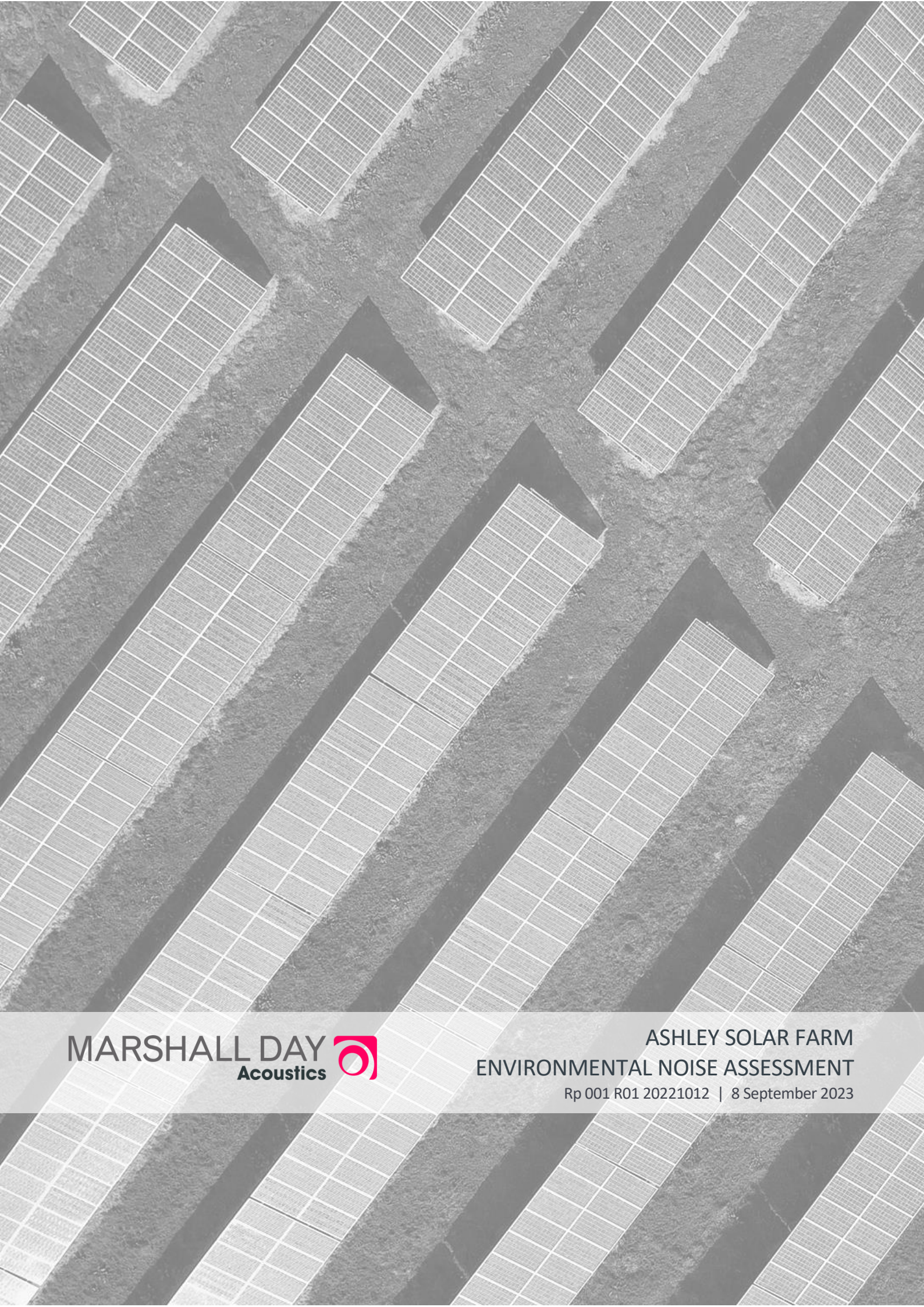
ANNEXURE E

ACOUSTIC REPORT



MARSHALL DAY Acoustics

ASHLEY SOLAR FARM
ENVIRONMENTAL NOISE ASSESSMENT

Rp 001 R01 20221012 | 8 September 2023

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Cover Photo: Red Zeppelin via Pexels

SUMMARY

Marshall Day Acoustics has undertaken a noise assessment for a proposed solar farm at 87 Upper Sefton Road in the Waimakariri District.

The main sources of noise associated with the proposed solar farm are the inverters and transformers that convert the low voltage DC current from the solar panels to high voltage AC current for the grid. The inverters typically emit more noise than the transformers and often exhibit tonal characteristics.

We understand that the system will operate during daylight hours only (there is no battery storage capacity) and therefore noise emissions could only occur from around 0600 hrs to 2100 hrs on the longest days of the year.

The Waimakariri District Plan provides noise limits in rural areas of 50 dB L_{A10} (daytime) and 40 dB L_{A10} (night-time), where daytime is defined as 0700 to 1900 hrs Monday to Saturday and 0900 to 1900 hrs on Sundays and Public Holidays. The definition of Sunday is important because it results in the potential for noise emissions to exceed the night-time noise limits at the closest properties, albeit it the unlikely event that high levels of noise emission occur prior to 0900 hrs. The noise emissions from the inverters vary with load and will therefore be highest at the times of maximum solar gain, which is normally later than 0900 hrs.

We note that the District Plan is currently undergoing a review process and the proposed rules, if adopted, would alter the daytime period to be 0700 to 2200 hrs on all days, in line with current industry best practice. This change would alleviate the potential for non-compliance identified above.

We have made some recommendations around appropriate consent conditions that seek to bridge the gap between the operative District Plan rules and current industry best practice, which is generally reflected by the proposed rule changes.

The results of our calculations indicate that, subject to optimal inverter orientation as per our recommendations, noise levels at the closest dwelling will be up to 40 dB L_{A10} in a maximum load scenario and 33 dB L_{A10} in a reduced load scenario. These noise levels comply with the applicable District Plan noise limits for both day and night-time periods.

We consider that the overall noise emissions from the proposed solar farm would be reasonable, without the need for any significant additional noise mitigation beyond the base design (e.g. barriers and enclosures).

We have also considered noise levels during the construction phase and do not expect any significant adverse noise effects to arise from temporary activities if consent is granted. Depending on the type of piling used to install the solar panel supports, the construction noise limits could be breached for a short period, and we have provided recommendations on how best to manage this risk.

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1.0 INTRODUCTION

Marshall Day Acoustics has been engaged by Solar Bay to assess noise associated with a proposed new solar farm at 87 Upper Sefton Road, Ashley in Canterbury's Waimakariri District.

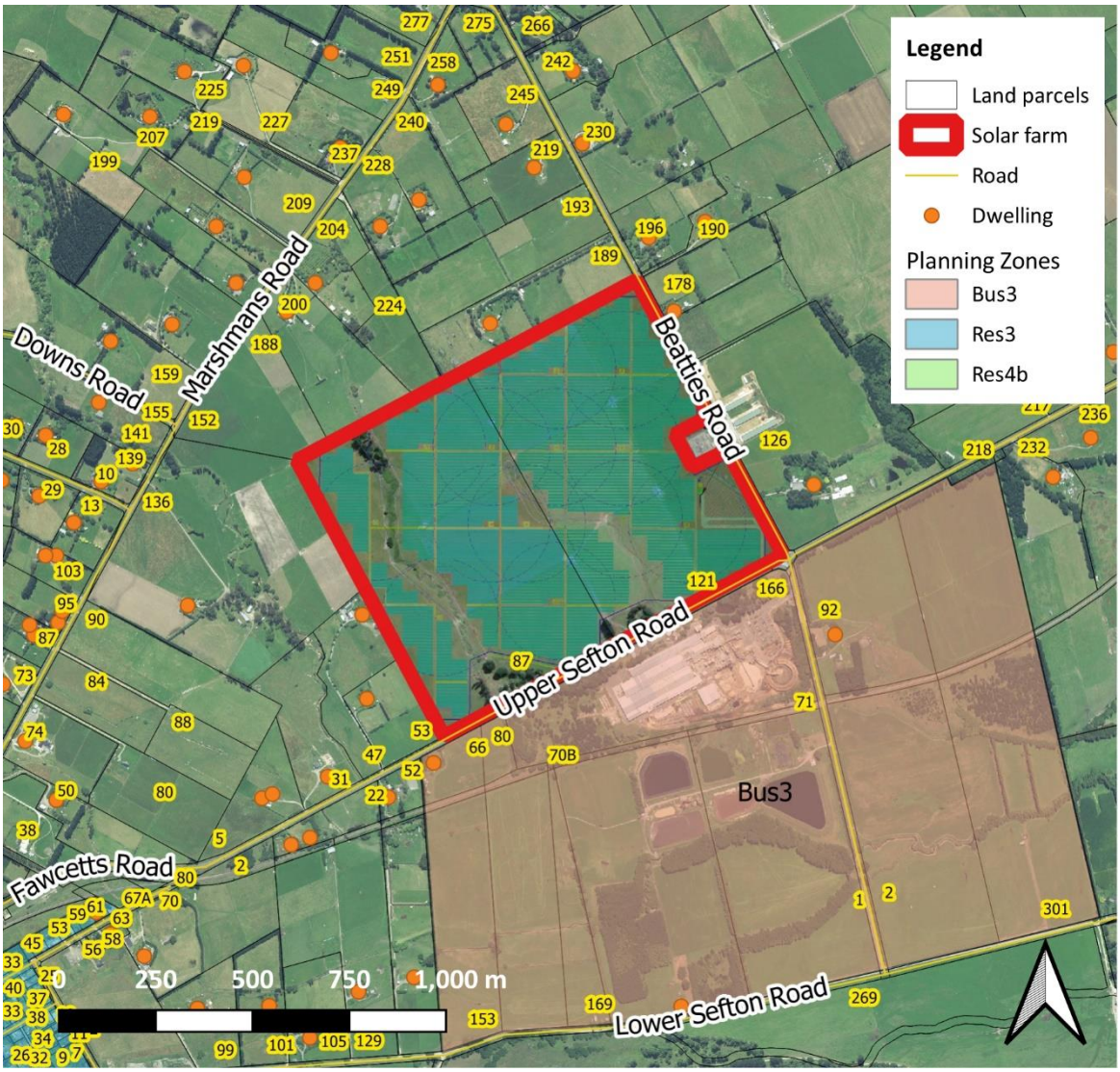
The proposed solar farm, which is in a predominantly rural area around 30 km north of Christchurch, will occupy the majority of the 80 hectare site, which is currently all in pastoral use. The site and surrounding area are shown in Figure 1 below, which also indicates the proximity of the closest dwellings to the site – these being the main noise-sensitive land uses in the area.

In this report, we provide:

- A summary of the proposal and describes the aspects of it that can lead to the generation of noise
- A review of the relevant noise standards and guidelines, including analysis of both the operative and proposed Waimakariri District Plan rules
- Details of our assessment methodology and results of our noise surveys and calculations
- An assessment of noise emissions against the relevant local noise rules and discussion of noise effects in the context of the guidance documents reviewed

A glossary of acoustical terminology used is provided for assistance in Appendix A.

Figure 1: Aerial view of the application site and surrounding area, with solar farm concept plan overlaid



2.0 PROPOSED SOLAR FARM DEVELOPMENT DETAILS

The solar farm will comprise almost 90,000 individual photovoltaic panels, each around 2.5 m^2 and combined on tables of around 50-100 panels each. There is no noise emitted by the panels themselves, but some of the ancillary equipment does generate noise.

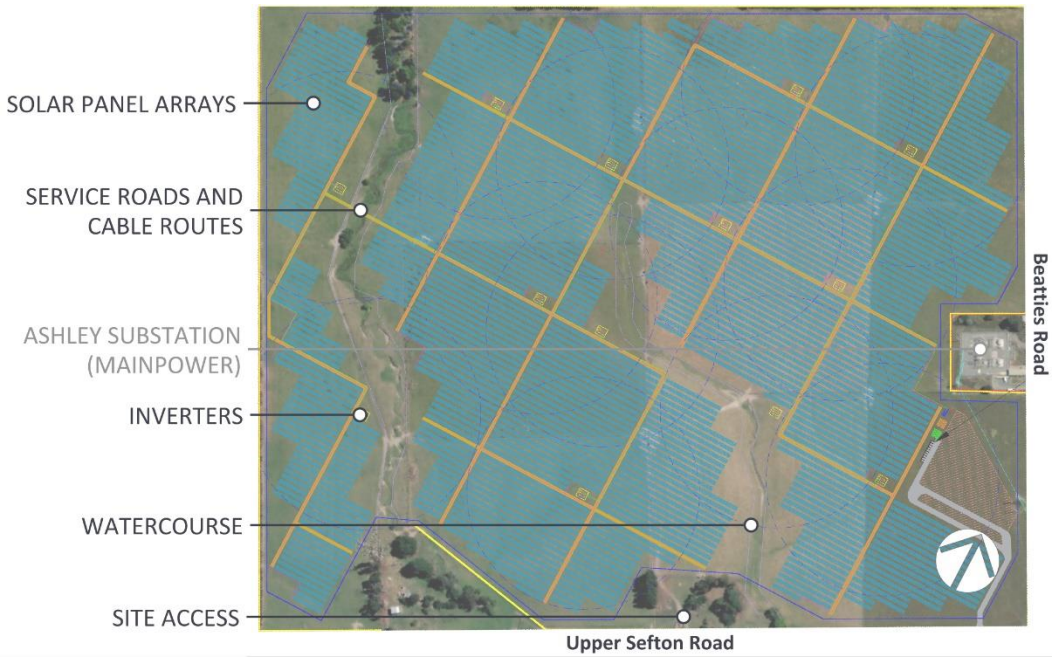
The tables will have a fixed-tilt design, meaning that the panels are mounted in a static position and do not move to track the sun's movement. There is therefore no additional noise from any tracker motors or similar systems (although tracker motors typically emit low levels of noise regardless).

The current from the solar panels is fed to DC-AC inverter units, of which there are 10 distributed over the site. Each inverter also has an associated transformer, to change the voltage of the AC power supplied to the grid via the adjacent MainPower Ashley Substation.

We understand that the preliminary equipment selection is for SMA *Sunny Central UP* 4400 KVA inverters. Limited noise data is available on inverters, but our experience is that inverters usually exhibit tonal characteristics at various frequencies. Tones can be more noticeable than broadband sound even at low noise levels and we have therefore accounted for this in our assessment.

We also understand that there is no battery storage system as part of this proposal, so we have not allowed for such a system in our assessment. The potential for noise emissions would therefore be limited to daylight hours only, which range from 0800 - 1700 hrs in June (9 hours of daylight) to 0545 - 2110 hrs in December (over 15 hours of daylight)[1].

Figure 2: Concept layout plan for the proposed Ashley Solar Farm



[1] Based on the sunrise and sunset times given by timeanddate.com for Rangiora, New Zealand.

3.0 EXISTING LOCAL NOISE ENVIRONMENT

The surrounding area is generally rural in character. Most of the land is within the Rural Zone of the Waimakariri District Plan, with other areas zoned for Business and Residential use, as shown in Figure 1.

3.1 Adjacent Land Uses

There are many dwellings in the area, the majority of which are situated to the north and west of the application site. The closest dwellings within 250 metres of the site are listed below in Table 1. There are approximately another 70 dwellings within 1 km of the site that, while we have considered these in our assessment and calculations, are not presented in this report for simplicity.

Table 1: Dwellings within 250 metres of the application site boundary

ID	Address	Distance to application site boundary, m	Distance to closest inverter, m	Receiving site zoning (Operative District Plan)
R1	47 Upper Sefton Road	38	183	*Rural*
R2	178 Beatties Road	48	205	*Rural*
R3	66 Upper Sefton Road	74	374	*Business 3*
R4	189 Beatties Road	79	210	*Rural*
R5	196 Beatties Road	115	358	*Rural*
R6	53 Upper Sefton Road	130	279	*Rural*
R7	126 Beatties Road	156	354	*Rural*
R8	52 Upper Sefton Road	213	480	*Rural*
R9	190 Beatties Road	234	449	*Rural*
R10	92 Beatties Road	248	480	*Business 3*

Aside from these dwellings, other features of the local area include the Daiken NZ medium density fibreboard (MDF) production facility to the south of the site, in the *Business 3* zone, and a pig farm located off Beatties Road.

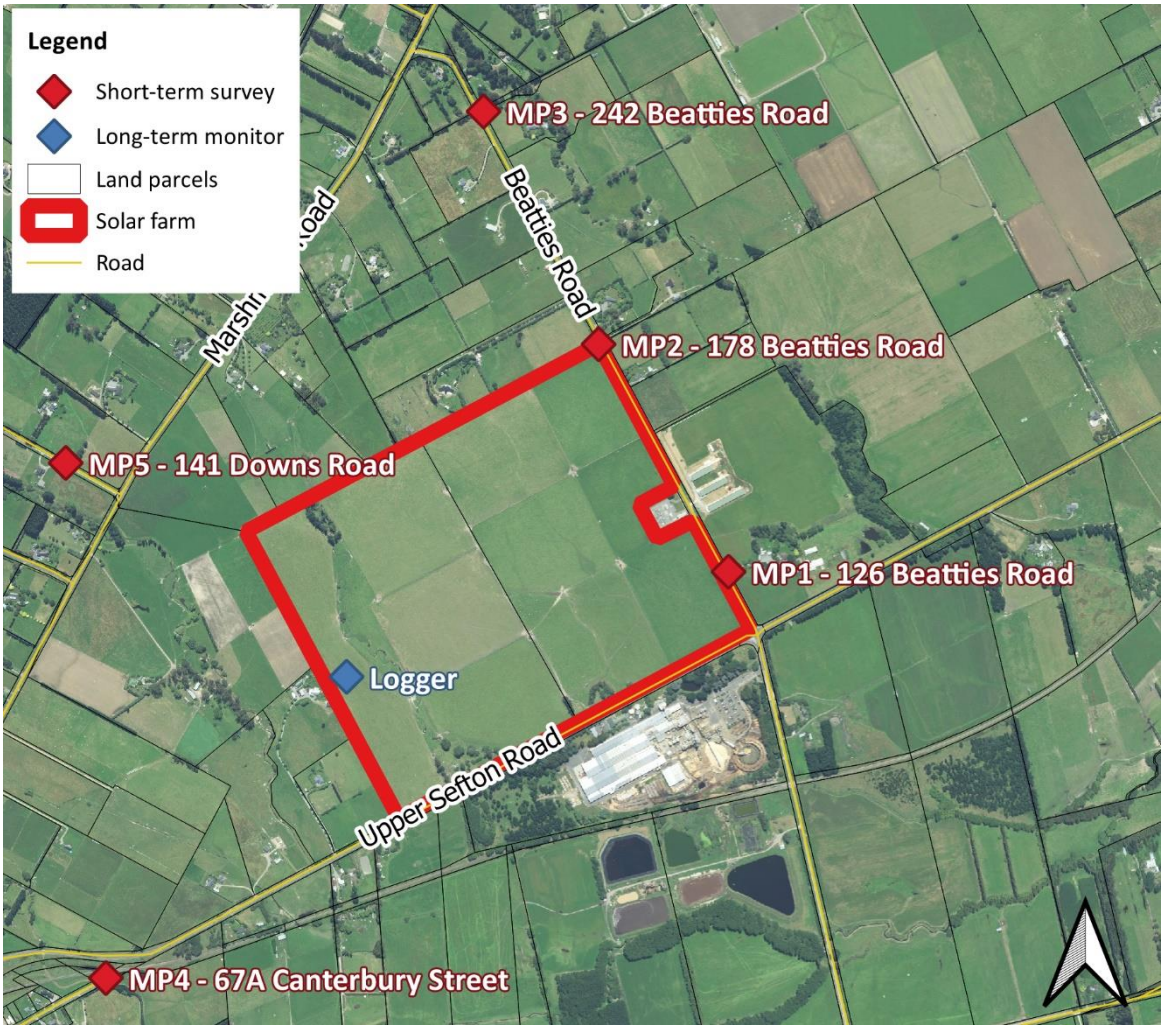
In terms of noise generation, road traffic (primarily on Upper Sefton Road) is a prominent feature of the current noise environment. Noise is also experienced from aircraft (associated with CIAL and Rangiora Airfield), rural agricultural activities, normal domestic activities and natural sounds such as birds and insects and wind-induced vegetation noise.

3.2 Existing Noise Levels

We visited the site in March 2023 to survey the existing noise levels. A continuous noise monitoring device (logger) was installed on the application site to measure noise levels over the course of a week, while additional short-term attended surveys were conducted to measure noise at other locations and make observations on the contributing noise sources. The survey positions are shown in Figure 3 overleaf.

The continuous logger was sited to measure levels that are expected to be representative of some of the most potentially affected dwellings at 47 Upper Sefton Road and 189 Beatties Road. These dwellings are relatively close to the application site boundary, so will receive the highest levels of noise, but are farthest from any roads and therefore will experience relatively low levels of traffic noise.

Figure 3: Noise survey positions



The noise levels at the logger will also be representative of those experienced at dwellings closer to local roads, but in the absence of local traffic passing. The short-term measurement positions were used to explore the differences in ambient noise level depending on the proximity of local roads.

Details of the noise surveys including equipment information are provided in Appendix B.

The results of the long-term monitoring are summarised in Table 2 below, with a time history of recorded data included in Appendix C. The short-term survey results are summarised in Table 3.

Table 2: Summary of long-term noise monitoring data

Date	Day (0700 - 1900 hrs)				Night (1900 - 0700 hrs)			
	L_{Aeq}	L_{A10}	L_{A90}	L_{AFmax}	L_{Aeq}	L_{A10}	L_{A90}	L_{AFmax}
15/3	-	-	-	-	44 (35-50)	45 (35-52)	38 (31-43)	57 (46-68)
16/3	45 (39-50)	46 (41-53)	38 (34-44)	60 (48-74)	43 (38-48)	45 (39-51)	39 (35-42)	57 (46-69)
17/3	46 (41-51)	47 (42-54)	40 (36-46)	61 (53-70)	45 (34-52)	44 (36-54)	36 (31-49)	58 (42-81)
18/3	49 (40-56)	49 (42-59)	41 (35-48)	64 (51-84)	44 (31-49)	45 (31-51)	37 (28-44)	57 (46-77)
19/3	48 (42-55)	49 (43-53)	41 (35-45)	64 (54-79)	45 (30-52)	45 (31-54)	38 (28-46)	58 (44-72)
20/3	50 (43-55)	51 (42-58)	44 (37-52)	64 (54-76)	42 (33-46)	43 (35-49)	35 (27-42)	56 (45-70)
Avg.	***48***	***48***	***41***	***63***	***44***	***45***	***37***	***57***

Recorded noise data at the logger position has been corrected to account for the influence of adverse weather conditions – periods during or following rainfall or high winds over 5 m/s – in line with NZS 6801:2008.

Table 3: Summary of short-term noise measurements, Wednesday 15 March 2023

Ref.	Time	Duration	Measured Sound Level, dB				Comments
			L_{Aeq}	L_{A10}	L_{A90}	L_{AFmax}	
MP1	13:05	15 min	52	53	45	76	Traffic on Upper Sefton Rd dominant. Sawmill audible, plus plant on pig farm.
MP2	13:27	15 min	53	50	41	78	Distant traffic noise from the east dominant. Some local traffic and animals.
MP3	13:52	15 min	54	45	38	80	Some cars pass on Beatties Rd, otherwise distant traffic audible. Multiple aircraft.
MP4	14:42	15 min	56	59	48	69	Constant traffic noise on Upper Sefton Rd dominant. Occasional aircraft overhead.
MP5	14:15	15 min	48	52	41	61	Marshmans Rd traffic governs level, no local Downs Rd traffic. Minor animal noise.

Noise levels at the short-term monitoring locations were all slightly higher than the average noise level measured at the logger position. This difference was because of local traffic.

At the logger position, we observed that distant traffic noise from Upper Sefton Road was generally the dominant source. However, a constant low level of sawmill noise was audible throughout our time on site, with intermittent noises from reversing alarms and similar sounds at the sawmill, plus noise from animals and aircraft.

Generally, the existing ambient noise environment can be described as broadly around 50 dB L_{Aeq} on average, with background noise levels around 40 dB L_{A90} at most receivers. Specific locations may be a little above or below these values, but these values represent most receivers.

This area is subject to background and ambient noise levels that are somewhat elevated in comparison with remote rural areas. We note that night-time background noise levels are somewhat higher than might be expected in more remote rural areas. There are only relatively brief periods where noise levels fall below 30 dB $L_{A90.}$

4.0 NOISE STANDARDS AND GUIDELINES

4.1 Waimakariri District Plan Standards

4.1.1 Operative District Plan

Under the Operative District Plan (ODP), noise emissions from activities in the *Rural* zone are controlled by Rule 31.12.1.2, which states that activities shall not exceed the following noise limits at the notional boundary of any dwelling in the *Rural* zone:

- Day: 50 dB L_{A10} (0700 to 1900 hrs, Monday to Saturday, 0900 to 1900 hrs Sundays and Holidays)
- Night: 40 dB L_{A10} (all other times) and 70 dB L_{Amax} (2200 to 0700 hrs daily)

Any activity that meets this standard is permitted with regard to noise. Rule 31.13.1 states that *"any land use that does not comply with* [the above rule] *… is a discretionary activity (restricted)".*

Rule 31.12.1.2 does not apply to activities or receivers in the *Business 3* zone, so we note that there is no noise limit for some receivers around the site – specifically, 92 Beatties Road and 66 Upper Sefton Road in Table 1.

Rule 31.12.1.3 provides limits for activities within the *Business 3* zone (so not applicable to the proposed solar farm) that only apply to the dwelling at 126 Beatties Road (*Rural* zone) and within residential zones. The limits are 5 dB higher than those listed above, with the timeframes being consistent (i.e. 55/45 dB L_{A10} day/night). We note this as it means that this dwelling receives less protection in terms of noise limits compared with the other *Rural* zone dwellings in the area.

Rule 31.12.1.1 prescribes the required methodology and requires the measurement and assessment of noise in accordance with NZS 6801:1991 "Measurement of Sound" and NZS 6802:1991 "Assessment of Environmental Sound".

The parts of this chapter that relate to noise and are relevant to this assessment are reproduced in full in Appendix D to this report, which includes some additional limitations on the application of NZS 6801:1991.

4.1.2 Proposed District Plan

The Proposed District Plan (PDP) has now been notified and provides revised noise limits. While the proposed rules do not have legal effect, we have reviewed the proposed changes and considered how they may apply to this project if they were adopted in their current form.

The zoning of the application site and surrounding area is not proposed to change. Although the names change – the *Rural* zone becomes the *Rural Lifestyle* zone and the *Business 3* zone becomes the *Heavy Industrial* zone – the zone boundaries remain the same as the ODP.

Noise limits are introduced for receivers within the *Heavy Industrial* zone, these being site boundary limits of 65 and 55 dB L_{Aeq} day/night. The PDP also introduces a Timber Processing Noise Contour, which reflects Daiken's noise emissions around their factory.

The PDP requires measurement and assessment of noise in accordance with the most recent, 2008 versions of NZS 6801 and 6802 – updating the requirements of the ODP. This implementation is consistent with the National Planning Standards.

The PDP notional boundary noise limits remain at 50 and 40 dBA, but the L_{Aeq} descriptor is adopted rather than use of the L_{A10}. This is again consistent with the NPS. The daytime period is defined as 0700 to 2200 hrs, seven days, and a night-time noise limit of 65 dB L_{AFmax} is proposed in rural zones.

A summary of the critical operative and proposed noise limits is given in Table 4 below. While we again acknowledge the proposed rules do not currently have any legal weighting, they are relevant in so far as they broadly represent current industry best practice.

Table 4: Comparison of average noise level District Plan limits for noise generated in Rural zones

Plan Version	Days	Hours	Receiving Site Zoning	
			***Rural* (ODP)** ***Rural Lifestyle* (PDP)**	***Business 3* (ODP)/ *Heavy Industrial* (PDP)**
Operative	Monday - Saturday	0700 - 1900	50 dB L_{A10}	N/A
		1900 - 0700	40 dB L_{A10}	N/A
	Sundays/Public Holidays	0900 - 1900	50 dB L_{A10}	N/A
		1900 - 0900*	40 dB L_{A10}	N/A
Proposed	All days	0700 - 2200	50 dB L_{Aeq}	65 dB L_{Aeq}
		2200 - 0700	40 dB L_{Aeq}	55 dB L_{Aeq}

** Or until 0700 hrs if the following day is between Monday and Saturday, inclusive.*

4.2 Other Relevant Guidance

In addition to rules relating to noise in the District Plan, there are both national and international standards and guidelines commonly used in New Zealand to provide guidance on acceptable noise criteria for the protection of residential amenity.

4.2.1 NZS 6802:2008 Upper Limits

New Zealand Standard NZS 6802:2008 *"Acoustics - Environmental Noise"* is the most recent version of the 1991 standard referred to in the ODP rules. The Standard provides the following guideline upper limits of sound exposure at the notional boundary of any rural dwelling:

- Daytime: 55 dB $L_{Aeq\,(15\,min)}$
- Evening: 50 dB $L_{Aeq\,(15\,min)}$

4.2.2 World Health Organisation

The World Health Organisation's (WHO) Guideline Values for Community Noise (1999) give guidelines for environmental noise exposure. For community or environmental noise in the daytime, the critical health effects (those effects which occur at the lowest exposure levels) are annoyance (moderate, high) and speech interference or communication disturbance.

The WHO Guideline Values for these critical health effects for community or environmental noise are presented in Table 5. These Guideline Values are the exposure levels that represent the onset of the effect for the general population. That is, at these noise levels, critical health effects only begin to appear in a small number of vulnerable or sensitive groups.

Table 5: WHO Guideline Values for the critical health effects of community or environmental noise

Specific Environment	Critical Health Effect(s)	Guideline Noise Levels		
		dB L_{Aeq}	L_{Aeq} time base	dB L_{Amax}
Outdoor living areas	Serious annoyance, daytime & evening	55	16 hrs	-
	Moderate annoyance, daytime & evening	50	16 hrs	-
Inside dwellings	Speech intelligibility and moderate annoyance, daytime & evening	35	16 hrs	-

4.2.3 Resource Management Act 1991

Regardless of any noise performance standards provided in local legislation or specific land-use consents, the RMA imposes overarching obligations on all generators of noise.

Section 16 of the Act concerns one's duty to avoid unreasonable noise and 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 also 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.

4.3 Recommended Noise Limits

As noise from electrical equipment is generally steady in nature, the noise level should be very similar when measured with the L_{10} or L_{eq} metrics. Compliance with the ODP daytime noise limit of 50 dB L_{A10} will therefore also mean that noise levels are within the lowest WHO guideline and PDP limit of 50 dB L_{Aeq}.

We also note that any future District Plan will have to give effect to the National Planning Standards, which require noise to be assessed in line with current best practice and, in particular, New Zealand Standard NZS 6802:2008, thus meaning that an L_{Aeq} based noise limit is likely to be adopted.

Whilst our analysis below predominately uses the L_{A10} parameter for ease of comparison with the ODP limits, we recommend that the noise limits adopted in the consent utilise the L_{Aeq} parameter and refer to the most recent New Zealand Standards in line with current best practice. Similarly, we recommend noise limits adopt the PDP daytime definition of 0700 to 2200 hrs on all days.

In this regard, we note that the 1991 and 2008 versions of NZS 6802 differ in their application of adjustments for the presence of "special audible characteristics" (SAC) from a specific noise source. Our assessment of SAC is described further below, but again for simplicity of reporting our analysis has been conducted in line with the 2008 methodology. We have compared this with the 1991 methodology and verified that use of the earlier method (as per the ODP) would not alter the findings of our assessment.

5.0 CALCULATED NOISE LEVELS

5.1 Noise Sources and Modelling Methodology

As previously described, the main noise sources associated with the proposed solar farm are the inverters and transformers. In most cases, the inverters (without any specific noise mitigation) generate more noise than the transformers.

We have prepared a noise model of the development using the SoundPLAN software suite, which implements the calculation procedure in ISO 9613-2:1996 "*Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation*". Table 6 summarises the input noise data used in the model.

Table 6: Source noise levels used in model

Noise Source	Sound Power Level, dB L_{WA}	Quantity	Directivity	Operation time
DC / AC inverter	92 (AC end) 86 (DC end)	10	Included	Daylight hours*
Transformer	78	10	Hemispherical	Daylight hours

** SWL given for peak load. Reduced load modelled at 5 dB lower for 10% load (e.g. around dawn/dusk)*

The source data is based on advice given by the manufacturers or from previous measurements carried out by Marshall Day Acoustics. We recommend that, if consent is granted, Solar Bay verify the final plant selection against these noise levels prior to procurement and installation.

5.1.1 Tonality

There is limited detailed manufacturers' data available for solar farm inverters, but in our experience, these typically show tonal characteristics at various frequencies. Tonal properties can have a negative effect on acoustic amenity at neighbouring sites and can warrant a 5 dB correction for SAC.

We have assumed that tonality will be present for most of the operating period, and that and SAC correction should be applied. However, we understand that inverter noise levels reduce at lower loads. Available data shows that tonal character is eliminated at low loads and we have therefore not applied an SAC correction for times of lower solar gain (e.g. early morning/evening).

5.1.2 Directivity and Model Scenarios

The inverters are likely to have appreciable directivity – i.e. higher emissions in one direction – as summarised in Table 6. We have analysed all of the possible directivity combinations in detail and have worked with Solar Bay to determine the best practicable option. As a result of this we have

recommended the optimal direction for each inverter (as shown in Appendix E) and our calculations are conducted on this basis. For record, the difference between the best and worst-case directivity combinations for the closest receivers is typically in the range of 5-7 dB.

5.1.3 Assessment Times

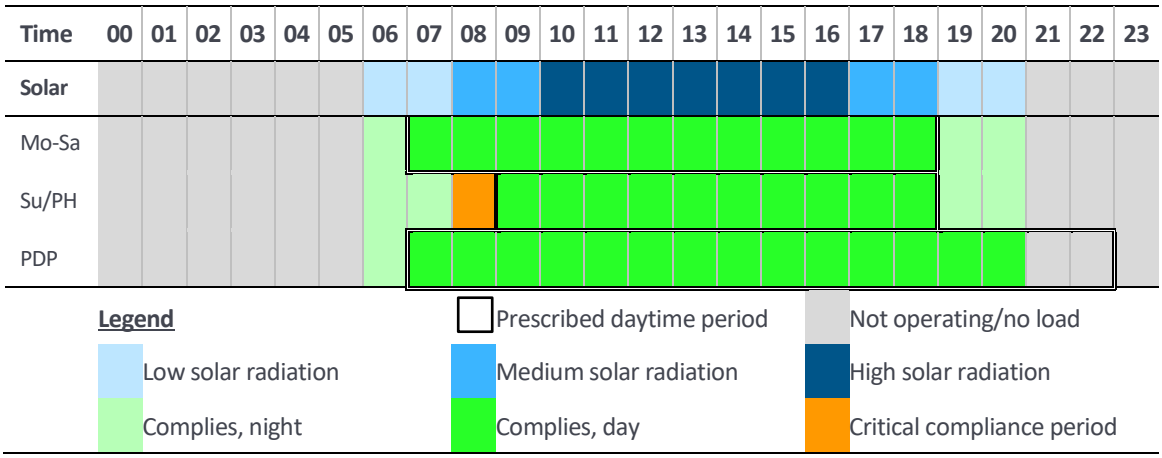
As the solar farm is likely to operate for more than 80% of the prescribed daytime period (particularly during summer), no correction has been applied to account for averaging over the daytime period, as described in NZS 6802.

The peak load – and therefore peak output – will generally occur in the middle of the day. The equipment may operate at reduced load early or late in the day and, during the summer months, this may occur within the ODP night-time period. We have therefore also assessed a low-load scenario to compare with the night-time noise limit.

However, we note that, under the ODP, the night-time period extends to 0900 on Sundays and public holidays. Our analysis of information from similar sites indicates that solar gain could be sufficient in mid-summer to result in received solar radiation of approximately 50% the midday peak by 0900 hrs.

To be conservative, we have assessed this period using our peak-load scenario (including tonality). While this scenario is unlikely to occur often in practice, it does represent the worst-case scenario for assessing compliance. These scenarios are summarised below in Table 7.

Table 7: Hourly assessment of District Plan compliance, summer solstice



5.1.4 Model Limitations

Noise levels have been calculated under meteorological conditions that are favourable to sound propagation (as per ISO 9613) and represent the 'worst-case' propagation situation for any sound sources.

It is important to note that under most daytime meteorological 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).

The strength of noise propagation may be markedly lower in lapse conditions than under temperature inversion conditions (which the model more closely represents)[2].

[2] Some calculation methods that account for meteorological differences give noise levels in meteorological category 1 (e.g. lapse) that are 5 to 10 dB lower (depending on distance) than meteorological category 5 (downwind or inversion).

5.2 Calculation Results

The results of our calculations are summarised in Table 8 below. The highest calculated noise levels at any receiver are:

- 40 dB L_{A10} for the maximum load scenario; and
- 33 dB L_{A10} for the reduced load scenario.

Table 8: Summary of calculated rating noise levels

ID	Address	Full Load (with SAC), dB L_{A10}	Reduced Load (no SAC), dB L_{A10}
R1	47 Upper Sefton Road	40	33
R2	178 Beatties Road	39	32
R3	169 Lower Sefton Road	35	29
R4	189 Beatties Road	40	33
R5	196 Beatties Road	35	28
R6	53 Upper Sefton Road	36	30
R7	126 Beatties Road	36	30
R8	52 Upper Sefton Road	32	26
R9	190 Beatties Road	32	27
R10	92 Beatties Road	35	29

6.0 ASSESSMENT OF SOLAR GENERATION NOISE

The highest noise levels presented above both comply with the ODP day and night-time noise limits of 50 and 40 dB L_{A10}, respectively. The reduced load noise levels also achieve the 40 dB L_{A10} ODP night-time limit with an appreciable margin.

While we had identified the potential to exceed the noise limits if maximum load noise levels occurred before 0900 hrs on Sundays or public holidays (refer Table 7), our calculations confirm that compliance is expected to be achieved, albeit only marginally.

Calculated noise emissions from the solar farm are relatively low overall in the context of the national and international guidelines for environmental noise levels that are typically applied within New Zealand. This is a positive indication that adverse noise effects are unlikely to arise.

In terms of the existing environment, the calculated levels of up to 40 dB L_{A10} are broadly consistent with the measured background noise levels in the area. This level is just below the measured background noise level of 41 dB L_{A90} (see Table 2). Noting that a 5 dB SAC correction has been applied to the inverters, it is only the potential tonal nature of the sound that may cause the solar farm noise to be readily identifiable over background sounds at times.

Whether tonality will be experienced at a given receiver is dependent on the distance and intervening topography, as well as prevailing environmental conditions. Given that high power output of the inverters will only be achieved under high solar gain and corresponding temperature lapse conditions, we expect that the occasions where tonal noise will be prominent at receivers will be infrequent.

We note that additional mitigation options could be possible if required, including:

- Fitting the manufacturer's noise attenuating enclosures for the inverters;
- Localised barriers around inverter/transformer areas; and/or
- Fences or bunds around on the site perimeter at the boundary with sensitive receivers.

Our analysis does not suggest that these further mitigation options are necessary, but it is important to note that potential solutions do exist in the unlikely event that complaints were to arise.

7.0 CONSTRUCTION NOISE LEVELS

Although the construction methodology is not known at this stage, in our experience construction of the solar farm is likely to involve:

- The delivery of panels, inverters and other infrastructure, requiring trucks and small cranes;
- Earthworks using trucks, loaders and excavators; and
- Use of a piling rig to drive the support piles into the ground. (In our experience, these will typically be sunk using a short-throw Vermeer-type pile driver. This piling rig "taps" the pile into place. The rig does generate high noise, but only for brief periods when pushing the pile into firmer soils.)

While ODP Rule 31.12.1.13 requires that construction noise be assessed using NZS 6803:1984P *"Measurement and Assessment of Noise from Construction, Maintenance, and Demolition Work"*, we note that this was only issued as a provisional Standard and was superseded by New Zealand Standard NZS 6803:1999 "*Acoustics - Construction Noise"*. The 1999 version represents current best practice (and is referenced in the PDP) and we recommend that any noise limits or monitoring are undertaken in line with this version.

From our experience with similar projects, we assume that the construction period will be between 14 days and 20 weeks – i.e. within the 'typical duration' construction noise limits given in NZS 6803:1999. Providing works occur during daytime hours only (Monday to Saturday), these noise

limits would be 75 dB L_{Aeq} and 90 dB L_{AFmax}. The noise limits apply at the façades of occupied sensitive buildings[3]. Typical sound levels for the most significant equipment likely to be used on the project is listed in Table 9.

Table 9: Activity specific noise levels at 1m from a building façade (without screening)

Item/Activity	Source Level, dB L_{WA}	Noise Level (dB L_{Aeq}) at Distance (m)					Required Setback (m) to meet 75 dB L_{Aeq}
		10	20	30	50	100	
Large Trucks	108	83	77	73	68	60	25
Excavators and other earthmoving plant	106	81	75	71	66	58	20
Impact piling (Vermeer - no mitigation)	123	98	92	88	83	75	90
Impact piling (small or with dolly)	114	89	83	79	74	66	44
Vibro-piling (excavator driving small piles)	106	81	75	71	66	58	20
Bored or screw piles (small rig)	103	78	72	68	63	55	14
Concrete truck & pump	103	78	72	68	63	55	14
Truck idling	91	66	60	56	51	43	4

The dwellings at 47 Upper Sefton Road and 178 Beatties Road are within approximately 50 metres of the closest construction area for solar tables and earthworks (though the closest inverters are much farther away, as per Table 1). Table 9 shows that activities other than piling will achieve the construction noise limits at distances of 30 metres and beyond.

Without mitigation, piling works between 50 and 90 metres of dwellings at 47 Upper Sefton Road and 178 Beatties Road will generate noise levels above 75 dB L_{Aeq}. Consent is therefore required to breach the NZS 6803 noise limits. However, the potential adverse noise effects from piling are relatively low as the rig moves quickly around the site and it is unlikely that noise levels would be above the NZS 6803 guidelines for more than a small number of days. Exceedances of the NZS 6803 noise limits are typically handled through implementation of a construction noise and vibration management plan (CNVMP). For this situation, we recommend the construction noise and vibration management plan address the following matters:

- **Required communication for the two affected dwellings.** Direct contact is recommended between the contractor and the building occupants. We also recommended this communication is extended to any dwellings within 150 metres.
- **Piling at the least sensitive times where practicable.** There is generally flexibility over when specific piles are sunk. Liaising with the residents will allow the periods of highest noise (between 50 and 90 metres from the dwelling) to occur at the least sensitive times (e.g. during their work/ school hours).
- **Required methods for dealing with complaints.**
- **General good noise management measures.**

[3] Note that regardless of the total duration of the construction works, the piling works will occur at any one location for only short period. Based on section c7.2.1 of NZS 6803:1999, the appropriate NZS 6803 noise limit is considered to be 75 dB L_{Aeq}.

We do not expect any significant adverse noise effects to arise from the construction phase if consent is granted and a construction noise and vibration management plan is diligently implemented.

Note that the use of a dolly in the Vermeer (or similar type) piling rig would likely reduce noise emissions appreciably. Alternatively, a shroud may be a practicable option (our previous measurements have shown these to be very effective on drop hammer piling rigs). However, our discussions with piling contractors on previous projects suggest that the tolerances of the Vermeer rig are very tight, making the use of a dolly potentially problematic.

We have been liaising with contractors on similar projects who are investigating the use of shrouds for future piling works – however the practicability of this has not yet been confirmed. We therefore recommend that the CNVMP require the contractor to use a dolly or shroud *if practicable* when within 150 metres of dwellings.

8.0 SUMMARY AND RECOMMENDATIONS

From our assessment we have concluded that noise emissions from the proposed solar farm would be reasonable without any significant additional noise mitigation beyond the base design.

The calculated noise emissions presented in this report are based on the optimal orientation of the inverter units, in accord with our recommendations in Appendix E. We recommend that a final design review is undertaken prior to construction to verify the directivity of the proposed units and to confirm that the most appropriate orientation of the units is being utilised in order to minimise noise emissions to the surrounding area (as far as practicable). We are mindful that small changes can occur as part of the detailed design process but after the resource consent process, so this recommendation is intended to capture any subsequent changes.

Should consent be granted, then the following recommendations may assist to form draft conditions of consent, subject to appropriate review and approval:

1. Once operational, noise emissions from the activity shall meet the following noise limits at the notional boundary of any existing dwellings:
    - 50 dB $L_{Aeq\ (15\ min)}$ from 0700 to 2200 hrs
    - 40 dB $L_{Aeq\ (15\ min)}$ and 70 dB L_{AFmax} from 2200 to 0700 hrs
2. 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".*
3. Noise from construction activities shall, as far as practicable, not exceed the limits recommended in, and shall be measured and assessed in accordance with, NZS 6803:1999 *"Acoustics – Construction Noise".*
4. Prior to the start of construction, an acoustic design review shall be undertaken to confirm:
    a. The noise emissions and expected acoustical directivity of the selected inverter units; and
    b. If the units do exhibit appreciable directivity, then the orientation of each unit is optimised to minimise noise received at the notional boundary of neighbouring dwellings.

APPENDIX A GLOSSARY OF TERMINOLOGY

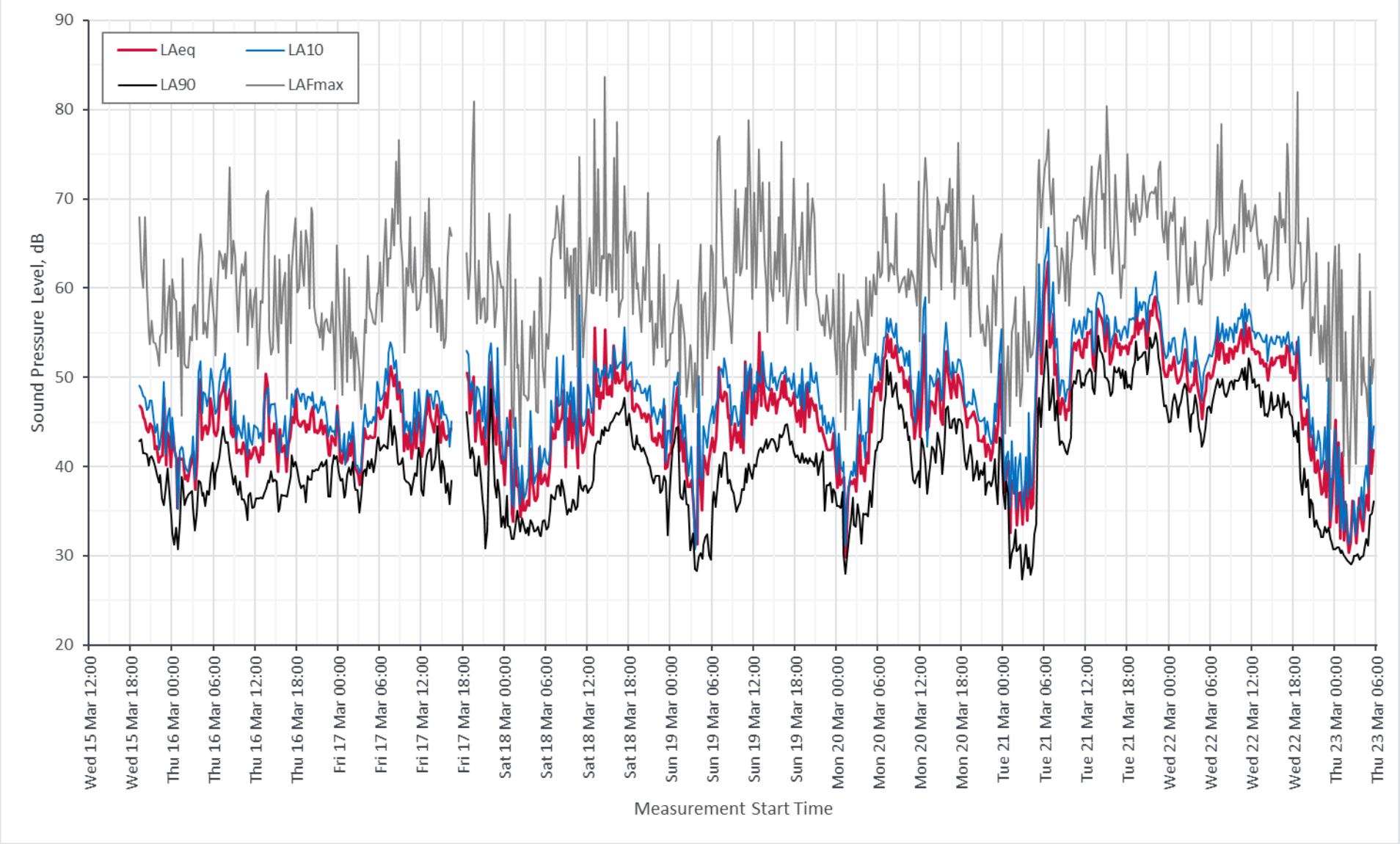
Ambient sound	Or Total Sound. The totally encompassing sound in a given situation at a given time, from all sources near and far, including the specific sound under investigation.
A-weighting	A set of frequency-dependent sound level adjustments that are used to better represent how humans hear sounds. Humans are less sensitive to low and very high frequency sounds. Sound levels using an "A" frequency weighting are expressed as dB L_A. Alternative ways of expressing A-weighted decibels are dBA or dB(A).
Background sound	The sound that is continuously present in a room our outdoor location. Often expressed as the A-weighted sound level exceeded for 90 % of a given time period i.e. L_{A90}.
dB	Decibel. The unit of sound level.
Emission	Sound that is generated by, and propagates away from, a source.
L_{A10}	The A-weighted sound level exceeded for 10% of the measurement period, measured in dB. Commonly referred to as the average maximum noise level.
L_{A90}	The A-weighted sound level exceeded for 90 % of the measurement period, measured in dB. Commonly referred to as the background noise level.
L_{Aeq}	The equivalent continuous A-weighted sound level. Commonly referred to as the average sound level and is measured in dB.
L_P	Sound pressure level. The sound level measured at distance from a source. Distinctly different from sound power level (L_W)
L_W	Sound Power Level. The calculated level of total sound power radiated by a sound source. Usually A-weighted i.e. L_{WA}.
Notional boundary	A line 20 metres from any side of a dwelling, or the legal boundary where this is closer to the dwelling.
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 NOISE SURVEY DETAILS

The key details of the noise survey are as follows:

Date:	15 March 2023, 1200 - 1500 hrs
Personnel:	Stephen Compton, Marshall Day Acoustics
Weather:	Average temperature 20 °C, scattered cloud, 3-5 m/s wind from the east
Instrumentation:	NTi XL2-TA analyser, serial A2A-20483-E0, calibration due 01/04/2024 Brüel & Kjær Type 4231 calibrator, serial 1882775, calibration due 20/02/2024 01dB CUBE Noise Monitoring Terminal, serial 11191, calibration due 29/07/2023
Calibration:	Field calibration of the equipment was carried out before measurements, and the calibration checked after measurements. Observed change less than 0.1 dB.

APPENDIX C MEASURED NOISE DATA



APPENDIX D OPERATIVE WAIMAKARIRI DISTRICT PLAN NOISE STANDARDS

Noise

31.12 Permitted Activities

Any land use is a permitted activity if it:

i. is not otherwise listed as a discretionary activity (restricted) under Rule 31.13, non-complying activity under Rule 31.14 or prohibited activity under Rule 31.15;

ii. complies with the conditions under Rule 31.12.1; and

iii. complies with all the conditions and provisions for permitted activities in this and all other chapters.

31.12.1 Conditions

31.12.1.1 All sound levels shall be measured and assessed in accordance with the provisions of NZS: 6801:1991 "Measurement of Sound" and NZS 6802:1991 "Assessment of Environmental Sound".

For the purposes of this Plan the following additional provisions shall limit application of NZS 6802:1991 (the Standard):

a. Adjustments for special audible characteristics, if present, as provided for in clauses 4.3 and 4.4 of the Standard, shall apply.

b. Where measured noise levels are averaged as provided for in clause 4.5 of the Standard, the L_{10} value shall be determined by an energy average (inverse logarithmic mean) of any four L_{10} measurement sample time intervals on the same day.

c. Measurement time intervals as provided for in clause 5.1 of the Standard shall be limited to 10 to 15 minutes excluding pause and data exclude times.

31.12.1.2 Activities in any zone, other than the Business 3 Zone, shall not exceed the following noise limits within measurement time intervals in the time-frames stated at any point within the notional boundary of any dwellinghouse in the Rural Zone, or at any point within any Residential Zone:

a. Daytime: 7am to 7pm Monday to Saturday, and 9am to 7pm Sundays and Public Holidays: 50dBA L_{10}.

b. Other times: 40dBA L_{10}.

c. Daily 10pm-7am the following day: 70dBA L_{max}.

31.12.1.3 Activities in the Business 3 Zone shall not exceed the following noise limits, within measurement time intervals in the time-frames stated, at any point within the notional boundary of the dwellinghouse located at 126 Beatties Road (GPS 43.264 Latitude South;172.626 Longitude East), or at any point within any Residential Zone:

a. Daytime: 7am to 7pm Monday to Saturday, and 9am to 7pm Sundays and Public Holidays: 55dBA L_{10}.

b. Other times: 45dBA L_{10}.

c. Daily 10pm to 7am the following day: 75dBA L_{max}.

...

Construction Noise

31.12.1.13 Construction noise in any zone shall not exceed the recommended limits specified in, and shall be measured and assessed in accordance with, the provisions of NZS:6803: P1984 "Measurement and Assessment of Noise from Construction, Maintenance, and Demolition Work". Adjustments and exemptions provided in clause 6 of NZS:6803: P1984 shall apply.

APPENDIX E RECOMMENDED INVERTER ORIENTATION

Inverter	Direction
1	South
2	South
3	East
4	South
5	South
6	South
7	North
8	East
9	East
10	South
11	South
12	East
13	East