

Supporting Information Report – Environmental Authority Amendment

Dalby Expansion Project (EPPG00972513)
DXP 4

February 2025

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Table of Contents

1. Purpose and Scope of this Document	4
2. Introduction	5
2.1 The Project Area.....	5
2.2 Currently Authorised Petroleum Activities.....	9
2.3 Details of the Proponent.....	10
2.4 Assessment Approach.....	10
2.5 Matters of National Environmental Significance - EPBC Act	12
3. Proposed EA Amendments – Disturbance	13
3.1 Overview	13
3.2 Updates to Water Conditions.....	13
3.3 Update to Biodiversity Conditions (ESAs)	4
3.3.1 Condition Biodiversity 5	4
3.3.2 Condition Biodiversity 7	4
3.3.3 Condition Biodiversity 8A.....	4
3.3.4 Condition Biodiversity 8B	4
3.4 Prescribed Environmental Matters	6
3.4.1 Regulated vegetation.....	8
3.4.2 Connectivity Areas - connectivity area that is a Regional Ecosystem (not in urban area).....	9
3.4.3 Wetlands and Watercourses	9
3.4.4 Protected wildlife habitat – habitat for an animal that is Endangered or Vulnerable	10
3.4.5 Protected wildlife habitat – habitat for an animal that is Special Least Concern	11
3.5 Administrative Changes.....	11
3.6 Impact Assessment for Environmental Values and Matters of State Environmental Significance (MSES).....	12
3.7 Land and Biodiversity	17
3.7.1 Applicable legislation	17
3.7.2 Description on Environmental Values.....	18
3.7.3 Assessment of environmental impacts.....	18
3.7.4 Potential Impacts and proposed management practices	22
4. Proposed EA Amendments – Lynwood Field Compression Station 24	
4.1 Overview	24
4.2 Description of Proposed Additional Infrastructure.....	29

Supporting Information Report
Environmental Authority Amendment DXP 4

4.2.1 Field Compression Station	29
4.2.2 Power Station	33
4.2.3 Power Supply	33
4.2.4 Water Supply and Management.....	34
4.3 Impact Assessment for Environmental Values and Matters of State Environmental Significance (MSES).....	35
4.4 Air	42
4.4.1 Applicable legislation	42
4.4.2 Description of environmental values	42
4.4.3 Existing air environment.....	42
4.4.4 Air quality objectives and indicators	45
4.4.5 Assessment of environmental impacts.....	46
4.4.6 Proposed management practices	47
4.5 Greenhouse Gas	50
4.5.1 Applicable legislation	50
4.5.2 Description on Environmental Values.....	52
4.5.3 Existing environment	52
4.5.4 Greenhouse Gas Objectives and indicators	53
4.5.5 Assessment of environmental impacts.....	53
4.5.6 Proposed management practices and continual improvement	62
4.6 Noise	68
4.6.1 Applicable legislation	68
4.6.2 Description on Environmental Values.....	68
4.6.3 Sensitive Receptors.....	68
4.6.4 Existing Noise Environment.....	69
4.6.1 Noise quality objectives and indicators	71
4.6.2 Assessment of environmental impacts.....	72
4.6.3 Proposed management practices	73
4.7 Community and Visual Amenity.....	75
4.7.1 Applicable legislation	75
4.7.2 Description on Environmental Values.....	75
4.7.3 Assessment of environmental impacts and proposed management practices..	76
5. Legislative Requirements	79
5.1 EIS Process and Compliance with the EP Act.....	79
5.2 Requirements for Amendment Applications.....	79
5.3 Requirements for Amendment Applications for CSG Activities.....	83
5.3.1 CSG Water Management and Underground Water Rights	83

Appendix A. Mark Up of Proposed DXP EA (EPPG00972513)	
Amendments.....	85
Appendix B. GHG Abatement Plan	86
Appendix C. Lynwood FCS Air Assessment	90
Appendix D. Lynwood FCS Noise Assessment	91
Appendix E. Surat Gas Project Terrestrial Ecological Report (EcoSmart 2017)	92
Appendix F. Surat Gas Project – DXP 4 Significant Residual Impacts to Prescribed Environmental Matters	93
Appendix G. CSG Water Management Plan.....	94

List of Tables

Table 2-1 Currently Authorised Petroleum Activities under [DXP] (EPPG00972513)	9
Table 3-1 Description of Proposed Disturbance, Land the Activity is Located, and Proposed Amendments (Wetlands)	4
Table 3-2 Authorised Disturbance Widths (Linear Infrastructure) - Condition Biodiversity 5	4
Table 3-3 Biodiversity 7 (Cleared Areas) Examples	4
Table 3-4 Description of Proposed Disturbance, Land the Activity is Located, and Proposed Amendments	4
Table 3-5 Updates to Schedule D, Table 3	6
Table 3-6 Assessment of potential for proposed activities to affect environmental values (Disturbance).....	12
Table 3-7 2023 – 2024 Contemporary ground-truthing survey effort.....	20
Table 4-1 Proposed amendments to Schedule A, Table 1 – Authorised Petroleum Activities	24
Table 4-2 Proposed amendments to Schedule F, Table 1 — Authorised point sources	25
Table 4-3 Proposed amendment to Schedule F, Table 2 – Annual Air Quality Monitoring	27
Table 4-4 Assessment of potential for proposed Lynwood FCS to affect environmental values (Additional Infrastructure)	35
Table 4-5 Assessment of potential for proposed Lynwood FCS to affect MSES.....	39
Table 4-6 Background Levels of Key Air Pollutants	44
Table 4-7 Overview of assessment approaches for each Activity/Source	44
Table 4-8 Air Quality Objectives relevant to the Project Area	46
Table 4-9 Air Quality Impact Mitigation measures.....	48
Table 4-10 Scope 3 Emissions Inclusions and Exclusions from GHG Assessment.....	54
Table 4-11 GHG Emissions Estimation Methodology Summary	56
Table 4-12 Annual Forecast Scope 1 GHG Emissions by Source.....	59
Table 4-13 Annual Forecast Scope 3 GHG Emissions by Source.....	60
Table 4-14 Contribution of the Project to State and National total GHG Emissions.....	61
Table 4-15 Carbon Management Hierarchy and application to the Project	62
Table 4-16 Management strategies to minimise GHG emissions.....	63
Table 4-17 Assessed GHG Abatement Measures	65
Table 4-18 Sensitive Receptors within 5 km of the Lynwood FCS	69
Table 4-19 Deemed background noise levels as per Streamlined Model Condition (DES, 2016) 69	

Supporting Information Report

Environmental Authority Amendment DXP 4

Table 4-20 Overview of Noise Sources and Assessment Approaches	70
Table 4-21 EPP (Noise) Acoustic quality objectives.....	71
Table 4-22 Best Practice Measured Outdoor Noise Emission Limits (DES, 2016).....	71
Table 4-23 Environmental Values – Community and Landscape.....	75
Table 5-1 Threshold criteria for an amendment to an EA.....	79
Table 5-2 EP Act Section 226 requirements for amendment application generally and Arrow Energy's response.....	81
Table 5-3 EP Act Section 226A requirements for amendment application and Arrow Energy's response.....	82
Table 5-4 EP Act Section 227 and Section 227AA requirements for amendment application and Arrow Energy's response.....	83
Table 6-1 GHG Abatement Plan Requirements as per DESI GHG Emissions Guideline	87

List of Figures

Figure 2-1 Surat Gas Project (SGP) Development Area.....	5
Figure 2-2 DXP EA Location and Tenures	7
Figure 2-3 Disturbance Subject to this Application	8
Figure 3-1 RoW Boundary Road Existing and Proposed Disturbance	4
Figure 3-2 Road Scope (Broadwater Rd) Despite.....	4
Figure 3-3 Road Scope (Wilkin Rd) Despite	5
Figure 4-1 Proposed FCS footprint and layout (including power generation).....	32
Figure 4-2 Forecast Scope 1 GHG Emissions (Before Abatement Measures).....	58
Figure 4-3 Forecast Scope 3 GHG Emissions	58
Figure 4-4 Hierarchy of Carbon Management.....	62
Figure 4-5 Scope 1 Emission Intensity Reduction from Assessed GHG Abatement Measures	66
Figure 4-6 Arrow Energy's GHG abatement opportunity maturation process	67
Figure 4-7 Indicative Multi-Point Ground Flare radiation fence	77

1. Purpose and Scope of this Document

Arrow Energy (Arrow), as the upstream operator of the Surat Gas Project, has prepared this Supporting Information Report to accompany an application to amend environmental authority (EA) EPPG00972513.

The purpose of this report is to support an amendment application to the Department of Environment, Technology Science and Innovation (DETSI) to seek an amendment to Arrow Energy's site-specific EPPG00972513, and to provide sufficient information to enable DETSI to decide on the application.

This amendment application relates to EA EPPG00972513 which currently authorises petroleum activities required for the development of the Dalby Expansion Project. The subject of the application is:

- the authorisation of petroleum activities in ESAs, HES wetlands, and their buffers;
- addition of prescribed environmental matters (PEMS); and
- the authorisation of additional infrastructure (Lynwood Field Compression Station (FCS)).

This disturbance and infrastructure are necessary for the construction and operation of natural gas wells, access tracks and gathering networks, which are all essential for bringing the gas resource to surface, and ultimately to market.

The following considerations support the application to authorise these activities.

- The gas through the proposed infrastructure (Lynwood FCS) will assist Arrow to meet statutory and contractual production obligations.
- There is no change to the risk of emissions or releases anticipated as a result of this amendment above what was assessed under the EIS.
- The locations of the proposed activities are constrained by environmentally sensitive areas, watercourses and landholder activities.
- The proposed activities, where possible, avoid disturbance in ESAs, remnant vegetation, wetlands and watercourses.
- The proposed activities, where possible, avoid clearing, by using previously cleared areas on non-remnant disturbed areas.
- To enable efficient development of PLs 258, 230, 198, 238, 252, and 260, some activities in and within a 200m buffer of a HES wetland, and within ESA and their PPZ is unavoidable.
- The location and extent of activities on the property are proposed to align with the existing land use and Landholder agricultural activities.

Arrow has assessed the environmental impacts of the proposed activity and actively sought to avoid or minimise adverse impacts to the greatest practicable extent.

The report has been prepared in accordance with the relevant requirements under Section 226 of the *Environmental Protection Act 1994* (Qld) (EP Act), the *Environmental Protection Regulation 2019*, and the DES guideline *Major and minor amendments* (ESR/2015/1684), version 11.00, of 26 September 2023.

Supporting Information Report

Environmental Authority Amendment DXP 4

The SGP covers an area of approximately 5,385 km² (538,500 ha) and is located approximately 160 km west of Brisbane in Queensland's Surat Basin. As shown in Figure 2-1, the SGP development area extends from the township of Wandoan in the north towards Goondiwindi in the south, in an arc shape through the township of Dalby.

The SGP phased development includes the Dalby Expansion Project (DXP), authorised under environmental authority (EAs) EPPG00972513. Topography throughout the project area is typically flat to gently undulating, with some low hills, jump-ups, and excised river/creek banks. The project location is shown in Figure 2-2, and the disturbance subject of this amendment in Figure 2-3.

Land use across the tenement and the broader surrounds is predominantly based upon agriculture, including pastoral holdings used for grazing in the central and western areas. Depending on the location of infrastructure, post operational land use will include forestry, mining, grazing or cropping. Key industries in the wider region surrounding the project area include CSG exploration and agriculture.





2.2 Currently Authorised Petroleum Activities

Arrow Energy prepared an environmental impact statement under the *Environmental Protection Act 1994* (Qld) (EP Act), the SGPEIS¹, which was submitted to the Chief Executive of the then Department of Environment and Heritage Protection in March 2012. Public consultation to the SGPEIS was conducted from March to June 2012 and a Supplementary Report to the SGPEIS (SGPSREIS)¹ was prepared which summarised and addressed the comments from the consultation process.

The SGPEIS was approved by the Queensland Government in October 2013 and by the Commonwealth Government in December 2013. The SGP obligations under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are being managed under the EPBC 2010/5344 approval².

Arrow Energy's SGPEIS considered the inclusion of the following infrastructure components:

- Coal Seam Gas (CSG) production wells;
- CSG and water gathering lines;
- Production facilities, including field compression (specifically the Lynwood FCS location) and water transfer stations;
- Water treatment and water storage facilities;
- Power generation facilities;
- High pressure gas pipelines; and
- Supporting infrastructure and logistics.

EPPG00972513 currently authorises the petroleum activities under *Schedule A, Table 1 – Authorised petroleum activities* as per Table 2-1. The only additional activity being sought under this application is an additional central gas processing facility comprising four (4) compressor units. There is no update needed to the total number of compressor units, just an additional CGPF and associated disturbance. This was considered in Arrow Energy's SGPEIS, and is approved under EPBC 2010/5344.

Table 2-1 Currently Authorised Petroleum Activities under [DXP] (EPPG00972513)

Activity(ies)	Total scale of petroleum activities / infrastructure	Intensity / maximum size
Total coal seam gas wells, including: Core wells Exploration wells Development wells Production wells	1,324 wells	1,324 ha
Communication towers	7	7 units, 7 ha
Injection well(s) and associated facilities	1	4 ha

¹ Arrow Energy Surat Gas Project Environmental Impact Statement, October 2013 (SGPEIS) and Supplementary Report ([Arrow Energy SGP EIS and Supplementary Report to the SGPEIS \(SGPSREIS\)](#)).

² Arrow Energy Surat Gas Project EPBC Approval, December 2013 ([EPBC 2010/5344](#)).

Activity(ies)	Total scale of petroleum activities / infrastructure	Intensity / maximum size
Compressor units	40	40 units, 8 ha
Central gas processing facilities	2	2 facilities, 8 ha
Regulated structures	22	22 dams
Water treatment facilities	2	12 ML/d (each), 2 ha
Sewage treatment plants	2	Less than 450 EP (each), 0.15 ha
Sewage treatment plants	9	Less than 100 EP (each), 0.15 ha
Power stations	1	40 MW, 1.2 ha

An application to amend the DXP EA was submitted to the Queensland Government in January 2025 to undertake petroleum activities in and within 200m of a wetland of High Ecological Significance. This was approved and granted with effective date 5 February 2025. This is the current EA, subject of this EA amendment application, and under which the activities as per Table 2-1 are authorised.

This proposed EA amendment does not significantly increase the level of environmental harm to that addressed and approved by the SGPEIS (2013) and its Supplementary Report (SGPSREIS, 2013) (refer to Section 3 and Section 4).

2.3 Details of the Proponent

Arrow Energy is an integrated energy company with interests in coal seam gas field developments, pipeline infrastructure and electricity generation.

Arrow Energy is a Queensland based wholly owned subsidiary of Arrow Energy Holdings Pty Ltd, a 50:50 joint venture between a subsidiary of Royal Dutch Shell plc and a subsidiary of PetroChina Company Limited (PetroChina).

Arrow Energy is a Registered Suitable Operator (RSO) in accordance with the Department of Environment and Science (DES) Suitable Operator Register, as required by the *Environmental Protection Act 1994* (Qld) (EP Act). Arrow Energy's RSO registered number is 632276.

2.4 Assessment Approach

The purpose of this report is to support an amendment application to the Department of Environment Science Technology and Innovation (DETSI) to seek an amendment to Arrow Energy's site-specific EPPG00972513, and to provide sufficient information to enable DETSI to decide on the application.

This EA amendment application seeks to authorise a number of proposed amendments to EPPG00972513 which are described in detail in this application.

The report has been prepared in accordance with the relevant requirements under Section 226 of the *Environmental Protection Act 1994* (Qld) (EP Act), the *Environmental Protection Regulation 2019*, and the DES guideline *Major and minor amendments* (ESR/2015/1684), version 11.00, of 26 September 2023.

This amendment application can be divided into two subsets:

- Section 3: Disturbance which impacts on ESAs and PEMS to construct and operate infrastructure already authorised under this EA
- Section 4: One (1) additional central gas processing facility to be authorised in Schedule A, Table 1, namely Lynwood Field Compression Station (FCS)

Section 3.6 and Section 4.3 provide a description of the existing environmental values that have potential to be impacted as a result of the proposed amendments. Potential impacts and corresponding environmental management practices are identified to appropriately minimise the impact of activities on these environmental values.

In accordance with Section 125 of the EP Act, the following is addressed as part of the assessment approach:

- Description of the environmental values likely to be affected by each relevant activity;
- Details of any emissions or releases likely to be generated by each relevant activity;
- Details of the management practices proposed to be implemented to prevent or minimise adverse impacts;
- Description of the risk and likely magnitude of impacts of the environmental values; and
- Details of how the land will be rehabilitated after each relevant activity ceases.

The assessment approach has been utilised to meet the requirements of the EP Act and demonstrate that Arrow have considered potential impacts of the proposed activities, with an aim to prioritise the avoidance of adverse impacts. Where no practicable alternate exists, these impacts can be managed, mitigated, and include being offset in accordance with the Environmental Offsets Act 2014 (EO Act).

The assessment has considered whether there are any significant on-ground conditions that may vary how the expected composition, structure and function of any regional ecosystem may be impacted by any proposed clearing. All reasonable steps have been taken to avoid, then where no reasonable alternative exists, minimise potential for adverse environmental impacts.

Proposed conditions to be amended are contained in Section 3.1 and Section 4.1. These seek to authorise disturbance to ESAs, address modifications to PEMS pursuant to Queensland's EO Act, and authorise an additional Field Compression Station (FCS).

Relevant PEMS are addressed, with a summary table provided in Section 3.4 and Section 3.7. For the purposes of this amendment report, information on individual PEMS has been provided where the proposed impact requires changes to the existing Schedule D, Table 3. A summary of the ecological investigations used to determine relevant biodiversity values is provided in Section 3.7.

As the disturbance limits are based on layout designs that are in advanced stages, a significant residual impact (SRI) assessment report, including all PEMS has been provided in

accordance with Condition Biodiversity 14. The SRI report (Appendix F) reflects further refinements of the field design which will be no greater than the disturbance areas approved.

Air Quality and Noise assessments were conducted by SLR Consulting specifically for the Lynwood FCS and are provided in Appendix C and Appendix D respectively.

2.5 Matters of National Environmental Significance - EPBC Act

Consideration has been given to the potential impacts of the EA amendments against the existing approval and current provisions of the Commonwealth Environment Protection and Biodiversity Act 1999 (EPBC Act).

The areas the subject of this EA amendment are part of the larger Surat Gas Project (SGP), which was referred to the Commonwealth (EPBC 2010/5344) and deemed to be a controlled action. Potential impacts of the project on matters of national environmental significance (MNES) were assessed by way of Environmental Impact Statement (EIS). Proposed disturbance areas and values relevant to this EA amendment application are within the overall disturbance for the Project as contemplated in the EIS.

Approval was subsequently granted by the then Commonwealth Department of the Environment (DoE) which included maximum disturbance limits for EPBC listed species and communities within the project and conditions relating to CSG water monitoring and management. The SGP project commenced under the EPBC Act on 22 October 2020.

There are some species that were not listed as MNES at the time Arrow received Commonwealth approval in 2013 (refer to Attachment 1) but were included within the SGP Stage 1 Offset Strategy in 2019. This plan has been approved by DoE.

The appropriate mechanism to recognise these species in the approval was discussed in meetings between The Department of Environment and Science (DES), Arrow and the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW), with all parties agreeing that they are to be included in the State EA PEMs tables (Section 3.4) and the potential impacts to be offset as matters of state environmental significance (MSES), rather than as MNES.

3. Proposed EA Amendments – Disturbance

3.1 Overview

Coal seam gas developments apply an iterative process in terms of locating wells and gathering lines to manage competing constraints associated with the location of surface infrastructure, including ecological values, landholder preferences, geological features, existing infrastructure, and access tracks. Planning and management of surface activities and ground disturbance is undertaken utilising a set of hierarchical management principles to avoid, minimise and mitigate impacts to environmental values. These principles are:

- **Avoid:** Arrow Energy's first preference is to avoid ESAS, PEMs, threatened ecological communities and the habitat of PEMs listed threatened species.
- **Minimise:** where other competing constraints or the scale and location of PEMs communities or species habitat dictate that avoidance is not possible (e.g. where there is riparian vegetation that need to be crossed or large areas of suitable habitat for wide ranging species such as the koala, Greater Glider or Painted Honeyeater), Arrow Energy's will preferentially locate infrastructure in a manner that minimises the impact to these values (e.g. cross the riparian vegetation at the narrowest or most degraded part or where practicable on the edge of suitable habitat for listed species so as not to bisect good quality habitat).
- **Mitigate:** implement mitigation measures to further minimise the direct and indirect impacts on ecological values.
- **Remediate and rehabilitate:** actively remediate and rehabilitate impacted areas to promote and maintain long term recovery.
- **Offset:** Arrow Energy will offset unavoidable significant residual impacts to PEMs.

The disturbance subject of this section of the EA amendment application is not the result of new infrastructure being authorised. All infrastructure which relates to this section is already authorised under current Schedule A, Table 1 - Authorised Petroleum Activities. Rather, this application seeks disturbance to ESAs and PEMS to allow this infrastructure to be developed.

3.2 Updates to Water Conditions

While avoiding disturbance to wetlands is a priority, clearing and disturbance within some HES wetlands and their buffers is unavoidable. There are current provisions in the DXP EA to authorise petroleum activities within 200m of a wetland of high ecological significance (by way of a despite table). Arrow is proposing additional locations to this table. Where impacts are predicted to result in a significant residual impact to HES wetlands (a Prescribed Environmental Matter), these have been recognised in Condition Biodiversity 10 and Schedule D, Table 3 (Significant residual impacts to prescribed environmental matters). Updates to this table, necessary to facilitate this amendment are discussed in 3.1.3.

Existing Water 3

Petroleum activities must not occur:

- a) within 200m of wetland of high ecological significance, other than disturbances identified by Schedule B, Table A – Authorised Disturbance Areas (Water)

- b) in a wetland of high ecological significance, other than that authorised by *Schedule D, Table 3 — Significant residual impacts to prescribed environmental matters*
- c) in or within 200m of a Great Artesian Basin Spring
- d) in or within 200m of a subterranean cave GDE.

Schedule B, Table A – Authorised Disturbance Areas (Water)

Tenure	Description of Infrastructure	ESA Type	Area of Disturbance (ha)
PL198	Access Track and Right of Ways to Tipton 119 well pad	<u>Within 200 metres of a wetland of high ecological significance</u>	1.031

Proposed Water 3

Petroleum activities must not occur:

- a) within 200m of wetland of high ecological significance, other than disturbances identified by Schedule B, Table 1 – Authorised Disturbance Areas (Water)
- b) in a wetland of high ecological significance, other than that authorised by *Schedule D, Table 5 — Significant residual impacts to prescribed environmental matters*
- c) in or within 200m of a Great Artesian Basin Spring
- d) in or within 200m of a subterranean cave GDE.

Schedule B, Table 1 – Authorised Disturbance Areas (Water)

Tenure	Description of Infrastructure	ESA Type	Area of Disturbance (ha)
PL198	Access Track and Right of Ways to Tipton 119 well pad	<u>Within 200 metres of a wetland of high ecological significance</u>	1.031
PL260	Access Track and Right of Ways to Longswamp 395 well pad	<u>Within 200 metres of a wetland of high ecological significance</u>	5
	Well pad (Longswamp 395)		1
	Well pad (Longswamp 396)		1
PL238	Right of Way (SPV_PAD_WP430)	<u>Within 200 metres of a wetland of high ecological significance</u>	1.1

Detail of individual disturbance locations can be found in Table 3-1.

Existing condition Biodiversity 4 sets criteria to ensure site selection prioritises areas of pre-existing disturbance and minimises impacts to environmental values. This condition remains relevant and will not be limited by this amendment. In some circumstances, Arrow would need to locate some infrastructure in the middle of intensively farmed paddocks (as fully cleared areas) to remain 200m from a HES wetland. This would be contrary to the co-existence principles under the Mineral and Energy (Common Provisions) Act 2014 (Qld). and

Land Access Code 2023. Demonstrating the co-existence principles is fundamental to having positive ongoing relationships with landholders.

In the areas of intensely farmed land, the wetland buffer is often highly disturbed as a result of being used for commercial agricultural cropping activities multiple times per year for decades. In these areas the buffer (and in some instances the wetlands itself) have almost no ecological value, as the areas are regularly disturbed by landholders as part of ongoing farming practices. As there is no way to groundtruth out HES wetlands (they are defined by occurrence on the Map of Queensland wetland environmental values), a despite table is the most appropriate mechanism for authorising this disturbance, even where they may be no increase to environmental impact over that already occurring at the location.

Table 3-1 Description of Proposed Disturbance, Land the Activity is Located, and Proposed Amendments (Wetlands)

Location	Infrastructure ID	Image	Details and Justification	Ecological Impact	Area (ha)
PL260	Within 200m of HES Wetland Access Track and Right of Ways to Longswamp 395 well pad		RoW and Access within 200m of a HES Wetland. The land where infrastructure is proposed is clear of native vegetation. Sections which result in disturbance to the HES Wetland itself will be authorised under Water 3(b) and are discussed in Section 3.4. There is no reasonable alternative to this routing, and the RoW has been narrowed through the mapped HES wetland and buffer. The separate access track is in a location where ongoing existing access is utilised by the landholder.	3.69 ha is within 200m of a mapped HES wetland. Total Access Track and RoW for this section is 4.94 ha. This entire area is within field validated cultivated or cleared land. No ecological impact is expected.	4.94
PL260	Within 200m of HES Wetland Well pad (Longswamp 395) Well pad (Longswamp 396)		RoW and Access within 200m of a mapped HES Wetland. The land where infrastructure is proposed is clear of native vegetation, and there is no practical alternate placement. Minimum well pad sizing has been used at these locations.	SLS_PAD_WP395 includes 0.93 ha within 200m of a mapped HES wetland SLS_PAD_WP396 includes 0.53 ha within 200m of a mapped HES wetland Both well pads are 1ha in size. Both areas are entirely within field validated cultivated land. No ecological impact is expected.	2 (2 x 1 ha well pads)
PL238	Within 200m of HES Wetland Right of Way (SPV_PAD_WP430)		ROW in and within 200m of a HES Wetland. The land where infrastructure is proposed is clear of native vegetation and cropped paddock. Sections which result in disturbance to the HES Wetland itself will be authorised under Water 3(b) and are discussed in Section 3.4. There is no reasonable alternative to this routing, and the RoW has been narrowed through the mapped HES wetland and buffer.	1.06ha is within 200m of a mapped HES wetland. 0.22ha is within a mapped HES wetland. This entire area is within field validated cultivated or cleared land. No ecological impact is expected.	1.28

3.3 Update to Biodiversity Conditions (ESAs)

While avoiding disturbance to land is a priority, clearing and disturbance within environmentally sensitive areas (ESAs) and impacts to matters of State environmental significance (MSES) are unavoidable. Amendments to Conditions Biodiversity 5, 7, 8A and 8B, as well as their associated tables is required.

Arrow submitted an EA amendment application in 2019 that requested approval for disturbance in ESAs that reflected predictions from the approved SGP EIS and SREIS (Arrow Energy 2012, 2013). Schedule D, Table 2 was introduced into the EA as a result, but with disturbance values that were not consistent with full disturbance predictions from the EIS. Since August 2019 Arrow have corresponded with DES regarding the most appropriate way to correct these discrepancies. It was acknowledged there would need to be an amendment to Schedule D, Table 2 to enable the extent of the planned development, as approved in the EIS.

Notwithstanding, Arrow has identified several instances where petroleum activities are required to occur in Category A PPZ, Category B ESA and PPZ, and Category C ESA and PPZ. Arrow has identified location where the infrastructure would not be authorised under the proposed Condition Biodiversity 8A. For completeness, and based on the Department's position, this has included an assessment considering Protected Wildlife Habitat, despite it not forming part of the current conditioning (but is proposed in the amended Condition Biodiversity 8A). Detail of individual disturbance locations can be found in the below sections.

Existing condition Biodiversity 4 sets criteria to ensure site selection prioritises areas of pre-existing disturbance and minimises impacts to environmental values. This condition remains relevant and will not be limited by this amendment. In some circumstances, Arrow would need to locate some infrastructure in the middle of intensively farmed paddocks (as fully cleared areas) to completely avoid the protection zones of ESAs. This would be contrary to the co-existence principles under the Mineral and Energy (Common Provisions) Act 2014 (Qld). and Land Access Code 2023. Demonstrating the co-existence principles is fundamental to having positive ongoing relationships with landholders.

In the areas of intensively farmed land, the protection zone is often highly disturbed as a result of being used for commercial agricultural cropping activities multiple times per year for decades. In these areas the protection zones have almost no ecological value, as the areas are regularly disturbed by landholders as part of ongoing farming practices.

Where impacts are predicted to result in a significant residual impact to Prescribed Environmental Matters (PEMS), these have been recognised in Condition Biodiversity 10 and Schedule D, Table 2 (Significant residual impacts to prescribed environmental matters). Updates to this table, necessary to facilitate this amendment are discussed in 3.4.

3.3.1 Condition Biodiversity 5

Existing Biodiversity 5 Linear infrastructure construction corridors must:

- a) maximise co-location;
- b) be minimised in width to the greatest practicable extent; and
- c) for linear infrastructure that is an essential petroleum activity authorised in an environmentally sensitive area or its protection zone, be no greater than 40m in total

width.

Proposed Biodiversity 5 Linear infrastructure construction corridors must:

- a) maximise co-location;
- b) be minimised in width to the greatest practicable extent; and
- c) for linear infrastructure that is an essential petroleum activity authorised in an environmentally sensitive area or its protection zone, be no greater than 40m in total width, **except for that authorised in Schedule D, Table 1**

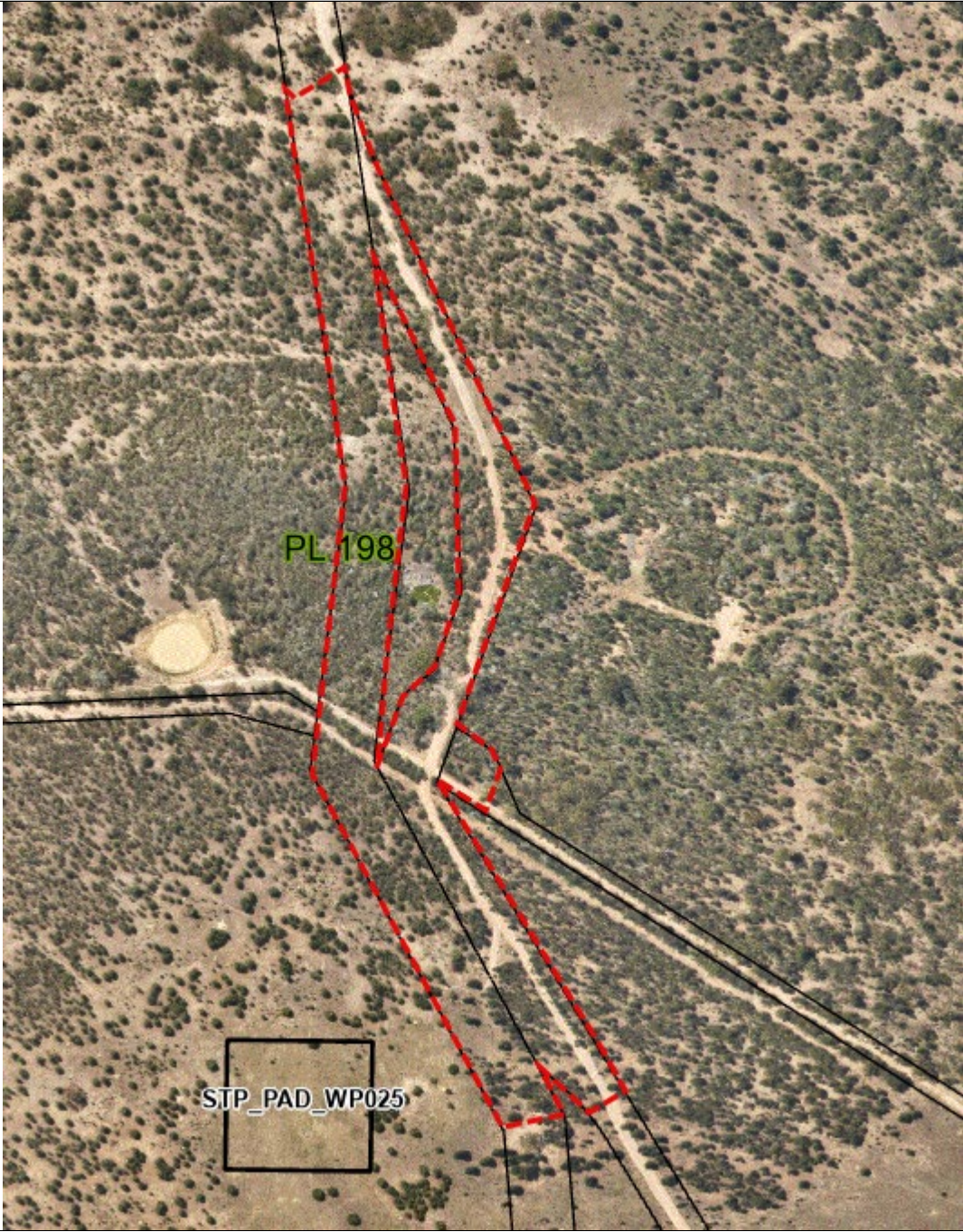
Schedule D, Table 1 – Authorised Disturbance Widths (Linear Infrastructure)

Infrastructure	ESA Type	Location	Maximum Disturbance Area
Road and Right of Way (Lynwood to Tipton)	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'	DXP 4 EA Disturbance Spatial Data	4.5
RoW (STP_PAD_WP623)	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'	DXP 4 EA Disturbance Spatial Data	1.4
Right of Way Boundary Road	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'	DXP 4 EA Disturbance Spatial Data	13.1

The current condition allows for linear infrastructure in an environmentally sensitive area or its protection zone, provided the total width is no greater than 40m. This condition provides that linear infrastructure can be located in these areas without impacting the ESA or PPZ. In some instances, the required infrastructure cannot be constructed within a 40m corridor. This is due to several reasons, not limited to safe construction distance from existing infrastructure, pipe dimensions and construction methodology, and safe areas for manoeuvring of plant and equipment.

In line with Arrow's other EAs, a despite table is being proposed to authorise the instances where this condition cannot be met. In all instances, the infrastructure is proposed within the PPZ, not the ESA itself and Arrow does not expect any impact to the ESA, over and above what is already occurring the area due to ongoing landholder activities. The areas subject to the despite table, and justification for their location are described in Table 3-2. In the instance of the Boundary Road RoW, the maximum disturbance area is the sum of existing and proposed disturbance. The existing disturbance was undertaken prior to protected wildlife habitat being considered an ESA in DXP EA.

Table 3-2 Authorised Disturbance Widths (Linear Infrastructure) - Condition Biodiversity 5

Location	Infrastructure ID	Image	Details and Justification	Ecological Impact	Maximum Disturbance Area (ha)
PL198	PPZ of Cat C (PWH) ESA Road and RoW (Lynwood to Tipton)		This section of access and gathering is within the PPZ of Cat C ESA (PWH). While it is essential petroleum activity, it exceeds the 40m width restriction required by Biodiversity 5 (c). Access has been designed with consideration to existing access which will require upgrade, and routing of gathering aligned with future scope does not allow for colocation. This infrastructure is required to support road construction in line with managing community expectations.	0.5 ha Cleared 1.52 ha Regrowth 11.5.1 1.45 ha Remnant 11.5.1 See Section 3.4 and Appendix F for assessment of PEMS.	4.47 ha

PL198	PPZ of Cat C ESA (PWH) RoW (STP_PAD_WP623)		This section of access and gathering is within the PPZ of Cat C ESA (PWH). While it is essential petroleum activity, it exceeds the 40m width restriction required by Biodiversity 5 (c). Access has been designed with consideration to existing access which will require upgrade, and routing of gathering aligned with future scope does not allow for colocation. This infrastructure is required to support road construction in line with managing community expectations to avoid Cecil Plains. Field validation identified the area as undifferentiated regrowth.	1.38 ha of undifferentiated Regrowth No impacts to PEMS. No ecological impact is expected.	1.38
PL198	PPZ of Cat C ESA (PWH) RoW Boundary Road	See Figure 3-1	This section of access and gathering is within the PPZ of Cat C (PWH). While it is essential petroleum activity, it exceeds the 40m width restriction required by Biodiversity 5 (c). Existing infrastructure and disturbance at this location necessitates a wider total corridor The new disturbance is a 30m wide corridor, however an existing 30m RoW, means the total disturbance will be 60m wide. This disturbance is necessary to ensure safe operating and construction distance from the existing live assets, as well as a wider area needed for safe manoeuvring of plant and equipment.	6.52 ha of existing disturbance (undertaken prior to addition of PWH to ESA) 6.55 ha of proposed disturbance consisting of: 3.38 ha regrowth undifferentiated 2.01 ha cleared 0.72 Remnant 11.7.4 See Section 3.4 and Appendix F for assessment of PEMS.	13.1 ha (includes proposed and existing)

Supporting Information Report
Environmental Authority Amendment DXP 4

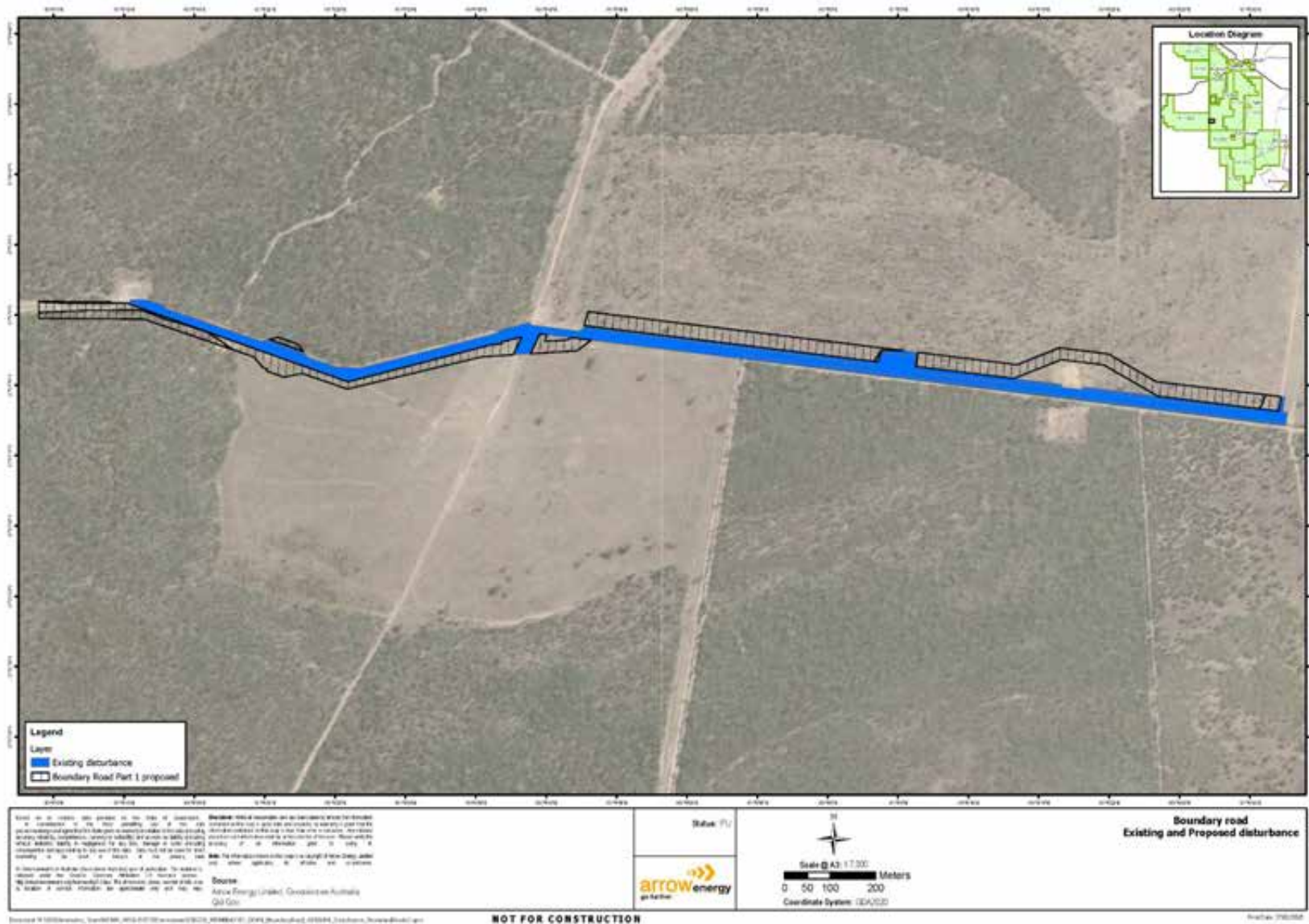


Figure 3-1 RoW Boundary Road Existing and Proposed Disturbance

S00-ARW-ENV-APL-00016

February 2025 - Version 0

Page 4 of 126

3.3.2 Condition Biodiversity 7

Existing Biodiversity 7 Despite condition (Biodiversity 8A), Extra Work Areas (EWAs) are authorised in areas clear of native vegetation, including primary protection zone (PPZ) and secondary protection zone (SPZ).

Proposed Biodiversity 7 Despite condition (Biodiversity 8A), activities are authorised in areas field verified as cleared, cropped, or grazing, including primary protection zones (PPZ) and secondary protection zones (SPZ)."

This current condition allows for EWAs (which do not meet the definition of a petroleum activity) in SPZ and PPZ where the area is clear of native vegetation, and recognises in these areas, the undertaking of essential petroleum activity does not have any environmental impact over and above that already occurring at the location.

The intent of the proposed condition is to authorise infrastructure in areas that are pre-cleared. Apart from being within a PPZ or SPZ, they would otherwise have no environmental constraints (e.g. PEMS) given they are located on land used intensively for agricultural activities. If there was proposed activity in a PPZ or SPZ where impacts to native vegetation were identified (outside of those authorised by Condition Biodiversity 8A and 8B), an EA amendment seeking a despite clause would be required to authorise the impacts in the PPZ regardless of whether the PEMS impact was already authorised by the EA.

Biodiversity 1 in the EA requires for ground-truthing surveys to be undertaken to confirm the on-the-ground biodiversity values prior to significant disturbance. As such, if there was a change in the biodiversity values over time (i.e. cleared area became regrowth or remnant vegetation) relating to the inclusion of this condition, it would be captured, and the activity would not be authorised unless via a specific 'despite' clause.

Arrow are proposing to extend this condition to include all activities, and more specifically outline the field validated criteria required to authorise the activity. As the area has been precleared for the purposes of cropping and agriculture, the activity will not necessitate any vegetation clearing, nor will there be any impacts to Prescribed Environmental Matters (PEMS) requiring offsets, or any other impacts to Matters of State Environmental Significance.

The proposed amendment aims to reduce administrative burden on both the Department and Arrow by not having to submit multiple EA amendments to insert a despite clause based on infrastructure proposed within the PPZ or SPZ where it does not have any impact on a PEMS. Table 3-3 provides examples of where this condition would and would not apply.

Table 3-3 Biodiversity 7 (Cleared Areas) Examples

Image	Description
	A multi well pad, totalling 2.05ha proposed in the PPZ of Cat C ESA. Existing condition Biodiversity 8A and Schedule D, Table 1 provides for essential petroleum activities only permitted in PPZ of Cat C ESA. This well pad exceeds the 1.5 ha allowed for a multi well pad under the definition of essential petroleum activity. While this area is within the PPZ, it has been field verified as Cleared. Under the proposed condition, this activity would be permitted. In this instance, this provides a better environmental outcome in that 8 wells are constructed with 2.05 ha, rather than 8 x 1 ha single well pads, which would be authorised at this location as an essential petroleum activity, resulting in 8 ha of disturbance.
	Example of two laydowns, both of which are partially within SPZ of ESA Cat B. Existing condition Biodiversity 8A and Schedule D, Table 1 provides for essential petroleum activities only permitted in SPZ of Cat B ESA. Laydowns are not included in the definition of essential petroleum activity. In this instance the green laydown, which, while within the SPZ, is entirely over an area field verified as “Cultivated”. Under the proposed condition, this activity would be permitted. By contrast, the red laydown (also within the SPZ), is located partially on land which has been field verified as regrowth undifferentiated. In this instance, a despite clause against Biodiversity 8A, included in Schedule D, Table 2 would be required to undertake the activity.

3.3.3 Condition Biodiversity 8A

In line with Arrow's other recently amended or approved EAs, Schedule D, Table 1— *Authorised petroleum activities in environmentally sensitive areas and their protection Zones*, will be updated to the below. This includes Protected Wildlife Habitat as a Category C ESA, which was not previously included in this EA, and proposed despite conditions have been assessed based on the updated Schedule D, Table 1 authorisations.

Schedule D, Table 1— *Authorised petroleum activities in environmentally sensitive areas and their protection zones*

Environmentally Sensitive Area (ESA)	Within the ESA	<u>Primary protection zone of the ESA</u>	<u>Secondary protection zone of the ESA</u>
Category A ESAs	No petroleum activities permitted.	Only <u>low impact petroleum activities</u> permitted.	Only essential petroleum activities permitted.
Category B ESAs that are other than 'endangered' regional ecosystems	Only low impact petroleum activities permitted.		Only essential petroleum activities permitted.
Category B ESAs that are 'endangered' regional ecosystems	Only low impact petroleum activities permitted.	Only essential petroleum activities permitted.	Only essential petroleum activities permitted.
Category C ESAs that are on the 'essential habitat map', or are 'of concern' regional ecosystems	Only low impact petroleum activities permitted.	Only essential petroleum activities permitted.	-
Category C ESAs that are 'protected wildlife habitat'	Only essential petroleum activities permitted.		-
Category C ESAs that are 'regional parks' (previously known as 'resources reserves')	Only essential petroleum activities permitted.		-
Category C ESAs that are 'state forests' or 'timber reserves'	Only essential petroleum activities permitted.	Petroleum activities permitted.	-
Areas of vegetation that are 'critically limited'	Only low impact petroleum activities permitted.	Only essential petroleum activities permitted.	-

3.3.4 Condition Biodiversity 8B

As discussed, while avoiding disturbance to land is a priority, clearing and disturbance within environmentally sensitive areas (ESAs) and their protection zones are unavoidable. This disturbance and infrastructure is necessary for the construction and operation of natural gas wells, access tracks and gathering networks, which are all essential for bringing the gas resource to surface, and ultimately to market.

Where Arrow are unable to avoid disturbance in ESAs and their protection zones, Arrow is seeking the addition of 'despite' clauses for specific infrastructure exemptions to Schedule D, Table 1, and propose this is done by the addition of infrastructure to the existing despite table (Schedule D, Table 2 - Coordinates and disturbance areas for authorised disturbances to environmentally sensitive areas and protection zones). An extract of the existing table is provided below with proposed additions in red. Arrow are seeking to remove the Nandi

Supporting Information Report
Environmental Authority Amendment DXP 4

Springvale Part 2 EWA05 row, as this would become authorised under the proposed Condition Biodiversity 7.

In line with the Department's preference, and existing despite clauses, where only a portion of the infrastructure is located within an ESA and/or protection zones, Arrow has included the total disturbance required for that particular piece of infrastructure, rather than just the portion which is located within the ESA and/or protection zone. Details of each location and a breakdown of actual ESA disturbance is provided in Table 3-4.

Existing Biodiversity 8B Despite (Biodiversity 8A), activities and associated activities necessary for construction, operation, monitoring and maintenance are permitted within the limits prescribed in Schedule D, Table 2 – Coordinates and disturbance areas for authorised disturbances to environmentally sensitive areas and protection zones.

Infrastructure	ESA Type	Latitude	Longitude	Maximum Disturbance Area (ha)
PL238 SPV_PAD_WP120 Multi Well Pad	<u>Primary Protection zone of Category C ESA OCRE and Essential Habitat.</u>	-27.344911	151.243697	1.75 ha
Nandi Springvale Part 2 EWA05	<u>Primary protection zone of Category C ESA</u>	-27.323413	151.187896	0.2 ha
Right of Way (SLS_PAD_WP369)	Category B ESAs that are 'endangered' regional ecosystems	DXP 4 EA Disturbance Spatial Data		0.07
Right of Way (SLS_PAD_WP382)	Category B ESAs that are 'endangered' regional ecosystems			0.05
Access Track (SPV_PAD_WP045)	Category C ESAs that are on the 'essential habitat map'			1.1
Laydown (SLS_PAD_WP378)	<u>Secondary Protection zone of Category B ESA</u> that are 'endangered' regional ecosystems			0.81
Well Pad (STP_PAD_WP642)	Category C ESAs that are 'of concern' regional ecosystems			1
Right of Way (STP_PAD_WP642, STP_PAD_WP643, STP_PAD_WP639)	Category C ESAs that are 'of concern' regional ecosystems			3.6
EWA (Wanka Rd Crossing)	Category C ESAs that are on the 'essential habitat map'			0.05
EWA (Greenbank Access Rd Crossing)	<u>Primary Protection Zone of Category B</u> ESAs that are 'endangered' regional ecosystems			0.05
Lynwood FCS and Ancillary Infrastructure	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'			32.77
Well Pad (Tipton 608) and Communication Tower	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'			1.75
Well Pad (Tipton 660)	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'			2.05
EWA (Crossing near STP_PAD_WP630)	Category C ESAs that are 'protected wildlife habitat' and <u>Primary Protection Zone of Category C</u> ESAs that are 'of concern' regional ecosystems			0.2
EWA (Crossing near STP_PAD_WP620)	Category C ESAs that are 'protected wildlife habitat'			0.2
EWA (Crossing near STP_PAD_WP623)	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'			0.16

Supporting Information Report
Environmental Authority Amendment DXP 4

EWA (Wilkin Rd Crossing)	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'		0.05
EWA (Boundary Road Crossing)	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat' <u>Primary Protection Zone of Category C</u> ESAs that are 'of concern' regional ecosystems		0.11
Segregation Valve Area	<u>Primary Protection Zone of Category C</u> ESAs that are 'protected wildlife habitat'		0.24
EWA Boundary Road RoW	<u>Category C</u> ESAs that are 'protected wildlife habitat'		0.13
EWA (STP_PAD_WP601) Gathering	<u>Category C</u> ESAs that are 'protected wildlife habitat'		0.06
Road (Broadwater Road)	<u>Primary Protection zone of Category A</u> ESA		9.3
Road (Wilkin Rd)	<u>Category C</u> ESAs that are on the 'essential habitat map'		5.9

Table 3-4 Description of Proposed Disturbance, Land the Activity is Located, and Proposed Amendments

Location	Infrastructure ID	Image	Details and Justification	Ecological Impact	Area (ha)
PL260	Cat B ESA (11.3.1 Regrowth) RoW (SLS_PAD_WP369)		A single trench containing DN630 gas, and DN450 water pipe. No ongoing access is being proposed, as well sites will be accessed using the road visible to the northeast. No practical alternative to routing while maintaining co-existence with landholder. Right of Way has been narrowed through the ground verified ESA to minimise impact to the ESA.	0.07 ha within field verified 11.3.1 Regrowth. See Section 3.4 and Appendix F for assessment of PEMS.	0.07
PL260	Cat B ESA (11.3.1 Regrowth) RoW (SLS_PAD_WP382)		A single trench containing DN630 gas, and DN450 water pipe. No ongoing access is being proposed, through the ESA, as the well site will be accessed from the east (seen here as a cleared paddock). No practical alternative to routing while maintaining co-existence with landholder. Right of Way has been narrowed through the ground verified ESA to minimise impact to the ESA.	0.05 ha within field verified 11.3.1 Regrowth. See Section 3.4 and Appendix F for assessment of PEMS.	0.05
PL238	Category C ESA (Essential Habitat) Access Track (SPV_PAD_WP045)		This area is mapped Essential Habitat (11.3.2 Regrowth) for Koala, however the area of disturbance has been field verified as Derived Grassland. Regardless, it must be treated as the mapped Essential Habitat. The access track (and turnout) is required to access Well Pad 45 for ongoing operations and maintenance. This is an existing landholder track which is being utilised, with minimal additional clearing required.	0.96 ha Derived Grassland 0.05 ha 11.3.2 Regrowth 0.09 ha Cleared See Section 3.4 and Appendix F for assessment of PEMS.	1.1

PL260	SPZ of Category B (11.4.3 Endangered) ESA Laydown (SLS_PAD_WP378)		This proposed laydown (not an essential petroleum activity) is in SPZ of Cat B ESA. This has been ground verified in part as cultivated, however a portion has been ground verified as regrowth undifferentiated. The laydowns are placed either side of the property boundary, and both are required as the south-eastern property operates as an organic farm, whereas the north-western property does not. Separate lay downs in these locations ensure no cross contamination between properties, necessary given their different management practices. The remainder of the infrastructure is authorised as essential petroleum activity.	0.62 ha within the SPZ of Category B ESA 0.24 ha field validated as Cultivated 0.38 ha Regrowth undifferentiated 0.19 ha outside of the SPZ See Section 3.4 and Appendix F for assessment of PEMS.	0.81
PL198	Category C ESA (11.3.2) Well Pad (STP_PAD_WP642)		This area is government mapped as cleared, however field verification identified the area as Cat C (OCRE 11.3.2) ESA. Of the 1 ha single well pad, a portion (0.15 ha) is in the field verified ESA. The well pad has been aligned largely within an area of existing disturbance and considers land holder preference and appropriate well spacing.	0.15 ha Remnant 11.3.2 OCRE 0.85 ha Regrowth 11.5.1a See Section 3.4 and Appendix F for assessment of PEMS.	1
PL198	Category C ESA (11.3.2) Right of Way (STP_PAD_WP642, STP_PAD_WP643, STP_PAD_WP639)		This area is government mapped as cleared, however field verification identified a portion of the area as Cat C (OCRE 11.3.2) ESA. The Right of Way has been narrowed where it needs to traverse the ESA. Wellpad Tipton 643 (eastern well pad) is in an area of field validated 11.5.1, which is not an ESA. Wellpad Tipton 642 is subject to a separate despite clause (above). The remaining infrastructure is authorised in the PPZ as essential petroleum activity.	1.83 ha Remnant 11.3.2 OCRE 1.77 ha Cleared See Section 3.4 and Appendix F for assessment of PEMS.	3.6

PL238	PPZ of Cat C ESA (Essential Habitat), EWA (Wanka Rd Crossing)		This EWA is proposed within the PPZ of mapped Cat C ESA (Essential Habitat for Koala), which has been field verified as 11.3.2 Regrowth. This EWA is necessary to construct the crossing immediately north of the EWA. The other EWAs are authorised under proposed Condition Biodiversity 7, given the land they are on has been field verified as Cultivated. The linear infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A.	0.05 ha of 11.3.2 Regrowth See Section 3.4 and Appendix F for assessment of PEMS.	0.05
PL260	PPZ of Cat B ESA (11.3.1 Endangered). EWA (Greenbank Access Rd Crossing)		This EWA is in the PPZ of Cat B ESA. Vegetation has been ground verified as partially cleared, and partially Regrowth 11.3.1. The vegetation is not wide enough to be considered a Cat B ESA, however, remains in the PPZ. This EWA is necessary to construct the road crossing west of the EWA. The other EWAs are authorised under proposed Condition Biodiversity 7, given the land they are on has been field verified as Cultivated. The linear infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A.	0.02 ha Regrowth 11.3.1 0.03 ha Cleared See Section 3.4 and Appendix F for assessment of PEMS.	0.05
PL198	PPZ of Cat C (Protected Wildlife Habitat) ESA Lynwood FCS and Ancillary Infrastructure		Lynwood FCS and ancillary infrastructure (laydowns, dams, power station, flare) are partially located within the PPZ of Cat C (Protected Wildlife Habitat) ESA. The total footprint is 32.77 ha, with 3.51 ha being within the PPZ. The area has been field verified as 11.5.1 Regrowth. The FCS has been sited to take advantage of existing cleared areas, with minor clearing in adjoining regrowth or remnant areas required for establishment. Arrow has worked to identify the most suitable location for the Lynwood FCS, which considered both technical and non-technical risk. This study was further verified and identified Arrow owned property 41DY363 and 40DY363 as the most suitable location. The actual FCS footprint is 15 ha, with the remaining area required for ancillary infrastructure.	1.6 ha 11.5.1 Regrowth 4.39 ha 11.5.1 Regrowth 0.3 ha 11.5.1 Remnant 23 ha derived grassland See Section 3.4 and Appendix F for assessment of PEMS.	32.77

PL198	PPZ of Cat C ESA (PWH) Well Pad (Tipton 608) and Communication Tower		The Tipton 608 well pad and communication tower are proposed in the PPZ of a Cat C ESA (PWH), which only allows for essential petroleum activities. The total 1.75 ha exceeds the allowance for Essential Petroleum Activity by 0.25 ha. This area is required for sequencing of construction, where, at this location, the communication tower is unable to be constructed prior to the well being drilled, and a safe distance is required. The linear infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A.	0.19 ha Regrowth undifferentiated 1.56 ha Remnant 11.3.14 See Section 3.4 and Appendix F for assessment of PEMS.	1.75
PL198	Cat C ESA (PWH) and PPZ Well Pad (Tipton 660)		Tipton 660 is a 2.05 ha eight well multi-well pad located within Cat C ESA (PWH) and PPZ, which only allows for essential petroleum activities. This size exceeds that to be permitted as an essential petroleum activity for a multi-well pad (1.5 ha). The area has been field validated as 11.5.1. While this is partially located in Cat C ESA (PWH), it provides for reduced net disturbance, given 8 (1 ha) single wells would be permitted in this ESA as essential petroleum activity, resulting in 8 ha disturbance, rather than the 2.05 ha proposed.	1.35 ha Remnant 11.5.1 0.70 ha Cleared See Section 3.4 and Appendix F for assessment of PEMS.	2.05
PL198	ESA Cat C (PWH) and PPZ of ESA Cat C (OCRE 11.3.2) EWA (Crossing near STP_PAD_WP630)		Two EWAs are proposed in ESA Cat C (PWH), which is overlapped by the PPZ of Cat C ESA (OCRE 11.3.2). Condition 8A allows for essential petroleum activities only in these ESA types. EWAs are not included in the definition of essential petroleum activity. Field Verification identified the area as 11.3.14 and 11.5.1 Regrowth. These EWAs, which are temporary in nature, are necessary to construct the crossing in between them, and there is no practicable alternative. The linear infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A.	0.13 Remnant 11.3.14 0.07 Regrowth 11.5.1 See Section 3.4 and Appendix F for assessment of PEMS.	0.2

PL198	Cat C ESA (PWH) EWA (Crossing near STP_PAD_WP620)		Two EWAs are proposed in ESA Cat C (PWH). Condition 8A allows for essential petroleum activities only in these ESA types. EWAs are not included in the definition of essential petroleum activity. Field Verification identified the area as 11.5.1 Regrowth. These EWAs, which are temporary in nature, are necessary to construct the crossing in between them, and there is no practicable alternative. The linear infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A.	0.20 ha Regrowth 11.5.1 See Section 3.4 and Appendix F for assessment of PEMS.	0.20
PL198	PPZ of Cat C ESA (PWH) EWA (Crossing near STP_PAD_WP623)		Two EWAs are proposed in the PPZ of ESA Cat C (PWH). Condition 8A allows for essential petroleum activities only in these ESA types. EWAs are not included in the definition of essential petroleum activity. Field Verification identified the area as Regrowth Undifferentiated. These EWAs, which are temporary in nature, are necessary to construct the crossing in between them, and there is no practicable alternative. The linear infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A.	0.16 ha Regrowth undifferentiated No impacts to PEMS. No ecological impact is expected.	0.16
PL198	PPZ of Cat C ESA (PWH) EWA (Wilkin Rd Crossing)		EWA proposed in the PPZ of ESA Cat C (PWH). Condition 8A allows for essential petroleum activities only in these ESA types. EWAs are not included in the definition of essential petroleum activity. Field Verification identified the area as 11.5.1 Regrowth. This EWA, which is temporary in nature, is required to conduct the crossing immediately east. The remaining infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A.	0.05 ha Regrowth 11.5.1 See Section 3.4 and Appendix F for assessment of PEMS.	0.05

PL198	PPZ of Cat C ESA (PWH and OCRE11.3.2) EWA (Boundary Road Crossing)		EWA proposed in the PPZ of ESA Cat C (OCRE 11.3.2). This EWA is over land which is mapped as cleared, however has been field verified as predominantly Derived Grassland, with a small section of regrowth undifferentiated in the southernmost section. This EWA is necessary to construct the crossing of the road immediately south. The remainder of infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A.	0.02 ha Regrowth undifferentiated 0.09 ha Derived Grassland See Section 3.4 and Appendix F for assessment of PEMS.	0.11
PL198	PPZ of Cat C ESA (PWH) Segregation Valve Area		This segregation valve area is proposed in the PPZ of Cat C ESA (PWH). Condition 8A allows for essential petroleum activities only in this ESA type. Segregation Valves do not meet the definition of essential petroleum activity. This area has been field validated as RE 11.5.1. This disturbance is necessary for installation of segregation valves, and there is no practical alternative to this location	0.24 ha Remnant 11.5.1 See Section 3.4 and Appendix F for assessment of PEMS.	0.24
PL198	PPZ of Cat C ESA (PWH) EWA Boundary Road RoW		EWAs proposed in the PPZ of ESA Cat C (PWH). Condition 8A allows for essential petroleum activities only in these ESA types. EWAs are not included in the definition of essential petroleum activity. Field Verification identified the area as partially in Regrowth undifferentiated or Remnant 11.5.1. This EWA, which is temporary in nature, is required to conduct the crossing immediately east. The remaining infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A, or proposed Condition Biodiversity 7.	0.03 ha Remnant 11.5.1 0.7 ha Regrowth undifferentiated 0.3 ha Cleared See Section 3.4 and Appendix F for assessment of PEMS.	0.13 (3 x EWA)

	PPZ of Cat C ESA (PWH) EWA (STP_PAD_WP601) Gathering		EWAs proposed in the PPZ of ESA Cat C (PWH). Condition 8A allows for essential petroleum activities only in these ESA types. EWAs are not included in the definition of essential petroleum activity. Field Verification identified the area as Remnant 11.5.1. This EWA, which is temporary in nature, is required to conduct the crossing immediately east. The remaining infrastructure is authorised as essential petroleum activity under Condition Biodiversity 8A	0.06 ha Remnant 11.5.1 See Section 3.4 and Appendix F for assessment of PEMS.	0.06
PL260	PPZ of Cat A ESA (National Parks - Lake Broadwater CP). Road (Broadwater Road)	See Figure 3-2	Scope is to widen existing Council Road in pre-disturbed area, which forms part of the PPZ of a Cat A ESA. No disturbance is proposed within the ESA itself. Field verification of these areas identified they were either cleared or regrowth undifferentiated. The cleared portion comprises approximately 9 ha of the total disturbance area. While most of this disturbance could be authorised under proposed Condition Biodiversity 7, for compliance and practicality, Arrow would prefer a despoite for the entire section, rather than piecemeal where regrowth has been ground verified.	0.32 ha Regrowth undifferentiated 8.98 ha Cleared No impacts to PEMS. No ecological impact is expected.	9.3
PL258	Cat C ESA (Essential Habitat) Road (Wilkin Rd)	See Figure 3-3	This is a necessary road upgrade of a Council Road, in an already heavily disturbed area. Ground verification identified approximately 4.6 ha of proposed disturbance as cleared, with the remaining 1.3 ha within 11.5.1 Regrowth. While some of this disturbance could be authorised under proposed Condition Biodiversity 7, for compliance and practicality, Arrow would prefer a despoite for the entire section, rather than piecemeal where regrowth has been ground verified.	1.3 ha Regrowth 11.5.1 4.6 ha Cleared See Section 3.4 and Appendix F for assessment of PEMS.	5.9

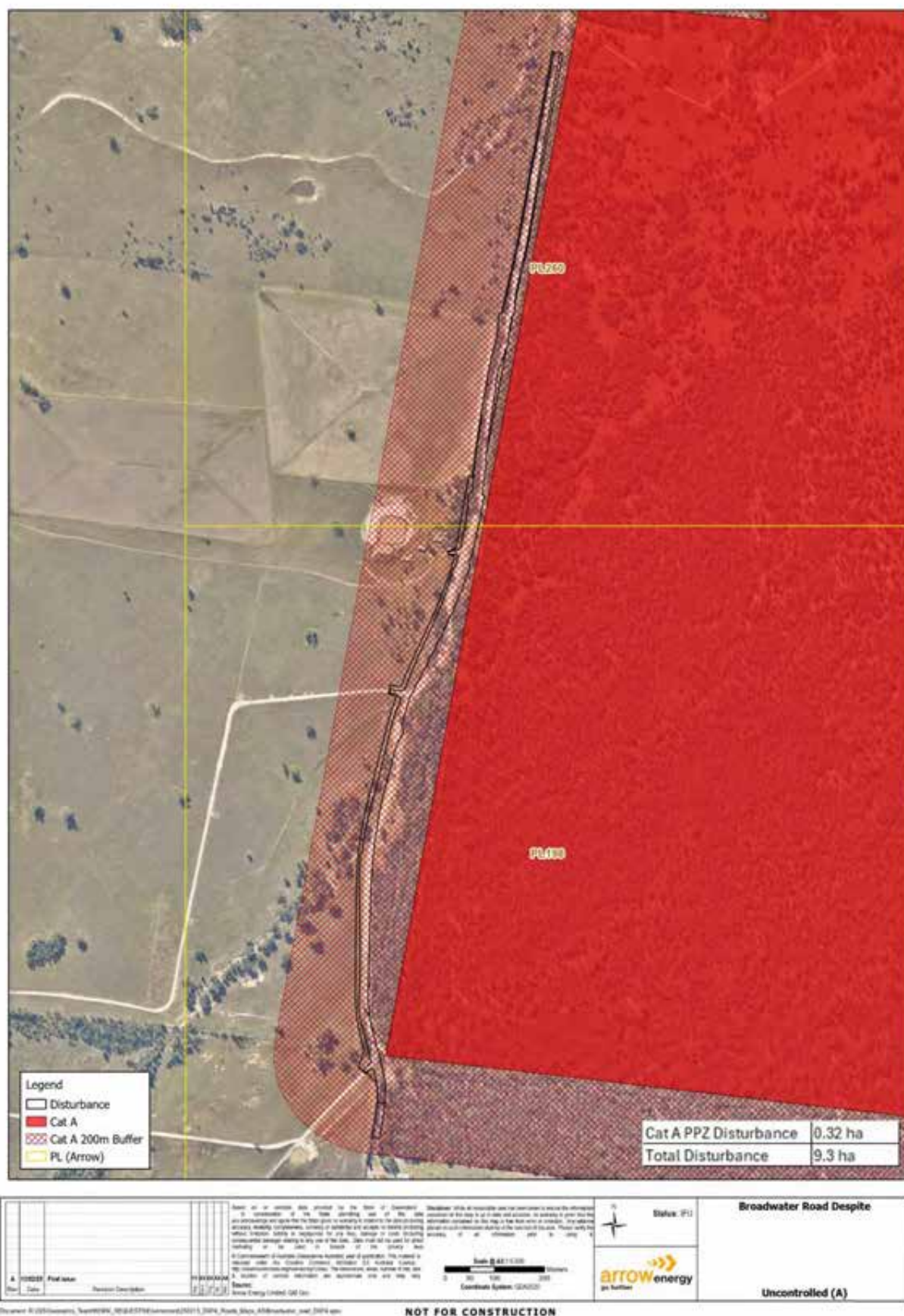


Figure 3-2 Road Scope (Broadwater Rd) Despite



Figure 3-3 Road Scope (Wilkin Rd) Despite

3.4 Prescribed Environmental Matters

Surat Gas Project – DXP 4 Significant Residual Impacts to Prescribed Environmental Matters (Appendix F) has been prepared to address relevant EA conditions for the above-mentioned project, specifically ‘Biodiversity 14’, by providing a significant residual impact (SRI) assessment on Prescribed Environmental Matters (PEMs) to determine the project’s environmental offset requirements under the Environmental Offsets Act 2014 (EO Act).

Arrow is yet to investigate options to avoid duplication regarding biodiversity offsets for many overlapping State and Federal matters for the same impact area. This, in combination with the time critical nature of this DXP4 SRI assessment report approval has led Arrow to identify a total of 132.40 ha of vegetation clearing to require an offset under the state processes for the following:

- Regulated vegetation:
 - Of Concern Regional Ecosystems
 - Regional ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse
 - Essential habitat (not in an urban area) for Endangered or Vulnerable wildlife for the Greater Glider.
- Connectivity Areas
- Wetlands of high ecological significance
- Protected wildlife habitat for the Koala, Grey Snake, Diamond Firetail, Death Adder, Greater Glider, Yellow-bellied Glider, Glossy Black-cockatoo, Brigalow Woodland Snail and Painted Honeyeater.

To facilitate the amendments necessary in Section 3.2 and 3.3, updates to the PEMS table will be required. Section 3.4.1 to 3.4.5 provide information on individual PEMs where the proposed impact requires an increase to the maximum extent of impact in existing Schedule D, Table 3.

Table 3-5 Updates to Schedule D, Table 3

Prescribed environmental matter	Maximum extent of impact (ha)	Stage 1f (DXP 4)
REGULATED VEGETATION		
Endangered regional ecosystem		
RE 11.3.21	3	0
RE 11.4.3	0.44	0.44 (MNES)
Of concern <u>regional ecosystem</u> (not within an urban area)		
RE 11.3.2	16	2.42
RE 11.3.4	15	0
RE 11.3.17	15	0
<u>Regional ecosystems</u> (not within an urban area) that intersect a <u>wetland</u> on the vegetation management <u>wetlands map</u>		
RE 11.3.4	1	0
RE 11.3.27	2	0
<u>Regional ecosystems</u> (not within an urban area) within the defined distance from the defining banks of a relevant <u>watercourse</u> on the vegetation management <u>watercourse map</u>		
RE 11.3.2 (17a)	0.86	0.11

Supporting Information Report
Environmental Authority Amendment DXP 4

RE 11.3.14	0.20	0.20
11.3.4 (16c)	4.28	0
11.3.18 (17a)	2.57	0.30
11.3.25 (16a; 22c)	12.86	0.56
11.4.12 (17a)	0.86	0
11.5.1 (17a; 18b)	4.28	0
11.7.4 (12a)	0.43	0.01
11.7.7 (12a)	0.86	0
Essential habitat (not in an urban area) for endangered wildlife		
<i>Hemiaspis damelii</i>	6	0
Essential habitat (not in an urban area) for vulnerable wildlife		
<i>Calyptorhynchus lathamii</i>	1	0
<i>Jalmenus eubulus</i>	0.5	0
<i>Petauroides volans</i>	0.003	0.003
CONNECTIVITY AREAS		
PL198	2.3 ha	
PL230	1.3 ha	
PL260	1 ha	
Connectivity area that is a Regional Ecosystem (not in urban area)	29.48	29.48
WETLANDS AND WATERCOURSES		
A wetland of high ecological significance shown on the Map of referable wetlands	1.5 ha 1.81	0.34 (no SRI)
PROTECTED WILDLIFE HABITAT		
An area shown as a high risk area on the flora survey trigger map that contains plants that are endangered or vulnerable wildlife		
<i>Picris barbarorum</i>	2.5	0
<i>Solanum papaverifolium</i>	3	0
Habitat for an animal that is vulnerable wildlife		
<i>Acanthophis antarcticus</i>	317	31.67
<i>Calyptorhynchus lathamii</i>	94	12.04
<i>Furina dunmalli</i>	27.25	27.25 (MNES)

<i>Grantiella picta</i>	0.94	0.94
<i>Nyctophilus corbeni</i>	29.11	29.11 (MNES)
<i>Petaurus australis</i>	21.79	21.79
<i>Petauroides volans</i>	24.40	24.50
<i>Stagonopleura guttata</i>	32.38	32.38
<i>Jalmenus eubulus</i>	17	0
<i>Tachyglossus aculeatus</i>	57	0
Habitat for an animal that is endangered wildlife		
<i>Hemiaspis damelii</i>	219	88.60
<i>Phascolarctos cinereus</i>	72.81	72.81
<i>Adclarkia cameroni</i>	8.27	8.27
Habitat for an animal that is Special Least Concern wildlife		
<i>Tachyglossus aculeatus</i>	57	11.69 (no SRI)
FISH HABITAT AREAS		
Waterway providing for fish passage – Fish passage (not in an urban area)	6.0	0.20 (no SRI)

3.4.1 Regulated vegetation

Endangered regional ecosystems

Approximately 0.44 ha of Endangered remnant RE 11.4.3 and 0.50 ha of Endangered regrowth RE 11.3.1 will be impacted by the Project. However, these vegetation communities (0.94 ha in total) are consistent with the Brigalow (*Acacia harpophylla* dominant and co-dominant) Threatened Ecological Community (TEC) listed as Endangered under the EPBC Act and as such offsets will be managed under the EPBC Act approval (EPBC 2010/5344).

However, The Department of Environment, Tourism, Science and Innovation (DETSI) considers regulated vegetation – Endangered Regional Ecosystems as a substantially different matter to habitat for protected species. Given the time-critical nature of the approval for this SRI report Arrow will include 0.94 ha in the Notice of Election (NoE) as protected wildlife habitat for applicable species (see Appendix F Section 4.2.7)

Regional ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse on the vegetation management watercourse map.

1.85 ha of seven (7) vegetation communities occur within the defined distance from the defining banks of a relevant watercourse will be impacted by the project. These include:

- 0.11 ha of remnant RE 11.3.2
- 0.27 ha of regrowth RE 11.3.2
- 0.20 ha of remnant RE 11.3.14
- 0.30 ha of remnant RE 11.3.18
- 0.56 ha of remnant RE 11.3.25

0.41 ha of regrowth RE 11.5.1
0.01 ha of remnant RE 11.7.4

These Regional Ecosystems are listed as 'Regional ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse on the vegetation management watercourse map' within the DXP4 EA with sufficient allowable impact areas.

Regulated vegetation is a prescribed regional ecosystem as defined in the EO Act and does not include regrowth vegetation. Therefore arrow, will only offset the remnant portion of the total area, not including the 0.27 ha of regrowth RE 11.3.2 and 0.41 ha regrowth RE 11.5.1.

This RE polygon also provides habitat for listed protected species under the EPBC Act. It is Arrow's consideration that under such circumstances the biodiversity offset associated with this PEM would therefore be managed under the EPBC Act approval (EPBC 2010/5343) and associated SGP Stage 1 Offset Strategy (EPBC Act Offset Strategy).

However, The Department of Environment, Training, Science and Innovation (DETSI) considers regulated vegetation within the defined distance from a watercourse as a substantially different matter to habitat for protected species. Given the time-critical nature of the approval for this SRI report Arrow will include 1.17 ha for this PEM in the Notice of Election (NoE) for this project.

Essential habitat (not in an urban area) for vulnerable wildlife

The remnant vegetation impacted by the project is located within the State-mapped Essential habitat mapping layer for one (1) Endangered species and one (1) Vulnerable species. This includes 0.01 ha within remnant RE 11.3.2 and 0.037 ha within regrowth RE 11.5.1 which is mapped as Essential Habitat for the Koala (*Phascolarctos cinereus*) (Vulnerable under the NC Act and Endangered under the EPBC Act) and 0.003 ha within remnant RE 11.3.25 which is mapped as Essential Habitat for Greater Glider (Endangered under the NC Act and Vulnerable under the EPBC Act).

Regulated vegetation is a prescribed regional ecosystem as defined in the EO Act and does not include regrowth vegetation. Therefore arrow, will only offset the remnant portion of the total area. Arrow will include 0.003 ha of essential habitat for Greater Glider for this PEM in the Notice of Election (NoE). The 0.38 ha of essential habitat in regrowth REs 11.3.2 and 11.5.1 is not regulated vegetation but overlaps with protected wildlife habitat for Koala (see Table 4 and Section 3.2.8) is offset for Koala under that PEM.

3.4.2 Connectivity Areas - connectivity area that is a Regional Ecosystem (not in urban area)

The LFC tool determined a significant impact on connectivity areas (*A significant a change from core to non-core remnant at the site scale is True*). The tool returned a total area of RVM Cat B clearing of 29.48 ha. Arrow will include a total area of 29.48 ha for connectivity areas within the Notice of Election for biodiversity offset.

3.4.3 Wetlands and Watercourses

A wetland of high ecological significance shown on the Map of referable wetlands

The Project intercepts 0.34 ha of a Government-mapped high ecological significance (HES) wetland/ Field surveys have shown that the bulk of this area has been subject to extensive

clearing and is highly disturbed and modified (e.g., existing access tracks, roads and cultivated areas). Where possible, to minimise impacts to mapped wetland areas, the RoW width has been reduced to 20m, with disturbances aligned with this existing infrastructure.

Arrow concludes that the disturbance of a total area of 0.34 ha for Government-mapped HES wetlands on land that has been cleared and is currently highly disturbed will not constitute a SRI and therefore will not be included this area in the Notice of Election for biodiversity offset.

Waterway providing for fish passage – Fish passage (not in an urban area).

There are fifteen mapped watercourses (Broadwater Gully and unnamed tributaries of Wilkie Creek and Condamine River) intersecting the project footprint, which are categorised by DAF as having 'low' and 'moderate' risks of impact for fish passage.

Waterway barrier works in a fish passage waterway will be undertaken in accordance with the DAF guideline "*Accepted development requirements for operational work that is constructing or raising waterway barrier works*" (DAF, 2018). The purpose of this section is to assess if the proposed pipeline crossing construction will have a SRI relating to the MSES 'Waterway providing for Fish Passage'.

Under the SRI Assessment Guideline (DEHP, 2014), an environmental offset may be required *'for any part of a waterway that provides for passage of fish (other than that part of a waterway within an urban area) if the construction, installation or modification of waterway barrier works carried out under an authority will limit the passage of fish along the waterway'*.

The results of the SRI assessment conclude that the construction and operation of the pipeline for the project is very unlikely to have a significant impact to a waterway providing for fish passage and will not limit the passage of fish along the waterway. An SRI for this PEM is not considered likely and therefore this PEM will not be included in the NoE for biodiversity offset for this project.

3.4.4 Protected wildlife habitat – habitat for an animal that is Endangered or Vulnerable

There is habitat for eleven (11) Endangered or Vulnerable species to be impacted by the project. In all situations, the specific area of habitat to be impacted for a listed species protected under the NC Act is also habitat to be impacted for a species protected under the EPBC Act. This includes 132.40 ha for the Koala, Grey Snake, Diamond Firetail, Death Adder, Corben's Long-eared Bat, Dunmall's Snake, Greater Glider, Yello-bellied Glider, Glossy Black-cockatoo, Brigalow Woodland Snail, and Painted Honeyeater, including:

0.50 ha of Regrowth RE 11.3.1
2.42 ha of remnant RE 11.3.2
4.08 ha of regrowth RE 11.3.2
2.00 ha of remnant RE 11.3.14
5.29 ha of remnant RE 11.3.18
0.71 ha of remnant RE 11.3.25
0.44 ha of remnant RE 11.4.3
10.55 ha of remnant RE 11.5.1
34.57 ha of regrowth RE 11.5.1
0.17 ha of remnant RE 11.5.1a
0.84 ha of regrowth RE 11.5.1a

0.14 ha of remnant RE 11.5.20
11.09 ha of remnant RE 11.7.4
29.09 ha of undifferentiated regrowth
30.50 ha of derived grassland

The 0.44 ha of remnant RE 11.4.3 and 0.50 ha of regrowth RE 11.3.1 are possible habitat for Koala, Grey Snake, Diamond Firetail, Death Adder, Glossy Black-Cockatoo, Brigalow Woodland Snail and Painted Honeyeater. However, this vegetation community is consistent with the Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC listed as Endangered under the EPBC Act and as such offsets will be managed under the EPBC Act approval (EPBC 2010/5344).

In most situations, the specific area of habitat to be impacted for a listed species protected under the NC Act is also habitat to be impacted for a species protected under the EPBC Act (Table 4). As noted in Section 3.2.1, Arrow will discuss with DES the approach to offsets when state matters overlap with federal matters to enable an agreed position for future SGP projects. However, given the time critical nature of this project (Stage 1f) application Arrow will include the areas of impacted PEMs for protected wildlife habitat. This totals an area of 132.40 ha to be included in the NoE for biodiversity offset for this project (refer to Appendix F Table 5 for full breakdown).

3.4.5 Protected wildlife habitat – habitat for an animal that is Special Least Concern

There is 11.69 ha of habitat for the Short-beaked Echidna, listed as a Special Least Concern species, to be impacted by the project. This habitat is comprised of State-mapped wildlife habitat (Special Least Concern species). It is unlikely that the construction of the pipeline will result in a long-term decrease in the size of a local population or reduce the extent of occurrence of the Short-beaked Echidna and is unlikely to result in population fragmentation or genetically distinct populations of Short-beaked Echidnas. Furthermore, it is unlikely that the construction works will result in a disruption to ecologically significant locations (breeding, feeding or nesting sites).

The results of the SRI assessment (Appendix F) conclude that the construction and operation of the pipeline for the project is unlikely to have a significant impact to the Short-beaked Echidna. An SRI for this PEM is not considered likely and therefore this PEM will not be included in the Notice of Election for biodiversity offset for this project

3.5 Administrative Changes

In addition to the amendments mentioned above, Arrow Energy also proposes to amend a number of administrative changes within the DXP EA. These are described in detail in **Appendix A**.

3.6 Impact Assessment for Environmental Values and Matters of State Environmental Significance (MSES)

Table 3-6 describes the environmental values identified as relevant to the proposed activity, based on surveyed and indicative alignments, and assesses potential impacts to identified values. Where the proposed amendment may potentially change the risk and magnitude of impacts to an environmental value, an assessment of impacts to these values is provided in the following sections. For completeness, a summary of the values not expected to be changed have been included in the table below. For these values there are existing conditions in the EA that appropriately manage the risk of emissions or releases as a result of construction or operational activities.

Table 3-6 Assessment of potential for proposed activities to affect environmental values (Disturbance)

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
Air	The Environmental Protection (Air) Policy 2019 identifies environmental values to be enhanced or protected in relation to the air environment. The environmental values to be enhanced or protected under the policy, which are relevant to this application are the qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems. The proposed activity is located in a rural area, predominantly used for pastoral activities, and intensely farmed cropping areas, with fragments of regional ecosystem. The location is also within active petroleum tenures, so some values of the air environment may be affected by authorised resource activities. DESI' Greenhouse Gas Emissions Guideline 2024 (ESR/2024/6819) notes that an amendment application	Air quality impacts, such as dust, will be minor and restricted to the worksite for a minimal period during construction. During normal operation, potential air quality impacts are expected to be minimal and restricted to ad-hoc light-vehicle traffic. Dust suppression measures will be implemented to minimise dust deposition as required. The subject of this application does not seek to increase or include the authorisation or operation of the wells and impacts on environmental values as they are already authorised under the EA. This application only seeks authorisation for the location of these well pads and associated infrastructure within ESAs and PEMS. Air environmental values and any potential impacts, managed and authorized by the existing conditions, are expected to remain unchanged as a result of the proposed activities.	No

Supporting Information Report
Environmental Authority Amendment DXP 4

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
	must include all information outlined in the Guideline, but only to the extent they relate to the proposed amendment.	The proposed activity would comply with existing EA conditions regarding the air environment.	
Noise	The Environmental Protection (Noise) Policy 2019 identifies and declares environmental values of the acoustic environment. The environmental values identified and declared by the policy which are relevant to this application are: <i>a. the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and</i> <i>c. the qualities of the acoustic environment that are conducive to protecting the amenity of the community.</i> The proposed activity is situated in a rural location that is expected, in general, to have a low background noise level. The location is also within active petroleum tenures, so some values of the air environment may be affected by authorised resource activities.	The proposed activity is located in an area primarily used for cropping and petroleum and gas activities. There will be no greater impact on any affected persons or affected community as a result of this amendment application. Acoustic environmental values and any potential impacts, managed and authorized by the existing conditions, are expected to remain unchanged as a result of the proposed amendment. Construction and operational noise impacts on the surrounding amenity of the rural community are assessed and are appropriately managed by Arrow, including stakeholder engagement, low-noise equipment, restricted hours of operation and / or alternative arrangements as required. The proposed activity would comply with existing EA conditions regarding the acoustic environment.	No
Land	See Section 3.7	See Section 3.7	Yes

Supporting Information Report
Environmental Authority Amendment DXP 4

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
Community	Persons and communities that may be impacted by the proposed amendment are the surrounding sensitive receptors.	Petroleum activities in DXP Project Area are authorised subject to existing conditions of EPPG00972513. These conditions include requirements to appropriately protect amenity values of the surrounding communities. Arrow holds a CCA with the landholders subject to the EA amendments. Arrow intends to continue to comply with those conditions. There will be no greater impact on any affected persons or affected community as a result of this amendment application. Environmental and social factors are considered as part of Arrow's internal processes in deciding appropriate locations for proposed petroleum activities. Construction and operational noise impacts on the surrounding amenity of the rural community are assessed and are appropriately managed including stakeholder engagement, quiet drilling practices, low-noise equipment, restricted hours of operation and / or alternative arrangements as required.	No
Waste	The proposed amendment will not generate any waste expected to affect existing environmental values, including the life, health, and wellbeing of people; the diversity of ecological processes and associated ecosystems; and the land use capability.		No

Supporting Information Report
Environmental Authority Amendment DXP 4

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
Water and Wetlands, and Cultural Heritage.	The <i>Environmental Protection (Water and Wetland Biodiversity) Policy 2019</i> identifies environmental values for waters and wetlands to be enhanced and protected. The environmental values of wetlands to be enhanced or protected, relevant to this application are: • Health of wetland ecosystems; • Natural state and biological integrity; and • Natural hydrological cycle; and interaction with other ecosystems. PL238 and PL260 are predominantly in the Condamine-Balonne Basin. The environmental values of waters to be enhanced or protected, relevant to this application are described in the Condamine River Basin Environmental Values and Water Quality Objectives: • Protection of aquatic ecosystems; The suitability of the water for human use	Watercourses in the Condamine- Balonne Basin are mostly ephemeral with the exception of major watercourses (i.e. the Condamine and Balonne Rivers). The catchment and watercourses have been heavily impacted by anthropogenic pressures including agriculture and intensive farming practises. The area of the proposed infrastructure is in precleared disturbed land and no impacts to the wetland are predicted beyond that already occurring at the location, due to the existing land use. The activities are on existing cropped disturbed land. With the implementation of erosion and sediment control, dust suppression and eventual rehabilitation, the risk of adverse environmental outcomes are considered very low. The proposed activities would not adversely impact wetlands or watercourses. Where possible, the proposed activities avoid disturbance to land in watercourses and wetlands. Erosion and sediment control would be appropriately managed, in accordance with Arrows existing management plans. Save for the proposed amendments, the proposed activities would comply with existing EA conditions regarding the water and wetlands environment.	Yes

Supporting Information Report
Environmental Authority Amendment DXP 4

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
		No material change to the environmental values protected by the current EA conditions, are expected as a result of the proposed activities.	
Underground water rights	The proposed amendment involves above ground activity that will not affect groundwater or the exercise of underground water rights.		No

3.7 Land and Biodiversity

3.7.1 Applicable legislation

The following legislation, policy and guidelines are relevant to identifying values and mitigating and managing impacts on biodiversity for the Project.

- *Environmental Protection Act 1994* (Qld) (EP Act): The objective of the EP Act is to protect Queensland's environment by promoting ecologically sustainable development.
- *Environmental Protection Regulation 2019* (Qld) (EP Reg): This regulation provides a mechanism to enforce the EP Act and allows for an assessment of the risk that an environmentally relevant activity poses to ESAs.
- *Environmental Offsets Act 2014* (Qld) (EO Act): The main purpose of this act is to counterbalance the significant residual impacts of particular activities on prescribed environmental matters through the use of environmental offsets, by: (a) establishing a framework for environmental offsets; (b) recognising the level of protection given to prescribed environmental matters under other legislation; (c) providing for national, State, and local matters of environmental significance to be prescribed environmental matters for the purpose of this act; (d) coordinating the implementation of the framework in conjunction with other legislation.
- *Environmental Offsets Regulation 2014* (EO Reg) (Qld): This regulation provides details of the prescribed activities regulated under the existing legislation and prescribed environmental matters to which the EO Act applies.
- *Queensland Environmental Offsets Policy, Version 1.14*: This policy provides a single, consistent, whole-of-government policy for the assessment of offset proposals to satisfy offset conditions.
- *Environment Protection and Biodiversity Act 1999* (Cwlth) (EPBC Act): This Commonwealth act provides for the protection of matters of national environmental significance, including groundwater resources that relate to coal seam gas development. Any action with the potential for a significant impact on these matters must be referred to the Minister for the Department of Climate Change, Energy, the Environment and Water and may require approval under this act.
- *Vegetation Management Act 1999* (Qld) (VM Act): This act regulates the clearing of vegetation in a way that: (a) conserves remnant vegetation that is an 'endangered' or an 'of concern' or a 'least concern' regional ecosystem; and (b) conserves vegetation in declared areas; and (c) ensures the clearing does not cause land degradation; and (d) prevents the loss of biodiversity; and (e) maintains ecological processes; and (f) manages the environmental effects of the clearing; and (g) reduces greenhouse gas emissions; and (h) allows for sustainable land use.
- *Planning Act 2016* (Qld): This act establishes an efficient, effective, transparent, integrated, coordinated, and accountable system of land use planning, development, assessment, and related matters that facilitates the achievement of ecological sustainability.
- *Nature Conservation Act 1992* (Qld) (NC Act): This act regulated the clearing of native plants in Queensland to protect 'critically endangered', 'endangered', 'vulnerable', and 'near threatened' plants. Provides for the gazettal of protected areas, including nature refuges; prescribes classes of wildlife; and sets out restrictions on the taking or harm to native wildlife without a valid permit.

- *Nature Conservation (Plants) Regulation 2020* (Qld) (NC Reg Plants): This regulation contains the clearing regulatory requirements and the list of 'critically endangered', 'endangered', 'vulnerable', or 'near threatened' plants.
- *Nature Conservation (Animals) Regulation 2020* (Qld) (NC Reg Animals): This regulation provides for the conservation and management of protected animals in Queensland by: listing animal species under the conservation classifications under the NC Act; providing a management approach for each classification based on the threat of extinction to the species; providing general authorisations for interactions with animals in the wild; providing a permitting and authorisation framework for taking, keeping, and using native animals outside of protected areas; streamlining the licencing framework for keeping and using animals; including administrative arrangements for permitting and licencing frameworks; specifying offences and associated penalties; and including transitional provisions to allow continuity and preserve existing rights.
- *Queensland Government Protected Plants Framework and Species Management Program*: establishes the requirement for proponents to complete flora surveys prior to clearing, to locate any extinct, extinct in the wild, critically endangered, endangered, vulnerable, or near threatened plants within a clearing impact area. Pre-clearing surveys are typically conducted twelve months prior to construction to support for a clearing permit under the NC Act.

3.7.2 Description on Environmental Values

Description of general ecological values

The area subject to the proposed infrastructure has undergone significant disturbance attributable to subsistence activities, including cropping and agriculture. Notably, the southern section of this area—specifically the tenement PL198 Boundary Road development—exhibits the most substantial remnants of native vegetation. The landscape within tenement PL198 is characterized by a combination of bushland and grazing areas, reflecting the intensive beef production practices prevalent in the region.

The impacts on these areas have notably affected habitat quality, particularly due to intensive land use for cultivation. This is especially true for regions near the Condamine River floodplain, which is collectively known as the Condamine River Alluvium. The productive alluvial clay soil in this area has led to significant agricultural activities, primarily focused on tilled cropping (Ecosmart 2017).

While ecosystem types found on soils of low fertility—specifically those associated with land zones 5 and 7—constitute the largest and most continuous areas of vegetation (mainly southern PL198), they have largely been exploited for their timber resources, which has resulted in varying levels of impact. In particular, habitats characterized by Narrow-leaf Ironbark species such as *Eucalyptus crebra*, *E. elegans*, and *E. woollsiana* (REs 11.5.1, 11.5.4, 11.7.4, and 11.5.20) have experienced logging to the extent that all mature canopy trees have been removed (Ecosmart, 2017).

3.7.3 Assessment of environmental impacts

Biodiversity impact assessment methodology

Coal seam gas developments apply an iterative process in terms of locating wells and gathering lines to manage competing constraints associated with the location of surface

Supporting Information Report

Environmental Authority Amendment DXP 4

infrastructure, including ecological values, landholder preferences, geological features, existing infrastructure, and access tracks. Planning and management of surface activities and ground disturbance is undertaken utilising a set of hierarchical management principles to avoid, minimise and mitigate impacts to environmental values. These principles are:

- **Avoid:** Arrow Energy's first preference is to avoid PEMs, threatened ecological communities and the habitat of PEMs listed threatened species.
- **Minimise:** where other competing constraints or the scale and location of PEMs communities or species habitat dictate that avoidance is not possible (e.g. where there is riparian vegetation that need to be crossed or large areas of suitable habitat for wide ranging species such as the koala, Greater Glider or Painted Honeyeater), Arrow Energy's will preferentially locate infrastructure in a manner that minimises the impact to these values (e.g. cross the riparian vegetation at the narrowest or most degraded part or where practicable on the edge of suitable habitat for listed species so as not to bisect good quality habitat).
- **Mitigate:** implement mitigation measures to further minimise the direct and indirect impacts on ecological values.
- **Remediate and rehabilitate:** actively remediate and rehabilitate impacted areas to promote and maintain long term recovery.
- **Offset:** Arrow Energy will offset unavoidable significant residual impacts to PEMs.

The siting of the Lynwood FCS has been selected on land owned by Arrow Energy. The FCS has been sited to take advantage of existing cleared areas, with minor clearing in adjoining regrowth or remnant areas required for establishment.

For disturbance relating to ESAs and PEMS, this generally relates to well pads, gathering, and access which is necessary for development, and where there are no suitable alternate routing alternatives.

Biodiversity values have been assessed through the following studies:

- Surat Gas EIS ecological studies – broad-scale aquatic and terrestrial ecology studies undertaken between 2011 and 2013;
- Surat Gas Project Terrestrial Ecological Report (EcoSmart 2017) – Studies undertaken to address EIS commitments and approval conditions. There were undertaken over an area just over 200,000 ha and included:
 - Habitat mapping rules – assessment of potential habitat based on the results of pre-clearance surveys and through the application of peer-reviewed mapping rules to assess habitat impacts for potential threatened species;
 - Pre-clearance surveys – targeted local scale ground-truthing surveys undertaken in and around the proposed works on proposed disturbance area. These surveys have occurred over the last 5 years and as recently as 2024. The occurrence of Regional Ecosystems has been ground-truthed using methodologies consistent with Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities (Neldner et al 2023).

The SGP ecology report (attachment 5) states:

Supporting Information Report

Environmental Authority Amendment DXP 4

For the purpose of targeted survey sites, the terrestrial fauna surveys used a variety of recognised survey methods consistent with relevant federal and state survey guidelines. These included trapping (Elliot, pitfall, funnel and Harp), observation (spotlighting, bird survey, and active search), remote sensing (Anabat ultrasonic bat detection and camera trapping), and targeted methods (Koala [SAT] and Glossy Black Cockatoo ort searches, tripline, artificial shelter).

In addition to those detailed in the EcoSmart Report, Arrow ecologists surveyed the area from 2013 to 2024. The entire alignment has been assessed, and further information is provided in the EcoSmart Report (Appendix E).

Ground Truthing Surveys

With the intention of obtaining contemporary data prior to the approval of construction, Arrow have undertaken a significant number of ground-truthing surveys across the DXP. Prior to 2023 (2011 to 2022), 168 Secondary and 52 Quaternary surveys (approximately 176.5 hours of survey effort) were completed within 300 m of the disturbance footprint. This historical data has allowed arrow to build a robust understanding of the key ecological constraints in the disturbance footprint. Contemporary surveys between January 2023 to December 2024 have assessed a large portion of the 611 ha DXP disturbance footprint, providing accurate ground-truthed information to inform the approvals process (Table 3-7). Assessments were completed within the disturbance footprint and the surrounding 300 m to account for ESA protection zones.

The ecological surveys have incorporated elements of both the BioCondition (Eyre, et al 2015) and CORVEG (Neldner, et al 2019) assessment methods in use in Queensland and enabled detailed descriptions of RE and vegetation communities, records of field traverses to verify RE, vegetation mapping (Site Validation), incidental observation of Wildlife and possible habitats, assessments of koala habitats (Spot Assessment Technique by Phillips and Callaghan, 2011) and analysis of the quality of the environment of koala habitats (Habitat Assessment by Jurskis, 2001) (Koala survey).

Table 3-7 2023 – 2024 Contemporary ground-truthing survey effort

Assessment	Assessment description	Site quantity			Approximate effort (hours)
		Disturbance footprint	300 m from disturbance footprint	Total sites	
Secondary	Secondary sites are intended for detailed classification of REs and can take up to one hour depending on a variety of factors such as the complexity of the site and the level of disturbance present. Data collected includes a complete structural assessment, an inventory of species, percentage cover and abundance of species (Neldner <i>et al.</i> 2024). Additionally, Arrow incorporates information on species habitat (i.e. habitat assessments) through assessments including site physiography, fauna habitat features, micro-habitat features and fauna signs within the ecologically stratified unit (ESU).	28	74	102	102 hours (1 hour per site)
Quaternary	Quaternary sites are intended to be rapid assessments, no longer than a couple of minutes (Neldner <i>et al.</i> 2024). Arrow undertakes these surveys to accompany Secondary sites when mapping broader areas of an ESU. Therefore, Quaternary sites will include additional information such as height, stratum and cover to demonstrate equivalence between the more detailed Secondary sites. Basic habitat information is	83	126	209	35 hours (10 minutes per site)

Supporting Information Report

Environmental Authority Amendment DXP 4

	recorded at these sites (e.g. presence of gilgai or presence of hollow-bearing trees).				
Koala surveys	Koala surveys were conducted in areas of remnant and regrowth vegetation with Koala habitat trees present. Floristics are recorded alongside a SAT search where any evidence of Koala is recorded.	2	20	22	7.5 hours (20 minutes per site)
Total		113	220	333	186.5

Two observations of Grey Snake (*Hemiaspis damelii*) have been made in the disturbance footprint; one deceased (March 2024) and another found adjacent to a well (April 2021). No other threatened species were observed within the DXP disturbance footprint.

As the DXP disturbance footprint avoids any protected plants high-risk trigger mapping, no formal threatened flora meanders were completed. Informal threatened flora searches were performed as Ecologists meandered the disturbance footprint on foot. No Threatened flora species were observed within the disturbance footprint.

Habitat loss or fragmentation and connectivity impacts

While the overall clearing areas are large, clearing within remnant vegetation for gas field development is undertaken in 'chunks', with disturbance areas of 1-2 ha for individual well pads or linear corridors of 20-27 m width with surrounding vegetation left intact. However, the Landscape Fragmentation and Connectivity (LFC) Tool which has determined the impacts on connectivity areas within the DXP amendment area to be significant. Impact values generated by the LFC Tool have been included in the PEMs table in Section 3.4

Specific EA amendments to the DXP EA Schedule D – Protecting Biodiversity Values

Biodiversity impacts associated with the development of the Project require amendments to the DXP EA, specifically:

- the inclusion of conditions to authorise impacts to ESAs where the petroleum activities proposed are not in accordance with *Schedule D, Table 1 – Authorised petroleum activities in environmentally sensitive areas and their protection zones* (refer to Section 3.3) ; and
- amendments to *Schedule D, Table 3 – Significant residual impacts to prescribed environmental matters* where the impact areas proposed by the Project exceed the authorised limits in the DXP EA (refer to Section 3.4)

3.7.4 Potential Impacts and proposed management practices

Arrow Energy implements environmental management controls and practices through its Environmental Management Framework (the framework) and the Health Safety and Environment Management System (HSEMS).

The principal objective of the environmental framework is to protect the environmental values of the project development area (as defined in government policies and regulations or as an attribute of the environment that is conducive to ecological health, public amenity, or safety), and to identify appropriate environmental management controls for the Project activities having regard to the constraints imposed by the environment values.

Implementation of the environmental framework allows Arrow to:

- Address uncertainty about potential impacts of the location and timing of coal seam gas infrastructure development;
- Identify constraints to coal seam gas development in the project development area having regard to the sensitivity of identified environmental values;
- Document the constraints through mapping or the establishment of guidelines (including buffers, thresholds, and trigger levels) to inform site and route selection for coal seam gas infrastructure;
- Develop environmental management controls to address the identified constraints; and
- Integrate the environmental framework with the HSEMS.

The framework approach ensures planning and development of coal seam gas fields will occur in an orderly manner through the application of environmental management controls such as avoidance, mitigation, and management, that are reflective of the level of sensitivity of environmental values. The sensitivity or vulnerability of an environmental value to change provides an indication of the level of constraint it poses to the development of coal seam gas infrastructure, which then determines the recommended environmental management controls, such as avoidance, separation distances, or buffers, or site specific management.

In summary, the level of environmental constraints provides an indication of the Project activities that could occur in a particular area, subject to the application of appropriate environmental management controls, and also of those activities that should not occur

Supporting Information Report
Environmental Authority Amendment DXP 4

in certain areas. Controls and mitigation measures are incorporated into the standard operating procedures.

The standard operating procedures describe the process and frequency of updates to the constraints maps (i.e., GIS layers), and incorporate the following requirements:

- A periodic review of the constraints criteria to ensure they reflect state and federal government policy, guidelines and listings, and the results of any environmental impact assessment undertaken by Arrow Energy;
- A periodic update of the Project GIS to incorporate updated government datasets and the results of any ecological surveys, and any environmental impact assessment processes undertaken by Arrow; and
- A constraints analysis, as required, to ensure constraints mapping is up to date.

Specific standard operating procedures include:

- Site and route selection;
- Ecological and pre-construction clearance surveys; and
- Equipment and materials selection and facility design.

For further detail and information regarding Arrow Energy's Environmental Framework, refer to SGPEIS Chapter 8 Environmental Framework.

4. Proposed EA Amendments – Lynwood Field Compression Station

4.1 Overview

All infrastructure requiring disturbance to ESA, HES, and their PPZ discussed in Section 3 is currently authorised under the DXP EA. The only exception is the additional four-compressor unit, Field Compression Station (Lynwood FCS) being sought under this amendment. This infrastructure was considered in the approved SGP EIS and SREIS (Arrow Energy 2012, 2013) and is approved under EPBC 2010/5344.

The purpose of the Lynwood FCS is to compress and dehydrate gas from Arrow's Surat Basin Lynwood production areas for delivery to QGC's existing Jordan CPP, where the gas will be further compressed and dehydrated to meet sales gas specification requirements. The Lynwood FCS will be sized for an initial nominal gas flow capacity of 115 MMscfd.

Table 4-1 outlines proposed amendments to Schedule A, Table 1 - Authorised Petroleum Activities. This amendment application is seeking an additional Central gas processing facility (the Lynwood FCS), however no increase to the total number of compressor units (40 units) is being sought.

Table 4-1 Proposed amendments to Schedule A, Table 1 – Authorised Petroleum Activities

Activity(ies)	Total scale of petroleum activities / infrastructure	Intensity / maximum size
Total coal seam gas wells, including: Core wells Exploration wells Development wells Production wells	1,324 wells	1,324 ha
Communication towers	7	7 units, 7 ha
Injection well(s) and associated facilities	1	4 ha
Compressor units	40	40 units, 8 23 ha
Central gas processing facilities (Field Compression Station including compressor units, power station, and flare)	2-3	2-3 facilities, 8 23 ha
Regulated structures	22	22 dams
Water treatment facilities	2	12 ML/d (each), 2 ha

Supporting Information Report
Environmental Authority Amendment DXP 4

Activity(ies)	Total scale of petroleum activities / infrastructure	Intensity / maximum size
Sewage treatment plants	2	Less than 450 EP (each), 0.15 ha
Sewage treatment plants	9	Less than 100 EP (each), 0.15 ha
Power stations	1	40 MW, 1.2 ha

Schedule F, Table 1 – Authorised Point Sources, and Schedule F Table 2 – Annual Air Quality Monitoring will require amendments to reflect the location and description of the additional infrastructure which form the additional FCS.

Table 4-2 Proposed amendments to Schedule F, Table 1 — Authorised point sources

Tenure	Facility	Release Point Reference	Unit Description	Minimum Release Height (m)	Minimum Efflux Velocity (m/sec) ¹	NOX as Nitrogen Dioxide	Carbon Monoxide
						Maximum Mass Emission Rate (g/sec) ¹	Maximum Mass Emission Rate (g/sec) ¹
PL230	Daandine Central Gas Processing Facility	A1	K-0001 Compressor 1	10	30	3	5.5
		A2	K-0002 Compressor 2				
		A3	K-0003 Compressor 3				
		A4	K-0004 Compressor 4				
		A5	K-0005 Compressor 5				
		A6	K-0006 Compressor 6				
		A7	K-0007 Compressor 7				
		A8	K-9008 Compressor 8	17	17	1.4	4.8
		A9	K-9009 Compressor 9				
		A10	K-9010 Compressor 10				
		A11	K-9011 Inlet Fuel Screw Compressor Engine 11	8.5	30	1.5	1
PL 198	Tipton West Central Gas Processing Facility	A14	K-0001 Compressor 1	7.6	30	6.8	5.5
		A15	K-0002 Compressor 2				
		A16	K-0003 Compressor 3				

Supporting Information Report
Environmental Authority Amendment DXP 4

		A17	K-0004 Compressor 4	17	17	1.4	4.8
		A18	K-0005 Compressor 5				
		A19	K-0006 Compressor 6				
		A20	K-0007 Compressor 7				
		A21	K-0008 Compressor 8				
		A22	K-0009 Compressor 9				
		A23	K-0010 Compressor 10				
	Tipton Water Treatment Facility ²	A24	K-0015 Inlet Fuel Gas Compressor Engine	8.5	38	1.5	1
		A25	Generator 1	7.5	27	1.5	1.5
		A26	Generator 2				
		A27	Generator 3				
		A28	Generator 4				
		A29	Generator 5				
	Lynwood Field Compression Station	A30	Generator Stack 1	5.5	12	0.8	NA
		A31	Generator Stack 2				
		A32	Generator Stack 3				
		A33	Generator Stack 4				
		A34	Generator Stack 5				
		A35	Generator Stack 6				
		A36	Generator Stack 7				
		A37	Generator Stack 8				
		A38	Generator Stack 9				
		A39	Generator Stack 10				
		A40	Generator Stack 11				
		A41	Generator Stack 12				
		A42	Generator Stack 13				
		A43	Generator Stack 14				
		A44	Generator Stack 15				
		A45	Generator Stack 16				
		A46	Generator Stack 17				

Supporting Information Report

Environmental Authority Amendment DXP 4

		A47	Generator Stack 18				

¹ Minimum efflux velocity, maximum mass emission and maximum concentration limits relate to plant maximum continuous ratings.

² The Water Treatment Facility's aggregated fuel consumption exceeds the 500 kg per hour threshold when all five generators are in simultaneous operation.

Table 4-3 Proposed amendment to Schedule F, Table 2 – Annual Air Quality Monitoring

Release Point	Parameter ¹		Minimum Monitoring Frequency
	Mass emission rate (g/s)	Concentration (mg/Nm ³)	
A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18, A19, A20, A21, A22, A23, A24, A25 ² , A26 ² , A27 ² , A28 ² , A29 ²	oxides of nitrogen (measured as NO ₂)	oxides of nitrogen (measured as NO ₂)	Biennial from commission
A30 ³ , A31 ³ , A32 ³ , A33 ³ , A34 ³ , A35 ³ , A36 ³ , A37 ³ , A38 ³ , A39 ³ , A40 ³ , A41 ³ , A42 ³ , A43 ³ , A44 ³ , A45 ³ , A46 ³ , A47 ³	carbon monoxide	carbon monoxide	

¹ Measured in flue gas at the 5% oxygen reference level

² Biennial monitoring is not required until at least four of the five generators are commissioned

³ Monitoring of carbon monoxide from A30 – A47 is not required as per Schedule F, Table 1 – Authorised point sources.

Schedule D – Land Management

Additional conditions to Schedule D are required to authorise stormwater management practices at the Lynwood FCS. Water management and associated infrastructure is discussed further in Section 4.2.4

Proposed Conditions

Land 10 Stormwater Management The size of any sedimentation dam must be sufficient to contain the run-off expected from a 24-hour storm with an average recurrence interval of 1 in 5 years.

Land 11 Contaminants other than settled/treated stormwater runoff waters must not be released from the site to land.

Land 12 There must be no release of stormwater runoff that has been in contact with any contaminants at the site to any waters, roadside gutter or stormwater drain other than as authorised under conditions Land 11

Land 13 Condition DX3 does not prohibit the release of stormwater provided that the stormwater has been treated in an oil/water interceptor, sedimentation basin or other process to effectively remove contaminants before the stormwater is released to waters.

These proposed conditions are in line with other Environmental Authorities which authorise similar activity at the same scale and intensity as Lynwood FCS (e.g. ERA14 conditions). Proposed condition Land 10 is in line with the International Erosion Control Association (IECA) Australasia recommended design event for Type A sediment basins. These conditions only relate

Supporting Information Report
Environmental Authority Amendment DXP 4

to stormwater. Process water will be captured, treated through an oil/water separator, and be pumped back into the Produce water network for further treatment and beneficial reuse.

Stormwater is unable to be managed in this way due to commercial obligations and definition within the Water Services Agreement (WSA) between Arrow and QGC. Instead, stormwater which does not fall directly over the FCS footprint will be segregated and report into one of two sediment basins. This system has been designed by a Certified Professional in Erosion and Sediment Control (CPESC) in line with IECA standards. Stormwater which falls over the FCS footprint and has potential to become contaminated with oil from FCS infrastructure will drain to an oil/water interceptor, and then into an overflow drain for release following treatment. Oil removed from this stormwater will be collected and transported by a third party licenced and authorised to transport the waste.

4.2 Description of Proposed Additional Infrastructure

4.2.1 Field Compression Station

Location and components

Gas through the Lynwood FCS will contribute to fulfilling the growing demand for natural gas in both domestic and international markets through a gas sales agreement with QGC.

Arrow has undertaken a desktop study to identify a suitable location for the Lynwood FCS, which considered both technical and non-technical risk. This study was further verified and identified PL198, Arrow owned property 41DY363 and 40DY363 as the most suitable location. A total footprint of 15ha will be used for the FCS, with an additional 18ha being proposed for ancillary infrastructure (laydown, dams, stockpiles etc).

The current Schedule A, Table 1 provides for 8ha of disturbance for the two CGPF. These CGPF (namely Tipton CGPF and Daandine CGPF) have a much smaller processing capacity 36 TJ/d and 70 TJ/d than the proposed Lynwood FCS (120 TJ/d) and as such less infrastructure and a smaller footprint was required.

Of the 20 compressor units authorised under existing Schedule A, Table 1, a total of 10 have been used across the two existing CGPFs. These are different designs to the Lynwood FCS, where much smaller units have been installed. The Lynwood FCS has been designed with four compressor units. The change to Schedule A, Table 1 is only required to authorise where these units are utilised.

The Lynwood FCS will compress and dehydrate gas from Arrow's Surat Basin Lynwood production areas for delivery to QGC's existing Jordan CPP, where the gas will be further compressed and dehydrated to meet sales gas specification requirements. The Lynwood FCS will consist of:

- Four (4) screw compressors which compress the low-pressure CSG with normal throughput of 115 MMscfd
- A dedicated power plant to provide electricity for the compressors and Lynwood FCS facilities, comprising 16 × 1.8 MW gas engines plus two standby 1.8 MW engines), which is further discussed in section 4.2.2;
- A Battery Energy Storage System (BESS) may be built within the compound and footprint of the Lynwood FCS power plant. In addition, a solar farm may be built as an incidental activity to help reduce GHG impacts, and offset power usage required at the power plant;
- A multi-point ground flare (MPGF)³ to manage distressed gas and upset conditions, which will normally operate during unplanned outages, maintenance, and commissioning ramp up. The MPGF is designed to feature a surrounding fence and wall to minimise noise impacts, prevent access by fauna, reduce radiation and to reduce visibility of the flare flame;
- A slug catcher to remove water in the gas line; and
- Filter coalescers to remove solids, liquids fines and carryover compressor oil in gas line.

³A Civil Aviation Safety Authority (CASA) approval is not required for the ground flare as the height is less than 100 m.
S00-ARW-ENV-APL-00016
February 2025 - Version 0
Page 29 of 126

Figure 4-1 shows the Lynwood FCS proposed footprint and layout, including the power plant.

Construction

During construction of the Lynwood FCS, it is expected that there will be heavy vehicle movements, buses, and light vehicles to and from site. A Traffic Management Plan will be developed to manage and reduce impacts on local roads and ensuring haulage routes and approved roads are utilised once final logistics and contracts have been confirmed. It is expected that work would occur seven days a week for the duration of the FCS construction but limited to daytime hours of 7 am to 6 pm and subject to compliance with the noise conditions in the DXP EA.

Construction materials including the compressors and gas fired generators, etc. will be brought in from the suppliers and staged at a laydown on site.

A construction office including crib rooms, toilets and ablution facilities will be provided on site at the Lynwood FCS for the duration of the construction and commissioning of the FCS and power station. Upon completion, the office, crib rooms and toilets may be decommissioned and taken off site with the area either utilised as laydown in the future or rehabilitated in agreement with the landholder or back to its previous land use.

Construction of the Lynwood FCS would take approximately 16 months and involve the following activities and typical equipment during the period of peak activity:

- Clear and grade of the site: Grader, D8 Dozer, tipper, bobcat, mulcher, and a couple of light vehicles.
- Constructing concrete foundations: Concrete truck, concrete vibrator, and a couple of light vehicles.
- Installing new components and sheds: a 250 tonne crane for lifting equipment, welding rigs (diesel), angle grinders, pile rig, three (3) Franna 20 tonne cranes, two (2) scissor/boom lifts, two (2) semi-trailers for delivery of equipment, and hand tools.

Commissioning

Commissioning of the Lynwood FCS and the power station will occur at the same time and will require CSG from the surrounding gas fields. As noted above, commissioning will utilise the existing construction offices and facilities, and may require workers to be present for 24/7 operating in two 12 hour shifts, although commissioning usually occurs during daytime, only with occasional night time works when doing compressor test runs. It is estimated that commissioning will last four (4) months.

In the event of upset conditions during commissioning, flaring of gas at the ground flare may occur resulting in visible smoke from the burning of gas for a period of time. Given the design of the ground flare and that methane burns with a non-smoky flame, this is unlikely to occur. The design of the ground flare includes a 16.7m high fence around the perimeter of the ground flare to minimise visual and noise impacts.

Operation & Maintenance

The Lynwood FCS is designed as a not normally manned facility. Operations and maintenance staff based in the Surat Basin will provide operations and maintenance support for the Lynwood FCS. Primary control and operation of the Lynwood FCS will be performed remotely from the Arrow Operating Centre in Brisbane.

Supporting Information Report
Environmental Authority Amendment DXP 4

During turn arounds and maintenance of the Lynwood FCS, which could occur once or twice a year depending on maintenance scheduling or in the event of an issue, there would be an influx of workers to the site during these events. It's likely that a turnaround will require 24/7 support operating in two 12-hour shifts to minimise downtime and impacts on gas production. In the event of upset conditions during a turnaround or maintenance, flaring of gas at the ground flare may occur.



4.2.2 Power Station

The Lynwood FCS will be provided with a local stand-alone Power Station to supply power to all electrical users within the FCS. The Power Station will not be designed to supply power to any external electrical users (e.g. production wells, water treatment facility) other than to the nearby Telecommunications Tower Equipment Room (TER). It is anticipated that the Power Station will be designed and installed as a stand-alone facility by a third-party turn-key Power Station Vendor.

The proposed Power Station design will comprise of 16 × 1.8 MW gas engines plus two standby 1.8 MW engines equipped with a battery energy storage system (BESS). This provides electrical power to the facility and is mainly used to power the compressors, and a 720kW Emergency Diesel Engine Generator. The stand-alone Power Station will also contain its own HV Switchroom, LV Switchroom, Transformers, Fuel Gas Conditioning Package as well as associated supporting utilities with no sharing of utilities with the FCS. Emergency and maintenance venting is done locally to atmosphere as required for PSV relief or isolation. The estimated peak power demand for the 163 MMscfd case is 31.4 MW with 6 x compressors and three propane refrigeration packages.

4.2.3 Power Supply

All required electrical power for the Lynwood FCS will be supplied from the 11 kV, 3 Ph, 50Hz HV Switchboard located in the FCS HV Switchroom. Power to the FCS HV Switchboard will be cabled from the power station 11 kV Switchboard. All FCS LV process and utility loads will be fed from separate utility and process FCS MCCs located in the FCS LV Switchroom / Control System Building at 400 V, 3 Ph, 50 Hz. Power for the FCS MCC will be supplied from 11 kV-400 V step down transformers configured with single radial feed main incomers. The Main Compressor Package electric motors will be controlled by Variable Speed Drives (VSDs) located in the VSD Switchroom. Power to the Main Compressor Package VSDs will be supplied from the FCS 11 kV Switchboard.

A 720 kW (To be confirmed), 400 V, 3 Ph, 50 Hz Emergency Diesel Engine Generator and the associated Diesel Storage Tank and Pump will be installed in the Power Station. The Emergency Diesel Engine Generator will provide back-up power to the Power Station LV MCC and FCS LV MCC, in the case of loss of normal power supply, which will provide power to all essential loads. The UPS, Power Station Auxiliary Loads, Flare System, Compressed Air Package, Distribution Boards located in the LV Switchroom / Control System Building, HV Switchroom and VSD Switchroom and the emergency lighting loads are considered essential loads.

A Battery Energy Storage System (BESS) of around 10 MW may be built within the compound and footprint of the Lynwood FCS power plant. The BESS will provide immediate power reserves to cover for energy requirements whilst the back-up generator comes online. In addition, a 20 MW solar farm may be built as an incidental activity to help reduce GHG impacts, and offset power usage required at the power plant. Should this eventuate, Arrow will seek an additional separate approval under the Queensland Planning Act 2014 for the authorisation of a solar farm to provide power to the hybrid (gas/solar) power plant located adjacent to the proposed Field Compression Station (i.e., Lynwood FCS).

4.2.4 Water Supply and Management

Uncontaminated storm water will be released to outside of the plant boundary limits to existing gullies/watercourses using stabilised earthen swales and outfalls designed to avoid scouring and erosion. The drainage design will provide multiple storm water discharge points and will ensure that impacts to downstream users and or natural catchments are minimised. Existing terrain, slopes, features, and drainage paths shall be maintained surrounding the facility so that the wider overland flow water is not materially changed in its volume, velocity, direction, destination, or quality, by the developed Arrow asset, during all phases of the work.

The Compressor Packages, the Gas Dehydration Package(s), the Lube Oil Coalescer Package, the Compressed Air Package, and the Oily Water Separation Unit will be designed to self-contain storm water potentially contaminated with lube oil and be transferred to the Oily Water Separation Unit (00-A-0005) which will consist of a skid-based centrifugal separation unit to separate oil and water based on fluid density difference from the oily water emulsion feed.

The treated water product will be directed to the off-skid Treated Water Tank (00-T-0006). A Treated Water Truck Out Pump may be provided to allow for beneficial use of the treated water for road dust suppression or irrigation, provided water is of appropriate quality or the water will be released in accordance with proposed conditions Land 10 to Land 13. Oily waste from this process will be removed and transported to a facility licenced and authorised to accept the waste.

The produced water from the Slug Catchers and from the Inlet Filter Separators will be directed to the Produced Water Storage Tank (00-T-0001). The commingled treated water from the Produced Water Storage Tank and Treated Water Tank will be directed to a Water Gathering Trunkline.

4.3 Impact Assessment for Environmental Values and Matters of State Environmental Significance (MSES)

Table 4-4 Assessment of potential for proposed Lynwood FCS to affect environmental values describes the environmental values identified as relevant to the proposed activity, based on surveyed and indicative footprint, and assesses potential impacts to identified values. Where the proposed amendment may potentially change the risk and magnitude of impacts to an environmental value, an assessment of impacts to these values is provided in the following sections. For completeness, a summary of the values not expected to be changed have been included in the table below. For these values there are existing conditions in the EA that appropriately manage the risk of emissions or releases as a result of construction or operational activities.

Table 4-4 Assessment of potential for proposed Lynwood FCS to affect environmental values (Additional Infrastructure)

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
Air	The areas surrounding the proposed Lynwood FCS site are predominantly rural in nature, with land uses such as grazing, preexisting gas field development and overlapping mining tenures dominating. The site is surrounded by Kumbarilla State Forrest to the west and agricultural and farming activities in other directions. Thus, depending on the location of infrastructure, post operational land use will include forestry, mining, grazing, or cropping. A total of 13 sensitive places were identified as relevant locations for impact assessment due to the construction and operation of the Lynwood FCS. All sensitive receptors in the study area are existing dwellings/residential premises. No national parks or protected areas under the Nature Conservation Act 1992, the Marine Parks Act 2004 or a World Heritage Area are identified in the study domain. All sensitive receptors are located at least three kilometres from the Lynwood FCS.	Air quality impacts, such as dust, will be minor and restricted to the worksite for a minimal period during construction. Dust suppression measures will be implemented to minimise dust deposition as required. During operation, the air quality assessment shows that the air quality criteria for protection of all air quality values listed in the <i>Environmental Protection (Air) Policy 2019</i> are achieved in the immediate area. The proposed activity would comply with existing EA conditions regarding the air environment, and air quality conditions relevant to the additional infrastructure are being requested to be added to the DXP EA as part of this EA amendment. Air environmental values and any potential impacts, managed and authorised by the existing conditions, are expected to remain unchanged as a result of the proposed activities. This is demonstrated in the air quality modelling studies conducted as part of this EA Amendment. Refer to Section 4.4 and Section 4.5.	No. Further discussed in Section 4.4 and Section 4.5.

Supporting Information Report
Environmental Authority Amendment DXP 4

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
	The <i>Environmental Protection (Air) Policy 2019</i> identifies environmental values to be enhanced or protected in relation to the air environment. The environmental values to be enhanced or protected under the policy, which are relevant to this application are <i>the qualities of the air environment that are conducive to human health and wellbeing</i>.		
Noise	The proposed activity is situated in a rural location that is expected, in general, to have a low background noise level. The location is also within active petroleum tenure, so some values of the noise environment may be affected by authorised resource activities. A total of 13 sensitive places were identified as relevant locations for impact assessment (refer to Section 4.7 due to the construction and operation of the Lynwood FCS. The <i>Environmental Protection (Noise) Policy 2019</i> identifies and declares environmental values of the acoustic environment. The environmental values identified and declared by the policy which are relevant to this application are: <i>a. the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems;</i> <i>b. 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</i>	Construction and operational noise impacts on the surrounding amenity of the rural community are assessed and are appropriately managed by Arrow Energy, including stakeholder engagement, low-noise equipment, restricted hours of operation and / or alternative arrangements as required. Predicted noise levels from Lynwood FCS under normal operations would comply with existing DXP EA conditions regarding the acoustic environment. As discussed in the Noise Assessment (Appendix D), acoustic environmental values and any potential impacts, managed and authorized by the existing conditions, are expected to remain unchanged as a result of the proposed variations. Refer to Section 4.6.	No. Further discussed in Section 4.6.

Supporting Information Report
Environmental Authority Amendment DXP 4

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
	<i>involved in recreation, including relaxation and conversation, and</i> <i>c. the qualities of the acoustic environment that are conducive to protecting the amenity of the community.</i>		
Land	Environmental values to protect and enhanced in relation to land are not identified by an environmental protection policy under the <i>Environmental Protection Act 1994</i> (Qld). The areas surrounding the proposed Lynwood FCS site are predominantly rural in nature, with land uses such as grazing, preexisting gas field development and overlapping mining tenures dominating. The site is surrounded by Kumbarilla State Forrest to the west and agricultural and farming activities in other directions. Thus, depending on the location of infrastructure, post operational land use will include forestry, mining, grazing, or cropping.	The proposed activities' locations avoids and / or minimises disturbance in regulated vegetation, ESAs, protected plants and EVNT species habitat, to the greatest extent practicable. The proposed FCS would comply with existing EA conditions regarding land, biodiversity, and rehabilitation. The environmental values of the land, including soils, landforms, rehabilitation and flora and fauna would be appropriately managed in accordance with Arrow Energy's existing management plans. No material change to the environmental values protected by the current EA conditions, are expected as a result of the proposed Lynwood FCS.	No
Community and Visual Amenity	Persons and communities that may be impacted by the proposed amendment are the surrounding sensitive receptors. The proposed Lynwood FCS is located approximately 35 km southwest of Dalby in the Surat Basin in the Darling Downs region of Queensland. The closest verified sensitive receptor to the Lynwood FCS is a dwelling located greater than three kilometres away.	Environmental and social factors are considered as part of AWP process, in deciding appropriate locations for proposed petroleum activities. Construction and operational noise impacts on the surrounding amenity of the rural community are assessed and are appropriately managed including stakeholder engagement, restricted hours of operation and / or alternative arrangements as required. There will be no greater impact on any affected persons or affected community as a result of this amendment application. See Section 4.7.	No. Further discussed in Section 4.7

Supporting Information Report
Environmental Authority Amendment DXP 4

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
Waste	The environmental values to be protected from the waste streams through the management of waste, including the management of CSG water are: • Biodiversity • Water resources • Land and soils • Visual amenity	The proposed amendment will not generate any additional waste that isn't already contemplated or authorised under the existing EA (i.e. there are existing FCS already authorised and operating under the EA currently). The proposed amendment will not generate any waste expected to affect existing environmental values, including the life, health, and wellbeing of people; the diversity of ecological processes and associated ecosystems; and the land use capability.	No
Water and Wetlands, and Cultural Heritage.	The <i>Environmental Protection (Water and Wetland Biodiversity) Policy 2019</i> identifies environmental values for waters and wetlands to be enhanced and protected. The environmental values of wetlands to be enhanced or protected, relevant to this application are: • Health of wetland ecosystems; • Natural state and biological integrity; and • Natural hydrological cycle; and interaction with other ecosystems. The environmental values of waters to be enhanced or protected, relevant to this application are described in the <i>Condamine River Basin Environmental Values and Water Quality Objectives</i>: • Aquatic ecosystems; • Irrigation; • Farm supply/use; • Stock water; • Aquaculture; • Human consumers; • Visual recreation; • Industrial use; and	The proposed activities avoid watercourses and wetlands. Erosion and sediment control would be appropriately managed, in accordance with the existing EA and Arrow Energy's management plans. Proposed conditions Land 10 to Land 13 provide for best practice erosion and sediment control measures in line with industry standards. The proposed amendment is not expected to affect existing environmental values. There is no watercourse or wetland that is impacted by the proposed location of the FCS. The proposed Lynwood FCS would comply with existing EA conditions regarding the water and wetlands environment. Water and wetland environmental values and any potential impacts, managed and authorised by the existing conditions, are expected to remain unchanged as a result of the proposed Lynwood FCS. Arrow Energy meets its aboriginal cultural heritage Duty of Care under a Cultural Heritage Management Plan developed with the Aboriginal Party for the area.	No

Supporting Information Report
Environmental Authority Amendment DXP 4

Environmental Aspect	Relevant Environmental Values	Assessment of Impact	Impacted by this Amendment
	Cultural and spiritual values. State mapping identifies all wetlands, lakes, or springs in locations greater than 200 m away from the proposed activities; State mapping identifies all watercourses in locations greater than 100 m away from the proposed activities; and Field surveys by suitably qualified persons confirmed all proposed activities are located outside wetland, lake, spring, and watercourse buffers. The Aboriginal Party for the area surveyed the location and provided recommendations with respect to aboriginal cultural duty of care.		
Underground water rights	The proposed amendment involves above ground activity that will not affect the exercise of underground water rights		No

Table 4-5 assesses whether any MSES are identified as relevant to the proposed activity based on surveyed and indicative footprint, and, where applicable, assesses potential impacts to identified MSES

Table 4-5 Assessment of potential for proposed Lynwood FCS to affect MSES

MSES	Presence	Impact
Regulated Vegetation	The surveyed area of the proposed Lynwood FCS is not in regulated vegetation	None. The proposed Lynwood FCS avoids regulated vegetation.

Supporting Information Report
Environmental Authority Amendment DXP 4

MSES	Presence	Impact
Connectivity Areas	The surveyed area of the proposed Lynwood FCS is not in remnant vegetation.	None. The proposed Lynwood FCS avoids remnant vegetation.
Wetland and Watercourses	The <i>Environmental Protection (Water and Wetland Biodiversity) Policy 2019</i> identifies environmental values for waters and wetlands to be enhanced and protected. State mapping identifies all wetlands, lakes, or springs in locations greater than 200 m away from the proposed activities; State mapping identifies all watercourses in locations greater than 100 m away from the proposed activities; and Field surveys by suitably qualified persons confirmed the proposed Lynwood FCS ;will be located outside wetland, lake, spring, and watercourse buffers.	The proposed Lynwood FCS avoids wetlands and watercourses. The proposed activity would comply with existing EA conditions regarding the water and wetlands environment. Water and wetland environmental values and any potential impacts, managed and authorised by the existing conditions, are expected to remain unchanged as a result of the proposed activities.
Protected Wildlife Habitat	The surveyed area of the proposed Lynwood FCS is not in Protected Wildlife Habitat. A small portion (xx ha) is within the Primary Protection Zone of Protected Wildlife Habitat.	None. The proposed Lynwood FCS avoids Protected Wildlife Habitat, and the small area over the PPZ is not expected to have any impact on the Protected Wildlife Habitat.
Koala Habitat in SEQ	The surveyed area of the proposed Lynwood FCS is not within SEQ.	None.
Protected Areas	The surveyed area of the proposed activities is not within any National Parks or Nature Refuges.	None.
Fish Habitat	The surveyed area of the proposed Lynwood FCS is not within any declared fish habitat areas.	None.
Fish Passage	State mapping identifies all wetlands, lakes, or springs in locations greater than 200 m away from the proposed activities; State mapping identifies all watercourses in locations greater than 100 m away from the proposed activities; and	None.

Supporting Information Report
Environmental Authority Amendment DXP 4

MSES	Presence	Impact
	Field surveys by suitably qualified persons confirmed the surveyed area of the proposed Lynwood FCS is located outside wetland, lake, spring, and watercourse buffers.	
Marine Plants	The surveyed area of the proposed Lynwood FCS is terrestrial and inland.	None.
Offset Areas	No legally secured offset areas were identified within the surveyed area of the proposed Lynwood FCS.	None.

4.4 Air

4.4.1 Applicable legislation

The following legislation, policy and guidelines are relevant to identifying values and mitigating and managing impacts on air quality for the Project.

- *Environmental Protection Act 1994 (Qld)* (EP Act): The objective of the EP Act is to protect Queensland's environment by promoting ecologically sustainable development. The Environmental Protection Regulation 2019 provides a mechanism to enforce the EP Act and allows for an assessment of the risk that an environmentally relevant activity poses to ESAs.
- *Environmental Protection Policy (Air) 2019* (EPP (Air)) and Amendment (EPP Air, 2024): This policy sits under the EP Act and aims to protect and enhance environmental values relating to Queensland's air environment. The EPP (Air) provides air quality objectives for the protection and enhancement of the environmental values.
- *National Environment Protection (Ambient Air Quality) Measure* (Ambient Air Quality NEPM, or AAQ NEPM). The AAQ NEPM provides a nationally consistent framework for jurisdictions to monitor and report ambient air quality through setting reporting standards for key air pollutants. The AAQ NEPM contains standards and goals for six common air pollutants, commonly referred to as criteria pollutants (i.e., sulfur dioxide, nitrogen dioxide, ozone, carbon monoxide, particles, and lead).

4.4.2 Description of environmental values

In accordance with the EPP (Air), the environmental values that are to be enhanced or protected include:

- The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems;
- The qualities of the air environment that are conducive to human health and wellbeing;
- The qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures, and other property; and
- The qualities of the air environment that is conducive to protecting agricultural use of the environment.

For the Lynwood FCS location, as all nearby sensitive receptors are dwellings or residential premises, the air quality environmental value for protection human health and wellbeing is relevant for this EA amendment. However, the air quality assessment shows that the air quality criteria for protection of all air quality values is also achieved in the immediate area.

Regulatory air quality parameters, objectives, and environmental values relevant to the project are provided in Section 4.4.4. Noting that a number of the air quality objectives have been revised in the EPP (Air) Amendment released in 2024 (EPP Air, 2024).

4.4.3 Existing air environment

This section provides a description of the relevant air pollutants, the climate and meteorology of the region, and the air quality of the regional airshed including concentrations of key pollutants.

Climate and Meteorology

The Project area has a climate typical of subtropical regions and is summarised as follows:

- Mean monthly minimum temperatures range from 4.1°C in winter (June to August) to 18.9°C in summer (December to February).
- Mean monthly maximum temperatures range from 19.8°C in winter to 32.7°C in summer.
- Monthly rainfall displays a consistent pattern across the area and ranges from an average of 30 mm in winter to 90 mm summer.
- Wind patterns across the area are characterised by easterly flow predominant in the mornings and afternoon periods, with a high frequency of westerly winds also evident in the afternoon.
- Mean daily solar exposure changes throughout the year in line with the seasons, with values ranging from 12.2 MJ/m² in winter (June) to 25.7 MJ/m² in summer (December).
- Relative humidity varies with time of day and season, increasing through summer and autumn before reaching a maximum in winter (June) and falling in spring. Morning humidity levels range from an average of around 80% in early winter to around 59% in mid-spring. Afternoon humidity levels are lower, at around 49% in summer and dropping to a low of 37% in mid of spring.

More detail on climate and meteorology is provided in Appendix C.

Existing Air Quality

In collaboration with industry partners, DESTI operates an air quality monitoring network across southwest Queensland to monitor for any air quality impacts associated with the intensive CSG production activities in the Western Downs region. These monitoring stations are located on properties near CSG infrastructure, including processing facilities and active gas wells. The AQMS located at Miles Airport is the nearest AQMS to the Lynwood FCS site. Given this, ambient air quality data recorded by the Miles Airport AQMS is used to estimate background air quality levels for assessing cumulative impacts.

Background levels of key air pollutants for the Project area are shown in **Table 4-6**. Ambient monitoring data shows that all criteria air pollutants are well below state and national objectives.

Table 4-6 Background Levels of Key Air Pollutants

Air Pollutant	EPP (Air) Objective	Air NEPM Objective	Averaging Period	Background Concentration
	(µg/m ³)			(µg/m ³)
Nitrogen dioxide (NO ₂)	164	162	1 hour	6.2 ^a
	31	30	Annual	6.1 ^a
Carbon monoxide (CO)	11,000	11,250	8 hours	232 ^a
Ground level ozone (O ₃)	210		1 hour	72.8 ^a
	171		4 hours	71.8 ^a
	139	139	8 hours	70.7 ^a
Sulfur dioxide (SO ₂)	286	286	1 hour	2.9 ^b
	57	57	1 day	2.0 ^b
	21	57	Annual	1.4 ^b
Total suspended particulate (TSP)	90		Annual	26 ^a
Particulate matter (PM ₁₀)	50		1 day	13 ^a
	25		Annual	12 ^a
Particulate matter (PM _{2.5})	25		1 day	16.8 ^a
	8		Annual	5.5 ^a

^a Monitoring data derived from Miles Airport air quality monitoring station for 2020-2022. The seventieth percentile of the data was taken for sub-annual averaging periods

^b Monitoring data for SO₂ derived from Flinders air quality monitoring station for 2020 and 2021.

Relevant Air Pollutants

This EA amendment is submitted to allow for the construction and operation of the Lynwood Field Compression Station (FCS). It is noted that small diesel gensets will be used to provide power to camps and minor pumps. These are assessed through screening appropriate for the source size and potential for impact.

Air pollutant sources relevant to the DXP EA, including sources relevant for this amendment, are summarised in **Table 4-7**.

Table 4-7 Overview of assessment approaches for each Activity/Source

Emission Source	Relevant Air Pollutants	Air Impact Assessment Approach
Construction		
Construction of Lynwood FCS	Construction dust (TSP, PM ₁₀ and PM _{2.5})	Site specific qualitative construction dust assessment
Operation		
Operation of small diesel generators (camp power, pumps stations)	Combustion products, mainly NO _x and CO	Screened as negligible based on larger rig diesel combustion assessment

Emission Source	Relevant Air Pollutants	Air Impact Assessment Approach
Operation of Lynwood Field Compression Station (FCS)	Combustion products from the CSG fired generators at the Lynwood power station (mainly NO _x and CO). Combustion products from flaring at Lynwood FCS	Site specific modelling assessment (NO _x , CO) of: • Normal operations • Maximum flaring scenario

Emissions of sulfur dioxide and volatile organic compounds from the sources in this EA application are negligible.

Ozone is a regional air pollutant that is formed from photochemical reactions between NO_x and VOCs. Ozone is mainly relevant for condensed urban areas and in constrained airsheds (e.g., Sydney, South East Queensland). Regional assessment of ozone has been conducted for the Surat Basin and is well within recommended air quality guidelines for the entire region even when considering planned project expansions within the region (SGPEIS and SREIS, Arrow Energy 2012, 2013). The project is expected to have negligible impact on regional ozone levels.

Also, as CSG contains negligible odorous compounds (e.g. sulfur compounds) and combustion is one of the most effective methods for controlling odour, impacts from odour are not expected from the project emissions.

The main air pollutant of concern from combustion is nitrogen dioxide (NO₂). Nitrogen dioxide is predominantly formed in gas combustion through 'thermal NO_x'. Thermal NO_x is the process of thermal dissociation and subsequent reaction of nitrogen (N₂) and oxygen (O₂) molecules in the combustion air to form NO_x.

Combustion also results in carbon monoxide (CO) emissions through incomplete combustion of fuel. However, as the combustion efficiency of flares, gas engines and diesel engines is so high, and background levels of CO are so low, potential impacts from CO emissions are negligible (and as demonstrated through the air quality assessments).

Particulate matter emissions are likely to be caused by construction activities and due to the disturbance and handling of material. Construction emissions will be infrequent and transient and will be managed through best practice measures to avoid dust emissions through a Construction Environmental Management Plan (see 'Management practices' below for further details).

4.4.4 Air quality objectives and indicators

Regulatory air quality parameters, objectives, and environmental values relevant to the Project area are provided in **Table 4-8**.

Table 4-8 Air Quality Objectives relevant to the Project Area

Substance		Queensland Objective	Air NEPM Objective	Environmental Value	Time Period
		(µg/m³)			
Carbon monoxide (CO)		11,000 ^a	11,250 ^d	Health	8 hours
Nitrogen dioxide (NO ₂)		164 ^a	162 ^d	Health	1 hour
		31 ^a	30 ^d	Health	Annual
		33 ^a		Health and biodiversity of ecosystems	Annual
Ozone (O ₃)		210 ^a		Health	1 hours
		171 ^a		Health	4 hours
		139	139 ^d	Health	8 hours
Total suspended particulate matter		90 ^a		Health	Annual
Particulate matter < 10 µm (PM ₁₀)		50 ^{a, d}		Health	1 day
		25 ^{a, d}		Health	1 year
Particulate matter < 2.5 µm (PM _{2.5})		25 ^{a, d}		Health	1 day
		8 ^{a, d}		Health	Annual
Sulfur dioxide		286 ^a	286 ^d	Health	1 hour
		57 ^a	57 ^d	Health	1 day
		21 ^a		Health	Annual
		31 ^a		Agriculture	Annual
		21 ^a		Ecosystems	Annual
Dust deposition		120 ^b (mg/m²/day)		Nuisance	Monthly
Odour	Tall stacks	0.5 (OU) ^c		Nuisance	1 hour
	Ground level/short stacks	2.5 (OU) ^c		Nuisance	1 hour

^a Queensland objective listed in the Queensland *Environmental Protection (Air) Policy 2019 and Amendment (EPP Air 2024)*

^b Queensland Department of Environment and Science (2017) *Guideline - Application requirements for activities with impacts to air*.

^c Queensland Department of Environment and Heritage (2014) *Guideline – Odour impact assessment for developments*

^d National Environment Protection (Ambient Air Quality) Measure, Compilation No. 3 – 2021.

It is noted that the Air NEPM standards apply at performance monitoring locations.

Performance monitoring stations are to be located so that they provide a representative measure of the air quality likely to be experienced by the general population in the region or sub-region. The Air NEPM standards are therefore not intended for use in assessing air quality impacts from individual sources, specific industries, or roadside locations. Nonetheless, many State regulatory agencies, including DES, have adopted them as air quality impact assessment criteria for use in AQIAs.

4.4.5 Assessment of environmental impacts

The key emission sources for the activities addressed in this amendment application are related to the Lynwood FCS.

There will be no change to the emissions generated from other sources as a result of this amendment application, such as:

- Construction of access tracks and Lynwood FCS.

- Operation of the FCS.
- Construction of wells, access, gathering and supporting infrastructure

It should be noted that the subject of this application does not include the authorisation or operation of the wells as they are already authorised under the EA.

An air quality impact assessment was conducted by SLR Consulting specifically for the Lynwood FCS and is provided in Appendix C. Air quality impact assessments for other associated activities including construction dust has also been completed by SLR Consulting (SLR, 2018).

The main potential air quality impacts associated with the construction activities are nuisance and health related impacts due to fugitive dust emissions from earthworks. These potential impacts have been assessed qualitatively using the IAQM methodology (refer to Appendix C).

Expected emissions to air during the construction activities will be primarily due to dust (i.e., particulate matter) associated with earthworks and the movement of vehicles, with some minor sources of combustion products such as nitrogen oxides (NO_x) and carbon monoxide (CO) generated by diesel vehicles and small diesel generators.

Modelling of dust from construction activities is generally not considered appropriate, as emission rates can vary significantly depending on a combination of the activity and prevailing meteorological conditions (i.e., rainfall and wind speed), which cannot be reliably predicted.

A qualitative assessment has therefore been performed of the potential risks to air quality associated with dust from construction activities associated with the EA, based on the IAQM Guidance on the Assessment of Dust from Demolition and Construction developed in the United Kingdom by the Institute of Air Quality Management (IAQM 2014), which uses a four step process for assessing dust impacts.

The risk-based assessment of potential health and nuisance impacts from fugitive dust emissions associated with construction of the FCS, concluded that there is negligible risk of any adverse impacts due to the large separation distances between the site and nearby sensitive receptors.

4.4.6 Proposed management practices

Arrow Energy is committed to applying a hierarchy of controls in order to minimise environmental impact. Arrow Energy has standard operating procedures determining how selection of equipment will be completed in regard to protecting environmental values.

Equipment that results in environmental impact will be:

- Avoided;
- Substituted out; and
- Have mitigations imposed to reduce the impact.

In order to determine what equipment should be installed for the project (and therefore what equipment should be avoided), equipment selection will consider as part of the assessment process:

- Low source of noise emissions;

Supporting Information Report
Environmental Authority Amendment DXP 4

- Low emissions to air;
- High energy efficiency and fuel efficiency;
- Low generation of waste;
- Low greenhouse gas emissions;
- Avoidance of ozone depleting substances;
- Avoidance of particularly hazardous chemicals;
- Low emissions of pollutants to water; and
- Low water use.

Across all of Arrow Energy's SGP activities, Arrow Energy has committed to the mitigation measures listed in **Table 4-9** to minimise air quality impacts. These measures are recorded in standard operating procedures included in the Surat Gas Project operating model.

In addition to these measures, Arrow Energy is committed to selecting sites for project infrastructure that will protect the environmental values of the project development area wherever practicable. The objectives of site selection are to:

- Ensure the selection of optimal, environmentally acceptable sites for infrastructure placement;
- Avoid or eliminate potential impacts to environmental values;
- Minimise, to the greatest extent practicable, potential impacts to environmental values unable to be avoided or eliminated during design; and
- Identify environmental measures for low, moderate, and highly constrained areas and 'No Go' such areas.

Table 4-9 Air Quality Impact Mitigation measures

Project Phase	Mitigation Measures
Operational Phase	• Implement a preventative maintenance program to ensure engines are operating efficiently to minimise NO_x, CO, methane, and VOC emissions. • Implement a quantifiable monitoring and measuring program. • Roads, access tracks and other areas may be watered to suppress dust. Vehicle travelling speeds will be restricted, and movements will be limited to approved access tracks. • Selection of gaskets, seals and vehicle exhaust systems that are suitable for the task, and maintained according to manufacturer's recommendations. • Manufacturer's recommendations and guidelines with respect to air emissions control systems are followed at all times. • Air pollution control technologies are to be maintained in good working order and kept in place at all times the equipment is operating. • Air emissions will be monitored at the source in accordance with the corresponding Environmental Authority conditions. • Equipment that produces abnormal monitoring results will trigger maintenance /review procedures to return emissions to acceptable

Supporting Information Report
Environmental Authority Amendment DXP 4

Project Phase	Mitigation Measures
	levels. Where practical, the equipment should not be brought back into service until normal operational emissions are achieved.
Vehicles and machinery	• Ensure all vehicles and machinery are fitted with appropriate emission control equipment, maintained frequently and serviced to the manufacturer's specifications. • Smoke from internal combustion engines should not be visible for more than ten seconds.

Arrow Energy implements a range of dust mitigation measures to ensure that adverse air quality impacts do not occur during well, pipeline and road construction activities. This includes the use of water carts and minimising the extent of disturbed areas to minimise wind erosion.

Given that the uncontrolled emissions are concluded to have negligible risk for adverse impacts on sensitive receptors due to the distance to the nearest sensitive receptors, the risks of residual impacts after mitigation measures are considered, would also remain negligible.

A water truck would also be used to suppress dust emissions and a mulcher/shredder may be required to process any cleared vegetation.

4.5 Greenhouse Gas

4.5.1 Applicable legislation

A summary of key applicable legislation related to greenhouse gas management is summarised as follows:

- *National Greenhouse and Energy Reporting Act 2007 (NGER Act)*: The NGER Act established the NGER Scheme, which is a national system for reporting greenhouse gas emissions, energy consumption and energy production by Australian corporations. Arrow is subject to compliance requirements under the NGER Act which mainly relate to:
 - Annual reporting of emissions, energy consumption and energy production; and
 - External auditing requirements to reasonably assure reported emissions and energy statistics.

Existing systems are in place for reporting under the NGER Act for Arrow. These will be maintained for the Project and reporting of greenhouse gas emissions, energy consumption and energy production under the NGER Act will be required.

- *National Greenhouse and Energy (Measurement) Determination 2008*: The NGER Measurement Determination was made under subsection 10(3) of the NGER Act, which provides for the Minister to determine methods, or criteria for methods, for the measurement of:
 - greenhouse gas emissions;
 - the production of energy; and
 - the consumption of energy.

Arrow is required to measure greenhouse gas emissions, energy production and energy consumption in accordance with the NGER (Measurement) Determination 2008.

- *NGER (Safeguard) Mechanism 2015*: The Safeguard Mechanism was designed to protect taxpayers' funds by ensuring that emissions reductions paid for through the crediting and purchasing elements of the Emissions Reduction Fund were not displaced by significant increases in emissions above business-as-usual levels elsewhere in the economy.

The Safeguard Mechanism started on 1 July 2016. It requires Australia's largest emitters to keep emissions within baseline levels. The Safeguard Mechanism applies to facilities that emit more than 100,000 t CO₂-e of covered emissions in an Australian financial year.

The Safeguard Mechanism was reformed on 1 July 2023 such that emission baselines decline to zero by 2050 to help achieve Australia's emissions reduction goals of:

- 43% reduction on 2005 emission levels by 2030, and
- reach "net-zero" emissions by 2050.

All covered facilities with scope 1 emissions above 100,000 tonnes CO₂-e were required to submit an Emissions Intensity Determination (EID) application to the Clean Energy Regulator (CER) by 30 April 2024.

This application sets the initial GHG emission intensities for each primary product a facility produces, which forms the basis for the facility's emissions baseline

(effectively an annual GHG emission limit). The emissions baseline is then determined annually based on:

- the amount of product produced in a year as reported in the NGER Section 19 report
- the emissions intensity set by the Emissions Intensity Determination
- a default decline rate of 4.9% per year from July 2023 until 2030 and of 3.285% from 2030 onwards to achieve an emission intensity of zero by 2050.

GHG emissions over the annual emissions baseline are required to be offset through the purchase and surrender of Australian Carbon Credit Units (ACCUs) or Safeguard Mechanism Credits (SMCs). This process “nets” off or “offsets” “excess emissions” and is designed to achieve ‘net zero’ emissions by 2050. As per Arrow Energy’s hierarchy of controls, GHG emission that can be avoided or reduced on site (direct emissions reduction) have higher priority than offsetting excess emissions via the Safeguard Mechanism.

Due to the gas interconnections between existing and future SGP assets, Arrow Energy made the decision to report all gas facilities under its operational control in the Surat Basin as a single NGER/ Safeguard facility from FY24; i.e. ‘Arrow Surat Operations’.

As such, an EID was submitted to the CER for Arrow Energy’s Surat Gas Operations in April 2024, which was approved by the CER in August 2024. The Project will form part of Arrow’s Surat Gas Operations. As such, the Safeguard Mechanism applies to the Project as cumulative greenhouse gas emissions would always be above the Safeguard participation threshold of 100,000 t CO₂-e/yr.

- *Petroleum and Gas (Production and Safety) Act 2004 (P&G Act):* The operation of CSG facilities in Queensland is covered by the P&G Act. This state legislation covers the management, measurement, and reporting of coal seam gas throughout all production operations associated with the development of the field.

With specific reference to released gas disposal, the P&G Act Part 1, Section 72, division 4, subdivision 3, states that:

"Flaring the gas is authorised if it is not commercially or technically feasible to use it

- *Commercially under the authority; or*
- *For an authorised activity for the authority.*
- *Venting is authorised if –*

It is not safe to use the gas for a purpose as outlined above; or
Flaring is not technically practicable."

In addition, venting is permitted in the situation under which safety is of concern, or if it is a part of a greenhouse abatement scheme. In summary, all disposed waste gas should be flared wherever it is deemed to be safe or technically practicable.

Section 801 of the P&G Act also states that:

"A petroleum producer must ensure that each product (e.g., gas and water) is measured by a meter in accordance with the relevant measurement scheme for the meter. These products include:

- *Petroleum the producer produces;*
- *Any of the petroleum produced that is used to produce petroleum (e.g. fuel gas);*
- *Any petroleum produced that is flared or vented by or for the producer; and*
- *Any petroleum produced that the producer, or someone else for the producer, injects into a natural underground reservoir.”*

Excluded from these requirements is any gas that is:

- *Unavoidably lost before it can be measured; or*
- *Lost or used as a part of normal operations for instrumentation, purging, blowdown or similar activities.*

The P&G Act also authorises the Code of Practice – for leak detection, management, and reporting at petroleum operating plant. This code requires that operators must conduct regular leak detection and repair programs over all infrastructure and report results to the P&G Inspectorate using prescribed methods. This ensures that all risks from gas leaks at CSG facilities are reduced to as low as reasonably practical and enables continuous management and minimisation of leaks from operating plant in Queensland.

4.5.2 Description on Environmental Values

The description of environmental values for air quality are provided in Section 4.4.2.

Greenhouse gases are an essential component of the earth’s climate, which sustains life and maintains the diversity of ecosystems.

As per the DESI’s Guideline *Application requirements for petroleum activities*, greenhouse gases are a subsection of Air. In accordance with the EPP (Air), the environmental values that are to be enhanced or protected include:

- The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems;
- The qualities of the air environment that are conducive to human health and wellbeing;
- The qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures, and other property; and
- The qualities of the air environment that is conducive to protecting agricultural use of the environment.

4.5.3 Existing environment

The existing air quality environment for the Project area is described in Section 4.4.3.

Australian natural gas is pivotal to reaching net zero in Australia and the region, supporting the transition away from coal, providing the firm dispatchable energy required to unlock renewable energy potential, and powering Australian industries including those processing the critical minerals necessary for net zero.

With structural changes underway in the power generation sector and growth in renewable energy technologies, natural gas is the perfect partner to intermittent renewable energy that requires ‘on-call’ electricity generation to manage falls in renewable output or peaks in demand. As more renewable energy is integrated into the

grid, this balancing role becomes more critical. For instance, the Australian Energy Market Operator (AEMO) forecasts in its Integrated System Plan (ISP) that gas fired peaking plants in Australia will be required to increase from current energy production of 7 GW to 10 GW by 2050 to achieve net zero GHG emissions by 2050. This trend will be required globally to meet the global emission reduction target of net zero by 2050.

Globally, fuel switching from coal to gas has provided significant global GHG emission reductions since 2010. The International Energy Agency's, World Energy Outlook special report into the *Role of Gas in Today's Energy Transitions* (IEA, 2019⁴) reports that fuel switching from coal-to-gas has saved around 500 Mt CO₂-e since 2010 (IEA, 2019). Further GHG emission benefits are achievable in the world through fuel switching.

It is also important to acknowledge the role of natural gas plays in providing energy security to a growing global population and also improvements to air quality when replacing other fossil fuel heating/cooking/power applications when considering the existing global environment.

4.5.4 Greenhouse Gas Objectives and indicators

The environmental objective for greenhouse gas emissions is to mitigate greenhouse gas emissions by achieving net zero GHG emissions by 2050. This GHG emission target is designed to limit global temperature increase.

This is aligned with the Australian and Queensland GHG emission target of:

- 43% reduction on 2005 emission levels by 2030; and
- "net-zero" emissions by 2050.

Arrow Energy supports the international, Australian and Queensland objective of achieving net zero emissions by 2050.

4.5.5 Assessment of environmental impacts

Scope of GHG Assessment

Under the Paris Agreement, which came into effect in 2016, the focus is on reducing a broad range of greenhouse gases (GHGs) to combat climate change. The main GHGs targeted include:

- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous oxide (N₂O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexafluoride (SF₆)
- Nitrogen trifluoride (NF₃).

These gases are included in the nationally determined contributions (NDCs) that countries submit, outlining their plans to reduce emissions and mitigate climate change. The Paris Agreement aims to limit global temperature rise to well below 2 degrees

⁴ [The Role of Gas in Today's Energy Transitions \(International Energy Agency \(IEA\), 2019\)](#)

Supporting Information Report

Environmental Authority Amendment DXP 4

Celsius above pre-industrial levels, with efforts to limit the increase to 1.5 degrees Celsius.

The standard methods are consistent with international guidance on greenhouse gas reporting provided by the World Business Council for Sustainable Development and the World Resources Institute Greenhouse Gas Reporting Protocol (The GHG Protocol). These methods are also incorporated into Australian legislation through the NGER (Measurement) Determination. The GHG Protocol, defines three scopes of emission categories:

- **Scope 1:** Covers direct emissions from sources within the boundary of an organisation such as fuel combustion (e.g. FCS fuel combustion, field gas combustion) and fugitive GHG emissions (e.g. flaring, venting and equipment leaks).
- **Scope 2:** Covers indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation. Scope 2 emissions result from the combustion of fuel to generate the electricity, steam or heat and do not include emissions associated with the production of fuel.
- **Scope 3:** Includes all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned or controlled by the organisation.

Emissions Sources Inclusions and Exclusions

Forecast operational GHG emissions associated with the proposed new activities as part of the Project include the following sources:

- Scope 1 emissions:
 - Fuel gas combustion in the CSG-fired internal combustion engines (16 x 1.8 MW with two generators as sparing capacity) at the hybrid power plant (including solar generation).
 - Flaring of distressed gas at the FCS multi-point ground flare (MPGF) during unplanned outages, maintenance, and commissioning ramp up. This also includes pilot/ purge gas flaring and flaring of gas that is captured from compressor starts and blowdowns, vessel blowdowns directed to the high-pressure flare.
 - Minor leaks from screw compressors and other equipment.
- Material Scope 3 emissions as outlined in Table 4-10.

Table 4-10 Scope 3 Emissions Inclusions and Exclusions from GHG Assessment

GHG Protocol Scope 3 Category ^a	Scope 3 Category Description	Emissions Sources Included
1	Purchased goods and services	Diesel combustion for drilling activities (part of the construction phase). As drilling activities will be performed by third party contractors operating under their own health and safety, operational and environmental policies, these emissions will be outside of Arrow Energy's operational control and are treated as Scope 3 emissions. Diesel consumption for drilling activities is anticipated to be

Supporting Information Report
Environmental Authority Amendment DXP 4

GHG Protocol Scope 3 Category ^a	Scope 3 Category Description	Emissions Sources Included
		the biggest source of construction emissions.
2	Capital goods	Immaterial
3	Fuel- and energy-related activities	
4	Upstream transportation and distribution	
5	Waste generated in operations	
6	Business travel	
7	Employee commuting	
8	Upstream leased assets	Not applicable
9	Downstream transportation and distribution	- Leaks and venting emissions from natural gas transmission to third-party LNG plant - Shipping emissions associated with LNG exports, including LNG regasification losses
10	Processing of sold products	- Third-party compression of Arrow Energy's sales gas from medium pressure to high pressure - Processing emissions to convert natural gas to LNG
11	Use of sold products	End-use (combustion) of LNG to generate electricity at third-party operated power stations. In accordance with Section 3.11.2 of the 'Estimating petroleum industry value chain (Scope 3) greenhouse gas emissions and overview of methodologies (June 2016)' ^b published by IPIECA and API, the use of sold products is typically the most significant contributor to emissions for fuel-producing companies and can account for more than 80% of total Scope 3 emissions.
12	End-of-life treatment of sold products	Not applicable
13	Downstream leased assets	
14	Franchises	
15	Investments	

a. [Corporate Value Chain \(Scope 3\) Standard | GHG Protocol](#)

b. [API | Climate Change](#)

The following emissions sources are excluded from this assessment or are not applicable:

- There are no Scope 2 emissions associated with the proposed facility as power will be supplied by the hybrid power plant (emissions accounted for as Scope 1 emissions).

Supporting Information Report

Environmental Authority Amendment DXP 4

- There are no Scope 1 reservoir CO₂ emissions from the Project. Reservoir CO₂ is accounted for as a Scope 3 emission source as this emission occurs downstream of Arrow's operations.
- Immaterial Scope 1 emissions sources (i.e. these sources correspond to approximately 1% of Arrow Energy's current total NGER emissions for its operated gas fields and compression facilities):
 - Liquid fuels consumed in light vehicles (owned or leased by Arrow Energy) and miscellaneous stationary combustion equipment (e.g. small generators, black start equipment)
 - Petroleum based oil and greases combustion in internal combustion engines.
- Emissions due to land use change on the basis that:
 - The Project includes a commitment/ requirement to minimise land disturbance and clearing, and an obligation to rehabilitate land to its original condition.
 - Cleared areas are also subject to offset requirements under the Environment Protection and Biodiversity Conservation (EPBC) Act and Environmental Offsets Act. Offsets made under the EPBC Act or Environmental Offsets Act do not result in carbon credits under the *Carbon Credits (Carbon Farming Initiative) Act 2011* due to 'regulatory additionality' and that the offset areas also offset the land clearing emissions.
 - As such, over the life of the activity, GHG emissions due to land use change are forecast to be net zero due to rehabilitation and environmental offset activities.
 - These emissions are not required to be reported under the NGER Scheme.

GHG Emissions Estimation Methodology

Forecast GHG emissions from the life of the Project (i.e. 2030 to 2047) were estimated using the estimation techniques from the following documents:

- NGER Measurement Determination published in July 2024
- NGER Regulations published in July 2024
- American Petroleum Institute (API) Compendium 2009.

The methodology used to estimate forecast emissions for this assessment is presented in Table 4-11.

Table 4-11 GHG Emissions Estimation Methodology Summary

Emissions Scope	Category	Emission Source	Methodology
Scope 1	Fuel gas combustion	CSG-fired internal combustion engines at the power plant	Method 1 - Division 2.3.2 of the NGER Measurement Determination
	Flaring at the FCS multi-point ground flare (MPGF)	Pilot/ purge gas flaring	Method 1 - Division 3.3.9A.10 of the Measurement Determination
		Venting from compressor starts and blowdowns, and vessels at the FCS directed to the high-pressure flare	

Supporting Information Report
Environmental Authority Amendment DXP 4

Emissions Scope	Category	Emission Source	Methodology
	Leaks at the FCS	Screw compressors and dehydrators	Method 2 - Division 3.3.6C of the Measurement Determination
Scope 2	Grid electricity	Not applicable	Not applicable
Scope 3	Liquid fuel combustion	Diesel combustion for drilling activities	Method 1 - Division 2.4.2 of the NGER Measurement Determination
	Fuel gas combustion	Shipping emissions	Shipping GHG emissions intensity of 0.024 kg CO ₂ -e per tonne.nautical mile shipping. LNG shipping GHG emissions intensity provided by Shell. Shipping distance estimated to be 4,110 nautical miles.
	Leaks and venting	Leaks and venting emissions from natural gas transmission	Method 1 - Division 3.3.7 of the NGER Measurement Determination
	Various	Third-party compression of Arrow Energy's sales gas from medium pressure to high pressure	Assumed to be 50% of Arrow Energy's existing CGPFs' emissions intensity, which compress gas from low pressure to high pressure.
	Various	Processing emissions to convert natural gas to LNG	Published emission intensity: Greenhouse Gas Emissions Intensity for Queensland Curtis LNG, Volume 7: Chapter 1
	Use of sold products	End-use (combustion) of LNG to generate electricity at third-party operated power stations	Method 1 - Division 2.3.2 of the NGER Measurement Determination

Forecast GHG Emissions

Forecast operational GHG emissions (CH₄, CO₂ and N₂O) associated with the proposed new activities as part of the Project are presented as:

- total annual Scope 1 emissions before any abatement measures (Figure 4-2)
- total annual Scope 3 emissions (Figure 4-3)
- annual Scope 1 (no abatement) and Scope 3 emissions by emission source (Table 4-12 and Table 4-13).

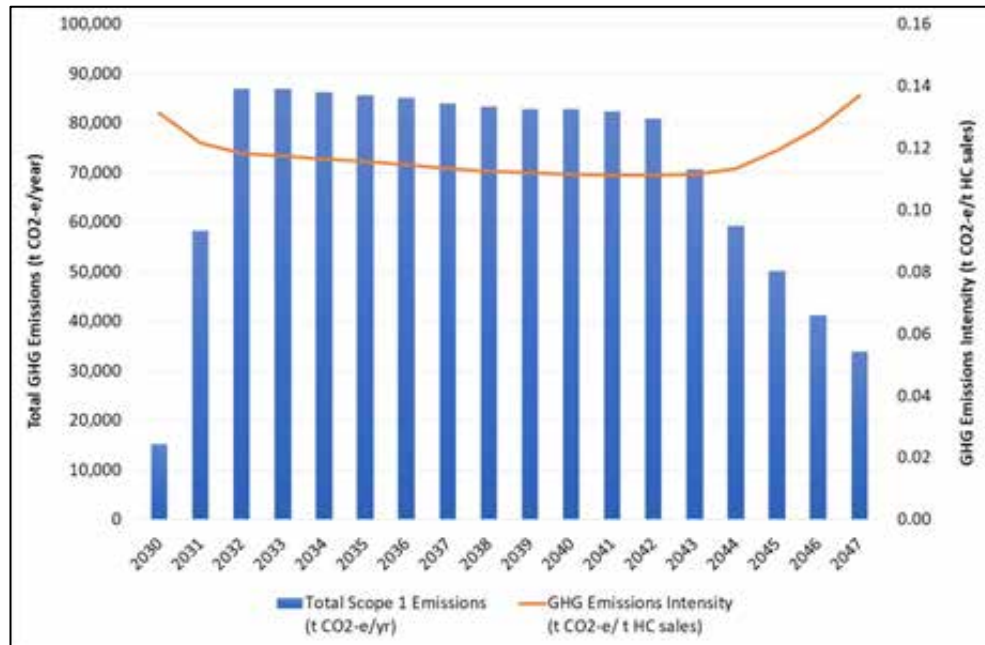


Figure 4-2 Forecast Scope 1 GHG Emissions (Before Abatement Measures)

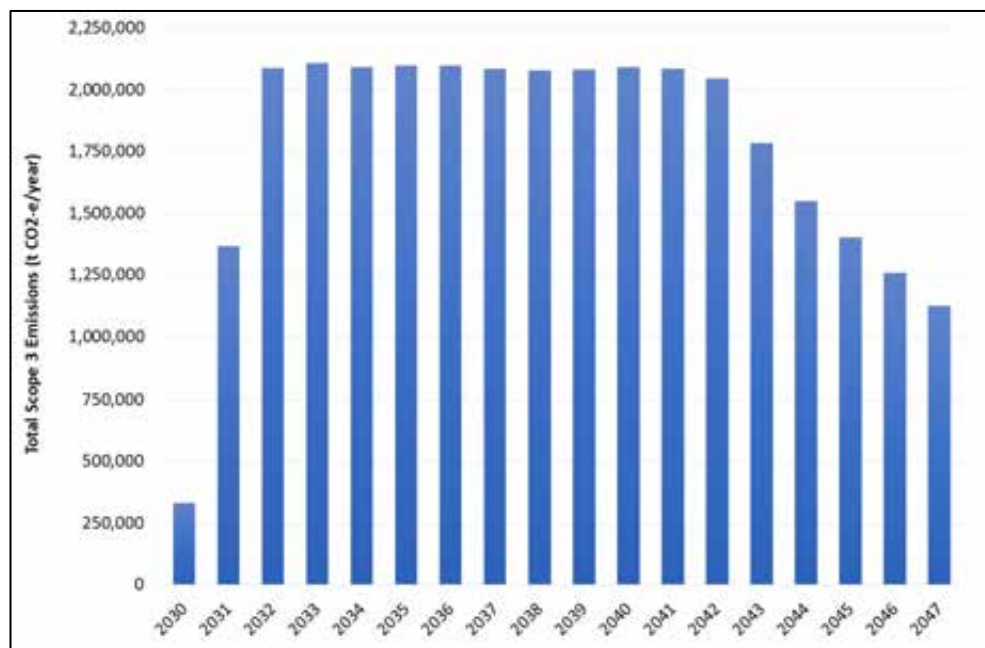


Figure 4-3 Forecast Scope 3 GHG Emissions

Supporting Information Report
Environmental Authority Amendment DXP 4

Table 4-12 Annual Forecast Scope 1 GHG Emissions by Source

Year	Scope 1 FCS Emissions (t CO ₂ -e/yr)						Total Scope 1 Emissions (t CO ₂ -e/yr)
	Flaring			Fugitives - Leaks		Fuel Gas Combustion	
	Distressed gas	FCF process losses redirected to flare	Pilot/Purge Gas	Screw Compressors	Dehydration	Compressor Engines	
2030	657	1	1,052	321	22	13,242	15,294
2031	2,726	3	1,052	963	22	53,569	58,335
2032	4,219	4	1,052	1,283	22	80,267	86,846
2033	4,276	4	1,052	1,283	22	80,318	86,955
2034	4,300	4	1,052	1,283	22	79,613	86,274
2035	4,303	4	1,052	1,283	22	78,970	85,634
2036	4,249	4	1,052	1,283	22	78,502	85,112
2037	4,235	4	1,052	1,283	22	77,394	83,989
2038	4,237	4	1,052	1,283	22	76,703	83,302
2039	4,210	4	1,052	1,283	22	76,347	82,917
2040	4,231	4	1,052	1,283	22	76,301	82,893
2041	4,212	4	1,052	1,283	22	75,873	82,445
2042	4,146	4	1,034	1,283	22	74,401	80,890
2043	3,621	4	902	1,283	22	64,895	70,727
2044	3,143	3	744	963	22	54,488	59,363
2045	2,862	3	598	963	22	45,762	50,210
2046	2,578	2	463	642	22	37,554	41,260
2047	2,315	2	352	642	22	30,630	33,963
TOTAL	64,520	56	16,715	19,894	395	1,154,829	1,256,409
AVERAGE	3,584	3	929	1,105	22	64,157	<u>69,800</u>

Table 4-13 Annual Forecast Scope 3 GHG Emissions by Source

Year	Scope 3 Emissions (t CO ₂ -e/yr)						Total Scope 3 Emissions (t CO ₂ -e/yr)
	Drilling	Third Party Compression (MP to HP)	NG Transmission	LNG Processing Emissions	LNG Shipping (incl. Regasification)	End User LNG Combustion (Power Generation)	
2030	81	9,100	233	30,835	16,568	277,065	333,883
2031	1,306	36,454	961	126,902	67,923	1,135,860	1,369,407
2032	1,153	54,393	1,474	194,664	103,906	1,737,589	2,093,180
2033	144	54,043	1,485	196,164	105,106	1,757,647	2,114,588
2034	1,139	52,504	1,485	196,164	104,121	1,741,181	2,096,595
2035	1,239	50,966	1,485	196,164	104,504	1,747,593	2,101,952
2036	488	49,563	1,489	196,702	104,714	1,751,104	2,104,060
2037	335	47,889	1,485	196,164	104,120	1,741,170	2,091,163
2038	368	46,350	1,485	196,164	103,881	1,737,162	2,085,411
2039	330	44,811	1,485	196,164	104,134	1,741,400	2,088,326
2040	330	43,391	1,489	196,702	104,635	1,749,772	2,096,319
2041	364	41,734	1,485	196,164	104,402	1,745,878	2,090,028
2042	416	39,508	1,460	192,808	102,607	1,715,868	2,052,667
2043	388	33,145	1,273	168,194	89,545	1,497,436	1,789,981
2044	368	26,804	1,051	138,776	78,208	1,307,855	1,553,063
2045	373	20,672	845	111,559	71,880	1,202,032	1,407,361
2046	378	15,314	653	86,299	65,425	1,094,083	1,262,152
2047	364	11,133	497	65,640	59,212	990,181	1,127,027
TOTAL	9,564	677,775	21,819	2,882,232	1,594,893	26,670,879	31,857,164
AVERAGE	531	37,654	1,212	160,124	88,605	1,481,716	1,769,842

GHG Emissions Assessment

Annual average Scope 1 GHG emissions over the life of the Project (2030 – 2047) are forecast to be an average of **70,000 tonnes CO₂-e/ annum** before any abatement measures (refer to Table 4-12). Fugitive GHG emissions (flaring, venting and leaks) account for 8% of total Scope 1 emissions over the life of the Project.

As per Table 4-13, annual average Scope 3 emissions are estimated to be an average of **1,800,000 tonnes CO₂-e/ annum** over the life of the Project. This corresponds to about 96% of total Scope 1 and 3 emissions (refer to Table 4-14), with 84% of Scope 3 emissions being associated with end-user LNG combustion.

The estimated gas loss rate for all fugitive sources (venting, leaks and flares) is approximately 0.26% (i.e. GJ gas lost per GJ gas sold). The estimated gas loss rate due to venting and leak sources is about 0.007%. This is in line with current best practice loss rates.

In relation to requirements under the Safeguard Mechanism, there are zero Scope 1 reservoir CO₂ emissions from the Project.

The contribution of the Project to the state and national total greenhouse gas emissions are presented in Table 4-14.

Supporting Information Report
Environmental Authority Amendment DXP 4

While contributions to total state and national GHG emissions appear minor, GHG emissions will be managed to ensure emissions are controlled to levels that are ‘as low as reasonably practical’ (ALARP).

Table 4-14 Contribution of the Project to State and National total GHG Emissions

Description	Total Annual GHG Emissions (Scope 1 & 2)	Units
The Project (Scope 1 Emissions) ^a	69,800	t CO ₂ -e/annum
The Project (Scope 2 Emissions) ^a	N/A	
The Project (Scope 3 Emissions) ^a	1,769,842	
Project (Total GHG emissions)	1,839,643	
Queensland ^b	124,096,800	
Australia ^b	432,620,900	%
Contribution to State Annual Total ^c	0.056	
Contribution to National Annual Total ^c	0.016	

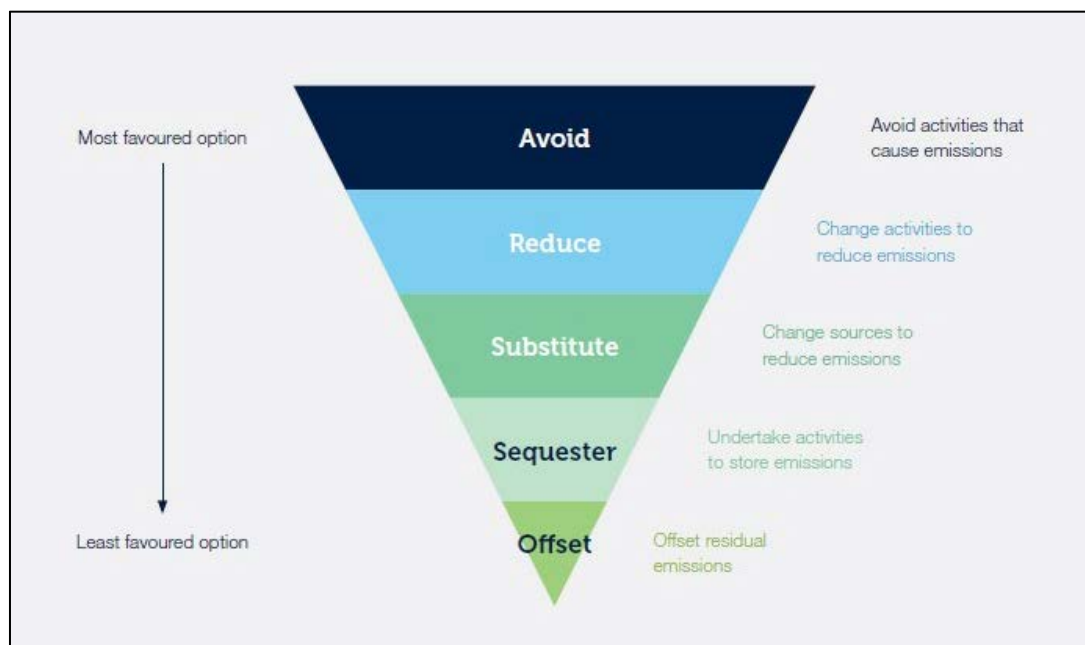
- Forecast average annual GHG emissions associated with the emissions sources described in Section 4.5.5. Refer to Table 4-12 and Table 4-13.
- Department of Climate Change, Energy, the Environment and Water (DCCEEW), 2022 inventory year - latest available year (<https://greenhouseaccounts.climatechange.gov.au/>)
- As the majority of Scope 3 emissions will occur outside of Australia (mainly exported LNG Combustion), Scope 3 emissions are not assessed against Queensland and Australia’s national emissions inventory.

Lifecycle GHG emissions, Scope 1, 2 and 3 emissions are forecast to result in a well to wire GHG emissions intensity of **440 g CO₂-e/kWh of electricity generated** (if gas is used in a combined cycle gas turbine to produce power). Power produced from gas produced from the Project has a relatively low lifecycle carbon intensity when compared to other fossil fuels. It is important to note the main role of gas in developing and transitioning energy markets, is to firm intermittent renewable electricity supply.

4.5.6 Proposed management practices and continual improvement

Greenhouse Gas Management

Arrow Energy's carbon management principles are based on well-established hierarchy of GHG emission controls. The hierarchy is applied through evaluation of carbon opportunities through the process as described in Figure 4-4.



Source: Royal Melbourne Institute of Technology (RMIT) (2019), Environmental Protection Authority Victoria (EPAV) (2020)

Figure 4-4 Hierarchy of Carbon Management

The carbon management hierarchy is applied through an iterative process favouring actions at the top of the pyramid (refer to **Figure 4-4**) and are described in **Table 4-15**.

Table 4-15 Carbon Management Hierarchy and application to the Project

Carbon Management Options	Description	Examples Relevant for the Project
Avoid	The best way to reduce the carbon impact is by avoiding direct greenhouse gas emissions and energy related indirect emissions. Some avoidance opportunities may not require a capital outlay and may just be a change in behaviour for a business.	- Avoid venting and flaring at the FCS through: - improved well control and responses to system upsets - improved planning for scheduled shutdowns.
Reduce	Reducing GHG emissions typically involves changing equipment so that it uses lower energy. It can encompass the recovery of energy from existing processes.	- Capturing vents at the FCS facility and directing to flare system - Further implementation of leak detection and repair (LDAR) on FCS leak sources and using this data for reporting - Minimising pilot/ purge gas requirements on the flare system

Supporting Information Report
Environmental Authority Amendment DXP 4

Carbon Management Options	Description	Examples Relevant for the Project
Substitute	Changing the primary energy source to be less emission-intensive source may offer carbon reductions	FCS hybrid power incorporating solar and battery energy storage systems (BESS) to minimise combustion emissions (subject to approval).
Sequester	Following the reduction of greenhouse gas emission sources in an organisation, the organisation may then look to the reductions that can occur that sequester carbon within the organisation	Natural carbon sequestration through forests, vegetation, soils on Arrow Energy properties or within organisation
Offset	Carbon offsetting is the purchase of a reduction certificate that allows a reduction project outside the scope of an organisation to be claimed against the emissions profile. Carbon offsets provide a legitimate means of reducing the net impact of greenhouse gas emissions. Offsets sit as the least favoured option in the hierarchy	Purchase and surrender of Australian Carbon Credit Units or SMCs on the Australian National Register of Emission Units (ANREU)

Key levers in line with the Oil and Gas Climate Initiative (OGCI), for Arrow Energy to reduce GHG emissions from the Project are as follows:

- Improve energy efficiency (reduce);
- Near zero flaring (reduce);
- Electrify operations with renewables where possible (substitute); and
- Near zero methane emissions (reduce).

Assessed GHG emissions abatement measures

Management and design strategies incorporated into the Project to minimise direct GHG emissions are presented in **Table 4-16**.

Table 4-16 Management strategies to minimise GHG emissions

GHG Source	Management and design strategies used to minimise GHG emissions
FCS Power – Fuel Gas	The Lynwood FCS is being designed as a hybrid gas power station that utilises solar, battery energy storage system (BESS) and gas fired internal combustion engines. This is designed to minimise GHG emissions due to the FCS power requirements. The Lynwood FCS is isolated from the electricity grid, such that grid connection is not currently feasible, although it might be an option in the future. The hybrid power option provides the lowest GHG emissions intensity available to the Lynwood Development with a forecast greenhouse gas intensity of 0.36 t CO₂-e/ MWh which is 50% less than the emissions intensity from the current Qld electricity grid at 0.71 t CO₂-e/MWh and 34% less than the prescribed emissions

Supporting Information Report
Environmental Authority Amendment DXP 4

GHG Source	Management and design strategies used to minimise GHG emissions
	intensity for electricity in the NGER (Safeguard Mechanism) Rule 2015 of 0.539 t CO₂-e/MWh .
FCS Flaring	The flare at Lynwood FCS will be used when a downstream compression train requires maintenance or there are downstream system upsets. During planned outages, the well field will be managed in advance to minimise flaring. During unplanned outages, the well field will be managed in reaction to the unplanned outage to minimise the flaring. Distressed gas management will be achieved by flaring. FCS vents and losses will also be directed to the FCS flare. In relation to venting and flaring, the overall philosophy is to eliminate venting and minimise flaring (Venting and Flaring Standard). This is in alignment with the requirements under the P&G Act. It is forecast that approximately 0.25% of produced gas (GJ of gas flared per GJ of gas sold) will be flared through the Lynwood FCS flare. The management strategies to reduce the rate of flaring include: • All production assets will be monitored and controlled via a single integrated Process Control and Production Information System referred to as the Process Automation System (PAS). The control system will be designed for 24/7 operation and have an availability of between 99.9% and 99.99% (value trade off to be completed). • Assigning all wells to a turn down class (1-5) based on their risk of failure after a shutdown (1 being best to 5 being worst). The recovery performance will be determined in the first 12-24 months post start-up of the well. • A control solution which will turn down well field production to match downstream demand by automatically turning down those wells that recover best (Class 1) first and progressively turning down subsequent well classes. Each field will include a block controller which allows the Control Room Operators (CRO) to turn down the field production from a single faceplate. The block controller will consider each well classification and adjust the wellhead metering skid pressure control valves to turn down the field flow. • FCS equipment train shutdowns will take place for major equipment inspection and maintenance. • Use of available line pack to enable production holds for short periods. • Interconnection enabling distressed gas flows to be diverted to alternative delivery points. • Once operational, further optimisation will be developed to minimise flaring rates. It is also noted that multi-point ground flares have higher methane destruction efficiencies when compared to elevated flares. Higher destruction efficiencies of methane result in lower GHG emissions due to flaring.
Venting	In relation to venting and flaring, the overall philosophy is to eliminate venting and minimise flaring (Venting and Flaring Standard). This is in alignment with the requirements under the P&G Act. All major vents at the Lynwood FCS are rerouted to the flare system to minimise GHG emissions.

Supporting Information Report
Environmental Authority Amendment DXP 4

GHG Source	Management and design strategies used to minimise GHG emissions
	Other design features to minimise venting include: Dehydrator A significant source of venting traditionally is from stripping gas used in glycol dehydrators. Emissions from the dehydrator at Lynwood FCS are controlled by capturing gas and routing to the FCS flare system. Cold process vents Significant cold process vents are eliminated from the current design concept. Emissions from vessel blowdowns at Lynwood FCS are controlled by capturing gas and routing to the FCS flare system. Gas driven pneumatic devices Natural gas-driven pneumatic devices are not used in the Development avoiding this potential fugitive emission source. Vessel blowdowns/ Compressor starts and blowdowns Blowdown of gas from vessels/ compressors will be directed to the flare header reducing this fugitive emission source (when compared to venting).
Leaks (emissions other than venting and flaring)	There is potential for leaks to occur from connectors, flanges, valves etc at compression facilities if such items fail or are improperly sealed. A leak detection and repair (LDAR) program is integral to the maintenance of compression facilities, where on a regular cycle, gas detection equipment is used to identify any leak points within the piping networks and process plant. The implementation of a LDAR program is mandatory under Schedule 1 of the Petroleum and Gas (Production and Safety) Act (2004) and there are specific requirements for the reporting of all identified leaks over certain thresholds to the Petroleum and Gas Inspectorate.

This application meets the medium to high GHG emission category in accordance with Section 3.2 of the Greenhouse Gas Emissions Guideline ⁵ published by DESI in May 2024; i.e. expected GHG emissions (Scope 1 and Scope 2) of 25,000 tonnes CO₂-e or more per year (at any time during the life of the project). As per Table 3 of the GHG Emissions Guideline, a GHG abatement plan is required as part of the application, which is provided in Appendix B.

A summary of estimated GHG emissions abatement for all abatement measures considered by Arrow Energy over the life of the Project is provided in Table 4-17. The resulting Scope 1 emission intensity (t CO₂-e/ t gas sales) incremental reduction for each assessed abatement measure is presented in Figure 4-5.

Table 4-17 Assessed GHG Abatement Measures

Emission Source	Opportunity	Total Estimated GHG Abatement for the Life of the Project (t CO ₂ -e)
FCF flare	Near zero flaring (<0.1% flaring)	50,187
FCF fuel gas	Solar farm + BESS (hybrid power plant)	230,966
TOTAL		281,153

⁵ [Greenhouse gas emissions \(desi.qld.gov.au\)](https://desi.qld.gov.au/greenhouse-gas-emissions-guideline)

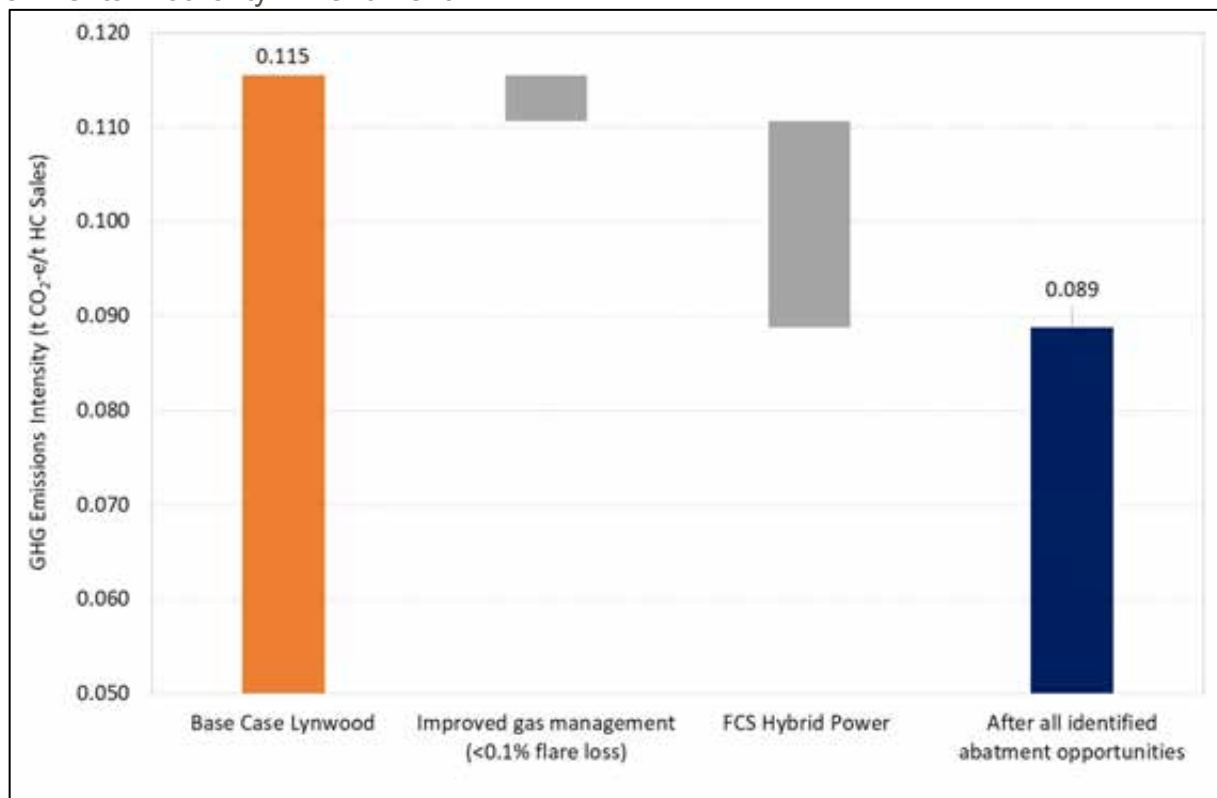


Figure 4-5 Scope 1 Emission Intensity Reduction from Assessed GHG Abatement Measures

The Project also includes a commitment/requirement to minimise land disturbance and clearing and a commitment to rehabilitate land to its original condition.

The Development is part of Arrow's upstream Surat Gas Project (SGP). Reporting of greenhouse gas emissions, energy consumption and energy production is required under the NGER Scheme.

As discussed in Section 4.5.1, due to the gas interconnections between existing and future SGP assets, the Project will form part of Arrow's Surat Gas Operations due to its commercial and operational interconnections. As such, the Safeguard Mechanism applies to the Project as cumulative greenhouse gas emissions are above the Safeguard participation threshold of 100,000 t CO₂-e/yr.

As such, declining emission baselines apply to the SGP in line with the government's emission reduction targets net zero emissions by 2050.

Where direct emission reductions are not technically feasible, obligations to meet the emissions baselines will be achieved through the acquisition, purchase and surrender of carbon credit units prescribed by the Safeguard Mechanism.

Commitment to continual improvement

The SGP is subject to international, national, state, and corporate greenhouse gas policies with abatement objectives and performance standards. Arrow Energy will comply with all mandatory international, national, and state objectives. Arrow Energy is committed to the ongoing measurement and monitoring of the Project's emissions, energy consumption and production.

Arrow Energy strives for continual improvement in greenhouse gas emissions performance. To achieve this, Arrow Energy sets GHG emission intensity targets for operating assets both on a total GHG emissions level and on a venting and flaring loss rate basis. Annual emissions intensity targets incorporate continuous improvement elements.

To achieve the reduction in GHG emissions from Arrow Energy's operating assets, Arrow Energy has implemented a GHG abatement opportunity maturation process (refer to **Figure 4-6**). To further drive adoption of GHG emission abatement opportunities, Arrow Energy incorporates an internal carbon price in the economic assessment of potential opportunities.

The Project may include a hybrid power plant as part of incidental activities, which involves the development of a solar farm and inclusion of a BESS with the intent of being able to increase the use of electricity in the operation of the Lynwood FCS from a renewable energy source.

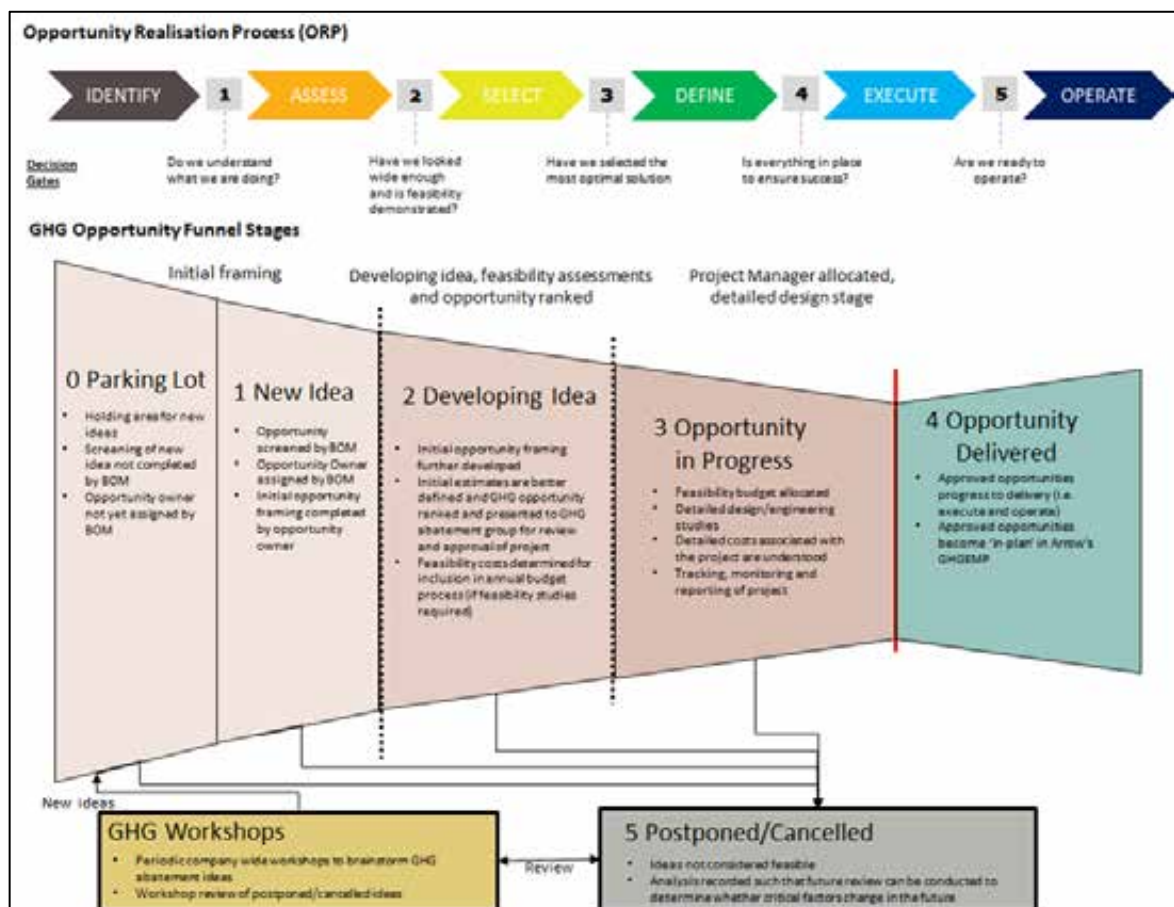


Figure 4-6 Arrow Energy's GHG abatement opportunity maturation process

4.6 Noise

4.6.1 Applicable legislation

The following legislation, policy and guidelines are relevant to identifying values and mitigating and managing impacts on noise quality for the Project.

- *Environmental Protection Act 1994* (EP Act): The objective of the EP Act is to protect Queensland's environment by promoting ecologically sustainable development. The *Environmental Protection Regulation 2019* provides a mechanism to enforce the EP Act and allows for an assessment of the risk that an environmentally relevant activity poses to ESAs.
- *Environmental Protection (Noise) Policy 2019* (EPP (Noise)): This policy sits under the EP Act and aims to protect and enhance environmental values relating to Queensland's noise environment. The EPP (Noise) provides noise quality objectives for the protection and enhancement of the environmental values.

4.6.2 Description on Environmental Values

The areas surrounding the Project area are predominantly rural in nature, with land uses such as grazing, pre-existing gas field development, and overlapping mining tenures dominating. 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.

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.

4.6.3 Sensitive Receptors

The DES guideline, *Application requirements for petroleum activities* (DES 2016) defines for noise, sensitive receptors are defined in Schedule 2 of the *Environmental Protection (Noise) Policy 2019*.

Noise sensitive receptors listed in the EPP (Noise) that are most relevant to Arrow's operations are:

- Residences (at all times);
- Commercial and retail activity (when the activity is open for business);
- Protected areas or critical areas (at all times); and
- Parks or gardens that are open to the public (at all times).

Sensitive receptors for the proposed Lynwood FCS area were identified as being located within 5 km and are presented in **Table 4-18**.

Table 4-18 Sensitive Receptors within 5 km of the Lynwood FCS

Receptor ID	Coordinates (GDA94 zone 56)	
	Easting	Northing
LFCS-1	310,802	6,955,215
LFCS-2	314,546	6,960,670
LFCS-3	314,462	6,960,716
LFCS-4	317,018	6,955,997
LFCS-5	313,164	6,953,290
LFCS-6	317,852	6,956,338
LFCS-7	318,230	6,955,420
LFCS-8	317,954	6,955,094
LFCS-9	318,264	6,955,584
LFCS-10	318,253	6,955,369
LFCS-11	318,563	6,956,439
LFCS-12	317,016	6,961,546
LFCS-13	318,185	6,953,373

4.6.4 Existing Noise Environment

The Lynwood 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.

The deemed minimum background noise levels as stated in the *2016 Streamlined Model Condition* have been applied for the basis of this assessment (refer to **Table 4-19**). The deemed minimum background noise levels are considered applicable given the rural nature that the Lynwood FCS area is located within and the expected low background noise levels within this area.

Table 4-19 Deemed background noise levels as per Streamlined Model Condition (DES, 2016)

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

Noise sources relevant to this amendment are summarised in **Table 4-20**.

Table 4-20 Overview of Noise Sources and Assessment Approaches

Noise Source	Description of noise source	Noise Impact Assessment Approach
Construction		
Construction of Lynwood FCS ^a	Construction activities of the FCS facility and associated infrastructure can potentially result in noise impacts. Construction noise levels inevitably depend upon the number of plant and equipment operating at any one time and on their precise location relative to the sensitive receptor(s). Therefore, a sensitive receptor may experience a range of values representing “minimum” and “maximum” construction noise emissions. Construction limited to daytime only.	Noise assessments have been conducted using conservative operating assumptions to derive a maximum distances where daytime noise may cause an issue. Construction noise and vibration and 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 Lynwood FCS development. Where construction is planned to be within the maximum separation distance, additional controls are required to minimise risk of daytime construction noise impact (e.g., reduced equipment operating at a time, site specific assessment and monitoring).
Operation		
Operation of camps and other incidental activities, such as: warehouse, offices	Noise from small diesel generators	Noise impact is screened using methodologies in Arrow Energy’s Environmental Noise and Vibration Management Plan. Noise is minimised and sources are located to ensure compliance with relevant Environmental Authority noise criteria.
Operation of Lynwood Field Compression Station (FCS) ^a	The Lynwood FCS has been assessed for the following operating scenarios: • Scenario 1 – Normal Operation ○ Up to four (4) Howden 510 screw compressors running at 2,000 RPM with coolers, and ○ Sixteen (16) operating CSG fired power station (internal combustion engines) and two (2) spare 1.8 MW units with BESS. • Scenario 2 – Flaring ○ MPGF to occur under four (4) separate flare flow rates being 116 MMscfd, 87 MMscfd, 58 MMscfd and 29 MMscfd.	Site specific noise modelling assessment (SLR Consulting 2024).

4.6.1 Noise quality objectives and indicators

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 proposed Lynwood FCS are presented in **Table 4-21**. Operations require continuous operation of plant and 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 4-21 EPP (Noise) Acoustic quality objectives

Receptor Type	Time of Day	Acoustic Quality Objective (dBA)		
		$L_{Aeq,adj,1hr}$	$L_{A10,adj,1hr}$	$L_{A1,adj,1hr}$
Residential dwelling (outdoors)	Day time and evening	50	55	65
Residential dwelling (indoors)	Day time and evening	35	40	45
	Nighttime	30	35	40

The Queensland Department 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.

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, DES, 2022) for each of the specified daily time periods are provided in **Table 4-22**. 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 4-22 Best Practice Measured Outdoor Noise Emission Limits (DES, 2016)

Time Period	Time of Day	Metric	Long Term Noise Limit (dBA) ^a
6:00 am – 7:00 am	Morning	$L_{Aeq, adj, 15 \text{ minutes}}$	35 (LABG + 5)
7:00 am – 6:00 pm	Day	$L_{Aeq, adj, 15 \text{ minutes}}$	40 (LABG + 5)
10:00 pm – 6:00 am	Evening	$L_{Aeq, adj, 15 \text{ minutes}}$	35 (LABG + 5)
6:00 pm – 10:00 pm	Night	$L_{Aeq, adj, 15 \text{ minutes}}$	28 (LABG + 3)
		Max $L_{pA, 15 \text{ minutes}}$	55

^a LABG 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

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. Furthermore, for continuous operating plant, compliance with the night time limit of 28 dBA demonstrates under worst case operating conditions and worst case weather conditions sufficiently protects against the risk of “background creep”. The risk of background noise creep for temporary noise sources is very low due to their temporary nature and background noise creep being a long-term measure.

4.6.2 Assessment of environmental impacts

A noise impact assessment was conducted by SLR Consulting for the Lynwood FCS and is provided in Appendix D.

Environmental noise impacts are informed by various studies conducted by Arrow Energy and management is achieved through implementation of Arrow Energy’s environmental noise and vibration management plan.

Noise assessments have been conducted on common CSG activities to inform planning and constraints analysis to avoid noise impacts from CSG activities. These activities relevant to this amendment are summarised as follows:

Construction noise

Arrow Energy limits construction activities to daytime only to avoid noise impact. Furthermore, conservative noise assessments have been made to derive maximum distances where daytime noise may cause an issue.

Where construction is planned to be within the maximum separation distance, additional controls are required to minimise risk of daytime construction noise impact.

Operation of camps and other incidental activities, such as: warehouse, offices, camps and other incidental activities may have minor noise sources associated with their operations such as diesel generators. These sources of noise are selected in order to avoid noise through selection of less noisy equipment and inclusion of appropriate noise abatement technology (e.g. exhaust silencers). Sources of noise from incidental activities are also located with sufficient separation distances to sensitive receptors to avoid amenity noise impact.

Operation of Lynwood FCS and power station

The location of the Lynwood FCS was selected to optimise the distance between the facility and nearby sensitive receptors to avoid the potential for noise impact. The impacts from noise from the Lynwood FCS was done considering the nearby sensitive receptors.

Furthermore, the Lynwood FCS incorporates several noise abatement technologies to reduce the potential for noise impact including:

- FCS Compressors:
 - Close fitting noise attenuation enclosures will be installed around each compressor casing.
- Power Station Engines:

- Engine enclosures to minimise noise emissions;
- Acoustically treated louvres on air intakes; and
- Exhaust silencers.

Lynwood FCS flare noise

The main sources of noise from flaring are from:

- Jet noise at the flare exit; and
- Combustion noise along the length of the flame.

Potential flare types include:

- Multi-point ground flares; and
- Enclosed flares.

Ground flares and enclosed flares provide improvements to visual pollution and reduce the noise impact when compared to elevated flares. The dominant source of noise from flaring is combustion roar (which occurs no matter which flare type is selected). As such, the best noise mitigation for flaring is avoidance/reduced flare rates.

The noise impact from MPGFs is slightly reduced when compared to elevated flares due to the ground flare structure which impacts the noise transmission from the flare to the receptor, thereby slightly reducing the noise received at the receptor.

Arrow Energy has selected a MPGF for the Lynwood FCS to reduce both the potential for noise and light impact on the surrounding area.

Noise assessment of the Lynwood FCS and power station and the FCS flaring has been conducted by acoustic specialists SLR Consulting (refer to Appendix D).

The noise assessment found that the:

- The proposed Lynwood FCS development is expected to meet all nominated noise criteria for both assessed weather conditions when operating under 'normal operations' and the maximum sound power noise level of 103 dBA is achieved for the Power Generation Units.
- During flaring events:
 - Noise objectives are expected to be met for more than 95% of flaring events.
 - Under neutral weather conditions, noise objectives are met for all possible flare flow rates.
 - Under adverse weather conditions and at flare flow rate of 87 MMscfd and above, marginal exceedance of the night-time noise limit of 28 dBA may occur at up to five (5) sensitive receptors. Noting, the worst case being up to two receptors to potentially exceed at the same time (LFCS-2 and LFCS-3 due to similar locality). All other receptors would be isolated occurrences. This is likely to be extremely rare events and for short periods only.

4.6.3 Proposed management practices

Noise is managed at Arrow Energy through its Environmental Noise and Vibration Management Plan, which has been developed based on the noise management principles and hierarchy of the EPP (Noise):

Supporting Information Report
Environmental Authority Amendment DXP 4

- Avoid – plan the activity and engage with affected stakeholders to avoid noise impacts.
- Minimise – implement noise mitigation measures; and
- Manage – conduct monitoring and ensure compliance.

The current DXP EA conditions are suitable for controlling noise impact from the operation of the Lynwood FCS.

4.7 Community and Visual Amenity

4.7.1 Applicable legislation

The following legislation, policy and guidelines are relevant to identifying values and mitigating and managing impacts on community and visual amenity from the Project.

- *Planning Act 2016* (Qld): This act establishes an efficient, effective, transparent, integrated, coordinated, and accountable system of land use planning, development, assessment, and related matters that facilitates the achievement of ecological sustainability.
- *Western Downs Planning Scheme (2017)*: This planning scheme has been prepared in accordance with the *Planning Act 2016* as a framework for managing development in a way that advances the purpose of the *Planning Act 2016*.
- *Material Change of Use Performance Criteria Codes*: These are applicable to the requirements set out in the planning schemes within the Western Downs Regional Council which might specify height restrictions, lighting nuisance and performance criteria dependant on the zoning.

4.7.2 Description on Environmental Values

The Project area is located in the Darling Downs Region, within the Western Downs Regional Council (WDRC). The area is a rural area predominantly comprised of cattle, wheat, and other grain activities. The geography is dominated by pastures, crop lands, roads, bush, ridges, and creeks.

As presented in the SGPEIS, the visual baseline is described in terms of views from selected representative viewpoints, which correspond to the location of residents, settlements, work places, recreational features, recognised vantage points, tourist trails, and roads.

The description of environmental values from a community perspective and landscape characteristic for the Project are provided in **Table 4-23**.

Table 4-23 Environmental Values – Community and Landscape

Environmental Values	Description
Land use	• The land use pattern for the Project area is predominantly rural with a focus on pastoral and agricultural activities as well as areas of remnant vegetation. • Most of the land within the Project area is 'freehold land' held by agricultural/pastoral families, mining, infrastructure or pastoral companies, or State Government entities. • The proposed Project area does not contain any areas zoned for urban development. Farming homesteads and associated farming infrastructure and/or dwellings are present. • Multiple overlapping mining and coal tenures are present within the Project area.
Stakeholders, sensitive receptors, and commercial places	• The closest towns to the Project Area are Wandoan and Miles, lying within close proximity to the proposed project activities. • There are approximately 438 Lot on Plan identified within the Project Area. • Commercial stakeholders include existing industry of mining and gas.

Environmental Values	Description
	- Other stakeholders include the Western Downs Regional Council (WDRC), the Banana Shire Council, and other State and Government departments. - Modern day communities have evolved from agricultural settlements established in the 1800s, and retain a rural and agricultural character. - Community values include relative proximity to services, relaxed lifestyle, safe and family-friendly community, and the rural outlook with open space and opportunity recreation.
Landscape ⁶	- Topography throughout the project area is typically flat to gently undulating, with some low hills, jump-ups, and excised river/creek banks. - Land use across the tenement and the broader surrounds is predominantly based upon agriculture, including pastoral holdings used for grazing in the central and western areas - Sparsely settled character, with only small towns and property homesteads and cottages. - Generally comprises a strong sense of remoteness away from major roads.

4.7.3 Assessment of environmental impacts and proposed management practices

Construction

There will be some localised impacts on visual amenity on local roads due to increased traffic movements and vehicle movements above normal traffic volumes for local rural roads during daylight hours during construction. During night-time vehicle movements would be reduced and impacts temporary in nature. Landholders and property owners immediately adjacent to the site entrance to the FCS and additional infrastructure location on Arrow Energy's own land could notice an increase in traffic movements and vehicles from above the expected number of vehicle movements on rural roads.

An assessment of the proposed infrastructure as part of the EA amendment has been determined as low given the siting of infrastructure is located on Arrow Energy's own property. The nearest sensitive receptors are located approximately at 3.2 km to the North of the proposed FCS and power station facilities, and 3.1 Km to the West. Other sensitive receptors are located along Retreat Road between 600 m and 1.0 km , of the proposed warehouse facilities location..

Given the proposed height of the fence around the MPGF and existing remnant vegetation within the surrounding area, it is expected that there only be localised visual impacts to vehicles traversing Retreat Rd, which would be limited to local landholders given the location of the proposed site away from main roads and highways. Given the height of existing remanent vegetation along road corridors and within the Arrow owned property and distance set back from the road, views of the proposed infrastructure would be low. The proposed FCS site including the MPGF, and radiation fence would be approximately 2.4 km from the nearest road, with the proposed warehouse facility only approximately 500 m from the nearest road.

Operation

⁶Source: [SGPEIS Chapter 18 Landscape and Visual Amenity](#)

Supporting Information Report
Environmental Authority Amendment DXP 4

During operation, a MPGF will be used to manage distressed gas. Potential visual impacts from the MPGF can include the MPGF components, such as: burners, a radiation shield (staggered fence panels) around the flare; pipe connections; a slug catcher for removing water in gas lines; and a cyclone separator to remove solids/fines in gas lines; and from the MPGF itself, with a maximum flame height anticipated to be up to 12 m high. The MPGF is expected to feature a 16.7 m radiation fence surrounding the flare in order to: minimise radiation impacts, and to reduce visibility of the flare flame. A typical MPGF fence is shown in **Figure 4-7**.



Figure 4-7 Indicative Multi-Point Ground Flare radiation fence

As noted above, the proposed MPGF will be located approximately 2.4 km from the closest roads, so impacts during daylight operations are considered low. In the event of flaring during the day at the FCS through the MPGF, impacts would be considered low and visual impacts impeded and hidden behind the radiation wall.

At night, impacts from lighting around the facilities such as warehouse, camps and the FCS would be noticeable with visible night glow due to little to no other sources of light in a rural environment. However, lighting can be directed down and shielded to reduce light spill into the surrounding environment. Given the distance from the nearest sensitive receptors and that landholders would likely be inside during the night, impacts from lighting at the proposed infrastructure is unlikely to impact on the visual amenity or would be considered temporary from vehicles travelling on Retreat Road.

In the event of flaring during the night at the FCS through the MPGF, impacts would be considered low. Whilst there will be a noticeable night glow from the flare due to no other light sources in the rural environment at night which would have the likelihood to be seen much further afield due to the likely intensity of the flare, the frequency of which flaring would occur under normal operating conditions is low. As noted in previous sections the frequency of flaring could be once or twice a year, however the intention is to minimise flaring as much as possible and may occur during upset or abnormal operating conditions. Similar to lighting around the facility, if flaring was to occur at night, landholders at nearby sensitive receptors would likely be inside their residences or asleep.

Supporting Information Report
Environmental Authority Amendment DXP 4

There will be some localised impacts on visual amenity on local roads due to increased traffic movements and vehicle movements above normal traffic volumes for local rural roads during daylight hours. During night-time vehicle movements would be reduced and impacts temporary in nature.

5. Legislative Requirements

5.1 EIS Process and Compliance with the EP Act

Arrow Energy prepared a voluntary Environmental Impact Statement (SGPEIS) and Supplementary Report to the EIS (SREIS) for the SGP under the EP Act. The EIS and the SREIS received both State and Federal government approval in 2013.

The DXP EA (EPPG00972513) was granted on 05 February 2025 which included all the infrastructure for the development of the gas fields to which the DXP EA applies, except for the proposed Lynwood FCS. The Lynwood FCS was included in the EIS and the SREIS.

As per Section 139 (1) (b) of the EP Act, the EIS for the SGP was completed, and Arrow Energy considers that the proposed amendment does not significantly increase the level of environmental harm to that which was assessed and approved under the SGPEIS, as the way in which the approved activities will be carried out have not materially changed since the SGPEIS process was completed. This EA amendment only seeks to authorise disturbance to ESAs and PEMS, and include an additional facility to be listed under the authorised petroleum activities (which will be constructed within the existing compressor unit allowance).

This Supporting document to amend the DXP EA (EPPG00972513) is to satisfy Section 125 (1) (l) of the EP Act, and has included the likely impacts of each relevant activity on the corresponding environmental values (refer to Section 3.6 and 4.3).

5.2 Requirements for Amendment Applications

Arrow Energy is applying to amend its DXP EA (EPPG00972513) as per Section 224 of the EP Act as it proposes to carry out additional resource activities as part of the SGP Project

An assessment of the proposed EA amendment has been conducted against the requirements under Section 223 of the EP Act for minor amendment (threshold) and is presented in **Table 5-1**.

Table 5-1 Threshold criteria for an amendment to an EA

Amendment Threshold Criteria (EP Act Section 223)	This EA Amendment Application (i.e. DXP EA Amendment)
a) is not a change to a standard condition identified in the authority as a standard condition, other than – (i) a change that is a condition conversion; or (ii) a change that is not a condition conversion but that replaces a standard condition of the authority with a standard condition for the environmentally relevant activity to which the authority relates; and	The proposed amendment does not propose any changes to standard conditions identified in the authority as a standard condition.
b) does not significantly increase the level of environmental harm caused by the relevant activity; and	The proposed amendment does not significantly increase the risk of environmental harm. The environmental risks associated with the Project activities, as assessed in the SGPEIS, have not materially changed.

Supporting Information Report
Environmental Authority Amendment DXP 4

Amendment Threshold Criteria (EP Act Section 223)	This EA Amendment Application (i.e. DXP EA Amendment)
c) does not change any rehabilitation objectives stated in the authority in a way likely to result in significantly different impacts on environmental values than the impacts previously permitted under the authority; and	There will be no change to the rehabilitation objective in the EA as a result of the proposed amendment.
d) does not significantly increase the scale or intensity of the relevant activity; and	The application does not seek to significantly increase the scale and intensity of the activity to what has previously been assessed and authorised under the SGP EIS and SREIS. This application seeks to authorise a field compression station and incidental activities to facilitate the development of the already approved wells. In addition, the application seeks to update the ESAs and impact to PEMs. As such Arrow do not believe that the proposed amendment significantly increases the scale and intensity of the activity.
e) does not relate to a new relevant resource tenure for the authority that is – (i) a new mining lease; or (ii) a new petroleum lease; or (iii) a new geothermal lease under the Geothermal Energy Act 2010; or (iv) a new greenhouse gas injection and storage lease under the Greenhouse Gas Storage Act 2009; and	No new resource tenure is proposed as part of this amendment.
f) Involves an addition to the surface area of the relevant activity of no more than 10% of the existing area; and	The proposed amendment will not increase the surface area for the relevant activity greater than 10% of the existing area, nor does it seek to authorise more than 10% of the existing authorised disturbance area. The only additional disturbance being authorised is for the proposed Lynwood FCS. Existing Schedule A, Table 1 allows for 1355 ha of disturbance. The proposed Lynwood FCS footprint is 15 ha, or 1.1% of the total authorised disturbance.
g) For an environmental authority for a petroleum activity: (i) involves constructing a new pipeline that does not exceed 150km; or (ii) involves extending an existing pipeline so that the extension does not exceed 10% of the existing length of the pipeline; and	None of the proposed pipelines will exceed the defined thresholds.
h) if the amendment relates to a new relevant resource tenure for the authority that is an exploration permit or greenhouse gas permit — seeks, in the amendment application under section 224, an amended environmental authority that is subject to the standard conditions for the relevant activity or authority, to the extent it relates to the permit.	No new resource tenure is required for the proposed amendment.

The assessment as outlined in **Table 5-1** demonstrates that the proposed amendment to the DXP EA considered in this application is a minor amendment.

Supporting Information Report
Environmental Authority Amendment DXP 4

Table 5-2 summarises the statutory requirements under Section 226 and the responses from Arrow Energy to each of these requirements.

Table 5-2 EP Act Section 226 requirements for amendment application generally and Arrow Energy's response

Statutory requirement under s226 of the EP Act	Arrow Energy's Response
(1) An amendment application must –	
(a) be made to the administering authority; and	This EA amendment application has been made to DETS which is the administering authority for this EA
(b) be in the approved form; and	Arrow Energy has applied for this EA using the most recent version of the approved application form. This report is provided as supporting information to the application.
(c) be accompanied by the fee prescribed under a regulation; and	Arrow Energy has elected to pay the fee prescribed under regulation by credit card
(d) describe the proposed amendment; and	Full details of this proposed EA amendment are included in this Supporting Document so that the administering authority, i.e., DETSI can clearly determine the requested changes to the DXP EA (EPPG00972513) The justifications of how this proposed EA amendment meets the criteria for a minor amendment is provided in Table 5-1 This document and its appendices provide the supporting information documentation to the DXP 4 EA amendment application.
(e) describe the land that will be affected by the proposed amendment; and	The Project will be carried out within existing designated areas of the DXP EA i.e., within PLs PL238, PL258, PL252, PL198, PL230, PL260. No new areas will be included. Maximum disturbance to ESAs and PEMs are discussed and provided in Section 3.
(f) include any other document relating to the application prescribed by regulation.	The CSG Water Management Plan, as prescribed by regulation, is included as part of this amendment application (refer to Appendix G)

Table 5-3 summarises the statutory requirements under Section 226A and the responses from Arrow Energy to each of these requirements.

Table 5-3 EP Act Section 226A requirements for amendment application and Arrow Energy's response

Statutory requirement under s226A of the EP Act	Arrow Energy's Response
(1) An amendment application must also –	
(a) describe any development permits in effect under the Planning Act for the carrying out of the relevant activity for the authority; and	Arrow Energy does not have any development permits in effect under the Planning Act for the carrying out of the relevant activities for the authority.
(b) state whether each relevant activity will, if the amendment is made, comply with any eligibility criteria for the activity; and	This is not relevant to Arrow Energy's application as the application is a site-specific EA amendment application.
(c) if the application states that each relevant activity will, if the amendment is made, comply with any eligibility criteria for the activity – include a declaration that the statement is correct; and	This is not relevant to Arrow Energy's application as the application is a site-specific EA amendment application.
(d) state whether the application seeks to change a condition identified in the authority as a standard condition; and	No changes to standard conditions are proposed with this EA amendment.
(e) if the application relates to a new relevant resource tenure for the authority that is an exploration permit or GHG permit – state whether the applicant seeks an amended environmental authority that is subject to the standard conditions for the relevant activity or authority, to the extent it relates to the permit; and	This is not relevant as this application relates to the existing PLs authorised by the DXP EA (EPPG00972513) and does not seek to include any new resource authorities.
(f) include an assessment of the likely impact of the proposed amendment on the environmental values, including – (i) a description of the environmental values likely to be affected by the proposed amendment; and (ii) details of emissions or releases likely to be generated by the proposed amendment; and (iii) a description of the risk and likely magnitude of impacts on the environmental values; and (iv) details of the management practices proposed to be implemented to prevent or minimise adverse impacts; and (v) if a PRCP schedule does not apply for each relevant activity – details of how the land the subject of the application will be rehabilitated after each relevant activity ends; and	(i) See Section 3.6 and 4.3 (ii) See Section 4.4 and 4.5 (iii) See Section 3.6 and 4.3 (iv) See Section 3.6 and 4.3 through 4.7 (v) Not applicable.
(g) include a description of the proposed measures for minimising and managing waste generated by amendments to the relevant activity; and	The proposed amendment does not change any generation of waste by the relevant activities covered under the existing DXP EA and the SGPEIS and SREIS.
(h) include details of any site management plan or environmental protection order that relates to the land the subject of the application.	Not applicable.

5.3 Requirements for Amendment Applications for CSG Activities

5.3.1 CSG Water Management and Underground Water Rights

Section 227 of the EP Act is not applicable to this proposed EA amendment as the proposed activities would not result in changes to the management of CSG water. Please refer to details provided in **Table 5-4** and the CSG Water Management Plan provided in Appendix G

Table 5-4 EP Act Section 227 and Section 227AA requirements for amendment application and Arrow Energy's response

Amendment application for CSG activities		Arrow Energy's response
Statutory requirements under s227 of the EP Act – CSG Activities		
(1) This section applies for an amendment application if –		Applicability
(a) the application relates to an environmental authority for a CSG activity; and	Yes. This EA amendment relates to an environmental authority for a CSG activity	This legislative requirement is deemed not applicable to this EA amendment.
(b) the proposed amendment would result in changes to the management of CSG water; and	No. This EA amendment will not result in changes to the management of CSG water. Arrow Energy is providing a revision update of its CSG Water Management Plan (refer to Appendix G) which is consistent with the proposed changes in the EA conditions and EOW Codes.	
(c) the CSG activity is an ineligible ERA.	Yes. The CSG activity is an ineligible ERA.	
(2) the application must also –		Applicability
(a) state the matters mentioned in section 126 (1); and	The matters under s126 (1) are stated in the CSG Water Management Plan as provided in Appendix G.	The requirements under this section are provided in the CSG Water Management Plan (refer to Appendix G)
(b) comply with section 126 (2)	Best practices environmental management for managing CSG water and alternative ways for managing water are provided in the CSG Water Management Plan (refer to Appendix G)	
Statutory requirements under s227AA of the EP Act – underground water rights		
(1) This section applies for an amendment application if –		
(a) the application relates to a site-specific environmental authority for -		Applicability
(i) a resource project that includes a resource tenure that is a mineral development licence, mining lease or petroleum lease; or	Yes. The application relates to a site-specific environmental authority that relates to a resource project which includes a resource tenure for a petroleum lease.	Applicable.
(ii) a resource activity for which the relevant tenure is a mineral development licence, mining lease or petroleum lease; and	Yes. The application relates to a site-specific environmental authority for which the relevant tenure is a petroleum lease.	Applicable.

Supporting Information Report
Environmental Authority Amendment DXP 4

Amendment application for CSG activities	Arrow Energy's response	
(b) the proposed amendment involves changes to the exercise of underground water rights.	The proposed EA amendment involves above ground activity. The proposed amendments will <i>not</i> involve changes to the exercise of underground water rights. There are no additional wells being authorised, only the disturbance to ESAs and PEMs to facilitate their construction and operation.	Not applicable.

Appendix A. Mark Up of Proposed DXP EA (EPPG00972513) Amendments

Appendix B. GHG Abatement Plan

This application meets the medium to high GHG emission category in accordance with Section 3.2 of the Greenhouse Gas Emissions Guideline ⁷ published by DESI in May 2024; i.e. expected GHG emissions (Scope 1 and Scope 2) of 25,000 tonnes CO₂-e or more per year (at any time during the life of the project). As per Table 3 of the GHG Emissions Guideline, a GHG abatement plan is required as part of the application. Table 5-5 outlines the requirements of a GHG abatement plan in more detail (as per Appendix A (Table 2) of the GHG Emissions Guideline).

Section 2.2 of the GHG Emissions Guideline states that the Safeguard Mechanism is not an approval framework and does not require details of how emissions will be reduced. Therefore, the GHG emissions information is still required for the Queensland Government to make a decision on new and amended EAs.

⁷ [Greenhouse gas emissions \(desi.qld.gov.au\)](https://desi.qld.gov.au/greenhouse-gas-emissions)

Table 5-5 GHG Abatement Plan Requirements as per DESI GHG Emissions Guideline

GHG Emissions Guideline Requirement	Description	Details
a) Project details	• Applicant • Project name and description (including location)	Refer to Section 1
b) Emissions projections and commencing abatement measures	• Emission inventory and estimates as developed in section 3.1 of the guideline; i.e.: 1. Include an emissions inventory identifying the GHG to be emitted and the stage of the project at which the emissions will occur. Include a breakdown of GHG emissions by source. 2. Estimate the projected annual Scope 1 and Scope 2 CO₂-e emissions over the life of the project. Include both unabated emissions and emissions after all avoidance and abatement measures (as outlined in section 3.3) have been accounted. 3. Provide an estimate of annual Scope 3 emissions and total Scope 3 emissions over the life of the project (refer to Section 3.1.1). a. As they are outside the control of the EA holder, they are not required to be included in a GHG abatement plan. b. Estimated Scope 3 emissions are not required to be included in applications where projected Scope 1 and Scope 2 emissions are expected to be less than 25,000 tonnes of CO₂-e per annum. 4. Emissions data should be supported by a description of how the values were determined including: a. information about the methodology used (including software) b. assumptions made (such as the boundary of where Scope 3 emissions were considered) c. identification and justification of any emissions that were excluded from the calculation. • Management practices proposed to be implemented at commencement to reduce GHG emissions as per section 3.3 of the guideline.	• The following information is provided in Section 4.5.5: ○ Breakdown of unabated annual emissions by source for the life of the Project is provided in Table 4-12 (Scope 1) and in Table 4-13 (Scope 3). ○ Total Scope 1 and Scope 3 emissions over the life of the Project is provided in Table 4-14. ○ Emissions estimation methodology is provided in Table 4-11. ○ Assumptions such as Scope 3 emissions boundaries. • The following information is provided in Section 4.5.6: ○ Estimated abated emissions and emissions after all avoidance and abatement measures (Scope 1) are provided in Table 4-17 and Figure 4-5. ○ Management practices proposed to be implemented.
c) GHG emissions reference point	• Outline the level of emissions against which ongoing reduction of GHG emissions will be assessed throughout the life of the project (reference point).	As discussed in Section 4.5.1 , it is anticipated that the Project will form part of Arrow Energy's Surat Gas Operations Safeguard

Supporting Information Report
Environmental Authority Amendment DXP 4

GHG Emissions Guideline Requirement	Description	Details																	
	- This is based on projected GHG emissions prior to implementation of the GHG abatement plan and may include multiple reference points developed for each stage of the activity. - For projects captured by the Commonwealth Safeguard Mechanism, the reference points may be determined by the Safeguard Mechanism (referred to as baseline). - Provide justification for the reference points proposed.	facility due to its commercial and operational interconnections. This would ensure that the Safeguard Mechanism applies to the Project as greenhouse gas emissions would always be above the Safeguard participation threshold of 100,000 t CO₂-e/yr.																	
d) Emission reduction targets	- Identify interim Scope 1 and Scope 2 GHG emission reduction targets to be applied throughout the life of the project. - Identify long-term overall Scope 1 and Scope 2 GHG emission reduction targets. - Targets may be set at intervals of up to 5 years to take into account emerging technologies over that period and allow for production variability, provided they result in a reduction of GHG emission at the end of the period. - For projects captured by the Commonwealth Safeguard Mechanism, the emission reduction targets may be determined by the Safeguard Mechanism. - Provide justification for the emission reduction trajectory and targets proposed and how they support the Queensland Government's greenhouse gas emission reduction targets.	The interim and long-term Scope 1 GHG emission reduction targets will be in line with the Safeguard Mechanism baseline annual reduction for Arrow Energy's Surat Gas Operations Safeguard facility, which is anticipated to include the Project when the asset becomes operational (refer to Section 4.5.1). The site-specific emission intensity reduction targets relevant for this Environmental Authority and Arrow's Surat Gas Operations Safeguard facility are shown in the below table. It is noted that the emission reduction targets apply to Arrow's entire Surat Gas Operations under the Safeguard Mechanism and are not isolated to this project. Production Variable Emission Intensity Reduction Targets <table> <tr> <th rowspan="2">Year</th><th>PV26 - Extracted Gas</th><th>PV 57 - Electricity Generation</th></tr> <tr> <th>(t CO₂-e/GJ)</th><th>(t CO₂-e/MWh)</th></tr> <tr> <td>Year 5</td><td>28%</td><td>59%</td></tr> <tr> <td>Year 10</td><td>46%</td><td>69%</td></tr> <tr> <td>Year 15</td><td>64%</td><td>79%</td></tr> <tr> <td>Year 20</td><td>82%</td><td>90%</td></tr> </table>	Year	PV26 - Extracted Gas	PV 57 - Electricity Generation	(t CO ₂ -e/GJ)	(t CO ₂ -e/MWh)	Year 5	28%	59%	Year 10	46%	69%	Year 15	64%	79%	Year 20	82%	90%
Year	PV26 - Extracted Gas	PV 57 - Electricity Generation																	
	(t CO ₂ -e/GJ)	(t CO ₂ -e/MWh)																	
Year 5	28%	59%																	
Year 10	46%	69%																	
Year 15	64%	79%																	
Year 20	82%	90%																	
e) GHG emission reduction program	A program that details the GHG emission reduction measures for Scope 1 and 2 that will be implemented throughout the life of the project, as developed in section 3.3 of the guideline and outlined in Part B.	Refer to the 'Assessed GHG emissions abatement measures' subsection of Section 4.5.6.																	
f) Advancing technologies and opportunities	Provisions for regularly reviewing new technologies to identify opportunities to further reduce emissions and energy efficiency.	Refer to the 'Commitment to continual improvement' subsection under Section 4.5.6. Figure 5 4 illustrates Arrow Energy's current GHG opportunity process including workshops with key internal stakeholders from various disciplines and ranks within Arrow Energy to identify GHG																	

Supporting Information Report
Environmental Authority Amendment DXP 4

GHG Emissions Guideline Requirement	Description	Details
		abatement opportunities and assess whether they are economically viable for implementation. This involves the consideration of new technologies such as solar hybrid technology.
g) Monitoring and auditing	• A program for monitoring GHG emissions and auditing against GHG emission reduction targets.	Arrow Energy's current key monitoring and assurance steps include: • Monthly review of incoming and outgoing reports (Production Surveillance, Operations, HSE, Energy Markets). This includes disclosure to internal key stakeholders of set annual emission intensity targets and Safeguard Baseline, and how Arrow Energy is tracking against them. • Quarterly report review of activity data (Operations) and emission estimates (HSE) • Annual review and summary report (HSE, CEO) • Targeted third-party assurance engagements on NGER emissions and energy estimates, which can be extended to also cover emission reduction targets.
h) Reporting	• A program for periodic public reporting on progress towards the GHG emission reduction targets outlined in the GHG abatement plan including details about how public reporting will be undertaken. • There is no intent to duplicate reporting requirements. Where companies are already reporting GHG emissions under another framework, this section can refer to that reporting. However, reporting must be against the emission reduction targets stated in the GHG abatement plan and must be publicly available. • Where the GHG abatement plan includes commercial-in-confidence information, the applicant may request that specific details are treated as confidential and are not made publicly available, with justification to support this request.	Arrow Energy will be required to disclose climate-related risks and opportunities under the Australian Sustainability Reporting Standards (ASRS) from financial year 2025, including: • governance • Scope 1 and 2 emissions • Scope 3 emissions (optional for Year 1) • climate scenario analysis • climate resilience assessment • climate transition plan • climate-related metrics and targets. However, the disclosures may not show the level of granularity that will capture the Project as a standalone asset given all of the existing and future Arrow Energy assets will be treated as a single Safeguard facility from financial year 2024 (1 July 2023) onwards.

Appendix C. Lynwood FCS Air Assessment



Surat Gas Project – Lynwood Field Compressor Station

Air Quality Impact Assessment

Arrow Energy Pty Ltd

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21 January 2025

Revision: 2.0

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
02	21 January 2025	F Rahaman	K Lawrence	K Lawrence
01	16 December 2024	F Rahaman	K Lawrence	K Lawrence

Basis of Report

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Arrow Energy Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.



Executive Summary

SLR Consulting Pty Ltd (SLR) has been engaged by Arrow Energy (Arrow) to perform an air quality impact assessment, including a detailed air dispersion modelling study, to assess potential air quality impacts from the proposed Field Compressor Station (FCS) to be located at Lynwood in the Surat Basin, Queensland.

The proposed FCS will consist of the following main plant:

- Screw compressors (up to four), which will compress low-pressure coal seam gas (CSG)
- CSG fired internal combustion power generation plant equipped with a battery energy storage system (BESS). This will provide electrical power to the facility, mainly to power the compressors.
- Multi-point ground flare (MPGF, to manage distressed gas),
- Slug catcher (to remove water in the gas line); and
- Cyclone separator (to remove solids/fines in the gas line).

All sensitive receptors in the study area are existing dwellings/residential premises. No other sensitive receptor types were identified within the study area. All sensitive receptors are located at least 3 kilometres (km) from the Lynwood FCS.

Meteorological and dispersion modelling was performed using a combination of The Air Pollution Model (TAPM), CALMET and CALPUFF models to predict downwind concentrations of nitrogen dioxide (NO₂) and carbon monoxide (CO) due to emissions from the proposed power plant and during a major potential flaring event at the proposed FCS.

All air dispersion modelling was conducted at maximum emission rates and maximum loads, which results in a conservative assessment of potential air quality impacts.

Based on the modelling results, the following conclusions have been drawn:

- The modelling results showed that under normal maximum operating conditions (i.e. concurrent operation of sixteen power station generators at maximum load) the proposed Lynwood FCS operation has no potential to result in any exceedances of the relevant ambient air quality criteria at surrounding sensitive receptors.
- The modelling of NO_x and CO emissions from a maximum flaring event at the proposed Lynwood FCS showed that predicted short term average NO₂ and CO concentrations would also remain well below the relevant ambient air quality guidelines.

Based on the above, no air quality constraints have been identified for the proposed Lynwood FCS by this air quality impact assessment. Mitigation measures and proposed air conditions have been identified for the FCS.



Table of Contents

Basis of Report	i
Executive Summary	ii
1.0 Introduction	1
1.1 Background	1
1.2 Scope of Work	2
2.0 Regulatory Framework	3
2.1 National Environment Protection Measure for Ambient Air Quality	3
2.2 Queensland EPP (Air) Policy	3
2.3 Air Quality Criteria Adopted in this Assessment	4
3.0 Site Description	6
3.1 Site Location and Surrounding Land Use	6
3.2 Climate and Meteorology	6
3.2.1 Temperature	6
3.2.2 Rainfall	6
3.2.3 Solar Radiation and Evaporation	7
3.2.4 Relative Humidity	8
3.2.5 Wind Speed and Direction	9
3.3 Topography	10
3.4 Existing Air Quality Environment	10
3.5 Sensitive Receivers	0
4.0 Assessment Methodology	3
4.1 Model Selection	3
4.2 Selection of Representative Year	3
4.3 Meteorological Modelling	3
4.3.1 TAPM	3
4.3.2 Summary of Meteorological Data Used in the Modelling	4
4.4 NO _x to NO ₂ Conversion	8
5.0 Source Parameters	10
5.1 Modelling Scenarios	10
5.2 Stack and Emission Data	10
5.2.1 Normal Operation	10
5.2.2 Flaring - Multi Point Ground Flare	11
5.2.3 Existing Emission Sources	11
6.0 Air Quality Impact Assessment	13
6.1 Normal Operations	13
6.2 Major Flaring Event	13



7.0	Mitigation and Monitoring	15
7.1	Mitigation Measures	15
7.2	Air Monitoring Programmes	16
7.3	Proposed Air Conditions	17
8.0	Conclusions	20
9.0	References	21

Tables in Text

Table 1	NEPM AAQ Standards and Goals for Relevant Criteria Pollutants	3
Table 2	Relevant EPP (Air) Ambient Air Quality Objectives	4
Table 3	Ground Level Concentration Criteria Adopted for use in this Study	4
Table 4	Summary of Review of Available Monitoring Data – Miles Airport	11
Table 5	Adopted Background Levels for Assessing Cumulative Impacts	0
Table 6	Identified Sensitive Receptors within 5 km of Lynwood FCS	1
Table 7	Meteorological Parameters Adopted (TAPM v 4.0.4)	4
Table 8	CALMET Configuration Used for this Study	4
Table 9	Meteorological Conditions Defining PGT Stability Classes	7
Table 10	Classification of Values for A and α by Season	9
Table 11	Modelling Scenarios	10
Table 12	Model Inputs for the Lynwood Power Station – Normal Operations	10
Table 13	MPGF Design Data	11
Table 14	Stack and Emission Data for Existing Tipton CGPF and WTF	12
Table 15	NO _x and CO Concentrations Predicted at the Nearest Sensitive Receptors – Lynwood FCS, Normal Operations	13
Table 16	NO ₂ and CO Concentrations Predicted at the Nearest Sensitive Receptors – Lynwood FCS, Flaring	14
Table 17	Mitigation Commitments	16
Table 18	Proposed Point Source Emission Limits for Lynwood FCS	17

Figures in Text

Figure 1	Site Layout – Lynwood FCS	1
Figure 2	Long Term Temperature Data for Dalby Airport	7
Figure 3	Long Term Monthly Rainfall Data for Dalby Airport	7
Figure 4	Long Term Solar Radiation and Evaporation Data for Dalby Airport	8
Figure 5	Long Term Humidity Data for Dalby Airport	8
Figure 6	Rose of Wind Direction vs Wind Speed (km/hr) at Dalby Airport (1992 -2023)	9
Figure 7	Local Topography	10



Figure 8	Measured 1-Hour Average NO ₂ and O ₃ Concentrations – Miles	12
Figure 9	Measured 8-Hour Average CO Concentrations – Miles	13
Figure 10	Identified Sensitive Receptors – Lynwood FCS	2
Figure 11	Annual and Seasonal Wind Roses as Predicted by CALMET for Lynwood FCS Site (2023)	5
Figure 12	Wind Speed Distributions as Predicted by CALMET (2023) at Lynwood FCS Site	6
Figure 13	Stability Class as Predicted by CALMET (2023) at Lynwood FCS Site	7
Figure 14	Mixing Heights as Predicted by CALMET (2023) at Lynwood FCS Site	8

Appendices

Appendix A Isopleths



1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Arrow Energy (Arrow) to undertake an air quality impact assessment (AQIA) for the proposed Lynwood Field Compressor Stations (FCS) as part of their Surat Gas Project (SGP) in Queensland. The Lynwood FCS site is located approximately 35 km southwest of Dalby in Queensland.

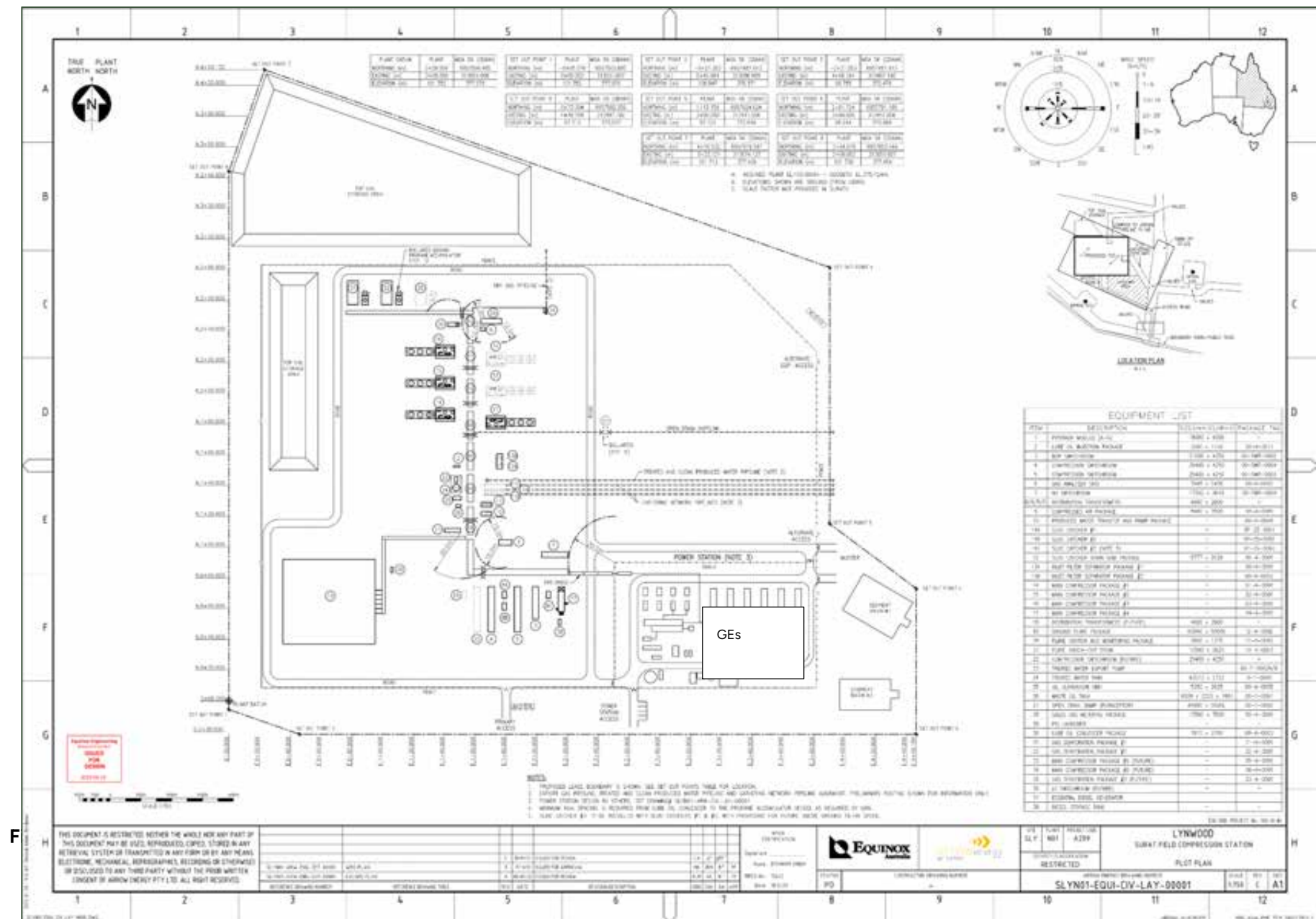
1.1 Background

The Lynwood FCS will facilitate compression of low-pressure coal seam gas (CSG) and deliver medium-pressurised gas downstream to the gas sales delivery point. This FCS will consist of the following:

- Screw compressors (up to four) which compress low-pressure CSG,
- CSG fired internal combustion power generation plant (comprising 16 × 1.8 MW gas engines plus two standby 1.8 MW engines) equipped with a battery energy storage system (BESS). This provides electrical power to the facility and is mainly used to power the compressors.
- Multi-point ground flare (MPGF, to manage distressed gas),
- Slug catcher (to remove water in the gas line); and
- Cyclone separator (to remove solids/fines in the gas line).

The proposed site layout of the Lynwood FCS is presented in **Figure 1**.

It is noted that an emergency diesel generator will also be located at the southern end of the site. This unit would only operate intermittently for short periods for maintenance and testing, or in the event of a gas feed failure to enable safe shutdown of the FCS. Given the very short-term and intermittent nature of its operation, air emissions from this unit have not been considered further.



1.2 Scope of Work

The scope of work for the AQIA was as follows:

- Confirm relevant regulatory criteria for relevant air pollutants, such as those set out in the *Queensland Environmental Protection (Air) Policy* (EPP Air 2019) and Amendment (EPP Air 2024).
- Characterise the background ambient air quality to enable an assessment of cumulative impacts. This included a review of air quality data collected by the nearest Air Quality Monitoring Station (AQMS) located at Miles.
- Review the FCS site layout plan, stack parameters and emissions data for key air pollutants (NO_x and CO) provided by Arrow for the proposed normal and upset operations.
- Model emissions of NO_x and CO from on-site CSG combustion sources (eg. gas generators and flares) to predict maximum downwind ground level pollutant concentrations for normal and flaring operational scenarios using the CALPUFF dispersion model.
- Based on the results of the dispersion modelling, assess the potential impacts on local air quality associated with the operation of this facility.
- Identify any required mitigation measures to manage air quality impacts and propose licence conditions for approval.



2.0 Regulatory Framework

2.1 National Environment Protection Measure for Ambient Air Quality

The *National Environment Protection (Ambient Air Quality) Measure* (NEPM AAQ) (NEPC 2021) provides a nationally consistent framework for jurisdictions to monitor and report ambient air quality through setting reporting standards for key air pollutants. The NEPM AAQ contains standards and goals for six common air pollutants, commonly referred to as *criteria pollutants*. The current NEPM AAQ standards for those pollutants relevant to this assessment (as updated on 18 May 2021) are presented in **Table 1**.

It is noted that the NEPM AAQ standards apply at performance monitoring locations. Performance monitoring stations are to be located so that they provide a representative measure of the air quality likely to be experienced by the general population in the region or sub-region. The NEPM AAQ standards are therefore not intended for use in assessing air quality impacts from individual sources, specific industries or roadside locations. Nonetheless, many State regulatory agencies, including the Queensland Department of Environment, Science and Innovation (DESI), have adopted them as air quality impact assessment criteria for use in AQIAs (see **Section 2.2**).

Table 1 NEPM AAQ Standards and Goals for Relevant Criteria Pollutants

Indicator	Maximum Concentration Standard		Averaging Period
	$\mu\text{g}/\text{m}^3$ at 0°C	ppm	
NO ₂	162	0.08	1-hour
	30	0.015	Annual
CO	11,100	9.0	8 hours

2.2 Queensland EPP (Air) Policy

The *Environmental Protection (Air) Policy* (EPP (Air)) (EPP Air 2019) is designed to achieve the objectives of the *Environmental Protection Act 1994* in relation to the air environment. The purpose of the EPP (Air) is achieved by identifying environmental values to be enhanced or protected, outlining indicators and air quality objectives for enhancing or protecting these values and providing a framework for making consistent, equitable and informed decisions about the air environment.

The environmental values listed in the EPP (Air) that are to be enhanced or protected under the policy are:

- The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and
- The qualities of the air environment that are conducive to human health and wellbeing; and
- The qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and
- The qualities of the air environment that are conducive to protecting agricultural use of the environment.

Air quality objectives for a range of pollutants are outlined within Schedule 1 of the EPP (Air) to protect these environmental values. A number of the air quality objectives have been revised in the EPP (Air) Amendment released in 2024 (EPP Air 2024). Those related to this AQIA are reproduced in **Table 2**.



As shown in **Table 2**, the EPP (Air) currently also includes an air quality objective for NO₂ to protect the health and biodiversity of ecosystems. The EHP Guideline, *Application requirements for activities with impacts to air* (DEHP 2017) states:

‘If a proposal involves the release of contaminants to air in a location where natural ecosystems may be affected (e.g. adjacent to national parks), the applicant must identify whether emissions are at levels that may impact on the health and biodiversity of the ecosystem.’

Table 2 Relevant EPP (Air) Ambient Air Quality Objectives

Indicator	Environmental Value	Air Quality Objectives		Averaging Period
		µg/m ³ at 0°C	ppm	
NO ₂	Health and wellbeing	164	0.12	1-hour
		31	0.03	Annual
	Health and biodiversity of ecosystems	33	0.016	Annual
CO	Health and wellbeing	11,000	9.0	8 hours

Section 9 of the EPP (Air) also sets out a management hierarchy for all activities involving air emissions:

- Firstly - **avoid** (e.g. using technology that avoids air emissions);
- Secondly - **recycle** (e.g. re-using air emissions in another industrial process);
- Thirdly - **minimise** (e.g. treating air emissions before disposal); and
- Fourthly - **manage** (e.g. locating an activity that releases air emissions in a suitable area to minimise the impact of the air emissions).

2.3 Air Quality Criteria Adopted in this Assessment

The ground level ambient air quality criteria that are considered appropriate for this air quality assessment are summarised in **Table 3**.

Table 3 Ground Level Concentration Criteria Adopted for use in this Study

Indicator	Averaging Period	Criterion (µg/m ³ at 0°C)	Reference
NO ₂	1 hour	164	EPP (Air) Amendment 2024



Indicator	Averaging period	Criterion ($\mu\text{g}/\text{m}^3$ at 0°C)	Reference
1 year	31		EPP (Air) Amendment 2024
CO 8 hours	11,000		EPP (Air) 2019



3.0 Site Description

3.1 Site Location and Surrounding Land Use

As outlined in **Section 1.0**, the proposed Lynwood FCS site is located approximately 35 km southwest of Dalby in the Surat Basin in the Darling Downs region of Queensland.

The areas surrounding the site are predominantly rural in nature, with land uses such as grazing, pre-existing gas field development and overlapping mining tenures dominating. Kumbarilla State Forest is located to the west. 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.

The Tipton Central Gas Processing Facility (CGPF) and Water Treatment Facility (WTF) is located approximately 10 km to the north of the Lynwood FCS site. Air emissions from these sources have been considered in this assessment to account for any potential cumulative impacts.

3.2 Climate and Meteorology

The nearest available meteorological monitoring stations collecting data suitable for use in a quantitative air dispersion modelling study operated by the Bureau of Meteorology (BoM) are located at Dalby Airport and Miles Airport. The following description of the regional climate is based on long-term data reported from Dalby Airport (Station 041522, elevation 344 m), located 40 km from the Lynwood FCS, which has data available from 1992 to 2024 for the following parameters:

- Temperature (°C)
- Rainfall (mm)
- Solar radiation (MJ/m²)
- Evaporation (mm)
- Relative humidity (%)
- Cloud cover
- Wind speed (m/s) and wind direction (degrees).

A review of the long-term data available is provided in the following sections.

3.2.1 Temperature

Long-term temperature statistics for Dalby Airport are summarised in **Figure 2**. Mean maximum temperatures range from 19.8°C in winter to 32.7°C in summer, while mean minimum temperatures range from 4.1°C in winter to around 18.9°C in summer. Maximum temperatures above 40°C and minimum temperatures less than -6°C have been recorded.

3.2.2 Rainfall

Long-term rainfall statistics for Dalby Airport are summarised in **Figure 3**. The average monthly rainfall is relatively high in summer, reducing from autumn to winter with the lowest average of 19.8 mm/month recorded during April. This month also recorded an average of around four rain days per month. The highest average monthly rainfall of 89.9 mm/month occurs in December, with an average of 9 rain days recorded in this month. The highest monthly rainfall recorded over the time period examined was 247.4 mm recorded in December 2010. Peak rainfall events occur during summer, with the maximum daily rainfall of 110 mm recorded on 5 February 2008.



Figure 2 Long Term Temperature Data for Dalby Airport

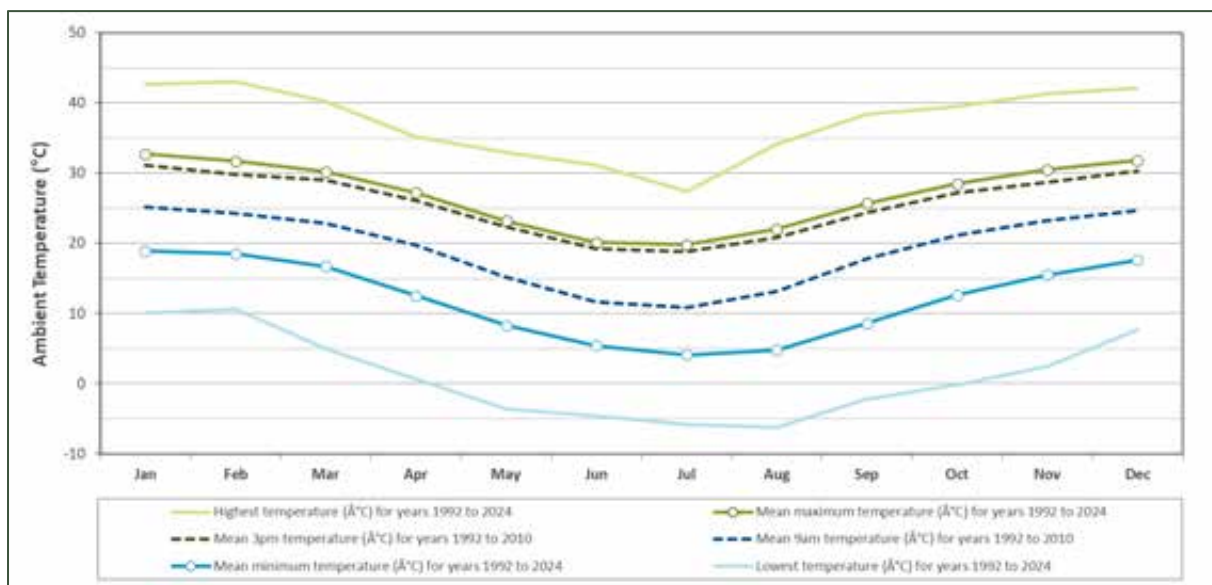
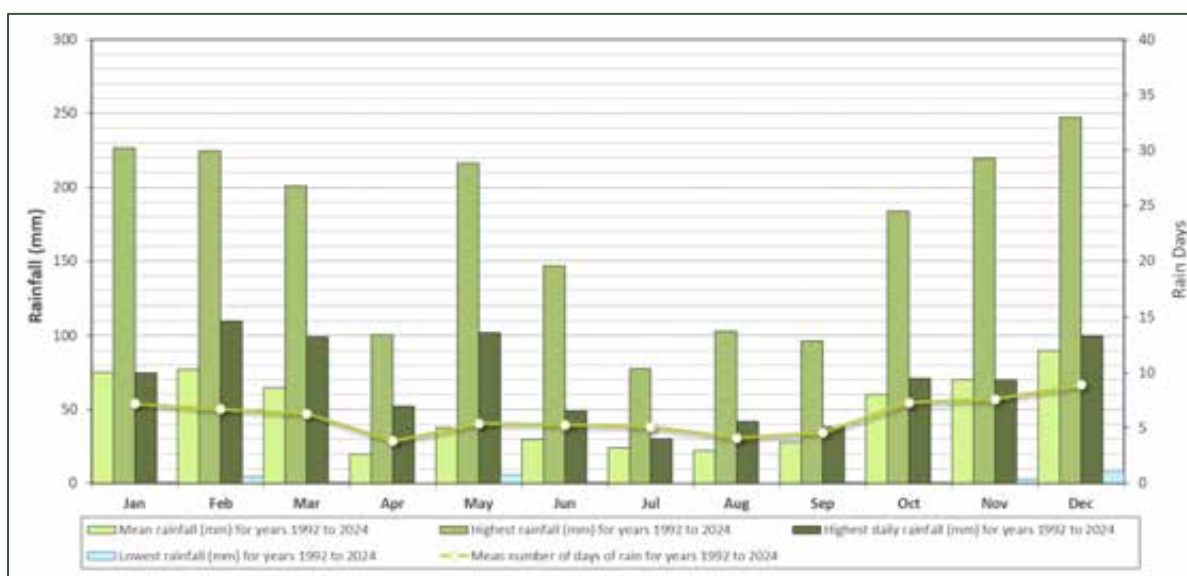


Figure 3 Long Term Monthly Rainfall Data for Dalby Airport

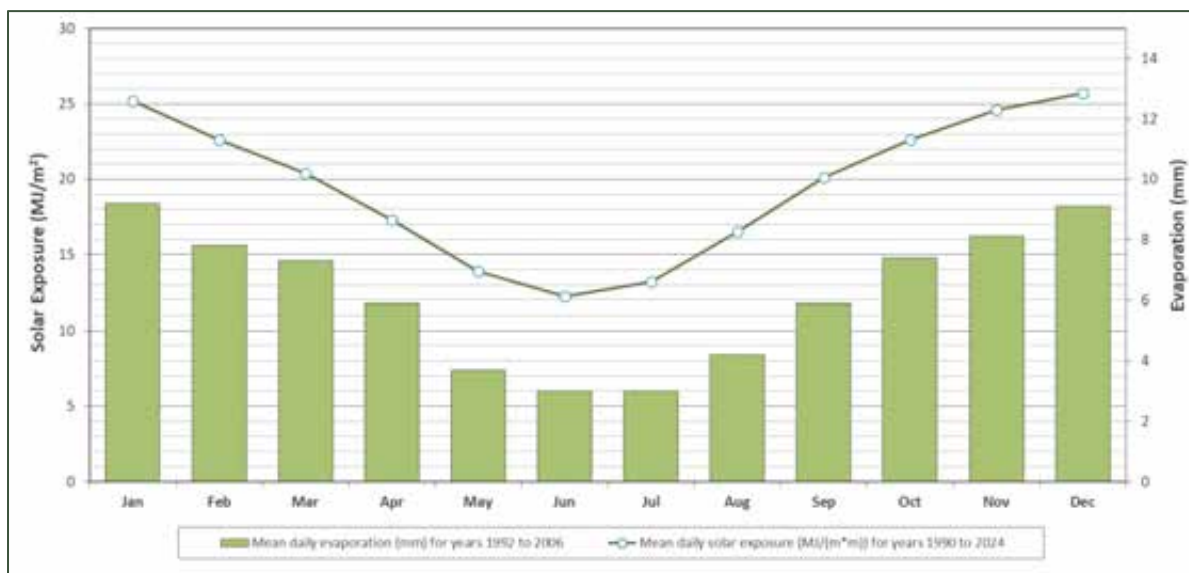


3.2.3 Solar Radiation and Evaporation

As would be expected, the mean daily solar exposure levels recorded at Dalby Airport (see **Figure 4**) are highest in summer (peaking at 25.7 MJ/m² in December) and lower in winter (dropping to 12.2 MJ/m² in June). The mean daily evaporation rates are also lowest in winter and increase during the summer months (ranging from 3 mm/day in June and July to 9.2 mm/day in January).



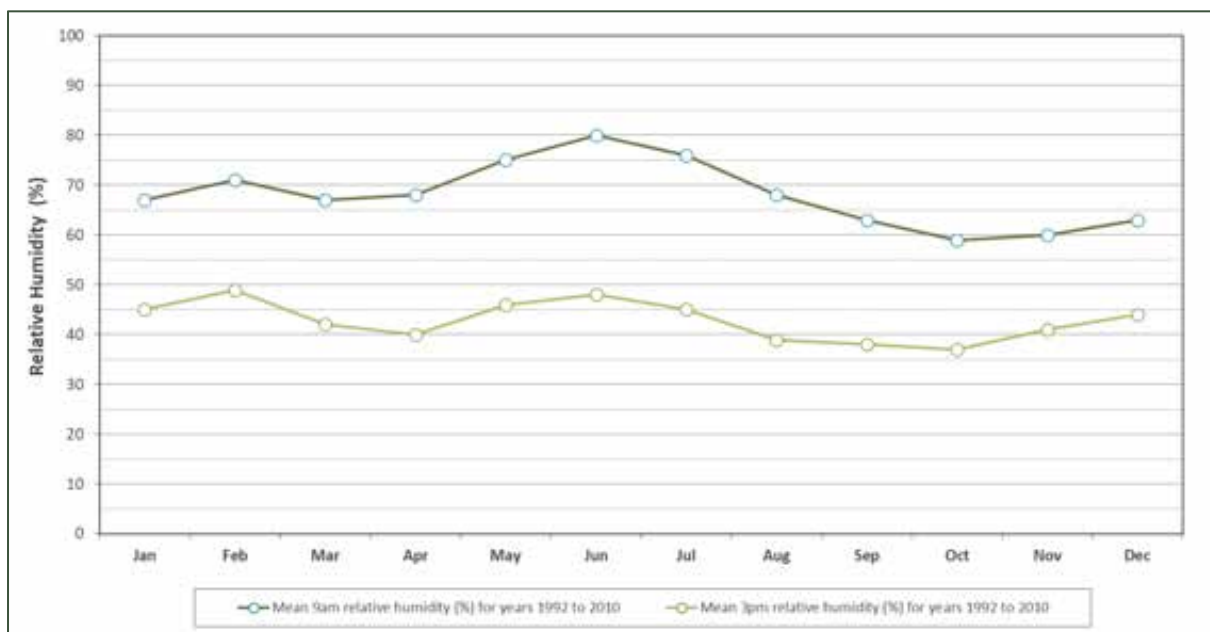
Figure 4 Long Term Solar Radiation and Evaporation Data for Dalby Airport



3.2.4 Relative Humidity

Long-term humidity statistics (9 am and 3 pm monthly averages) for Dalby Airport are summarised in **Figure 5**. Morning humidity levels range from an average of around 80% in early winter to around 59% in mid-spring. Afternoon humidity levels are lower, at around 49% in summer and dropping to a low of 37% in mid of spring.

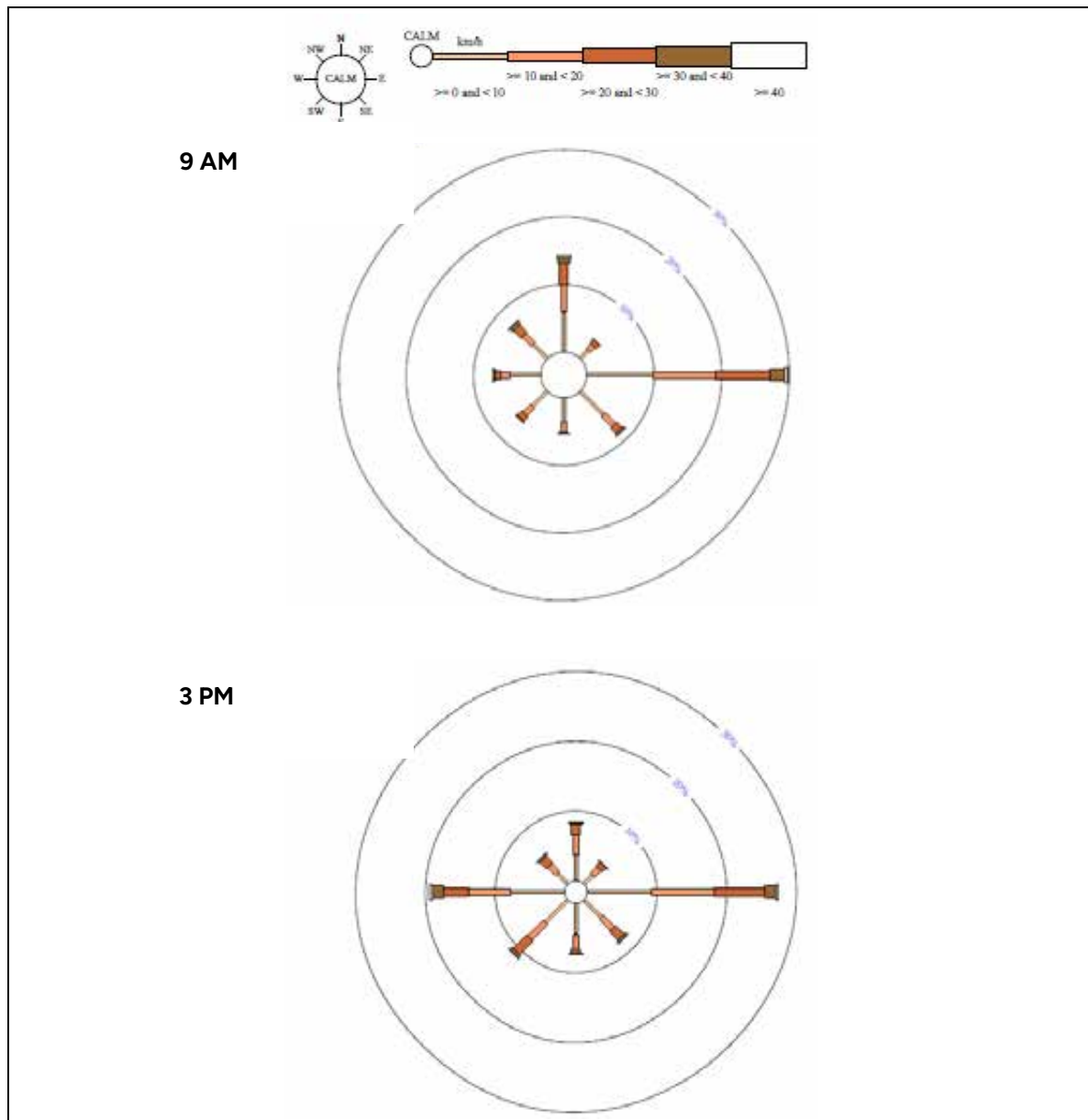
Figure 5 Long Term Humidity Data for Dalby Airport



3.2.5 Wind Speed and Direction

Long term wind data (9 am and 3 pm) for Dalby Airport are presented as wind roses in **Figure 6**. The wind roses show that winds from east are predominant in the morning and afternoon periods, with a high frequency of westerly winds also evident in the afternoon.

Figure 6 Rose of Wind Direction vs Wind Speed (km/hr) at Dalby Airport (1992 -2023)

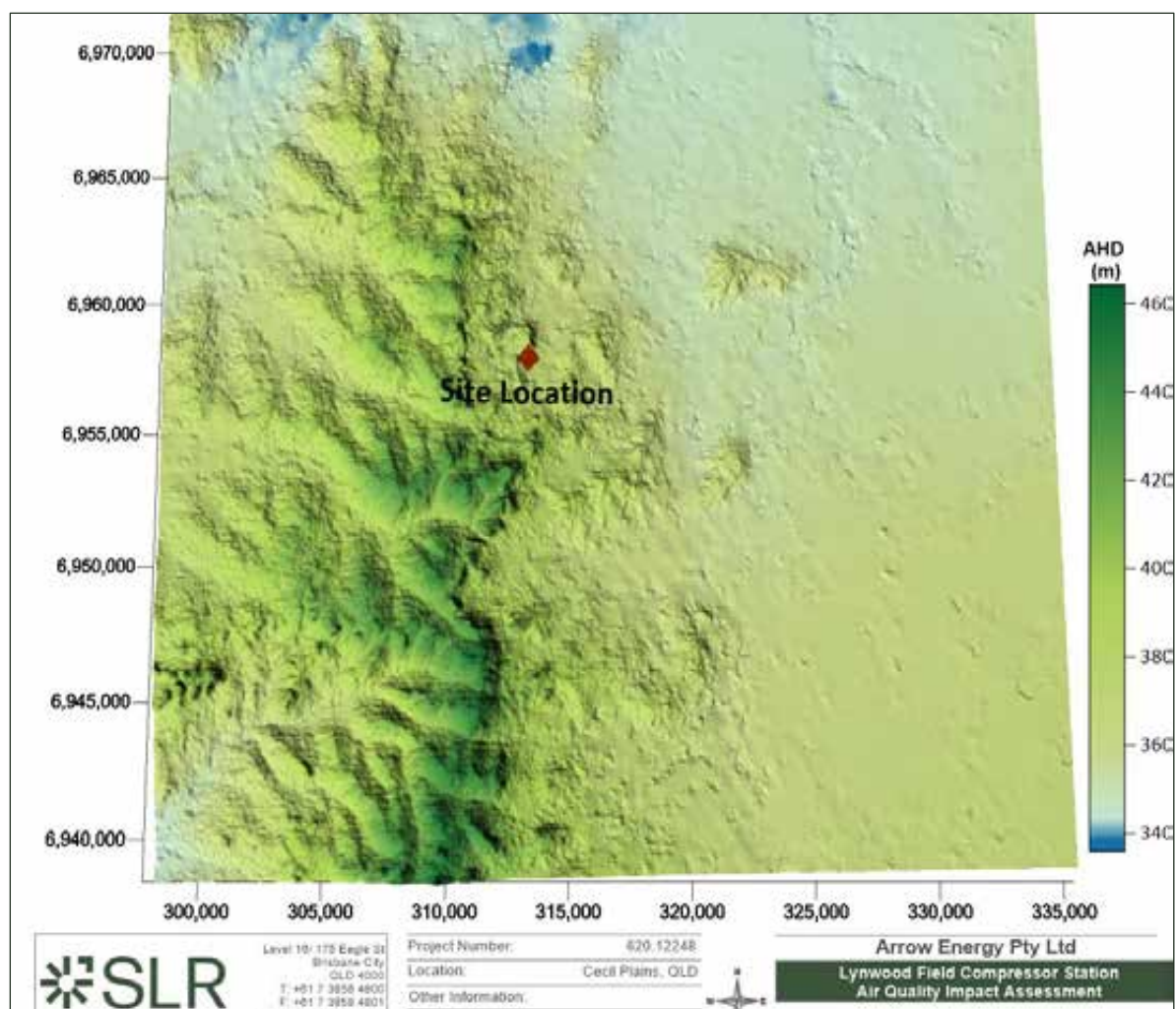


3.3 Topography

The Lynwood FCS site is located in an area with relatively complex topography at an elevation of 380 m.

For this study, topographical data was sourced from the Shuttle Radar Topography Mission (SRTM) database, which obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth. There are two resolution outputs available, 1 km and 90 m resolutions. SRTM data with 90 m resolution was input into the CALMET model to characterise terrain heights within the model domain, as presented in **Figure 7**.

Figure 7 Local Topography



3.4 Existing Air Quality Environment

Ambient air quality criteria relate to the total cumulative pollutant concentration that the population may be exposed to. Air dispersion modelling assessments therefore require the background air quality to be characterised, so that background concentrations of key pollutants of interest can be added to the incremental impacts predicted as a result of the modelled emission sources to provide an assessment of cumulative impacts.

In collaboration with industry partners, DESI operates an air quality monitoring network across southwest Queensland to monitor for any air quality impacts associated with the intensive CSG



production activities in the Western Downs region. These monitoring stations are located on properties near CSG infrastructure, including processing facilities and active gas wells. The AQMS located at Miles Airport is the nearest AQMS to the Lynwood FCS site. Given this, ambient air quality data recorded by the Miles Airport AQMS was used to estimate background CO and NO₂ levels for assessing cumulative impacts in this study. Background ozone (O₃) concentrations have also been reviewed to inform the estimation of NO₂ concentrations from the predicted off-site NO_x concentrations (see **Section 4.4**).

Available validated NO₂, CO and O₃ concentration data recorded by the Miles AQMS during the 2020-2023 period are summarised in **Table 4** and presented as timeseries plots in **Figure 8** and **Figure 9**. It is noted that data records for the year 2019 and 2023 had a very low data capture rate (<75%). Given this, the data recorded in 2019 and 2023 have not been considered in establishing site representative background levels.

A summary of the background pollutant levels adopted for this study is presented in **Table 5**.

Table 4 Summary of Review of Available Monitoring Data – Miles Airport

Percentile	1-Hour Average NO ₂ (µg/m ³)			1-Hour Average O ₃ (µg/m ³)			8- Hour Average CO (µg/m ³)		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
Maximum	63.6	49.2	32.8	128.4	117.7	98.4	500	946	667
95 th percentile	16.4	14.4	12.3	92.0	85.6	72.8	339	250	250
90 th Percentile	12.3	10.3	10.3	87.7	79.2	68.5	281	214	218
70 th Percentile	6.2	6.2	6.2	72.8	68.5	55.6	232	125	125
Average	5.9	6.1	5.3	59.6	57.7	47.0	172	136	143



Figure 8 Measured 1-Hour Average NO₂ and O₃ Concentrations – Miles



Figure 9 Measured 8-Hour Average CO Concentrations – Miles

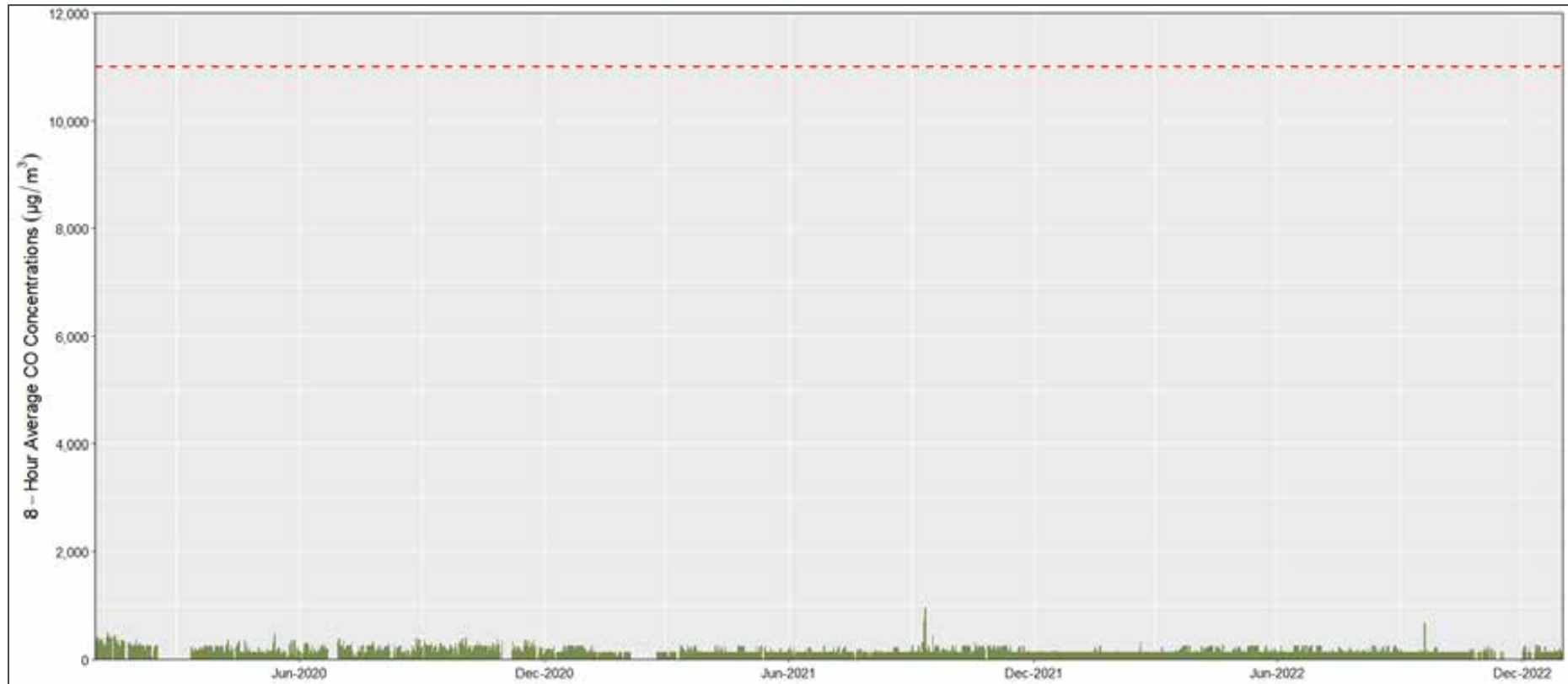


Table 5 Adopted Background Levels for Assessing Cumulative Impacts

Pollutant	Averaging Period	Adopted Background Concentration ($\mu\text{g}/\text{m}^3$)	Basis
NO ₂	1-Hour	6.2	Maximum 70 th percentile 1-hour average concentration recorded in 2020-2022 period
	Annual	6.1	Maximum annual average concentration recorded in 2020-2022 period
CO	8-Hour	232	Maximum 70 th percentile 8-hour average concentration recorded in 2020-2022 period
O ₃	1-Hour	72.8	Maximum 70 th percentile 1-hour average concentration recorded in 2020-2022 period

3.5 Sensitive Receivers

The DESI guideline, *Application requirements 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*
- *A place used as a workplace including an office for business or commercial purposes.*

Where there is potential for rezoning or subdivision of nearby land that may be impacted by air emissions, the applicant should also identify potential future land uses.

Information on sensitive receptors located in and around the Lynwood FCS site was provided by Arrow. Receptors identified as being located within 5 km of the Lynwood FCS are listed in **Table 6** and shown in **Figure 10**.

Note that all identified sensitive receptors in **Table 6** and **Figure 10** are dwellings/residential premises. No national parks or protected areas under the *Nature Conservation Act 1992, the Marine Parks Act 2004* or a World Heritage Area are identified in the study domain.



Table 6 Identified Sensitive Receptors within 5 km of Lynwood FCS

Receptor ID	Coordinates (GDA 94 zone 56)	
	Easting	Northing
L1	310,802	6,955,215
L2	314,546	6,960,670
L3	314,462	6,960,716
L4	317,018	6,955,997
L5	313,164	6,953,290
L6	317,852	6,956,338
L7	317,983	6,955,466
L8	317,954	6,955,094
L9	318,264	6,955,584
L10	318,253	6,955,369
L11	318,563	6,956,439
L12	317,016	6,961,546
L13	318,185	6,953,373



Figure 10 Identified Sensitive Receptors – Lynwood FCS



4.0 Assessment Methodology

4.1 Model Selection

Emissions from the proposed sources associated with the Lynwood FCS operation have been modelled using a combination of the The Air Pollution Model (TAPM), CALMET and CALPUFF models. CALPUFF is a transport and dispersion model that ejects “puffs” of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so, it typically uses the fields generated by a meteorological pre-processor CALMET, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

CALPUFF is a widely used model in assessing potential air quality impacts associated with CSG operations in Queensland and has been adopted for this assessment.

4.2 Selection of Representative Year

SLR conducted a review of the latest five years (2019-2023) of meteorological data recorded by the BoM’s Miles Constance Street station (Station ID 42112) to identify a suitable representative year for use in the modelling. Based on this analysis, the 2023 calendar year was identified as a suitably representative year.

4.3 Meteorological Modelling

4.3.1 TAPM

To calculate all required meteorological parameters required by the dispersion modelling process, meteorological modelling using TAPM, v 4.0.4 has been performed. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model that may be used to predict three-dimensional meteorological data and air pollution concentrations. TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rainfall and atmospheric turbulence. The model allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere.

Additionally, TAPM may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. Hourly wind speed and wind direction data from the nearest BoM stations located at Dalby Airport and Oakey Aero were used to ‘nudge’ the TAPM model run.

Table 7 outlines the input data used in the TAPM modelling.



Table 7 Meteorological Parameters Adopted (TAPM v 4.0.4)

Parameter	Data
Modelling Period	1 January 2023 to 31 December 2023
Centre of analysis	313,275 mE; 6,957,807mS (UTM 56 Coordinates)
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Data assimilation *	Dalby Airport (41522) and Oakey Aero (41359)
Terrain	AUSLIG 9 second DEM

4.3.1.1 CALMET

CALMET is a diagnostic meteorological model that develops wind and temperature fields on a 3-dimensional gridded modelling domain. Associated 2-dimensional fields such as mixing height, surface characteristics, and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final wind field thus reflects the influences of local topography and land uses.

CALMET modelling was conducted for a 36 km x 36 km domain with a resolution of 250 m. TAPM-generated, three-dimensional meteorological data was used as the initial guess wind field. The local topographical data and available surface weather observations in the area were then used to refine the initial guess wind field predetermined by the TAPM data.

The topographical data was sourced from the SRTM database as outlined in **Section 3.3**. The land use data file was created using the latest publicly available aerial imagery.

Table 8 details the parameters used in the meteorological modelling to drive the CALMET model.

Table 8 CALMET Configuration Used for this Study

Domain	Data
Meteorological grid	36 km × 36 km
Meteorological grid resolution	0.25 km
Initial guess field	3D output from TAPM
Data Assimilation	None

4.3.2 Summary of Meteorological Data Used in the Modelling

4.3.2.1 Wind Speed and Direction

A summary of the annual and seasonal wind behaviour predicted by CALMET for the Lynwood FCS site is presented as wind roses in **Figure 11**. Further information on the wind speed distributions is provided in **Figure 12**. These plots indicate that on an annual basis, the site predominantly experiences low to moderate wind speed conditions (between 1.0 m/s and 6 m/s), mainly from the eastern and southwestern quadrants. Calm wind conditions (wind speeds less than 0.5 m/s) were predicted to occur for about 0.9% of the time throughout the modelling period.



Figure 11 Annual and Seasonal Wind Roses as Predicted by CALMET for Lynwood FCS Site (2023)

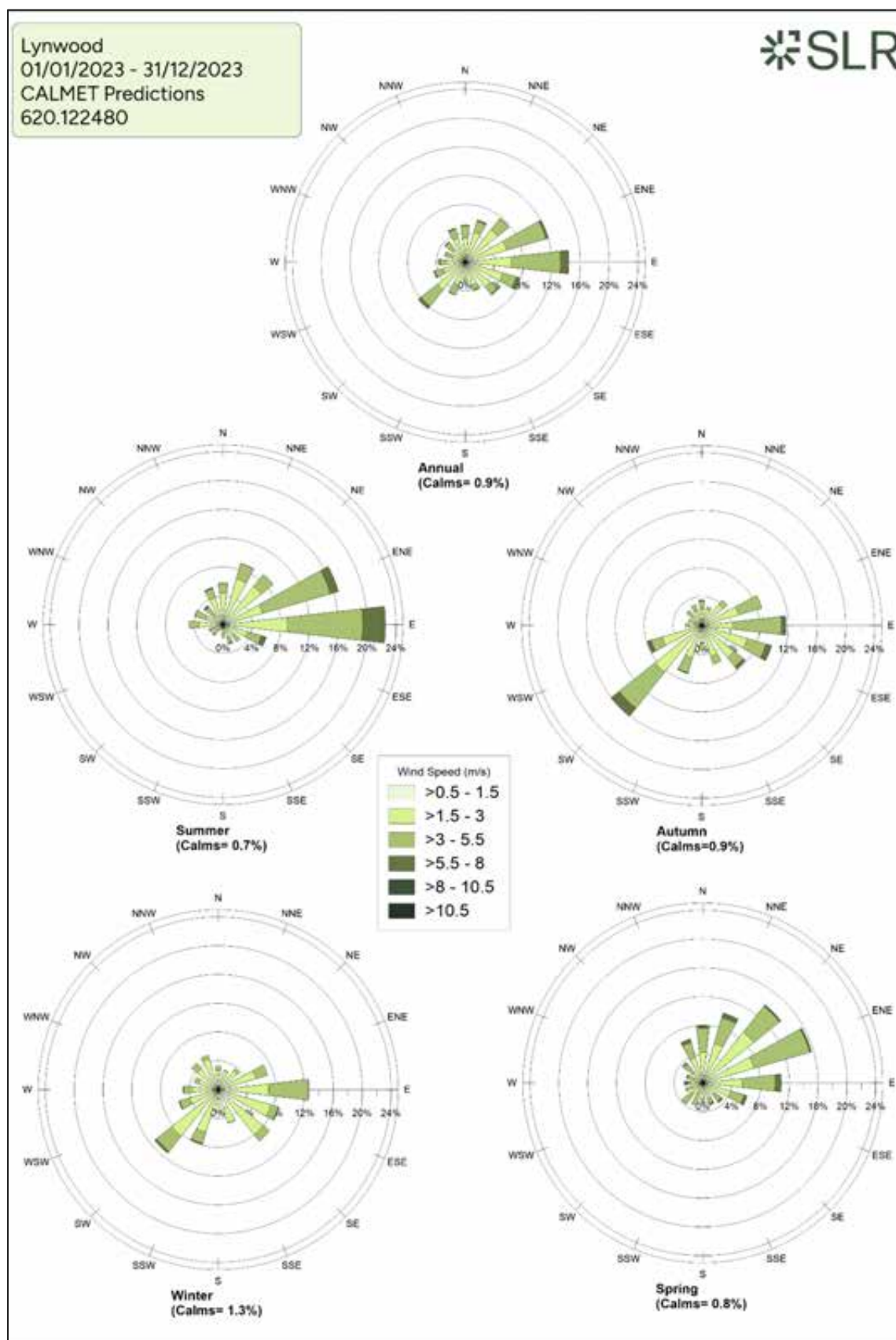
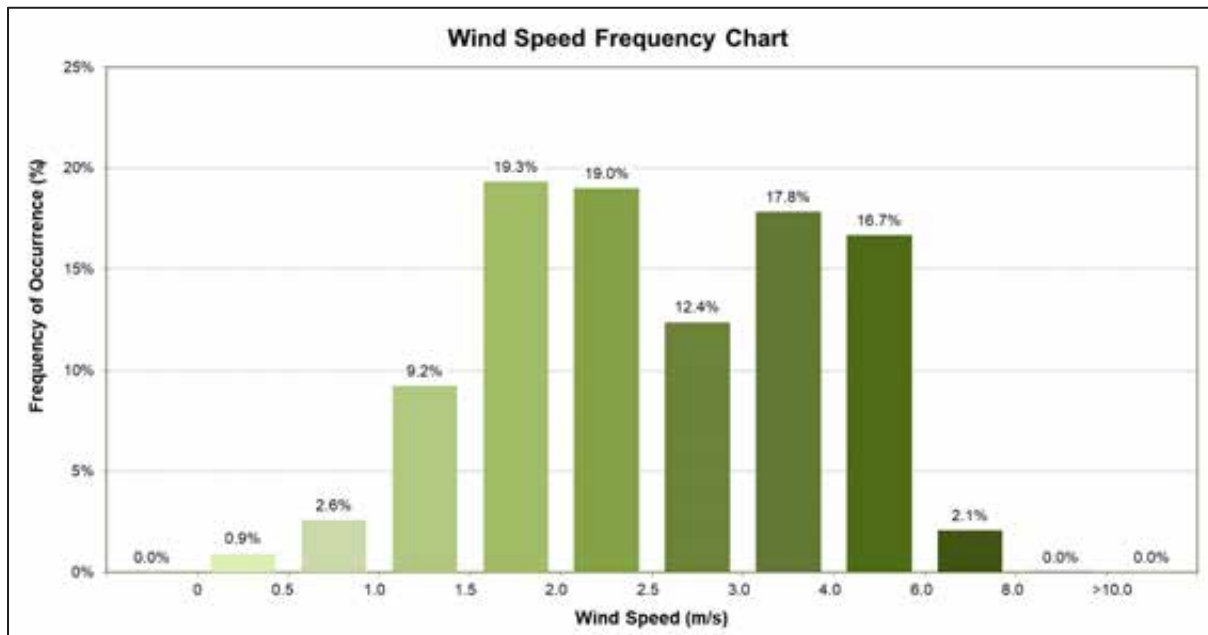


Figure 12 Wind Speed Distributions as Predicted by CALMET (2023) at Lynwood FCS Site



4.3.2.2 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-Turner (PGT) assignment scheme identifies six Stability Classes, A to F, to categorise the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each PGT stability class are shown in **Table 9**. The frequency of each stability class predicted by CALMET at the site during the modelling period is presented in **Figure 13**.

The results indicate a high frequency of conditions typical to Stability Class F, with a low frequency of very unstable conditions (Stability Class A). Stability Class F represents stable stability conditions that inhibit pollutant dispersion.



Table 9 Meteorological Conditions Defining PGT Stability Classes

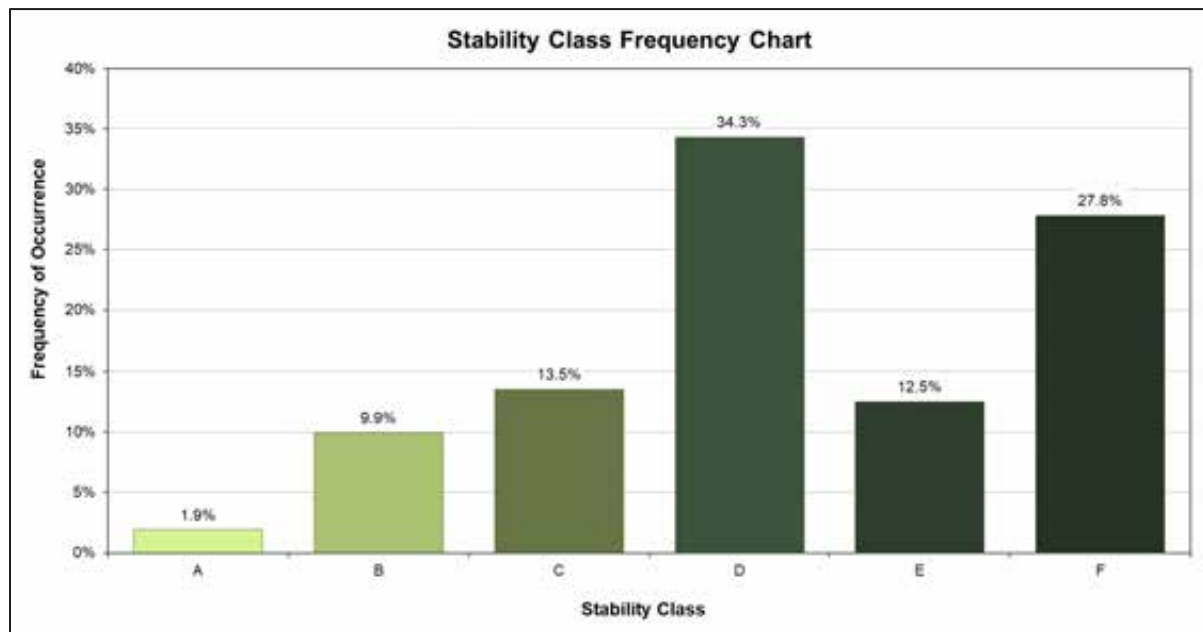
Surface Wind Speed (m/s)	Day-time Insolation			Night-time Conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	≤ 4/8 Cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

SOURCE: (NOAA 2018)

Notes:

1. Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.
2. Night refers to the period from 1 hour before sunset to 1 hour after sunrise.
3. The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

Figure 13 Stability Class as Predicted by CALMET (2023) at Lynwood FCS Site

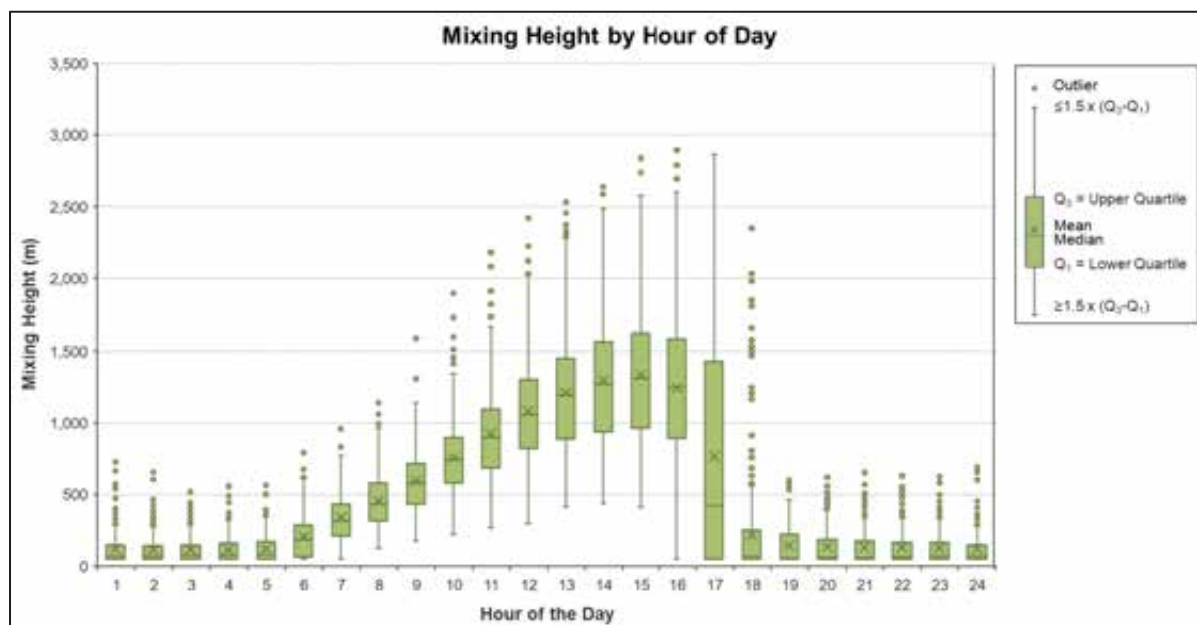


4.3.2.3 Mixing Heights

Plots showing the diurnal variations in maximum and average mixing heights predicted by CALMET at the Lynwood FCS site during 2023 are provided in **Figure 14**. As would be expected, an increase in the mixing height during the morning is apparent at all locations, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of the convective mixing layer.



Figure 14 Mixing Heights as Predicted by CALMET (2023) at Lynwood FCS Site



4.4 NO_x to NO₂ Conversion

NO_x emitted from combustion processes mainly consists of NO with a small portion (approximately 10%) of NO₂. In the atmosphere however, NO emitted from the source oxidises to NO₂ in the presence of O₃ and sunlight as it travels further from the source. The rate of oxidation depends on a number of parameters including the ambient O₃ concentration.

The *Approved Methods for Modelling and Assessment of Air Pollutants in NSW* (NSW EPA 2022) lists the following methods that can be applied to take account the oxidation of NO to NO₂ in estimating downwind NO₂ concentrations at receptor locations.

Method 1 – 100% Conversion

This method is usually used as a screening level assessment and assumes 100% conversion of NO to NO₂ before the plume arrives at the receptor location. Use of this method can significantly over-predict NO₂ concentrations at nearfield receptors.

Method 2 – Ambient Ozone Limiting Method (OLM)

This method assumes that all the available ozone in the atmosphere will react with NO in the plume until either all the O₃ or all the NO is used up. NO₂ concentrations can be estimated by this method using the following equation:

$$[\text{NO}_2]_{\text{total}} = \{0.1 \times [\text{NO}_x]_{\text{pred}}\} + \text{MIN}\{(0.9) \times [\text{NO}_x]_{\text{pred}} \text{ or } (46/48) \times [\text{O}_3]_{\text{bkgd}}\} + [\text{NO}_2]_{\text{bkgd}}$$

Again, when sensitive receptors are located close to the source, resulting in relatively short transport durations, Method 2 can be highly conservative as it assumes that the atmospheric reaction is instantaneous when in reality, the reaction takes place over a number of hours (NSW EPA 2022).

Method 3 – NO to NO₂ Conversion using Empirical Relationship

This method uses an empirical equation for estimating the oxidation rate of NO in power plant plumes dependent on distance downwind from the source and the parameters A and α, which has the following form:

$$\text{NO}_2 = \text{NO}_x \times A(1 - e^{-\alpha x})$$



where x is the distance from the source and A and α are classified according to the O_3 concentration, wind speed and season (Janssen, et al. 1988) as provided in **Table 10**.

Table 10 Classification of Values for A and α by Season

Season	Ozone (ppb)	Wind Speed (m/s)		
		5	15	>15
Winter	40	$A = 0.87 \quad \alpha = 0.07$	$A = 0.87 \quad \alpha = 0.07$	$A = 0.87 \quad \alpha = 0.15$
	30	$A = 0.82 \quad \alpha = 0.07$	$A = 0.83 \quad \alpha = 0.07$	$A = 0.83 \quad \alpha = 0.07$
	20	$A = 0.74 \quad \alpha = 0.07$	$A = 0.74 \quad \alpha = 0.07$	$A = 0.74 \quad \alpha = 0.07$
	10	$A = 0.49 \quad \alpha = 0.05$	$A = 0.49 \quad \alpha = 0.05$	$A = 0.49 \quad \alpha = 0.05$
Spring/Autumn	60	$A = 0.85 \quad \alpha = 0.10$	$A = 0.85 \quad \alpha = 0.15$	$A = 0.85 \quad \alpha = 0.30$
	40	$A = 0.80 \quad \alpha = 0.10$	$A = 0.80 \quad \alpha = 0.10$	$A = 0.80 \quad \alpha = 0.25$
	30	$A = 0.74 \quad \alpha = 0.10$	$A = 0.74 \quad \alpha = 0.10$	$A = 0.74 \quad \alpha = 0.15$
	20	$A = 0.635 \quad \alpha = 0.10$	$A = 0.635 \quad \alpha = 0.10$	$A = 0.635 \quad \alpha = 0.10$
Summer	200	$A = 0.93 \quad \alpha = 0.40$	$A = 0.93 \quad \alpha = 0.65$	$A = 0.93 \quad \alpha = 0.80$
	120	$A = 0.88 \quad \alpha = 0.20$	$A = 0.88 \quad \alpha = 0.35$	$A = 0.88 \quad \alpha = 0.45$
	60	$A = 0.81 \quad \alpha = 0.15$	$A = 0.81 \quad \alpha = 0.25$	$A = 0.81 \quad \alpha = 0.35$
	40	$A = 0.74 \quad \alpha = 0.10$	$A = 0.74 \quad \alpha = 0.15$	$A = 0.74 \quad \alpha = 0.25$
	30	$A = 0.67 \quad \alpha = 0.10$	$A = 0.67 \quad \alpha = 0.10$	$A = 0.67 \quad \alpha = 0.10$

Method 2, conversion of NO_x to NO_2 using the OLM was adopted for this assessment. Background ozone concentration data presented in **Section 3.4** was used in calculating NO_2 concentrations based on the model-predicted NO_x concentrations in the surrounding areas.



5.0 Source Parameters

5.1 Modelling Scenarios

The emission sources modelled for both normal and maximum flaring events are shown in **Table 11**.

Table 11 Modelling Scenarios

Source	Operational Scenario	Sources Modelled
Lynwood FCS	Normal operations	16 × 1.8 MW CSG-fired engines operating at full load (two units are on standby). Note the standby units will be rotated through the equipment fleet to manage load and operations.
	Maximum flaring event	Multi point ground flare operating at flare design capacity All generators off-line

5.2 Stack and Emission Data

5.2.1 Normal Operation

The stack and emission data provided by Arrow for the Lynwood FCS power station engines are summarised in **Table 12**.

Table 12 Model Inputs for the Lynwood Power Station – Normal Operations

Generator Stack	Easting	Northing	Stack Height	Exhaust Temperature	Stack Diameter	Minimum Velocity	NO _x Emission	CO Emission
	(m)	(m)	(m)	(°C)	(m)	(m/s)	(g/s)	(g/s)
1	313,365	6,957,574	5.5	400	0.4	12	0.8	1.5
2	313,372	6,957,574	5.5	400	0.4	12	0.8	1.5
3	313,379	6,957,574	5.5	400	0.4	12	0.8	1.5
4	313,386	6,957,574	5.5	400	0.4	12	0.8	1.5
5	313,393	6,957,574	5.5	400	0.4	12	0.8	1.5
6	313,400	6,957,574	5.5	400	0.4	12	0.8	1.5
7	313,407	6,957,574	5.5	400	0.4	12	0.8	1.5
8	313,414	6,957,574	5.5	400	0.4	12	0.8	1.5
9	313,421	6,957,574	5.5	400	0.4	12	0.8	1.5
10	313,365	6,957,547	5.5	400	0.4	12	0.8	1.5
11	313,372	6,957,547	5.5	400	0.4	12	0.8	1.5
12	313,379	6,957,547	5.5	400	0.4	12	0.8	1.5
13	313,386	6,957,547	5.5	400	0.4	12	0.8	1.5
14	313,393	6,957,547	5.5	400	0.4	12	0.8	1.5
15	313,400	6,957,547	5.5	400	0.4	12	0.8	1.5
16	313,407	6,957,547	5.5	400	0.4	12	0.8	1.5
17	Standby – not included in this assessment							
18	Standby – not included in this assessment							



5.2.2 Flaring - Multi Point Ground Flare

Flaring may occur at Lynwood FCS when a compressor trips or downstream capacity is restricted such that the gas being delivered to the facility (Girrawheen 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.

In this study, modelling has been performed for the worst-case flaring scenario, based on the maximum design capacity of the flare. This scenario would only be expected to occur during unplanned events when plant is at full load and full facility shutdown occurs (eg. emergency shut down, loss of electrical power), which would be a highly infrequent event and has been chosen to provide an assessment of the maximum potential air quality impact from flaring operations.

The design data provided by Arrow for the MPGFs is summarised in **Table 13**.

Table 13 MPGF Design Data

Flare	Easting	Northing	Flare Height	Flare Diameter	Maximum Flaring Rate
	(m)	(m)	(m)	(m)	(MMscfd)
Lynwood FCS flare	313,115	6,957,573	16.7	64.8	116

The following methodology was used to compile the stack and emission data required for modelling:

- NO₂ and CO emission rates were estimated based on the maximum flaring rate of the flare (converting from million standard cubic feet per day (MMscfd) to tonnes/day using a conservative gas density value of 0.73 kg/Sm³) and emission factors of 1.5 kg/tonne NO_x and 8.7 kg/tonne CO from the National Pollutant Inventory (NPI) *Emission Estimation Technique Manual (EETM) for Oil and Gas Extraction and Production* (DEE 2013).
- Assumed flare temperature of 750°C
- Assumed vertical exit velocity of 20 m/s

5.2.3 Existing Emission Sources

As identified in **Section 3.1**, existing air emission sources in the area surrounding the proposed FCS site include existing CSG compressor stations and processing facilities located within approximately 10 km of the site include the Tipton CGPF and WTF. Emissions from these sources have been included in the modelling of emissions to account for any potential cumulative impacts.

The stack and emission data used for the Tipton CGPF and WTF are shown in **Table 14**.



Table 14 Stack and Emission Data for Existing Tipton CGPF and WTF

Site	Location (m)		Stack Height	Stack Diameter	Exit Velocity	Exit Temperature	NO _x Emission	CO Emission
	Easting	Northing	(m)	(m)	(m/s)	(°C)	(g/s)	(g/s)
Tipton West CGPF								
K-0001 Compressor 1	313,769	6,967,799	7.6	0.35	30	400	6.8	5.5
K-0002 Compressor 2	313,727	6,967,816	7.6	0.35	30	400	6.8	5.5
K-0003 Compressor 3	313,773	6,967,809	7.6	0.35	30	400	6.8	5.5
K-0004 Compressor 4	313,732	6,967,825	7.6	0.35	30	400	6.8	5.5
K-0005 Compressor 5	313,777	6,967,819	7.6	0.35	30	400	6.8	5.5
K-0006 Compressor 6	313,736	6,967,835	7.6	0.35	30	400	6.8	5.5
TEG reboiler	313,784	6,967,859	6.8	0.16	38	400	0.2	0.004
Tipton WTF Plant								
Gas-fired generator 1	312,894	6,968,155	7.5	0.33	27	452	1.5	1.5
Gas-fired generator 2	312,889	6,968,146	7.5	0.33	27	452	1.5	1.5
Gas-fired generator 3	312,885	6,968,139	7.5	0.33	27	452	1.5	1.5



6.0 Air Quality Impact Assessment

6.1 Normal Operations

The estimated NO_x and CO emissions listed in **Table 12** for Lynwood FCS under normal operating conditions have been modelled to predict maximum downwind, ground level NO₂ and CO concentrations. The maximum 1-hour and annual average NO₂ concentrations and 8-hour average CO concentrations predicted at the nearest identified sensitive receptors are presented in **Table 15** compared to the relevant ambient air quality criteria. As outlined in **Section 4.4**, the OLM was used to convert the NO_x predictions to NO₂ concentrations, and the background concentrations estimated in **Table 5** have been used to estimate cumulative impacts.

Table 15 shows that the downwind NO₂ and CO concentrations predicted at the nearest sensitive receptors under normal operating conditions are below the relevant air quality criteria and would not have potential to give rise to adverse air quality impacts at these locations.

Contour plots of the maximum concentrations predicted (including background) across the modelling domain are presented in **Appendix A**.

Table 15 NO_x and CO Concentrations Predicted at the Nearest Sensitive Receptors – Lynwood FCS, Normal Operations

Receptor ID	NO ₂ Concentrations (µg/m ³)				CO Concentrations (µg/m ³)	
	Maximum* 1-Hour Average		Annual Average		Maximum 8-Hour Average	
	Incremental Impact	Including Background	Incremental Impact	Including Background	Incremental Impact	Including Background
L1	96	102	7.6	14	350	582
L2	91	97	3.2	9.3	145	377
L3	91	97	3.0	9.1	132	364
L4	82	88	1.7	7.8	103	335
L5	99	105	3.3	9.4	254	486
L6	79	85	1.2	7.3	55	288
L7	81	87	1.4	7.5	81	313
L8	82	88	1.6	7.7	87	319
L9	80	86	1.3	7.4	82	314
L10	81	87	1.4	7.5	82	314
L11	79	85	1.1	7.2	40	273
L12	83	90	1.7	7.8	79	312
L13	78	85	1.3	7.4	60	292
EPP (Air) Objective		164		31		11,000
* Based on the 99.9 th percentile prediction						

6.2 Major Flaring Event

The estimated NO_x and CO emissions listed in **Table 13** for a major flaring event at the Lynwood FCS have been modelled to predict maximum downwind, ground level NO₂ and CO concentrations. The maximum 1-hour NO₂ concentrations and 8-hour CO concentrations predicted at the nearest



identified sensitive receptors are presented in **Table 16**. The OLM was used to convert the NO_x predictions to NO₂ concentrations as per **Section 4.4**

Annual average concentrations have not been presented as major flaring events only occur on rare occasions and would be operating for a short period only, hence a compliance assessment against the annual average criterion is not warranted.

Table 16 shows that the downwind incremental and cumulative NO₂ and CO concentrations predicted at the nearest sensitive receptors during a major flaring event at the Lynwood FCS are below the relevant air quality criteria presented in **Table 3**, and would not have potential to give rise to any significant adverse air quality impacts at these locations.

Contour plots of the maximum concentrations predicted (including background) across the modelling domain are presented in **Appendix A**.

Table 16 NO₂ and CO Concentrations Predicted at the Nearest Sensitive Receptors – Lynwood FCS, Flaring

Receptor ID	NO ₂ Concentrations (µg/m ³)		CO Concentrations (µg/m ³)	
	Maximum* 1-Hour Average		Maximum 8-Hour Average	
	Incremental Impact	Including Background	Incremental Impact	Including Background
L1	85	91	85	317
L2	91	97	105	337
L3	91	97	93	325
L4	82	88	53	285
L5	81	87	45	277
L6	79	85	41	273
L7	81	87	54	286
L8	82	88	61	293
L9	80	86	52	284
L10	81	87	58	290
L11	79	85	40	273
L12	83	90	55	287
L13	78	85	40	272
EPP (Air) Objective		164		11,000
* Based on the 99.9 th percentile prediction				



7.0 Mitigation and Monitoring

This AQIA impact assessment has not identified any potential for adverse air quality impacts associated with the proposed Lynwood FCS operation. Nonetheless, the design and operation of the facility will be undertaken to minimise and manage emissions from the plant as outlined below.

7.1 Mitigation Measures

Arrow is committed to applying a hierarchy of controls to minimise environmental impact. Arrow has standard operating procedures determining how selection of equipment will be completed with regard to protecting environmental values. Equipment that results in environmental impact will be:

- Avoided
- Substituted out
- Have mitigations imposed to reduce the impact.

To determine what equipment should be installed for the project (and therefore what equipment should be avoided), equipment selection will consider as part of the assessment process:

- Low source of noise emissions
- Low emissions to air
- High energy efficiency and fuel efficiency
- Low generation of waste
- Low greenhouse gas emissions
- Avoidance of ozone depleting substances
- Avoidance of particularly hazardous chemicals
- Low emissions of pollutants to water
- Low water use.

Across all of Arrow's SGP activities, Arrow has committed to the mitigation measures listed in **Table 17** to minimise air quality impacts. These measures are recorded in standard operating procedures included in the Surat Gas Project operating model.

In addition to these measures, Arrow is committed to selecting sites for project infrastructure that will protect the environmental values of the project development area wherever practicable. The objectives of site selection are to:

- Ensure the selection of optimal, environmentally acceptable sites for infrastructure placement.
- Avoid or eliminate potential impacts to environmental values.
- Minimise, to the greatest extent practicable, potential impacts to environmental values unable to be avoided or eliminated during design.
- Identify environmental measures for low, moderate and highly constrained areas and 'No Go' such areas.



Table 17 Mitigation Commitments

Project Phase	Mitigation Measures
Operational Phase	- Implement a preventative maintenance program to ensure engines are operating efficiently to minimise NO_x, CO, methane and VOC emissions. - Implement a quantifiable monitoring and measuring program. - Roads, access tracks and other areas may be watered to suppress dust. Vehicle travelling speeds will be restricted, and movements will be limited to approved access tracks. - Selection of gaskets, seals and vehicle exhaust systems that are suitable for the task, and maintained according to manufacturer's recommendations. - Manufacturer's recommendations and guidelines with respect to air emissions control systems are followed at all times. - Air pollution control technologies are to be maintained in good working order and kept in place at all times the equipment is operating. - Air emissions will be monitored at the source in accordance with Environmental Authority conditions. - Equipment that produces abnormal monitoring results will trigger maintenance /review procedures to return emissions to acceptable levels. Where practical, the equipment should not be brought back into service until normal operational emissions are achieved.
Vehicles and machinery	- Ensure all vehicles and machinery are fitted with appropriate emission control equipment, maintained frequently and serviced to the manufacturer's specifications. - Smoke from internal combustion engines should not be visible for more than ten seconds.

7.2 Air Monitoring Programmes

As shown in **Section 10**, ambient air quality monitoring is currently being performed by DESI in the area surrounding the SGP. Given that the downwind concentrations of NO₂ and CO predicted in this assessment are far below ambient air quality guidelines, no additional ambient monitoring is recommended for the Lynwood FCS operations assessed in this AQIA.

Based on DESI's streamlined conditions for petroleum activities, the only additional¹ fuel burning and combustion equipment included in this assessment that would warrant air emissions monitoring are the FCS power station engines. Consistent with the emission rates modelled in this AQIA, the point source emission limits for NO_x presented in **Table 18** are proposed for assessing compliance.

The air dispersion modelling results showed that the potential for adverse impacts due to CO emissions is negligible, and as such, annual monitoring of CO is not considered necessary.

¹ Note that fuel burning and combustion equipment at Daandine and Tipton CGPFs are authorised under a separate Environmental Authorities (EPPG00972513)



Table 18 Proposed Point Source Emission Limits for Lynwood FCS

Source	Minimum Release Height	Minimum Exit Velocity	NO _x as Nitrogen Dioxide	
			Maximum Concentration	Maximum Mass Emission Rate
	(m)	(m/s)	(mg/Nm ³)	(g/s)
Generator Stack 1	5.5	12	500	0.8
Generator Stack 2	5.5	12	500	0.8
Generator Stack 3	5.5	12	500	0.8
Generator Stack 4	5.5	12	500	0.8
Generator Stack 5	5.5	12	500	0.8
Generator Stack 6	5.5	12	500	0.8
Generator Stack 7	5.5	12	500	0.8
Generator Stack 8	5.5	12	500	0.8
Generator Stack 9	5.5	12	500	0.8
Generator Stack 10	5.5	12	500	0.8
Generator Stack 11	5.5	12	500	0.8
Generator Stack 12	5.5	12	500	0.8
Generator Stack 13	5.5	12	500	0.8
Generator Stack 14	5.5	12	500	0.8
Generator Stack 15	5.5	12	500	0.8
Generator Stack 16	5.5	12	500	0.8
Generator Stack 17	5.5	12	500	0.8
Generator Stack 18	5.5	12	500	0.8

7.3 Proposed Air Conditions

It is understood that this facility will be incorporated into Arrow Energy's Environmental Authority for the Dalby Expansion Project (EPPG00972513). In line with the existing air conditions included in EPPG00972513, the recommended conditions for this development are provided by conditions Air 1 to Air 3 as follows.

Venting and flaring

Air 1.

Unless venting is authorised under the *Petroleum and Gas (Production and Safety) Act 2004* or the *Petroleum Act 1923*, waste gas must be flared in a manner that complies with all of (Air 1(a)) and (Air 1(b)) and Air 1 (c)), or with (Air 1(d)):

- (a) an automatic ignition system is used, and
- (b) a flame is visible at all times while the waste gas is being flared, and
- (c) there are no visible smoke emissions other than for a total period of no more than 5 minutes in any 2 hours, or
- (d) it uses an enclosed flare.

Fuel burning and combustion facilities – authorised point sources

Air 2A.

A fuel burning or combustion facility must not be operated unless it is listed in **Protecting air values, Table 1–Authorised point sources**.



Air 2B.

If a fuel burning or combustion facility is listed in **Schedule F, Table 1—Authorised point sources**, the fuel burning or combustion facility must be operated so that the releases to air do not exceed the limits specified in **Schedule F, Table 1—Authorised point sources** at the specified release point reference.

Air 3.

Point source air monitoring for each fuel burning or combustion facility listed in **Schedule F, Table 1—Authorised point sources** must:

- (a) be undertaken once:
 - i. once in the first three months after each facility is first commissioned, and then
 - ii. annually or biennially thereafter at the frequency specified in **Schedule F, Table 2 – Annual Air Quality Monitoring**
- (b) be carried out when the facility the subject of the sampling is operating under maximum operating conditions for the annual period; and
- (c) demonstrate compliance with the limits listed in **Schedule F, Table 1 – Authorised point sources** at each release point reference.

Schedule F, Table 1 – Authorised point sources (only additional sources are included here)

Tenure	Facility	Release Point Reference	Unit Description	Minimum Release Height (m)	Minimum Efflux Velocity (m/s) ^a	NO _x as NO ₂	Carbon Monoxide
						Maximum Mass Emission Rate (g/s)	Maximum Mass Emission Rate (g/s)
PL198	Lynwood FCS	A30	Generator Stack 1	5.5	12	0.8	NA
		A31	Generator Stack 2	5.5	12	0.8	NA
		A32	Generator Stack 3	5.5	12	0.8	NA
		A33	Generator Stack 4	5.5	12	0.8	NA
		A34	Generator Stack 5	5.5	12	0.8	NA
		A35	Generator Stack 6	5.5	12	0.8	NA
		A36	Generator Stack 7	5.5	12	0.8	NA
		A37	Generator Stack 8	5.5	12	0.8	NA
		A38	Generator Stack 9	5.5	12	0.8	NA
		A39	Generator Stack 10	5.5	12	0.8	NA
		A40	Generator Stack 11	5.5	12	0.8	NA
		A41	Generator Stack 12	5.5	12	0.8	NA
		A42	Generator Stack 13	5.5	12	0.8	NA
		A43	Generator Stack 14	5.5	12	0.8	NA
		A44	Generator Stack 15	5.5	12	0.8	NA
		A45	Generator Stack 16	5.5	12	0.8	NA
		A46	Generator Stack 17	5.5	12	0.8	NA
		A47	Generator Stack 18	5.5	12	0.8	NA

Note: Minimum efflux velocity, maximum mass emission and maximum concentration limits relate to plant maximum continuous ratings.



Schedule F, Table 2 – Annual Air Quality Monitoring (only additional release points are included here)

Release Point	Parameter		Minimum Monitoring Frequency
	Mass Emission Rate (g/s)	Concentration (mg/Nm ³)	
A30 – A47 c	Oxides of nitrogen (measured as NO ₂) carbon monoxide	Oxides of nitrogen (measured as NO ₂) carbon monoxide	Biennially from commission

Note: Monitoring of carbon monoxide from A30 – A47 is not required as per Schedule F, Table1 – Authorised point sources.



8.0 Conclusions

An air quality impact assessment, including a detailed air dispersion modelling study, has been performed to assess potential air quality impacts from the proposed Lynwood FCS operation. Dispersion modelling was performed for both normal maximum operating conditions and for flaring events.

Based on the modelling results, the following conclusions have been drawn for the proposed Lynwood FCS:

- The modelling of NO_x and CO emissions from the proposed Lynwood FCS showed that under normal maximum operating conditions (i.e. concurrent operation of sixteen power station generators at maximum load) these emissions have no potential to give any significant rise to ground level exceedances of the relevant ambient air quality criteria at surrounding sensitive receptors. The incremental impacts predicted by the modelling of CO emissions are negligible.
- The modelling of NO_x and CO emissions from maximum flaring events at the proposed Lynwood FCS showed that maximum predicted cumulative NO₂ and CO concentrations at all nearby sensitive receptors would remain well below the relevant ambient air quality guidelines.

Based on the above, no air quality constraints have been identified for the proposed Lynwood FCS operation as a result of this air quality impact assessment.

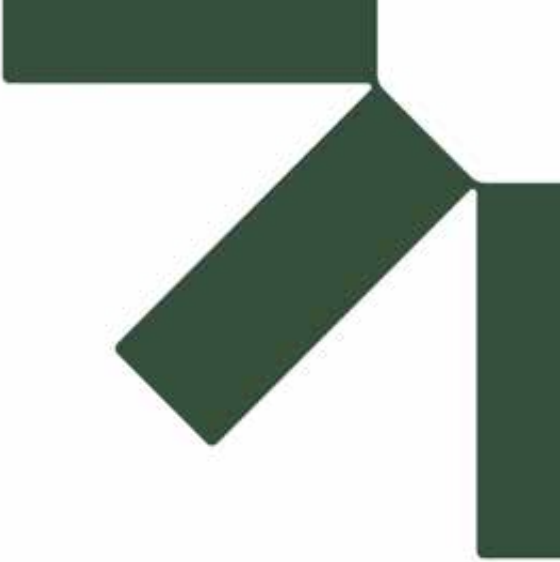
Mitigation and monitoring measures are presented in this report to minimise emissions to air and assist in the management of air quality impacts associated with the proposed Lynwood FCS operation.



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Appendix A Isopleth plots

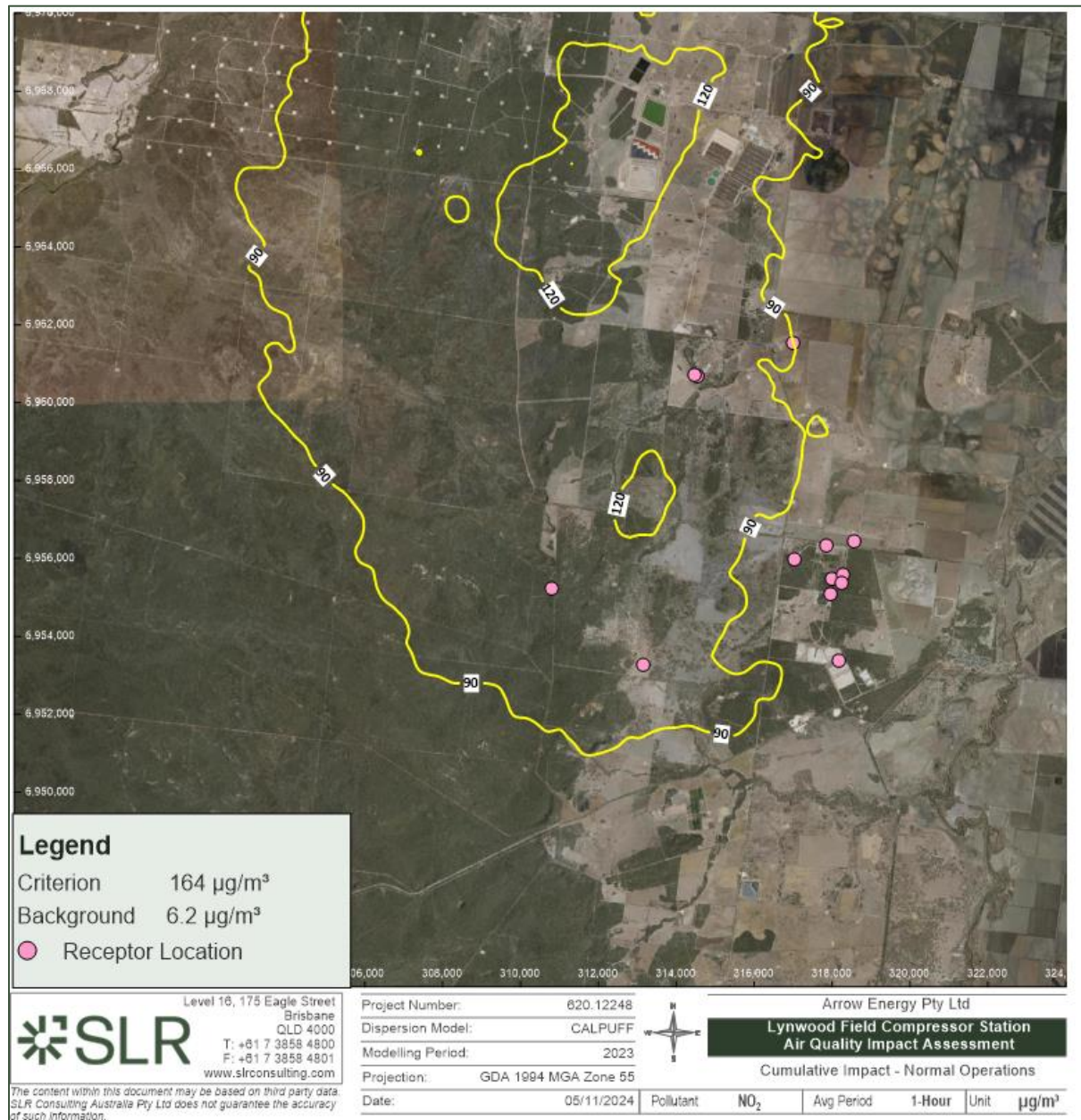
Surat Gas Project – Lynwood Field Compressor Station

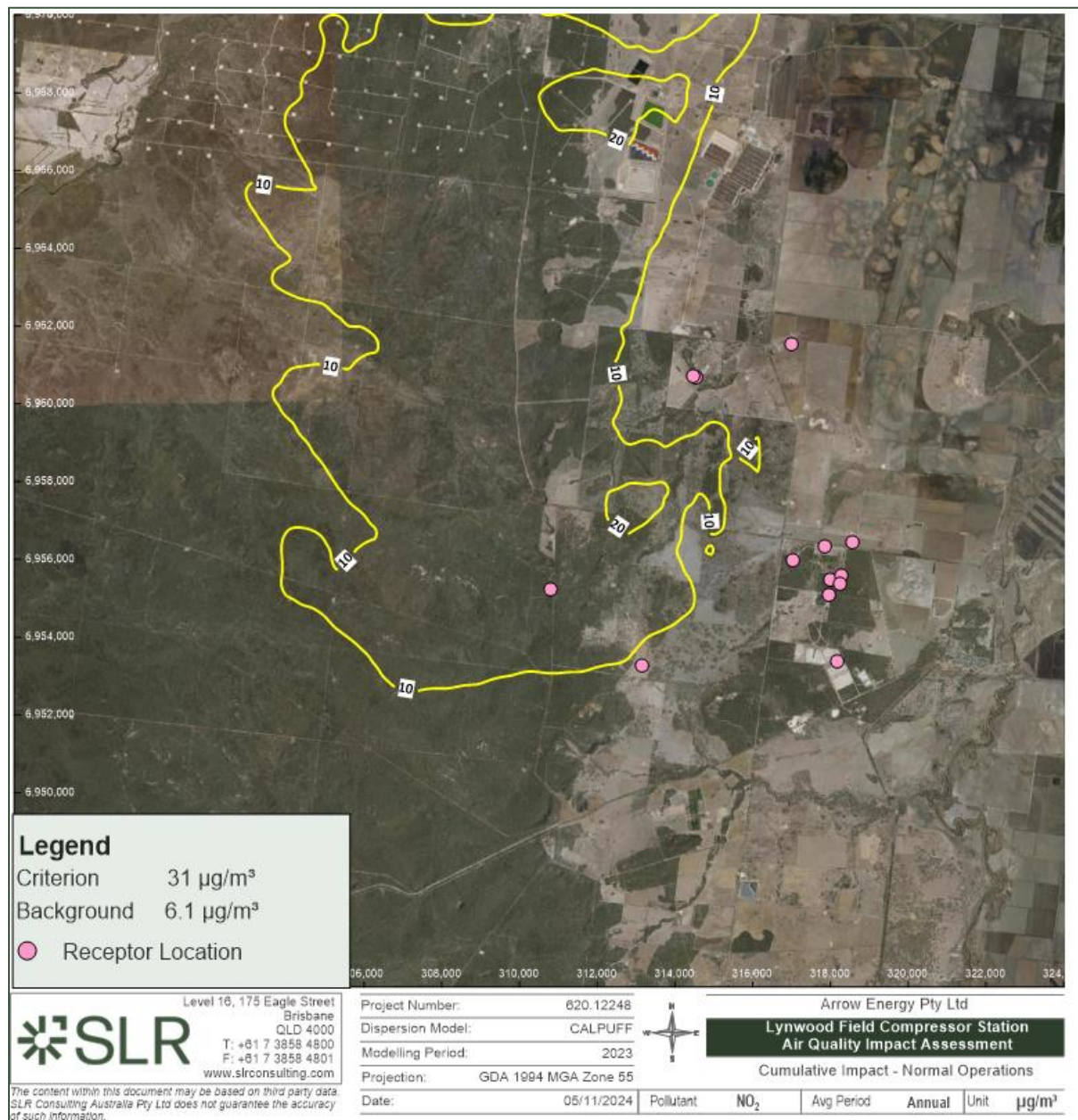
Air Quality Impact Assessment

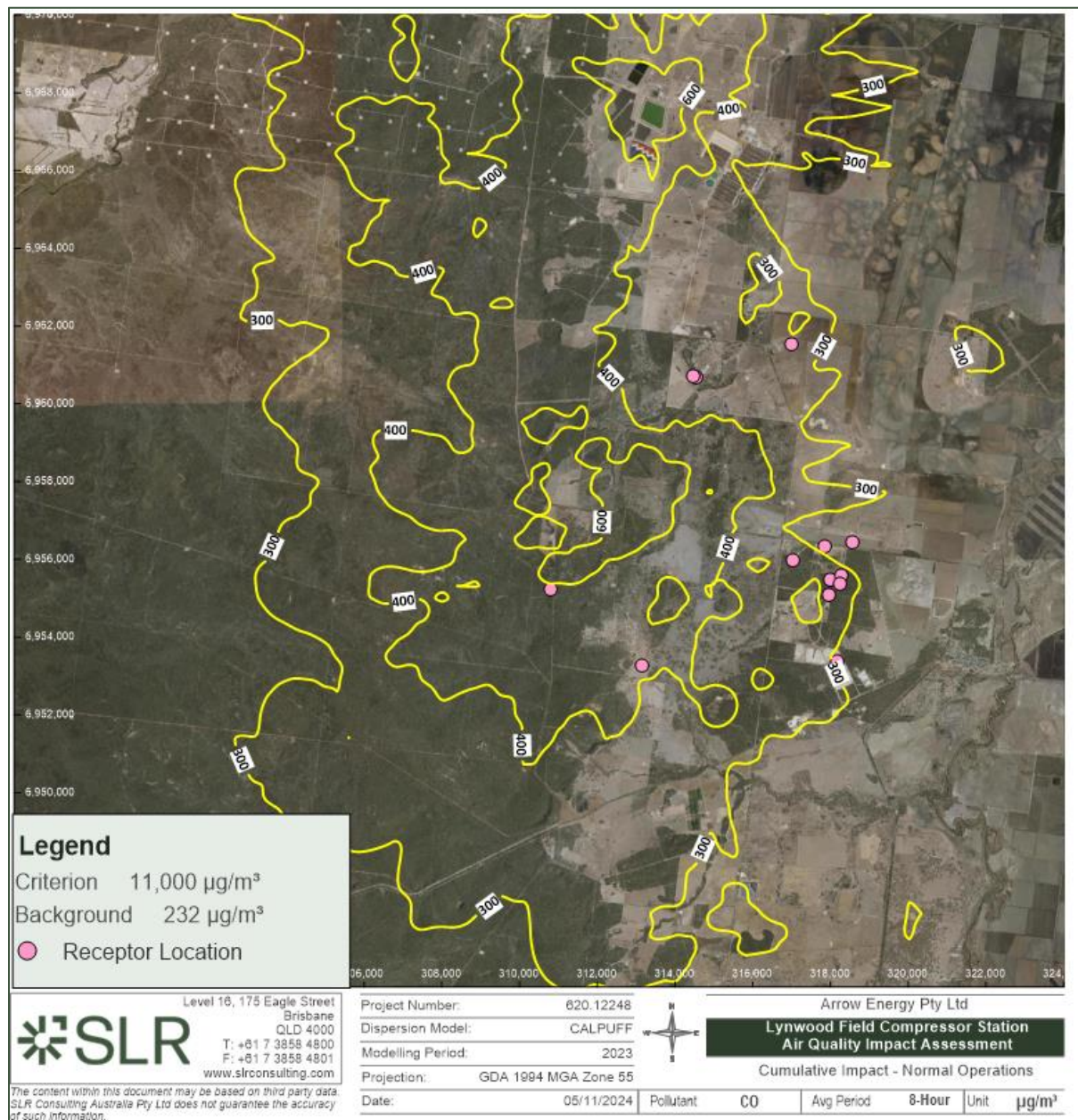
Arrow Energy Pty Ltd

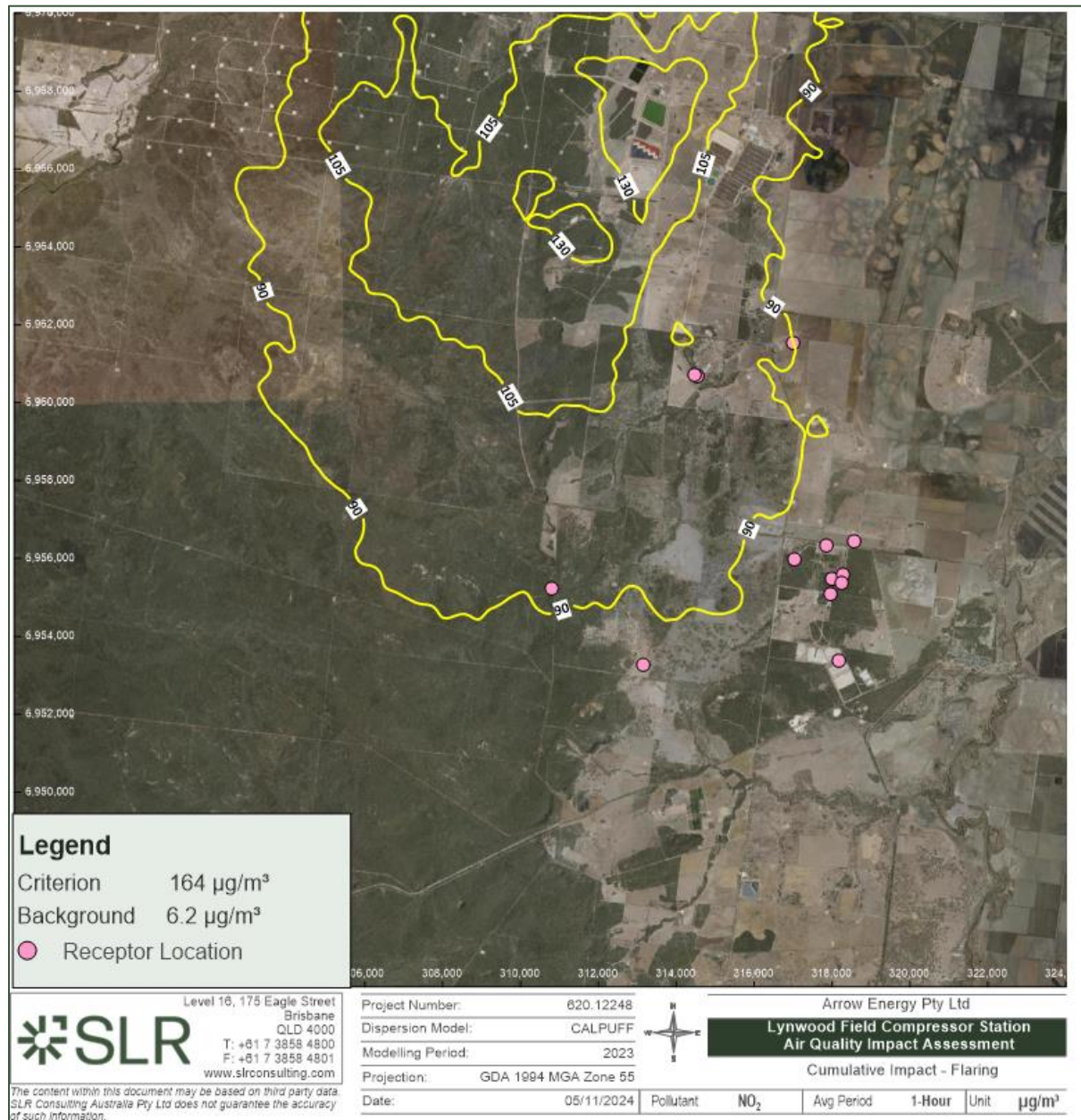
SLR Project No.: 620.12248.01609

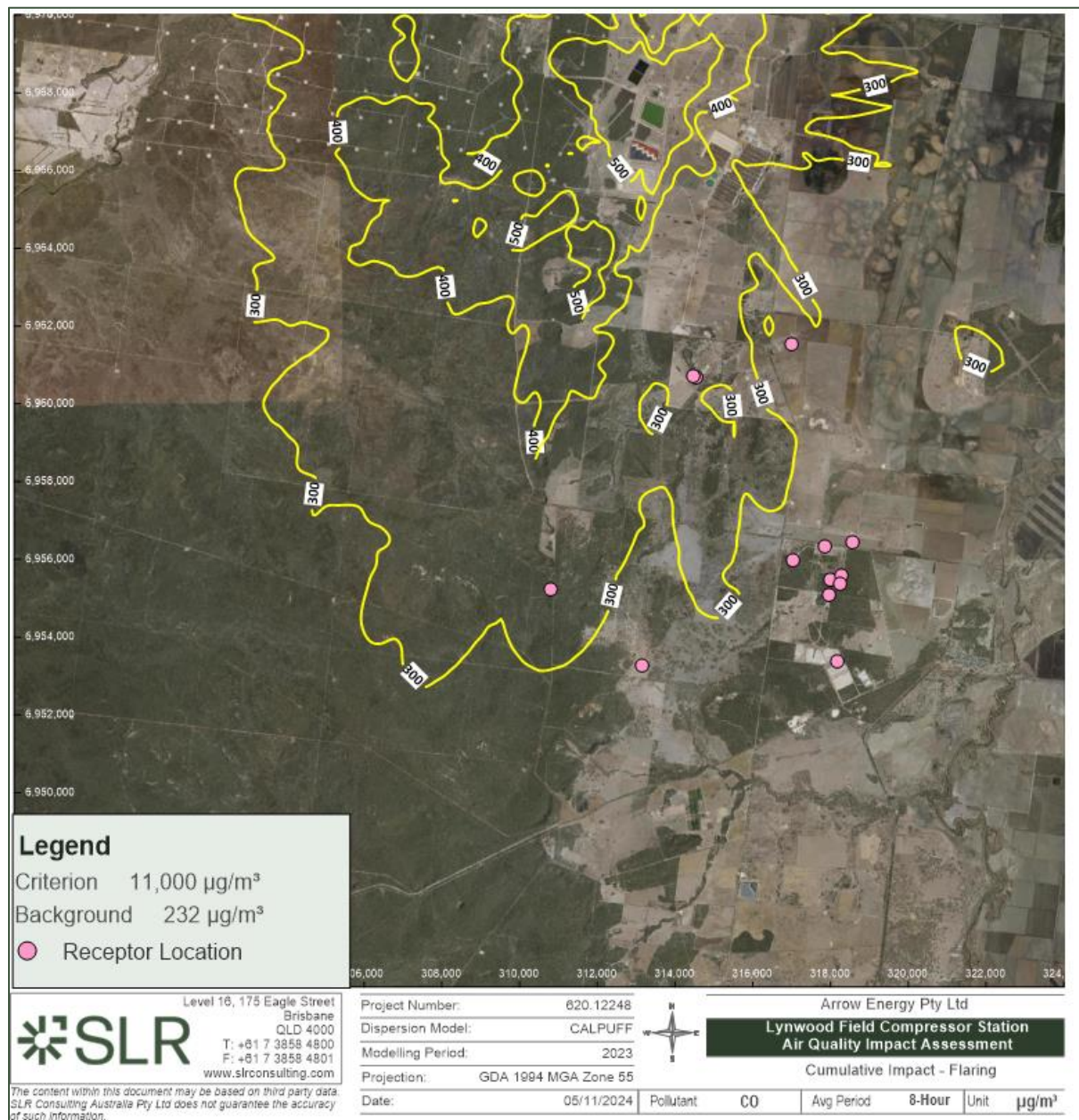
21 January 2025

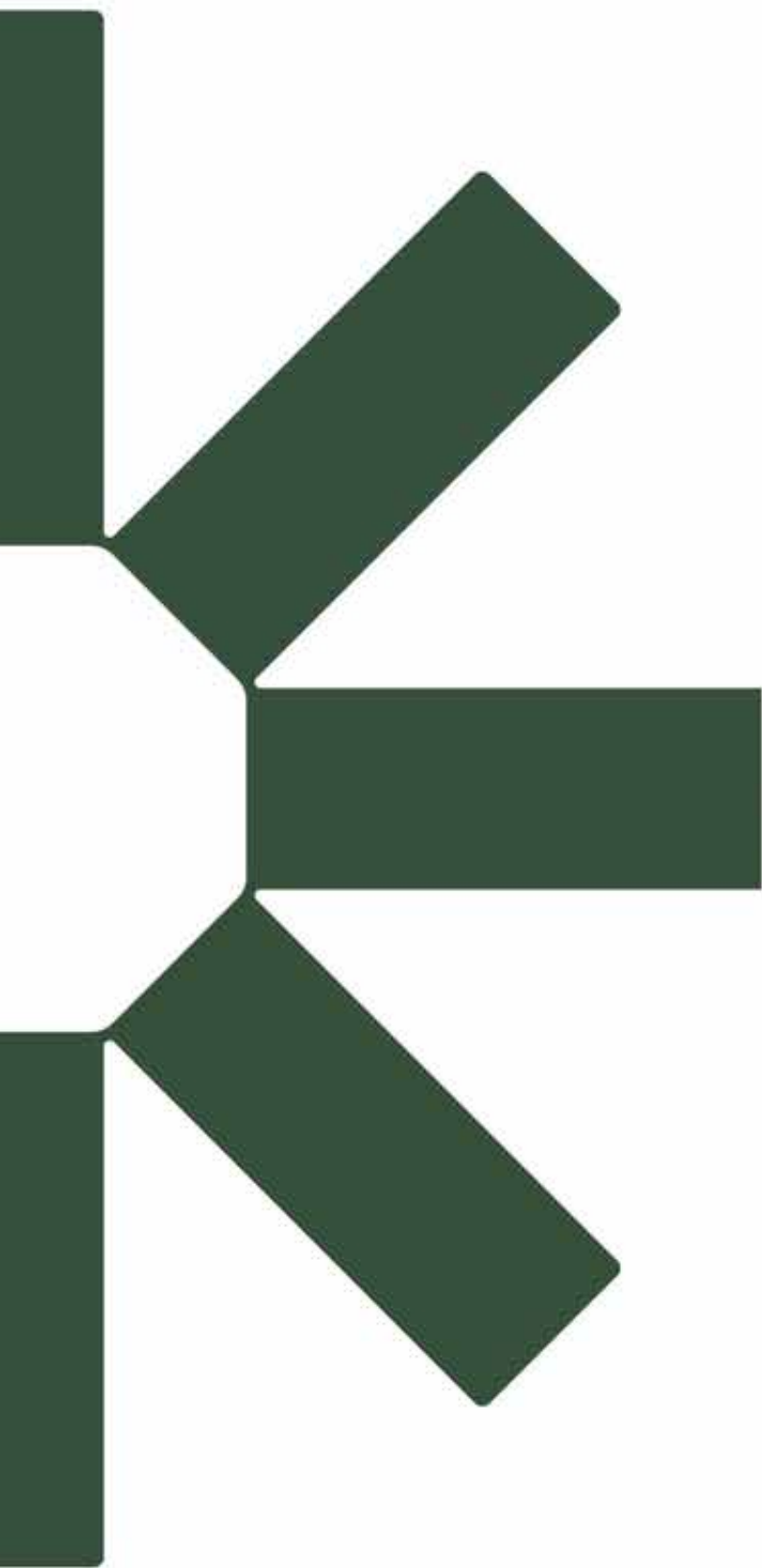












Making Sustainability Happen

Appendix D. Lynwood FCS Noise Assessment

SURAT GAS PROJECT - LYNWOOD 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-R04
Version No: -v1.0
December 2024



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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Arrow Energy Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.12448.01600-R04-v1.0	16 December 2024	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 Lynwood Field Compressor Station (FCS), which is located approximately 35 km south-west of Dalby, Queensland.

The Lynwood 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 four) which compress low-pressure coal seam gas (CSG),
- CSG fired internal combustion power generation plant equipped with a battery energy storage system (BESS). This 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
- Cyclone separator (to remove solids/fines in gas line).

The Lynwood FCS will also incorporate several noise abatement technologies to reduce noise emissions, which include:

- 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, minimizing 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 Lynwood FCS has been assessed for the following operating scenarios:

- Scenario 1 – Normal Operation at maximum operating capacity
 - Four (4) Howden 510 screw compressors running at 2,000 RPM with coolers, and
 - Sixteen (16) operating CSG fired power station (internal combustion engines) and two (2) spare 1.8 MW Engine with BESS.
 - Two (2) Centrifugal pumps.
- Scenario 2 – Flaring
 - MPGF to occur under four (4) separate flare flow rates being 116 MMscfd, 87 MMscfd, 58 MMscfd and 29 MMscfd.

EXECUTIVE SUMMARY

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 (Lynwood 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 (further information is outlined below). 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 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 29 MMscfd (or 9.5% of the time during an hourly period).
- Flaring events greater than 29 MMscfd are expected to occur approximately 2% of the time over an hourly period (<1% at night-time).

Flare flow rates between 58 MMscfd and 116 MMscfd have been used to assess the worst-case noise potential during the rare maximum flare flow rate occurrences that may be experienced at the Lynwood 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 Lynwood FCS operational noise assessment identified the following:

- The proposed Lynwood FCS development is expected to meet all nominated noise criteria outlined in **Section 3.3** for both assessed weather conditions when operating under 'normal operations' (Scenario 1) and the maximum sound power noise level of 103 dBA is achieved for the Power Generation Units. The frequency octave band noise levels associated with the Power Generation Units and Screw Compressor Units are not to exceed those outlined in **Table 1**.

Table 1 Maximum Octave Band Noise Levels

Plant Items	Sound Power Level, LAeq dBA									Overall SWL dBA
	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1k	2k	4k	8k	
Power Generator Unit, including Generator Engine Exhaust (Mitigated)	75	86	102	93	88	89	81	78	70	103

EXECUTIVE SUMMARY

Plant Items	Sound Power Level, LAeq dBA									Overall SWL dBA
	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1k	2k	4k	8k	
Mitigated Howden Screw Compressor Unit (fitted with acoustic panels)	71	76	84	101	99	95	92	87	78	104
Screw Compressor Coolers	73	87	96	100	101	101	95	91	83	107

- 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 58 MMscfd and under for all weather conditions. This represents 95% of expected flaring events that would potentially occur at the Lynwood FCS.
 - At a flare flow rate of 87 MMscfd and above, marginal exceedance of the night-time noise limit of 28 dBA during adverse weather may occur at up to five (5) receptors. Noting, the worst case being up to two receptors too potentially exceed at the same time, LFCS-2 and LFCS-3 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 Lynwood FCS location is EPPG00972513. Schedule E of EPPG00972513 contains conditions that are designed to protect the acoustic environment. This noise assessment demonstrates that the Lynwood FCS can operate in compliance within the existing noise conditions within EPPG00972513.

CONTENTS

1	INTRODUCTION	9
1.1	Background	9
1.2	Objectives of this Assessment	9
2	SITE DESCRIPTION	11
2.1	Site Location.....	11
2.2	Sensitive Receptors.....	11
2.3	Existing Noise Environment	12
2.4	Background Noise Levels	13
3	REGULATORY FRAMEWORK.....	15
3.1	Queensland Noise Regulations	15
3.2	DES Guideline - Prescribing Noise Conditions for Petroleum and Gas Activities	16
3.2.1	Deemed Background Noise Levels	16
3.2.2	Noise Limits	16
3.2.3	Low Frequency Noise	17
3.3	Summary of Project Noise Conditions	18
4	LYNWOOD FCS OPERATIONAL NOISE ASSESSMENT	18
4.1	Assessed Operational Scenarios	18
4.2	Noise Modelling	20
4.2.1	Noise Modelling Methodology	20
4.2.2	Noise Model Inputs	20
4.2.3	Calculation Method – CONCAWE	21
4.3	Assessed Meteorological Conditions	21
4.4	Modelled Plant Sound Power Levels	21
4.4.1	Multi-point Ground Flare Radiation Fence	23
4.5	Noise Assessment Results.....	23
4.5.1	Scenario 1 – Normal Operations	23
4.5.1.1	Scenario 1 – Normal Operations Noise Mitigation Recommendation.....	24
4.5.2	Scenario 2 – Flaring	26
4.6	Flare Noise Summary	27
4.7	Low Frequency Noise Assessment.....	27
5	CONCLUSION.....	28

CONTENTS

DOCUMENT REFERENCES

TABLES

Table 1	Maximum Octave Band Noise Levels	4
Table 2	Identified Receptors – Lynwood FCS (LFCS)	12
Table 3	EPP(Noise) Acoustic Quality Objectives	15
Table 4	Deemed Background Noise Levels	16
Table 5	Best Practice Measured Outdoor Noise Emission Limits (DES, 2016)	17
Table 6	Project Noise Emission Limit Overview	18
Table 7	Noise Model Inputs	20
Table 8	Modelled Meteorological Conditions – Neutral and Adverse	21
Table 9	Operating Unit Maximum Plant SWLs	21
Table 10	Quantity of Noise Sources Modelled for Each Scenario	22
Table 11	Predicted Noise Level at Receptor – Normal Operations	24
Table 12	Maximum Sound Power Noise Levels for the Power Generation Units (Mitigated)	25
Table 13	Predicted Noise Level at Receptor – Normal Operations with Mitigated Power Generation Units	25
Table 14	Predicted Noise Level at Receptor – Flaring	26
Table 15	Maximum Octave Band Noise Levels	28

FIGURES

Figure 1	Lynwood FCS Layout	10
Figure 2	Lynwood FCS and Receptors	14
Figure 3	Indicative MPGF Fence (Image source: Zeeco)	23
Figure 4	Scenario 1 – Normal Operation Under Neutral Weather Conditions	6
Figure 5	Scenario 1 – Normal Operation Under Adverse Weather Conditions	6
Figure 6	Scenario 2 – MPGF Flaring Operating at 25% Under Neutral Weather Conditions	8
Figure 7	Scenario 2 – MPGF Flaring Operating at 50% Under Neutral Weather Conditions	8
Figure 8	Scenario 2 – MPGF Flaring Operating at 75% Under Neutral Weather Conditions	8
Figure 9	Scenario 2 – MPGF Flaring Operating at 100% Under Neutral Weather Conditions	8
Figure 10	Scenario 2 – MPGF Flaring Operating at 25% Under Adverse Weather Conditions	8
Figure 11	Scenario 2 – MPGF Flaring Operating at 50% Under Adverse Weather Conditions	8
Figure 12	Scenario 2 – MPGF Flaring Operating at 75% Under Adverse Weather Conditions	8
Figure 13	Scenario 2 – MPGF Flaring Operating at 100% Under Adverse Weather Conditions	8

CONTENTS

APPENDICES

Appendix A Acoustic Glossary

Appendix B Scenario 1 – Normal Operations Noise Contour Maps

Appendix C Scenario 2 – Flaring Noise Contour Maps

1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Arrow Energy (Arrow) to undertake a noise assessment of the Lynwood Field Compressor Station (FCS), which is located approximately 35 km south-west of Dalby, Queensland.

1.1 Background

The Lynwood 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:

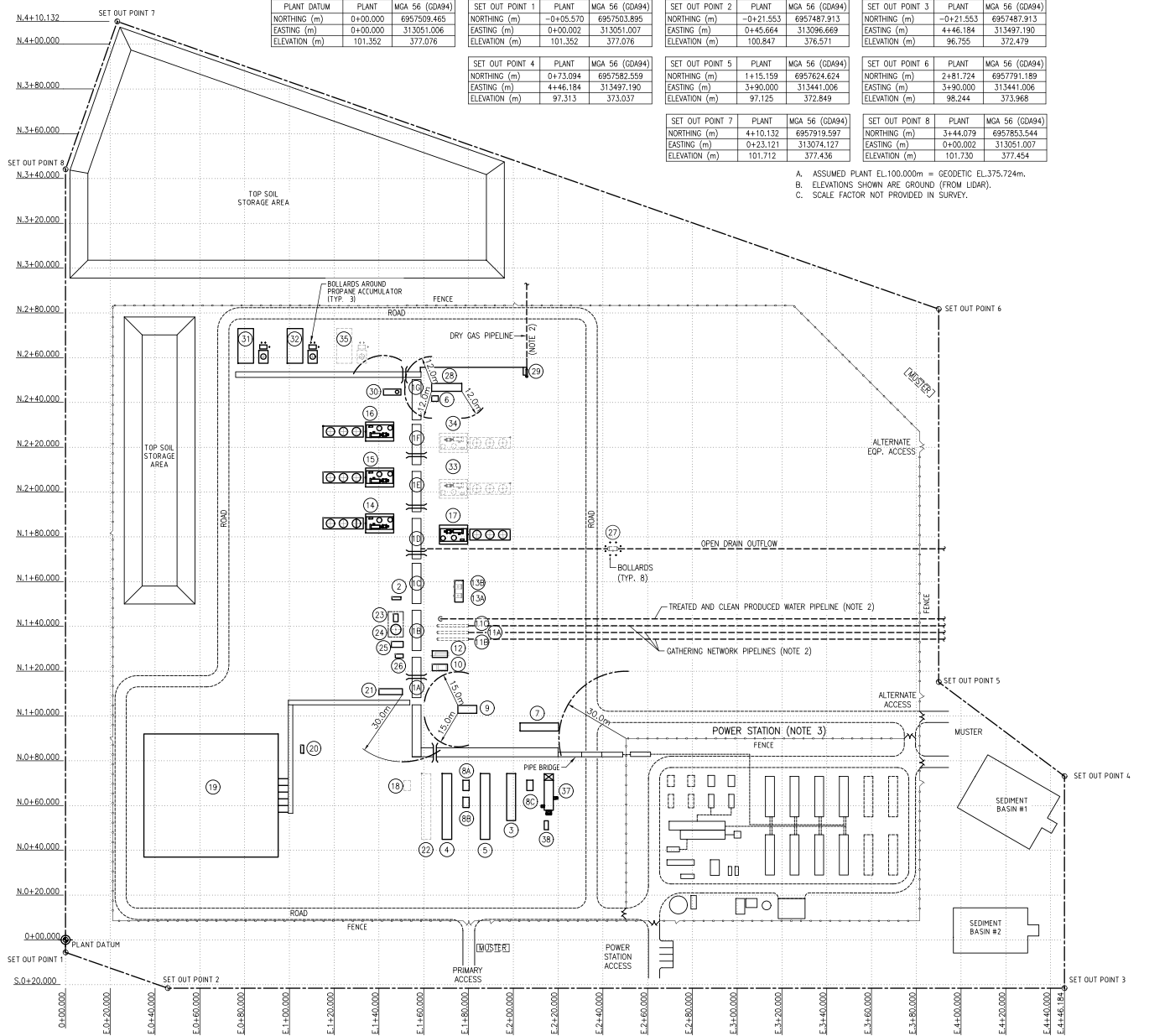
- Screw compressors (up to four) which compress low-pressure coal seam gas (CSG),
- CSG fired internal combustion power generation plant equipped with a battery energy storage system (BESS). This provides electrical power to the facility mainly used to power the compressors.
- Multi-point ground flare (MPGF, to manage distressed gas),
- Slug catcher (to remove water in gas line; and
- Cyclone separator (to remove solids/fines in gas line).

The proposed Lynwood 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 Lynwood FCS. This noise assessment will be used to support an application for an Environmental Authority (EA) for the Lynwood 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 Lynwood 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.

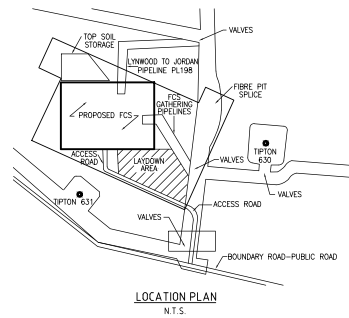
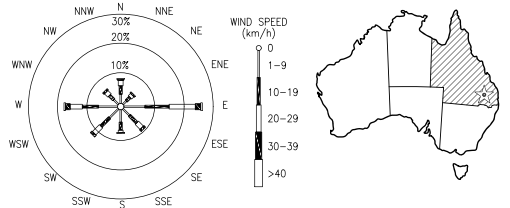


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NOTES:

1. PROPOSED LEASE BOUNDARY IS SHOWN. SEE SET OUT POINTS TABLE FOR LOCATION.
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# SLYB01-ARW-CIV-LAY-00001.
4. MINIMUM 10m SPACING IS REQUIRED FROM LUBE OIL COALESCE TO THE PROPANE ACCUMULATOR VESSEL AS REQUIRED BY QRA.
5. SLUG CATCHER #3 TO BE INSTALLED WITH SLUG CATCHERS #1 & #2, WITH PROVISIONS FOR FUTURE ABOVE GROUND TIE-IN SPOOL.



EQUIPMENT LIST			
ITEM	DESCRIPTION	SIZE(mm)(LxWxH)	PACKAGE TAG
1	PIPERACK MODULE (A-C)	18000 x 4000	-
2	LUBE OIL INJECTION PACKAGE	3500 x 1750	00-A-0011
3	BOP SWITCHROOM	21000 x 4250	00-SWR-0002
4	COMPRESSION SWITCHROOM	29400 x 4250	00-SWR-0004
5	COMPRESSION SWITCHROOM	29400 x 4250	00-SWR-0003
6	GAS ANALYZER SKID	3048 x 2438	50-A-0002
7	HV SWITCHROOM	17250 x 3610	00-SWR-0001
8/A/B/C	DISTRIBUTION TRANSFORMERS	4600 x 2800	-
9	COMPRESSED AIR PACKAGE	8400 x 3500	40-A-0001
10	PRODUCED WATER TRANSFER AND PUMP PACKAGE	-	00-A-0004
11A	SLUG CATCHER #1	-	SP-25-0001
11B	SLUG CATCHER #2	-	SP-25-0002
11C	SLUG CATCHER #3 (NOTE 5)	-	SP-25-0003
12	SLUG CATCHER DRUM SKID PACKAGE	6777 x 2929	99-A-0001
13A	INLET FILTER SEPARATOR PACKAGE #1	-	00-A-0001
13B	INLET FILTER SEPARATOR PACKAGE #2	-	00-A-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	DISTRIBUTION TRANSFORMERS (FUTURE)	4600 x 2800	-
19	GROUND FLARE PACKAGE	60000 x 55000	12-A-0002
20	FLARE IGNITION AND MONITORING PACKAGE	3600 x 1375	12-A-0003
21	FLARE KNOCK-OUT DRUM	10500 x 2625	12-Y-0001
22	COMPRESSION SWITCHROOM (FUTURE)	29400 x 4250	-
23	TREATED WATER EXPORT PUMP	-	00-P-0002A/B
24	TREATED WATER TANK	ø3573 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 (PURCEPTOR)	ø1800 x 5900L	00-T-0002
28	SALES GAS METERING PACKAGE	13500 x 3500	50-A-0001
29	PIG LAUNCHER	-	-
30	LUBE OIL COALESCE PACKAGE	7810 x 2700	00-A-0003
31	GAS DEHYDRATION PACKAGE #1	-	21-A-0001
32	GAS DEHYDRATION PACKAGE #2	-	22-A-0001
33	MAIN COMPRESSOR PACKAGE #5 (FUTURE)	-	05-A-0001
34	MAIN COMPRESSOR PACKAGE #6 (FUTURE)	-	06-A-0001
35	GAS DEHYDRATION PACKAGE #3 (FUTURE)	-	23-A-0001
36	LV SWITCHROOM (FUTURE)	-	-
37	ESSENTIAL DIESEL GENERATOR	-	-
38	DIESEL STORAGE TANK	-	-

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SLYN01-ARW-ENG-SSP-00001	ESCAPE PLAN	B	17/01/22	ISSUED FOR APPROVAL
		A	06/07/22	ISSUED FOR REVIEW

RPO CERTIFICATION
Signature: Name: BRAHAM SINGH
RPO No.: 15622
Date: 18/01/23

STATUS: IFD
CONTRACTOR DRAWING NUMBER: -
ARROW ENERGY DRAWING NUMBER: SLYN01-EQUI-CIV-LAY-00001

SITE: SLY
PLANT: N01
PROJECT CODE: A209
SECURITY CLASSIFICATION: RESTRICTED
LYNWOOD SURAT FIELD COMPRESSION STATION
PLOT PLAN
SCALE: 1:750
REV: C
SIZE: A1

2 Site Description

2.1 Site Location

Lynwood FCS is located in the Surat Basin approximately 35 km south-west of Dalby 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.

2.2 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 5 km of the Lynwood FCS are listed in **Table 2** and **Figure 2**.

Table 2 Identified Receptors – Lynwood FCS (LFCS)

Receptor ID	Coordinates (GDA 94 zone 56)		Receptor ID	Coordinates (GDA 94 zone 56)	
	Easting	Northing		Easting	Northing
LFCS-1	310,802	6,955,215	LFCS-8	317,954	6,955,094
LFCS-2	314,546	6,960,670	LFCS-9	318,264	6,955,584
LFCS-3	314,462	6,960,716	LFCS-10	318,253	6,955,369
LFCS-4	317,018	6,955,997	LFCS-11	318,563	6,956,439
LFCS-5	313,164	6,953,290	LFCS-12	317,016	6,961,546
LFCS-6	317,852	6,956,338	LFCS-13	318,185	6,953,373
LFCS-7	318,230	6,955,420			

2.3 Existing Noise Environment

Lynwood 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.

Existing noise sources specifically relevant to the Lynwood FCS area have been identified:

- There is a cotton processing facility (cotton gin) located approximately 6 km to the southeast of the planned Lynwood FCS, on Cecil Plains Moonie Road. Noise sensitive receptors LFCS-4, LFCS-6 and LFCS-11 are identified as the most exposed to potential noise from the cotton processing facility.
- Previous reporting concluded that receptors LFCS-4, LFCS-6 and LFCS-11 which are adjacent to the cotton processing facility would be subject to existing noise source emissions (from the cotton processing facility) during day-time periods given the proximity. An assessment of the potential existing noise emissions onto these receptors from the cotton processing facility operations were modelled and determined that the maximum noise level at these receptors would be below 19 dBA.
- Therefore, operations from the Lynwood FCS resulting in compliance with the nominated noise criteria would remain compliant when considering the cumulative noise impact from both developments.

2.4 Background Noise Levels

The deemed minimum background noise levels as stated in 2016 *Streamlined Model Condition* (see **Section 3.2** 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 2.3** 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.

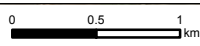
For this assessment, the deemed minimum background noise levels are considered applicable given the rural nature that the Lynwood FCS area is located within and the expected low background noise levels within this area.

H:\Projects\SLR\620-BNE\620-BNE\620-12248 Arrow Energy - Project Pearl06 SLR Data\01 CADGIS\ArcGIS\62012248_F02 Lynwood FCS and Receptor Location.mxd



LEGEND

- Receptors
- Infrastructure Site



Scale: 1:45,000 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 17-May-2023
Project Number: 620.12248.01600



Data Source:
ESRI basemap world imagery (May 2023)

Arrow Energy – Lynwood FCS and Receptor Location

FIGURE 2

3 Regulatory Framework

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

3.1 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 3**. Project operations require continuous operation of plant as such this Assessment has referenced the 1-hour LAeq and LA1 AQO to assess the noise emissions from Project noise sources.

Table 3 EPP(Noise) Acoustic Quality Objectives

Receptor Type	Time of Day	Acoustic Quality Objective (dBA)		
		LAeq,adj,1hr	LA10adj,1hr	LA1,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:

- LAeq,adj,1hr 42 dB during the daytime and evening.

- LAeq,adj,1hr 37 dB during the night-time.
- LA1,adj,1hr 52 dB during the daytime and evening.
- LA1,adj,1hr 47 dB during the night-time.

3.2 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.

3.2.1 Deemed 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. Deemed background noise levels are to be applied where site specific noise monitoring has not been undertaken.

The Project has adopted the deemed background noise levels presented in **Table 4**.

Table 4 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)*.

3.2.2 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 5**. These noise limits closely align with the 'Streamlined Conditions' contained within the *DESI Streamlined Model Conditions for Petroleum Activities* (DESI Guideline, 2024), effective 13 May 2024 (hereafter referred to as SMC).

Table 5 Best Practice Measured Outdoor Noise Emission Limits (DES, 2016)

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

Note 1: LABG 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.

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.

3.2.3 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.

3.3 Summary of Project Noise Conditions

In summary, the nominated noise limits that are considered appropriate for this noise assessment are summarised in **Table 6**. Reference to the EPP (Noise) AQO is provided for the purpose of comparison to other noise legislation in Queensland.

Table 6 Project Noise Emission Limit Overview

Time Period	Time of Day	Metric	Long Term Noise Limit, dBA
7:00 am – 6:00 pm	Daytime	LAeq, adj, 15 minutes	40 ($35^1 + 5$)
6:00 pm – 10:00 pm	Evening	LAeq, adj, 15 minutes	35 ($30^1 + 5$)
10:00 pm – 6:00 am	Night-time	LAeq, adj, 15 minutes	28 ($25^1 + 3$)
		Max LpA, 15 minutes	55
6:00 am – 7:00 am	Morning	LAeq, adj, 15 minutes	35 ($30^1 + 5$)

Note 1: LABG 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 emission of any low frequency noise must not exceed:

- 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.

4 Lynwood FCS Operational Noise Assessment

4.1 Assessed Operational Scenarios

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

- Scenario 1 – Normal Operation
 - Four (4) Howden 510 screw compressors running at 2,000 RPM with coolers, and
 - Sixteen (16) operating CSG fired power station (internal combustion engines) and two (2) spare 1.8 MW Engine with BESS.
 - Two (2) Centrifugal pumps.
- Scenario 2 – Flaring
 - MPGF to occur under four (4) separate flare flow rates being 116 MMscfd, 87MMscfd, 58 MMscfd and 29 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 (Lynwood 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 29 MMscfd (or 9.5% of the time during an hourly period).
- Flaring events greater than 29 MMscfd are expected to occur approximately 2% of the time over an hourly period (<1% at night-time).

Flare flow rates between 58 MMscfd and 116 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 Lynwood 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 Lynwood 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, minimizing 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 Lynwood 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, Lynwood 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 3.3** 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 Noise Model Inputs

A summary of the noise model inputs considered in the assessment are provided in **Table 7**.

Table 7 Noise Model Inputs

Inputs	Model Type	Comments
Receivers	Single Point Receivers (SPR)	SPR were modelled 1.5m above ground level in close proximity to the dwellings/noise sensitive receivers.
Terrain	3-D Digital Ground Model (DGM)	3-D terrain data has been supplied by Arrow and digitised in SoundPLAN for assessment.
Ground Absorption	Ground Absorption Area, 1.0	The Project is predominately surrounded by vegetation and grass with dirt access tracks, therefore, has been modelled as 'soft' ground, which is typical for Arrow noise assessments for rural areas of this nature.
Calculation Method	CONCAWE	Refer to Section 4.2.3 for the adopted model calculation method.
Meteorological Conditions	Both neutral and adverse weather conditions modelled	Refer to Section 4.3 for the modelled weather conditions. Adverse weather conditions are representative of temperature inversions.
Noise Sources	Single Point Noise Source	Refer to Section 4.4 for the modelled noise sources considered in the assessment.

4.2.3 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 Lynwood FCS operations. These neutral and adverse meteorological conditions are consistent with historical Arrow noise assessments and outlined in **Table 8**.

Table 8 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 Lynwood FCS were provided by Arrow and are outlined in **Table 9**.

Table 9 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	
Power Generator Unit & Generator Engine Exhaust	2.0 m	71	90	106	97	92	93	85	82	74	107
Battery (BESS) 2.2 MWh unit	2.5 m	80	84	80	81	79	73	69	67	64	88
Inverter Transformer	2.5 m	84	85	86	86	81	79	77	82	76	93
Centrifugal Pumps	1.0 m	50	70	84	75	78	85	91	92	80	96
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 116 MMscfd	5.0 m	94	111	120	126	128	129	127	120	119	134

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	
Multi-Point Flaring 87 MMscfd		90	107	116	122	124	125	123	116	115	130
Multi-Point Flaring 58 MMscfd		86	103	112	118	120	121	119	112	111	126
Multi-Point Flaring 29 MMscfd		84	101	110	116	118	119	117	110	109	124

The number of sources modelled for each scenario are shown in **Table 10**.

Table 10 Quantity of Noise Sources Modelled for Each Scenario

Plant Items	Modelled Noise Source Location/Coordinates, General Plant Locality Representative of Each Plant Area GDA2020		Number of Plant at Lynwood FCS				
			Scenario 1 – Normal operations	Scenario 2 – Flaring ¹			
	X, m	Y, m		Assessed Flare Flow Rates (MMscfd)			
				29	58	87	116
Power Generator Unit & Generator Engine Exhaust	313357.81	6957577.94	16	13	10	7	4
Battery (BESS) 2.2 MWh unit	313412.51	6957547.97	4	4	4	4	4
Inverter Transformer	313417.62	6957538.64	2	2	2	2	2
Centrifugal Pumps	313258.71	6957829.29	2	2	2	2	2
Mitigated Howden Screw Compressor Unit (fitted with acoustic panels)	313209.76	6957715.26	4	3	2	1	0
Screw Compressor Cooling Towers	313209.76	6957715.26	4	3	2	1	0
Multi-Point Ground Flare (for all flaring rates)	313115.25	6957572.17	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 9** for the MPGF do not include any potential noise reduction provided by the radiation fence. Arrow has provided SLR with a flare noise study report¹ 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 MPGF 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 Lynwood FCS operating under 'normal operations' for both neutral and adverse weather. **Table 11** summarises the predicted noise levels at the surrounding identified noise sensitive receptors.

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.

Table 11 Predicted Noise Level at Receptor – Normal Operations

Receptor ID	Predicted Noise Level at Receptor, LAeq dBA		Expected to Achieve 28 dBA LAeq,15min Night-time Noise limits?
	Neutral Weather	Adverse Weather	
LFCS-1	24	29	No
LFCS-2	25	30	No
LFCS-3	25	30	No
LFCS-4	22	27	Yes
LFCS-5	22	26	Yes
LFCS-6	21	25	Yes
LFCS-7	20	24	Yes
LFCS-8	19	24	Yes
LFCS-9	19	24	Yes
LFCS-10	19	24	Yes
LFCS-11	19	24	Yes
LFCS-12	19	24	Yes
LFCS-13	17	22	Yes

Predicted noise levels presented in **Table 11** from Lynwood FCS under ‘normal operations’ comply with the most stringent night-time noise limit of 28 dBA LAeq,15min under neutral weather and predominately adverse weather conditions. Under adverse weather conditions (only) up to three (3) dwellings are predicted to exceed the most stringent night-time noise limit of 28 dBA LAeq,15min with the most exposed receptors being LFCS-2 and LFCS-3, predicting 3 dBA above the 28 dBA LAeq,15min criterion. The dominant noise sources were found to be from the Power Generator Units. Noise mitigation is expected to be required in order to reduce the predicted noise exceedances under adverse weather conditions, refer to **Section 4.5.1.1** for further discussion.

Compliance with the most stringent night-time noise limit of 28 dBA LAeq,15min under both neutral and adverse weather conditions has also resulted in compliance with all other noise criteria outlined in **Table 11**. Compliance has also been predicted for all other criteria at receptors predicted to exceed the night-time noise limit of 28 dBA LAeq,15min under adverse weather conditions.

4.5.1.1 Scenario 1 – Normal Operations Noise Mitigation Recommendation

Noise mitigation is required to achieve full compliance with the night-time noise limit of 28 dBA LAeq,15min under adverse weather conditions at all surrounding receptors. To achieve this outcome, SLR recommends that the sixteen (16) Power Generation Units with a sound power noise level of 107 dBA are designed to achieve a minimum 4 dBA noise reduction in all frequency octave bands (in particular 125 Hz and 250 Hz) to result in a maximum sound power noise level of 103 dBA per unit. Recommended noise attenuation to consider is engine exhaust silencer, air inlet silencer and/or acoustic enclosure for each proposed unit.

The Power Generation Units are required to achieve up to the maximum sound power noise levels in each frequency octave band (in particular 125 Hz and 250 Hz) shown in **Table 12**, to reach compliance with the night-time noise limit of 28 dBA LAeq,15min under both neutral and adverse weather conditions.

Table 12 Maximum Sound Power Noise Levels for the Power Generation Units (Mitigated)

Plant Items	Sound Power Level, LAeq dBA									Overall SWL dBA
	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1k	2k	4k	8k	
Power Generator Unit, including Generator Engine Exhaust (Mitigated)	75	86	102	93	88	89	81	78	70	103

Revised noise predictions considering the sound power noise levels in **Table 12** are summarised in **Table 13** for all surrounding identified noise sensitive receptors.

Table 13 Predicted Noise Level at Receptor – Normal Operations with Mitigated Power Generation Units

Receptor ID	Predicted Noise Level at Receptor, LAeq dBA		Expected to Achieve 28 dBA ¹ LAeq,15min Night-time Noise limits?
	Neutral Weather	Adverse Weather	
LFCS-1	21	26	Yes
LFCS-2	22	27	Yes
LFCS-3	22	27	Yes
LFCS-4	19	24	Yes
LFCS-5	18	23	Yes
LFCS-6	17	22	Yes
LFCS-7	16	21	Yes
LFCS-8	16	21	Yes
LFCS-9	16	20	Yes
LFCS-10	15	20	Yes
LFCS-11	16	20	Yes
LFCS-12	15	20	Yes
LFCS-13	<15	18	Yes

Note 1: Compliance with the most stringent night-time 28 dBA LAeq, 15min noise criterion is expected to result in compliance with all other noise criteria.

Mitigating the Power Generation Units noise levels by a minimum 4 dBA across all frequency octave bands would predict compliance against the most stringent night-time noise limit of 28 dBA LAeq,15min under both neutral and adverse weather conditions, and therefore, has also resulted in compliance with all other noise criteria outlined in **Table 6**.

No other design changes are deemed required for 'normal operations'.

4.5.2 Scenario 2 – Flaring

The noise model predicted noise emissions at nearby noise sensitive receptors when considering the Lynwood FCS operating during a flaring event for both neutral and adverse weather. **Table 14** summarises the predicted noise levels at the surrounding identified noise sensitive receptors.

Table 14 Predicted Noise Level at Receptor – Flaring

Receptor ID	Predicted Noise Level at Receptor2, LAeq,15min dBA							
	Considering Different MPGF Flow Rates, MMscfd							
	116 (100%)	87 (75%)	58 (50%)	29 (25%)	116 (100%)	87 (75%)	58 (50%)	29 (25%)
	Neutral Weather				Adverse Weather			
LFCS-1	27	23	20	19	33	30	26	25
LFCS-2	26	23	20	19	33	29	26	25
LFCS-3	26	23	20	19	33	29	26	25
LFCS-4	22	19	16	16	29	25	22	21
LFCS-5	22	19	16	15	29	25	22	21
LFCS-6	20	16	14	13	26	23	20	19
LFCS-7	18	15	12	12	25	21	18	18
LFCS-8	18	14	12	12	24	21	18	17
LFCS-9	17	14	12	12	24	20	18	17
LFCS-10	17	14	12	11	24	20	17	17
LFCS-11	17	14	12	11	24	20	17	17
LFCS-12	17	14	12	11	24	20	17	17
LFCS-13	14	11	9	9	20	17	15	14

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 14** from Lynwood FCS during flaring predominately complies with all noise criteria outlined in **Table 6**, with the exception of the night-time noise criterion of 28 dBA LAeq,15min under adverse weather conditions (only). The dominant noise sources were found to be from the MGPF in all operation modes.

Considering either unmitigated or mitigated Power Generation Units in the modelled flaring scenario's does not result in a predicted noise level change at the noise sensitive receptors; due to the flaring sound power noise levels being 17 dBA or greater than the Power Generation Units, resulting in the noise contribution from these units being negligible (during flaring events).

When assessing under adverse weather conditions compliance is expected to be achieved when flaring occurs up to a flow rate of 58 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 receptors LFCS-1, LFCS-2 and LFCS-3 have predicted noise levels between 1 to 2 dBA above the (most stringent) night-time noise limit of 28 dBA $L_{Aeq,15min}$, which is considered an acoustically marginal exceedance during flow rates equal to 87 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 87 MMscfd.

When assessed under maximum flare flow rates (116 MMscfd), up to five (5) sensitive receptors, being LFCS-1, LFCS-2, LFCS-3, LFCS-4 and LFCS-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 be expected to only occur at an individual dwelling with the worst case being up to two receptors potentially exceeding at the same time, LFCS-2 and LFCS-3 due to similar locality.

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

The noise predictions shown in **Table 14** 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 16.7 m radiation fence surrounding the MGPF.
- The Lynwood 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 Lynwood FCS development layout, which is proposed to be located approximately 35 km south-west of Dalby, Queensland.

The Lynwood 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 Lynwood FCS operational noise assessment identified the following:

- The proposed Lynwood FCS development is expected to meet all nominated noise criteria outlined in **Section 3.3** for both assessed weather conditions when operating under 'normal operations' (Scenario 1) and the maximum sound power noise level of 103 dBA is achieved for the Power Generation Units.
- The frequency octave band noise levels associated with the Power Generation Units and Screw Compressor Units are not to exceed those outlined in **Table 15**.

Table 15 Maximum Octave Band Noise Levels

Plant Items	Sound Power Level, LAeq dBA									Overall SWL dBA
	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1k	2k	4k	8k	
Power Generator Unit, including Generator Engine Exhaust (Mitigated)	75	86	102	93	88	89	81	78	70	103
Mitigated Howden Screw Compressor Unit (fitted with acoustic panels)	71	76	84	101	99	95	92	87	78	104
Screw Compressor Coolers	73	87	96	100	101	101	95	91	83	107

- 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 58 MMscfd and under for all weather conditions. This represents 95% of expected flaring events that would potentially occur at the Lynwood FCS.
 - At a flare flow rate of 87 MMscfd and above, marginal exceedance of the night-time noise limit of 28 dBA during adverse weather may occur at up to five (5) sensitive receptors. Noting, the worst case being up to two sensitive receptors to potentially exceed at the same time, LFCS-2 and LFCS-3 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 Lynwood FCS can operate in compliance within the existing noise conditions outlined in EPPG00972513.

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	

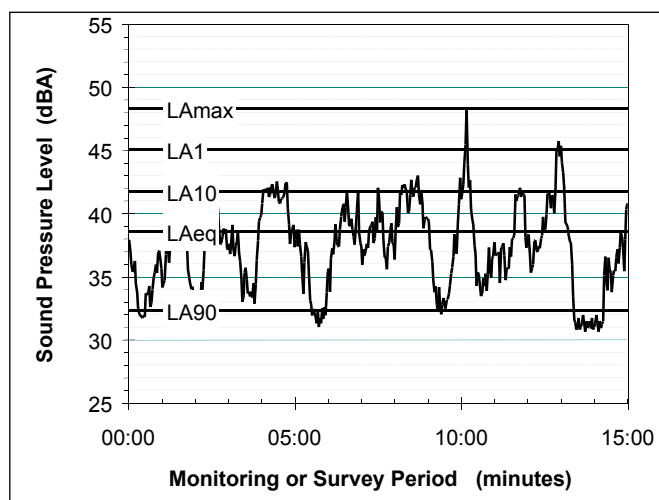
Sound pressure level (dBA)	Typical example	Subjective (human) evaluation
60	Ambient noise level in urban area close to main roads	Moderate to quiet
50	Typical rural environment with high insect noise or close to a main road	
40	Ambient noise level in a rural environment with light breezes and some noise 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 level 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

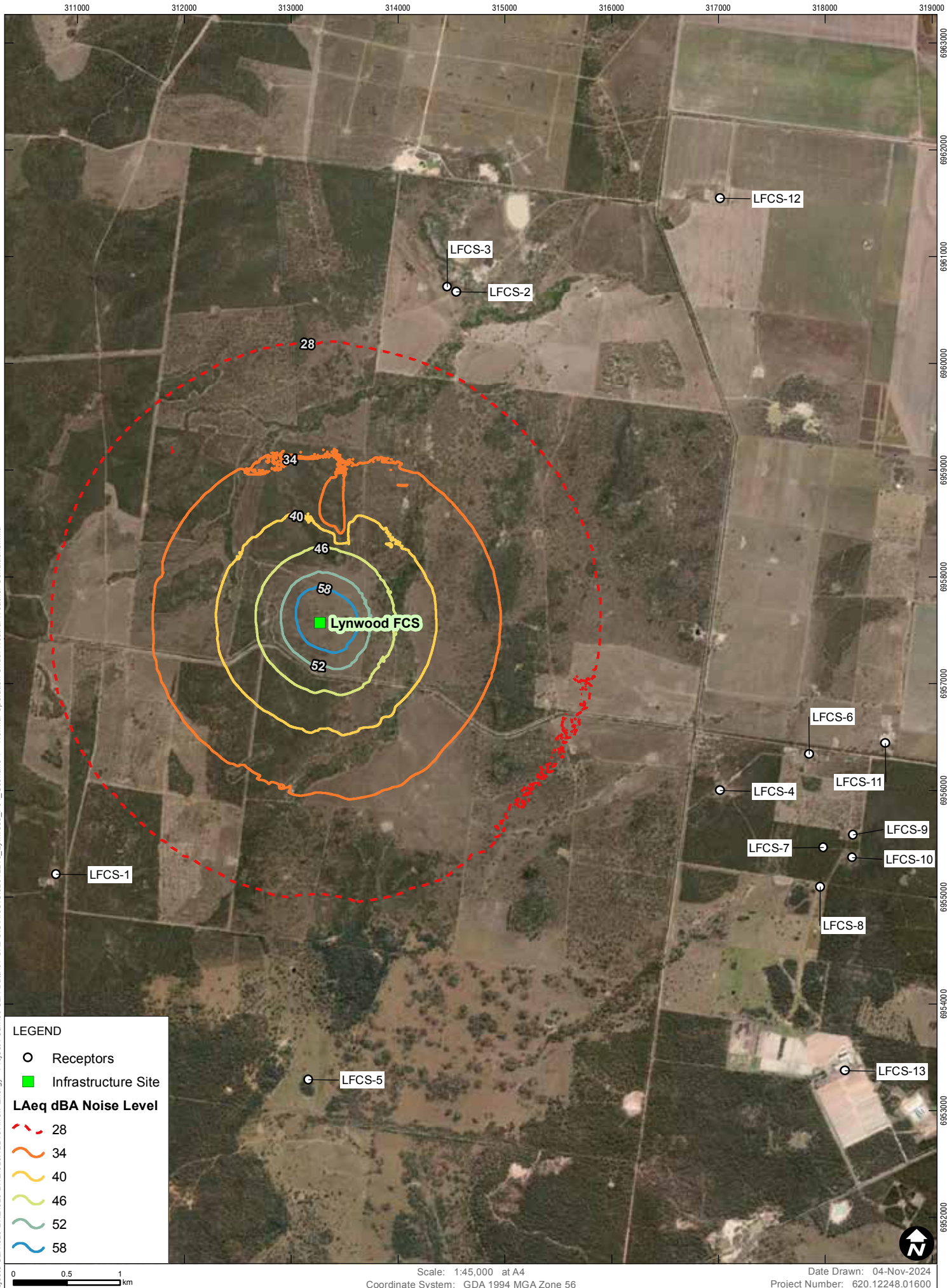
Temperature inversions are a meteorological phenomenon where a layer of cold air is trapped at the ground surface under a layer of warmer air. Temperature inversions enhance noise propagation because sound travelling away from the ground is reflected back down from where the colder air meets the warmer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

Appendix B:

Scenario 1 – Normal Operations Noise Contour Maps

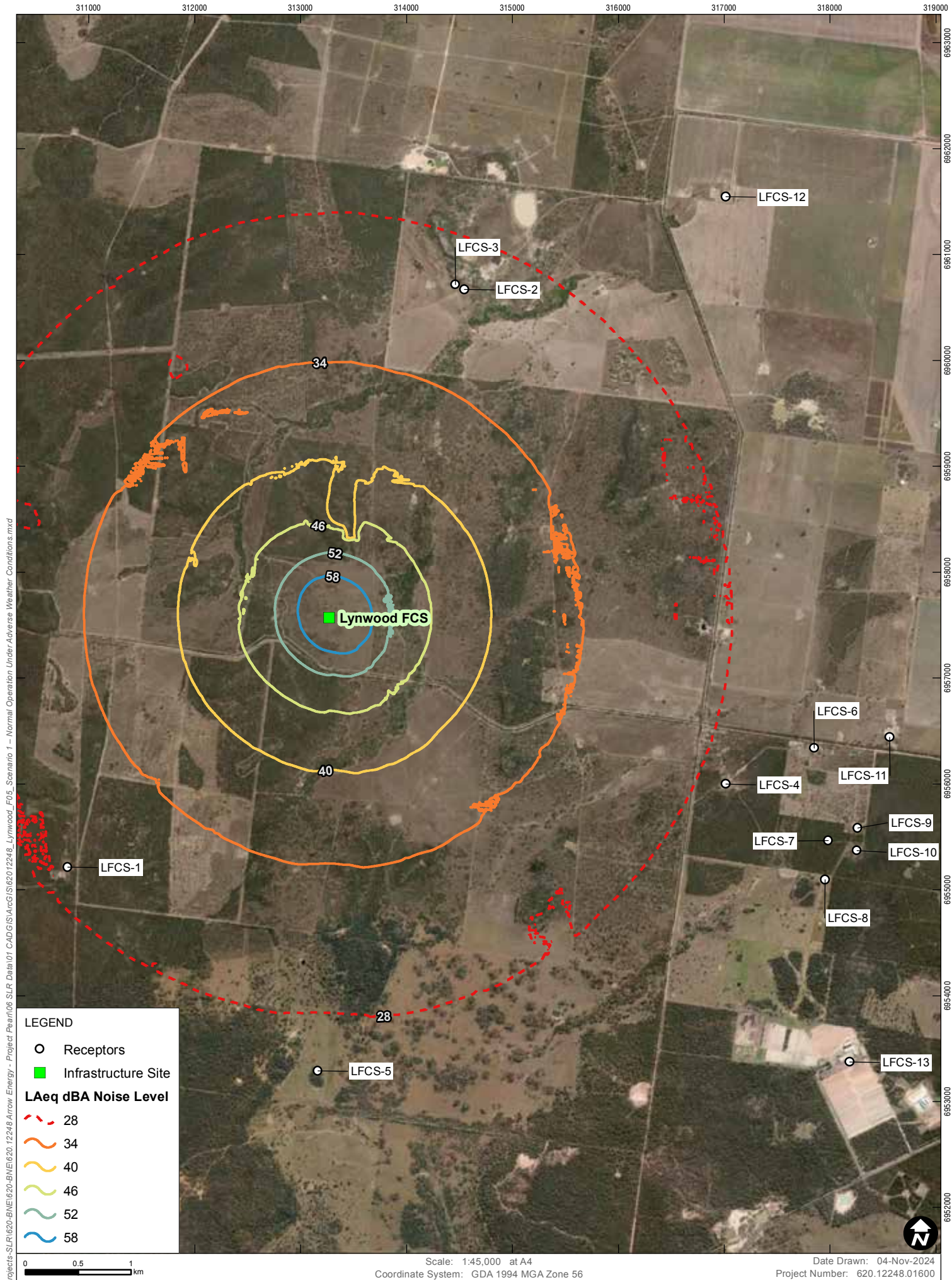
\\au.slr.local\Corporate\Projects\SLR\620-BNE\620-BNE\620-12248 Arrow Energy - Project Pearl\06 SLR Data\01 CAD\GIS\4-cGIS\62012248_Lynwood_F04_Scenario 1 - Normal Operation Under Neutral Weather Conditions.mxd



Data Source:
ESRI basemap world imagery (October 2024)

Arrow Energy
Scenario 1 – Normal Operation Under
Neutral Weather Conditions

FIGURE 4



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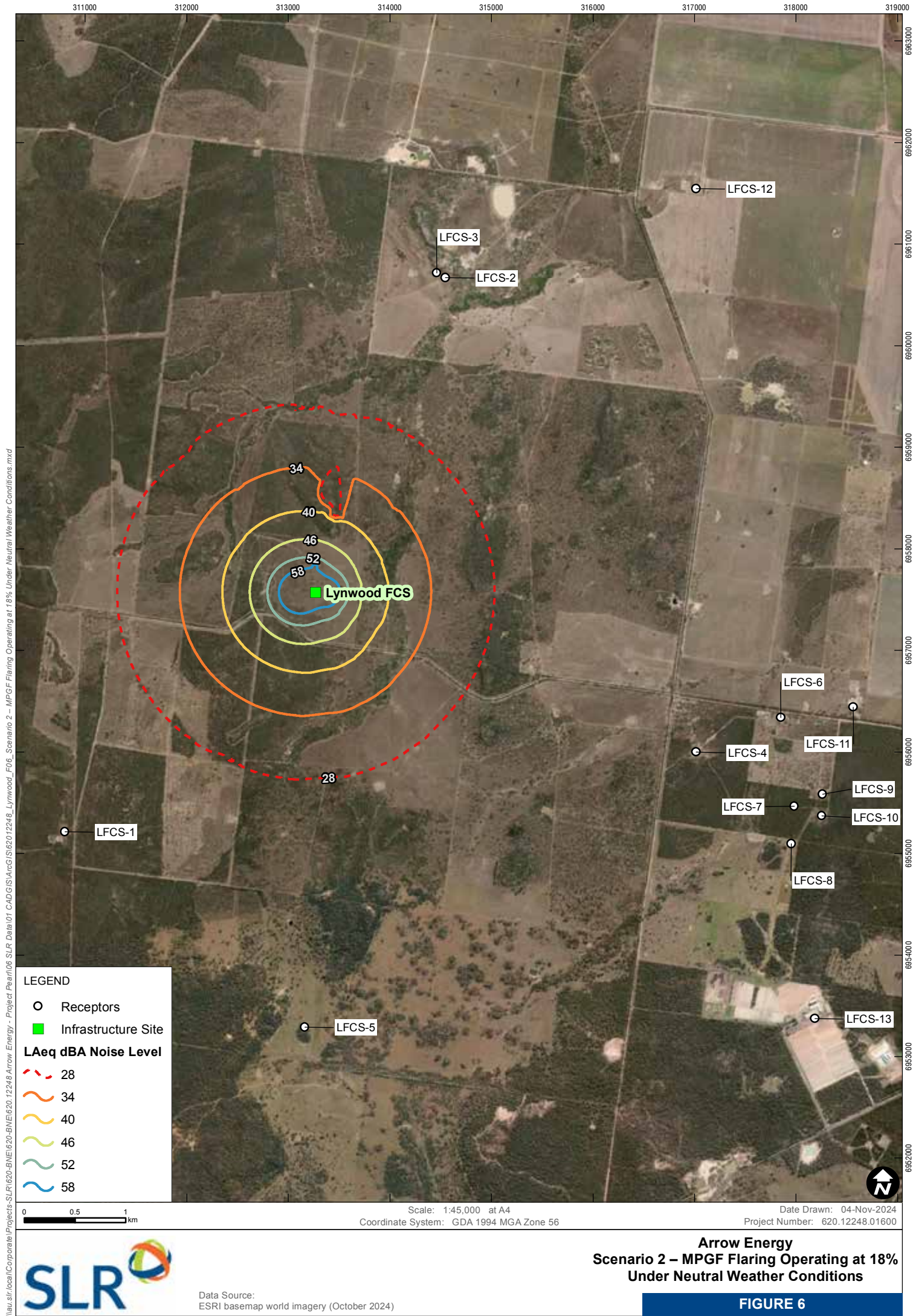
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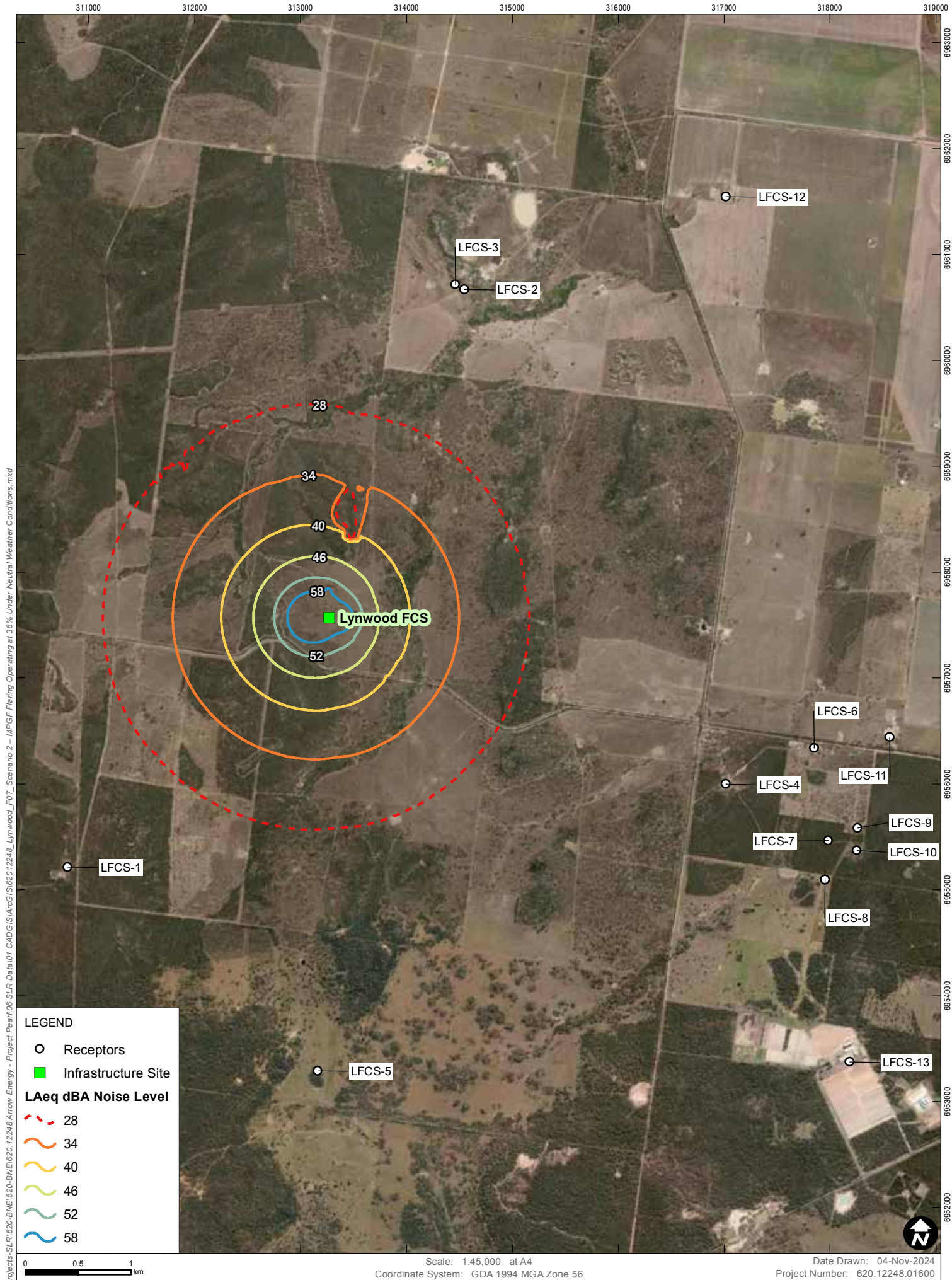
Arrow Energy
Scenario 1 – Normal Operation Under
Adverse Weather Conditions

FIGURE 5

Appendix C:

Scenario 2 – Flaring Noise Contour Maps





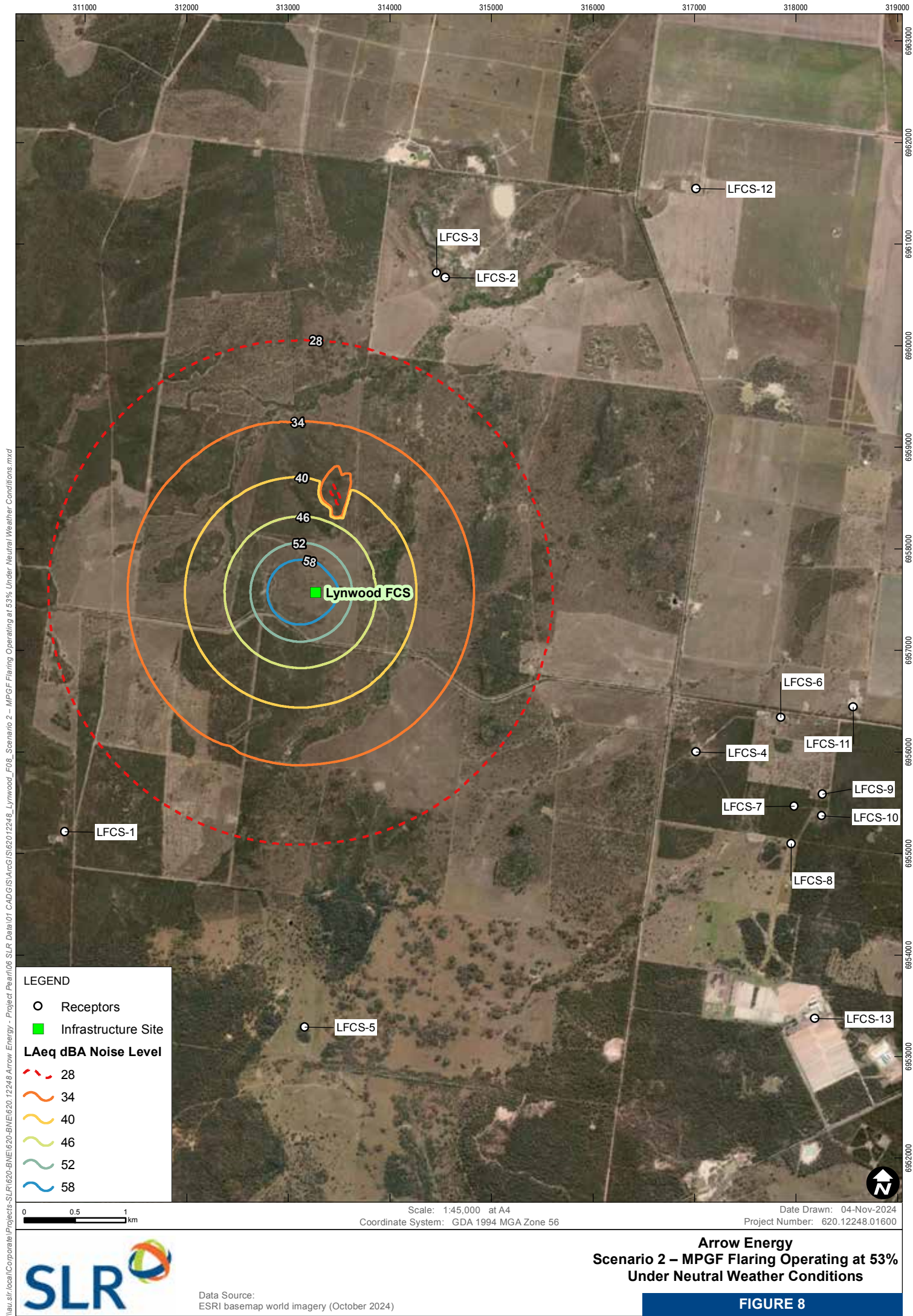
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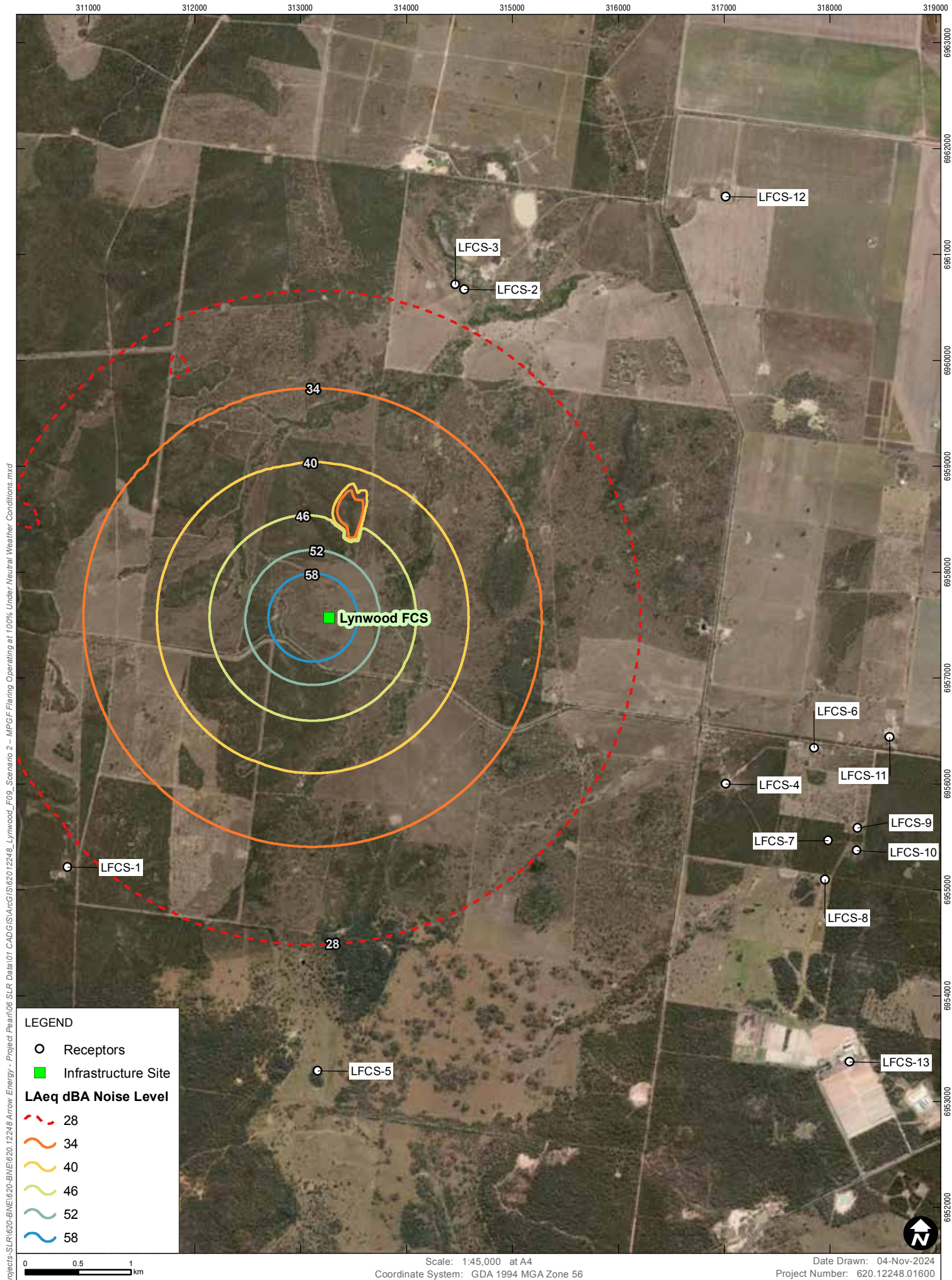


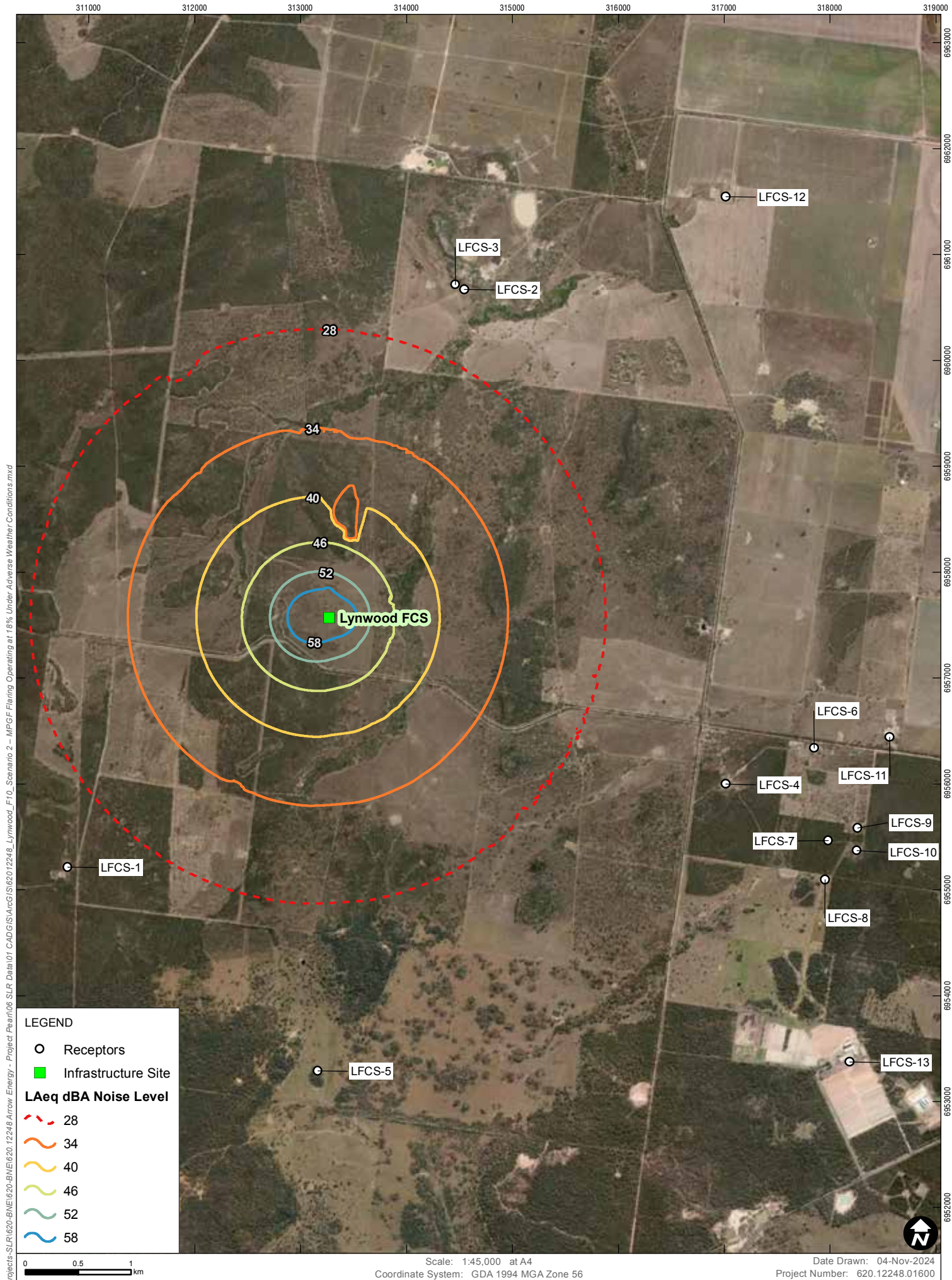
Data Source:
ESRI basemap world imagery (October 2024)

Arrow Energy
Scenario 2 – MPGF Flaring Operating at 36% Under Neutral Weather Conditions

FIGURE 7







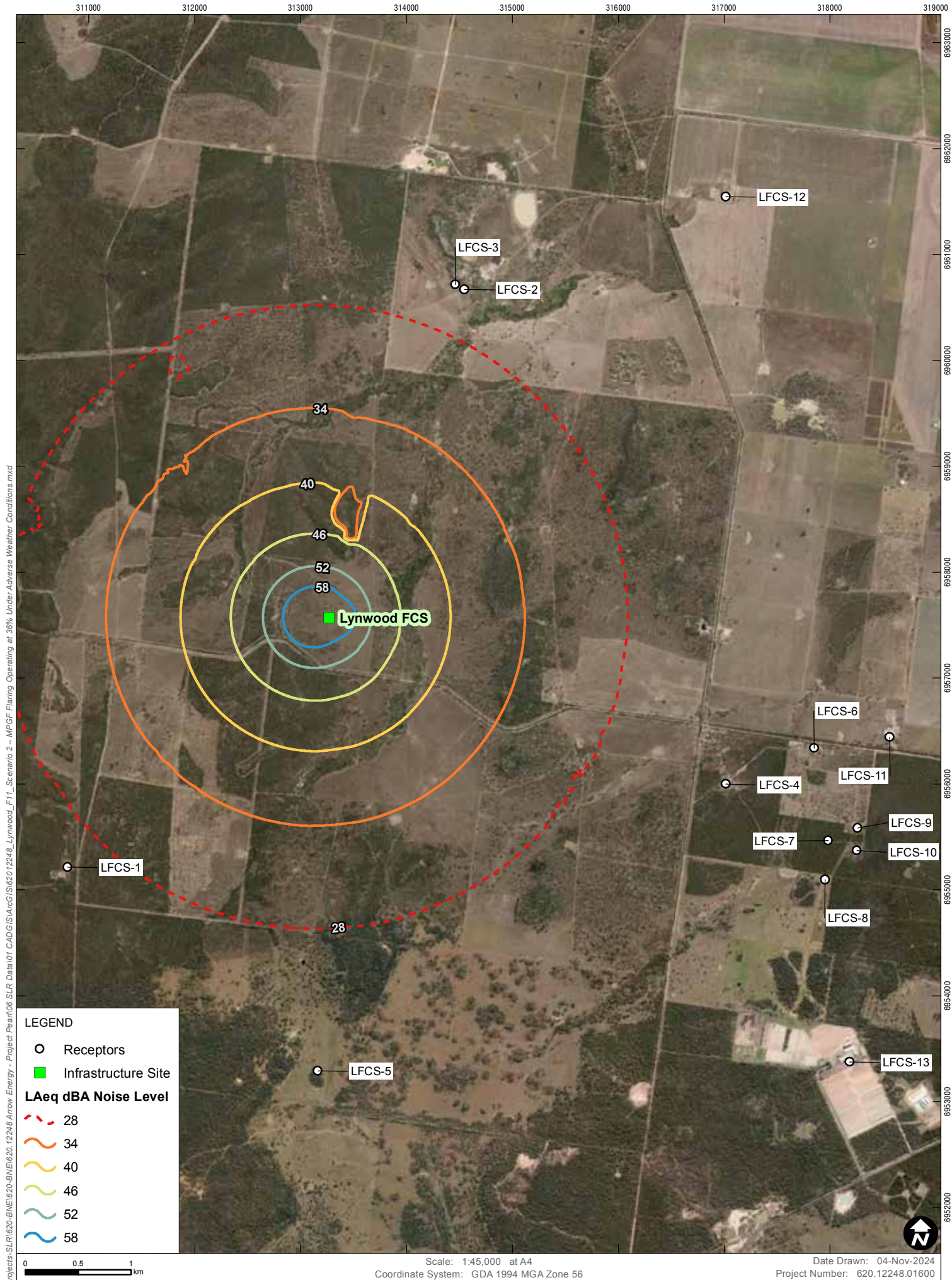
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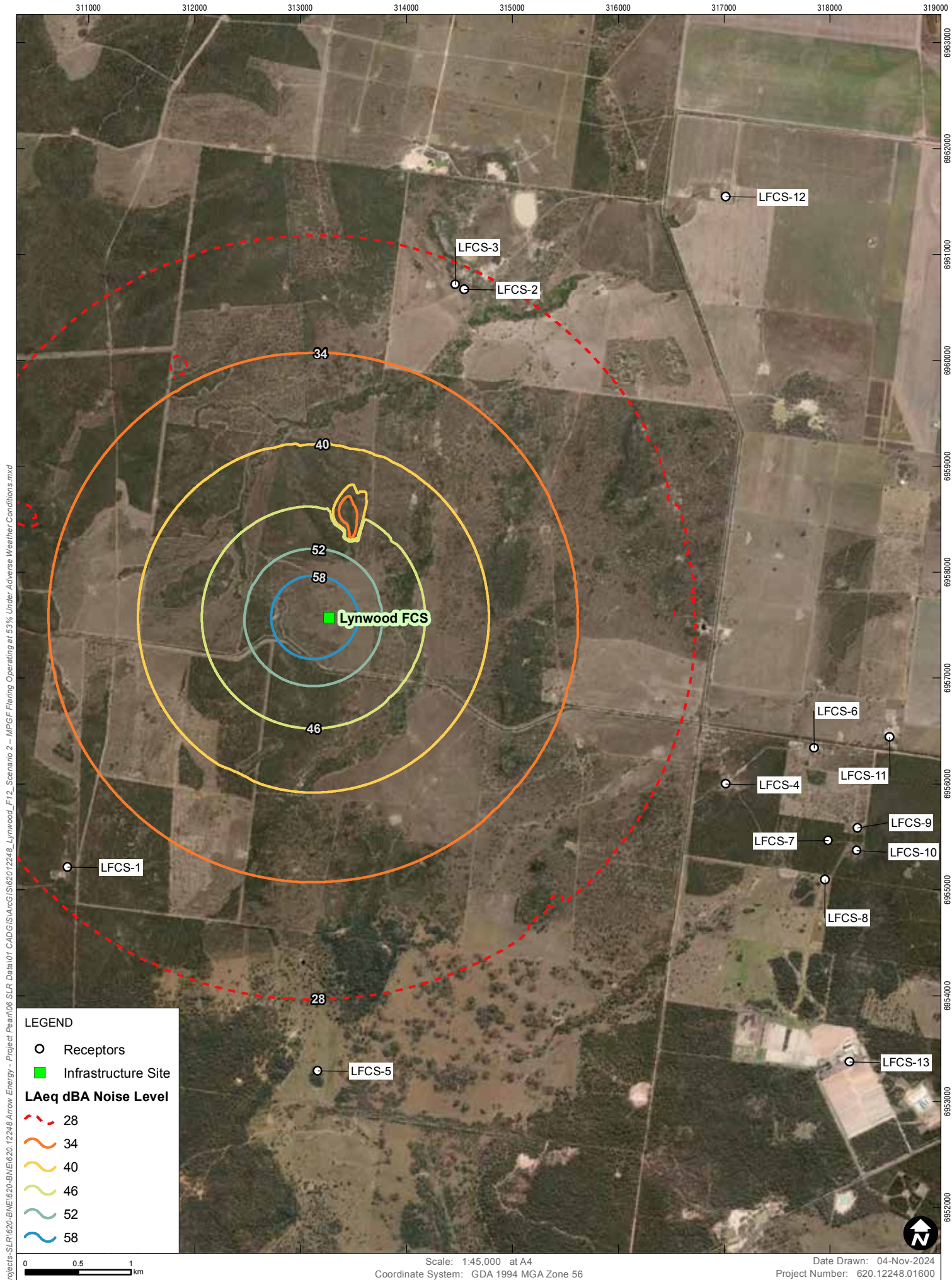


Data Source:
 ESRI basemap world imagery (October 2024)

Arrow Energy
Scenario 2 – MPGF Flaring Operating at 18% Under Adverse Weather Conditions

FIGURE 10





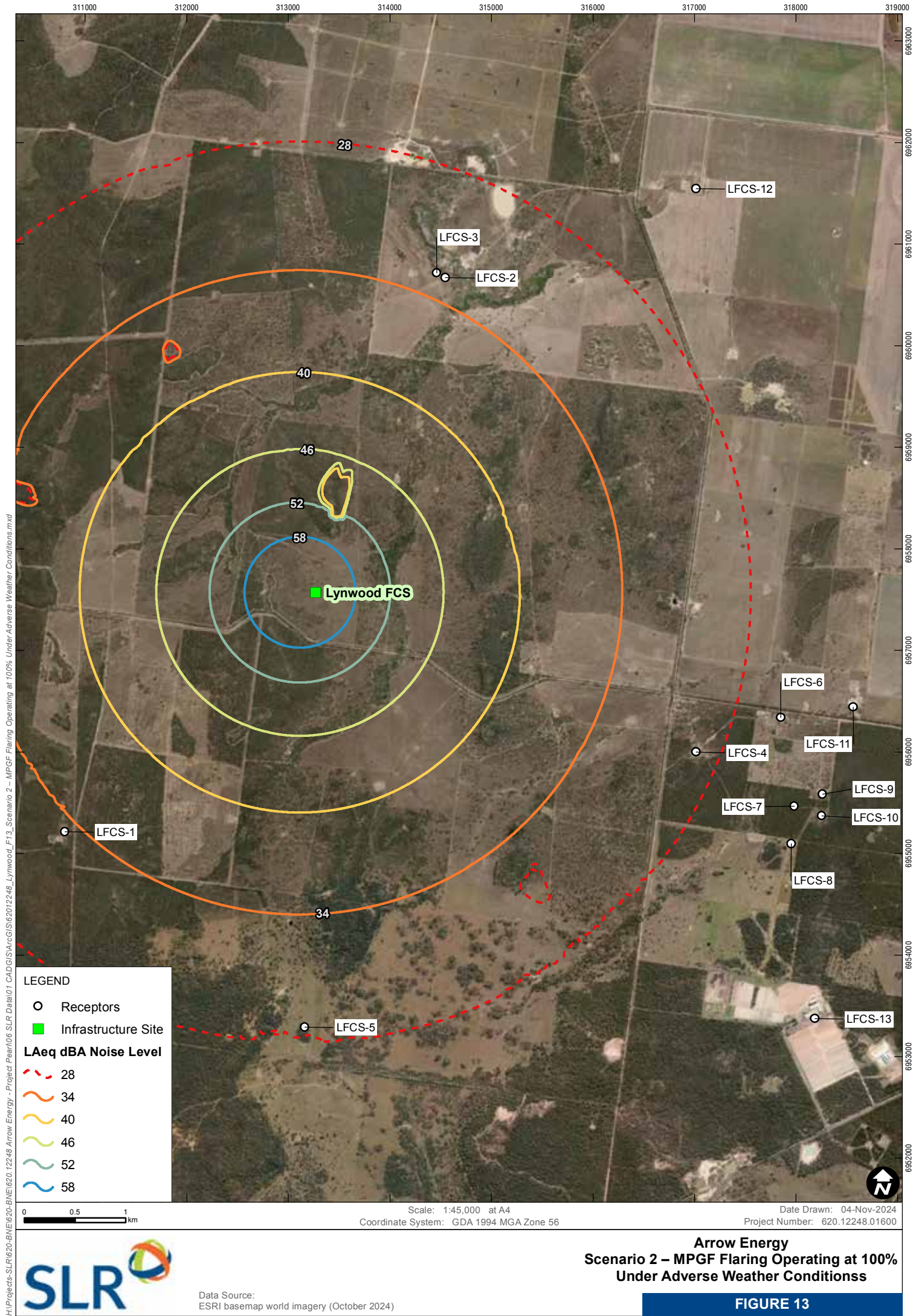
\\au.slr.local\Corporate\Projects\SLR\620-BNE\620-BNE\620.12248 Arrow Energy - Project Pearl\06 SLR Data\01 CAD\GIS\4\c\GIS\62012248_Lynwood_FI2_Scenario 2 - MPGF Flaring Operating at 53% Under Adverse Weather Conditions.mxd



Data Source:
 ESRI basemap world imagery (October 2024)

Arrow Energy
Scenario 2 – MPGF Flaring Operating at 53%
Under Adverse Weather Conditions

FIGURE 12



H:\Projects\SLR\620-BNE\620.12248 Arrow Energy - Project Pearl\06 SLR Data\01 CAD\GIS\src\GIS\620.12248_Lynwood_F13_Scenario 2 - MPGF Flaring Operating at 100% Under Adverse Weather Conditions.mxd

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Appendix E. Surat Gas Project Terrestrial Ecological Report (EcoSmart 2017)



SURAT GAS PROJECT

Terrestrial Ecology Report

PREPARED FOR ARROW ENERGY PTY LTD
June 2017



3D Environmental
vegetation analysis and mapping specialists

Surat Gas Project

Terrestrial Ecology Report

June 2017

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	IV
1.0 INTRODUCTION	1
2.0 STUDY AREA DESCRIPTION	2
2.1 STUDY AREA AND EXTENT	2
2.2 GEOLOGY AND WATER RESOURCES	2
2.3 PROTECTED ESTATE	4
2.4 FIRE HISTORY	4
3.0 METHODS, SURVEY CONDITIONS AND LIMITATIONS.....	8
3.1 DESKTOP DATA.....	8
3.2 FLORA FIELD SURVEY METHODS.....	9
3.2.1 Survey Overview and Site Selection.....	9
3.2.2 Flora Survey Techniques	10
3.2.3 Mapping Scale and Attributes.....	12
3.3 FAUNA FIELD SURVEY METHODS.....	13
3.3.1 Stratification, Survey Design and Site Selection	13
3.3.1.1 <i>Spatial Stratification</i>	13
3.3.1.2 <i>Habitat Stratification</i>	15
3.3.1.3 <i>Survey Design</i>	15
3.3.1.4 <i>Survey Site Selection</i>	15
3.3.1.5 <i>Contingency Survey</i>	18
3.3.2 Survey Techniques	19
3.3.2.1 <i>Fauna Trapping</i>	19
3.3.2.2 <i>Observation Based Detection</i>	20
3.3.2.3 <i>Automatic Detection Methods</i>	22
3.3.2.4 <i>Targeted Detection</i>	22
3.3.3 Summary of Fauna Survey Effort.....	23
3.4 ASSESSING LIKELY OCCURRENCE OF THREATENED TAXA.....	23
3.5 SURVEY CONDITIONS AND LIMITATIONS	25
3.5.1 Survey Conditions.....	25
3.5.2 Survey Limitations	26
4.0 RESULTS	27
4.1 DESKTOP RESULTS	27
4.1.1 Wetlands of High Ecological Significance.....	27
4.1.2 Essential Habitat.....	27
4.1.3 Protected Plant 'High Risk' Buffers.....	27

4.1.4	Environmentally Sensitive Areas.....	30
4.1.5	Matters of State Environmental Significance.....	30
4.1.6	Threatened Flora and Fauna.....	32
4.2	TERRESTRIAL FLORA RESULTS	32
4.2.1	Threatened Ecological Communities and Regional Ecosystems.....	32
4.2.1.1	<i>Threatened Ecological Communities</i>	<i>32</i>
4.2.1.2	<i>Regional Ecosystems:.....</i>	<i>34</i>
4.2.2	Flora Diversity	43
4.2.3	Threatened Flora Species Likelihood Assessments	43
4.2.4	Exotic Flora Species	46
4.3	TERRESTRIAL FAUNA RESULTS	48
4.3.1	Likely Threatened Terrestrial Fauna Species.....	48
4.3.2	Migratory Fauna Species	51
4.3.3	Exotic Pest Species	55
5.0	HABITAT CONDITION	57
5.1	CONDITION OF WETLANDS INCLUDING LONG SWAMP	57
5.2	GENERAL HABITAT CONDITION	58
6.0	REFERENCES.....	61

TABLE OF FIGURES

Figure 2.1.	SGP study area location.....	3
Figure 2.2.	Protected Estate within and surrounding the SGP study area	5
Figure 2.3.	Fire scars since 2012 within the SGP study area.....	7
Figure 3.1.	Floristic survey locations within the SGP study area.....	11
Figure 3.2.	Previous and current fauna survey locations and focus areas	14
Figure 3.3a and b.	Detailed fauna trapping sites with respect to BVG	17
Figure 4.1.	Wetland Management Areas within the SGP study area	28
Figure 4.2.	'High Risk' protected plant buffers assessed during SGP surveys (2016 – 2017)..	29
Figure 4.3.	MSES in the SGP Assessment Area.	31
Figure 4.4.	Threatened Ecological Communities within the SGP study area	33
Figure 4.5.	Endangered, Of Concern, and Least Concern REs within the northern region of the SGP study area	37
Figure 4.6.	Endangered, Of Concern, and Least Concern REs within the central region of the SGP study area.....	38

Figure 4.7. Endangered, Of Concern, and Least Concern REs within the southern region of the SGP study area	39
Figure 4.8. Endangered, Of Concern, and No Concern at Present REs (biodiversity status) within the northern region of the SGP study area	40
Figure 4.9. Endangered, Of Concern, and No Concern at Present REs (biodiversity status) within the central region of the SGP study area	41
Figure 4.10. Endangered, Of Concern, and No Concern at Present REs (biodiversity status) within the southern region of the SGP study area	42
Figure 4.11. Survey Records of EVNT flora species from within the SGP study area.	44
Figure 4.12. Records of possible, likely or present EVNT fauna species within and adjacent (10km buffer) of the SGP study area	50
Figure 4.13. Migratory species records within the SGP study area	54

APPENDICES

Appendix A. GIS Package Contents

Appendix B. Fauna Survey Effort Compared to EPBC Survey Guidelines

Appendix C. Threatened Species Likelihood Assessments

Appendix D. Threatened Ecological Communities and Regional Ecosystem Descriptions

Appendix E. Present, Likely or Possible Threatened Flora Species Profiles and Mapping Criteria

Appendix F. Recorded Vertebrate Fauna List

Appendix G. Present, Likely or Possible Threatened Fauna Species Profiles and Mapping Criteria Mapping Criteria

Appendix H. Metadata and description of fields for floristic survey database

EXECUTIVE SUMMARY

At the request of Arrow Energy, EcoSmart Ecology and 3D Environmental undertook seasonal terrestrial flora and fauna surveys throughout the Surat Gas Project study area. This study area has a total extent of 202,915 ha, which for the purposes of the ecological survey was divided into three distinct regions (Figure 2.1):

- The northern region encompassing an area of 7,601 ha located just south of Wandoan,
- A central region of 53,048 ha located to the north-east of Miles, and
- A southern region of 142,266 ha located to the west of Dalby

Remnant vegetation in the northern (Wandoan) region was sparse, representing 2.8% (164.7 ha) of the area. However large continuous patches of remnant vegetation are present within the central (67%; 35,554 ha) and southern (28.7%, 104,035.8 ha) regions. Survey effort predominantly focused on these later two regions.

Survey Methods

A desktop assessment was undertaken prior to field investigations to gather relevant information and literature for the Surat Gas Project study area. This work included a gap assessment to identify areas, species or features which required targeted or additional field survey.

The flora gap assessment rated areas of interest at a property scale as follows:

1. Priority 1 – Properties with mapped Endangered or Of Concern vegetation, prior records of EVNT Flora species, Protected Plant high risk trigger areas, mapped as Core Habitat Known in the SGP Supplementary EIS (3d Environmental 2013),
2. Priority 2 – Properties with well-preserved remnant vegetation, limited prior sampling and strong indications of habitat suitability for a range of threatened flora species although no prior records, and
3. Priority 3 – Properties with intact, least concern remnant vegetation not recognised as hosting populations of EVNT species or habitats of any specific legislative significance, and
4. Priority 4 – Properties subject to intensive sampling effort during previous survey events.

In total, 114 Priority 1, 74 Priority 2, 65 Priority 3 and 31 Priority 4 properties were identified. Field surveys aimed to sample vegetation on all priority 1 and priority 2 properties throughout the course of the 'wet' and 'dry' season surveys, though access limitations prevented sampling some properties (i.e. 86 of 114 Priority 1 and 66 of 74 Priority 2 properties were sampled).

The flora field survey was consistent with Queensland Herbarium standards (Neldner *et al* 2012) and included secondary, tertiary and quaternary sites. In total 218 secondary, 17 tertiary and 2,223 quaternary flora survey sites have been sampled throughout the Surat

Gas Project study area (including sites sampled in previous work identified during the desktop assessment).

The fauna gap assessment used sampling locations from existing works to identify large areas of remnant vegetation which had not been subject to previous fauna survey. Once identified, Broad Vegetation Group mapping by the Queensland Herbarium (version 3.0) was used to identify the location and extent of Broad Vegetation Groups at a 2 million scale. The contribution of each Broad Vegetation Group to the extent of remnant vegetation was calculated and theoretical trap effort distributed accordingly.

The terrestrial fauna surveys used a variety of recognised survey methods consistent with relevant federal and state survey guidelines. These included trapping (Elliot, pitfall, funnel and Harp), observation (spotlighting, bird survey, and active search), remote sensing (Anabat ultrasonic bat detection and camera trapping), and targeted methods (Koala [SAT] and Glossy Black Cockatoo ort searches, tripline, artificial shelter).

Desktop Results

The desktop assessment identified the following ecological values:

- Two major wetlands of High Ecological Significance; i) Lake Broadwater, a major lacustrine Wetland of National Significance and ii) Long Swamp, a palustrine wetland which follows a shallow sinuous path to the north of Lake Broadwater,
- Protected Plant 'High Risk Buffers' (see Section 4.1.3), and
- The following Environmentally Sensitive Areas:
 - Category A - National Parks and Conservation Parks, specifically Lake Broadwater Conservation Park (Lot 68/SP139357),
 - Category B – Regional Ecosystems scheduled as Endangered (Biodiversity Status) by Queensland Department of Environment and Heritage Protection, and
 - Category C – which includes the following:
 - Lake Broadwater Resources Reserve (Lot69/DY6009),
 - Regional Ecosystems with 'Of Concern' Biodiversity Status,
 - State Forest areas (detailed Section 2.3), and
 - Essential Habitat (see Section 4.1.2).

Flora Survey Results

The flora surveys identified three Threatened Ecological Communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* within the study area including:

- Brigalow (*Acacia harpophylla* dominant and co-dominant) (Endangered),
- Weeping Myall Woodlands (Endangered), and

- Coolibah – Black Box Woodlands of the Darling Riverine Plains and Brigalow Belt South Bioregions (Endangered).

These communities occupied 954.3, 0.9 and 22.6 hectares respectively.

Twenty Regional Ecosystems were recorded, three are listed as Endangered and six as Of Concern, with the remainder being classed as Least Concern under the *Vegetation Management Act 1999*. Endangered Ecosystems include:

- Regional Ecosystem 11.3.1 – *Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains. Total extent within the study area = 217.5 hectares,
- Regional Ecosystem 11.4.3 - *Acacia harpophylla* and/or *Casuarina cristata* shrubby open forest on Cainozoic clay plains. Total extent within the study area = 388.7 hectares, and
- Regional Ecosystem 11.9.5. *Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks. Total extent within the study area = 4.3 hectares.

Of Concern Ecosystems include:

- Regional Ecosystem 11.3.17 - *Eucalyptus populnea* woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains. Total extent within the study area = 213.5 hectares,
- Regional Ecosystem 11.3.2. *Eucalyptus populnea* woodland on alluvial plains. Total extent within the study area = 580.7 hectares,
- Regional Ecosystem 11.3.3c. Palustrine wetland (e.g. vegetated swamp). *Eucalyptus coolabah* woodland to open-woodland (to scattered trees) with a sedge or grass understorey in back swamps and old channels. Total extent within the study area = 26.8 hectares,
- Regional Ecosystem 11.3.4. *Eucalyptus tereticornis* and/or *Eucalyptus spp.* tall woodland on alluvial plains. Total extent within the study area = 898.6 hectares,
- Regional Ecosystem 11.9.7. *Eucalyptus populnea*, *Eremophila mitchellii* shrubby woodland on fine-grained sedimentary rocks. Total extent within the study area = 1.5 hectares, and
- Regional Ecosystem 11.9.10. *Eucalyptus populnea* open forest with a secondary tree layer of *Acacia harpophylla* and sometimes *Casuarina cristata* on fine-grained sedimentary rocks. Total extent within the study area = 15 hectares.

A total of 438 flora species were recorded during the flora surveys including 38 exotic species, 2 Conifers, 2 ferns, 90 grasses, 2 species of grasstree and a balance of trees, shrubs and forbs across 65 plant families.

Only one threatened flora species, *Philotheca sporadica* (Near Threatened under the *Nature Conservation Act 1992* and Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*), has been recorded within the study area during previous assessments completed by Arrow Energy and the current 2016 – 2017 surveys. However database records (Herbrecs and Australia's Virtual Herbarium) indicate a number of

additional threatened species have been recorded either within the Surat Gas Project study area including:

- *Cryptandra ciliata* (Near Threatened, *Nature Conservation Act 1992*),
- *Solanum papaverifolium* (Endangered, *Nature Conservation Act 1992*),
- *Fimbristylis vagans* (Endangered, *Nature Conservation Act 1992*), and
- *Digitaria porrecta* (Near Threatened, *Nature Conservation Act 1992*).

Based on historic records these four species are considered present, though it is noted that some have no contemporary records despite extensive searches in suitable habitat.

Fauna Survey Results

The terrestrial fauna surveys identified a total of 266 vertebrate species within the Surat Gas Project study area including 20 amphibians, 55 reptiles, 151 birds and 40 mammals.

The likelihood of thirty-nine threatened species known to occur within the local area (i.e. the study area plus a 50km buffer) was assessed based on record relevance (i.e., record location and date) and habitat suitability. Based on results from the current 2016-17 surveys, six were recognised as occurring within the study area including:

- *Strophurus taenicauda* (Golden-tailed Gecko) – Near Threatened, *Nature Conservation Act 1992*,
- *Hemiaspis daemeli* (Grey Snake) – Endangered, *Nature Conservation Act 1992*,
- *Calyptorhynchus lathami* (Glossy Black-Cockatoo) – Vulnerable, *Nature Conservation Act 1992*,
- *Phascolarctos cinereus* (Koala) – Vulnerable, *Environment Protection and Biodiversity Conservation Act 1999* and *Nature Conservation Act 1992*,
- *Petauroides volans* (Greater Glider) – Vulnerable, *Environment Protection and Biodiversity Conservation Act 1999* and *Nature Conservation Act 1992*, and
- *Nyctophilus corbeni* (South-eastern Long-eared Bat) – Vulnerable, *Environment Protection and Biodiversity Conservation Act 1999* and *Nature Conservation Act 1992*.

The following five species were assessed to be either likely or possible within the study area:

- *Jalmenus eubulus* (Pale Imperial Hairstreak) – Vulnerable, *Nature Conservation Act 1992*,
- *Acanthophis antarcticus* (Common Death Adder) – Vulnerable, *Nature Conservation Act 1992*,
- *Furina dunmalli* (Dunmall's Snake) – Vulnerable, *Environment Protection and Biodiversity Conservation Act 1999* and *Nature Conservation Act 1992*,
- *Rostratula australis* (Australian Painted Snipe) – Endangered, *Environment Protection and Biodiversity Conservation Act 1999* and *Nature Conservation Act 1992*, and

- *Grantiella picta* (Painted Honeyeater) – Vulnerable, *Environment Protection and Biodiversity Conservation Act 1999* and *Nature Conservation Act 1992*.

Three Migratory species, listed under the *Environment Protection and Biodiversity Conservation Act 1999*, were recorded during the 2016-17 surveys including:

- Rufous Fantail (*Rhipidura rufifrons*),
- White-throated Needletail (*Hirundapus caudacutus*), and
- Fork-tailed Swift (*Apus pacificus*).

Thirteen other Migratory species are known to occur, most are vagrants restricted to habitats around Lake Broadwater.

1.0 INTRODUCTION

Arrow Energy (Arrow) has received Federal and State government approval for its Environmental Impact Statement (EIS) for the Surat Gas Project (SGP). The approval includes Federal conditions requiring flora and fauna surveys in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) survey guidelines (or as otherwise agreed with the Commonwealth Department of the Environment and Energy) and State (Department of Environment and Heritage Protection) survey guidelines.

To meet these obligations Arrow engaged EcoSmart Ecology, in conjunction with 3D Environmental, to undertake seasonal terrestrial flora and fauna surveys. This work aimed to:

- Complete detailed seasonal terrestrial ecological surveys sampling the range of habitats within the SGP study area and targeting likely threatened species to satisfy State and Federal survey guidelines. Surveys considered:
 - Environmentally Sensitive Areas (ESAs),
 - Wetlands and watercourses, particularly wetlands of High Ecological Significance,
 - Endangered or Of Concern Regional Ecosystems (REs), or Threatened Ecological Communities (TECs),
 - Essential Habitat,
 - Areas of high connectivity,
 - Protected plants high risk areas, and
 - *Core Habitat Known* and *Core Habitat Possible* identified in the SREIS for EPBC listed taxa.
- Validate and refine existing RE mapping, including wetlands of High Ecological Significance, and
- Refine *Core Habitat Known* and *Core Habitat Possible* mapping for *Environment Protection and Biodiversity Act 1999* (EPBC Act) and *Nature Conservation Act 1992* (NC Act) taxa.

This document supports a separate GIS package which includes revised RE mapping, location records of significant taxa and features, and revised threatened species habitat mapping (see Appendix A for list of contents).

2.0 STUDY AREA DESCRIPTION

2.1 STUDY AREA AND EXTENT

The SGP Study Area has a total extent of 202,915 ha, which for the purposes of this ecological study has been divided into three distinct regions (Figure 2.1):

- The northern region encompassing an area of 7,601 ha located just south of Wandoan,
- A central region of 53,048 ha located to the north-east of Miles, and
- A southern region of 142,266 ha to the west of Dalby

Remnant vegetation in the northern (Wandoan) region is sparse, representing 2.8% (164.7 ha) of the area. However large continuous patches of remnant vegetation are present within the central (67%; 35,554 ha) and southern (28.7%, 104,035.8 ha) regions, and as such, survey effort has predominantly focused on these later two regions.

2.2 GEOLOGY AND WATER RESOURCES

Geology

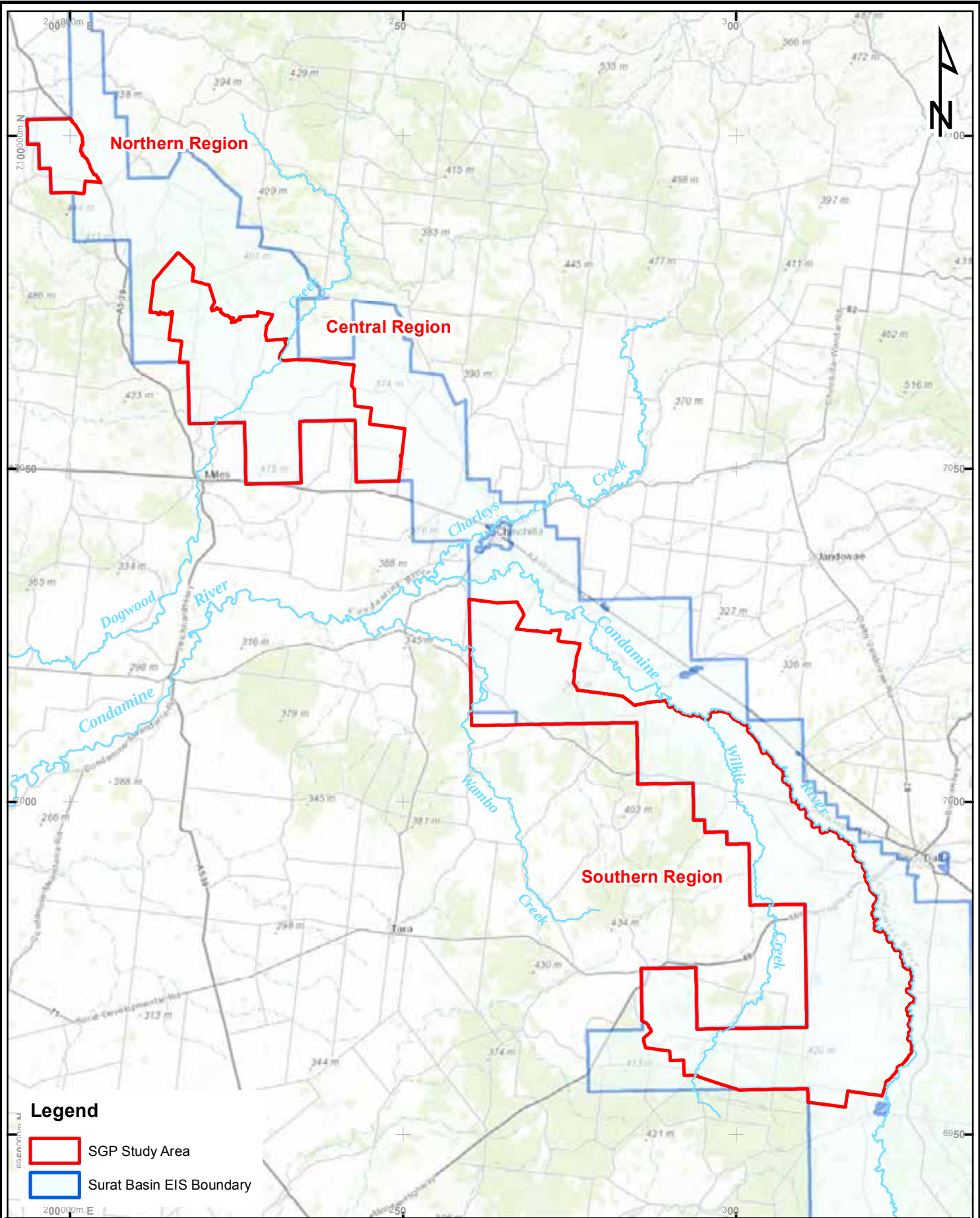
The SGP study area is characterised by relatively gentle topography. In the larger southern region, the dominant landform is the expansive alluvial deposits of the Condamine River. These deposits form a gently undulating fertile clay to sandy clay plain geologically referred to as the 'Condamine Alluvium' which covers the south-eastern portion of the SGP study area stretching northwards to near Chinchilla. The Condamine Alluvium is bound to the west by low hills formed by indurated exposures of the Kumbarrilla Beds, a thick sequence of Jurassic to Cretaceous aged sandstones and fine grained sedimentary rocks. Small indurated sandstone caprock occurs in some localities which form suppressed jump-ups and low mesas.

The Kumbarrilla Beds outcrop dominates the central area, overlain in some localities by a weakly consolidated blanket of Tertiary aged alluvial and colluvial sediments to form a gently undulating landscape of low stony rises and gently incised gullies and intermittent streams.

A major change in topography occurs between the central (Miles) and northern (Wandoan) sections where a steep breakaway escarpment exposes the fine grain metasedimentary and volcanic rocks of the Injune Creek Group. The landscape in the vicinity of Wandoan has much more pronounced topography with low rounded hills formed on fine grained sedimentary rock with characteristic heavy clay soils and rounded rocky lag deposited on the soil surface.

Water Resources

Drainage systems in the SGP study area are divided into those contributing to the west flowing Condamine River (part of the Murray River Catchment) and the Dawson River catchment (part of the Fitzroy River catchment).



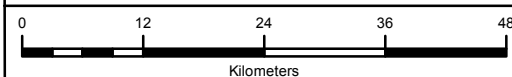
Legend

- SGP Study Area
- Surat Basin EIS Boundary

FIGURE 2.1 SGP study area location

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Scale 1:750,000

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Within the SGP study area the Condamine River is by far the largest catchment, supplemented by the tributaries of Wambo, Wilkie, Charleys and Dogwood Creeks. The fertile alluvial soils of the Condamine River floodplain provide an extremely productive agricultural area that has been historically sustained and supplemented by an abundant source of groundwater within the underlying Condamine Alluvium aquifer.

In contrast, the Dawson River catchment forms only a minor portion of the study area and is characterised by Juandak Creek which flows through the township of Wandoan.

2.3 PROTECTED ESTATE

The SGP study area and nearby surrounds includes numerous State Forests and Conservation Reserves (Figure 2.2). In the southern (Dalby) region of the study area this includes:

- The Kumbarilla State Forest area (including the adjacent Waar Waar and Vickery State Forests), located immediately south of the Moonie Highway,
- Dunmore, Western Creek, and Boondandilla State Forest areas, which form a large continuous patch of remnant vegetation connected to the southern boundary of Kumbarilla State Forest, extending south to near the Gore Highway,
- Lake Broadwater Resource Reserve and Conservation Park, a small area of vegetation connected by remnant vegetation to Kumbarilla State Forest,
- Braemer State Forest to the north of the Moonie Highway, and
- Dalby State Forest just east of Kogan.

Together these areas of state forest, and intervening vegetation, form a large near-contiguous tract of remnant vegetation separated only by roads and highways.

Protected Estate within or adjacent the central (Miles) region includes:

- Barakula State Forest to the immediate north-east,
- Blinkey State Forest 1 in the north of the SGP study area,
- Cherwondah State Forest to the north-west, and
- Gurulmundi State Forest to the west.

These forested areas and the intervening vegetation form a very large near-continuous patch of remnant vegetation separated only by roads and highways.

2.4 FIRE HISTORY

Vegetation within the SGP study area has been subjected to repeated fire events spanning several decades, though most fires have occurred between 2012 and 2014. With the exception of three, historic fires were limited in their extent (Figure 2.3) and, based on current vegetation condition, cool fires which did not cause extensive canopy death or damage. These cooler fires are likely to have little long-term impact on ecological values.

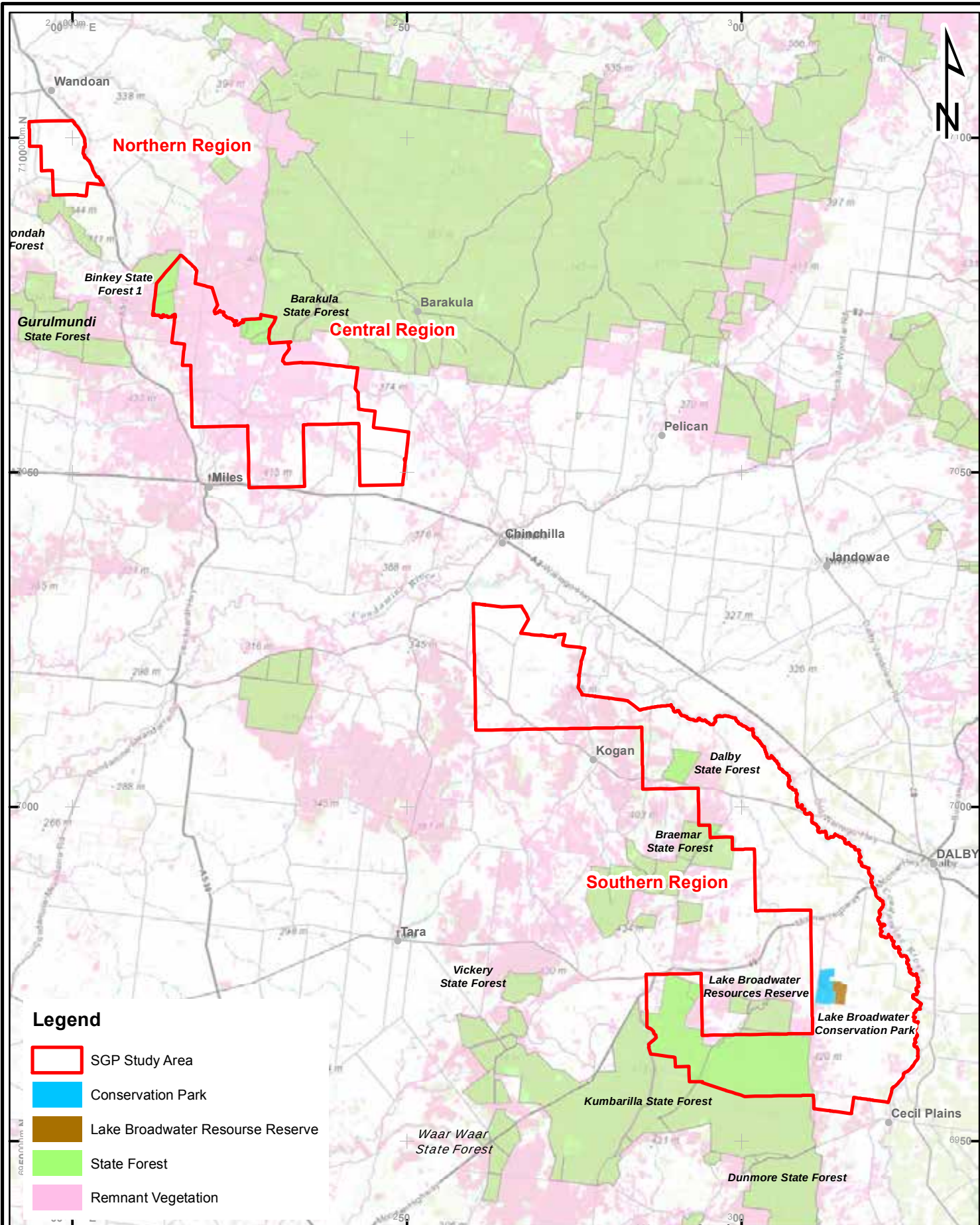
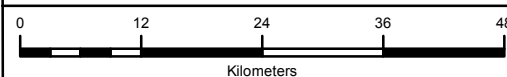


FIGURE 2.2 Protected Estate within and surrounding the SGP Study Area

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Two hot wildfires, one extending from Barakula State Forest south to near Miles, and a second within Kumbarilla State Forest, affected large areas of vegetation in 2012. A third wildfire occurred in the eastern portion of Kumbarilla State forest in December of 2016 (i.e., between spring and summer sampling for this work).

These wildfires caused extensive canopy damage, and in many locations complete canopy loss. While the vegetation and habitat should recover in time (provided there are no subsequent wildfires), the damage will affect flora and fauna community composition with fire sensitive species likely to be absent for many decades.

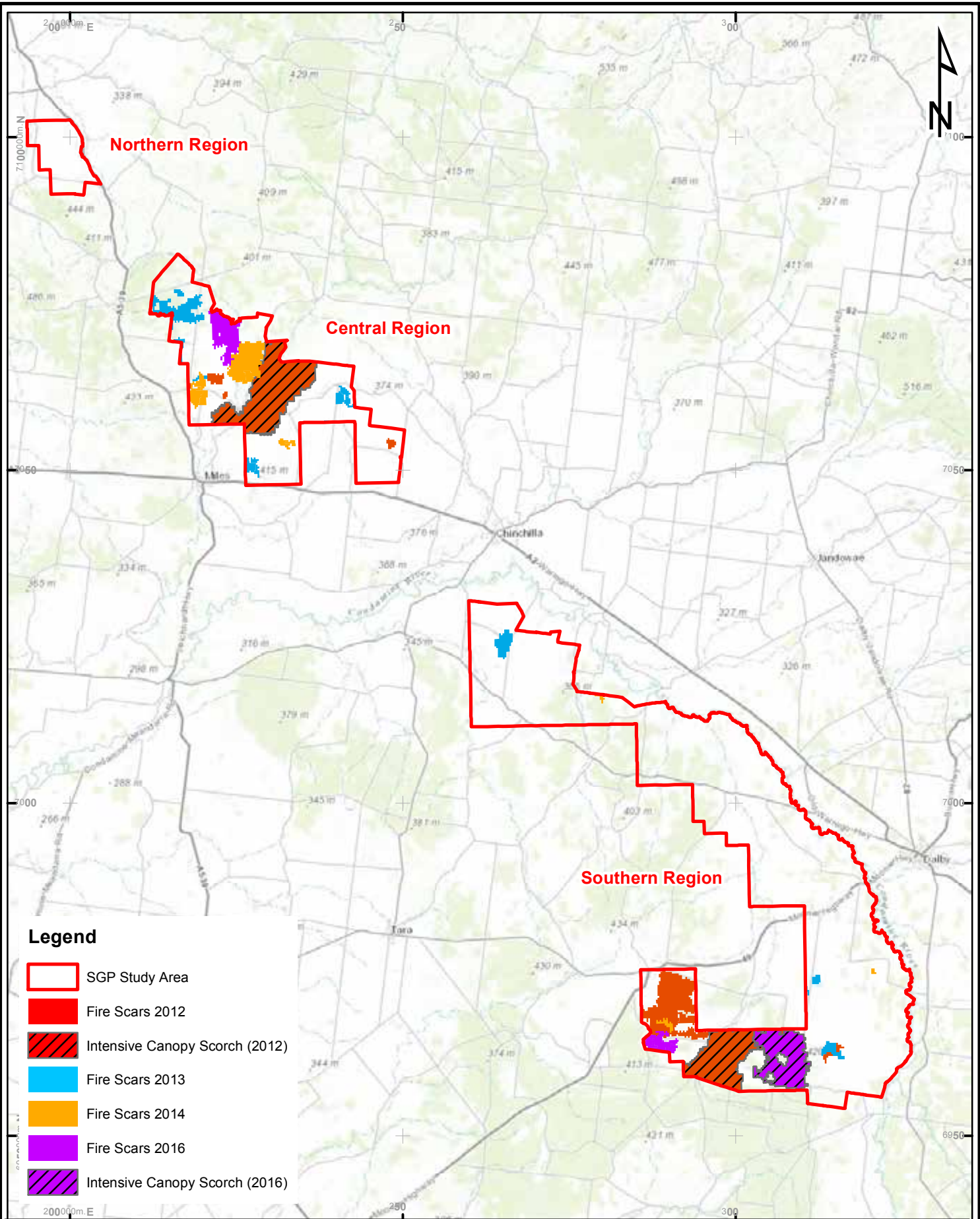


FIGURE 2.3 Historic fire scars within the
SGP Study Area

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3.0 METHODS, SURVEY CONDITIONS AND LIMITATIONS

3.1 DESKTOP DATA

A detailed desktop review of available ecological information was undertaken as part of the SGP Supplementary EIS Terrestrial Ecology Assessment (3D Environmental/EcoSmart Ecology 2013). The results from this earlier assessment, as well as the data contained therein, has been used throughout this work. However several sources have been re-inspected to ensure the data is current. Data sourced during this work included:

- The Essential Habitat spatial layer,
- Birdlife atlas database, including geo-referenced data for threatened taxa,
- Wildnet database, including inspecting threatened species profile data to gather geo-referenced locations (where possible),
- The EPBC Act Protected Matters Search Tool,
- Queensland Herbarium Herbrecks database of vouchered specimen collections within a 50km buffer surrounding the assessment area,
- *Vegetation Management Act 1999* (VM Act) Status and Biodiversity Status of Pre-clearing and Remnant Regional Ecosystems Queensland - Version 10.0 (EHP 2015),
- Queensland Wetland Data Version 4.0 (EHP 2016),
- Matters of State Environmental Significance datasets (EHP 2014),
- Australia's Virtual Herbarium (AVH 2016) for vouchered specimen records sourced from a number of Australian Herbarium,
- Nature Conservation Act protected plants flora survey trigger map spatial layer – Version 4.1 (EHP 2016),
- Prior flora and fauna assessment within or in close proximity to the SGP study area including:
 - The SGP EIS Terrestrial Ecology Specialist Report (3D Environmental 2011),
 - The SGP Supplementary EIS Terrestrial Ecology Specialist Report (3D Environmental 2013),
 - Surat Gas Pipeline Project surveys (Aecom 2009) and addition field data collected by various consultants including Ecosure, RPS and SKM between 2009 and 2013, and
 - The Daandine CGPF and Daandine Phase 1 Projects (EcoSmart Ecology 2014a, b).

The assessment included a compilation of survey data from prior surveys.

3.2 FLORA FIELD SURVEY METHODS

Flora surveys were conducted under license Number WISP10337Grey011 (non-protected estate), TWB/14/2016 (State Forests) and WITK17580216 (Lake Broadwater National Park). Table 3.1 provides details of the survey team.

Table 3.1. Terrestrial Fauna Field Team Qualifications and Experience

Name	Qualifications	Exp (yrs)	Role	Survey
David Stanton	BSc (Hons)	22	Team leader/field ecologist	Dry/wet season
Paul Williams	BSc (Hons), PhD (Ecology)	22+	Team leader/field ecologist	Dry/wet season
David Fell	Associate Diploma of Applied Science	25+	Team leader/field ecologist	Dry
Eleanor Collins	BSc (Hons)	22+	Field Ecologist	Dry/wet season
Peter Wagner	BSc (Hons), MSc	5+	Team leader/field ecologist	Wet season
Lincoln Smith	BSc (Env)	15	Field ecologist	Dry/wet season
Bill Hoskins	BSc (Hons). Grad Dip Environmental Rehabilitation	30+	Field ecologist	Dry/wet season

3.2.1 Survey Overview and Site Selection

Prior to field surveys the 284 properties which make up the SGP study area were assessed using desktop resources for:

- The presence and extent of remnant vegetation,
- The presence of 'Of Concern' or 'Endangered' REs under the VM Act or TECs under the EPBC Act,
- Prior records of threatened flora taxa on, or in close proximity to, the property including Protected Plant high risk trigger areas,
- The quality of habitat including disturbance, vegetation structure and contiguity with larger remnant patches, and
- The spatial location and intensity of prior floristic surveys (see Section 3.1)

With the further aid of aerial imagery, properties were prioritised for access based on the following criteria:

5. Priority 1 – Properties with mapped Endangered or Of Concern vegetation, prior records of EVNT Flora species, Protected Plant high risk trigger areas, mapped as Core Habitat Known in the SGP Supplementary EIS (3d Environmental 2013),
6. Priority 2 – Properties with well-preserved remnant vegetation, limited prior sampling and strong indications of habitat suitability for a range of threatened flora species although no prior records,

7. Priority 3 – Properties with intact, least concern remnant vegetation not recognised as hosting populations of EVNT species or habitats of any specific legislative significance, and
8. Properties subject to intensive sampling effort during previous survey events.

In total, 114 Priority 1, 74 Priority 2, 65 Priority 3 and 31 Priority 4 properties were identified. While the field assessment aimed to sample all Priority 1 and Priority 2 properties throughout the course of the 'dry' and 'wet' season surveys, not all of these were able to be sampled due to access limitations (i.e. 86 of the 114 (or 75%) Priority 1 and 66 of the 74 (89%) Priority 2 properties were sampled).

3.2.2 Flora Survey Techniques

Surveys collected floristic data consistent with Queensland Herbarium standards (Neldner *et al* 2012) and included secondary, tertiary and quaternary sites. The location of these sites was selected using aerial photograph analysis, or opportunistically during traverse, to ensure that the field survey targeted a representative range of habitats.

Secondary sites consisting of 50 m x 10 m plots were located within the vegetation to avoid sampling across community boundaries. Crown intercept transects were extended to 100 m for the purpose of providing sufficient data for reference sites where an assessment of remnant / non-remnant status was required. Full species lists for all strata were established during the secondary sampling procedure, and supplemented by a detailed search of the nearby vicinity. The abundance of all species within the plot was recorded by stem counts, or by visual assessment as a 1-5 cover-abundance ranking using the braun-blanket method (Neldner *et al.* 2012). Groundcover was assessed using five 1x1 m subplots placed at 10 m intervals along transects with visual cover estimations of dominant species. Ecological and structural data together with full species lists were compiled. In some instances identification to species level was not possible due to the lack of fertile material, particularly for grasses. Unidentified species were classified to the next highest denominator (typically genus level) and would account for <1% of all identifications.

Tertiary sites were completed in a similar fashion to the secondary procedure, although non-woody species were not recorded. Quaternary sites included a description of floristic structure, composition, and associated landform, and were used specifically for the purpose of mapping unit verification.

During the 'dry' season survey (September 2016) a total of 896 floristic survey sites were established including 58 secondary, 1 tertiary and 837 quaternary survey points. The wet season assessment completed in early February 2017 (plus an additional 3 day survey in late March 2017) resulted in a further 47 secondary and 682 quaternary survey points. In total, 1,625 floristic survey sites were established by 3D Environmental during this work, and combined with previous works, a total of 2,458 locations have been subject to structured floristic survey within the SGP study area (Table 3.2). The distribution of these survey points in relation to survey events is shown in Figure 3.1.

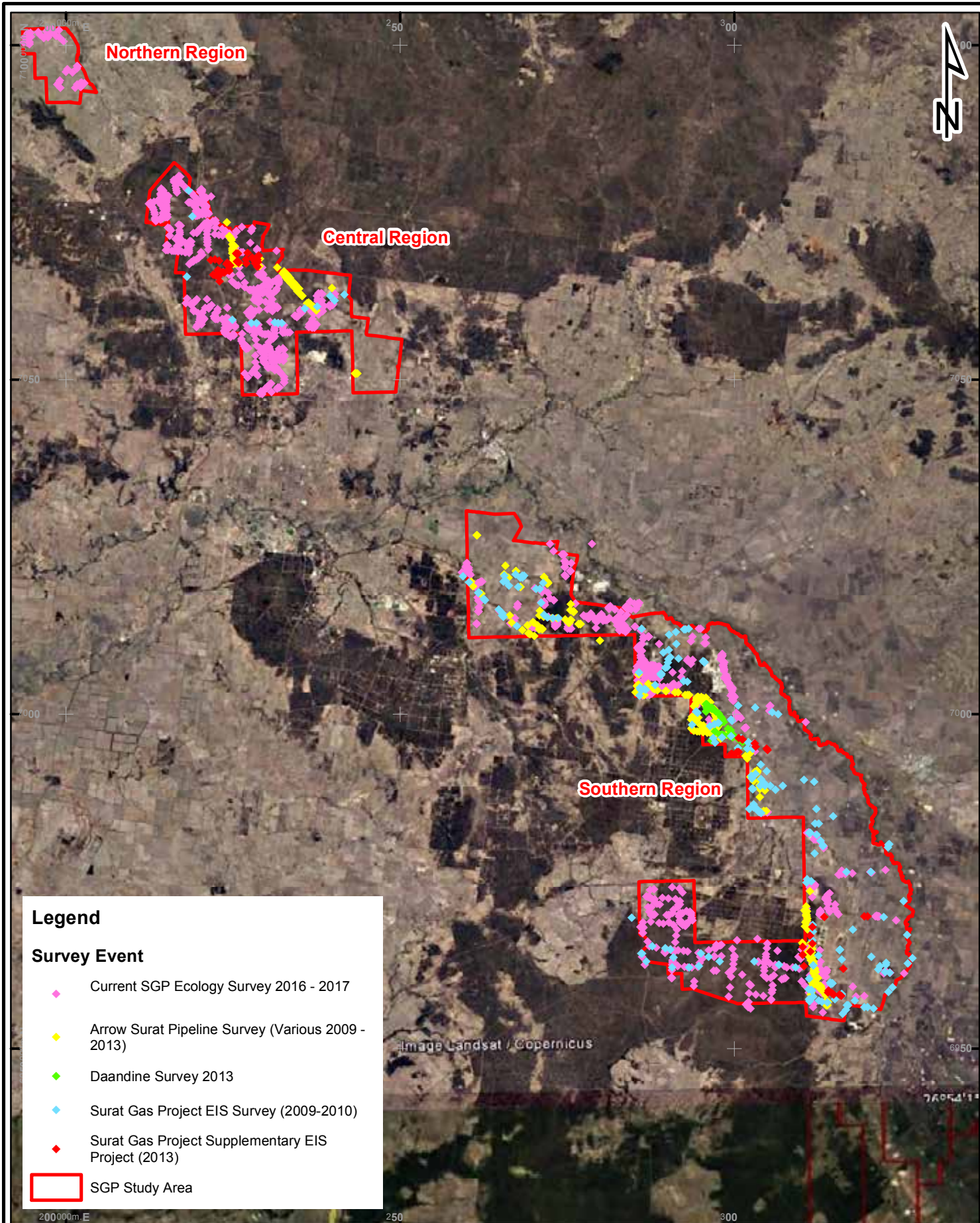


FIGURE 3.1 Floristic survey locations within the SGP Study Area

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Table 3.2. The contribution of individual floristic surveys to overall survey effort within the SGP study area

Survey/Project	Year	Seasonal Effort	Undertaken By	No of Survey Sites			Total Sites
				Sec	Tert	Quat	
Current SGP Ecology Survey	2016	Dry	ESE/3DE*	58	1	837	896
Current SGP Ecology Survey	2017	Wet	ESE/3DE	47	0	682	729
Daandine CGPF and Phase 1 Project (EcoSmart Ecology 2014a, b)	2014	Late Wet	ESE/3DE	5	1	32	38
Surat EIS (3d Environmental 2011)	2009/10	Dry/Wet	3DE	46	2	170	218
SGP Supp. EIS (3d Environmental 2013)	2013	Wet	3DE	28	3	37	68
Arrow Surat Pipeline (Aecom 2009 - 2013)	2009/13	Mostly Wet	Ecosure/Aecom	34	10	465	509
Totals				218	17	2,223	2,458

*EcoSmart Ecology and 3D Environmental

3.2.3 Mapping Scale and Attributes

Vegetation linework was established at a scale of 1:25,000 providing an accuracy of hard boundaries of +/-25 m and a minimum polygon size of 0.5 ha. A polygon of 0.5 ha represents the minimum patch size threshold for both the Brigalow and Weeping Myall Woodlands Ecological Communities, listed as Endangered under the EPBC Act and known to occur within the SGP Ecology Survey area.

A seamless GIS dataset has been produced to incorporate mapped REs, TECs and habitat mapping for all threatened species (flora and fauna) known from the study area including the mapping of Core Habitat Known and Possible. The habitat mapping will assist in locating future project infrastructure to minimise impacts and the determination of offset requirements where avoidance cannot be achieved.

GIS shapefiles of all floristic survey sites within the surveyed area have been provided to Arrow in a separate package to accompany this report, which also includes the locations and findings of previous and current survey efforts.

3.3 FAUNA FIELD SURVEY METHODS

Fauna surveys were conducted under licenses WISP14610914 (non-protected estate), TWB/14/2016 (State Forests) and WITK17580216 (Lake Broadwater National Park). Table 3.3 below provides details of the terrestrial fauna survey team's qualifications and experience.

Table 3.3. Terrestrial Fauna Field Team Qualifications and Experience

Name	Qual	Exp (yrs)	Role	Survey
Mark Sanders	BSc (Hons)	20+	Team leader/field ecologist	Dry/wet
Terry Reis	BSc (Hons)	22+	Team leader/field ecologist	Dry/wet
Greg Ford	B. App. Sc.; Grad. Dip. Res. Mgt.	25	Team leader/field ecologist	Dry/wet
Dr Ed Meyer	BSc (Hons), PhD (Zoology)	20+	Team leader/field ecologist	Dry/wet
Angus McNab	BSc (Hons), MSc.	10+	Field ecologist	Dry
Anders Zimny	BSc (Hons)	8+	Field ecologist	Dry
Dr Katrine Lowe	BSc (Hons), PhD	10+	Field ecologist	Dry/wet
Lincoln Smith	BSc (Env)	15	Field ecologist	Dry/wet
Jesse Rowland	BSc (Env Man)	10+	Field ecologist	Wet
Kate Grundy	BSc (Hons)	7+	Field ecologist	Wet

3.3.1 Stratification, Survey Design and Site Selection

3.3.1.1 Spatial Stratification

Remnant vegetation mapping shows the bulk of land within the northern region of the SGP study area is cleared, with remaining vegetation fragmented and minor in extent. The likelihood of significant terrestrial fauna values within this section is greatly reduced, lessening the need for detailed seasonal surveys. Further, those threatened taxa most likely to occur in these fragmented areas (e.g., Squatter Pigeon, Painted Honeyeater) can be detected using rapid survey methods. Detailed trapping was not therefore deemed necessary for the northern region of the SGP study area. By contrast the central and southern regions retain large areas of remnant vegetation, and while some detailed fauna work has occurred, fauna values in these two regions remains poorly known.

Within the central and southern regions areas of vegetation with little, or no, historic survey effort was identified by overlaying the locations of previous fauna work (see Section 3.1) on pre-existing RE mapping (Queensland Herbarium V10.0) (Figure 3.2). The identified areas were the focus of the current SGP fauna survey.

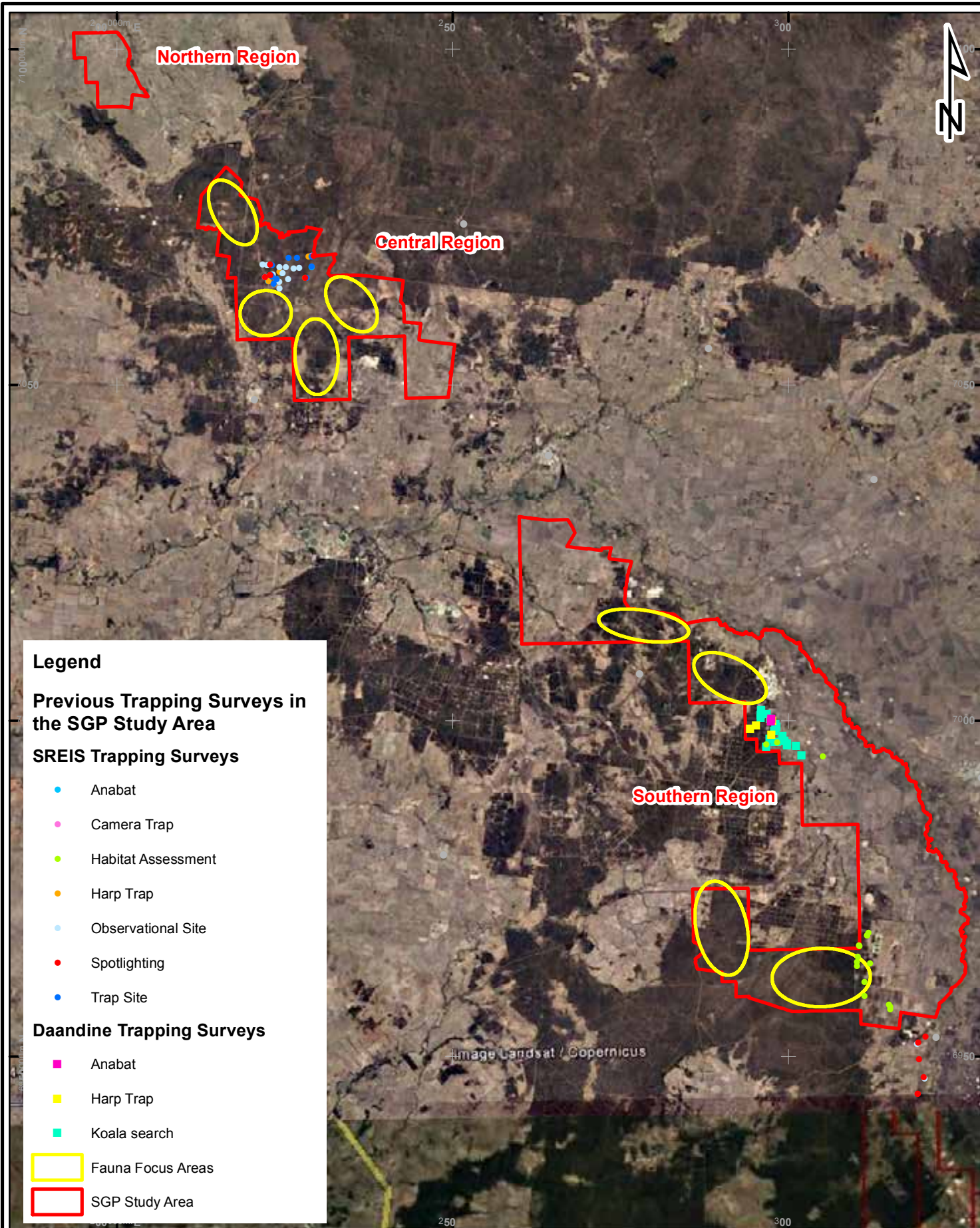


FIGURE 3.2 Previous fauna survey locations within the SGP Study Area

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While Lake Broadwater National Park lies within the SGP study area, it was not the focus of detailed works. Frequent surveys are conducted in the National Park by Griffith University, and the area has been frequently visited by EcoSmart Ecology staff over many years. The fauna communities and values within the National Park are well documented and understood. All observations within the Park during this survey were taken ad-hoc.

3.3.1.2 Habitat Stratification

To stratify the trapping program and encapsulate habitat variety, Broad Vegetation Group (BVG) mapping by the Queensland Herbarium (version 3.0) was used to identify the location and extent of BVGs¹ at the 2 million (2M) scale. The contribution of each BVG to the extent of remnant vegetation was calculated and theoretical trap effort distributed accordingly.

3.3.1.3 Survey Design

Having completed the above spatial and habitat analyses, a survey program was developed to fill the identified gaps and included:

- A five-day pilot study (August 2016) to visually inspect the SGP study area, identify survey constraints, and locate possible detailed fauna trap sites,
- Two, 12-day detailed surveys were completed, one during the 'dry' (September 2016) and one during the 'wet' (February/March 2016) season, by four teams (eight ecologists/survey). Each team serviced 10 detailed trap sites over the 12 days, with each trap site operational for four consecutive nights, and
- A three-day follow-up survey (March 2016) to sample fragmented habitats (including habitats for Squatter Pigeon, Painted Honeyeater and Yakka Skink), habitats not subject to effort during the detailed surveys (e.g., wetlands), or areas which may not have been otherwise inspected.

3.3.1.4 Survey Site Selection

Detailed Survey Sites

The location of detailed survey sites (which included Elliot, Pitfall, Funnel, white-flash camera, detailed bird survey, spotlight, active searches, Spot Assessment Technique (SAT) searches) were determined during the pilot study, which used the above spatial and BVG stratification, as well as considering:

- Landholder access constraints - access was not granted to some parcels of land, while others had stringent conditions preventing ease of movement on or off the property,
- Travel logistics and limitations, trap sites must be located so they could be cleared before 9.00 am each morning,
- Any notable geomorphological features such as rock outcrops, caves etc,
- Habitats likely to support specially protected species, and

¹ as described in Nelder *et al*/2015.

- Vegetation condition and in particular fire scarring (see Section 2.4).

Once selected, each site was inspected and approved by traditional owners to ensure trapping activities would not impact upon indigenous cultural values. As no pitfall trapping could occur without prior cultural heritage assessment, trap site locations could not be relocated after the pilot study. The pilot study occurred prior to the flora investigations and did not account for any subsequent vegetation mapping changes.

Where possible trap sites were surveyed during both the 'dry' and 'wet' season, though in some cases this was not possible without compromising spatial or BVG representation. Trap site effort within each BVG is documented in Table 3.4 and trap locations are shown in Figure 3.3a and b.

Table 3.4. Number of trap sites by BVG based on ground-truthed vegetation mapping

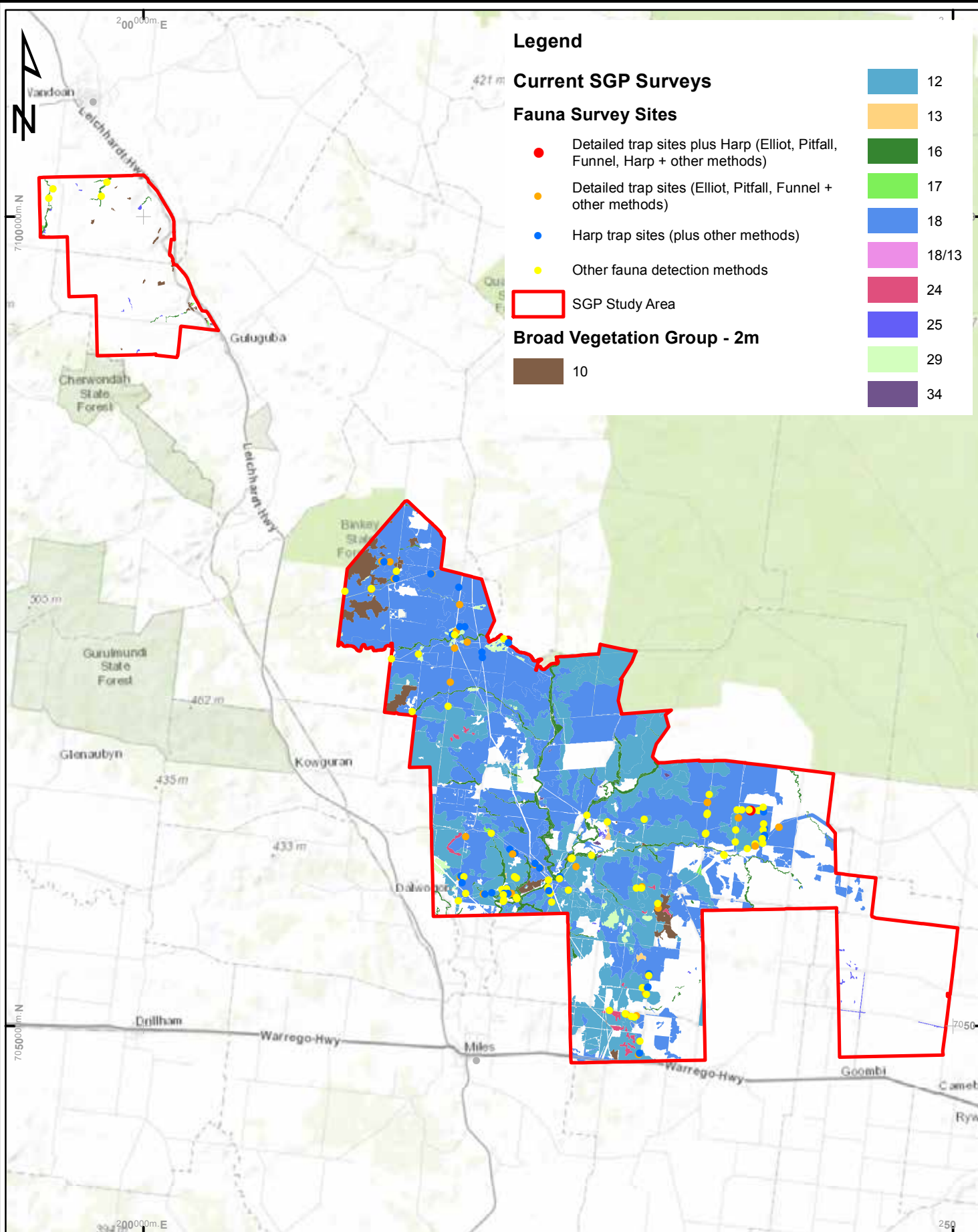
BVG#	Description	Mapped Extent (ha) ⁺	No. Detailed sites*	No. Target Sites
10	<i>Corymbia citriodora</i> dominated open forests to woodlands on undulating to hilly terrain	1,040 (1.3%)	2	2
12	Dry eucalypt woodlands to open woodlands, mostly on shallow soils in hilly terrain (mainly on sandstone and weathered rocks)	22,186 (28.6%)	23	49
13	Dry to moist eucalypt woodlands and open forests, mainly on undulating to hilly terrain of mainly metamorphic and acid igneous rocks	5,448 (7.0%)	4	17
16	<i>Eucalyptus</i> spp. dominated open forest and woodlands drainage lines and alluvial plains	3,211 (4.1%)	4	27
17	<i>Eucalyptus populnea</i> or <i>E. melanophloia</i> (or <i>E. whitei</i>) dry woodlands to open woodlands on sandplains or depositional plains	1,189 (1.5%)	0	5
18	Dry eucalypt woodlands to open woodlands primarily on sandplains or depositional plains	41,158 (53.0%)	43**	90**
24	<i>Acacia</i> spp. on residuals. Species include <i>A. clivicola</i> , <i>A. sibirica</i> , <i>A. shirleyi</i> , <i>A. microsperma</i> , <i>A. catenulata</i> , <i>Acacia rhodoxylon</i>	176 (0.2%)	0	0
25	<i>Acacia harpophylla</i> sometimes with <i>Casuarina cristata</i> open forests to woodlands on heavy clay soils	886 (1.1%)	0	3
29	Heathlands and associated scrubs and shrublands on coastal dunefields and inland rocky substrates	467 (0.6%)	1	2
30	<i>Astrebla</i> spp. (mitchell grass), <i>Dichanthium</i> spp. (bluegrass) tussock grasslands	0 (0%)	0	1***
34	Wetlands. Swamps (wooded or otherwise) and lakes (permanent or ephemeral), claypans. Includes fringing woodlands and shrublands	630 (0.8%)	0	3
18/13	Mixed community of BVGs 18 and 13.	1,233 (1.6%)	3	1
N/A	Non-remnant regrowth	N/A		3
Total		77,624	80	203

⁺BVG extent and trap position with relation to BVG based on 3DE ground-truthed mapping.

*Replicated sites are counted twice, once for each survey.

**Includes one detailed site and two target sites placed in advanced regrowth.

***An area of derived grassland previously mapped as remnant by the Queensland Herbarium.



NOTES:
Other methods includes one or more of the following techniques; opportunistic bird survey, spotlight, active search, Anabat, remote sensor camera, and/or Glossy Black Cockatoo and Koala signs/scat searches.

FIGURE 3.3A Detailed fauna trapping sites within the SGP Study Area - Northern and Central Regions

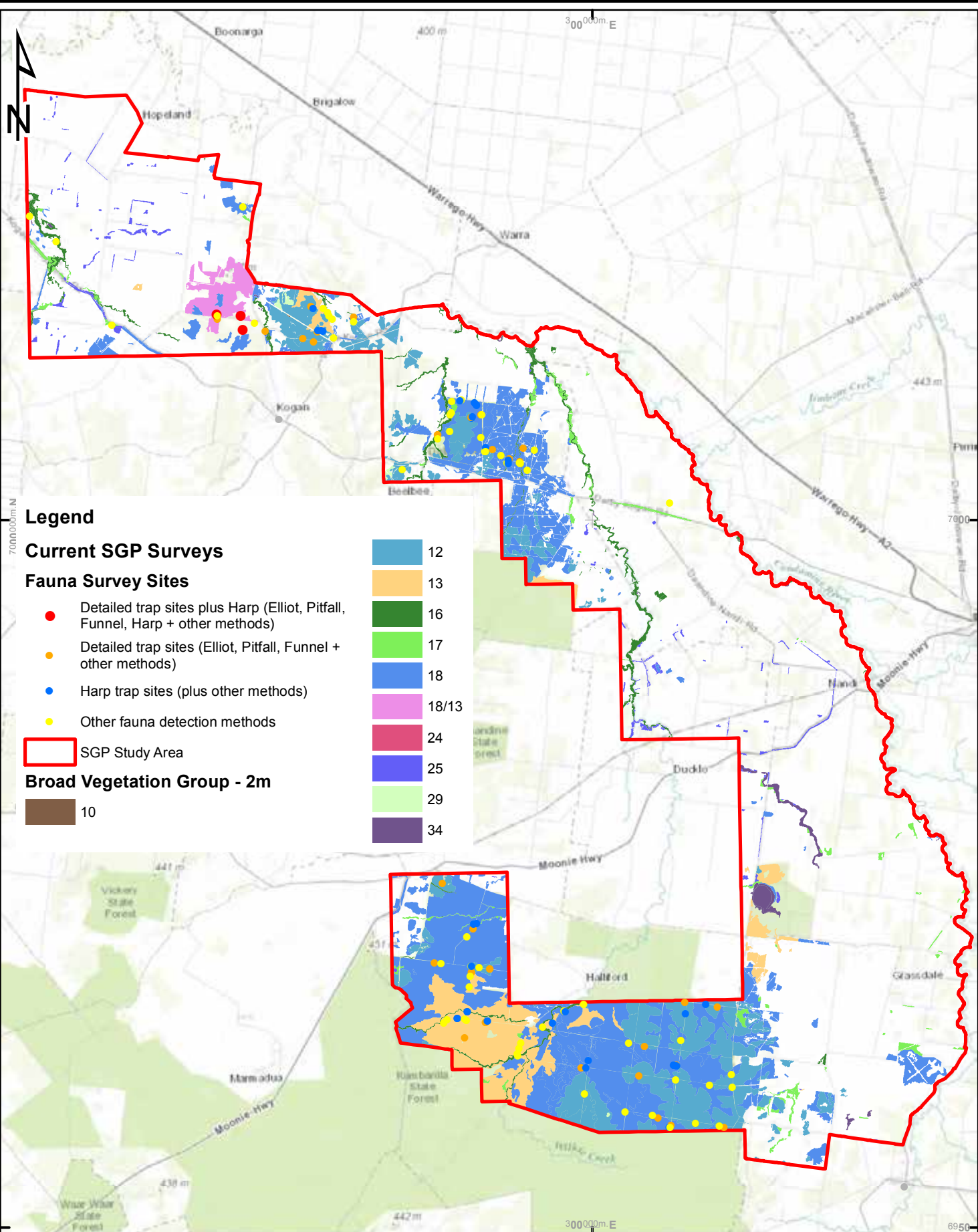
Client
ARROW ENERGY

Scale 1:312,525 **Drawn By** DG **Date** 23-Jun-17 **A4**

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NOTES:
Other methods includes one or more of the following techniques;
opportunistic bird survey, spotlight, active search, Anabat,
remote sensor camera, and/or Glossy Black Cockatoo and
Koala signs/scat searches.

FIGURE 3.3B Detailed fauna trapping sites
within the SGP Study Area - Southern Region

Client			
ARROW ENERGY			
Scale	1:357,316	Drawn By	DG
Date	23-Jun-17	A4	

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The allocation of actual detailed fauna survey sites across the BVG's varied slightly from 'theoretical' due to survey constraints (e.g., travel times, access conditions, and recent fire damage) and changes to RE mapping following the flora investigations. No detailed trap sites were located in five BVG's (17, 24, 25, 30 or 34):

- Detailed trap sites were positioned in areas mapped as BVG 17 during the pilot study (based on Queensland Herbarium mapping). Mapping inaccuracies were corrected by ground-truthed assessment and resulted in no detailed trap sites remaining in BVG 17. Due to cultural heritage restrictions, the pre-survey selected trap locations could not be altered to account for these changes (see discussion above),
- It was not until vegetation mapping and fauna surveys had been completed that BVG 24 was identified within the SGP study area,
- While the existing RE mapping showed patches of accessible Brigalow (BVG 25), field inspection found these areas to be incorrect. Rather, Brigalow was restricted to small, usually linear, fragments which were often separated from other vegetation by considerable distance. Travel logistics prevented trapping these habitats in detail, though sampling using rapid survey methods (e.g., bird survey, habitat search) was undertaken during a three-day follow-up survey,
- Queensland Herbarium mapping showed a small area of BVG 30 which was separated from other vegetation by considerable distance. Travel logistics prevented trapping of this habitat. The vegetation was altered following the completion of the flora surveys to 'derived grassland' and does not therefore represent a remnant community, and
- Surface water and the risk of possible flooding prevents trapping (particularly pitfall) in wetlands (BVG 34), though wetland locations were sampled using other survey methods (e.g., bird survey and active search).

Those BVG not subject to detailed trapping represent only a very small portion of remnant vegetation within the SGP study area (representing only 3.6% of total remnant vegetation).

Targeted Survey Sites

Targeted survey sites were used throughout the survey to supplement data collected at the detailed survey sites. Methods used at targeted sites varied from site to site and could include one or more of the following: opportunistic bird survey, spotlight, white- or black-flash camera, Harp trap, active search, SAT search, Glossy Black Cockatoo search, and Anabat. Two target sites included tripline over waterbodies to target microchiropteran bats and artificial shelter to detect grassland reptiles.

Targeted sites are used to sample BVG that cannot be sampled by trapping (see above), or to increase spatial representation.

3.3.1.5 Contingency Survey

In December 2016 a wildfire roared through the eastern portion of the SGP study area in the Kumbarella State Forest, significantly damaging the vegetation and habitat (Photo 1). The affected area included the five detailed fauna sites that were to be surveyed in March

2017 (i.e., the 'wet' season survey). A one-day contingency survey was undertaken in February 2017 to select new survey locations in the eastern area of the study area and gain the necessary cultural clearance. The locations of new trap sites were constrained by the extent and damage of both the December 2016 and 2012 wildfires (see Section 2.4 for fire extent).



Photo 1. Fire scarring following the December 2016 wildfire in the south-east portion of the SGP study area (i.e., Kumbarilla State Forest) (photo taken during the February contingency survey)

3.3.2 Survey Techniques

The terrestrial fauna surveys used a variety of recognised survey methods consistent with relevant federal and state survey guidelines. These included trapping (Elliot, pitfall, funnel and Harp), observation (spotlighting, bird survey, and active search), remote sensing (Anabat ultrasonic bat detection and camera trapping), and targeted methods (Koala [SAT] and Glossy Black Cockatoo ort searches, tripline, artificial shelter). These methods, detailed below, were replicated in both the dry and wet season survey unless otherwise indicated.

3.3.2.1 Fauna Trapping

Fauna trapping includes Elliot, pitfall, funnel and harp trapping. With the exception of Harp trapping, all trap methods remain at a designated location for the duration of the survey. These locations are the detailed fauna survey sites discussed in Section 3.3.1. Twenty detailed fauna sites (designated with a prefix of 'Det' in the associated GIS package) were operational within both the central and southern regions four consecutive nights during both the 'dry' (October) and 'wet' (March) season survey. The location of detailed trap sites is shown in Figure 3.3a and b. A summary of trap effort is provided in Section 3.3.3.

Elliot, Pitfall and Funnel Trapping

Pitfall trapping consisted of four 20L buckets and two drift fences set in a T configuration. Six funnel traps, positioned in pairs at the end of each fence, augmented the pitfall traps. This configuration is consistent with Eyre *et al* (2012) and resulted in a survey effort of 1276 bucket nights² and 1,914 funnel nights.

Ten Elliot traps, positioned approximately five to ten meters apart, were located in the vegetation immediately surrounding each pitfall/funnel array. Each Elliot trap was baited with a combination of peanut butter, rolled oats, and vanilla essence. Elliot survey effort was 3,190 nights².

All trapping sites were visited twice daily, once in the morning and once in the late afternoon. Animals were identified and released at the site of capture.

Harp Trapping

Insectivorous (microchiropteran) bat capture using harp traps was undertaken along flyways, which are linear clearings through vegetation such as tracks and creeks. Flyways are not necessarily located in areas suitable for other trapping methods, and as such, harp trapping did not coincide with pitfall, funnel or Elliot techniques. Unlike other trapping methods, harp traps are not used in a single location over consecutive nights but rather moved to a new location each night. Due to flyway width, two harp traps were placed at each harp trap location, side-by-side.

While each 'dry' and 'wet' season survey aimed to have 16 harp traps operational for three nights within both the central and southern areas, the lack of flyways and adverse weather reduced trap effort. Total harp survey effort was 86 harp nights (43 locations) in the 'dry' season survey and 78 harp nights (39 locations) during the 'wet' season survey.

3.3.2.2 Observation Based Detection

Observation based detection methods included bird survey (detailed bird survey and opportunistic bird survey), nocturnal spotlighting, and active searches. These methods are used at each trap site in both the 'dry' and 'wet' season survey, as well as additional locations as indicated in Figure 3.3a and b. Opportunistic bird surveys and active searching was also undertaken during the follow-up survey.

Bird Surveys

Detailed bird surveys were undertaken on two separate mornings at each detailed trap site, typically before 9am. Each survey took 30 minutes, but less time may have been spent if bird activity was poor, with the balance of time spent at the site whenever bird activity was high. Thus, a minimum of one hour birding over a minimum of two mornings was dedicated to detailed bird survey at each trap site. During each survey the maximum number of

² One trap site (4 buckets, 6 funnels and 10 Elliots) was closed for one night during the 'wet' season survey at the central region (see Section 3.5.1).

individuals for each species was recorded, though no abundance was noted if heard calling in the far distance or seen as flying-over. Total detailed bird survey effort was 80hrs.

Opportunistic bird surveys of an indeterminate period, but usually approximating 20 minutes, were undertaken at additional survey locations (Figure 3.3a and b). These surveys were not replicated and typically occurred between the hours of 9 and 11 am. Unlike detailed bird surveys, opportunistic bird surveys did not attempt to record the number of individuals, but rather only recorded species as 'present'. Opportunistic bird survey effort was approximately 8hrs during the 'dry' season, 13hrs during the 'wet season' and 5hrs during the follow-up survey (26hrs total).

Nocturnal (spotlighting) Surveys

Nocturnal foot-based surveys included two observers walking through habitats spotlighting for arboreal mammals, including small and medium sized terrestrial mammals, frogs, geckoes, nocturnal snakes and birds. Animals were detected by eye shine, call, or direct observation. Surveys typically lasted between 30-60 min per site, and were conducted by between two and three observers. Nocturnal foot surveys were undertaken at each trap site, as well as other locations. Nocturnal spotlight effort was approximately 72hrs during the 'dry' season and 68hrs during the 'wet' season.

Active Search

Active searches of habitats were undertaken at each trap site as well as additional locations. Active habitat searches involved two observers spending 30 minutes rolling rocks and logs, searching debris, inspecting trees for scratches and searching for scats or feeding remains. Greater Glider and Koala scats (or signs), and Glossy Black Cockatoo feeding remains (orts) were noted during the search.

Active searching was undertaken for approximately 56hrs/region during the 'dry' season and 64hrs/region during the 'wet season' (excluding the north region). Five hours of active search was also conducted during the follow-up survey.

Opportunistic Observations

Opportunistic observations of fauna not previously noted or infrequently observed were recorded throughout the surveys. Sightings were recorded from direct observation, or from indirect signs such as scats, tracks, scratch marks, nests, feeding indicators, or remains. Opportunistic observations were also used while traversing the SGP study area in a vehicle, a method recognised as suitable for detecting Squatter Pigeon. Traverses made by the flora teams, who are familiar with Squatter Pigeons, have been included within the traverse survey effort. It is estimated that 160hrs of traversing was undertaken in both the 'dry' and 'wet' season surveys (320hrs total) and 18hrs in the follow-up survey. An additional 700hrs of traverse through the SGP study area was undertaken during the pilot study, two flora surveys and the contingency survey.

3.3.2.3 Automatic Detection Methods

Ultrasonic bat call detectors and remote sensors cameras were used in both the 'dry' and 'wet' season surveys.

Ultrasonic Bat Call Detection

Ultrasonic calls of microchiropteran bats were recorded using ANABAT devices selectively positioned across the central and southern regions of the SGP study area. The ANABAT devices were set to record from dusk till dawn and sampled a new location each night. Locations were selected based on the likelihood of high bat activity, such as along flyways or over water bodies. Total Anabat survey effort was 33 Anabat nights in the 'dry' season (17 in the central region and 16 in the southern) and 35 Anabat nights in the 'wet' season (17 Anabat nights in the central region and 18 in the southern region). Recordings were analysed by Greg Ford.

Remote Sensor Cameras

Remote sensor cameras were used to survey small to large terrestrial vertebrates and is preferred over cage or hair-tube trapping as it is non-invasive, allows for greater detection rates, whilst minimising stress on animals (de Bondi *et al.* 2010; Claridge *et al.* 2010; Meek *et al.* 2012). Further, camera traps are effective for many species which are difficult to capture using cage or hair tubes (Vine *et al.* 2009; Robley *et al.* 2010).

Twenty-four white-flash cameras (Reconyx HC550) were in operation over four consecutive nights in both the central and southern regions during the 'dry' and 'wet' season surveys. One of these white-flash cameras was positioned in proximity to each detailed trap site (n=20), while another four were located at random positions. An additional 12 cameras were operational at one site (A7_Det06) for two consecutive nights during the follow-up survey. Each camera was baited by smearing quantities of peanut butter and Macadamia oil on the ground within the detection zone. Total white-flash camera effort was 396 camera nights.

In addition to the white-flash cameras, four black-flash (infra-red) cameras were located within the central and southern regions and baited with peanut butter, Macadamia oil and chicken wings. These cameras, which are intended to target exotic pests, were located near a track or road and were operational for four consecutive nights. Total black-flash camera effort was 64 camera nights.

3.3.2.4 Targeted Detection

Targeted detection methods included targeted searches for Koala evidence (scratches and scats) and Glossy Black Cockatoo feeding remains (called orts) as well as the use of artificial shelter.

Targeted Searches

Targeted searches were used for detecting Greater Glider, Koala and Glossy Black Cockatoo in areas of suitable habitat. Koala detection was based on the SAT method (Phillips and Callaghan 2011), but due to high densities of non-koala feed trees and only requiring confirmation of Koala presence, the method was modified to include twenty eucalypt trees

(rather than 30 trees of any species) or Koala evidence, whichever occurred first. Greater Glider scats were also noted during SAT searches. In total two SAT searches were undertaken in the northern region, 50 in the central region and 57 in the southern region during the surveys.

Searches were also conducted under stands of *Allocasuarina* for Glossy Black Cockatoo feeding remains (orts). *Allocasuarina inophloia*, *A. cristata* and *A. litoralis* are the primary food tree of this species in the Southern Brigalow Belt. Ort searches were conducted until 20 feed trees had been searched or feeding remains located. Searches were only conducted in suitable habitat, which was greatly reduced following a wildfire in the best areas of habitat prior to the 'wet' season survey. In total, nine dedicated ort searches were undertaken during the surveys.

Artificial Shelter

Nine hardwood tiles, approximately 40x40x4 cm in size, were scattered throughout the only area of mapped native grassland within the SGP study area³. These artificial shelters were positioned during the 'dry' season survey and later collected during the 'wet' season survey, allowing them to remain in-situ for approximately 20 weeks. The tiles were collected in the early morning, when ambient temperatures were low, to increase the likelihood of reptile capture. This method is frequently used to detect grassland reptiles (Sadler *et al.* 2011).

3.3.3 Summary of Fauna Survey Effort

Table 3.5 provides a summary of 2016-2017 fauna survey effort within the SGP study area. Appendix B compares the survey effort with EPBC survey guidelines, which are intended to be applied to small areas of interest. The application of these guidelines across large areas (as required in this project) will result in an unachievable survey effort.

3.4 ASSESSING LIKELY OCCURRENCE OF THREATENED TAXA

While an assessment of the likely occurrence of threatened taxa was completed for the approved EIS (3d Environmental and EcoSmart Ecology 2011), this assessment was based on data available in 2011. Since this assessment was completed the conservation status of several species has changed, and it is possible that new populations have been discovered or previously known populations are no longer present. A new assessment has therefore been undertaken.

The likelihood that individual threatened species could occur within the study area over the life of operation is based on habitat (existence and quality as assessed during field investigations) and existing record relevance (the number of records, record date, and proximity to the SGP study area). Each species is ranked as present, likely, possible, unlikely, or transient base on criteria outlined in Table 3.6.

³ Mapped as remnant by Queensland Herbarium but re-classed as non-remnant vegetation during this work.

Table 3.5. Terrestrial Fauna Survey Effort.

Method	Unit	'Dry' season (Oct)	'Wet' Season (Mar)	Follow-up (Mar)	TOTAL
Pitfall	Trap nights	640	636		1276
Funnel		960	954		1914
Elliot		1600	1590		3190
Harp		86	78		164
Anabat		36	33		69
Camera trap (white-flash)		186	186	24	396
Camera trap (black-flash)					64
Active Search	Person hrs	56.25	64	5	125.25
Detailed Bird		40	40		80
Opportunistic Bird		8	13	5	26
Foot Spotlight		71.75	68		139.75
Vehicle Spotlight		9.58	17.5		27.08
Traverse (fauna surveys)		160	160	18	338
Traverse (flora surveys & other)		Includes traverses during the pilot study, dry (Sept) and wet (Feb) season flora surveys and the contingency survey			700
SAT	Sites	60	43	8	111
GBC ort search		8	3		11

Table 3.6. Assessment guidelines for determining species likelihood

Likelihood	Criteria	Probability
Present	Recorded within and/or immediately adjacent study area during this work. Likely resident populations of these species are known from within the SGP study area within the last 10 years.	100%
Likely	Suitable habitat within or adjacent the study area; numerous relevant records (less than 20 years old and within 10 km) from desktop assessment.	>80%
Possible	Suitable habitat within or adjacent the study area; numerous records from desktop assessment study area but records > 10 km away or 20-50 years old. OR Marginal habitat within or adjacent the study area; few, but recent (<20 yrs), records within 10 km of study area.	10-80%
Unlikely	Little suitable habitat or habitat marginal; few records from desktop assessment, usually >50years old, and records > 10 km from study area.	<10%
Transient	Species highly mobile and known to occasionally appear in areas away from known population centres (usually birds). These species could occur sporadically over time (i.e., >10% likelihood), but records and observations are unlikely to represent an established population worthy of special protection. This category does not include species which might occur seasonally or frequently.	N/A

3.5 SURVEY CONDITIONS AND LIMITATIONS

3.5.1 Survey Conditions

August Pilot Survey

The pilot survey was conducted between the 29th August and 2nd September 2016. Chinchilla received a total of 117 mm of rain between the 15th and 20th of September resulting in the presence of some surface water during the pilot survey. Maximum daily temperatures during the survey ranged from 23°C (31st Aug) to 27°C (2nd Sept), while minimum overnight temperatures ranged between 3.2°C (29th Sept) and 14.9°C.

'Dry' Season Surveys

The 'dry' season flora surveys were conducted between the 12th and 23rd September 2016 working progressively north from Kumbarilla State Forest toward Wandoan over the 12 day period. Significant rainfall occurred during the survey with 152.4mm of rainfall recorded in Miles between September 15th to September 22nd and 63.5mm recorded at Dalby (Bureau of Meteorology data) for the same period. This caused localised flooding, limiting access to foot traverses on a large number of properties.

The 'dry' season fauna surveys were conducted between the 18th and 28th October 2016, with works concentrating on the central region (Miles) on the 18th and 22nd October, and the southern region (Dalby) between the 23rd and 27th October. Accumulative rainfall at Miles in the months (Jun – Oct) prior to the work was 260mm, while 259mm of rain fell at Dalby over the same period.

During the fauna 'dry' season survey Miles received 10.8mm, 0.8mm and 6.0mm of rainfall on the 18th, 21st and 23rd of October. However this rainfall was patchy and affected only some areas within the SGP study area. The storm front which moved through on the 21st of October coincided with nocturnal spotlighting, and while the SGP study area did not receive rain, lighting, thunder and high humidity was widespread. These conditions promote nocturnal fauna activity and ideal conditions for nocturnal fauna searches.

Minimum overnight temperatures during the fauna survey ranged between 5.0°C (24th) and 17.7°C (22nd). Spotlighting coincided with minimum overnight temperatures of between 12.9°C and 17.7°C while working in the central region, but due to a wide-spread cold front, dropped to ~ 5.0°C before recovering to 11.2°C while surveying the southern region.

'Wet' Season Surveys

Wet season flora surveys were completed between February 6th and 18th 2017. This period coincided with extremely hot weather where the initial 9 days of survey had maximum temperatures exceeding 43°. The conditions both slowed the rate of field surveys as well as wilted some groundcover forb species and caused general scorching of groundcovers in some habitats. This may have resulted in an under-sampling of total floristic diversity in some habitats, particularly grassy woodlands.

'Wet' season fauna surveys were undertaken between the 7th and 16th March 2017 (inclusive) with works commencing on the southern (Dalby) region (7th-11th) and finishing

in the central (Miles) region (12th-16th). A total of 213mm of rainfall was recorded at Miles, and 273mm at Dalby, in the months preceding the work (Nov 16-Mar 17).

Temperatures at Miles during the fauna survey ranged from a minimum of 14.2°C on one night and a minimum of 18.8 °C thereafter, to a maximum of 35 °C. Rainfall fell over three nights at Miles totalling 18.8mm, however rainfall was patchy with some areas receiving much greater rainfall events causing localised flooding. This flooding caused the closure of some traps (i.e., A02_Det05 was abandoned after three nights) due to access concerns.

Temperatures at Dalby during the fauna survey ranged from a minimum of 14.8 °C to a maximum of 33.2 °C. No rain fell while surveying the southern region.

3.5.2 Survey Limitations

While unlikely to have significantly affected the results of this work, the following limitations are recognised:

- Floristic surveys were hampered by extremely wet weather during the 'dry' (September) season survey meaning access was restricted in some localities and nearly all unsealed roads were impassable for a period of several days. This reduced site coverage in the first stage of the survey.
- Access was not possible to a small subset of properties. Generally this is unlikely to have affected survey results as surveys on adjacent land allowed assessment of a similar vegetation/habitat unit. However it is possible that some smaller features, such as wetlands or waterbodies, may have been overlooked.
- 'Dry' season fauna surveys conducted in the southern (Dalby) region coincided with unseasonably cold night temperatures. Temperatures quickly dropped to near 12-13°C within the first hour after sunset. These conditions, which affected only two nights of survey effort in the southern region, are largely unsuitable for the detection of a variety of fauna species, particularly nocturnal reptiles and bats.
- The coincidence of extremely hot weather with the 'wet' season flora survey effort may have resulted in the under-sampling of some of the more sensitive grass and forb species in woodland habitats. Of the EVNT species, this may have reduced the effectiveness of searches for the grass species *Digitaria porrecta*. The 'Endangered' forb species *Solanum papaverifolium* was observed flowering in populations observed outside the assessment area during the wet season survey and the effectiveness of searches for this species are not expected to have been affected.
- Rainfall was experienced during both the 'dry' season and 'wet' season fauna surveys in the central (Miles) region. However no rain fell while undertaking fauna surveys in the southern region (Dalby) and this is likely to have affected frog activity and detectability in the region.
- An extreme wildfire impacted the eastern portion of the southern region (Kumbarilla SF) prior to the 'wet' season survey. This affected the spatial distribution of trap effort within Kumbarilla State forest, but did not affect BVG representation. The fire inhibited surveys over the impacted area during the 'wet' season.

4.0 RESULTS

4.1 DESKTOP RESULTS

4.1.1 Wetlands of High Ecological Significance

The SGP study area contains an extensive mosaic of palustrine wetland habitats, many of which are associated with the Condamine River floodplain. Across Queensland, comprehensive mapping has been undertaken to identify Wetland Management Areas (WMAs) which categorise wetlands as either General Ecological Significance (GES) or High Ecological Significance (HES). These units include habitats associated with RE 11.3.27, 11.3.25 and RE 11.4.3a.

Wetland Management Areas are of specific relevance to the project, requiring adherence to appropriate management buffers and specific mitigation measures. The location of Wetland Management Areas in the SGP study area is shown in Figure 4.1. Two major wetlands of HES occur within the SGP study area; i) Lake Broadwater, a major lacustrine Wetland of National Significance and ii) Long Swamp, a palustrine wetland which follows a shallow sinuous path to the north of Lake Broadwater. Further characterisation of these habitats based on field assessment is provided in Section 4.1.1.

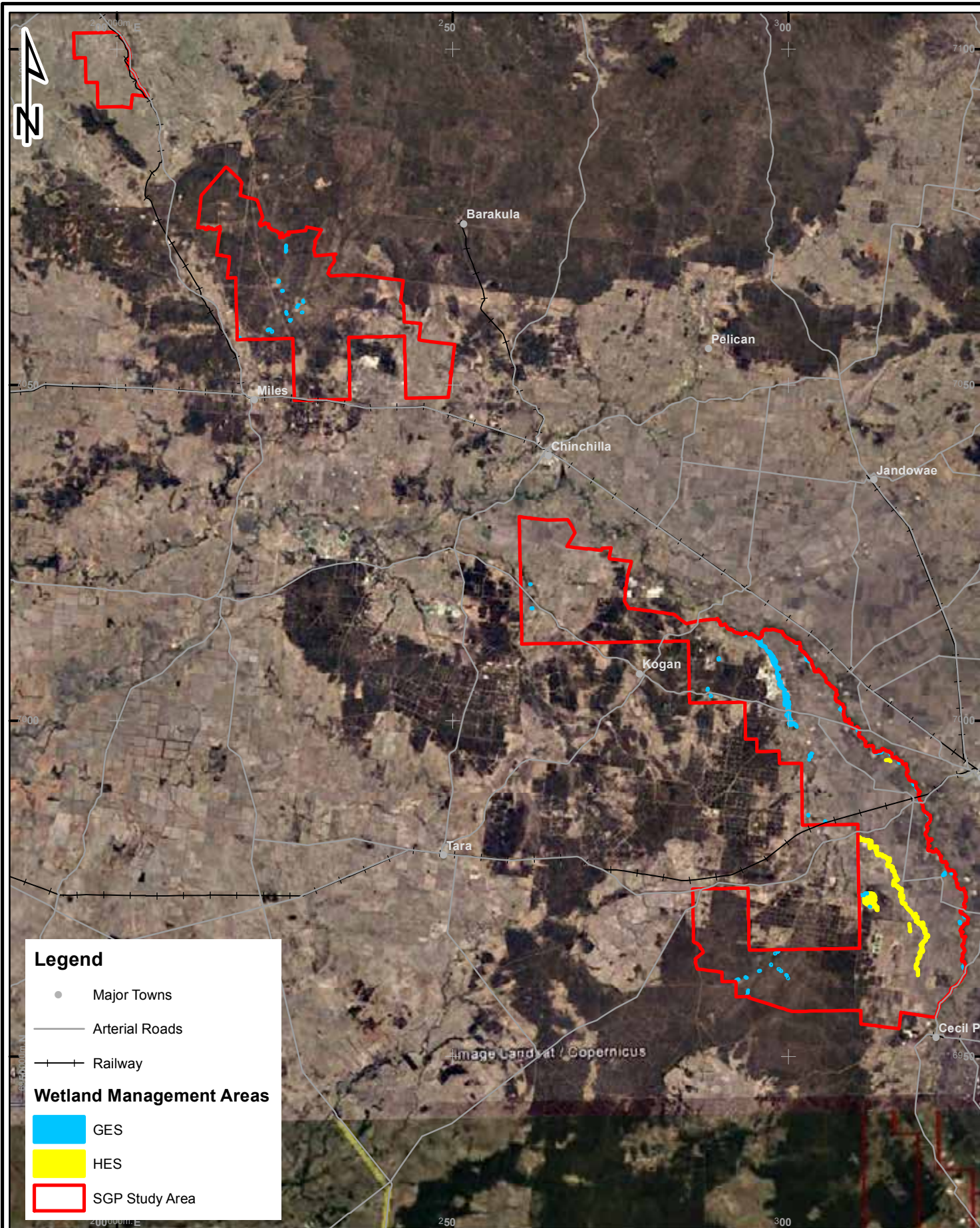
4.1.2 Essential Habitat

The essential habitat layer (Version 4.41; available at <http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=essential+habitat>) represents the most up-to-date essential habitat available. This layer however, is updated infrequently by the Queensland Government and at the time of preparing this report included essential habitat for species no longer specially protected under Queensland legislation (and therefore includes areas that should no longer constitute essential habitat). Unfortunately, recent government changes require property by property examination of Essential Habitat, which limits its use for assessments over large areas encompassing many properties and areas of essential habitat. Closer examination will be required in the future to assess essential habitat values.

4.1.3 Protected Plant 'High Risk' Buffers

A 'High Risk' plant buffer protects plants listed as Endangered, Vulnerable and Near Threatened under the NC Act. These protected areas are generated by placing a 2km wide buffer around confirmed locations of individuals to show where protected plant species are considered likely to be present.

The locations of High Risk buffers for protected plants that were assessed in accordance with Flora Survey Guidelines – Protected Plants (DEHP 2016) during SGP Surveys are shown in Figure 4.2.



Legend

- Major Towns
- Arterial Roads
- +— Railway

Wetland Management Areas

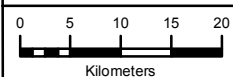
- GES
- HES
- SGP Study Area

NOTES:
Queensland wetland data version 4 (2016)

FIGURE 4.1 Wetland Management Areas within the SGP Study Area

Client

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Scale 1:750,000

Drawn By DG

Date 23-Jun-17

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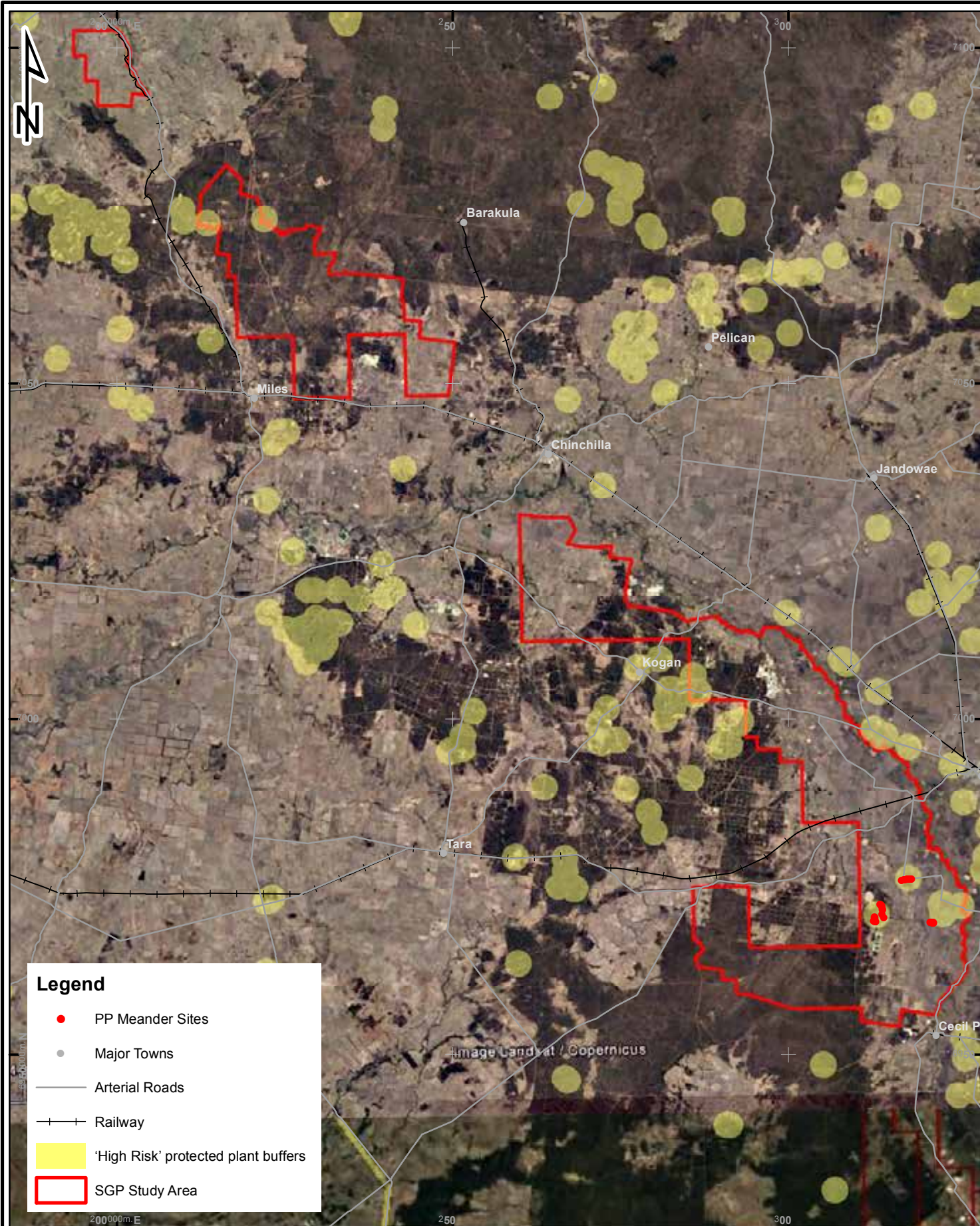
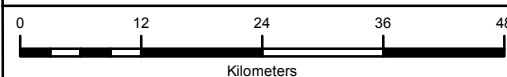


FIGURE 4.2 'High Risk' protected plant buffers assessed during SGP Study

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4.1.4 Environmentally Sensitive Areas

Environmentally Sensitive Areas relevant to the SGP study area include:

- Category A - National Parks and Conservation Parks, specifically Lake Broadwater Conservation Park (Lot 68/SP139357),
- Category B - REs scheduled as Endangered (Biodiversity Status) by Queensland Department of Environment and Heritage Protection (DEHP), and
- Category C – which includes the following:
 - Lake Broadwater Resources Reserve (Lot69/DY6009),
 - Regional Ecosystems with 'Of Concern' Biodiversity Status,
 - State Forest areas as previously detailed in Section 2.3, and
 - Essential Habitat as described in Section 4.1.2.

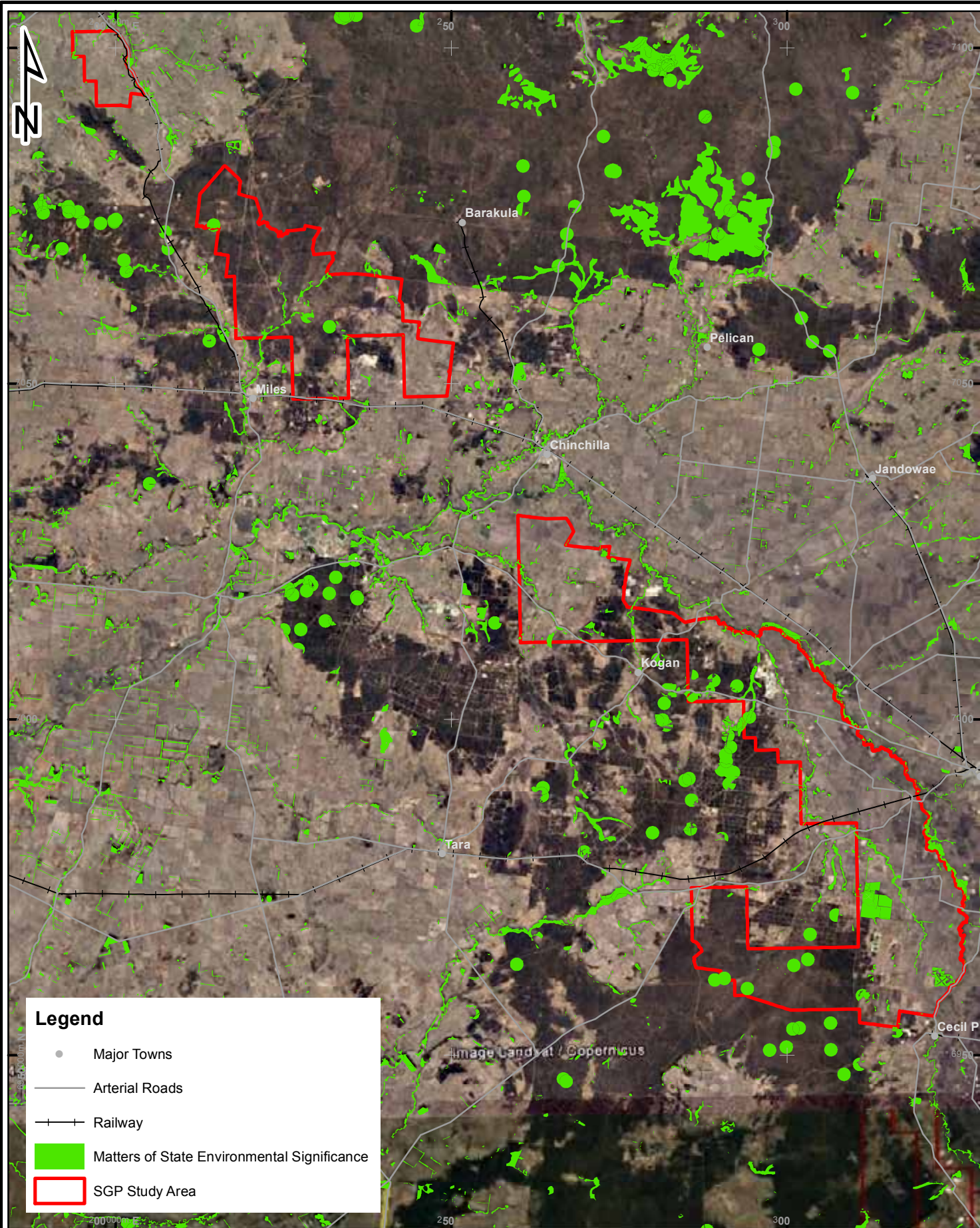
It should be noted that a property designated as a Category A ESA based on tenure overrides any attribution of ESA status based on vegetation composition (i.e. Of Concern and Endangered Biodiversity Status).

4.1.5 Matters of State Environmental Significance

Impacts to Matters of State Environmental Significance (MSES) may trigger a requirement for offsets under the Queensland Environmental Offsets Policy (Version 1.1). Within the SGP assessment area, the following features may be considered MSES:

- Areas or habitats that contains plants that are Endangered or Vulnerable wildlife (including those within protected plant High Risk buffers,
- Habitat (e.g. foraging, roosting, nesting or breeding habitat) for an animal that is Endangered, Vulnerable or a Special Least Concern animal,
- Remnant Endangered REs,
- Remnant Of Concern REs,
- Least Concern REs intersecting a watercourse or associated with a wetland,
- VM Act wetland habitats,
- National Parks and Nature Refuges, and
- Connectivity (as calculated using the Landscape Fragmentation and Connectivity (LFC) tool)

The Queensland Government has mapped MSES throughout the SGP study area and more broadly throughout Queensland with a comprehensive MSES dataset (DEHP 2014). MSES in the assessment area, as per DEHP (2014) is shown in Figure 4.3. It should be noted that this data excludes those areas identified in the current survey as habitat for protected animals or plants.



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4.1.6 Threatened Flora and Fauna

Examination of relevant databases and literature (see Section 3.1) identified threatened flora and fauna species recorded within 50km of the SGP study area, or having some possibility of occurring. While a long list of threatened species are known to occur within the SGP study area, not all are likely to occur with frequency, but rather, records may represent species which have become locally extinct or individuals which periodically appear but do not represent a permanent or seasonal population (i.e., particularly mobile fauna species). Closer analysis (see Appendix C) recognises a subset as being resident (i.e., present), or considered likely/possible. Present, or taxa likely to occur, are assessed further in Sections 4.2.3 (flora) and 4.3.1 (fauna) and have been provided detailed habitat maps in the attached GIS package.

4.2 TERRESTRIAL FLORA RESULTS

4.2.1 Threatened Ecological Communities and Regional Ecosystems

4.2.1.1 Threatened Ecological Communities

Past and present flora surveys have identified three TECs listed under the EPBC Act within the SGP study area. These communities are:

- Brigalow (*Acacia harpophylla* dominant and co-dominant) (Endangered),
- Weeping Myall Woodlands (Endangered), and
- Coolibah – Black Box Woodlands of the Darling Riverine Plains and Brigalow Belt South Bioregions (Endangered).

The spatial extent of these TECs within each of the three regions of the SGP study area are provided in Table 4.1 and their locations show in Figure 4.4.

Table 4.1. Spatial extent of TECs within the SGP study area

TEC	Area (ha) / SGP study area region			Total Area (ha)
	North	Central	South	
Brigalow (<i>Acacia harpophylla</i> dominant and co-dominant)	16.6	66.8	870.9	954.3
Weeping Myall Woodlands	0	0	0.9	0.9
Coolibah – Black Box Woodlands	0	0	22.6	22.6

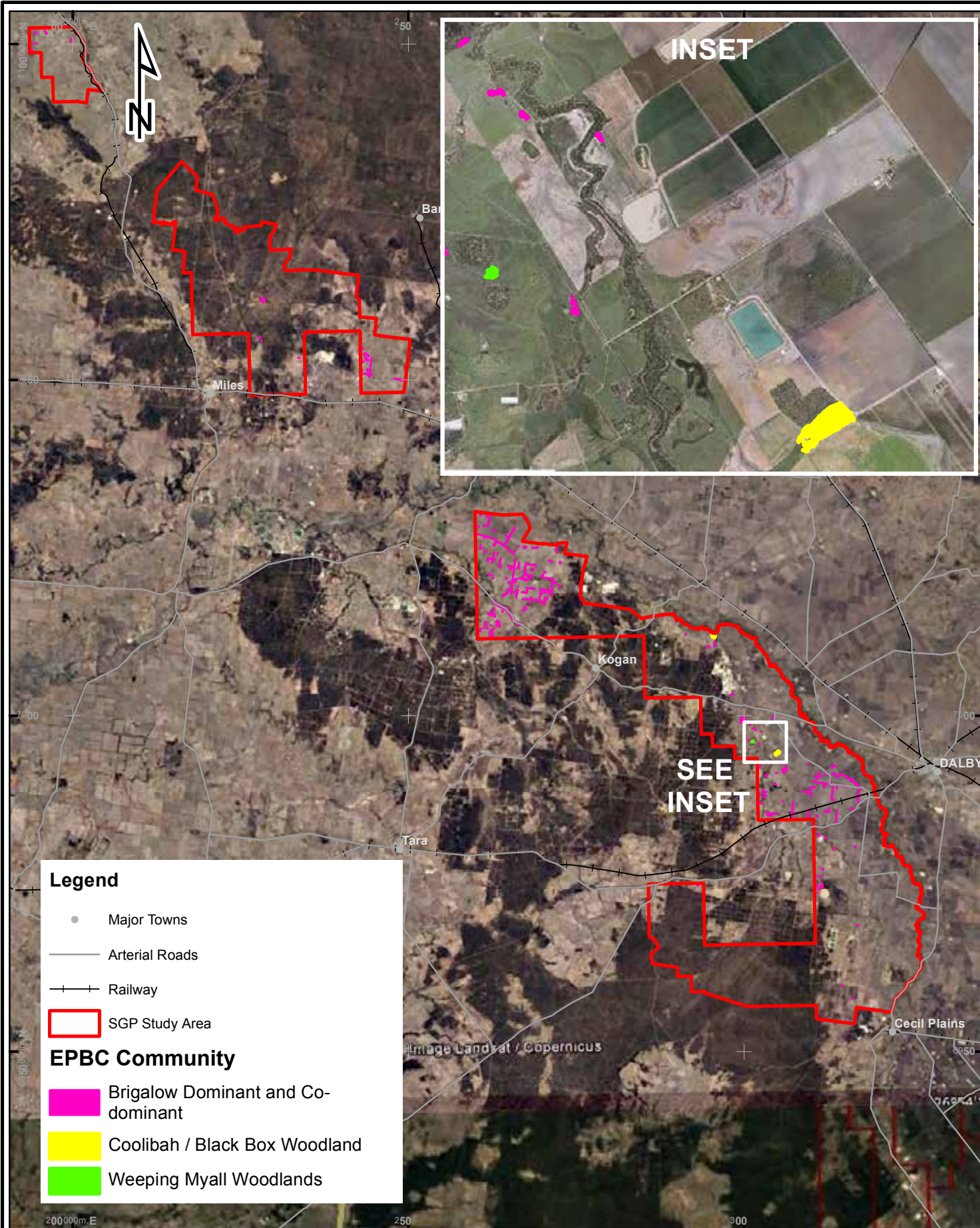


FIGURE 4.4 Threatened Ecological Communities within the SGP Study Area.

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Scale 1:750,000

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4.2.1.2 Regional Ecosystems:

Of the 20 REs recorded within the SGP study area, three are listed as Endangered and six as Of Concern, with the remainder being Least Concern under the VM Act. The extent of each RE within the three regions of the SGP study area is provided in Table 4.2 and their spatial distribution based on VM Act is shown in Figure 4.5 to Figure 4.7 and biodiversity status (as surrogate for ESA status) shown in Figure 4.8 to Figure 4.10. A detailed description for each RE listed as occurring within the SGP study area is provided within Appendix D.

It should be noted that heterogeneous polygons of RE11.3.25 and 11.3.4 are often mapped along riparian corridors, represented as either 'Of Concern Dominant' or 'Of Concern Sub-dominant' (under the VM Act) dependent on relative proportion. This is the result of scale limitations where large numbers of contiguous riparian polygons fall below the 0.5ha mapping threshold.

Table 4.2. Regional Ecosystem extent within the three regions of the SGP study area.

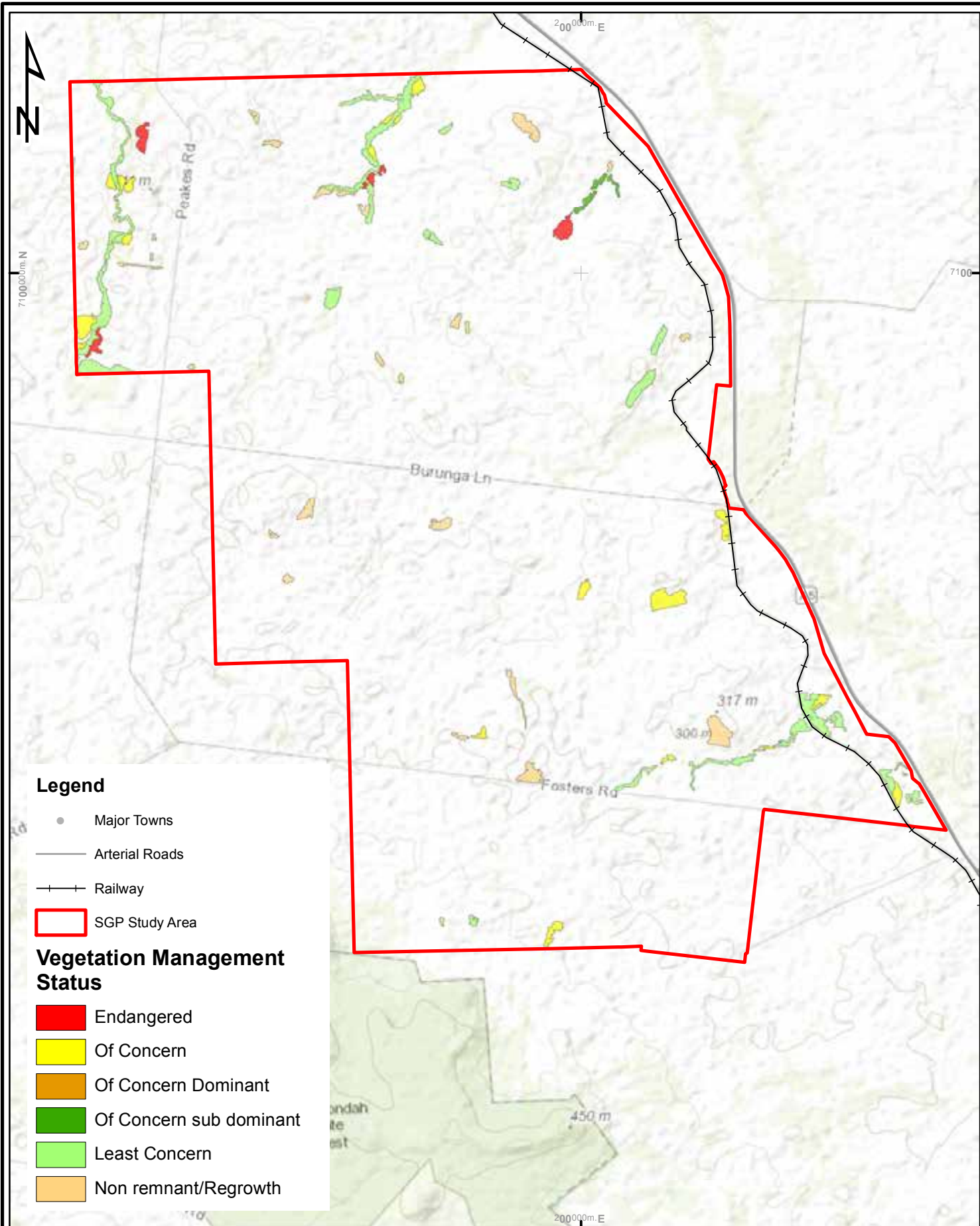
RE	Description	VM Act Stat.	Biodiversity Stat.	Extent by region (ha)		
				North	Central	South
11.3.1	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on alluvial plains.	E	E	7.7	14.8	195.0
11.3.14	<i>Eucalyptus</i> spp., <i>Angophora</i> spp., <i>Callitris</i> spp. woodland on alluvial plains.	LC	NCAP	0	127.1	205.23
11.3.17	<i>Eucalyptus populnea</i> woodland with <i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> on alluvial plains.	OC	E	12.3	0	201.2
11.3.18	<i>Eucalyptus populnea</i> , <i>Callitris glaucophylla</i> , <i>Allocasuarina luehmannii</i> shrubby woodland on alluvium.	LC	NCAP	0	0	418.4
11.3.2	<i>Eucalyptus populnea</i> woodland on alluvial plains.	OC	OC	9.9	3.0	580.7
11.3.25	<i>Eucalyptus tereticornis</i> or <i>Eucalyptus camaldulensis</i> woodland fringing drainage lines.	LC	OC	61.6	804.23	778.7
	11.3.25g: Seasonal vegetation associated with larger waterholes and areas of open water.			3.8	-	-
11.3.26	<i>Eucalyptus moluccana</i> or <i>E. microcarpa</i> woodland to open forest on margins of alluvial plains.	LC	NCAP	0	18.3	7.1
11.3.27	11.3.27a: Palustrine wetland (e.g. vegetated swamp). Mixed grassland or sedgeland with areas of open water +/- aquatic species.	LC	OC	0	36.1	256.5
	11.3.27d: Palustrine wetland <i>Eucalyptus camaldulensis</i> and/or <i>Eucalyptus tereticornis</i> woodland			1.5	0	15.15

RE	Description	VM Act Stat.	Biodiversity Stat.	Extent by region (ha)		
				North	Central	South
	11.3.27f: <i>Eucalyptus coolabah</i> and/or <i>E. tereticornis</i> open woodland to woodland fringing swamps.			0	0	320.8
11.3.3	11.3.3c: Palustrine wetland (e.g. vegetated swamp). <i>Eucalyptus coolabah</i> woodland to open-woodland (to scattered trees) with a sedge or grass understorey in back swamps and old channels.	OC	OC	0	0	26.82
11.3.4	<i>Eucalyptus tereticornis</i> and/or <i>Eucalyptus</i> spp. tall woodland on alluvial plains.	OC	OC	5.8	476.3	898.61
11.4.3	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> shrubby open forest on Cainozoic clay plains	E	E	0	0	388.7
	11.4.3a: Palustrine wetland (e.g. vegetated swamp). <i>Melaleuca bracteata</i> woodland associated with <i>Acacia harpophylla</i> communities.			0	0	56.64
11.5.1	11.5.1: <i>Eucalyptus crebra</i> , <i>Callitris glaucophylla</i> , <i>Angophora leiocarpa</i> , <i>Allocasuarina luehmannii</i> woodland on Cainozoic sand plains/remnant surfaces	LC	NCAP	0	17,972.06	18,607.9
	11.5.1a: <i>Eucalyptus populnea</i> woodland with <i>Allocasuarina luehmannii</i> low tree layer.			0	23.2	327.7
11.5.20	<i>Eucalyptus moluccana</i> and/or <i>E. microcarpa</i> / <i>E. pilligaensis</i> ⁴ ± <i>E. crebra</i> woodland on Cainozoic sand plains.	LC	NCAP	0	20.9	6635.7
11.5.21	<i>Corymbia bloxsomei</i> ± <i>Callitris glaucophylla</i> ± <i>Eucalyptus crebra</i> ± <i>Angophora leiocarpa</i> woodland on Cainozoic sand plains/remnant surfaces.	LC	NCAP	0	2,238.9	0
11.5.4	<i>Eucalyptus chloroclada</i> , <i>Callitris glaucophylla</i> , <i>C. endlicheri</i> , <i>Angophora leiocarpa</i> woodland on Cainozoic sand plains and/or remnant surfaces	LC	NCAP	0	287.4	2941
11.7.4	<i>Eucalyptus decorticans</i> and/or <i>Eucalyptus</i> spp., <i>Corymbia</i> spp., <i>Acacia</i> spp., <i>Lysicarpus angustifolius</i> on Cainozoic lateritic duricrust.	LC	NCAP	0	176.4	0
11.7.5	Shrubland on natural scalds on deeply weathered coarse-grained sedimentary rocks.	LC	NCAP	0	5,669.9	7243.6
	11.7.5b: <i>Acacia aprepta</i> shrubland.			0	371.2	95.4

⁴ *E. pilligaensis* has been recently consumed within the broader reclassification of *E. woollsiana*.

RE	Description	VM Act Stat.	Biodiversity Stat.	Extent by region (ha)		
				North	Central	South
11.7.6	<i>Corymbia citriodora</i> or <i>Eucalyptus crebra</i> woodland on Cainozoic lateritic duricrust.	LC	NCAP	0	950.8	5.3
11.7.7	<i>Eucalyptus fibrosa</i> subsp. <i>nubila</i> ± <i>Corymbia</i> spp. ± <i>Eucalyptus</i> spp. on Cainozoic lateritic duricrust.	LC	NCAP	0	6,297.2	2,988.5
11.9.2	<i>Eucalyptus melanophloia</i> +/- <i>E. orgadophila</i> woodland on fine-grained sedimentary rocks	LC	NCAP	48.27	0	0
11.9.5	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on fine-grained sedimentary rocks.	E	E	4.3	0	0
11.9.7	<i>Eucalyptus populnea</i> , <i>Eremophila mitchellii</i> shrubby woodland on fine-grained sedimentary rocks	OC	OC	1.5	0	0
11.9.10	<i>Eucalyptus populnea</i> open forest with a secondary tree layer of <i>Acacia harpophylla</i> and sometimes <i>Casuarina cristata</i> on fine-grained sedimentary rocks	OC	E	15	0	0

E = Endangered, OC = Of Concern, LC = Least Concern, NCAP = No Concern at Present



Legend

- Major Towns
- Arterial Roads
- + + Railway
- SGP Study Area

Vegetation Management Status

- Endangered
- Of Concern
- Of Concern Dominant
- Of Concern sub dominant
- Least Concern
- Non remnant/Regrowth

FIGURE 4.5 Endangered, Of Concern, and Least Concern REs within the northern region of the SGP Study Area

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Drawn By DG

Date 25-Jun-17

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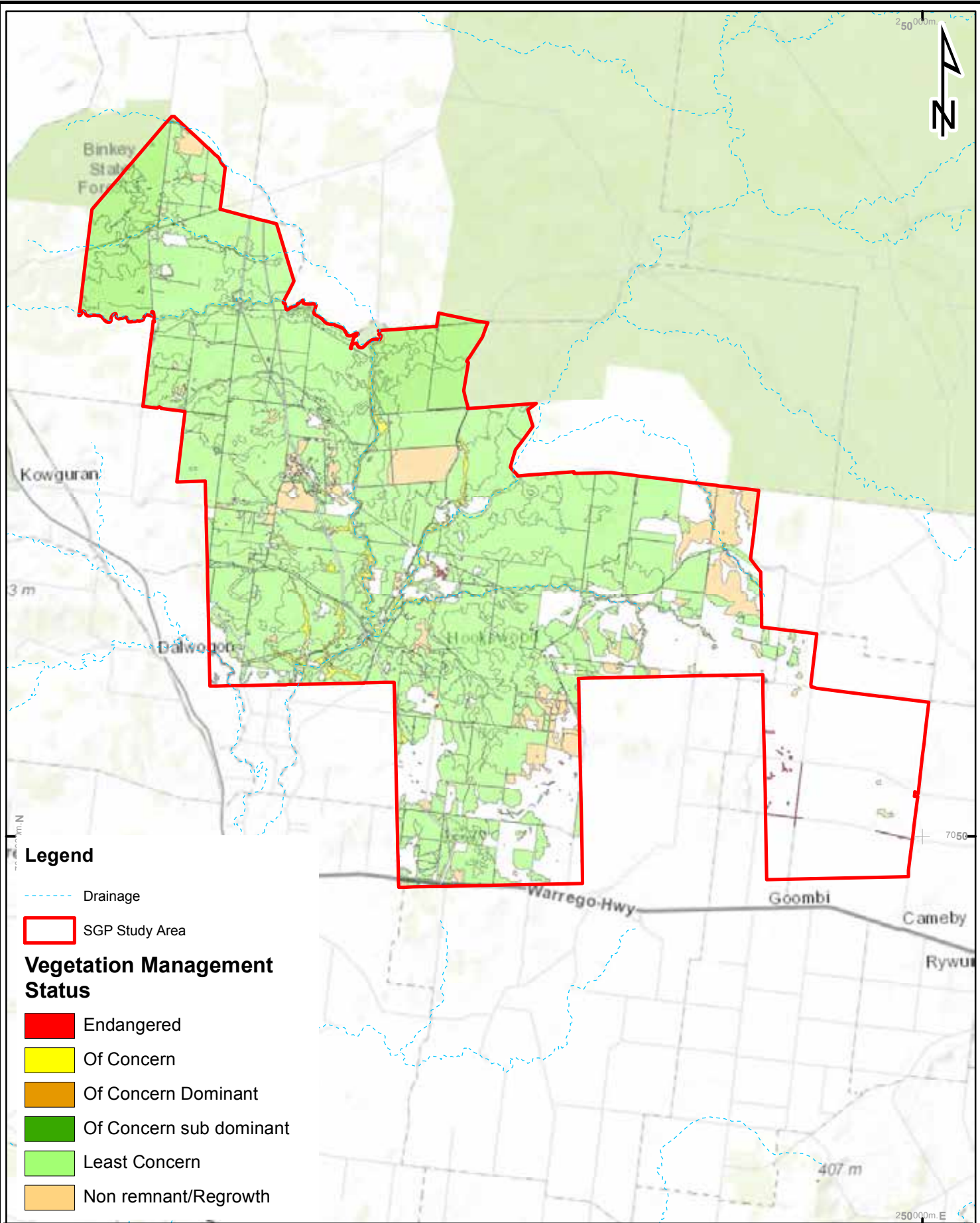
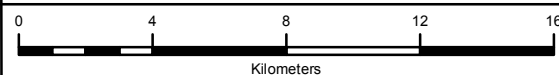


FIGURE 4.6 Endangered, Of Concern, and Least Concern REs within the central region of the SGP Study Area

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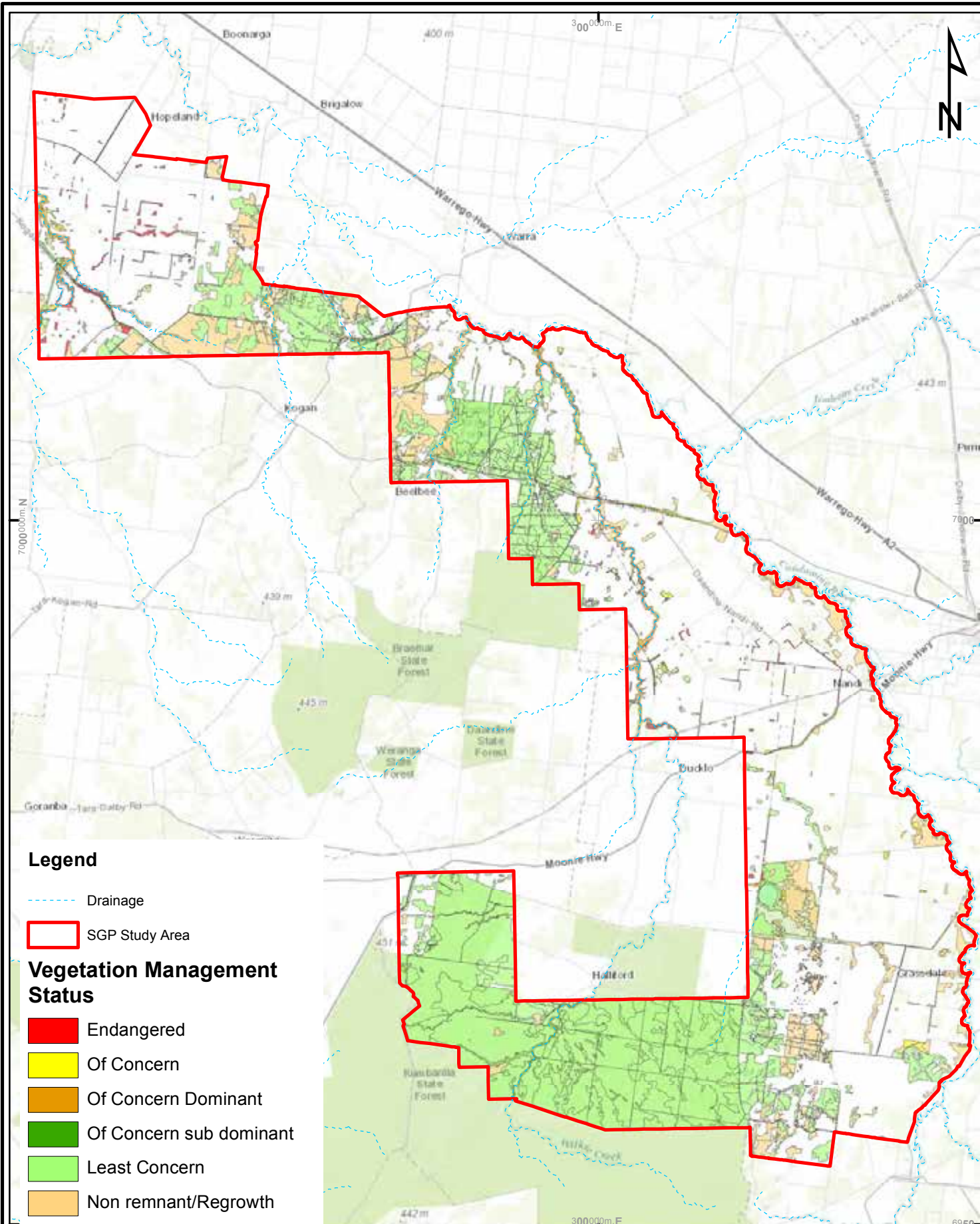
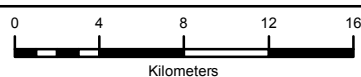


FIGURE 4.7 Endangered, Of Concern, and Least Concern REs within the southern region of the SGP Study Area

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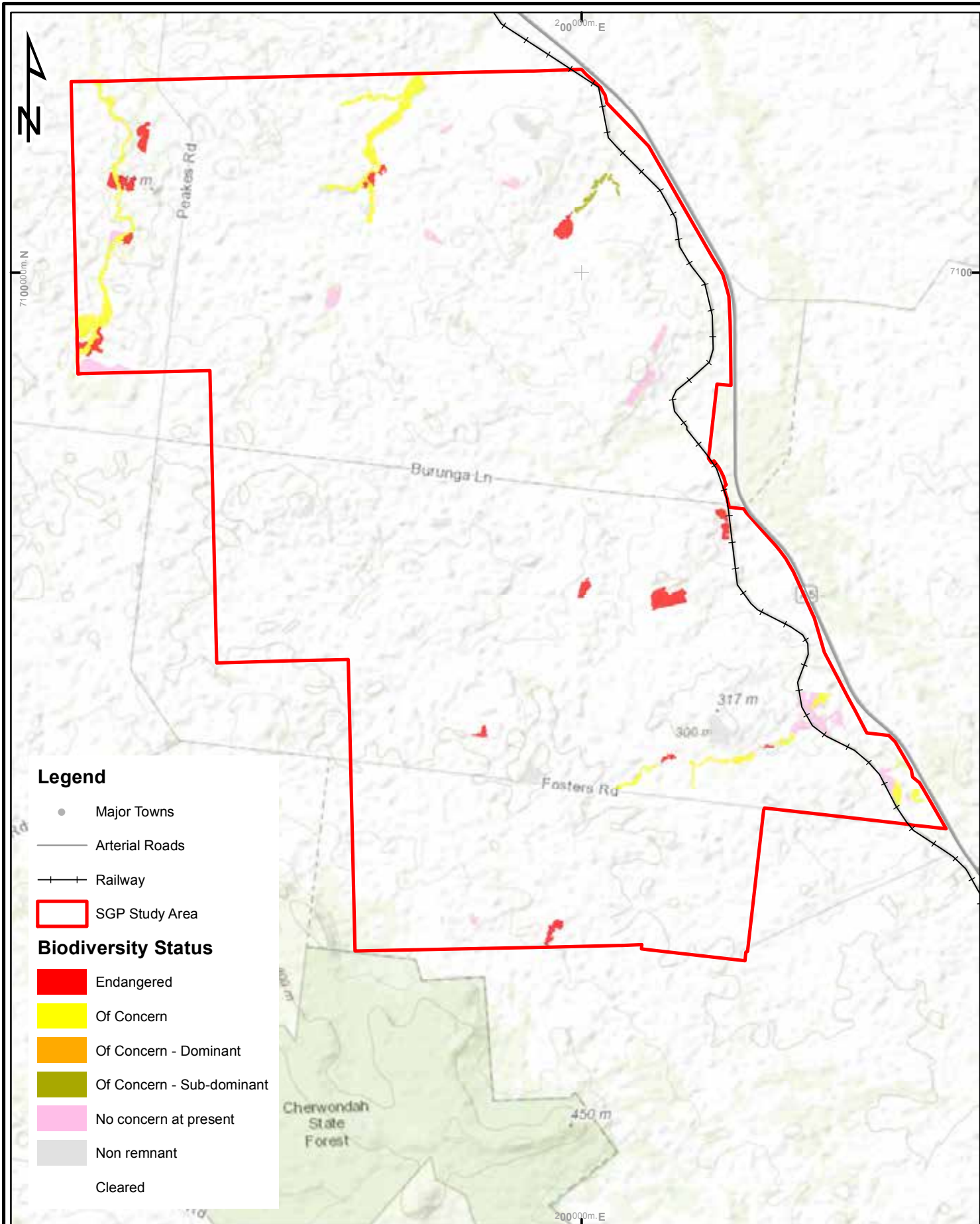
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Legend

- Major Towns
- Arterial Roads
- + + Railway
- SGP Study Area

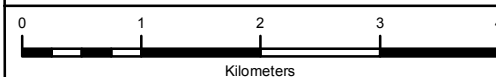
Biodiversity Status

- Endangered
- Of Concern
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Non remnant
- Cleared

FIGURE 4.8 Biodiversity Status of Regional Ecosystems in the northern region of the SGP Study Area.

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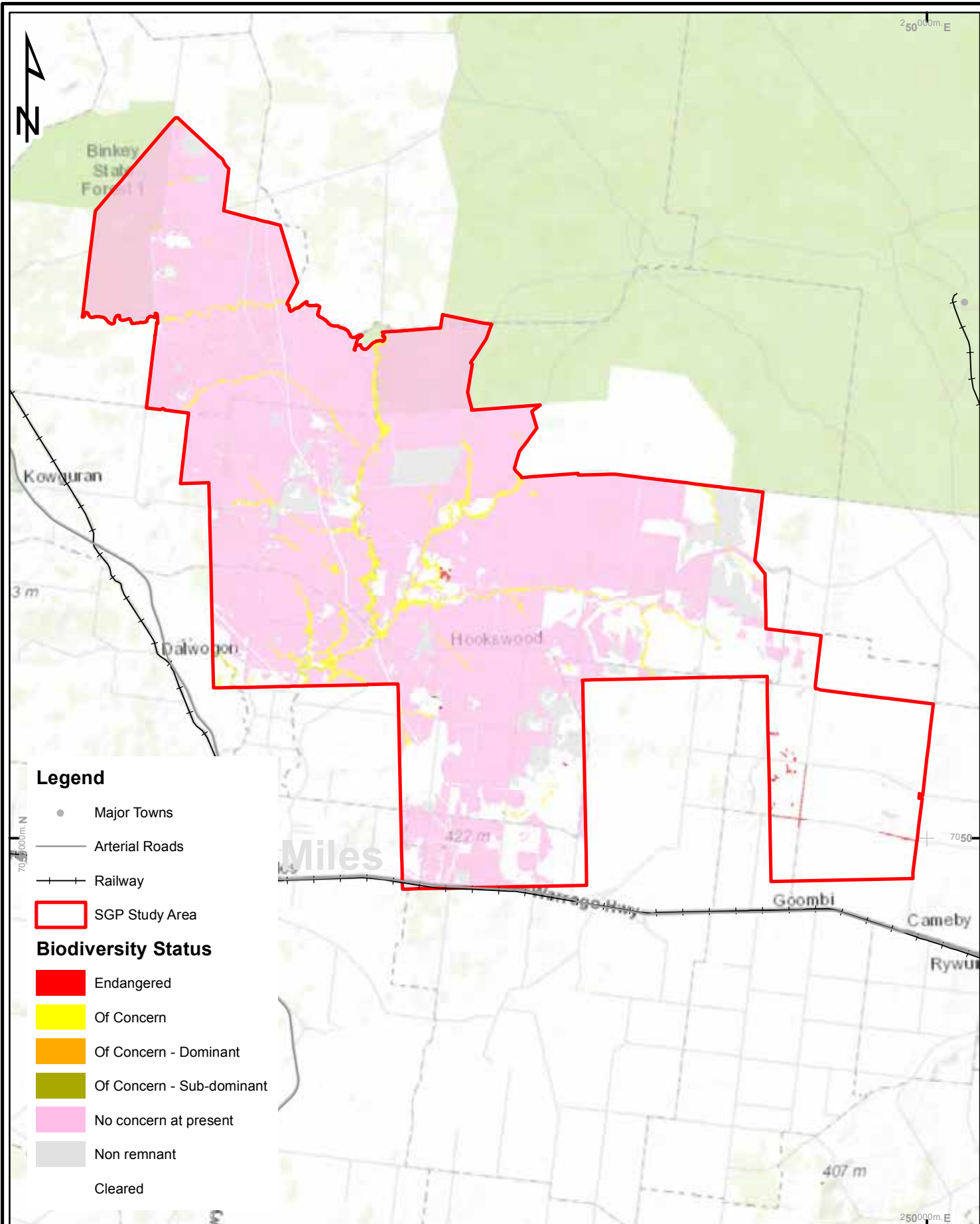


FIGURE 4.9 Biodiversity Status of Regional Ecosystems in the central region of the SGP Study Area.

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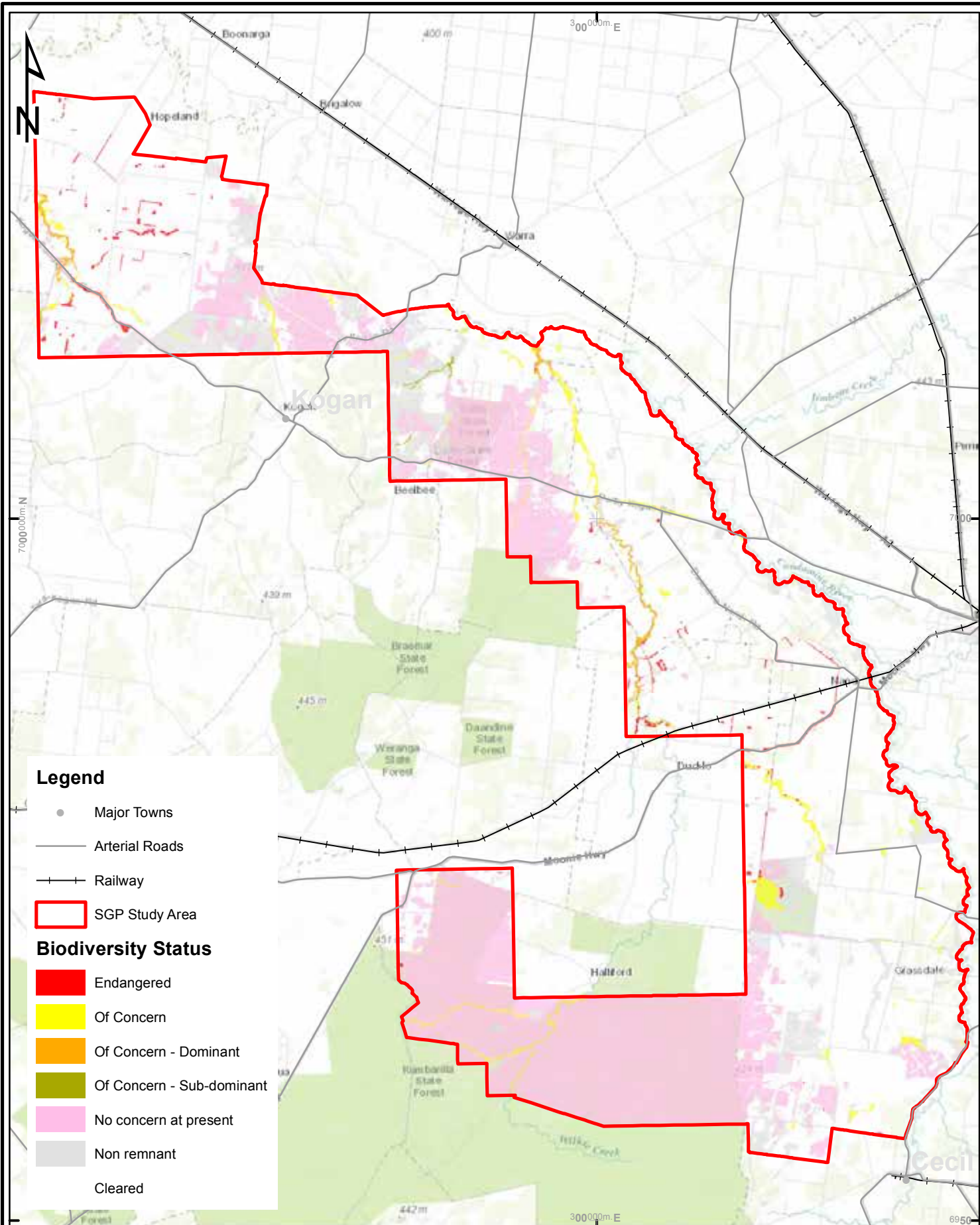
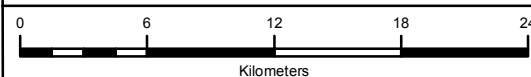


FIGURE 4.10 Biodiversity Status of Regional Ecosystems in the southern region of the SGP Study Area.

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4.2.2 Flora Diversity

A total of 438 flora species were recorded during the SGP study area flora surveys including:

- 38 exotic species
- 2 Conifers
- 2 ferns
- 90 grasses
- 2 species of grasstree
- A balance of trees, shrubs and forbs across 65 plant families.

The highest floristic diversity was associated with RE 11.5.1 where 100 species were recorded across all survey sites. The high diversity would be in part due to the REs considerable extent and variation in floristic structure.

4.2.3 Threatened Flora Species Likelihood Assessments

Only one threatened flora species, *Philothea sporadica* (Near Threatened NC Act; Vulnerable EPBC Act) has been recorded during assessments completed by Arrow Energy, including the current 2016 – 2017 survey event. However database records (HerbreCs and Australia's Virtual Herbarium) indicate a number of additional EVNT species have been previously recorded either in or adjacent to the SGP study area. These species include *Cryptandra ciliata* (Near Threatened NC Act); *Solanum papaverifolium* (Endangered NC Act), *Fimbristylis vagans* (Endangered NC Act) and *Digitaria porrecta* (Near Threatened NC Act). Some of these records are relatively old and there are no contemporary records despite extensive searches in suitable habitat. *Digitaria porrecta*, for example has not been recorded from within the SGP study area since 1995, and *Fimbristylis vagans* was last recorded from the Lake Broadwater area in 1984.

Figure 4.11 identifies the locations of all EVNT species records contained within 1km of the SGP study area boundary based on Herbarium records and a range of surveys undertaken on behalf of Arrow Energy.

Whilst only five EVNT flora species are considered known or likely to be present within the SGP study area, an additional 31 species are known from the regional area (i.e. within a 50km buffer of the SGP study area boundary). An analysis of the likelihood of these species occurring is provided in Appendix C which identifies an additional 14 species that may possibly occur within the SGP study area (Table 4.3). In general, species with records greater than 25km from the SGP study area were considered unlikely unless large tracts of sparsely surveyed habitat was present.

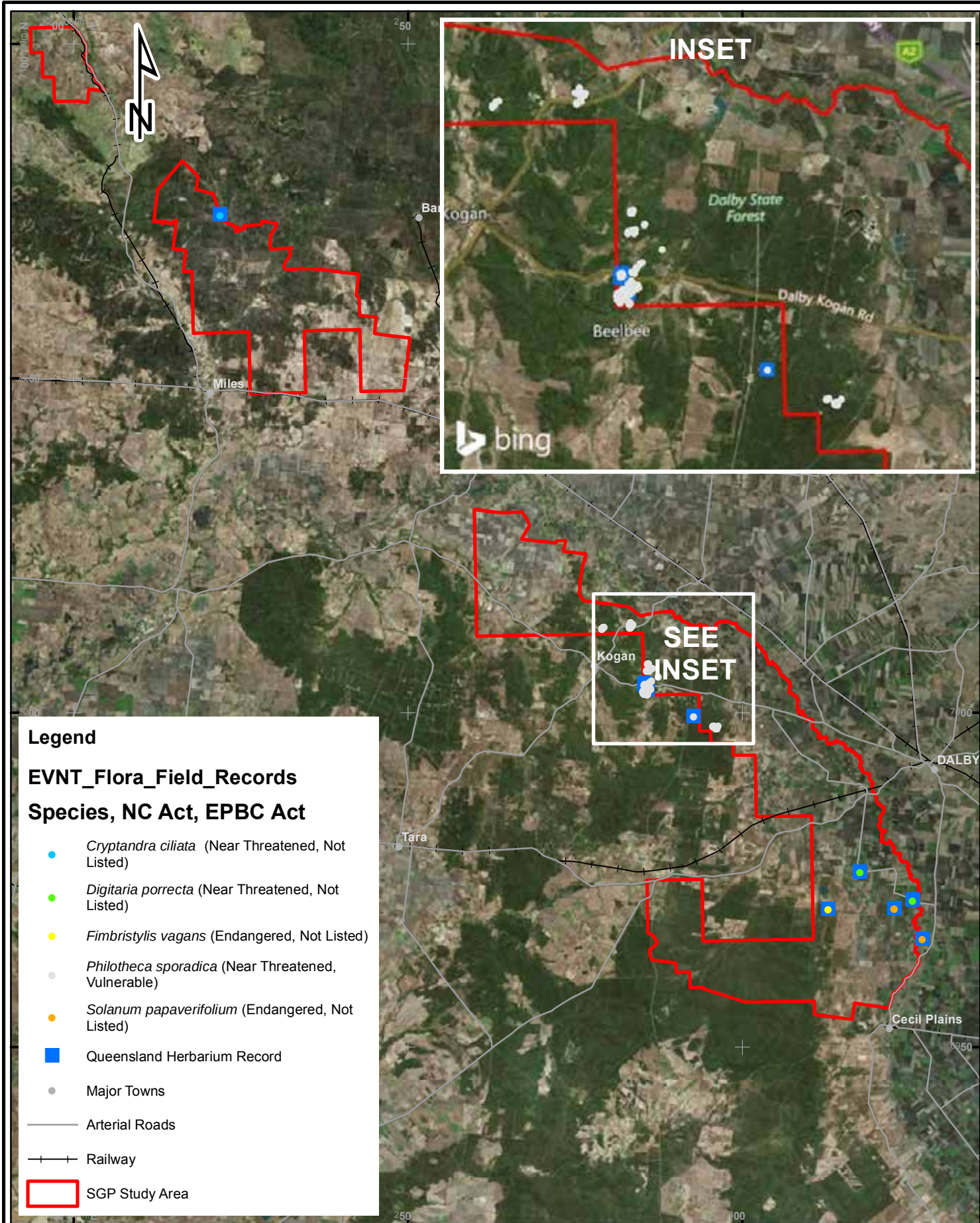


FIGURE 4.11 Survey records of EVNT flora species from within the SGP Study Area.

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Table 4.3. Likelihood assessment for Threatened flora species in the SGP study area.

Scientific Name	Common Name	EPBC Status	NC Status	Likelihood
Shrubs and Trees				
<i>Philotheca sporadica</i>	Kogan waxflower	V	NT	Present
<i>Acacia barakulensis</i>	Waaje wattle	-	V	Possible
<i>Acacia curranii</i>	Curly-bark wattle	V	V	Possible
<i>Acacia handonis</i>	Hando's wattle	V	V	Possible
<i>Callitris baileyi</i>	Bailey's cypress	-	NT	Possible
<i>Calytrix gurlmundensis</i>	Gurulmundi fringe myrtle	V	V	Possible
<i>Micromyrtus carinata</i>	Gurulmundi heath myrtle	-	E	Possible
<i>Eucalyptus curtisii</i>	Plunkett mallee	-	NT	Possible
<i>Acacia lauta</i>	Tara wattle	V	V	Unlikely
<i>Acacia wardellii</i>	Wardell's wattle	-	NT	Unlikely
<i>Cadellia pentastylis</i>	Ooline	V	V	Unlikely
<i>Denhamia parviflora</i>	Small-leaved denhamia	V	V	Unlikely
<i>Eucalyptus argophloia</i>	Chinchilla white gum	V	V	Unlikely
<i>Eucalyptus virens</i>	Shiny-leaved ironbark	V	V	Unlikely
Grasses and Sedges				
<i>Digitaria porrecta</i>	Finger panic grass	-	NT	Present
<i>Fimbristylis vagans</i>	NA	-	E	Present
<i>Homopholis belsonii</i>	Belson's panic	V	E	Possible
<i>Cyperus clarus</i>	-	-	V	Unlikely
Herbs and Orchids				
<i>Solanum papaverifolium</i>	-	-	E	Present
<i>Cymbonotus maidenii</i>	-	-	E	Possible
<i>Picris barbarorum</i>	-	-	V	Possible
<i>Rutidosis lanata</i>	-	-	NT	Possible
<i>Solanum stenopterum</i>	-	-	V	Possible
<i>Xerothamnella herbacea</i>	Xerothamnella	E	E	Possible
<i>Cryptandra ciliata</i>	-	-	NT	Likely
<i>Thesium australe</i>	Austral toadflax	V	V	Possible
<i>Pomaderris coomingalensis</i>	-	-	E	Unlikely

E = Endangered; V = Vulnerable; NT = Near Threatened

Further discussion regarding threatened flora taxa considered possible, likely or present from the SGP study area is provided in Appendix E. The appendix includes the criteria used to develop individual species habitat maps in the associated GIS product, and an assessment of the mapping accuracy for predicting the species habitat/extent. Table 4.4 shows the extent of habitat available to each species based on the GIS mapping product.

Table 4.4. The extent of mapped habitat for Threatened flora species present or possibly occurring within the SGP study area.

Scientific Name	Common Name	Status		Habitat extent in SGP (ha)*		
		EPBC	NCA	CHK	CHP	GH
<i>Acacia barakulensis</i>	Waaie wattle	V	-	0	0	33,811.2
<i>Acacia curranii</i>	Curly-bark wattle	V	V	0	0	33,811.2
<i>Acacia handonis</i>	Hando's wattle	V	V	0	0	33,811.2
<i>Callitris baileyi</i>	Bailey's cypress	NT	-	0	0	33,811.2
<i>Cryptandra ciliata</i>	NA	.	-	103.4	-	33,707.8
<i>Calytrix gurlmundensis</i>	Gurulmundi fringe myrtle	V	V	0	0	13,096.5
<i>Cymbonotus maidenii</i>	NA	E	-	0	0	3,677.6
<i>Digitaria porrecta</i>	Finger panic grass	NT	-	99.8	0	3,675.5
<i>Eucalyptus curtisii</i>	Plunkett mallee	NT	-	0	0	24,167.5
<i>Fimbristylis vagans</i>	NA	V	-	5.3	499.1	3,181.7
<i>Homopholis belsonii</i>	Belson's panic	V	V	0	19.3	1,206.9
<i>Micromyrtus carinata</i>	Gurulmundi heath myrtle	E	-	0	0	6,217.0
<i>Philotheca sporadica</i>	Kogan waxflower	NT	V	1,574.5	2,213.0	20,308.0
<i>Picris barbarorum</i>	NA	V	-	0	0	3,788.9
<i>Rutidosia lanata</i>	NA	-	NT	0	0	3,393.9
<i>Solanum papaverifolium</i>	NA	E	-	2.9	0	3,672.2
<i>Solanum stenopterum</i>	NA	E	-	0	0	2,764.5
<i>Thesium australe</i>	Austral Toadflax	V	V	0	0	526.7

*CHN = Core Habitat Known, CHP = Core Habitat Possible and GH = General Habitat

4.2.4 Exotic Flora Species

Of the 38 exotic species recorded during the assessment, five are listed as Restricted Invasive Plants under Queensland's Biosecurity Act 2014 meaning that they cannot be given away, sold, or released into the environment without a permit. The majority of these plants are from the Cactus (Cactaceae) family which includes the genera of *Opuntia* and *Harissia*. African lovegrass (*Eragrostis curvula*), whilst not listed as a restricted plant in Queensland is considered a 'High Priority Weed' under the Western Downs Regional Council Pest Management Plan (2011 to 2015). The species was also abundant in the study area, particularly in southern portions in the vicinity of Dalby. A summary of significant pest plants recorded during the survey is provided in Table 4.5.

Table 4.5. Summary of declared weeds and weeds of national significance (WONS) known to occur in the study area from database searches and field survey.

Scientific Name Common Name	Category*	Significantly Infested Res	Comments
<i>Opuntia tomentosa</i> Velvet tree pear	3/WONS	11.3.1, 11.3.4, 11.4.3, 11.3.17, 11.9.5.	Dense infestations of velvet tree pear were universally associated with brigalow habitats where it formed up to 15% cover in the taller shrub layers. The plant was also scattered throughout the majority of habitats although infestations considerably less vigorous on soils of lower fertility.
<i>Opuntia stricta</i> Prickly pear	3/WONS	Occurs at low to moderate levels throughout all ecosystems	Scattered individuals occur throughout all habitats although the species is more abundant in regional ecosystems with fertile alluvial soils.
<i>Opuntia aurantiaca</i> Tiger pear	3/WONS	11.3.1, 11.3.2, 11.3.4, 11.3.14, 11.3.17, 11.3.18, 11.3.25, 11.4.3, 11.9.5 and non-remnant habitats	Dense infestations typically recorded adjacent to or within brigalow habitats where it formed up to 10% ground cover in patches. Particularly heavy infestations associated with the riparian margins of Wilkie Creek.
<i>Harrisia martinii</i> Harrisia cactus	3	Mostly Brigalow habitats including REs 11.3.1 11.3.17, 11.4.3 and 11.9.5.	Most commonly associated with brigalow habitats where it typically formed cover of < 5%. Tends to be less common and in lower abundance than tiger pear in infested habitats.
<i>Bryophyllum delagoensis</i> Mother of millions	3	Generally in riparian ecosystems including REs 11.3.2, 11.3.4, 11.3.25.	Dense infestations of >50% groundcover recorded in REs 11.3.25 and 11.3.17 adjacent to Wilkie Creek and Braemar Creeks. Scattered infestations recorded on drainage lines throughout the SGP study area.
<i>Eragrostis curvula</i> African love grass**	N/A	Mostly non-remnant habitats, particularly roadside margins with sandy soils.	An aggressive coloniser that is most typically associated with roadside margins although extends into remnant woodland habitats in the vicinity of Dalby.

*As per Queensland's Biosecurity Act 2014 / Weed of National Significance; ** Priority plant in the Western Downs Regional Council Pest Management Plan 2011 – 2015.

4.3 TERRESTRIAL FAUNA RESULTS

Terrestrial fauna surveys for this work identified a total of 266 vertebrate species⁵ within the SGP study area including 20 amphibians, 55 reptiles, 151 birds and 40 mammals (Appendix F). Based on available database sources and previous works, one species was recorded for the first time within the region of the SGP study area (i.e., the SGP and ~50km buffer), the Pink-tongue Lizard (*Cyclodomorphus gerrardii*). An investigation of previous records (WildNet) revealed three records east of Toowoomba, one due south of the SGP study area (located on the southern side of the Gore Highway) and two within Southwood National Park (approximately 85km west of the SGP study area).

A number of species recorded during the surveys are at, or near, their distributional limit including Green Tree Snake (*Dendrelaphis punctulata*), Cotton Pygmy-goose (*Nettapus coromandelianus*), Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*), Azure Kingfisher (*Ceyx azureus*), White-naped Honeyeater (*Melithreptus lunatus*), Scarlet Honeyeater (*Myzomela sanguinolenta*), Rufous Fantail (*Rhipidura rufifrons*), Broad-toed Feathertail Glider (*Acrobates frontalis*) and Yellow-footed Antechinus (*Antechinus flavipes*).

Other notable observations include two *Amalosia* geckos, which while most closely resembling *A. jacovae*, lacked the distinctive toe webbing diagnostic to the species. According to current knowledge, neither *A. rhombifera* or *A. jacovae* occur in the Miles region (Wilson 2015), and the captured individuals had a mix of both characteristics. Subject to further study, these individuals may be assigned to one of these two taxa, extending their current range, or prove to be a new undescribed taxon. One individual was submitted to the Queensland Museum.

Recent taxonomic work on *Carlia pectoralis* (Open-litter Rainbow Skink) found the species to be a composite of three distinct taxa (Hoskin and Couper 2012). Two of these newly described species, *C. rubigo* and *C. pectoralis*, have the potential to occur within the SGP study area. Our field studies assigned most individuals to *C. rubigo*, though several individuals matched the description of *C. pectoralis*. However numerous captured animals had a mix of characters and could not be assigned to either species.

Eleven of the 266 identified species (4%) are non-native introduced species (Table 4.9, Appendix F).

4.3.1 Likely Threatened Terrestrial Fauna Species

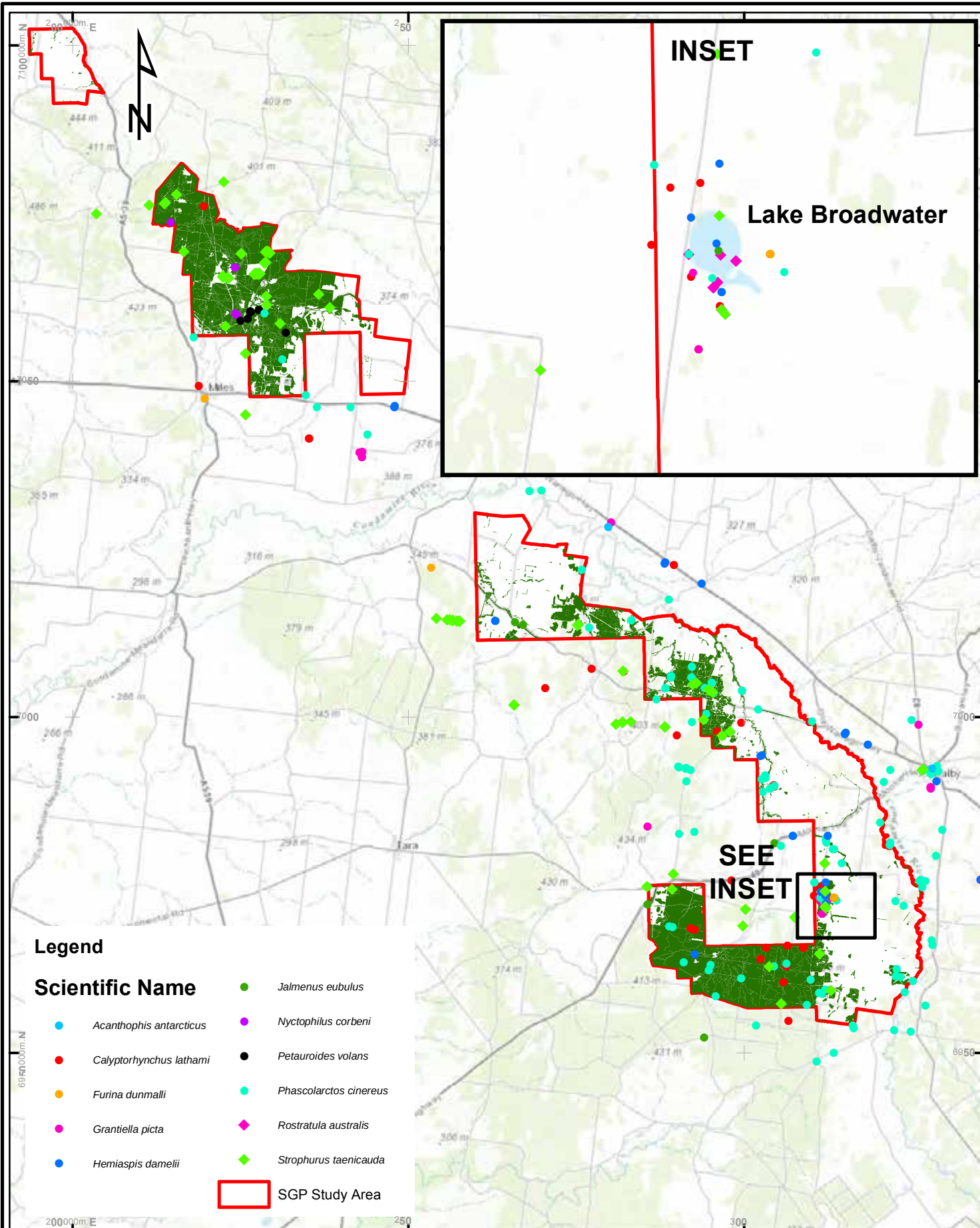
Database searches including the EPBC Act Online Protected Matters Search Tool have identified 39 threatened species as occurring, or potentially having habitat, within the SGP study area (Table 4.6). An assessment of these species based on record relevance and habitat suitability (see Appendix C) suggests 11 are present, or have potential to occur.

⁵ Species totals discussed in this text do not include unidentified taxa (e.g., *Uperoleia* sp.), but do include recognisable taxa of taxonomic uncertainty (e.g., *Amalosia* sp. cf. *jacovae*).

Table 4.6. Likelihood assessment for Threatened fauna species in the SGP study area.

Scientific Name	Common Name	EPBC Status	NC Status	Likelihood
BUTTERFLIES				
<i>Jalmenus eubulus</i>	Pale Imperial Hairstreak	-	Vul	Likely
REPTILES				
<i>Rheodytes leukops</i>	Fitzroy River turtle	Vul	Vul	Unlikely
<i>Elseya albagula</i>	Southern snapping turtle	CEnd	End	Unlikely
<i>Strophurus taenicauda</i>	Golden-tailed Gecko	-	NT	Present
<i>Delma torquata</i>	Collared Delma	Vul	Vul	Unlikely
<i>Anomalopus mackayi</i>	Long-legged Worm-skink	Vul	End	Unlikely
<i>Egernia rugosa</i>	Yakka Skink	Vul	Vul	Unlikely
<i>Tympanocryptis condaminensis</i>	Condamine earless dragon	End	End	Unlikely
<i>Aspidites ramsayi</i>	Woma	-	NT	Unlikely
<i>Acanthophs antarcticus</i>	Common Death Adder	-	Vul	Possible
<i>Furina dunmalli</i>	Dunmall's Snake	Vul	Vul	Possible
<i>Hemiaspis daemeli</i>	Grey Snake	-	End	Present
<i>Denisonia maculata</i>	Ornamental Snake	Vul	Vul	Unlikely
BIRDS				
<i>Botaurus poiciloptilus</i>	Australasian Bittern	End	LC	Unlikely
<i>Calidris ferruginea</i>	Curlew Sandpiper	C End	End	Transient
<i>Limosa lapponica baueri</i>	Bar-tailed Godwit	Vul	Vul	Unlikely
<i>Rostratula australis</i>	Australian Painted Snipe	End	Vul	Possible
<i>Pedionomus torquatus</i>	Plains Wanderer	C End	Vul	Unlikely
<i>Turnix melanogaster</i>	Black-breasted Button-quail	Vul	Vul	Unlikely
<i>Falco hypoleucos</i>	Grey Falcon	-	Vul	Unlikely
<i>Erythrotriorchis radiatus</i>	Red Goshawk	Vul	End	Unlikely
<i>Geophaps scripta scripta</i>	Squatter Pigeon (southern)	Vul	Vul	Transient
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	-	Vul	Present
<i>Lophochroa leadbeateri</i>	Major Mitchell Cockatoo	-	Vul	Unlikely
<i>Lathamus discolor</i>	Swift Parrot	End	End	Unlikely
<i>Ninox strenua</i>	Powerful Owl	-	Vul	Unlikely
<i>Grantiella picta</i>	Painted Honeyeater	Vul	Vul	Possible
<i>Anthochaera phrygia</i>	Regent Honeyeater	C End	End	Unlikely
<i>Poephila cincta cincta</i>	Black-throated Finch	End	End	Unlikely
MAMMALS				
<i>Dasyurus hallucatus</i>	Northern Quoll	End	LC	Unlikely
<i>Dasyurus maculata maculata</i>	Spotted-tailed Quoll	End	Vul	Unlikely
<i>Phascolarctos cinereus</i>	Koala	Vul	Vul	Present
<i>Petauroides volans</i>	Greater Glider	Vul	Vul	Present
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	Vul	Vul	Unlikely
<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	Vul	LC	Unlikely
<i>Macroderma gigas</i>	Ghost Bat	Vul	End	Unlikely
<i>Chalinolobus dwyeri</i>	Large Pied Bat	Vul	Vul	Unlikely
<i>Nyctophilus corbeni</i>	South-eastern Long-eared Bat	Vul	Vul	Present
<i>Pseudomys australis</i>	Plains Rat	Vul	End	Unlikely

The of EVNT records detected during the current surveys are shown in Figure 4.12.



Vegetation_Management_Status

Remnant Vegetation

FIGURE 4.12 Survey records of EVNT fauna species from within the SGP Study Area Region

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Many threatened species considered in the original SGP EIS (3d Environmental 2011) are no longer specially protected including Rough Collared Frog (*Cyclorana verrucosa*), Brigalow Scalyfoot (*Paradelma orientalis*), Grey Goshawk (*Accipiter novaehollandiae*), Black-necked Stork (*Ephippiorhynchus asiaticus*), Square-tailed Kite (*Lophoictinia isura*), Black-chinned Honeyeater (*Melithreptus gularis*), Turquoise Parrot (*Neophema pulchella*), Cotton Pygmy-goose (*Nettapus coromandelianus*), and Little Pied Bat (*Chalinolobus picatus*).

Profiles for Threatened fauna considered to be possible, likely or present from the study area are provided in Appendix G. The profiles include the criteria used to develop individual species habitat maps in the associated GIS package, and an assessment of mapping accuracy. Table 4.7 shows the extent of habitat available to each species based on the GIS mapping product.

Table 4.7. The extent of mapped habitat for Threatened fauna species present or possibly occurring within the SGP study area.

Scientific Name Common Name	Status		Habitat extent (ha) in SGP by region*			Likelihood
	EPBC	NCA	CHK	CHP	GH	
<i>Jalmenus eubulus</i> Pale Imperial Hairstreak	-	Vul	0	869.4	0	Likely
<i>Strophurus taenicauda</i> Golden-tailed Gecko	-	NT	7,160.3	74,649.4	1,341.5	Present
<i>Acanthophis antarcticus</i> Common Death Adder	-	Vul	69.81	72,052.9	1,550.6	Possible
<i>Furina dunmalli</i> Dumnall's Snake	Vul	Vul	297.9	71,463.1	6,504.8	Possible
<i>Hemiaspis daemeli</i> Grey Snake	-	End	939.6	9,280.7	44,189.4	Present
<i>Rostratula australis</i> Australian Painted Snipe	End	Vul	266.5	223.3	0	Possible
<i>Calyptorhynchus lathami</i> Glossy Black Cockatoo	-	Vul	5,165.3	1,852.8	35.1	Present
<i>Grantiella picta</i> Painted Honeyeater	Vul	Vul	696.5	863.6	359	Possible
<i>Phascolarctos cinereus</i> Koala	Vul	Vul	8,187.4	5,015.36	71,949.8	Present
<i>Petauroides volans</i> Greater Glider	Vul	Vul	324.7	3,413.8	1,914.1	Present
<i>Nyctophilus corbeni</i> South-eastern Long-eared Bat	Vul	Vul	3,531.4	55,836.2	26,146.0	Present

*CHN = Core Habitat Known, CHP = Core Habitat Possible and GH = General Habitat

4.3.2 Migratory Fauna Species

Three Migratory species, listed under the EPBC Act, were recorded during the 2016-17 SGP surveys (Table 4.8). Other species have been historically recorded within the SGP study area, predominantly from Lake Broadwater (Figure 4.13) which is likely to be significant habitat for Migratory taxa. A discussion on the likelihood of each species occurring in the SGP study area over Life of Operation (approximately 25 years) is also provided in Table 4.8.

Table 4.8. Migratory species recorded within the SGP study area

Scientific Name Common Name	ESE 2016-17	DB Recs	Discussion
<i>Gallinago hardwickii</i> Latham's Snipe		X	The Latham's Snipe frequents Lake Broadwater, with only on other record restricted to a small dam in the southern region of the SGP study area. While it has potential to occur throughout the SGP study area on suitable dams, swamps and flooded paddocks, best habitat is largely limited to Lake Broadwater and Long Swamp. These two locations should be considered 'Important Habitat' as defined in Department of Environment, Water, Heritage and Arts 2009).
<i>Limosa lapponica</i> Bar-tailed Godwit		X	The Bar-tailed Godwit has been recorded twice from Lake Broadwater in 1985 and 1987. It is a vagrant species unlikely to occur within the SGP study area during Life of Operation. Lake Broadwater represents the only area of suitable habitat within the SGP study area.
<i>Limosa limosa</i> Black-tailed Godwit		X	The Black-tailed Godwit has been recorded once from Lake Broadwater in 1995. It is a vagrant species unlikely to occur within the SGP study area during Life of Operation. Lake Broadwater represents the only area of suitable habitat within the SGP study area.
<i>Numenius phaeopus</i> Whimbrel		X	The Whimbrel has been recorded only once from Lake Broadwater in 1990. It is a vagrant species unlikely to occur within the SGP study area during Life of Operation. Lake Broadwater represents the only area of suitable habitat within the SGP study area.
<i>Tringa nebularia</i> Common Greenshank		X	Common Greenshank is only known at Lake Broadwater where the most recent observation occurred in 2007. It is a vagrant which has a very low probability of occurring within the SGP study area during Life of Operation. The only area of suitable habitat occurs at Lake Broadwater.
<i>Calidris ferruginea</i> Curlew Sandpiper		X	The Curlew Sandpiper has been recorded on seven occasions within the SGP study area, all but one at Lake Broadwater. The most recent record (2007) is from an artificial dam approximately 6.5km SSE of Lake Broadwater. All other records predate 1995. It is likely the species will appear at Lake Broadwater during SGP operations, but is unlikely elsewhere. These vagrant individuals will not represent a significant population.
<i>Plegadis falcinellus</i> Glossy Ibis		X	The Glossy Ibis has been frequently recorded at Lake Broadwater. Lake Broadwater and Long Swamp represent the best areas of habitat within the SGP study area, and at these locations the species is expected to occur over Life of Operation. Alternative habitat is scarce, but the species could possibly occur in other wetlands or flooded paddocks.
<i>Tringa stagnatilis</i> Marsh Sandpiper		X	Marsh Sandpipers have been recorded semi-frequently at Lake Broadwater where it was last observed in 2007. It is possible this species could occur within Lake Broadwater during Life of Operation, but is unlikely to occur elsewhere due to lack of suitable habitat.

Scientific Name Common Name	ESE 2016-17	DB Recs	Discussion
<i>Myiagra cyanoleuca</i> Satin Flycatcher		X	A single Satin Flycatcher has been recorded within the central region of the SGP study area in 1997. It is a vagrant species and is unlikely to occur over Life of Operation.
<i>Calidris acuminata</i> Sharp-tailed Sandpiper		X	Sharp-tailed Sandpipers are recorded semi-frequently at Lake Broadwater where it was last observed in 2009. This species could occur at Lake Broadwater or possible Long Swamp during Life of Operation. While habitat elsewhere is limited, there is some potential for the species to occur in smaller farm dams, wetlands and flooded paddocks.
<i>Tringa glareola</i> Wood Sandpiper		X	The Wood Sandpiper has been recorded once from Lake Broadwater in 1995. It is a vagrant species that is unlikely to occur during Life of Operation or away from the Lake.
<i>Gelochelidon nilotica</i> Gull-billed Tern		X	Gull-billed Terns have been recorded on only nine occasions within the SGP study area, most recently in 2013. In all but two occasions the species has been recorded at Lake Broadwater. There is some possibility the species could sporadically appear on isolated waterbodies, but on balance it is only likely to occur infrequently at Lake Broadwater.
<i>Chlidonias leucopterus</i> White-winged Black Tern		X	The White-winged Black Tern has been recorded once from Lake Broadwater in 1995. It is a vagrant species that is unlikely to occur during Life of Operation or away from either Lake Broadwater or Long Swamp. It typically only occurs around larger waterbodies, wetlands or swamps.
<i>Hirundapus caudacutus</i> White-throated Needletail	X	X	Recorded at seven separate locations during the 2016-17 ESE surveys, all within the central region. These records represent large foraging flocks moving across the region. Records are also present in databases. Being aerial in nature, this species can occur over both natural and modified landscapes (including urban cities), though large stands of forest may be important for roosting. The species is likely to frequently occur throughout the SGP study area.
<i>Apus pacificus</i> For-tailed Swift	X	X	Recorded at fourteen separate locations during the 2016-17 ESE surveys. Known from an additional 14 records in databases. Strictly aerial in nature, they can occur over modified landscapes (including tilled crops and urbanisation) though large tracts of woodland may be a key habitat requirement (Department of Environment 2015). They will occur throughout the SGP study area.
<i>Rhipidura rufifrons</i> Rufous Fantail	X	X	Recorded at four locations during the current surveys, all within or adjacent Dalby State Forest. The species has also been recorded at six other locations in databases, also only within the southern region of the SGP study area. Habitats within the SGP study area are marginal, the species prefers rainforest or wet sclerophyll forests. These records approximate the limit of the species western extent (only four records further west, all <100km of the SGP study area), and therefore their populations could be considered 'Important' as defined under the MNES impact assessment guidelines (Department of Environment 2013).

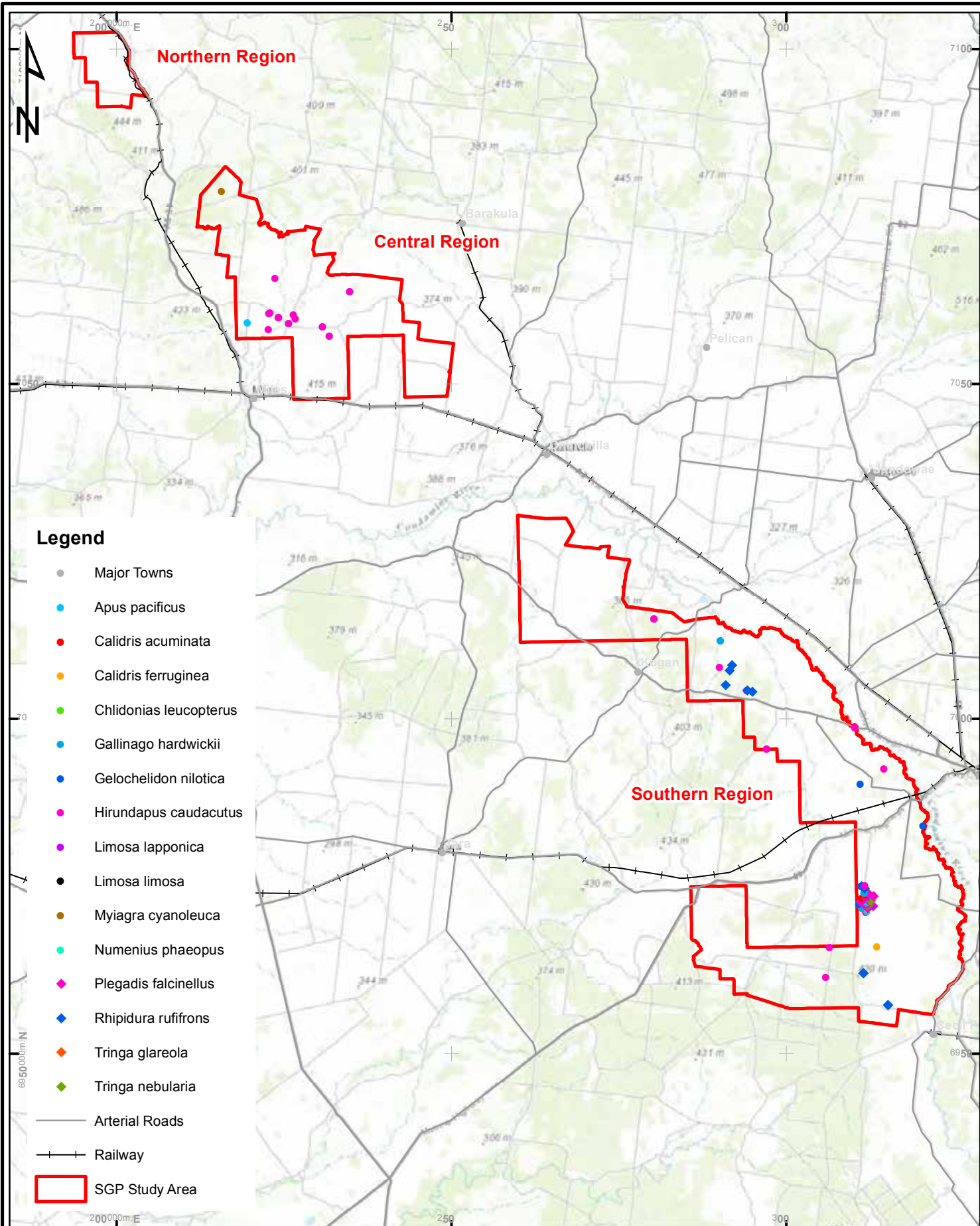


FIGURE 4.13 Migratory species records within the SGP Study Area

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4.3.3 Exotic Pest Species

Feral pest species known to occur within the SGP study area are discussed in Table 4.9.

Table 4.9. Exotic pest species known from the SGP study area

Scientific Name Common Name	Recorded during ESE surveys	Discussion
<i>Sus scrofa</i> Feral Pig	Y	While only a handful of individuals were observed, feral pig evidence was commonly encountered. Evidence of pig activity was at its highest in locations with water or damp soils (e.g., creeklines and gullies), particularly in the larger tracks of forest. They are likely to be throughout the SGP study area. Predation, habitat destruction, competition and disease transmission by Feral Pigs is a Key Threatening Process under the EPBC Act.
<i>Rhinella marina</i> Cane Toad	Y	Cane Toads are common in the northern portion of the SGP study area, being frequently recorded north of the Dalby-Kogan Rd. South of this road they become increasingly less abundant, only one individual was recorded south of the Moonie Highway. A similar pattern is apparent in database records. The biological effects, including lethal toxic ingestion, caused by Cane Toads is a Key Threatening Process under the EPBC Act.
<i>Canus lupus familiaris/dingo</i> Dog/dingo	Y	Dogs/dingos and their signs were frequently observed during the survey and the species is likely to be widespread throughout the SGP study area. Highest densities may occur within larger tracts of vegetation away from grazing land where they are more likely to be actively hunted and controlled.
<i>Felis catus</i> Feral Cat	Y	Feral Cats were noted at 12 locations during the surveys and will be abundant and widespread within the SGP study area. Feral Cats pose a significant threat to biodiversity and predation by Feral Cats is a Key Threatening Process under the EPBC Act.
<i>Oryctolagus cuniculus</i> European Rabbit	Y	Rabbits are uncommon within the SGP study area. They were recorded four times during these surveys, and have only been recorded at two other locations within databases.
<i>Lepus europeaus</i> Brown Hare	N	Brown Hares are infrequently encountered within the SGP study area. Individuals were observed on only two occasions during these surveys, and the species has been recorded only eight times within the SGP study area in other databases.
<i>Sturnus vulgaris</i> Common Starling	N	Common Starlings are abundant in modified land along the Condamine River. They are largely absent from the heavily wooded areas covering most of the SGP study area.
<i>Sturnus tristis</i> Common Myna	Y	Within the SGP study area Common Mynas have a similar distribution to Common Starlings, being abundant in modified lands along the Condamine River and rare elsewhere.
<i>Columba livia</i> Rock Dove	Y	Rock Doves have not been frequently recorded within the SGP study area. They are usually more abundant around larger urban centres, but can be found in surrounding farmlands. They have only been noted from the southern region of the SGP study area, and in most cases in modified land along the Condamine River.

Scientific Name Common Name	Recorded during ESE surveys	Discussion
<i>Mus musculus</i> House Mouse	Y	House Mice have been recorded throughout the SGP study area. While they are likely to be most abundant in modified agricultural areas and adjacent remnant vegetation, they can occur from within large tracts of native vegetation.
<i>Streptopelia chinensis</i> Spotted Dove	N	Rare recorded from the SGP study area; all historic records (4) noted from Lake Broadwater between 2003 and 2009.
<i>Rattus rattus</i> Black Rat	N	Likely to be more abundant than suggested by the few database records. Likely to be largely restricted to around human dwellings and occupied centres.
<i>Vulpes vulpes</i> Red Fox	Y	Records of the Red Fox are restricted to the southern region of the SGP study area where grazing land is widespread. While they will have lower abundance in large continuous tracts of vegetation, they are likely to occur throughout the SGP study area. Red Foxes pose a significant threat to biodiversity and predation by European Red Fox is a listed Threatened Process under the EPBC Act.
<i>Passer domesticus</i> House Sparrow	N	House Sparrows will be largely restricted to urban towns. Currently they occur infrequently in the SGP study area, and are most likely to turn up in the southern region along the Condamine River where large-scale land clearing has occurred.
Unidentified Deer Species	Y	An unidentified species of deer was briefly observed during the March surveys north of Kogan. While unmistakably a deer, the species could not be identified. This is the first deer record within the region (i.e., SGP study area + 50km buffer).

5.0 HABITAT CONDITION

5.1 CONDITION OF WETLANDS INCLUDING LONG SWAMP

A relatively complex system of floodplain wetlands occurs in the southern region of the SGP study area, generally associated with sinuous overflows of the Condamine River and its larger tributaries. The southern region also contains Lake Broadwater, a seasonal water feature that is recognised nationally for its natural values, being significant at a national and state level. The lake is listed on the Directory of Important Wetlands and is recognised as being a rare example of a semi-permanent freshwater lake in the bioregional area (Blackman *et al.* 1999, EHP 2006). The Lake is fringed by an open forest of River Red Gum (*Eucalyptus camaldulensis*) (RE 11.3.27d) which is broadest (approx. 200m) around the north-eastern portion of the lake. Habitats surrounding the lake are generally in good condition.

The numerous flood plain wetlands are almost universally heavily infested with Lippia (*Phylla canescens*) during seasonal drying periods. This severely limits the ability of native aquatic species to re-colonise these areas during wetter, more favourable seasons.

Long Swamp is a sinuous hydrological feature (overland flow path) that flows across the Condamine Alluvium in a north-westerly direction to the east and north of Lake Broadwater, before joining with Wilkie Creek to the west. The feature occupies a broad depression on the alluvium with the central portion of the depression formed by heavy clay. Surface water is present seasonally and following dry spells the associated vertosol soils form deep hummocks and cracks. There was no flow, nor any significant pooled water within Long swamp during the field visits, despite heavy recent rains. These observations together with the observations of deep, open cracks in the central swamp channel soil surface confirmed that the feature is only active during significant flooding.

At Long Swamp the vegetation is predominantly native, although exotic groundcovers are predominant in some localities. The canopy is formed by tall, broadly spaced River Red Gum (*Eucalyptus camaldulensis*) at approximately 15 - 30% cover with Poplar Box (*Eucalyptus populnea*) forming on the swampy margins. The canopy is significantly stressed in some areas with signs of senescence and foliage loss. The noted senescence is possibly due to historic groundwater drawdown for irrigation (Kath *et al.* 2014; 3d Environmental, 2017) although may have been further compounded by surface water extraction.

Four secondary vegetation survey sites were completed within Long Swamp during the dry season survey (DS21, DS22, DS26, DS31 completed when the swamp was dry). At these locations exotic vegetation cover contributed an average of 15% to the total groundcover, and formed 39% of the total living groundcover. Common native species included Nardoo (*Marsilea drummondii*), Water Chestnut (*Eleocharis dulcis*) and scattered native grasses including *Panicum decompositum*. Lippia (*Phylla canescens*) was the most abundant exotic forb blanketing the clay soils, particularly where grazing pressure is most intense. It should be noted that groundcover composition will vary seasonally with native aquatic sedges, particularly Water Chestnut, becoming dominant during periods of standing surface water.



Photo 2. Long Swamp with characteristic Red Gum showing moderate signs of stress as suggested by foliage loss.

5.2 GENERAL HABITAT CONDITION

The SGP study area incorporates a number of landscapes, ranging from the broad river flood plains centred on the Condamine River and its associated tributaries, rolling hills on fine grained sedimentary rocks in the Wandoan (northern) area, rangeland woodlands formed on skeletal rocky soils, and ironstone jump ups and extensive tracts of ironbark dominant woodland associated with older Tertiary / Cainozoic plains. The impacts of land use vary across the landscape dependant largely on the fertility of the underlying substrate.

The productivity of the alluvial clay soils on the Condamine River floodplain, collectively referred to as the Condamine River Alluvium (CRA), has resulted in heavy utilisation of these areas for agricultural purposes, predominantly tilled cropping. Floodplain vegetation is generally restricted to the immediate river channel and associated flood pockets, with scattered areas on crown or council owned land and as isolated fragments adjacent to floodplain overflows and swamps. Long-term abstraction of groundwater associated with the CRA, has lowered groundwater levels by up to 25m in some localities (Kath *et. al.* 2014). It is understood that Arrow is currently investigating the presence and connectivity of perched aquifers and deeper aquifers in this area. The loss of water from the rooting zone of deeper rooted species such as River Red Gum (*Eucalyptus camaldulensis*) and Poplar Box (*Eucalyptus populnea*) has resulted in severe loss of canopy vigour and dieback in some localities. It is expected that based on

historic groundwater levels (take from Arrow well baseline assessments), maximum tree rooting depth would not have exceeded 15m across the dominant portion of the CRA. The reduction of canopy vigour has resulted in increased light penetration, coupled with the impact of grazing, which has resulted in pervasive displacement of native groundcovers by exotic species such as Green Panic (*Megathyrsus maximum* var. *trichoglume*) and Lippia (*Phylla canescens*).

Brigalow communities (RE 11.3.1, RE 11.4.3 and RE 11.9.5) and Brigalow/Eucalypt associations (RE 11.3.17) have been cleared to the margins of adjacent vegetation types and generally exist as small unviable remnants, slivers along the margins of riparian forest types, or as secondary forests with limited structural complexity or floristic diversity. Native ground covers, although naturally sparse in these communities are often displaced by exotic species including Prickly Pear (*Opuntia stricta*), Mother of Millions (*Bryophyllum delagoense*) and Harrisia Cactus (*Harrisia martinii*). Dense infestations of velvet tree pear are typical in brigalow habitats forming up to 20% cover in the taller shrub layer of many occurrences. Despite their extent, brigalow patches can still have significant value for several threatened fauna species including the Pale Imperial Hairstreak (*Jalmenus eubulus*) and Painted Honeyeater (*Grantiella picta*).

Although ecosystem types on soils of low fertility, typically those REs associated with land zones 5 and 7, form the largest and most continuous tracts of vegetation in the study area, these ecosystems have invariably been heavily utilised for their timber resources with varying degrees of impact. In particular, habitats dominated by the Narrow-leaf Ironbark species *Eucalyptus crebra*, *E. elegans* and *E. woollsiana* (RE 11.5.1, 11.5.4, 11.7.4 and 11.5.20) have been logged to a degree that all mature canopy trees have been removed. The remaining vegetation comprises of secondary growth with a thickened shrub layer forming the canopy. Examination of 1981 aerial photography for the SGP study area demonstrates closely spaced rip-lines through large areas of remnant vegetation indicating the intensity of historical timber extraction practices.

The impact of logging is also evident in the majority of state forests within the SGP study area including Braemar SF, Kumbarilla SF to the west of Dalby and Barakula SF to the north of Chinchilla. However from general observation these logging regimes have been less severe than those applied on freehold land.

A number of ecosystems appear more resilient to landscape-wide processes of degradation. In particular *Eucalyptus fibrosa* subsp. *nubila* forest communities (RE11.7.7) have, in general, a better-preserved canopy structure, a greater number of mature canopy trees, and fewer large canopy gaps. This preservation is likely to be due to the quality and usefulness of the timber resource rather than an inherent ability to recover from disturbance.

While, on balance, the State Forests have retained greater conservation value than vegetation on freehold land, the future of these areas may be affected by changes to fire regime. Within the last 10 years, three extremely hot fires have affected large expanses of State Forest within the SGP study area, and in the case of Kumbarilla State Forest on more than one occasion (see Section 2.4). These hot fires can cause significant damage to the canopy and vegetation composition (by removing fire-sensitive species). It is likely the vegetation will take many decades to fully recovery after a significant wildfire. The frequency and intensity of wildfires are predicted to increase due to climate change (Williams *et al.* 2001), possibly leading to possible broad-scale vegetation changes.

In the northern portion of the SGP study area surrounding Wandoan, the arable clay soils and favourable nature of the gently undulating landscape has promoted widespread land clearing for an intensive cattle grazing land use. Only scattered vestiges of remnant vegetation remain including degraded patches of brigalow and riparian remnants adjacent to drainage lines. These patches have invariably suffered from canopy disturbance and invasion of exotic groundcovers, most notably Buffel Grass (*Cenchrus ciliaris*) and Green Panic (*Megathyrsus maximus var. trichoglume*).

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Appendix A.

GIS Package Contents

Contents of the associated Geodatabase package are outlined in the below table.

Geodatabase Dataset	Contents	Notes
Vegetation		
Arrow_Vegetation	RE mapping, TEC mapping and Threatened species habitat mapping (Core Habitat Possible, General Habitat).	Primary vegetation mapping database which identifies vegetation type in terms of Regional Ecosystem, Threatened Ecological Community and Conservation Status under relevant state and federal legislation. Provides the basis for mapping of EVNT fauna habitats based on vegetation type.
Core Habitat		
Core_Habitat_Flora	Core Habitat Known for all possible, likely or Present flora species	Overlaps the Threatened species mapping in Arrow_Vegetation dataset but takes priority.
Core_Habitat_Fauna	Core Habitat Known for all possible, likely or Present fauna species	Overlaps the Threatened species mapping in Arrow_Vegetation dataset but takes priority.
Ecological Survey Sites		
Flora_Survey_Sites	Compilation of all Secondary, Tertiary, Quaternary and Observation sites collected in floristic ecology surveys commissioned by Arrow Energy since 2009.	Included records from Surat Gas Pipeline Assessments, EIS and Supplementary EIS assessments as well as survey points from the recent 2016 – 2017 surveys.
ESE_Survey_Sites	Location of fauna survey methods completed during current surveys (2016-17)	SGP advanced exploration project works
Daandine_Trapping_Surveys	Location of fauna survey methods completed during Daandine fauna assessments (2014)	Ecosmart Ecology 2014.
SREIS_Trapping_Surveys	Location of fauna survey methods completed during Surat Gas Project supplementary EIS (2013).	3D Environmental (2013)
EVNT_Flora_and_Fauna_Field_Records		
EVNT_Fauna_Field_Records	Terrestrial fauna survey results collected during the current work	Error vetted. Includes geo-referenced sightings and opportunistic records without coordinates. Where opportunistic records have been recorded without specific dates the first day of the survey has been attributed.

Geodatabase Dataset	Contents	Notes
EVNT_Flora_Field_Records	Terrestrial flora survey results for both recent and historical collections in the SGP study area.	Includes EVNT records for all Arrow commissioned survey works from 2009 onwards plus Queensland Herbarium records within the SGP study area.
HerbreCs_SGP_25km_Buffer	Queensland Herbarium database records for EVNT flora species recorded within a 25+km buffer surrounding the SGP assessment area	Queensland Herbarium records within both the SGP and adjacent areas.
Additional Datasets		
ESE+DB_Recs_SGP	All coordinate based fauna records from both database sources and this work within the SGP.	No error vetting and duplicate records likely. Includes only geo-references sightings
SGP_EVNT_Recs	All known Threatened fauna species records within the SGP + 10km buffer	

Appendix B.
Fauna Survey Effort Compared to
EPBC Survey Guidelines

The table below details the recommended survey effort for EPBC threatened taxa compared to survey effort achieved during this work. Note that the recommended EPBC survey effort is based on small project sites.

Scientific Name Common Name	Guideline Requirements							Adjusted for Habitat Extent			ESE Effort	
	Survey Period	Techniques	Value	Effort	Min Duration	Area unit	Notes	Possible BVG's	Extent (ha)	Required effort (approx)		
<i>Delma torquata</i> Collared Delma	Late spring/ summer	Primarily hand searches.	primary	No documented species-specific survey effort. Large survey areas (> 50ha) must include sampling of distinct vegetation types and provide good spatial coverage. Documentation must include justification of survey effort.				10,12,13,16,25	32,771	N/A	122.75 hrs	
		Pitfall traps	supp								1276 trap nights	
<i>Anomalopus mackayi</i>	Late spring/ summer	Active search (when possible)	primary					30	0	N/A	125.25 hrs	
		Pitfall traps	primary								1,276 trap nights	
		Artificial shelter	primary								Nine shelters	
<i>Tympanocryptis condamiensis</i> Condamine Earless Dragon	Late spring/ summer	Pitfall traps	primary					30	0	N/A	1,276 trap nights	
<i>Furina dunmalli</i> Dunmall's Snake	Late spring/ summer	Active search	primary					10,12,13,16,17,18,25,30,34	76,351	N/A	122.75 hrs	
	Late spring/ summer	Pitfall traps	primary								1276 trap nights	
	Late spring/ summer	Road driving	supp								48 hrs	
<i>Anthochaera phrygia</i> Regent Honeyeater	Breeding season	Area search	primary	20hrs	10 days	< 50ha		13,16,17,18,34	15,239	6,095hrs	106 hrs bird survey + 1038 hrs site traverse	
	Peak flowering	Targeted searches	primary	20hrs	10 days	-				6,095hrs	NIL	
<i>Grantiella picta</i> Painted Honeyeater	No survey guidelines								25	176	N/A	106 hrs bird survey + 1038 hrs site traverse
<i>Rostrulata australis</i> Australian Painted Snipe	-	Transect/ area search	primary	10 hrs	3 days	< 50ha		34	1,233	147hrs	106 hrs bird survey + 1038 hrs site traverse (NIL in suitable habitat)	

Scientific Name Common Name	Guideline Requirements							Adjusted for Habitat Extent			ESE Effort
	Survey Period	Techniques	Value	Effort	Min Duration	Area unit	Notes	Possible BVG's	Extent (ha)	Required effort (approx)	
	-	Targeted stationary watches	suppl	10 hrs	5 days	< 50ha				147hrs	NIL
<i>Geophaps scripta scripta</i> Squatter Pigeon	-	Transect/ area search	primary	15hrs	3 days	< 50ha		10,12, 13,16, 17,18, 25,29, 30,34	35,660	1,548hrs	106 hrs bird survey
	-	Flush survey	primary	10hrs	3 days	< 50ha				7,132hrs	1038 hrs site traverse
<i>Petauroides volans</i> Greater Glider	No survey guidelines							13,16, 17,18, 34	52,239	N/A	139.75 hrs foot-based + 27.08 hrs vehicle-based spotlight
<i>Phascolarctos cinereus</i> Koala	-	Indirect signs (scratch/ scat).	primary	No specific survey effort documented. Surveys must undertaken to 'maximise the chance of detection'				13,16, 17,18, 34	52,239	N/A	122.75 hrs active search + 111 SAT searches
	Aug-Jan	direct observation (search/ spotlight)	supp								139.75 hrs foot-based + 27.08 hrs vehicle-based spotlight
<i>Nyctophilus corbeni</i> South-eastern Long-eared Bat	Not cold nights	Harp nets	primary	20 nights	>=5 nights	< 50ha	Mutually exclusive (i.e., don't need both harp and mist nets)	10,12, 13,16, 17,18, 25	75,118	30,047 trap nights	164 trap nights
	Not cold nights	Mist nest	primary	20 nights	>=5 nights	< 50ha					NIL
<i>Chalinolobus dwyeri</i> Large Pied Bat	Not cold nights	Unattended Anabat	primary	16 nights	4 nights	< 50ha		10,12, 13,16, 17,18, 25	75,118	24,038 nights	69 Anabat nights
	Not cold nights	Attended Anabat	primary	6 hrs	3 nights	< 50ha				9,014hrs	NIL
	Not cold nights	harp	supplementary	16 nights	4 nights	< 50ha	Useful near possible roosts			24,038 trap nights	164 trap nights
<i>Dasyurus maculata</i> Spotted-tailed Quoll	-	Active searches	primary	2hrs	1 day	5ha	Recommendation for	10,12, 13,20	28,674	11,469hrs	122.75 hrs active search

<i>Scientific Name</i> Common Name	Guideline Requirements							Adjusted for Habitat Extent			ESE Effort
	Survey Period	Techniques	Value	Effort	Min Duration	Area unit	Notes	Possible BVG's	Extent (ha)	Required effort (approx)	
	-	Hair-tubes	primary	40 tubes	14 nights	5ha	small sites. No guideline for larger sites			3,211,488 trap nights	NIL
	-	Camera trap	primary	10 nights	14 nights	1ha				4,014,360 trap nights	460 camera nights

Appendix C.

Threatened Species Likelihood Assessments

The table below lists flora and fauna species that either known from within 50 km of the SGP or have been identified in the EPBC online Protected Matters search. The Likelihood assessment has been based on the SGP having a Life of Operation of approximately 25 years. Mobile fauna species which could occur within the SGP over this timeframe, but are unlikely to represent a permanent population or a population relying on the SGP for its long-term viability (vagrants) are assessed as 'Transient'.

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
FLORA						
<i>Philotheca sporadica</i> Kogan Waxflower	NT	Vul	Based on field survey observation, the species is universally restricted to open scalds and low <i>Eucalyptus exserta</i> dominant woodlands associated with RE11.7.4.	The extent of habitat including known, core habitat possible and general habitat has been provided within the attached GIS package	There are 11 known populations, seven occur on road verges, seven extend onto freehold land and one population is within Braemar State Forest (Halford 1995c in TSSC 2008j). The extent of known populations and habitat has been expanded considerably as a result of the current assessment.	Present
<i>Acacia barakulensis</i> Waaje Wattle	Vul	-	HERBRECS specimen records indicate species is associated with woodland and shrubland habitats formed by <i>Eucalyptus tenuipes</i> , <i>Corymbia trachyphloia</i> , <i>Calytrix gurulumundensis</i> , and <i>Triodia mitchellii</i> . Habitat is consistent with RE 11.7.4, 11.7.5, 11.7.6, and 11.7.7.	The extent of habitat including core habitat possible and general habitat has been provided within the attached GIS package. The species is considered to possibly occur based on suitability of habitat in the SGP and contiguity of adjacent habitats	Herbrecs identifies 5 confirmed populations 28 km to the north-east of the SGP study area within Barakula State Forest.	Possible

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Acacia curranii</i> Curly Bark Wattle	Vul	Vul	Plants are known to occur in shrubby heaths, dry sclerophyll forests and semi-arid woodlands where they can occur as widely scattered thickets in very species-rich heathy scrub with emergent eucalypts (Pickard 1995c, Threatened Species Scientific Committee 2008). Curly-bark wattle grows on sandy clay soils that are poorly drained on weathered sandstone (Pickard 1995c).	The extent of habitat including core habitat possible and general habitat has been provided within the attached GIS package. The species is considered to possibly occur based on suitability of habitat in the SGP and contiguity of adjacent habitats	Sixteen local populations are recorded in Herbrecks with the nearest population 11 km west of the SGP study area with Gurulmundi State Forest (excluding low precision records).	Possible
<i>Acacia handonis</i> Hando 's Wattle	Vul	Vul	Hando's wattle has only been collected on rocky ridges and slopes on sandstone-derived geology in eucalypt woodland and open forest. The vegetation it grows within is a shrubby woodland of <i>Eucalyptus fibrosa</i> subsp. <i>nubila</i> , <i>Eucalyptus watsoniana</i> subsp. <i>watsoniana</i> , <i>Lysicarpus angustifolius</i> , and <i>Allocasuarina inophloia</i> (Halford 1995). This is consistent with RE11.7.7	The extent of habitat including core habitat possible and general habitat has been provided within the attached GIS package. The species is considered to possibly occur based on suitability of habitat in the SGP and contiguity of adjacent habitats	Seventeen local populations are recorded in Herbrecks with the nearest population 35 km east of the SGP study area within Barakula SF (54 km west-north-west of Miles)	Possible

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Callitris bayleyi</i> Bailey's Callitris	NT	-	A 3D Environmental survey record associated with the Surat EIS (3D Environmental 2011) confirms its presence in low open forest (11-15m) of <i>Eucalyptus exserta</i> , <i>E. crebra</i> and <i>Callitris glaucophylla</i> with a mid-dense shrubby understorey dominated by <i>Micromyrtus sessilis</i> with <i>Acacia crassa</i> , <i>Alphitonia excelsa</i> , and <i>Petalostigma pubescens</i> . Habitat typical of RE11.7.4	Extensive tracts of suitable habitat occur in the central portion of the SGP area. The extent of habitat including core habitat possible and general habitat has been provided within the attached GIS package.	Nearest local record is 2.6 km west of the SGP study area (40 km north of Miles) in Gurulmundi State Forest.	Possible
<i>Calytrix gurulmundensis</i> Gurulmundi Fringe Myrtle	Vul	Vul	Gurulmundi fringe myrtle has been recorded growing in patches of shrubland on very shallow soils (EPA 2002). Soils are lateritic sandstone ridges, which contain yellow sandy-clay that retains moisture (Williams 1979). Vegetation is predominately eucalypt, acacia, casuarina dense shrublands with spinifex, and spinifex grassland with scattered shrubs. This habitat description is consistent with RE 11.7.5 (shrubland on natural scalds on deeply weathered coarse-grained sedimentary rocks).	Suitable habitats include patches of RE11.7.5 and RE11.7.4 in to the west and north-west of the central assessment area. The extent of habitat including core habitat possible and general habitat has been provided within the attached GIS package.	Nearest local record is 12 km west of the SGP study area (30 km north of Miles) within Gurulmundi State Forest. A population also exists in Waaje Scientific Reserve 36 km east of Wandoan.	Possible
<i>Micromyrtus carinata</i>	E	-	Herbreccs records indicate suitable habitat in heathland and low woodland typical of REs 11.7.4 and 11.7.5.	Estimated extent of suitable habitat within the SGP provided in GIS package.	Nearest Herbarium Record is 10km north-west of Miles and 4 km west of the SGP study area on the Wyona Property.	Possible

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Eucalyptus curtisii</i> Plunkett Mallee	NT	-	Lateritic sandstone and sandstone rises/ridges and slopes often with <i>Eucalyptus exserta</i> , <i>E. fibrosa</i> subsp. <i>nubila</i> , <i>Corymbia trachyphloia</i> , and <i>Callitris glaucophylla</i> . Typical habitats include RE11.7.7, 11.7.5 and 11.7.5.	Has potential to occur throughout the SGP study area in suitable habitats. Estimated extent of suitable habitat within the SGP provided in GIS package.	Numerous local records mostly west of the SGP study area with the nearest record 2.5 km west of the SGP study area and 35km north of Miles	Possible
<i>Acacia lauta</i> Tara Wattle	Vul	Vul	Associated with sandy soils hosting ironbark woodland. Known populations have been mapped within REs 11.7.7, 11.7.4 and 11.7.5. These REs provide a representative mix of shrubland and woodland of which ironbark (<i>Eucalyptus crebra</i> , <i>Eucalyptus sideroxylon</i> or <i>Eucalyptus fibrosa</i>) forms a dominant to sub-dominant component (TSSC 2008o).	Populations are localised to the area surrounding Tara and Inglewood. Due to a lack of survey record following comprehensive survey, this species is considered unlikely to occur.	Nearest record is 20km west of the Kumbarilla State Forest in the vicinity of Tara (64 km west of Dalby).	Unlikely
<i>Acacia wardellii</i>	NT	-	The species inhabits gravelly soils on shallow weathered sandstone in eucalypt woodland (Pedley, 1978). Herbreys data (EHP 2013) indicates typical habitats including RE 11.7.4, RE 11.7.7 and RE 11.7.5.	Potential habitats include REs 11.7.4 and 11.7.7 to in the vicinity of Kogan although extensive ground survey in this locality suggest a new population within the SGP is unlikely.	Three populations recorded all approximately 16 km west of the SGP study area and 25 km west of Chinchilla. Greater than 30km west of the nearest suitable habitat near Kogan.	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Cadellia pentastylis</i> Ooline	Vul	Vul	Ooline grows in semi-evergreen vine thickets, brigalow and occasionally in adjacent eucalypt woodland, where it maybe locally dominant in the canopy layer or occur as an emergent (TSSC 2008e) and also residual trees in cleared paddocks. Substrates include clay plains, sandstone and residual ridges (Eddie 2007).	Although Ooline occupies a range of substrates, local records are located in sandstone ravines in Gurulmundi State Forest. There are no known similar habitats in the SGP study area.	Nearest local record is 23 km west of the SGP study area and 50 km NE of Miles, No other local records.	Unlikely
<i>Denhamia parviflora</i> Small-leaved Denhamia	Vul	Vul	Small-leaved Denhamia grows in semi-evergreen vine thickets, vine scrubs and brigalow (<i>Acacia harpophylla</i>) softwood communities on fertile, red brown sandy clay loam hillslopes and crests (DNR 2000).	Suitable habitat and substrate within the assessment area is extremely limited.	2 pre-1985 records located to the east of Chinchilla, approximately 20 km east of the SGP study area.	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Eucalyptus argophloia</i> Chinchilla white gum	Vul	Vul	The existing natural population exists largely in highly disturbed regrowth vegetation with associated tree species including brigalow (<i>Acacia harpophylla</i>), grey box (<i>Eucalyptus molluccana</i> / <i>Eucalyptus microcarpa</i>) white cypress pine (<i>Callitris glauca</i>) and poplar box (<i>Eucalyptus populnea</i>). The tree is associated with red loams, grey brown clays and clay loams of moderate to high fertility (Boland et al. 2006). According to TSSC (2008p), no known populations occur in vegetation classified as remnant under the VM Act.	Suitable red high fertility loamy substrates have not been identified in the assessment area.	Nine records located east of the SGP study area with the nearest population 25 km from the SGP boundary and 18 km north-west of Chinchilla	Unlikely
<i>Eucalyptus virens</i> Shiny-leaved Ironbark	Vul	Vul	The species is known to inhabit plateaus and sandstone escarpments and sandy soils which form low rises. Based on Herbrechts data (EHP 2013), populations are mapped as occurring in association with REs 11.7.7, 11.7.4, 11.7.5, 11.7.6 and 11.5.1, all associated with residual soils.	Suitable habitat present although extensive field survey did not identify any new populations.	Extremely localised population with 2 records from the vicinity of Tara, 9 km west of the SGP study area (64 km west of Dalby).	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Digitaria porrecta</i> Finger Panic Grass	NT	-	Finger panic grass grows in grasslands, woodlands and open forests with a grassy understory, on black soil plains of the Darling Downs, and lighter textured soils to the west (Goodland 2000; Fensham 1998). Fensham (1998) found it is most abundant in grassland, but is “relatively unspecific” in its habitat preference. It is not restricted to high quality native grasslands, but also grows along roadsides and can be found in highly disturbed sites.	The most suitable habitats are associated with derived grassland habitats, typically associated with roadside easements between Chinchilla and Cecil Plains.	Two records within the SGP study area, both in non-remnant derived grasslands adjacent to roadside easements between Dalby and Cecil Plains. Both records collected in 1995. A further 15 records within 25 km east of the SGP study area boundary.	Present
<i>Fimbristylis vagans</i>	E	-	A sedge to 80cm tall that fringes ephemeral watercourses and lagoons on alluvium.	A large number of potential habitats associated with swamps and drainage lines.	A single record from the SGP study area associated with the swampy inlet of Lake Broadwater. Has not been recorded or collected since 1984.	Present
<i>Homopholis belsonii</i>	E	V	Belson’s panic prefers moderate to highly fertile soils, especially those derived from basalt and fertile alluvial flats. It is generally associated with poplar box and brigalow woodlands on light red/brown earths (Fensham and Fairfax 1997, Goodland 2000). It is most likely to be associated with RE11.3.1, 11.3.17, 11.4.3, 11.9.5, 11.9.10.	Regional ecosystems associated with heavy clay, typically brigalow. Scattered remnants of REs 11.3.1, 11.3.17, 11.4.3, 11.9.5, 11.9.10 occur throughout the SGP EIS Area.	A considerable number of records to the east of Dalby with the nearest 12 km from the eastern boundary of the SGP study area. Two records within 8 km of the boundary of the northern study region within 10 km of Wandoan.	Possible

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Cyperus clarus</i>	V	-	Known from heavy soils with records from remnant and disturbed <i>Eucalyptus orgadophila</i> woodland on basaltic soils and grassland on heavy alluvium.	Limited suitable remnant habitat in the assessment area and the species is not known to be associated with non-remnant habitats.	A single 1995 herbarium record exists in the Jandowae area, 18 km east of the SGP study area and 25 km north of Dalby.	Unlikely
<i>Solanum papaverifolium</i>	E	-	Occurs in wetter (swampy) areas of grasslands or open eucalypt woodland on heavy alluvial soils (Goodland 2000). The species is often recorded in non-remnant habitat.	Suitable habitat occurs within derived grassland and associated woodlands typically associated with roadside reserves.	Two records contained within the SGP study area to the south of Dalby with an large number of herbarium records to the east of the SGP study area between Chinchilla and Dalby.	Present
<i>Cymbonotus maidenii</i>	E	-	The species is associated with a range of remnant and non-remnant habits with records occurring on disturbed roadside drains, native and derived grasslands. It is typically associated with heavy brown to grey cracking clay soils (Holland & Funk 2006).	Suitable habitat occurs within derived grassland habitats to the south of Dalby.	Five Herbreces specimens recorded within 10 m of the eastern boundary of the SGP study area, mostly in the Cecil Plains / Millmerran Area including collections on road reserves on the Cecil Plains - Millmerran Road.	Possible
<i>Picris barbarorum</i>	V	-	Known from native grassland (12.3.21) of <i>Dichanthium sericeum</i> in stock routes, road reserves adjacent to disturbed areas such as cultivated paddocks and road and rail lines on black clay soil.	Potential habitat associated with derived grassland in road reserves to the north and south of Dalby.	Four herbarium records within 5km of the SGP study area with the nearest less than 2 km from the assessment area boundary, 14km north-west of Dalby.	Possible

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Rutidosia lanata</i>	NT	-	Mainly found in roadside vegetation of Acacia and Eucalypt woodland/open forest on red sandy ridges and clay flats between 280-320m altitude adjacent to cleared or partly cleared grazing and cropping land (DNR 2000).	Most likely to be recorded within REs 11.3.4, 11.3.2 and 11.3.3 in the vicinity of Chinchilla although may occur in these habitats throughout the entire project area.	Eight Herbarium records within 20 km from the SGP study area, all recorded in the Miles / Chinchilla area.	Possible
<i>Solanum stenopterum</i>	V	-	Occurs in disturbed grassland, <i>Casuarina cristata</i> forest or <i>Eucalyptus populnea</i> woodland on clay soils (Bean 2004).	Derived grassland, Brigalow and grassy woodlands of <i>Eucalyptus populnea</i> between Dalby and Cecil Plains.	Known to occur in non-remnant grassland approximately 7.5km south of Dalby; 3.5 km east of Cecil Plains in a roadside gravel pit; and approximately 6 km south east of Cecil Plains in remnant <i>Eucalyptus populnea</i> woodland on alluvium (11.3.2). All herbarium records outside SGP study area.	Possible
<i>Xerothamnella herbacea</i>	E	E	Occurs in remnant and disturbed brigalow (<i>Acacia harpophylla</i>) and belah (<i>Casuarina cristata</i>) dominated communities in shaded situations, often in leaf litter (TSSC 2008n).	Numerous brigalow habitats (RE11.3.1, 11.4.3, 11.9.5), both remnant and disturbed have potential to host this species.	Two herbarium records to within 20km of the SGP Boundary, 20km to the east and north of Chinchilla.	Possible
<i>Cryptandra ciliata</i>	NT	-	Suitable habitat in eucalypt dominated woodland, lancewood (<i>Acacia shirleyi</i>) woodland and <i>Triodia</i> grassland on rocky on low lateritic and sandstone ridges. Habitat in the PDA is consistent with RE 11.7.5, 11.7.4, 11.7.6, 11.5.1, 11.5.4, 11.5.21.	Woodlands in the Chinchilla / Miles region in the Central assessment area provide for potential habitat for the species.	Three herbarium records within 5km of the assessment area boundary with a single record within 1km of the eastern boundary, 30km to the north of Miles.	Possible

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Pomaderris coomingalensis</i>	E	-	Occurs in Eucalyptus and Callitris woodland in shallow sandy soil or Eucalyptus woodland on hard sandstone jump ups. Herbarium records (DERM 2011) include woodland of narrow leaved ironbark (<i>Eucalyptus crebra</i>) and <i>E. fibrosa subsp nubila</i> .	Extensive areas of potential habitat in the Kogan / Kumbarilla areas in RE11.5.1, 11.7.4 and 11.7.7.	A single record to then west of Kumbarilla State forest, 10km from the west of the SGP study area. Not recorded in field surveys despite extensive survey effort in suitable habitat	Unlikely
<i>Thesium australe</i> Austral toadflax	V	V	Austral toadflax has been collected within popular box (<i>Eucalyptus populnea</i>) woodland on alluvial flats (RE 11.3.2) north-west of Dalby, within the project development area.	Most likely to occur on habitats formed on heavy clay associated with the Condamine Alluvium. RE11.3.2 provides the most suitable habitat within the assessment area.	Two herbarium records within 10km of the SGP study area, with the nearest record 2.7k east of the eastern SGP study area boundary, 25km north west of Dalby.	Possible
FAUNA						
<i>Jalmenus eubulus</i> Pale imperial hairstreak	Vul	-	Restricted to Brigalow (<i>Acacia harpophylla</i>)-dominated woodlands and open-forests, particularly those areas with Belah (<i>Casuarina cristata</i>), emergent eucalypts such as <i>Eucalyptus populnea</i> and understorey shrubs (Breitfuss and Hill 2003; Eastwood et al. 2008).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Three records are located within the SGP, the most recent of which is nearly 20 years old. An additional five records are within 10km of the SGP boundary. The species requires targeted surveys to detect, even during suitable conditions. Current number of records are likely to underestimate abundance and distribution	Likely
<i>Rheodytes leukops</i> Fitzroy River turtle	Vul	Vul	Reliant on faster flowing riffle habitats and generally does not move far from them within its home range (Tucker et al. 2001)	No suitable habitat within the SGP.	Only found in the Fitzroy River catchment. No records within 50km of the SGP boundary.	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Elseya albagula</i> Southern snapping turtle	End	CE	Restricted to clear, flowing, well-oxygenated waters with the Fitzroy, Mary and Burnett Rivers and associated smaller drainages (Todd et al. 2013).	No suitable habitat within the SGP.	No records within 50km of the SGP boundary and not known to occur outside the Fitzroy, Mary and Burnett River catchments.	Unlikely
<i>Strophurus taenicauda</i> Golden-tailed gecko	NT	-	Found mainly in association with brigalow (Acacia harpophylla), cypress (Callitris spp.) and ironbark (Eucalyptus spp.).	Recorded during surveys. Estimated extent of suitable habitat within the SGP provided in GIS package.	Recorded during surveys.	Present
<i>Delma torquata</i> Collared delma	Vul	Vul	Rocky areas associated with dry open forest, and brigalow	Some suitable habitat for the species exists within the SGP, however, rarely recorded within the Brigalow Belt.	No records within 50km of the SGP boundary.	Unlikely
<i>Anomalopus mackayi</i> Long-legged worm-skink	Vul	End	Open grasslands with cracking black soil.	Marginal habitat (derived grasslands) for the species exists within the SGP, particularly in the southern region.	No records within the SGP; one record within 10km of the SGP. Most recent records (<20 years old) centred around Oakey and the Dalby. Never recorded west of the Condamine River.	Unlikely
<i>Egernia rugosa</i> Yakka skink	Vul	Vul	Usually occurs on well-drained, coarse, gritty soils in the vicinity of low ranges, foothills and undulating terrain (Wilson and Swan 2008; Richardson 2006), but can also be found on loam and clay soils (Eddie 2012).	Some suitable habitat for the species exists within the SGP, though the bulk is marginal or unsuitable.	Limited records within the region, one old historic record from within 25km of the SG, and anecdotally said to have been recently recorded somewhere in Barakula SF.	Unlikely
<i>Tympanocryptis condaminensis</i> Condamine Earless Dragon	End	End	Open grasslands and cropland with cracking black soil	Marginal habitat (derived grasslands) for the species exists within the SGP, particularly in the southern region.	Closest record 20km from SGP. No records known west of the Condamine River.	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Aspidites ramsayi</i> Woma	NT	-	Open habitats, brigalow and mulga woodlands, spinifex deserts	Some suitable habitat for the species exists within the SGP.	No records of the species within 50 km of the SGP. SGP outside species typical range.	Unlikely
<i>Acanthopis antarcticus</i> Common Death Adder	Vul	-	Found in a wide variety of habitats, including rainforest, open woodland, shrubland and heath (Wilson and Swan 2003).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Two records of the species are located within 5km of the SGP boundary, including one from 2015.	Possible
<i>Furina dunmalli</i> Dunmall's snake	Vul	Vul	Wide range of habitats, including forests and woodlands dominated by brigalow (<i>Acacia harpophylla</i>) and other <i>Acacia</i> spp., cypress (<i>Callitris</i> spp.) or bullock (<i>Allocasuarina luehmannii</i>) on black alluvial cracking clay and clay loams (Covacevich <i>et al.</i> 1988; Stephenson and Schmida 2008).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Two old records (i.e. >20 years) exist in the southern portion of the SGP. An additional two records are located within 8km outside the SGP area, with the most recent record from 2000.	Possible
<i>Hemiaspis damelii</i> Grey snake	End	-	Inhabits dry eucalypt forest and occasionally pasture, favouring areas of cracking, flood-prone soils along floodplains and near watercourses within the Brigalow Belt (Wilson 2005).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Recorded during surveys.	Present

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Denisonia maculata</i> Ornamental Snake	Vul	Vul	Found in Brigalow (<i>Acacia harpophylla</i>), Gidgee (<i>A. cambagei</i>), Blackwood (<i>A. argyrodendron</i>) or Coolibah (<i>Eucalyptus coolabah</i>)-dominated vegetation communities; can occur in regrowth. Typically associated with black soils (particularly gilgai).	Some suitable habitat for the species exists within the SGP, though suitable remnant habitat is typically fragmented and isolated.	No records within 50km of the SGP boundary. SGP considered outside species typically range.	Unlikely
<i>Botaurus poiciloptilus</i> Australasian Bittern	LC	End	Freshwater wetlands with dense vegetation, particularly reeds and sedges.	There are scattered areas of suitable habitat (i.e. ephemeral waterbodies with dense fringing vegetation in the western portion of Lake Broadwater and Long Swamp). However, these areas are marginal for the species.	Three records exist within 50km of the project area, with the most recent being in 1999. This species is highly vagrant and would be a very rare visitor to the SGP area.	Unlikely
<i>Calidris ferruginea</i> Curlew Sandpiper	End	CE	Saline and freshwater wetlands, saltmarshes, estuaries, mudflats. Prefers areas with exposed mud for foraging.	Estimated extent of suitable habitat within the SGP provided in GIS package.	Four records known from the southern section of the SGP, three at Lake Broadwater. While it is likely to occur at Lake Broadwater, the species has a low probability of occur at other locations within the SGP during Life of Operation.	Transient
<i>Limosa lapponica baureri</i> Bar-tailed Godwit	Vul	Vul	Saline and freshwater wetlands, saltmarshes, estuaries, mudflats. Prefers areas with exposed mud for foraging, usually within proximity to the coast.	Only likely at Lake Broadwater.	With the exception of two pre-1900 records, this species has been recorded on only three occasions between 1980 and 1987. All records are from Lake Broadwater	Unlikely/ Transient

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Rostratula australis</i> Australian Painted Snipe	Vul	End	Found in a wide range of habitats including ephemeral swamps, dams, rice paddocks, waterlogged grasslands, roadside drains and even brackish waterways (Marchant and Higgins 1993).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Six records known from the southern section of the SGP, in the vicinity of Lake Broadwater. The species could occur with the SGP Life of Operation, though most likely restricted to these two areas.	Possible
<i>Pedionomus torquatus</i> Plains-wanderer	Vul	Vul	Open grasslands with patches of bare ground, low sparse shrublands	There is little suitable habitat within the SGP.	Outside of known range and all records are old (ie. >40 years).	Unlikely
<i>Turnix melanogaster</i> Black-breasted button-quail	Vul	Vul	Leaf litter in drier rainforests, vine thickets, lantana on rainforest edges, hoop pine plantation	There is no suitable habitat within the SGP.	Known from state forests north of, but connected to, Barakula State Forest. No known record from the SGP.	Unlikely
<i>Falco hypoleucos</i> Grey Falcon	NT	-	Lightly treed inland plains, gibber deserts, pastoral lands	Open areas of grazing land and derived grasslands might be considered marginal habitat.	Rarely recorded within the Brigalow Belt. The species does not occur with any frequency in the Project Area.	Unlikely
<i>Erythrotriorchis radiata</i> Red goshawk	End	Vul	Open forests, woodlands, wetlands, rainforest fringes	Suitable habitat for the species exists within the SGP.	One record from within the southern portion of the SGP and an addition three records within 20km of the SGP boundary. All records are old (i.e. >30 years) and the species rarely recorded in the Brigalow Belt.	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Geophaps scripta scripta</i> Squatter Pigeon	Vul	Vul	Occurs mainly in dry grassy eucalypt woodlands and open forests and also inhabits cypress pine (<i>Callitris</i> spp.) and Acacia dominated woodlands (Frith 1982)	Suitable habitat for the species exists within the SGP.	Two records exist within the SGP in the central region of the SGP, the most recent in 2012. Despite suitable habitat being present, this species is likely to be vagrant, with individuals not representing a resident or seasonal population. May sporadically occur in the northern and central regions of the SGP during Life of Operation.	Transient
<i>Calyptorhynchus lathami</i> Glossy black-cockatoo	Vul	-	Inhabits woodlands and forests that have abundant <i>Allocasuarina</i> species and abundant large hollows suitable for nesting. Many populations are restricted to remnant vegetation within hills and gullies surrounded by agricultural land (Higgins 1999).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Recorded during surveys.	Present
<i>Lophochroa leadbeateri</i> Major Mitchell's cockatoo	Vul	-	Sparsely timbered open grasslands, <i>Callitris</i> and <i>Casuarina</i> woodlands, mulga woodlands, trees in proximity to watercourses	Some areas of habitat SGP are marginal. Large areas are unsuitable.	Two records exist within the project site in the Lake Broadwater area. However, these records are more than 30 years old and indicate the species does not occur in the area with any frequency.	Unlikely
<i>Lathamus discolor</i> Swift parrot	End	CE	Flowering trees in forests and woodlands	Suitable habitat for the species exists within the SGP.	Records known from outside the SGP and are more than 50 years old. Any possible current or future occurrence would be of vagrant individuals.	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Ninox strenua</i> Powerful owl	Vul	-	Eucalypt forests on ranges with densely vegetated gullies, drier and lower elevation forest with sufficient prey and large hollows	Suitable habitat for the species exists within the SGP.	No records within the SGP and all records are old (i.e. >20 years). Rarely recorded within the Brigalow Belt.	Unlikely
<i>Anthochaera phrygia</i> Regent Honeyeater	End	CE	Forests and woodlands of ironbark, box, swamp mahogany and river oak.	Suitable habitat for the species exists within the SGP.	Only two records exist within 10km of the SGP. Vagrant within the southern Brigalow Belt.	Unlikely
<i>Grantiella picta</i> Painted honeyeater	Vul	Vul	Found mainly in dry open woodlands and forests, particularly box-ironbark woodlands. It may also occur in riparian forest, on plains with scattered eucalypts and in remnant trees on farmland and their occurrence is strongly associated with mistletoe.	Estimated extent of suitable habitat within the SGP provided in GIS package.	Three records within the SGP in the southern portion near Lake Broadwater, and several records located within 10km of the SGP boundary, including records from the past few years. Likely to occur within the SGP infrequently.	Possible
<i>Poephila cincta cincta</i> Black-throated finch	End	End	Grassy scrublands, woodlands, dunes, Pandanus near water	Most areas of open woodland or grassland are heavily grassed and dominated by exotic grasses. Some areas of derived grassland may be suitable.	No longer occurs within local area or region. One record exists of the species within 10 km of the Project Area, however, this record is more than 50 years old.	Unlikely
<i>Dasyurus hallucatus</i> Northern Quoll	LC	End	Most common in rocky eucalypt woodland and open forest within 200 kilometres of the coast.	Some suitable habitat for the species exists within the SGP	No records within 50km of the SGP.	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Dasyurus maculatus maculatus</i> Spotted-tailed quoll	Vul	End	Inhabits a variety of forested habitats including subtropical and temperate rainforests, vine thickets, wet and dry sclerophyll forests, woodland and coastal scrub.	Some suitable habitat for the species exists within the SGP	Three records within the SGP and several within 20km of the SGP boundary, however, all records are old (i.e. >20 years), with the exception of a confirmed sighting of an injured animal near Tara within the past 5 years. This was likely a transient individual. The current status of this species in the Brigalow Belt is uncertain, and transient individuals may occur throughout the SGP, although this would be a rare occasion.	Unlikely
<i>Petauroides volans</i> Greater Glider	Vul	Vul	Mainly restricted to eucalypt forests and woodlands where they typically occur in highest abundance in taller, montane, moist eucalypt forests with larger, relatively old trees and abundant hollows (Eyre 2004). In areas west of the Great Dividing Range, they are found in low woodlands (McKay 2008).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Recorded during surveys.	Present

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Phascolarctos cinereus</i> Koala	Vul	Vul	Found in a diversity of habitats including temperate, sub-tropical and tropical forest, woodland and semi-arid communities, and sclerophyll forest, on foothills, plains and in coastal areas (Dyck & Stratham 2008). On the western side of the Great Dividing Range at the western edges of their range, the species is often associated with riparian vegetation although are not restricted to them (Melzer et al. 2000; Sullivan et al. 2003).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Recorded during surveys.	Present
<i>Petrogale penicillata</i> Brush-tailed Rock-wallaby	Vul	Vul	Inhabits rock piles and cliff lines in vegetation ranging from rainforest to dry sclerophyll forests.	No suitable habitat for the species exists within the SGP	No records within 50km of the SGP.	Unlikely
<i>Pteropus poliocephalus</i> Grey-headed flying-fox	LC	Vul	Foraging habitat includes rainforests, open eucalypt forests, woodlands, Melaleuca swamps and Banksia woodlands. Roosts are commonly within dense vegetation close to water, primarily rainforest patches, stands of Melaleuca, mangroves or riparian vegetation (Nelson 1965).	Suitable foraging habitat for the species exists within the SGP.	Three records within 50km of SGP, including records from 2011. Individuals are known to occasionally use a seasonal flying-fox camp along Myall Creek in Dalby. The species is a typically a vagrant west of the Great Dividing Range and would be a rare visitor to the SGP.	Unlikely
<i>Macroderma gigas</i> Ghost Bat	End	Vul	Habitats used for foraging vary from dry open woodlands to tropical rainforests (Wilmer 2012).	Suitable foraging habitat for the species exists within the SGP.	One very old record (i.e. >200 years) outside of the SGP. Presumed locally extinct in the area.	Unlikely

Scientific Name Common Name	Status [#]		Typical Habitat	Habitat within the SGP	Local Records	Likelihood Assessment
	NCA	EPBC				
<i>Chalinolobus dwyeri</i> Large-eared Pied Bat	Vul	Vul	Often observed along ecotones on rainforest edges or in association with sandstone escarpments (DoE 2017).	No suitable habitat for the species exists within the SGP.	No records within 50km of the SGP.	Unlikely
<i>Nyctophilus corbeni</i> South-eastern long-eared bat	Vul	Vul	Found more commonly in box/ironbark/cypress pine woodland on sandy soils. It also occurs in bulloak (<i>Allocasuarina luehmannii</i>), brigalow (<i>Acacia harpophylla</i>) and belah (<i>Casuarina cristata</i>) communities (Turbill and Ellis 2006; Churchill 2008).	Estimated extent of suitable habitat within the SGP provided in GIS package.	Recorded during surveys.	Present
<i>Pseudomys australis</i> Plains Rat	End	Vul	Cracking clay depressions and small drainage lines on arid gibber plains, and vast, cracking clay plains (Van Dyck et al 2013).	No suitable habitat for the species exists within the SGP	One very old record (i.e. >100 years) within 10km outside of the SGP. Presumed locally extinct in the area.	Unlikely

[#] LC = Least Concern, NT = Near Threatened, Vul = Vulnerable, E = Endangered, CE = Critically Endangered, Mig = Migratory

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Appendix D.
Threatened Ecological Communities
and Regional Ecosystem Descriptions

THREATENED ECOLOGICAL COMMUNITIES

Brigalow Dominant and Co-dominant

Status

Endangered EPBC Act: Component Regional Ecosystem 11.3.1, 11.4.3/11.4.3a, 11.9.5
Endangered under the VM Act and Biodiversity Act.

Total number of survey sites:

70 Sites in Total (RE11.3.1- 11 Secondary, 23 Quaternary; RE11.4.3 - 8 Secondary, 19 Quaternary; 11.9.5 – 2 Secondary, 7 Quaternary).

Within the SGP assessment area, the Brigalow Dominant and Co-dominant Ecological Community comprises the following REs:

- RE11.3.1 (*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains)
- RE11.4.3/ 11.4.3a *Acacia harpophylla* and/or *Casuarina cristata* shrubby open forest on Cainozoic clay plains)
- RE11.9.5 (*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks)

Other relevant habitats included in the ecological community include Brigalow regrowth >15 yrs old which have similarly been mapped under the Brigalow ecological community.

Regional Ecosystem 11.3.1

The ecosystem has been highly fragmented throughout its range, generally existing as linear remnants within roadside reserves and stock routes. The most extensive occurrences are located on the floodplain of the Condamine River and Wilkie Creek to the west of Dalby with scattered occurrences occurring throughout the broader project development area. Typical canopy heights range from 15 to 23 m in better preserved examples where projected canopy covers range 30 to 60%. Whilst *Acacia harpophylla* generally forms the dominant canopy, *Casuarina cristata* predominates in some locations. Typical sub-canopy trees include *Acacia harpophylla*, and *Casuarina cristata* with shrubby layers often dominated by *Geijera parviflora*, *Pittosporum angustifolium*, *Melaleuca bracteata*, *Alectryon oleofolius* subsp. *elongatus*, *Alectryon diversifolius*, *Elaeodendron australe* var. *integrifolium*, *Ehretia membranifolium*, and *Opuntia stricta**. Ground cover percentage is variable with typical species being *Paspalidium caespitosum*, *Ancistrachne uncinulata*, *Aristida* spp., *Enychleana tomentosa*, *Rhagodia spinescens*, *Einadia hastata*, and *Solanum parvifolium*, although *Harissia martinii** and *Bryophyllum delagoense** may be typically abundant.

Community condition is typically poor, a testament to edge effects created by massive fragmentation. The class 2 declared weed species prickly pear (*Opuntia stricta*), velvet pear (*Opuntia tomentosa*) and harissa cactus (*Harissia martinii*) are highly prominent in shrub and ground layers and frequent canopy gaps, caused by canopy dieback and senescence in the absence of recruitment is a compounding problem.



Tall brigalow woodland (RE11.3.1) on the alluvial plain of Wilkie Creek (Site AS138).

Regional Ecosystem 11.4.3

The distinction between RE11.3.1 and RE11.4.3 is based largely on landscape position rather than any recognisable floristic expression. RE11.3.1 by definition, occupies alluvial landforms, and as such is associated with flood plains, river terraces and associated drainage depressions and swamps. The heavy clay soils associated with land zone (LZ) 4 are raised above the influence of current river systems and in the majority cases, this provides the only basis for distinction. Both ecosystems occupy heavy clay soils with shrink and swell properties (vertisols) and gilgai micro-topography.

The productivity of the associated soil types has resulted in extensive fragmentation of this ecosystem and remaining occurrences are generally highly fragmented and isolated. Intact examples are generally associated with stock routes where the remnants, although linear, are generally continuous with adjacent ecosystems. The Chinchilla Sporting Shooters Club (which is located on the Chinchilla Sands Local Fossil Fauna Site) hosts one of the better preserved and more extensive examples observed with the project development area. In this location *Acacia harpophylla* forms the dominant canopy to 25 m, mixed to varying degrees with *Casuarina cristata* with a predominant canopy cover ranging from 30% to 60% dependant largely on habitat condition. The sub-canopy is typically formed by *Acacia harpophylla* and *Casuarina cristata* mixed with a range of vine thicket shrubs and trees including *Geijera parviflora*, *Ehretia membranifolia*, *Alectryon oleifolia* subsp. *elongatus* and *Carissa ovata*.

The classification also includes RE11.4.3a, a wetland community formed by *Eucalyptus woollsiana* with a sub-canopy formed by *Melaleuca bracteata* (Site AQ163). A relatively extensive area is mapped within PL 253 (in the Linc-Energy operational area) although this area was assessed remotely and requires ground truthing to confirm the true nature of the habitat for confirmation.

The community is degraded throughout much of its range with sub-canopy layers often dominated by *Opuntia spp.* and *Harissia martini*. Canopy dieback, although a natural feature of the brigalow community, is severe in some locations. Excessive light penetration through a dramatically reduced canopy cover has further promoted the invasion of exotic species into the ground cover and shrub layers.



Well-developed woodland of *Acacia harpophylla* and *Casuarina cristata* characteristic of RE11.4.3.

Regional Ecosystem 11.9.5

This ecosystem was sampled in one locality to the west of Wandoan where it formed an open forest of *Acacia harpophylla* mixing with *Casuarina cristata* and emergent of *Brachychiton rupestris*. The canopy typically form 60% cover and canopy heights reaching 23m. Shrub layers are typically mid-dense and predominantly occupied by *geijera parviflora*, *Eremophila mitchellii* and *Santalum lanceolatum*. RE11.9.5 forms small scattered remnants throughout the rolling sedimentary landscapes of the Wandoan region in the northern portion of the SGP assessment area.



Fragmented patch of RE11.9.5 in the Wandoan area.

Weeping Myall Woodlands

Status

Endangered EPBC Act (Not Represented in VM Act)

Total Number of Survey Sites

2 Secondary

In Queensland, the Weeping Myall Woodlands TEC is known to occur as small patches within REs 11.3.2 and 11.3.28 (DEWHA, 2009a), although the latter ecosystem is not known to occur in the project development area. The best-preserved examples are typically associated with road reserves and stock routes although the community is not considered to form woodland communities of sufficient extent to be consistently separated as an ecosystem. As such, the community is not recognised as an individual ecosystem within the framework of Queensland's VM Act. The patchy nature of the community also makes delineation difficult, hence the ecological community may be easily overlooked. Based on descriptions provided by DEWHA (2009a) and TSSC (2008t), the following applies to the Weeping Myall Woodlands TEC:

- The Weeping Myall Woodlands TEC range from open woodlands to woodlands, generally 4 to 12m high. The overstorey is dominated by weeping myall (*Acacia pendula*) trees and in

some cases this species may be the only tree canopy species. Other common names for weeping myall include myall, boree, balaar, nilyah, bastard gidgee, and silver leaf boree.

- Other woodland species may also form part of the overstorey of the ecological community. These include: western rosewood (*Alectryon oleifolius* subsp. *elongatus*); poplar box (*Eucalyptus populnea*); or black box (*Eucalyptus largiflorens*). Grey mistletoe (*Amyema quandang*) commonly occurs on the branches of weeping myall trees throughout the ecological community's range.
- The Weeping Myall Woodlands ecological community can naturally occur either as a grassy or a shrubby woodland. However, the understorey often includes an open layer of shrubs over a ground layer which includes a diversity of grasses and forbs. The ground layers can vary in species composition and cover depending on past and current grazing regimes, and the occurrence of recent rain.

The following condition thresholds for the Weeping Myall Ecological Community apply based on DEWHA (2009):

- The patch of woodland must be at least 0.5 ha (5000 m²) in size.
- The overstorey must have at least 5 per cent tree canopy cover or at least 25 dead or defoliated mature weeping myall trees per hectare.
- The tree canopy must be dominated (at least 50 per cent of trees present) by living, dead or defoliated weeping myall trees.
- The patch has more than two layers of regenerating weeping myall present.

A single occurrence of the Weeping Myall Ecological Community was observed in the Theten area although the habitat was not recorded within any other location within the SGP assessment area. The observed community formed a low open woodland with canopy heights ranging from 6 m to 10 m with a lower shrub layer at 3m to 6m, merging with a lower shrub layer. The projected canopy cover of the community was formed by 55 % cover of weeping myall (*Acacia pendula*) with scattered eucalypts including poplar box (*Eucalyptus populnea*) forming less than four % of the upper strata. Ground cover is formed by predominantly native graminoids and soils were moist, becoming saturated in depressions. The community was fringed by regrowth woodland of Poplar Box and Queensland Blue Gum (*Eucalyptus tereticornis*) although there is no clear indication that the ecological community originally occurred within RE 11.3.2. The extent of the ecological community at this location was 0.85 ha, well within patch size thresholds. Regional distribution mapping provided by DEWHA (2009) indicates the greatest likelihood for occurrence of the Weeping Myall TC is in a band that stretches from Roma to Blackall, west of the project development area meaning that any occurrences are highly significant, representing the eastern limits of the ecological community distribution.



The Weeping Myall TEC in the Theten area (survey site GB82).

Coolibah – Black Box Woodland

Status

Endangered EPBC Act: Component Regional Ecosystems 11.3.3 (Of Concern VM Act and Biodiversity Status)

Total number of survey sites across project area

3 Sites in Total (3 Secondary).

The Coolibah – Black Box Woodlands TEC represents occurrences of one type of eucalypt woodland where *Eucalyptus coolabah* subsp. *coolabah* (coolibah) and/or *Eucalyptus largiflorens* (black box) are the dominant canopy species and where the understory tends to be grassy (TSSC 2011a). The condition thresholds to identify the ecological community are provided below (from TSSC 2011b):

- Patch size: The minimum patch size is 5 ha which may include areas of native vegetation that may be naturally open or contain regrowth.
- The crown cover of trees must be > 8 %.
- Coolibah and coolibah and/or black box in the tree canopy must be present in the patch that are either mature trees with a DBH > 30cm; are coppiced trees with a main stem > 20cm or; hollow bearing trees.
- The ecological community must have a ground-cover in which 10% or more contains native graminoids, herbs or shrubs.

Whilst RE11.3.3 is mapped relatively broadly in certified regional ecosystem mapping (Version 8.0, 2017) in the Chinchilla region, and *Eucalyptus coolabah* occurs as a component tree in riparian habitats of the Condamine River, the majority of these patches are considered too small or degraded to provide representation of the TEC. A few minor occurrences are however identified on the Theten property and the adjacent habitats of Wilkie Creek where they occupy a combined area of 23 ha with the largest patch covering an area of 10ha. Typical canopy heights range from 10 – 15m and up to 40 % projected canopy cover. Ground layers are dominated by native species (> 60 %) including a range of native graminoids and forbs (*Eleocharis* spp. *Walwhelleya subxerophila* and *Marsilea drummondii* predominate). Exotic species, which form < 20% of the ground cover are dominated by lippia (*Phyla canescens*). The habitat typically occupies broad drainage depressions and overflow channels on major watercourses.



Coolibah / Black Box Woodland Ecological Community (RE11.3.3) on Theten (survey site GB74_2433)

OTHER ENDANGERED/OF CONCERN REGIONAL ECOSYSTEMS

Regional Ecosystem 11.3.17

Eucalyptus populnea woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains

Status

VMA Status: Endangered

Biodiversity Status: Endangered

Total number of survey sites across project area

15 Sites in Total (1 Secondary and 14 Quaternary / Observation).

This community occurs on alluvial plains, typically near watercourses with the largest representations in the southern survey area in the Lake Broadwater Region. The habitat is also mapped in the northern assessment area near Wandoan. In a typical occurrence, the canopy is dominated by Poplar Box (*Eucalyptus populnea*) and ranges between 16-26m in height with a mean PPC of 40%. Additional trees in the canopy layer are Belah (*Casuarina cristata*), Brigalow (*Acacia harpophylla*) and occasional Grey Box (*Eucalyptus woollsiana*). The second tree layer is well developed and comprises the above canopy species together with Western Rosewood (*Alectryon oleofolius*), Weeping Pittosporum (*Pittosporum angustifolium*) Sally Wattle (*Acacia salicina*), *Casuarina cristata* and other associated species including *Callitris glaucophylla*, *Alectryon oleofolius* subsp. *elongatus*, *Melaleuca bracteata*, and *Alphitonia excelsa*. The shrub layer is typically dominated by a sparse cover of *Geijera parviflora*, *Citrus glauca*, *Capparis mitchellii*, and *Elaeodendron australe* var. *integrifolium*. Exotic ground covers, in particular Lippia (*Phyla canescens**) in the south and Buffel Grass (*Cenchrus ciliaris*) Green Panic (*Megathyrsus maximus* var. *trichoglume*) contribute to approximately 50% of the overall cover, with scattered infestations of Harissa Cactus (*Harissia martin**), Noogoora Bur (*Xanthium occidentale**), and Mayne's Pest (*Verbena aristigera**), African Love Grass (*Eragrostis curvula**), Paspalum (*Paspalum dilatatum**), and Giant Panic (*Megathyrsus maximus* var. *maximus**). Native grasses and sedges dominate the cover.



Degraded patch of RE11.3.17 in the Wandoan region (Site DS155_300).

Regional Ecosystem 11.3.2

Eucalyptus populnea woodland on alluvial plains.

Status

VMA Status: Of concern

Biodiversity Status: Of concern

Total number of survey sites across project area

54 Sites in Total (9 Secondary and 45 Quaternary / Observation).

This community is consistently dominated by poplar box (*Eucalyptus populnea*) with a canopy height ranging between 10-16m and a mean crown cover of 41%. Associated canopy trees may include Queensland Blue Gum (*Eucalyptus tereticornis*) and Moreton Bay Ash (*Corymbia tessellaris*). A sparse second tree layer comprises the above canopy species. The shrub layer is generally poorly developed with scattered poplar box saplings and occasional shrubs of velvet pear (*Opuntia tomentosa**).

The groundcover is often weedy, affected by infestations of Buffel Grass (*Cenchrus ciliaris*), African Love Grass (*Eragrostis curvula**), Lippia (*Phyla canescens*), Mayne's pest (*Verbena aristigera**), Harissa Cactus (*Harissia martin**) and Mother of Millions (*Bryophyllum*

delagoense) in some localities, which contribute to a mean exotic cover of 35% across all survey sites. Dominant graminoid species include *Aristida caput-medusae*, *Aristida acuta*, *Chloris truncata*, *Dichanthium sericeum* subsp. *sericeum*, *Digitaria brownii*, *Eulalia aurea*, and *Paspalidium* sp., with common native herbs of *Chrysocephalum apiculatum*, *Cheilanthes sieberi*, *Cyanthillium cinereum*, *Desmodium campylocaulon*, *Rostellularia adscendens*, and *Wahlenbergia communis*.

There is often some evidence of selective thinning of the canopy species, although large mature trees remain throughout with evidence of canopy recruitment in the shrub layers in most habitats.



Well preserved representation of RE11.3.2 in the Central Assessment Area (Site DS132_275).

Regional Ecosystem 11.3.4

Eucalyptus tereticornis and/or *Eucalyptus* spp. tall woodland on alluvial plains.

Status

VMA Status: Of concern

Biodiversity Status: Of concern

Total number of survey sites across project area

52 Sites in Total (12 Secondary and 40 Quaternary / Observation).

This ecosystem occurs on seasonally flooded alluvial plains associated with both minor and major drainage lines. The canopy height ranges between 14-24m and a mean crown cover of 28 - 45%. A typical representation is dominated by Queensland blue gum (*Eucalyptus tereticornis*) and rough-barked apple (*Angophora floribunda*) mixed with other species including Moreton Bay Ash (*Corymbia tessellaris*) and occasional Poplar Box (*Eucalyptus populnea*). The relative proportions of these tree varies with rough-barked apple dominant in some habitats, particularly along the frontage of Wambo Creek.

The second tree layer is sparse and comprises the above canopy species together with *Acacia salicina* and kurrajong (*Brachychiton populnea*). The shrub layer ranges between 1-4 m in height with a mean cover of 22%. Dominant species are Moon Wattle (*Acacia semilunata*) in the northern area with frequent Yellow Tea Tree (*Leptospermum polygalifolium*), Black Wattle (*Acacia leiocalyx*), Glory Wattle (*Acacia spectabilis*), Wilga (*Geijera parviflora*), and Paper Bark (*Melaleuca decora*).

The ground layer is variable ranging from good condition in the habitats surrounding Miles to highly degraded in habitats associated with the Condamine River Flood Plain in the Dalby region. Typical native groundcover species include *Lomandra longifolia*, *Aristida caput-medusae*, *Aristida acuta*, *Chloris truncata*, *Dichanthium sericeum* subsp. *sericeum*, *Digitaria brownii*, *Eulalia aurea*, *Gahnia aspera*, *Heteropogon contortus*, *Juncus continuus*, and *Paspalidium* sp., with common native herbs including *Chrysocephalum apiculatum*, *Cheilanthes sieberi*, *Cyanthillium cinereum*, *Desmodium campylocaulon*, *Dianella longifolia* var. *longifolia*, *Rostellularia adscendens*, and *Wahlenbergia communis*. Exotic species associated with this regional ecosystem include Green Panic (*Panicum maximum* var. *trichoglume*) limited to scattered occurrences Mayne's Pest (*Verbena aristigera**), Buffel Grass (*Pennisetum ciliare**) and Liverseed Grass (*Urochloa mosambicensis**).

There is some evidence of selective thinning in many locations and canopy recruitment is lacking in some habitats along the Condamine River where grazing pressure is particularly high. Heavily grazed fringe of RE11.3.4 along the Condamine River



Heavily grazed fringe of RE11.3.4 along the Condamine River

Regional Ecosystem 11.3.25

Eucalyptus camaldulensis or *Eucalyptus tereticornis* open-forest to woodland. Occurs on fringing levees and banks of major rivers and drainage lines of alluvial plains.

Status

VMA Status: Least concern

Biodiversity Status: Of concern

Total number of survey sites across project area

130 Sites in Total (17 Secondary, 4 Tertiary and 109 Quaternary / Observation).

Maximum development of RE11.3.25 is associated with the riparian margins of the lines of Condamine River and larger tributaries such as Wilkie Creek. The ecosystem however occurs broadly throughout the SGP assessment areas where it fringes both major and minor drainage lines. At its maximum development, canopy heights range from 23 - 33 metres and a mean crown cover of 46%. Dominant canopy trees are River Red Gum (*Eucalyptus camaldulensis*) and Queensland Blue Gum (*Eucalyptus tereticornis*), Rough Barked Apple (*Angophora floribunda*) and Moreton Bay Ash (*Corymbia tessellaris*). A sparse sub-canopy is dominated by the above species with occasional willow wattle (*Acacia salicina*) and cooba (*Acacia*

stenophylla). Shrub cover is very sparse (0-5% cover) with scattered willow wattle, cooba and prickly mimosa (*Acacia farnesiana**). The sparse ground cover which averages at 23% is attributed to scouring of groundcover species from recent flood events. Mean cover is dominated by exotic species with grasses such as Green Panic (*Megathyrsus maximus var. trichoglume**), Purple Top Rhodes (*Chloris virgata**), and Couch Grass (*Cynodon dactylon**). Saltwater Couch (*Sporobolus virginicus*) was also a dominant cover on some sections of Wilkie Creek, being an indication of salinity. Natives such as Mat rush (*Lomandra longifolia*) and Blady Grass (*Imperata cylindrica*) characterise the native component of the groundcover in most habitats examined.



Weedy representation of RE11.3.25 on the Condamine River.

Regional Ecosystem 11.3.27

Palustrine wetland (vegetated swamp).

Status

VMA Status: Least concern

Biodiversity Status: Of concern

Total number of survey sites across project area

28 Sites in Total (7 Secondary, 21 Quaternary / Observation).

Floodplain wetlands are generally associated with the flood overflow channels characteristic of the flood plains of major river systems throughout the SGP assessment area. The wetlands play an important hydrological role, facilitating nutrient exchange between aquatic and terrestrial ecosystems during periods of seasonal overbank flow. The Condamine River floodplain hosts a complex wetland system with RE11.3.27 forming mosaics with RE11.3.25, 11.3.2 and 11.3.4 throughout its entire length with a variety of wetland types recognised.

Lake Broadwater, mapped as RE11.3.27a (Freshwater Lake) is a seasonal water feature that is recognised nationally for its natural values, being significant at a national and state level. The lake is listed on the Directory of Important Wetlands and is recognised as being a rare example of a semi-permanent freshwater lake in the bioregional area (Blackman *et al.* 1999).

Long Swamp, a similar vegetated wetland ecosystem that discharges on a seasonal basis into Wilkie Creek. Representation of the feature as RE11.3.2 in Certified RE Mapping (DERM 2009b) is incorrect with field survey confirming features typical of RE11.3.27d (palustrine wetland). Long Swamp is heavily utilised for irrigation purposes which has undoubtedly affected hydrological function, species composition of the ground layers, the vigour of the canopy trees and reduced its overall biodiversity values. Long Swamp is a sinuous hydrological feature (overland flow path) that flows across the Condamine Alluvium in a north-westerly direction to the east and north of Lake Broadwater, before joining with Wilkie Creek to the west. The feature occupies a broad depression on the alluvium with the central portion of the depression formed by heavy clay. Surface water is present seasonally and following dry spells the associated vertosol soils form deep hummocks and cracks. There was no flow, nor any significant pooled water within Long swamp during the field visits, despite heavy recent rains. These observations together with the observations of deep, open cracks in the central swamp channel soil surface confirmed that the feature is only active during flooding.

Vegetation is predominantly native with although exotic groundcovers predominant in some localities. The canopy is formed by tall, broadly spaced River Red Gum (*Eucalyptus camaldulensis*) at approximately 15 - 30% cover with Poplar Box (*Eucalyptus populnea*) forming on the swampy margins. The canopy is significantly stressed in some areas with signs of senescence and foliage loss in the Red Gums which predominate the canopy. The noted senescence can largely be attributed to historic groundwater drawdown in shallow sandy alluvial aquifers, compounded by surface water extraction for irrigation (Kath et al 2014; 3D Environmental 2016).

Of the four secondary vegetation survey sites completed during the dry season survey (DS21, DS22, DS26, DS31 completed when the swamp was dry), exotic vegetation cover contributed on average to 15% to the total groundcover, and formed 39% of the total living groundcover mixing with native species including Nardoo (*Marsilea drummondii*), Water Chestnut (*Eleocharis dulcis*) and scattered native grasses including *Panicum decompositum*. Lippia (*Phylla canescens*) was the most abundant exotic forb blanketing the clay soils, particularly where grazing pressure is most intense. It should be noted that groundcover composition will vary seasonally with native aquatic sedges, particularly Water Chestnut becoming dominant during periods of standing surface water.



Long Swamp with characteristic River Red Gum (*Eucalyptus camaldulensis*) showing moderate signs of stress as suggested by foliage loss.

The most extensive of the wetland types is RE11.3.27c which forms by the extensive floodplain system of channel overflows and anabranches that are seasonally activated during periods of overbank flow. The regional ecosystem sub-type is associated with the alluvial depressions along the Condamine River floodplain. It is a palustrine wetland ecosystem with an overstorey of scattered River Red Gum over a sedgeland groundcover with semi-permanent water. The composition of the ground cover is simple and limited to Water Chestnut (*Eleocharis plana*), Juncus (*Juncus continuus*) with scattered native herbs such as Lesser joyweed (*Alternanthera denticulata*) and Eclipta (*Eclipta prostrata*). Infestations of Lippia (*Phyla canescens*) occur throughout the ecosystem, although are generally only evident when wetlands are dry.



Overflow channel of the Condamine River providing representation of RE11.3.27c. The system was seasonally dry and ground cover was dominated by a dense infestation of Lippia.

Regional Ecosystem 11.9.7

Acacia harpophylla, Eucalyptus populnea open forest on fine-grained sedimentary rocks

Status

VMA Status: Of Concern

Biodiversity Status: Endangered

Total number of survey sites across project area

1 Quaternary

A single small polygon of 1.5ha is located in the northern assessment area, representing a remnant sliver that runs along a footslope, contiguous with remnant riparian vegetation on a creek line. The canopy has been fragmented with a cover of up to 30% and canopy heights range from 18 to 23m. The sub-canopy and shrub layers are sparse, typically < 5% cover formed by Wilga (*Geijera parviflora*) and Sandalwood (*Santalum lanceolatum*). Whilst the habitat has been subject to heavy grazing, the ground covers are predominantly native and are formed by *Themeda triandra*, *Dicanthium sericeum*, *Paspalideum caespitosum*, and *Chloris ventricosa*.

Regional Ecosystem 11.9.10

Acacia harpophylla, Eucalyptus populnea open forest on fine-grained sedimentary rocks

Status

VMA Status: Of Concern

Biodiversity Status: Endangered

Total number of survey sites across project area

3 Sites in Total (3 Quaternary)

Small scattered remnants are located in the northern assessment area with the fragmented landscapes surrounding Wandoan where patch sizes are typically 1 to 2ha. The ecosystem exists in small remnants that are isolated from larger patches of remnant vegetation. Canopy heights are generally in the range of 9 to 16m with up to 35 % projected canopy cover formed by *Eucalyptus populnea* and a sub-canopy of *Acacia harpophylla*, *Casuarina cristata* and occasional *Callitris glaucophylla*. Shrub layers are sparse (10 – 20%) dominated by *Geijera parviflora*, *Eremophila mitchellii* and *Atalaya hemiglauca*. Ground covers are formed by a mix of native and exotic species including *Paspalidium caespitosum*, *Sporobolus creber*, *Aristida ramosa*, *Capparis lasiantha*, *Sclerolaena sp.*, *Enchylaena tomentosa*, *Sida sp.*, *Nyssanthus diffusa*, *Senecio brigalowensis*, *Salsola australis*, *Bothriochloa decipiens*, *Enteropogon acicularis*, *Aristida calycina*, *Enteropogon ramosus*, *Sporobolus caroli* and patches of Buffel Grass (*Cenchrus ciliaris*).



Regional ecosystem 11.9.10 at Site Q69_631 near Wandoan.

LEAST CONCERN REGIONAL ECOSYSTEMS

Regional Ecosystem 11.3.14

Eucalyptus tereticornis and/or *Eucalyptus* spp. tall woodland on alluvial plains.

Status

VMA Status: Least Concern

Biodiversity Status: No Concern at Present

Total number of survey sites across project area

31 Sites in Total (8 Secondary, 1 Tertiary and 22 Quaternary / Observation).

This ecosystem is associated with both shallow alluvial depressions and sandy rises on flood plains where it is characterised by mix of eucalyptus species including River Red Gum (*Eucalyptus camaldulensis*), Rough Barked Apple (*Angophora floribunda*), Smooth Barked Apple (*Angophora leiocarpa*) and an often dense to mid-dense sub-canopy of *Callitris glaucophylla*. Sub-canopy is variable although habitats on sandy substrates are often characterised by a mid-dense sub-canopy of *Callitris glaucophylla* and Black Wattle (*Acacia leiocalyx*). The canopy height ranges between 18-26m and canopy cover that ranges from 40 to 65%. Ground covers are generally intact, formed by dense swards of Blady Grass (*Imperata*

cylindrica), Reed Grass (*Arundinella nepalensis*), *Heteropogon contortus* and often dense cover of Mat-rush (*Lomandra longifolia*).



RE11.3.14 associated with a sandy rise above the Condamine River Flood Plain (AS12_2346)

Regional Ecosystem 11.3.18

Eucalyptus populnea, *Callitris glaucophylla*, *Allocasuarina luehmannii* shrubby woodland on alluvium

Status

VMA Status: Least Concern

Biodiversity Status: No Concern at Present

Total number of survey sites across project area

13 Sites in Total (2 Secondary, 11 Quaternary / Observation).

Regional ecosystem RE 11.3.18 is restricted to the southern assessment area where it occupies sandy alluvial associated with largely with ephemeral watercourses. Canopy heights range from 12 – 23m with typical canopy cover of 35 – 45%. The dominant canopy tree is Poplar Box (*Eucalyptus populnea*) with occasional Moreton Bay Ash (*Corymbia tessellaris*), Rough Barked Apple (*Angophora floribunda*) and Narrow leafed Ironbark (*Eucalyptus crebra*). The sub-canopy and shrub layer is universally occupied by a dense to mid-dense sub-canopy of White Cypress (*Callitris glaucophylla*) and less abundant Bulloke (*Allocasuarina leuhmannii*) with Sally Wattle (*Acacia salicina*) and Black Wattle (*Acacia leiocalyx*) generally associated. Ground cover is typically native, often with dense mats of Matrush (*Lomandra longifolia*) and native grasses including *Chrysopogon fallax*, Kangaroo Grass (*Themeda triandra*), *Chloris truncata*, Black Spear Grass (*Heteropogon contortus*) and *Aristida caput-medusae* in areas of poorer soil. African Love Grass (*Eragrostis curvula*) is prominent in some occurrences south of Dalby and Mother of Millions forms a dense infestation in habitats associated with Braemar Creek.



RE11.3.18 at site on a broad drainage channel in the Tipton Area (GB101_2402)

Regional Ecosystem 11.3.26

Eucalyptus moluccana or *E. microcarpa* woodland to open forest on margins of alluvial plains.

Status

VMA Status: Least Concern

Biodiversity Status: No Concern at Present

Total number of survey sites across project area

8 Sites in Total (3 Secondary, 5 Quaternary / Observation).

Small areas (25ha in total) occur in the southern and central assessment areas on broad loamy flats formed from alluvial outwash. Canopy heights range from 12 – 22m with typical canopy cover ranging from 25 to 55%. The dominant canopy tree is Grey Box (*Eucalyptus woollsiana*) occasionally with scattered Poplar Box (*Eucalyptus populnea*) in the sub-canopy. Shrub layers are typically sparse formed by Grey Box, *Acacia semilunata* and Bulloke (*Allocasuarina leuhmannii*). The ground layer is also sparse with up to 40% living cover of *Eragrostis bimaculate*, *Aristida caput-medusae*, *Gahnia aspera*, Variable Sword Sedge (*Lepidosperma laterale*) and the low shrub *Dodonaea macrocarpa*. Regional Ecosystem 11.3.26 provides habitat for the Endangered sedge *Fimbristylis vagans* in the Lake Broadwater area.

Regional Ecosystem 11.5.1

Eucalyptus crebra, *Callitris glaucophylla*, *Angophora leiocarpa*, *Allocasuarina leuhmannii* woodland on Cainozoic sand plains/remnant surfaces.

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

542 Sites in Total (30 Secondary, 2 Tertiary, 510 Quaternary / Observation).

Regional Ecosystem 11.5.1, including sub-type 11.5.1a is the most extensive habitat type in the SGP assessment area. The ecosystem occurs on loamy to sandy clay soils which are associated with extensive areas of broad, flat to gently undulating plains. The typical canopy height ranges between 10-22m and a mean crown cover of 37%. It is dominated by Narrow Leaf Ironbark (*Eucalyptus crebra* / *Eucalyptus elegans*) with associated Smooth Barked Apple (*Angophora leiocarpa*), White Cypress (*Callitris glaucophylla*) and Poplar Box (*Eucalyptus populnea*). Where Poplar Box is dominant, the ecosystem is mapped as RE11.5.1a. A sparse second tree layer has an average height of 8.5m and is dominated by White Cypress (*Callitris glaucophylla*) and Bulloke (*Allocasuarina leuhmannii*) with less frequent narrow leaf ironbark.

A diverse upper shrub layer ranges between 5-30% in cover with a mean height of 4%. Bulloke and White Cypress predominate across all sites surveyed. Other typical species are Moon Wattle (*Acacia semilunata*), *Acacia ixiophylla*, *Melaleuca decora*, *Acacia apprepata*, *Acacia crassa* subsp. *crassa*, *Acacia leiocalyx*, *Acacia spectabilis*, *Petalostigma pubescens*, *Alphitonia excelsa*,

Grevillea striata, and *Ozanthamnus diosmifolius*. The lower shrub layer averaging at 2m in height and 18.5 % in cover, is similarly diverse comprising species which include *Leucopogon* sp., *Callitris glaucophylla*, *Acacia crassa* subsp. *crassa* and *Allocasuarina Luehmannii*.

Diversity of the the ground layer varies dependent on disturbance history and grazing regimes although in tends to be relatively diverse. Dominant species include *Aristida caput-medusae*, *Fimbristylis dichotoma*, *Chrysopogon fallax*, *Cyanthillium cinereum*, *Dodonaea macrossanii*, *Panicum decompositum*, and *Themeda triandra*. Frequent species include *Aristida calycina*, *Commelina lanceolata*, *Eragrostis sororia*, *Goodenia* sp. and *Lomandra multiforla*. Naturalised species are limited to scattered occurrences of *Melinus repens**, *Opuntia stricta**, *Opuntia tomentosa**, *Paspalum dilatatum** and *Pennisetum ciliare**.

Most occurrences have been moderately to heavily logged with selective targeting of the Narrow Leaf Ironbark.



Typical occurrence of RE11.5.1 in Kumbarilla State Forest. Habitat in this location is in good condition.

Regional Ecosystem 11.5.4

Eucalyptus chloroclada, *Callitris glaucophylla*, *C. endlicheri*, *Angophora leiocarpa* woodland on Cainozoic sand plains and/or remnant surfaces

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

55 Sites in Total (2 Secondary, 53 Quaternary / Observation).

Regional Ecosystem 11.5.4 shares floristic similarities with RE11.5.1 merging in regard to floristic attributes and landform associations. The ecosystem tends to occur on sandier soils than RE11.5.1, often occupying low sandy rises. The canopy height tends to vary with examples of lower stature ranging in height between 10-22m with some taller representations in Kumbarella State Forest attaining heights of up to 30m. Crown cover values range from Canopy cover also tends to vary ranging from 30 to 60%. Smooth Bark Apple (*Angophora leiocarpa*) and Dirty Gum (*Eucalyptus chloroclada*) are the dominant species with Narrow Leaf Ironbark (*Eucalyptus crebra*) generally present. A sparse to mid-dense second tree layer has an average height of 8.5m and is generally present attaining heights of 12m and dominated by Smooth Barked Apple, Dirty Gum and White Cypress (*Callitris glaucophylla*), Budgeroo (*Lysicarpus angustifolius*), Stringy Bark She-oak (*Allocasuarina inophloia*), *Melaleuca decora* with less frequent Bullocke (*Allocasuarina Luehmannii*).

Shrub layers are generally dominated by White Cypress, Budgeroo, Stringy Bark She-oak, *Acacia ixiophylla*, *Melaleuca decora*, *Acacia crassa* subsp. *crassa*, *Acacia leiocalyx*, *Acacia spectabilis*, *Petalostigma pubescens*, *Alphitonia excelsa* and *Acacia semilunata* in the northern occurrences.

Ground cover tends to be sparse to mid-dense (15 to 40% living cover) with dominant species include *Aristida caput-medusae*, *Ancistrachne uncinellata*, *Gahnia aspera*, *Lomandra multiflora*, *Aristida ramosa*, *Aristida salicina* and Grass Tree (*Xanthorrhoea johnsonii*) in some localities.



Representative structure of RE11.5.4 in Kumbarilla State Forest with sparse canopy cover.

Regional Ecosystem 11.5.20

Eucalyptus moluccana and/or *E. microcarpa*/ *E. pilligaensis* +/- *E. crebra* woodland on Cainozoic sand plains.

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

80 Sites in Total (8 Secondary, 72 Quaternary / Observation).

Regional ecosystem 11.5.20 is represented most abundantly in the southern assessment area, particularly Kumbarilla State Forest by a woodland of 16-23m in height. Grey Box (*Eucalyptus woollsiana*) is the dominant species, occasionally with associated narrow leaf ironbark (*E. crebra*). Canopy species also occur in the second tree layer with bull oak (*Allocasuarina Luehmannii*) and psydrax (*Psydrax* sp.).

A typically sparse native groundcover (15 – 25% cover) is dominated by Many-Headed Wire Grass (*Aristida caput-medusae*), Barbed Wire Grass (*Aristida calycina*), Love Grass (*Eragrostis*

lacunaria), barbed wire grass (*Cymbopogon refractus*), Paspalidium (*Paspalidium distans*), and Windmill Grass (*Chloris truncata*) and *Gahnia aspera*.

This ecosystem has almost universally been subject to heavy logging regimes greatly simplified the original habitat structure.



Regional ecosystem 11.5.20 in the Kumbarilla State Forest with heavily modified structure through timber extraction and Grazing.

Regional Ecosystem 11.5.21

Corymbia bloxsomei +/- *Callitris glaucophylla* +/- *Eucalyptus crebra* +/- *Angophora leiocarpa* woodland on Cainozoic sand plains/remnant surfaces.

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

62 Sites in Total (7 Secondary, 1 Tertiary, 54 Quaternary / Observation).

This woodland ecosystem generally occupies sandier localities on Tertiary age plains. The canopy height ranges between 14-23m and a mean crown cover of 32%. It is dominated by yellow bloodwood (*Corymbia bloxsomei*) in association with smooth barked apple (*Angophora*

leiocarpa), narrow leaf ironbark (*Eucalyptus crebra*), Queensland blue gum (*Eucalyptus tereticornis*), and white cypress (*Callitris glaucophylla*).

The second tree layer is poorly formed and often absent with white cypress, bull oak (*Allocasuarina luehmannii*) and occasional narrow leaf ironbark. The shrub layer ranges between 1-5 m in height with a very sparse cover average of 11%. Characteristic species are *Acacia spectabilis*, *Callitris glaucophylla*, *Allocasuarina Luehmannii*. Others include *Acacia amblygona*, *Acacia ixiophylla*, *Eucalyptus crebra*, *Hakea purpurea*, *Leptospermum polygalifolium*, *Leucopogon* sp., *Micromyrtus sessilis*, *Opuntia tomentosa* *, and *Xylomelum cunninghamianum*.

The ground layer is in good condition with a mean PFC of 62%, and comprises native species which include *Triodia scariosa*, *Aristida caput-medusae*, *Brachyscome* sp., *Cheilanthes sieberi*, *Chrysocephalum apiculatum*, *Cymbopogon refractus*, *Dianella brevipedunculata*, *Eragrostis* sp., *Eulaia aurea*, *Fimbristylis dichotoma*, *Homoranthus melanostictus*, *Lomandra leucocephala* subsp. *leucocephala*, *Murdannia graminea*, *Pimelea novae-hollandaei*, *Pleurocarpaea* sp., *Tricoryne elatior* and *Xanthorrhoea johnsonii* which forms a dominant cover in some localities.

The habitat is generally well preserved with limited disturbance evident in most representations.



Regional ecosystem 11.5.21 in Barakula State Forest, central assessment area.

Regional Ecosystem 11.7.2

Acacia spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

25 Sites in Total (5 Secondary, 20 Quaternary / Observation).

Regional ecosystem 11.7.2 occupies areas of extremely shallow soil, typically growing on rudosols formed on indurated sandstones in the central assessment area. The habitat is dominated by Lancewood (*Acacia shirleyi*) although have other species scattered throughout its canopy including *Eucalyptus fibrosa subsp. nubile*, Narrow Leaf Ironbark (*Eucalyptus crebra*) and Queensland Peppermint (*Eucalyptus exserta*). Canopy heights range from 14-23m and crown cover varies between 30 to 80%.

The second tree layer is often absent or sparse Lancewood. The upper shrub layer is formed by Lancewood, *Alphitonia excelsa*, *Ehretia membranifolia*, Bitter Bark (*Alstonia constricta*) while the lower layer consists of *Dodonaea biloba*, *D. macrossanii*, *Prostanthera cryptandroides subsp. euphrasioides*, *Leucopogon sp.*, *Dodonaea triangularis* and *Acacia triptera*.

The ground layer generally retains near natural condition with up to 70% cover of wiry grasses include *Ancistrachne uncinellata* and *Thyridolepis mitchelliana*. The habitat is generally well preserved although clearing and timber harvesting affects some localities.



Tall straight stand of Lancewood characteristic of RE11.7.2

Regional Ecosystem 11.7.4

Eucalyptus decorticans and/or *Eucalyptus* spp., *Corymbia* spp., *Acacia* spp., *Lysicarpus angustifolius* on lateritic duricrust.

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

538 Sites in Total (20 Secondary, 4 Tertiary, 514 Quaternary / Observation).

An extensive habitat type within the central and southern assessment areas. This woodland ecosystem is restricted to low hills and rises where soils are shallow and gravelly ridges. Characteristic species in the canopy are Queensland peppermint (*Eucalyptus exserta*), Brown Bloodwood (*Eucalyptus trachyphloia*) and Smooth Barked Apple (*Angophora leiocarpa*) with less frequent White Cypress (*Callitris glaucophylla*), Narrow Leaf Ironbark (*Eucalyptus crebra*) and Lancewood (*Acacia shirleyi*). The canopy height ranges from 11 – 18m and average crown cover is around 40%.

A well-developed second tree layer has an average cover of around 50% and comprises Queensland Peppermint, Miles Mulga (*Acacia apprepta*), White Cypress, False Mahogany (*Eucalyptus rubiginosa*), Stringy Bark Sheoak (*Allocasuarina inophloia*) and Budgeroo (*Lysicarpus angustifolius*). Tall shrubs of *Acacia crassa* subsp. *crassa*, *Acacia julifera*, and *Acacia semilunata* dominate a sparse upper shrub layer. A distinct yet very sparse lower shrub layer features a range of low shrubs in particular *Leucopogon* sp., *Westringia cheellii*, *Acacia conferta*, and *Micromyrtus sessilis*.

The ground layer is mid dense and diverse with 42 species recorded. The native graminoids, include *Ancistrachne uncinellata*, *Thyridolepis mitchelliana*, *Aristida calycina*, *Aristida caput-medusae*, *Eragrostis sororia*, *Panicum decompositum*, *Scleria sphacelata* and *Triodia scariosa* occupy the predominant living groundcover with the remainder of cover comprising perennial native herbs such as *Brunoniella acaulis*, *Cheilanthes sieberi*, *Goodenia* sp. and *Pleurocarpaea* sp. The woodland ecosystem generally retains good condition although some timber extraction is evident and severe fire damage is evident in Kumbarilla State Forest and some portions of the central assessment area to the north-west of Miles.



Typical structure of RE11.7.4 in the central assessment area (Site AG313_129).

Regional Ecosystem 11.7.5

Shrubland on natural scalds on deeply weathered coarse-grained sedimentary rocks.

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

15 Sites in Total (2 Secondary, 13 Quaternary / Observation).

This shrubland ecosystem is restricted to shallow sandy soils on the surface of lateritic duricrust. Although most commonly found around Barakula State Forest in the central assessment area, small patches also occur in the south within Kumbarilla State Forest. The habitat is typified by a mid-dense upper shrub layer of Broombush (*Melaleuca uncinata*) or *Melaleuca nodosa* forms the ecological dominant layer with scattered Miles Mulga (*Acacia apprepata*), micromyrtus (*Micromyrtus sessilis*), Budgeroo (*Lysicarpus angustifolius*) and emergent White Cypress (*Callitris glaucophylla*) and Yellowjacket (*Corymbia bloxomeii*). A distinct lower shrub layer is also dominated by Broombush and Micromyrtus in association with dodder laurel (*Cassytha*

pubescens), *Leucopogon* sp. (GBS3/7), *Hakea purpurea*, *Pimelea nova-anglica*, and *Callitris glaucophylla*.

In comparison to woodland habitats this shrubland ecosystem is depauperate in species. Low species diversity is reflected in the ground layer that supports a limited number of grasses including *Spinifex* (*Triodia scariosa*), *Aristida leichardtiana*, *Aristida ramosa*, *Panicum decompositum*, *Panicum queenslandicum*, *Paspalidium distans* and the herbs *Cheilanthes sieberi*, *Drosera indica*, *Cassytha filiformis*, and *Boronia bipinnata*.



Recently burnt heath in Kumbarilla State Forest with dominant *Melaleuca uncinnata*.

Regional Ecosystem 11.7.6

Corymbia citriodora or *Eucalyptus crebra* woodland on Cainozoic lateritic duricrust.

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

17 Sites in Total (5 Secondary, 12 Quaternary / Observation).

Regional ecosystem 11.7.6 is largely restricted to the central assessment area to the north of Miles. This woodland to open forest ecosystem typically occurs on hills and ridge crests hills

with associated shallow gravelly soils. Spotted Gum (*Corymbia citriodora*) characterises the habitat and forms a relatively tall, continuous canopy cover up to 25m tall and cover ranging from 40 to 70%. Associated species include Narrow Leaf Ironbark (*Eucalyptus crebra*) Brown Bloodwood (*Eucalyptus trachyphloia*) and Smooth Barked Apple (*Angophora leiocarpa*) with less frequent White Cypress (*Callitris glaucophylla*), and Lancewood (*Acacia shirleyi*) although these are more commonly associated with a sparse sub-canopy layer forming 15 to 25% cover.

Tall shrubs of *Acacia crassa* subsp. *crassa*, *Alphitonia excelsa*, *Acacia semilunata*, *Acacia conferta* and *Allocasuarina leuhmanni* dominate a sparse shrub layer. Lower shrub layers are also sparse and are formed by *Dodonaea macrocarpa*, *Mirbellia pungens*, *Acacia melliodora*, *Prostanthera* sp., *Westringea cheellii*, *Acacia conferta*, *Callitrix tetragona* and *Leucopogon muticus*.

The ground layer is mid dense and generally diverse with native covers including *Arundinella nepalensis*, *Ancistrachne uncinellata*, *Thyridolepis mitchelliana*, *Gahnia aspera*, *Lomandra leucocephala*, *Lomandra multiflora*, *Aristida calycina*, *Aristida caput-medusae*, *Eragrostis sororia*, *Panicum decompositum*, *Scleria spachelata* and *Triodia scariosa*.



A heavily logged representation of RE11.7.6 in the central assessment area.

Regional Ecosystem 11.7.7

Eucalyptus fibrosa subsp. *nubila* +/- *Corymbia* spp. +/- *Eucalyptus* spp. on lateritic duricrust.

Status

VMA Status: Least concern

Biodiversity Status: No concern at present

Total number of survey sites across project area

212 Sites in Total (16 Secondary, 2 Tertiary, 194 Quaternary / Observation).

This widespread and relatively abundant woodland and open forest ecosystem occurs on low hills and ranges formed from deeply weathered sediments. Soils are shallow with sandy and gravelly surface horizons. Blue Leaved Ironbark (*Eucalyptus fibrosa* subsp. *nubila*) forms a distinct canopy which ranges between 11 and 25m in height. The canopy may also include Narrow Leaf Ironbark (*E. crebra* and *E. elegans*), Queensland peppermint (*E. exserta*) and white cypress (*Callitris glaucophylla*). These species also characterize a distinct yet discontinuous second tree layer. *Eucalyptus elegans* dominates the canopy in restricted locations although *Eucalyptus fibrosa* is always present.

Scattered tall shrubs such as *Acacia semilunata*, *Acacia conferta* and *Callitris glaucophylla* form a sparse to very sparse upper shrub layer. The lower shrub layer is similarly sparse and poorly formed and also comprises *Leucopogon* sp., *Acacia ixiophylla*, *Acacia muelleriana*, *Hakea purpurea* and *Westringea cheelii*.

The native species dominated ground layer is mid dense with grasses such as *Eulalea aurea*, *Paspalidium* sp., *Chloris truncata* and *Gahnia aspera* forming the majority of the cover. Characteristic native herbs and low herbaceous shrubs are *Dodonaea macrocarpa*, *Dianella longifolia* var. *longifolia*, *Cheilanthes sieberi*, *Boronia bipinnata*, and *Brunoniella acaulis*.



Regional Ecosystem 11.7.7 on Girraween, central assessment area.

Regional Ecosystem 11.9.2

Eucalyptus melanophloia +/- *E. orgadophila* woodland on fine-grained sedimentary rocks

Status

VMA Status: Of Concern

Biodiversity Status: Endangered

Total number of survey sites across project area

1 Quaternary Site

Only a few, scattered remnants of this regional ecosystem are mapped in the northern assessment area to the north of Miles. The habitat is invariably dominated by a sparse canopy layer of Silver Leaf Ironbark (*Eucalyptus melanophloia*) with a mid-dense sub-canopy and shrub layer of White Cypress Pine. Canopy heights generally do not exceed 10m which is in part testament to a repetitive and heavy disturbance regime. There is limited canopy recruitment in these fragments and a significant portion of the original Silver Leaf Ironbark canopy layer is suffering from dieback and senescence. Ground covers are universally displaced by exotic Buffel Grass (*Cenchrus ciliaris*).



An extremely degraded patch of Callitris regrowth with scattered Silver Leaf Ironbark. The habitat is non-remnant in this location although remnants of the original ecosystem (RE11.9.2) are preserved in the vicinity.

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Appendix E.
Present, Likely or Possible
Threatened Flora Species Profiles and
Mapping Criteria

TREES AND SHRUBS

Kogan Waxflower (*Philotheca sporadica*)

Status

Near Threatened (NC Act); Vulnerable (EPBC Act)

Distribution and Habitat

Philotheca sporadica is a Queensland and bioregional endemic known from south-east Queensland, from just north of Tara, to approximately 12 km east of Kogan (TSSC 2008j). Of the 11 known populations, seven occur on road verges, seven extend onto freehold land and one population is within Braemar State Forest (Halford 1995c in TSSC 2008j).

The majority of records are in low open forest and woodland of *Acacia burrowii*, *Eucalyptus exserta*, *Eucalyptus crebra*, *Eucalyptus fibrosa* subsp. *nubila* and *Callitris glaucophylla* (Halford 1995 in TSSC 2008j), and also on residual hills which are remnants of laterised Cretaceous sandstones, where the soils are shallow, uniform sandy loams to clay loams of extremely low fertility and poor condition (TSSC 2008j). Field survey indicates that the species occurs almost exclusively within RE 11.7.4 (*Eucalyptus decorticans* and/or *Eucalyptus* spp., *Corymbia* spp., *Acacia* spp., *Lysicarpus angustifolius* on lateritic duricrust) and possibly RE11.7.5 with a few individual plants overlapping with RE11.7.7. The species has a tendency to form dense, locally restricted populations, particularly on scalded areas with limited soil

Known Threats to the Species

This species is threatened by clearing, particularly localised populations that might be impacted by well pads and linear infrastructure.

Records Relevant to the SGP

Six localised populations are identified within the assessment area to the east of Kogan, both within both private land and State Forest. Populations may cover extensive areas although the margins of populations are generally discrete.

Rule(s) for Habitat Mapping:

1. The species will most likely occur within a 25km wide buffer surrounding Kogan although cannot be discounted as occurring within suitable habitats throughout the SGP assessment area.
2. REs 11.7.4 and 11.7.7 are classified as "Core habitat Possible" within 25km from Kogan.
3. Regrowth habits (non-remnant) derived from RE11.7.4 within 25km from Kogan are classified as "General Habitat".
4. All "Core Habitat Possible" and "General Habitat" within 1km of a recent (1980+), accurate ($\pm 100m$) record is reclassified as "Core Habitat Known".
5. The remaining areas of RE11.7.4 throughout the SGP assessment area are classified as "General Habitat".
6. All other areas are classified as "Absence Suspected".

Mapping Confidence

The detailed ground surveys undertaken throughout habitats for this species in the SGP area and highly localised populations gives habitat mapping is presented with high confidence.



Photograph: David Stanton

Waaje Wattle (*Acacia barakulensis*)

Status

Vulnerable (NC Act)

Distribution and Habitat

Waaje Wattle is a Queensland and bioregional endemic that is Restricted to Barakula State Forest north of Chinchilla where it grows on sandy soils in eucalypt communities in the Waaje Wildflower Area (Lithgow 1997, Chinchilla Field Naturalists Club 1997, Maslin 2001).

HERBRECS specimen records indicate habitat in flat gently undulating plains on the crest of the slope on deep yellow loamy sand soil derived from sandstone or laterite. Vegetation is tall shrubland with *Eucalyptus tenuipes*, *Corymbia trachyphloia*, *Calytrix gurlmundensis*, and *Triodia mitchellii* (DEHP 2017). Habitat is consistent with RE 11.7.4, 11.7.5, 11.7.6, and 11.7.7. Survey records identified the species in woodland of narrow leaf ironbark (*Eucalyptus crebra*) + smooth barked apple (*Angophora leioclada*) + white cypress pine (*Callitris*

glaucophylla) with a subcanopy of white cypress and bulloak (*Allocasuarina luehmannii*) on old loamy plains (RE 11.5.1, 11.5.4, 11.5.21).

Ecology

Similarity to many Acacias, there is a likelihood that *Acacia barakulensis* will respond to disturbance, or populations rejuvenated by fire. Knowledge of the species biology and response to disturbances such as habitat fragmentation, changed fire regimes and edge effects requires is poorly understood.

Known Threats to the Species

The species may be impacted by habitat clearing or fragmentation that leads to changes in fire frequency and intensity. As known populations are well away from the SGP assessment area impacts are more likely to be generated during forestry operations.

Records Relevant to the SGP

Herbrechts identifies 5 confirmed populations 28 km to the north-east of the SGP area within Barakula State Forest. Due to contiguity of habitats between populations and the SGP assessment area, it is considered possible that the species may occur.

General Rule(s) for Habitat Mapping:

1. The species will only likely occur in the Central assessment area.
2. Within the central area of the SGP, RE's 11.5.1, 11.5.14, 11.5.21, 11.7.4, 11.7.5, 11.7.6 and 11.7.7 are mapped as "General Habitat" due to lack of local records.

Mapping Confidence

Due to the relatively broad habitat tolerances, mapping of general habitat is considered to be of moderate accuracy.

Curly-bark Wattle (*Acacia curranii*)

Status

Vulnerable (NC Act)

Distribution and Habitat

The only known Queensland population occurs in and adjacent to the Gurulmundi State Forest area of the Darling Downs, approximately 65 km north-west of Chinchilla (Pedley 1987; Maslin 2001). The Gurulmundi population is restricted to an area of less than 20 km diameter and represents a highly disjunct northern limit of distribution with southern populations in NSW.

Plants are known to occur in shrubby heaths, dry sclerophyll forests and semi-arid woodlands where they can occur as widely scattered thickets in very species-rich heathy scrub with emergent eucalypts (Pickard 1995c, Threatened Species Scientific Committee 2008a). The Gurulmundi population has been reported as growing in dense "groves" (Pedley 1987). Queensland collections of curly-bark wattle, recorded in Herbrechts, mostly occur within areas

mapped by the Queensland Herbarium as Regional Ecosystem 11.7.5; shrubland with *Calytrix* spp., *Hakea* spp., *Kunzea* spp., *Micromyrtus* spp., *Acacia* spp., *Melaleuca* spp. and a spinifex grass layer, on natural scalds on deeply weathered sedimentary rocks.

Ecology

The typical life span of curly-bark wattle is unknown, but it is probably similar to many other shrubby *Acacia* species in being a moderately long-lived shrub of 10 to 30 years. It has been



recorded flowering during August and September, with pods maturing several months later (Pedley 1987). As a hard-seeded legume, the soil-stored seed reserves of *A. curranii* are likely to be long lived (i.e. > 10 years). The observed abundant regeneration via seedlings after fire suggests *Acacia curranii* will also germinate seedlings following mechanical disturbance of the topsoil, although repeated soil disturbance would kill the seedlings that germinate after any initial disturbance. The impact of stock grazing is unknown, but damage from grazing by feral goats has been observed (Cohn 1995).

Known Threats to the Species

Grazing, browsing and trampling of adult and seedling plants by feral goats and rabbits (and to less an extent by stock, and macropods). This may be facilitated installation of well ponds which artificially increases watering points for feral animals. Additional threats include clearing of vegetation

for road widening, gravel extraction and mining

Records Relevant to the SGP

Sixteen records of the species are confirmed in Herbrecks with the nearest population 11 km west of the SGP area with Gurulmundi State Forest (excluding low precision records).

General Rule(s) for Habitat Mapping:

1. The species will only occur in the central portion of the SGP assessment area to the north of Miles.
2. In the absence of survey records within the SGP area, RE11.7.5, 11.7.4, 11.7.7 in the potential area of occurrences have been allocated as "General Habitat".

3. All other regional ecosystems, regrowth and cleared areas are mapped as "Absence Suspected".

Mapping Confidence

High mapping confidence is applied to be species based on the revised mapping boundaries and detailed on-ground assessment.

Curly-bark wattle (*Acacia curranii*). Photograph M. Fagg, Australian National Botanical Gardens

Hando's Wattle (*Acacia handonis*)

Status

Vulnerable (NC Act); Vulnerable (EPBC Act Act)

Distribution and Habitat

Hando's wattle has an extremely restricted occurrence, being known only from the Barakula State Forest, approximately 40 km north of Chinchilla (Maslin 2001). This population of Hando's wattle was considered to occur in three adjacent areas and was estimated in 1994 to contain around 10 080 individuals over approximately 28 ha (Halford 1995b). The extent of population was considered to have broadened within the Barakula State Forest between the initial collections in 1978 and 1997 (Lithgow, 1997).

Hando's wattle has only been collected on rocky ridges and slopes on sandstone-derived geology in eucalypt woodland and open forest (Maslin 2001). The vegetation it grows within is a shrubby woodland of *Eucalyptus fibrosa* subsp. *nubila*, *Eucalyptus watsoniana* subsp. *watsoniana*, *Lysicarpus angustifolius*, and *Allocasuarina inophloia* (Halford 1995). The descriptions of the habitat from which it has been collected are consistent with the regional ecosystem mapping for its locations. This is, primarily RE 11.7.7: *Eucalyptus fibrosa* subsp. *nubila* +/- *Corymbia* spp. +/- *Eucalyptus* spp. on lateritic duricrust. One collection is also recorded in RE 11.7.6: *Corymbia citriodora* or *Eucalyptus crebra* woodland on lateritic duricrust.

Ecology

The life span of Hando's wattle plants in the wild is unknown, but they live for about 10 years in cultivation (Hando 2007). Plants have been collected in flower in July, August and September, and with pods in August, September and November. As a hard-seeded legume, the soil-stored seed reserves of Hando's wattle are likely to be long lived (i.e. > 10 years). The response to fire by Hando's wattle has not been well studied. However, it is suggested that it regenerates well from seed following burning (DNR 2000).

Known Threats to the Species

Inappropriate fire regimes, habitat destruction, disturbance from timber harvesting, inappropriate grazing regimes (DNR 2000) are considered the major threats to *Acacia handonis* populations. Halford (1995b) suggested the main threat to Hando's wattle was

inappropriate fire regimes. That is, fires that are too frequent, intense fires, or complete fire exclusion.

Records Relevant to the SGP

Seventeen records in Herbrecks with the nearest population 35 km east of the SGP assessment area within Barakula SF.

Rule(s) for Habitat Mapping:

Regional Ecosystems 11.7.4, 11.7.5, 11.7.6, 11.7.7 and 11.5.1 in the Central region of the SGP (North of Miles) should be classed as "General Habitat" on account of the intensive survey undertaken in the assessment area

Mapping Confidence

High mapping confidence is applied to be species based on the revised mapping boundaries and detailed on-ground assessment.



Photograph M. Fagg, Australian National Botanical Gardens.

Bailey's Callitris (*Callitris baileyi*)

Status

Near Threatened (NC Act)

Distribution and Habitat

In Queensland, Baileys Cypress occurs from the state border to Goomeri in the north and west to the Bunya Mountains. The distribution is predominantly within the Southeast

Queensland bioregion extending into the Brigalow Belt near the bioregional boundary (EHP 2017b). The species also occurs in the drier ranges of NSW.

Typical habitat is open woodland and woodland of *Eucalyptus exserta*, *E. crebra* and *Callitris glaucophylla* with a mid-dense shrubby understorey typical of RE11.7.4. Stanley & Ross (1983) describe its habitat as eucalypt woodland, with ironbark, blue gum and spotted gum on rocky slopes, hilly or mountainous areas, in shallow and often clay soils.

Ecology

Little is known concerning the ecology of this species. Male and female flowers occur on the same tree and fruiting has been recorded all year round.

Known Threats to the Species

This species is threatened by direct loss as a result of clearing as well as inappropriate fire regimes.

Records Relevant to the SGP

Nearest local record is 2.6 km west of the SGP assessment area (40 km north of Miles) in Gurulmundi State Forest. The record was collected during SGP EIS studies in 2011.

Rule(s) for Habitat Mapping:

REs 11.5.1, 11.7.4, 11.7.5, 11.7.6 and 11.7.7 in the Gurulmundi area to the north of Chinchilla (-27.75) in the Central Assessment Area should be considered "General Habitat". Any subsequent collections of the species should be buffered by 1km and General Habitat re-assigned to "Core Habitat Known". Other habitats should be assigned to "Absence Suspected".

Mapping Confidence

The general nature of habitat for this species makes preferred habitats relatively easy to predict and habitat mapping for the species is considered to have high to moderate confidence.

Gurulmundi Fringe Myrtle (*Callitrix gurulmundensis*)

Status

Vulnerable (NC Act); Vulnerable (EPBC Act)

Distribution and Habitat

The species is endemic to the Gurulmundi and Barakula areas north of Chinchilla (Halford 1996). Gurulmundi fringe myrtle has been recorded growing in patches of shrubland on very shallow soils. Soils are lateritic sandstone ridges, which contain yellow sandy-clay that retains moisture (Williams 1979). Vegetation is predominately eucalypt, acacia, casuarina dense shrublands with spinifex, and spinifex grassland with scattered shrubs. This habitat description is consistent with RE 11.7.5 (shrubland on natural scalds on deeply weathered coarse-grained sedimentary rocks). The coordinates of Gurulmundi fringe myrtle collections

derived from Herbrechts place them in areas mapped by as RE11.7.4, 11.7.5, 11.7.6 and 11.7.7.

Ecology

The life span of Gurulmundi fringe myrtle is unknown, but it is likely to live for at least a decade. Flowers have been recorded from June to October (Halford 1996). Plants as small as 15 cm tall have been observed to flower (Williams 1979). Gurulmundi fringe myrtle can be quite common at sites where it grows, being described in several collection labels as abundant or co-dominant at the collection site (AVH 2013a).

Known Threats to the Species

Clearing, disturbance for track creation and maintenance and inappropriate fire regimes are the key threats to habitat for this species. At least one population is identified as having been damaged in the past due to gravel extraction (Williams 1979).

Records Relevant to the SGP

The nearest local record is 12 km west of the SGP assessment area (30 km north of Miles) within Gurulmundi State Forest. A population also exists in Waaje Scientific Reserve 36 km east of Wandoan.

Rule(s) for Habitat Mapping:

REs 11.5.1, 11.7.4, 11.7.5, 11.7.6 and 11.7.7 in the Gurulmundi area to the north of Chinchilla (-27.75) in the Central Assessment Area should be considered "General Habitat". Any subsequent collections of the species should be buffered by 1km and General Habitat re-assigned to "Core Habitat Known". Other habitats should be assigned to "Absence Suspected

Mapping Confidence

High mapping confidence is applied to be species based on the revised mapping boundaries and detailed on-ground assessment that did not locate any additional populations.



Gurulmundi fringe myrtle (*Calytrix gurulmundensis*) foliage and flower. Copyright © Boobook

Gurulmundi Heath-myrtle (*Micromyrtus carinata*)

Status

Endangered (NC Act)

Distribution and Habitat

Endemic to Queensland, *Micromyrtus carinata* is known only from the Gurulmundi State Forest 40 km to the north of Miles with a sub-population also located on the Wyona Property 10km to the north of Miles (Herbreccs).

Herbarium records indicate *Micromyrtus carinata* is associated with landscapes formed on lateritised sediments with an upper soil layer of red to yellow sand (DEHP 2017c). Associated regional ecosystems include inhabits the tops of laterised ridges, on shallow to deep, yellow or red sands. Associated habitats include heath and shrubland (RE11.7.5) and low woodland dominated by *Eucalyptus exserta*, *Corymbia trachyphloia* and *Callitris glaucophylla* (RE11.7.4).

Ecology

Little is known regarding the ecology of this species. Bean (1997) suggest that it likely flowers at any time in response to rain although fruits and flowers have been collected between May and October (DEHP 2017c).

Known Threats to the Species

The species is considered to be threatened by mining activity, gravel extraction and inappropriate fire regimes (Bean, 1997, DEHP 2017c).

Records Relevant to the SGP

Nearest Herbarium Record is 10km north-west of Miles and 4 km west of the SGP assessment area on the Wyona Property. The major population of the species occurs in Gurulmundi State Forest 12km west of the SGP assessment area (Herbrechts)

Rule(s) for Habitat Mapping:

REs 11.7.4 and 11.7.5 in the Gurulmundi area to the north of Chinchilla (-27.75) in the Central Assessment Area should be considered "General Habitat". Any subsequent collections of the species should be buffered by 1km and General Habitat re-assigned to "Core Habitat Known". Other habitats should be assigned to "Absence Suspected"

Mapping Confidence

High mapping confidence is applied to be species based on the revised mapping boundaries and detailed on-ground assessment that did not locate any additional populations.

Plunkett Mallee (*Eucalyptus curtisii*)

Status

Near Threatened (NC Act)

Distribution and Habitat

The plant is scattered but nowhere common occurring on coastal hinterland to 80 km north and south of Brisbane and inland over 300 km north west to the Dalby and Miles districts (DNR 2000). Occurs in the Burnett, Leichhardt, Moreton and Darling Downs pastoral districts (Bostock and Holland 2016). Conserved in Expedition Range, Robinson Gorge and Isla Gorge National Parks (Brooker and Kleinig 2004).

DEHP (2017d) suggests *Eucalyptus curtisii* has two growth forms that occur in different habitats with a shorter shorter mallee associated with shrublands dominated by banksia in poorly drained lowland sites with a larger growth occurring as scattered individuals on better drained soils in the more open areas of mixed eucalypt forests. The species is most typically associated with lateritised landscapes within regional ecosystems 11.7.4 and 11.7.5. Commonly associated species include *C. trachyphloia*, *Eucalyptus exserta* and *Callitris endlicheri* and less commonly associated with *E. fibrosa*.

Ecology

Flowering of *Eucalyptus curtisii* has been recorded between the months of September and November, and fruiting occurs throughout the year (Queensland Herbarium, 2012 cited in DEHP 2017d). Response to fire is not documented.

Known Threats to the Species

Known threatening process related largely to clearing, timber harvesting and inappropriate grazing and fire regimes.

Records Relevant to the SGP

Numerous local records mostly west of the SGP with the nearest record 2.5 km west of the SGP assessment area and 35km north of Miles. A number of records in Kumbarilla State Forest to the south although well outside the SGP assessment area.

Rule(s) for Habitat Mapping:

Eucalyptus curtisii may occur throughout the entire assessment area. Through the assessment area, REs 11.7.2, 11.7.4, 11.7.5, 11.7.6 and 11.7.7 should be classified as "General Habitat" in recognition of the extensive survey effort undertaken. All other REs and non-remnant vegetation should be classified as "Absence Suspected".

Mapping Confidence

Due to the extensive survey effort and known habitat preferences, mapping of *Eucalyptus curtisii* is attributed as having a high degree of confidence.

GRASSES AND SEDGES

Finger Panic Grass (*Digitaria porrecta*)

Status

Near Threatened (NC Act)

Distribution and Habitat

Finger panic grass is known from four disjunct areas extending over 1000 km across NSW and Queensland. The Queensland distribution includes broad populations in the Nebo district; the Central Highlands between Springsure and Rolleston; and from Jandowae south to Warwick. In NSW, it is known from near Inverell, south to the Liverpool Plains near Coonabarabran and Werris Creek (TSSC 2008f).

Finger panic grass grows in grasslands, woodlands and open forests with a grassy understory, on black soil plains of the Darling Downs, and lighter textured soils to the west (Goodland 2000; Fensham 1998). Fensham (1998) found it is most abundant in grassland, but is "relatively unspecific" in its habitat preference. It is not restricted to high quality native grasslands, but also grows along roadsides and can be found in highly disturbed sites (Goodland 2000). Finger panic grass been recorded inside the project development area, within roadside remnant grasslands on dark cracking clay plains (RE11.3.21); poplar box (*E.*

populnea) open forest and woodland with grassy understorey, on dark cracking clay plain (RE11.3.2); and along disturbed railway reserves on dark cracking clay soils (EHP 2013). The primary habitats for this species in the project development area are RE11.3.2, RE 11.3.21 and non-remnant derived grasslands.

Ecology

Finger panic grass is a spreading perennial that can reproduce vegetatively (Halford 1995a). Older clumps are reported to die in the centre, with the outer edges of the clump becoming separate plants. Seeds drop to the ground when mature, but appear to have a six month to one year dormancy prior to germinating (Halford 1995a). This is similar to some other sub-tropical grasses, such as black spear grass, and delays germination until the wet season rains. The species produces fertile material from March to April (TSSC 2008f).

Known Threats to the Species

The grassland habitat for this species has been heavily fragmented by clearing for agriculture, and sowing of exotic pasture grasses that can replace finger panic grass. It is mainly restricted to stock routes and road reserves and threatened by degradation from mechanical disturbance, invasive weeds and inappropriate grazing regimes. Goodland (2000) notes that finger panic grass can withstand disturbance, although populations decline where introduced species (e.g. Rhodes grass) become dominant.

Records Relevant to the SGP

Two records within the SGP assessment area, both in non-remnant derived grasslands adjacent to roadside easements between Dalby and Cecil Plains. Both records collected in 1995. A further 15 records within 25km east of the SGP boundary.

Rule(s) for Habitat Mapping:

1. The species is most likely to occur on heavy clay soils associated with the Condamine Alluvium although may occur throughout the entire assessment area.
2. Regional Ecosystem 11.3.2 should be treated as "General Habitat".
3. Derived native grassland where it is associated with the Condamine Alluvium or other heavy clay soil should be considered "General Habitat".
4. High precision (+/- 500m) species records should be buffered by 1km and all General Habitat upgraded to "Core Habitat Known".
5. All other remnant vegetation in the project development area and all cleared agricultural and grazing land should be treated as "Absence Suspected".

Mapping Confidence

Digitaria porrecta has relatively predictable habitat preferences and with the availability of project scale mapping (1:50 000), it is considered that the habitat mapping has a high level of confidence. It should be noted that no records of the species have been formally documented since 1995 and

Fimbristylis vagans

Status

Endangered (NC Act)

Distribution and Habitat

A little-known Queensland and bioregional endemic restricted to the Darling Downs district between Lake Broadwater and Nudley Creek area (30 km NE of Chinchilla) (DERM 2011). The species occupies habitats that fringe ephemeral watercourses and lagoons on alluvium. Typical regional ecosystems include RE11.3.2, 11.3.4, 11.3.14 and 11.3.26 where they fringe watercourses and wetlands (RE11.3.27). The species is not known to be associated with non-remnant habitats.

Ecology

Species ecology is poorly documented although like most species associated with wetland habitats, is likely to be a seasonally dependent species that flowers and reproduces following rainfall.

Known Threats to the Species

Threats are poorly documented although major threats are likely to be associated with damage created by feral animals, particularly pigs and intensive grazing.

Records Relevant to the SGP

A single herbarium record from the SGP assessment area associated with the swampy inlet of Lake Broadwater. The species has not been recorded or collected since 1984.

Rule(s) for Habitat Mapping:

1. The species may occur throughout the entire EIS area.
2. "Core Habitat Possible" includes the wetland fringe of Lake Broadwater characterised by RE11.3.27f and wetland habitats of Long Swamp.
3. REs 11.3.2, 11.3.3, 11.3.4, 11.3.25 and 11.3.26 throughout the broader SGP assessment area is classified as "General Habitat".
4. All Core Habitat Possible and General Habitat within 1km of a recent (1980+), accurate ($\pm$ 500m) record is classed as "Core Habitat Known".
5. All remaining remnant and non-remnant vegetation is mapped as "Absence Suspected".

Mapping Confidence

Habitat characteristics for this species are well understood and can be matched to regional ecosystem descriptions. The mapping is considered to be highly accurate.

Belson's Panic (*Homopholis belsonii*)

Status

Endangered (NC Act); Vulnerable (EPBC Act)

Distribution and Habitat

In Queensland, major populations occur on the Darling Downs near Oakey, Jondaryan, Bowenville, Dalby, Acland, Sabine, Quinalow, Goombungee, Gurulmundi and Millmerran, and further west between Miles and Roma (Goodland 2000). Also known from the north-western slopes and plains of NSW (TSSC 2008g).

Belson's panic prefers moderate to highly fertile soils, especially those derived from basalt and fertile alluvial flats. It is generally associated with poplar box and brigalow woodlands on light red/brown earths (Fensham and Fairfax 1997, Goodland 2000). Based on Herbrechts specimens, the species is most commonly associated with habitats on heavy clay soils, particularly those dominated by Brigalow including REs 11.3.1, 11.3.17, 11.4.3, 11.9.5 and 11.9.10. Herbarium records also indicate some potential for the species to overlap with RE11.3.2.

Belson's panic is also capable of growing within disturbed habitats. Of the 22 collections within the study area, 15 (68%) are located in non-remnant areas such as roadside easements. It has been seen growing among fallen timber at the base of trees or shrubs, among branches and the bottom of netting fences (TSSC 2008g).

Ecology

Belson's panic tends to grow in shade under trees, but can grow in cleared regrowth. As a rhizomatous perennial grass, it probably is capable of living for many years, and to have some tolerance to fire and at least low levels of grazing. It is reported to spread out very rapidly (Menkins 1998). Flowers have been recorded between February and May (Sharp and Simon 2002).

Known Threats to the Species

Loss of habitat from vegetation clearing, pasture improvement, and overgrazing is a major threatening process (TSSC 2008g). Belson's panic declines in abundance with grazing pressure and appears to grow best under tree or shrub cover. Roadside populations are threatened by invasion of pasture grasses such as green panic (*Megathyrsus maximus* var. *trichoglume*), and road works (Goodland 2000), however it is known to re-colonise disturbed areas if tree cover is available (Menkins 1998 in TSSC 2008g).

Records Relevant to the SGP

A considerable number of records to the east of Dalby with the nearest 12km from the eastern boundary of the SGP assessment area. Two records within 8km of the boundary of the northern assessment area within 10km of Wandoan.

Rule(s) for Habitat Mapping:

1. The species may occur throughout the entire EIS area although is most likely to occur in Brigalow associated habitats in the northern assessment area.

2. Regional Ecosystems 11.9.5, 11.9.10 and 11.3.17 including derived non-remnant regrowth is mapped as "Core Habitat Possible" in the northern assessment area.
3. REs 11.3.1, 11.3.17, 11.4.3 and 11.9.5 including non-remnant derived regrowth in central and southern portions of the SGP assessment area are classified as "General Habitat"

Mapping Confidence

Due to the relatively specific habitat requirements, detailed survey throughout the assessment area and resolution of the revised mapping database, mapping is considered to have a high degree of confidence.



Belson's panic (*Homopholis belsonii*).
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FORBS AND HERBS

Solanum papaverifolium

Status

Endangered (NC Act)

Distribution and Habitat

Recorded in the Darling Downs from between Jimbour and Warwick, where it is known from three locations (Bean 2004). Known from a number of very old records in the Dalby-Cecil Plains area. Goodland (2000) reports two populations west of Dalby on the Warrego Highway before Kogan Rd), and large populations up to 100m extent off Cecil Plains Rd. Known in NSW north from Inverell to Quirindi and Singleton area and west to Narrabri and Moree (Bean 2004). Occurs in wetter (swampy) areas of grasslands or open eucalypt woodland on heavy alluvial soils (Goodland 2000, Bean 2004).

Ecology

Little is documented on the ecology of the species. It has been observed flowering throughout the year and populations are most likely rejuvenated following rainfall.

Known Threats to the Species

The species occurs on soils utilised by intensive agriculture and remains on roadside reserves and stock routes. Populations remain threatened by habitat destruction, weed invasion, and roadworks (Goodland 2000, Bean 2004).

Records Relevant to the SGP

Two records are contained within the SGP assessment area to the south of Dalby with an large number of herbarium records to the east of the SGP assessment area between Chinchilla and Dalby.

Rule(s) for Habitat Mapping:

1. The species is most likely to occur on habitat formed by heavy clay soils associated in particular with the Condamine Alluvium.
2. Regional Ecosystems 11.3.2 and Derived Native Grassland (non-remnant) provide the most suitable habitats for the species. Where these habitats occur on the alluvial landforms to the west and south of Dalby, they are mapped as "General Habitat".
3. All General Habitat within 1km of a recent (1980+), accurate ($\pm$ 500m) record is classed as "Core Habitat Known".
4. All remaining remnant and non-remnant vegetation is mapped as "Absence Suspected".

Mapping Confidence

Due to the relatively specific habitat requirements, detailed survey throughout the assessment area and resolution of the revised mapping database, mapping is considered to have a high degree of confidence.



Solanum papaverifolium (Photograph David Stanton).

Solanum stenopterum

Status

Vulnerable (NC Act)

Distribution and Habitat

Recorded in Queensland from Gayndah in the Burnett Pastoral district to Moonie and west to Glenmorgan and Yuleba (Bean 2004, Bostock and Holland 2016). Known in NSW from Ashford (Bean 2004). The species is known to occur in non-remnant grassland approximately 7.5km south of Dalby; 3.5km east of Cecil Plains in a roadside gravel pit; and approximately 6km south east of Cecil Plains in remnant *Eucalyptus populnea* woodland on alluvium (11.3.2).

Ecology

Little is documented on the ecology of the species although similar to many *Solanum* species in the Brigalow Belt, likely flowers at multiple times throughout the year in response to rainfall events.

Known Threats to the Species

The species occurs on soils utilised by intensive agriculture and occurs on roadside reserves. Populations remain threatened by habitat destruction from land clearing, agricultural practices, weed invasion, roadworks and roadside maintenance (Bean 2004).

Records Relevant to the SGP

Known to occur in non-remnant grassland approximately 7.5km south of Dalby; 3.5km east of Cecil Plains in a roadside gravel pit; and approximately 6km south east of Cecil Plains in remnant *Eucalyptus populnea* woodland on alluvium (11.3.2). All herbarium records are outside SGP assessment area.

Rule(s) for Habitat Mapping:

1. REs 11.3.2, 11.3.1 and 11.3.17 to the west and south of Dalby should be classed as "General Habitat" on account of comprehensive surveys.
2. Derived grasslands on alluvium and regrowth vegetation derived from the aforementioned REs

All other remnant vegetation and cleared agricultural land in the project development area should be treated as "Absence Suspected".

Mapping Confidence

Due to the relatively specific habitat requirements, detailed survey throughout the assessment area and resolution of the revised mapping database, mapping is considered to have a high degree of confidence.

Cymbonotus maidenii

Status

Endangered (NC Act)

Distribution and Habitat

The species occurs in scattered populations throughout central areas of NSW and in southern inland districts as far west as Mitchell (Holland and Funk, 2006).

The species is associated with a range of remnant and non-remnant habits with records occurring on disturbed roadside drains, native and derived grasslands. It is typically associated with heavy brown to grey cracking clay soils (Holland & Funk 2006). Habitats favoured by the species are RE11.3.21 from which it is known to occur. The woodland RE11.3.2 and derived native grassland also present potential habitat for the species. It can however occur in a range of highly disturbed locations and hence its occurrence may not be readily predicted.

Ecology

Other than being a perennial, very little is known about this species although, though as a daisy it is probably fairly short-lived (e.g. living < 5 years). The species is known to flower throughout the year but most prominently in spring, possibly in response to rainfall. The

seeds are likely to be wind dispersed, which should assist colonisation. It has the ability to survive along disturbed roadsides in in other highly disturbed habitats.

Known Threats to the Species

The species is threatened by roadside clearing and herbicide drift. It may also be threatened by invasion of exotic species of which lippia (*Phyla canescens*) and green panic (*Megathyrsus maximus var. pubiglumis*) pose the most immediate threat.

Records Relevant to the SGP

Five Herbrecks specimens recorded within 10 km of the eastern boundary of the SGP assessment area, mostly in the Cecil Plains / Millmerran Area including collections on road reserves on the Cecil Plains - Millmerran Road.

Rule(s) for Habitat Mapping:

The species is most likely to occur from the Dalby area (-27.00) south to Millmerran (-27.9) generally on the Condamine Alluvium. RE 11.3.2 and associated derived grasslands occurring between in this area should be treated as "general habitat".

All other remnant vegetation and cleared agricultural land in the project development area should be treated as "absence suspected".

Mapping Confidence

Due to the relatively specific habitat requirements, detailed survey throughout the assessment area and resolution of the revised mapping database, mapping is considered to have a high degree of confidence. There may however be a number of potential habitats adjacent to roadsides that are beyond mapping resolution.

Picris barbarorum

Status

Vulnerable (NC Act)

Distribution and Habitat

Occurs from the Darling Downs and Warrego pastoral districts in southern Queensland (Bostock & Holland 2016), to north of the north-west plains of NSW. Herbrecks data indicates that in the Darling Downs, it has a restricted distribution but may be locally abundant along roadsides. Known to occur from the Jandowae, Macalister, Norwin localities and along the Warrego highway west of Dalby.

Herbrecks specimens indicate occurrence in native grassland (12.3.21) of *Dichanthium sericeum* in stock routes, road reserves adjacent to disturbed areas such as cultivated paddocks and road and rail lines on black clay soil (DERM 2011).

Ecology

Very little is known about this species although, though as a daisy it is probably fairly short-lived (e.g. living < 5 years). Flowering period is not documented although it is likely to be re-invigorated in response to rainfall, particularly in the spring period.

Known Threats to the Species

Vouchered records of Plains Picris suggest that the annual herb may be tolerant of light disturbance. Its known occurrence on roadsides suggest it may be impacted by roadworks. In similarity to Picris evae it may well be intolerant of grazing and capable of surviving other forms of disturbance.

Records Relevant to the SGP

Four herbarium records within 5km of the SGP assessment area with the nearest less than 2 km from the assessment area boundary, 14km north-west of Dalby.

Rule(s) for Habitat Mapping:

The following REs and habitats should be classified as "General Habitat" where they are associated with the Condamine Alluvium.

1. RE 11.3.2 and derived regrowth vegetation.
2. Non-remnant derived native grasslands

All other remnant vegetation in the SGP Assessment area and cleared agricultural and grazing land should be treated as "absence suspected".

Mapping Confidence

Due to the relatively specific habitat requirements, detailed survey throughout the assessment area and resolution of the revised mapping database, mapping is considered to have a high degree of confidence. There may however be a number of potential habitats adjacent to roadsides that are beyond mapping resolution.

Rutidosia lanata

Status

Vulnerable (NC Act)

Distribution and Habitat

Endemic to south central Queensland from near Jackson to Hannaford on the western Darling Downs (DNR 2000). Mainly found in roadside vegetation of Acacia and Eucalypt woodland/open forest on red sandy ridges and clay flats between 280-320m altitude adjacent to cleared or partly cleared grazing and cropping land (DNR 2000). Based on Herbrechts notes, associated vegetation includes open grassy woodland of *Eucalyptus populnea* with *Eremophila mitchellii*; *Acacia harpophylla*, *Casuarina cristata*, and *Eucalyptus woollsiana* woodland on reddish-brown loamy clay; remnant *Acacia harpophylla*, *Eucalyptus coolabah*,

Eucalyptus populnea open forest on alluvium clay loam and gentle sedimentary rises; and in cleared areas along powerlines adjoining *Acacia aprepta* thicket.

Ecology

Rutidosis lanata flowers and fruits from October to March and produces a soil-stored seed bank that lasts for less than one year (DEHP 2017e; Pollock, 1997).

Known Threats to the Species

The species and habitat are known to be threatened by clearing with possible threats of inappropriate grazing, road verge maintenance, and habitat disturbance by weeds and introduced pastures (DNR 2000).

Records Relevant to the SGP

Eight Herbarium records within 20km from the the SGP Assessment area, all recorded in the Miles / Chinchilla area.

Rule(s) for Habitat Mapping:

1. The species may occur throughout the entire project area although is more likely north from Chinchilla based on vouchered herbarium records. Throughout the assessment area, the following REs should be treated as 'General Habitat'; 11.3.4, 11.3.2, 11.3.17, 11.9.5 and 11.9.7.
2. All other remnant vegetation in the project development area, regrowth vegetation and cleared agricultural land should be treated as "Absence Suspected".

Mapping Confidence

Due to the relatively specific habitat requirements, detailed survey throughout the assessment area and resolution of the revised mapping database, mapping is considered to have a high degree of confidence.

Xerothamnella herbacea

Status

Endangered (NC Act): Endangered (EPBC Act)

Distribution and Habitat

Xerothamnella herbacea is known from seven locations between Goondiwindi and Theodore. Scattered populations occur to the north-east of Chinchilla (between Chinchilla and Boondooma Lake), within Palmgrove and Expedition National Parks to the southwest of Moura. Two isolated population occur between Goondiwindi and Millmerran.

Occurs in remnant and disturbed Brigalow (*Acacia harpophylla*) and Belah (*Casuarina cristata*) dominated communities in shaded situations, often in leaf litter (TSSC 2008n). The species is associated with Brigalow dominated communities, preferring shady locations where it grows in leaf litter (TSSC 2008n). The plant often occurs in gilgais in vertic clay soils (vertisols) and is known to occur in non-remnant and highly disturbed habitats. Regional

ecosystems associated with this species are typically dominated by Brigalow or Belah and include REs 11.3.1, 11.4.3 and 11.9.5.

Ecology

Little is known in regard to the ecology of *Xerothamnella herbacea* although it can live for a few years and establish vegetatively by rooting from nodes along stems.

Known Threats to the Species

The species is threatened by competition from invasive grasses such as green panic (*Megathyrsus maximus* var. *pubiglumis*) and to a lesser extent buffel grass (*Cenchrus ciliaris*) either by direct competition or by increasing the fuel load and altering fire regimes. Potential threats include road widening and maintenance activities, surface erosion, and grazing and trampling by cattle and native macropods (TSSC 2008n).

Records Relevant to the SGP

Two herbarium records to within 20km of the SGP Boundary, 20km to the east and north of Chinchilla.

Rule(s) for Habitat Mapping:

The species may occur throughout the entire project area where it may be associated with Brigalow dominant habitats. Throughout the assessment area, the following REs and any derived regrowth Brigalow > 15 yrs age should be treated as 'General Habitat'; 11.3.1, 11.4.3 and 11.9.5.

All other remnant vegetation in the project development area, regrowth vegetation and cleared agricultural land should be treated as "Absence Suspected".

Mapping Confidence

Due to the relatively specific habitat requirements, detailed survey throughout the assessment area and resolution of the revised mapping database, mapping is considered to have a high degree of confidence.



Xerothamnella herbacea. Photograph Copyright © Boobook

Cryptandra ciliata

Status

Near Threatened (NC Act)

Distribution and Habitat

Restricted to the Gurulmundi, Barakula and Cracow areas of south-eastern Queensland (Chinchilla Field Naturalists Club 1997, DNR 2000). Typical habitat is eucalypt dominant woodland, lancewood (*Acacia shirleyi*) woodland and *Triodia* grassland on rocky on low lateritic and sandstone ridges. Habitat in the PDA is consistent with RE 11.7.5, 11.7.4, 11.7.6, 11.5.1, 11.5.4, 11.5.21.

Ecology

There is little documented information on the ecology of this species.

Known Threats to the Species

DNR (2000) indicate that the species and habitat is possibly threatened by clearing associated with gravel extraction. Other potential threats may include road construction and maintenance, and inappropriate fire regimes.

Records Relevant to the SGP

Three herbarium records within 5km of the assessment area boundary with a single record within 1km of the eastern boundary, 30km to the north of Miles.

Rule(s) for Habitat Mapping:

1. The species is only likely to occur in the central portion of the SGP assessment area where the following REs should be treated as "General Habitat"; 11.5.1, 11.5.4, 11.5.21, 11.7.4, 11.7.5, 11.7.6 and 11.7.7.
2. All General Habitat within 1km of a recent (1980+), accurate ($\pm$ 500m) record is classed as "Core Habitat Known".
3. All other remnant vegetation in the project development area, regrowth vegetation and cleared agricultural land should be treated as "Absence Suspected".

Mapping Confidence

Due to the general habitat requirements, intensity of the field survey and detailed mapping revision available, mapping is considered to have a high degree of confidence.

Austral Toadflax (*Thesium australe*)

Status

Vulnerable (NC Act): Vulnerable (EPBC Act)

Distribution and Habitat

Historical collections (including the late 1800's) were made from Tasmania, but it is now considered extinct in that state (DSE, 2003). Austral Toadflax occurs in eastern Victoria, NSW and southern Queensland. The majority of southern Queensland collections are from the Darling Downs and Moreton districts (Bostock and Holland 2016). The Dalby area represents the species western limits on the Darling Downs.

Austral toadflax has been collected within popular box (*Eucalyptus populnea*) woodland on alluvial flats (RE 11.3.2) north-west of Dalby, within the project development area. Other Herbarium collection records of Austral toadflax are from along roadsides, mountain coolibah (*Eucalyptus orgadophila*) grassy open woodlands with kangaroo grass (*Themeda triandra*) and Queensland blue grass (*Dichanthium sericeum*). RE11.3.2 in the Dalby region is considered the most likely habitat in the SGP assessment area.

Ecology

A root parasite of kangaroo grass (*Themeda triandra*) and other grasses, Austral toadflax lives for at least two years. Flowers have been recorded from spring to autumn with fruit developing in summer. Austral toadflax has been observed to germinate prolifically after fire and also after drought. The species is relatively short lived, persisting up to two years after germination (Department of Sustainability and Environment (DSE) 2003).

Known Threats to the Species

Populations in road reserves are threatened by roadwork and maintenance activities such as spraying, grading, slashing, by inappropriate grazing and burning regimes, and weed infestation (Goodland 2000). The species is known to be susceptible to rabbit, horse and cattle grazing but able to tolerate light, non-continuous cattle grazing. Populations of the species are thought to be declining. Austral toadflax cannot survive beneath a dense shaded

canopy (Griffith, 1992), nor is it likely to be capable of surviving dense infestations of exotic grass.

Records Relevant to the SGP

Two herbarium records within 10km of the SGP assessment area, with the nearest record 2.7k east of the eastern SGP assessment area boundary, 25km north west of Dalby.

Rule(s) for Habitat Mapping:

Intact representation of Poplar Box dominant woodland (RE11.3.2) associated with the Condamine River Alluvium (Condamine River Floodplain) should be treated as "General Habitat". All other REs, non-remnant regrowth and cultivated areas should be treated as "Absence Suspected".

Mapping Confidence

Due to the relatively specific habitat requirements, detailed survey throughout the assessment area and resolution of the revised mapping database, mapping is considered to have a high degree of confidence.

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Appendix F.

Recorded Vertebrate Fauna List

List of Terrestrial Vertebrate Fauna Recorded during the 2016-17 SGP surveys

GROUP			Status		SGP Region		
	Scientific Name	Common Name	EPBC	NCA	Sth	Cnt	Nth
AMPHIBIAN							
	<i>Crinia parinsignifera</i>	Beeping froglet		LC	X	X	
	<i>Pseudophryne major</i>	Great brown broodfrog		LC		X	
	<i>Uperoleia laevis</i>	Eastern toadlet		LC	X		
	<i>Uperoleia rugosa</i>	Chubby toadlet		LC	X	X	
	<i>Uperoleia</i> sp.			LC	X	X	
	<i>Limnodynastes fletcheri</i>	Barking marsh frog		LC		X	
	<i>Limnodynastes salmini</i>	Salmon-striped frog		LC		X	
	<i>Limnodynastes tasmaniensis</i>	Spotted marsh frog		LC	X	X	
	<i>Limnodynastes terraereginae</i>	Scarlet-sided pobblebonk		LC	X	X	
	<i>Neobatrachus sudellae</i>	Meeowing frog		LC	X	X	
	<i>Notaden bennettii</i>	Holy cross frog		LC		X	
	<i>Platyplectrum ornatum</i>	Ornate burrowing frog		LC	X	X	
	<i>Cyclorana alboguttata</i>	Greenstripe frog		LC	X	X	
	<i>Cyclorana brevipes</i>	Superb collared frog		LC		X	
	<i>Cyclorana novaehollandiae</i>	Eastern snapping frog		LC	X	X	
	<i>Litoria caerulea</i>	Green tree frog		LC	X	X	
	<i>Litoria fallax</i>	Eastern sedge frog		LC	X	X	
	<i>Litoria latopalmata</i>	Broad-palmed rocketfrog		LC	X	X	
	<i>Litoria peronii</i>	Emerald-spotted treefrog		LC	X	X	
	<i>Litoria rubella</i>	Ruddy treefrog		LC	X	X	
	<i>Rhinella marina</i>	Cane toad		I	X	X	
<u>Amphibian Total</u>		<u>20</u>			<u>16</u>	<u>20</u>	<u>0</u>
REPTILE							
	<i>Underwoodisaurus milii</i>	Thick-tailed gecko		LC	X	X	
	<i>Amalosia</i> sp. cf. <i>jacovae</i>			LC		X	
	<i>Amalosia</i> sp. cf. <i>rhombifer</i>			LC		X	
	<i>Diplodactylus vittatus</i>	Eastern stone gecko		LC	X	X	
	<i>Lucasium steindachneri</i>	Box-pattern gecko		LC	X	X	
	<i>Nebulifera robusta</i>	Robust velvet gecko		LC	X	X	
	<i>Oedura tryoni</i>	Southern spotted velvet gecko		LC		X	
	<i>Strophurus taenicauda</i>	Golden-tailed gecko		NT	X	X	
	<i>Gehyra dubia</i>	Dubious dtella		LC	X	X	X
	<i>Heteronotia binoei</i>	Bynoe's gecko		LC	X	X	X
	<i>Delma plebeia</i>	Common delma		LC		X	
	<i>Lialis burtoni</i>	Burton's legless lizard		LC		X	
	<i>Pygopus schraderi</i>	Eastern hooded scaly-foot		LC		X	
	<i>Anomalopus leuckartii</i>	Two-clawed Worm-skink		LC		X	
	<i>Carlia munda</i>	Striped rainbow skink		LC		X	
	<i>Carlia pectoralis</i>	Open-litter rainbow skink		LC	X		

GROUP	Scientific Name	Common Name	Status		SGP Region		
			EPBC	NCA	Sth	Cnt	Nth
	<i>Carlia rubigo</i>	Orange-flanked rainbow skink		LC	X	X	X
	<i>Carlia sp.</i>	Rainbow skink		LC	X	X	
	<i>Carlia vivax</i>	Tussock rainbow-skink		LC	X		
	<i>Cryptoblepharus pulcher</i>	Elegant snake-eyed skink		LC	X	X	X
	<i>Cryptoblepharus sp.</i>			LC	X	X	
	<i>Ctenotus allotropis</i>	Brown-blazed wedgesnout ctenotus		LC	X	X	
	<i>Ctenotus spaldingi</i>	Straight-browed ctenotus		LC	X	X	
	<i>Cyclodomorphus gerrardii</i>	Pink-tongue lizard		LC	X		
	<i>Egernia striolata</i>	Tree skink		LC	X		
	<i>Lerista fragilis</i>	Eastern mulch-slider		LC	X	X	X
	<i>Lerista punctatovittata</i>	Eastern robust slider		LC	X	X	
	<i>Lerista timida</i>	Timid slider		LC	X	X	
	<i>Lygisaurus foliorum</i>	Tree-base litter-skink		LC	X	X	
	<i>Menetia greyii</i>	Common dwarf skink		LC	X	X	
	<i>Menetia sp.</i>			LC	X		
	<i>Morethia boulengeri</i>	South-eastern morethia skink		LC	X	X	X
	<i>Pygmaeascincus timlowi</i>	Dwarf litter-skink		LC	X	X	
	<i>Tiliqua rugosa</i>	Shingleback		LC	X		
	<i>Tiliqua scincoides</i>	Eastern blue-tongue lizard		LC	X		
	<i>Amphibolurus burnsi</i>	Burns' dragon		LC	X		
	<i>Amphibolurus sp.</i>			LC	X		
	<i>Diporiphora australis</i>	Tommy round-head dragon		LC		X	
	<i>Intellagama lesueurii</i>	Eastern water dragon		LC	X	X	
	<i>Pogona barbata</i>	Eastern bearded dragon		LC	X	X	
	<i>Varanus gouldii</i>	Sand monitor		LC	X	X	
	<i>Varanus panoptes</i>	Yellow-spotted monitor		LC	X	X	
	<i>Varanus tristis</i>	Black-headed monitor		LC		X	
	<i>Varanus varius</i>	Lace monitor		LC	X	X	
	<i>Morelia spilota</i>	Carpet python		LC			
	<i>Boiga irregularis</i>	Brown tree snake		LC		X	
	<i>Dendrelaphis punctulata</i>	Common tree snake		LC	X		
	<i>Tropidonophis mairii</i>	Keelback		LC		X	
	<i>Brachyurophis australis</i>	Coral snake		LC		X	
	<i>Cryptophis nigrescens</i>	Eastern small-eyed snake		LC		X	
	<i>Demansia psammophis</i>	Yellow-faced whipsnake		LC	X	X	
	<i>Furina diadema</i>	Red-naped snake		LC	X	X	
	<i>Hemiaspis damelii</i>	Grey snake		End	X		
	<i>Hoplocephalus bitorquatus</i>	Pale-headed snake		LC	X	X	
	<i>Parasuta dwyeri</i>	Dwyer's snake		LC	X		
	<i>Pseudechis porphyriacus</i>	Red-bellied black snake		LC	X	X	
	<i>Pseudonaja textilis</i>	Eastern brown snake		LC		X	
	<i>Vermicella annulata</i>	Bandy Bandy		LC	X		
Reptile Total		55			44	44	6

GROUP			Status		SGP Region		
	Scientific Name	Common Name	EPBC	NCA	Sth	Cnt	Nth
BIRD							
	<i>Dromaius novaehollandiae</i>	Emu		LC	X	X	
	<i>Cygnus atratus</i>	Black Swan		LC	X		
	<i>Chenonetta jubata</i>	Australian wood duck		LC	X		X
	<i>Nettapus coromandelianus</i>	Cotton pygmy-goose		LC		X	
	<i>Anas gracilis</i>	Grey teal		LC	X	X	
	<i>Anas superciliosa</i>	Pacific black duck		LC	X	X	X
	<i>Tachybaptus novaehollandiae</i>	Australasian grebe		LC	X	X	
	<i>Columba livia</i>	Rock dove		I			
	<i>Phaps chalcoptera</i>	Common bronzewing		LC	X	X	
	<i>Ocyphaps lophotes</i>	Crested pigeon		LC	X	X	X
	<i>Geopelia striata</i>	Peaceful dove		LC	X	X	
	<i>Geopelia humeralis</i>	Bar-shouldered dove		LC	X	X	
	<i>Podargus strigoides</i>	Tawny frogmouth		LC	X	X	
	<i>Eurostopodus mystacalis</i>	White-throated nightjar		LC	X	X	
	<i>Eurostopodus argus</i>	Spotted nightjar		LC	X	X	
	<i>Aegotheles cristatus</i>	Australian owl-nightjar		LC	X	X	X
	<i>Hirundapus caudacutus</i>	White-throated needletail	M	LC	X	X	
	<i>Apus pacificus</i>	Fork-tailed swift	M	LC		X	
	<i>Elanus axillaris</i>	Black shouldered kite		LC	X		
	<i>Microcarbo melanoleucos</i>	Little pied cormorant		LC	X	X	
	<i>Phalacrocorax sulcirostris</i>	Little black cormorant		LC	X		
	<i>Pelecanus conspicillatus</i>	Australian pelican		LC	X		
	<i>Ardea pacifica</i>	White-necked heron		LC	X		
	<i>Egretta novaehollandiae</i>	White-faced heron		LC	X	X	
	<i>Nycticorax caledonicus</i>	Nankeen Night-Heron		LC	X	X	
	<i>Threskiornis molucca</i>	Australian white ibis		LC		X	
	<i>Threskiornis spinicollis</i>	Straw-necked Ibis		LC	X		
	<i>Aviceda subcristata</i>	Pacific baza		LC			
	<i>Haliaeetus leucogaster</i>	White-bellied sea-eagle		LC	X		
	<i>Haliastur sphenurus</i>	Whistling kite		LC	X		
	<i>Accipiter fasciatus</i>	Brown goshawk		LC	X		X
	<i>Accipiter cirrocephalus</i>	Collared sparrowhawk		LC		X	
	<i>Circus approximans</i>	Swamp harrier		LC	X		
	<i>Aquila audax</i>	Wedge-tailed eagle		LC	X		
	<i>Falco cenchroides</i>	Nankeen kestrel		LC	X		
	<i>Falco berigora</i>	Brown falcon		LC	X	X	X
	<i>Falco longipennis</i>	Australian Hobby		LC		X	
	<i>Gallirallus philippensis</i>	Buff-banded Rail		LC		X	
	<i>Gallinula tenebrosa</i>	Dusky moorhen		LC		X	
	<i>Fulica atra</i>	Eurasian coot		LC		X	
	<i>Ardeotis australis</i>	Australian bustard		LC			
	<i>Burhinus grallarius</i>	Bush stone-curlew		LC		X	
	<i>Vanellus miles</i>	Masked lapwing		LC	X		

GROUP	Scientific Name	Common Name	Status		SGP Region		
			EPBC	NCA	Sth	Cnt	Nth
	<i>Dendrocygna arcuata</i>	Wandering whistling duck		LC			
	<i>Turnix varius</i>	Painted button-quail		LC	X	X	
	<i>Calyptorhynchus banksii</i>	Red-tailed Black-cockatoo		LC			
	<i>Calyptorhynchus lathami</i>	Glossy black-cockatoo		Vul	X	X	
	<i>Calyptorhynchus funereus</i>	Yellow-tailed Black-cockatoo		LC			
	<i>Eolophus roseicapillus</i>	Galah		LC	X	X	X
	<i>Cacatua sanguinea</i>	Little corella		LC	X		
	<i>Cacatua galerita</i>	Sulphur-crested cockatoo		LC	X	X	X
	<i>Nymphicus hollandicus</i>	Cockatiel		LC	X		
	<i>Trichoglossus haematodus</i>	Rainbow lorikeet		LC	X	X	
	<i>Trichoglossus chlorolepidotus</i>	Scaly-breasted lorikeet		LC	X	X	
	<i>Daphoenositta chrysoptera</i>	Varied sitella		LC	X	X	
	<i>Glossopsitta pusilla</i>	Little lorikeet		LC	X	X	
	<i>Alisterus scapularis</i>	Australian king-parrot		LC	X	X	
	<i>Aprosmictus erythropterus</i>	Red-winged parrot		LC	X	X	X
	<i>Platycercus adscitus</i>	Pale-headed rosella		LC	X	X	X
	<i>Psephotus haematonotus</i>	Red-rumped parrot		LC	X		
	<i>Centropus phasianinus</i>	Pheasant coucal		LC	X	X	
	<i>Eudynamys orientalis</i>	Eastern koel		LC		X	
	<i>Scythrops novaehollandiae</i>	Channel-billed cuckoo		LC		X	
	<i>Chalcites basalis</i>	Horsfield's bronze-cuckoo		LC	X	X	
	<i>Chalcites osculans</i>	Black-eared cuckoo		LC		X	
	<i>Chalcites lucidus</i>	Shining bronze-cuckoo		LC	X	X	
	<i>Chalcites minutillus</i>	Little bronze-cuckoo		LC		X	
	<i>Cacomantis flabelliformis</i>	Fan-tailed cuckoo		LC		X	
	<i>Cacomantis variolosus</i>	Brush cuckoo		LC	X	X	
	<i>Cacomantis pallidus</i>	Pallid cuckoo		LC	X	X	
	<i>Tyto delicatula</i>	Eastern barn owl		LC		X	
	<i>Ninox boobook</i>	Southern boobook		LC	X	X	
	<i>Ceyx azureus</i>	Azure kingfisher		LC		X	
	<i>Dacelo novaeguineae</i>	Laughing kookaburra		LC	X	X	X
	<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher		LC	X		
	<i>Todiramphus sanctus</i>	Sacred kingfisher		LC	X	X	
	<i>Merops ornatus</i>	Rainbow bee-eater		LC	X	X	
	<i>Eurystomus orientalis</i>	Dollarbird		LC	X	X	
	<i>Cormobates leucophaea</i>	White-throated treecreeper		LC	X	X	
	<i>Climacteris picumnus</i>	Brown treecreeper		LC	X		
	<i>Malurus cyaneus</i>	Superb fairy-wren		LC	X	X	X
	<i>Malurus melanocephalus</i>	Red-backed fairy-wren		LC		X	X
	<i>Malurus lamberti</i>	Variegated fairy-wren		LC	X	X	X
	<i>Chthonicola sagittata</i>	Speckled warbler		LC	X	X	
	<i>Smicrornis brevirostris</i>	Weebill		LC	X	X	X
	<i>Gerygone fusca</i>	Western gerygone		LC			
	<i>Gerygone olivacea</i>	White-throated gerygone		LC	X	X	X

GROUP	Scientific Name	Common Name	Status		SGP Region		
			EPBC	NCA	Sth	Cnt	Nth
	<i>Acanthiza nana</i>	Yellow thornbill		LC	X	X	X
	<i>Acanthiza chrysorrhoa</i>	Yellow-rumped thornbill		LC		X	X
	<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill		LC			X
	<i>Acanthiza reguloides</i>	Buff-rumped thornbill		LC	X	X	
	<i>Acanthiza apicalis</i>	Inland thornbill		LC	X	X	X
	<i>Acanthiza pusilla</i>	Brown thornbill		LC	X	X	
	<i>Pardalotus punctatus</i>	Spotted pardalote		LC	X	X	
	<i>Pardalotus striatus</i>	Striated pardalote		LC	X	X	X
	<i>Lichenostomus chrysops</i>	Yellow-faced honeyeater		LC	X	X	X
	<i>Gavicalis virescens</i>	Singing honeyeater		LC		X	
	<i>Lichenostomus leucotis</i>	White-eared honeyeater		LC	X	X	
	<i>Lichenostomus melanops</i>	Yellow-tufted honeyeater		LC	X		
	<i>Ptilotula fusca</i>	Fuscous honeyeater		LC	X	X	
	<i>Lichenostomus penicillatus</i>	White-plumed honeyeater		LC	X	X	
	<i>Manorina melanocephala</i>	Noisy miner		LC	X	X	X
	<i>Manorina flavigula</i>	Yellow-throated miner		LC	X	X	
	<i>Acanthagenys rufogularis</i>	Spiny-cheeked honeyeater		LC	X	X	X
	<i>Myzomela sanguinolenta</i>	Scarlet honeyeater		LC	X	X	
	<i>Lichmera indistincta</i>	Brown honeyeater		LC	X	X	X
	<i>Melithreptus gularis</i>	Black-chinned honeyeater		LC	X	X	
	<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater		LC	X	X	
	<i>Melithreptus albogularis</i>	White-throated honeyeater		LC	X		
	<i>Melithreptus lunatus</i>	White-naped Honeyeater		LC		X	
	<i>Entomyzon cyanotis</i>	Blue-faced honeyeater		LC	X	X	
	<i>Philemon corniculatus</i>	Noisy friarbird		LC	X	X	
	<i>Philemon citreogularis</i>	Little friarbird		LC	X	X	
	<i>Plectorhyncha lanceolata</i>	Striped honeyeater		LC	X	X	X
	<i>Pomatostomus temporalis</i>	Grey-crowned babbler		LC	X	X	X
	<i>Coracina novaehollandiae</i>	Black-faced cuckoo-shrike		LC	X	X	
	<i>Coracina papuensis</i>	White-bellied cuckoo-shrike		LC	X	X	
	<i>Coracina tenuirostris</i>	Cicadabird		LC	X	X	
	<i>Lalage tricolor</i>	White-winged triller		LC	X	X	
	<i>Pachycephala pectoralis</i>	Golden whistler		LC	X	X	
	<i>Pachycephala rufiventris</i>	Rufous whistler		LC	X	X	X
	<i>Colluricincla harmonica</i>	Grey shrike-thrush		LC	X	X	
	<i>Oriolus sagittatus</i>	Olive-backed oriole		LC	X	X	X
	<i>Artamus leucorhynchus</i>	White-breasted woodswallow		LC	X	X	
	<i>Artamus superciliosus</i>	White-browed woodswallow		LC	X	X	
	<i>Artamus cyanopterus</i>	Dusky woodswallow		LC	X	X	
	<i>Artamus minor</i>	Little woodswallow		LC	X		
	<i>Cracticus torquatus</i>	Grey butcherbird		LC	X	X	X
	<i>Cracticus nigrogularis</i>	Pied butcherbird		LC	X	X	
	<i>Cracticus tibicen</i>	Australian magpie		LC	X	X	X
	<i>Strepera graculina</i>	Pied currawong		LC	X	X	

GROUP	Scientific Name	Common Name	Status		SGP Region		
			EPBC	NCA	Sth	Cnt	Nth
	<i>Dicrurus bracteatus</i>	Spangled Drongo		LC	X		
	<i>Rhipidura rufifrons</i>	Rufous fantail	M	LC	X		
	<i>Rhipidura albiscapa</i>	Grey fantail		LC	X	X	
	<i>Rhipidura leucophrys</i>	Willie wagtail		LC	X	X	X
	<i>Corvus coronoides</i>	Australian raven		LC	X	X	X
	<i>Corvus orru</i>	Torresian crow		LC	X	X	
	<i>Myiagra rubecula</i>	Leaden flycatcher		LC	X	X	
	<i>Myiagra inquieta</i>	Restless flycatcher		LC	X	X	
	<i>Grallina cyanoleuca</i>	Magpie-lark		LC	X	X	X
	<i>Corcorax melanorhamphos</i>	White-winged chough		LC	X	X	
	<i>Struthidea cinerea</i>	Apostlebird		LC	X	X	X
	<i>Microeca fascinans</i>	Jacky winter		LC	X	X	
	<i>Petroica goodenovii</i>	Red-capped robin		LC	X	X	
	<i>Eopsaltria australis</i>	Eastern yellow robin		LC	X	X	
	<i>Zosterops lateralis</i>	Silvereye		LC	X		
	<i>Hirundo neoxena</i>	Welcome Swallow		LC	X		
	<i>Petrochelidon nigricans</i>	Tree martin		LC	X	X	
	<i>Dicaeum hirundinaceum</i>	Mistletoebird		LC	X	X	X
	<i>Taeniopygia bichenovii</i>	Double-barred finch		LC	X	X	X
	<i>Anthus novaeseelandiae</i>	Australian pipit		LC			X
	<i>Sturnus tristis</i>	Common myna		I	X		
	Bird Total	151			122	116	38
MAMMAL							
	<i>Tachyglossus aculeatus</i>	Short-beaked echidna		LC	X	X	X
	<i>Antechinus flavipes</i>	Yellow-footed Antechinus		LC	X		
	<i>Planigale maculata</i>	Common planigale		LC	X	X	
	<i>Sminthopsis murina</i>	Common dunnart		LC	X	X	
	<i>Phascolarctos cinereus</i>	Koala	Vul	Vul	X	X	
	<i>Trichosurus vulpecula</i>	Common brushtail possum		LC	X	X	
	<i>Petaurus breviceps</i>	Sugar glider		LC	X	X	
	<i>Petaurus norfolcensis</i>	Squirrel glider		LC	X	X	
	<i>Petauroides volans</i>	Greater glider	Vul	Vul	X	X	
	<i>Acrobates frontalis</i>	Broad-toed Feathertail glider		LC		X	
	<i>Aepyprymnus rufescens</i>	Rufous bettong		LC		X	
	<i>Macropus dorsalis</i>	Black-striped wallaby		LC	X	X	
	<i>Macropus giganteus</i>	Eastern grey kangaroo		LC	X	X	
	<i>Macropus robustus</i>	Wallaroo		LC	X		
	<i>Macropus rufogriseus</i>	Red-necked wallaby		LC	X	X	X
	<i>Wallabia bicolor</i>	Swamp wallaby		LC	X	X	
	<i>Saccolaimus flaviventris</i>	Yellow-bellied sheath-tail bat		LC	X	X	
	<i>Austronomus australis</i>	White-striped freetail bat		LC	X	X	
	<i>Mormopterus lumsdenae</i>	Northern free-tailed bat		LC	X	X	
	<i>Mormopterus ridei</i>	Ride's free-tailed bat		LC	X	X	

GROUP		Status		SGP Region		
Scientific Name	Common Name	EPBC	NCA	Sth	Cnt	Nth
<i>Mormopterus petersi</i>	Inland free-tailed bat		LC	X	X	
<i>Mormopterus sp.</i>			LC	X		
<i>Chalinolobus gouldii</i>	Gould's wattled bat		LC	X	X	
<i>Chalinolobus picatus</i>	Little pied bat		LC	X	X	
<i>Nyctophilus geoffroyi</i>	Lesser long-eared bat		LC	X		
<i>Nyctophilus gouldi</i>	Gould's long-eared bat		LC	X	X	
<i>Nyctophilus corbeni</i>	South-eastern long-eared bat	Vul	Vul	X	X	
<i>Nyctophilus sp.</i>				X	X	
<i>Scotorepens balstoni</i>	Inland broad-nosed bat		LC	X	X	
<i>Scotorepens greyii</i>	Little Broad-nosed bat		LC	X	X	
<i>Vespadelus baverstocki</i>			LC	X	X	
<i>Vespadelus troughtoni</i>	Eastern cave bat		LC		X	
<i>Vespadelus vulturnus</i>	Little forest bat		LC	X	X	
<i>Pseudomys delicatulus</i>	Delicate Mouse		LC		X	
<i>Rattus tunneyi</i>	Pale field rat		LC	X		
<i>Mus musculus</i>	House mouse		I		X	
<i>Canis lupus</i>	Dingo/dog		I	X	X	
<i>Felis catus</i>	Feral cat		I	X	X	
<i>Lepus capensis</i>	Brown hare		I	X	X	
<i>Oryctolagus cuniculus</i>	European rabbit		I	X	X	
<i>Sus scrofa</i>	Feral pig		I	X	X	
<i>Vulpes vulpes</i>	Red fox		I	X		
	Unidentified deer species		I	X		
Mammal Total	40			38	35	2
Grand Total	266			220	215	46

Appendix G.
Present, Likely or Possible
Threatened Fauna Species Profiles
and Mapping Criteria Mapping
Criteria

BUTTERFLIES

Pale Imperial Hairstreak (*Jalmenus eubulus*)

Status

Vulnerable (NC Act)

Distribution and Habitat

Jalmenus eubulus is restricted to the eastern Brigalow Belt Bioregion. The northern limit of its distribution appears to be around the latitude of Mackay and ranges south to around Boggabilla in northern NSW. The eastern limit of its distribution is roughly designated by the Great Dividing Range, being found near Kroombit Tops, Binjour Plateau, Bunya Mountains and Jondaryan (Eastwood et al. 2008). It may be found as far west as Carnarvon (Sands and New 2002).

The species is restricted to Brigalow (*Acacia harpophylla*)-dominated woodlands and open-forests. Its core habitat is old-growth Brigalow, particularly those areas with Belah (*Casuarina cristata*), emergent eucalypts such as *Eucalyptus populnea* and understorey shrubs and adults are always observed in association with old-growth (remnant) *A. harpophylla* communities (Breitfuss and Hill 2003; Eastwood et al. 2008). Being highly mobile, isolated patches may also provide suitable habitat.

Ecology

Jalmenus eubulus feeds exclusively on Brigalow (*A. harpophylla*) shrubs ranging in height from 0.5 to 5m and (Braby 2000; Breitfuss and Hill 2003; Eastwood et al. 2008). The species has also been documented as feeding on other *Acacia* species (Sands and New 2002), but this has been discarded as erroneous in recent reviews (Eastwood et al. 2008).

It is likely that eggs enter diapause shortly after being laid. Emergence is triggered by summer rainfall, which may fall irregularly throughout the species' range, resulting in apparent different activity patterns between populations and years. Adults have been recorded between October and April, with peak activity in February and March. Peak activity appears to occur approximately two months after the wettest months of the year (December and January) (Eastwood et al. 2008).

Larvae feed singly, or occasionally in small groups of up to three individuals (Braby 2000). As in many lycaenid butterflies, the larvae are always attended by ants of the *Iridomyrmex* group, on which they are likely to be reliant for survival (Braby 2000; Sands and New 2002; Eastwood et al. 2008).

Known Threats to the Species

This species is threatened by clearing of suitably sized stands of old-growth Brigalow woodland (Sands and New 2000).

Records Relevant to the SGP

Three records are located within the SGP, the most recent is nearly 20 years old. An additional five records are within 10km of the SGP boundary. The species requires targeted

surveys by experts experienced in butterfly identification. The lack of records is likely to reflect low survey effort as the species is expected to be more widespread and abundant than indicated in databases.

Rule(s) for Habitat Mapping:

1. The species may occur throughout the entire SGP area.
2. Within the SGP, all areas of remnant Brigalow (11.3.1, 11.3.17, 11.4.3 11.4.3a, 11.9.5) are classed as "Core Habitat Possible".
3. All "Core Habitat Possible" within 2km of a recent (1980+), accurate ($\pm$ 500m) record is reclassified as "Core Habitat Known".
4. The remaining Regional Ecosystems and non-remnant areas are classed as "Absence Suspected".

Specific Map Modifications

None.

Mapping Confidence

The life-cycle and habitat requirements for the Pale Imperial Hairstreak is well documented and understood. Correlation between important habitat characteristics and Regional Ecosystem descriptions is high. The habitat mapping for this species is expected to be highly accurate.

REPTILES

Golden-tailed Gecko (*Strophurus taenicauda*)

Status

Near Threatened (NC Act)

Distribution and Habitat

Golden-tailed geckoes are distributed from the western slopes of the Great Dividing Range to Carnarvon, and from Emerald in the north to Inglewood/Millmerran in the south. Areas within and surrounding Barakula State Forest may represent a stronghold for this species (Richardson 2006).

This species is a Brigalow Belt endemic. They are found in a wide variety of woodland and forest habitats, mainly in association with brigalow (*Acacia harpophylla*), cypress (*Callitris* spp.) and ironbark (*Eucalyptus* spp.). They can also be common in areas with a shrubby understorey (particularly *Acacia* spp. and *Callitris* spp, including regrowth). Ground cover, tree hollows and loose or peeling bark on standing trees and tree stumps may be important shelter sites for this species (Richardson 2006).

Ecology

During the daytime, golden-tailed geckos shelter under loose bark and in tree hollows (Wilson 2015). They may also bask during the daytime. In Spring/Summer, females lay a clutch of two eggs. Females may lay more than one clutch in a season.

Movement patterns of the species have not been documented. However, individuals have been recorded crossing dual lane roads during warm summer nights.

Known Threats to the Species

Habitat loss and degradation including inappropriate roadside management, inappropriate fire regimes, clearing and thinning of vegetation for agriculture appear to be the species main threats (Richardson 2006). Deaths on roads and predation from introduced carnivores (e.g., foxes and cats) may also affect populations.

Records Relevant to the SGP

The Golden-tailed Gecko have been frequently recorded during these surveys as well during previous ecological works. It is currently known from 82 observations within the SGP, but is likely to be much more widely distributed than indicated by these records. It has been recorded in both the central and southern regions of the SGP, but not the northern region where possible habitat is fragmented and minor in extent. The species has also been regularly recorded in the surrounding area.

General Rule(s) for Habitat Mapping:

1. The species may occur throughout the entire SGP area.
2. Within the SGP, RE's 11.3.1, 11.3.14, 11.3.17, 11.3.18, 11.4.3 11.4.3a, 11.5.1, 11.5.1a, 11.5.4, 11.5.4a, 11.5.20, 11.5.21, 11.7.2, 11.7.4, 11.7.6, 11.7.7, 11.9.2, 11.9.5 are mapped as "Core Habitat Possible".

3. Within the SGP, RE's 11.3.2, 11.3.4, 11.3.26, 11.7.5, 11.7.5b, and 11.7.5x are mapped as "General Habitat".
4. All areas of advanced regrowth (10+) should be treated as remnant vegetation and classed according to the above rules.
5. Core Habitat Possible and General Habitat within 1km of a recent (1980+), accurate ($\pm$ 500m) record is classed as "Core Habitat Known".
6. Habitat patches <5ha and not adjacent or near other remnant vegetation (i.e., isolated) are reclassified as "Absence Suspected".
7. "Core Habitat Possible" or "General Habitat" between 5ha and 10ha in size and not adjacent or near other remnant vegetation (i.e., isolated) are reclassified as "General Habitat" and "Absence Suspected" respectively.
8. Remaining regrowth and RE's are classed as "Absence Suspected".
9. Cleared agricultural, grazing land and palustrine and lacustrine wetlands (RE 11.3.3c, 11.3.27c) is classed as "Absence Likely".

Specific Map Modifications

Habitats in the northern section of the SGP (Wondoan) are open and heavily impacted by grazing activities. They generally lack a shrubby understory preferred by this species. All habitats classed as "Core Habitat Possible" or "General Habitat" using the above rules in the northern (Wondoan) section have been reclassified as "Absence Suspected".

Inspections along Wilkie Creek and the Condamine River suggest the bulk of vegetation in this alluvial system lack a suitable shrubby understorey and have been classed as "Absence Suspected".

A small number of small fragments which are unlikely to be valuable for the species based on their landscape position have been manually removed from the mapping product or dropped to a lower mapping category (i.e., Core Habitat Possible to General Habitat).

Mapping Confidence

Golden-tailed Geckos appear to be unevenly distributed throughout suitable habitat. However, they can also inhabit regrowth or cleared habitats with abundant shrubs. As such, the mapped habitat area is likely to have a moderate accuracy.

Common Death Adder (*Acanthophis antarcticus*)

Status

Vulnerable (NC Act)

Distribution and Habitat

This species is widespread throughout Queensland, with the exception of Cape York Peninsula and the Mulga Lands in the south-west (Wilson 2015). Once abundant in the Brigalow Belt, it is now rarely observed and in the southern Brigalow belt the species seems

to be particularly aligned with large contiguous tracts of vegetation (e.g. state forests around Inglewood and Southwood National Park may represent strongholds) which maintains a healthy ground strata (and in particular ground debris) (EPA 2008).

It is found in a wide variety of habitats, including rainforest, open woodland, shrubland and heath (Ehmann 1992; Wilson and Swan 2013).

Ecology

The Common Death Adder is a slow-moving, sedentary snake that lies motionless while partially buried in leaf litter, vegetation or soil. Breeding takes place in spring and autumn (Ehmann 1992).

Diet consists of lizards and small mammals, and to a lesser extent, birds and frogs. However, diet changes with age, young animals consuming more reptiles and frogs, whilst adults feed predominantly on small mammals and birds (Shine 1980).

Known Threats to the Species

Threats to this species are poorly known. Land clearing and fragmentation are likely to have extensively affected the occurrence of this species in the Brigalow Belt. Alteration to microhabitats is also likely to detrimentally affected ambush snakes such as death adders, as they require ground cover to ambush their prey. Grazing, agriculture, urbanisation and inappropriate fire regimes modify ground cover considerably, reducing potential ambush sites (Ehmann 1992; Reed and Shine 2002, EPA 2008). Similar patterns of decline have been seen in other ambush snake species (Shine 1994). The species is also at risk from Cane Toad ingestion in areas where toad abundance is high.

Records Relevant to the SGP

Two records of the species are located within 5km of the SGP boundary, including one from 2015. It is possible the species is present within the SGP although this species is very cryptic and difficult to detect, even during suitable conditions.

General Rule(s) for Habitat Mapping:

1. The species could occur throughout the entire EIS area.
2. Vegetation with a combined extent >5,000ha should be classed as "Core Habitat Possible".
3. Core Habitat Possible within 1km of a recent (1980+), accurate (± 500 m) record is classed as "Core Habitat Known".
4. Vegetation not connected to larger patches, but within close proximity (<500m) can be classed as "General Habitat".
5. Regrowth and cleared areas are mapped as "Absence Suspected".
6. Cleared farmland or tilled crops are classed "Absence Likely".

Specific Map Modifications

Areas along the Kogan-Condamine Rd (in the north-west corner of the southern region) include suitable habitat types (e.g., brigalow communities) but are limited in extent reducing

their value for the species. However, this vegetation connects larger remnant patches in the west (just outside the SGP) and has been mapped as "General Habitat".

A number of small linear patches, which are mapped as "Core Habitat Possible" or "General Habitat" using the above guidelines were removed.

Mapping Confidence

Habitat use by Death Adders is difficult to predict; they may occur in any remnant habitat, yet are absent from seemingly good habitats within their range. This may reflect historic land use or events that have affected ground structure. Historical fires, for example, may have reduced ground cover and resulted in local extinctions. Following fire, recolonisation may only occur if remaining patches are large or well connected to nearby populations. Due to these difficulties, the habitat map for this species is considered to have a low accuracy.

Dunmall's Snake (*Furina dunmalli*)

Status

Vulnerable (NC Act); Vulnerable (EPBC Act Act)

Distribution and Habitat

Dunmall's snake (*Furina dunmalli*) is confined to the Brigalow Belt bioregion of south-eastern Queensland and north-eastern New South Wales, occurring north to Clermont and near Rockhampton. Most records are from the Dalby-Tara area of the Darling Downs (Hobson 2012a).

The species has been found in a wide range of habitats, including forests and woodlands dominated by brigalow (*Acacia harpophylla*) and other acacias (*A. burowii*, *A. deanii*, *A. leiocalyx*), cypress (*Callitris* spp.) or bullock (*Allocasuarina luehmannii*) on black alluvial cracking clay and clay loams (Covacevich *et al.* 1988; Stephenson and Schmida 2008; Brigalow Belt Reptiles Workshop 2010; Hobson 2012a). It also occurs in spotted gum (*Corymbia citriodora*) and ironbark (*Eucalyptus crebra* and *E. melanophloia*) on sandstone-derived soils and there is a record from the edge of dry vine scrub (Stephenson and Schmida 2008; Brigalow Belt Reptiles Workshop 2010). However, preferred habitat appears to be brigalow growing on cracking black clay and clay loams (Cogger *et al.* 1993), with the majority of records from between 200 to 500 m elevation (Hobson 2012a). The species can, on rare occasions, inexplicably appear in sub-optimal vegetation. Advanced regrowth habitat should not be excluded, particularly when adjacent or linking areas of suitable habitat. It is unlikely to occur in highly fragmented vegetation, particularly narrow linear strips.

Ecology

Dunmall's snake is a nocturnal, cryptic, secretive species that is possibly genuinely scarce and very rarely encountered (Wilson 2015; Hobson 2012a). The species has been found sheltering under fallen timber and ground litter (Cogger *et al.* 1993; Brigalow Belt Reptiles Workshop 2010) and may use cracks in alluvial clay soils (Ehmann 1992). Little is known of its ecology, but it reportedly preys on lizards and geckoes (Gow and Swanson 1977; Shine

1981). Nothing is known of its breeding biology other than that it lays eggs (Wilson and Swan 2013).

Known Threats to the Species

Due to the paucity of records and secretive nature of Dunmall's snake, it is not known if the species has declined, although records suggest a decline in eastern parts of its range. Its distribution, however, is confined to the Brigalow Belt bioregion, an area that has been highly modified for agriculture, the timber industry, natural gas and coal extraction, and urban development. Much of its habitat has been cleared or fragmented, particularly in its core area on the Darling Downs (Hobson 2012a). The main threats to the local populations of Dunmall's snake are thought to be:

- Predation by feral animals,
- Pasture improvement practices,
- Livestock grazing,
- Inappropriate roadside management, because much of its core habitat now only exists as linear fragments along roads and in stock routes (Richardson 2006; Hobson 2012a), and
- Increased mortality from vehicle strike.

Other possible threats include loss of fallen timber and ground litter (e.g., fuel reduction burns, firewood collection), weed invasion and drainage of swamps (DoE 2017a).

Records Relevant to the SGP

Two old records (i.e. >20 years) exist in the southern portion of the SGP. An additional two records are located within 8km of the SGP, most recent from 2000. The species is cryptic and difficult to detect, even during suitable conditions.

Rule(s) for Habitat Mapping:

1. The species could occur throughout the entire EIS area.
2. All remnant vegetation >50ha in extent and within 500m of a larger vegetation patch of RE 11.3.1, 11.3.14, 11.3.17, 11.3.18, 11.4.3, 11.4.3a, 11.5.1, 11.5.1a, 11.5.4, 11.5.20, 11.5.21, 11.7.2, 11.7.4, 11.7.6, and 11.7.7 should be classed as "Core Habitat Possible".
3. Smaller vegetation patches of the above RE's may be mapped as "General Habitat" if they are in close proximity to large areas of "Core Habitat Possible".
4. Core Habitat Possible within 1km of a recent (1980+), accurate (± 500 m) record is classed as "Core Habitat Known".
5. Advanced regrowth of all the above RE's are mapped as "General Habitat" if they are adjacent to or connect large areas of "Core Habitat Possible" or "General Habitat".
6. Remaining regrowth is mapped as "Absence Suspected".

Specific Map Modifications

A number of narrow linear fragments (particularly Brigalow communities) were removed based on their limited extent and surrounding land use (high intensity farming practices).

Mapping Confidence

This species is very poorly understood and records are scarce. Predicting its occurrence is extremely difficult and the mapping is likely to have low accuracy.

Grey Snake (*Hemiaspis damelii*)

Status

Endangered (NC Act)

Distribution and Habitat

Grey snakes occur throughout the Brigalow Belt, from coastal districts near Rockhampton, south-east to the Lockyer Valley in South East Queensland (Wilson 2015).

Grey snakes inhabit dry eucalypt forest and pasture (Covacevich and Wilson 1995), favouring cracking, flood-prone soils along floodplains and near watercourses within the Brigalow Belt (Hobson 2002; Wilson 2015).

Ecology

Grey Snakes are nocturnal frog specialists (Wilson and Swan 2013), sheltering during the day under fallen logs, within soil cracks and down in animal burrows. They are known to give birth to up to 10 live young (Covacevich and Wilson 1995), but little else is known of their breeding biology.

Known Threats to the Species

This species is threatened by habitat loss, habitat degradation and fragmentation. Existing habitats and populations are under threat from agriculture and urban development (Eyre et al. 1997), as well as mining activities and the loss of waterways or wetlands. In addition, ingestion of cane toads and subsequent death from poisoning pose a threat to the species.

Records Relevant to the SGP

The Grey Snake was recorded during these surveys as well during previous ecological works. It is currently known from 16 observations within the SGP and has been recorded in both the central and southern regions of the SGP, but not the northern region where the habitat is fragmented and minor in extent.

Rule(s) for Habitat Mapping:

1. The species could occur throughout the entire EIS area.
2. All remnant vegetation where surface water could collect provides potential habitat for these species. In particular, vegetation on Landzones 3, and 4 should be classed as "Core Habitat Possible". In addition, the following RE's have clay soils, gilgai's or are likely to be subject to temporal ponding and should also be "Core Habitat Possible"; 11.9.5.
3. Derived Grasslands, which occur in alluvial floodplains in the SGP, are mapped as "Core Habitat Possible".

4. Larger contiguous areas of RE's 11.5.1, 11.5.1a, 11.5.20, and 11.5.21, or where these are immediately adjacent Core Habitat Possible, are included as "General Habitat".
5. Artificial waterbodies are mapped as "General Habitat".
6. All remnant vegetation, non-remnant vegetation, regrowth or cleared land within 1km of a recent (1980+), accurate ($\pm 500\text{m}$) record is classed as "Core Habitat Known".
7. Regrowth be classed according to its parent regional ecosystem.
8. Cleared farmland or tilled crops are mapped as "Absence Suspected".

Specific Map Modifications

Field investigations in the northern area (Wondoan) showed riparian habitats in this area were highly fragmented and heavily impacted from cattle grazing leading to loss of soil structure (ie., reduced soil cracks etc). Habitats in this area have been reduced to "General Habitat" in recognition of their reduced value.

Some unsuitable farm dams were removed.

Mapping Confidence

This species may occur in a number of habitats, including artificial grazing land. Predicting its occurrence is therefore difficult based on RE mapping. The habitat map for this species is moderately accurate.

BIRDS

Glossy Black-Cockatoo (*Calyptorhynchus lathami*)

Status

Vulnerable (NC Act)

Distribution and Habitat

Glossy Black-Cockatoos (*Calyptorhynchus lathami*) have a patchy distribution along the east coast and ranges south from near the Paluma Range to Gippsland in Victoria. An isolated population is located on Kangaroo Island in South Australia. They are uncommon and declining, especially in the south-western parts of its range, and are now extinct in mainland South Australia (Garnett *et al.* 2011). There has been concern for the status of Glossy Black-Cockatoos in the Southern Downs due to the loss of feeding and nesting resources (EPA 2003).

Birds inhabit woodlands and forests that contain abundant *Allocasuarina* spp. and abundant large hollows suitable for nesting. Many populations are restricted to remnant vegetation within hills and gullies surrounded by agricultural land (Higgins 1999); however, some populations move through artificial landscapes such as semi-urban parks, gardens and golf courses to access favoured food resources (Higgins 1999, M. Sanders pers. obs.). Groups are never far from waterbodies, which are visited daily. Being highly mobile, birds may travel considerable distances to isolated fragments in search of food. Advanced regrowth may also provide some foraging opportunity.

Ecology

Typically encountered in small family parties, Glossy Black-Cockatoos are dietary specialists, feeding exclusively on the seeds of *Allocasuarina* and *Casuarina* spp. Favoured species include *A. torulosa*, *A. littoralis*, *A. luehmannii*, *A. distyla*, *A. diminuta*, *A. gymnanthera* and *A. verticillata* (Chapman 2007). It is poorly documented, but Glossy Black-Cockatoos also feed on *A. inophloia* in and around the Kumbarilla to Inglewood area (M. Sanders pers. obs.).

Observations of the species feeding on other resources (e.g., *Callitris* and *Banksia* spp.) are likely to represent food switching during periods of poor *Allocasuarina* cone production (Chapman 2007). It is unclear if the use of *A. inophloia* by local populations reflect food switching, or if local populations rely on stands of *A. inophloia*. However, given the abundance of orts (feeding signs) in some locations, and their repeated observation over consecutive years, the latter seems plausible.

Birds show a preference for productive trees (e.g., higher seed/cone weight ratio), notwithstanding the influence of other factors such as distance from water or breeding hollows (Clout 1989; Pepper et al. 2000; Crowley and Garnett 2001; Cameron and Cunningham 2006; Chapman and Paton 2006; Chapman 2007). Stands of *Allocasuarina* spp. are therefore not of uniform value, and the loss of individual stands or trees may have disproportionate impacts.

The production of cones by *Allocasuarina* spp. closely tracks rainfall (Cameron 2006a), and hence the availability of resources for resident Glossy Black-Cockatoos fluctuate between

years. While resources may be sufficient to support existing birds, drought is likely to reduce breeding success (Cameron 2009).

Pairs breed during winter, mainly from April to July, although breeding has been recorded as late as August or as early as March (Beruldsen 2003). Nests are located in a large vertical hollow extending one or two meters deep. Hollows may be reused over many years (Beruldsen 2003). Females incubate and care for the young alone, but are regularly attended and fed by the male. Only one egg is produced, which hatches in about 30 days. Once hatched the chick fledges in around 60 days, but remains with its parents and is fed for another three months (Garnett et al. 1999).

Known Threats to the Species

Threats to Glossy Black-Cockatoo populations include:

- Clearing of habitat remains a serious threat. Previous clearing has reduced the species' range in the south and west of the Great Dividing Range (Garnett and Crowley 2000),
- Fire can reduce or remove suitable feed trees from large areas for several years and, if followed by grazing, prevent regeneration of previous habitats.,
- Fragmentation of habitats may also result in an increase in predation of nestlings and eggs or alternatively result in higher competition for hollows (Downes et al. 1997). This threat may be particularly severe where species adapted to altered or open habitats are abundant. These 'edge' species may include Common Brushtail Possum (*Trichosurus vulpecula*), Little Corella (*Cacatua sanguinea*), Galah (*Eolophus roseicapilla*) and Sulphur-crested Cockatoo (*Cacatua galerita*). By out-competing cockatoos for nest hollows, these predators and/or competitors can significantly reduce recruitment of Glossy Black-Cockatoos (Garnett et al. 1999),
- Prolonged and severe drought can significantly reduce *Allocasuarina* cone production, reducing feeding resources and therefore breeding success. Global climate change may therefore negatively impact the species on a broad scale, particularly on the western slopes of the Great Divide (Cameron 2009), and
- The loss of suitable hollow-bearing trees through processes such as fire or logging (Cameron 2006).

Records Relevant to the SGP

The Glossy Black-cockatoo has been frequently recorded during these surveys as well as previous ecological works. It is currently known from 29 observations within the SGP. It has been recorded in both the central and southern regions of the SGP, although it has been more commonly recorded in the southern portion where there is possibly more suitable foraging habitat available.

Rule(s) for Habitat Mapping:

1. The species could occur throughout the entire EIS area.
2. Regional Ecosystems containing *Casuarina cristata* (11.3.1, 11.3.17, 11.4.3, 11.4.3a, 11.9.5) and *Allocasuarina inophloia* (11.5.4) are classed as "Core Habitat Possible". South

of the Warrego Highway areas of RE 11.7.4 may also have *Allocasuarina littoralis* and have been mapped as "Core Habitat Possible".

3. Regrowth of the above RE's, which could contain larger trees with suitable foraging resources, are mapped as "Core Habitat Possible".
4. Core Habitat Possible and General Habitat within 2km of a recent (1980+), accurate ($\pm$ 500m) record is classed as "Core Habitat Known".
5. All remaining Regional Ecosystems are classed "Absence Suspected".

Specific Map Modifications

None

Mapping Confidence

Within the SGP Core Habitat Possible accurately predicts the presence of *Allocasuarina* foraging resources, though it is acknowledged that individual trees can be scattered throughout remnant vegetation or modified landscapes. While Core Habitat Possible is abundant in the southern region (Dalby region) of the SGP, it is more scattered in the central region, reducing the likelihood that Glossy Black-cockatoos will occur.

A hot wildfire severely damaged large areas of Glossy Black-cockatoo habitat in Kumbarilla State forest in late 2016. It may take several decades for foraging resources to recover in this area.

General Habitat will be an overestimate as areas of suitable regrowth vegetation (mapped as "General Habitat") will not contain trees of sufficient size to attract foraging birds.

Nests are located in large tree hollows, usually in proximity to foraging resources. Predicting where suitable nest trees might occur is difficult and no attempt has been made to capture possible nest areas in the mapping product.

A supply of water is also important for Glossy Black-cockatoo populations, and suitable locations which may attract birds are likely to be scattered throughout areas of vegetation not mapped.

Painted Honeyeater (*Grantiella picta*)

Status

Vulnerable (NC Act); Vulnerable (EPBC Act)

Distribution and Habitat

Endemic to Australia, the Painted Honeyeater (*Grantiella picta*) may be found from the eastern section of the Northern Territory to Victoria and southern regions of South Australia (Pizzey and Knight 2007). Rare in the Northern Territory, they are widespread throughout Queensland, absent only from Cape York and high rainfall areas.

Painted Honeyeaters occur mainly in dry open woodlands and forests, particularly box-ironbark woodlands. They may also be located in riparian forest, on plains with scattered

eucalypts, and in remnant trees on farmland. Their occurrence is strongly associated with mistletoe, on which they feed (Higgins *et al.* 2001) and fragmented or disturbed *Acacia* communities often have the highest density of Mistletoe. More advanced stands of *Acacia* regrowth may also have abundant mistletoe.

Ecology

Painted Honeyeaters feed almost exclusively on mistletoe fruit, but may also collect nectar and invertebrates (Oliver *et al.* 2003). Most foraging is undertaken within the canopy of trees (Higgins *et al.* 2001).

Nesting occurs during spring-summer (Sept.-Feb.), predominantly in the south-east of its range north to and around Brisbane. The breeding season is determined by photoperiod to coincide with warmer summer months, but actual breeding is cued in relation to the progression of mistletoe fruiting. This ensures that breeding is matched by peak resource availability, avoiding temporal variation inherent in unpredictable environments (Barea and Watson 2007).

Small, frail cup-shape nests with narrow sides are constructed in the outer foliage and branchlets of eucalypts, casuarinas and acacias. However, a disproportionately large number of nests are placed in mistletoe clumps in taller trees (Whitemore and Eller 1983; Beruldsen 2003; Barea 2008).

While not well understood, movement patterns are generally described as a north-south migration (Keast 1968). Populations move north during winter and return south of approximately 26° during spring-summer to breed (Higgins *et al.* 2001).

Known Threats to the Species

Large areas of suitable woodland habitat have been extensively cleared throughout this species' range. However, increased mistletoe abundance in degraded woodlands and roadside reserves may have benefited the species and alleviated somewhat the impacts of broad-scale habitat loss (Higgins *et al.* 2001; Bowen *et al.* 2009).

Records Relevant to the SGP

Three records are located within the SGP in the southern portion near Lake Broadwater where mistletoe is abundant in tall *Eucalyptus* spp., and several records exist within 10km of the SGP boundary, including records from the past few years. Likely to occur within the SGP infrequently, depending on availability and density of mistletoe fruit.

Rule(s) for Habitat Mapping:

1. The species could occur throughout the entire EIS area.
2. RE's 11.3.1, 11.3.17, 11.4.3, 11.4.3a and 11.9.5 (including 'disturbed' communities) are mapped as "Core Habitat Possible".
3. The above RE's and RE's 11.5.20 and 11.5.27 are mapped as "Core Habitat Known" around Lake Broadwater.
4. Regrowth RE 11.3.1, 11.3.17, 11.4.3, 11.4.3a, 11.9.5, and 'Regrowth Brigalow (>15yrs)' are mapped as "General Habitat".

5. All "Core Habitat Possible" within 2km of a recent (1980+), accurate ($\pm$ 500m) record is classed as "Core Habitat Known".
6. All remaining regional ecosystems and non-remnant areas are "Absence Suspected"

Specific Map Modifications

A small non-remnant (below patch threshold size) of Weeping Myall (*Acacia pendula* woodland) was added as "Core Habitat Possible".

Mapping Confidence

The presence of abundant mistletoe can only be accurately determined through field assessment, though it can be predicted to occur with moderate accuracy in areas of Core Habitat Possible. The mapped General habitat, to capture more advanced *Acacia* regrowth, is likely to over evaluate habitat extent and will have a low accuracy.

Australian Painted Snipe (*Rostratula australis*)

Status

Australian Painted Snipe - Vulnerable (NC Act); Endangered (EPBC Act)

Distribution and Habitat

Most records of the species occur east of a line between Eyre Peninsula and the Gulf of Carpentaria, excluding Cape York Peninsula where they appear to be absent (Marchant and Higgins 1993). However, scattered individuals occur west as far as Western Australia, where they may have once been common in the Kimberley and Swan Coastal Plain (Johnstone and Storr 1998). Recent records mostly centre on the Murray-Darling basin of eastern Queensland and New South Wales (Marchant and Higgins 1993; Rogers et al. 2005). Lake Broadwater is considered to be important habitat for this species within Brigalow Belt South, although there is no known breeding record from this location (EPA 2003).

Birds may be recorded singly or in small groups in freshwater marshes. They are extremely nomadic, coming and going in response to local rainfall and flooding. Although its occurrence in a location is often erratic, with the bird absent some years and common in others (Marchant and Higgins 1993) there is indication of some regular seasonal migration, e.g., to central and north coastal Queensland in autumn and winter (Black et al. 2010). Breeding only occurs in swamps with temporary water regimes and complex shorelines forming islands, shallow water, exposed wet mud and dense low fringing vegetation (Rogers et al. 2005; Geering et al. 2007). During non-breeding periods, they may be found in a wider range of habitats including dams, rice paddocks, waterlogged grasslands, roadside drains and even brackish waterways (Marchant and Higgins 1993).

Ecology

The Australian painted snipe appears to be crepuscular and nocturnal, feeding on mudflats or in shallow water during the morning and evening and throughout the night (Geering et al. 2007). A variety of foods are eaten, including vegetation, seeds, insects, worms, molluscs,

crustaceans and other invertebrates including beetles (Marchant and Higgins 1993; Johnstone and Storr 1998).

Nesting occurs in spring and summer in southern Australia and during the wet season in northern Australia (Geering et al. 2007). Nests consist of a simple scrap in the ground lined by dry grasses, fine twigs and other vegetation. These nests are located in specific positions such as on a small island surrounded by shallow water, or occasionally on small mounds of purpose-built vegetation surrounded by water (Beruldsen 2003; Rogers et al. 2005). Breeding occurs only in suitable temporary wetlands with low relief and complex shorelines after an influx of water (Rogers et al. 2005).

Migration patterns are poorly known for the species (Pringle 1987). They are possibly dispersive or migratory. It is possible that such movements are due to local conditions, moving to flooded areas from drying wetlands (Marchant and Higgins 1993).

Known Threats to the Species

Threats to Australian Painted Snipe populations include:

- Loss or alteration of wetland habitats and their water regimes, particularly areas of breeding habitat (Rogers et al. 2005; Garnett et al. 2011).
- Degradation of existing wetlands through weed invasion.
- Trampling of habitat by cattle and feral pigs (*Sus scrofa*) (Rogers et al. 2005; Tzaros et al. 2012).
- Reduced water quality due to a lack of flushing, increased nutrient runoff, pesticide and herbicide runoff, saline discharge and increased erosion and turbidity due to vegetation removal (Tzaros et al. 2012).

Records Relevant to the SGP

Six records for Australian Painted Snipe are known from the southern section of the SGP, all in the vicinity of Lake Broadwater. The species is likely to be a vagrant and rare visitor to the SGP, though there is a low possibility the species might occur at Lake Broadwater and breed in the surrounding habitat during the SGP life of operation..

Rule(s) for Habitat Mapping:

1. Lake Broadwater (RE 11.3.27c and 11.3.27f) is mapped as 'Core Habitat Known'.
2. Long Swamp (RE 11.3.27d and 11.3.27f) is mapped as "Core Habitat Possible".c
3. All remaining regional ecosystems are "Absence Suspected"

Specific Map Modifications

None

Mapping Confidence

While the Australian Painted Snipe can occur on a variety of wetlands (including minor waterbodies), it is only known to occur within the immediate area of Lake Broadwater. Habitats outside these are likely to be marginal.

MAMMALS

South-eastern long-eared Bat (*Nyctophilus corbeni*)

Status

Vulnerable (NC Act); Vulnerable (EPBC Act)

Distribution and Habitat

The south-eastern long-eared bat (*Nyctophilus corbeni*) is largely restricted to the Murray-Darling Basin (Churchill 2008; Turbill et al. 2008), with its stronghold in the Pilliga forests of central New South Wales (Turbill and Ellis 2006). In Queensland, the species is mainly recorded in the southern areas of the Brigalow Belt (Reardon 2012). The distributional limits in Queensland are uncertain. McFarland et al. (1999) states that the species is found north to near Duaringa and Venz et al. (2002) consider that the Dawson River area is at, or close to, its northern range limit. However, Parnaby (2009), in a taxonomic review of Australian greater long-eared bats previously known as *N. timoriensis*, states that the most northerly record of the species is from 80 km west of Taroom. It is unknown if possible misidentifications of the species have resulted in the uncertainty attached to its distribution.

The species is most common in box/ironbark/cypress pine woodland on sandy soils (Turbill and Ellis 2006; Churchill 2008; Turbill et al. 2008), though it also occurs in bullock (Allocasuarina luehmannii), brigalow (Acacia harpophylla) and belah (Casuarina cristata) communities (Turbill et al. 2008), dry sclerophyll forests with Corymbia citriodora, and semi-evergreen vine thickets. The species prefers areas with a distinct canopy and a dense understorey (Churchill 2008). Most records are from large tracts of vegetation, approximately 5000+ ha in size (e.g., Southwood National Park) (EPA 2008), although the species can be occasionally recorded from smaller vegetation tracts of 600 ha (e.g., Erringibba National Park). Field observations and published literature also suggests it may use riparian habitats, though these habitats may be more important for providing roosting sites (hollow-bearing trees) and water.

Ecology

Little is known about the ecology of this species and most of what is known comes from research outside of Queensland (Reardon 2012). Roosting has been recorded in hollows of live trees, cracks in tree limbs, occasionally under exfoliating bark and even within foliage (Churchill 2008; Turbill et al. 2008; Reardon 2012).

With broad, short wings, the south-eastern long-eared bat is highly manoeuvrable and well-adapted to its cluttered habitat. They fly close to vegetation, often through the canopy and can drop suddenly to almost ground level after prey (Churchill 2008). Individuals are known to fly more than seven kilometres between roosts and foraging areas. Roosts may be changed frequently, each used for an average of 1.3 days in one study (Reardon 2012).

Mating occurs in autumn and winter. Females are able to store spermatozoa until ovulation and conception in early spring. Two young are usually born in late October to November and lactation continues until January (Turbill et al. 2008).

Known Threats to the Species

The main threats the south-eastern long-eared bat are:

- Major habitat loss over a large part of its distribution, mostly clearing of brigalow (Reardon 2012),
- Degradation of habitat from grazing,
- Loss of hollows and larger trees from logging and fires (Turbill et al. 2008),
- Increased competition for hollows from other species, and
- Increased exposure to predators (Reardon 2012).

Survey data suggest that large, intact remnants of suitable habitat are required to support populations (Turbill and Ellis 2006; Turbill et al. 2008). With more than 75% of habitat cleared in some parts of its range, land clearing and fragmentation continue to threaten this species (Duncan et al. 1999). Increased competition for hollows is an example of a flow-on impact from fragmentation (Reardon 2012).

Records Relevant to the SGP

The South-eastern Long-eared Bat has been recorded during these surveys as well as during previous ecological works. It is currently known from eight observations within the SGP and has been recorded in both the central and southern regions, although it was captured more frequently in the central region.

Rule(s) for Habitat Mapping:

1. The species may occur throughout the entire EIS area.
2. Only remnant vegetation which contributes to significantly large contiguous vegetation patches (>500ha) is considered suitable. Within these larger continuous vegetation patches:
 - a. RE's 11.3.14, 11.3.25, 11.3.27d, 11.3.27f, 11.5.1, 11.5.1a, 11.5.4, and 11.5.21 are mapped as "Core Habitat Possible", and
 - b. RE's 11.3.1, 11.3.14, 11.3.17, 11.3.18, 11.3.2, 11.3.26, 11.4.3, 11.4.3a, 11.5.20, 11.7.2, 11.7.4, 11.7.6, 11.7.7, 11.9.7, and 11.9.5 are mapped as "General Habitat"
3. All "Core Habitat Possible" or "General Habitat" within 2km of a recent (1980+), accurate ($\pm$ 500m) record is classed as "Core Habitat Known".
4. All remaining remnant and non-remnant vegetation is mapped as "Absence Suspected".

Specific Map Modifications

None

Mapping Confidence

Identifying suitably large tracts of remnant vegetation within the SGP is relatively easy. Predicting where the species might occur within this vegetation is more complex. While those RE's listed as "Core Habitat Possible" accurately reflect the best areas of habitat, large tracts of "General Habitat" may have suitable structure and provide good habitat for the

species. A precautionary approach would be to consider all areas of Core Habitat Possible or General Habitat as suitable.

While several RE's have been excluded as not suitable ("Absence Suspected") in the mapping product, their landscape position often contributes to patch integrity and they may therefore provide an important role in ensure a populations persistence.

Greater Glider (*Petauroides volans*)

Status

Vulnerable (EPBC Act)

Distribution and Habitat

The Greater Glider (*Petauroides volans*) is the largest gliding possum in Australia. Its distribution extends from the Windsor Tableland in north Queensland, south to Wombat State Forest in central Victoria (Woinarski et al. 2014). Inland isolated subpopulations are also known from the Gregory Range (west of Townsville) (Winter et al. 2004), and another in the Einasleigh Uplands bioregion of Queensland (Vanderduys et al. 2012).

The species is predominately restricted to eucalypt forests and woodlands. Greater gliders occur in highest abundance in taller, montane, moist eucalypt forests with larger, relatively old trees and abundant hollows (Andrews et al. 1994; Kavanagh 2000; Eyre 2004; van der Ree *et al.* 2004; Vanderduys et al. 2012). In areas west of the Great Dividing Range, they are found in low woodlands (McKay 2008). The species prefers forests with a diverse range of eucalypt species, due to seasonal variation in its favoured tree species (usually one or two species of eucalypt in any particular area) (Kavanagh 1984). Even in suitable habitat, the distribution may be patchy (Kavanagh 2000).

Ecology

The species is an arboreal nocturnal marsupial which is primarily folivorous, foraging on eucalypt leaves and occasionally flowers (Kehl and Borsboom 1984; Kavanagh and Lambert 1990; van der Ree et al., 2004). It shelters during the day in large tree hollows (Henry 1984; Kehl and Borsboom 1984; Lindenmayer et al., 1991; Smith et al., 2007; Goldingay 2012) and its abundance is often link to hollow density (Andrews et al. 1994; Smith et al. 1994, 1995). Research has shown that in southern Queensland, the species require at least 2–4 live den trees for every 2 ha of suitable forest habitat (Eyre 2002).

Home ranges are usually 1-4ha in size (Henry 1984; Kehl and Borsboom 1984; Comport et al. 1996; Gibbons and Lindenmayer 2002; Pope et al. 2005), however in lower productivity forest and more open woodland habitats home ranges can be up to 16 ha (Eyre 2004; Smith et al. 2007). Males have a larger home range size than females and sexes usually share a den when the breeding season commences (Kavanagh and Wheeler 2004; Pope et al. 2005; McKay 2008).

Females give birth to only one young from March to June. Juveniles emerge from the pouch when three to four months old and become independent at around nine months. However,

greater gliders do not reach their sexual maturity and start breeding until their second year (Tyndale-Biscoe and Smith 1969; McKay 2008). It is estimated that the species can live up to 15 years (Harris and Maloney 2010).

Known Threats to the Species

The main threats to the greater glider are:

- Major habitat loss and fragmentation, mostly through clearing, clearfell logging and the loss of senescent trees due to prescribed fire regimes (Eyre 2006; Lindenmayer et al., 2000; Taylor and Goldingay 2009),
- Inappropriate fire regimes (Lindenmayer et al. 2013),
- Effects from climate change such as range contraction (particularly in northern parts of its range) and declines in the health of eucalypt trees (Kearney et al. 2010; Matusick et al. 2013),
- Hyper-predation by owls (McKay 2008; Bilney et al. 2010; Lindenmayer et al. 2011), and
- Increased competition for hollows from other species (e.g. sulphur-crested cockatoos).

Records Relevant to the SGP

The Greater Glider was recorded several times during these surveys and is currently known from 11 observations within the SGP, in both the central and southern regions. Although, it was detected more frequently in the central portion, particularly along riparian areas.

Rule(s) for Habitat Mapping:

1. The species may occur throughout the entire EIS area. "Core Habitat Possible" includes RE's 11.3.4, 11.3.25 and 11.3.26.
2. Patches of RE 11.3.2, 11.3.3, 11.3.14, 11.3.17, 11.3.18 and 11.3.26 immediately adjacent the above RE's are mapped as "General Habitat".
3. All Core Habitat Possible within 1km of a recent (1980+), accurate ($\pm$ 500m) record is classed as "Core Habitat Known".
4. All remaining remnant and non-remnant vegetation is mapped as "Absence Suspected".

Specific Map Modifications

Isolated fragments of Core Habitat Possible or General Habitat were removed as Absence Suspected.

Mapping Confidence

Important habitat characteristics for this species are well understood and can be matched to regional ecosystem descriptions. The mapping is considered to be highly accurate.

Koala (*Phascolarctos cinereus*)

Status

Vulnerable (NC Act); Vulnerable (EPBC Act)

Distribution and Habitat

Endemic to eastern Australia, the Koala is a solitary species that is widespread across coastal and inland areas from Cooktown, Queensland to the Mt. Lofty ranges, South Australia (Martin et al. 2008). Restricted to altitudes below 800m elevation (Munks et al. 1996),

Koalas occur in a diversity of habitats including temperate, sub-tropical and tropical forest, woodland and semi-arid communities, and sclerophyll forest, on foothills, plains and in coastal areas (Martin and Handasyde 1999; Martin et al. 2008). Koalas on the western side of the Great Dividing Range at the western edges of their range are often associated with water courses though are not restricted to them (Melzer et al. 2000; Sullivan et al. 2003). Favoured feed tree species in these areas include *E. camaldulensis*, *E. coolabah* and *Eucalyptus populnea*.

Koalas have been translocated into a range of areas where they did not occur historically, such as Magnetic, Kangaroo and Phillip Island's.

Ecology

Koalas are well known to have a preference for eucalypt trees as a food source, though not all eucalypts species are equal and diet varies between regions. Although an arboreal species, preferences for individual trees and the distances between feed trees forces individuals to the ground, this is when they are most vulnerable to predation and human-induced mortalities (Hindell et al. 1985; Martin 1985).

Koalas are not strongly territorial and home ranges will overlap. Home ranges vary in size from 1-2 hectares in optimum habitat, and up to 135 hectares in semi-arid regions (Ellis et al. 2002; Martin et al. 2008). Movements are often as short as the distance between feed trees, however dispersing individuals will move over larger distances. Established individuals have been known to make exploratory movements over larger distances before returning to home ranges (Dique 2003).

The breeding season occurs between October and May with females producing up to one offspring per year (Martin et al. 2008). Juveniles become independent from one year of age with males living for over 12 years and females living for over 15 years (Martin and Handasyde 1999). Breeding occurs from two years of age, and is often determined by the establishment of a male hierarchy as males become vocal and fiercely fight for females (Martin et al. 2008).

Known Threats to the Species

Significant threats to Koalas include loss and fragmentation of habitat, vehicle strike, and predation by pet dogs (*Canis lupus familiaris*), whilst wildfire, disease, drought and extreme heat can also be damaging to both individual and population health.

Koalas inhabiting the north-western portion of their range are sparse and insufficiently studied. Although threats are similar to those in areas such as South-east Queensland where more research has been undertaken on Koala populations, it is likely that the severity of some threats is different. In particular, threats such as drought, and extreme heat events, may be more frequent and severe (Munks et al. 1996; Sullivan et al. 2003).

Records Relevant to the SGP

The Koala has been detected numerous times during these surveys as well during previous ecological works. It is currently known from a total of 73 observations within the SGP and has been recorded in both the central and southern regions. However, there are far more records in the southern portion where the Condamine and Wilkie Creek catchments appear to be a stronghold for the species in the southern Brigalow Belt.

Rule(s) for Habitat Mapping:

1. The species may occur throughout the entire EIS area.
2. RE's 11.3.2, 11.3.3, 11.3.4, 11.3.14, 11.3.17, 11.3.18, 11.3.25, 11.3.26, 11.3.27d and 11.3.27f are mapped as "Core Habitat Possible".
3. RE's 11.4.3, 11.4.3a, 11.5.1, 11.5.1a, 11.5.4, 11.5.20, 11.7.2, 11.7.4, 11.7.6, 11.7.7, 11.9.2 and 11.9.7 are mapped as "General Habitat".
4. Regrowth and disturbed vegetation should be mapped as per their parent RE.
5. All Core Habitat Possible and General Habitat within 1km of a recent (1980+), accurate ($\pm 500\text{m}$) record is classed as "Core Habitat Known".
6. All remaining remnant vegetation is mapped as "Absence Suspected".

Mapping Confidence

Important habitat for this species is reasonably well understood and can be matched to regional ecosystem descriptions. Core Habitat Possible is likely to closely reflect the species distribution, particularly in the southern region of the SGP where the species remains relatively abundant. However, field studies from this work frequently found Koala's in habitats not previously considered high value (mapped as General Habitat), and as such these areas may be more important for the local population than previously understood.

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Appendix H.

Metadata and description of fields for floristic survey database

Appendix F. Metadata and description of fields for floristic survey database.

Metadata Field	Description	Additional Information
Survey Event	The survey program during which the data was collected	Includes data collected during Surat Gas Pipeline Survey, Surat Gas Project EIS and Supplementary EIS, Daandine and Surat Gas Advanced Exploration Surveys.
Survey Event Recorders	Field personnel responsible for recording information	Survey event during which data was collected and personnel responsible for collection of the information.
PP Meander	Timed meander points for Protected Plants within Protected Plant 'High Risk' buffer areas.	Recorded every 5 mins for a 30 minute interval as per the Department of Environment and Heritage Protection (DEHP) (2014). Flora Survey Guidelines – Protected Plants. Department of Environment and Heritage Protection, Queensland Government, Brisbane.
Waypoint Number	Waypoint number from combined survey efforts	Renumbered waypoints based on combined data collected from field personnel.
Ind. Ref. Number	The site number recorded by the individual field personnel. Retained to allow Site Nos to be readily referenced if required by field personnel in the future.	
Survey Type	The intensity of recorded site data as described in Neldner et al (2012)	Secondary: Secondary site data quantifies structural and floristic information for all strata. This includes structural and floristic data for the Emergent (E), Canopy / Sub-canopy (T1, T2), Shrub (S1, S2) and Ground (G) layers. Plot size is a standard 10 x 50 m plot. Ground covers are measured in standard 5 x 1m ² or 10 x 1m ² quadrats along a measured centreline. Tertiary: Quantifies structural and floristic information for woody vegetation (T1, T2, S1, S2) in a 10 x 50m plot. Does not record non woody vegetation in ground-covers. Quaternary: Estimates and describes structural and floristic information at a given location. Identifies dominant only and is not plot based. Observation: Provides a description of dominant species and structural formation only. Non-plot based rapid survey effort.
Lat	Latitude in decimal degrees	
Long	Longitude in decimal degrees	
Elevation	Recorded elevation from GPS	
Q Herbarium Mapped RE_2	RE indicated in mapping databases produced by Qld Government agencies (DSITIA).	Most current version is produced by Department of Resources and Mines (Version 8.0, 2014).
RE Ground Truthed	RE recorded at a specific location during field survey.	RE recorded by field ecologists at a specified waypoint. Used to verify RE mapping databases.
VMA Status	Status of RE listed under the VM Act	Categories of Endangered, Of Concern, Least Concern and Non-remnant.
Biodiversity Status	Biodiversity Status of RE	Categories of Endangered, Of Concern, No Concern at Present.
EPBC Status	Status of ecological community listed under the EPBC Act 1999.	Categories of Critically Endangered, Endangered, Vulnerable
Vegetation Structure	Vegetation Structural Formation as defined in Neldner et al 2012.	Categories of Vine forest/ Thicket, Open Forest, Woodland, Open Woodland, Shrubland and Grassland. Further information defined in Neldner et al 2012.
Emergent Height	Height of the Emergent structural layer.	Generally defined as the upper structural layer forming less than 5% total cover (Walker and Hopkins 1990). Neldner et al 2012, define the emergent layer as the upper structural layer that does not form the dominant ecological layer (the layer with the dominant biomass) which typically corresponds with the definition by Walker and Hopkins.
T1 Canopy Height	Measured height of the canopy layer.	Canopy (T1) layer is defined as the upper structural layer that forms the dominant biomass. Often represented as a height interval (e.g. 11 – 13m).

Metadata Field	Description	Additional Information
T1 Canopy Cover	Measured cover of the canopy layer.	Measured by projected canopy cover (PCC) rather than projected foliage cover (PFC). Measured over either a 50 or 100m linear transect.
T1 Count	The number of T1 stems within a standard floristic survey plot.	Standard secondary survey plot is 10 m x 50 m.
T1 Dominant	The dominant species recorded within the T1 structural layer	
T1 Sub-dominant	The sub-dominant species recorded within the T1 structural layer	
T1 Associated	Species associated with the canopy other than dominant and sub-dominant species.	
T2 Canopy Height	Measured height of the sub-canopy layer.	Sub-canopy is the tree layer that lies directly below the canopy (covered by the canopy layer).
T2 Canopy Cover	Measured cover of the canopy layer.	Measured by projected cover of the sub-canopy (PCC).
T2 Count	The number of T2 stems within a standard floristic survey plot.	Standard secondary survey plot is 10 m x 50 m.
T2 Dominant	The dominant species recorded within the T2 structural layer	
T2 Sub-dominant	The sub-dominant species recorded within the T2 structural layer	
T2 Associated	Species associated with the sub-canopy (T2) structural layer other than dominant and sub-dominant species.	
S1 Canopy Height	Measured height of the tallest shrub layer (S1) layer.	Multi-stemmed woody species typically with upper height limits of 8m.
S1 Canopy Cover	Measured cover of the tallest shrub (S1) layer.	
S1 Count	The number of S1 stems within a standard floristic survey plot.	Standard secondary survey plot is 10 m x 50 m.
S1 Dominant	The dominant species recorded within the S1 structural layer	
S1 Sub-dominant	The sub-dominant species recorded within the S1 structural layer	
S1 Associated	Species associated with the tallest shrub layer (S1) other than dominant and sub-dominant species.	
S2 Canopy Height	Measured height of the secondary shrub layer (S2) layer.	Secondary shrub layer falls below the upper (S1) shrub layer. Typical S2 heights range from 0.5 – 2m.
S2 Canopy Cover	Measured cover of the secondary shrub (S2) layer.	
S2 Count	The number of S2 stems within a standard floristic survey plot.	Standard secondary survey plot is 10 m x 50 m.
S2 Dominant	The dominant species recorded within the S2 structural layer	
S2 Sub-dominant	The sub-dominant species recorded within the S2 structural layer	
S2 Associated	Species associated with the secondary (S2) shrub layer other than dominant and sub-dominant species.	

Metadata Field	Description	Additional Information
Ground - % cover live plants.	Total foliage cover of live plants within a standard survey plot. Sometimes represented by an estimate in quaternary plots.	Includes grasses and graminoids, forbs and shrubs <0.5 m, native and exotic species. Excludes leaf litter, timber and bare ground. Measured only in secondary survey plots although estimates can be made in Quaternary survey data. Ground cover measurement is undertaken within 5 or 10 x 1m ² quadrats (Secondary) and calculated as an average score. Estimates may be made in Quaternary plots.
Ground - % leaf litter	Cover of leaf litter in standard survey plot.	Leaf litter includes dead leaves, bark and other non-specific organic matter.
Ground - % leaf litter	Cover of leaf litter in standard survey plot.	Leaf litter includes dead leaves, twigs, bark and other non-specific organic matter.
Ground - % cover bare ground.	Cover of bare ground in standard survey plot.	Bare ground typically relates to exposed soil and sometimes rock.
Ground - % cover timber.	Cover of timber in standard survey plot.	Timber typical describes woody material (branches) > 5 cm diameter.
Ground - % cover rocks.	Cover of bare rock in standard survey plot.	Exposed rock not covered by soil.
Ground - % Cover Perennial Native Grass	% cover of perennial native grass measured in a standard secondary plot. Sometimes represented by an estimate in quaternary plots.	% cover of native perennial grasses taken as an average of sampled quadrats (Secondary sites) or an estimate (Quaternary plots). Perennial describes plants that persist throughout seasons although might die back in less favourable growing conditions, resprouting when growth conditions improve (i.e following rain).
Ground - % Cover Native Shrubs < 1m	% cover of shrubs measured within quadrats.	% foliage and branch cover of native shrubs < 1m height taken as an average of sampled quadrats (Secondary sites) or an estimate (Quaternary sites)
Ground - % Cover Native Forbs	% cover of native forbs measured in a standard secondary plot. Sometimes represented by an estimate in quaternary plots.	% cover of native forbs taken as an average of sampled quadrats (secondary sites) or an estimate (quaternary sites). Forbs are herbaceous flowering plants that are not graminoids (grasses and sedges).
Ground - % Cover Exotic Grass	% cover of exotic grass measured in a standard secondary plot. Sometimes represented by an estimate in quaternary plots.	% cover of exotic grasses taken as an average of sampled quadrats (secondary sites) or an estimate (quaternary sites). Perennial describes plants that persist throughout seasons although might die back in less favourable growing conditions, resprouting when growth conditions improve (i.e following rain).
Ground - % Cover Exotic Forbs	% cover of exotic forbs measured in a standard secondary plot. Sometimes represented by an estimate in quaternary plots.	% cover of exotic forbs taken as an average of sampled quadrats (secondary sites) or an estimate (quaternary sites). Exotic forbs are herbaceous flowering plants that are not graminoids (grasses and sedges) and are not native (introduced) to the survey area.
Cryptogams - % Cover	% cover of cryptogams covering soils in the ground layers.	Cryptogams are plants that reproduce by spores without flowers, seeds or leaves. Remnants persist as surface crusts during dry periods.
Grass / Forb dominant	The dominant grass/ forb species measured in ground layers. May be one or several species.	Includes both native and exotic species.
Grass / Forb sub-dominant	The sub-dominant grass / forb species measured in ground layers. May be one or several species.	Includes both native and exotic species.
Total spp. No	Total number of species recorded within a standard secondary survey plot.	Includes all woody and non-woody species although excludes cryptogams.
Harissia cactus % cover	Measured ground cover of Harrisia cactus (Harrisia martini), a declared Class 2 exotic pest.	
Opuntia % cover	Measured ground cover of Opuntia spp., a declared Class 2 exotic pest.	

Metadata Field	Description	Additional Information
Bryophyllum. % cover	Measured ground cover of exotic <i>Sporobolus</i> spp. (<i>Sporobolus fertilis</i> , <i>Sporobolus pyramidalis</i> , <i>Sporobolus jacquemontii</i>).	
Geology/ Soil	Field description of landform, soil and geology at a given survey site.	
Notes	Additional relevant information used to describe site characteristics.	
Philotheca S1 Cover	Measured crown cover of <i>Cerbera dumicola</i> in the S1 shrub layer in a standard Secondary site.	Philotheca sporadica is the only threatened species recorded during Arrow Surat Gas Project studies.
Philotheca Stems / ha	Stem counts for <i>Philotheca sporadica</i> in standard Secondary site in the shrub layer	
Date of Survey	Time and date of field recording	
Altitude	Altitude of survey location taken as metres above sea level, recorded on GPS.	
Photo number.	Photo number for individual survey locations.	Photo points collected by field recorders according to site location.
Additional Information	Reference to additional structural / floristic data	Reference to structural and floristic information specifically relating to native grassland assessments. Held separately from structural summary table. Includes floristic collection numbers.
Seasonal Effort	Relates to wet or dry season survey	Dry season survey undertaken from June to December and wet season typically from January to May.

Appendix F. Surat Gas Project – DXP 4 Significant Residual Impacts to Prescribed Environmental Matters

Surat Gas Project – DXP4

Significant Residual Impacts to Prescribed Environmental Matters
EPPG00972513

Version	<i>3.0</i>
Released	<i>28/02/2025</i>
Document Status	<i>Final</i>
Security Classification	<i>Routine</i>

Please see document administration section for more information

Table of Contents

1.	Introduction	4
2.	Purpose.....	11
2.1	Surat Gas Project development	11
2.2	Surat Gas Project EPBC Act Approval	11
3.	Methods	12
3.1	Identifying Prescribed Environmental Matters (PEMs).....	12
3.2	Significant residual impact (SRI) assessment.....	13
4.	Results	14
4.1	Assessment of PEMs for Potential SRI.....	14
4.2	Assessment of PEMs for Actual SRI.....	25
4.2.1	Regulated vegetation – Endangered Regional Ecosystems	27
4.2.2	Regulated vegetation – Of Concern Regional Ecosystems.....	27
4.2.3	Regulated vegetation – Regional Ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse.	28
4.2.4	Regulated vegetation – essential habitat (not in an urban area) for Endangered and Vulnerable wildlife.	29
4.2.5	Connectivity Areas – connectivity area that is a Regional Ecosystem (not in urban area).	29
4.2.6	Wetlands and watercourses – a wetland of high ecological significance.....	29
4.2.7	Protected wildlife habitat – habitat for an animal that is Critically Endangered, Endangered or Vulnerable.....	30
4.2.8	Protected wildlife habitat – habitat for an animal that is Special Least Concern.	31
4.2.9	Waterway providing for fish passage – Fish passage (not in an urban area).	32
5.	Conclusion.....	34
5.1	Distinct Matter Area (DMA) Grouping Justification for Financial Offsets	36
6.	References.....	41
7.	Document Administration.....	42

Figures

Figure 1 Project location	5

Tables

Table 1 Project details	4
Table 2 Ground-verified vegetation communities and cleared areas impacted by the project with Road scope sections condensed	9
Table 3 Expanded summary of Road scope ground-verified vegetation communities and cleared areas impacted.....	10
Table 4 Analysis of all Prescribed Environmental Matters (PEMs) and whether or not they have the potential for a Significant Residual Impact (SRI)	14
Table 5 Summary of Impacted Prescribed Environmental Matters (PEMs) including areas (ha), vegetation communities, and co-locations.....	26
Table 6 Significant Residual Impacts (SRIs) to Prescribed Environmental Matters (PEMs) with the Environmental Authority (EA) Table 3	35
Table 7 Distinct Matter Area (DMA) Groupings for Financial Offsets Calculation.....	37

1. Introduction

Arrow Energy Pty Ltd (Arrow) is planning to construct the remaining parts of The Dalby Expansion Project (DXP4), hereafter the project, as a component of our Surat Gas Project (SGP). This part of the SGP (Stage 1f) comprises a series of well pads, coal seam gas pipelines, water pipelines, Field Compressor Station (FCS) and infrastructure required to transfer coal seam gas and produced water. The key details for the current report are outlined in Table 1.

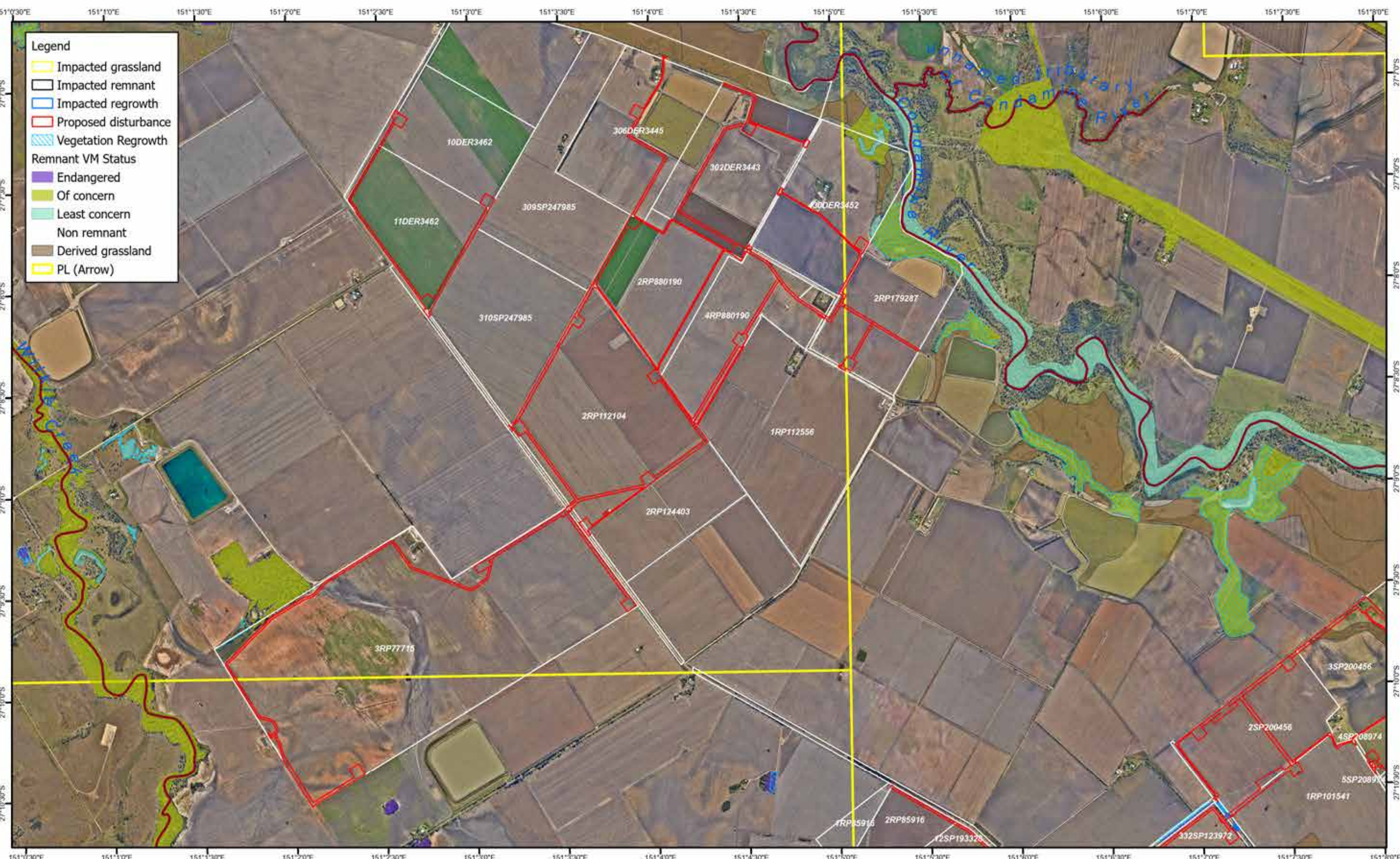
Table 1 Project details

	Key project details
Project Name	Dalby Expansion Project (DXP4)
Petroleum Lease	PLs 238, 258, 252, 198, 230, 260
Environmental Authority	EPPG00972513
Appropriately Qualified Person and Contact	Dr Paul Finn, Principal Ecologist paul.finn@arrowenergy.com.au

The relevant Environmental Authority (EA) for the project is the Dalby Expansion Project (DXP) EPPG00972513. This report addresses relevant EA conditions for the above-mentioned project, by providing a significant residual impact (SRI) assessment on Prescribed Environmental Matters (PEMs) to determine the project's environmental offset requirements under the *Environmental Offsets Act 2014* (EO Act). The DXP EA is currently dated 5 February 2025, however Arrow has an amendment being assessed which if approved will allow the estimated impacts to PEMs from this project. This SRI assessment report has been provided with the EA amendment approval so that it may be assessed in conjunction with the EA amendment decision.

The project is located on petroleum lease (PL) 238, 258, 252, 198, 230 and 260 in the Southern Brigalow Belt Bioregion. The project has a total disturbance footprint of approximately 614.45 ha, and is predominantly located in pre-disturbed, cleared land. The total area of remnant, regrowth and derived grassland vegetation to be cleared is approximately 151.6 ha (Table 2).

The location of the project is shown in Figure 1.



Legend

- Impacted grassland
- Impacted remnant
- Impacted regrowth
- Proposed disturbance
- Vegetation Regrowth
- Remnant VM Status
- Endangered
- Of concern
- Least concern
- Non remnant
- Derived grassland
- PL (Arrow)

Status: IFU

Source: Arrow Energy Limited, Geosciences Australia, Qld Gov.

Figure 1a
Daandine East
location along with that
of ground-verified remnant
and regrowth vegetation

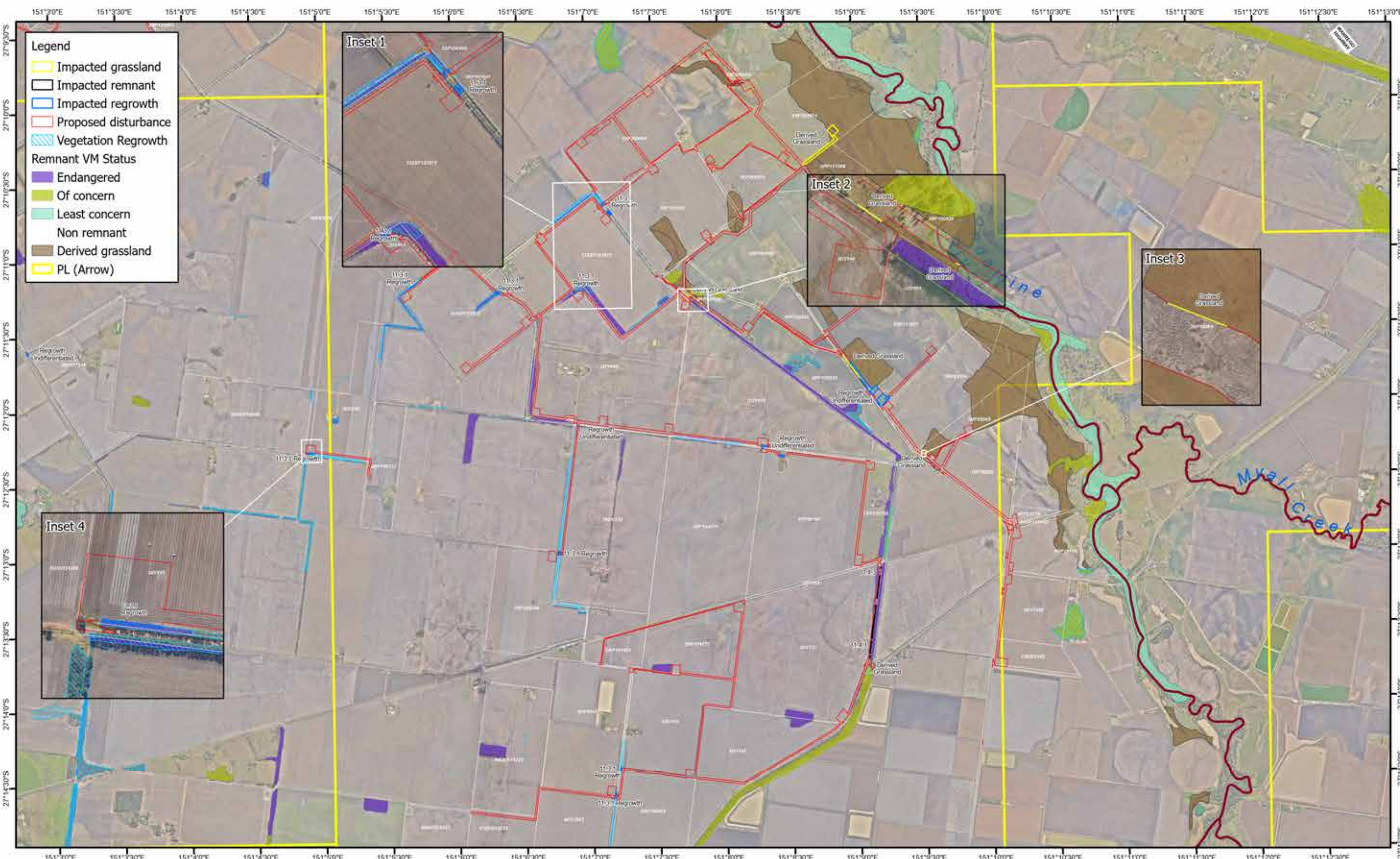
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Status: IFU

Figure 1b
Daandine Nandi Rd & Duleen Kupunn Part 3
location along with that
of ground-verified remnant
and regrowth vegetation

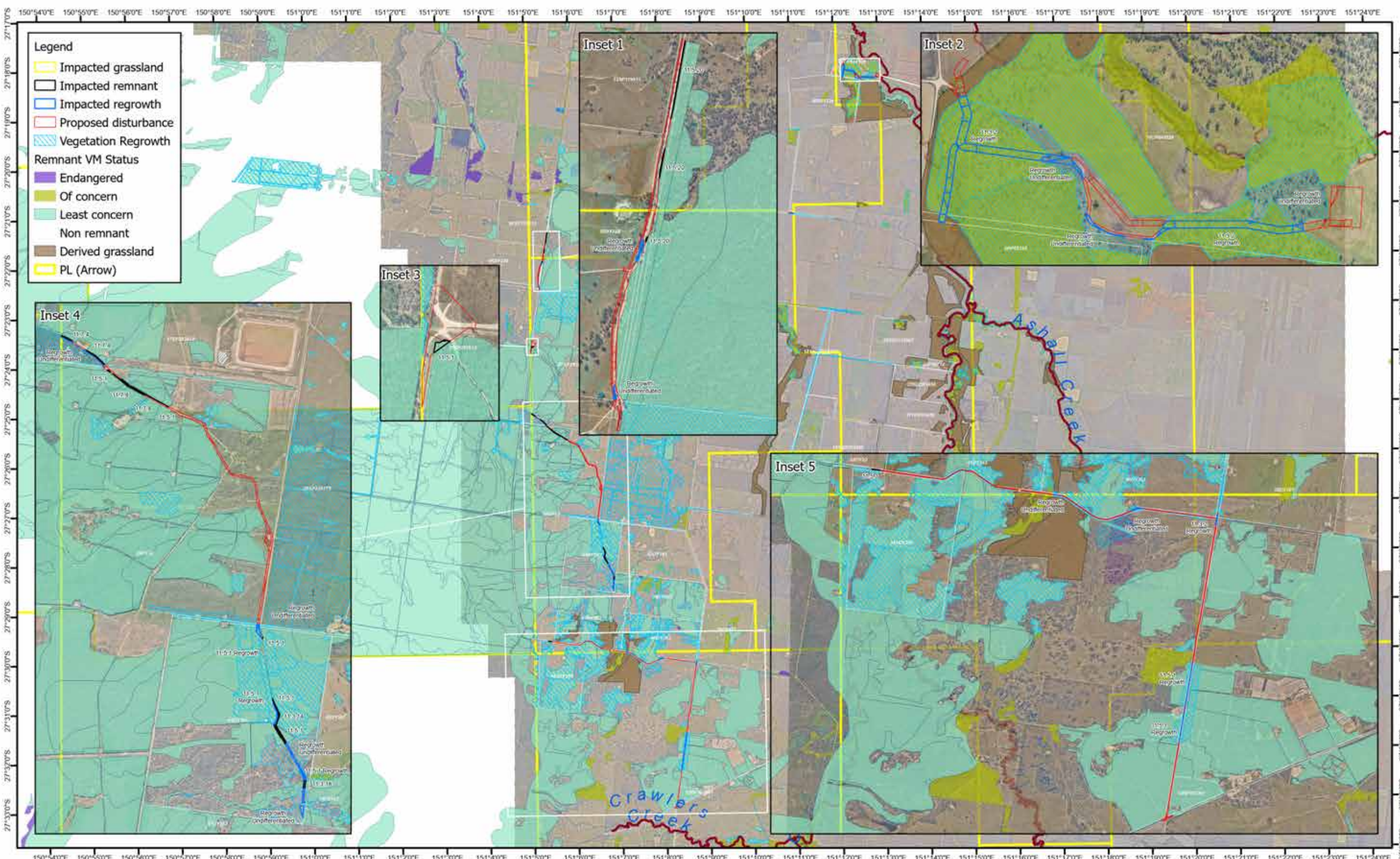
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Figure 1c
Nandi Springvale Part 1 and Road Scopes
location along with that
of ground-verified remnant
and regrowth vegetation

Uncontrolled (A)

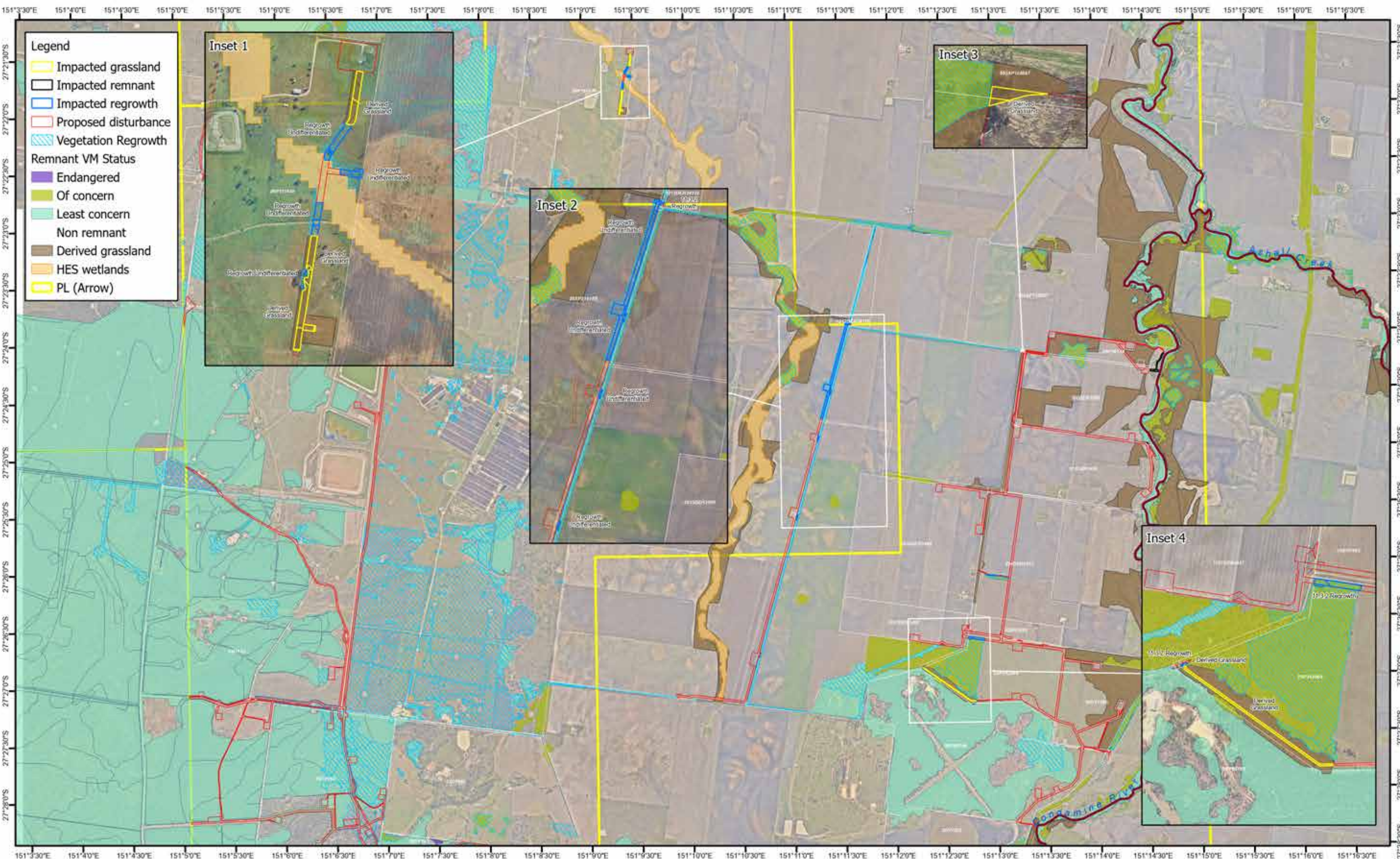
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0 1 2 4 km

Coordinate System: GDA2020 MGA Zone 56

N

Print Date: 13/02/2025



Legend

- Impacted grassland
- Impacted remnant
- Impacted regrowth
- Proposed disturbance
- Vegetation Regrowth
- Remnant VM Status
- Endangered
- Of concern
- Least concern
- Non remnant
- Derived grassland
- HES wetlands
- PL (Arrow)

Inset 1

Inset 2

Inset 3

Inset 4

Figure 1d
Grassdale Rd P2, Grassdale Rd Sth, Tipton
location along with that
of ground-verified remnant
and regrowth vegetation

Uncontrolled (A)

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0 0.33 0.65 1.3 km

Coordinate System: GDA2020 MGA Zone 56

Table 2 Ground-verified vegetation communities and cleared areas impacted by the project with Road scope sections condensed

Vegetation Community	Area (ha)									
	Boundary Rd Pt. 1	Duleen Kupunn Pt. 3	Grassdale Rd Sth	Grassdale Rd Pt. 2	Daandine Nandi Rd	Daandine East	Lynwood FCS	Nandi Springvale Pt 1	Road scope*	Total
Regrowth RE 11.3.1		0.46			0.04					0.50
Remnant RE 11.3.2	2.42									2.42
Regrowth RE 11.3.2			0.99					2.92	0.21	4.08
Remnant RE 11.3.14	1.97								0.03	2.00
Remnant RE 11.3.18	3.48						1.63		0.18	5.29
Remnant RE 11.3.25				0.71						0.71
Remnant RE 11.4.3		0.44								0.44
Remnant RE 11.5.1	9.31						0.28		0.95	10.55
Regrowth RE 11.5.1	27.36						5.89		1.32	34.57
Remnant RE 11.5.1a	0.17									0.17
Regrowth RE 11.5.1a	0.84									0.84
Remnant RE 11.5.20									0.14	0.14
Remnant RE 11.7.4	10.35								0.75	11.09
Undifferentiated regrowth	29.83	0.21	6.11		3.16	0.04		0.38		42.81
Derived grassland	10.00	0.01	1.02	0.01	2.68		22.28		0.01	35.99
Cleared land	57.28	91.45	82.02	32.34	82.80	76.65		3.17	29.87	454.39
Total Disturbance	153.01	92.56	90.14	33.06	89.69	76.69	30.08	6.47	35.81	614.45

*Road scope are further grouped in this table and expanded in Table 2.

Table 3 Expanded summary of Road scope ground-verified vegetation communities and cleared areas impacted

Vegetation community	Area (ha)					
	Road Scope - Boundary Road	Road Scope - Broadwater Road Stage 1	Road Scope - Broadwater Road Stage 2	Road Scope - Hennings Connection Road	Road Scope - Lynwood to Tipton	Road Scope - Wilkin Road
Regrowth RE 11.3.1						
Remnant RE 11.3.2						
Regrowth RE 11.3.2				0.08		0.13
Remnant RE 11.3.14					0.03	
Remnant RE 11.3.18					0.18	
Remnant RE 11.3.25						
Remnant RE 11.4.3						
Remnant RE 11.5.1	0.12				0.83	
Regrowth RE 11.5.1					0.92	0.39
Remnant RE 11.5.1a						
Regrowth RE 11.5.1a						
Remnant RE 11.5.20		0.01	0.13			
Remnant RE 11.7.4					0.75	
Undifferentiated regrowth	0.19	0.15	0.02		1.98	
Derived grassland	0.01					
Cleared	4.96	3.76	1.25	0.25	14.27	5.37
Total Disturbance	5.28	3.93	1.40	0.33	18.98	5.89

2. Purpose

There are several requirements of EA EPPG00972513 relating to managing environmental offsets for the proposed activities to be undertaken.

2.1 Surat Gas Project development

The subject of this SRI is to support the amendment to the DXP EA which includes:

- Approximately 191 Wells, on 101 well pads.
- A communication tower.
- Three mobile drilling camps.
- Water and gas gathering.
- Access tracks to wells and infrastructure.
- Local Infrastructure, including laydowns, spoil stockpiles, and Extra Work Areas.
- Lynwood Field Compression Station (FCS) and associated infrastructure (dams, power station, laydowns, flare).

2.2 Surat Gas Project EPBC Act Approval

The areas of the SGP that are located on Arrow PL tenements, of which the project is a part, is approved under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval (EPBC 2010/5344). As an approval condition, the SGP Stage 1 Offset Strategy (EPBC Act Offset Strategy) was prepared by Arrow to address the offset requirements for Stage 1 of the SGP. The strategy was approved by The Department of Agriculture, Water and the Environment (DAWE) on 7 July 2019. This EPBC Act approval for Stage 1 incorporates impacts from infrastructure located on all PLs in the DXP EA and as such addresses the offsets from any impacts to all relevant Matters of National Environmental Significance (MNES) on these tenures.

MNES and MSES where they are substantially the same matter

On many occasions, remnant and high-value regrowth vegetation listed as PEMs or Matters of State Environmental Significance (MSES) also provide habitat for species listed as MNES. In these situations, the Federal approval takes precedent and therefore offsets provided for MNES also satisfies the requirement for State offsets.

All MNES species identified in the project (Table 4), are the same matters as those assessed and approved under the EPBC Act SGP Stage 1 Offset Strategy.

While the EPBC Act Offset Strategy area shown in the figures (5.4a and 5.5a) does not cover the entire area of the SGP Stage 1 project footprint, the offset strategy foresees that infrastructure location changes would occur and addresses this with the inclusion of the following statement in section 1:

‘Figure 1.1 shows an indicative location of the Stage 1 activities in relation to the project. The locations shown are subject to change as the project progresses through the detailed design phase and Arrow shareholder and joint venture partner approval processes.’

The offset strategy also notes that whilst specific locations may change, the principles and strategies for securing offsets that are presented in the EPBC Act Stage 1 Offset Strategy will be implemented.

3. Methods

3.1 Identifying Prescribed Environmental Matters (PEMs)

The project's disturbance footprint (Figure 1) has been used to identify areas that may have a SRI on PEMs as defined in the EO Act. The presence/absence of each matter was determined in accordance with the 'Method for mapping matters of state environmental significance' (DESI, 2024a).

Detailed and seasonal ecological assessment over 2024 including supplementary reports (Ecosmart Ecology and 3D Environmental, 2017, 2018, 2019 and 2021) was undertaken for the SGP area which provided ground-verified data on PEMs that are regulated vegetation, protected wildlife habitat and connectivity areas. This assessment included:

- detailed, seasonal terrestrial ecological surveys across the full range of habitats occurring within the SGP area.
- validating and refining Regional Ecosystem (RE) mapping for the project.
- refining mapping for 'core habitat known' and 'core habitat possible' for all relevant species identified under the EPBC Act and *Nature Conservation Act 1992* (NC Act).

This ground-verified data was used to cross-check government supplied mapping data on PEMs that are regulated vegetation, protected wildlife habitat and connectivity areas. Government supplied mapping data was relied upon to identify the following PEMs:

- Wetlands and watercourses.
- Designated precincts in strategic environmental areas.
- Protected areas.
- Highly protected zones of State marine parks.
- Fish habitat areas.
- Waterway providing for fish passage.
- Marine plants.
- Legally secured offset areas.

Additionally, the government's Landscape Fragmentation and Connectivity (LFC) Tool was used to assess potential impacts on connectivity areas using ground-verified data.

Conclusions drawn on the presence/absence of PEMs are provided in Section 5 (Table 4), which covers all PEMs listed in the DXP EA and whether or not they were identified within impact areas. Further detailed assessment is provided in Sections 4.2.1 to 4.2.9 for those PEMs that were identified from mapping sources and potentially impacted by the project.

3.2 Significant residual impact (SRI) assessment

The following documents have been used to assess whether the project will have a SRI on PEMs:

- *Environmental Offset Act 2014* (EO Act).
- *Environmental Offset Regulation 2014* (EO Regulation).
- Queensland Environmental Offsets Policy (Version 1.16) (DESI, 2024b).
- Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DEHP, 2014).
- Method for mapping matters of state environmental significance (Version 7) (DESI, 2024a).
- Surat Gas Project – Threatened Species Mapping Rules Review Report (Ecosmart Ecology and 3D Environmental, 2023).

4. Results

4.1 Assessment of PEMs for Potential SRI

Table 4 includes an analysis and estimated significant residual impact against all of the PEMs listed in the DXP EA. It identifies nine (9) PEMs that warrant further assessment to establish the presence or absence of a significant residual impact. These being:

- 1) Regulated vegetation – Endangered regional ecosystem.
- 2) Regulated vegetation – Of Concern regional ecosystem.
- 3) Regulated vegetation – regional ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse.
- 4) Regulated vegetation – essential habitat (not in an urban area) for Critically Endangered, Endangered or Vulnerable wildlife.
- 5) Connectivity Areas – connectivity area that is a Regional Ecosystem (not in urban area).
- 6) Wetlands and watercourses – a wetland of high ecological significance.
- 7) Protected wildlife habitat – habitat for animals that are Critically Endangered, Endangered or Vulnerable wildlife.
- 8) Protected wildlife habitat – habitat for an animal that is Special Least Concern wildlife.
- 9) Waterway providing for fish passage – fish passage (not in an urban area).

Table 4 Analysis of all Prescribed Environmental Matters (PEMs) and whether or not they have the potential for a Significant Residual Impact (SRI)

Item	PEM	Potential for SRI	Details
1	Regulated vegetation – Endangered regional ecosystems.	Yes	0.44 ha of ground-verified Endangered remnant RE 11.4.3 will be cleared on Lot on Plan 1DY787 and 2DY169 (Glenmorgan Branch Railway). 0.50 ha of ground-verified Endangered regrowth RE 11.3.1 will also be cleared, however as regrowth this is not regulated vegetation so will not be considered further as part of this PEM but will be included in protected wildlife habitat. These vegetation polygons are co-located with habitat for Koala, Glossy Black-cockatoo, Brigalow Woodland Snail, and Painted Honeyeater, and Grey Snake (Table 5). The SRI assessment of this PEM in Section 4.2.1.
2	Regulated vegetation – Of Concern regional ecosystems.	Yes	2.42 ha of ground-verified Of Concern remnant RE 11.3.2 will be cleared on at Boundary Road Pt. 1 on Lot on Plan 39DY363. 4.08 ha of ground-verified Of Concern regrowth RE 11.3.2 will also be cleared, however as regrowth this is not regulated vegetation so will not be considered further as part of this PEM but will be included in protected wildlife habitat.

Item	PEM	Potential for SRI	Details
			These vegetation polygons are co-located with (Table 5): • RE within the defined distance of a watercourse, noted in item 4. • Habitat for Koala, Diamond Firetail, Death Adder, Brigalow Woodland Snail, and Grey Snake, noted in item 14. • Waterways providing for fish passage, noted in item 19. The SRI assessment of this PEM in Section 4.2.2.
3	Regulated vegetation – Regional ecosystems (not within an urban area) that intersect a wetland on the vegetation management wetlands map.	No	Not located within the disturbance footprint of the current project.
4	Regulated vegetation – Regional ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse on the vegetation management watercourse map.	Yes	1.85 ha of ground-verified regional ecosystems over several properties, including: Boundary Road Pt. 1: • 0.11 ha of remnant RE 11.3.2 (39DY363). • 0.20 ha of remnant RE 11.3.14 (40DY363, 41DY363). • 0.17 ha of remnant RE 11.3.18 (41DY363, 43DY363). • 0.41 ha of regrowth RE 11.5.1 (181DY359, 39DY363, 40DY363, 41DY363, 43DY363). Although mapped within the defined distance, as regrowth this is not regulated vegetation so will not be considered further as part of this PEM but will be included in protected wildlife habitat. This vegetation is located adjacent to tributaries of Wilkie Creek (stream orders one and two). Grassdale Road Pt. 2: • 0.56 ha of remnant RE 11.3.25 (2RP36714, 370DER3450, 371DER3450, and an unnamed road reserve). This vegetation is located adjacent to The Condamine River (stream order eight) Nandi Springvale Part 1: • 0.27 ha of regrowth RE 11.3.2 (78CP844529). Although mapped within the defined distance, as regrowth this is not regulated vegetation so will not be considered further as part of this PEM but will be included in protected wildlife habitat.

Item	PEM	Potential for SRI	Details
			This vegetation is located adjacent to a tributary of the Condamine River (stream order one). Road scope – Lynwood to Tipton 0.12 ha of remnant RE 11.3.18 (43DY363) 0.01 ha of remnant RE 11.7.4 (27SP253612) This vegetation is located adjacent to a tributary of Broadwater Gully (stream order one) and a tributary of Wilkies Creek (stream order two). Road scope – Wilkin Road 0.001 of regrowth RE 11.3.2 (Wilkin Road reserve). Although mapped within the defined distance, as regrowth this is not regulated vegetation so will not be considered further as part of this PEM but will be included in protected wildlife habitat. 0.001 ha of remnant RE 11.5.1 (Wilkin Road reserve). This vegetation is located adjacent to a tributary of Wilkies Creek (stream order one) and one tributary of Crawlers Creek (stream order one). These vegetation polygons are co-located with (Table 4): - An Of Concern Regional Ecosystem, noted in item 2. - Habitat for the Koala, Grey Snake, Diamond Firetail, Death Adder, Corben's Long-eared Bat, Dunmall's Snake, Greater Glider, Yellow-bellied Glider, Glossy Black-cockatoo, and Brigalow Woodland Snail, noted in item 5 and 14. - Habitat for the Short-beaked Echidna, noted in item 15. - Waterways providing for fish passage, noted in item 19. The SRI assessment of this PEM is presented in Section 4.2.3.
5	Regulated vegetation – Essential habitat (not in an urban area) for Endangered or Vulnerable wildlife.	Yes	0.38 ha for Koala (<i>Phascolarctos cinereus</i>) (Endangered under the NC and EPBC Act), including 0.37 ha of regrowth RE 11.5.1 and 0.01 ha of regrowth RE 11.3.2 at the following locations: 0.01 ha at Grassdale Road Sth (2SP242069, Miss Jurgs Road reserve, and Percy Jurgs Road Cook Road Miss Jurgs Road reserve). 0.37 ha at Road Scope - Wilkin Road: (Wilkin Road reserve).

Item	PEM	Potential for SRI	Details
			Although mapped as Essential Habitat, as regrowth this is not regulated vegetation so will not be considered further as part of this PEM but will be included in protected wildlife habitat. 0.003 ha of remnant RE 11.3.25 for Greater Glider (<i>Petauroides volans</i> (southern and central populations) (Endangered under the NC Act and EPBC Act) at Grassdale Road Part 2 (370DER3450). These vegetation polygons are co-located with (Table 4): • REs within the defined distance of a watercourse, noted in item 4. • Habitat for the Koala, Greater Glider, Yellow-bellied Glider, and Brigalow Woodland Snail, noted in item 14. • Habitat for the Short-beaked Echidna, noted in item 15. • Waterways providing for fish passage, noted in item 19. The SRI assessment of this PEM is presented in Section 4.2.4.
6	Connectivity Areas – Connectivity area that is a regional ecosystem (not in urban area)	Yes	The project has a significant impact on connectivity areas, with a total RVM Cat B clearing of 29.48 ha. The results of the assessment are: • Significance test one (reduction in core remnant vegetation at the local scale): The percent change of core habitat at the local scale post impact for the project is 0.15%. The local impact threshold for this project is 5%. The project does not have a significant impact on connectivity in significance test one. • Significance test two (change from core to non-core remnant at the site scale): the number of core remnant areas occurring on the site is reduced from five (5) before impact to four (4) post impact. The project does have a significant impact on connectivity in significance test two. The SRI assessment of this PEM is presented in Section 4.2.5.
7	Wetlands and watercourses – A wetland in a wetland protection area shown on the Map of referable wetlands (HES wetlands in GBR)	No	Not located within the disturbance footprint of the current project.

Item	PEM	Potential for SRI	Details
8	Wetlands and watercourses – A wetland of high ecological significance shown on the Map of referable wetlands	No	0.34 ha of wetland (0.22 ha of cleared land and 0.12 ha of cultivated land) associated with a tributary of Wilkies Creek, including: - Daandine Nandi Road: 0.12 ha (3SP200456). - Grassdale Road South: 0.22 ha (26SP216179). These vegetation polygons are co-located with a level three waterway providing for fish passage (a tributary of Wilkie Creek) and noted in item 19 (Table 4). The SRI assessment of this PEM is presented in Section 4.2.6.
9	Wetlands and watercourses – A wetland or watercourse in high ecological value waters	No	Not located within the disturbance footprint of the current project.
10	Designated precinct in a strategic environmental area	No	Not located within the disturbance footprint of the current project.
11	Protected wildlife habitat – An area shown as a high-risk area on the flora survey trigger map that contains plants that are Endangered or Vulnerable.	No	Not located within the disturbance footprint of the current project.
12	Protected wildlife habitat – An area that is not shown as a high risk area on the flora survey trigger map, to the extent the area contains plants that are critically Endangered, Endangered or Vulnerable.	No	Not located within the disturbance footprint of the current project.
13	Protected wildlife habitat – A koala habitat area as determined by the chief executive on the koala conservation plan map.	No	Not located within the disturbance footprint of the current project.

14	Protected wildlife habitat – Habitat for an animal that is Endangered or Vulnerable.	Yes	A total of 132.40 ha of ground-verified remnant and regrowth vegetation will be cleared (includes 0.94 ha of Brigalow TEC (MNES)), including (ranked from largest to smallest area; species listed under the NC Act only are bolded): • 88.60 ha for Grey Snake (<i>Hemiaspis damelii</i>) (Endangered under the NC and EPBC Act), including: • Boundary Rd Pt. 1: 40.84 ha • Daandine East: 0.04 • Daandine Nandi Rd: 5.89 ha • Duleen Kupunn Pt. 3: 1.11 ha • Grassdale Rd Pt. 2: 0.72 ha • Grassdale Rd Sth: 7.06 ha • Lynwood FCS: 23.91 ha • Nandi Springvale Rd Pt. 1: 3.30 ha • Road Scopes: ○ Boundary Rd: 0.08 ha ○ Broadwater Rd Stage 1: 0.17 ha ○ Broadwater Rd Stage 2: 0.15 ha ○ Hennings Connection Rd: 0.08 ha ○ Lynwood to Tipton: 3.22 ha ○ Wilkin Rd: 0.13 ha • 72.81 ha for Koala (<i>Phascolarctos cinereus</i>) (Endangered under the NC and EPBC Act), including: • Boundary Rd Pt. 1: 55.89 ha • Daandine Nandi Rd: 0.04 ha • Duleen Kupunn Pt. 3: 0.90 ha • Grassdale Rd Pt. 2: 0.71 ha • Grassdale Rd Sth: 0.95 ha • Lynwood FCS: 7.81 ha • Nandi Springvale Rd Pt. 1: 2.92 ha • Road Scopes: ○ Boundary Rd: 0.12 ha ○ Broadwater Rd Stage 1: 0.01 ha ○ Broadwater Rd Stage 2: 0.13 ha ○ Hennings Connection Rd: 0.08 ha ○ Lynwood to Tipton: 2.72 ha ○ Wilkin Rd: 0.52 ha • 32.38 ha for Diamond Firetail (<i>Stagonopleura guttata</i>) (Vulnerable under the NC and EPBC Act), including: • Boundary Rd Pt. 1: 27.69 ha • Grassdale Rd Pt. 2: 0.71 ha • Lynwood FCS: 1.91 ha • Road Scopes:

- Boundary Rd: 0.12 ha
- Broadwater Rd Stage 1: 0.01 ha
- Broadwater Rd Stage 2: 0.13 ha
- Lynwood to Tipton: 1.80 ha

- **31.67 ha for Common Death Adder (*Acanthophis antarcticus*) (Vulnerable under the NC Act), including:**
 - Boundary Rd Pt. 1: 27.69 ha
 - Lynwood FCS: 1.91 ha
 - Road Scopes:
 - Boundary Rd: 0.12 ha
 - Broadwater Rd Stage 1: 0.01 ha
 - Broadwater Rd Stage 2: 0.13 ha
 - Lynwood to Tipton: 1.80 ha
- 29.11 ha for Corben's Long-eared Bat¹ (*Nyctophilus corbeni*) (Vulnerable under both the NC Act and EPBC Act), including:
 - Boundary Rd Pt. 1: 25.28 ha
 - Lynwood FCS: 1.91 ha
 - Road Scopes:
 - Boundary Rd: 0.12 ha
 - Lynwood to Tipton: 1.80 ha
- 27.25 ha for Dunmall's Snake¹ (*Furina dunmalli*) (Vulnerable under both the NC Act and EPBC Act), including:
 - Boundary Rd Pt. 1: 23.31 ha
 - Duleen Kupunn Pt. 3: 0.005 ha
 - Lynwood FCS 1.91 ha
 - Road Scopes:
 - Boundary Rd: 0.12 ha
 - Broadwater Rd Stage 1: 0.01 ha
 - Broadwater Rd Stage 2: 0.13 ha
 - Lynwood to Tipton: 1.77 ha
- 24.50 ha for Greater Glider (*Petauroides volans* (southern and central populations)) (Endangered under the NC Act and EPBC Act), including:
 - Boundary Rd Pt. 1: 21.63 ha
 - Grassdale Rd Pt. 2: 0.71 ha
 - Lynwood FCS: 0.28 ha
 - Road Scopes:
 - Boundary Rd: 0.12 ha
 - Broadwater Rd Stage 1: 0.01 ha
 - Broadwater Rd Stage 2: 0.13 ha
 - Lynwood to Tipton: 1.61 ha

- 21.79 ha for Yellow-bellied Glider (*Petaurus australis australis*) (Vulnerable under the NC and EPBC Act), including:
 - Boundary Rd Pt. 1: 19.66 ha
 - Lynwood FCS: 0.28 ha
 - Road Scopes:
 - Boundary Rd: 0.12 ha
 - Broadwater Rd Stage 1: 0.01 ha
 - Broadwater Rd Stage 2: 0.13 ha
 - Lynwood to Tipton: 1.58 ha
- 12.04 ha for Glossy Black-Cockatoo (*Calyptrorhynchus lathami lathami*) (Vulnerable under the NC and EPBC Act), including:
 - Boundary Rd Pt. 1: 10.35 ha
 - Daandine Nandi Rd: 0.04 ha
 - Duleen Kupunn Pt. 3: 0.90 ha
 - Road Scopes:
 - Lynwood to Tipton: 0.75 ha
- 8.27 ha for Brigalow Woodland Snail (*Adclarkia cameroni*) (Endangered under the NC and EPBC Act), including:
 - Boundary Rd Pt. 1: 2.42 ha
 - Daandine Nandi Rd: 0.04 ha
 - Duleen Kupunn Pt. 3: 0.90 ha
 - Grassdale Rd Pt. 2: 0.71 ha
 - Grassdale Rd Sth: 0.95 ha
 - Nandi Springvale Rd Pt. 1: 2.92 ha
 - Road Scopes:
 - Hennings Connection Rd: 0.08 ha
 - Lynwood to Tipton: 0.12 ha
 - Wilkin Rd: 0.13 ha
- 0.94 ha for Painted Honeyeater (*Grantiella picta*) (Vulnerable under the NC and EPBC Act), including:
 - Daandine Nandi Rd: 0.04 ha
 - Duleen Kupunn Pt. 3: 0.90 ha

This vegetation is present over the following properties:

- Boundary Rd Pt. 1: 181DY359, 26SP216179, 28DY22, 39DY363, 40DY363, 41DY363, 43DY363, and Boundary Road reserve.
- Daandine Nandi Rd: 4SP208974, 5RP171007, Greenbank Access Road, and Hereward Road reserve.
- Duleen Kupunn Pt. 3: 1DY787, 1DY931, 2DY169, 2DY944, 2RP99387, 331SP123972, 332SP123972, 36DY45, 4RP101433,

Item	PEM	Potential for SRI	Details
			60DY802, 62DY43, 70DY138, 7RP128589 and Daandine Nandi Road, Greenbank Access Road reserve, and Kupunn Road, Moonie Highway and unnamed road reserve. - Grassdale Rd Pt. 2: 2RP36714, 370DER3450, 371DER3450, 955SP128667, and an unnamed road adjacent to the Condamine River reserve. - Grassdale Rd Sth: 26SP216179, 2SP242069, 424DER3451, Grassdale Road reserve, Miss Jurgs Road reserve, Percy Jurgs Road reserve, and Cook Road reserve. - Lynwood FCS: 41DY363. - Nandi Springvale Rd Pt. 1: 2RP55328, 78CP844529, and an unnamed gazetted temporarily closed road reserve. - Road Scopes: - Boundary Rd: Boundary Road reserve and Wilkin Road reserve. - Broadwater Rd Stage 1: Broadwater road reserve - Broadwater Rd Stage 2: 95DY228, and Broadwater road reserve - Hennings Connection Rd: Hennings Road reserve and Hennings Connection Road reserve. - Lynwood to Tipton: 27SP253612, 28DY22, 43DY363 and an unnamed road reserve. - Wilkin Rd: Wilkin road reserve and Boundary Wilkin Road reserve These vegetation polygons are co-located with (Table 5): - An Endangered RE, noted in item 1. - An Of Concern RE, noted in item 2. - REs within the defined distance of a watercourse, noted in item 4. - Habitat for the Short-beaked Echidna, noted in item 15. - Waterways providing for fish passage, noted in item 19. The SRI assessment of this PEM is presented in Section 4.2.7.

Item	PEM	Potential for SRI	Details
15	Protected wildlife habitat – Habitat for an animal that is Special Least Concern.	Yes	11.69 ha of ground-verified remnant or regrowth vegetation for the Short-beaked Echidna (<i>Tachyglossus aculeatus</i>) (Special Least Concern under the NC Act), including: • Boundary Road Pt. 1: 11.52 ha (39DY363, 40DY363, 41DY363). • Road Scope – Broadwater Road Stage 2: 0.09 ha (Broadwater Road reserve). • Road Scope – Wilkin Road: 0.08 ha (Wilkin Road reserve). These vegetation polygons are co-located with (Table 5): • REs within the defined distance of a watercourse, noted in item 4. • Habitat for the Koala, Diamond Firetail, Death Adder, Corben's Long-eared Bat, Dunmall's Snake, Greater Glider, Yellow-bellied Glider, and Brigalow Woodland Snail, noted in item 14. • Waterways providing for fish passage, noted in item 19. The SRI assessment of this PEM is presented in Section 4.2.8.
16	Protected areas	No	Not located within the disturbance footprint of the current project.
17	Highly protected zones of State marine parks	No	Not located within the disturbance footprint of the current project.
18	Fish habitat area	No	Not located within the disturbance footprint of the current project.

19	Waterway providing for fish passage – Fish passage (not in an urban area)	Yes	0.20 ha including: - Boundary Road Part 1: 0.09 ha within seven tributaries of Wilkie Creek (fish passage levels one and two). These impacted waterways are located adjacent to remnant REs 11.3.2, 11.3.14, and 1.3.18 and regrowth RE 11.5.1 on 28DY22, 39DY363, 41DY363, 43DY363, and 43DY363). - Daandine East: 0.01 ha within one tributary of Wilkie Creek (fish passage level one). This impacted waterway is located adjacent to cleared land on 3RP77715. - Grassdale Road Part 2: 0.020 ha within one tributary of the Condamine River (fish passage level one). This impacted waterway is located adjacent to cleared land on 371DER3450. - Grassdale Road South: 0.01 ha within one tributary of Wilkie Creek (fish passage level two). This impacted waterway is located adjacent to cleared land on 26SP216179. - Nandi Springvale Part 1: 0.01 ha within one tributary of the Condamine River (fish passage level one). This impacted waterway is located adjacent to regrowth RE 11.3.2 on 78CP844529. - Road Scope – Boundary Road: 0.01 ha within one tributary of the Wilkie Creek (fish passage level one). This impacted waterway is located adjacent to cleared land on an unnamed road reserve. - Road Scope – Broadwater Road Stage 1: 0.01 ha within Broadwater Gully (fish passage level two). This impacted waterway is located adjacent to cleared land on 95DY228. - Road Scope – Broadwater Road Stage 2: 0.003 ha within Broadwater Gully (fish passage level two). This impacted waterway is located adjacent to cleared land on 95DY228. - Road Scope – Lynwood to Tipton: 0.02 ha within one tributary of Wilkie Creek (fish passage level two). This impacted waterway is located adjacent to remnant RE 1.3.18 and 11.7.4, cleared land, and undifferentiated regrowth on 27SP253612 and 43DY363. - Road Scope – Wilkin Road: 0.01 ha within one tributary of Wilkie Creek (fish passage level one) and one tributary of Crawlers Creek (fish passage level one). This impacted waterway is located adjacent to remnant RE 11.5.1 and cleared land on Wilkin Road reserve. These vegetation polygons are co-located with (Table 5): - An Of Concern RE, noted in item 2.

Item	PEM	Potential for SRI	Details
			- REs within the defined distance of a watercourse, noted in item 4. - Habitat for the Koala, Diamond Firetail, Death Adder, Corben's Long-eared Bat, Dunmall's Snake, Greater Glider, Yellow-bellied Glider, Glossy Black-cockatoo, and Brigalow Woodland Snail, noted in item 14. - Habitat for the Short-beaked Echidna, noted in item 15. The SRI assessment of this PEM is presented in Section 4.2.9.
20	Marine plants	No	Not located within the disturbance footprint of the current project.
21	Legally secured offset area	No	Not located within the disturbance footprint of the current project.

(¹) Instances where the PEM corresponds to a MNES assessed under EPBC Act Approval (EPBC 2010/5344).

4.2 Assessment of PEMs for Actual SRI

Review of Table 4 shows nine PEMs with a potential for SRI (see Figure 1 for locations). Sections 4.2.1 to 4.2.9 provide a further assessment of these nine matters. Prior to that assessment, Table 5 provides a breakdown of each vegetation community that is impacted by the project and the relevant PEM that is associated with each one.

Table 5 Summary of Impacted Prescribed Environmental Matters (PEMs) including areas (ha), vegetation communities, and co-locations

Vegetation Community	Total area (ha)	Regulated Vegetation					Protected Wildlife Habitat (ha) – Endangered or Vulnerable wildlife											Protecte d wildlife habitat – Special Least Concern	Protected wetlands	Waterway providing for fish passage (ha)
		RE within the defined distance of defining bank of a watercou rse	Endange red Regional Ecosyste ms*	Of Concern Regional Ecosyste ms	Essential habitat for Koala	Essential habitat for Greater Glider	Koala	Grey Snake	Diamond firetail	Death Adder	Corben's Long- eared Bat*	Dunmall' s Snake*	Greater Glider	Yellow- bellied Glider	Glossy Black- cockatoo	Brigalow Woodlan d Snail	Painted honeyea ter	Short- beaked Echidna	High ecological significanc e wetlands	Fish passage (not in an urban area)
Regrowth RE 11.3.1	0.50		0.50				0.50	0.50							0.50	0.50	0.50			
Remnant RE 11.3.2	2.42	0.11		2.42			2.42	2.42	2.42	2.42						2.42				0.008
Regrowth RE 11.3.2	4.08	0.27		4.08	0.01		4.08	4.08								4.08				0.01
Remnant RE 11.3.14	2.00	0.20					2.00	2.00	2.00	2.00	2.00		2.00					0.24		0.012
Remnant RE 11.3.18	5.29	0.30					5.29	5.29	5.29	5.29	5.29	5.29						0.19		0.02
Remnant RE 11.3.25	0.71	0.56				0.003	0.71	0.71	0.71				0.71			0.71				
Remnant RE 11.4.3	0.44		0.44				0.44	0.44							0.44	0.44	0.44			
Remnant RE 11.5.1	10.55						10.55	2.25	10.55	10.55	10.55	10.55	10.55	10.55		0.12		0.77		
Regrowth 11.5.1	34.57	0.41			0.37		34.57	3.14										10.40		0.02
Remnant RE 11.5.1a	0.17						0.17	0.17	0.17	0.17	0.17	0.17								
Regrowth 11.5.1a	0.84						0.84													
Remnant RE 11.5.20	0.14						0.14	0.14	0.14	0.14		0.14	0.14	0.14				0.09		
Remnant RE 11.7.4	11.09	0.01					11.09	7.87	11.09	11.09	11.09	11.09	11.09	11.09	11.09					0.001
Undifferentiated regrowth	42.81							29.09												
Derived grassland	35.99							30.50												
Cleared land (disturbed)	461.65																		0.34	0.12
Total ^	614.45	1.85	0.94	6.50	0.38	0.003	72.81	88.60	32.38	31.67	29.11	27.25	24.50	21.79	12.04	8.27	0.94	11.69	0.34	0.20

* = Instances where the PEM corresponds to a MNES assessed under EPBC Act Approval (EPBC 2010/5344)
^ = The addition of areas in each row of this table may slightly differ from the total area provided because totals have been calculated using the full, not rounded, numbers.

4.2.1 Regulated vegetation – Endangered Regional Ecosystems

Table 4 and Table 5 show that approximately 0.44 ha of Endangered remnant RE 11.4.3 and 0.50 ha of Endangered regrowth RE 11.3.1 will be impacted by the Project. However, these vegetation communities (0.94 ha in total) are consistent with the Brigalow (*Acacia harpophylla* dominant and co-dominant) Threatened Ecological Community (TEC) listed as Endangered under the EPBC Act and as such offsets will be managed under the EPBC Act approval (EPBC 2010/5344).

Please also note that the Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DEHP, 2014) states that regulated vegetation must be a prescribed regional ecosystem which as defined in the EO regulation does not include regrowth (Category C) vegetation.

As shown in Table 4, these RE polygons also provides habitat for listed protected species under both the NC Act and EPBC Act. It is Arrow's consideration that under such circumstances the biodiversity offset associated with this PEM would therefore be managed under the EPBC Act approval (EPBC 2010/5344) and associated SGP Stage 1 Offset Strategy (EPBC Act Offset Strategy).

However, The Department of Environment, Tourism, Science and Innovation (DETSI) considers regulated vegetation – Endangered Regional Ecosystems as a substantially different matter to habitat for protected species. Given the time-critical nature of the approval for this SRI report Arrow will include 0.94 ha in the Notice of Election (NoE) as protected wildlife habitat for applicable species (see Section 4.2.7). It is noted that Arrow will discuss this matter with DETSI to avoid duplication of offset requirements for future SGP projects.

4.2.2 Regulated vegetation – Of Concern Regional Ecosystems

Table 4 and Table 5 show that approximately 2.42 ha of Of Concern remnant RE 11.3.2 and 4.08 ha of Of Concern regrowth RE 11.3.2 will be impacted by the Project. Regional Ecosystem 11.3.2 is listed as 'Regulated Vegetation Of Concern RE' within the DXP EA with sufficient allowable impact areas. The Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DEHP, 2014) states that regulated vegetation must be a prescribed regional ecosystem which as defined in the EO regulation does not include regrowth (Category C) vegetation.

As shown in Table 5, these RE polygons also provide habitat for listed protected species under both the NC Act and EPBC Act. It is Arrow's consideration that under such circumstances the biodiversity offset associated with this PEM would therefore be managed under the EPBC Act approval (EPBC 2010/5344) and associated SGP Stage 1 Offset Strategy (EPBC Act Offset Strategy).

However, DETSI considers regulated vegetation – Of Concern Regional Ecosystems as a substantially different matter to habitat for protected species. Given the time-critical nature of the approval for this SRI report Arrow will include the full 6.5 ha in the Notice of Election (NoE) as protected wildlife habitat for applicable species (see Section 4.2.7). It is noted that Arrow will discuss this matter with DETSI to avoid duplication of offset requirements for future SGP projects.

Arrow will include a total area of 2.42 ha of remnant RE 11.3.2 within the Notice of Election (NoE) for biodiversity offset (both under this PEM and for the overlapping protected wildlife habitat as shown in Table 5, see also Section 4.2.7).

4.2.3 Regulated vegetation – Regional Ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse.

Table 4 and Table 5 show that 1.85 ha of seven (7) vegetation communities occur within the defined distance from the defining banks of a relevant watercourse will be impacted by the project. These include:

- 0.11 ha of remnant RE 11.3.2
- 0.27 ha of regrowth RE 11.3.2
- 0.20 ha of remnant RE 11.3.14
- 0.30 ha of remnant RE 11.3.18
- 0.56 ha of remnant RE 11.3.25
- 0.41 ha of regrowth RE 11.5.1
- 0.01 ha of remnant RE 11.7.4

These Regional Ecosystems are listed as 'Regional ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse on the vegetation management watercourse map' within the DXP4 EA with sufficient allowable impact areas.

Regulated vegetation is a prescribed regional ecosystem as defined in the EO Regulation and does not include regrowth vegetation. Therefore Arrow, will only offset the remnant portions of the total area, not including the areas of regrowth RE 11.3.2 and regrowth RE 11.5.1, under this PEM. As shown in Table 4, these RE polygons also provides habitat for listed protected species under the EPBC Act. It is Arrow's consideration that under such circumstances the biodiversity offset associated with this PEM would therefore be managed under the EPBC Act approval (EPBC 2010/5344) and associated SGP Stage 1 Offset Strategy (EPBC Act Offset Strategy).

However, DETSI considers regulated vegetation within the defined distance from a watercourse as a substantially different matter to habitat for protected species. Given the time-critical nature of the approval for this SRI report Arrow will include 1.17 ha for this PEM in the Notice of Election (NoE) for this project.

This PEM overlaps with protected wildlife habitat for Endangered and Vulnerable species and Special Least Concern species (possible habitat for Koala, Diamond Firetail, Death Adder, Corben's Long-eared Bat, Dunmall's Snake, Greater Glider, Yellow-bellied Glider, Glossy Black-cockatoo, Brigalow Woodland Snail and Short-beaked Echidna) PEMs under the NoE, as shown in Table 5 (see Sections 4.2.7 and 4.2.8). This PEM also overlaps with Regulated Vegetation – Of Concern Regional Ecosystems under the NoE, as shown in Table 5 (see Section 4.2.2) and Waterways Providing for Fish Passage (see Section 4.2.9).

It is noted that Arrow will discuss this matter with DETSI to avoid duplication of offset requirements for future SGP projects.

4.2.4 Regulated vegetation – essential habitat (not in an urban area) for Endangered and Vulnerable wildlife.

Table 4 and Table 5, the remnant vegetation impacted by the project is located within the State-mapped Essential habitat mapping layer for one (1) Endangered species and one (1) Vulnerable species. This includes 0.01 ha within regrowth RE 11.3.2 and 0.037 ha within regrowth RE 11.5.1 which is mapped as Essential Habitat for the Koala (*Phascolarctos cinereus*) (Endangered under the NC Act and EPBC Act) and 0.003 ha within remnant RE 11.3.25 which is mapped as Essential Habitat for Greater Glider (Endangered under the NC Act and Vulnerable under the EPBC Act). Regulated vegetation is a prescribed regional ecosystem as defined in the EO Regulation and does not include regrowth vegetation. Therefore Arrow, will only offset the remnant portion of the total area. Arrow will include 0.003 ha of Essential Habitat for Greater Glider for this PEM in the Notice of Election (NoE). The 0.38 ha of mapped Essential Habitat in regrowth REs 11.3.2 and 11.5.1 is not regulated vegetation but overlaps with protected wildlife habitat for Koala (see Table 5 and Section 4.2.7) and will be offset for Koala under that PEM.

This PEM also overlaps with the following PEMs under the NoE:

- Regulated vegetation - RE within the defined distance from the defining banks of a relevant watercourse, as shown in Table 5 (see Section 3.2.3).
- Protected wildlife habitat for the Koala, Greater Glider, Grey Snake, Diamond Firetail and Brigalow Woodland Snail, as shown in Table 5 (see Section 4.2.7).

4.2.5 Connectivity Areas – connectivity area that is a Regional Ecosystem (not in urban area).

The LFC tool determined a significant impact on connectivity areas (*A significant a change from core to non-core remnant at the site scale is True*). The tool returned a total area of RVM Cat B clearing of 29.48 ha. Arrow will include a total area of 29.48 ha for connectivity areas within the Notice of Election for biodiversity offset.

4.2.6 Wetlands and watercourses – a wetland of high ecological significance.

The Project intercepts 0.34 ha of a Government-mapped high ecological significance (HES) wetland (Long Swamp, Wilkie Creek tributary). Field surveys show this area has been subject to extensive clearing and is highly disturbed and modified (e.g. access tracks, roads and cultivated areas). Where possible, to minimise impacts to mapped wetland areas, the RoW width has been reduced to 20m, with disturbances aligned with this existing infrastructure. As per the SRI Guidelines (DEHP, 2014), this section does not address impacts on riparian vegetation that lies within the mapped wetland. Vegetation associated with wetlands are discussed under 'regulated vegetation' (see Item 3 of Table 4).

Arrow concludes that the disturbance of a total area of 0.34 ha for Government-mapped HES wetlands on land that has been cleared and is currently highly disturbed will not constitute a SRI and therefore will not be included this area in the Notice of Election for biodiversity offset.

4.2.7 Protected wildlife habitat – habitat for an animal that is Critically Endangered, Endangered or Vulnerable.

Table 4 and Table 5 there is habitat for eleven (11) Endangered or Vulnerable species to be impacted by the project. In all situations, the specific area of habitat to be impacted for a listed species protected under the NC Act is also habitat to be impacted for a species protected under the EPBC Act. Arrow will further investigate options to avoid this sort of duplication of offset requirements when State matters overlap with Federal matters for the same impact area. However, given the time-critical nature of the approval for this SRI report, Arrow will include the areas of impacted PEMs for protected wildlife habitat.

Protected wildlife habitat includes 132.40 ha for the Koala, Grey Snake, Diamond Firetail, Death Adder, Corben's Long-eared Bat, Dunmall's Snake, Greater Glider, Yellow-bellied Glider, Glossy Black-cockatoo, Brigalow Woodland Snail and Painted Honeyeater, including:

- 0.50 ha of regrowth RE 11.3.1
- 2.42 ha of remnant RE 11.3.2
- 4.08 ha of regrowth RE 11.3.2
- 2.00 ha of remnant RE 11.3.14
- 5.29 ha of remnant RE 11.3.18
- 0.71 ha of remnant RE 11.3.25
- 0.44 ha of remnant RE 11.4.3
- 10.55 ha of remnant RE 11.5.1
- 34.57 ha of regrowth RE 11.5.1
- 0.17 ha of remnant RE 11.5.1a
- 0.84 ha of regrowth RE 11.5.1a
- 0.14 ha of remnant RE 11.5.20
- 11.09 ha of remnant RE 11.7.4
- 29.09 ha of undifferentiated regrowth
- 30.50 ha of derived grassland

The 0.44 ha of remnant RE 11.4.3 and 0.50 ha of regrowth RE 11.3.1 are possible habitat for Koala, Grey Snake, Glossy Black-Cockatoo, Brigalow Woodland Snail, and Painted Honeyeater as shown in Table 5. These vegetation communities are consistent with the Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC listed as Endangered under the EPBC Act and as such offsets will be managed under the EPBC Act approval (EPBC 2010/5344). It is Arrow's consideration that under such circumstances the biodiversity offset associated with this PEM would therefore be managed under the EPBC Act approval (EPBC 2010/5344) and associated SGP Stage 1 Offset Strategy (EPBC Act Offset Strategy). Given the time-critical nature of the approval for this SRI report Arrow will include the full areas of impacted PEMs for protected wildlife habitat. This totals an area of 132.40 ha to be included in the NoE for biodiversity offset for this project (refer to Table 5 for breakdown). It is noted that Arrow will discuss this matter with DETSI to avoid duplication of offset requirements for future SGP projects.

4.2.8 Protected wildlife habitat – habitat for an animal that is Special Least Concern

Table 4 and Table 5 there is 11.69 ha of habitat for the Short-beaked Echidna, listed as a Special Least Concern species, to be impacted by the project. This habitat is comprised of State-mapped wildlife habitat (Special Least Concern species) and records of sightings during Arrow field work, buffered by one kilometre. Under the SRI Assessment Guideline (DEHP, 2014), an action is likely to have a significant impact on a Special Least Concern (non-migratory) animal wildlife habitat if it is likely that it will result in:

- a long-term decrease in the size of a local population; or
- a reduced extent of occurrence of the species; or
- fragmentation of an existing population; or
- result in genetically distinct populations forming as a result of habitat isolation; or
- disruption to ecologically significant locations (breeding, feeding or nesting sites) of a species.

The Short-beaked Echidna is a widespread and common mammal, occurring throughout all of mainland Australia. They are generalist in their habitat preference, occurring within alpine and cold-temperate areas to deserts and tropical regions. The Short-beaked Echidna appears to have no specific habitat requirements beyond a food supply of ants and termites.

As this species is widespread, highly mobile, non-territorial, and a generalist in habitat preference, the removal of 11.69 ha of potential habitat for the Short-beaked Echidna is not likely to lead to a long-term decrease in the size of a local population, or a reduced extent of occurrence of the species.

The nature of the clearing works for the DXP4 Project and associated infrastructure does not involve broadscale clearing and is instead linear in nature, with vegetation clearing comprising of narrow (<40 meters wide) linear strips, and well pads approximately one ha in size. This type of clearing footprint is not likely to result in fragmentation of an existing population, as the species will move through disturbed and cleared areas such as access tracks, and the nature of the clearing does not create a 'hard' barrier to dispersal (such as a permanent road or large building). Therefore, the proposed action is unlikely to result in fragmentation of populations, or result in genetically distinct populations forming because of habitat isolation.

Although no burrows or potential den sites have been specifically recorded within the project area, Arrow's *Species management program for Tampering with Animal Breeding Places* (2023) (SMP) will be implemented prior to and during habitat disturbance. The SMP outlines specific controls and mitigation measures to be implemented if individuals Echidnas, as well as potential or active burrows are found within the clearing area during pre-clearing surveys or clearing works. The Impact Minimisation Hierarchy ensures that avoiding disturbance during breeding season (July – November) is the highest priority in the hierarchy of controls, as well as additional measures including exclusion zones around individuals or burrows, and specific management by an experienced fauna spotter/catcher. Therefore, the proposed action is unlikely to result in disruption to ecologically significant locations for the Short-beaked Echidna.

Therefore, it is unlikely that the construction of the pipeline will result in a long-term decrease in the size of a local population or reduce the extent of occurrence of the Short-beaked Echidna and is unlikely to result in population fragmentation or genetically distinct populations of Short-beaked

Echidnas. Furthermore, it is unlikely that the construction works will result in a disruption to ecologically significant locations (breeding, feeding or nesting sites).

The results of this SRI assessment conclude that the construction and operation of the pipeline for the project is unlikely to have a significant impact to the Short-beaked Echidna. An SRI for this PEM is not considered likely and therefore this PEM will not be included in the Notice of Election for biodiversity offset for this project.

4.2.9 Waterway providing for fish passage – Fish passage (not in an urban area).

There are fifteen mapped watercourses (Broadwater Gully and unnamed tributaries of Wilkie Creek and Condamine River) intersecting the project footprint, which are categorised by DAF as having 'low' and 'moderate' risks of impact for fish passage.

Waterway barrier works in a fish passage waterway will be undertaken in accordance with the DAF guideline "*Accepted development requirements for operational work that is constructing or raising waterway barrier works*" (DAF, 2018). The purpose of this section is to assess if the proposed pipeline crossing construction will have a SRI relating to the MSES 'Waterway providing for Fish Passage'.

Under the SRI Assessment Guideline (DEHP, 2014), an environmental offset may be required *'for any part of a waterway that provides for passage of fish (other than that part of a waterway within an urban area) if the construction, installation or modification of waterway barrier works carried out under an authority will limit the passage of fish along the waterway'*.

In accordance with DEHP (2014), the construction and operation of the pipeline for the project is not likely to:

- result in the mortality or injury of fish; or
- result in conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage such as through the depletion of fishes energy reserves, stranding, increased predation risks, entrapment or confined schooling behaviour in fish; or
- reduce the extent, frequency or duration of fish passage previously found at a site; or
- substantially modify, destroy or fragment areas of fish habitat (including, but not limited to in-stream vegetation, snags and woody debris, substrate, bank or riffle formations) necessary for the breeding and/or survival of fish; or
- result in a substantial and measurable change in the hydrological regime of the waterway, for example, a substantial change to the volume, depth, timing, duration and frequency of flows; or
- lead to significant changes in water quality parameters such as temperature, dissolved oxygen, pH and conductivity that provide cues for movement in local fish species.

Except for The Condamine River which will be under bored (HDD - horizontal directional drilling), the focal watercourses are ephemeral in nature. Construction of the pipelines are proposed to be a standard open-cut (trenching) method. This technique is most suited to dry or low flow conditions and involves establishing a stable working platform either side of the watercourse and creating a trench using excavators, or similar. Tie-in points will be located on high ground, away from any water flow. Trench spoil removed from the watercourse will be positioned above the high

bank. Welded pipe will be laid in the trench and spoil material returned to the trench. Trench and backfill activities will be undertaken to ensure that the bed and bank materials are stockpiled separately and returned to the trench to match original conditions to the greatest extent possible. Rock protection may be placed over the trench if required, to prevent potential scouring during high water flow conditions.

Pipeline construction will be undertaken outside of the wet season when the watercourses are not expected to be flowing. As such it is very unlikely that fish species will be present during construction. Construction time for watercourse crossing is expected to be approximately 10 days. Construction methodology will not introduce any chemicals or solvents, alter water chemistry, or change flow regimes. All construction works will be undertaken and completed in accordance with IECA Best Practice Erosion & Sediment Control Guidelines (IECA, 2008). If water is present in the watercourse, erosion and sediment control (ESC) measures such as temporary coffer dams and silt curtains, as determined by a suitably qualified person, will be installed for the duration of instream works. These measures may temporarily restrict passage whilst in place. If required, water quality monitoring (such as, total dissolved solids (TDS), dissolved oxygen, pH, etc.) will be undertaken during instream construction works to ensure ESC measures and construction methodology is effective. Fauna spotter-catchers will regularly monitor the crossing for possible presence of aquatic species including fish. If monitoring has indicated an impact then works will cease until such time as the issue is resolved in consultation with a suitably qualified person. The ESC measures will be removed once in-stream construction works are completed.

Following construction, the construction trench will be backfilled using spoil to match original conditions. All temporary construction materials and equipment will be removed from the crossing location prior to the onset of the following wet season. No permanent structure or water barrier will be left in-situ that will meaningfully change local hydrology. Following completion of construction activities, the disturbed area will be rehabilitated to reflect the pre-disturbance state and surrounding area.

Therefore, it is very unlikely that the construction of the pipeline will result in the direct mortality or injury of fish or substantially increase risks to fish health and wellbeing through stranding, entrapment, or confined schooling behaviour. The extent, frequency or duration of fish passage is unlikely to be reduced. The construction and operation of the pipeline is unlikely to substantially modify, destroy or fragment areas of fish habitat necessary for the breeding and/or survival of fish. It is also very unlikely to result in a substantial and measurable change in the hydrological regime of the waterway or lead to significant changes in water quality.

The results of this SRI assessment conclude that the construction and operation of the pipeline for the project is very unlikely to have a significant impact to a waterway providing for fish passage and will not limit the passage of fish along the waterway. An SRI for this PEM is not considered likely and therefore this PEM will not be included in the NoE for biodiversity offset for this project.

5. Conclusion

Arrow is yet to investigate options to avoid duplication regarding biodiversity offsets for many overlapping State and Federal matters for the same impact area. This, in combination with the time critical nature of this DXP4 SRI assessment report approval has led Arrow to identify a total of 132.40 ha of vegetation clearing to require an offset under the state processes for the following:

- Regulated vegetation:
 - Of Concern Regional Ecosystems
 - Regional ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse
 - Essential habitat (not in an urban area) for Endangered or Vulnerable wildlife for the Greater Glider.
- Connectivity Areas
- Protected wildlife habitat for the Koala, Grey Snake, Diamond Firetail, Death Adder, Greater Glider, Yellow-bellied Glider, Glossy Black-cockatoo, Brigalow Woodland Snail and Painted Honeyeater.

These PEMs are within the following vegetation communities:

- 0.50 ha within regrowth RE 11.3.1
- 2.42 ha within remnant RE 11.3.2
- 4.08 ha within regrowth RE 11.3.2
- 2.00 ha within remnant RE 11.3.14
- 5.29 ha within remnant RE 11.3.18
- 0.71 ha within remnant RE 11.3.25
- 0.44 ha within remnant RE 11.4.3
- 10.55 ha within remnant RE 11.5.1
- 34.57 ha within regrowth RE 11.5.1
- 0.17 ha within remnant RE 11.5.1a
- 0.84 ha within regrowth RE 11.5.1a
- 0.14 ha within remnant RE 11.5.20
- 11.09 ha within remnant RE 11.7.4
- 29.09 ha within undifferentiated regrowth
- 30.50 ha within derived grassland

Table 6 summarises the authorised SRIs to PEMs as listed in the DXP EA Table 3. All matters, both MSES and MNES, identified as present and to be disturbed trigger a SRI.

Table 6 Significant Residual Impacts (SRIs) to Prescribed Environmental Matters (PEMs) with the Environmental Authority (EA) Table 3

PEM	Total area (ha) authorised in EA	Total additional area (ha) from DXP4 (SGP Stage 1f)
REGULATED VEGETATION		
Endangered Regional Ecosystem		
RE 11.4.3	0.00	0.44 (MNES)
Of Concern regional ecosystem		
RE 11.3.2	16	2.42
Regional Ecosystems (not within an urban area) within the defined distance from the defining banks of a relevant watercourse on the vegetation management watercourse map		
RE 11.3.2	0.86	0.11
RE 11.3.14	0.00	0.20
RE 11.3.18	2.57	0.30
RE 11.3.25	12.86	0.56
RE 11.7.4	0.43	0.01
Essential habitat (not in an urban area) for Vulnerable wildlife		
<i>Petauroides volans</i>	0.00	0.003
CONNECTIVITY AREAS		
Connectivity area that is a Regional Ecosystem (not in urban area)	4.6	29.48
WETLANDS AND WATERCOURSES		
A wetland of high ecological significance shown on the Map of referable wetlands	1.81	0.34 (no SRI)
Waterway providing for fish passage – Fish passage (not in an urban area)	6.0	0.20 (no SRI)
PROTECTED WILDLIFE HABITAT		
Habitat for an animal that is Endangered wildlife		
<i>Adclarkia cameroni</i>	0.00	8.27
<i>Hemiaspis damelii</i>	219	88.60
<i>Phascolarctos cinereus</i>	0.00	72.81
Habitat for an animal that is Vulnerable wildlife		
<i>Acanthophis antarcticus</i>	317	31.67

PEM	Total area (ha) authorised in EA	Total additional area (ha) from DXP4 (SGP Stage 1f)
<i>Calyptorhynchus lathamii</i>	94	12.04
<i>Furina dunmalli</i>	0.00	27.25 (MNES)
<i>Grantiella picta</i>	0.00	0.94
<i>Nyctophilus corbeni</i>	0.00	29.11 (MNES)
<i>Petaurus australis australis</i>	0.00	21.79
<i>Petauroides volans</i>	0.00	24.50
<i>Stagonopleura guttata</i>	0.00	32.38
Habitat for an animal that is Special Least Concern wildlife		
<i>Tachyglossus aculeatus</i>	57.0	11.69 (no SRI)

5.1 Distinct Matter Area (DMA) Grouping Justification for Financial Offsets

If this SRI assessment is approved by DETSI a corresponding Notice of Election (NoE) submission will be made as a Financial Offsets Calculation. Table 7 outlines the Distinct Matter Area (DMA) grouping for the financial offset calculation. The purpose of this Section is to provide supporting justification that demonstrates why it is appropriate to group these matters in the same DMA, in relation to their required habitat requirements and rehabilitation management actions.

Appendix 6 of the Queensland Environmental Offsets (EO) Policy (v1.16) (DESI, 2024) outlines several examples of direct management actions that can achieve a conservation outcome. The implementation of such management actions when applied to rehabilitated areas of the REs applicable to each focal species (Table 5; Ecosmart Ecology and 3D Environmental, 2023) can lead to an improvement in the extent and quality of available habitat for these species. Based on the habitat mapping rules (Ecosmart Ecology and 3D Environmental, 2023), management actions intended to restore disturbed and/or degraded areas of the applicable REs for the focal species will simultaneously result in an improvement in the shelter and foraging habitat for these species.

Table 7 Distinct Matter Area (DMA) Groupings for Financial Offsets Calculation

DMA	Matter Groups	Impact Area (ha)
1.1	1.1.1: Regional Ecosystem 11.3.2 (<i>Eucalyptus populnea</i> woodland on alluvial plains) (regulated vegetation - Of Concern regional ecosystem) (2.42 ha) 1.1.2: Regional Ecosystem 11.3.2 (<i>Eucalyptus populnea</i> woodland on alluvial plains) (regulated vegetation – remnant RE within defined distance of a watercourse) (0.11 ha) 1.1.3: Threatened animals — <i>Phascolarctos cinereus</i> (Koala) (2.42 ha) 1.1.4: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (2.42 ha) 1.1.5: Threatened animals — <i>Acanthophis antarcticus</i> (Death Adder) (2.42 ha) 1.1.6: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (2.42 ha) 1.1.7: Threatened animals — <i>Adclarkia cameroni</i> (Brigalow Woodland Snail) (2.42 ha)	2.42
1.2	1.2.1: Regional Ecosystem 11.3.14 (<i>Eucalyptus spp.</i> , <i>Angophora spp.</i> , <i>Callitris spp.</i> woodland on alluvial plains) (regulated vegetation – remnant RE within defined distance of a watercourse) (0.20 ha) 1.2.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.20 ha) 1.2.3: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.20 ha) 1.2.4: Threatened animals — <i>Acanthophis antarcticus</i> (Death Adder) (0.20 ha) 1.2.5: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (0.20 ha) 1.2.6: Threatened animals — <i>Petauroides volans</i> (Greater Glider) (0.20 ha)	0.20
1.3	1.3.1: Regional Ecosystem 11.3.18 (<i>Eucalyptus populnea</i> , <i>Callitris glaucophylla</i> , <i>Allocasuarina luehmannii</i> shrubby woodland on alluvium) (regulated vegetation – remnant RE within defined distance of a watercourse) (0.30 ha) 1.3.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.30 ha) 1.3.3: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.30 ha) 1.3.4: Threatened animals — <i>Acanthophis antarcticus</i> (Death Adder) (0.30 ha) 1.3.5: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (0.30 ha)	0.30
1.4	1.4.1: Regional Ecosystem 11.3.25 (<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines) (regulated vegetation – remnant RE within defined distance of a watercourse) (0.56 ha) 1.4.2: Essential habitat — <i>Petauroides volans</i> (Greater Glider) (0.003) 1.4.3: Threatened animals — <i>Phascolarctos cinereus</i> (Koala) (0.56 ha) 1.4.4: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.56 ha) 1.4.5: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (0.56 ha) 1.4.6: Threatened animals — <i>Petaurus australis australis</i> (Yellow-bellied Glider) (0.56 ha) 1.4.7: Threatened animals — <i>Adclarkia cameroni</i> (Brigalow Woodland Snail) (0.56 ha)	0.56

DMA	Matter Groups	Impact Area (ha)
1.5	1.5.1: Regional Ecosystem 11.7.4 (<i>Eucalyptus decorticans</i> and/or <i>Eucalyptus spp.</i>, <i>Corymbia spp.</i>, <i>Acacia spp.</i>, <i>Lysicarpus angustifolius</i> woodland on Cainozoic lateritic duricrust) (regulated vegetation – remnant RE within defined distance of a watercourse) (0.01 ha) 1.5.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.01 ha) 1.5.3: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.01 ha) 1.5.4: Threatened animals — <i>Acanthopis antarcticus</i> (Death Adder) (0.01 ha) 1.5.4: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (0.01 ha) 1.5.6: Threatened animals — <i>Petauroides volans</i> (Greater Glider) (0.01 ha) 1.5.7: Threatened animals — <i>Petaurus australis australis</i> (Yellow-bellied Glider) (0.01 ha) 1.5.8: Threatened animals— <i>Calyptorhynchus lathami</i> (Glossy Black-cockatoo) (0.01 ha)	0.01
1.6	1.6.1 Regrowth Regional Ecosystem 11.3.1 (non-regulated vegetation) 1.6.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.50 ha) 1.6.3: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.50 ha) 1.6.4: Threatened animals — <i>Adclarkia cameroni</i> (Brigalow Woodland Snail) (0.50 ha) 1.6.5: Threatened animals — <i>Grantiella picta</i> (Painted Honeyeater) (0.50 ha) 1.6.6: Threatened animals— <i>Calyptorhynchus lathami</i> (Glossy Black-cockatoo) (0.50 ha)	0.50
1.7	1.7.1: Regrowth Regional Ecosystem 11.3.2 (non-regulated vegetation) (4.08 ha) 1.7.2: Essential habitat for Koala (0.01 ha) 1.7.3: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (4.08 ha) 1.7.4: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (4.08 ha) 1.7.5: Threatened animals — <i>Adclarkia cameroni</i> (Brigalow Woodland Snail) (4.08 ha)	4.08
1.8	1.8.1: Remnant RE 11.3.14 (non-regulated vegetation) (1.80 ha) 1.8.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (4.08 ha) 1.8.3: Threatened animals — <i>Acanthopis antarcticus</i> (Death Adder) (1.80 ha) 1.8.4: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (1.80 ha) 1.8.5: Threatened animals — <i>Petauroides volans</i> (Greater Glider) (1.80 ha) 1.8.6: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (1.80 ha)	1.80
1.9	1.9.1: Remnant RE 11.3.18 (non-regulated vegetation) (4.99 ha) 1.9.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (4.99 ha) 1.9.3: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (4.99 ha) 1.9.4: Threatened animals — <i>Acanthopis antarcticus</i> (Death Adder) (4.99 ha) 1.9.5: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (4.99 ha)	4.99

DMA	Matter Groups	Impact Area (ha)
1.10	1.10.1: Remnant RE 11.3.25 (non-regulated vegetation) (0.15 ha) 1.10.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.15 ha) 1.10.3: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (0.15 ha) 1.10.4: Threatened animals — <i>Petauroides volans</i> (Greater Glider) (0.15 ha) 1.10.5: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.15 ha)	0.15
1.11	1.11.1: Remnant RE 11.4.3 (non-regulated vegetation, Brigalow TEC) (0.44 ha) 1.11.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.44 ha) 1.11.3: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.44 ha) 1.11.4: Threatened animals — <i>Grantiella picta</i> (Painted Honeyeater) (0.44 ha) 1.11.5: Threatened animals — <i>Adclarkia cameroni</i> (Brigalow Woodland Snail) (0.44 ha) 1.11.6: Threatened animals— <i>Calyptrorhynchus lathamii</i> (Glossy Black-cockatoo) (0.44 ha)	0.44
1.12	1.12.1: Remnant RE 11.5.1 (non-regulated vegetation) 1.12.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (10.55 ha) 1.12.3: Threatened animals — <i>Acanthophs antarcticus</i> (Death Adder) (10.55 ha) 1.12.4: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (10.55 ha) 1.12.5: Threatened animals — <i>Petauroides volans</i> (Greater Glider) (10.55 ha) 1.12.6: Threatened animals — <i>Petaurus australis australis</i> (Yellow-bellied Glider) (10.55 ha) 1.12.7: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (2.25 ha) 1.12.8: Threatened animals — <i>Adclarkia cameroni</i> (Brigalow Woodland Snail) (0.12 ha)	10.55
1.13	1.13.1: Regrowth 11.5.1 (non-regulated vegetation) 1.13.2: Essential habitat for Koala (0.37 ha) 1.13.3: Threatened animals — <i>Phascolarctos cinereus</i> (Koala) (34.57 ha) 1.13.4: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (3.14 ha)	34.57
1.14	1.14.1: Remnant RE 11.5.1a (non-regulated vegetation) (0.17 ha) 1.14.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.17 ha) 1.14.3: Threatened animals — <i>Acanthophs antarcticus</i> (Death Adder) (0.17 ha) 1.14.4: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (0.17 ha) 1.14.5: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.17 ha)	0.17
1.15	1.13.1: Regrowth 11.5.1a (non-regulated vegetation) (0.84 ha) 1.13.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.84 ha)	0.84

DMA	Matter Groups	Impact Area (ha)
1.16	1.14.1: Remnant RE 11.5.20 (non-regulated vegetation) (0.14 ha) 1.14.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (0.14 ha) 1.14.3: Threatened animals — <i>Acanthophs antarcticus</i> (Death Adder) (0.14 ha) 1.14.4: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (0.14 ha) 1.14.5: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (0.14 ha) 1.14.6: Threatened animals — <i>Petauroides volans</i> (Greater Glider) (0.14 ha) 1.14.7: Threatened animals — <i>Petaurus australis australis</i> (Yellow-bellied Glider) (0.14 ha)	0.14
1.17	1.15.1: Remnant RE 11.7.4 (non-regulated vegetation) (11.08 ha) 1.15.2: Threatened animals— <i>Phascolarctos cinereus</i> (Koala) (11.08 ha) 1.15.3: Threatened animals — <i>Acanthophs antarcticus</i> (Death Adder) (11.08 ha) 1.15.4: Threatened animals — <i>Stagonopleura guttata</i> (Diamond Firetail) (11.08 ha) 1.15.5: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (7.86 ha) 1.15.6: Threatened animals — <i>Petauroides volans</i> (Greater Glider) (11.08 ha) 1.15.7: Threatened animals — <i>Petaurus australis australis</i> (Yellow-bellied Glider) (11.08 ha) 1.15.8: Threatened animals— <i>Calyptrorhynchus lathamii</i> (Glossy Black-cockatoo) (11.08 ha)	11.08
1.18	1.16.1: Undifferentiated regrowth (non-regulated) (29.09 ha) 1.16.2: Derived grassland (non-regulated) (30.50 ha) 1.16.3: Threatened animals — <i>Hemiaspis damelii</i> (Grey Snake) (59.59 ha)	59.59
1.19	1.17.1: Connectivity	29.48

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Acceptance and release

Author

Position	Incumbent	Release Date
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Stakeholders and reviewers

Position	Incumbent	Review Date
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Regulatory Approvals Specialist	Alison Sternes	27/02/2025

Appendix G. CSG Water Management Plan

Plan
S00-ARW-PMC-PLA-00169



Surat Gas Project CSG Water Management Plan

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Please see document administration section for more information

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SGP CSG Water Management Plan

Contents

1.	Introduction	4
1.1	Location and Project Description	4
1.2	Purpose	4
1.3	Scope	6
1.4	Conformance Table	6
1.5	Project Approvals	7
1.6	DES CSG Water Management Policy	7
2.	Existing Environment	9
2.1	Climate	9
2.2	Surface Water	9
2.3	Groundwater	10
2.4	Terrain, Geology and Soils	10
3.	CSG Water Characterisation	12
3.1	CSG Water Quantity	12
3.2	CSG Water Quality Characteristics	15
3.3	CSG Water and Salt Management Strategy	17
3.4	Water Management Options	19
3.5	Brine and Salt Management Options	22
4.	SGP CSG Water Management Network	24
4.1	Conceptual Water Management	24
4.2	SGP Water Management	25
4.3	EA Specific Water Assets	29
5.	Risk Management	33
6.	Management Criteria	37
6.1	Measurable Criteria	37
6.2	Response Procedures	40
6.3	Arrow Operating Procedures	40
7.	Monitoring	41
7.1	Environmental Monitoring	41
7.2	Monitoring of CSG Water Management Dams	41
8.	Reporting	43

SGP CSG Water Management Plan

8.1	Annual Return	43
8.2	Annual Inspection Report	43
8.3	Annual Monitoring Report	43
8.4	Incident Reporting	43
9.	Document Administration	44

SGP CSG Water Management Plan

1. Introduction

1.1 Location and Project Description

This Coal Seam Gas Water Management Plan (CWMP) is for Arrow Energy Pty Ltd.'s (Arrow) Surat Gas Project (SGP). The project development area is located approximately 160 km west of Brisbane in Queensland's Surat Basin and extends from the township of Wandoan in the north towards Millmerran in the south, in an arc through Dalby (Figure 1-1). The towns of Wandoan, Chinchilla, Kogan, Dalby, Cecil Plains, Millmerran, and Miles are located in or adjacent to the project development area.

The SGP will be a phased development over the approximate 40 year life of the project, including wells, gathering, compression facilities, processing facilities and associated supporting infrastructure. It considers the lifecycle Surat development, comprising both sanctioned and unsanctioned scope.

1.2 Purpose

The purpose of this CWMP is to:

- Address the requirements of section 126 of the EP Act as required for a site specific EA application;
- Address Arrow's commitment under the Surat Gas Project Environmental Impact Statement (EIS) to produce a CWMP; and
- Describe how SGP's CSG water will be managed in a way that protects and maintains environmental values whilst balancing social and economic considerations.

This CWMP has been prepared in accordance with the following Queensland Government regulatory guidance documents:

- The *Environmental Protection Act 1994* (Qld) (EP Act) – specifically Section 126 (1) and 126 (2); and
- The Department of Environment and Heritage Protection Coal Seam Gas Water Management Policy¹; – specifically its prioritisation hierarchy for managing and using CSG water and for managing saline waste.

¹ Queensland Department of Environment and Heritage Protection (2012), Coal Seam Gas Water Management Policy.

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**FIGURE 1-1
SURAT GAS PROJECT
TENURES**

Uncontrolled (A)

SGP CSG Water Management Plan

1.3 Scope

The scope of this CWMP includes:

- Characterisation of CSG water and the existing environment;
- Description of current and proposed CSG water management including the use, treatment, storage and beneficial use of water; and
- Description of procedures, controls and monitoring programs that minimise risk of CSG water management causing environmental harm.

The strategies for managing CSG water described in this CWMP align with Arrow Energy's broader vision for CSG water management in the Surat basin, as outlined in its Surat Gas Project CSG Water Management Strategy².

1.4 Conformance Table

Table 1-1 lists specific CWMP regulatory requirements specified under Section 126 of the EP Act, and identifies the relevant sections of the CWMP which address each specific requirement.

Table 1-1 EP Act Conformance Table

Requirement Under Section 126 of the EP Act	Relevant Section of CWMP
The quantity of CSG water the applicant reasonably expects will be generated in connection with carrying out each relevant activity.	Section 3.1
The flow rate at which the applicant reasonable expects CSG water will be generated.	Section 3.1
The quality of the water, including changes in the water quality that the applicant reasonably expects will happen while each relevant activity is carried out.	Section 3.2
The proposed management of CSG water including use, treatment, storage or disposal.	Section 3 and 4
The measurable criteria (the management criteria) against which the applicant will monitor and assess the effectiveness of water management including: • The quantity and quality of the water used, treated, stored or disposed of. • Protection of environmental values affected by each relevant activity; and the disposal of waste, including, for example, salt.	Section 6
The action proposed to be taken if any of the management criteria are not complied with, to ensure the criteria will be able to be satisfied in the future.	Section 6

² Arrow Energy (2017), Surat Gas Project CSG Water Management Strategy, Rev: 0, Doc No: ORG-ARW-ENV-STR-00001

SGP CSG Water Management Plan

1.5 Project Approvals

Table 1-2 lists the status of Arrow Energy's CSG water management approvals applicable to the scope of this CWMP.

Table 1-2 Arrow Energy's CSG Water Management Approvals in the Surat Basin

Responsible Department	Area of Regulation	Requirement of Regulation	Status (as of October 2023)
Department of Environment & Science	CSG activities including CSG water management	Environmental Authority (EA)	Daandine Expansion Project (EPPG00972513): PL198, PL230, PL238, PL252, PL258 and PL260 –
			Kogan North (P-EA-100464322): PL194
			Surat Gas Project North (EA0001399): PL1044, PL304, PL305, PL491, PL492 and PL494
			Surat Gas Project South (EA0001613): PL1039, PL1040, PL1041, PL1042, PL1043, PL185, and PL493
			Hopeland (EA0001401): PL253 –
			Surat Gas Project Kogan East (EA0001498): PL1052 and PL1053 -
			Kenya Pipelines and Brine Dam (EA0001540): PPL 2034
			McNulty Pipeline EA0002214 PPL2048
			David Pipeline: PPL2033
			Harry Pipeline: PPL2052
			Jammat Pipeline: PPL2047
			Treated Water Return Pipeline (TWRP) PPLA 2058
		CWMP	Updated November 2023 to support EA Applications

1.6 DES CSG Water Management Policy

The *CSG Water Management Policy* (DEHP, 2012) outlines the Queensland Government's position on the management of CSG water and guides CSG operators to consider the feasibility of using such water to meet the obligations of the EP Act as part of developing their CSG water management strategies and plans.

The policy aims to encourage the beneficial use of CSG water in a way that protects the environment and that maximises its productive use as a valuable resource. To achieve this, the policy outlines prioritisation hierarchies for managing and using CSG water, and for managing saline waste.

The policy focuses on the management and use of CSG water under the EP Act, and does not change obligations from the Water Act 2000 (Water Act), including 'making good' any

SGP CSG Water Management Plan

relevant impacts that may result from a CSG operation on water bores. Such measures executed under the Water Act may require the provision of water to mitigate impacts.

Arrow has adopted the DES prioritisation hierarchy as its starting point for determining the options for management of CSG water and brine. DES's prioritisation hierarchies for CSG water and brine are presented in Figure 1-2. In accordance with the Policy, Arrow evaluates potential management options for water and brine against the prioritisation hierarchy, and implements Priority 1 options wherever feasible. Where Priority 1 options are not feasible, Priority 2 options are implemented. In determining the feasibility of options, factors that may be considered include technical and economic aspects in assessing identified options.

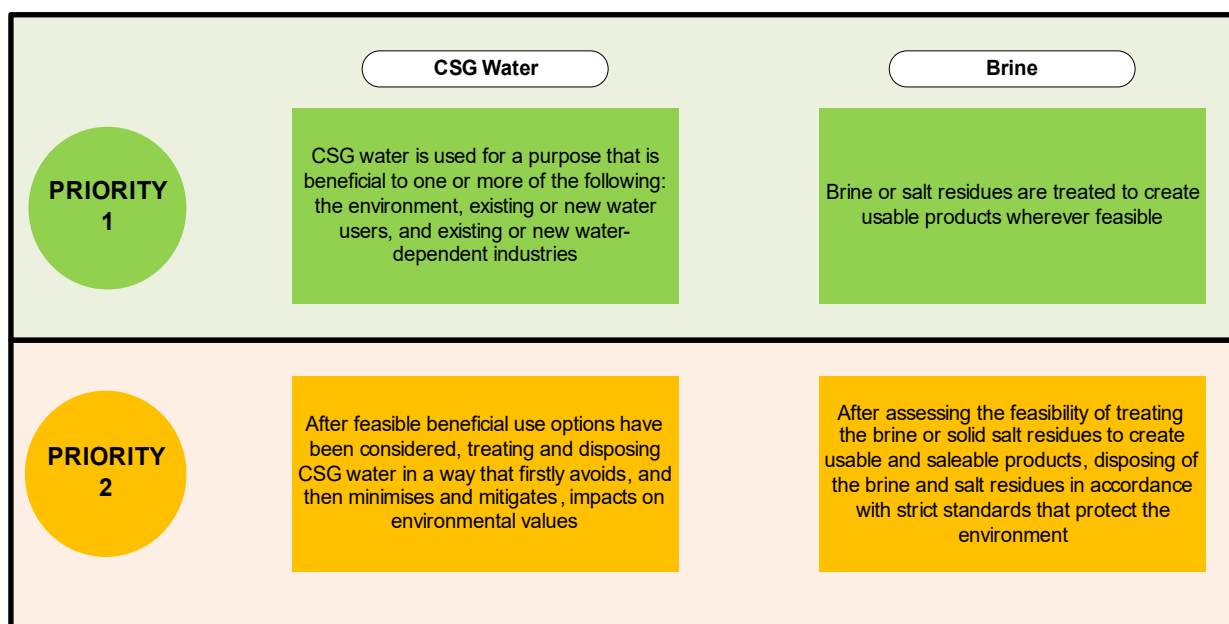


Figure 1-2 DEHP (now DES) Prioritisation Hierarchies for CSG Water and Brine Management

SGP CSG Water Management Plan

2. Existing Environment

2.1 Climate

The Darling Downs has a warm climate typical of subtropical regions with mean temperatures in the project development area ranging from a mean monthly minimum of 3.6 in winter months (June to August) to a mean monthly maximum of 35°C in summer months (December to February).

The majority of rain falls between November and February. The average annual rainfall varies across the region and ranges from an average of 20 to 40 mm a month in winter, to 70 to 100 mm a month in summer. Around 20 thunderstorm days per year occur in the region, often involving strong winds, heavy rainfall and flooding.

2.2 Surface Water

Two regional drainage basins intersect the SGP development area: Condamine-Balonne Basin (Condamine River and Balonne River), Fitzroy Basin (Dawson River). The Condamine-Balonne forms part of the Murray-Darling drainage division, while the Fitzroy Basin is part of the North-East Coast drainage division.

Basins can be divided into sub-basins, with three sub-basins in the project development area: Balonne River, Condamine River and Dawson River. The Condamine is the predominant sub-basin within the project development area, accounting for over 50% of the total area.

The location or origin of each drainage basin is as follows:

- The Condamine- Balonne Basin forms the northern headwaters of the Murray-Darling river system;
- The Fitzroy Basin is located in central eastern Queensland and contains the Dawson River sub-basin. The Fitzroy River is formed by the confluence of the Dawson and MacKenzie rivers and then flows into the Coral Sea north of Rockhampton.

The project area is characterised by an extensive network of watercourses that are largely ephemeral, with varying geomorphic stream types that provide geomorphic diversity and contribute to habitat diversity. Rivers and creeks are generally intermittent, with surface waters in many streams receding to disconnected pools and dry beds during the dry season.

Potential water uses within catchments that include the SGP are:

- Agricultural (crop production and stock watering)
- Pastoral;
- Urban;
- Power generation;
- Mining; and
- Recreation.

SGP CSG Water Management Plan

2.3 Groundwater

The geology of the Surat Basin, in which the development is located, reflects approximately 200 million years of sedimentation producing a sedimentary sequence with up to a 2,500 m maximum depth. Geology underlying the project area consists of a sequence of interbedded aquifers and aquitards and is situated on the eastern section of the Great Artesian Basin (GAB).

The following groundwater systems have been identified in the vicinity of the project area (listed in order of increasing depth):

- Shallow groundwater system – Condamine Alluvium;
- Intermediate groundwater system – Gubberamunda Sandstone, Westbourne Formation and Springbok Sandstone;
- Coal seam gas groundwater system – Walloon Coal Measures; and
- Deep groundwater system – Hutton Sandstone, Evergreen Formation and Precipice Sandstone.

2.4 Terrain, Geology and Soils

2.4.1 Terrain

Topography of the SGP area is characterised by gently undulating land formed by fluvial deposition and erosion processes. Rock outcrops are present where resistance to erosion and channel scour has occurred. The underlying geology and geomorphic conditions have influenced the landscape and the area is characterised by the Great Dividing Range highlands, the Kumbarilla Ridge uplands and two drainage basins, the Condamine-Balonne and Fitzroy.

2.4.2 Geology

Gas reserves within the SGP project area are primarily contained within the Walloon Coal Measures. The Walloon Coal Measures were formed during the Middle Jurassic period and are characterised by carbonaceous mudstone, siltstone, minor sandstone and coal. The geology of the Walloon Coal Measures comprises the following formations:

- Juandah Formation;
- Tangalooma Sandstone;
- Taroom Coal Measures; and
- Euromah Formation.

Only the Juandah Formation and Taroom Coal Measures are targeted for CSG production for the SGP.

2.4.3 Soils

Soil types across the SGP area have been classified under the Australian Soil Classification System and divided into seven broad types:

- Gilgai Clays - Occurring on flat to gently undulating terrain.
- Cracking Clays - Widespread across the Project area.

SGP CSG Water Management Plan

- Uniform Non-cracking Clays - Occurring on gently undulating plains and rises, and upper slopes of hills.
- Texture Contrast Soils - Sharp textural contrast between surface and subsoil horizons of low agricultural value.
- Uniform Loams and Clays - Loams found along upper slopes whereas clay occur on lower slopes.
- Sands and Sandy Loams - Consists of alluvial and residual sands found on plains.
- Skeletal, Rocky or Gravelly Soils - Occur adjacent to rocky outcrops.

2.4.4 Land Use

The SGP is located within the Darling Downs, which is an important agricultural area. The land use in the area is strongly related to the different soil types and topography. Soils within the project development area are dominated by heavy clays, which form rich agricultural soil around the Condamine River. These soils are characterised by self-mulching, cracking clays with a deep profile. At higher elevations, shallow, gravelly soils are present.

Soil erosion is evident in areas where brigalow woodland has been extensively cleared. Agricultural land use within the project development area ranges from concentrated agriculture on the Condamine River floodplain, where many paddocks have been laser-levelled to achieve effective flood irrigation, through to cattle grazing in more marginal areas located to the north and west. Limited agricultural activity exists in areas of higher elevation and within state forests.

Current agricultural activities in the greater Darling Downs region include:

- Dryland broadacre farming;
- Irrigated broadacre farming;
- Horticulture;
- Fruit;
- Vineyards;
- Livestock industries; and
- Timber production.

SGP CSG Water Management Plan

3. CSG Water Characterisation

This section presents forecast CSG water production data and expected water quality.

3.1 CSG Water Quantity

CSG is the name given to naturally occurring gas trapped in underground coal seams by water and ground pressure. The gas lines the open fractures between the coal (called cleats) and the inside of the pores within the coal (the matrix). Coal seams store both gas and water. When the water pressure is reduced, the gas is released. In the production process, the water pressure is reduced when a well is drilled into a coal seam and the water is gradually pumped out of the seam. This allows the gas to flow to the surface via the well. CSG water production volumes and qualities vary considerably with location, well-spacing and coal seam depth. Water production forecasts fluctuate over time as a product of progressively commissioning and decommissioning wells to meet Gas Sale Agreements. For these reasons, forecasts for the timing, volumes and quality of CSG water production are updated as required, typically on a monthly basis. Production forecasting involves the following steps:

1. Developing key assumptions such as expansion areas, gas sales targets and gas usage for production activities;
2. Simulating the required production rates using a reservoir engineering model;
3. Developing and maintaining well program based on forecast timing; and
4. Reviewing model performance against actual production data and history matching.

Figure 3-1 presents the CSG water production forecast for the SGP. The forecast indicates that approximately 307 GL of water will be produced between 2024 and 2047. Water production peaks at approximately 18 GL/yr, with average production of 12 GL/yr. Water production will diminish from the peak until project completion in approximately 2047.



Figure 3-1 SGP Water Production Forecast

At the time of writing, the produced water forecast per Environmental Authority is as follows.

SGP CSG Water Management Plan

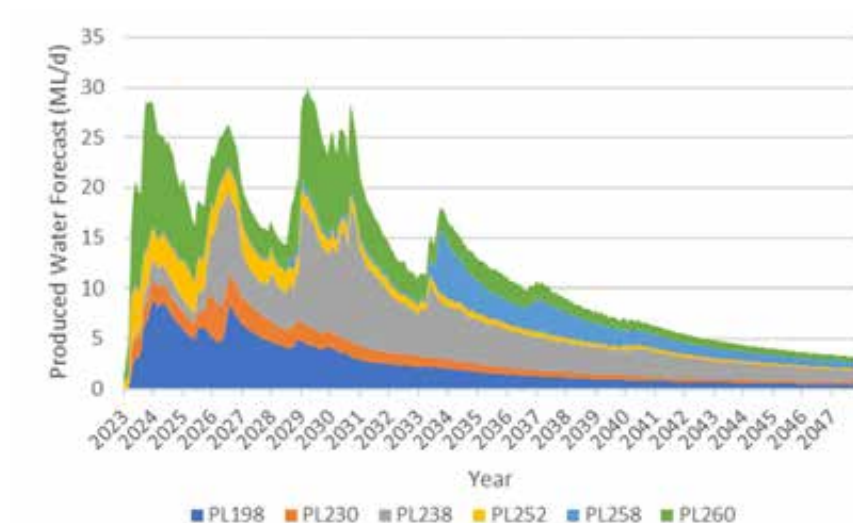


Figure 3-2 Daandine Expansion Project Environmental Authority (EPPG00972513)

Based on the current field development plan, the Daandine Expansion Project will produce an average ~4.5 GL/year CSG water between 2024 and 2047, with a total production of 109 GL. The peak production rate is estimated at 10 GL/year.

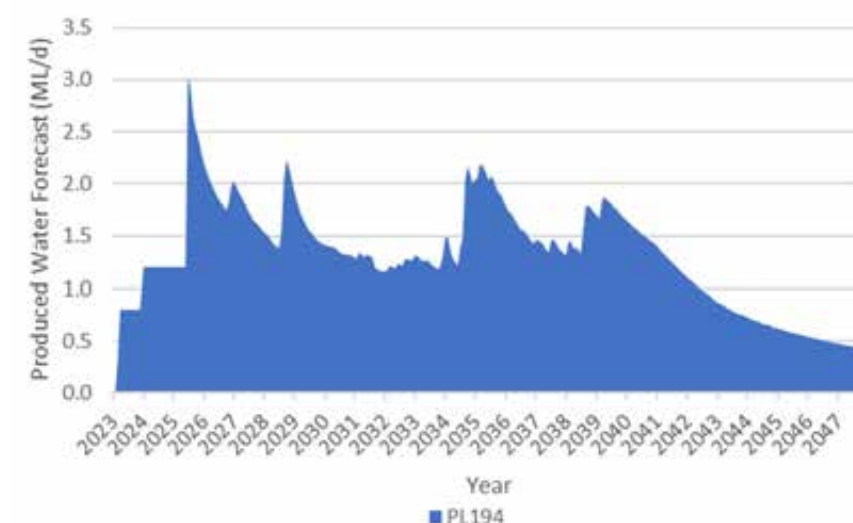


Figure 3-3 Kogan North Environmental Authority (P-EA-100464322)

Based on the current field development plan, the Kogan North development will produce an average ~0.5 GL/year CSG water between 2024 and 2047, with a total production of 11 GL. The peak production rate is estimated at 0.7 GL/year.

SGP CSG Water Management Plan

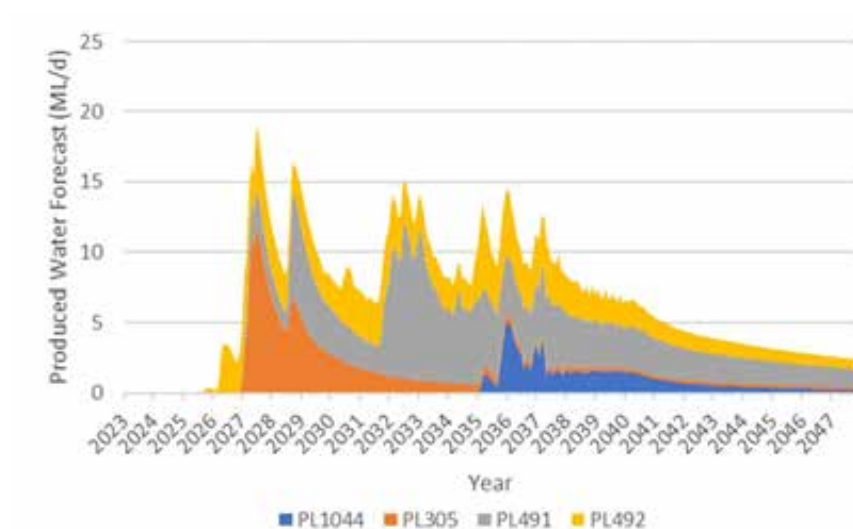


Figure 3-4 SGP North Environmental Authority (EA0001399)

Based on the current field development plan, the SGP North development will produce an average ~2.5 GL/year CSG water between 2024 and 2047, with a total production of 60 GL. The peak production rate is estimated at 5 GL/year.

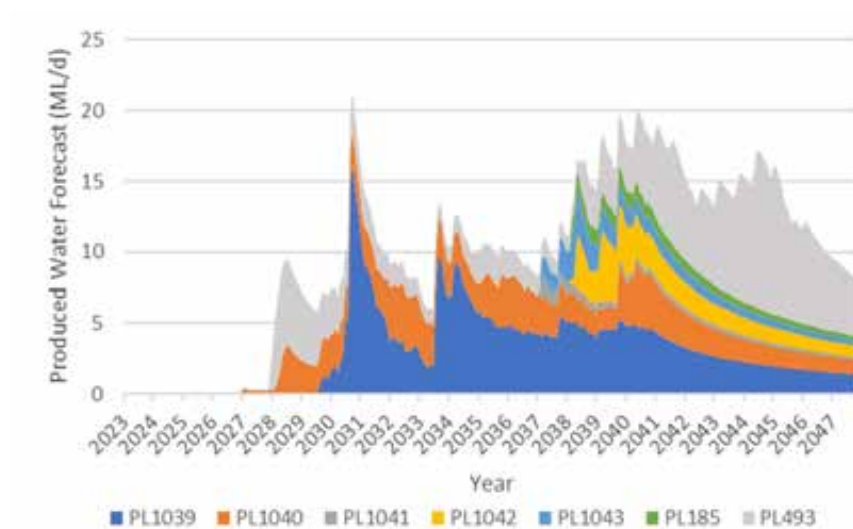


Figure 3-5 SGP South Environmental Authority (EA0001613)

Based on the current field development plan, the SGP South development will produce an average ~3.7 GL/year CSG water between 2024 and 2047, with a total production of 89 GL. The peak production rate is estimated at 6.7 GL/year.

SGP CSG Water Management Plan

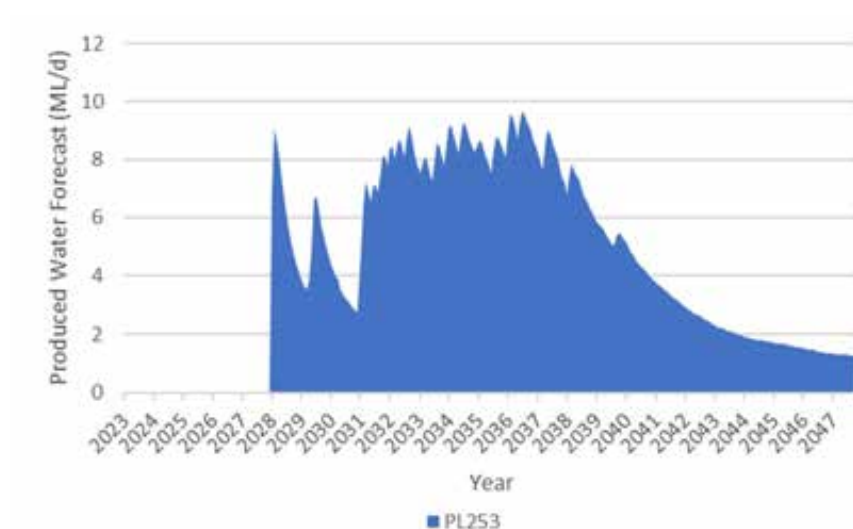


Figure 3-6 Hopeland Environmental Authority (EA0001401)

Based on the current field development plan, the Hopeland development will produce an average ~1.6 GL/year CSG water between 2024 and 2047, with a total production of 38 GL. The peak production rate is estimated at 3.3 GL/year.

3.2 CSG Water Quality Characteristics

The SGP targets the Walloon Coal Measures. CSG water quality in these formations varies from slightly brackish to brackish. The water typically has the following characteristics:

- pH of approximately 8.5 to 9.5;
- Salinity in the range of 5,000 to 13,000 $\mu\text{S}/\text{cm}$ (i.e. brackish);
- Suspended solids that will usually settle out over time;
- Trace metals and low levels of nutrients.

Table 3-1 presents a summary of expected water quality for wells across the SGP development area. CSG water quality may vary over the life of a well, however significant variations have not been seen to date within fields of same geographical area.

Table 3-1 SGP Expected Water Quality

Parameter	Unit	LOR	10%ile	Median	90%ile
Stream Properties					
pH Value	pH Unit	0.01	8.86	9.14	9.38
Electrical Conductivity @ 25°C	$\mu\text{S}/\text{cm}$	1	5640	8660	13060
Total Dissolved Solids @180°C	mg/L	10	3190	4620	7546
Suspended Solids (SS)	mg/L	5	9	34	80.5
Dissolved Organic Carbon	mg/L	1	4.1	16	37.9
Total Organic Carbon	mg/L	1	8	22	64.1

SGP CSG Water Management Plan

Parameter	Unit	LOR	10%ile	Median	90%ile
Silicon as SiO ₂	mg/L	0.1	10.3	18.2	21.23
Reactive Silica	mg/L	0.1	7.186	16.6	19.24
Nitrite as N	mg/L	0.01	<LOR	<LOR	<LOR
Nitrate as N	mg/L	0.01	<LOR	<LOR	0.03
Nitrite + Nitrate as N	mg/L	0.01	<LOR	<LOR	0.03
Total Phosphorus as P	mg/L	0.01	0.15	0.55	1.228
Total Hardness as CaCO ₃	mg/L	1	31	41	55
Dissolved Oxygen	mg/L		1.48	1.91	3.97
Anions					
Hydroxide Alkalinity as CaCO ₃	mg/L	1	<LOR	<LOR	<LOR
Carbonate Alkalinity as CaCO ₃	mg/L	1	254.6	440	751
Bicarbonate Alkalinity as CaCO ₃	mg/L	1	910.8	1090	1250
Total Alkalinity as CaCO ₃	mg/L	1	1340	1500	1900
Sulfate as SO ₄ - Turbidimetric	mg/L	1	<LOR	<LOR	8.4
Chloride	mg/L	1	1540	2190	3540
Fluoride	mg/L	0.1	2.4	2.8	3.3
Cations					
Calcium	mg/L	1	7	9	12
Magnesium	mg/L	1	3	5	9
Sodium	mg/L	1	1626	2040	2884
Potassium	mg/L	1	6	10	15
Total Metals					
Aluminium	mg/L	0.01	<LOR	0.03	0.11
Arsenic	mg/L	0.001	<LOR	0.001	0.003
Beryllium	mg/L	0.001	<LOR	<LOR	<LOR
Barium	mg/L	0.001	1.136	1.4	1.92
Cadmium	mg/L	0.0001	<LOR	<LOR	<LOR
Chromium	mg/L	0.001	<LOR	<LOR	0.001
Cobalt	mg/L	0.001	<LOR	<LOR	<LOR
Copper	mg/L	0.001	<LOR	0.004	0.1584
Lead	mg/L	0.001	<LOR	<LOR	<LOR
Lithium	mg/L	0.001	0.09	0.0965	0.1084
Manganese	mg/L	0.001	0.004	0.006	0.013
Molybdenum	mg/L	0.001	<LOR	<LOR	0.002

SGP CSG Water Management Plan

Parameter	Unit	LOR	10%ile	Median	90%ile
Nickel	mg/L	0.001	<LOR	<LOR	0.001
Selenium	mg/L	0.01	<LOR	<LOR	<LOR
Strontium	mg/L	0.001	1.85	2.56	4.36
Uranium	mg/L	0.001	<LOR	<LOR	<LOR
Vanadium	mg/L	0.01	<LOR	<LOR	<LOR
Zinc	mg/L	0.005	<LOR	<LOR	0.0134
Boron	mg/L	0.05	0.38	0.46	0.56
Iron	mg/L	0.05	<LOR	0.11	0.254
Dissolved Metals					
Aluminium	mg/L	0.01	<LOR	<LOR	0.01
Arsenic	mg/L	0.001	<LOR	<LOR	0.001
Beryllium	mg/L	0.001	<LOR	<LOR	<LOR
Barium	mg/L	0.001	0.7869	1.12	1.23
Cadmium	mg/L	0.0001	<LOR	<LOR	<LOR
Chromium	mg/L	0.001	<LOR	<LOR	<LOR
Cobalt	mg/L	0.001	<LOR	<LOR	<LOR
Copper	mg/L	0.001	0.003	0.0075	0.2432
Lead	mg/L	0.001	<LOR	<LOR	<LOR
Manganese	mg/L	0.001	<LOR	0.003	0.0067
Molybdenum	mg/L	0.001	<LOR	<LOR	0.001
Nickel	mg/L	0.001	<LOR	<LOR	0.002
Selenium	mg/L	0.01	<LOR	<LOR	<LOR
Strontium	mg/L	0.001	1.586	1.805	2.004
Vanadium	mg/L	0.01	<LOR	<LOR	<LOR
Zinc	mg/L	0.005	<LOR	<LOR	0.0074
Boron	mg/L	0.05	0.42	0.48	0.534
Iron	mg/L	0.05	<LOR	<LOR	<LOR

3.3 CSG Water and Salt Management Strategy

Arrow is committed to managing CSG water in a way that maximises beneficial use and that minimises environmental impact. To demonstrate this, Arrow has developed a Surat Gas Project Water Management Strategy³ to ensure that the SGP manages water and salt consistently and within the Queensland Government regulatory framework. The strategy is

³ Arrow Energy (2017), Surat Gas Project CSG Water Management Strategy, Rev: 0, Doc No: ORG-ARW-ENV-STR-00001

SGP CSG Water Management Plan

supported by a series of plans and procedural documents to ensure that the following objectives are achieved:

- Communicate corporate policy and principles for the management of CSG water and salt;
- Align with the regulatory framework that applies to the:
 - Gathering, treatment, storage, distribution, beneficial use and disposal of CSG water and salt;
 - Monitoring and management of groundwater and predicted impacts to groundwater level changes in quality;
- Facilitate management of CSG water and salt in a way that maximises beneficial use and minimises the potential for environmental impacts; and
- Establish a framework for development of aquifer, surface water and infrastructure groundwater monitoring programs.

3.3.1 Water and Salt Management Options

Arrow CSG Water and Salt Management Strategy aligns with the DES CSG Water Management Policy as defined in Section 1.6.

To ensure that the most sustainable CSG water management portfolio is implemented, Arrow evaluates all strategy management options using a systematic and transparent multi-criteria assessment (MCA) process (refer Figure 3-7). The performance of each identified option is assessed against a set of weighted criteria and options selected as either “preferred”, “reserved” or “not preferred” based on the weighted score derived from the MCA.

Preferred options are prioritised for investment whilst reserved options continue to be evaluated through targeted feasibility studies. Non-preferred options are put on hold. To ensure that Arrow’s approach to CSG water utilisation remains reflective of the latest information, MCAs may be updated on a periodic basis.

SGP CSG Water Management Plan

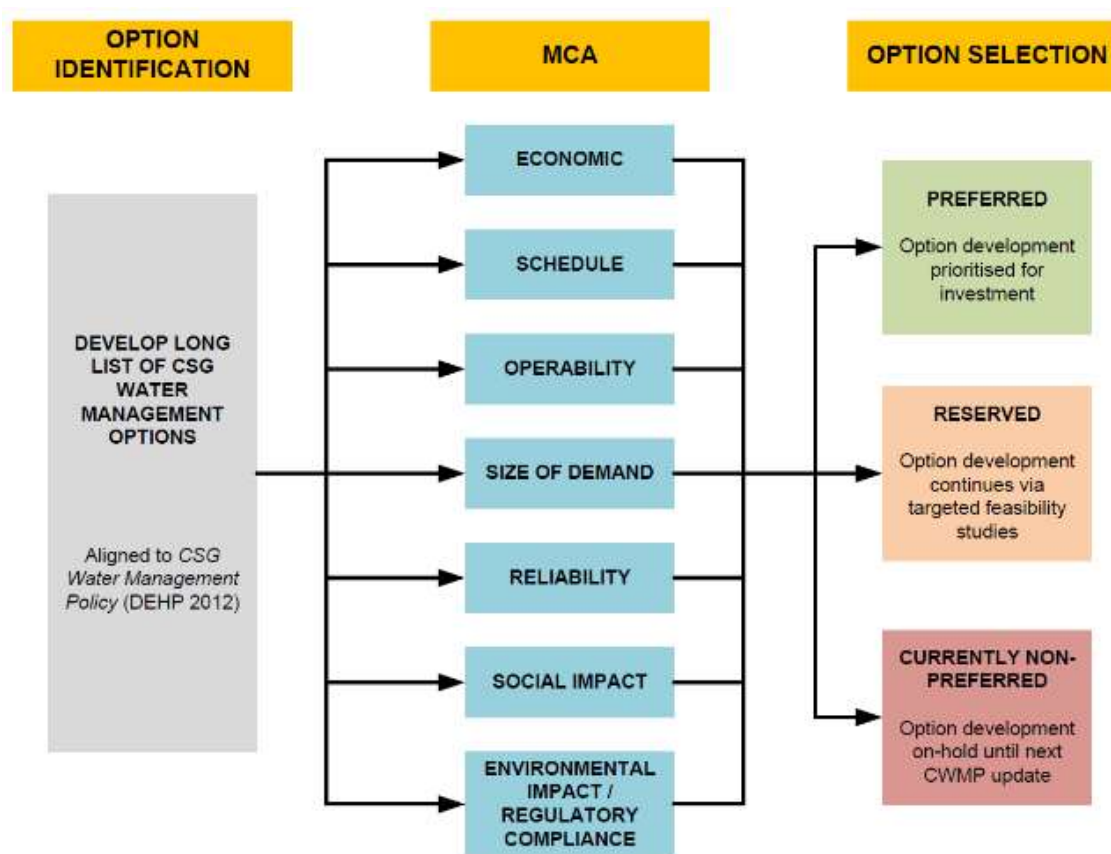


Figure 3-7 Option Selection and MCA Framework

3.4 Water Management Options

This section presents the water management options considered for the SGP. Saline waste management is discussed in Section 3.5.

Implementation of the preferred CSG water management options will result in the distribution of CSG water to a range of beneficial uses. Currently identified options are described below.

3.4.1 Agricultural Uses

Irrigation is the predominant water use within the SGP development area. Options exist to provide water to existing irrigators, to replace other water sources used for irrigation (including through substitution of their existing groundwater allocations), or to supply water to new irrigation projects. However, supply to new users or expansions to existing users is not a preferred water management option, as the CSG water supply will only be available for a reasonably short period of time, and the development of new water reliant uses may result in potential legacy issues when CSG water is no longer available

Key considerations for providing CSG water to end users for irrigation include:

- The ability of end users to take large volumes of water regularly and reliably;
- The location of end users in relation to the water treatment facility (due to the cost of transporting water over large distances);

SGP CSG Water Management Plan

- The approvals framework;
- The extent to which the user is going to become reliant on water supplied by Arrow; and
- The appropriateness of the supply given the short-term nature of CSG water availability.

The water and implications of its use will be the responsibility of the end users. Arrow retains no control over how the water is used beyond the transfer point, however Arrow will ensure the obligations regarding approved use and meeting General Environmental Duties (GED) are communicated with the end users.

Where practical, Arrow's preferred management option for CSG water is beneficial use through substitution of existing groundwater allocations in the operating area. Substitution of allocations has the advantage that it constitutes both a beneficial means of managing produced CSG water, and a means of offsetting the potential impacts of Arrow's CSG production to bore owners with groundwater allocations.

Currently, there is no specific regulatory basis to facilitate substitution. Therefore, Arrow is developing a commercial scheme to support the supply of treated CSG water to groundwater users who hold allocations. Under this scheme end users receive and utilise water supplied by Arrow in lieu of their groundwater allocations.

Arrow has committed to offsetting its component of modelled likely flux impacts to the Condamine Alluvium in the area of greatest predicted drawdown, as a result of CSG water extraction from the Walloon Coal Measures. This can be achieved through a beneficial use network that will distribute water to groundwater users within specified areas of the Condamine Alluvium to mitigate the modelled likely flux impact by substitution of their allocations.

3.4.2 Other Agricultural Uses

Other potential agricultural beneficial uses include provision of water for livestock watering purposes (including feedlots) or for aquaculture.

3.4.3 Discharge

Discharge of treated CSG water to watercourses is a reserved option in the event that other beneficial uses of CSG water are temporarily unavailable.

3.4.4 Urban Uses

Urban supply remains a potential CSG water end use, but is subject to further negotiation and a suitable supply arrangement that economically satisfies regulatory requirements.

3.4.5 Industrial Users

Supply of CSG water to industrial users, predominantly for power stations within the Surat area.

SGP CSG Water Management Plan

3.4.6 New Uses

Over the course of the SGP, water demands across areas in which Arrow operates will vary and it is anticipated that new opportunities for use of treated and untreated water may emerge.

Whilst Arrow may choose to evaluate any such opportunities in accordance with the adopted selection methodology (refer Section 3.3.1), supply to new users is not a preferred water management option. This is because the CSG water supply will only be available for a reasonably short period of time, and the development of new water reliant uses may result in potential legacy issues when CSG water is no longer available.

3.4.7 Aquifer Injection

Aquifer injection, either for re-pressurisation or as a means for CSG water management, is not currently proposed for the SGP due to the potential risks and the lack of an appropriate regulatory system.

3.4.8 Ocean Outfall

Disposal of CSG water to the sea via an ocean outfall pipeline is recognised as a technically feasible option, but currently non-preferred due to environmental and community concerns, and potential schedule impact.

3.4.9 Alignment of Arrow and DES Priorities

A summary of the CSG water management options is presented in Table 3-2 which aligns Arrows preferred and non-preferred options with the DES prioritisation hierarchy.

Table 3-2 CSG Water Management – Alignment of Arrow and DES priorities

Arrow Priority	Option	Comments	DES Priority
Preferred	Arrow operational supply	Dust suppression, construction, potable etc.	Priority 1
	Substitution of allocations	Beneficial use to existing abstractors (virtual injection)	Priority 1
	Industrial supply to existing users	Non-Arrow use, where established	Priority 1
Reserved	Discharge to watercourse	Subject to DXP Environmental Authority conditions	Priority 2
Non-preferred	MAR	Managed aquifer recharge	Priority 1
	Industrial supply to new users	Non-Arrow use, where established	Priority 1
	Urban water supply	Non-preferred by LGA due to cost of compliance	Priority 1

SGP CSG Water Management Plan

Arrow Priority	Option	Comments	DES Priority
	Ocean outfall	Non-preferred due to environmental and community concerns, and potential schedule impact	Priority 2
	Deep aquifer injection	Currently no identified target aquifer	Priority 2

3.5 Brine and Salt Management Options

The preferred management options listed above largely require treatment to reduce water salinity to acceptable levels in accordance with DES approval conditions, resulting in a brine stream by-product.

Assuming an average salt concentration of 4,500 mg/L for water from the Walloons formation in the Surat Basin, treatment of CSG water via reverse osmosis (to ~500 mg/L TDS) will generate in the order of 4 tonnes of salt per megalitre of treated water. Raw water feed concentrations vary across tenements and may also change over time within a given CSG field. Brine stream concentrations will therefore change accordingly.

Specific measures are required to manage the storage and use (or disposal) of brine. A range of brine management options are identified, and described in the following sections.

3.5.1 Salt Recovery

The concentrated brine by-product of desalinated water from the Surat Basin coal measures is comprised primarily of sodium chloride, sodium carbonate and sodium bicarbonate salts. A range of options for salt recovery are under consideration for the SGP.

Any future Salt Encapsulation Facility (SEF) will be designed to the relevant legislation and guidelines at the time, and consider risks associated with location and integrity, and implementation of a monitoring system.

i. Non-selective salt recovery and SEF

Non-selective recovery can be undertaken in purpose designed, lined solar evaporation ponds, through other thermal processes, or using mechanical crystallisers. The mixed salt product recovered has little or no commercial value, therefore disposal of the solid product is required, by encapsulation of the solid salts in purpose designed cells.

ii. Selective salt recovery and SEF

SSR requires the selective crystallisation of salts from RO brine to provide separate end product streams – typically sodium chloride, sodium carbonate and sodium bicarbonate, enabling commercial opportunity for sale of the product. A waste salt by-product is also produced that is dependent on the chemical characteristics of the brine processed at the salt recovery facility and therefore still requires disposal.

SGP CSG Water Management Plan

SSR is currently a reserved option because work to date has demonstrated that the recovered salt product has only modest value and the market is fully supplied by existing low cost producers. Furthermore, the process is energy intensive and substantial transport distances to market would present issues of safety and cost. The combined energy and transport requirements would also result in high emissions intensity for the final product.

3.5.2 Brine Injection

Brine injection requires identification of a target formation with permeability and parameters sufficient to enable injection and storage, and where the water quality is such that injection of the brine will not impact the environmental values of the groundwater system.

To date, suitable aquifers have not been identified within Arrow's Surat tenements, and brine injection is a non-preferred management option.

3.5.3 Ocean Outfall

As for water, disposal of brine to the sea via an ocean outfall pipeline is recognised as a technically feasible option, but is currently non-preferred due to environmental and community concerns, and potential schedule impact.

3.5.4 Alignment of Arrow and DES Priorities

A summary of the brine and salt management options is presented in Table 3-3 which aligns Arrows preferred and non-preferred options with the DES prioritisation hierarchy.

Table 3-3 CSG Brine Management – Alignment of Arrow and DES priorities

Arrow Priority	Option	Comments	DES Priority
Preferred	Non-selective salt recovery and salt encapsulation facility	Solid product salt encapsulation facility in purpose designed regulated waste facilities	Priority 2
Reserved	Selective salt recovery and salt encapsulation facility	Currently uneconomic, unable to demonstrate a commercial market, has high emissions intensity and greater safety risk. Salf encapsulation facility remains required for waste salt by-products.	Priority 1
Non-preferred	Brine injection	Currently no identified target aquifer	Priority 2
	Ocean outfall	Non-preferred due to community concerns, and potential schedule impact	Priority 2

SGP CSG Water Management Plan

4. SGP CSG Water Management Network

4.1 Conceptual Water Management

Management of CSG water will comprises six main process components:

1. CSG production wells and associated water gathering system;
2. Water transfer pipeline(s);
3. Aggregation dam(s);
4. Water Treatment Plants (WTP);
5. Treated water dam(s) and associated beneficial use offtakes; and
6. Brine dam(s).

Figure 4-1 provides a conceptual diagram of this process.

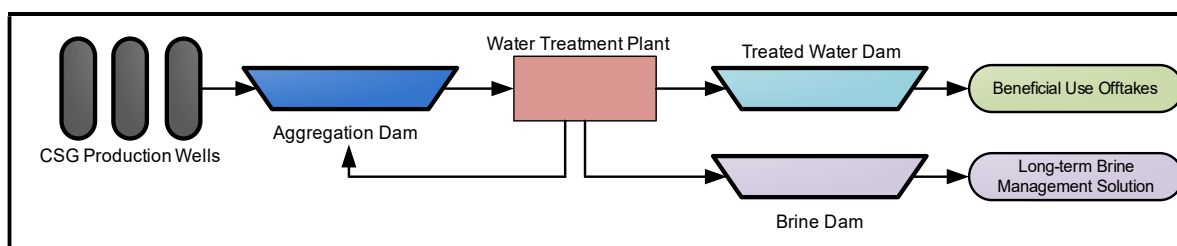


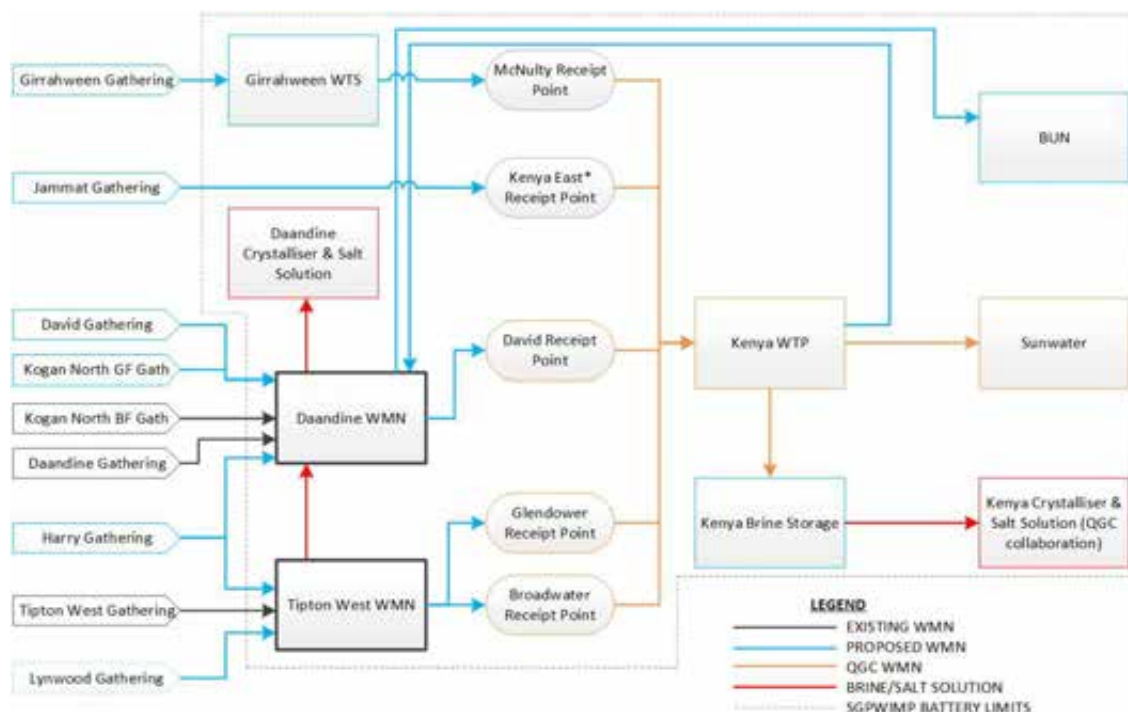
Figure 4-1 Conceptual Diagram of CSG Water Management

SGP CSG Water Management Plan

4.2 SGP Water Management

The water management scheme for the SGP comprises a number of assets and agreements to manage the CSG water originating from the Arrow tenures. Figure 4-2 provides an overview of the integrated SGP water management network.

Arrow has entered into a Water Services Agreement (WSA) with QGC, to utilise QGC infrastructure to manage Arrow CSG water. This includes existing dams, treatment plants and irrigation infrastructure. These assets are approved and managed in accordance with QGC's Environmental Authorities. The majority of water produced by the SGP will be transferred to the Arrow-QGC receipt points, minimising the need for investment in new Arrow facilities infrastructure.



*Opportunity to discharge to Kenya Orana Ponds in development

Figure 4-2 Proposed SGP CSG Water Management Network

The management of CSG water through each main asset type is discussed in the following sub-sections.

4.2.1 CSG Water Gathering and Transfer Pipelines

CSG water is gathered via a network of buried HDPE low pressure pipes to a downstream facility for management.

Arrow has two existing brownfield facilities, Daandine and Tipton.

Daandine receives produced water from the DXP, Kogan North and parts of the SGP South development areas. Produced water is transferred from the Daandine Feedwater Dam to QGC's David Pond, for management within the QGC network, or retained for local treatment

SGP CSG Water Management Plan

by the Daandine WTP. In addition, Daandine plans to receive water from the Demineralisation Plant treatment process at the nearby Braemar 2 Power Station.

Tipton receives produced water from the DXP and parts of the SGP South development areas. Produced water is transferred from the Tipton Feedwater Dam to QGC's Broadwater and Glendower Ponds, for management within the QGC network, or retained for local treatment by the Tipton WTP.

The brownfield Kogan North development produces water to the Kogan North Dam. Prior to entering the dam, water can be pumped to a number of beneficial users or transferred to the Daandine Feedwater Dam. Water which is not diverted is discharged into the Dam. The greenfield Kogan North development will produce water directly to the Daandine Facility

CSG water from the initial southern part of the SGP North development will be discharged directly to QGC's McNulty Pond for management within the QGC network. Once the gathering has extended to the Girrahween Facilities area, comprising the Girrahween FCS and Girrahween Water Transfer Station (WTS), the gathering will be redirected to the Girrahween WTS and pumped to QGC's McNulty Pond via a dedicated transfer line. The Girrahween WTS is supported by an upstream Feed Tank.

Produced water generated by the Hopeland development will be transferred to the QGC's Kenya East or Orana Ponds.

4.2.2 CSG Water Treatment

Arrow operates two Water Treatment Plants, one at Daandine and the other at Tipton. Both plants utilise a process of Microfiltration (MF) and Reverse Osmosis (RO). MF is a microporous membrane separation process with selectivity on the basis of the size of the particle. Most MF membranes are screen filters with the feed inlet pressure serving as the driving force for filtration. The membranes allow the removal of turbidity, bacteria, cysts and particulates from the water to sizes of 0.1 to 3 µm. Following MF, water is treated using RO to remove dissolved salts. RO is significantly more complex than MF and involves the separation of salts from solution through a semi-permeable, microporous membrane under elevated hydrostatic pressure creating a permeate stream of treated CSG water and a brine waste stream containing concentrated salts.

QGC's Kenya Water Treatment Facility (WTF) uses similar technologies to treat CSG water originating from Arrow tenures.

4.2.3 CSG Water Storage

Water storages provide buffer between management processes, and long term storage of waste products. Water is stored primarily in dams, with tanks utilised where a short process buffer is required.

Arrow defines its dams as follows:

- **Aggregation Dams** – contain CSG water from gathering network. Aggregation dams provide a buffer to address variations in CSG water production and water treatment capacity.

SGP CSG Water Management Plan

- **Treated Water Dams** – contain treated CSG water. Treated water dams provide a buffer between treatment plant output and beneficial use demand.
- **Central Gas Processing Facility (CGPF) and WTP Utility Dams** – contain waste lubricants and chemicals used in treatment and compression systems.
- **Brine Dams** – contain brine produced from the reverse osmosis water treatment process.

Arrow's SGP development comprises the following dams:

- The Daandine water management network includes seven (7) dams.
- The Tipton water management network includes seven (7) dams
- The SGP North development includes three (3) existing appraisal dams
- The SGP South development includes one (1) existing appraisal dams
- The Hopeland development includes one (1) existing appraisal dams
- The Kenya Pipelines and Brine Dam includes one (1) dam

4.2.4 Beneficial Use

As detailed above in Section 3.4, the preferred DES CSG water management strategy is beneficial use. Across the SGP, the most substantial beneficial use option is irrigation. Other major beneficial use options include supply to industrial users (power stations or coal mines) and intensive livestock (feedlots, piggeries). Selection of beneficial use options requires careful consideration of the predicted water volumes, stakeholder requirements and Arrow's approval obligations.

Arrow's preferred management option for CSG water is beneficial use through substitution of existing Condamine Alluvium (CA) groundwater allocations. Under this scheme end users would receive and utilise water supplied by Arrow in lieu of their groundwater allocations. Arrow has committed to offsetting its component of modelled likely flux impacts to the Condamine Alluvium in the area of greatest predicted drawdown as a result of CSG water extraction from the Walloon Coal Measures and is conditioned to do so under its Federal environmental approval.

The Condamine Alluvium Substitution Scheme (CASS) has been established with a number of Condamine users to assist Arrow meet obligations and its offset target based on OGIA modelling. The users will agree to seasonally assign their CA allocation to Arrow (and not utilise it) in return for that same (plus an allowance for losses) volume of Arrow treated water. The permitted purpose of this supply is irrigation.

The CASS will be physically implemented through a Beneficial Use Network (BUN) constructed to distribute treated water to groundwater users within specified areas of the Condamine Alluvium. Users connected to the network will receive water from Arrow's Daandine facility as well as a proportion of Arrow's water treated at the QGC Kenya facility. Arrow's treated water from the Kenya facility (originating from the CSG water transfers to the QGC receipt points) will be provided back to the Arrow BUN via the Treated Water Return Pipeline (TWRP), which discharges into the Daandine facility. Any remaining Arrow treated water from Kenya will be supplied to the existing SunWater beneficial use scheme which connects Kenya to the Chinchilla weir, with associated end users along the pipeline.

SGP CSG Water Management Plan

It is preferred that treated water distributed to the CASS will be supplied under the relevant EA, however the End of Waste Code⁴ could also be used. Other beneficial use offtakes are supplied per the conditions in the relevant EA or by using the relevant End of Waste Code. Treated water specifications from all of the water treatment facilities will meet the requirements of these approvals.

A small portion of produced water may selectively be used by Arrow for construction purposes, dust suppression and operational and maintenance purposes, or may be supplied for industrial uses (e.g. coal mines or power stations) or stock watering.

4.2.5 Contingency Discharge

Arrow is currently licensed under the DXP EA to release treated CSG water to Wilkie Creek. Arrow is committed to maximising beneficial use of its CSG water prior to disposal methods and thus discharge to Wilkie Creek is held as a contingency measure to adapt to seasonal fluctuation in irrigation demand or to preserve dam integrity during excessive rainfall. The infrastructure required to facilitate discharge to Wilkie Creek has not yet been constructed.

4.2.6 Brine and Salt Management

Water treatment processes that include desalination, such as reverse osmosis, produce a brine stream by-product. The resulting brine is stored in purpose-built brine storage dams until such time as Arrow selects a brine management solution. A range of brine management options have been identified and are described above in Section 3.5.

Both Arrow's Daandine WTF and QGC's Kenya WTF include secondary brine concentration technologies to minimise the brine stream and thereby reduce the number of required brine storage dams. The Kenya facility has thermal brine concentrators to produce a highly concentrated brine stream, whilst the Arrow Daandine WTP utilises Closed Circuit Reverse Osmosis (CCRO) membrane concentration technology.

Whilst a long-term salt solution has not been selected, the preferred option (refer Section 3.5) for managing the residual stored brine at the Daandine and Tipton Facilities is currently to crystallise the brine to a solid waste salt product near the Daandine facility, and then to dispose of this waste at a dedicated salt encapsulation facility (location to be confirmed). Brine stored at the Tipton facility will be transferred to Daandine in the future for crystallisation. As the required infrastructure is not required for a number of years, alternative salt management options will be periodically reviewed to confirm the selected option.

Similarly, the preferred option for brine produced at the Kenya WTF, from water transferred to the various Arrow-QGC transfer receipt points, is crystallisation of the brine to a solid waste salt product near the Kenya facility, and then to disposal of this waste at a dedicated salt encapsulation facility (location to be confirmed). As the required infrastructure is not required for a number of years, alternative salt management options will be periodically reviewed to confirm the selected option.

⁴ Associated Water (including coal seam gas water) (ENEW07547018/2023)

SGP CSG Water Management Plan

4.3 EA Specific Water Assets

The water infrastructure per EA, which comprises the SGP is outlined within this section.

4.3.1 Daandine Expansion Project Water Management Network

The DXP WMN contains the following water assets, in addition to water gathering and transfer pipelines.

Table 4-1 Daandine Water Management Network Storages

Dam Name	Type	Volume at Design Storage Allowance (ML)	Volume at Mandatory Reporting Level (ML)	Volume at Spillway (ML)
Daandine Aggregation Dam	Aggregation	1,166	1,239	1,458
Daandine Feedwater Dam	Aggregation	392	418	458
Daandine Treated Water Dam	Treated	199	208	238
Daandine Brine Dam	Brine	1,045	1,096	1,184
Daandine Utility Dam	Utility	26	31	48
Daandine CGPF Dam	CGPF	16	18	20
Kogan North Aggregation Dam	Aggregation	261	299	427

Table 4-2 Tipton Water Management Network Storages

Dam Name	Type	Volume at Design Storage Allowance (ML)	Volume at Mandatory Reporting Level (ML)	Volume at Spillway (ML)
Tipton Aggregation Dam 1	Aggregation	1,096	1,443	1,240
Tipton Aggregation Dam 2	Aggregation	1,781	2,046	1,728
Tipton Feedwater Dam	Aggregation	357	422	388
Tipton Treated Water Dam	Treated	367	422	404
Tipton Brine Dam	Brine	879	1,141	989
Tipton Utility Dam	Utility	41	61	57
Tipton CGPF Dam	CGPF	1.8	2.7	3.3

SGP CSG Water Management Plan

Table 4-3 Daandine Water Treatment Facilities

Facility Type	Technology	Nameplate Throughput (ML/d)
Water Treatment Plant	MF/RO	12
Brine Concentration	CCRO	2

Table 4-4 Tipton Water Treatment Facilities

Facility Type	Technology	Nameplate Throughput (ML/d)
Water Treatment Plant	MF/RO	12

Table 4-5 Daandine Beneficial Use Supply

Status	Beneficial Use Offtake	Peak Daily Supply (ML/d)	DES Hierarchy Priority
Existing	Irrigation	9.5 ¹	Priority 1
	Power Station	0.5	Priority 1
	Arrow Projects (construction and operational uses)	1	Priority 1
	Feedlot	0.6	Priority 1
Proposed	CASS	23.5 ²	Priority 1

Notes:

1. Irrigation offtake rate has no minimum or maximum under the existing agreement. Supply rates are limited to pumping and pipeline infrastructure at 9.5 ML/day.
2. CASS primarily supported by 23.5 ML/d capacity Treated Water Return Pipeline transfer from the Kenya WTF

Table 4-6 Tipton Beneficial Use Supply

Status	Beneficial Use Offtake	Peak Daily Supply (ML/d)	DES Hierarchy Priority
Existing	Arrow Projects (construction and operational uses)	1	Priority 1
	Feedlot	4	Priority 1

4.3.2 Kogan North Water Management Network

The Kogan North WMN does not contain any water assets, except for the water gathering network.

SGP CSG Water Management Plan

4.3.3 SGP North Water Management Network

SGP North contains the following water assets, in addition to water gathering and transfer pipelines.

Table 4-7 SGP North CSG Water Storages

Dam Name	Type	Volume at Design Storage Allowance (ML)	Volume at Mandatory Reporting Level (ML)	Volume at Spillway (ML)
Castledean Pilot Dam	Aggregation	173	195	216
Kedron Pilot Dam	Aggregation	151	175	195
Punchbowl Pilot Dam	Aggregation	222	231	264
Girrahween WTS Feed Tank (Proposed)	Aggregation	N/A	N/A	N/A

4.3.4 SGP South Water Management Network

SGP South contains the following water assets, in addition to water gathering and transfer pipelines.

Table 4-8 SGP South CSG Water Storages

Dam Name	Type	Volume at Design Storage Allowance (ML)	Volume at Mandatory Reporting Level (ML)	Volume at Spillway (ML)
Hillview Pilot Dam	Aggregation	373	383	465

4.3.5 Hopeland Water Management Network

The Hopeland development contains the following water assets, in addition to water gathering and transfer pipelines.

Table 4-9 Hopeland CSG Water Storages

Dam Name	Type	Volume at Design Storage Allowance (ML)	Volume at Mandatory Reporting Level (ML)	Volume at Spillway (ML)
Hopeland Pilot Dam	Aggregation	241	248	280

SGP CSG Water Management Plan

4.3.6 Kenya Pipeline and Brine Dam

The following section provides details of the Kenya Brine Dam.

Table 4-10 Kenya Pipeline and Brine Dam Water Storages

Dam Name	Type	Volume at Design Storage Allowance (ML)	Volume at Mandatory Reporting Level (ML)	Volume at Spillway (ML)
Kenya Brine Dam	Brine	1566	1586	1748

SGP CSG Water Management Plan

5. Risk Management

Arrow implements a standardised approach to risk management, enabling risks to be ranked and prioritised across all operations. Arrow's approach to risk management seeks to:

- Identify and understand risks inherent to the business; and
- Apply adequate risk response by:
 - Decreasing the likelihood and consequence of adverse effects;
 - Increasing the likelihood and impact of positive effects;
 - Implementing effective controls;
 - Setting boundaries for risk acceptance;
 - Focusing assurance activities towards the highest areas of risk.

An assessment of the risks related to CSG water management for the SGP was completed in March 2018 and reviewed in October 2023. The risk assessment used the Arrow Energy framework⁵. Table 5-1 summarises the most pertinent CSG water management risks for the SGP development, alongside mitigation measures that will control all risks to acceptable levels.

The risk assessment shows that:

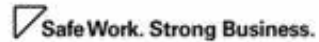
- Most risks are ranked as Low considering existing management controls;
- Risks related to the failure of the WTP to achieve desired design water quality, the failure to secure off-take agreements and the failure to deliver a long-term brine management solution ranked as Medium;
- For risks which ranked as Medium, the residual risk ranking is Low after consideration of risk response measures.

⁵ Arrow Energy, 2018 Arrow Energy Risk Management Procedure, Appendix 1 - Risk Assessment Matrix, Version 5.0, Doc No: ORG-ARW-RMT-PRO-00001

Plan

S00-ARW-PMC-PLA-00169

Table 5-1 Summary of Risk Assessment



Hazard / Threat	Consequences	Existing Controls	Current Risk Ranking	Risk Response	Residual Risk Ranking
Dam Break – collapse of the structure due to any possible cause	Dam break has the potential to cause: harm to humans; harm to the environment; general economic loss or property damage; and non-compliance with EA conditions.	Dams are designed and operated in accordance with Queensland regulation. ⁶ Monitoring and maintenance is undertaken in accordance with Dam Operating Plans. Annual dam inspections conducted. Weekly operator inspections of dam levels.	LOW <i>Aggregation Dam</i>	Implementation of emergency procedures as defined in the Dam Operating Plans.	LOW <i>Aggregation Dam</i>
			LOW <i>Treated Water Dam</i>		LOW <i>Treated Water Dam</i>
			LOW <i>Brine Dam</i>		LOW <i>Brine Dam</i>
Failure to contain – seepage - significant changes to Groundwater from seepage	Seepage has the potential to cause: harm to humans; harm to the environment; general economic loss or property damage; and non-compliance with EA conditions.	Dams are designed and operated in accordance with Queensland regulation. Regular monitoring of groundwater quality in the immediate vicinity of regulated dams as per the Groundwater Monitoring Program. Seepage controls such as HDPE liners and collection systems are in place where risks are present. Brine management dams include capability to capture any seepage that may pass through HDPE lining. Monitoring and maintenance undertaken in accordance with Dam Operating Plans.	LOW <i>Aggregation Dam</i>	Implementation of emergency procedures as defined in the Dam Operating Plans.	LOW <i>Aggregation Dam</i>
			LOW <i>Treated Water Dam</i>		LOW <i>Treated Water Dam</i>
			LOW <i>Brine Dam</i>		LOW <i>Brine Dam</i>

⁶ Department of Environment and Heritage Protection, Manual for Assessing Consequence Categories and Hydraulic Performance of Structures, DES, Queensland, Australia (ESR/2016/1933).

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SGP CSG Water Management Plan

Hazard / Threat	Consequences	Existing Controls	Current Risk Ranking	Risk Response	Residual Risk Ranking
Failure to Contain – overtopping – releases due to overtopping of the structure	Overtopping has the potential to cause: harm to humans; harm to the environment; general economic loss or property damage; and non-compliance with EA conditions.	Dams are designed and operated in accordance with Queensland regulation. Operation of storages in accordance with dam operating plans and EA conditions. Adherence to DSA and MRL operating rules. Release reduction strategy in place including production forecasting and water balance model scenario testing. Emergency spillways on dams.	LOW	Implementation of emergency procedures (including emergency discharge strategy) as defined in the Dam Operating Plans.	LOW
Failure of water treatment plant to achieve required water quality	Plant failure has the potential to cause: an inability to use treated CSG water for intended beneficial use options; and non-compliance with EA conditions.	Upstream buffer storage to allow for temporary system shut down to resolve potential issues. Automated monitoring within the WTP system to allow for early detection and mitigation of issues. Automated water quality sampling in permeate dam prior to beneficial use.	LOW	Water treatment plant upgrades (including pre and post treatment systems) or replacements to achieve water quality objectives. Option to turn down / shut in wells if upstream storage becomes limiting.	LOW
Failure to secure water off-takes	Insufficient off-takes have the potential to require disposal of CSG water instead of beneficial use.	CSG water utilisation portfolio to be maintained with sufficient capacity (above upper bound water production curves) to address this risk. Market analysis and identification of off-take opportunities.	LOW	Ability to provide excess capacity into existing SunWater beneficial use pipeline to Chinchilla weir.	LOW

SGP CSG Water Management Plan

Hazard / Threat	Consequences	Existing Controls	Current Risk Ranking	Risk Response	Residual Risk Ranking
Failure to deliver long-term brine management solution.	No long-term brine management solution has the potential to: require additional brine storage construction when existing capacity is exhausted; increase operational footprint and create additional impact on environmental receptors; and require utilisation of 3 rd party treatment and/or disposal services	Brine feasibility studies have been undertaken to identify a feasible long term brine management solution Construction of additional brine storage dams to account for short term needs.	MEDIUM ⁷	Alternative salt management options will be periodically reviewed to confirm the selected option. Ongoing engagement with Industry and DES.	LOW

⁷ Risk ranks as moderate due to increased costs to deal with residual brine.

Plan

S00-ARW-PMC-PLA-00169



6. Management Criteria

6.1 Measurable Criteria

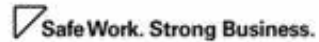
Arrow Energy has defined Measurable Criteria for the SGP in accordance with Section 126 (1) of the EP Act 1994. To ensure criteria are targeted towards those CSG water management activities and elements that require greatest control, they have been developed from the outcomes of the risk assessment described in Section 5. The Measurable Criteria will be used to monitor and assess the effectiveness of CSG water management across a range of indicators and will be reported in the annual return.

Table 6-1 presents the measurable criteria required to satisfy the requirements of the EP Act. The criteria will be re-evaluated if required as a result of changes in the way which Arrow manages CSG water.

Plan

S00-ARW-PMC-PLA-00169

Table 6-1 Measurable Criteria



Management Component	Objectives	Environmental Value Protected	Controls	Measurable Criteria
Transmission of CSG water via pipelines	Effective containment of water throughout transmission activities from well to beneficial use / disposal.	Surface and groundwater quality. Soil quality (including structural and chemical properties).	Regular monitoring and maintenance in accordance with asset integrity and maintenance plan. Process safety in design and controls.	No reportable unplanned releases of CSG water.
Storage of CSG water in regulated dams	Effective containment of CSG water in dams. Regulated dams operated and maintained in accordance with approvals.	Surface and groundwater quality. Soil quality (including structural and chemical properties).	Dam designed and constructed as per relevant guidelines and regulations. Annual dam integrity inspections. Groundwater monitoring program. Scheduled maintenance of infrastructure and facilities. Dam operating plans. Water balance modelling to develop operating philosophy and strategy.	Water level below DSA at Nov-1 ⁸ . No breaches of MRL. Annual inspections completed. No unplanned releases.
Beneficial Use	Maximise beneficial use of CSG water. Ensure that supplied beneficial use water is in accordance with approvals.	Surface and groundwater quality. Soil quality (including structural and chemical properties).	Regular monitoring of the qualities and quantities of water supplied for beneficial use. Scheduled maintenance of infrastructure and facilities. CSG Water and Salt Management Strategy.	Water supply agreements in place. Water quality for beneficial use meets approval conditions.

⁸ If the dam is a regulated structure as per the failure to contain overtopping scenario in the *Queensland Department of Environment and Heritage Protection, Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*, DEHP, Queensland, Australia (ESR/2016/1933).

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SGP CSG Water Management Strategy

Management Component	Objectives	Environmental Value Protected	Controls	Measurable Criteria
Management of salt and brine	Management of salt in accordance with the regulatory framework.	Land use capability, having regard to economic considerations. Surface and ground water quality. Soil quality (including structural and chemical properties).	Continual assessment of feasible options for beneficial use and/or disposal of salt in accordance with the CSG Water Management Policy 2012. Containment of salt and brine in fit for purpose storage infrastructure operated and maintained in accordance with approvals.	Water level below DSA at Nov 1 ⁹ . No breaches of MRL. Annual inspections completed. No reportable unplanned releases.

⁹ If the dam is a regulated structure as per the failure to contain overtopping scenario in the *Queensland Department of Environment and Heritage Protection, Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*, DEHP, Queensland, Australia (ESR/2016/1933).

Plan

S00-ARW-PMC-PLA-00169



6.2 Response Procedures

Should any of the Measurable Criteria in Table 6-1 not be met, the following response procedure will be implemented:

- Where relevant, reporting of incident in line with the relevant Environmental Authority requirements;
- Evaluation (including root cause analysis) of the underlying cause of the criteria not being met;
- Review of relevant procedures, protocols and management plans and make changes where required;
- Implementation of corrective actions to address underlying cause. This, for example, could include:
 - Engineering solutions;
 - Amendments to operating procedures; and/or
 - Change to management process.

6.3 Arrow Operating Procedures

Arrow Energy commits its staff to the adoption of a series of procedures that control important elements of CSG water management. These procedures include:

- 99-H-PR-0010 (5) Incident Reporting Recording and Investigation Procedure;
- ORG-ARW-HSM-PRO-00016 (11) Chemical Management Procedure;
- ORG-ARW-HSM-PRO-00066 (6) Waste Management Procedure; and
- ORG-ARW-HSM-PRO-00073 (9) Land Rehabilitation Procedure.

Each of Arrow Energy's procedures is reviewed regularly in order to ensure that all operating factors are considered, and that procedures continue to reflect latest understanding.

SGP CSG Water Management Strategy

7. Monitoring

7.1 Environmental Monitoring

7.1.1 Surface Water

Contingency discharge of treated CSG water to watercourses is a potential option in the event that other beneficial uses of CSG water are temporarily unavailable. Prior to the release of treated CSG water to a watercourse, Arrow will develop a Receiving Environment Monitoring Plan (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, water quality, and flows due to authorised releases. The REMP will be developed in accordance with granted EA conditions. Arrow does not currently have any installed watercourse release infrastructure.

7.1.2 Groundwater

The Groundwater Monitoring Program will provide for the early detection of significant risks and changes in groundwater quality and levels as a result of activities authorised under the SGP EAs.

The Groundwater Monitoring Program may include:

- regular monitoring of groundwater quality in the immediate vicinity of regulated dams;
- monitoring of background sites;
- monitoring of dam water quality;
- establishment of site-specific environmental values for the shallow groundwater system;
- development of site-specific trigger values;
- ongoing monitoring of groundwater to identify environmental impacts; and
- implementation of management actions in the event of environmental impact.

Monitoring groundwater quality at dam sites requires installation of monitoring bores in close proximity to dams. The exact location of these bores is guided by geotechnical investigations to identify the direction in which groundwater impact is likely to travel. Background sites are also installed at distances of 500m to 1,500m (where access allows) both up and down gradient of the dams.

Site-specific trigger levels are developed by considering the background groundwater quality, established trigger levels (such as ANZECC water quality criteria), and the potential impacts of seepage from regulated dams. Ongoing monitoring is then used to identify whether, and to what extent, environmental impacts, with reference to the aforementioned criteria, are occurring. Where unacceptable impacts have occurred, management actions are initiated to remedy these.

7.2 Monitoring of CSG Water Management Dams

In accordance with dam operating plans, Arrow Energy will conduct the following monitoring:

- Dam water levels monitored against MRL and DSA;
- Visual inspections for algae, surface slicks or fauna interaction;

SGP CSG Water Management Strategy

- Visual structural inspection for early identification of integrity issues;
- Identification of any changes to the dam service/contents;
- Groundwater impact monitoring for physico-chemical parameters;
- Each regulated dam will be inspected by a suitably qualified and experienced person with an Annual Inspection Report prepared and certified; and
- An assessment of the DSA will be undertaken on or before 1 November each year.

SGP CSG Water Management Strategy

8. Reporting

8.1 Annual Return

In accordance with the requirements of the SGP EAs, Arrow Energy will complete and submit an Annual Return which will include an evaluation of the effectiveness of the management of CSG water under the criteria described in Section 126(1)(e) of the EP Act.

8.2 Annual Inspection Report

Arrow Energy will undertake inspection and reporting for each of its regulated structures in accordance with the SGP EAs. Annual Inspection Report(s) will be certified by a suitably qualified and experienced person.

8.3 Annual Monitoring Report

An Annual Monitoring Report summarising monitoring results over the previous 12 month period will be prepared and made available to DES upon request. All monitoring results will be retained for no less than five years.

8.4 Incident Reporting

If any contaminant levels are identified as having caused, or have the potential to cause environmental harm, this will be reported to DES in accordance with EP Act and EA requirements.