SURAT GAS PROJECT - GIRRAHWEEN FIELD COMPRESSOR STATION

Operational Noise Assessment

Prepared for:

Arrow Energy Pty Ltd
Level 39, 111 Eagle St
Brisbane QLD 4001

SLR Ref: 620.12448.01600-R02
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PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 16, 175 Eagle Street
Brisbane QLD 4000 Australia
T: +61 7 3858 4800
E: brisbane@slrconsulting.com   www.slrconsulting.com

BASIS OF REPORT

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.12448.01600-R02-v1.0	22 June 2023	Logan Le Petit	Glyn Cowie	Glyn Cowie

EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Arrow Energy (Arrow) to undertake a noise assessment of the Girrahween Field Compressor Station (FCS), which is located approximately 18 km north of Miles, Queensland.

The Girrahween FCS will facilitate the compression of low-pressure coal seam gas (CSG) and deliver medium-pressurised gas downstream to the gas sales delivery point. The facility consists of the following main processes:

- Screw compressors (up to six) which compress low-pressure coal seam gas (CSG),
- A hybrid-ready power plant consisting of:
  - Thermal generation through CSG fired internal combustion engines (7 x 3.36 MW with one generator as sparing capacity),
  - Battery energy storage system (BESS), and
  - Capacity to install solar farm to supplement power.
- The hybrid power plant provides electrical power to the facility mainly used to power the compressors.
- Multi-point ground flare (MPGF, to manage distressed gas),
- Slug catcher (to remove water in gas line; and
- Filter coalescers (to remove solids and liquids in gas line).

The Girrahween FCS incorporates several noise abatement technologies to reduce noise emissions including:

- FCS Compressors:
  - Compressor enclosures with acoustic lining to minimise noise emissions.
- FCS Engines:
  - Engine enclosures to minimise noise emissions,
  - Acoustically treated louvres on air intakes, and
  - Exhaust silencers.
- Flare noise:
  - The use of a MPGF with a radiation fence has been selected over an elevated flare or sonic tip ground flare due to the reduced noise levels (when noise level output is compared) and therefore, minimising the potential for flare noise impact.

This noise assessment assesses the residual noise impact after the noise abatement techniques have been applied to avoid the potential for noise impact.

The Girrahween FCS has been assessed for the following operating scenarios:

- Scenario 1 – Normal Operation
  - Six (6) Howden 510 screw compressors running at 2,000 RPM with coolers, and
  - Seven (7) operating CSG fired power station (internal combustion engines) and one (1) spare 3.36 MW Jenbacher units with BESS.

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- Scenario 2 – Flaring
  - MPGF to occur under four (4) separate flare flow rates being 130 MMscfd, 97.5 MMscfd, 65 MMscfd and 32.5 MMscfd.

Scenario 1 is typical of 24 hours 7 days operation and is considered normal operation which is likely to be constant and potentially audible during any period of the day.

Scenario 2 assesses flaring which occurs when a compressor trips or downstream capacity is restricted such that the gas being delivered to the facility (Girrahween FCS) exceeds the delivery capacity. In these situations, gas must be flared until the well field can be turned down or compression/delivery capacity is restored. Flaring of gas occurs on rare occasions and is minimised to as low as reasonably practical (ALARP) through Arrow's advanced gas management. The occurrence of flaring events are not scheduled (ie not limited to daytime only). Flaring during scheduled events, such as annual maintenance activities can be scheduled to occur during the day and gas flow is minimised to reduce gas loss (maximum flare rates do not occur on a scheduled basis).

A range of flare flow rates has been assessed, representing typical ranges for flaring events that may be experienced at the facility. Arrow has provided the following additional information regarding the facilities flaring flows rates:

- For approximately 88% of the time over an hourly period, no flaring is expected to occur (ie no flare noise from the facility).
- 95% of flaring events are predicted to be less than 32.5 MMscfd (or 9.5% of the time during an hourly period).
- Flaring events greater than 32.5 MMscfd are expected to occur approximately 2% of the time over an hourly period (<1% at night-time).

Flare flow rates between 65 MMscfd and 130 MMscfd have been used to assess the worst-case noise potential during the rare occurrence of maximum flare flow rate that may be experienced at the Girrahween FCS. The assessment has considered the potential for a worst-case scenario where flaring occurs for a minimum 15-minute duration during any assessable period (day, evening and night). This is considered a conservative approach and should be considered along with the expected frequency of each flaring event.

The Girrahween FCS operational noise assessment identified the following:

- The proposed Girrahween FCS development is expected to meet all nominated noise criteria outlined in **Section 2.3** when operating under 'normal operations' (Scenario 1) for both assessed weather conditions.
- Predicted noise levels considering flaring noise from the MPGF in conjunction with other operating plant found the following:
  - Compliance at all sensitive receptors was achieved for all flare flow rates under neutral weather conditions.
  - Compliance at all sensitive receptors was achieved for all flare rates up to 65 MMscfd and under for all weather conditions. This represents 95% of expected flaring events that would potentially occur at the Girrahween FCS.

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- At a flare flow rate of 97.5 MMscfd and above, marginal exceedance of the night-time noise limit of 28 dBA during adverse weather may occur at up to four (4) receptors. Noting, the worst case being up to two receptors too potentially exceed at the same time, GFCS-2 and GFCS-4 due to similar locality. All other receptors would be isolated occurrences.

The noise assessment included a minimum 'flat' overall 8.7 dB noise reduction to account for potential noise insertion loss from the flare radiation fence. Any change to the derived 8.7 dB noise reduction from the fence would see the predicted noise levels increase at the receptor for the flaring scenario (2) by an equal amount (1 dB reduction to the fences acoustic performance would equal a 1 dB increase to noise level predictions). It is also possible that the noise reduction due to the flare radiation fence is under-predicted in this assessment. If the noise reduction in the flare fence is greater than 8.7 dB, lower noise levels at the sensitive receptors would be expected for each flaring event.

The current Environmental Authority for the Girrahween FCS location is EA0001399. Schedule C of EA0001399 contains conditions that are designed to protect the acoustic environment. This noise assessment demonstrates that the Girrahween FCS can operate in compliance within the existing noise conditions within EA0001399.

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Arrow Energy (Arrow) to undertake a noise assessment of the Girrahween Field Compressor Station (FCS), which is located approximately 18 km north of Miles, Queensland.

1.1 Background

The Girrahween FCS will facilitate the compression of low-pressure coal seam gas (CSG) and deliver medium-pressurised gas downstream to the gas sales delivery point. The facility consists of the following main processes:

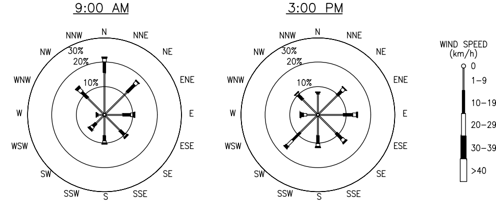
- Screw compressors (up to six) which compress low-pressure coal seam gas (CSG),
- A hybrid-ready power plant consisting of:
    - Thermal generation through CSG fired internal combustion engines (7 x 3.36 MW with one generator as sparing capacity),
    - Battery energy storage system (BESS), and
    - Capacity to install solar farm to supplement power.
- The hybrid power plant provides electrical power to the facility mainly used to power the compressors.
- Multi-point ground flare (MPGF, to manage distressed gas),
- Slug catcher (to remove water in gas line; and
- Filter coalescers (to remove solids and liquids in gas line).

The proposed Girrahween FCS layout is shown in **Figure 1**.

1.2 Objectives of this Assessment

The objective of this noise impact assessment is to assess the potential for noise impact from the operation of the Girrahween FCS.

Construction noise and vibration and gas field operational noise is covered in Arrow's noise and vibration management plan, document reference ORG-ARW-HSM-PLA-00043. This management plan includes Arrow's management framework that will be used to manage noise impacts for the Girrahween FCS development. Therefore, construction noise and vibration is not covered in this assessment and reference should be made to the Arrow document ORG-ARW-HSM-PLA-00043 for construction noise and vibration management.



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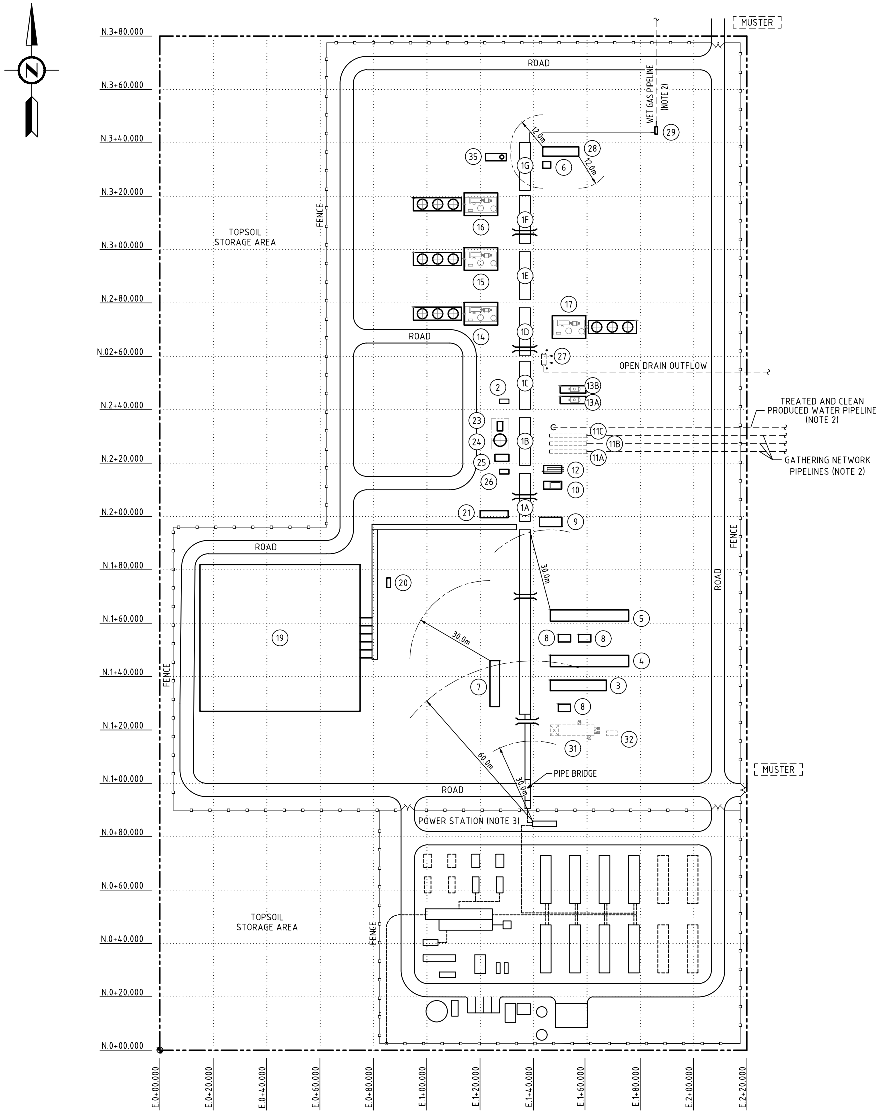
LOCATION PLAN
N.T.S.



EQUIPMENT LIST

ITEM	DESCRIPTION	SIZE (mm) (LxWxH)	PACKAGE TAG
1	PIPERACK MODULE (A-G)	18000 x 4000	-
2	LUBE OIL INJECTION PACKAGE	3500 x 1750	00-A-0011
3	BOP SWITCHROOM	21000 x 4000	-
4	COMPRESSION SWITCHROOM	29400x 4250	-
5	COMPRESSION SWITCHROOM	29400x 4250	-
6	GAS ANALYZER SKID	3048 x 2438	50-A-0002
7	HV SWITCHROOM	15000 x 3800	-
8	DISTRIBUTION TRANSFORMERS	3500 x 1750	-
9	AIR COMPRESSOR PACKAGE	8400 x 3500	40-A-0001
10	PRODUCED WATER TRANSFER AND PUMP PACKAGE	-	00-A-0004
11A/B	SLUG CATCHER #1 AND #2	-	SP-25-0001/0002
11C	SLUG CATCHER #3 (FUTURE TIE-IN)	-	SP-25-0003
12	SLUG CATCHER DRAIN SKID PACKAGE	6777 x 2929	99-A-0001
13A/B	INLET FILTER SEPARATOR PACKAGE #1 & #2	-	00-A-0001/0002
14	MAIN COMPRESSOR PACKAGE #1	-	01-A-0001
15	MAIN COMPRESSOR PACKAGE #2	-	02-A-0001
16	MAIN COMPRESSOR PACKAGE #3	-	03-A-0001
17	MAIN COMPRESSOR PACKAGE #4	-	04-A-0001
18	-	-	-
19	GROUND FLARE PACKAGE	60000 x 55000	12-A-0002
20	FLARE CONTROL SKID	3600 x 1375	-
21	FLARE KNOCKOUT DRUM PACKAGE	10500 x 2625	12-A-0001
22	-	-	-
23	TREATED WATER EXPORT PUMP	-	00-P-0002A/B
24	TREATED WATER TANK	Φ3573 x 2722	0-T-0006
25	OIL SEPARATION UNIT	5250 x 2625	00-A-0005
26	WASTE OIL TANK	4920 x 2220 x 1601	00-T-0007
27	OPEN DRAIN SUMP (PURACEPTOR)	Φ1800 x 5900L	00-T-0002
28	SALES GAS METERING PACKAGE	13500 x 3500	50-A-0001
29	PIG LAUNCHER	-	-
30	LUBE OIL COALESCER PACKAGE	7810 x 2700	00-A-0003
31	ESSENTIAL DIESEL GENERATOR (FUTURE)	-	-
32	DIESEL STORAGE TANK (FUTURE)	-	-
33	-	-	-
34	-	-	-
35	-	-	-

NOTES:

1. NORTHING AND EASTING COORDINATES ARE REFERENCED IN RELATION TO THE LOCAL FIELD COMPRESSOR STATION GRID SYSTEM. CONVERSION FROM THE LOCAL FIELD COMPRESSOR STATION GRID SYSTEM TO TRUE COORDINATES SHALL BE CONFIRMED BY SITE SURVEY PRIOR TO DETAILED ENGINEERING.
2. EXPORT GAS PIPELINE, TREATED AND CLEAN PRODUCED WATER PIPELINE AND GATHERING NETWORK PIPELINE ALIGNMENT. PRELIMINARY ROUTING SHOWN FOR INFORMATION ONLY.
3. POWER STATION DESIGN BY OTHERS. SEE DRAWING# S00B01-ARW-CIV-LAY-00001.

EQUINOX PROJECT No. 910-00-08

REFERENCE DRAWING NUMBER	REFERENCE DRAWING TITLE	REV	DATE	REVISION DESCRIPTION	ORIG	CHK	QA	APP
-	-	A	06/10/22	ISSUED FOR REVIEW	RJM			

RPEQ CERTIFICATION
Signature
Name: BRAHAM SINGH
RPEQ No.: 15622
Date: 23.08.22

EQUINOX Australia — arrow energy go further

SITE	PLANT	PROJECT CODE
S00	N01	A275

SECURITY CLASSIFICATION: RESTRICTED

GIRRAHWEEN
SURAT GAS PROJECT
FIELD COMPRESSION STATION
PLOT PLAN

STATUS: IFR
CONTRACTOR DRAWING NUMBER: -
ARROW ENERGY DRAWING NUMBER: S00N01-ARW-CIV-LAY-00001
SCALE: 1:1000
REV: A
SIZE: A1

2 Regulatory Framework

The following section outlines the regulatory framework in which the Girrahween FCS noise assessment has been performed.

2.1 Queensland Noise Regulations

The Environmental Protection (Noise) Policy 2019 (EPP (Noise)) is subordinate legislation under the Queensland Environmental Protection (EP) Act and the environmental values to be enhanced or protected under the EPP(Noise) are:

- The qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems.
- The qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following: sleep, study or learn or be involved in recreation, including relaxation and conversation.
- The qualities of the acoustic environment which are conducive to protecting the amenity of the community.

The EPP(Noise) contains Acoustic Quality Objectives (AQO) for receptors potentially sensitive to noise. Where the overall level of noise at the receptors, from all sources but excluding road and rail transport noise, are within the AQO, the environmental values are considered to be achieved.

The AQO for the noise sensitive receptors and land use surrounding the Project are presented in **Table 1**. Project operations require continuous operation of plant as such this Assessment has referenced the 1-hour L_{Aeq} and L_{A1} AQO to assess the noise emissions from Project noise sources.

Table 1 EPP(Noise) Acoustic Quality Objectives

Receptor Type	Time of Day	Acoustic Quality Objective (dBA)		
		$L_{Aeq,adj,1hr}$	$L_{A10adj,1hr}$	$L_{A1,adj,1hr}$
Residential dwelling (outdoors)	Day time and evening	50	55	65
Residential dwelling (indoors)	Daytime and evening	35	40	45
	Night-time	30	35	40

To assess noise levels to the internal (indoor) AQO at residential dwellings, the external noise levels predicted by the noise modelling are adjusted by a façade correction which accounts for the reduction of noise achieved by the building (with windows open). In this Assessment, a conservative 7 dB façade noise reduction has been applied in line with the DES guideline titled '*Noise and Vibration EIS Information Guideline*', where, at page 3, it states:

> *When assessing outdoor to indoor noise attenuation at sensitive receptors … use an outdoor to indoor attenuation value of 7dB, which is appropriate for typical Queensland buildings with open windows.*

Accordingly, internal residential noise levels would be expected to be within the indoor AQO where external noise levels are not more than:

- $L_{Aeq,adj,1hr}$ 42 dB during the daytime and evening.

- $L_{Aeq,adj,1hr}$ 37 dB during the night-time.
- $L_{A1,adj,1hr}$ 52 dB during the daytime and evening.
- $L_{A1,adj,1hr}$ 47 dB during the night-time.

2.2 DES Guideline - Prescribing Noise Conditions for Petroleum and Gas Activities

The Queensland Departments of Environment and Science (DES) has published a noise assessment guideline entitled *Prescribing noise conditions for environmental authorities for petroleum activities* (DES, 2016), which is intended to assist in the assessment of noise impacts and the development of noise conditions for petroleum activities within the general framework provided by the EP Act.

This guideline addresses noise management and includes best practice noise emission limits for CSG activities.

2.2.1 Background Noise Levels

In accordance with the noise assessment guideline (DES 2016), there are deemed backgrounds to be used in the determination of noise limits in rural areas where background noise levels can be very low. The intent of the deemed background noise levels are to achieve a balance between economic development and environmental protection required by the EP Act. The deemed background noise levels are presented in **Table 2**.

Table 2 Deemed Background Noise Levels

Time Period	Deemed Background Noise Level (dBA)
7:00 am – 6:00 pm (day)	35
6:00 pm – 10:00 pm (evening)	30
10:00 pm – 6:00 am (night)	25
6:00 am – 7:00 am (morning)	30

Note 1: Referenced from *Table 2 – Deemed background noise levels, page 8 (DES 2016).*

2.2.2 Noise Limits

The guideline noise limits are designed to protect the acoustic values of a sensitive receptor in rural or isolated areas and to satisfy the acoustic quality objectives of the EPP (Noise) whilst considering cumulative impacts and background creep.

Best practice measured noise emission limits for long term noise exposure applicable to the Surat Basin from the guideline (DES, 2016) for each of the specified daily time periods are provided in **Table 3**. These noise limits closely align with the 'Streamlined Conditions' contained within the DES *Streamlined Model Conditions for Petroleum Activities* (DES, 2016), effective 5 May 2016 (hereafter referred to as SMC).

Table 3 Best Practice Measured Outdoor Noise Emission Limits (DES, 2016)

Time Period	Time of Day	Metric	Long Term Noise Limit, dBA [1]
7:00 am – 6:00 pm	Daytime	$L_{Aeq, adj, 15 minutes}$	40 (L_{ABG} + 5)
6:00 pm – 10:00 pm	Evening	$L_{Aeq, adj, 15 minutes}$	35 (L_{ABG} + 5)
10:00 pm – 6:00 am	Night-time	$L_{Aeq, adj, 15 minutes}$	28 (L_{ABG} + 3)
		Max $L_{pA, 15 minutes}$	55
6:00 am – 7:00 am	Morning	$L_{Aeq, adj, 15 minutes}$	35 (L_{ABG} + 5)

Note 1: L_{ABG} is the deemed background noise levels which are:
7:00 am – 6:00 pm: 35 dBA
6:00 pm – 10:00 pm: 30 dBA
10:00 pm – 6:00 am: 25 dBA
6:00 am – 7:00 am: 30 dBA

The night period is considered the most critical daily period in respect to noise compliance. Compliance with the long-term night noise limit for operating plant and equipment will ensure compliance with the noise limit for all other daily periods.

2.2.3 Low Frequency Noise

The SMC contains the following emission limits for low frequency noise, which are relevant to the Project:

- 60 dBC measured outside the sensitive receptor; and
- The difference between the external A-weighted and C-weighted noise levels is no greater than 20 dB.

2.3 Summary of Project Noise Conditions

The current Environmental Authority for the Girrahween FCS location is EA0001399. Schedule C of EA0001399 contains conditions that are designed to protect the acoustic environment. The Schedule C noise conditions for EA000139 are as follows:

Noise 1)

*Notwithstanding condition (General 21), emission of noise from the petroleum activity(ies) at levels less than those specified in **Table 4** are not considered to be environmental nuisance.*

Table 4 Adopted Noise Nuisance Limits (DES, 2016)

Time Period	Time of Day	Metric	Long Term Noise Limit, dBA [1, 3]
6:00 am – 7:00 am	Morning	$L_{Aeq, adj, 15 minutes}$	35 (L_{ABG} + 5)
7:00 am – 6:00 pm	Daytime	$L_{Aeq, adj, 15 minutes}$	40 (L_{ABG} + 5)
6:00 pm – 10:00 pm	Evening	$L_{Aeq, adj, 15 minutes}$	35 (L_{ABG} + 5)
10:00 pm – 6:00 am	Night-time	$L_{Aeq, adj, 15 minutes}$	28 (L_{ABG} + 3)
		Max $L_{pA, 15 minutes}$	55
Drilling activities undertaken from 10:00 pm – 7:00 am [2]		$L_{Aeq, adj, 15 minutes}$	28 (measured indoors) 33 (measured outdoors)

Note 1: L_{ABG} is the deemed background noise levels which are:
6:00 am – 7:00 am: 30 dBA
7:00 am – 6:00 pm: 35 dBA
6:00 pm – 10:00 pm: 30 dBA
10:00 pm – 6:00 am: 25 dBA

Note 2: Drilling activities (e.g. drilling, workover, completion activities) undertaken from 10:00 pm to 7:00 am must be temporary and mobile in nature and must not contribute to long-term background noise creep.

Note 3: EPPG00972513 also includes noise limits for short and medium term events for morning, daytime and evening time periods. As these limits are not critical for this noise assessment, these noise limits are not repeated here.

Noise 2)

*If the noise subject to a valid complaint is tonal or impulsive, the adjustments detailed in **Table 5** are to be added to the measured noise level(s) to derive LAeq, adj, 15 min.*

Table 5 Noise Adjustments to be Considered at a Sensitive Receptor

Noise characteristic	Adjustment to noise
Tonal characteristic is just audible	+ 2 dBA
Tonal characteristic is clearly audible	+ 5 dBA
Impulsive characteristic is detectable	+ 2 to + 5 dBA

Noise 3)

Notwithstanding condition (Noise 1), emission of any low frequency noise must not exceed either (Noise 3(a)) and (Noise 3(b)), or (Noise (c)) and (Noise 3(d)) in the event of a valid complaint about low frequency noise being made to the administering authority.

(a) 60 dB(C) measured outside the sensitive receptor, and

(b) The difference between the external A-weighted and C-weighted noise levels is no greater than 20 dBA; or

(c) 50 dB(Z) measured inside the sensitive receptor; and

(d) The difference between the internal A-weighted and Z-weighted (Max $L_{pZ,}$ 15 min) noise levels is no greater than 15 dB.

This noise assessment assesses the FCS operation against the existing noise conditions in EPPG00972513.

Reference to the EPP (Noise) AQO is provided for the purpose of comparison to other noise legislation in Queensland.

3 Site Description

3.1 Site Location

Girrahween FCS is located in the Surat Basin approximately 18 km north of Miles in the Darling Downs region of Queensland in predominantly rural land.

Areas where Arrow has tenure are predominantly rural and industrial with land uses such as grazing, pre-existing gas field development and overlapping mining tenure. Existing road infrastructure typically includes a number of rural secondary roads linking the major regional road network as well as numerous CSG field access roads and mining activities.

3.2 Sensitive Receptors

The DES guideline, *Streamlined Model Conditions for Petroleum Activities (DES, 2016)* defines sensitive receptors as follows:

> *A sensitive place could include but is not limited to:*
>
> - *A dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises;*
> - *A motel, hotel or hostel;*
> - *A kindergarten, school, university or other educational institution;*
> - *A medical centre or hospital;*
> - *A protected area under the Nature Conservation Act 1992, the Marine Parks Act 2004 or a World Heritage Area;*
> - *A public park or garden; and*
> - *A place used as a workplace including an office for business or commercial purposes.*

Information on sensitive receptors located in and around the Project was provided by Arrow. Those receptors identified as being located within 9 km of the Girrahween FCS are listed in **Table 6** and shown in **Figure 2**.

Table 6 Identified Receptors – Girrahween FCS (GFCS)

Receptor ID	Coordinates (GDA 94 zone 56)		Receptor ID	Coordinates (GDA 94 zone 56)	
	Easting	Northing		Easting	Northing
GFCS-1	222,680	7,068,507	GFCS-10	218,243	7,067,196
GFCS-2	220,766	7,064,862	GFCS-11	218,247	7,064,078
GFCS-3	220,144	7,067,178	GFCS-12	228,263	7,064,589
GFCS-4	220,272	7,064,803	GFCS-13	228,626	7,065,108
GFCS-5	220,584	7,063,619	GFCS-14	226,966	7,061,991
GFCS-6	220,381	7,063,139	GFCS-15	227,791	7,062,623
GFCS-7	219,152	7,064,353	GFCS-16	220,018	7,061,057
GFCS-8	220,013	7,062,935	GFCS-17	227,278	7,061,081
GFCS-9	218,668	7,068,376	GFCS-18	217,814	7,072,105

3.3 Existing Noise Environment

Girrahween FCS site and surroundings is predominantly rural with land uses such as grazing and pre-existing gas field development. Existing infrastructure typically includes a number of rural secondary roads linking the major regional road network as well as numerous CSG field access roads. Existing noise sources are generally typical of rural roads and include fauna (birds and insects), traffic and local sources associated with mining activity and rural based human occupation.

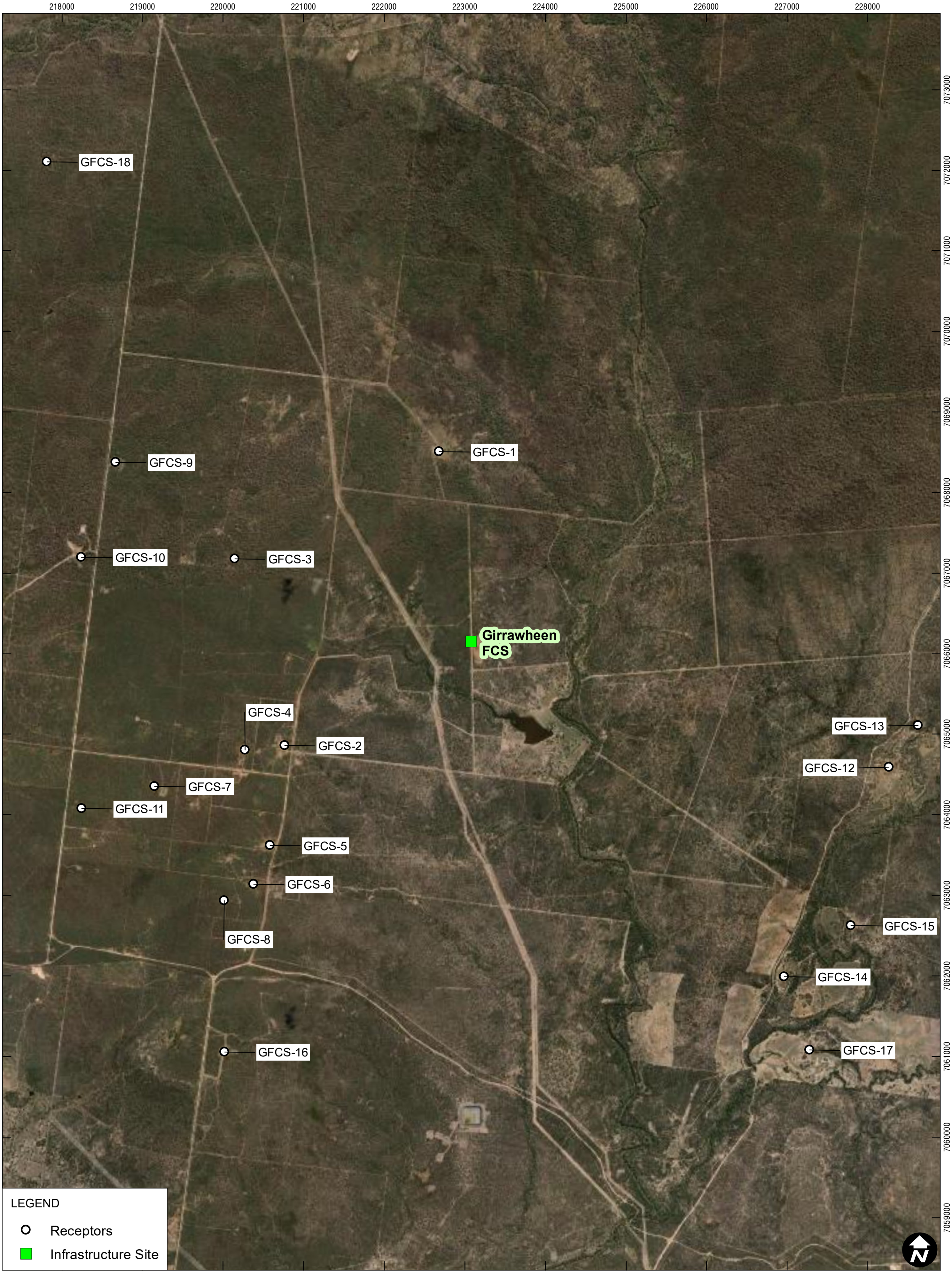
3.4 Deemed Minimum Background Noise Levels

The deemed minimum background noise levels as stated in 2016 *Streamlined Model Condition* (see **Section 2.2** for further details) have been applied for the basis of this assessment and are reproduced in **Table 2**.

Based on SLRs experience in conducting background noise measurements in Queensland’s CSG fields, measured background noise levels at noise sensitive receptors are routinely equal to or lower than the deemed background noise levels. This is generally due to ‘natural’ noise sources (ie bird song, wind and wind generated vegetation noise, seasonal insects) controlling the sound scape. During the most sensitive night-time periods, these ‘natural’ sources are often either infrequently measured or are not present for periods of time, therefore the background noise level is routinely below the deemed minimum background noise level of 25 dBA LA90.

Even where ‘introduced’ noise sources are present (ie those sources discussed in **Section 0** above), their contribution tends to be influenced by meteorological conditions. That is, there are periods of time where these sources can contribute to or dominate the measured background noise level (and potentially elevate it above the deemed minimum noise levels), however the opposite can also occur where meteorological conditions are such that these sources are either inaudible/unmeasurable or they do not significantly contribute to the measured background noise level.

For this assessment, the deemed minimum background noise levels are considered applicable given the rural nature that the Girrahween FCS area is located within and the expected low background noise levels within this area.



0 0.5 1 km

Scale: 1:60,000 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 18-May-2023
Project Number: 620.12248.01600

SLR

Data Source:
ESRI basemap world imagery (May 2023)

Arrow Energy –
Girrawheen FCS and Receptor Location

FIGURE 2

H:\Projects-SLR\620-BNE\620-BNE\620.12248 Arrow Energy - Project Pearl\06 SLR Data\01 CADGIS\ArcGIS\62012248_F02 Girrawheen FCS and Receptor Location.mxd

4 Girrahween FCS Operational Noise Assessment

4.1 Assessed Operational Scenarios

The Girrahween FCS has been assessed for the following operating scenarios:

- Scenario 1 – Normal Operation
  - Six (6) Howden 510 screw compressors running at 2,000 RPM with coolers, and
  - Seven (7) operating CSG fired power station (internal combustion engines) and one (1) spare 3.36 MW Jenbacher units with BESS.
- Scenario 2 – Flaring
  - MPGF to occur under four (4) separate flare flow rates being 130 MMscfd, 97.5 MMscfd, 65 MMscfd and 32.5 MMscfd.

Scenario 1 is typical of 24 hours 7 days operation and is considered normal operation which is likely to be constant and potentially audible during any period of the day.

Scenario 2 assesses flaring which occurs when a compressor trips or downstream capacity is restricted such that the gas being delivered to the facility (Girrahween FCS) exceeds the delivery capacity. In these situations, gas must be flared until the well field can be turned down or compression/delivery capacity is restored. Flaring of gas occurs on rare occasions and is minimised to as low as reasonably practical (ALARP) through Arrow's advanced gas management. The occurrence of flaring events are not scheduled (ie not limited to daytime only). Flaring during scheduled events, such as annual maintenance activities can be scheduled to occur during the day and gas flow is minimised to reduce gas loss (maximum flare rates do not occur on a scheduled basis).

A range of flare flow rates has been assessed, representing typical ranges for flaring events that may be experienced at the facility. Arrow has provided the following additional information regarding the facilities flaring flows rates:

- For approximately 88% of the time over an hourly period, no flaring is expected to occur (ie no flare noise from the facility).
- 95% of flaring events are predicted to be less than 32.5 MMscfd (or 9.5% of the time during an hourly period).
- Flaring events greater than 32.5 MMscfd are expected to occur approximately 2% of the time over an hourly period (<1% at night-time).

Flare flow rates between 65 MMscfd and 130 MMscfd have been used to assess the worst-case noise potential during the rare occurrence of maximum flare flow rate that may be experienced at the Girrahween FCS. The assessment has considered the potential for a worst-case scenario where flaring occurs for a minimum 15-minute duration during any assessable period (day, evening and night). This is considered a conservative approach and should be considered along with the expected frequency of each flaring event.

The Girrahween FCS incorporates several noise abatement technologies to reduce noise emissions including:

- FCS Compressors:
  - Compressor enclosures with acoustic lining to minimise noise emissions.

- FCS Engines:
    - Engine enclosures to minimise noise emissions,
    - Acoustically treated louvres on air intakes, and
    - Exhaust silencers.
- Flare noise:
    - The use of a MPGF with a radiation fence has been selected over an elevated flare or sonic tip ground flare due to the reduced noise levels (when noise level output is compared) and therefore, minimising the potential for flare noise impact.

This noise assessment assesses the residual noise impact after the noise abatement techniques have been applied to avoid the potential for noise impact.

4.2 Noise Modelling

4.2.1 Noise Modelling Methodology

In order to predict noise emission levels for the Girrahween FCS, a SoundPLAN (Version 8.2) environmental computer model was used. SoundPLAN is a software package which enables compilation of a sophisticated computer model comprising a digitised ground map (containing ground contours and buildings), the location and acoustic SWL of the noise sources, namely Howden 510 screw compressors with coolers, CSG fired power station (internal combustion engines) and MPGF on site and the location of receivers for assessment purposes.

The computer model can generate noise emission levels taking into account such factors as the source sound power levels and locations, distance attenuation, ground absorption, air absorption and shielding attenuation, as well as meteorological conditions, including wind effects.

For this assessment, 3D terrain data, Girrahween FCS and sensitive receptor locations were incorporated into the noise model to predict noise emissions at nearby noise sensitive receptors.

All noise sources were modelled in a central position (containing all acoustic energy) with noise levels predicted to determine if compliance with the noise limit stated in **Section 2.3** is achieved. The terrain is considered mostly ‘flat’ and predominately of grass, thus, the noise model has incorporated ‘soft’ ground absorption factor of 1.0, which is typical for Arrow noise assessments.

4.2.2 Calculation Method – CONCAWE

The CONCAWE prediction methodology was utilised within SoundPLAN. The CONCAWE prediction method is specially designed for large facilities and incorporates the influence of wind effects and the stability of the atmosphere. The statistical accuracy of environmental noise predictions using CONCAWE was investigated by Marsh (Applied Acoustics 15 - 1982). Marsh concluded that CONCAWE was accurate to ±2 dBA in any one octave band between 63 Hz and 4 kHz and ± 1 dBA overall.

4.3 Assessed Meteorological Conditions

For this assessment, consideration was given to the effects of both neutral and adverse meteorological conditions (wind, temperature, humidity and temperature inversions) on noise propagation during Girrahween FCS operations. These neutral and adverse meteorological conditions are consistent with historical Arrow noise assessments and outlined in **Table 7**.

Table 7 Modelled Meteorological Conditions – Neutral and Adverse

Weather Parameter	Neutral Condition	Adverse Condition
Temperature	19°C	13°C
Humidity	60%	86%
Pasquil Gifford Turner Stability Class	D	F
Wind Speed	0 m/s	2 m/s (source to receptor)

4.4 Modelled Plant Sound Power Levels

Modelled plant sound power levels (SWLs) for the Girrahween FCS were provided by Arrow and are outlined in **Table 8.**

Table 8 Operating Unit Maximum Plant SWLs

Plant Items	Source Height above Ground	Sound Power Level, LAeq dBA									Overall SWL dBA
		Octave Band Centre Frequency (Hz)									
		31.5	63	125	250	500	1k	2k	4k	8k	
Generator Engine Exhaust (Silenced)	2.0 m	38	58	72	63	66	73	79	80	68	**84**
Power Generator Unit (mitigated)	2.0 m	35	48	61	70	79	82	82	77	67	**87**
Mitigated Howden Screw Compressor Unit (fitted with acoustic panels)	2.0 m	71	76	84	101	99	95	92	87	78	**104**
Screw Compressor Coolers	1.5 m	73	87	96	100	101	101	95	91	83	**107**
Multi-Point Flaring 130 MMscfd	5.0 m	94	111	120	126	128	129	127	120	119	**134**
Multi-Point Flaring 97.5 MMscfd		90	107	116	122	124	125	123	116	115	**130**
Multi-Point Flaring 65 MMscfd		86	103	112	118	120	121	119	112	111	**126**
Multi-Point Flaring 32.5 MMscfd		84	101	110	116	118	119	117	110	109	**124**

The number of sources modelled for each scenario are shown in **Table 9.**

Table 9 Quantity of Noise Sources Modelled for Each Scenario

Plant Items	Number of Plant at Girrahween FCS				
	Scenario 1 – Normal operations	Scenario 2 – Flaring[1]			
		Assessed Flare Flow Rates (MMscfd)			
		32.5	65	97.5	130
Generator Engine Exhaust (Silenced)	7	7	7	3	3
Power Generator Unit (mitigated)	7	7	7	3	3
Mitigated Howden Screw Compressor Unit (fitted with acoustic panels)	6	5	3	2	0
Screw Compressor Coolers	6	5	3	2	0
Multi-Point Ground Flare (for all flaring rates)	0	1	1	1	1

Note 1: Plant items are switched off depending on the flaring event.

4.4.1 Multi-point Ground Flare Radiation Fence

The MPGF is expected to feature a 16.7 m radiation fence surrounding the flare in order to:

- Minimise radiation impacts, and
- Reduce visibility of the flare flame.

A typical MPGF fence is illustrated in **Figure 3.**

Figure 3 Indicative MPGF Fence (Image source: Zeeco)

The SWLs shown in **Table 8** for the MPGF do not include any potential noise reduction provide by the radiation fence. Arrow has provided SLR with a flare noise study report[1] outlining measured MPGF noise data with and without the inclusion of the fence at a separation distance of 50 m from the source.

From this study, SLR has derived an overall 'flat'[2] 8.7 dB noise reduction correction from the measured Sound Pressure Levels (SPL) inside to outside of the radiation fence to determine the insertion loss. Therefore, the noise predictions have included the overall potential noise reduction when assessing the MGPF noise emissions at nearby sensitive receptors. This approach was preferred over constructing a physical barrier in SoundPLAN as the overlapping ventilation openings in the fence would not be possible to simulate in SoundPLAN.

4.5 Noise Assessment Results

4.5.1 Scenario 1 – Normal Operations

The noise model predicted noise emissions at nearby noise sensitive receptors when considering the Girrahween FCS operating under 'normal operations' for both neutral and adverse weather. **Table 10** summarises the predicted noise levels at the surrounding identified noise sensitive receptors.

Table 10 Predicted Noise Level at Receptor – Normal Operations

Receptor ID	Predicted Noise Level at Receptor, L_{Aeq} dBA		Expected to Achieve 28 dBA $L_{Aeq,15min}$ Night-time Noise limits?
	Neutral Weather	Adverse Weather	
GFCS-1	19	26	Yes
GFCS-2	19	26	Yes
GFCS-3	15	22	Yes
GFCS-4	17	24	Yes
GFCS-5	16	23	Yes
GFCS-6	14	21	Yes
GFCS-7	12	18	Yes
GFCS-8	12	19	Yes
GFCS-9	8	15	Yes
GFCS-10	9	15	Yes
GFCS-11	9	15	Yes
GFCS-12	12	19	Yes
GFCS-13	11	18	Yes
GFCS-14	10	17	Yes
GFCS-15	11	17	Yes
GFCS-16	8	14	Yes

[1] GASCO Flare Noise Study report, document reference Q12551A-C01 Rev 0 *Surat Upstream Development, dated* 15 August 2019.
[2] Minimum noise reduction is achieved in all octave frequency bands.

Receptor ID	Predicted Noise Level at Receptor, LAeq dBA		Expected to Achieve 28 dBA LAeq,15min Night-time Noise limits?
	Neutral Weather	Adverse Weather	
GFCS-17	8	15	Yes
GFCS-18	2	7	Yes

Predicted noise levels presented in **Table 10** from Girrahween FCS under 'normal operations' comply with the most stringent night-time noise limit of 28 dBA $L_{Aeq,15min}$ under both neutral and adverse weather conditions. The dominant noise sources were found to be from the Screw Compressors.

4.5.2 Scenario 2 – Flaring

The noise model predicted noise emissions at nearby noise sensitive receptors when considering the Girrahween FCS operating during a flaring event for both neutral and adverse weather. **Table 11** summarises the predicted noise levels at the surrounding identified noise sensitive receptors.

Table 11 Predicted Noise Level at Receptor – Flaring

Receptor ID	Predicted Noise Level at Receptor2, LAeq,15min dBA							
	Considering Different MPGF Flow Rates, MMscfd							
	130 (100%)	97.5 (75%)	65 (50%)	32.5 (25%)	130 (100%)	97.5 (75%)	65 (50%)	32.5 (25%)
	Neutral Weather				Adverse Weather			
GFCS-1	25	21	18	16	**32**	28	25	23
GFCS-2	27	23	19	18	**33**	**30**	26	24
GFCS-3	21	18	14	12	28	24	21	19
GFCS-4	24	20	16	15	**31**	27	23	22
GFCS-5	23	19	16	<15	**30**	26	22	21
GFCS-6	21	17	<15	<15	28	24	20	19
GFCS-7	18	<15	<15	<15	25	21	17	16
GFCS-8	19	15	<15	<15	26	22	18	17
GFCS-9	<15	<15	<15	<15	20	16	<15	<15
GFCS-10	<15	<15	<15	<15	20	17	<15	<15
GFCS-11	<15	<15	<15	<15	21	17	<15	<15
GFCS-12	17	<15	<15	<15	24	20	17	15
GFCS-13	16	<15	<15	<15	23	19	16	<15
GFCS-14	16	<15	<15	<15	23	20	16	15
GFCS-15	16	<15	<15	<15	23	19	16	<15
GFCS-16	<15	<15	<15	<15	20	16	<15	<15

Receptor ID	Predicted Noise Level at Receptor2, $L_{Aeq,15min}$ dBA							
	Considering Different MPGF Flow Rates, MMscfd							
	130 (100%)	97.5 (75%)	65 (50%)	32.5 (25%)	130 (100%)	97.5 (75%)	65 (50%)	32.5 (25%)
	Neutral Weather				Adverse Weather			
GFCS-17	<15	<15	<15	<15	20	16	<15	<15
GFCS-18	<15	<15	<15	<15	<15	<15	<15	<15

Note 1: Exceedance of 28 dBA LAeq,15min Night-time Noise limits are shown in **Bold.**

Note 2: Presented noise predictions include the derived 8.7 dB overall noise reduction to account for the noise screening of the radiation fence.

Predicted noise levels presented in **Table 11** from Girrahween FCS during flaring complies with the most stringent night-time noise limit of 28 dBA $L_{Aeq,15min}$ under neutral weather conditions. The dominant noise sources were found to be from the MGPF.

When assessing under adverse weather conditions compliance is expected to be achieved when flaring occurs up to a flow rate of 65 MMscfd. When considering the expected occurrence of flaring events this implies that 95% of all potential flaring events are predicted to result in noise levels below the proposed noise limits (in particular under adverse weather conditions).

Sensitive receptor GFCS-2 has predicted noise levels 2 dBA over the (most stringent) night-time noise limit of 28 dBA $L_{Aeq,15min}$ during flow rates equal to 97.5 MMscfd. This flaring event is considered to be a rare occurrence, which is predicted to occur less than 1% of the time during an hour period and would be representative of a major sudden outage. All other receptors are considered to comply during flaring at a flow rate of 97.5 MMscfd, noting receptor GFCS-1 has precited noise level equal to the night-time noise limit of 28 dBA $L_{Aeq,15min}$.

When assessed under maximum flare flow rates (130 MMscfd), up to four (4) sensitive receptors, being GFCS-1, GFCS-2, GFCS-4 and GFCS-5 are predicted to potentially exceed the night-time noise limit of 28 dBA $L_{Aeq,15min}$ when considering the maximum flare flow rate to occur during adverse weather conditions at each receptor. The possibility of the maximum flare flow rate event to occur during adverse weather ('source to receiver' wind conditions) could not occur at all receptors at the same time; therefore, predicted exceedances would only occur at the individual dwellings with the worst case being up to two receptors potentially exceeding at the same time, GFCS-2 and GFCS-4 due to similar locality.

All other nominated noise limits and receptor locations are expected to comply.

The noise predictions shown in **Table 11** include the derived overall 8.7 dB (flat) noise reduction correction to account for the proposed radiation fence. Any changes that would reduce the assessed 8.7 dB noise reduction from the fence would see the predicted noise levels increase at the receptor for the flaring scenario by an equal amount (1 dB reduction to the fence acoustic performance would equal a 1 dB increase to noise level predictions). It is also possible that the noise reduction due to the flare radiation fence is under-predicted in this assessment. If the noise reduction in the flare fence is greater than 8.7 dB, lower noise levels at the sensitive receptors would be expected for each flaring event.

4.6 Flare Noise Summary

The proposed MPGF is expected to achieve the nominated noise limits under the following parameters:

- A minimum 8.7 dB (flat) overall noise reduction is achieved by the radiation fence surrounding the MGPF.
- The Girrahween FCS MPGF SWL does not exceed 126 dBA. This would result in achieving the night-time noise limit at all receptors under all weather conditions.

4.7 Low Frequency Noise Assessment

For the purposes of this assessment, the low frequency noise emissions have been analysed to assess for compliance with the nominated 60 dBC (external) low frequency noise limit. This review indicated that noise levels at the identified receptors were well below 55 dBC (external) and are therefore predicted to comply with the 60 dBC (external) low frequency noise limit for all modelling scenarios under all weather conditions.

This assessment incorporated all the sound power spectral information available at the time of modelling for all plant items.

5 Conclusion

SLR was commissioned by Arrow to undertake a noise assessment of the Girrahween FCS development layout, which is proposed to be located approximately 18 km north of Miles, Queensland.

The Girrahween FCS will incorporate several noise abatement technologies to reduce noise emissions including:

- FCS Compressors:
  - Compressor enclosures with acoustic lining to minimise compressor noise.
- FCS Engines
  - Engine enclosures to minimise generator noise.
  - Acoustically treated louvres on air intakes.
  - Exhaust silencers.
- Flare noise
  - The use of a MPGF with a radiation fence has been selected over an elevated flare or sonic tip ground flare due to the reduced noise levels (when compared) and therefore, minimizing the potential for flare noise impact.

This noise assessment assesses the residual noise emissions after the noise abatement techniques have been applied to reduce the potential noise impact onto surrounding receptors.

The Girrahween FCS operational noise assessment identified the following:

- The proposed Girrahween FCS development is expected to meet all nominated noise criteria outlined in **Section 2.3** when operating under ‘normal operations’ (Scenario 1) for both assessed weather conditions.

- Predicted noise levels considering flaring noise from the MPGF in conjunction with other operating plant found the following:
  - Compliance at all sensitive receptors was achieved for all flare flow rates under neutral weather conditions.
  - Compliance at all sensitive receptors was achieved for all flare rates up to 65 MMscfd and under for all weather conditions. This represents 95% of expected flaring events that would potentially occur at the Girrahween FCS.
  - At a flare flow rate of 97.5 MMscfd and above, marginal exceedance of the night-time noise limit of 28 dBA during adverse weather may occur at up to four (4) sensitive receptors. Noting, the worst case being up to two sensitive receptors to potentially exceed at the same time, GFCS-2 and GFCS-4 due to similar locality. All other sensitive receptors would be isolated occurrences.

The noise assessment included a minimum ‘flat’ overall 8.7 dB noise reduction to account for potential noise insertion loss from the radiation fence. Any change to the derived 8.7 dB noise reduction from the fence would see the predicted noise levels increase at the receptor for the flaring scenario (2) by an equal amount (1 dB reduction to the fences acoustic performance would equal a 1 dB increase to noise level predictions). It is also possible that the noise reduction due to the flare radiation fence is under-predicted in this assessment. If the noise reduction in the flare fence is greater than 8.7 dB, lower noise levels at the sensitive receptors would be expected for each flaring event.

This noise assessment demonstrates that the Girrahween FCS can operate in compliance within the existing noise conditions within EA0001399.

Appendix A:
Acoustic Glossary

Explanation of the key technical terminology contained within this Report is provided below.

Sound Level (or Noise Level)

The terms sound and noise are almost interchangeable, except that in common usage noise is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear (and those of other species) responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (dB or dBL) scale reduces this ratio to a more manageable size by the use of logarithms.

A-weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to human hearing.

There are numerous alternative frequency weightings available but none specifically designed for the assessment of noise affecting fauna. For the purposes of this Report, A-weighting has been used.

Sound Power Level

The sound power of a source is the rate at which it emits acoustic energy. As with sound pressure, sound power levels (SWL) are expressed in dB units, but are identified by the symbols SWL.

The relationship between sound power and sound pressure may be likened to an electric radiator, which is characterised by a power rating but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

Change in Sound Pressure Levels

For human perception, a change of 1 dBA or 2 dBA in the level of a sound is considered to be indiscernible, while a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

Typical Sound Pressure Levels

The table below lists examples of typical sound pressure levels.

Table Examples of Typical Sound Pressure Levels

Sound pressure level (dBA)	Typical example	Subjective (human) evaluation
130	Threshold of pain	Intolerable
120	Metal hammering	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 metres (m)	Very noisy
90	Dog bark at 1 m	
80	Cicadas at 1 m	Loud
70	Noise level directly adjacent to a busy main road	

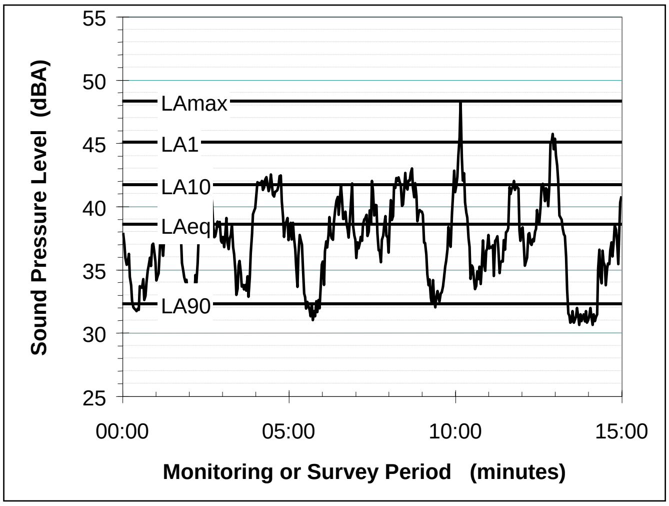
Sound pressure level (dBA)	Typical example	Subjective (human) evaluation
60	Ambient noise level in urban area close to main roads	Moderate to quiet
50	Typical rural environment with high insect noise or close to a main road	
40	Ambient noise level in a rural environment with light breezes and some noise from insects, birds and distant traffic	Quiet to very quiet
30	Ambient noise level in a typical rural noise environment in the absence of insect noise and wind	
20	Ambient noise level in remote and quiet rural environment away from main roads with no wind and no insect noise	Almost silent

Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels (LAN), where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time and LA10 the noise exceeded for 10% of the time.

The Figure below presents a hypothetical 15-minute noise measurement, illustrating various common statistical indices of interest.

Figure Hypothetical 15 Minute Noise Measurement



Of particular relevance to this study, are:

- LAeq The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.
- LAmax The maximum A-weighted noise level during any given measurement period.

Noise Propagation

Provided the receiver is in the far-field of the noise source, noise levels will reduce as a receiver moves further away from the source. This is due to spreading of the noise source energy over distance. For a simple point source (for example, a motor) the theoretical reduction in noise levels is 6 dBA per doubling of distance. For a line source (for example, a busy road) the theoretical reduction is 3 dBA per doubling of distance. In reality however other factors affect noise propagation. These include ground absorption, air absorption, acoustic screening and meteorological effects.

Meteorological Effects

At distances over 500 m, meteorological affects (for example, local weather and atmospheric conditions) can substantially enhance or impair noise propagation. The most influential meteorological conditions on noise propagation are wind speed and direction and the occurrence of temperature inversions. Ambient air temperature and humidity and atmospheric pressure also affect noise propagation although to a lesser extent than wind and temperature inversions.

Wind Conditions

Wind conditions enhance noise propagation when the wind is blowing from a noise source towards a receiver and therefore noise levels at the receiver will be higher under these conditions. The wind can be thought to carry the noise in the direction it is heading. Where winds blow from the receiver towards the source, the propagation of noise is impaired and therefore lower noise levels will be experienced at the receiver.

It is important to consider the effect of prevailing wind conditions when assessing noise propagation over larger distances. Wind roses, which graph long term variations in wind speed and direction, are a useful tool for analysing prevailing wind conditions where available.

Temperature Inversions

Temperature inversions are a meteorological phenomenon where a layer of cold air is trapped at the ground surface under a layer of warmer air. Temperature inversions enhance noise propagation because sound travelling away from the ground is reflected back down from where the colder air meets the warmer air due to the change in pressure between the two layers.

Conditions that favour the development of a strong surface inversion are nights with calm winds and clear skies. Calm winds prevent warmer air above the surface from mixing down to the ground, and clear skies increase the rate of cooling at the Earth's surface. It is therefore important to consider the effect of temperature inversions when assessing noise propagation over larger distances and during night-time periods.

ASIA PACIFIC OFFICES

ADELAIDE
60 Halifax Street
Adelaide SA 5000
Australia
T: +61 431 516 449
E: adelaide@slrconsulting.com

BRISBANE
Level 16, 175 Eagle Street
Brisbane QLD 4000
Australia
T: +61 7 3858 4800
E: brisbane@slrconsulting.com

CAIRNS
Level 1, Suite 1.06
14 Spence Street
Cairns QLD 4870
Australia
T: +61 7 4722 8090
E: cairns@slrconsulting.com

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
E: canberra@slrconsulting.com

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
E: darwin@slrconsulting.com

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516
E: goldcoast@slrconsulting.com

MACKAY
1/25 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300
E: mackay@slrconsulting.com

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
E: melbourne@slrconsulting.com

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
E: newcastleau@slrconsulting.com

PERTH
Level 1, 500 Hay Street
Subiaco WA 6008
Australia
T: +61 8 9422 5900
E: perth@slrconsulting.com

SUNSHINE COAST
Suite 2, 14-20 Aerodrome Rd
Maroochydore QLD 4558
Australia
T: +61 7 3858 4800
E: SunshineCoast@slrconsulting.com

SYDNEY
Tenancy 202 Submarine School
Sub Base Platypus
120 High Street
North Sydney NSW 2060
Australia
T: +61 2 9427 8100
E: sydney@slrconsulting.com

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
E: townsville@slrconsulting.com

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 2 4249 1000
E: wollongong@slrconsulting.com

AUCKLAND
201 Victoria Street West
Auckland 1010
New Zealand
T: 0800 757 695
E: auckland@slrconsulting.com

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628
E: nelson@slrconsulting.com

WELLINGTON
12A Waterloo Quay
Wellington 6011
New Zealand
T: +64 2181 7186
E: wellington@slrconsulting.com

SINGAPORE
39b Craig Road
Singapore 089677
T: +65 6822 2203
E: singapore@slrconsulting.com