

APPENDIX 2: Landscape and Visual Effects Assessment Methodology

Landscape and Visual Effects Assessment Methodology

Introduction

The landscape and visual effects assessment process provides a framework for assessing and identifying the nature and level of likely effects that may result from a proposed development. Such effects can occur in relation to changes to physical elements, the existing character of the landscape and the experience of it. In addition, the landscape assessment method may include an iterative design development processes which includes stakeholder involvement. The outcome of any assessment approach should seek to avoid, remedy or mitigate adverse effects. A separate assessment is required to assess changes in natural character in coastal areas and other waterbodies.

When undertaking landscape and visual effects assessments, it is important that a structured and consistent approach is used to ensure that findings are clear and objective. Judgement should always be based on skills and experience, and be supported by explicit evidence and reasoned argument.

While landscape and visual effects assessments are closely related, they form separate procedures. The assessment of the potential effect on the landscape forms the first step in this process and is carried out as an effect on an environmental resource (i.e. landscape elements, features and character). The assessment of visual effects considers how changes to the physical landscape affect the viewing audience. The types of effects can be summarised as follows:

Landscape effects:

Change in the physical landscape, which may change its characteristics or qualities.

Visual effects:

Change to views which may change the visual amenity experienced by people.

The policy context, existing landscape resource and locations from which a development or change is visible all inform the 'baseline' for landscape and visual effects assessments. To assess effects, the landscape must first be described, including an understanding of the key landscape characteristics and qualities. This process, known as landscape characterisation, is the basic tool for understanding landscape character and may involve subdividing the landscape into character areas or types. The condition of the landscape (i.e. the state of an individual area of landscape or landscape feature) should also be described alongside a judgement made on the value or importance of the potentially affected landscape.

This outline of the landscape and visual effects assessment methodology has been undertaken with reference to the Quality Planning Landscape Guidance Note¹ and its signposts to examples of best practice which include the UK guidelines for landscape and visual impact assessment² and Te Tangi a te Manu³.

Assessing landscape effects requires an understanding of the nature of the landscape resource and the magnitude of change which results from a proposed development to determine the overall level of landscape effects.

Nature of the landscape resource

Assessing the nature of the landscape resource considers both the susceptibility of an area of landscape to change and the value of the landscape. This will vary upon the following factors:

- Physical elements such as topography / hydrology / soils / vegetation;
- Existing land use;
- The pattern and scale of the landscape;
- Visual enclosure / openness of views and distribution of the viewing audience;

¹ <http://www.qualityplanning.org.nz/index.php/planning-tools/land/landscape>

² Landscape Institute and Institute of Environmental Management and Assessment (2013) Guidelines for Landscape and Visual Impact Assessment, 3rd Edition (GLVIA3)

³ Te Tangi a te Manu (Aotearoa New Zealand Landscape Guidelines), NZILA July 2022.

- The zoning of the land and its associated anticipated level of development;
- The value or importance placed on the landscape, particularly those confirmed in statutory documents; and
- The scope for mitigation, appropriate to the existing landscape.

The susceptibility to change takes account of both the attributes of the receiving environment and the characteristics of the proposed development. It considers the ability of a specific type of change occurring without generating adverse effects and/or achievement of landscape planning policies and strategies.

Landscape value derives from the importance that people and communities, including tangata whenua, attach to particular landscapes and landscape attributes. This may include the classification of Outstanding Natural Landscape (RMA s.6(b)) based on important biophysical, sensory/ aesthetic and associative landscape attributes, which have potential to be affected by a proposed development.

Magnitude of Landscape Change

The magnitude of landscape change judges the amount of change that is likely to occur to existing areas of landscape, landscape features, or key landscape attributes. In undertaking this assessment, it is important that the size or scale of the change is considered within the geographical extent of the area influenced and the duration of change, including whether the change is reversible. In some situations, the loss /change or enhancement to existing landscape elements such as vegetation or earthworks should also be quantified.

When assessing the level of landscape effects, it is important to be clear about what factors have been considered when making professional judgements. This can include consideration of any benefits which result from a proposed development. Table 1 below helps to explain this process. The tabulating of effects is only intended to inform overall judgements.

Contributing factors		Higher	Lower
Nature of Landscape Resource	Susceptibility to change	The landscape context has limited existing landscape detractors which make it highly vulnerable to the type of change which would result from the proposed development.	The landscape context has many detractors and can easily accommodate the proposed development without undue consequences to landscape character.
	The value of the landscape	The landscape includes important biophysical, sensory and associative attributes. The landscape requires protection as a matter of national importance (ONF/L).	The landscape lacks any important biophysical, sensory or associative attributes. The landscape is of low or local importance.
Magnitude of Change	Size or scale	Total loss or addition of key features or elements. Major changes in the key characteristics of the landscape, including significant aesthetic or perceptual elements.	The majority of key features or elements are retained. Key characteristics of the landscape remain intact with limited aesthetic or perceptual change apparent.
	Geographical extent	Wider landscape scale.	Site scale, immediate setting.
	Duration and reversibility	Permanent. Long term (over 10 years).	Reversible. Short Term (0-5 years).

Table 1: Determining the level of landscape effects

Visual Effects

To assess the visual effects of a proposed development on a landscape, a visual baseline must first be defined. The visual 'baseline' forms a technical exercise which identifies the area where the development may be visible, the potential viewing audience, and the key representative public viewpoints from which visual effects are assessed.

The viewing audience comprises the individuals or groups of people occupying or using the properties, roads, footpaths and public open spaces that lie within the visual envelope or 'zone of visual influence' of the site and proposal. Where

possible, computer modelling can assist to determine the theoretical extent of visibility together with field work undertaken to confirm this. Where appropriate, key representative viewpoints should be agreed with the relevant local authority.

Nature of the viewing audience

The nature of the viewing audience is assessed in terms of the susceptibility of the viewing audience to change and the value attached to views. The susceptibility of the viewing audience is determined by assessing the occupation or activity of people experiencing the view at particular locations and the extent to which their interest or activity may be focused on views of the surrounding landscape. This relies on a landscape architect's judgement in respect of visual amenity and reaction of people who may be affected by a proposal. This should also recognise that people more susceptible to change generally include: residents at home, people engaged in outdoor recreation whose attention or interest is likely to be focused on the landscape and on particular views; visitors to heritage assets or other important visitor attractions; and communities where views contribute to the landscape setting.

The value or importance attached to particular views may be determined with respect to its popularity or numbers of people affected or reference to planning instruments such as viewshafts or view corridors.

Important viewpoints are also likely to appear in guide books or tourist maps and may include facilities provided for its enjoyment. There may also be references to this in literature or art, which also acknowledge a level of recognition and importance.

Magnitude of Visual Change

The assessment of visual effects also considers the potential magnitude of change which will result from views of a proposed development. This takes account of the size or scale of the effect, the geographical extent of views and the duration of visual change which may distinguish between temporary (often associated with construction) and permanent effects where relevant. Preparation of any simulations of visual change to assist this process should be guided by best practice as identified by the NZILA⁴.

When determining the overall level of visual effect, the nature of the viewing audience is considered together with the magnitude of change resulting from the proposed development. Table 2 has been prepared to help guide this process:

Contributing factors		Higher	Lower
Nature of Landscape Resource	Susceptibility to change	Views from dwellings and recreation areas where attention is typically focussed on the landscape..	Views from places of employment and other places where the focus is typically incidental to its landscape context. Views from transport corridors.
	The value of the landscape	Viewpoint is recognised by the community such as an important view shaft, identification on tourist maps or in art and literature. High visitor numbers.	Viewpoint is not typically recognised or valued by the community. Infrequent visitor numbers..
Magnitude of Change	Size or scale	Loss or addition of key features in the view. High degree of contrast with existing landscape elements (i.e. in terms of form scale, mass, line, height, colour and texture). Full view of the proposed development	Most key features of view retained. Low degree of contrast with existing landscape elements (i.e. in terms of form scale, mass, line, height, colour and texture). Glimpse / no view of the proposed development.
	Geographical extent	Front on views. Near distance views; Change visible across a wide area.	Oblique views. Long distance views. Small portion of change visible.
	Duration and reversibility	Permanent. Long term (over 15 years).	Transient / temporary. Short Term (0-5 years).

Nature of Effects

⁴ Best Practice Guide: Visual Simulations BPG 10.2, NZILA

In combination with assessing the level of effects, the landscape and visual effects assessment also considers the nature of effects in terms of whether this will be positive (beneficial) or negative (adverse) in the context within which it occurs. Neutral effects can also occur where landscape or visual change is benign.

It should also be noted that a change in a landscape does not, of itself, necessarily constitute an adverse landscape or visual effect. Landscape is dynamic and is constantly changing over time in both subtle and more dramatic transformational ways, these changes are both natural and human induced. What is important in managing landscape change is that adverse effects are avoided or sufficiently mitigated to ameliorate the effects of the change in land use. The aim is to provide a high amenity environment through appropriate design outcomes.

This assessment of the nature effects can be further guided by Table 3 set out below:

Nature of effect	Use and definition
Adverse (negative):	The proposed development would be out of scale with the landscape or at odds with the local pattern and landform which results in a reduction in landscape and / or visual amenity values
Neutral (benign):	The proposed development would complement (or blend in with) the scale, landform and pattern of the landscape maintaining existing landscape and / or visual amenity values
Beneficial (positive):	The proposed development would enhance the landscape and / or visual amenity through removal of restoration of existing degraded landscapes uses and / or addition of positive elements or features

Table 3: Determining the Nature of Effects

Cumulative Effects

During the scoping of an assessment, where appropriate, agreement should be reached with the relevant local authority as to the nature of cumulative effects to be assessed. This can include effects of the same type of development (e.g. wind farms) or the combined effect of all past, present and approved future development⁵ of varying types, taking account of both the permitted baseline and receiving environment. Cumulative effects can also be positive, negative or benign.

Cumulative Landscape Effects

Cumulative landscape effects can include additional or combined changes in components of the landscape and changes in the overall landscape character. The extent within which cumulative landscape effects are assessed can cover the entire landscape character area within which the proposal is located, or alternatively, the zone of visual influence from which the proposal can be observed.

Cumulative Visual Effects

Cumulative visual effects can occur in combination (seen together in the same view), in succession (where the observer needs to turn their head) or sequentially (with a time lapse between instances where proposals are visible when moving through a landscape). Further visualisations may be required to indicate the change in view compared with the appearance of the project on its own.

Determining the nature and level of cumulative landscape and visual effects should adopt the same approach as the project assessment in describing both the nature of the viewing audience and magnitude of change leading to a final judgement. Mitigation may require broader consideration which may extend beyond the geographical extent of the project being assessed.

Determining the Overall Level of Effects

The landscape and visual effects assessment concludes with an overall assessment of the likely level of landscape and visual effects. This step also takes account of the nature of effects and the effectiveness of any proposed mitigation.

⁵ The life of the statutory planning document or unimplemented resource consents

This step informs an overall judgement identifying what level of effects are likely to be generated as indicated in Table 4 below. This table which can be used to guide the level of landscape and visual effects uses an adapted seven-point scale derived from Te Tangi a te Manu (Aotearoa New Zealand Landscape Guidelines)

	Effect rating	Use and definition
More than minor • • • •	Very high	Total loss of key elements / features / characteristics, i.e. amounts to a complete change of landscape character
	High	Major modification or loss of most key elements / features / characteristics, i.e. little of the pre-development landscape character remains. Concise Oxford English Dictionary Definition High: adjective- Great in amount, value, size, or intensity
	Moderate to high	Modifications of several key elements / features / characteristics of the baseline, i.e. the pre-development landscape character remains evident but materially changed.
	Moderate	Partial loss of or modification to key elements / features / characteristics of the baseline, i.e. new elements may be prominent but not necessarily uncharacteristic within the receiving landscape. Concise Oxford English Dictionary Definition Moderate: adjective- average in amount, intensity, quality or degree
Minor • • • •	Moderate to low	Minor loss of or modification to one or more key elements / features / characteristics, i.e. new elements are not prominent or uncharacteristic within the receiving landscape.
	Low	No material loss of or modification to key elements / features / characteristics. i.e. modification or change is not uncharacteristic and absorbed within the receiving landscape. Concise Oxford English Dictionary Definition Low: adjective- 1. Below average in amount, extent, or intensity
Less than minor	Very low	Little or no loss of or modification to key elements/ features/ characteristics of the baseline, i.e. approximating a 'no change' situation.

Table 4: Determining the overall level of landscape and visual effects

Determination of “minor”

Decision makers determining whether a resource consent application should be notified must also assess whether the effect on a person is less than minor⁶ or an adverse effect on the environment is no more than minor⁷. Likewise, when assessing a non-complying activity, consent can only be granted if the s104D ‘gateway test’ is satisfied. This test requires the decision maker to be assured that the adverse effects of the activity on the environment will be ‘minor’ or not be contrary to the objectives and policies of the relevant planning documents.

These assessments will generally involve a broader consideration of the effects of the activity, beyond the landscape and visual effects. Through this broader consideration, guidance may be sought on whether the likely effects on the landscape resource or effects on a person are considered in relation to ‘minor’. It must also be stressed that more than minor effects on individual elements or viewpoints does not necessarily equate to more than minor effects on the wider landscape resource. In relation to this assessment, moderate-low level effects would generally equate to ‘minor’.

⁶ RMA, Section 95E

⁷ RMA Section 95D

APPENDIX 3: Determination of Landscape Quality

Determination of landscape quality		
Category	Criteria	Typical Example
High - Exceptional	Strong landscape structure, characteristics, patterns, balanced combination of landform and land cover	International or nationally recognised site – national park.
	Appropriate management for land use and land cover	
	Distinct features worthy of conservation	
	Sense of place	
	No detracting features	
High	Strong landscape structure, characteristics, patterns, balanced combination of landform and land cover	Nationally or regionally recognised site – national park
	Appropriate management for land use and land cover but potential scope for improvement.	
	Distinct features worthy of conservation	
	Sense of place	
	Occasional detracting features	
Good	Recognisable landscape structure, characteristics, patterns, balanced combination of landform and land cover still evident	Nationally, regionally recognised site all or great majority of area of local landscape importance
	Scope to improve management for land use and land cover	
	Some features worthy of conservation	
	Sense of place	
	Some detracting features	
Ordinary	Distinguishable landscape structure, characteristic patterns of landform and land cover often masked by landuse	
	Some features worthy of conservation	
	Some detracting features	
Poor	Weak landscape structure, characteristic patterns of landform and land cover often masked by landuse	
	Mixed land use evident	
	Lack of management and intervention has resulted in degradation	
	Frequent detracting features	
Very poor	Degraded landscape structure, characteristic patterns of landform and land cover are masked by landuse	
	Mixed land use dominates	
	Lack of management and intervention has resulted in degradation	
	Extensive detracting features	
Damaged landscape	Damaged landscape structure	
	Single land use	
	Disturbed or derelict land requires treatment	
	Detracting features dominate.	

Table 3 has been adapted for NZ conditions from an example of threshold criteria used by practitioners in the United Kingdom. The original document was prepared by Jeff Stevenson Associates and published in *Guidelines for Landscape and Visual Assessment ("GLVIA")* 3rd Edition. Landscape Institute (UK) and IEMA 2013.

APPENDIX 4: Visual simulations

Viewpoint Location Map



Far North Solar Farm Ltd Waipara Solar Farm

- Viewpoint 01
State Highway 7
(E)398999.078 (N)862138.581
- Viewpoint 02
State Highway 7
(E)399306.062 (N)861615.999
- Viewpoint 03
State Highway 7
(E)401370.876 (N)858856.455
- Viewpoint 04
State Highway 7
(E)401987.902 (N)858411.926
- Viewpoint 05
21 Glenmark Drive
(E)402226.824 (N)858518.030
- Viewpoint 06
53 Glenmark Drive
(E)402347.547 (N)858908.489
- Viewpoint 07
Glenmark Station Carpark
(E)402518.378 (N)859485.528
- Viewpoint 08
MacKenzies Road
(E)402330.985 (N)859845.206
- Viewpoint 09
MacKenzies Road
(E)401435.419 (N)861854.746
- Viewpoint 247
247 MacKenzies Road
(E)400838.584 (N)860968.526



Date Printed : 25-09-2023



Viewpoint 01 - Existing



Viewpoint 01 - Proposed - Planting Year 3 - Solar Panel Angle +50°

	Easting: 398999.078 Northing: 862138.581 Elevation : 129.203m Height of Camera : 1.5m Orientation of View : SE Date of Photography : 07 Sept 2023 Time of Photography : 15:05pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 01 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 01 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

	Easting: 398999.078 Northing: 862138.581 Elevation : 129.203m Height of Camera : 1.5m Orientation of View : SE Date of Photography : 07 Sept 2023 Time of Photography : 15:05pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 01 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 01 - Proposed - Planting Year 3 - Solar Panel Angle +50°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

	Easting: 398999.078 Northing: 862138.581 Elevation : 129.203m Height of Camera : 1.5m Orientation of View : SE Date of Photography : 07 Sept 2023 Time of Photography : 15:05pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 01 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 02 - Existing



Viewpoint 02 - Proposed - Planting Year 3 - Solar Panel Angle +50°

	Easting: 399306.062 Northing: 861615.999 Elevation : 120.479m Height of Camera : 1.5m Orientation of View : SE Date of Photography : 07 Sept 2023 Time of Photography : 15:21pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 02 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 02 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

	Easting: 399306.062 Northing: 861615.999 Elevation : 120.479m Height of Camera : 1.5m Orientation of View : SE Date of Photography : 07 Sept 2023 Time of Photography : 15:21pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 02 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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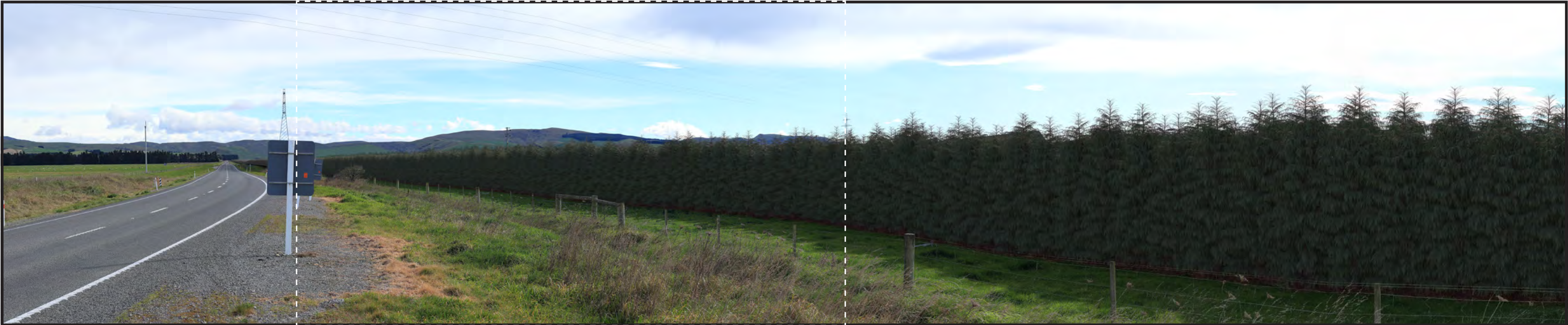
Viewpoint 02 - Proposed - Planting Year 3 - Solar Panel Angle +50°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

	Easting: 399306.062 Northing: 861615.999 Elevation : 120.479m Height of Camera : 1.5m Orientation of View : SE Date of Photography : 07 Sept 2023 Time of Photography : 15:21pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 02 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 03 - Existing



Viewpoint 03 - Proposed - Planting Year 3 - Solar Panel Angle -50°

	Easting: 401370.876 Northing: 858856.455 Elevation : 80.411m Height of Camera : 1.5m Orientation of View : N Date of Photography : 07 Sept 2023 Time of Photography : 10:05am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 03 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 03 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 401370.876 Northing: 858856.455 Elevation : 80.411m Height of Camera : 1.5m Orientation of View : N Date of Photography : 07 Sept 2023 Time of Photography : 10:05am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 03 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 03 - Proposed - Planting Year 3 - Solar Panel Angle -50°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

	Easting: 401370.876 Northing: 858856.455 Elevation : 80.411m Height of Camera : 1.5m Orientation of View : N Date of Photography : 07 Sept 2023 Time of Photography : 10:05am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 03 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 04 - Existing



Viewpoint 04 - Proposed - Planting Year 3 - Solar Panel Angle -40°

	Easting: 401987.902 Northing: 858411.926 Elevation : 63.119m Height of Camera : 1.5m Orientation of View : NW Date of Photography : 07 Sept 2023 Time of Photography : 10:25am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 04 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 04 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 401987.902 Northing: 858411.926 Elevation : 63.119m Height of Camera : 1.5m Orientation of View : NW Date of Photography : 07 Sept 2023 Time of Photography : 10:25am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 04 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 04 - Proposed - Planting Year 3 - Solar Panel Angle -40°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 401987.902 Northing: 858411.926 Elevation : 63.119m Height of Camera : 1.5m Orientation of View : NW Date of Photography : 07 Sept 2023 Time of Photography : 10:25am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 04 - State Highway 7	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 05 - Existing



Viewpoint 05 - Proposed - Planting Year 3 - Solar Panel Angle -30°

	Easting: 402226.824 Northing: 858518.03 Elevation : 65.702m Height of Camera : 1.5m Orientation of View : NW Date of Photography : 07 Sept 2023 Time of Photography : 11:05am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 05 - 21 Glenmark Drive	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 05 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 402226.824 Northing: 858518.03 Elevation : 65.702m Height of Camera : 1.5m Orientation of View : NW Date of Photography : 07 Sept 2023 Time of Photography : 11:05am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 05 - 21 Glenmark Drive	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 05 - Proposed - Planting Year 3 - Solar Panel Angle -30°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 402226.824 Northing: 858518.03 Elevation : 65.702m Height of Camera : 1.5m Orientation of View : NW Date of Photography : 07 Sept 2023 Time of Photography : 11:05am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 05 - 21 Glenmark Drive	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 06 - Existing



Viewpoint 06 - Proposed - Planting Year 3 - Solar Panel Angle -20°

	Easting: 402347.547 Northing: 858908.489 Elevation : 74.324m Height of Camera : 1.5m Orientation of View : W Date of Photography : 07 Sept 2023 Time of Photography : 11:27am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 06 - 53 Glenmark Drive	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 06 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

	Easting: 402347.547 Northing: 858908.489 Elevation : 74.324m Height of Camera : 1.5m Orientation of View : W Date of Photography : 07 Sept 2023 Time of Photography : 11:27am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 06 - 53 Glenmark Drive	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 06 - Proposed - Planting Year 3 - Solar Panel Angle -20°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 402347.547 Northing: 858908.489 Elevation : 74.324m Height of Camera : 1.5m Orientation of View : W Date of Photography : 07 Sept 2023 Time of Photography : 11:27am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 06 - 53 Glenmark Drive	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 07 - Existing



Viewpoint 07 - Proposed - Planting Year 3 - Solar Panel Angle -40°

	Easting: 402518.378 Northing: 859485.528 Elevation : 75.375m Height of Camera : 1.5m Orientation of View : W Date of Photography : 07 Sept 2023 Time of Photography : 10:41am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 07 - Glenmark Station Carpark	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 07 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 402518.378 Northing: 859485.528 Elevation : 75.375m Height of Camera : 1.5m Orientation of View : W Date of Photography : 07 Sept 2023 Time of Photography : 10:41am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 07 - Glenmark Station Carpark	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 07 - Proposed - Planting Year 3 - Solar Panel Angle -40°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 402518.378 Northing: 859485.528 Elevation : 75.375m Height of Camera : 1.5m Orientation of View : W Date of Photography : 07 Sept 2023 Time of Photography : 10:41am	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 07 - Glenmark Station Carpark	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 08 - Existing



Viewpoint 08 - Proposed - Planting Year 3 - Solar Panel Angle -0°

	Easting: 402330.985 Northing: 859845.206 Elevation : 79.087m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 12:29pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 08 - MacKenzie's Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 08 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 402330.985 Northing: 859845.206 Elevation : 79.087m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 12:29pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 08 - MacKenzies Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 08 - Proposed - Planting Year 3 - Solar Panel Angle -0°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 402330.985 Northing: 859845.206 Elevation : 79.087m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 12:29pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 08 - MacKenzies Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 09 - Existing



Viewpoint 09 - Proposed - Planting Year 3 - Solar Panel Angle +30°

	Easting: 401435.419 Northing: 861854.746 Elevation : 108.221m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 13:54pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 09 - MacKenzies Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 09 - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 401435.419 Northing: 861854.746 Elevation : 108.221m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 13:54pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 09 - MacKenzie's Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 09 - Proposed - Planting Year 3 - Solar Panel Angle +30°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

	Easting: 401435.419 Northing: 861854.746 Elevation : 108.221m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 13:54pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 09 - MacKenzie's Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 247 - Existing



Viewpoint 247 - Proposed - Planting Year 3 - Solar Panel Angle +40°

	Easting: 400838.584 Northing: 860968.526 Elevation : 102.278m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 14:19pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 247 - 247 MacKenzies Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Dashed white line indicates cropped viewpoint portion. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 247a - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

	Easting: 400838.584 Northing: 860968.526 Elevation : 102.278m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 14:19pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 247 - 247 MacKenzies Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 247a - Proposed - Planting Year 3 - Solar Panel Angle +40°

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 400838.584 Northing: 860968.526 Elevation : 102.278m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 14:19pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 247 - 247 MacKenzies Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Viewpoint 247b - Existing

IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 400838.584 Northing: 860968.526 Elevation : 102.278m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 14:19pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 247 - 247 MacKenzies Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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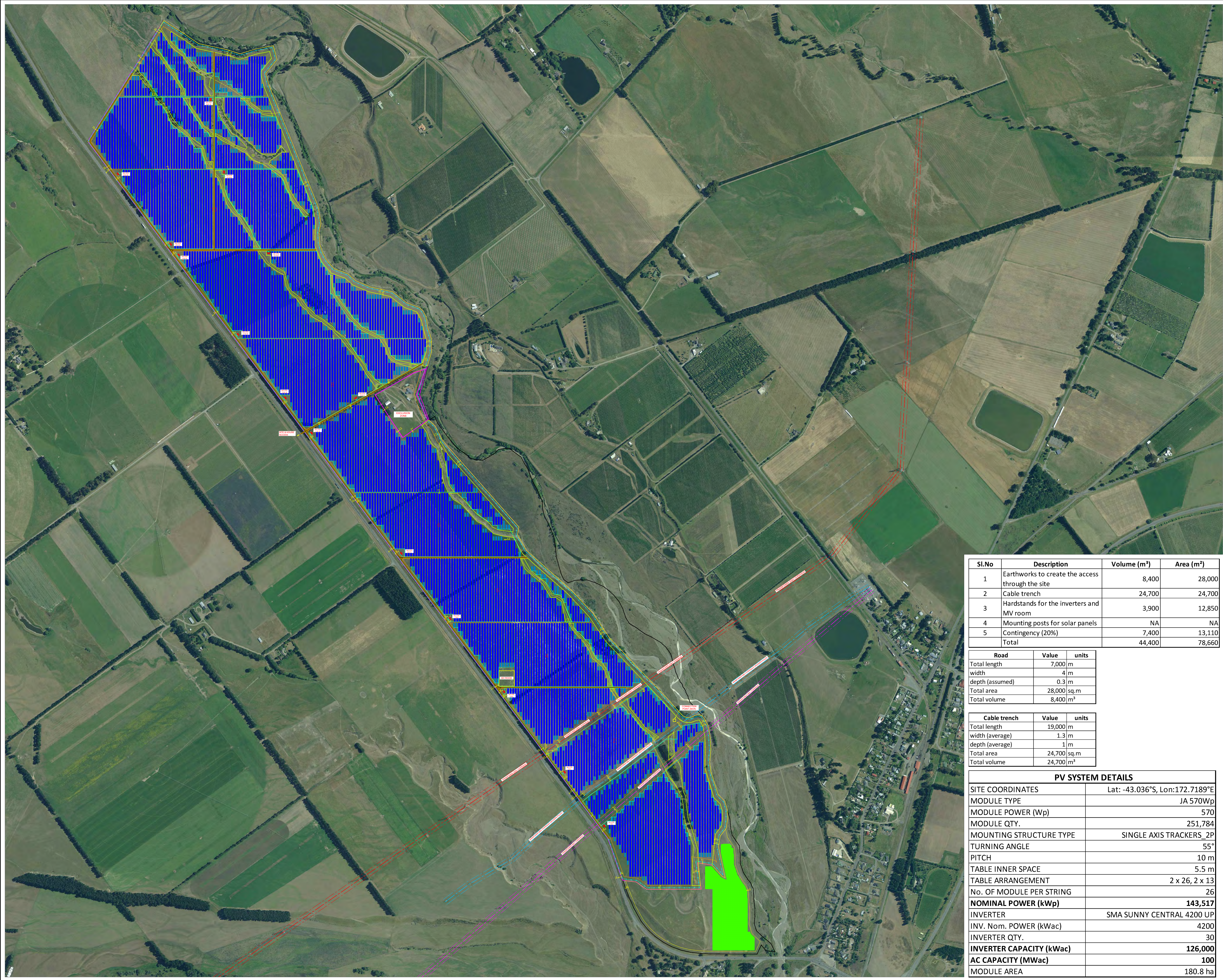


Viewpoint 247b - Proposed - Planting Year 3 - Solar Panel Angle +40°

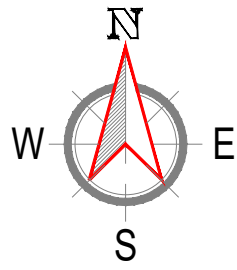
IMAGE TO BE VIEWED AT 50cm FROM EYE FOR CORRECT VIEWING SCALE WHEN PRINTED AT A3

 VIRTUALVIEW 3D VISUALISATION SPECIALISTS	Easting: 400838.584 Northing: 860968.526 Elevation : 102.278m Height of Camera : 1.5m Orientation of View : SW Date of Photography : 07 Sept 2023 Time of Photography : 14:19pm	Farm North Solar Farm Ltd - Waipara Solar Farm Viewpoint 247 - 247 MacKenzies Road	NOTES: All photos were taken by Virtual View with a Canon 5Dmk2 and a 50mm lens. Photo positions were surveyed by Virtual View. Photo background edited in lieu of proposed tree removal. Version info: 0001 Date Printed: 25-09-2023	
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Appendix E. Site Plans



PRELIMINARY DESIGN



GENERAL NOTES

1. ALL DIMENSIONS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. FINAL LAYOUT WILL BE DETERMINED AFTER SITE SURVEY.

2P TRACKER OPTION

LEGEND

- PV MODULE BOUNDARY LINE
- 2 x 26 PV TRACKER MODULE (JA 570Wp)
- 2 x 13 PV TRACKER MODULE (JA 570Wp)
- WINE TREES (15,000 Nos.)
- TRANSPOWER 220kV OVERHEAD LINE
- MAINPOWER 66kV OVERHEAD (WOODEN POLE)
- TRANSPOWER 66kV OVERHEAD LINE
- FENCE LINE
- PLANT INTERNAL ROAD (4m WIDTH)
- INVERTER STATION
- SLOPES LINE
- GRAPE TREES FOR WINERY

REFERENCE DRAWINGS

No.	DRAWING TITLE	DRAWING No.

I	11-03-2024	DRAFT- REMOVED SITE ACCESS #1	
H	28-02-2024	DRAFT- SETBACK 12m @ TRANSMISSION LINE	
G	19-09-2023	DRAFT-UPDATED WITH TOPO, LAND PARCEL & TREES.	
F	15-09-2023	DRAFT-UPDATED WITH TOPO & LAND PARCEL	
E	24-08-2023	DRAFT-WINE TREE ADDED.	
D	03-07-2023	DRAFT-REMOVED PANELS AT EXTENDED LAND AREA	
C	24-05-2023	DRAFT-UPDATED 1P TRACKER WITH 13SMWP.	
B	30-03-2023	DRAFT-UPDATED 1P TRACKER & EXTEND LAND	
A	23-02-2023	DRAFT	
R	DATE	DESCRIPTION OF REVISION	REMARKS

PROJECT NAME :

WAIPARA 143.5MWp
NEW ZEALAND

OWNER'S ENGINEER :

GENERAL CONTRACTOR :

AQUILA CAPITAL GENERATING
ESSENTIAL
INVESTMENTS

Aquila Capital Renewables Asia Pte. Ltd.
138 Market Street #09-04 CapitaGreen
Singapore 048946. www.aquila-capital.com

This drawing is property of Aquila Capital and may not be copied (in whole or in part)
used for manufacturing or disclosed without prior consent of Aquila Capital Singapore.

DRAWN BY : HARI	SIGN : H.S	TITLE :
DATE : 11-03-2024		
CHECKED BY : ARUL	A.M	MODULE GENERAL
DATE : 11-03-2024		ARRANGEMENT LAYOUT
APPROVED BY : ROW	R.K	
DATE : 11-03-2024		

DRAWING No. **ACRA-NZD-WP-001**

SHEET SIZE A1	SHEET 1 OF 1	SCALE 1:6800	REV I
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Sl.No	Description	Volume (m³)	Area (m²)
1	Earthworks to create the access through the site	8,400	28,000
2	Cable trench	24,700	24,700
3	Hardstands for the inverters and MV room	3,900	12,850
4	Mounting posts for solar panels	NA	NA
5	Contingency (20%)	7,400	13,110
Total		44,400	78,660

Road	Value	units
Total length	7,000	m
width	4	m
depth (assumed)	0.3	m
Total area	28,000	sq.m
Total volume	8,400	m³

Cable trench	Value	units
Total length	19,000	m
width (average)	1.3	m
depth (average)	1	m
Total area	24,700	sq.m
Total volume	24,700	m³

PV SYSTEM DETAILS	
SITE COORDINATES	Lat: -43.036°S, Lon:172.7189°E
MODULE TYPE	JA 570Wp
MODULE POWER (Wp)	570
MODULE QTY.	251,784
MOUNTING STRUCTURE TYPE	SINGLE AXIS TRACKERS_2P
TURNING ANGLE	55°
PITCH	10 m
TABLE INNER SPACE	5.5 m
TABLE ARRANGEMENT	2 x 26, 2 x 13
No. OF MODULE PER STRING	26
NOMINAL POWER (kWp)	143,517
INVERTER	SMA SUNNY CENTRAL 4200 UP
INV. Nom. POWER (kWac)	4200
INVERTER QTY.	30
INVERTER CAPACITY (kWac)	126,000
AC CAPACITY (MWac)	100
MODULE AREA	180.8 ha

Appendix F. Proposed Consent Conditions

PROPOSED CONDITIONS

1. The activity shall be carried out in general accordance with the assessment and approved plans contained in the resource consent titled *Assessment of Environmental Effects Waipara Solar Farm – 380 Waipara Flat Road*, prepared by Williamson Water & Land Advisory, dated 15 March 2024 and all supporting technical reports.

Landscaping

2. Implementation of the landscape plan prepared by Simon Cocker, dated 12 March 2024 (titled: *Proposed Waitara Solar Farm*) is to be undertaken within the first two planting seasons (approximately March-September) directly following commencement of any of the works relating to the solar farm (from detailed design stage onwards) and shall be maintained by the consent holder from that point onwards for the term of the resource consent to the satisfaction of Hurunui District Council or duly delegated Council officer.
3. The vegetation identified within the landscape plan prepared by Simon Cocker, shall not be cut down, damaged or destroyed (except for the purposes of replacing any vegetation that has died or represents an unacceptable risk to buildings or people as a result of a natural event) without the prior written consent of the Council. Such consent may be given in the form of resource consent.
4. The Consent Holder shall ensure that the ground underneath the solar panels is covered in established vegetation at all times to prevent sediments entering stormwater. Should the vegetation under the solar panels not thrive in the shade of the solar panels then the vegetation shall be immediately replaced with shade tolerant species.

General Management Plans

5. The Consent Holder shall submit to Council for certification a Construction Management Plan (CMP) from a Chartered Professional Engineer or the suitably qualified person as defined by Council's Engineering Standard prior to commencing construction. The CMP shall contain information on, and site management procedures, including but not limited to:
 - (a) The timing of building and construction works, including hours of work, key project and site management personnel.
 - (b) The transportation of construction materials from and to the site and associated controls on vehicles through sign-posted site entrance / exits and the loading / unloading of materials.
 - (c) Publicity measures and safety measures, including signage, to inform adjacent landowners and occupiers, pedestrians and other road users.
 - (d) Construction drawings, plans, procedures, methods and measures to demonstrate that all the construction activities undertaken on the site will meet the safe distances within the New Zealand Electrical code of Practice for Electrical Safe Distance 2001 (NZECP 34: 2001) or any subsequent revision of the code, including (but not limited to) those relating to:
 - i. Excavation and construction near towers (Section 2);

- ii. Building to conductor clearance (Section 3);
 - iii. Ground to conductor clearance (Section 4);
 - iv. Mobile plant to conductor clearance (Section 5); and
 - v. People to conductor clearance (Section 9).
- (e) Details on how existing National Grid transmission lines and support structures will remain accessible during and after construction activities.
- (f) Details on any areas that may be “out of bounds” during construction and / or areas within which additional management measures are required, such as fencing off, entry and exit hurdles, maximum height limits or where a safety observer may be required.
6. A Pre-Construction Traffic Management Plan (PCTMP) shall be prepared by a suitably qualified and experienced person. The objective of the PCTMP is to provide a framework to be adopted by the Consent Holder to avoid, remedy or mitigate any actual or potential adverse traffic effects of the construction works. The PCTMP shall be submitted to New Plymouth District Council for certification at least three months prior to the construction commencement date.
7. The PCTMP shall include consideration of:
- (a) Minimisation of the safety impacts of construction activities on the users of public roads;
 - (b) Means by which the total number of truck movements to and from the construction activities could be minimised (e.g. back loading of departing vehicles); and
 - (c) Means by which the movement of large machinery can be undertaken at times and in a manner that minimises effects on public road users.

Traffic

8. Delivery trucks associated with the construction and operation of the project is limited to Sunday to Friday (inclusive).
9. There must be no damage to public roads, footpaths, berms, kerbs, drains, reserves, or other public assets directly associated as a result of the activities granted under this consent. In the event that such damage does occur, the Council will be notified within 24 hours of its discovery. The cost of rectifying such damage and restoring the assets to its original condition will be met by the Consent Holder.

Noise

10. Noise from construction of the solar farm must be managed and controlled in accordance with NZS 6803:1999 Acoustics - Construction noise. To avoid doubt, the typical duration noise limits apply.
11. Piling activity must not take place outside the hours of 0730hrs to 1800hrs Monday to Friday. The site may be accessible to personnel outside these times, provided the construction noise limits are complied with at all times.

12. A Construction Noise Management Plan (CNMP) shall be provided to Council's Planning Lead or nominee no less than 20 working days prior to pile driving commencing. The CNMP shall be prepared by a suitably qualified and experienced acoustic consultant for approval that it adequately addresses the requirements of these conditions.
13. The CNMP shall detail all procedures, mitigation and methodologies required to ensure compliance with the construction noise limits referred to in this consent. The CNMP shall include those matters set out in Section 8 and Annex E of NZS6803:1999 and shall include, but not necessarily be limited to the following matters:
 - a. The hours and days of operation for construction activities;
 - b. The extent, location and timing of noise producing construction;
 - c. Activities during the construction period;
 - d. Any specific noise mitigation measures that should be considered by the contractor where practicable (e.g. dollies , shrouds;
 - e. Noise complaint procedures; and
 - f. Procedures and processes for updating the CNVMP
14. A compliance monitoring report by an appropriately qualified and experienced acoustic consultant shall be lodged with the Consent Authority within 30 working days of the commencement of the solar farm operation (or each part of the solar farm if undertaken in stages) demonstrating that the solar farm complies with the operational noise limits set out in conditions.

Earthworks

15. The Consent Holder or its agent /contractor shall submit an Erosion Sediment Control Plan (ESCP) to the Council's assigned monitoring officer for certification by the Council's Compliance Manager. The ESCP must be prepared by a suitably qualified person who shall provide certification that the erosion and sediment controls in the ESCP have been designed in accordance with the relevant best practice guidelines. As a minimum, the ESCP shall include the following:
 - a. The expected duration (timing and staging) of earthworks;
 - b. Details of all erosion and sediment controls;
 - c. Diagrams and / or plans of a scale suitable for on-site reference, showing the locations of any cut and fill operations (including earthworks for internal accessways);
 - d. The commencement and completion dates for the implementation of the proposed erosion and sediment controls;
 - e. Measures to minimise sediment being deposited on public roads;
 - f. Measures to ensure sediment or dust discharge from the earthwork's activity does not create a nuisance on neighbouring properties;
 - g. Measures to prevent spillage of fuel, oil and similar contaminants;
 - h. Means of ensuring contractor compliance with the ESCP; and
 - i. The name and telephone number of the person responsible for monitoring and maintaining all erosion and sediment control measures.

Dust

16. All earthworks must be undertaken in accordance with the approved Dust Management Plan.

Works in Proximity to National Grid Infrastructure

17. The Consent Holder shall provide Transpower NZ Ltd 10 working days notice in writing prior to commencing the proposed works.
Advice note: notification can be sent to transmission.corridor@transpower.co.nz
18. No buildings or structures shall be located within 12 metres of the centre of Transpower's transmission lines.
19. No buildings or structures shall be located within 12 metres of any outer visible edge of the foundation of the National Grid support structures on site, except for non-conductive fencing and upgrades to the access, which can be located 6 m from any outer visible edge of the support structure foundation.
20. All land use activities, including the construction of new structures, earthworks, fences and any operation of mobile plant and / or persons working near exposed lines shall comply with the New Zealand Electrical Code of Practice for Electrical Safe Distances (NZECP 34:2001) or any subsequent revision of the code.
21. All buildings, structures and vegetation must be located to ensure vehicle access is maintained to Transpower's National Grid transmission lines and support structures for maintenance at all reasonable times, and emergency works at all times.
22. All machinery and mobile plant operated in associated with the works shall maintain a minimum clearance distance of 4 metres from the live overhead conductors (wires) of Transpower's National Grid transmission lines at all times to avoid the potential of machinery striking the lines.
23. All machinery, mobile plant and vehicles operating within 12 metres of the transmission lines, and traversing beneath the lines, shall be limited to a maximum reach height of 2.1 metres. This includes any loads being lifted or transported underneath the transmission lines.
24. Any proposed vegetation or trees within 12 metres either side of Transpower's National Grid transmission lines must not exceed 2 metres in height at full maturity and must comply with the Electricity (Hazards from Trees) Regulations 2003, or any subsequent revision of the regulations.
25. Any proposed new trees or vegetation outside of 12 metres either side of the centreline of Transpower's National Grid transmission lines must be setback sufficiently to ensure the trees / vegetation cannot fall within 4 metres of the National Grid transmission lines and must comply with the Electricity (Hazards from Trees) Regulations 2003, or any subsequent revision of the regulations.

26. The CMP as required under Condition 6, must be provided to Transpower NZ Ltd for its certification at least 20 working days prior to being submitted to Council.

Advice note: The CMP should be sent to Transpower via PATAI Form 5:

<https://transpower.patai.co.nz/new-enquiry>

Appendix G. Acoustic Assessment

Project: **WAIPARA SOLAR FARM**

Prepared for: **Far North Solar Farms
Level 1
65 Main Road
Kumeu 0810
New Zealand**

Attention: **John Andrews and Pareekshit Parihar**

Report No.: **Rp 001 20230887**

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Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Approved	-	-	12 Feb 2024	George Edgar	Peter Ibbotson

SUMMARY

Marshall Day Acoustics has been engaged by Far North Solar Farms to undertake a noise assessment for the operation and construction of a proposed solar farm at Waipara. The Waipara area is located on the Canterbury Plains north of Christchurch.

The proposed generation-only 143.8 MWp solar farm would be located on a 230 Ha site alongside Waipara Flat Road, Waipara.

The proposed solar farm is in a rural area. The surrounding land is generally flat and is used for rural farming, viticulture, and rural lifestyle purposes. A tributary of the Waipara river lies to the east of the site. The Waipara settlement lies approximately 450 m to the southeast of the site. The site and surrounding area are generally flat.

The generation facility would include 30 inverters. These would be distributed in pairs over the farm. The solar panel arrays would include 5,164 motors.

Our assessment concludes the following:

- The location of the solar farm is well chosen from a noise perspective. The fairly large distances between the inverters and the nearest receivers would result in noise from the solar farm being low overall.
- The solar farm will typically operate during periods of daylight and, although it will operate during the “statutory night-time” at times. The solar farm is expected to generate lower noise levels during cooler periods of lower solar gain (e.g. mornings and evenings). Noise levels will typically be below the existing ambient noise level.
- Operational traffic noise won’t be significant compared to existing noise traffic noise levels on Waipara Flat Road.
- District Plan noise rule of 55 dB L_{Aeq} will be readily complied with by the proposed operation. The night-time noise rule of 45 dB L_{Aeq} (during dawn and dusk in the summer months) would also be readily complied with.
- The NZS 6803:1999 construction noise guidelines would be complied with at all times.
- Reverse sensitivity risks from the establishment of dwellings across SH7 from an inverter pair are likely to be low, but need to be considered by FNSF if future dwellings can be established as a permitted activity in this location. If any such dwelling was established (and noise levels were above 45 dB L_{Aeq} during the night period) the closest inverter pair may need to be relocated inwards to the site or noise from the inverter further attenuated.

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APPENDIX A GLOSSARY OF TERMINOLOGY

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APPENDIX C LOGGED NOISE RESULTS

APPENDIX D PREDICTED NOISE CONTOURS FROM INVERTERS AND TRACKERS

1.0 INTRODUCTION

Marshall Day Acoustics has been engaged by Far North Solar Farms to undertake a noise assessment for the operation and construction of a proposed solar farm at Waipara, North Canterbury. Our assessment considers noise from the operation and construction of the solar farm. This report is intended to form part of an application for resource consent.

A glossary of terminology is included in Appendix A.

2.0 SITE

The proposed generation-only 143.8 MWp solar farm is located on the eastern side of Waipara Flat Road, Waipara. The site is approximately 230 Ha, with approximately 180 Ha taken up by the solar panels. Each panel array will have a tracker motor associated with it. Electricity generated by the panels will be sent to the Waipara substation on MacKenzies Road, approximately 800 m to the east of the site. It will then be supplied to the national grid by a transformer.

The proposed solar farm is in a rural area which is notable for grape production. The surrounding land is generally flat and is used for viticultural, rural farming and rural lifestyle purposes. A tributary of the Waipara river lies to the east of the site. Waipara settlement lies approximately 450 m to the southeast of the site. Aside from the slight river gully that has formed around the Waipara River tributary, the area is flat.

The proposed solar farm is fairly well removed from the nearest dwellings. The nearest inverter pair is around 500 metres from the nearest dwelling. The closest dwellings are on MacKenzies Road and Glenmark Drive to the east, Barnetts Road to the south, and Waipara Flat Road and Bain Road to the west. We have included details of the surrounding receivers in Table 1 and Figure 1.

Table 1: Surrounding Receivers

Receiver Location	Details	Typical Use	Approx dist of closest dwelling notional boundary (m) ¹	
			To solar farm boundary	To nearest inverter
Waipara Flat Road and Bain Road (west)	There are five dwellings on the western side of Waipara Road (two on Bain Road and three on Waipara Road). These dwellings are well separated from the proposed solar farm and inverters.	Rural	500 ²	500 ²
Barnetts Road (south)	There are three dwellings located to the south of the site at the intersection of Barnetts and Waipara Flat Rd. These dwellings are around 900 m of the southern extent of the proposed solar farm and are adjacent to a busy road.	Rural	300	600
Waipara settlement (Glenmark Drive – SE)	Waipara is the nearest settlement There are several residential dwellings on Glenmark Drive, 450 m to the southeast to the site (but 900m from the inverters)	Res	450	900
MacKenzies Road and Glenmark Drive (east)	There are 12 rural or rural-lifestyle dwellings on the western side of MacKenzies Road, and one on Glenmark Drive, to the east of the site. These dwellings are all 200 m or more from the nearest solar panels and 500 metres from the nearest inverters.	Rural	200	500

Note 1: Existing land use and distances have predominantly been determined from aerial photography. The noise model uses specific distances between source and receiver.

Note 2: Excluding 380 Waipara Flat Road which is the farm owner from whom the land will be leased.

Figure 1: Site and surrounds



3.0 PROPOSAL

We understand that approximately 180 hectares of the 230 hectares (total) site would be used for the solar farm arrays. The proposed farm location in relation to the surrounding area is given in Figure 1. A site layout plan is given in Appendix B.

3.1 Facility Description

Solar panels would be installed in rows spaced apart to allow access by agricultural machinery and grazing animals. Access to the site would be off Waipara Flat Road.

The total generation power rating of the farm would be around 143.8 MWp¹.

An existing substation is located to the west of the solar farm on MacKenzie Road. The solar farm would be connected to the substation by the 33kV transmission line that already intersects the site.

The key operational noise sources would be from the following plant:

- **30 central inverters.** An inverter turns Direct Current (DC) created by the photovoltaic cells to alternating current (AC) current used in the electricity grid². These central inverters would be used in the generation of power from the solar arrays. The inverters would generally be arranged in pairs of two as shown in Appendix B. The inverters have been located along the western side of the site adjacent to Waipara Flat Rd. This results in a large setback between dwellings and the inverters.
- **5,164 tracker motors** would be associated with the solar panel arrays. Each solar panel array table would be attached to a tracker motor³.

Power generation at the solar farm would occur during daylight/sunshine hours. In summer, operating daylight hours could begin earlier and extend later than the prescribed⁴ daytime period of 7am to 7pm. In particular, generation is still likely to be appreciable after 7pm during the longer days of summer. We have allowed for full load on the inverters when solar load is high.

3.2 Written Approvals

We have assumed that written approval will be obtained from the owner of 380 Waipara Flat Road as they are leasing land to Far North Solar Farms for the solar farm site.⁵

3.3 Acoustic Mitigation

We don't consider acoustic mitigation such as enclosure or attenuation of the inverters likely to be necessary on this project. Some inverter manufacturers have shrouds / lined bends that can be provided to the inverter intake and discharge ventilation openings. These result in around 3 to 5

¹ This is the alternating current generation power. The power of each inverter is nominally 4,200 kVA.

² No specific inverter supplier has been selected at this stage of the project. There are two major manufacturers of inverters that are used on most solar projects, although other manufacturers may be considered.

³ Trackers consist of many solar panels on a frame that tilts vertically to align the panels to the sun throughout the day. The trackers are rotated around a central horizontal axis by a small DC motor (approximately 300 watts running at 24V DC). The motor is the main noise source associated with each tracker. The tracker motors are understood to operate intermittently during daylight hours and only for a short period as they are only required to make small incremental adjustments to the trackers. DC motors are quiet, even under continuous load and operation, and the collective sound power level of even a large number of tracker motors is not normally significant when considered over the normally large solar farm sites.

⁴ Refer to Section 5 for discussion of the District Plan noise rules and statutory timeframes.

⁵ Council must not, when considering the application, have regard to any effect on a person who has given their written approval to the application (Section 104 (3) of the Resource Management Act 1991).

decibels of attenuation per source. However, we do not consider these would be required for this project based on the proposed location and orientation of the inverters.

4.0 EXISTING NOISE ENVIRONMENT

We visited the site and surrounding area to measure noise in the over a period of two days. We carried out the following:

- Attended noise measurements on the afternoon of 1 February 2024 (between 3:30pm and 8:00pm) and the morning of 2 February 2024 (between 8:45am and 10:30am)
- A site visit to install a noise logger at 15:00pm on 30 January 2024. The logger data used in this analysis comprises the period 30 January 2024 (afternoon) to 2 February 2024 (morning), a period of two full days and two-part days.

The purpose of the measurements was to establish representative ambient noise levels in the site and surrounding areas. We observed a background and ambient noise character that was typically dominated by human-made noises over the daytime, such as traffic, farming activity and viticultural activities. Natural noises such as insects, birds and wind in trees were also (cicadas were not noted as significant in this area during our site visits)

Weather conditions were clear and fine throughout the measurements. Wind was generally light throughout the Canterbury plains over the measurement period, though wind speeds were observed to increase to higher levels on the night / early morning of 2 February 2024. This site is anecdotally notable for receiving seasonal high NW winds at times⁶.

Our attended and unattended noise measurements results are summarised in the following sections:

4.1 Logger Data

The logger was set up on the subject site at a distance of 210 metres from Waipara Flat Road (MP1, refer Figure 1). This location was chosen as it was on an accessible part of the site and was considered to be suitable for demonstrating the general diurnal noise level that would be received by dwellings in proximity to Waipara Flat Road. Dwellings located further from the road would receive lower overall noise levels, however the diurnal variation in noise is likely to be broadly similar. The main purpose of the noise logger is to show the typical variation in noise from sunrise to sunset – the attended noise measurements in Section 4.2 are intended to show the variation in noise levels that occur around the site.

Observations at the logger position and wider area during the daytime showed that noise levels in this area are set predominantly by traffic. Viticultural and farming activity was audible at times, consisting of large irrigators, bird scarers (gas guns) and general tractor, truck and vehicle movements. Frost fans are visible at vineyards, however these do not operate in the summer months and were not operating during our visit. Frost fans typically operate throughout the night – it is understood that helicopters are used at some sites.

Vehicles on Waipara Flat Road (SH7) are regular and traffic is typically audible at all times of the day when in proximity to this road. This road carries around 4,300 vehicles per day, with 14% heavy vehicles. MacKenzie Road carries fewer vehicles.

In this District, the daytime period applies between 7am and 7pm. During the longer days of summer, it is probable that the solar farm will still generate some power prior to 7am (dawn) and after 7pm (dusk).

⁶ NIWA data shows this area of the Canterbury plains receiving more regular and stronger NW winds than Christchurch, though less frequent winds from the NE or SW.

We have analysed background noise level over periods that relate to the District Plan statutory periods that are relevant to the solar farm operation. Table 2 summarises noise levels at the logger position.

Table 2: Measured Ambient Noise Levels (logged)

Date	Overall Measured Level (dB) ¹						Meteorological conditions
	“Early morning” 5:00am to 7:00am ²		“Daytime” 7:00am to 7:00pm ³		“Night” 7:00pm to 9:00pm ⁴		
	L _{Aeq}	L _{A90}	L _{Aeq}	L _{A90}	L _{Aeq}	L _{A90}	
30/01	-	-	-	-	45	32	Clear and fine, SE winds light <5m/s
31/01	48	33	44	36	47	33	Clear and fine, winds light except for two hours around midday when wind speeds exceed 5m/s. Wind direction variable: NE to SW.
1/02	49	34	46	36	42	29	Clear and fine, winds light <4 m/s typically from NE
2/02	48	36	-	-	-	-	Higher winds overnight from NW exceeding 5m/s

Notes to Table 2:

- (1) An explanation of technical terms is provided in Appendix A
- (2) These are the dawn “night-time” hours prior to 7am in summer
- (3) This is the statutory daytime period
- (4) The night-time is given as the two dusk hours during the statutory night period.

Refer to Appendix C for a graph showing the noise level variation over the logging period.

The logger data shows that average daytime noise levels (7am to 7pm) are around 44 to 46 dB L_{Aeq}. Average background noise levels during this time were 36 dB L_{A90}.

During the early morning (around dawn) and the early night (around dusk), ambient noise levels are similar to or higher than the daytime average noise levels (typically 48 to 49 dB L_{Aeq} around dawn and 42 to 47 dB L_{Aeq} around dusk). Recordings on the noise loggers do not show any obvious reasons for this, though it may be due to traffic, insects and bird activity increasing around these times. Background noise levels at dawn and dusk are somewhat lower than the background noise levels during the day, though typical background noise levels at these times are in the order of 35 dB L_{A90}.

In terms of diurnal variation, the logger data does not show that there is a considerable change in ambient noise levels throughout the daytime and night-time. This is likely to be due to the presence of traffic noise (on SH7 and SH1) as the dominant source in the environment. Background noise levels show more of a diurnal variation, though daytime background noise levels appear fairly constant between dawn and dusk and only drop to low levels during the hours around midnight (when no solar power would be generated by the proposed solar farm).

4.2 Attended Measurements

We also carried out attended measurements near the site to directly observe the existing noise environment and identify the main sources of noise that occur at surrounding dwellings. Table 3 summarises our attended measurement results.

Table 3: Measured ambient noise levels (attended)

Measurement Position	Measurement		Measured Level (dB) ¹				Noise Source ²
	Date Start (hh:mm)	Dur min:sec	L _{Aeq}	L _{A10}	L _{A90}	L _{AFmax}	
MP2: Bain Rd, 500m from SH7	1/02/2024 3:38 pm	15:01	38	41	32	57	<u>SH7 traffic dominates.</u> Noise from large irrigator to SW. Vineyard noise on adjacent properties occasionally.
MP3: Near 165 and 251 Mackenzies Rd	1/02/2024 5:06 pm	16:07	39	38	31	60	<u>Wind, crickets,</u> distant traffic on SH1, dogs barking, occasional bangs (likely bird scarers), bird calls
MP4: Near Barnettts Rd dwellings	1/02/2024 5:38 pm	15:01	64	69	36	79	<u>SH7 traffic noise dominates</u> – few periods of quiet between vehicles, crickets and birds, some domestic noise (car doors, voices)
MP5: Waipara residential area	1/02/2024 7:27 pm	17:04	44	48	34	62	<u>Distant traffic, birds,</u> wind in foliage, people at Railway Motel
MP2: Bain Rd 500m, from SH7	2/02/2024 8:45 pm	10:10	43	46	38	52	<u>SH7 traffic dominates,</u> magpies and other birds.
MP3: Near 165 and 251 Mackenzies Rd	2/02/2024 9:09 pm	12:31	36	39	31	50	<u>Traffic noise fairly light</u> due to upwind conditions, breeze in trees at times, SH1 noise from east, gas guns, gulls, bird song, dog barks, insects, vehicles on adjacent properties / vineyards
MP4: Near Barnettts Rd dwellings	2/02/2024 9:34 pm	10:09	65	70	41	82	<u>SH7 traffic noise dominates</u> – few periods of quiet between vehicles, birdsong
MP5: Waipara residential area	2/02/2024 9:49 pm	12:01	49	46	36	71	<u>Distant traffic, local traffic,</u> birds, people in neighbourhood distant conversation, bird scarers/gas guns.

Note to Table 3:

- (1) An explanation of technical terms is provided in Appendix A.
- (2) Dominant sources are underlined.

The results show a variation in ambient and background noise levels around the proposed solar farm site. Ambient noise levels were as low as 36 dB L_{Aeq} at the east side of the farm near the Mackenzie Road dwellings, however dwellings near SH7 receive ambient noise levels of up to 65 dB L_{Aeq} at times. The ambient noise level in this area is broadly dependant on the proximity to the main roads.

Background noise levels vary less than the ambient noise levels. Background noise levels were typically between 31 and 41 dB L_{A90} around the site. These background noise levels show that there are typically short periods of relative quiet in most locations even where residents receive higher noise levels from nearby roads.

4.3 Overall Comments on Ambient Noise Levels

The ambient noise environment in this environment is broadly typical of a rural / viticultural area close to settlements. Ambient noise levels around the site vary significantly depending on the proximity of dwellings to roads, whereas background noise levels show less variation. The general noise environment of the area is neither “particular noisy” or “particularly quiet”. The character of the area is largely one that is already dominated by human-made noise rather than natural sounds.

The area is likely to receive variable noise levels with the seasons. The site is likely to be subject to seasonal winds that may be high at times, and the presence of significant wine growing in this sometimes-cold climate will mean that frost fans operate through the colder winter months. Seasonal viticulture and farming works (e.g. grape harvest, feed cutting, stock work) will also vary with seasons.

5.0 NOISE PERFORMANCE STANDARDS AND LEGISLATION

The site is subject to the Hurunui District Plan (the District Plan) noise rules.

5.1 Operative District Plan

5.1.1 Zoning

The application site and surrounding sites are situated on land in the *Rural* in the Operative District Plan.

5.1.2 Operative Noise Rules

Rule 3.4.3.9 Noise of the District Plan sets out limits for noise received within the notional boundary of any dwelling in the *Rural zone* from activities on any site. We have summarised these in Table 3 below.

Table 3: District Plan Noise Rules

Daytime (7 am – 7 pm)	Night-time (7 pm – 7 am)
55 dB L_{Aeq}	45 dB L_{Aeq}
	70 dB L_{AFmax}

The District Plan states noise will be measured in accordance with *NZS 6801:2008 “Acoustics – Measurement of Environmental Sound”* and assessed in accordance with *NZS 6802:2008 “Acoustics - Environmental Noise”*.

5.1.3 Construction Noise Rules

The Operative District Plan 3.4.3.9 (g) states: *Construction noise – construction noise must be measured and assessed in accordance with the provisions of NZS 6803:1999 “Acoustics - Construction Noise”*

The relevant noise limits for construction of the solar farm are 75 dB L_{Aeq} and 90 dB L_{Amax} between the hours of 7:30 am and 6 pm.

5.1.4 Other noise rules

There are other noise rules in the District Plan that are specific to noise sources that are regularly encountered in the District. None of these specifically relate to solar farm activity.

5.2 Resource Management Act

Under the provisions of the Resource Management Act (RMA) there is a duty to adopt the best practicable option to ensure that noise (including vibration⁷) from any development does not exceed a reasonable level. Specifically, Sections 16 and 17 reference noise effects as follows.

Section 16 states that “every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level”.

Section 17(1) states that “every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person, whether or not the activity is in accordance with –

(a) Any of sections 10, 10A, 10B and 20A; or

(b) A national environmental standard, a rule, a resource consent, or a designation”.

6.0 OPERATIONAL NOISE LEVELS

6.1 Noise Sources and Modelling Methodology

The main noise sources from the proposed solar farm would be the central generation inverters. Tracker motors also generate noise, but to a lesser degree than unattenuated inverters. We understand electricity will be transmitted to the substation along the existing 33 kV line and that transformers will not be required on the subject site.

We have prepared a noise model using SoundPLAN® environmental noise modelling which considers factors such as the terrain, screening by buildings, and ground effect. We calculated sound propagation using ISO 9613-2:1996 "Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation". We have calculated the noise levels at the closest receivers under meteorological conditions that are favourable to sound propagation⁸. This represents the typical 'worst case' situation⁹.

We have used the following sound power data for the inverters in our noise model. We have relied on advice given by the manufacturers or from previous measurements we have carried out. We recommend that any final inverter selection is in accordance with this data.

⁷ RMA 1991 Part 1 Section 2 Interpretation: Noise includes vibration

⁸ These are set out in ISO9613-2 and represent downwind or temperature inversion conditions.

⁹ Under most daytime metrological conditions, noise levels will be lower than calculated. This is because when the solar farm is operating at full generation, it will be during periods of high solar gain (typically during the middle part of the day). In general, high solar gain conditions correspond with conditions that are not favourable to sound propagation, as sound will refract upward when air temperatures reduce with increasing altitude (temperature lapse). In temperature lapse conditions, noise levels are expected to be around five decibels lower than calculated for the temperature inversion condition.

Table 4: Sound Power Levels

Noise Source	Sound Power Level dBA re 10 ⁻¹² Watts	Number of Units	Directivity	Operation time
Generation Inverters				
DC / AC inverter 4.2 MVA	93 dB L _{WA} (AC end) 88 dB L _{WA} (DC end)	30	Included	Operation during sunshine hours (within the statutory night period at times)
Tracker modules	74 dB L _{WA} (emission when moving) = 100 dB L _{WA} (total L _w for all trackers across total farm ¹⁰)	5,164	None	68 seconds per 15 minutes – sunshine hours
TOTAL SOURCES		30 + Trackers		

Solar farm inverters may have tonal characteristics at various frequencies. The assessment of environmental noise effects for resource consent allows for inverters to have some tones and the relevant penalties have been applied¹¹.

We understand that inverter noise levels would reduce at low loads. We have allowed a reduction in sound power level of four decibels at 10% inverter power output¹². Available data shows that tonal character is eliminated at low loads.

6.2 Noise Level Calculations

We have calculated noise levels at the notional boundaries of the receivers surrounding the farm.

Noise from inverter units will likely have appreciable directivity. We have calculated noise from the inverter pairs facing east and west. While it is possible that the final orientations of the inverters may be in alternative directions, we expect that this is unlikely to result in significant increases in noise. The final design of the solar farm can be subject to detailed design review and any issues associated with the inverter orientation can be addressed through reorientation or via the provision of a proprietary noise attenuation package. Subject to these measures we expect that noise levels will be similar to those set out in this assessment.

Our calculations have been carried out with the following assumptions:

- Inverter source heights at 4 metres above ground
- Inverters distributed across the site as shown in the site drawings
- Inverters operating at 100% load at times
- Tracker motors below the table rotational axis at 3m above ground level

¹⁰ Recent data from manufacturers suggests a sound power level of 74 dB L_{WA} for solar farm 24V DC-type motors at all ranges of torque loads.

¹¹ Tonality would typically be expected to occur at higher frequencies. Higher frequencies are attenuated with distance due to air and ground absorption, as well as topographical screening. Given the distances involved, tonality may not be audibly present at the receiver as any tones may be below the background level. Nonetheless we have conservatively allowed for tonality to be potentially present at low levels.

¹² Our analysis has allowed for inverter ventilation fans to operate at 100% even during times of low power generation. This is likely a conservative assumption where fans are variable speed.

We have applied a +5 dB special audible character¹³ correction in accordance with NZS 6802:2008. As the solar farm could potentially operate for more than 80% of the prescribed daytime period (particularly during summer), no duration correction has been applied. Additionally, as the solar farm can generate during part of the proposed District Plan statutory night period (after 7 pm), no duration correction is possible at that time.

6.3 Calculated Noise Levels from Proposed Solar Farm

Table 5 summarises the results of our calculations.

Table 5: Calculated Noise levels

Receiver Location	Noise Limits [daytime / night] (dB LAeq)	Calculated Rating Noise Level (dB L _R)	
		100% LOAD	10% LOAD
253 Waipara Flat Road	55 / 45	33	29
279 Waipara Flat Road	55 / 45	30	26
419 Waipara Flat Road	55 / 45	33	29
86 Bain Road	55 / 45	29	25
27 Bain Road	55 / 45	35	31
1 Barnettts Road	55 / 45	26	22
3 Barnettts Road	55 / 45	25	21
16 Barnettts Road	55 / 45	28	24
43 and 63 Glenmark Drive (Waipara settlement)	55 / 45	29	25
55 Glenmark Drive	55 / 45	28	24
59 MacKenzie Road	55 / 45	27	23
73 MacKenzies Road	55 / 45	28	24
97 MacKenzies Road	55 / 45	29	25
119 MacKenzies Road	55 / 45	29	25
139 MacKenzies Road	55 / 45	29	25
161 MacKenzies Road	55 / 45	29	25
165 MacKenzies Road	55 / 45	34	30
167 MacKenzies Road	55 / 45	31	27
169 MacKenzies Road	55 / 45	31	27
247 MacKenzies Road	55 / 45	35	31
249 MacKenzies Road	55 / 45	31	27
251 MacKenzies Road	55 / 45	34	30
255 MacKenzies Road	55 / 45	32	28
257 MacKenzies Road	55 / 45	34	30
380 Waipara Flat Road (solar farm site owner)	55 / 45	42	38

Note 1: These sites are unbuilt, so they are not strictly compliance receivers. We have assessed noise at the legal boundary for informational purposes.

¹³ Spectral data from some inverter manufacturers shows the potential for tones therefore, a five-decibel special audible character penalty has been applied to the overall noise level from this solar farm. It is possible that tonality will not occur and rating noise levels could be lower – data shows this will occur at lower inverter loads.

6.4 Results Summary

Our calculations show that for the closest receivers:

- The proposed solar farm would readily comply with the recommended daytime noise rule of 55 dB L_{Aeq} . Even in the worst-case “100%” scenario, noise levels would be at least 20 decibels below the daytime noise rule.
- Operation at dusk or dawn of the proposed solar farm would readily comply with the night-time noise rule of 45 dB L_{Aeq} . Even in the worst-case “100%” scenario, noise levels would be at least 10 dB below the night-time noise rule.
- Solar farm noise levels are expected to be typically below the existing ambient noise levels when received at dwellings. In some cases, noise will be significantly below the existing ambient noise level.
- Noise levels at dwellings to the immediate east of the solar farm are likely to be similar to the existing ambient noise levels. A slight increase in background noise levels could occur at the closest dwellings. At many dwellings, noise levels will be below the existing daytime background noise levels.
- Overall daytime noise levels are expected to be low: well below guidelines that are used to inform the potential amenity effects of noise.

6.5 Noise Contours

The calculated rating noise levels are illustrated in the noise contour map in Appendix D. This shows that noise levels are well below 40 dB L_{Aeq} at all existing dwelling notional boundary locations.

The noise contour map shows that the 45 dB L_{Aeq} noise emission from the proposed solar farm could extend across SH7 and onto the adjacent farmland/vineyards by around 60 metres. While it seems unlikely that future residential development would occur this close to the State Highway¹⁴ if dwellings can be established at this distance as a permitted activity then the reverse sensitivity effects on the solar farm need to be considered. If a dwelling was to be constructed within this distance (and noise levels were above 45 dB L_{Aeq} during the night-time) then this may require the attenuation of noise from the closest inverter pairs, or the relocation of those inverters further within the farm.

We note that other solar farm consents have dealt with the above issue in different ways: some consents have been issued subject to meeting the noise rules at existing notional boundaries only, whereas others that are in progress have been subject to an agreement to meet the noise limits at existing and future notional boundaries.

6.6 Operational Traffic

We have assessed noise from operational traffic. We understand the farm would only require around two staff on site which we expect could generate perhaps 4 to 12 vehicle movements per day along Waipara Flat Road. During the initial period of commissioning, we understand that there may be more staff on site and a higher number of traffic movements may result. Operation of the solar farm would only require very occasional heavy vehicle movements, which are not expected to occur during the evening and night periods.

The location of the vehicle entry point is well removed from most dwellings and so we expect noise from on-site movements to be very low, typically below the existing background noise level at most dwellings at most times.

¹⁴ the existing dwellings are at least 400 metres from the state highway

Based on existing traffic data, the above number of vehicles would not significantly increase traffic on Waipara Flat Road. Additionally, this is a public road, and so the District Plan rules do not apply.

We consider that operational traffic noise won't be significant compared to existing noise traffic noise levels in the area.

7.0 SUMMARY OF OPERATIONAL NOISE EFFECTS

- The location of the solar farm is well chosen from a noise perspective. The fairly large distances between the inverters and the nearest receivers would result in noise from the solar farm being low overall.
- The solar farm will typically operate during periods of daylight and, although it will operate during the "statutory night-time" at times, the solar farm is expected to generate lower noise levels during cooler periods of lower solar gain (e.g. mornings and evenings). We expect noise levels to be generally below the existing ambient noise level.
- We consider that operational traffic noise won't be significant compared to existing noise traffic noise levels on Waipara Flat Road.
- We predict ready compliance with the District Plan noise limits for the proposed operation.
- Reverse sensitivity risks from the establishment of dwellings across SH7 from an inverter pair are likely to be low, but need to be considered by FNSF if future dwellings can be established as a permitted activity in this location. If any such dwelling was established (and noise levels were above 45 dB L_{Aeq} during the night period) the closest inverter pair may need to be relocated inwards to the site or noise from the inverter further attenuated.

8.0 CONSTRUCTION NOISE LEVELS

8.1 On-site construction

Construction of the solar farm is likely to involve the following:

- Delivery of panels, inverters, and other infrastructure, requiring trucks and small cranes. Around three trucks per day are expected.
- A Vermeer PD10 Pile Driver to impact drive the support piles into the ground.

Construction activities would likely take place over a 12 month period between the hours 7:30 am to 6 pm, Monday to Friday.

All significant equipment likely to be used on the project is listed in Table 6. The sound levels given are based on measurements we have made of similar plant or from BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites* Part 1: Noise.

Table 6: Activity Specific Noise Levels at 1m from a building façade (without screening)

Item/Activity	Operating Sound Power Level (dB L _{WA})	Noise Level (dB L _{Aeq})				75dBA Limit Setback (m)
		100m	250m	500m	750m	
Large Trucks (operating within the site)	108	60	50	43	38	25m
Vermeer PD10 Pile Driver (unattenuated impact piling noise level)	123	75	65	58	53	100m
Impact piling (with casing and dolly)	114	66	58	49	44	44m
Concrete truck & pump	103	55	45	38	33	14m
Truck idling	91	43	33	26	21	4m

All dwellings would be well beyond 100 metres from the piling. The closest dwelling with direct line of sight to piles will be 250 metres away. At this distance, noise levels will be in the order of 65 dB L_{Aeq} when piling is undertaken and thus compliance with the District Plan construction noise rules would be achieved.

Although construction activity will readily comply with the District Plan NZS6803:1999 construction noise limits, there is a duty under the RMA to implement the best practicable option to ensure noise levels are reasonable. Given the number of piles required, we recommend that the contractor consider if there are practicable measures that can be implemented to reduce noise levels as far as practicable. These may involve the use of alternative piling methods, or shrouds or dollies where these are judged to be practicable for the Vermeer piling rig (without unreasonably extending the duration of piling as this would not be beneficial for neighbours). A Construction Noise Management Plan can be utilised if necessary.

There would be no perceptible vibration from the above construction activity.

8.2 Construction vehicles on public roads

Truck and construction passenger vehicle movements would occur on Waipara Flat Road during construction. These are public roads and the construction noise and vibration limits do not technically apply to activities on these roads. We expect that construction traffic will comply with the NZS6803:1999 noise rules.

9.0 RECOMMENDED NOISE CONDITIONS

It is recommended that the following noise conditions are imposed on any consent granted. Condition 1 is a condition similar to that which has been applied to a recent solar farm consent where the consented noise limit applied only at dwellings existing at the time consent was granted.

1. The noise level from operation of the solar farm shall meet the following noise limits at the notional boundary of dwellings existing at the time of consent on any other site (excluding those within the site or where written approval has been obtained):

Daytime (7 am – 7 pm)	Night-time (7 pm – 7 am)
55 dB LAeq	45 dB LAeq
	70 dB LAFmax

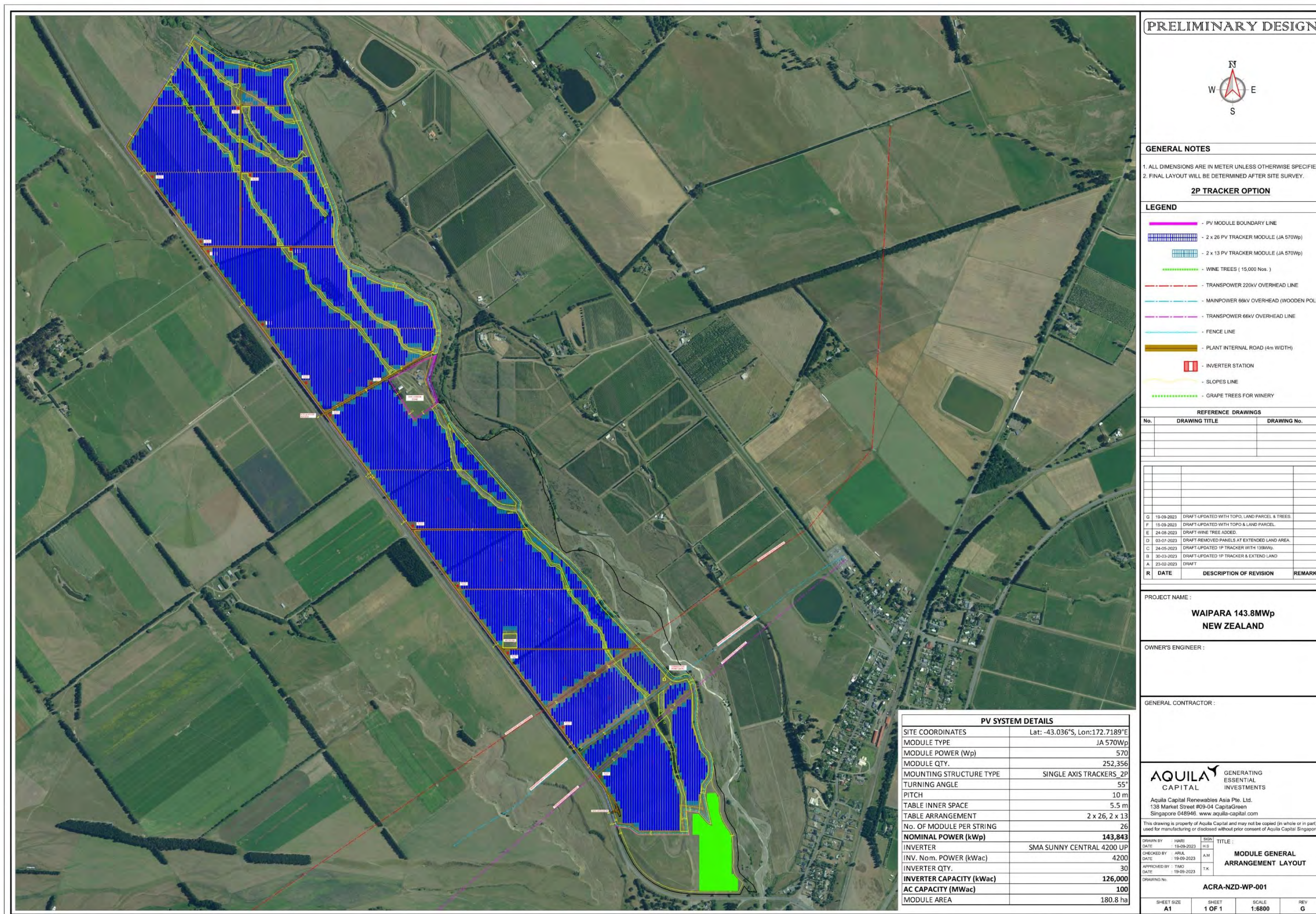
Noise levels shall be measured and assessed in accordance with NZS 6801:2008 *Acoustics – Measurement of Environmental Sound* and NZS 6802:2008 *Acoustics – Environmental Noise*.

2. Noise from construction activities shall not exceed the typical duration limits recommended in, and shall be measured and assessed in accordance with, New Zealand Standard NZS 6803: 1999 “*Acoustics – Construction Noise*”.
3. A Construction Noise Management Plan (CNMP) shall be prepared and submitted to Council. The CNMP shall identify methods of noise attenuation (if any) that can be practicably be used by the contractor to reduce noise over the duration of the piling works.

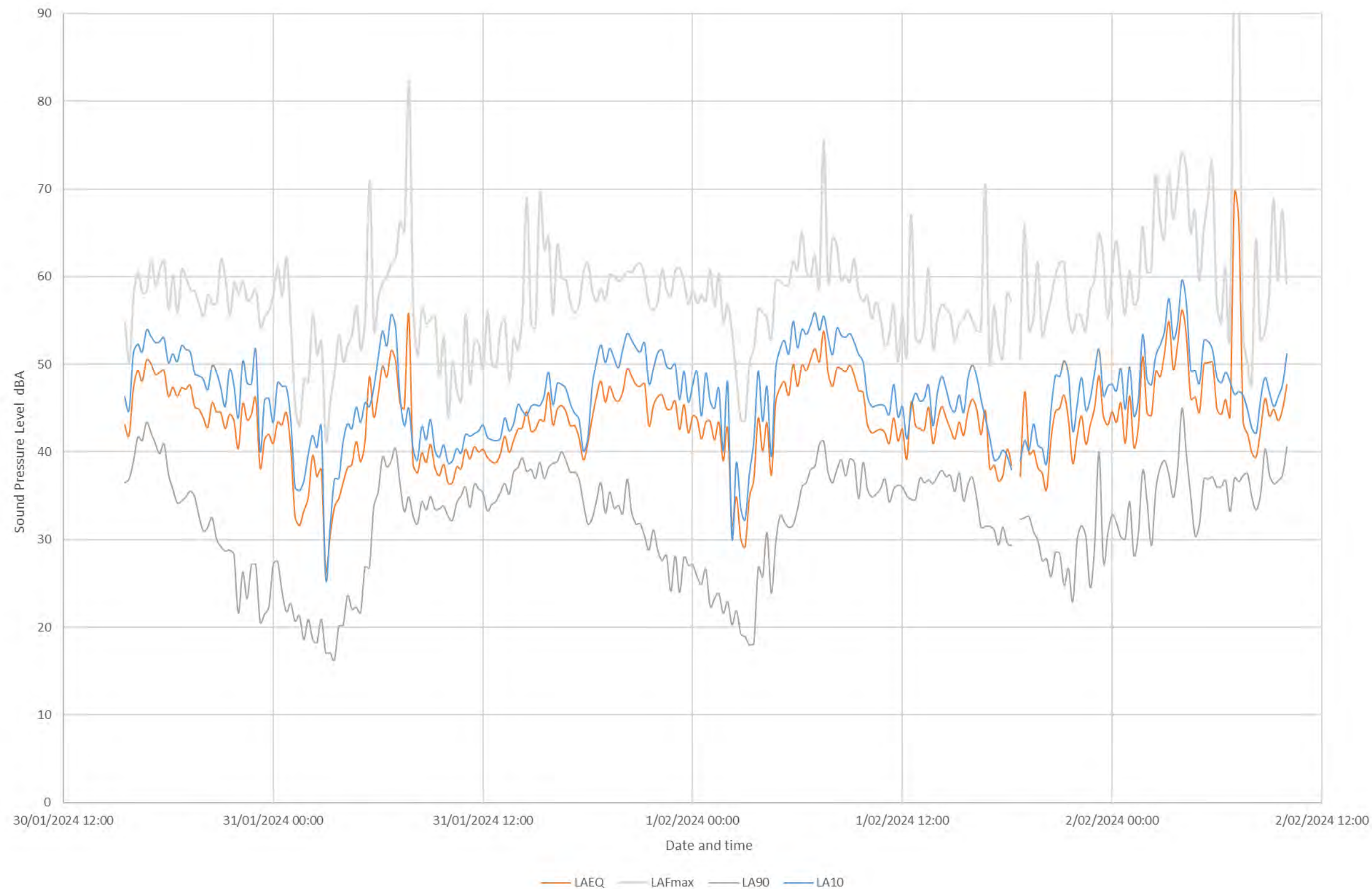
APPENDIX A GLOSSARY OF TERMINOLOGY

Ambient Noise	Ambient Noise is the all-encompassing noise associated with any given environment and is usually a composite of sounds from many sources near and far.
dBA	A measurement of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
L_{eq}	The time averaged sound level (on a logarithmic/energy basis) over the measurement period (normally A-weighted).
L₉₀	The sound level which is equalled or exceeded for 90% of the measurement period. L ₉₀ is an indicator of the mean minimum noise level and is used in New Zealand as the descriptor for background noise (normally A-weighted).
L₁₀	The sound level which is equalled or exceeded for 10% of the measurement period. L ₁₀ is an indicator of the mean maximum noise level and is used in New Zealand as the descriptor for intrusive noise (normally A-weighted).
L_{AFmax}	The maximum sound level recorded during the measurement period (normally A-weighted).
NZS 6801:2008	New Zealand Standard NZS 6801:2008 <i>Acoustics – Measurement of environmental sound</i>
NZS 6802:2008	New Zealand Standard NZS 6802:2008 <i>Acoustics - Environmental Noise</i>
NZS 6803:1999	New Zealand Standard NZS 6803:1999 <i>“Acoustics – Construction Noise”</i>
NZS 6803P:1984	New Zealand Standard NZS 6803P:1984 <i>“The Measurement and Assessment of Noise from Construction, Maintenance and Demolition Work”</i>
Prescribed time frame	‘Daytime’, ‘night-time’, ‘evening’, or any other relevant period specified in any rule or national environmental standard or in accordance with 8.3.2 in NZS 6802:2008.
Rating level	A derived level used for comparison with a noise limit. Considers any and all corrections described in NZS 6801 and NZS 6802, e.g. duration, special audible character, residual sound etc. This definition is from NZS 6802:2008.
Special audible characteristics	Distinctive characteristics of a sound that make it more likely to cause annoyance or disturbance. A penalty of up to 5 decibels can be applied when assessing sounds with SAC Examples are tonality – a hum or a whine) and impulsiveness – bangs or thumps.

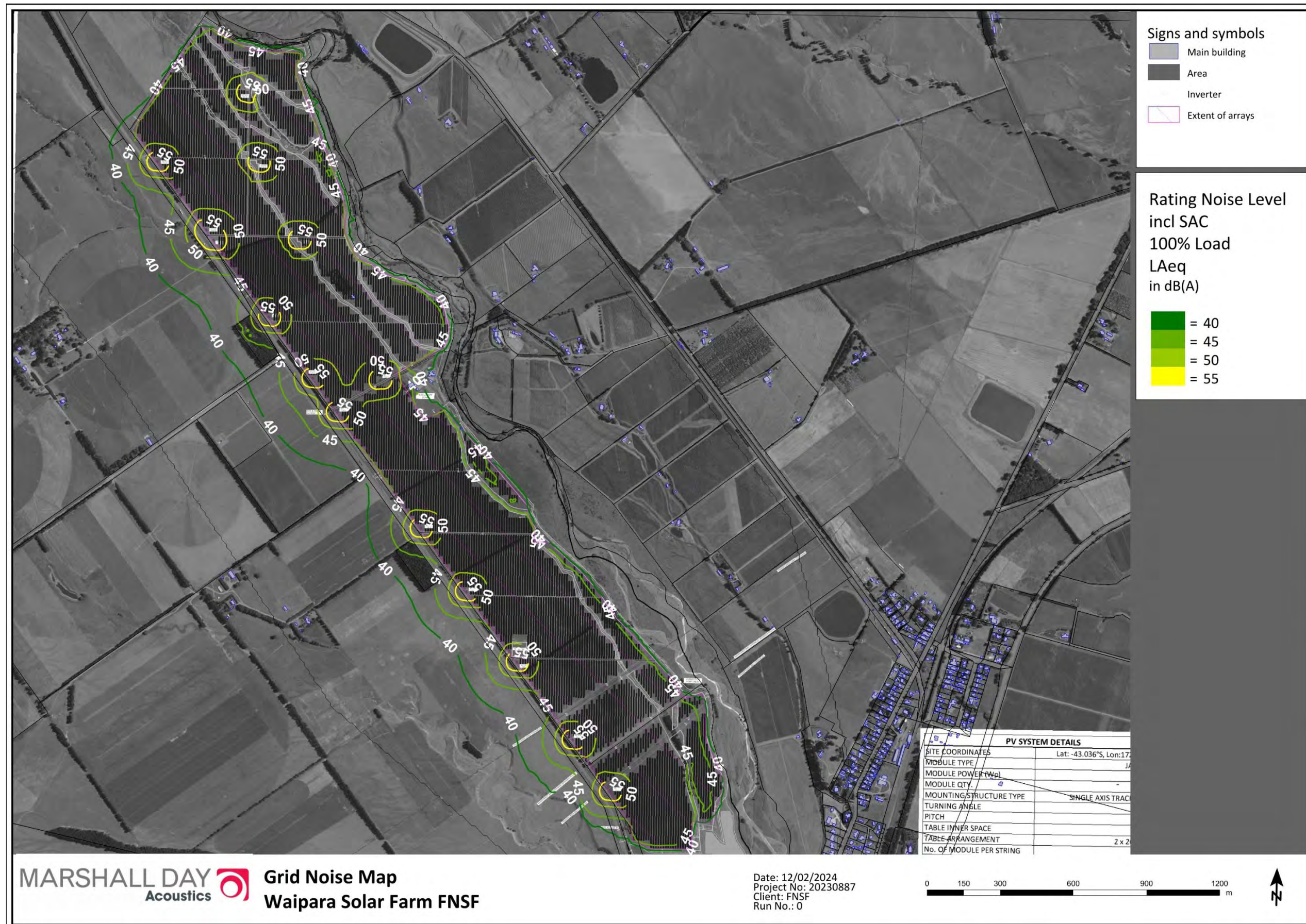
APPENDIX B SITE LAYOUT PLAN



APPENDIX C LOGGED NOISE RESULTS



APPENDIX D PREDICTED NOISE CONTOURS FROM INVERTERS AND TRACKERS



Appendix H. Stormwater Assessment

Stormwater Assessment
for Proposed Solar Farm
at 380 SH 7, Waipara, Canterbury
for Far North Solar Farm Ltd

Haigh Workman reference 23 185

21 November 2023 – FINAL



Revision History

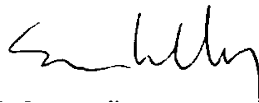
Revision N ^o	Issued By	Description	Date
Draft	Alan Collins	Final	21 November 2023

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Executive Summary

Haigh Workman Ltd was commissioned by Far North Solar Farm Ltd to undertake a stormwater assessment and subsequent management plan for a proposed solar farm (the Site) in Waipara. The proposed development would see the erection of photovoltaic (PV) modules and ancillary infrastructure across 180.8 ha of existing sheep pastureland. In addition, 4.8 ha of existing pastureland near the southern end of the Site is to be planted with a vineyard for community aesthetics. Grass growth will not be impeded by the PV modules and grazing of the land will continue.

Because the ground has high soakage, stormwater runoff only occurs in low probability rain events. Modelling with the rational method supported that the proposed development maintains stormwater neutrality. Concurrently, the partial shading from the PV modules will reduce evapotranspiration in the summer months, reducing potential demand for irrigation. This is an external positive effect on the Waipara catchment water resource.

Negative effects on stormwater quality are not foreseen. The ground infiltration provides adequate hydraulic retention time to absorb heat transferred from the PV modules. Long-term sediment yield into the Weka Creek will decrease. Erosion prone ridge faces are to be stabilised with native flora for visual aesthetics. There is potential for short-term sediment yield during construction. An Erosion Sediment Control Plan in accordance with GD05 is recommended as a consent condition.

1 Introduction

Haigh Workman Ltd was commissioned by Far North Solar Farm Ltd (the Client) to undertake a stormwater assessment for consent application. The proposed development is a 135 MWp Solar Farm. The site is accessed from 380 State Highway 7, Waipara, Canterbury.

The proposed development will occupy the following parcels:

Lot 2 DP 19025
Lot 1 DP 320376
Section 4 SO 17514
Section 3 SO 17514

Herein referred to as 'the Site'.

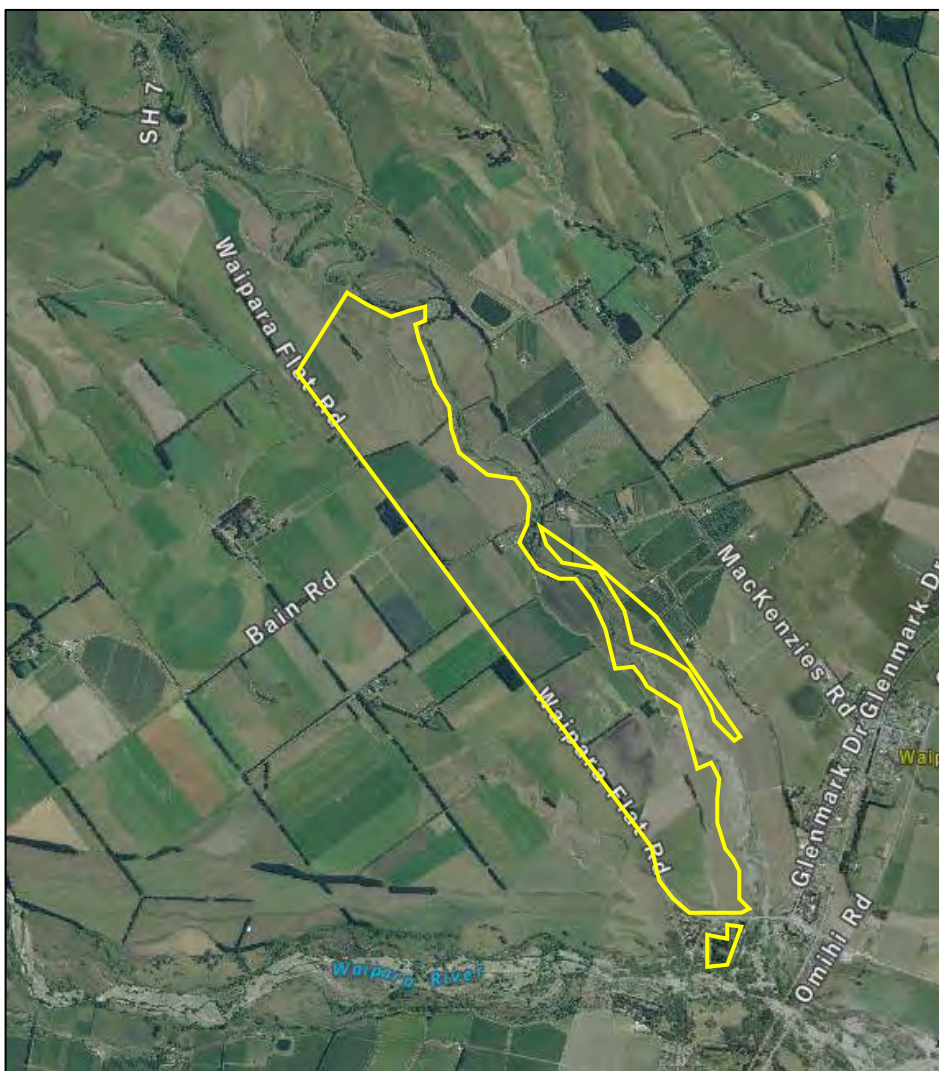


Figure 1: Site Outline

1.1 Objective and Scope

The objectives of this investigation are to:

- Undertake a site visit and make observations of stormwater flow paths, catchments, hazards, and other features.
- Review the regulatory framework for rules, policies, and objectives as it relates to stormwater.
- Assess the runoff effects from the proposed development.
- Assess water quality effects from the proposed development.
- Assess the necessity for water quantity control.
- Prepare a compliant stormwater assessment report for consent application.

1.2 Limitations

This report is intended to support a consent application with the Hurunui District Council. It is to be used by the Council when considering the application for the proposed development. The information and opinions expressed in this report shall not be used in any other context without prior approval from Haigh Workman Ltd.

All details and the scheme plan for the proposed development have been given to Haigh Workman Ltd by the Client. If the design diverges from the conceptual brief, the recommendations of this report will need to be revisited.

Haigh Workman Ltd does not take responsibility for the engineering aspects of the proposed development that are not covered in the agreed brief.

2 Site Description

2.1 Site Location

Site Address: 380 State Highway 7, Waipara, Canterbury

Area to be developed: 180.8 hectares

2.2 Site Features

2.2.1 Site Topography

The Site is elongated along the southwestern bank of the Weka Creek – a braided river. Inclines on the site are mostly flat to 5%. However, there are several ridges running near parallel with Weka Creek. The ridge faces are facing towards the north-east and have vertical heights up to 8m and inclines up to 70 degrees. The steepest area of the ridge is undercut by Weka Creek and has led to toppling failure.



Figure 2: Instability near Weka Creek flood plain. The Creek has undercut the hillside leading to toppling.

2.2.2 Site Geology

The Site is sub-par farming land with free draining gravel soils.

Geological mapping by GNS indicates that the upper plateau of the Site is arranged in low-lying river terraces with river deposits for the Late Pleistocene. Soil is described as unweathered, brownish-grey, gravels/sands/silts.

The low-lying areas of the Site within the flood plain of Weka Creek are described as active river bed deposits (Holocene). The sediments are unweathered, rounded-subangular variable gravels with greywacke origins.



Figure 3: GNS Geological mapping of Site.

Site Observations confirmed the mapped geology. There is 0-50mm of topsoil. Grass growth is patchy in places. Chalky grey, rounded, gravel particles are seen throughout the Site. There is negligible evidence of overland flowpaths for a very large area of the catchment. This indicates that precipitation infiltrates into the ground rather than moving as surface runoff.



Figure 4: Patchy grass cover and exposed gravels were found throughout the Site. However, bare patches were more concentrated in the low-lying flood plain.

2.2.3 Site Features

The Site is currently grazed by sheep at low intensity. There is an existing 370m² house with residential garden and parking. There is a large livestock barn (240m²) to the west of the house on the upper terrace. The runoff of the barn enters a 20,000L water tank with overflow. The overflow discharges directly to the ground with no evidence of flowpaths or springs downhill. This is indicative of the free-draining characteristic of the soil.

There are several windbreaks of mature pine trees on the farm, perpendicular to the predominant nor-westerly.

The ridge faces were relatively stable except for the one isolated location where toppling has occurred (shown in Figure 2). One flowpath was observed in the most southerly section of the Site (Figure 5). The flowpath exists as it takes overflow from another creek's catchment to the west. Overland flowpaths (OLFP) are not present on the Site from direct precipitation.



Figure 5: OLFP in southern section of Site. Carries overflow from a creek west of the Site.

2.3 Proposed Development

The proposed development will see photovoltaic panels erected across 180.8 ha of the Site. Non of the PV modules are to be erected in the Flood Assessment Overlay. The panels will be set on 2.285m wide tables orientated north-south with single axle oscillation tracking the trajectory of the sun through the day. The

tables will tilt up to a 30-degree incline east and west. There is a 4m gap between table mounts, giving an overall pitch of 6.0m. The table tracking axis are to be mounted 1.5m above ground.

For visual aesthetic and planning purposes, the far south-east corner of the Site that is within view for the Waipara township, is to be developed into a vineyard, replacing gravelly and patchy pasture.

The steep east facing ridges between terraces are to be planted with 3-5m tall revegetation plants (details found in the Landscape Mitigation plan, Simon Cocker Landscape Architecture, 20 September 2023.). In total, 15.5 hectares of marginal pasture is to be revegetated apart from the 180.8 ha developed for PV modules.

Approximately 10km of deer fence around the perimeter of the Site is to be erected. 4m wide gravel access tracks will traverse the Site for 7km or 2.8 ha. As the Site geology is already free draining and gravel, the import of aggregate is expected to be negligible.

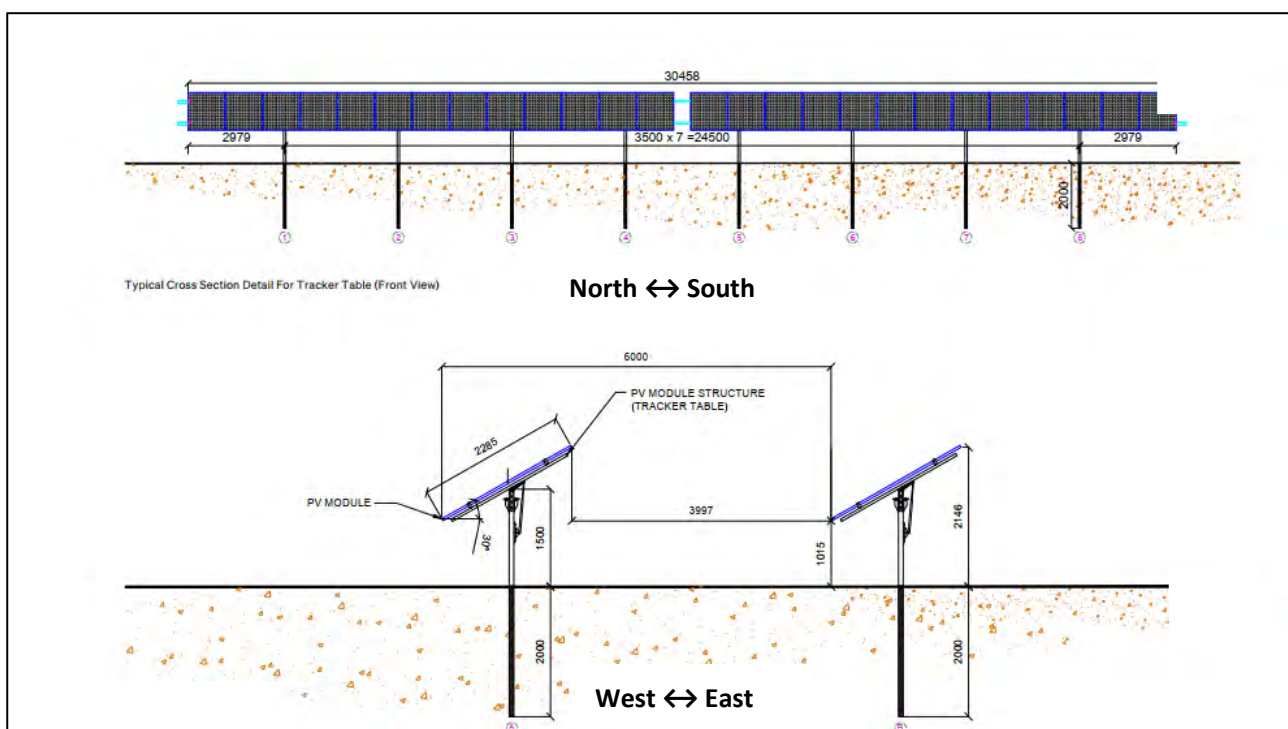


Figure 6: Proposed module arrangement

3 Stormwater Management

3.1 Regulatory Framework

3.1.1 Huranui District Council Plan

The Huranui District Plan zones the Site as 'Rural Zone'. A small portion of the Site in the southern end of the parcel is in the 'Flood Assessment Zone' overlay, however this area of the site is not to be developed.

Section 3 of the District Plan gives policies and rules for the Rural Zone but does not address stormwater specifically. Sediment and Stormwater runoff must be assessed for earthworks (3.4.8.9 (b)). Flood assessment only applies for development within the Flood Assessment Overlay (15.2).

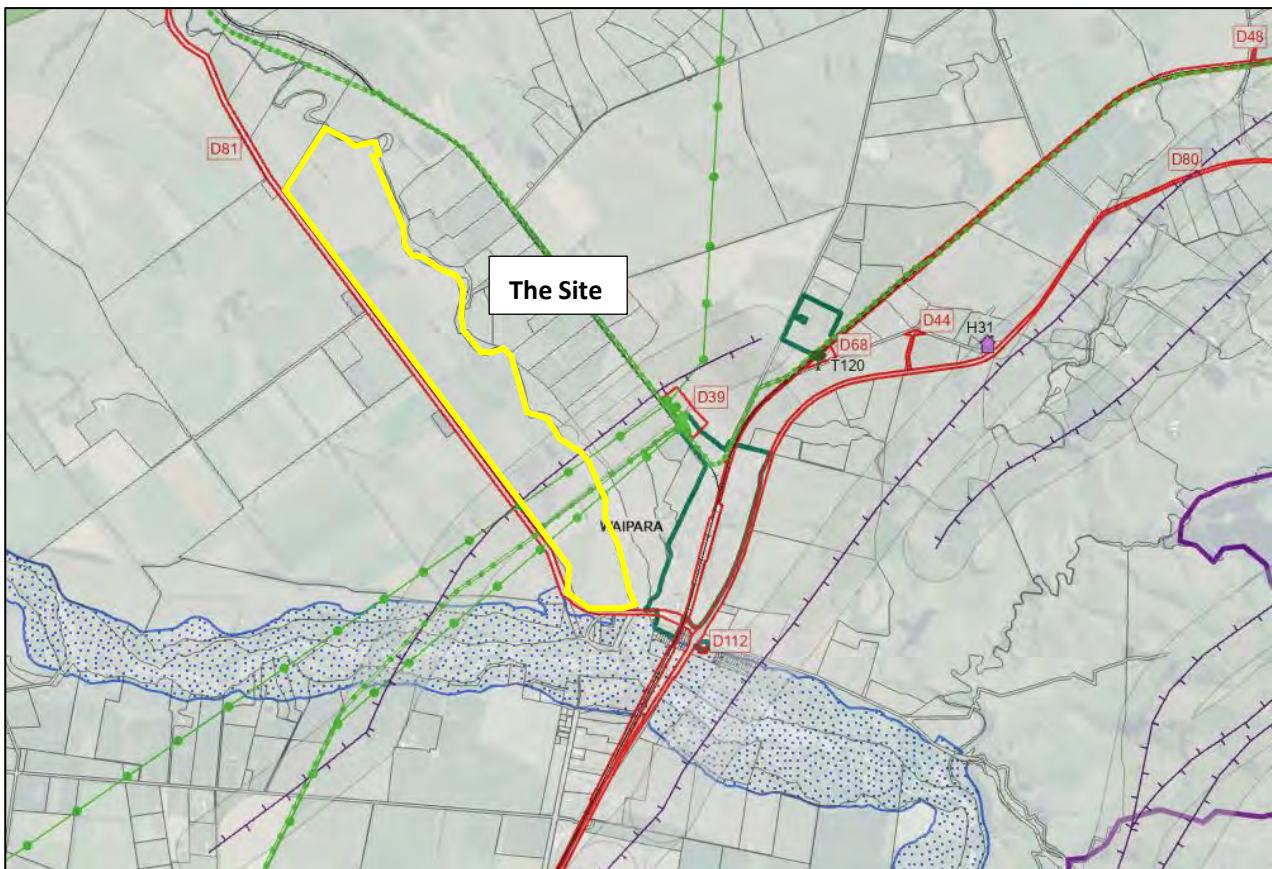


Figure 7: District Plan - Flood Hazard Assessment Overlay

3.1.2 Operative Environment Canterbury Land and Water Regional Plan 2018

The Regional Plan gives policies, rules, and targets for various Canterbury catchments for the ecological conservation of river systems. Policy 4.3 states that the natural variability of flowrates, including floods, is to be maintained. The natural colour of water in a river is not to be altered. Developments are to consider how sedimentation of rivers is to be avoided or minimized (4.22). The discharge of stormwater into a river is a permitted activity so long as the river is not a wetland and not in a natural state (5.95). The discharge is not to increase the 20% AEP flowrate by more than 1% from pre-development. In addition, the discharge is to meet the water quality standards found in Schedule 5.

Schedule 5 gives the parameters for water quality. The Total Suspended Solids (TSS) of the stormwater discharge is not to exceed 50g/m³. Temperature changes of inflows are not to exceed 2.0 °C. The water quality testing flowrate for design purposes is to be the seven-day mean annual low flow rate (7DMALF).

3.1.3 *Waipara Catchment Environmental Flow and Water Allocation Regional Plan*

The specific catchment plan for protecting the environmental values of the Waipara River became operative in 2012. The plan mostly deals with outtake management for the purpose of irrigation. The Waipara River catchment includes Weka Creek which is a tributary.

Issue 4 states the river has particular volume sensitivity and that changes to runoff within the catchment are to be carefully managed and restricted.

Part 7 of the plan gives specific rules for the management of surface water and groundwater within the catchment. The maximum amount of surface water that can be diverted as a permitted activity is 10m³/d (7.1.2(a)). Water is not to be diverted out of the riverbed and surface flow is to remain continuous (7.1.3(a)(b)).

To protect the runoff volume into the river, the plan has controls for minimising the planting of woody exotic plants that retain runoff within the catchment (Policy 3.6).

3.1.4 *New Zealand Building Code*

Section 2.1 of E1/VM1 recommends the rational method for estimating the effects on runoff from changes in land use. Appropriate runoff coefficients for a variety of surfaces are given. The Building Code also provides helpful guidance in determining the Time of Concentration for catchments for hydrological modelling.

3.2 **Stormwater Quantity Control**

3.2.1 *PV modules*

The combination of a high panel height, low angles, array spacing, and the ridgeline gap allow for adequate direct and diffused lighting to allow grass to grow. Site observations showed that partially shaded areas had Crop growth being improved (Figures 8 and 9). It is reasonable to assume that the ground will continue to have grass growth post-development, and that the runoff properties will remain close to pre-development.



Figure 8: Site Observations showed areas with partial shading had greater grass growth.



Figure 9

The justification for the runoff coefficient of the PV module area remaining the same as, or better than, predevelopment is as follows:

1. The experience of other NZ Solar farms has shown that stormwater runoff remains largely unchanged between pre and post development. (See Figures 10 and 11).
2. Rainwater Distribution: rain will fall through the spacing of the PV modules along 1.1m spaced lines. Surface sheet runoff will distribute from these lines, so that no patch of the ground will become unirrigated.
3. Reduced evapotranspiration: The partial shading provided by the PV modules can reduce evapotranspiration of the grass during dry summer months. This means that the grass cover may increase in dry seasons when there is a risk of greater stormwater and sediment runoff.
4. The Site already has fast infiltration with minimal evidence of surface flowpaths or sheet runoff resulting from precipitation. Once precipitation passes through the PV module spacing it will soak into the ground as it has always done. Soakage may improve because of increased grass coverage.



Figure 10: A similar PV module arrangement at the Kapuni Solar Farm, Taranaki. The photo shows that grass coverage over the ground is practically unchanged because of the PV modules.



Figure 11: Another NZ Solar Farm - Keswick Farm Dairies Ltd, Rangiora. The photo shows grass coverage over the ground does not diminish because of the PV modules.

3.2.2 Runoff Effects

Runoff Effects were assessed for the 10% AEP event. The rainfall intensity used the RCP 8.5 data from the NIWA HIRDS dataset for a 10min duration.

Runoff Coefficients for different surfaces were derived from Table 1 in E1 AS1/VM1 of the NZ Building Code. The pre and post development scenarios were determined using the Rational Method as detailed in the building code.

Modelled results are as follows:

Pre-Development Runoff

	Area	C	I ₁₀	Q
	m ²		mm/hr	L/s
metal access road	5000	0.5	47.28	32.8
roof area	610	0.9	47.28	7.2
high soakage grass paddocks	2418790	0.2	47.28	6353.4
Total	2424400			6393.4

Post-Development Runoff

	Area	C	I ₁₀	Q
	m ²		mm/hr	L/s
metal access road (2.8 new & 0.5ha existing)	33000	0.5	47.28	216.7
roof area	610	0.9	47.28	7.2
PV table	603000	0.2	47.28	1583.9
proposed native shrubbery	155000	0.15	47.28	305.4
proposed vineyard	48000	0.15	47.28	94.6
high soakage grass paddocks	1584790	0.2	47.28	4162.7
Total	2424400			6370.4
Excess Runoff	2424400			-23.0

The model shows that the proposed development. will decrease peak stormwater runoff by 23 L/s in a 10% AEP flood event. In the context of a 242 hectare land parcel, the reduction in runoff is miniscule and well within the margins of error for modelling stormwater neutrality.

Directions of stormwater runoff and groundwater will not change because of the proposed development. Stormwater volumes will not change as no volume is to be retained or detained. Stormwater will continue to enter the Weka Creek and tribute into Waipara River.

3.2.3 Effects on Water Allocation in the Waipara Catchment

The partial shading of the PV modules will decrease evapotranspiration in the summer months – when irrigation demand in the catchment is at its highest. The partial shading will put downward pressure on water demands for the Site's farm. This is a positive external effect for the Waipara Catchment Flow and Water Allocation Plan.

3.3 Erosion and Scour Effects

Entry points into Weka Creek is primarily by groundwater ingress. The southern overland flowpath (Figure 5) has adequate energy dissipation at its outlet into Weka Creek by natural riverbed armouring.

Currently, the highest likelihood of erosion is from localised shallow slumping on the steep ridge faces. The proposed development would see these areas planted with deep rooted native flora that will stabilize the inclines in the long-term.

Minimal aggregate is expected to be imported for construction as the existing near-surface gravel is suitable for access road pavement. Erosion and sediment deposition is a risk during the construction of the Solar Farm when grass coverage may be temporarily reduced. While earthworks have minimal volume, they cover a large area. We recommend that an Erosion Sediment Control Plan in accordance with GD05 guidelines be required as a condition of consent.

3.4 Water Quality Effects

3.4.1 Livestock Pollutants

The proposed solar farm will continue to allow sheep grazing to manage pasture in the solar farm. Sheep grazing will be at a similar intensity as pre-development. The proposed development may have long-term water quality benefits by inhibiting future intensification of the farm and greater use of fertilisers.

3.4.2 Soil and Sediment

The PV modules are not expected to inhibit grass coverage (section 3.2.1). Bare ground during the construction of the Solar Farm can lead to higher sediment yields for the construction period. A GD05 Erosion Sediment Control Plan is recommended as a consent condition.

3.4.3 Temperature

PV modules can reach temperatures upwards of 40 degrees Celsius. The detention time of rain runoff on PV modules is not more than 5 seconds before it reaches the ground and infiltrates. The small length of time that precipitation runs off a hot PV module is more than offset by the extended hydraulic retention time in the groundwater system.

4 Conclusions

The high-soakage capability of the soil means that there are few overland flow paths on the Site. Precipitation infiltrates directly into the ground in most rain events. For extreme rain events, sheet runoff towards Weka Creek is to be expected. The proposed solar farm is not expected to affect the water quality or water quantity of stormwater discharged from the Site.

The PV modules themselves will not inhibit grass growth or ground infiltration. Runoff in heavy rain events is affected by the proposed creation of several gravel access tracks. But the effect is offset by the proposed planting of a vineyard and native shrubbery on the ridge faces for amenity.

Long term stormwater quality will remain the same or improve. Livestock pollutant yield will remain the same as pre-development. Heat is a common water pollutant for solar farms, but the ground infiltration ensures

that heat transferred from the PV modules will be absorbed by the ground before the water reaches Weka Creek.

Long term sediment yield is expected to decrease because of the proposed native planting in erosion-prone areas. Short term sediment yield during construction can be effectively managed with an Erosion Sediment Control Plan.

Appendix I. Dust Management Plan



DUST MANAGEMENT PLAN

Waipara Solar Farm– Construction Earthworks		Rev 1, March 2024
Overview: This Dust Management Plan (DMP) has been prepared to provide procedures to mitigate dust emissions during soil disturbance associated with the proposed solar farm at 380 Waipara Flat Road, Waipara. This DMP has been prepared in accordance with the requirements of Schedule 2 the Canterbury Air Regional Plan (CARP)¹.		
1. Roles and responsibilities	Implementation of the DMP lies with the appointed contractor.	
2. Soil description	The land type is described as being defined by broad, very low angle coalescing outwash fans and associated low terraces of the major rivers (Waimakariri, Rakaia, Rangitata and Waitaki Rivers), comprising Pleistocene glacial outwash gravels with variable loess cover, and extensive Holocene alluvium, coastal swamp deposits and minor inland dune belts. The elevation is ranging from 0 m to 150 m, and the rainfall is being between 600–800mm.	
3. Soil disturbance works proposed (activity description)	Earthworks (with potential to generate dust) associated with the site clearance and construction of the solar farm will be include the following: 1) Approximately 44,00 m³ of earthworks will be required to enable installation of piles to support the solar panels and to form access tracks. 2) No earthworks will be undertaken within 100 m of any surface waterbody. 3) The proposed works will be undertaken in accordance with an approved Erosion and Sediment Control Plan (ESCP), which will be developed in line with best practice erosion and sediment control measures as set out in Environment Canterbury's Erosion and Sediment Control Toolbox. Soil disturbance works will occur during normal working hours (0700-1800), 5-6 days a week, and is expected to occur over a 9-12 month period. Dust mitigation proposed in this plan must be in place for the full duration of the works.	
4. Dust management principles	Dust control measures shall comply with the <i>Good Practice Guide for Assessing and Managing Dust, Ministry for the Environment</i> (2016). The primary dust control measure is for wetting exposed soil surfaces to prevent dust generation.	
5. Dust management practices to be implemented by the Contractor	Staging: Excavations shall be staged to minimise the area exposed ground as far as practicable. • Piling will happen progressively across the site. • Vegetation removal will only occur as needed to develop a firm travelling surface for access tracks and to establish an appropriate grade for the solar farm's infrastructure. Vegetation will be promptly reestablished beneath the solar arrays after construction is completed, with controls remaining in place until stabilisation by vegetation is complete. Dust suppression methods: • Frequent spraying of water shall occur to ensure working surfaces remain damp in dry conditions. Dry conditions are defined as those in which any visible dust is created and are expected after two to five days without rain (depending on wind speed, high wind conditions will dry out ground faster than low wind conditions). • Water spraying can be achieved through mobile water tanker or portable water misting systems. The amount of water dispensed should not be of a magnitude that produces run off.	

¹ Environment Canterbury, October 2017. Canterbury Air Regional Plan.

	Instruct construction workers and truck drivers to monitor their own dust generation and to use lower travelling speeds on unpaved surfaces to avoid producing excessive quantities of dust. Works shut down requirements: If there is an extended break in the works (such as for the Christmas holiday period) then exposed soil surfaces shall be left in an erosion-free state through cover with geotextile, polythene or hardfill.
6. Monitoring	The contractor shall undertake the following monitoring: - At a minimum daily checks shall be made by the Contractor to ensure that dust is not being generated from exposed soil surfaces or during soil disturbance works. - Weather forecasts shall be monitored for predicted high wind events and plans for additional dust suppression activities put in place if required. - Water spraying equipment shall be inspected daily to ensure it is operating effectively.
7. Contingency measures	In the event that dust continues to be generated (e.g. due to breakdown of water tanker or misting system, or extremely strong winds) or complaints from the public are received, the following additional control measures shall be considered: - Cease dust-generating activities until effective dust controls measures can be implemented. - Audit of mitigation by the appointed contractor. - Additional measures such as the following may be required: - Alternative water delivery equipment and more frequent/ intense application. - Install windbreak fences. - Potential use of polymer dust suppression sprays.
8. Complaints records	Records shall be kept of all complaints made by the public about dust nuisance from the site. Notes shall be made about the time of the complaint, weather conditions including wind direction and intensity, works being undertaken at the time, dust suppression measures that were in place, and the actions taken in response to the complaint.

Appendix J. Soil Assessment

Waipara Solar Farm – Expert Statement on Highly Productive Land

Prepared By: Ian Hanmore

Prepared For: Far North Solar Farm Limited

9th September 2023

WAITARA SOLAR FARM - EXPERT STATEMENT ON HIGHLY PRODUCTIVE LAND

Introduction

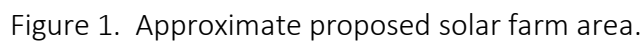
Qualifications and experience

1. My name is Ian Hanmore. I am the Director of Hanmore Land Management Limited, a company specialising in land management and environmental consultancy. Prior to this I contracted my service through AgFirst Northland. I provide services to a range of private clients, planners, Regional and District Councils, and Māori Trusts throughout New Zealand, with a particular focus on the Waikato, Auckland, and Northland regions.
2. I hold a Master of Applied Science majoring in Natural Resource Management from Massey University, I am an approved competent mapper for the National Environmental Standards for Plantation Forestry Erosion Susceptible Classification with MPI, I have an Advanced Nutrient Management Certificate from Massey University and am a member of the New Zealand Association of Resource Managers, the New Zealand Institute of Primary Management and the New Zealand Society of Soil Science.
3. I have been a consultant in the above capacity for 17 years and have worked extensively throughout the North Island. As part of my work I carry out soil and land use capability (LUC) mapping. This work involves detailed soil and LUC surveys to map soils suitable for horticultural and specific horticultural crops, to identify prime, elite, high class and highly versatile soils and highly productive land. This work is used in regard to subdivisions and land use consents, assisting farmers matching their production policy to their land resource, identifying land use development opportunities and enterprise diversification.

THE IMPACTS OF A PROPOSED SOLAR FARM ON HIGHLY PRODUCTIVE LAND

Background

A proposed solar farm is to be located at 380 Waipara Flat Road, Waipara and covers approximately 190ha (see figure 1 below). The land on which the proposed solar farm is to be located is classified as Highly Productive Land (HPL) under the National Policy Statement for Highly Productive Land (NPS-HPL). As such, the effects of the proposed project on the HPL need to be assessed.



The following information has been supplied to Hanmore Land Management Ltd by Far North Solar Farm Limited (FNSF) regarding the proposed solar array structures and supporting hard stand areas for inverters and a substation.

The project utilizes a single axis tracking system, arranged in 1-module-in-portrait configuration. The arrangement includes 26 modules in series, corresponding to a 1x26 table arrangement. Solar panels will be mounted on H piles driven into the ground as illustrated in Figure 2 below. Piles will be 50mm wide with a maximum cross section height of 150mm and

be driven 2.0m into the ground, with approximately 72,896 piles across the whole site. Hard surface areas will be needed for 27 x 20' shipping containers (6.06m x 2.43m) for inverters, a 65m x 30m area for the switch yard and a maximum of 1000m² for firefighting trucks (details are subject to slight changes after geophysical testing conducted by the EPC team).

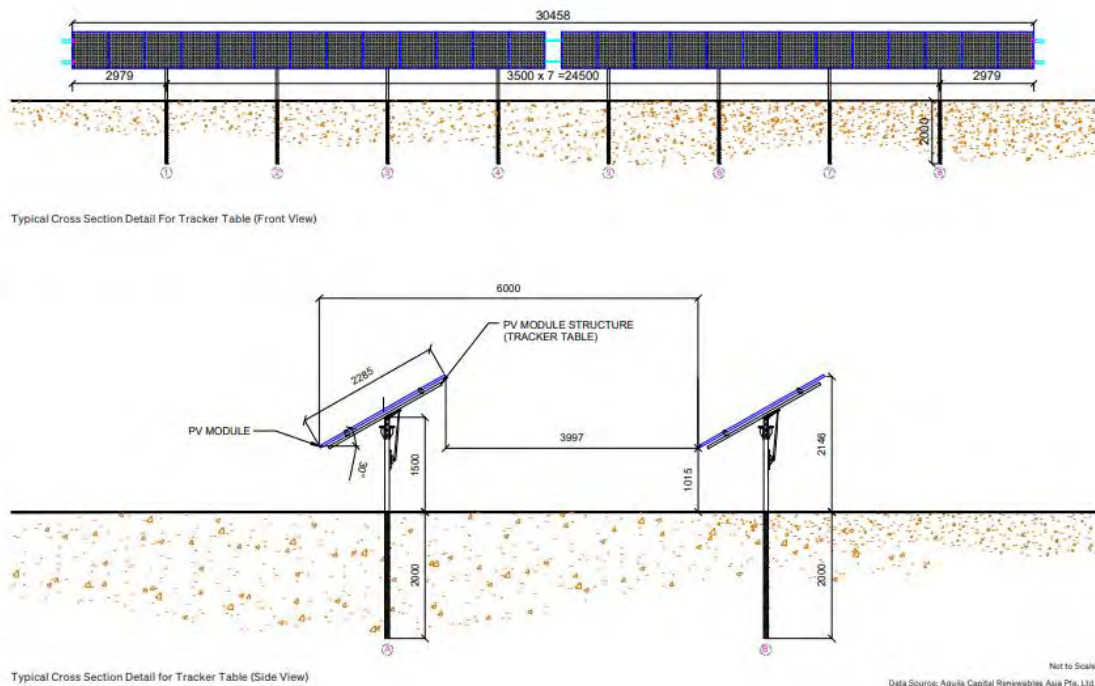


Figure 2. Proposed solar panel structures.

While the solar farm is in operation the area will be grazed by sheep to control pasture growth and when the project is decommissioned structures will be unscrewed and removed, piles uplifted and wiring/cabling taken out.

Soil Surface Area Impacted

Based on the information supplied by FNSF the total surface area of ground impacted by the installation of the solar structures has been calculated below.

Area for 20' shipping containers: $27 \times 6.06\text{m} \times 2.43\text{m} = 397.5966\text{m}^2$

Switch yard $65\text{m} \times 30\text{m} = 1,950\text{m}^2$

Area for firefighting trucks $1,000\text{m}^2$ (max)

Total surface area impacted: $397.5966 + 1950 + 1000 = 3,347.5966\text{m}^2$

Total area of the project approximately 190ha = 1,900,000m²

Percentage of whole site impacted by structures: **0.18%**

Assessment of Effects on HPL

As can be seen from the calculations above the total surface area impacted by the proposed solar structures is approximately 3,348m². In the context of the whole site this area will have a less than a minor impact on the site and would not be dissimilar to any agriculture or horticulture operation. Using H piles rather than solid piles to support the solar panels will minimize soil impacts and have a negligible impact on soil structure across the site.

The overall project will be potentially more beneficial to soil structure and long-term potential productivity than many farming or horticulture operations. Eliminating any heavy stock such as cattle and horticulture cropping will minimize the risk of soil compaction and organic matter loss due to pugging damage, soil cultivation and machinery movement. If good stock and pasture management are followed on the proposed site soil structure, water hold capacity, aeration and nutrient status will be improved through minimizing compaction and increased organic matter incorporation in the soil profile. When the project is decommissioned, as outlined by FNSF, minimal soil disturbance will occur which will preserve the productivity potential of the HPL.

Over the life of the proposed project energy generation will be the main production focus with primary production on the HPL continuing in a supporting capacity through sheep grazing for meat production. The project itself as outlined above will not reduce or negatively impact the productivity potential of the HPL. When the project is decommissioned, the HPL will be available for primary based production with potentially improved soil structure and productivity potential.

Appendix K. Glint and Glare Study



Waipara Solar Farm

Glint and glare study

Final Report



DOCUMENT CONTROL

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ABOUT THIS REPORT

This report assesses the glint and glare impact of the proposed Waipara Solar Farm located west of Waipara, New Zealand. It was commissioned by Far North Solar Farm (FNSF).

ABBREVIATIONS

AC	Alternating current
CASA	Civil Aviation Safety Authority
DC	Direct current
FAA	Federal Aviation Administration (United States)
FNSF	Far North Solar Farm
ha	Hectare
ITP	ITP Renewables
MW	Megawatt, unit of power (1 million Watts)
MWp	Megawatt-peak, unit of power at standard test conditions; used to indicate PV system capacity
OP	Observation point
PV	Photovoltaic
SGHAT	Solar Glare Hazard Analysis Tool

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EXECUTIVE SUMMARY

ITP Renewables conducted a glint and glare assessment for a solar farm proposed by Far North Solar Farm west of Waipara, Central Hawkes Bay. Our analysis divided the array into 12 sections and modelled the glare received at 57 observation points and along 18 routes. The GlareGauge analysis was conducted for two scenarios:

1. Array rest angle of 0° as the base case scenario
2. Array rest angle of 3° as an option to mitigate glare impacts

The results of the GlareGauge analysis using a rest angle of 0° indicated that 34 observation points 10 road routes received green glare, while one observation point and 2 road routes received yellow glare. Yellow glare has the potential to cause after-image to observers, while green glare has low potential to cause after-image.

Using a rest angle of 3° reduced the glare impact for all receptors, with 5 road routes receiving green glare and no receptors receiving yellow glare. In particular, the NZ State Highways were not subjected to any yellow glare over the year. In this scenario, the glare impact is low and further mitigation is not required.

1 INTRODUCTION

1.1 Overview

Far North Solar Farm (FNSF) has requested a glint and glare assessment for a proposed solar photovoltaic (PV) installation located west of Waipara, in the Central Hawkes Bay. This assessment will be submitted as part of the resource consent process for the project. It includes:

- Identification of potential receptors of glint and glare from the proposed solar farm
- Assessment of the glint and glare hazard using the Solar Glare Hazard Analysis Tool (SGHAT) GlareGauge analysis

1.2 Glint and Glare

The United States Federal Aviation Administration (FAA) defines glint and glare as follows:¹

- **Glint** is a momentary flash of bright light
- **Glare** is a continuous source of excessive brightness relative to ambient lighting.

Glint and glare can occur when light reflected off a surface (reflector) is viewed by a person (receptor). Glint typically occurs when either the receptor or the reflector is moving, while glare typically occurs when the reflector and receptor are completely, or nearly, stationary. For a transparent material (e.g., glass, water) the quantity of light reflected depends on the surface itself (i.e., material and texture), and the angle at which the light intercepts it (angle of incidence). More light is reflected at higher angles of incidence as shown in Figure 1.

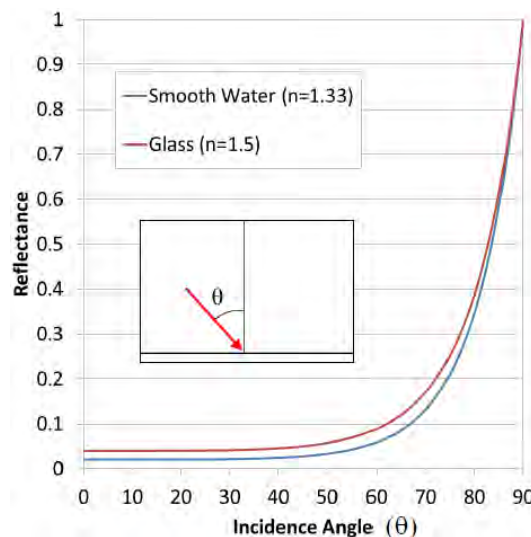


Figure 1: Angles of incidence and increased levels of reflected light

¹ Federal Aviation Administration [FAA], 2018

Potential visual impacts from glint and glare include distraction and temporary afterimage; at its worst, it can cause retinal burn. The ocular hazard caused by glint or glare is a function of:

1. The intensity of the glare upon the eye (retinal irradiance)
2. The subtended angle of the glare source (i.e., the extent to which the glare occupies the receptor's field of vision; dependent on size and distance of the reflector).

The severity of the ocular hazard can be divided into three levels, as shown in Figure 2:

- **Green glare**, which has low potential to cause temporary afterimage
- **Yellow glare**, which has potential to cause temporary afterimage
- **Red glare**, which can cause retinal burn and is not expected for PV.

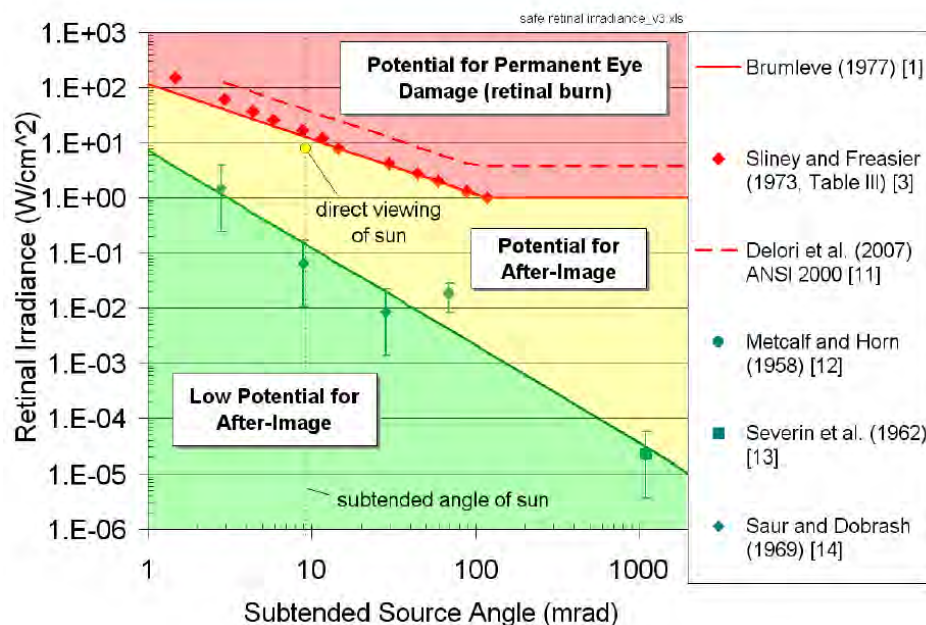


Figure 2: Classification of glare based on severity of ocular effects

1.3 Glare from Solar PV

Solar photovoltaic (PV) cells are designed to absorb as much light as possible to maximise efficiency (generally around 98% of the light received). To limit reflection, solar cells are constructed from dark, light-absorbing material and are treated with an anti-reflective coating. PV modules generate less glare than many other surfaces, as shown in Figure 3.

The small percentage of light reflected from PV modules varies depending on the angle of incidence. Figure 4 shows an example of this with a solar module. A larger angle of incidence will result in a higher percentage of reflected light.

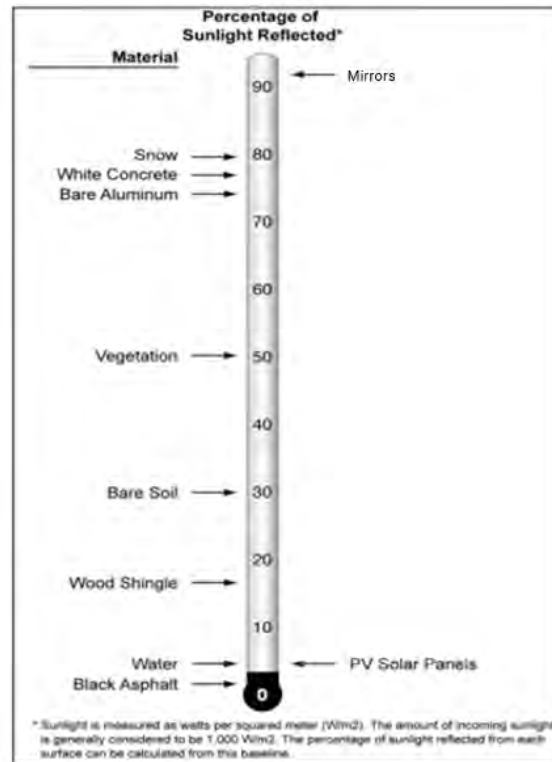


Figure 3: Typical percentage of sunlight reflected from different surfaces (Source: Adapted from Journal of Airport Management, 2014)

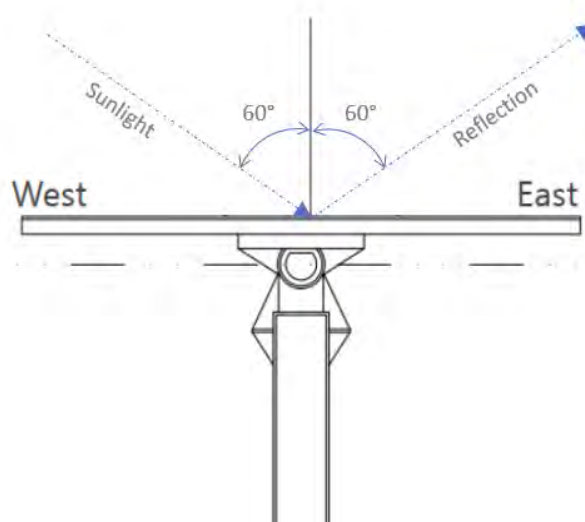


Figure 4: Typical sunlight reflection off the surface of a solar module

The two most common PV mounting structures are fixed tilt and single axis tracking. Fixed tilt arrays are stationary, while single axis tracking arrays rotate the receiving surface of the modules from east to west throughout the day as the sun moves across the sky.

In a fixed tilt PV array, since the sun is moving but the modules are stationary, the angle of incidence varies as the sun moves across the sky. It is smallest around noon when the sun is overhead and largest in the early morning and late afternoon when the sun is near the horizon. There is therefore a higher potential for glare at these times.

The angle of incidence for a single axis tracking system varies less as the reflective surface of the modules rotates on a horizontal axis to follow the sun. Single axis tracking arrays therefore generate less glare than fixed tilt arrays. The tracking varies throughout the year to match seasonal changes in the sun's path (see Figure 5).

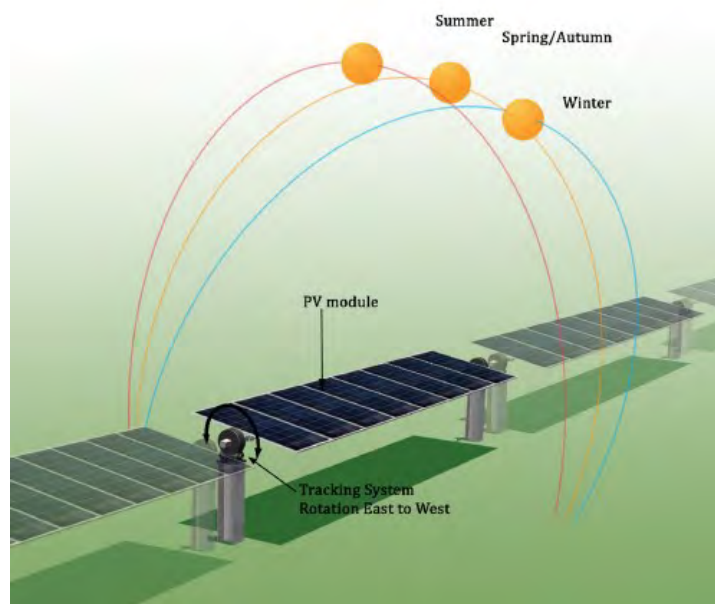


Figure 5: Sun position relative to PV modules on a horizontal single-axis tracking system

2 PROJECT DESCRIPTION

2.1 Site Overview

FNSF is proposing a solar farm at the location described in Table 1. The site is located immediately northwest of Waipara in Central Hawkes Bay. An indicative layout is displayed in Figure 6.

Table 1: Site Information

Parameter	Description
Title Nos.	Section 3 SO 17514, Lot 1 DP 320376
Address	66-380 Waipara Flat Road, Waipara
Council	Hurunui District Council
Project area	180.8 ha

2.2 Solar Farm Details

Table 2 summarises the details of the proposed solar farm.

Table 2: Solar farm information

Parameter	Description
Solar farm name	Waipara Solar Farm
Capacity	144 MWp
Mounting system	Single-axis tracking

FNSF is proposing to construct a solar farm with a capacity of 144 MWp on a 181 ha site. There will be approximately 252,400 solar modules installed in single-axis tracking tables running north to south. Panels are arranged in a dual portrait configuration, with tracker rows of 13 or 26 modules in length. The solar farm will include 30 medium voltage (MV) inverters, each with a capacity of 4.2 MVA.

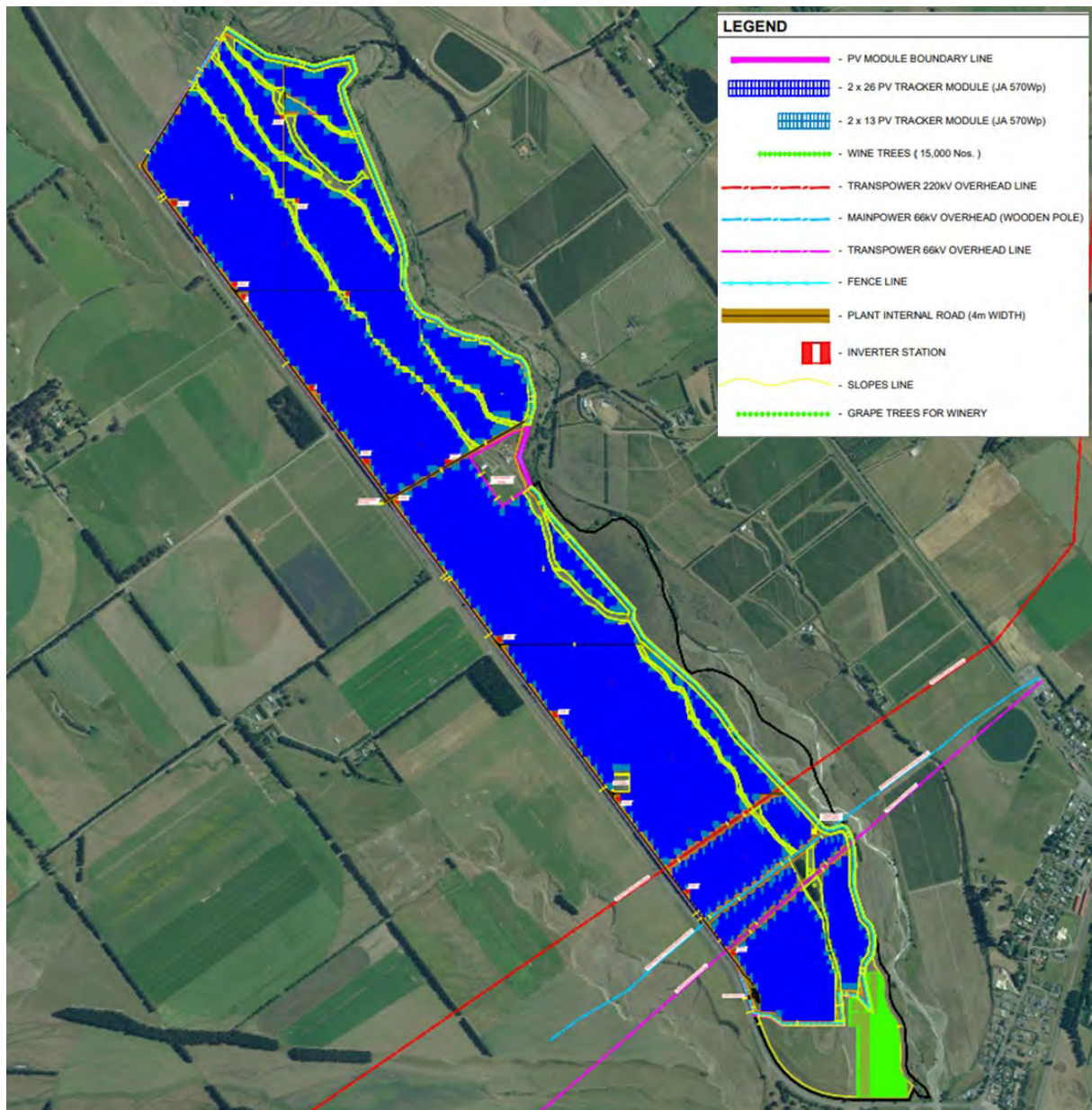


Figure 6: Waipara Solar Farm Preliminary PV layout

3 ANALYSIS

3.1 Overview

The Solar Glare Hazard Analysis Tool (SGHAT) was developed by Sandia National Laboratories to evaluate glare resulting from solar farms at different viewpoints, based on the location, orientation, and specifications of the PV modules. This tool was required by the United States FAA for glare hazard analysis near airports until 2021 and is also recognised by the Australian Government Civil Aviation Safety Authority (CASA).

The GlareGauge software uses SGHAT to provide an indication of the type of glare expected at each potential receptor. It runs with a simulation timestep of one minute. Glint lasting for less than one minute is unlikely to occur from the sun on PV modules due to their slow movement.

3.2 Assumptions

The visual impact of a solar farm depends on the scale and type of infrastructure, the prominence and topography of the site relative to the surrounding environment, and any proposed screening measures to reduce visibility of the site. Our model includes selected obstructions² as described in Section 3.3.2.

Atmospheric conditions such as cloud cover influence light reflection and the resulting impact on visual receptors. GlareGauge does not model varying atmospheric conditions; instead, the model assumes clear sky conditions, with a peak direct normal irradiance (DNI) of 1,000 W/m² which varies throughout the day.

Table 3 details the parameters used in the SGHAT model. GlareGauge default settings were adopted for the analysis time interval, direct normal irradiance, observer eye characteristics and slope error. The height of the observation points for road users was assumed to be 1.5 m for cars and 2.5 m for trucks and railways. The height for a person standing was assumed to be 1.65 m.

Table 3: SGHAT specification inputs

Parameters	Input
Time zone	UTC+13:00
Module surface material	Smooth glass with ARC (anti-reflective coating)
Module tracking	Single Axis Tracking with backtracking

² In the GlareGauge model, obstructions are opaque barriers that block the transmission of incident and reflected light

Parameters	Input
Maximum tilt angle	$\pm 55^\circ$
Module axis orientation	0°
Height of modules above ground	2.4 m (height from the ground to the table centre)

3.3 Model construction

3.3.1 Study area

This assessment considers potential visual receptors (e.g., residences and road users) within 3 km of the site. There is no formal guidance on the maximum distance for glint and glare assessments; however, the significance of a reflection decreases with distance for two main reasons:

1. The solar farm appears smaller (smaller subtended angle), and glare has less impact
2. Visual obstructions (e.g., terrain, vegetation) may block the view of the solar farm

Glint and glare impacts beyond 3 km are highly unlikely. This choice of distance is conservative and is based on existing studies and assessment experience.

3.3.2 Model components

The model (see Figure 7) was constructed as follows:

- The array was divided into 12 separate PV objects based on the general arrangement (see Figure 8).
- Receptors were placed at 57 observation points, 17 road routes, and 1 rail route (see Figure 9 and Figure 10). Truck routes were included for highways.
- 21 observation points and 7 road routes were excluded (see Figure 11, Figure 12, and Appendix A).
- Per the General Arrangement,³ revegetation zones and boundary screening vegetation were included in the model as obstructions with a height of 3 m (revegetation) or 5 m (boundary screening), as shown in Figure 8.

In some instances, a single OP is used in the model to denote a few buildings located close together, as the received glare is generally not very sensitive to precise locations (assuming that line of sight is not impacted by obstructions). We have excluded buildings in towns that are not on the edge facing the solar farm, as their line of sight is obstructed by surrounding buildings.

³ Document titled 2023-09-19-Genesis-WPR_GA-143.8MWp_JA-570_Tr_2P_Tree-parcel

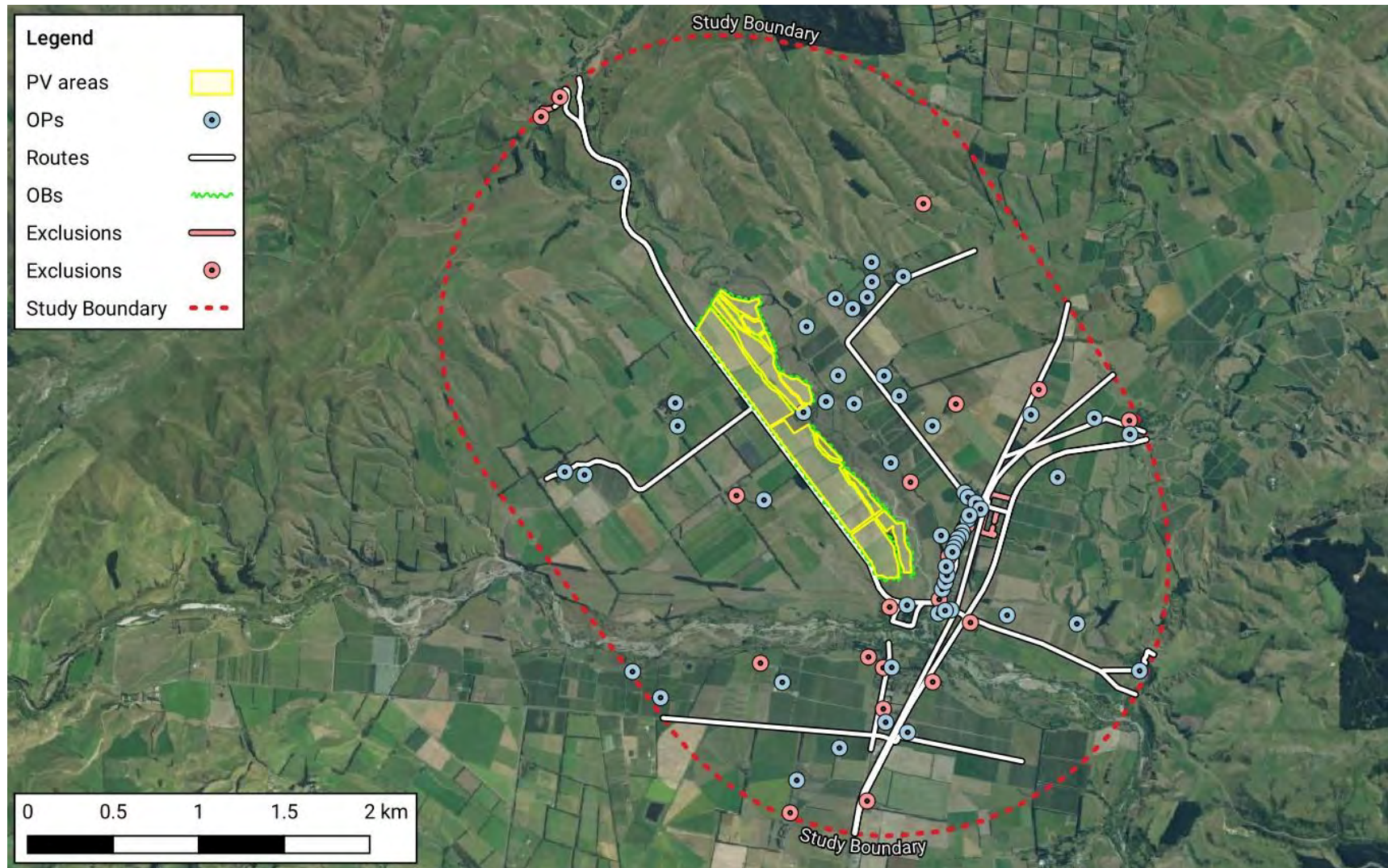


Figure 7: Model showing study area, arrays, receptors, and obstructions.

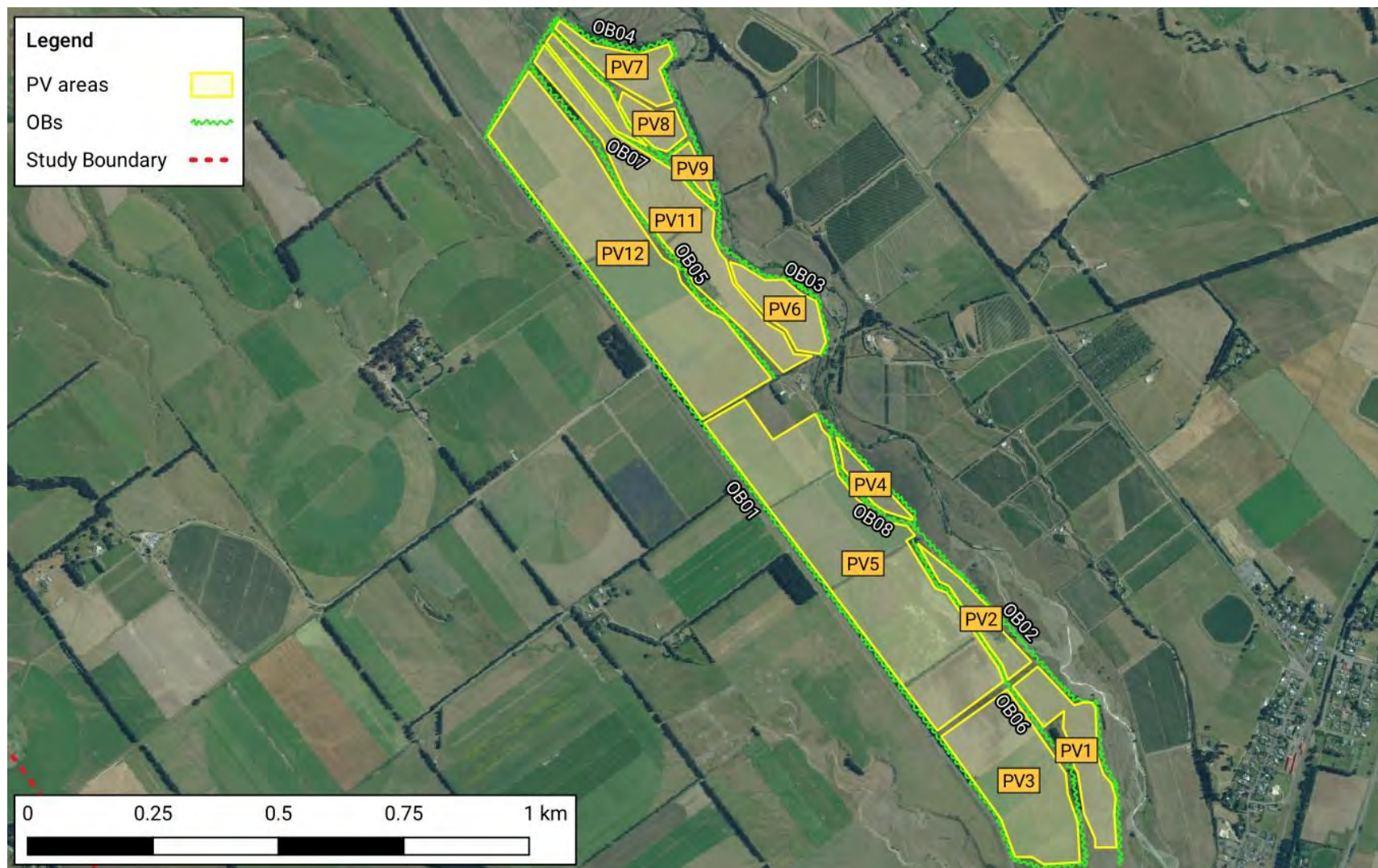


Figure 8: PV array sections and obstructions

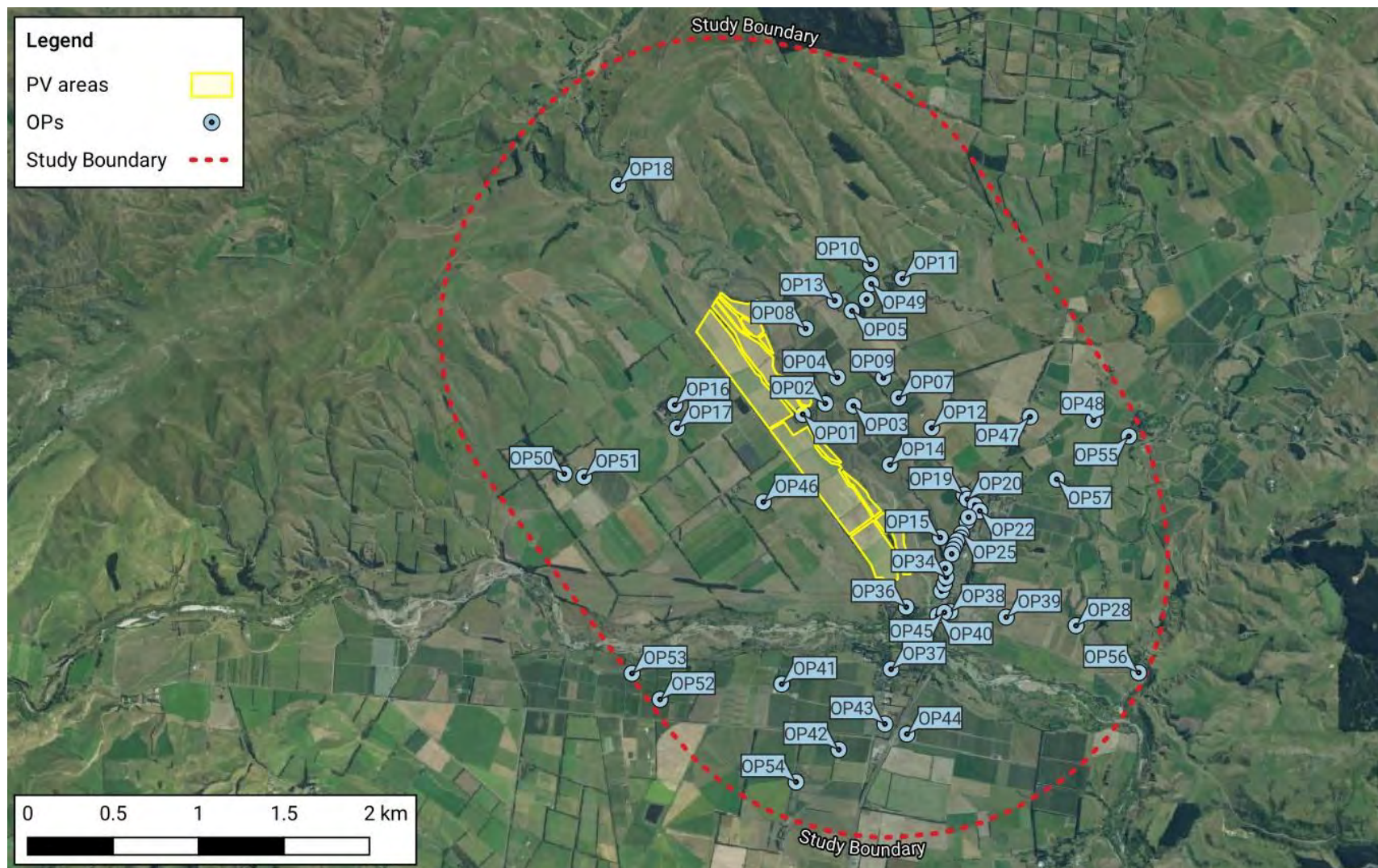


Figure 9: Observation points

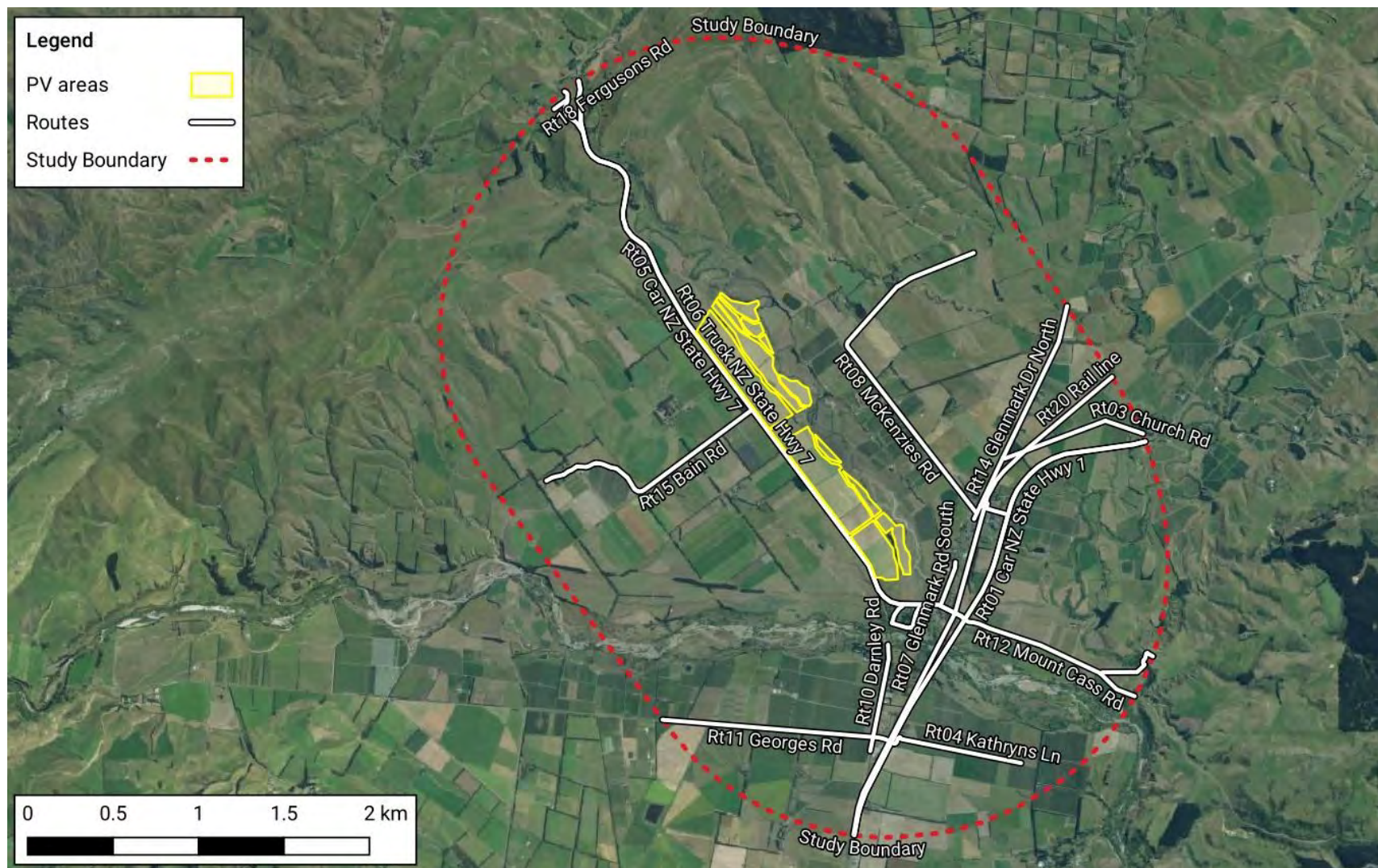


Figure 10: Routes

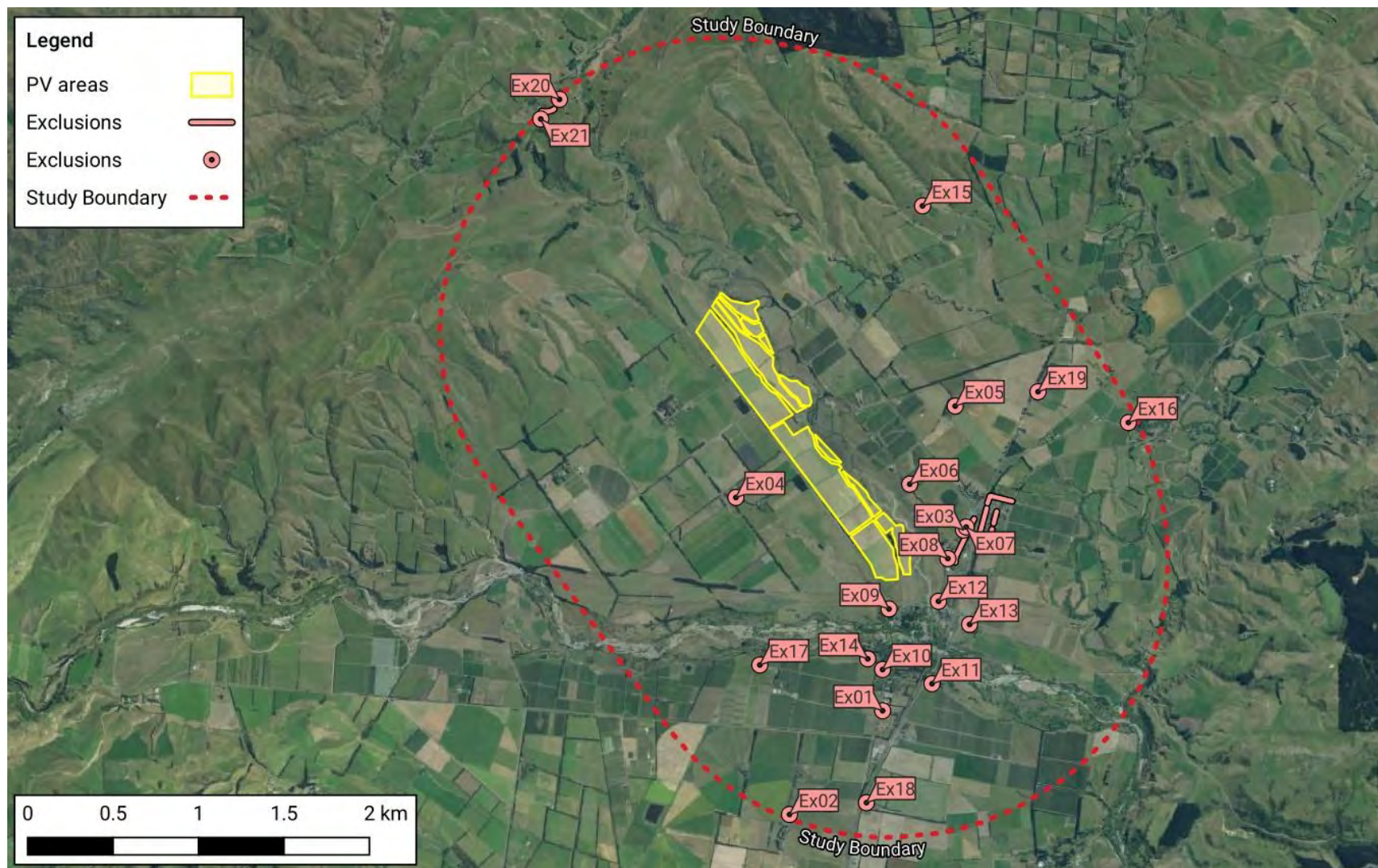


Figure 11: Excluded receptors. Excluded receptors are detailed in Appendix A.

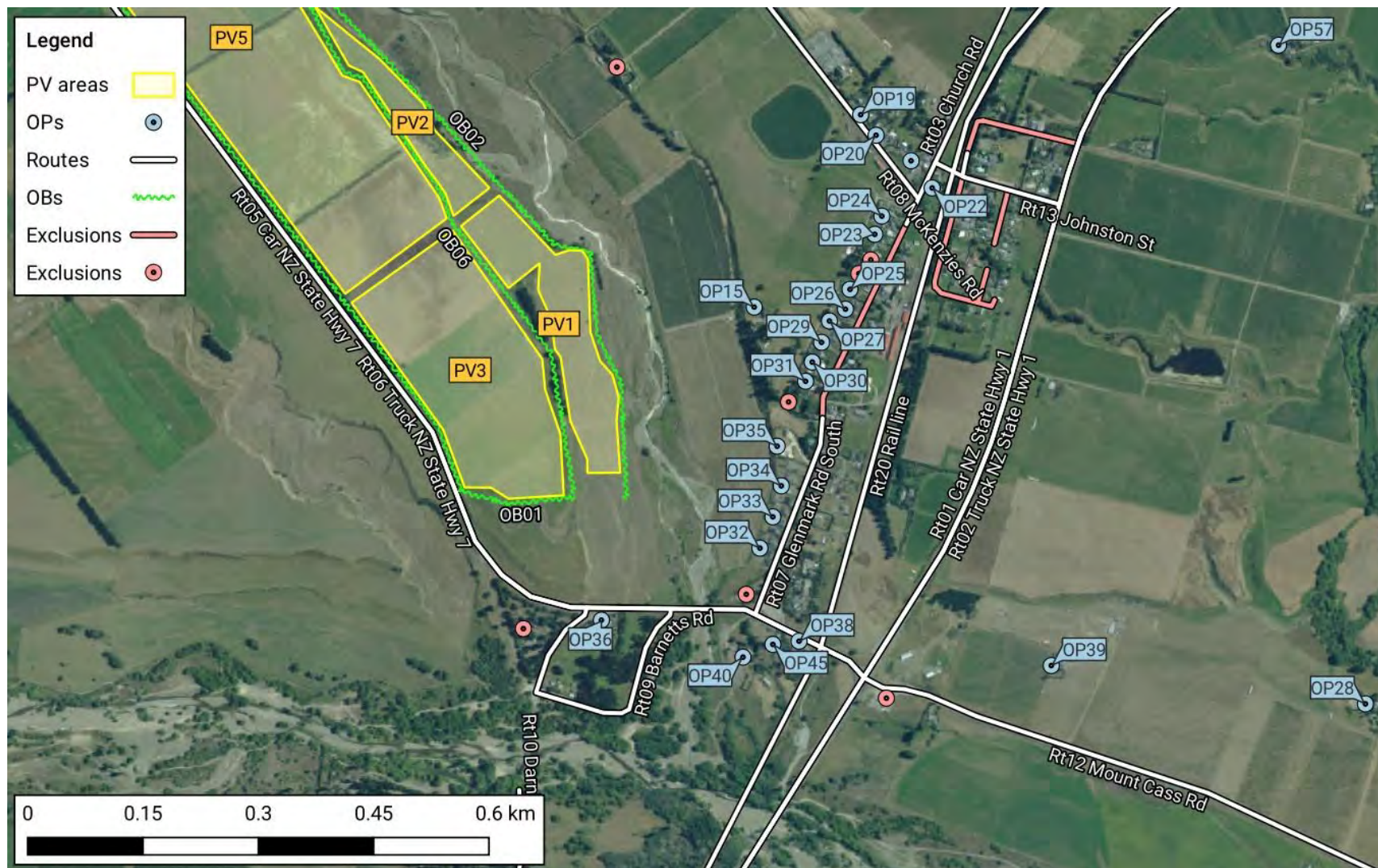


Figure 12: Receptors and exclusions southeast of site

3.4 Results

Our results are presented below for two scenarios

1. Array rest angle of 0° as the base case scenario
2. Array rest angle of 3° as an option to mitigate glare impacts

3.4.1 0° Rest Angle Results

The results of the GlareGauge analysis (Appendix B) are summarised in Table 4. Over the period of a year, the analysis identified 12,778 minutes (~213 hours) of cumulative green glare and 990 minutes (~17 hours) spread across 10 routes and 34 observation points.

The glare received each day varied across the year. For observation points where some glare occurred, the impact is described qualitatively. No observation points or routes received more than 14 minutes of green glare or more than 7 minutes of yellow glare in any single day. The time of day at which glare was observed varied between observation points and across the year. In general, most glare occurred in the early mornings or late evenings, when the array is backtracking.

Table 4: Glare potential at each receptor with 0° rest angle.

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP01	-43.0447, 172.7342	0	0	None
OP02	-43.0435, 172.7374	270	61	Up to 2 minutes of yellow glare between 4:30 pm and 5:15 pm, from 7 May to 10 June.
OP03	-43.0438, 172.7414	0	0	None
OP04	-43.0408, 172.7391	160	0	Up to 6 minutes of green glare between 4:30 pm and 5:00 pm, from 17 May to 17 June.
OP05	-43.0338, 172.7413	52	0	Up to 4 minutes of green glare between 6:00 pm and 8:00 pm, on 2 January, from 20 March to 4 April, and from 8-9 September.
OP06	-43.0326, 172.7434	68	0	Up to 4 minutes of green glare between 6:15 pm and 7:00 pm, from 12-24 March and from 19 September to 1 October.
OP07	-43.043, 172.7479	165	0	Up to 4 minutes of green glare between 4:45 pm and 5:15 pm, from 29 May to 15 July.
OP08	-43.0356, 172.7346	219	0	Up to 5 minutes of green glare between 4:45 pm and 6:15 pm, from 11 April to 12 June and from 15-31 August.
OP09	-43.0409, 172.7457	216	0	Up to 4 minutes of green glare between 4:45 pm and 5:15 pm, from 17 May to 20 July.
OP10	-43.0289, 172.744		0	None
OP11	-43.0304, 172.7485	41	0	Up to 3 minutes of green glare between 6:15 pm and 7:00 pm, from 6- 12 March and from 30 September to 12 October.
OP12	-43.0461, 172.7527	62	0	Up to 3 minutes of green glare between 4:45 pm and 5:15 pm, from 10 June to 4 July.
OP13	-43.0327, 172.7388	53	0	Up to 5 minutes of green glare between 6:15 pm and 7:00 pm, from 11- 25 March and from 1-2 October.
OP14	-43.05, 172.7467	208	0	Up to 9 minutes of green glare between 4:30 pm and 5:00 pm, from 23 May to 16 June.
OP15	-43.0577, 172.7538	44	0	Up to 5 minutes of green glare between 4:30 pm and 5:15 pm, from 5-12 May and from 2 June to 18 June.

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP16	-43.0436, 172.7158	0	0	None
OP17	-43.0461, 172.7161	0	0	None
OP18	-43.0204, 172.7077	0	0	None
OP19	-43.0532, 172.7573	411	0	Up to 12 minutes of green glare between 4:30 pm and 6:15 pm, from 4 May to 19 June and from 14-15 September.
OP20	-43.0537, 172.7577	302	0	Up to 9 minutes of green glare between 4:30 pm and 5:15 pm, from 11 May to 16 June.
OP21	-43.0543, 172.7589	304	0	Up to 10 minutes of green glare between 4:30 pm and 5:15 pm, from 11 May to 16 June.
OP22	-43.0549, 172.7595	290	0	Up to 8 minutes of green glare between 4:30 pm and 5:15 pm, from 13 May to 16 June.
OP23	-43.056, 172.7577	177	0	Up to 9 minutes of green glare between 4:30 pm and 5:00 pm, from 26 May to 16 June.
OP24	-43.0556, 172.7579	204	0	Up to 9 minutes of green glare between 4:30 pm and 5:00 pm, from 22 May to 16 June.
OP25	-43.0573, 172.7569	0	0	None
OP26	-43.0577, 172.7568	40	0	Up to 4 minutes of green glare between 4:30 pm and 5:00 pm, from 23 May to 18 June.
OP27	-43.058, 172.7562	25	0	Up to 5 minutes of green glare between 4:30 pm and 5:00 pm, from 29 May to 18 June.
OP28	-43.067, 172.7733	136	0	Up to 6 minutes of green glare between 4:45 pm and 5:15 pm, from 5 May to 3 June.
OP29	-43.0585, 172.756	58	0	Up to 6 minutes of green glare between 4:30 pm and 5:15 pm, from 5-15 May and from 31 May to 18 June.
OP30	-43.059, 172.7557	203	0	Up to 7 minutes of green glare between 4:15 pm and 5:30 pm, from 3 May to 14 June.
OP31	-43.0594, 172.7555	181	0	Up to 7 minutes of green glare between 4:30 pm and 5:15 pm, from 5 May to 4 June.
OP32	-43.0633, 172.754	0	0	None
OP33	-43.0626, 172.7544	0	0	None

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP34	-43.0619, 172.7547	114	0	Up to 7 minutes of green glare between 4:30 pm and 5:00 pm, from 21 May to 15 June.
OP35	-43.0609, 172.7546	184	0	Up to 7 minutes of green glare between 4:30 pm and 5:15 pm, from 12 May to 14 June.
OP36	-43.065, 172.7489	0	0	None
OP37	-43.0715, 172.7467	0	0	None
OP38	-43.0655, 172.7552	0	0	None
OP39	-43.0661, 172.7633	118	0	Up to 7 minutes of green glare between 4:30 pm and 5:00 pm, from 24 May to 14 June.
OP40	-43.0659, 172.7534	0	0	None
OP41	-43.0731, 172.731	0	0	None
OP42	-43.08, 172.7392	0	0	None
OP43	-43.0773, 172.7458	0	0	None
OP44	-43.0784, 172.749	0	0	None
OP45	-43.0656, 172.7544	0	0	None
OP46	-43.0539, 172.7284	0	0	None
OP47	-43.045, 172.7668	57	0	Up to 4 minutes of green glare between 5:00 pm and 6:00 pm, from 24 April to 13 May and from 30 July to 19 August.
OP48	-43.0454, 172.7759	53	0	Up to 4 minutes of green glare between 5:15 pm and 6:00 pm, from 19 April to 4 May and from 15-24 August.
OP49	-43.031, 172.744	46	0	Up to 3 minutes of green glare between 6:45 pm and 7:15 pm, from 6-14 March and from 29 September to 11 October.
OP50	-43.0509, 172.6999	0	0	None
OP51	-43.0512, 172.7027	0	0	None

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP52	-43.0746, 172.7135	67	0	Up to 5 minutes of green glare between 7:45 am and 8:15 am, from 19 July to 6 August.
OP53	-43.0719, 172.7095	0	0	None
OP54	-43.0834, 172.733	0	0	None
OP55	-43.0471, 172.781	49	0	Up to 4 minutes of green glare between 5:15 pm and 6:00 pm, from 20 April to 4 May and from 13-22 August.
OP56	-43.072, 172.7823	217	0	Up to 10 minutes of green glare between 4:30 pm and 5:15 pm, from 11 May to 18 June.
OP57	-43.0516, 172.7706	69	0	Up to 2 minutes of green glare between 4:45 pm and 5:30 pm, from 19 May to 24 July.
RT01	Car NZ State Hwy 1	269	0	Up to 6 minutes of green glare between 4:45 pm and 6:15 pm, from 5 April to 30 May and from 12 July to 7 September.
RT02	Truck NZ State Hwy 1	279	0	Up to 6 minutes of green glare between 4:45 pm and 6:15 pm, from 5 April to 31 May and from 12 July to 7 September.
RT03	Church Rd	400	0	Up to 8 minutes of green glare between 4:45 pm and 6:15 pm, from 5 April to 7 September.
RT04	Kathryns Ln		0	None
RT05	Car NZ State Hwy 7	1,242	492	Up to 4 minutes of yellow glare between 5:00 am and 6:45 am, on 12 January, from 21 January to 9 November, and from 22-23 November.
RT06	Truck NZ State Hwy 7	1,344	437	Up to 7 minutes of yellow glare between 4:45 am and 6:45 am, from 12 January to 19 March and from 23 September to 23 November.
RT07	Glenmark Rd South		0	None
RT08	McKenzies Rd	1,649	0	Up to 11 minutes of green glare between 4:30 pm and 8:00 pm, on 11 January, from 5-19 March, from 1 April to 10 September, from 23 September to 7 October, from 3-14 December, and from 27-31 December.
RT09	Barnetts Rd	0	0	None

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
RT10	Darnley Rd	0	0	None
RT11	Georges Rd	497	0	Up to 8 minutes of green glare between 7:45 am and 8:30 am, from 16 May to 28 July.
RT12	Mount Cass Rd		0	None
RT13	Johnston St	770	0	Up to 11 minutes of green glare between 4:30 pm and 5:30 pm, from 7 May to 6 August.
RT14	Glenmark Dr North	0	0	None
RT15	Bain Rd	0	0	None
RT16	Loffhagen Dr	0	0	None
RT17	Weka Pass Loop Rd	0	0	None
RT18	Fergusons Rd	0	0	None
RT19	Symonds Rd	1,442	0	Up to 14 minutes of green glare between 4:30 pm and 6:00 pm, from 15 April to 27 August.
RT20	Rail line	23	0	Up to 2 minutes of green glare between 5:45 pm and 6:15 pm, from 8-14 April and from 28 August to 3 September.
		12,778	990	

3.4.2 3° Rest Angle Results

The results of the GlareGauge analysis with a 3° array rest angle (Appendix B) are summarised in Table 5 for receptors that were subject to some glare when the array used a rest angle of 0°. Over the period of a year, the analysis identified 1,675 minutes (~28 hours) of cumulative green glare spread across 5 routes. In particular, the NZ State Highways were not subjected to any yellow glare over the year. This is an 87% reduction in green glare and a 100% reduction in yellow glare when compared to a rest angle of 0°.

Table 5: Glare potential with 3° rest angle

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP02	-43.0435, 172.7374	0	0	None
OP04	-43.0408, 172.7391	0	0	None
OP05	-43.0338, 172.7413	0	0	None
OP06	-43.0326, 172.7434	0	0	None
OP07	-43.043, 172.7479	0	0	None
OP08	-43.0356, 172.7346	0	0	None
OP09	-43.0409, 172.7457	0	0	None
OP11	-43.0304, 172.7485	0	0	None
OP12	-43.0461, 172.7527	0	0	None
OP13	-43.0327, 172.7388	0	0	None
OP14	-43.05, 172.7467	0	0	None
OP15	-43.0577, 172.7538	0	0	None
OP19	-43.0532, 172.7573	0	0	None
OP20	-43.0537, 172.7577	0	0	None
OP21	-43.0543, 172.7589	0	0	None
OP22	-43.0549, 172.7595	0	0	None
OP23	-43.056, 172.7577	0	0	None
OP24	-43.0556, 172.7579	0	0	None
OP26	-43.0577, 172.7568	0	0	None
OP27	-43.058, 172.7562	0	0	None
OP28	-43.067, 172.7733	0	0	None
OP29	-43.0585, 172.756	0	0	None
OP30	-43.059, 172.7557	0	0	None
OP31	-43.0594, 172.7555	0	0	None

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP34	-43.0619, 172.7547	0	0	None
OP35	-43.0609, 172.7546	0	0	None
OP39	-43.0661, 172.7633	0	0	None
OP47	-43.045, 172.7668	0	0	None
OP48	-43.0454, 172.7759	0	0	None
OP49	-43.031, 172.744	0	0	None
OP52	-43.0746, 172.7135	0	0	None
OP55	-43.0471, 172.781	0	0	None
OP56	-43.072, 172.7823	0	0	None
OP57	-43.0516, 172.7706	0	0	None
RT01	Car NZ State Hwy 1	0	0	None
RT02	Truck NZ State Hwy 1	0	0	None
RT03	Church Rd	0	0	None
RT05	Car NZ State Hwy 7	297	0	Up to 5 minutes of green glare between 4:45 am and 5:45 am, , from 9 November to 4 February.
RT06	Truck NZ State Hwy 7	357	0	Up to 6 minutes of green glare between 4:45 am and 5:45 am, from 4 November to 8 February.
RT08	McKenzies Rd	132	0	Up to 4 minutes of green glare between 4:30 pm and 5:00 pm, from 29 May to 13 July.
RT11	Georges Rd	0	0	None
RT13	Johnston St	92	0	Up to 3 minutes of green glare between 4:30 pm and 5:00 pm, from 29 May to 13 July.
RT19	Symonds Rd	797	0	Up to 13 minutes of green glare between 4:30 pm and 5:30 pm, from 2 May to 10 August.
RT20	Rail line	0	0	None
Total		1,675	0	

4 SUMMARY

The results of the GlareGauge analysis using a rest angle of 0° indicated that 34 observation points 10 road routes received green glare, while one observation point and 2 road routes received yellow glare. Yellow glare has the potential to cause after-image to observers, while green glare has low potential to cause after-image.

Using a rest angle of 3° reduced the glare impact for all receptors, with 5 road routes receiving green glare and no receptors receiving yellow glare. In particular, the NZ State Highways were not subjected to any yellow glare over the year. In this scenario, the glare impact is low and further mitigation is not required.

5 REFERENCES

Federal Aviation Administration (FAA), 2018. Solar Guide: Technical Guidance for Evaluating Selected Solar Technologies on Airports. Retrieved from the FAA website:

<https://www.faa.gov/airports/environmental/>

Thompson, R., Ave, I., Anne, D., Jan, M., David, S. and Robert, C., 2013. Interim policy, FAA review of solar energy system projects on federally obligated airports.

Barrett, S., Devita, P., Ho, C. and Miller, B., 2014. Energy technologies' compatibility with airports and airspace: Guidance for aviation and energy planners. *Journal of Airport Management*, 8(4), pp.318-326.

APPENDIX A. EXCLUDED RECEPTORS

Table 6: Excluded receptors

Receptor	Location	Justification
Exc 01	-43.0748, 172.7402	Business and not a residence.
Exc 02	-43.0851, 172.7315	View of solar farm obscured by surrounding vegetation
Exc 03	-43.0566, 172.7575	View of solar farm obscured by surrounding vegetation
Exc 04	-43.053, 172.7252	View of solar farm obscured by surrounding vegetation
Exc 05	-43.0434, 172.756	View of solar farm obscured by surrounding vegetation
Exc 06	-43.0524, 172.75	View of solar farm obscured by surrounding vegetation
Exc 07	-43.0571, 172.7571	View of solar farm obscured by surrounding vegetation
Exc 08	-43.0594, 172.7543	View of solar farm obscured by surrounding vegetation
Exc 09	-43.0658, 172.746	View of solar farm obscured by surrounding vegetation
Exc 10	-43.0716, 172.7477	View of solar farm obscured by surrounding vegetation
Exc 11	-43.0743, 172.7544	View of solar farm obscured by surrounding vegetation
Exc 12	-43.0647, 172.7535	Building is a business, not a residence
Exc 13	-43.066, 172.7572	Building is a business, not a residence
Exc 14	-43.0714, 172.7433	Building is a business, not a residence
Exc 15	-43.0224, 172.7532	Building is a business, not a residence
Exc 16	-43.0452, 172.7823	Building is a business, not a residence
Exc 17	-43.0712, 172.7286	Buildings are sheds, not residences
Exc 18	-43.0847, 172.7445	View of solar farm obscured by surrounding vegetation

Exc 19	-43.0417, 172.7685	View of solar farm obscured by surrounding vegetation
Exc 20	-43.0109, 172.6994	View of solar farm is obscured by hills
Exc 21	-43.0127, 172.6989	View of solar farm is obscured by hills
Exc Route 1	Glenmark Drive	View of solar farm obscured by surrounding vegetation and buildings
Exc Route 2	Ferguson Avenue	View of solar farm obscured by surrounding vegetation
Exc Route 3	Anzac St	View of solar farm obscured by surrounding vegetation
Exc Route 4	South section of Townend Street	View of solar farm obscured by surrounding vegetation and buildings
Exc Route 5	North section of Townend Street	View of solar farm obscured by vegetation to the south
Exc Route 6	Loffhagen Drive	View of solar farm obscured by surrounding vegetation
Exc Route 7	Fergusons Road	View of solar farm obscured by hills

APPENDIX B. FORGESOLAR GLARE ANALYSIS

We have attached the analysis reports exported from ForgeSolar:

- ForgeSolar analysis OP1-40 0deg
- ForgeSolar analysis OP41-57 0deg
- ForgeSolar analysis OP1-40 3deg
- ForgeSolar analysis OP41-57 3deg



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Appendix L. Consultation Record

Project Reps	Topic	Summary	Follow-up actions (if any)
GH	introductions	Attended the wananga and Jacquie pointed out Ngāi Tūāhuriri Rūnanga representative Tania Wati. I introduced myself to Tania and asked if I could speak to her briefly about FNSF and our plans in Waipara. Tania was quite curt with me and said she did not want to hear anything about our plans until we told her what the benefits to Ngāi Tūāhuriri would be. I tried to explain that we wished to work together to try and identify these things in partnership. She directed me to talk with Katherine Snook (who was also at the table Tania was sitting at with others at the Wananga). Katherine and I spoke briefly and we exchanged contact details. I said I would liaise with her and hoped to form a pathway forward that could involve the runanga in the planning of the development.	
GH	engagement	Wrote to Just following up on an email from late May regarding a wish to engage with Ngāi Tūāhuriri. Said we were keen to engage as early as possible in order to allow a proper consultation to occur. Asked her to let me know what next steps the Rūnanga would like to follow	
GH	asking to engage to discuss project	Katherine wrote to suggest an online meeting. asked me to suggest a time	
GH		GH wrote to Katherine to suggest 18th or 19th July as a time to meet online	
GH		Wrote to Katherine to say we were not having much luck connecting with regard to the solar farm development in Waipara that we were very keen to ensure we do engage with mana whenua early on this project so could I suggest we have a call on either Thursday or Friday this week? I am available at any time on either day. Please let me know if this is possible and if so what time might suit. I will then send a calendar invite. Katherine replied same day and provided a phone number for herself.	
GH	to see if we can advance engagement request	Spoke with Katherine briefly by phone to follow up on email correspondence. I explained a little about what the proposal involved and again expressed the desire to wish to communicate this with rananga if they wished to know more, or be involved. Asked for guidance on how best to proceed, if that was what runanga wanted to do.	
GH	engagement to discuss proposal	Shared draft layout of the proposal and informed it was selected as it was close to existing infrastructure and on flat land. Provided list of benefits to iwi from project (see email 10 August).	Katherine replied 15 August saying she would take request and info to Board chair to ask for next steps
gh		Katherine wrote to say she received the list of benefits and layout and was talking to her Board Chair and will come back to me on next steps shortly.	
GH	Follow up on request to engage	I wrote to ask if there was any update on our request to engage with Ngāi Tūāhuriri. Said we would welcome the opportunity to meet kanohi kitea and that we looked to enhance and enable the Rūnanga aspirations and developing appropriate mechanisms that support a mātauraka Māori vision tailored to the values and needs of your Rūnanga.	write again in two weeks if haven't heard anything
Greg Hay	engagement to discuss proposal	Katherine wrote to say Runanga was willing to engage. Stated we should progress under a Memorandum of Agreement to cover the matters we previously proposed and align with any other priorities. Said that with respect to resource consenting the runanga don't support/oppose these - the assessment of resource consents are led by an environmental agency (didn't say which one).	reply and take up offer
GH	face to face engagement opportunity	GH replied to Katherine's email confirming runanga would be happy to engage and talk about the list of benefits we've provided earlier etc. Said we would like to meet in person if possible and if she could indicate when this might occur. said that the opinions of mana whenua are important to us from a partnership point of view but also because they are also required in an official capacity so we seek your guidance on how these two can be achieved and coexist	date and place TBC

GH		In lieu of a response regarding our latest communication on 27 October confirming we would be grateful to meet with Ngāi Tūāhuriri, can I ask if the rūnanga would have any interest in preparing a Cultural Impact Assessment in relation to the solar proposal. This is in addition to the items of benefit to the rūnanga from the solar proposal we have already shared. Happy to follow whatever procedure is deemed appropriate.	
GH	engagement requests	Wrote to Katherine again to ask if the runanga wished to meet as they had indicated they did. informed that we would be submitting the RC application in the coming months. Asked about the agency the runanga uses to assess applications and who this was and how we might go about engaging with them if that was required.	no reply as at 7/2/24