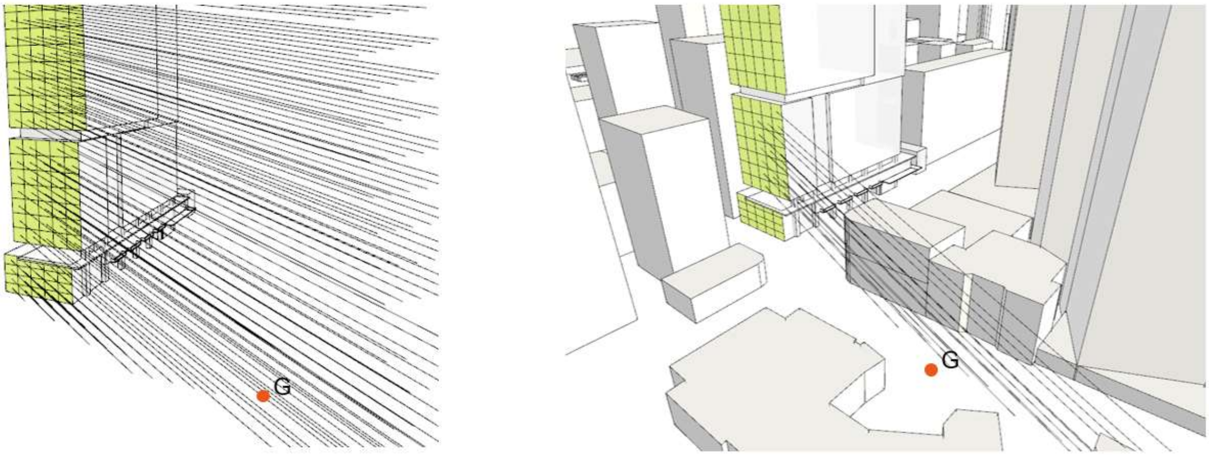


Figure 10: Glancing reflection from the north façade impacting drivers heading east in the morning (without surrounds, LEFT, and with, RIGHT)

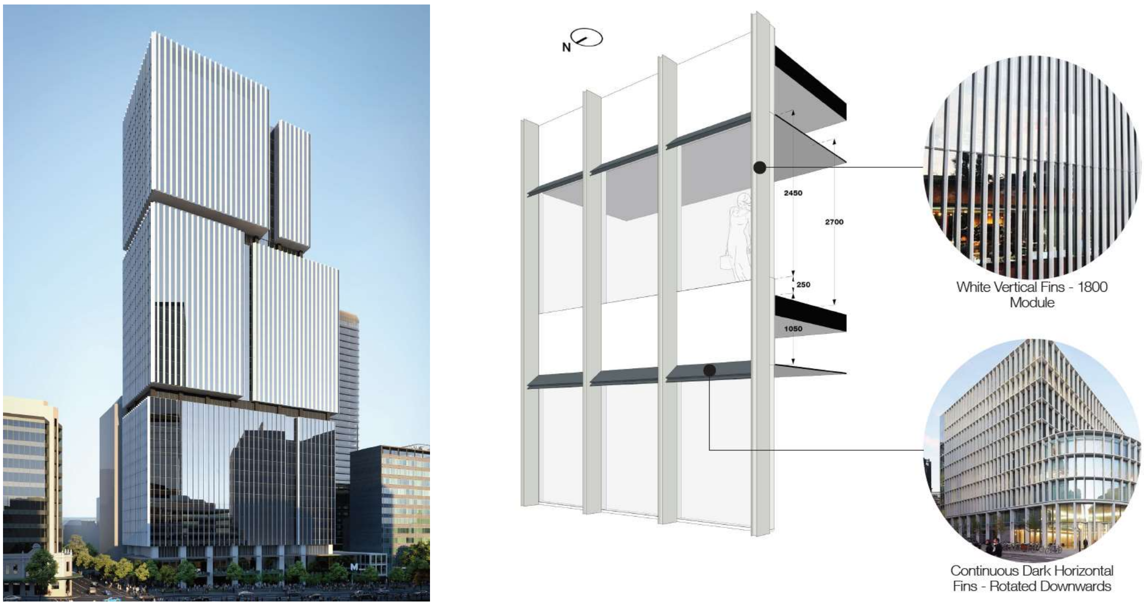
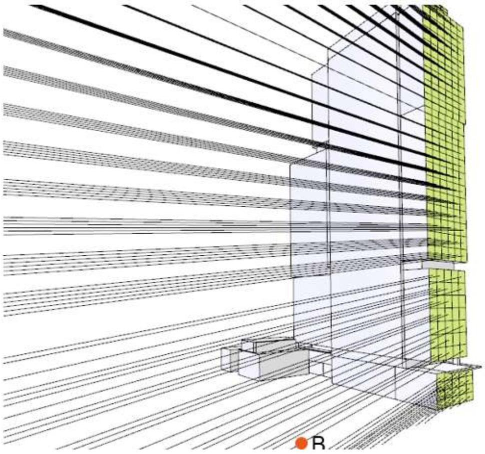


Figure 11: North and west façade – proposed form

4.4 Drivers heading West along Berry Street (Point B)

- At Point B drivers will experience high levels of glare as the calculation in Table 4 shows veiling luminance exceeding 500 cd/m2 due to the North face. Figure 17 shows this occurs over an hour in the afternoon in late August. Figure 18 demonstrates the West face has no glare effects.
- Given the exceedance, this aspect was assessed further using parametric modelling as shown below in Figure 12. A glancing reflection is clearly apparent from the north façade, with however surrounding buildings shielding this glare. It should also be noted however that drivers will be heading into the sun at that time of day. Notwithstanding that, the north façade has external fins which will significantly mitigate glancing reflections as shown in Figure 11, (glancing reflections due to vertical fins are completely blocked) therefore ensuring compliance with the criterion.



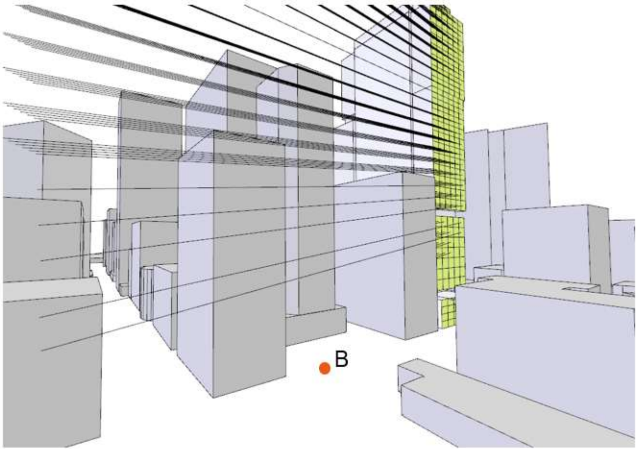


Figure 12: Glancing reflection from the north façade impacting drivers heading West in the evening (without surrounds, LEFT, and with, RIGHT)

4.5 Drivers heading North along Pacific Highway & Warringah Freeway (Point I. J and H)

As shown in Table 4 above Point I, J and H, results in extremely low values which are acceptable for these views (based on review without the incorporation of the adjacent buildings), thus drivers travelling north on the Pacific Highway and Warringah Freeway will not be affected.

In addition this aspect will not be affected by the development as the Pacific Highway and Warringah Freeway is shielded by both the 1 Denison Street and 100 Mount Street developments and the surrounding built environment, and reflections will occur at higher angles of incidence with the reflectance coefficient less than 20%, and the façade is comprised of a mixture of aluminium cladding and glass with vertical fins providing additional control of glancing reflections.

5. Impact on Buildings

The surrounding built form relative to the surrounds is shown below in Figure 13. Potential Impacts on nearby buildings will only occur with glancing reflections from the façade, otherwise the reflection coefficient is less than 20%.

The east façade is predominately precast elements, with therefore no potential to cause impact. The south façade will only have the potential for glancing reflections when the sun is low in the sky in the early morning or late afternoon; At these times the surrounding built environment will shield the façade and otherwise glare will be reflected upwards and away from the surrounding built environment.

Glancing reflections from the west façade are only likely around midday, when the sun is high in the sky with reflected glare down onto Miller St, but mitigated using vertical fins as outlined above with regard to potential hazards to road users.

Glancing reflections from the north façade are likely early-mid morning or mid-late afternoon. At these times, the sun will either be shielded by surrounding buildings, or if not reflected glare will be well controlled by vertical fins as noted above with regard to glare hazard potential.

It is not considered that there will be any impact from reflected glare on the surrounding built form.

Figure 13 Proposed built form relative to the surrounding built form

6. Summary and Conclusions

A reflectivity analysis has been carried out assessing the potential for hazardous glare from the façade of Victoria Cross OSD.

The method published by David N. H. Hassall in 1991 was used, with solar charts used to calculate veiling luminance as a measure of glare, which is considered adequate when <500 cd/m2.

Seven assessment points were selected along Berry Street and Miller Street in all orientations to capture a diverse range of situations. The worst-case scenario has been considered by assuming entirely glazed facades and initially ignoring the shielding effects of surrounding buildings and external shading elements on the facade.

After calculating the veiling luminance three scenarios exceeded the 500 cd/m2 limit. These were then assessed more rigorously using parametric modelling, which accounted for the shielding effects due to surrounding buildings. Additional mitigation from sun-visors and external shading elements of the façade were shown to provide good control of glancing reflections from the façade to ensure compliance with the limit.

The proposed façade glazing system and external shading elements will ensure compliance with the veiling luminance criterion to prevent glare causing discomfort or being hazardous to road users and the surrounding built environment.

7. References

Van Derlofske, J nd., "NHTSA Workshop: Balancing Visibility and Glare", https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/balancing_visability_and_glare-vanderlofske.pdf

Geoscience Australia, 2015, "Compute Sun and Moon Azimuth & Elevation", http://www.ga.gov.au/geodesy/astro/smpos.jsp

Hassall, D.N., 1991, "Reflectivity, Dealing with Rogue Solar Reflections", (published by author).

Sydney DCP, 2012, "Section 3 General Provisions", https://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0020/128018/Section3_DCP2012_280818.pdf

Appendix A: Solar Charts

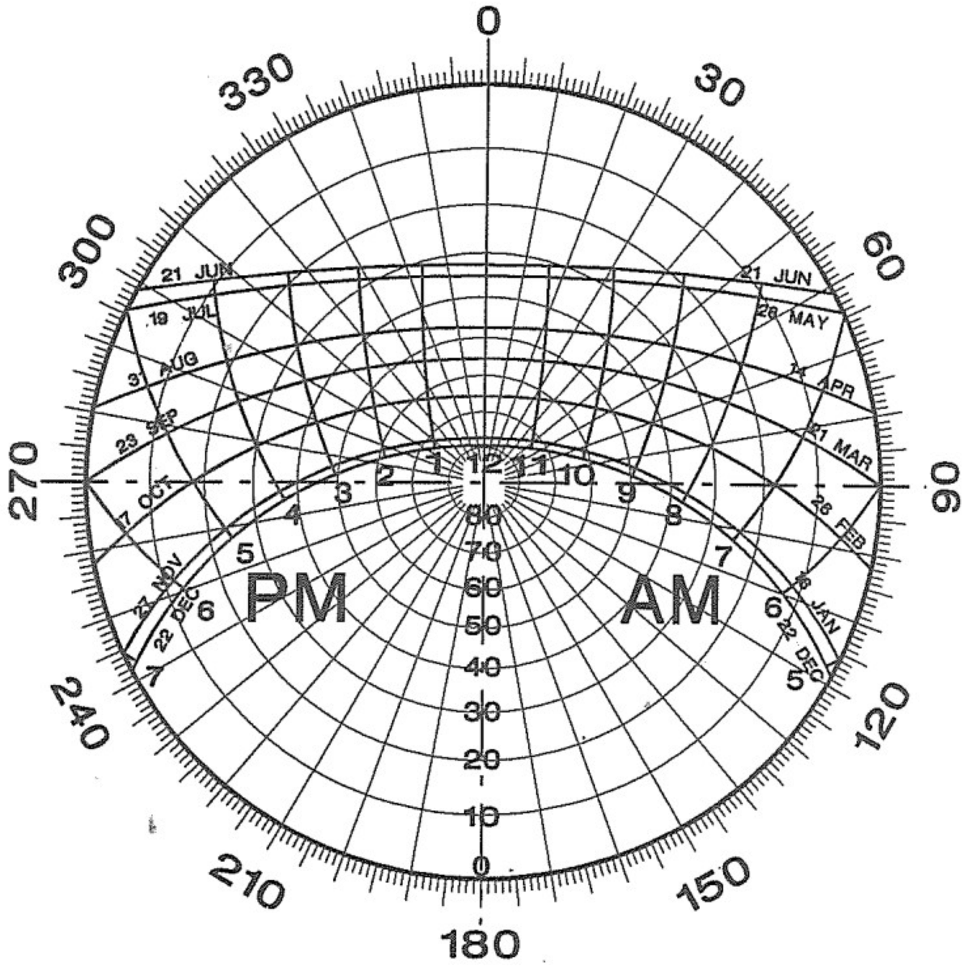


Figure 14 General Solar Chart (Hassall, 1991)

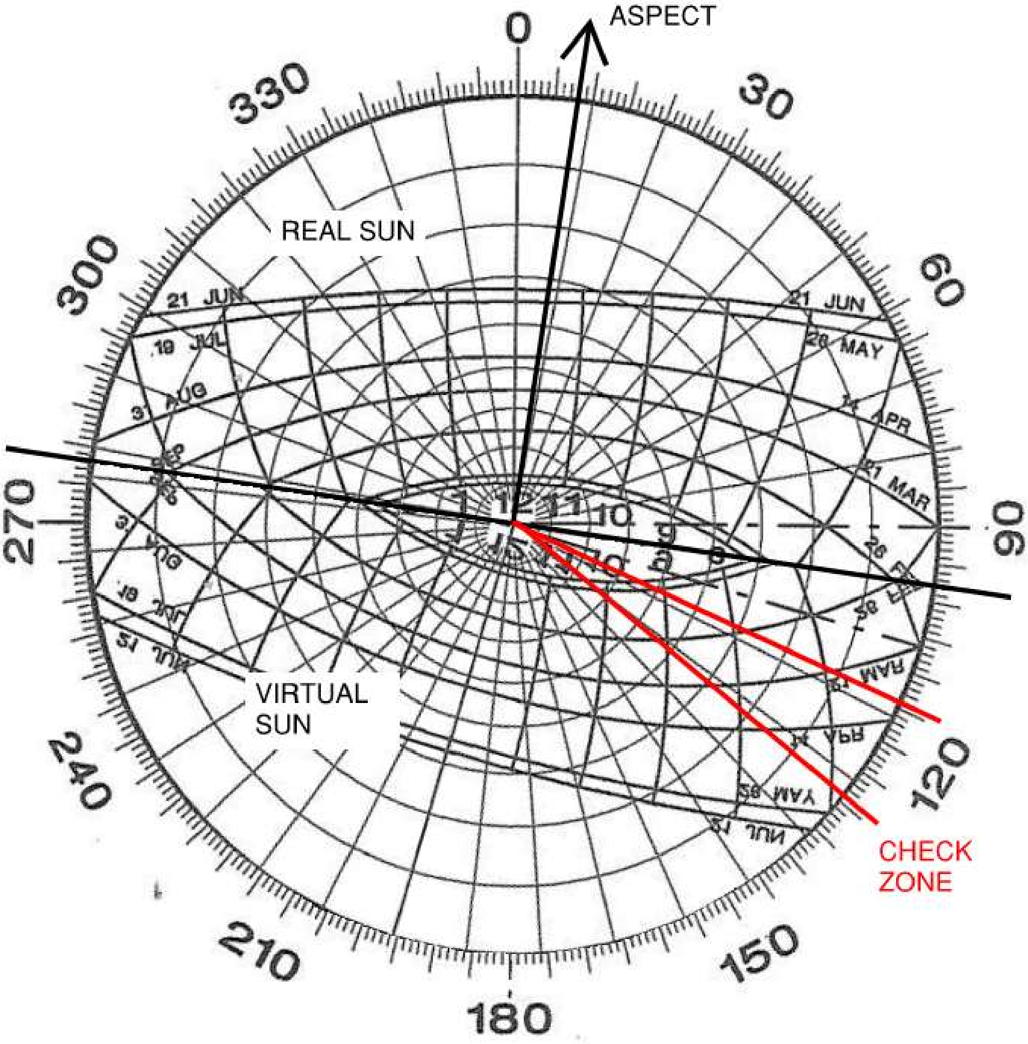


Figure 15 North Face (8°) Solar Chart at Point A

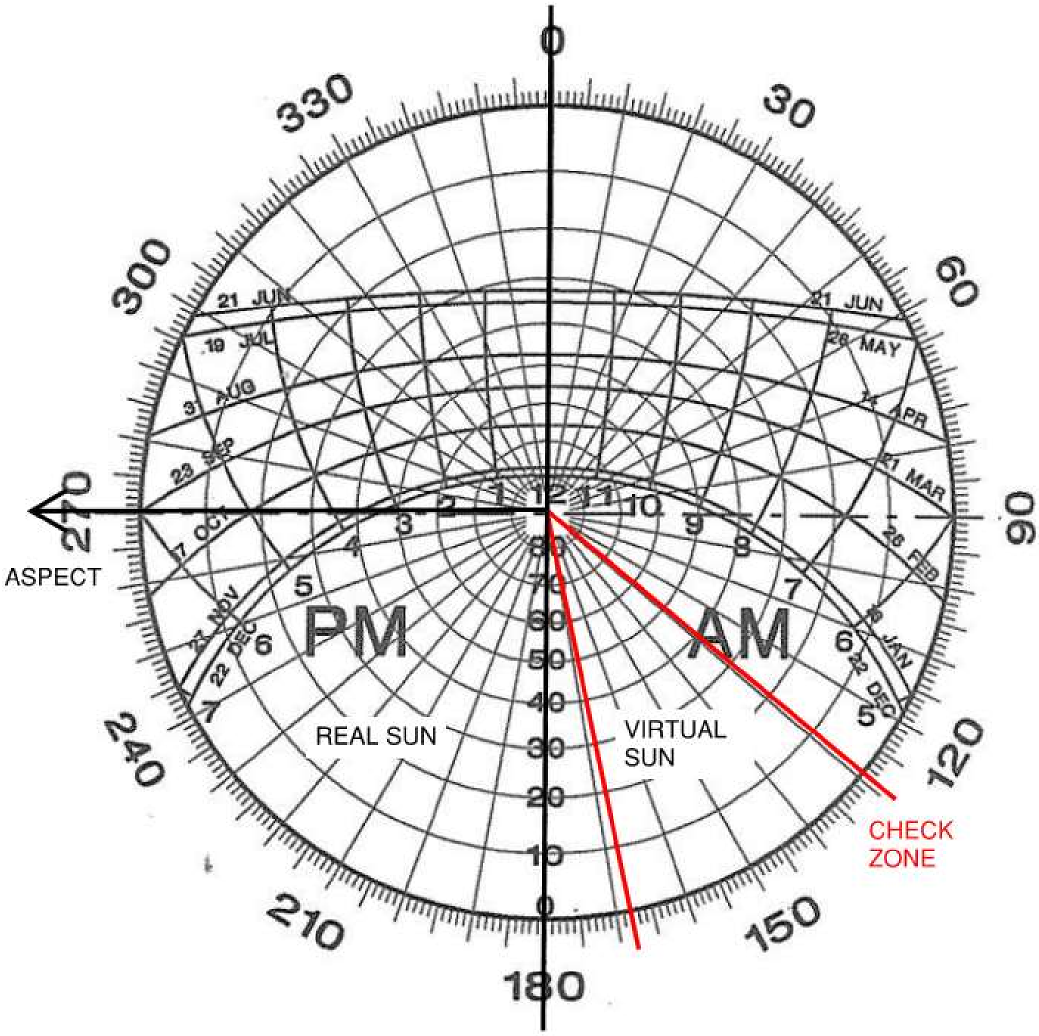


Figure 16 West Face (278°) Solar Chart at Point A

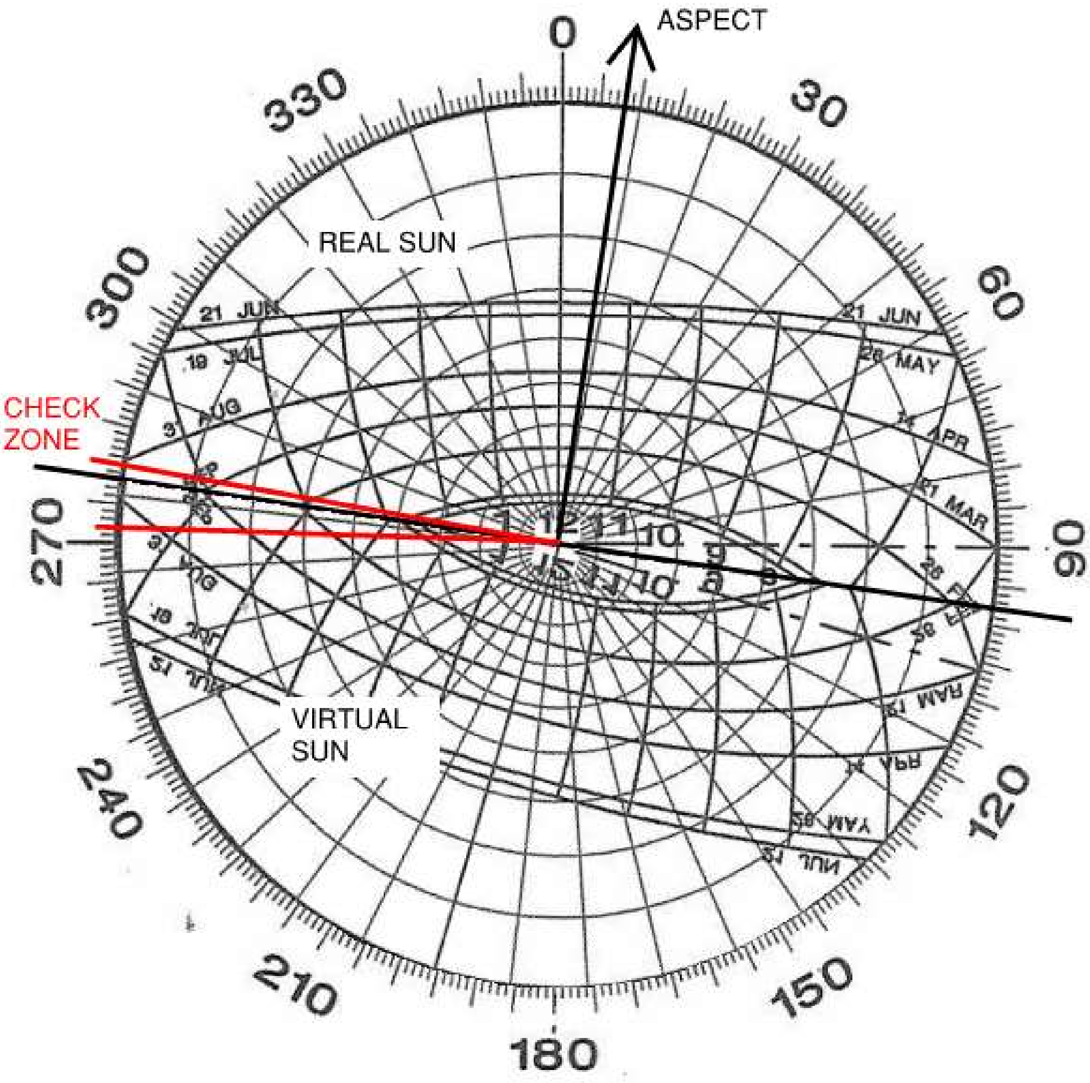


Figure 17 North Face (8°) Solar Chart at Point B

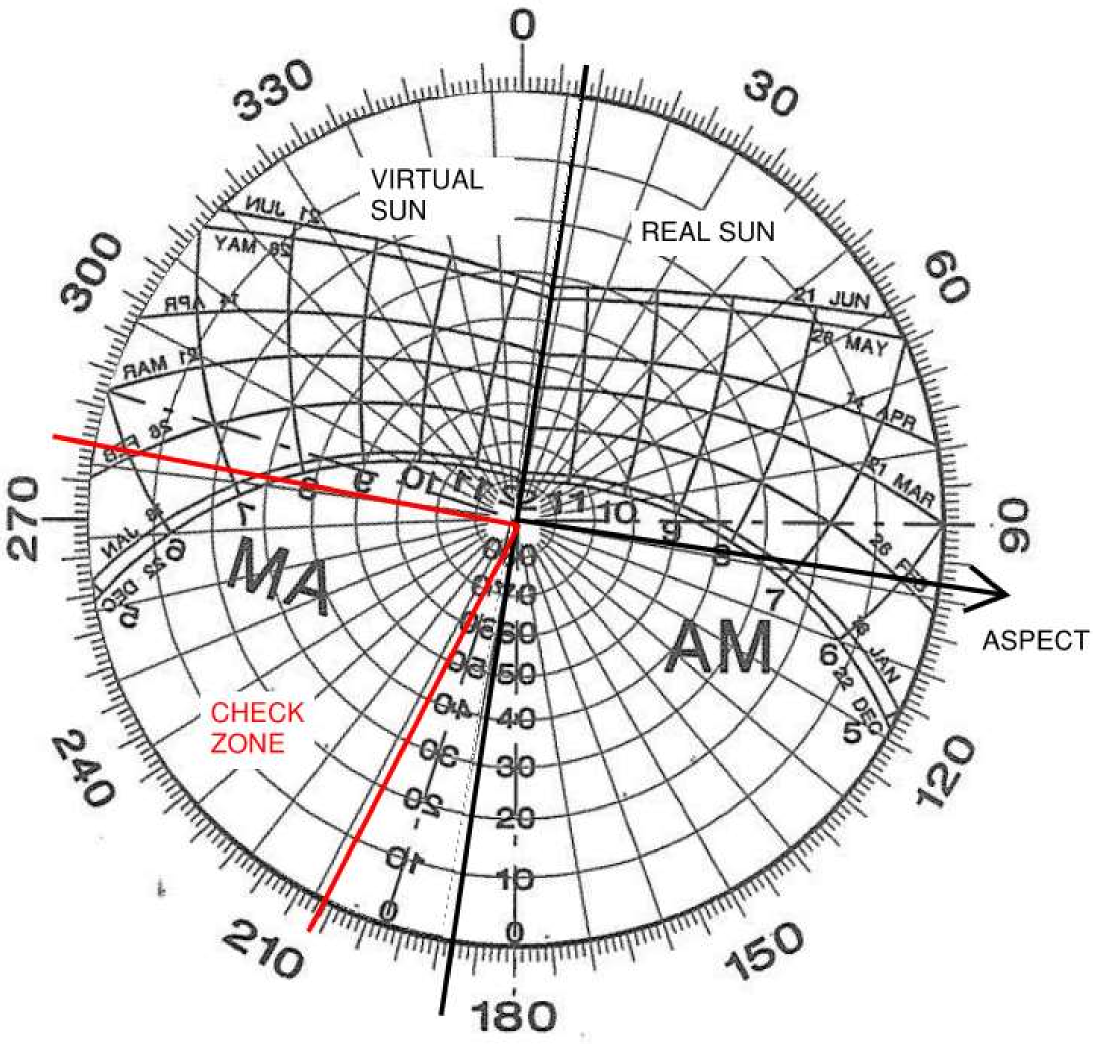


Figure 18 East Face (98°) Solar Chart at Point B

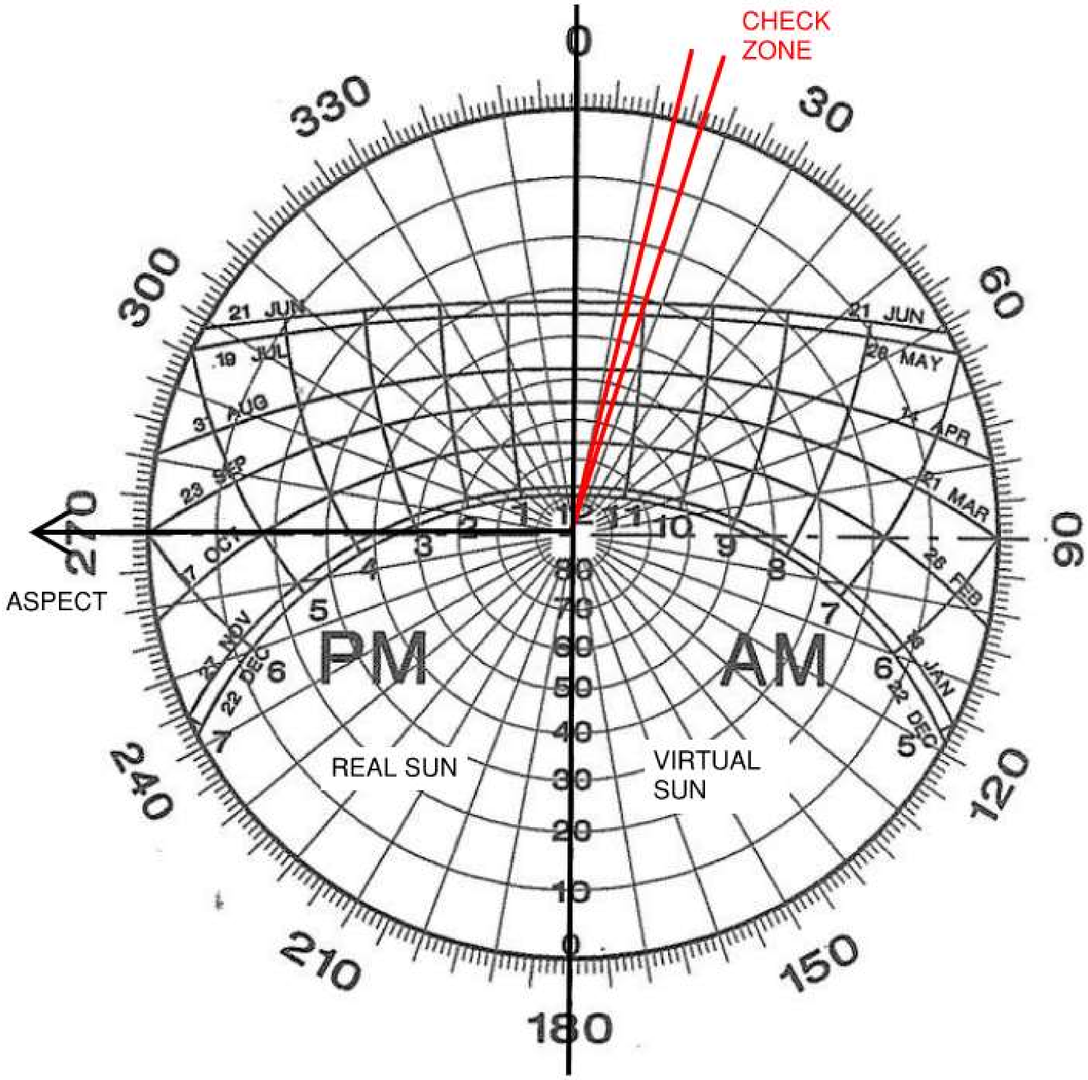


Figure 19 West Face (278°) Solar Chart at Point C

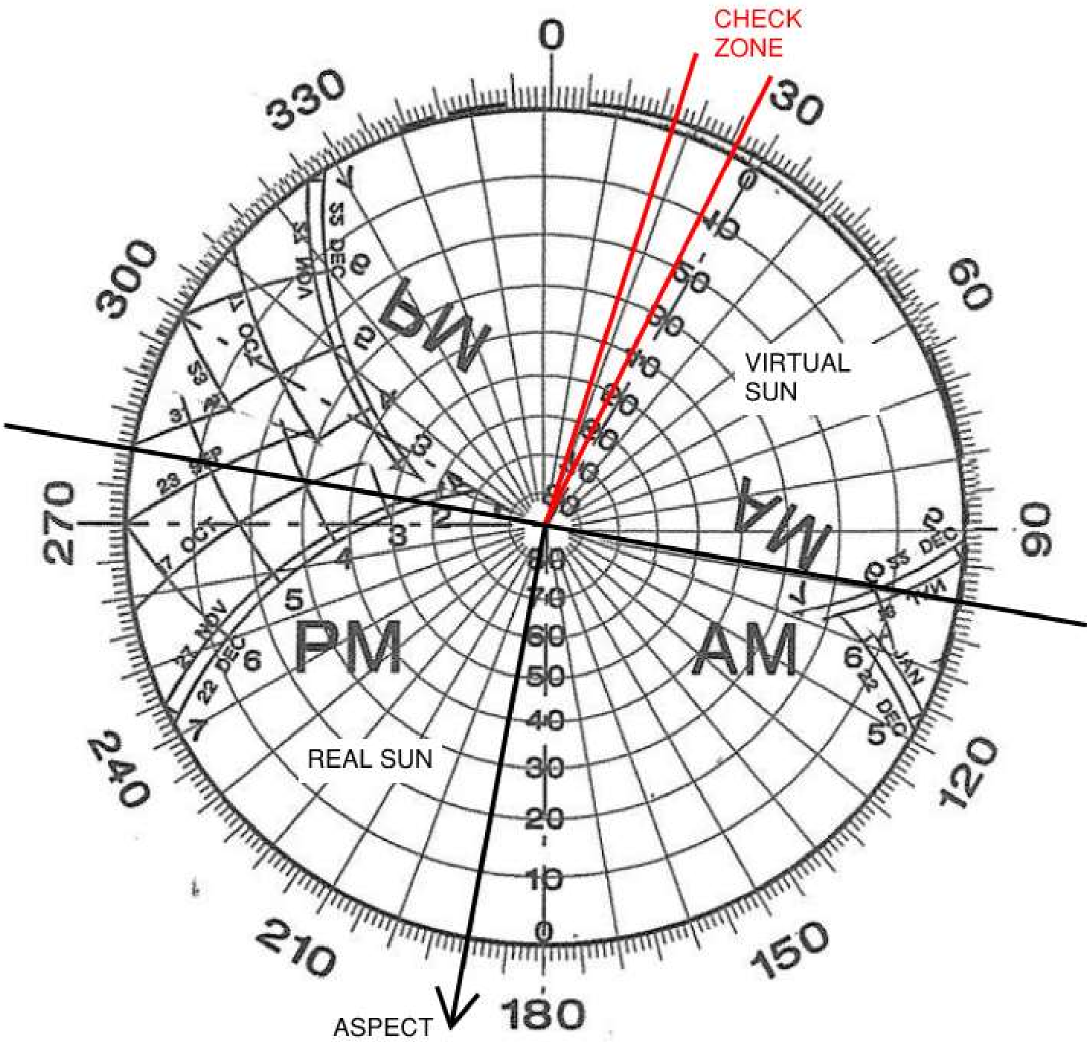


Figure 20 South Face (188°) Solar Chart at Point C

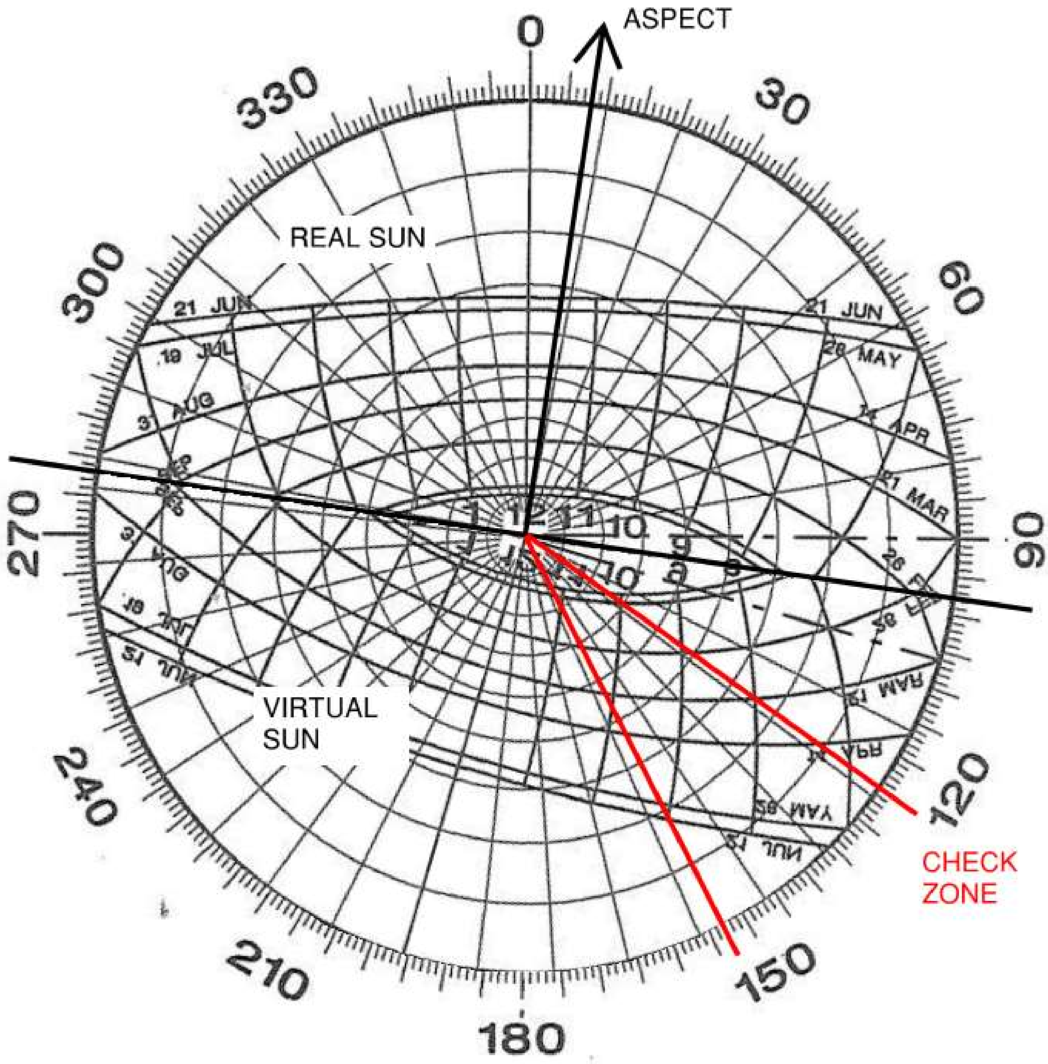


Figure 21 North Face (8°) Solar Chart at Point D

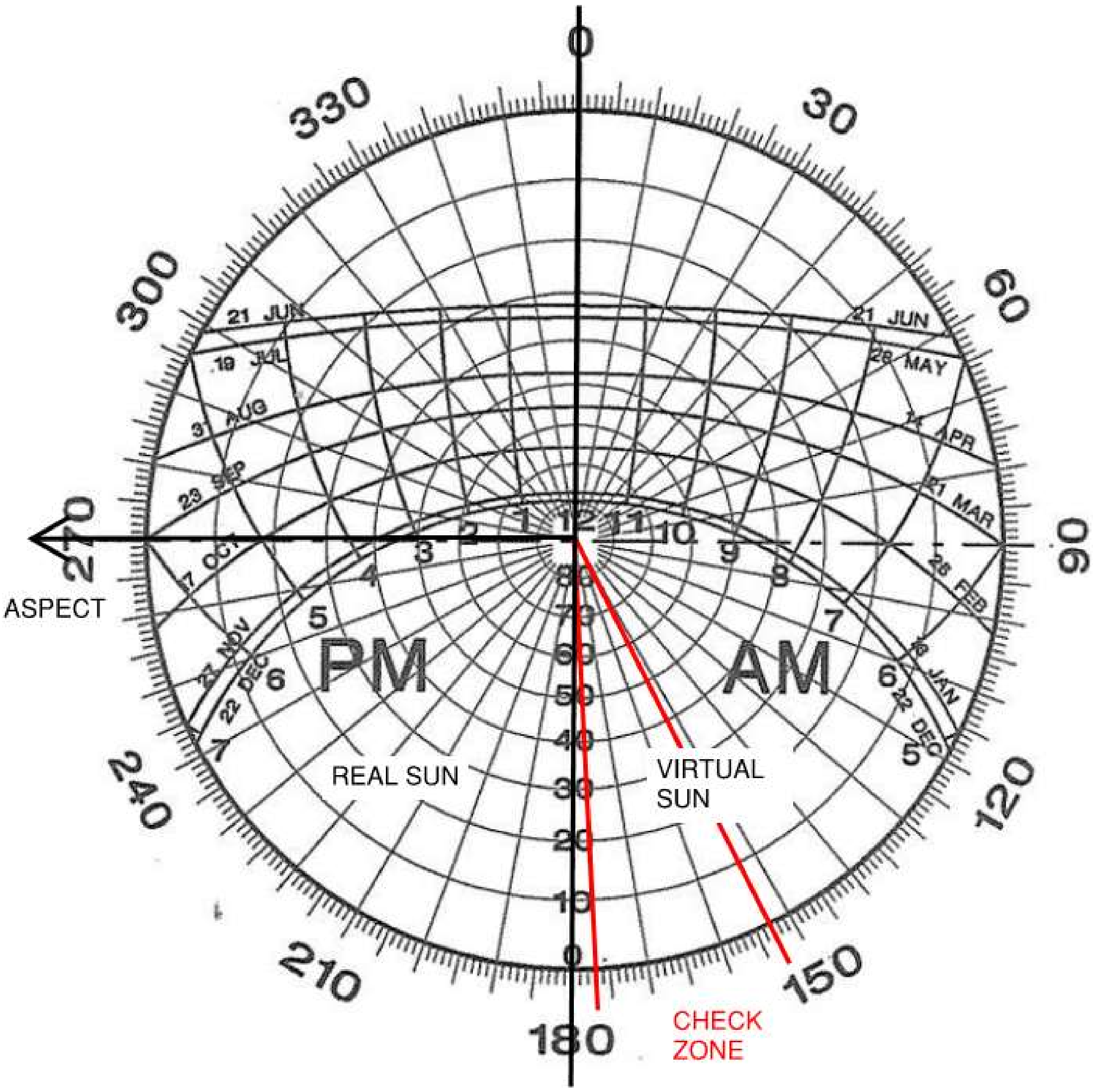


Figure 22 West Face (278°) Solar Chart at Point D

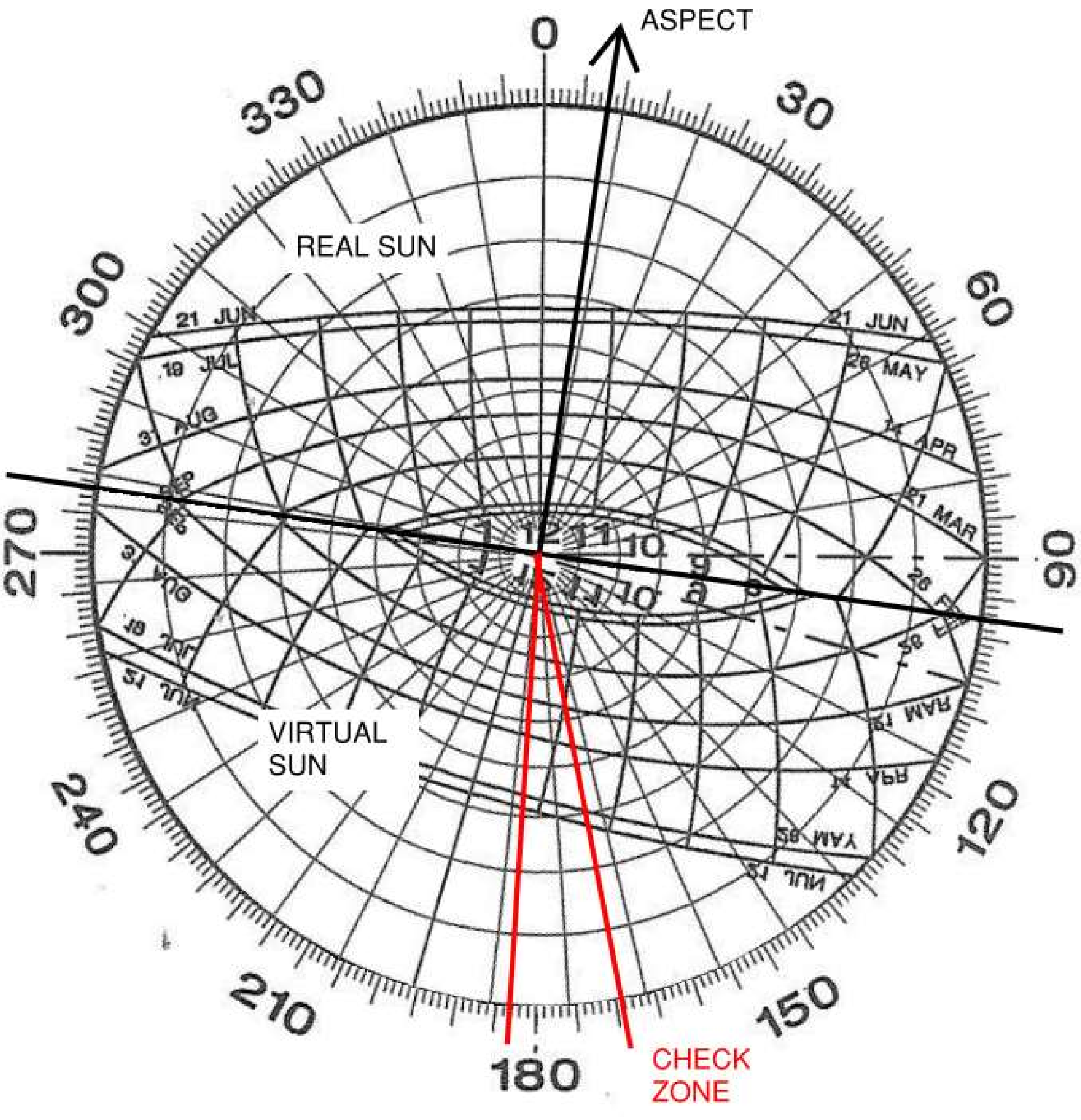


Figure 23 North Face (8°) Solar Chart at Point E

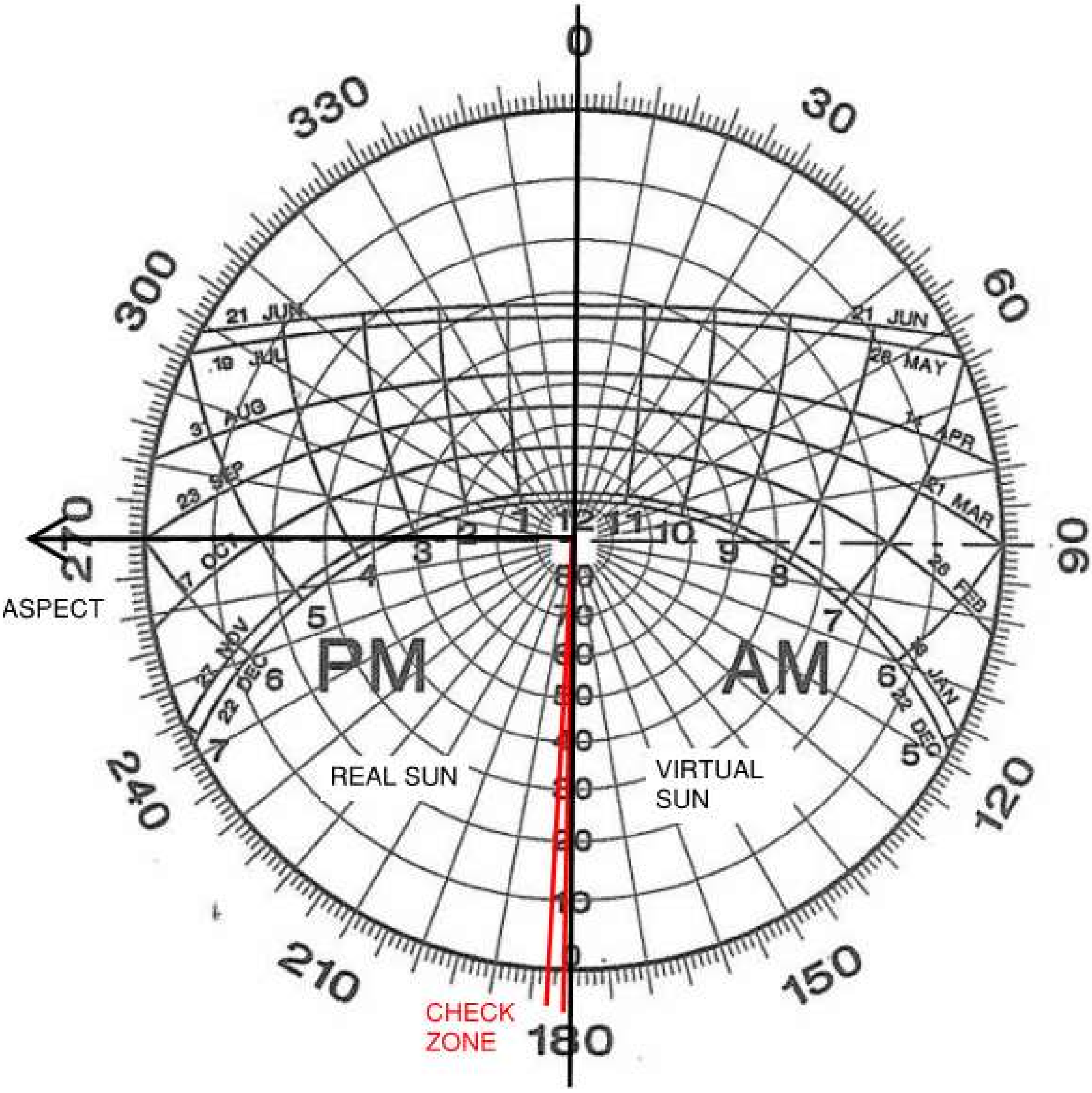


Figure 24 West Face (278°) Solar Chart at Point E

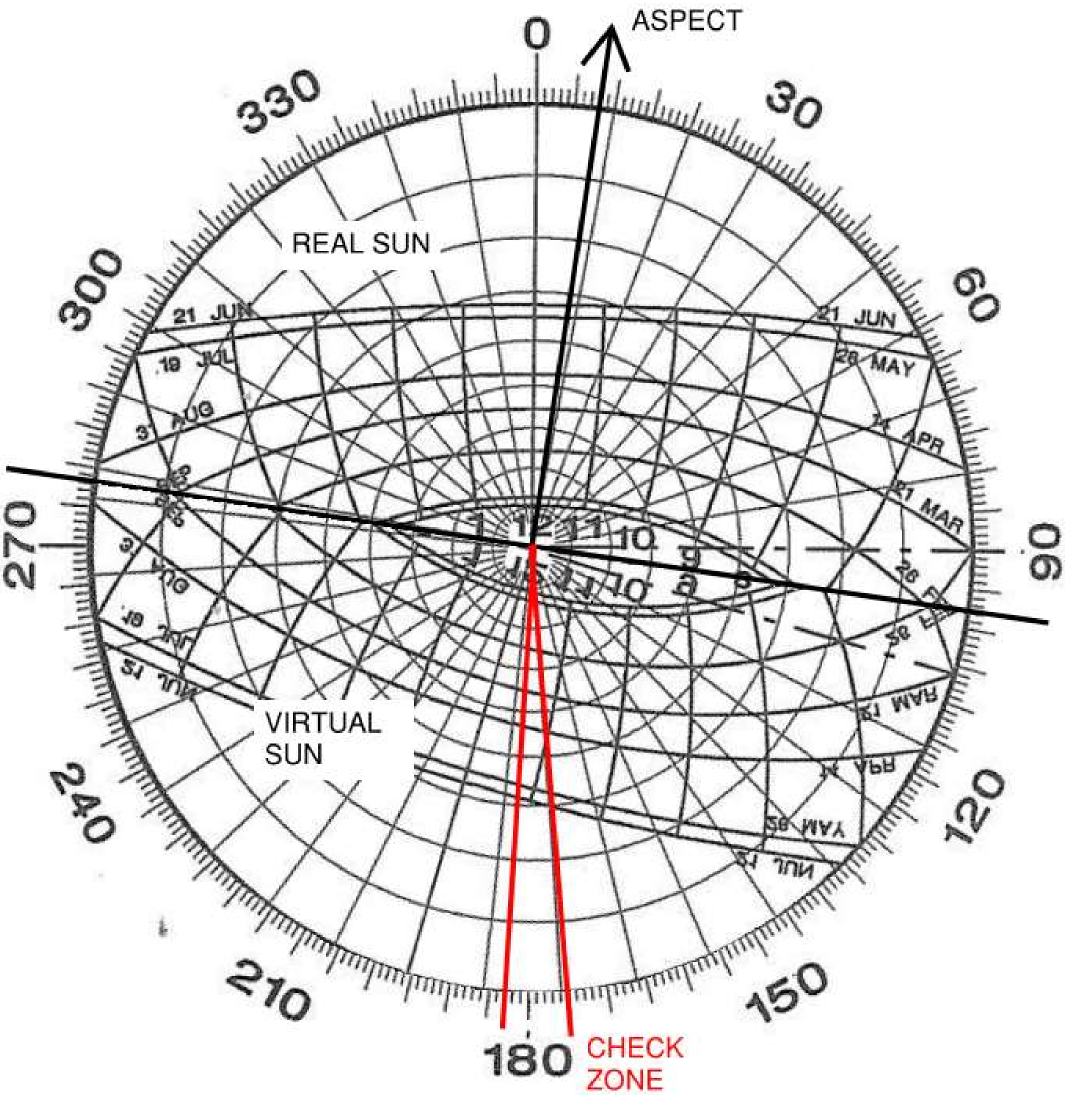


Figure 25 North Face (8°) Solar Chart at Point F

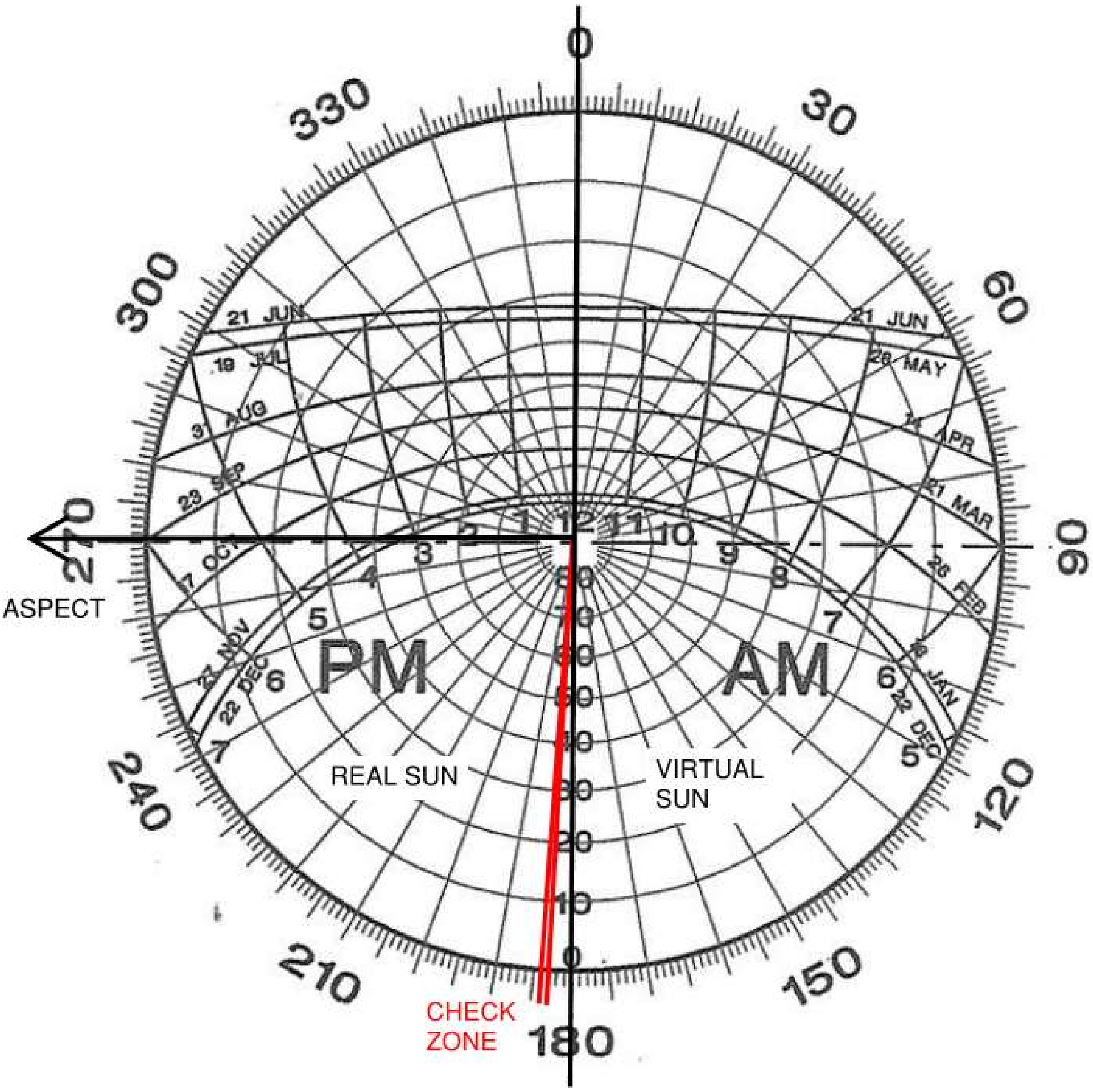


Figure 26 West Face (278°) Solar Chart at Point F

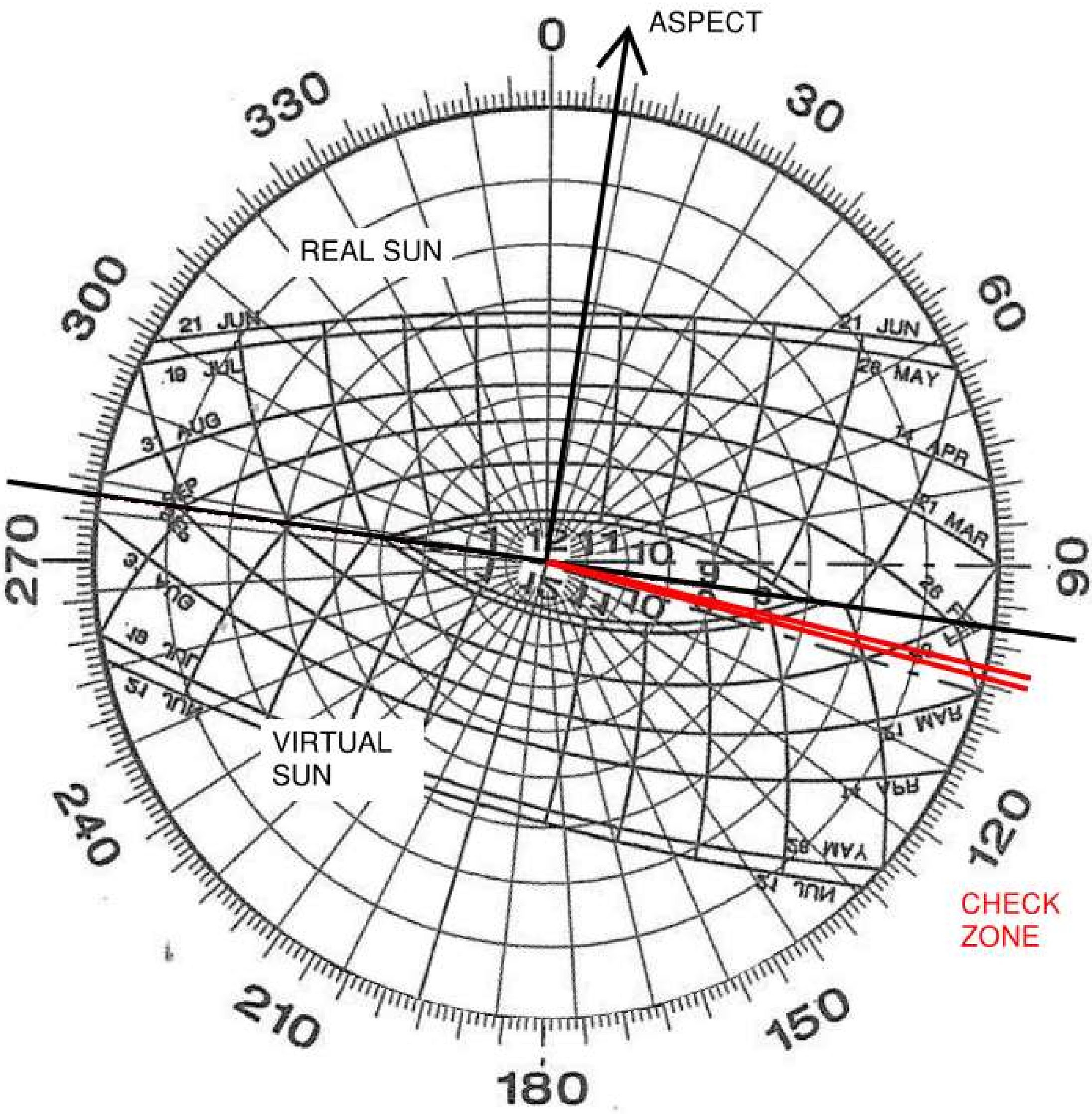


Figure 27 North Face (8°) Solar Chart at Point G

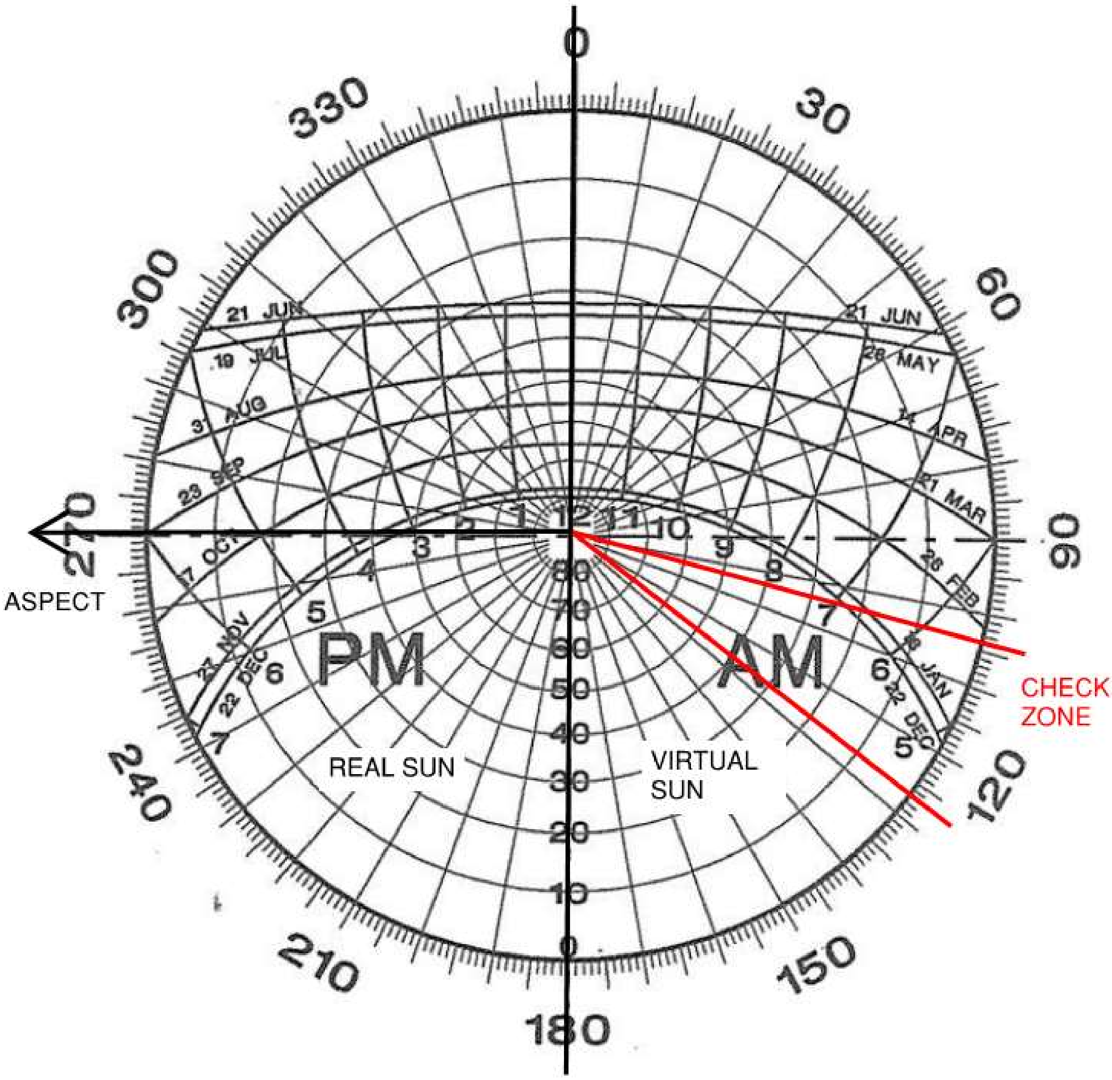


Figure 28 West Face (278°) Solar Chart at Point G