Yara Pilbara Fertilisers Pty Ltd
Ammonia Plant, Murujuga (Burrup Peninsula)
Renewable Hydrogen Project

Cultural Heritage and Visual Amenity Management Plan

14 November 2022

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JBS&G Australia Pty Ltd T/A Strategen-JBS&G

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Acronyms and Definitions

Term	Definition
CAR	Compliance Assessment Report
CEO	The Chief Executive Officer of the Department of the Public Service of the State responsible for the administration of Section 48 of the *Environmental Protection Act 1986*, or the CEO's delegate
CHVAMP	Cultural Heritage and Visual Amenity Management Plan
DBCA	Department of Biodiversity, Conservation and Attractions.
DPLH	Department of Planning, Lands and Heritage
Dust event	The occurrence of visible fugitive dust from a source or activity in the Disturbance Footprint that crosses the boundary of the Disturbance Footprint or an exclusion zone for a duration of greater than one minute.
DWER	Department of Water and Environmental Regulation
EMP	Environmental Management Plan
EP Act	*Environmental Protection Act 1986* (WA)
EPA	Environmental Protection Authority
EPC	Engineering, Procurement & Construction Contractor
Ground disturbing activities	Any ground disturbing activity undertaken in the implementation of the Proposal, including any clearing, civil works, or construction, other than preliminary works to which approval has been given under the EP Act.
HIR	Heritage Inspection Record
Incident	An incident arising from Proposal activities that has caused or has the potential to cause an adverse impact to cultural heritage or environmental values.
MAC	Murujuga Aboriginal Corporation
MNP	Murujuga National Park
MS	Ministerial Statement
PV	Photovoltaic
Registrar of Aboriginal Sites	The person appointed Registrar of Aboriginal Sites under the *Aboriginal Heritage Act 1972* (WA), or any successor entity appointed under that Act as amended or replaced from time to time.
Social and cultural places and activities of significance	Places and activities that are important to the Aboriginal people of the State, and are recognised through social, spiritual, historical, scientific, or aesthetic values, as part of Aboriginal tradition.
UNESCO	United Nations Educational, Scientific and Cultural Organization
WA	Western Australia
YOPL	Yuri Operations Pty Ltd. A Joint Venture between Engie Australia & Mitsui.
YPF	Yara Pilbara Fertiliser Pty Ltd

1. Executive Summary

This Cultural Heritage and Visual Amenity Management Plan (CHVAMP) is prepared to support Yara Pilbara Fertilisers Pty Ltd (YPF; the Proponent) develop the proposed Ammonia Plant, Murujuga (Burrup Peninsula) – Renewable Hydrogen Project (the Proposal).

The Proposal is located approximately 11 km northwest of Karratha, in the Pilbara region of Western Australia (WA). The Proposal is a significant amendment to the existing Ammonia Plant, which was referred to the Environmental Protection Authority (EPA) in 2001 and approved in February 2002 subject to conditions set out in Ministerial statement 586 (MS 586). On 4 August 2022, the Minister for Environment agreed that the Proposal may be implemented subject to conditions set out in Ministerial Statement 1194 (MS 1194).

Table ES1.1 provides a summary of the Proposal details as relevant to this plan.

Table ES1.1: Summary of the Proposal (from MS 1194)

Proposal name	Ammonia Plant, Murujuga (Burrup Peninsula) – Renewable Hydrogen Project
Proponent name	Yara Pilbara Fertilisers Pty Ltd (YPF)
Ministerial Statement (MS)	MS 1194
Purpose of the CHVAMP	To meet environmental outcomes and objectives of Condition 2 (Cultural Heritage and Visual Amenity) of MS 1194 as set out in Conditions 2-1 to 2-9.
Key environmental factor	Social Surroundings
EPA objective	*To protect social surroundings from significant harm.*
Key environmental factors, outcomes and objectives	**Cultural Heritage and Visual Amenity** <u>Environmental Outcomes</u> The Proponent shall implement the Proposal to meet the following outcomes: 1. Avoid direct disturbance of Aboriginal Heritage sites located in the exclusion zones within the Development Envelope; 2. Subject to reasonable health and safety requirements, allow traditional owner and custodian access and connection to culturally significant areas within and surrounding the Development Envelope; and 3. Allow traditional owner and custodian access to the Development Envelope following decommissioning of the Proposal. <u>Environmental Objectives</u> The Proponent shall implement the Proposal to meet the following objectives: 1. Avoid, where possible, and otherwise minimise indirect impacts to social, cultural, heritage, and archaeological values within and surrounding the Disturbance Footprint; and 2. Avoid, where possible, and otherwise minimise direct and indirect impacts to the visual and amenity values of social and cultural places and activities of significance.

Condition clauses (if applicable)	At least one (1) month prior to ground disturbing activities, the Proponent shall, in collaboration with the Murujuga Aboriginal Corporation and the DPLH, prepare and submit to the CEO[1] and the Registrar of Aboriginal Sites a Cultural Heritage and Visual Amenity Management Plan, to meet the objectives specified in condition 2-2 and this plan shall: 1. Specify the objectives to be achieved, as specified in condition 2-2; 2. Include a framework for consultation with traditional owners and custodians via the Murujuga Aboriginal Corporation and other relevant stakeholders during the life of the Proposal; 3. Specify construction environmental management activities relevant to cultural heritage, not limited to and including noise, vehicle emissions and provide for relevant traditional owners and custodians to be invited to observe any ground disturbing activities during construction and take reasonable steps to facilitate the observation of those activities by those persons; 4. Specify operational environmental management activities relevant to cultural heritage and visual amenity; 5. Specify management actions that will be implemented to demonstrate compliance with the outcomes specified in condition 2-1 and the objectives specified in condition 2-2; 6. Specify measurable management target(s) to determine the effectiveness of the management actions; 7. Specify monitoring to measure the effectiveness of management actions against management targets; 8. Specify a process for revision of management actions and changes to activities, in the event that the outcomes, objectives, and management targets are not achieved, and such process must include an investigation to determine the cause of the outcome, objective or management target(s) not being met; 9. Provide the format and timing to demonstrate that conditions 2-1, 2-2, and 2-3 have been met for the reporting period in the Compliance Assessment Report required by condition 8-6 including, but not limited to: a. verification of the implementation of management actions; and b. reporting on the effectiveness of management actions against the outcomes, objectives, and management target(s).
Key EMP components	Refer to Section 3.1 (outcome-based) and Section 3.2 (objective-based)
Proposed construction date	October 2022
EMP required pre-construction?	Yes ☒ No ☐

[1] For the purposes of this document, unless otherwise specified, the term CEO refers to Chief Executive Officer of the Department of Water and Environmental Regulation as defined in Ministerial Statement 1194 and the Acronyms and Abbreviations section of this document.

2. Context, Scope, And Rationale

2.1 Proposal

The Ammonia Plant, Murujuga (Burrup Peninsula) – Renewable Hydrogen Project (the Proposal) is a significant amendment to the existing Proposal (existing Ammonia Plant) located approximately 11 km northwest of Karratha, in the Pilbara region of Western Australia (see Figure 1 in Attachment A). The existing Ammonia Plant was referred to the Environmental Protection Authority (EPA) in 2001 and approved subject to conditions set out in Ministerial Statement 586 (MS 586) in February 2002.

The Proposal includes an electrolysis plant and a dedicated solar photovoltaic (PV) farm. Energy from the PV farm will be used in the electrolysis plant to split water into hydrogen and oxygen. The hydrogen will be piped to the adjacent Ammonia Plant. The Proposal will produce about 640 tonnes of 'green hydrogen' per annum for the Ammonia Plant. This is about 0.4% of the hydrogen required by the Ammonia Plant and is the commercial demonstration (Phase 0, pilot project) for a future longer-term, larger-scale renewable (green) hydrogen proposal.

The Proponent for the Proposal is Yara Pilbara Fertilisers Pty Ltd (YPF).

On 4 August 2022, the Minister for Environment agreed that the Proposal may be implemented subject to conditions set out in Ministerial Statement 1194 (MS 1194). The elements of the Proposal which have been subject to the EPA's assessment are included in Table 2.1 below. The approved Development Envelope and Disturbance Footprint are shown in Figure 2 in Attachment A.

Table 2.1: Location and proposed extent of Proposal elements

Proposal element	Location	Approved Proposal (MS 586) (Ammonia Plant)	Proposal (significant amendment) (Renewable Hydrogen Project)	Combined Proposal (Ammonia Plant and Renewable Hydrogen Project)
Physical elements				
• Ammonia plant • Laydown area • Desalination plant • Access road and product pipeline to plant • **PV solar plant, hydrogen production plant, site tracks, and associated infrastructure.**	Figure 2	Clearing of no more than 29 ha within a 73 ha development envelope	**Increase in disturbance of 22.94 ha (which includes 21.23 ha of vegetation and 1.71 ha that has been previously cleared)**	Clearing of no more than **51.94** ha within a 73 ha development envelope
Operational elements				
Oxygen emissions	-	-	**Approximately 14,400 kg/day**	**Approximately 14,400 kg/day**

2.2 Key Environmental Factors

The key environmental factors for the Proposal are:

- Social surroundings;
- Flora and vegetation; and
- Terrestrial fauna.

The potential impacts associated with the flora and vegetation and terrestrial fauna environmental factors are managed through a separate Terrestrial Fauna and Weed Management Plan (TFWMP; JBS&G 2022).

2.3 Social Surroundings

2.3.1 Cultural Heritage

Murujuga is the traditional Aboriginal name for the Dampier Archipelago and surrounds, including the Burrup Peninsula. Murujuga has been listed on Australia's National Heritage List under the Dampier Archipelago (including Burrup Peninsula) by the Australian Government since 2007, and portions of the National Heritage Listing Area form the Murujuga National Park. On 23 January 2020, the Murujuga Cultural Landscape was added to Australia's World Heritage Tentative List by the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Centre.

The Ngarluma, Yindjibarndi, Yaburara, Mardudhunera and Wong-Goo-Tt-Oo groups, collectively known as the *Ngurra-ra Ngarli*, are represented by the Murujuga Aboriginal Corporation (MAC) who are the custodians of Murujuga. MAC was established in 2003 under the Burrup and Maitland Industrial Estates Agreement. Murujuga is sacred to the *Ngura-ra Ngarli* – it is a place where everything is connected through the Ancestral Beings – the land, the sky, the plants, the animals, the Lore and the spiritual world.

Cultural heritage values include tangible heritage (movable, immobile and underwater) and intangible cultural heritage embedded into cultural, and natural heritage artefacts, sites or monuments.

As per the *Aboriginal Heritage Act 1972*, Aboriginal cultural heritage applies to any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object natural or artificial, used for or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present; and any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent.

The following cultural values have been identified in proximity to the Proposal:

- Murujuga National Park which is located about 115 m north of the Development Envelope, and jointly managed by MAC and the Department of Biodiversity, Conservation and Attractions (DBCA);
- Nganjarli (previously known as Deep Gorge), which is located about 800 m south-east of the Development Envelope within the Murujuga National Park and includes rock art and a new boardwalk and interpretive signage to educate visitors about its cultural significance to the traditional owners;
- The National Heritage Listed Area, which is partially within the Development Envelope;
- The World Heritage Tentative Listing of Murujuga, whose boundary is yet to be defined; and
- A total of 11 Aboriginal heritage places were identified within the Development Envelope during ethnographic and archaeological heritage surveys carried out by MAC and YPF (refer to Section 2.5.2 and Figure 3 in Appendix A).

The Proposal has been designed to avoid impacts on social surroundings by excluding the National Heritage Listing Area and Aboriginal heritage sites that were identified in the Disturbance Footprint. The Proposal could significantly impact cultural heritage through:

- Construction causing disturbance of tangible and intangible Aboriginal heritage values;
- Construction causing indirect damage to Aboriginal heritage sites; and
- Construction and new infrastructure preventing access by traditional owners to Aboriginal heritage sites.

2.3.2 Amenity

The Burrup Peninsula is a popular tourist and recreational destination characterised by coastline, rocky outcrops and lowlands. The Burrup Peninsula also features several large industrial facilities located within the Burrup Strategic Industrial Area.

Hearson Cove is located about 1.4 km to the east of the Proposal, and the beach is a popular recreational area with a strong social value for residents and visitors. The Hearson Cove foreshore is zoned as 'Conservation, Recreation and Natural Landscapes' in the City of Karratha Local Planning Scheme No. 8. Hearson Cove is currently accessed via Hearson Cove Road, about 250 m to the south of the Development Envelope. Hearson Cove Road also enables the public and tourists to access Nganjarli (Deep Gorge).

The Proposal could significantly impact amenity through new infrastructure visually impacting the landscape and its values.

2.4 Condition Requirements

The condition requirements relevant to meeting the key environmental outcomes and objectives of Condition 2 of MS 1194 and the sections of the CHVAMP addressing those conditions are detailed in Table 2.2.

Table 2.2: Condition Requirements

#	Condition Requirement	Plan Section
2-1	The Proponent shall implement the Proposal to meet the following outcomes: 1. avoid direct disturbance of Aboriginal Heritage sites located in the exclusion zones within the development envelope that are shown in Figure 3; 2. subject to reasonable health and safety requirements, allow traditional owner and custodian access and connection to culturally significant areas within and surrounding the development envelope; and 3. allow traditional owner and custodian access to the development envelope following decommissioning of the Proposal.	Section 2.6 and Section 3.1
2-2	The Proponent shall implement the Proposal to meet the following objectives: 1. avoid, where possible, and otherwise minimise indirect impacts to social, cultural, heritage, and archaeological values within and surrounding the disturbance footprint; and 2. avoid, where possible, and otherwise minimise direct and indirect impacts to the visual and amenity values of social and cultural places and activities of significance.	Section 2.6 and Section 3.2
2-3	At least one (1) month prior to ground disturbing activities, the Proponent shall, in collaboration with the Murujuga Aboriginal Corporation and the DPLH, prepare and submit to the CEO and the Registrar of Aboriginal Sites a Cultural Heritage and Visual Amenity Management Plan, to meet the objectives specified in condition 2-2 and this plan shall:	
	1. specify the objectives to be achieved, as specified in condition 2-2;	Section 2.5.1
	2. include a framework for consultation with traditional owners and custodians via the Murujuga Aboriginal Corporation and other relevant stakeholders during the life of the Proposal;	Section 5
	3. specify construction environmental management activities relevant to cultural heritage, not limited to and including noise, vehicle emissions and provide for relevant traditional owners and custodians to be invited to observe any ground disturbing activities during construction and take reasonable steps to facilitate the observation of those activities by those persons;	Section 3.1 and Section 3.2
	4. specify operational environmental management activities relevant to cultural heritage and visual amenity;	Section 3.2
	5. specify management actions that will be implemented to demonstrate compliance with the outcomes specified in condition 2-1 and the objectives specified in condition 2-2;	Section 3.1 and Section 3.2
	6. specify measurable management target(s) to determine the effectiveness of the management actions;	Section 3.2
	7. specify monitoring to measure the effectiveness of management actions against management targets;	Section 3.2

#	Condition Requirement	Plan Section
	8. specify a process for revision of management actions and changes to activities, in the event that the outcomes, objectives, and management targets are not achieved, and such process must include an investigation to determine the cause of the outcome, objective or management target(s) not being met;	Section 3.3 and Section 4
	9. provide the format and timing to demonstrate that conditions 2-1, 2-2, and 2-3 have been met for the reporting period in the Compliance Assessment Report required by condition 8-6 including, but not limited to: a. verification of the implementation of management actions; and b. reporting on the effectiveness of management actions against the outcomes, objectives, and management target(s).	Section 3.3
2-4	The Proponent must not commence ground disturbing activities until the CEO confirmed in writing that the plan submitted under condition 2-3 satisfies the requirements of condition 2-3.	Strict requirement
2-5	The Proponent must implement the most recent version of the confirmed Cultural Heritage and Visual Amenity Management Plan until the CEO has confirmed by notice in writing that the Proponent has demonstrated the Ammonia Plant, Murujuga (Burrup Peninsula), Renewable Hydrogen Project Environmental Protection Authority outcomes specified in condition 2-1 and objectives in condition 2-2 have been met, or are able to be met under another statutory decision-making process.	Strict requirement
2-6	In the event that monitoring, tests, surveys or investigations indicate non-achievement of outcomes specified in condition 2-1 or management target(s) specified in the confirmed Cultural Heritage and Visual Amenity Management Plan, the Proponent must: 1. report the non-achievement in writing to the CEO, the Murujuga Aboriginal Corporation within twenty-one (21) days of the non-achievement being identified; 2. where the non-achievement impacts a registered Aboriginal site where consent has not been granted under section 18 of the *Aboriginal Heritage Act 1972*, report the non-achievement to DPLH, and the Registrar of Aboriginal Sites within twenty-one (21) days of the non-achievement being identified; 3. investigate to determine the cause of the outcome or management target(s) not being achieved; 4. provide a further report to the CEO, the Murujuga Aboriginal Corporation, the DPLH, and the Registrar of Aboriginal Sites within ninety (90) days of the non-achievement being reported as required by condition 2-6(1) and, where relevant, 2-6(2) which must include: a. description of the cause of outcome or management target(s) being exceeded if known, or analysis of likely causes if not known; b. the findings of the investigation required by condition 2-6(3); c. details of revised and/or additional management actions to be implemented to prevent non-achievement; and d. relevant changes to activities.	Section 3.3.1
2-7	In the event that monitoring, tests, surveys or investigations indicate that one or more management action(s) specified in the confirmed Cultural Heritage and Visual Amenity Management Plan have not been implemented, the Proponent must: 1. report the failure to implement the management action(s) in writing to the CEO, the Murujuga Aboriginal Corporation, within seven days of identification; 2. where the failure impacts a registered Aboriginal site where consent has not been granted under section 18 of the Aboriginal Heritage Act 1972, report the non-achievement to DPLH, and the Registrar of Aboriginal Sites within seven days of identification; 3. investigate to determine the cause of the management action(s) not being implemented; 4. investigate to determine potential environmental harm or alteration of the environment that occurred due to the failure to implement management action(s); 5. provide a further report to the CEO, the Murujuga Aboriginal Corporation, and where relevant the DPLH, and the Registrar of Aboriginal Sites within twenty-eight (28) days of the failure being identified, which must include: a. cause for failure to implement management action(s); 2 b. the findings of the investigation required by condition 2-7(3); c. relevant changes to activities; and d. measures to prevent, control or abate the environmental harm which may have occurred.	Section 3.3.2

#	Condition Requirement	Plan Section
2-8	Without limiting condition 2-5 (implementation of the plan) and notwithstanding compliance with condition 2-6 (response to exceedance), the Proponent must not cause or allow: 1. a failure to implement one or more management actions specified in the confirmed Cultural Heritage and Visual Amenity Management Plan, and/or 2. failure to comply with the requirements of the confirmed Cultural Heritage and Visual Amenity Management Plan.	Strict requirement
2-9	The Proponent, in collaboration with the Murujuga Aboriginal Corporation: 1. may review and revise the confirmed Cultural Heritage and Visual Amenity Management Plan and submit it to the CEO; and 2. shall review and revise the confirmed Cultural Heritage and Visual Amenity Management Plan and submit it to the CEO as and when directed by the CEO.	Section 4 (adaptive management and review) and Section 5 (consultation)

2.5 Rationale and Approach

The CHVAMP has been prepared based on the environmental impact assessment carried out for the Proposal as documented in the Environmental Review Document (GHD 2021) and associated studies, surveys and management plans .

The EMP components of this plan have been prepared in collaboration with the Murujuga Aboriginal Corporation (MAC). As requested by MAC, this collaboration was initiated through the preparation of draft versions of this plan, which have been reviewed by MAC and its lead heritage consultants. This collaboration will continue through the implementation of the plan as described in Section 5.

Ensuring traditional owners and custodians have access to the Development Envelope is important to YPF. In this regard, MAC has stated that access to the Development Envelope will be managed through an annual site visit and inspection by the Circle of Elders or other designated traditional owners as determined by MAC. YPF will reimburse MAC for resource time for such visits and inspections and will provide a summary support after each such inspection. With the safety of all staff and visitors to the site being paramount, these arrangements take account of the condition of access to a Major Hazard Facility as set by State Government regulations, as well as the inherent risks associated with a construction site. Hence, to ensure personal safety is maintained during construction, arrangements will be in place to escort traditional owners and custodians around the Development Envelope.

MAC will identify the traditional owners and custodians who have been designated as MAC Heritage Monitors for the purposes of this CHVAMP.

2.5.1 Environmental Outcomes and Management Objectives

The Proposal will be implemented to meet the following environmental outcomes:

- Avoid direct disturbance of Aboriginal heritage sites located in the exclusion zones within the Development Envelope (shown in Figure 3 in Attachment A);
- Subject to reasonable health and safety requirements, allow traditional owners and custodians access and connection to culturally significant areas within and surrounding the Development Envelope; and
- Allow traditional owners and custodians access to the Development Envelope following decommissioning of the Proposal.

The Proposal will be implemented to achieve the following environmental objectives:

- Avoid, where possible, and otherwise minimise indirect impacts to social, cultural, heritage, and archaeological values within and surrounding the Disturbance Footprint; and
- Avoid, where possible, and otherwise minimise direct and indirect impacts on the visual and amenity values of social and cultural places and activities of significance.

2.5.2 Survey and Study Findings

The surveys and studies outlined in Table 2.2 were used to inform the assessment of the potential impacts on cultural heritage and visual amenity.

Table 2.3: Surveys and studies relevant to this CHVAMP

Key environmental factor	Report (Author Year)	Survey/study description	Survey findings

Social surroundings (cultural heritage)	Yara Development Envelope Archaeological Site Verifications, Burrup Peninsula, WA – Report
	Land Access Solutions (LAS) 2020
		Land Access Solutions undertook a desktop heritage survey and an archaeological site verifications survey to verify the heritage values within the Development Envelope.
		The survey involved archaeologists and an anthropologist and consultation with MAC.
			• A desktop assessment identified 32 previously recorded Aboriginal heritage places intersecting the Development Envelope:
			  ○ Nine of which are 'Registered sites' and have been assessed by the Aboriginal Cultural Material Committee to fall under the *Aboriginal Heritage Act 1972*;
			  ○ Nineteen are 'Lodged' and yet to be assessed;
			  ○ Three were not deemed Aboriginal sites under the *Aboriginal Heritage Act 1972*;
			  ○ One does not fall into any of these categories;
			  ○ The hills in the northwest of the Development Envelope were considered likely to have a number of heritage sites. In consultation with MAC, this area was not surveyed, and recommendations made to exclude it from development.
			• The field survey verified eight of the nine heritage sites, with one site (20266) unable to be located. This site was recorded as being on the same granophyre outcrop as another site (20265).
			• Consultation with MAC representatives acknowledged these nine sites as being of cultural importance and should not be disturbed. The Disturbance Footprint has been designed to avoid all identified heritage sites.
			• LAS (2020) provides several recommendations to manage potential heritage impacts from the Proposal.

		Land Access Solutions completed a follow-up heritage survey in July 2020 to identify heritage values in areas west and east of the existing YPF Ammonia Plant.	No heritage values were identified from these areas.

Key environmental factor	Report (Author Year)	Survey/study description	Survey findings
Social Surroundings (Cultural Heritage)	Report of an avoidance level archaeological survey at the Yara Development Envelope, Murujuga, Western Australia Scarp Archaeology (2022)	The avoidance level archaeological survey was completed from 14-16 December 2021 as part of an archaeological and ethnographic cultural heritage assessment of the Proposal. The survey was undertaken at the request of MAC. The avoidance level archaeological survey was undertaken by Scarp Archaeology with the cooperation of MAC and representatives from Ngarluma, Yindjibarndi, Yaburara, Mardhudunera and Wong-Goo-Tt-Oo.	The results of the archaeological survey consisted of the following: 1. Three new sites that are likely to constitute Aboriginal Sites within and near to the project boundary were recorded to Avoidance Level. 2. Additional site features were recorded at one of the previously identified sites and a revised boundary provided (ID: DPLH 20265). 3. Seven previously recorded locations could not be relocated. 4. A buffer of 50 m was applied to the northern boundary of the Disturbance Footprint due to concerns of the proximity of the area to exposed granophyre boulders likely to feature engravings.
	Report of an ethnographic Site Avoidance survey for Yara's project Yuri Solar Hydrogen Plant Development, Burrup Peninsula, Western Australia Archae-aus (2022)	The ethnographic Site Avoidance survey was carried out from 14-16 December 2021. The objectives of the scope of works were to: • Provide a desktop assessment of previous surveys, recorded sites and National Heritage listed values in order to inform the assessment of any cultural material recorded within the survey area. • Identify any known or potential Aboriginal heritage issues that may affect the proposed activity. • Undertake research and / or consultation that may be required to meet the requirements of the *Aboriginal Heritage Act 1972.* • Locate and record any newly identified Aboriginal sites to a Site Avoidance level. • Identify and record site boundaries to ensure avoidance of sites located within the project area during proposed works. • Make recommendations regarding the management of any newly recorded heritage sites, including any further research and / or consultations may be required during or after the proposed activity.	The ethnographic survey did not locate any previously unrecorded ethnographic sites. However, it did highlight that the entire project the area is of high cultural and heritage value to the Ngarda-Ngarli Traditional Owners. It was noted that the survey area is a part of the broader Murujuga landscape which is of high cultural significance.

Key environmental factor	Report (Author Year)	Survey/study description	Survey findings
Social Surroundings (Amenity)	Glare Impact Assessment Report GHG (2022) – Appendix B	This study was to quantify the intensity and duration of sunlight glare reflected by the Proposal's solar panels by use of a Solar Glare Hazard Analysis Tool. Glare was considered at indigenous heritage, public roads, and Karratha Airport receptors.	From the results, it was concluded that the low sun angle in the morning creates potential yellow glare for receptors to the northwest of the solar arrays. In the evening, low sun angle creates potential yellow glare for receptors to the northeast of the solar arrays. It was also noted that green glare can occur during the day: • At Observation Point (OP) 05 (Murujuga National Park), there is potential for yellow glare to last up to 20 minutes per day between 5.30 pm and 6.30 pm from November to February; • At OP 05, there is potential for green glare to last up to 25 minutes per day between 5.30 pm and 6.30 pm from November to February; and • At OP 06 there is potential for yellow glare to last about 15 minutes per day between 6.00 and 7.00am in December and January. Landforms obstruct glare from the solar farm for route west of the solar farm - Zone of Theoretical Visibility. Receptors to the south of the solar farm, due to the fixed angle of the solar panels facing north, are not at risk of potential glare. Sections of routes throughout the Ammonia Plant and Yara Pilbara Technical Ammonium Nitrate Plant are low lying relative to the surrounding land proposed for the solar farm and likely to be obstructed from glare.

2.5.3 Key Assumptions and Uncertainties

Key assumptions and uncertainties are detailed in Table 2.4.

Table 2.4: Key assumptions and uncertainties

Aspect	Assumptions and uncertainties
Social surroundings	It is assumed that the surveys undertaken within the Development Envelope have accurately identified and mapped cultural heritage sites. It is also assumed that data taken from the Aboriginal Heritage Inquiry System and the State Heritage Register (Inherit) was current and correct at the time of enquiry. Several assumptions were noted in the glare assessment (Appendix B) regarding the viewing level range of photos, the representativeness of receptors and limitations of the Zone of Theoretical Visibility.

2.6 Environmental Management Plan Components

The CHVAMP has been prepared to align with EPA (2021) Instructions on *How to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans*. The plan includes the following components:

- **Outcome-based** EMP components for the:
  - Avoidance of direct disturbance of Aboriginal heritage sites located in the exclusion zones within the Development Envelope;
  - Provision for traditional owner and custodian access and connection to culturally significant areas within and surrounding the Development Envelope; and
  - Provision of traditional owner and custodian access to the Development Envelope following decommissioning of the Proposal.

These outcome-based provision have been identified as the desired outcomes are specific (e.g., no disturbance of an Aboriginal heritage site) and can be measured (e.g., through physical inspection, survey and photographic record of sites to ensure no disturbance).

- **Objective-based** EMP components for setting management actions and targets relating to:
  - Avoidance, where possible, and otherwise minimisation of indirect impacts to social, cultural, heritage, and archaeological values within and surrounding the Disturbance Footprint; and
  - Avoidance, where possible, and otherwise minimisation of direct and indirect impacts to the visual and amenity values of social and cultural places and activities of significance.

Objective-based provisions have been used where the desired environmental outcomes cannot be easily measured, and monitoring of management actions is required. The objective-based provisions relate to potential indirect impacts that could occur if Proposal activities are not conducted with the appropriate controls in place (i.e., potential disturbance of Aboriginal heritage sites through impact of fugitive dust).

2.6.1 Rationale for Choice of Indicators and/or Management Actions

This CHVAMP adopts provisions that align with established industry practices for avoidance and minimisation of environmental and heritage impacts for developments in the Pilbara region. The overall management approach is to avoid disturbance of key environmental and heritage values as far as practicable.

The Proposal has been designed to avoid impacts to social surroundings by excluding the National Heritage Listing Area and Aboriginal heritage sites identified during site surveys from the Disturbance Footprint (exclusion zones).

In addition, following the archaeological and ethnographic surveys carried out in December 2021, the Disturbance Footprint was reduced in collaboration with MAC to:

- Avoid three new sites identified within and just outside the survey areas; and
- Provide a 50 m buffer from the northern boundary to avoid exposed granophyre boulders likely to feature engravings.

The Disturbance Footprint and exclusion zones are shown in Figure 3 in Attachment A and the management actions that have been or will be implemented for each Aboriginal heritage site identified in the Development Envelope are summarised in Table 2.5 below. These actions were approved by the MAC Circle of Elders in March 2022.

Table 2.5: Aboriginal heritage site management

Site ID	Type	Management approach
9838	Artefact scatter	Excluded from Disturbance Footprint with a buffer of 10 m demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors Track constructed and maintained between Site 9838 and Site 20897
18612	Engraving	Excluded from Disturbance Footprint with a buffer of 10 m demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors
18613	Quarry	Excluded from Disturbance Footprint with a buffer of 10 m demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors
20264	Grinding patch	Excluded from Disturbance Footprint with a buffer of 10 m demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors
20265	Engraving	Excluded from Disturbance Footprint with a minimum buffer of 8.9 m demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors
20894	Engraving	Excluded from Disturbance Footprint with a buffer demarcated of 10 m with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors
20895	Engraving	Excluded from Disturbance Footprint with a buffer demarcated of 10 m with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors
20897	Quarry	Excluded from Disturbance Footprint with a 10 m buffer demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors Track constructed and maintained between Site 9838 and Site 20897
YUR-2021-A-001-01	Engraving	Excluded from Disturbance Footprint with a buffer of 50 m
YUR-2021-A-001-02	Engraving	Excluded from Disturbance Footprint with a buffer of 10 m demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors
YUR-2021-A-001-AS	Artefact scatter	Excluded from Disturbance Footprint with a buffer of 10 m demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors

The objective-based management provisions have been identified using a risk-based approach considering potential sources, pathways, receptors and impacts. Recommendations from the relevant surveys and studies have also been considered and included where possible.

Where a credible risk event was determined (i.e., a potential source-pathway-receptor linkage) management targets and actions have been defined. This risk-based approach considered the potential direct, indirect and cumulative impacts of the Proposal and the expected intensity and duration of these impacts during construction and operation.

In the case of glare from the solar array, the potential impacts have been determined through computer modelling. The Glare Impact Assessment Report (Appendix B) recommended a risk assessment approach to determine if further controls are needed (e.g., screening). Objective-based management targets and actions have been defined to ensure that, post construction of the solar array, visual observations are carried out at the viewpoints identified as being at risk of glare impacts and that a risk assessment is conducted based on the field observations to determine if further controls are required. The CHVAMP will be updated once the glare risk assessment has been completed if additional management targets and actions are required.

2.7 Responsibilities

As the Proponent for the Proposal, YPF is responsible for the implementation of this CHVAMP Contact details for YPF are provided below.

Name: Brian Howarth
Position: Project Director
Phone: +61 8 9183 4112
Email: Brian.Howarth@yara.com

The Project Director may delegate the responsibility for implementing components of this plan to other Yara team members, YOPL or other third parties.

3. EMP Components

This section identifies the outcome-based and objective-based components that the CHVAMP will implement. The outcome-based components are provided in Section 3.1 and the objective-based components in Section 3.2.

3.1 Outcome-Based EMP Components

Management of ground disturbance activities and impacts to Aboriginal heritage sites

Rationale: Construction of the Proposal could cause disturbance of Aboriginal heritage sites, sites of ethnographic significance and intangible Aboriginal cultural heritage. Construction of the Proposal and new infrastructure could prevent access by traditional owners to Aboriginal heritage sites. The Proposal has been designed to avoid impacts on social surroundings by excluding the National Heritage Listing Area and Aboriginal heritage sites that were identified during the site surveys from the Disturbance Footprint.

EPA factors and objectives:	**Social Surroundings:** *To protect social surroundings from significant harm.*
Outcomes:	• To avoid direct disturbance of Aboriginal Heritage sites located in the exclusion zones within the Development Envelope. • To allow traditional owner and custodian access and connection to culturally significant areas within and surrounding the Development Envelope (subject to reasonable health and safety requirements). • To allow traditional owner and custodian access to the Development Envelope following decommissioning of the Proposal.
Key environmental values:	Cultural heritage values and National and World Heritage Listings.
Key impacts and risks:	• Construction activities causing disturbance of Aboriginal heritage sites, sites of ethnographic significance and intangible Aboriginal cultural heritage. • Construction activities and new infrastructure preventing access by traditional owners to Aboriginal heritage sites.

#	Criteria	Response actions	Monitoring	Timing / frequency of monitoring	Records
Condition requirements:					
2-1 The Proponent shall implement the Proposal to meet the following outcomes: *1. avoid direct disturbance of Aboriginal Heritage sites located in the exclusion zones within the development envelope that are shown in Figure 3;* *2. subject to reasonable health and safety requirements, allow traditional owner and custodian access and connection to culturally significant areas within and surrounding the development envelope; and* *3. allow traditional owner and custodian access to the development envelope following decommissioning of the Proposal.*					
1.1	**Threshold criteria**: The exclusion zones are directly disturbed during construction or operation of the Proposal.	**Trigger level action**: MAC Heritage Monitors will be appointed for the duration of construction works.	Audit of appointed MAC Heritage Monitors.	Prior to commencement of construction and quarterly thereafter.	List of appointed MAC Heritage Monitors.
1.2		**Trigger level action:** MAC Heritage Monitors will be present during all ground disturbing activities.	ID of MAC Heritage Monitors. Visitor access requirements (i.e., sign-in, sign-out). Heritage inspections.	Daily during ground disturbing activities until completion.	List of appointed MAC Heritage Monitors. Visitor access logs. Heritage Inspection Records (HIRs).
1.3		**Trigger level action:** The exclusion zones will be clearly demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors.	Surveillance and inspection of demarcations with MAC Heritage Monitors.	Prior to commencement of construction and daily during ground disturbing activities until completion. Monthly during operations. Daily during decommissioning activities.	Heritage Inspection Records (HIRs).
1.4		**Threshold contingency action;** If the exclusion zones are directly disturbed, then works will cease and an incident declared. The response and reporting procedure detailed in Section 3.3.1 will be initiated.	Surveillance and inspection of exclusion zones with MAC Heritage Monitors.	Prior to commencement of construction and daily during ground disturbing activities until completion. Monthly during operations. Daily during decommissioning activities.	Heritage Inspection Records (HIRs). Incident response records.
1.5		**Trigger level action:** Archaeological survey of exclusions zones.	Survey completed by MAC approved heritage consultant.	Completion of construction activities.	Survey report.

#	Criteria	Response actions	Monitoring	Timing / frequency of monitoring	Records
1.6	**Trigger criteria:** The exclusion zones are not clearly demarcated with appropriate signage, fencing or flagging prior to the commencement of construction and during ground disturbing activities.	**Trigger level action:** Works will cease until the demarcations are installed and an incident declared. The response and reporting procedure detailed in Section 3.3.1 will be initiated.	Surveillance and inspection of exclusion zones with MAC Heritage Monitors.	Prior to commencement of construction and daily during ground disturbing activities until completion. Monthly during operations. Daily during decommissioning activities.	Heritage Inspection Records (HIRs). Incident response records
1.7	**Trigger criteria**: A new object reasonably suspected as having cultural heritage values is identified within the Development Envelope.	**Trigger level action:** Works will cease, and an investigation commenced in accordance with the protocol in Appendix C. The response and reporting procedure detailed in Section 3.3.1 will be initiated. New object will be reported as per section 15 of the *Aboriginal Heritage Act 1972.*	Visual inspection with MAC Heritage Monitors within Development Envelope during ground disturbing activities. Surveillance and inspection of demarcated exclusion zones through the construction and operational phases of the Proposal.	Daily during ground disturbing activities until completion. Monthly during operations. Daily during decommissioning activities.	Heritage Inspection Records (HIRs). Incident response records.
2.1	**Threshold criteria**: Traditional owners and custodians are denied access and connection (subject to reasonable health and safety requirements) to culturally significant areas within and surrounding the development envelope during the life of the Proposal.	**Threshold contingency action**: The MAC Circle of Elders will be allowed access and connection to culturally significant areas within and surrounding the development envelope during the life of the Proposal.	Surveillance and inspection of culturally significant areas within and surrounding the development envelope.	Annually (MAC preferred frequency) or at any other culturally appropriate time requested by MAC.	Visitor access logs. Heritage Inspection Records (HIRs). Complaints log.
2.2	**Threshold criteria**: Traditional owners and custodians are denied access and connection to culturally significant areas within and surrounding the development envelope after decommissioning and rehabilitation of the Proposal.	**Threshold contingency action:** During decommissioning and rehabilitation of the Proposal, all internal physical structures and hazards limiting access and connection to culturally significant areas will be removed; access paths will be maintained in collaboration with MAC.	Surveillance and inspection of culturally significant areas within and surrounding the development envelope during decommissioning and rehabilitation.	During implementation of the Proposal Decommissioning and Rehabilitation Plan.	Heritage Inspection Records (HIRs).

3.2 Objective-based EMP components

Management of ground disturbance activities, new infrastructure and impacts to Aboriginal heritage sites and the landscape and its values

Rationale: Ground disturbing activities could cause indirect damage to Aboriginal heritage sites. Installation of new infrastructure could visually impact the landscape and its values. YPF has proposed measures to minimise impacts to cultural heritage values and National and World Heritage Listings and amenity (including tourism).

EPA factors and objectives:	**Social Surroundings**: *To protect social surroundings from significant harm.*
Objectives:	To avoid, where possible, and otherwise minimise indirect impacts to the: • social, cultural, heritage, and archaeological values within and surrounding the disturbance footprint; and • visual and amenity values of social and cultural places and activities of significance.
Key environmental values:	Cultural heritage values, National and World Heritage Listings and amenity (visual)
Key impacts and risks:	• Potential indirect impacts to parts of the National Heritage Listed Area and exclusion zones through noise, vehicle emissions, dust, noise, fly rock and vibration; and • Indirect impacts to visual amenity.

#	Management target	Management action	Monitoring	Timing/frequency of monitoring	Records
Condition requirements:					
2-2 The Proponent shall implement the Proposal to meet the following objectives: *1. avoid, where possible, and otherwise minimise indirect impacts to social, cultural, heritage, and archaeological values within and surrounding the disturbance footprint; and* *2. avoid, where possible, and otherwise minimise direct and indirect impacts to the visual and amenity values of social and cultural places and activities of significance.*					
1.1	Avoid, where possible, and otherwise minimise indirect impacts to the social, cultural, heritage, and archaeological values. **Target**: All employees, contractors and visitors are provided with relevant induction and training.	All site personnel will be inducted on Aboriginal heritage values and responsibilities including management of potential impacts to the social, cultural, heritage, and archaeological values in accordance with this plan: • All site personnel will, as a minimum, complete an online Aboriginal cultural heritage induction provided by MAC. • All site supervisors and managers will complete Aboriginal cultural heritage training that is presented by a traditional owner or custodian.	Review of induction and training records.	Monthly.	Induction and training records.

#	Management target	Management action	Monitoring	Timing/frequency of monitoring	Records
1.2		Implement complaints management procedure.	Review of number and type of complaints received.	Monthly	Complaints log. Incident response reports.
2.1	Avoid, where possible, and otherwise minimise indirect impacts from dust events. **Target**: Zero dust events.	Vehicles and equipment access limited to designated roads/access tracks and cleared areas which will be clearly identified on site plans and marked by signage.	Surveillance and inspection, including marked maps and photo or video evidence of vehicles using designated roads and tracks.	Daily during construction activities.	Inspection reports.
2.2		Dust generating activities to cease until dust control measures are implemented.	Visual monitoring of dust events in the active work areas, including photo or video evidence.	Daily during construction activities.	Inspection reports.
2.3		Vehicle speed limits will be imposed and enforced on nominated routes and work areas. Speed limits will be identified on site plans and marked by signage.	Surveillance and inspection, including video evidence or use of hand-held or fixed speed detection equipment.	Daily during construction activities.	Inspection reports.
2.4		Dust suppression, including use of water carts on access roads, must be implemented during construction activities as required.	Inspection of work areas, including photo or video evidence of water cart use. Number of water cart runs per day or volume of water used per day for dust suppression.	Daily during construction activities	Inspection reports. Annual compliance report
3.1	Avoid, where possible, and otherwise minimise indirect impacts from blasting, including fly rock and vibration. **Target**: • No fly rock of debris outside the disturbance footprint or within cultural heritage exclusion zones. • No non-compliance with Environmental Protection (Noise) Regulations 1997.	Blasting will be carried out in accordance with the Environmental Protection (Noise) Regulations 1997.	Surveillance and Inspection. Audit blasting procedures and work instructions.	Prior to and during each blasting event.	Inspection records. Audit reports.
3.2		Any blasting to be undertaken by a licenced shotfirer with the licence current for the extent of works employed for.	Surveillance and Inspection, including video recording of each blast. Audit of blasting procedures and work instructions. Review of induction and training records.	Prior to each blasting event.	Inspection reports. Audit reports. Induction and training records.
3.3		• Low percussion explosives will be used. • Blast mats/shields will be used where recommended by the licensed shotfirer. • Explosives stemming depths will be closely monitored.	Surveillance and Inspection. Audit of blasting procedures and work instructions.	Prior to and during each blasting event.	Inspection reports. Audit reports.

#	Management target	Management action	Monitoring	Timing/frequency of monitoring	Records
3.4		All works conducted during construction will be subject to vibration mitigation actions.	Surveillance and inspection.	Daily during construction activities.	Inspection reports.
4.1	Avoid, where possible, and otherwise minimise indirect impacts from vehicle emissions.	Vehicles will be switched off when not in use.	Surveillance and inspection, including measuring fuel usage (kL) to enable emission calculations.	Daily during construction activities.	Inspection reports.
4.2		Low sulphur fuels will be used in construction vehicles and machinery.	Fuel specification.	Monthly during construction activities.	Fuel delivery receipts.
5	Avoid, where possible, and otherwise minimise indirect impacts from noise emissions. **Target**: No noise complaints from publicly accessible areas.	All construction works will comply with the Environmental Protection (Noise) Regulations 1997.	Noise monitoring using a handheld Class 1 or Class 2 sound level meter. Complaints.	Spot-check as determined by the site manager or delegate.	Noise monitoring results. Complaints log.
6.1	Avoid, where possible, and otherwise minimise indirect impacts to visual and amenity values. **Target**: No complaints of glare from publicly accessible areas.	Assess for yellow and green glare at Observation Points (OP) 05 and 06 (refer to Figure 4 in Attachment A). Visual observations to be completed by suitably qualified personnel.	Visual observations and photographic record.	OP05 – weekly from 1730-18:30 during the first 1 November-31 December period after installation of all solar arrays. OP06 – weekly from 0600-0700 during the first 1 December-31 January period after installation of all solar arrays.	Glare assessment reports. Complaints log
6.2		Complete risk assessment for glare impacts at OP5 and OP6.	Review of risk assessment.	After completion of weekly observation periods.	Completed risk assessment

3.3 Reporting

3.3.1 Outcome-based EMP Components

If monitoring, tests, surveys or investigations indicate the non-achievement of a threshold or trigger criteria specified in Section 3.1, YPF will:

1. Report the non-achievement to MAC within 21 days of the non-achievement being identified (as per Condition 2-6(1).
2. Report the non-achievement in writing to the CEO within 21 days of the non-achievement being identified (as per Condition 2-6(1)).
3. Where the non-achievement impacts a registered Aboriginal site where consent has not been granted under section 18 of the *Aboriginal Heritage Act 1972*, report the non-achievement to DPLH and the Registrar of Aboriginal Sites within 21 days of the non-achievement being identified (as per Condition 2-6(2)).
4. Investigate to determine the cause of the threshold or trigger criteria not being achieved (as per Condition 2-6(3)):
    a. The investigation must be carried out in collaboration with MAC;
    b. An interim incident response report must be provided to MAC prior to Step 5.
5. As per Condition 2-6(4), provide the incident response report the CEO, MAC, DPLH and the Registrar of Aboriginal Sites within 90 days of the non-achievement being reported as required by Step 2 and, where relevant, Step 3, which must include:
    a. A description of the cause of the threshold or trigger criteria being exceeded if known, or analysis of likely causes if not known;
    b. The findings of the investigation required by Step 4;
    c. Details of revised and/or additional management actions to be implemented to prevent non-achievement; and
    d. Relevant changes to activities.

The records specified in Section 3.1 will be maintained by YPF and reported to the CEO and MAC annually as part of the annual Compliance Assessment Report (CAR) required by Condition 8 of MS 1194.

3.3.2 Objective-based EMP Components

If monitoring, tests, surveys or investigations indicate that one or more management actions specified in Section 3.2 have not been implemented, YPF will:

1. Report the failure to implement the management action in writing to MAC within seven days of identification (as per Condition 2-7(1)).
2. Report the failure to implement the management action in writing to the CEO within seven days of identification (as per Condition 2-7(1)).
3. Where the failure impacts a registered Aboriginal site where consent has not been granted under section 18 of the *Aboriginal Heritage Act 1972*, report the failure to the DPLH and the Registrar of Aboriginal Sites within seven days of identification (as per Condition 2-7(2)).
4. Investigate to determine the cause of the management actions not being implemented (as per Condition 2-7(3)) and to determine potential environmental harm or alteration of the environment that occurred due to the failure to implement management actions (as per Condition 2-7(4)):

a. The investigation must be carried out in collaboration with MAC;

b. An interim incident response report must be provided to MAC prior to Step 5.

5. As per Condition 2-7(4), provide the incident response report to the CEO, MAC and, where relevant, DPLH and the Registrar of Aboriginal Sites within 28 days of the failure being identified, which must include:

   a. Cause for failure to implement management actions;

   b. The findings of the investigation required by Step 4.

   c. Relevant changes to activities; and

   d. Measures to prevent, control or abate the environmental harm which may have occurred.

The records specified in Section 3.2 will be maintained by YPF and reported to the CEO and MAC annually as part of the annual Compliance Assessment Report (CAR) required by Condition 8 of MS 1194.

4. Adaptive Management and Review

YPF will implement an adaptive management approach to improving set outcomes and objectives during the implementation of the Proposal through the evaluation of the monitoring and management components of the CHVAMP.

Adaptive management concerning this plan includes review, at a minimum, every six months in collaboration with MAC. Reviews may also be initiated:

- At any time in collaboration with MAC (as per Condition 2-9(1));
- At the direction of the CEO (as per Condition 2-9(2));
- On completion of an investigation into non-achievement of trigger or threshold criteria or a management action not being implemented;
- On completion of the annual CAR;
- Before any significant changes to construction activities; or
- On changes to any relevant legislation or approvals.

Each adaptive management review will include:

- Review of the outcomes and objectives that this CHVAMP addresses;
- Review of the implementation of the response and management actions and associated monitoring, recording and reporting requirements;
- Review of the response and management actions based on evaluation of:
  - Monitoring data and records;
  - Review of assumptions, uncertainties and understanding (e.g., of the Aboriginal heritage sites);
  - Risk assessment;
  - External changes (e.g., technical advances or innovation); and
- Collaboration with MAC.

Any revisions to this CHVAMP will be agreed with MAC and submitted to the CEO for approval prior to implementation in accordance with Condition 2-9 of MS 1194.

5. Stakeholder Collaboration and Consultation

5.1 Collaboration and Consultation

YPF has collaborated extensively with MAC throughout the development phases of the Proposal, commencing in February 2020 and which continues. YPF has consulted with other relevant stakeholders during the preparation of this CHVAMP and other plans relevant to the Proposal and will continue to engage with all stakeholders, including MAC, for the life of the Proposal.

A summary of the collaboration and consultation carried out with stakeholders during preparation of this CHVAMP, the comments and advice received, and YPF's response is provided in Table 5.1.

Table 5.1: Stakeholder collaboration and consultation

Stakeholder	Date	Issues/topics raised	Response/outcome
DPLH	22 June 2022	Follow up from MS1194 requirements and management plan process with MAC	Nil
MAC	2 August 2022	• High-level targets discussed. Management provisions confirmed for use; • Archae-aus to be appointed through MAC to provide heritage comments and review on behalf of MAC • YPF to draft document and circulate; • Glint assessment study results discussed. No issues were raised.	• CHVAMP to be prepared. • YPF supports the use of Archae-aus to provide peer-review of the CHVAMP. • Draft CHVAMP provided to MAC on 2nd August 2022. • Management actions prepared consistent with study findings.
MAC	8 August 2022	Approved version of Ministerial Statement 1194.	Management plan collaboration process.
MAC	22 August 2022	• Management plan timeline. • EPC introduction and Section 9 related matters.	Revised timeline and process agreed with all stakeholders.
MAC	28 August 2022	Discussion on process for collaboration with MAC and lead heritage consultants.	Approach confirmed (YPF to provide funding for engagement of MAC lead heritage consultants).
MAC	1 September 2022	Draft Cultural Heritage & Environment Management Plan provided to MAC.	MAC review / comment
MAC	16 September 2022	Discussion on engagement of MAC Heritage Monitors, access for observations and management plan.	• YPF requested a quote for the engagement of MAC Heritage Monitors. • MAC updated on the management plan delivery date from lead heritage consultants.
MAC	21 September 2022	Request from MAC for PO generation.	Agreement provided by YPF for engagement of MAC Heritage Monitors.
MAC	23 September 2022	Project update and discussion on use of utilities corridors for temporary construction areas.	Discussion on delivery timelines, last management plan.
MAC	16 September 2022	Discussion on MAC Heritage Monitors and lead heritage consultant feedback on the draft plan.	Requested a quote for the MAC Heritage Monitors and an update on the management plan delivery date from MAC.
MAC	30 September 2022	Management plan comments and responses.	Discussed management plan amendments and comments on the draft plan.
EPA	4 October 2022	Submission plan and process for management plan.	Noted.
MAC	5 October 2022	Revision C of the management plan forwarded to MAC.	MAC review.

Stakeholder	Date	Issues/topics raised	Response/outcome
MAC	6 October 2022	MAC's comments and feedback on the management plan.	YPF to incorporate MAC recommendations and comments.
MAC	10 October 2022	Submission of management plan to MAC.	MAC to present and review with Circle of Elders.

5.2 Communication Protocols

The Consultation and communication matrix for the Proposal is detailed in the table below (Table 5.2).

Table 5.2: Communication matrix

Phase	Activity	Key Topics	Stakeholders	Frequency	Documentation
Clearing	Daily toolbox meeting Daily heritage checklist	Daily workplan etc.	MAC Heritage Monitors ProjectCo/EPC YPF	Daily during ground disturbing activities	Daily heritage report
Construction	Weekly heritage report	Weekly heritage inspection status Compliance with planned heritage activities	ProjectCo/EPC MAC YPF	Weekly – each Monday	Weekly heritage snapshot report
Project	Monthly MAC and YPF meeting	Ground disturbance report (as required) Compliance to CHVAMP Upcoming activities	MAC CEO MAC Heritage Manager YPF Project Director ProjectCo Project Director	Monthly	Monthly heritage report Visitor log

5.3 Dispute Resolution

YPF and MAC have an ongoing constructive and collaborative relationship, which is expected to continue during the implementation of the Proposal. The cultural authority of the MAC Circle of Elders will always be respected and YPF will defer to MAC's guidance and advice for all matters associated with Aboriginal heritage cultural values, as has occurred through the development of the Proposal to date.

In the event of a dispute between YPF and MAC that cannot be resolved at an operational level:

1. The matter will be raised in writing by either the MAC Chief Executive Officer or the YPF Project Director with their respective counterpart;
2. The parties will schedule a discussion with the relevant counterpart;
3. The parties will discuss the issue with the relevant stakeholders from each party with the objective of reaching an agreement.

5.4 Publication of CHVAMP

The CHVAMP will be made publicly available on the Yara Pilbara website at:

www.yara.com.au/about-yara/about-yara-australia/pilbara/Project-YURI/

6. Document Changes

YPF will implement the most recent version of the approved CHVAMP until the CEO has confirmed by notice in writing that the environmental outcomes in Condition 2-1 and objectives detailed in Condition 2-2 have been met.

This version of the CHVAMP is the first version of the plan. Any future changes to the plan will be summarised in this section.

Limitations

Scope of services

This report ("the report") has been prepared by Strategen-JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen-JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen-JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen-JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen-JBS&G has also not attempted to determine whether any material matter has been omitted from the data. Strategen-JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen-JBS&G. The making of any assumption does not imply that Strategen-JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen-JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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References

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Appendix A Figures

Figure 1: Regional location of the Proposal

Figure 2: Development Envelope for the Proposal

Figure 3: Aboriginal heritage site exclusion zones

Figure 4: Observation point receptors

Appendix B Glare Impact Assessment Report

Glare Impact Assessment Report

YURI Phase 0 Solar Farm

Yara Pilbara Fertilisers Pty Ltd

1 July 2022

The Power of Commitment

Project name	Glare Assessment
Document title	YURI Phase 0 Solar Farm | YURI Phase 0 Solar Farm
Project number	12586863
File name	

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S0	A	E.Salter	J. Vaessen		J.Vaessen		7-7-22

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Abbreviations

Abbreviations	Definition
ARC	Anti-reflective coating
CASA	Civil Aviation Safety Authority
km	Kilometre
LGA	Local Government Area
MW	Megawatts
min	Minutes
PV	Photovoltaic
SGHAT	Solar Glare Hazard Analysis Tool
W/m^2	Watts per square meter

1. Introduction

1.1 Overview

As part of their strategy in producing renewable hydrogen, Yara Pilbara Fertilisers Pty Ltd, Yara, is proposing to develop an 18MW Solar Farm, surrounding their existing fertiliser plant on the Burrup peninsula in the Pilbara. The solar farm is to be within immediate proximity of indigenous heritage sites, public roads and within range of Karratha Airport. This study was to quantify the intensity and duration of sunlight glare reflected by the solar panels by use of a Solar Glare Hazard Analysis Tool. Glare was considered at indigenous heritage, public roads, and Karratha Airport receptors.

1.2 Purpose of this report

This report provides a brief of the methodology of the glare study conducted with the Solar Glare Hazard Analysis Tool. The report lists the assumptions and parameters used and details the results and conclusions made.

1.3 Scope and limitations

This report: has been prepared by GHD for Yara Pilbara Fertilisers Pty Ltd and may only be used and relied on by Yara Pilbara Fertilisers Pty Ltd for the purpose agreed between GHD and Yara Pilbara Fertilisers Pty Ltd as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Yara Pilbara Fertilisers Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.5 and 1.6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Yara Pilbara Fertilisers Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

If the GHD document containing the disclaimer is to be included in another document, the entirety of GHD's report must be used (including the disclaimers contained herein), as opposed to reproductions or inclusions solely of sections of GHD's report.

1.4 Software overview

Solar Glare Hazard Analysis Tool (SGHAT), licensed from Sandia National Laboratories (available from ForgeSolar) is an industry standard technical modelling tool. SGHAT was developed for evaluating the impact of hazardous solar glare reflected by solar panels has on the aviation industry, such as aeroplane pilots and air-traffic controllers. SGHAT can also be used to determine the impact of glare on pedestrians, motorists and train drivers. SGHAT calculates the sun position and sunlight intensity at 1-minute intervals specific to location data, time of day and time of year to determine the direction and intensity of the glare. SGHAT calls on the Google Earth topography database to determine elevation specific to location data.

1.4.1 Glare assessment parameters

The ForgeSolar SGHAT can account for the following factors:

- the tilt, orientation, and optical properties of the solar panels in the solar farm and the elevation;
- sun position with respect to, geographic location, time of year and time of day; and
- the location of sensitive receptors (viewers) and their elevation.

ForgeSolar SGHAT uses the following assumptions for evaluation:

- The Google Earth topography database utilised by the software, provides an accurate model of the terrain;
- gaps between solar panels not considered;
- clear atmospheric conditions will present the strongest conditions for glare and therefore the effect of clouds and dust will not be included;
- there is no shading by native vegetation on the solar; and
- all solar panels will have a flat surface.

1.4.2 Limitations

ForgeSolar SGHAT is limited by the following:

- The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results.
- Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result.
- The algorithm assumes that the PV array is aligned with a plane defined by the approximate total heights of the PV vertices.
- The algorithm does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc. Because of this, the ZTV, photos and the contours from the PSD1629 CAD file has been drawn upon to account for glare obstructed by landforms at certain receptors.
- The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
- The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modelling methods.
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

1.5 YURI Phase 0 Solar Farm

The 18MW solar farm is a key component of the Renewable Hydrogen Plant and associated infrastructure that form the first step (Phase 0) in Yara's multi-phase project; YURI. YURI Phase 0 aims to demonstrate commercial operation of the Renewable Hydrogen Plant.

1.5.1 Location

The proposed site, the Site, for YURI Phase 0 Solar Farm, the solar farm, is within the existing lease area of the Yara Pilbara Fertiliser Plant, within the Burrup Strategic Industrial Area on the Burrup Peninsula. The Burrup Strategic Industrial Area is surrounded by the Murujuga National Park. The site is located 1.5 km east of Heason Cove, surrounded by industrial and public roads and is approximately 9.5km north of Karratha Airport. It has a land area of approximately 25 hectares.

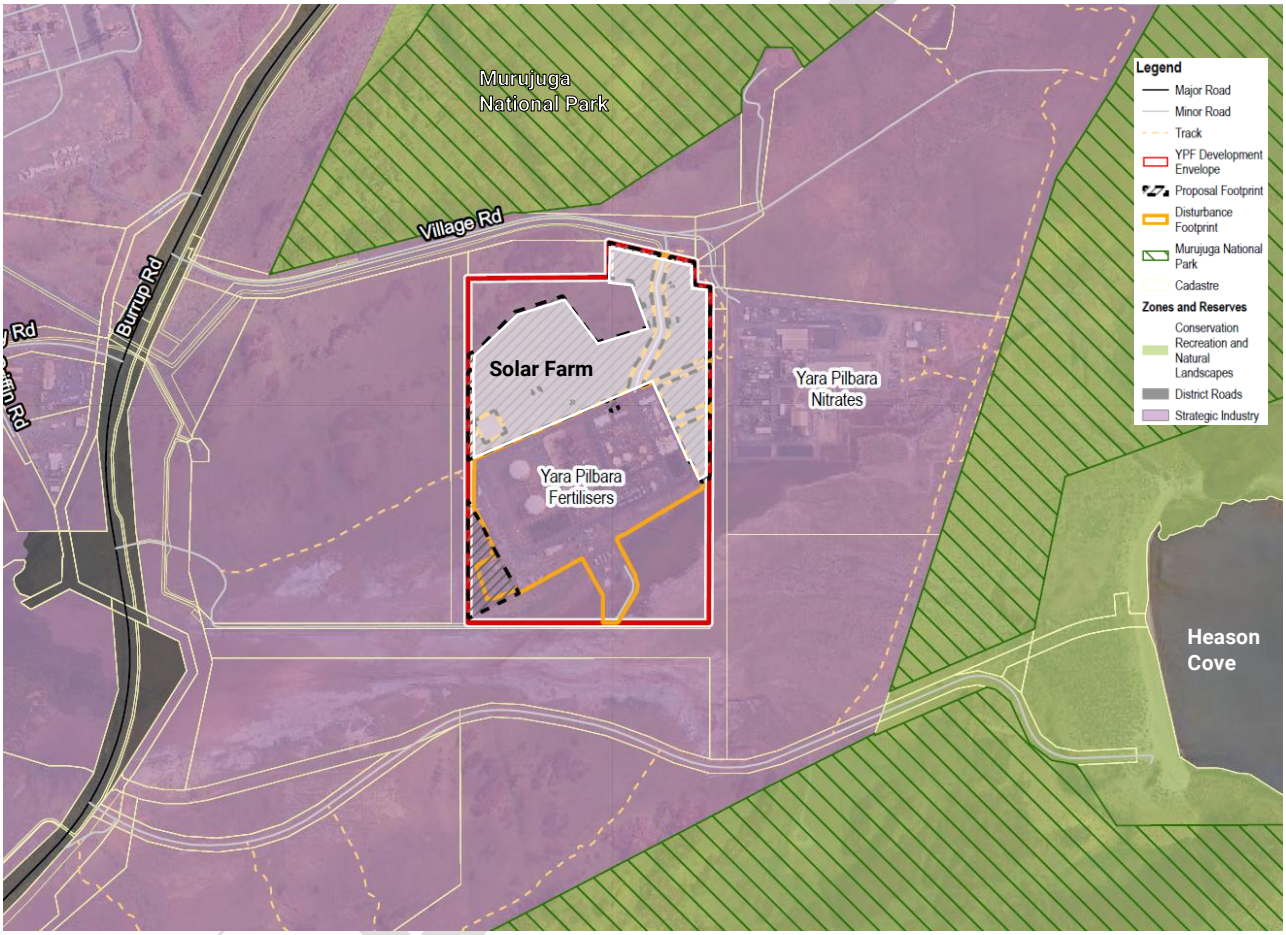

Figure 1 **Location of YURI Phase 0 Solar Farm (GHD Section 38 Referral Supporting Report)**

1.5.2 Glare Study Inputs

This glare study utilised the Visual Considerations Report[1] which GHD completed in September 2020 to assist the Environmental Protection Authority (EPA) in its assessment decision on YURI Phase 0. The Visual Considerations Report summarises a study which identified potential Sensitive Visual Receptors. These Sensitive Visual Receptors were assessed for potential glare;

- VP01 Entry into Hearson Cove Road Tourists, road users, local visitors and traditional owners
- VP02 Hearson Cove Road Tourists, local visitors and traditional owners
- VP03 Deep Gorge, Murujuga National Park Tourists, local visitors and traditional owners

[1] Yara Pilbara Fertilisers Pty Ltd Ammonia Plant, Burrup Peninsula - Renewable Hydrogen Project; GHD Visual Considerations Report September 2020

- VP04 Hearson Cove Tourists, local visitors and traditional owners
- VP05 Murujuga National Park Tourists, local visitors and traditional owners
- VP06 Village Road Tourists, road users, local visitors and traditional owners

The Visual Considerations Report also presents a Zone of Theoretical Visibility (ZTV). ESRI ArcGIS software was used to model the theoretical visibility of the solar farm from the surrounding landscape. This glare study takes guidance from the ZTV to conclude where glare is likely to be encountered.

Yara Pilbara Pty Ltd has provided the following parameters for modelling YURI Phase 0 Solar Farm.

Table 1 YURI Phase 0 Solar Farm project parameters

Parameter/Information	Value
Solar farm size	18MWp
Solar panel tilt angle	15
Solar panel orientation	North
Coordinates of solar farm	–20.623739°, 116.780696°
Solar panels proposed	Canadian Solar CS7N650
Layout	PSD1629 (in CAD and PDF) Includes terrain contours and GPS coordinates
Photos	Ground level perspective of routes around the Yara Pilbara Fertiliser and Nitrate Plants

1.6 Assumptions

The glare assessment was conducted with the following assumptions:

- The author did not undertake a site visit or take the photographs within this report. The images were provided by Yara Pilbara Pty Ltd. It is assumed the photos were taken within the typical viewing level range of an adult.
- The receptors identified in the GHD Visual Considerations Report are a sufficient representation of sensitive visual receptors in the proximity of the solar farm.
- The glare assessment used the Zone of Theoretical Visibility (ZTV) presented in the GHD Visual Considerations Report[1] to draw conclusions as to the limit of the visibility of the solar farm from specific locations. The ZTV is limited to the following
    - A viewing height of 1.7 m, which is the average within the typical viewing level range of an adult
    - Height of solar panels at 4 m above natural ground surface.
    - The same solar farm layout used for modelling the photomontages was used to model the ZTV.
    - The ZTV only took into account the landform and did not include land cover factors such as the presence of buildings and trees, hence it represents the worst-case scenario of potential visibility
    - The ZTV is only accurate to the resolution of the elevation model.
- The PSD1629 CAD file was used to extract location and terrain data of the immediate landscape of the solar farm and Yara Pilbara Fertilisers. It is assumed, as this model was provided with GDA 94 MGA 50 coordinates, elevations reference average sea level. It is assumed as this data accurate and may be relied upon.

2. Glare principles

2.1 Angle of incidence and reflection

Solar panels aim to maximise the conversion of sunlight energy to electrical energy by, in parts, minimising energy loss through reflection of sunlight. Some manufacturers of solar panels provide Anti-reflective coatings (ARC) to reduce surface reflectivity. ARC is most effective with small angles of incidence (angle between panel perpendicular and sun) and is not as effective as angle of incidence increases, demonstrated by Yellowhair, 2015, Figure 2. ForgeSolar explains this as the greater surface texturing can increase the size of the subtended source angle (i.e. glare spot) increasing reflection. The ForgeSolar SGHAT can account for ARC.

Figure 2 also demonstrates that reflected light is fairly insignificant at low angles of incidence, however, increases exponentially as angle of incidence exceeds 60°.

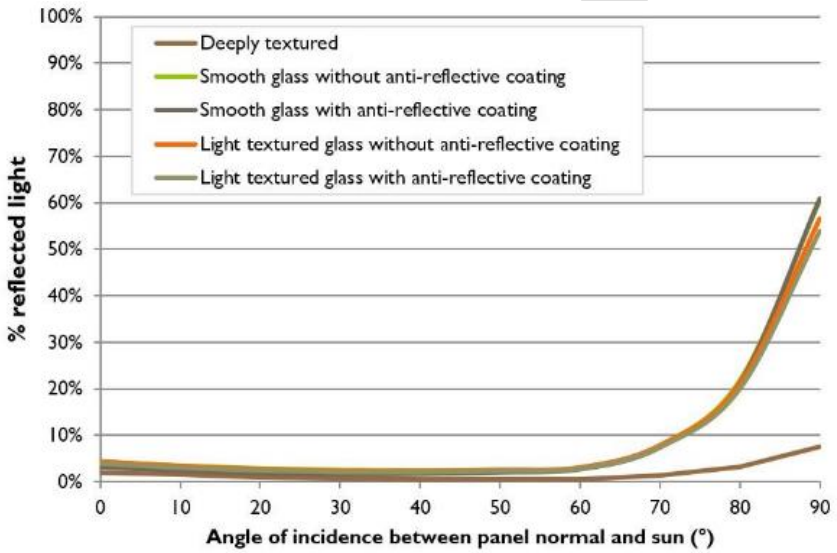

Figure 2 **Angle of incidence and panel reflectance (Yellowhair, 2015)**

The reflection of solar panels can be classified into two types, specular and diffuse –Figure 3 below. Specular reflection has a direction symmetrical to the angle of incidence with reference to the panel's normal direction.

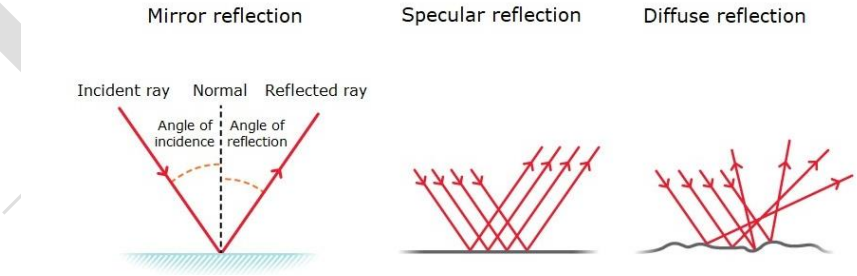

Figure 3 **Specular and diffuse reflection**

Diffuse reflections result from a beam of light being scattered in multiple angles due to a rough surface. Such reflections may occur on a solar farm due to any slight roughness of the panel surface type, or by dust and contaminants. Diffuse reflection lowers the intensity of the overall specular reflection and therefore it can be considered to lower the likelihood of hazardous glare.

2.2 Direct normal irradiance

Direct normal irradiance is the measurement of power that a given surface area may absorb when it is exposed to sunlight, measured in watts per square meter (W/m^2). The maximum irradiance occurs at midday when the sun is

directly overhead; however, this irradiance will decrease as the sun angle decreases; as the sunlight passes through more of the atmosphere and less energy will reach the solar panel surface. SGHAT accounts for the variation in sunlight intensity by applying a subtractive function depending on the sun angle.

2.3 Glare ocular impact categories

Ocular impact is a measure of the potential for after-image and damage that may occur to the human eye when exposed to glare. Ocular impact is a function of both the magnitude of the reflected sunlight received by the observer "retinal Irradiance" (W/cm^2) and the size of the glare source perceived by the observer, measured by the subtended angle of the reflected glare (millradians). Glare is classified by SGHAT, as:

- low potential for after-image, also referred to as green glare;
- potential for after-image, also referred to as yellow glare; and
- potential for permanent eye damage, also referred to as red glare.

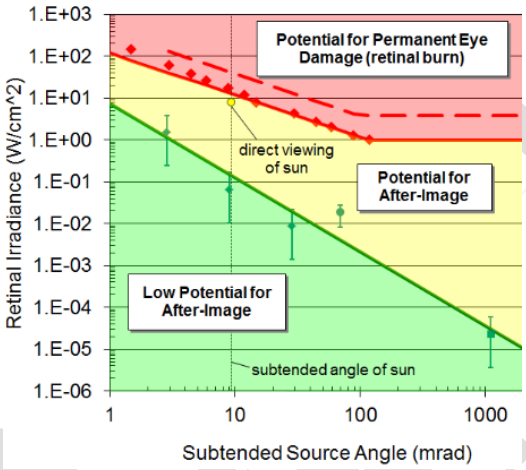

Figure 4 **Ocular impact categories (Ho, 2011)**

3. Methodology

3.1 Modelling

3.1.1 Solar Farm

YURI Phase 0 Solar Farm is proposed to utilise Canadian Solar CS7N650, 650W solar panels, the solar cells of this panel are protected with tempered glass with anti-reflective coating (ARC).
The solar panels will be mounted using fixed tilt solar panel mounting structures. The mounting structures support the north facing solar panels at an angle of 15 degrees from horizontal, such as Figure 5. The horizontal dimensions taken from the CAD PSD1629 Layout, confirm the orientation is two rows of solar panels in portrait orientation.

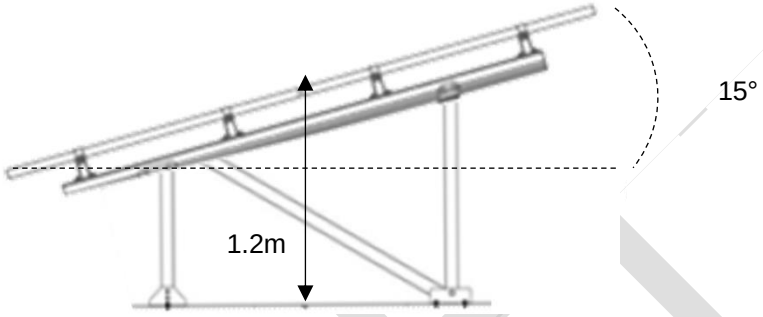

Figure 5 **Indicative cross section of solar panel mounting structure**

From generic mounting structure dimensions, the midpoint (or centroid) of the solar panels was calculated to be 1.2m. The centroid of the provides the height of the solar panels for the ForgeSolar SGHAT.

The YURI Phase 0 Solar Farm has a fairly complicated layout. The rows of solar panels have to negotiate the fertiliser plant, its access road, product pipelines and nine registered Aboriginal Heritage sites within its Development Envelope. This is illustrated in Figure 6.

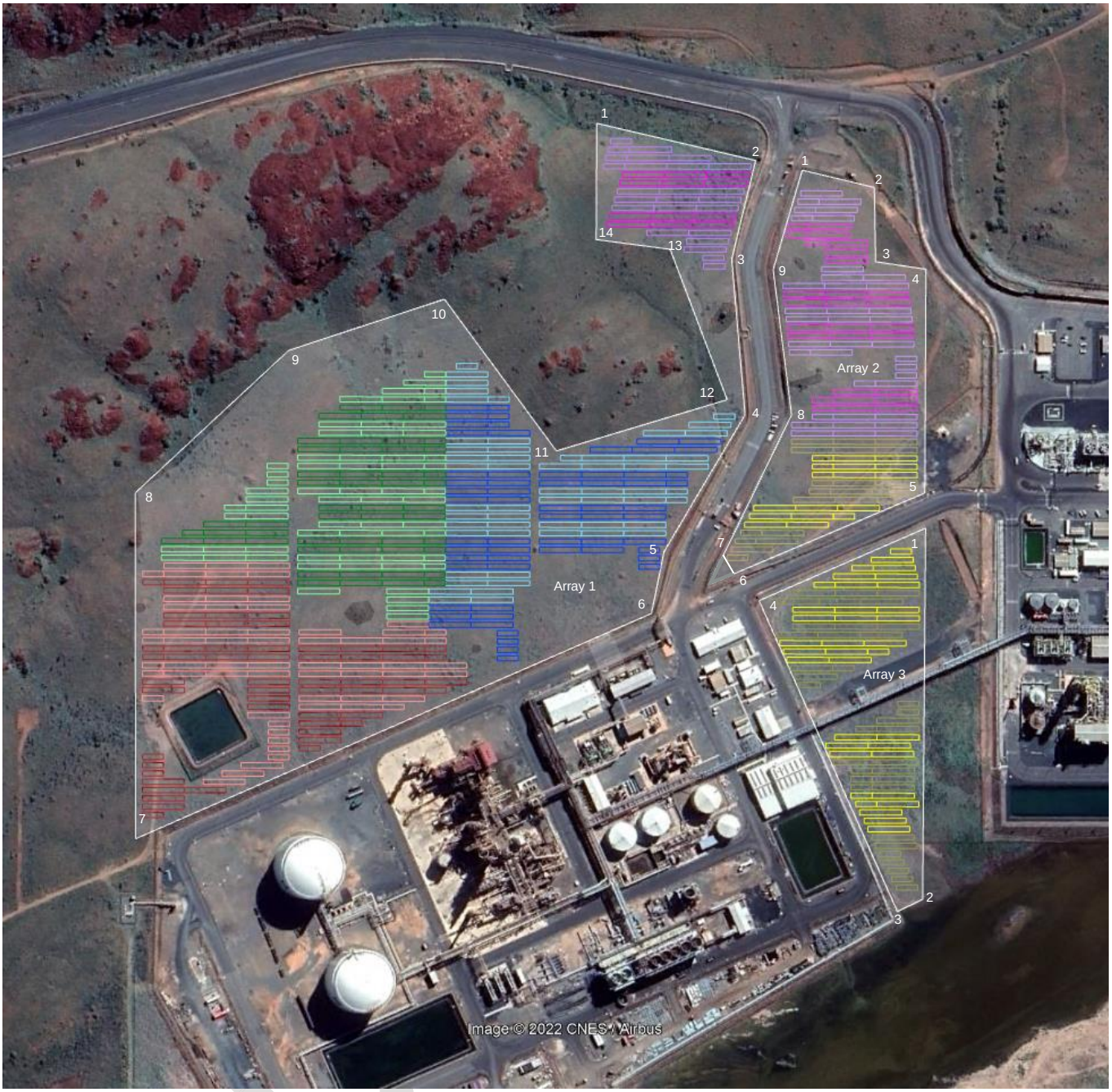

Figure 6 **YURI Phase 0 Solar Farm proposed layout and polygon vertices**

The extent of the Development Envelope; shown by the polygons in Figure 6, were used as a simplified alternative to model the solar farm. The coordinates of the polygon vertices were obtained from the CAD PSD1629 Layout and converted to latitude and longitude. ForgeSolar determines the elevation from the Google Earth topography database, however the vertices elevation was adjusted to that of the contours embedded in the CAD PSD1629 Layout. ForgeSolar incorporates the midpoint of the solar panels to estimate the total elevation of the solar farm.

Table 2 **YURI Phase 0 Solar Farm polygon vertex parameters**

	Vertex	Latitude	Longitude	Ground Elevation	Measured off CAD	Solar Panel Centroid	Total Elevation
Array 1	1	-20.62	116.782	29.35	20.5	1.20	21.7
	2	-20.621	116.784	21.34	17	1.20	19.2
	3	-20.621	116.783	18.67	16.25	1.20	19.45
	4	-20.623	116.784	15.16	11.25	1.20	15.45
	5	-20.624	116.783	11.38	9	1.20	14.2
	6	-20.624	116.783	9.64	7.75	1.20	13.95
	7	-20.626	116.778	12.28	8.5	1.20	15.7
	8	-20.623	116.778	29.1	25.25	1.20	33.45
	9	-20.622	116.78	36.68	29.5	1.20	38.7
	10	-20.622	116.781	36.32	31.75	1.20	41.95
	11	-20.623	116.782	16.35	14.25	1.20	25.45
	12	-20.623	116.783	15.48	12	1.20	24.2
	13	-20.621	116.783	20.35	16	1.20	29.2
	14	-20.621	116.782	26.76	20.5	1.20	34.7
	Vertex	Latitude	Longitude	Ground Elevation	Measured off CAD	Solar Panel Centroid	Total Elevation
Array 2	1	-20.621	116.784	20.67	16.50	1.20	17.70
	2	-20.621	116.785	19.62	14.50	1.20	15.70
	3	-20.622	116.785	18.43	15.00	1.20	16.20
	4	-20.622	116.785	16.41	12.50	1.20	13.70
	5	-20.623	116.785	11.58	7.50	1.20	8.70
	6	-20.624	116.783	12	8.75	1.20	9.95
	7	-20.624	116.783	12	8.75	1.20	9.95
	8	-20.623	116.784	15.53	12.50	1.20	13.70
	9	-20.621	116.784	19.45	20.50	1.20	21.70
	Vertex	Latitude	Longitude	Ground Elevation	Measured off CAD	Solar Panel Centroid	Total Elevation
Array 3	1	-20.624	116.785	11.05	7.00	1.20	8.20
	2	-20.627	116.785	4.61	3.25	1.20	4.45
	3	-20.627	116.785	4.8	3.25	1.20	4.45
	4	-20.624	116.784	11.65	7.75	1.20	8.95

All arrays are modelled as fixed tilt at 15° North (0°) orientation with smooth glass and ARC coating.

3.1.2 Observation Point Receptors

In ForgeSolar, an Observation Point (OP) receptor allows the simulation of an observer at a single, discrete location, defined by a latitude, longitude, elevation, and height above ground. OP receptors were used to assess the viewpoints "VP", identified as sensitive visual receptors by the Visual Considerations Report[2];

- VP01 Entry into Hearson Cove Road Tourists, road users, local visitors and traditional owners
- VP02 Hearson Cove Road Tourists, local visitors and traditional owners
- VP03 Deep Gorge, Murujuga National Park Tourists, local visitors and traditional owners
- VP04 Hearson Cove Tourists, local visitors and traditional owners
- VP05 Murujuga National Park Tourists, local visitors and traditional owners
- VP06 Village Road Tourists, road users, local visitors and traditional owners

The CAD PSD1629 Layout and contour elevation data does not extend to these viewpoints. Coordinates of the viewpoints were acquired from the Visual Considerations Report (in GDA 1994 MGA Zone 50) and converted to latitude and longitude. From the latitude and longitude, ForgeSolar determines the elevation from its Google Earth

[2] Ammonia Plant, Burrup Peninsula - Renewable Hydrogen Project Visual Considerations Report September 2020

topography database. The viewing height of 1.7m has been used for consistency with the Visual Considerations Report. The sensitive visual receptors south of the solar farm are not expected to receive any glare but have been assessed to validate this assumption.

From Google Earth imagery, the Karratha Airport Air Traffic Control Tower (ATCT) could be identified. An observation point receptor was also used to simulate the ATCT. Table 3 lists the coordinates and heights of the OP receptors.

Table 3 Observation point receptors

Viewpoint	OP Receptor	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
VP01 Entry into Hearson Cove Road	OP 1	-20.635631	116.768505	7.29	1.70
VP02 Hearson Cove Road	OP 2	-20.633122	116.777272	10.81	1.70
VP03 Deep Gorge, Murujuga National Park	OP 3	-20.636859	116.788776	26.35	1.70
VP04 Hearson Cove	OP 4	-20.633517	116.797467	8.19	1.70
VP05 Murujuga National Park	OP 5	-20.616130	116.796146	16.44	1.70
VP06 Village Road	OP 6	-20.619857	116.782356	30.15	1.70
Air Traffic Control Tower	7-ATCT	-20.708319	116.774170	9.00	20.00

The observation point receptors are depicted in Figure 7.

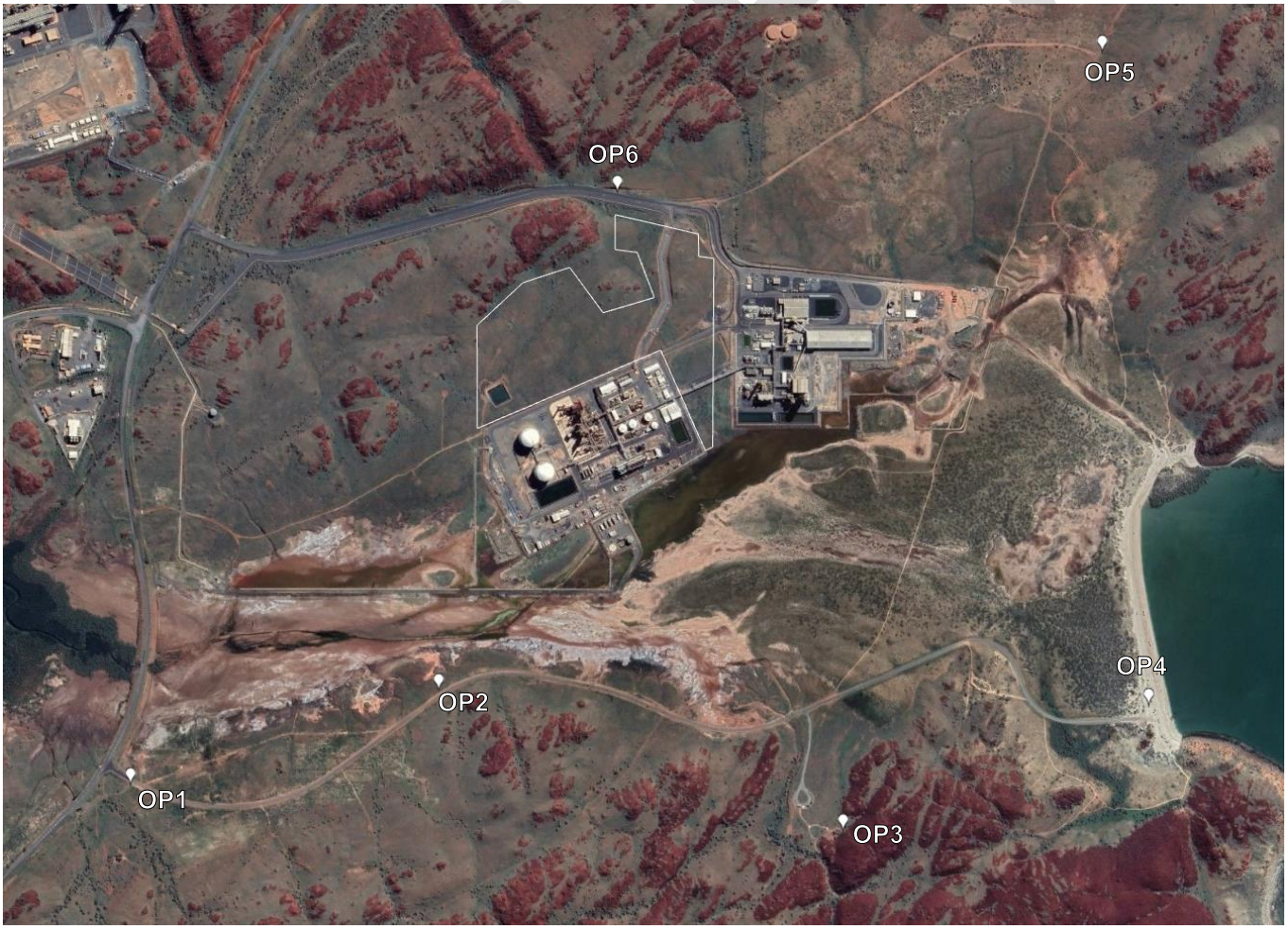

Figure 7 Observation point receptors

The ATCT receptor at Karratha Airport is depicted in Figure 8

Figure 8 **Air Traffic Control Tower observation point receptor**

The ATCT is south of the solar farm so is not expected to receive any glare but has been assessed to validate this assumption.

3.1.3 Route Receptors

The SGHAT route receptor function can simulate observers traveling along continuous paths such as roads or railways. This function was used to represent both light vehicles (LVs) and heavy vehicles (HVs) travelling along the nearby roads. SGHAT nominates a default observer viewing angle of 50° left and right of visual center line (total field of view 100°). According to a FAA research study (Rogers, 2015), pilots are not impacted by glare predicted at greater than 50° of their visual center line. In extension to LV and HV operators, 50° was nominated for the route receptors for these roads, permitting SGHAT to disregard any glare predicted outside of this field of view.

The SGHAT algorithm does not consider obstacles (either man-made or natural) between the observation points and the solar farm that may obstruct observed glare, such as trees, hills, buildings, etc. To account for this, the ZTV from the Visual Considerations Report was utilised to determine which routes the solar farm is visible from, Figure 9.

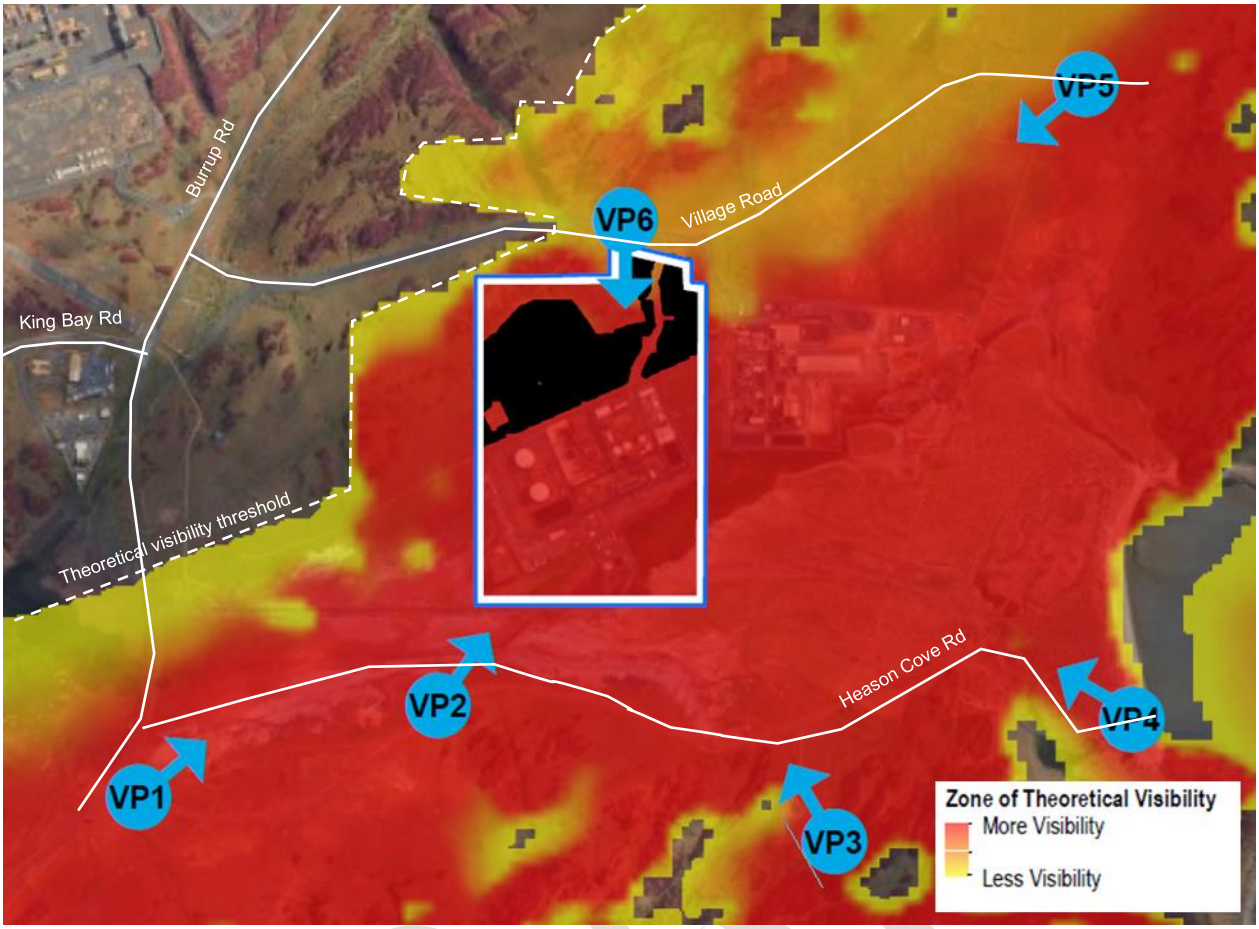

Figure 9 **ZTV performed 16/09/2020 for Yara Pilbara Fertilisers Pty Ltd Renewable Hydrogen Project (Visual Considerations Report figure 3-4)**

The highlighted area of the ZTV indicates areas likely to be visible from viewing height of 1.7 m. Visibility depends on viewer's elevation (due to terrain) and any landform obstructions between the viewer and the solar.
The assumptions made from the ZTV are;

- The solar farm cannot be seen from King Bay Rd
- The solar farm cannot be seen from Burrup Road north of the Theoretical visibility threshold
- The solar farm cannot be seen from Village Road west of the Theoretical visibility threshold
- The solar farm can be seen from both YPF and YPN
- The solar farm can be seen from Heason Cove Rd

Figure 10, taken on Village Road in proximity to VP06, shows landforms in the foreground, explaining the obstructions west of the theoretical threshold of visibility.

Figure 10 **Taken from Village Road, in proximity to VP06 (Photo: Yara)**

The routes south of the solar farm are not expected to receive any glare, so Heason Cove Rd and Burrup Rd have not been assessed, however OP receptors south of the solar farm have been assessed to demonstrate the validity of this assumption.

Figure 11 shows the extent of the route receptors assessed. The Village Road receptor excludes the section outside the theoretical visibility threshold. Internal access routes of Yara Pilbara Fertiliser (YPF) and Yara Pilbara Nitrates (YPN) Plants have been assessed as three route receptors: YPF Access 1 and 2 and YPN Access.

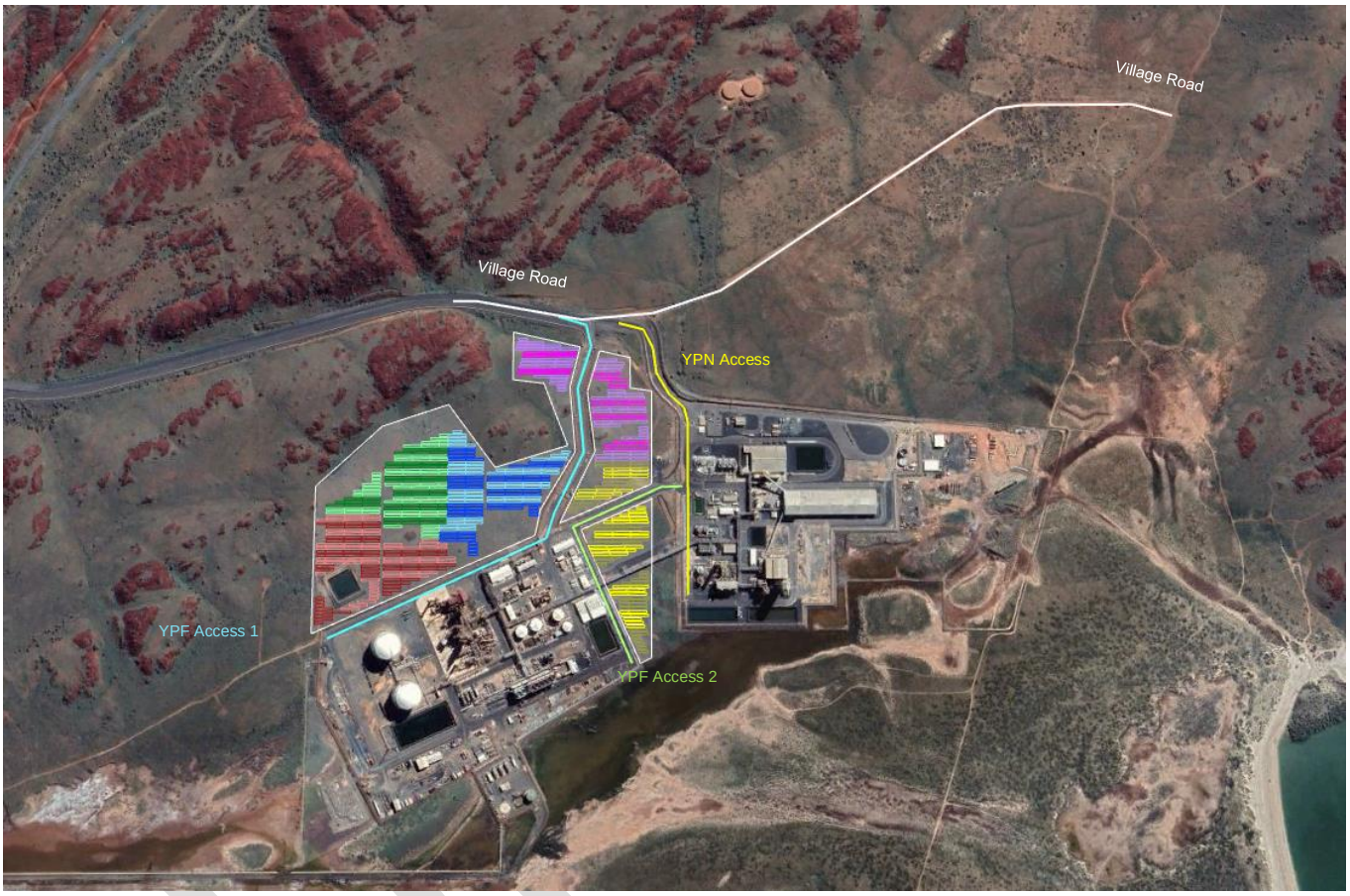

Figure 11 **Route receptors; Village Road and internal YPF and YPN access roads**

The receptors height was set to 2.5m to account for the viewing level of HV operators, it can be assumed LV operators will receive similar or slightly less glare due to having greater obstructions at lower heights. Assumptions are provided in Table 4.

Table 4 **Route Receptors**

Name	Type	Vehicle	Receptor Height	Observer Viewing Angle
Village Road	Industrial Plant /National Park Access Road	HV	2.5 m	50°
YPF Access 1	Internal Access Road	HV	2.5 m	50°
YPF Access 2	Internal Access Road	HV	2.5 m	50°
YPN Access	Internal Access Road	HV	2.5 m	50°

Latitude, longitude and elevation of the route receptors are provided in the Component Data section of the ForgeSolar reports.

3.1.4 Flight path receptors

In the past, the Australian Civil Aviation Safety Authority (CASA) has used guidance from the Federal Aviation Administration (FAA), on solar glare hazard analysis. According to the interim FAA policy October 2013, SGHAT was required to "demonstrate that the proposed solar energy system meets the following standards:

1. No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and

2. No potential for glare or "low potential for after-image" (shown in green in Figure 4**)** along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."

This advice has been reduced in the final policy, May 2021 that FAA "will rely on the airport sponsor to include a statement… that the proposed solar project will not result in ocular (i.e. glint or glare) impacts to the airport's ATCT cab.", and in recent correspondence with CASA, it was advised "there is currently no formal instruction as such in regard to solar glare… simply request that there be an analysis to determine whether there will be any impact on an ATCT".

Despite the easing of advice, and the unlikelihood of glare due to Karratha Airport's location to the solar, GHD conducted the glare analysis on the 2-mile flight receptors and ATCT to validate the assumption there will be no glare.

SGHAT allows a 2-mile flight path receptor to simulate an aircraft's straight-line approach toward a runway. The flight paths were adjusted to reflect Karratha Airport's runway.

Figure 12 Proposed location of YURI Phase 0 Solar Farm and Karratha Airport with 2-mile flight path receptors

This study modelled both final approaches of the Karratha airport, Figure 12. The input parameters are provided in Table 5

Table 5 2-mile flight path receptors

Approach	Direction (° bearing)	Glide slope (°)	Threshold crossing height
Eastern Final Approach	84	3.0	15.24
Western Final Approach	264	3.0	15.24

3.2 Interpretation of results

3.2.1 Glare on vehicle operators

There are no existing Australian Standards on the recommended level of glare from solar panels. Hence, it is at Yara's discretion what is deemed acceptable in reference to glare intensity. GHD recommends that if any glare with the 'potential for permanent eye damage' (see Figure 4) is predicted for vehicle operators, is to be considered a failure criterion.

GHD recommends that any glare with 'potential for after-image' be examined with a risk assessment. The risk assessment process should identify potential risks and frequency and determine the consequences imposed by the risks.

3.2.2 Glare on Air Traffic Controllers

Given CASA advised "request that there be an analysis to determine whether there will be any impact on an ATCT", and additionally that "In the event that a development is constructed, and glare is identified post construction, CASA does have regulations in place that give us the power to require an existing development to be modified, shielded or removed if necessary to resolve a glare issue", GHD recommend that any glare identified at an ATCT be considered a failure criterion.

4. Results

The reports extracted from ForgeSolar are attached in Appendix A, the results are summarised in Table 6. Potential for glare is expressed in total annual hours of either green, yellow or red glare.

Table 6 Potential total annual glare duration (hours) from arrays 1, 2 and 3.

Observer		Receptor Type	Receptor Name	Total annual glare predicted (hrs)		
				Green	Yellow	Red
Tourists, local visitors and traditional owners	Road users	Observation Point Receptors	OP 1	0	0	0
			OP 2	0	0	0
			OP 3	0	0	0
			OP 4	0	0	0
			OP 5	26.3	32.1	0
			OP 6	0	10	0
		Route Receptors	Village HV	26	124.7	0
			YPF Access 1	596.7	371.4	0
			YPF Access 2	0	343.2	0
			YPN Access	0	70.3	0
Karratha Airport		Observation Point Receptors	7-ATCT	0	0	0
		Flight Path Receptors	Eastern Final Approach	0	0	0
			Western Final Approach	0	0	0

Potential total annual glare is the sum of predicted glare duration from arrays 1, 2 and 3, (Table 7). This breakdown is provided in the ForgeSolar reports with details of each receptor's predicted potential glare from each array with intensity, duration and time of day and year glare is likely to occur.

Table 7 Predicted annual glare duration by array

Receptor	Predicted green glare (hrs)				Predicted yellow glare (hrs)			
	Total	PV Array			Total	PV Array		
		1	2	3		1	2	3
Observation point OP 05	26.3	0	26.3	0	32.1	32.1	0	0
Observation point OP 06	0	0	0	0	10	0	10	0
Route receptor Village Road	26	0	26	0	124.7	100.4	24.3	0
Route receptor YPF Access 1	596.7	596.7	0	0	371.5	340.8	0	30.7
Route receptor YPF Access 2	0	0	0	0	343.3	96.2	36.9	210.2
Route receptor YPN Access	0	0	0	0	70.3	65	5.3	0

4.1 Observation point receptors

There was no glare predicted for the observation point receptors 01, 02, 03 and 04. Glare was only predicted for OP 05 and 06.

At OP 05 (VP05 Murujuga National Park), there is potential for yellow glare from array 1 to last up to 20 minutes per day between 5.30pm and 6.30pm from November to February. There is potential for green glare from array 2 with potential to last up to 25 minutes per day between 5.30pm and 6.30pm from November to February.

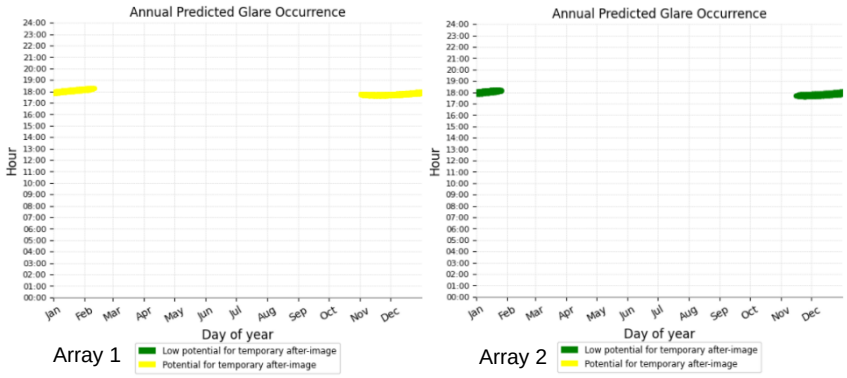

Figure 13 **Predicted annual glare for sensitive visual receptor OP5 (VP05 Murujuga National Park)**

At OP 06 there is potential for yellow glare from array 2, to last about 15 minutes per day between 6.00 and 7.00am in December and January, Figure 14.

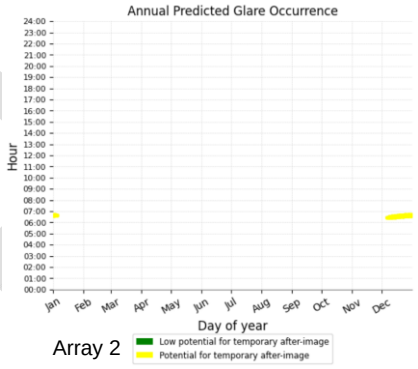

Figure 14 **Predicted annual glare for sensitive visual receptor OP6 (VP06 Village Road)**

4.2 Route Receptors

Route receptors with heights of 2.5m were used to assess the impact glare has on HV and LV operators. The route receptors were assessed as two-way routes with 50° field of view either side of the visual centre line.

The glare duration is the sum of the minutes of glare incurred along the route.

4.2.1 Village Road

Yellow and green glare was predicted for the Village Road route receptor. Potential glare is predicted both mornings November – February and evenings September – March. In January and December, the glare from Array 1 is predicted to last an hour a day. October, November, February and March the duration is expected to be less than 40 minutes. Throughout April to August glare is not predicted.

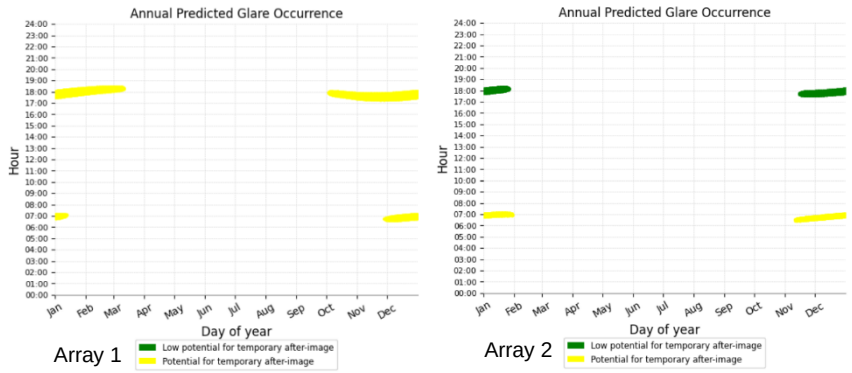

Figure 15 **Predicted annual glare for Village Road Route Receptor**

Most of the glare is expected to occur on Village Road immediately north of arrays 1 and 2, however some green glare is predicted for Village Road in Murujuga National Park near OP5 (VP05).

4.2.2 Roads internal to Yara Pilbara Fertiliser and Nitrates Plants

4.2.2.1 YPF Access 1

Yellow glare and green glare were predicted for the YPF Access 1 route receptor.

From array 1, through October - April, green glare is predicted to occur in the afternoon, approximately 1pm onward. Green glare duration is expected to be greatest, through November – February, lasting for several hours. There is potential for up to an hour of green glare to occur June and July. Yellow glare is predicted to occur throughout the year every evening, as early as 4.30pm October – March and from 5.30pm April - September.

Yellow glare is predicted to last for approximately 15minutes in the morning (6.00am – 7.00am) during October – March from array 3.

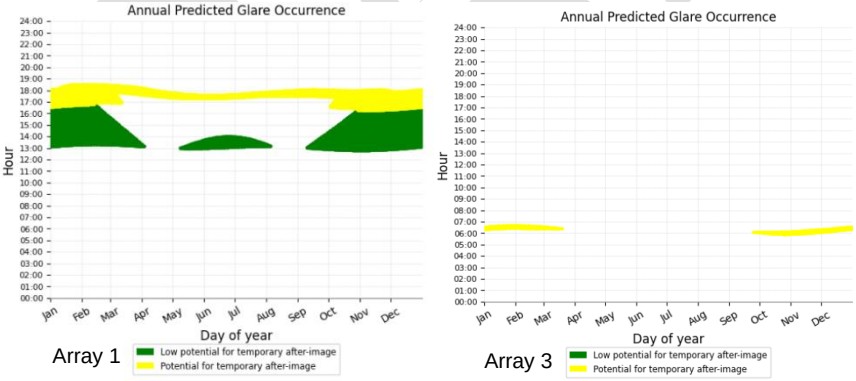

Figure 16 **Predicted annual glare for YPF Access 1 route receptor**

4.2.2.2 YPF Access 2

Yellow glare was predicted for the YPF Access 2 route receptor, Figure 17.

Yellow glare is predicted to last for up to 30 minutes in the evening (5.30pm – 6.30pm) during August – April (from arrays 1, 2 and 3).

Yellow glare from array 3 is predicted to last for over 90 minutes in the mornings in October - March, 6.00 am – 8.00 am.

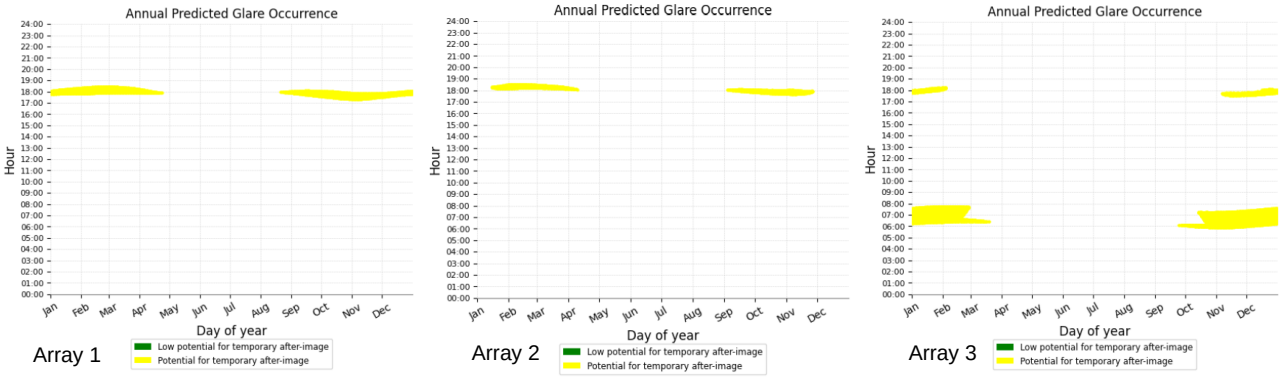

Figure 17 **Predicted annual glare for YPF Access 2 route receptor**

4.2.2.3 YPN Access

Yellow glare was predicted for the YPN Access route receptor.

Yellow glare is predicted to occur most evenings October - April from array 1 or 2. It is generally expected to last less than 20 minutes.

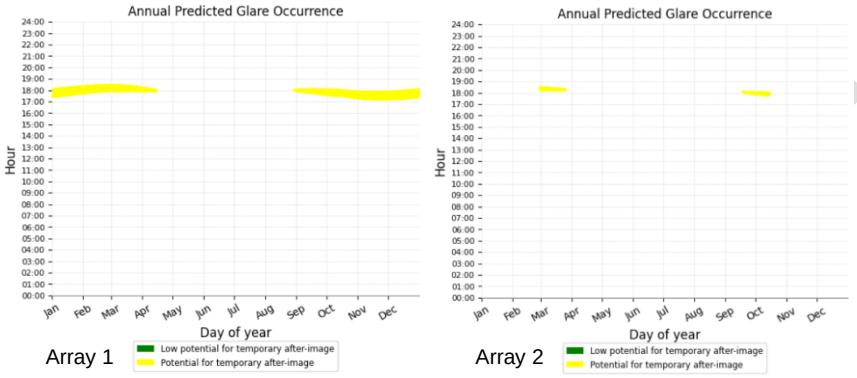

Figure 18 **Predicted annual glare for YPN Access route receptor**

4.3 Karratha Airport

There was no glare predicted for Karratha Airport ATCT or for either final approach flight paths.

4.4 Photographic Assessment

The elevation of the YPF and YPN access roads in relation to that of the land proposed for the solar farm is quite variable.

Figure 19 **Photo viewpoints**

Photos provided from Yara at the viewpoints show in Figure *19* help to illustrate this.

Figure 20 **Viewpoint A (Village Road) looking southeast at land proposed for array 1 and 2, photo: Yara**

Photos taken from viewpoint A (Figure 20) shows there is a generally unobstructed view to the land area proposed for the northern parts of arrays 1 and 2.

Figure 21 **Viewpoint B (YPF Access 1) looking southwest at land proposed for array 1, photo: Yara**

Photos taken from viewpoint B (Figure 21) shows there is a generally unobstructed view to the land area proposed for the southern parts of array 1.

Figure 22 **Viewpoint B (YPF Access 1) looking northeast at land proposed for array 2, photo: Yara**

Figure 22 at viewpoint B, shows the elevation of the land proposed for array 2 is very high relative to the YPF Access 1 route. This is likely to obstruct any glare from array 2 for the YPF Access 1 route.

Figure 23 **Viewpoint C (YPF Access 1) looking southwest at land proposed for array 1, photo: Yara**

Figure 23 at viewpoint C, shows there are generally unobstructed views to the land area proposed for southern parts of array 1.

Figure 24 **Viewpoint C (YPF Access 1) looking southeast at land proposed for array 2, photo: Yara**

Figure 24 at viewpoint C, shows there are unobstructed views to the land area proposed for array 2.

Figure 25 **Viewpoint D (YPF Access 1) looking west at land proposed for array 1, photo: Yara**

Figure 25 at viewpoint D, shows there are generally unobstructed views to the land area proposed for the southern part of array 1.

Figure 26 **Viewpoint D (YPF Access 1) looking east at land proposed for array 2, photo: Yara**

Figure 26 at viewpoint D, shows there are generally unobstructed views to the land area proposed for array 2.

E F G H

Figure 27 **Viewpoints E, F, G and H (YPF Access 1) looking east at land proposed for array 1, photo: Yara**

Figure 27; viewpoints E, F, G and H along the YPF Access 1 route, shows the elevation of the land proposed for array 1 ranging from fairly level (E), increasing to high (H) relative to the route.

Figure 28 **Viewpoint I (YPF Access 2) looking southwest at land proposed for array 3, photo: Yara**

Figure 28 at viewpoint I, shows there are unobstructed views to the land area proposed for array 3.

Figure 29 **Viewpoint J (YPF Access 2) looking south at land proposed for array 3, photo: Yara**

Figure 29 at viewpoint J, shows there are unobstructed views to the land area proposed for array 3.

Figure 30 **Viewpoint K (YPN Access) looking south at land proposed for array 2, photo: Yara**

Figure 30 at viewpoint K, shows there are unobstructed views to the land area proposed for array 2.

Figure 31 **Viewpoint L (YPN Access) looking south at land proposed for array 2, photo: Yara**

Figure 31 at viewpoint L, shows the elevation of the land proposed for array 2 is quite high relative to the YPN Access route.

Figure 32 **Viewpoint M (YPN Access) looking west at land proposed for array 2, photo: Yara**

Figure 32 at viewpoint M, shows the elevation of the land proposed for array 2 is very high relative to the YPN Access route.

5. Conclusions

From the results, it is concluded that the low sun angle in the morning creates potential yellow glare for receptors to the north - west of the solar arrays. In the evening, low sun angle creates potential yellow glare for receptors to the north - east of the solar arrays. It is also noted that green glare can occur during the day.

Landforms obstruct glare from the solar farm for route west of the solar farm - Zone of Theoretical Visibility (Figure 9). Receptors to the south of the solar farm, due to the fixed angle of the solar panels facing north, are not at risk of potential glare.

Sections of routes throughout the Yara Pilbara Fertilisers and Nitrate Plants are low lying relative to the surrounding land proposed for the solar farm and likely to be obstructed from glare.

5.1 No red glare predicted

The ForgeSolar SGHAT predicted no potential for red glare at any receptor, hence there is no potential for permanent eye damage. The hazard plots generated by ForgeSolar show the glare potential from YURI Phase 0 Solar Farm has lower intensity than that of the sun.

5.2 Yellow glare predicted at sensitive visual receptors

Yellow (and green) glare was only predicted for the observation point receptors OP 05 and 06 (Murujuga National Park and Village Road). Observation point receptors OP 01, 02, 03 and 04 are south of the solar farm and do not receive any glare.

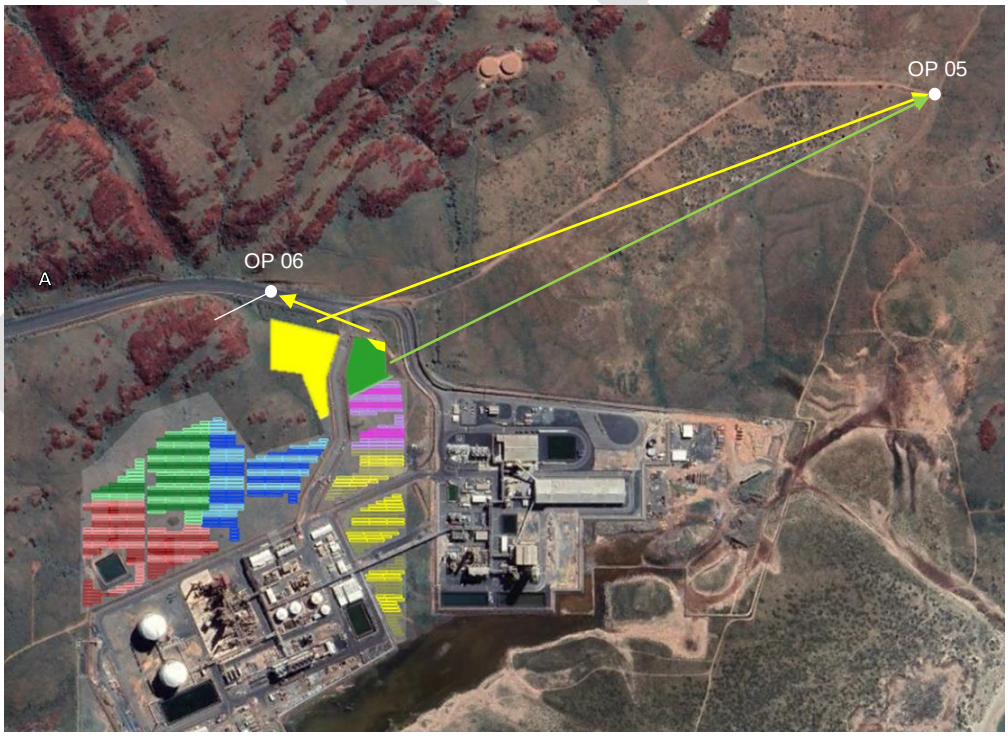

Figure 33 **Potential yellow and green glare for receptors OP 05 and OP 06 superimposed on satellite image of site.**

Figure 33, the potential yellow and green glare predicted for OP 05 (Murujuga National Park) is caused by the northern part of arrays 1 and 2 reflecting the evening sun.

The potential glare for OP 06 (Village Road) is predicted to be caused by the small northeast corner of array 2 reflecting the morning sun.

5.3 Glare predicted for roads

Roads in the general proximity of YURI Phase 0 Solar Farm were considered for potential glare. Burrup, King Bay and the first kilometre of Village Road are outside the Zone of Theoretical Visibility (Figure 9), so were dismissed of being at risk for glare. Terrain between the solar farm and the roads obstruct the line of sight. Roads to the south of the solar farm are not at risk of potential glare as the solar farm's panels are to be mounted with fixed tilt to the north.

5.3.1 Glare predicted for Village Road

The remainder of Village Road falls within the Zone of Theoretical Visibility (Figure 9), a route receptor predicted glare for sections along Village Road. The source of the glare is predicted to be from the northern sections of arrays 1 and 2.

Vehicles travelling east along Village Road (to Murujuga National Park or Yara Pilbara Plants) are likely to experience glare in the morning November – February. Vehicles travelling west along Village Road (returning from Murujuga National Park or Yara Pilbara Plants) are likely to experience glare in the evenings through September – March.

Figure 34 **Yellow and green glare predicted for Village Road (clouded white) and glare source from arrays 1 and 2 superimposed on satellite image**

Photos taken from viewpoint A shows there is a generally unobstructed view to the land area proposed for the northern parts of arrays 1 and 2. However due to the fairly level viewpoint, it is expected only the first few rows of solar panels is likely to cause glare here (the rows behind will be obstructed). This is generally reflected by the SGHAT results which suggest only the northern most parts of arrays 1 and 2 have potential for creating glare.

5.3.2 Glare predicted for Roads internal to Yara Pilbara Plants

Roads internal to Yara Pilbara Fertiliser and Nitrates Plants receive glare as solar panels are both east and west of some routes. It is noted that external to security gates, speed limits are enforced at 40km/hr and internal to the Plants to 20km/hr on these routes. Vehicles travelling in a north direction on these routes will not experience glare due to the solar panel's north orientation.

5.3.2.1 Afternoon glare predicted year around for YPF Access 1

From array 1 for YPF Access 1, most of the year, green glare is predicted to occur afternoon onwards, yellow glare is predicted for the evenings. This is expected to impact vehicles travelling south, into Yara Pilbara Fertilisers. Vehicles travelling north along this route will be shielded from glare due to the north facing solar panels. Array 3 is expected to contribute only briefly to glare during mornings October – March.

Figure 35 **Yellow and green glare predicted for YPF Access 1 (clouded white) and glare source from arrays 1 and 3 superimposed on satellite image**

Photos taken at viewpoint B; Figure 21, viewpoint C; Figure 23, viewpoint D; Figure 25 and viewpoints E, F, G and H; Figure 27 shows there are generally unobstructed views of the land proposed for southern parts of array 1. The SGHAT generally reflect this showing the majority of glare from the southern part of array 1.

Land proposed for northern parts of array 2, Figure 22 at viewpoint B is very high relative to the YPF Access 1 route hence vehicles are likely to be shielded from any glare from array 2 in this location.

Although viewpoint C; Figure 24 and viewpoint D; Figure 26 show there are unobstructed views to the land area proposed for array 2, the SGHAT results didn't predict any glare from array 2 for the YPF Access 1 route receptor.

It is probable any glare created by this section of array 2 is outside of the receptors field of view (50° either side of visual centre line). It must be noted that glare from array 2 cannot be discounted for pedestrians looking directly at the solar panels from this viewpoint.

Array 3 was predicted to contribute glare along the YPF Access 1 route; however it is likely that the fertiliser plant infrastructure will obstruct most of the predicted glare from reaching vehicles travelling east (northeast) on the southern part of this route.

5.3.2.2 Morning glare predicted October to March YPF Access 2,

YPF Access 2, is predicted to receive yellow glare from array 3, mornings October - March and from all arrays for the evenings August – April. This will impact vehicles travelling both directions along this route

Figure 36 **Yellow glare predicted for YPF Access 2 (clouded white) and glare source from arrays 1, 2 and 3 superimposed on satellite image**

Array 1 was predicted to contribute glare along the YPF Access 2 route; however it is likely that the fertiliser plant infrastructure will obstruct most of the predicted glare from reaching vehicles travelling north (northwest) on the southern part of this route.

Photos taken at viewpoint I; Figure 28 and viewpoint J; Figure 29 shows there are unobstructed views to the land area proposed for array 3. As predicted by the SGHAT results, Figure 36, there is potential for glare from solar panels to occur here.

5.3.2.3 Afternoon glare predicted October to May for YPN Access

As access to Yara Pilbara Nitrates Plant is east of the solar farm, glare is only predicted for this route in the evenings from arrays 1 and 2.

Figure 37 **Yellow glare predicted for YPN Access (clouded white) and glare source from arrays 1 and 2 superimposed on satellite image**

Photos taken at viewpoint K; Figure 30 shows there are unobstructed views to the land area proposed for array 2. As predicted by the SGHAT results, Figure 36, there is potential for glare from solar panels to occur at the northern section of the YPN Access route.

Figure 31 at viewpoint L, Figure 32 at viewpoint M, shows the elevation of the land proposed for array 2 is quite high relative to the YPN Access route. This is likely to obstruct any glare from array 2 for the YPN Access route. This is reflected by the SGHAT not detecting any glare at viewpoints L and M along the YPN Access route.

5.4 No glare predicted at the airport

There was no glare found for Karratha Airport or for either flight path final approaches. Its concluded this is due to being located a significant distance south of the solar farm.

6. Recommendations

Based on the SGHAT results, GHD makes the following recommendations:

With regards to the glare predicted at sensitive visual receptors VP (OP) 05 Murujuga National Park and VP (OP) 06 Village Road, GHD recommends:

- consultation with the relevant stake holders; Shire of Karratha, custodians of Murujuga National Park and Burrup Industrial Park to ensure that visitors are made aware of the potential glare intensity, duration and occurrence; and
- risk assessment to determine whether planting of vegetation or installation of glare screening would be necessary along the northern section of the solar farm on Village Road. Note, this would not prevent glare at OP05. A site visit would be required to confirm locations screening.

With regards to the glare predicted for internal roads at Yara Pilbara Fertilisers and Nitrate Plants; It is acknowledged, that the potential glare will not have greater intensity of existing reflective surfaces around the plants such as bodies of water. It is also noted that enforced speed limits will reduce the risk of glare contributing to vehicle incidents, however GHD does recommend:

- sunglass enforcement for vehicle operators
- risk assessment considering shift patterns and staff movements to determine whether planting of vegetation or installation of glare screening would be necessary along internal roads. A site visit would be required to confirm locations screening, for example Figure 38.

Figure 38 **Glare screen placement example, specific locations will need to be confirmed.**

With regards to Karratha Airport:

- Although there is no glare predicted at Karratha Airport, GHD recommends consultation with City of Karratha Airport Management to advise of Yara's intention to develop YURI Phase 0 Solar Farm and verify the flight paths assessed are representative of the air traffic.

7. References

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Federal Aviation Administration, DOT (May 2021) Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports, https://www.federalregister.gov/documents/2021/05/11/2021-09862/federal-aviation-administration-policy-review-of-solar-energy-system-projects-on-federally-obligated

Rogers, J. A., et al. (2015). "Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach", Federal Aviation Administration

Yellowhair, J. and C.K. Ho. "Assessment of Photovoltaic Surface Texturing on Transmittance Effects and Glint/Glare Impacts". ASME 2015 9th International Conference on Energy Sustainability collocated with the ASME 2015 Power Conference, the ASME 2015 13th International Conference on Fuel Cell Science, Engineering and Technology, and the ASME 2015 Nuclear Forum. 2015. American Society of Mechanical Engineers

Appendix A

ForgeSolar Glare Analysis Reports

FORGESOLAR GLARE ANALYSIS

Project: **Yuri Solar Farm**
Site configuration: **Yara Pilbara**

Client: Yara

Created 23 Jun, 2022
Updated 05 Jul, 2022
Time-step 1 minute
Timezone offset UTC8
Site ID 71145.12562
Category 10 MW to 100 MW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
Methodology V2

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
Array 1	15.0	0.0	35,801	596.7	38,074	634.6	30,370,000.0
Array 2	15.0	0.0	3,134	52.2	4,586	76.4	7,473,000.0
Array 3	15.0	0.0	0	0.0	14,452	240.9	5,542,000.0

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Village Rd	1,558	26.0	7,484	124.7
YPF Access 1	35,801	596.7	22,287	371.4
YPF Access 2	0	0.0	20,594	343.2
YPN Access	0	0.0	4,220	70.3
Eastern Final Approach	0	0.0	0	0.0
Western Final Approach	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	1,576	26.3	1,929	32.1

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
OP 6	0	0.0	598	10.0
7-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: Array 1
Axis tracking: Fixed (no rotation)
Tilt: 15.0°
Orientation: 0.0°
Rated power: 12600.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-20.620402	116.782294	20.50	1.20	21.70
2	-20.620698	116.783646	17.00	1.20	18.20
3	-20.621496	116.783389	16.25	1.20	17.45
4	-20.622742	116.783501	11.25	1.20	12.45
5	-20.623846	116.782858	9.00	1.20	10.20
6	-20.624353	116.782745	7.75	1.20	8.95
7	-20.626105	116.778368	8.50	1.20	9.70
8	-20.623349	116.778357	25.25	1.20	26.45
9	-20.622214	116.779666	29.50	1.20	30.70
10	-20.621823	116.780991	31.75	1.20	32.95
11	-20.623013	116.781967	14.25	1.20	15.45
12	-20.622611	116.783421	12.00	1.20	13.20
13	-20.621421	116.782927	16.00	1.20	17.20
14	-20.621341	116.782278	20.50	1.20	21.70

Name: Array 2
Axis tracking: Fixed (no rotation)
Tilt: 15.0°
Orientation: 0.0°
Rated power: 3100.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-20.620796	116.784057	16.50	1.20	17.70
2	-20.620924	116.784655	14.50	1.20	15.70
3	-20.621527	116.784674	15.00	1.20	16.20
4	-20.621574	116.785095	12.75	1.20	13.95
5	-20.623309	116.785077	7.50	1.20	8.70
6	-20.623924	116.783538	8.75	1.20	9.95
7	-20.623804	116.783447	8.75	1.20	9.95
8	-20.622772	116.784035	12.50	1.20	13.70
9	-20.621459	116.783882	20.50	1.20	21.70

Name: Array 3
Axis tracking: Fixed (no rotation)
Tilt: 15.0°
Orientation: 0.0°
Rated power: 2300.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-20.623635	116.785088	7.00	1.20	8.20
2	-20.626597	116.785070	3.25	1.20	4.45
3	-20.626682	116.784844	3.25	1.20	4.45
4	-20.624182	116.783669	7.75	1.20	8.95

Route Receptors

Name: Village Rd
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-20.619835	116.781785	33.64	2.50	36.14
2	-20.620176	116.784022	21.63	2.50	24.13
3	-20.619945	116.785626	18.26	2.50	20.76
4	-20.619493	116.786698	18.41	2.50	20.91
5	-20.616296	116.791859	15.86	2.50	18.36
6	-20.615964	116.792535	15.45	2.50	17.95
7	-20.615884	116.793061	14.99	2.50	17.49
8	-20.615869	116.794874	13.14	2.50	15.64
9	-20.615929	116.795260	13.85	2.50	16.35
10	-20.616130	116.795867	15.63	2.50	18.13
11	-20.616115	116.796097	16.30	2.50	18.80

Name: YPF Access 1
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-20.620145	116.783721	19.00	2.50	21.50
2	-20.620383	116.783876	18.25	2.50	20.75
3	-20.620637	116.783906	17.25	2.50	19.75
4	-20.621530	116.783605	16.25	2.50	18.75
5	-20.622836	116.783713	11.25	2.50	13.75
6	-20.623970	116.783058	6.75	2.50	9.25
7	-20.624402	116.782962	5.75	2.50	8.25
8	-20.626149	116.778681	5.75	2.50	8.25

Name: YPF Access 2
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-20.626541	116.784646	5.75	2.50	8.25
2	-20.624131	116.783487	5.75	2.50	8.25
3	-20.623408	116.785279	6.25	2.50	8.75
4	-20.623408	116.785740	5.75	2.50	8.25

Name: YPN Access
Path type: Two-way
Observer view angle: 50.0°

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-20.620180	116.784024	17.75	2.50	20.25
2	-20.620295	116.784871	14.75	2.50	17.25
3	-20.620496	116.785075	13.25	2.50	15.75
4	-20.621028	116.785150	9.25	2.50	11.75
5	-20.621450	116.785279	7.00	2.50	9.50
6	-20.621832	116.785698	5.75	2.50	8.25
7	-20.622113	116.785858	5.75	2.50	8.25
8	-20.625878	116.785826	5.75	2.50	8.25

Flight Path Receptors

Name: Eastern Final Approach
Description:
Threshold height: 15 m
Direction: 264.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-20.711755	116.786228	6.71	15.24	21.95
Two-mile	-20.708732	116.817005	6.53	184.11	190.63

Name: Western Final Approach
Description:
Threshold height: 15 m
Direction: 84.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-20.713993	116.764910	11.88	15.24	27.12
Two-mile	-20.717015	116.734133	0.00	195.81	195.81

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-20.635631	116.768505	7.29	1.70
OP 2	2	-20.633122	116.777272	10.81	1.70
OP 3	3	-20.636859	116.788776	26.35	1.70
OP 4	4	-20.633517	116.797467	8.19	1.70
OP 5	5	-20.616130	116.796146	16.44	1.70
OP 6	6	-20.619857	116.782356	30.15	1.70
7-ATCT	7	-20.708319	116.774170	9.00	20.00

Map image of 7-ATCT

Glare Analysis Results

Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
Array 1	15.0	0.0	35,801	596.7	38,074	634.6	30,370,000.0
Array 2	15.0	0.0	3,134	52.2	4,586	76.4	7,473,000.0
Array 3	15.0	0.0	0	0.0	14,452	240.9	5,542,000.0

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Village Rd	1,558	26.0	7,484	124.7
YPF Access 1	35,801	596.7	22,287	371.4
YPF Access 2	0	0.0	20,594	343.2
YPN Access	0	0.0	4,220	70.3
Eastern Final Approach	0	0.0	0	0.0
Western Final Approach	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	1,576	26.3	1,929	32.1
OP 6	0	0.0	598	10.0
7-ATCT	0	0.0	0	0.0

PV: Array 1 potential temporary after-image

Receptor results ordered by category of glare

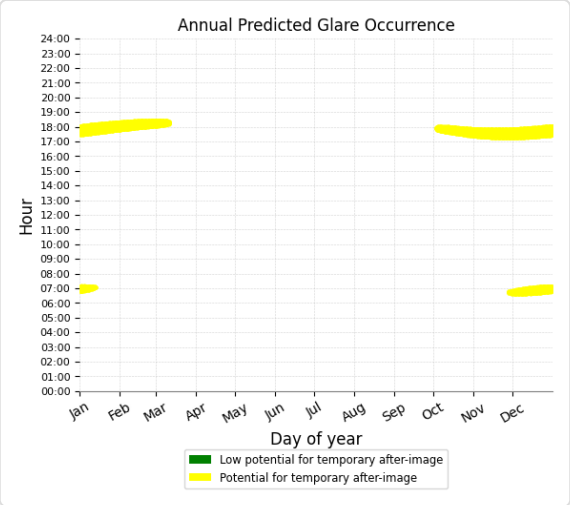
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Village Rd	0	0.0	6,025	100.4
YPF Access 1	35,801	596.7	20,446	340.8
YPF Access 2	0	0.0	5,772	96.2
YPN Access	0	0.0	3,902	65.0
Eastern Final Approach	0	0.0	0	0.0
Western Final Approach	0	0.0	0	0.0
OP 5	0	0.0	1,929	32.1
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
7-ATCT	0	0.0	0	0.0

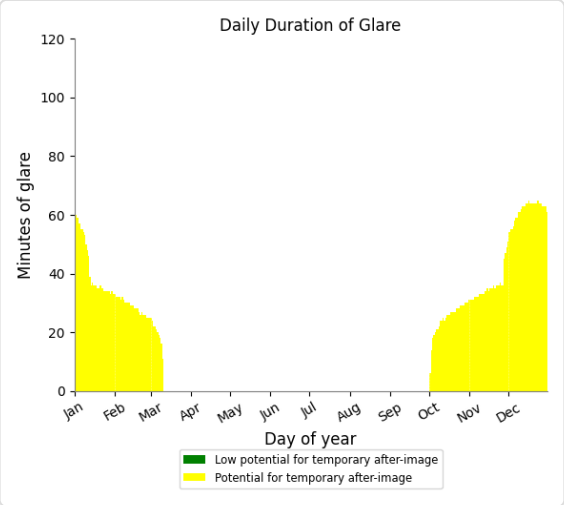
Array 1 and Village Rd

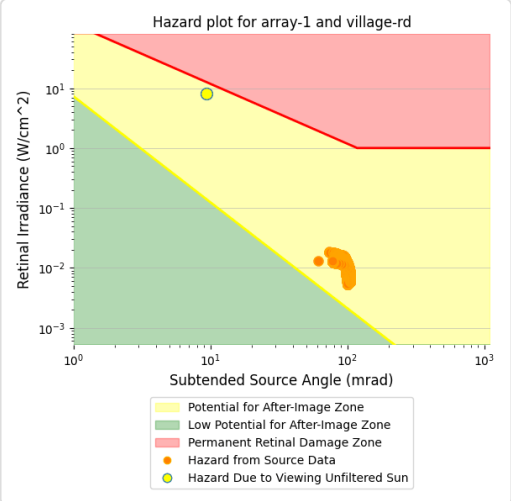
Receptor type: Route

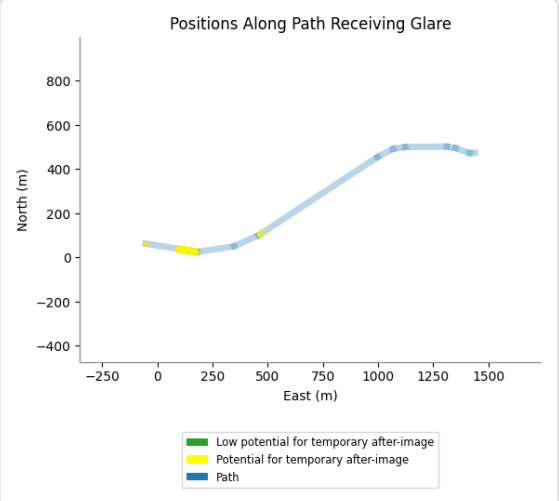
6,025 minutes of yellow glare

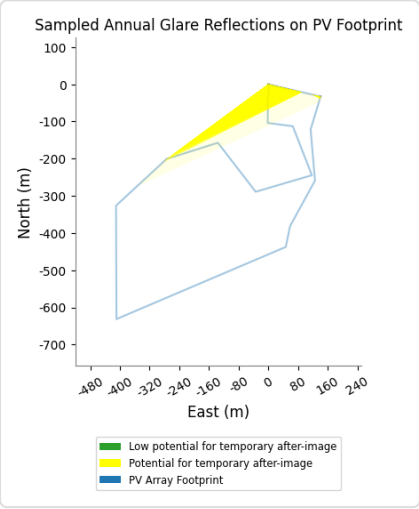
0 minutes of green glare









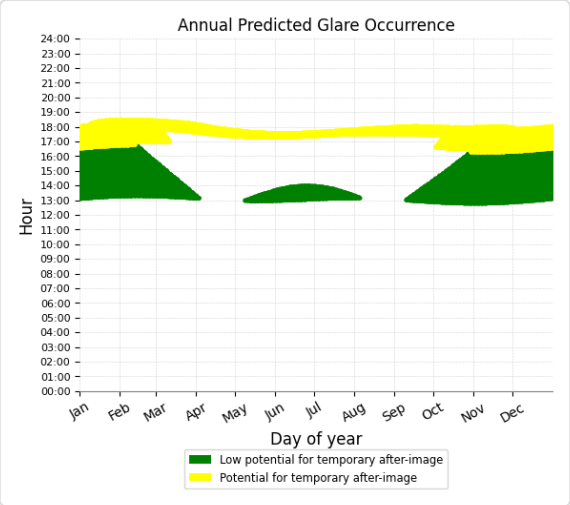


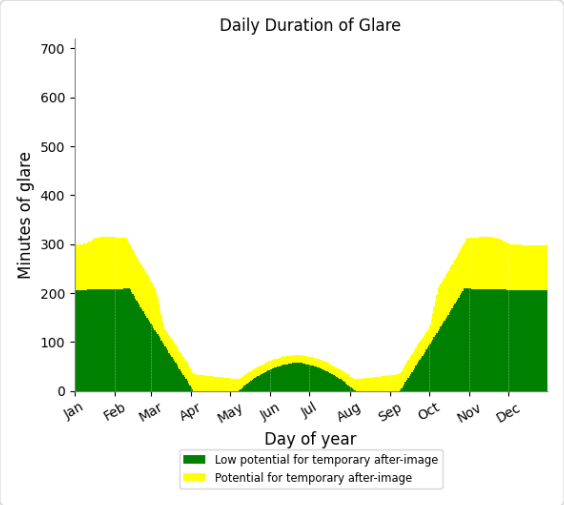
Array 1 and YPF Access 1

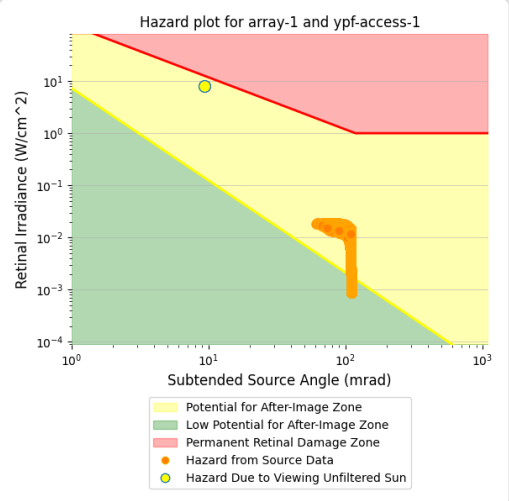
Receptor type: Route

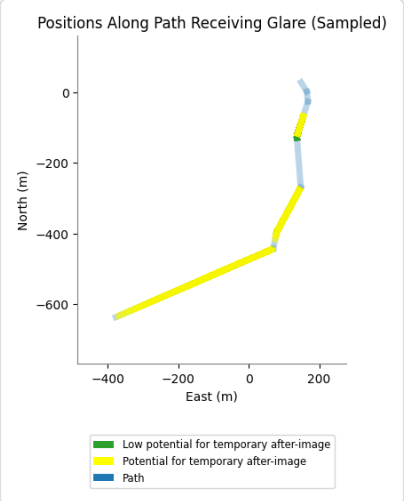
20,446 minutes of yellow glare

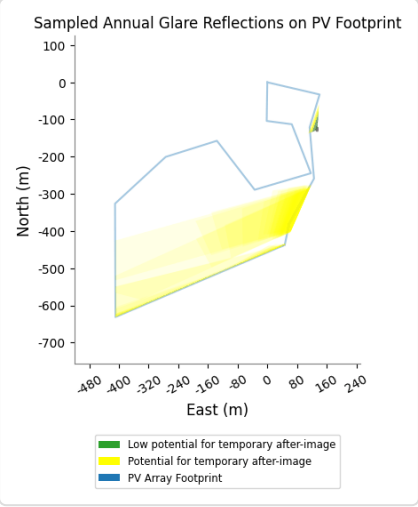
35,801 minutes of green glare









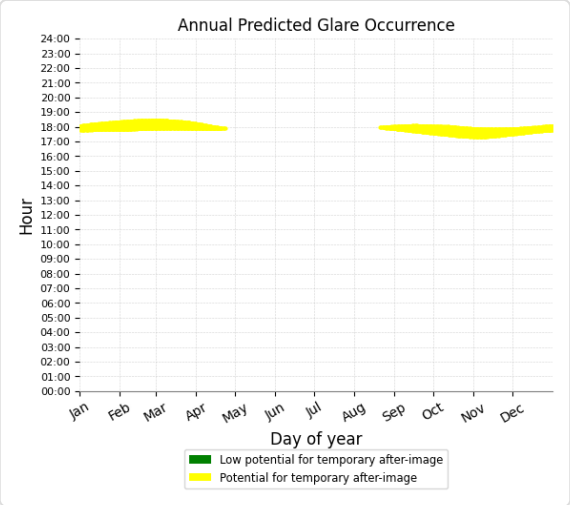


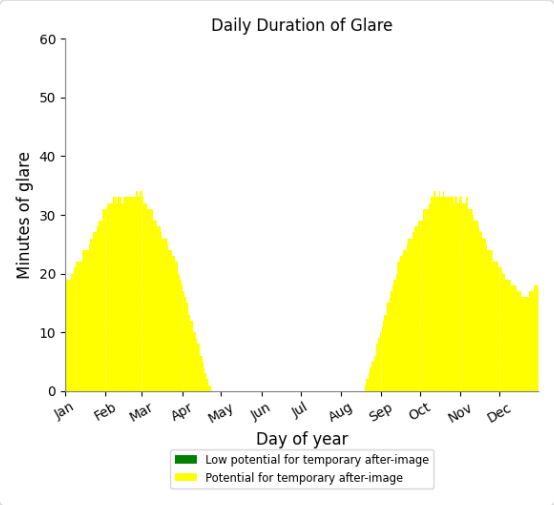
Array 1 and YPF Access 2

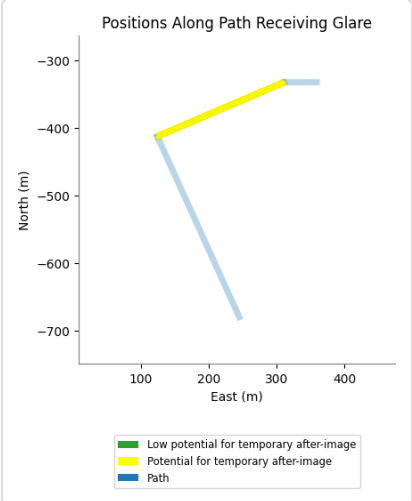
Receptor type: Route

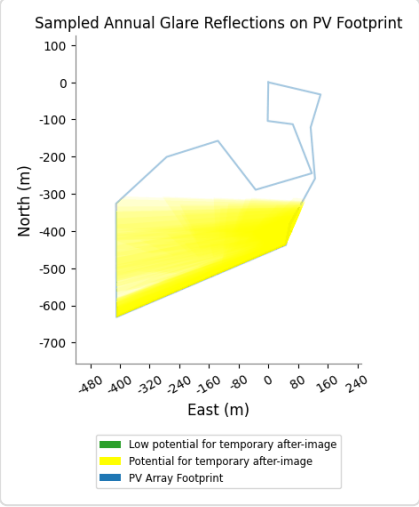
5,772 minutes of yellow glare

0 minutes of green glare







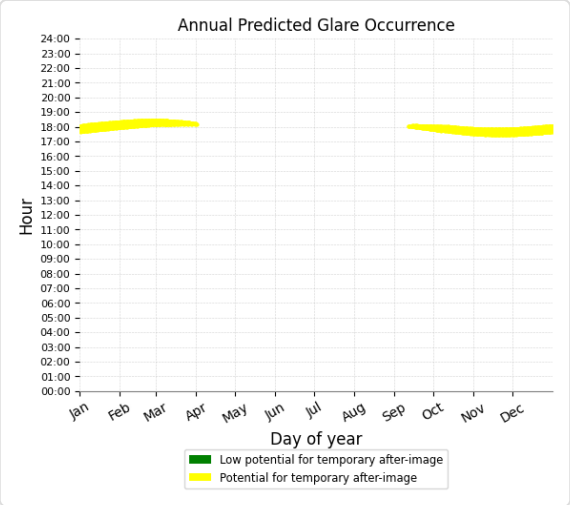


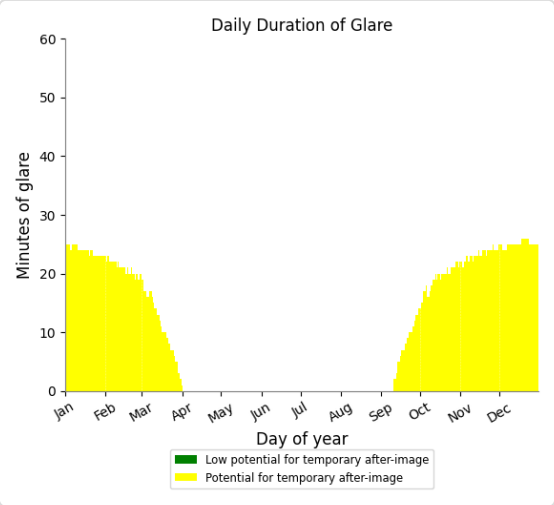
Array 1 and YPN Access

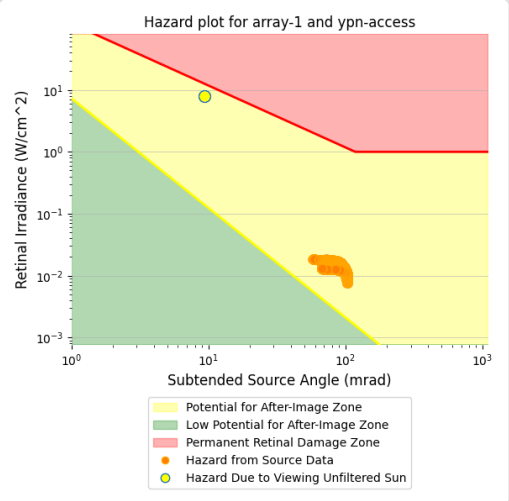
Receptor type: Route

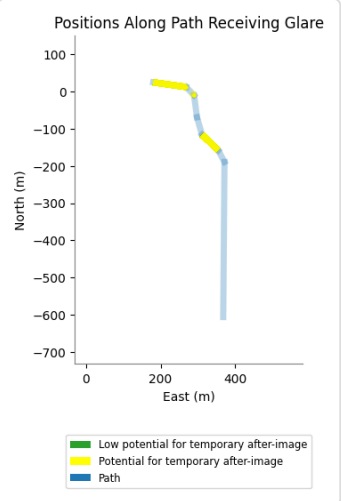
3,902 minutes of yellow glare

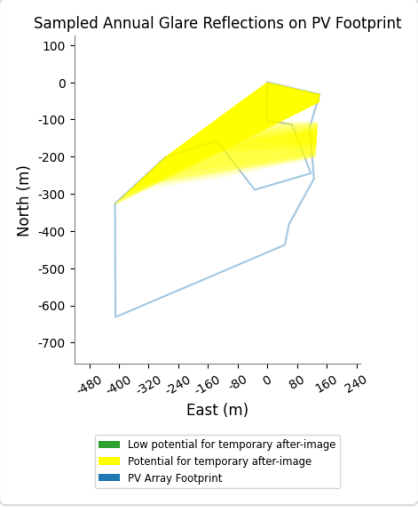
0 minutes of green glare











Array 1 and Eastern Final Approach

Receptor type: 2-mile Flight Path

No glare found

Array 1 and Western Final Approach

Receptor type: 2-mile Flight Path

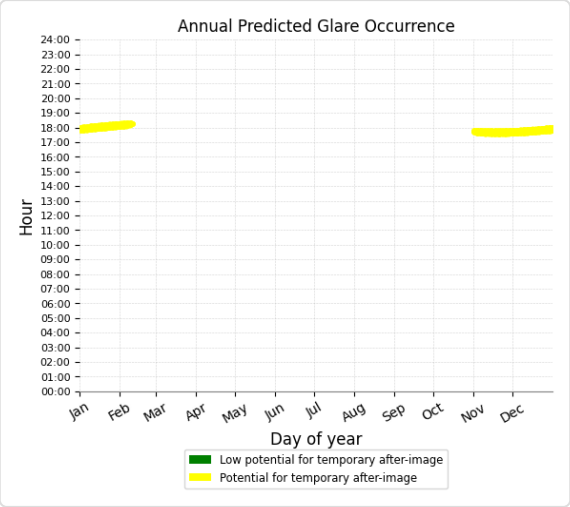
No glare found

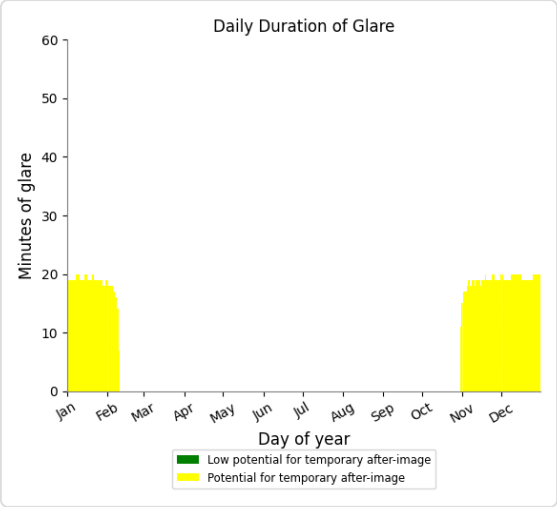
Array 1 and OP 5

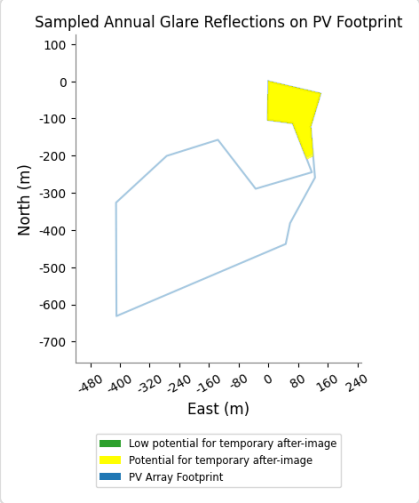
Receptor type: Observation Point

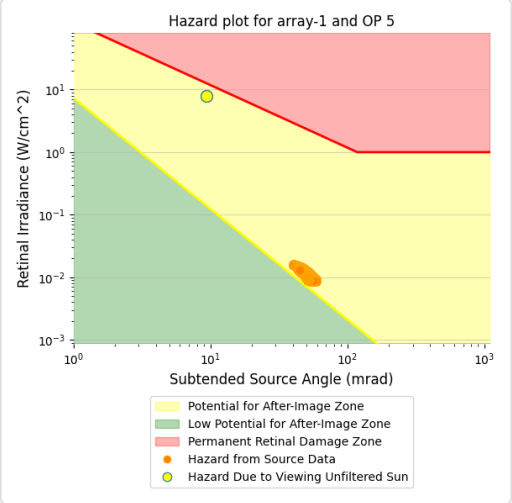
1,929 minutes of yellow glare

0 minutes of green glare









Array 1 and OP 1

Receptor type: Observation Point

No glare found

Array 1 and OP 2

Receptor type: Observation Point

No glare found

Array 1 and OP 3

Receptor type: Observation Point

No glare found

Array 1 and OP 4

Receptor type: Observation Point

No glare found

Array 1 and OP 6

Receptor type: Observation Point
No glare found

Array 1 and 7-ATCT

Receptor type: Observation Point
No glare found

PV: Array 2 potential temporary after-image

Receptor results ordered by category of glare

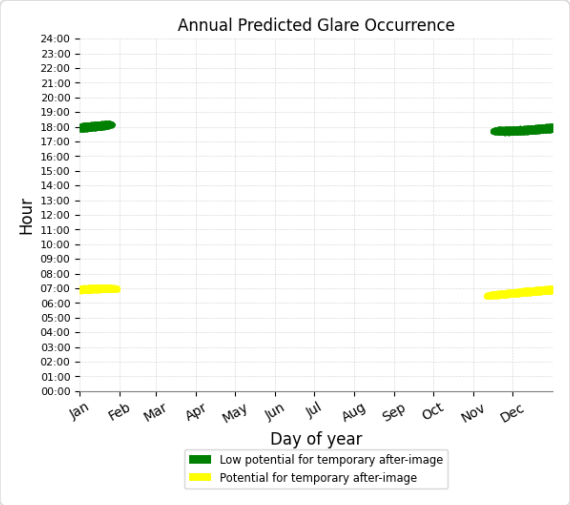
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
Village Rd	1,558	26.0	1,459	24.3
YPF Access 2	0	0.0	2,211	36.9
YPN Access	0	0.0	318	5.3
YPF Access 1	0	0.0	0	0.0
Eastern Final Approach	0	0.0	0	0.0
Western Final Approach	0	0.0	0	0.0
OP 6	0	0.0	598	10.0
OP 5	1,576	26.3	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
7-ATCT	0	0.0	0	0.0

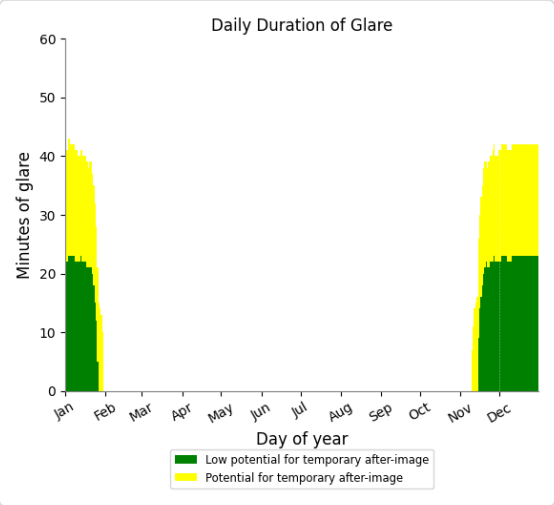
Array 2 and Village Rd

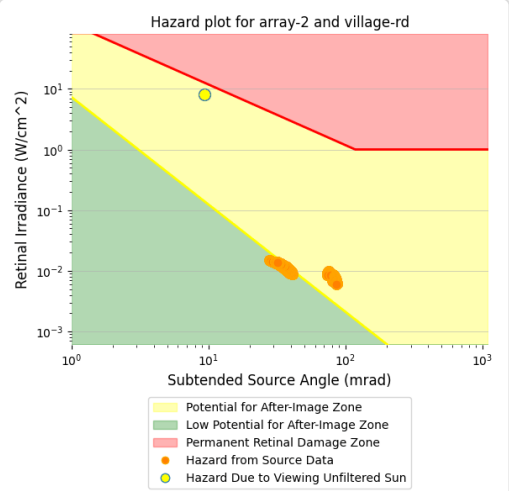
Receptor type: Route

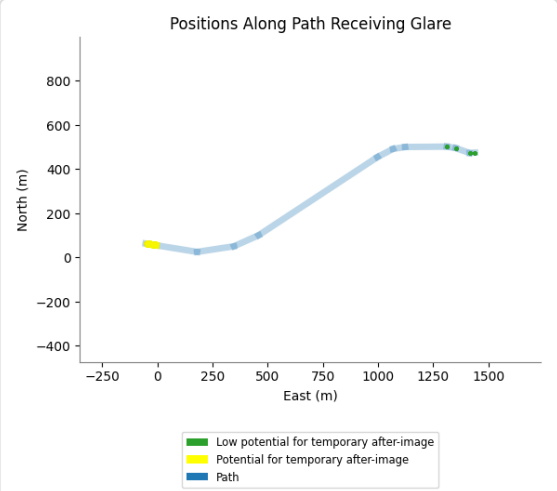
1,459 minutes of yellow glare

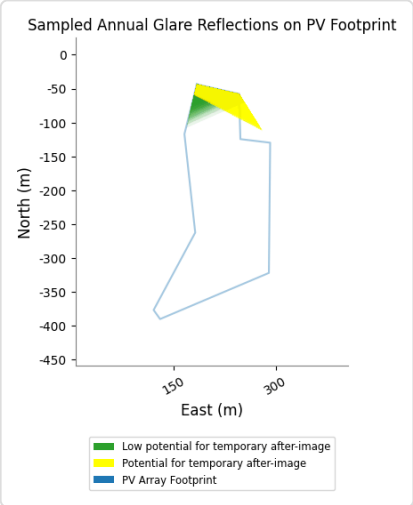
1,558 minutes of green glare









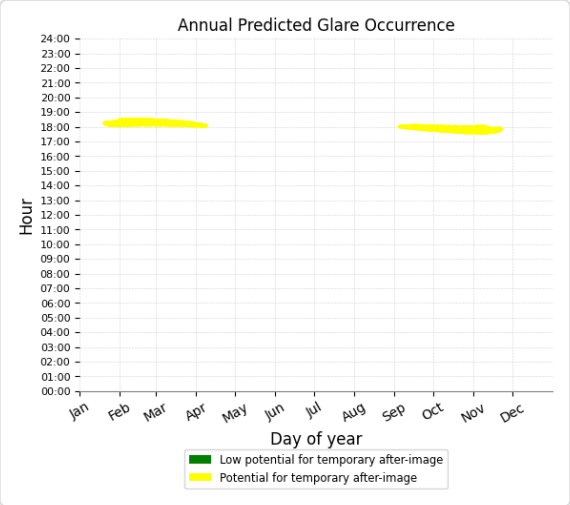


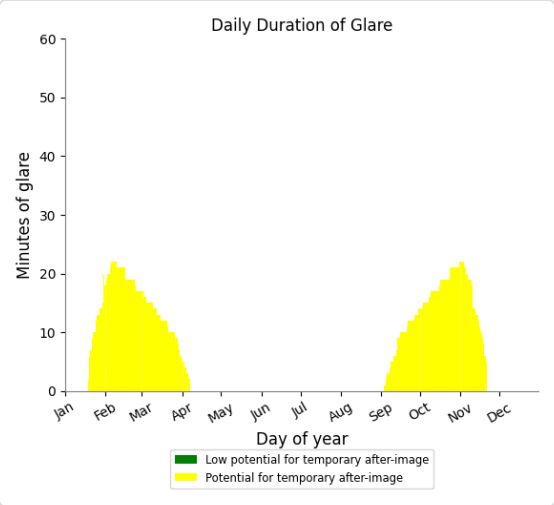
Array 2 and YPF Access 2

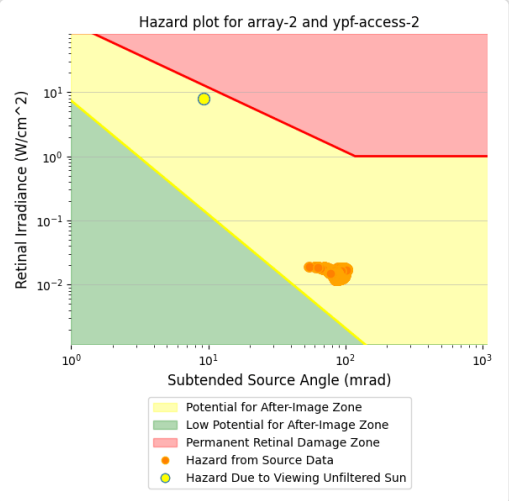
Receptor type: Route

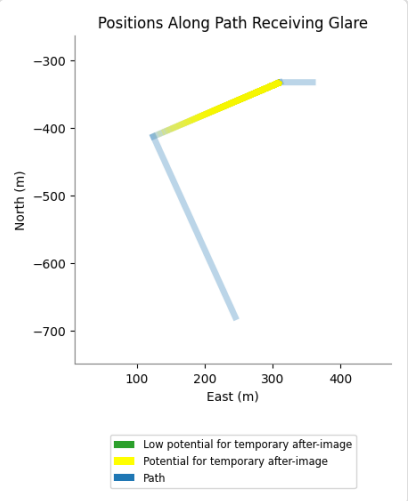
2,211 minutes of yellow glare

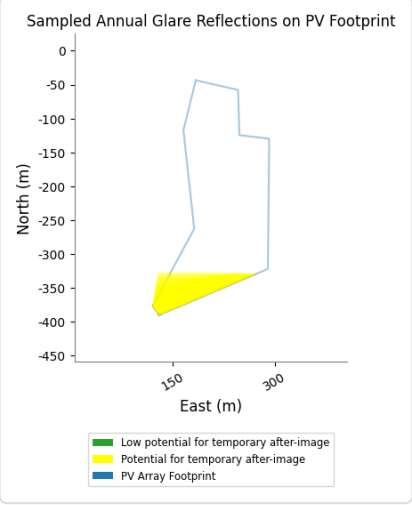
0 minutes of green glare









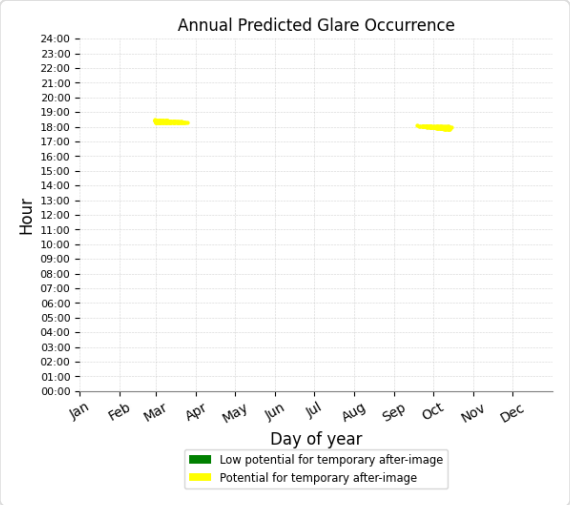


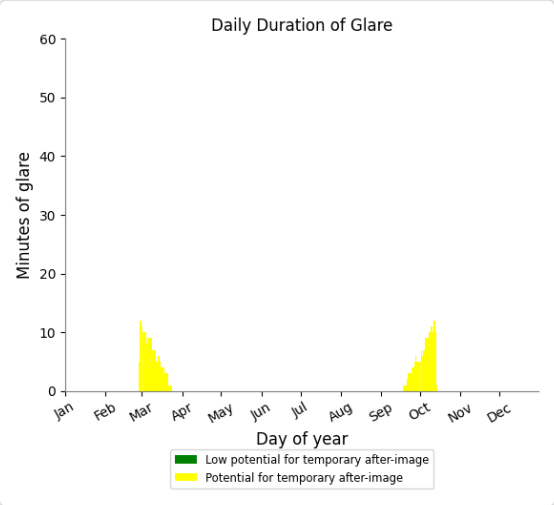
Array 2 and YPN Access

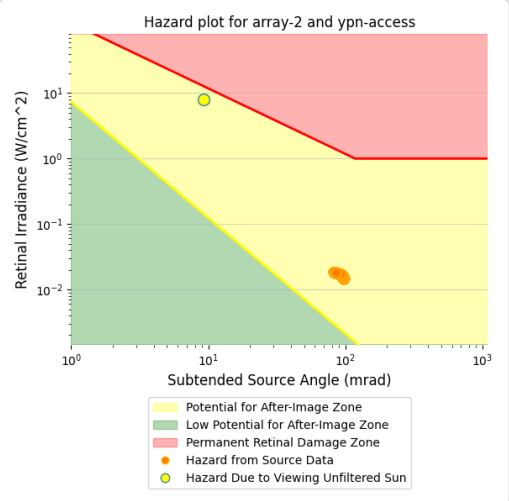
Receptor type: Route

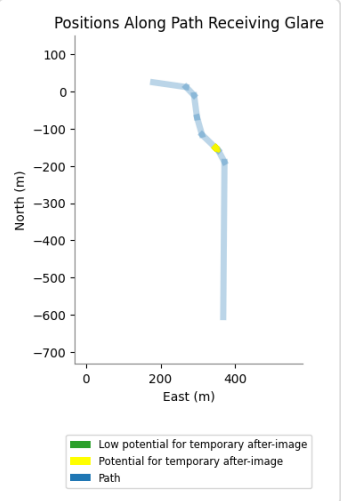
318 minutes of yellow glare

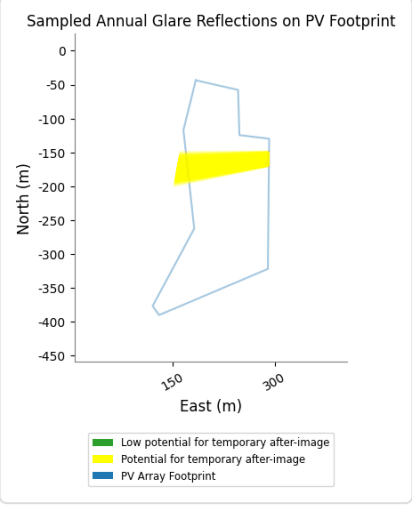
0 minutes of green glare











Array 2 and YPF Access 1

Receptor type: Route

No glare found

Array 2 and Eastern Final Approach

Receptor type: 2-mile Flight Path

No glare found

Array 2 and Western Final Approach

Receptor type: 2-mile Flight Path

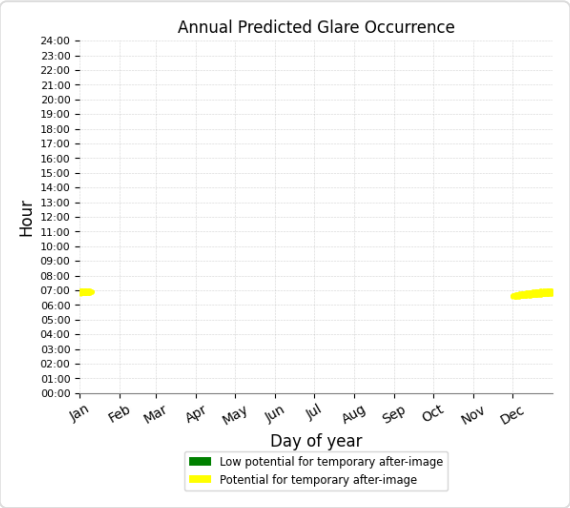
No glare found

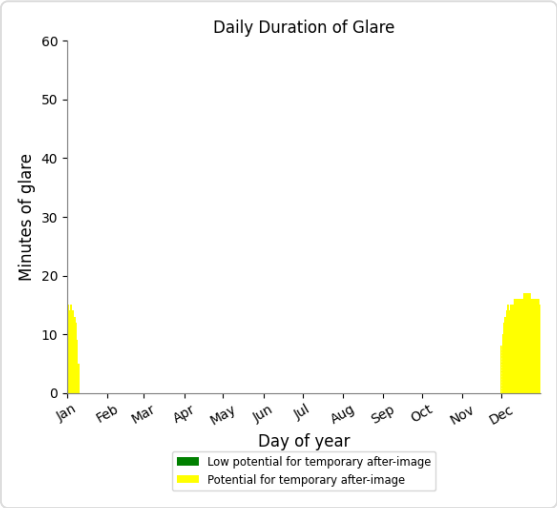
Array 2 and OP 6

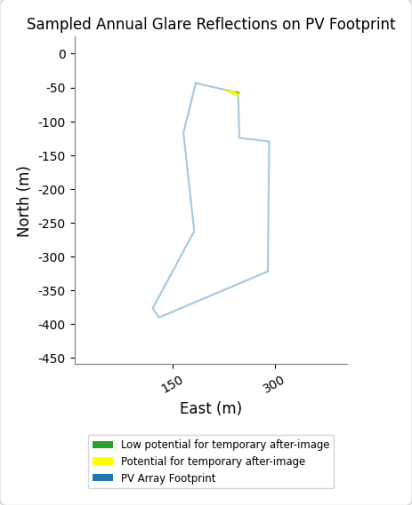
Receptor type: Observation Point

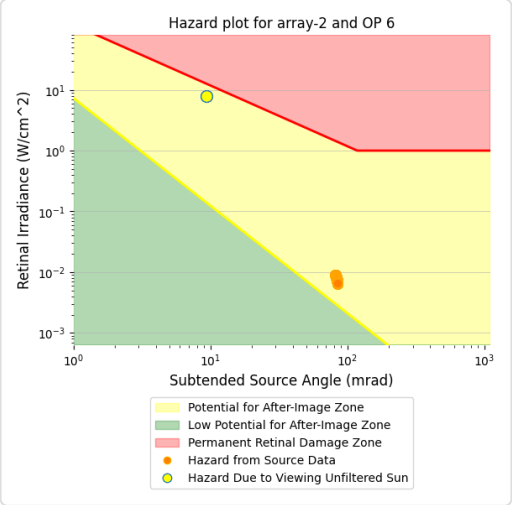
598 minutes of yellow glare

0 minutes of green glare



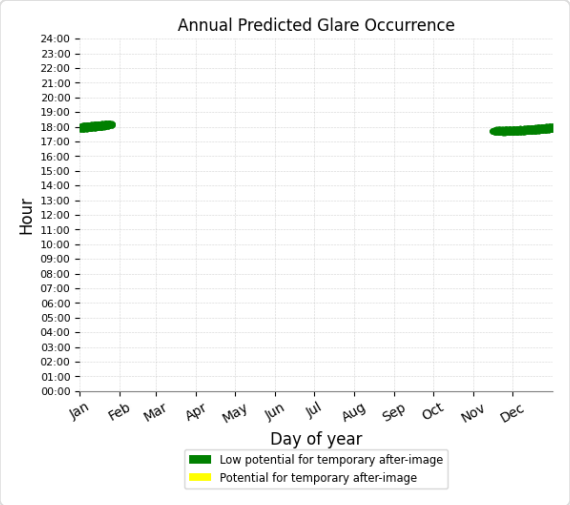


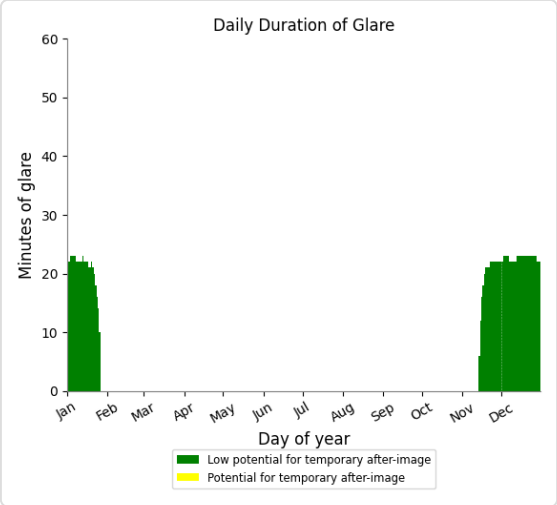


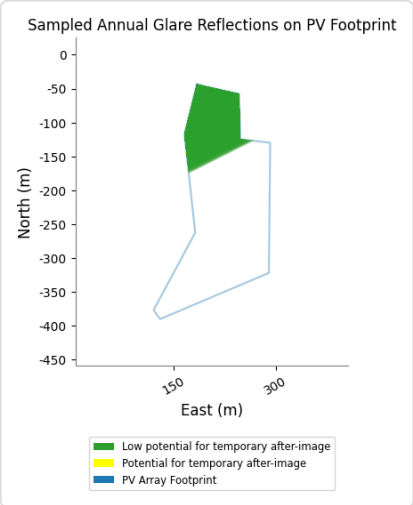


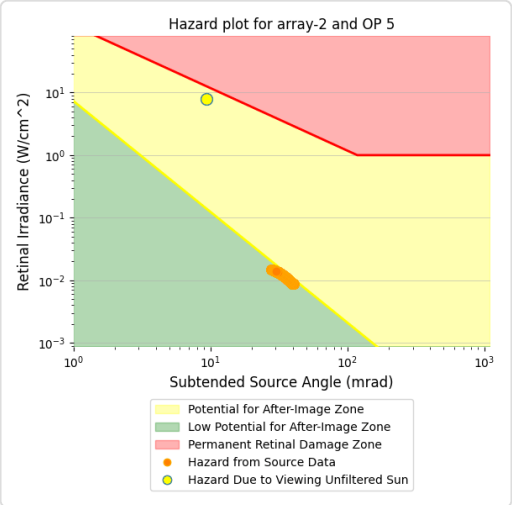
Array 2 and OP 5

Receptor type: Observation Point
0 minutes of yellow glare
1,576 minutes of green glare









Array 2 and OP 1

Receptor type: Observation Point
No glare found

Array 2 and OP 2

Receptor type: Observation Point
No glare found

Array 2 and OP 3

Receptor type: Observation Point
No glare found

Array 2 and OP 4

Receptor type: Observation Point
No glare found

Array 2 and 7-ATCT

Receptor type: Observation Point
No glare found

PV: Array 3 potential temporary after-image

Receptor results ordered by category of glare

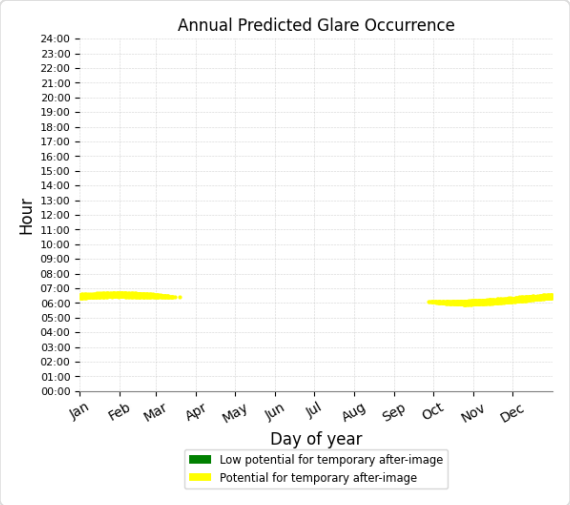
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
YPF Access 1	0	0.0	1,841	30.7
YPF Access 2	0	0.0	12,611	210.2
Village Rd	0	0.0	0	0.0
YPN Access	0	0.0	0	0.0
Eastern Final Approach	0	0.0	0	0.0
Western Final Approach	0	0.0	0	0.0
OP 1	0	0.0	0	0.0
OP 2	0	0.0	0	0.0
OP 3	0	0.0	0	0.0
OP 4	0	0.0	0	0.0
OP 5	0	0.0	0	0.0
OP 6	0	0.0	0	0.0
7-ATCT	0	0.0	0	0.0

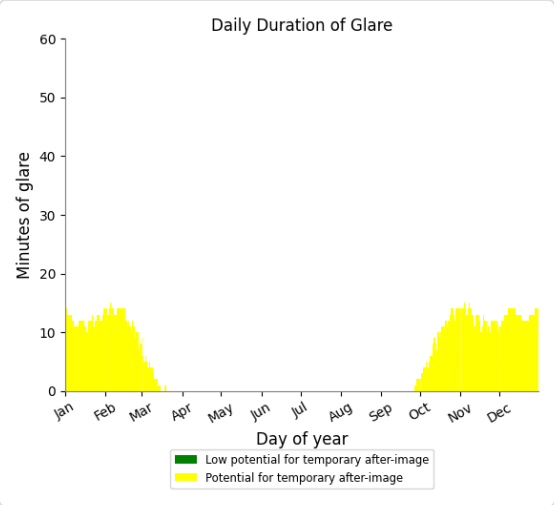
Array 3 and YPF Access 1

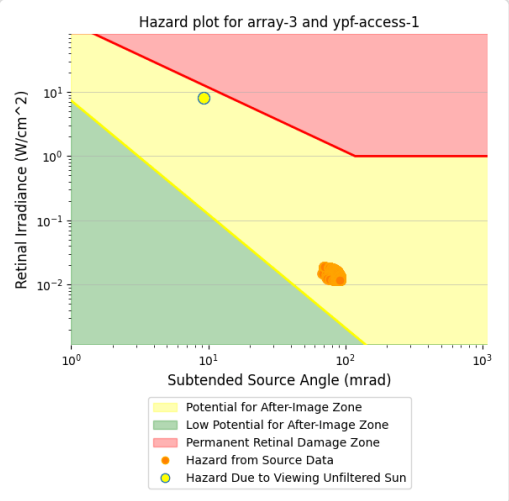
Receptor type: Route

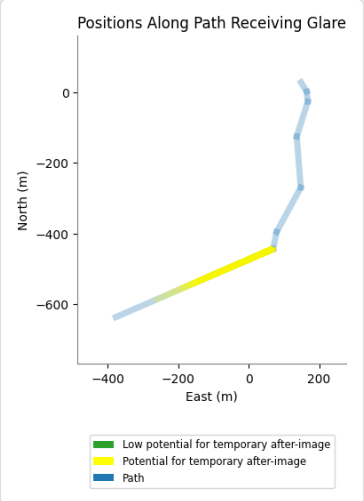
1,841 minutes of yellow glare

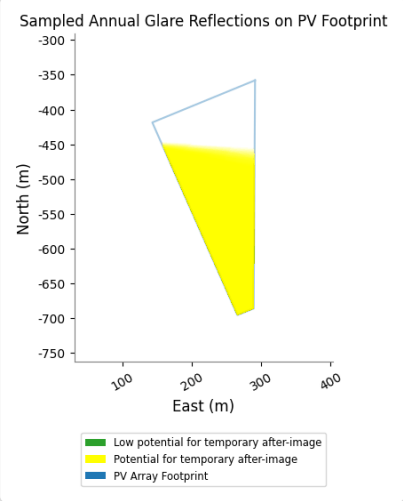
0 minutes of green glare









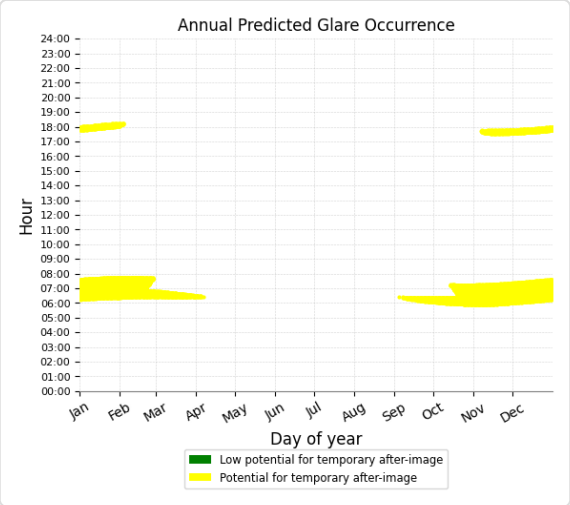


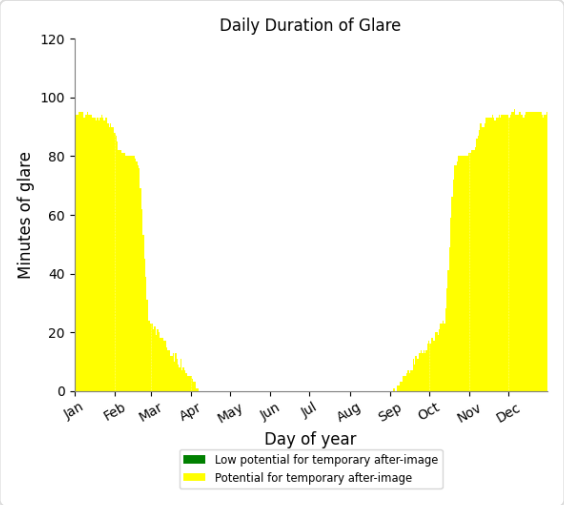
Array 3 and YPF Access 2

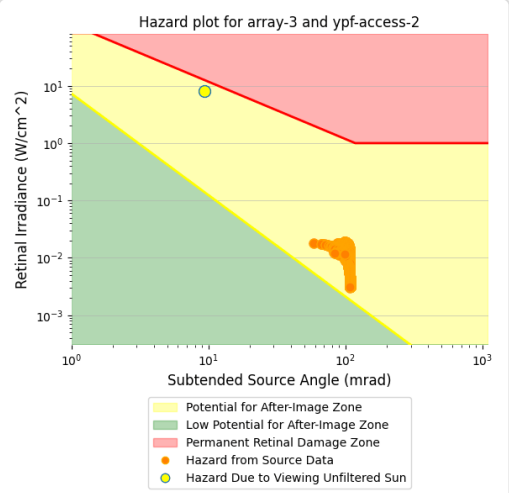
Receptor type: Route

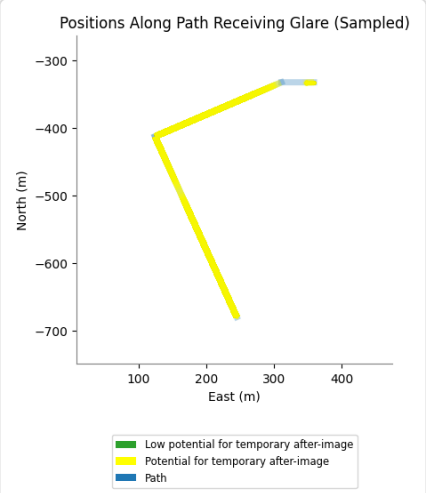
12,611 minutes of yellow glare

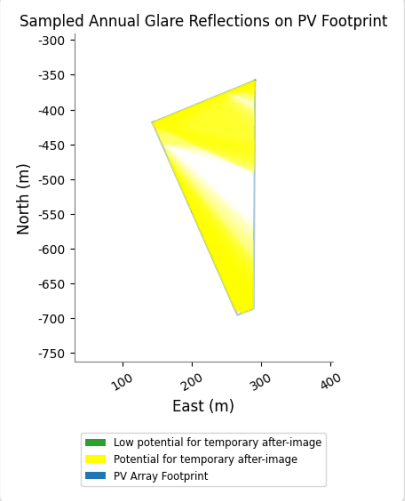
0 minutes of green glare











Array 3 and Village Rd

Receptor type: Route
No glare found

Array 3 and YPN Access

Receptor type: Route
No glare found

Array 3 and Eastern Final Approach

Receptor type: 2-mile Flight Path
No glare found

Array 3 and Western Final Approach

Receptor type: 2-mile Flight Path
No glare found

Array 3 and OP 1

Receptor type: Observation Point
No glare found

Array 3 and OP 2

Receptor type: Observation Point
No glare found

Array 3 and OP 3

Receptor type: Observation Point
No glare found

Array 3 and OP 4

Receptor type: Observation Point
No glare found

Array 3 and OP 5

Receptor type: Observation Point
No glare found

Array 3 and OP 6

Receptor type: Observation Point
No glare found

Array 3 and 7-ATCT

Receptor type: Observation Point
No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

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The Power of Commitment

Appendix C Unexpected Aboriginal Heritage Finds Protocol

C1. Aboriginal Sites and Objects

If a suspected Aboriginal site or object is identified during ground disturbing activities, the following procedure should be followed:

1. Stop all work in the immediate area of the item and notify the YPF Project Director and MAC Heritage Monitors.
2. Establish an exclusion area around the item demarcated with appropriate signage, fencing or flagging in collaboration with MAC Heritage Monitors.
3. No ground disturbing activity should be carried out within the exclusion zone until further investigations are completed and, if required, appropriate approvals are obtained.
4. Inspect, document (including GPS coordinates) and photograph the item.
5. MAC Heritage Monitors to assess the find and determine if an Aboriginal heritage constraint is present. Where required, additional specialist advice may be sought from MAC or an Aboriginal heritage consultant.
6. If no constraint is present, MAC should provide clearance to remove the exclusion area and resume ground disturbing activities.
7. If a heritage constraint is present, then:
    a. Implement investigation and reporting procedures in accordance with Section 3.3.1.
    b. Report the constraint to the Registrar of Aboriginal Sites as per s15 of the Aboriginal Heritage Act 1972:

    "Any person who has knowledge of the existence of anything in the nature of Aboriginal burial grounds, symbols or objects of sacred, ritual or ceremonial significance, cave or rock paintings or engravings, stone structures or arranged stones, carved trees, or of any other place or thing to which this Act applies or to which this Act might reasonably be suspected to apply shall report its existence to the Registrar, or to a police officer, unless he has reasonable cause to believe the existence of the thing or place in question to be already known to the Registrar."
8. Ground disturbing activities should not recommence until the constraint is removed or is managed in accordance with the CHVAMP and the *Aboriginal Heritage Act 1972*.

C2. Ancestral Remains

After discovering a burial site or Aboriginal remains, the following action should be taken:

1. Immediately contact the police (131 444) and the Registrar of Aboriginal Sites (08 6551 8002).
2. Stop all work in the immediate area of the item and notify the YPF Project Director and MAC Heritage Monitors.
3. The police will investigate the remains as soon as possible. The Registrar will liaise with police to ensure that the minimum amount of disturbance takes place before identification of whether the remains are of Aboriginal origin and not a matter for further police involvement.
4. Upon notification that the remains are of Aboriginal origin and not a matter for further police involvement, the Registrar will seek the immediate involvement of MAC.
5. YPF will develop an appropriate action plan for the management of the remains, in consultation with MAC and the Registrar.

6. The Registrar will ensure that the burial place is recorded and placed on the Register of Aboriginal Sites.
7. The Registrar will ensure that the burial place is reported to the Commonwealth Minister for Indigenous Affairs, in accordance with the legal requirements under the *Aboriginal and Torres Strait Islander Protection Act 1984*.
8. The location will remain excluded from the Disturbance Footprint and managed in accordance with the CHVAMP.

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