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Hopeland Environmental Authority (EA0001401)

EA Amendment Application Supporting Information Report

Hopeland Stage 2

30 April 2026

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1. Introduction

1.1 The Project Area

Arrow CSG (Australia) Pty Ltd.'s (Arrow Energy) Surat Gas Project (SGP) is a multi-decade natural gas development in Queensland's Surat Basin to fulfill gas supply agreements. The SGP is being developed in a staged approach and is underpinned by a Gas Sales Agreement (GSA) and a Water Services Agreement with QGC Pty Ltd (QGC). The GSA provides access to existing gas and water processing facilities within the Queensland Brigalow Belt Region (refer to **Figure 1**).

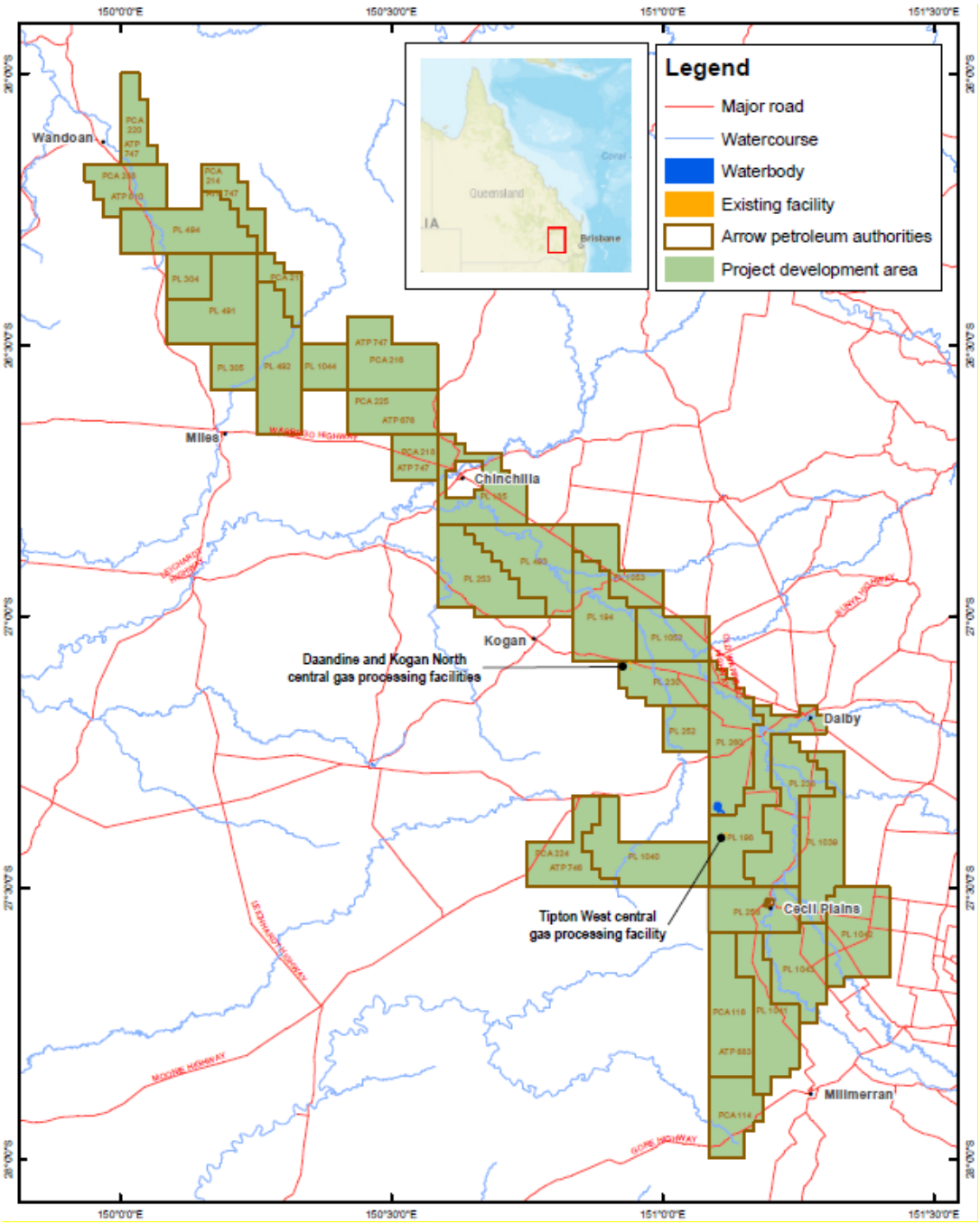


Figure 1 **Surat Gas Project (SGP) Development Area**

The SGP covers an area of approximately 5,385 km^2 (538,500 ha) and is located approximately 160 km west of Brisbane in Queensland's Surat Basin. As shown in **Figure 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 staged development includes the Hopeland development area, authorised under environmental authority (EA) EA0001401 (the Hopeland EA). **Figure 2** shows the extent of the SGP gas tranches to both North and South. The Hopeland development area being applicable to tranches 3 and 6 and is located on Petroleum Lease (PL) 253.

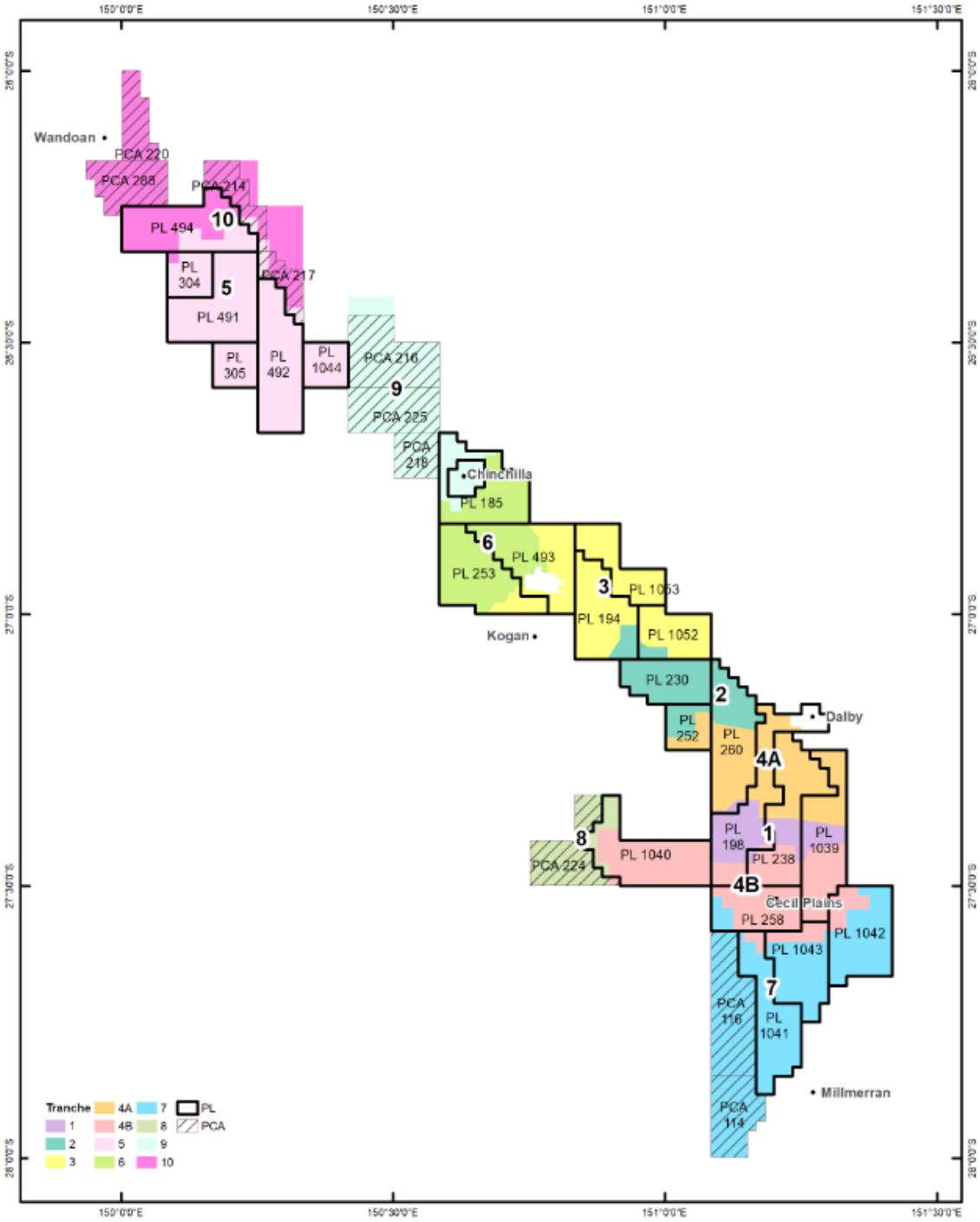


Figure 2 Extent of the SGP Gas Tranches – North and South

The Hopeland development area (hereafter the Project), will deliver Natural Gas to the QGC Jammat Field Compression Facility (FCS). Proposed petroleum activities located on PL253 are associated with the Hopelands EA0001401, which is located south of the town of Chinchilla in Southern Queensland (refer to **Figure 3**).

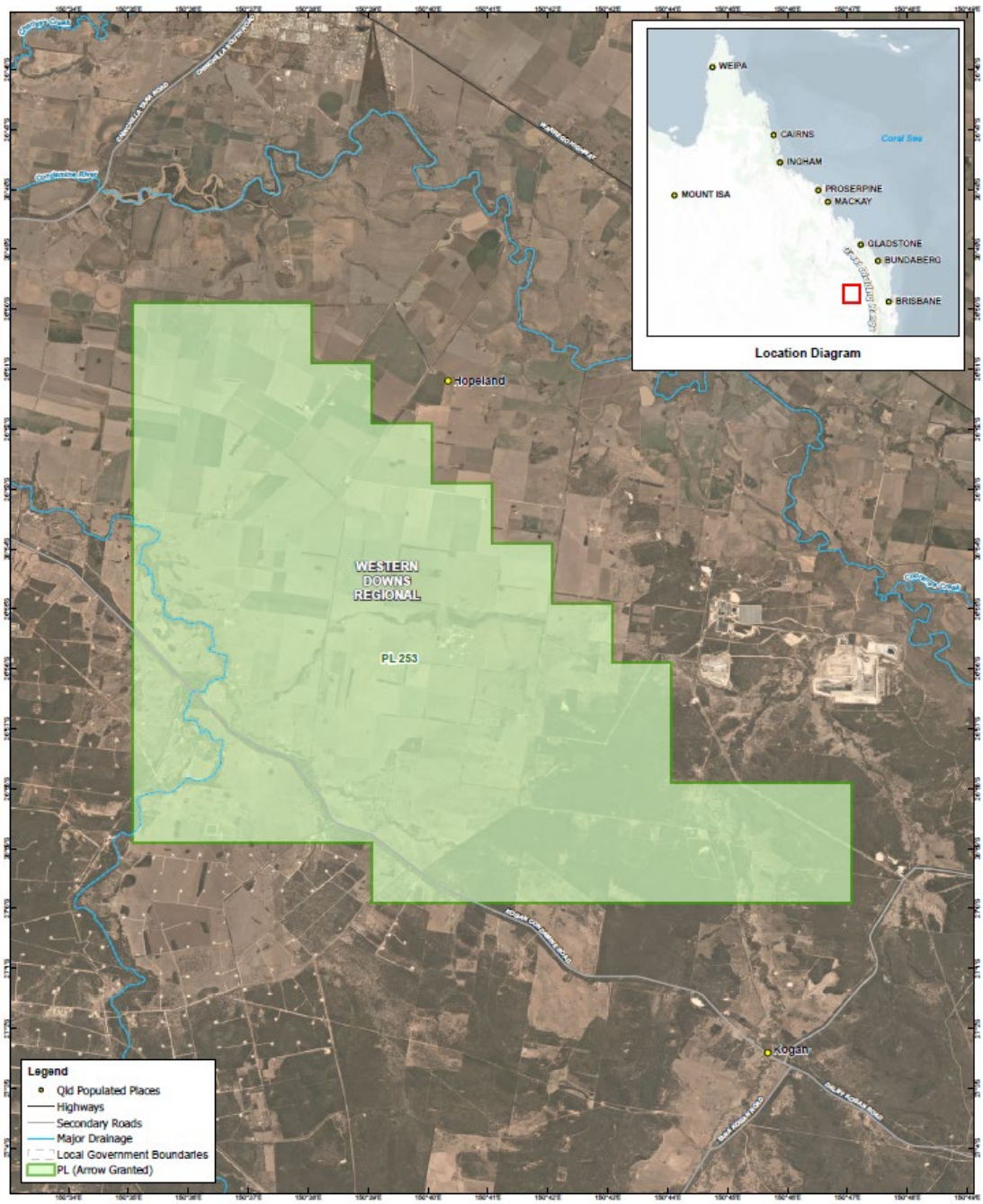


Figure 3 Hopeland Development Area (the Project) PL253

The Project, located on PL253 is authorised under the Hopeland EA. The full development case for PL253 includes up to 280 wells and associated infrastructure on PL253 (refer to Section 1.2) which is planned to be developed in the following stages:

- Hopeland Development Stage 1: consisting of an initial 55 wells (previously authorised);

- Hopeland Development Stage 2: consisting of an additional 55 wells; and
- Hopeland Development Later Stages: consisting of the remaining wells to be developed.

Details regarding the Project are provided in Section 1.4 and 1.5.

Subject of this EA amendment for the Hopeland Development Stage 2 (the Project) are:

- Authorisation for an additional 55 wells on PL253 as well as the associated infrastructure required for petroleum activities. This would authorise wells included in Stage 2 of the Hopelands development case;
- The authorisation of biodiversity impacts for the development of Stage 2 of the Project, including an additional 55 wells, access and gathering. This will require an update to the significant residual impacts to Prescribed Environmental Matters (PEMs) and activities with the protection zones of environmentally sensitive area (ESAs), specifically to the maximum extent of impact to environmental values as currently considered in the Hopeland EA (for more detail on changes to the ESAs and PEMs table impact data please refer to Section 5.6;
- Authorisation of proposed impacts to groundwater and current groundwater monitoring programs (see Appendix E for details on groundwater assessment and impacts); and
- Authorisation of changes to greenhouse gas impacts as a result of the authorisation of the additional proposed wells.

Details regarding all the proposed EA amendments are provided in Section 2 as well as Appendix A, and Appendix C.

1.2 Regulatory Approval Background

1.2.1 Environmental Impact Statement

Arrow Energy prepared a voluntary environmental impact statement under the *Environmental Protection Act 1994* (Qld) (EP Act), the SGP EIS[1], which was submitted to the Chief Executive of the then Department of Environment and Heritage Protection in March 2012 as a mechanism to establish environmental protection objectives and measures.

Public consultation to the SGP EIS was conducted from March to June 2012 and a Supplementary Report to the SGP EIS (SGP SREIS)[1] was prepared which summarised and addressed the comments from the consultation process.

The SGP EIS 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 approval[2].

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

- Coal Seam Gas (CSG) production wells;

[1] Arrow Energy Surat Gas Project Environmental Impact Statement, October 2013 (SGP EIS) and Supplementary Report (Arrow Energy SGP EIS and Supplementary Report to the SGP EIS (SGP SREIS)).
[2] Arrow Energy Surat Gas Project EPBC Approval, December 2013 (EPBC 2010/5344).

- CSG and water gathering lines;
- Production facilities, including field compression and water transfer stations;
- Water treatment and water storage facilities;
- Power generation facilities;
- High pressure gas pipelines; and
- Supporting infrastructure and logistics.

The SGPEIS addressed the potential environmental impacts of the proposed construction, operation, maintenance, and decommissioning activities of the SGP.

A summary of the environmental values of the terrestrial ecology within the development area of the SGP is contained in Chapter 17 of the SGP EIS. This chapter includes an assessment of the potential for these values to be affected by direct and indirect impacts associated with the SGP activities. The terrestrial ecology impact assessment comprised a desktop study, a habitat suitability assessment, and field surveys (refer to SGP EIS Chapter 17, Section 17.2.3), followed by a significance assessment to determine the scale of the potential impacts that could result from SGP development activities.

The field surveys conducted included the Project area with the field survey sites being selected based on their representativeness of the range of environmental values that exist across the SGP area, as the precise location of project activities was not known at the time of the SGP EIS. Regional Ecosystem mapping was used to identify these sites, with the aid of aerial photography and ground-truthing data (refer to SGP EIS Appendix H[3] for further details on the survey methodology used for terrestrial ecology).

A detailed assessment of the potential impacts on the terrestrial ecology environmental values identified as being at risk from the project development activities within the SGP area is included in Appendix K of the SGP EIS.

Ecological values within the SGP development area were assessed in relation to the impacts from the SGP, specifically on Environmentally Sensitive Areas (ESAs), based on the level of sensitivity of these[4].

At the time of the SGP EIS, three (3) Category A ESAs were identified, as well as areas with Category B and C. A range of mitigation and management measures were proposed as part of the SGP EIS to manage the impacts to these terrestrial ecological values, which included 'avoidance', 'minimisation', and 'active management' (refer to SGP SREIS Attachment 6 Draft Environmental Offsets Strategic Management Plan). These measures are in place to maintain the risk to ecological values at levels that are as low as practically possible, and the residual impact considers that the proposed mitigation and management measures were applied.

A supplementary terrestrial ecology assessment was undertaken as part of the SGP SREIS to address updates to the SGP description after the finalisation of the SGP EIS

[3] Terrestrial Ecology Impact Assessment, 3D Environmental and Ecosmart Ecology, for Arrow Energy, September 2011.

[4] Environmentally Sensitive Areas (ESAs) are classified depending on the level of sensitivity, i.e, the level of susceptibility or vulnerability, to a certain threatening process and are ranked as Category A, B, or C (refer to Environmental Protection Regulation 2019).

and to provide further information on the environmental values of the SGP development area obtained through improved vegetation mapping and additional field surveys.

Since the SGP EIS and the SGP SREIS were approved there have been many updates to the government regional ecosystem digital data mapping. There have also been updates to Government policies, guidelines and legislation that impact on the management of terrestrial ecology values. These changes introduced new species to protected species lists, changes in listing status of some species and ecological communities, changed offset requirements and interpretation of environmental authority conditions.

Post EIS approval and as the location of the CSG development infrastructure has become progressively known over the life of the project, Arrow Energy has implemented its Environmental Management Framework to managing potential impacts from the SGP on terrestrial ecology values, mainly by applying its constraints mapping processes whilst identifying sites for production wells, pipelines, production facilities, access roads and accommodation camps. Environmental constraints as identified through the EIS process, plus the application of appropriate environmental management controls ensures that protection of environmental values are integrated into project planning. This approach maximises the opportunity to select appropriate site locations that minimise potential environmental impacts (further details are provided in Section 5.6.4).

At the time of the SGP EIS and the SGP SREIS the precise locations of the facilities and infrastructure to be developed within the Project's development area was unknown. The terrestrial ecology assessment took a precautionary approach in assessing residual impacts for each species or ecological communities on the basis that avoidance may not be possible in many cases, although avoidance is the first preference in site and route selection for habitat for listed species.

1.2.2 Environmental Authority

An application for an environmental authority was submitted to the Queensland Government and the Hopeland EA was granted on 08 August 2018, authorising petroleum activities to be undertaken wholly on PL253. The initial EA authorised 6 x pilot wells and water monitoring wells as well other petroleum activities such as pipelines (gas and water), access tracks, sediment ponds and regulated structures.

A request to amend the Hopeland EA was initially submitted in July 2020 which proposed to authorise the full PL253 development case of 280 production wells and associated infrastructure. The proposed field layout for the full development case (which includes wells proposed in this application) were supplied in the amendment.

This application was withdrawn following feedback from the (former) Department of Environment and Science (DES) relating potential groundwater impacts associated with the proposed amendments. A new application was lodged which split the full development case into a staged approach and sought to authorise 55 new production wells and was approved by DES in February 2023.

The Hopeland development scope was optimised and the overall footprint for the previously authorised 55 wells was reduced which required revision to the impacts to Prescribed Environmental Matters and also impacts to ESAs and their protection zones. An amendment that reflected the revised footprint and offsetable matters (i.e. PEMs) was submitted and approved by DETSI in May 2025.

The Hopeland EA currently authorises petroleum activities under *General Condition 1 Table 1 – Authorised petroleum activities* and as described in **Table 1-1**. This includes 55 Stage 1 wells in addition to the 6 existing pilot wells authorised in the initial EA.

Table 1-1 Currently Authorised Petroleum Activities under the Hopelands EA

Petroleum Activities and Infrastructure	Scale	
	Intensity (Extent)	Maximum
Existing Wells	6ha See definition of Essential Petroleum Activities for well pad disturbance size (in hectares)	6
Stage 1 Wells	55ha See definition of Essential Petroleum Activities for well pad disturbance size (in hectares)	55
Existing and additional Water Monitoring Bores	0.03ha for shallow monitoring bores 1ha for deep monitoring bores	30
Gathering and Raw Water Pipelines	155ha	N/A
Access Tracks	74km	74km
Borrow Pits	3ha	6 borrow pits
Sediment Ponds	0.76ha	2 sediment ponds
Hopeland Water Dam (regulated structure)	21ha	1 dam

The July 2020 amendment application, while withdrawn outlined the full development plan for PL253 and included the scope for development of the SGP on PL253 as the following activities:

- Drilling and completion of vertical and deviated wells;
- The vertical well pads will generally be sized at 110 x 100 m. Three types of designs will be used; either minimal disturbance (clear and grub only) or formed (cleared and grubbed with light and/or heavy compaction of soil as required) or formed by using gravel (see Plate 4-2 for image of a pad being prepared);
- Multi well pads will generally be sized at 110 m x 145 m to 174 m, depending on the number of wells per pad (which will range from 2 to 8 wells per pad). However, this size will need to be increased for some multi well pads (e.g. if located on steeper gradients) up to a maximum area of 2.50 hectares. As with the vertical well, at least three types of designs will be used (i.e. minimal disturbance or formed);

- Access tracks to the well site and along some of the gathering lines will be constructed with a width of approximately 5 to 6 m. The flat to gently undulating terrain in the area suggests that approximately half of the tracks will require minimal disturbance to construct. For track construction in steeper areas, cut and fill with imported material such as gravel or road base will be required;
- Wellhead facility and infrastructure as shown in Plate 4-3 and Plate 4-4 will consist of wellhead skid, reticulated power (transformer) or, gas engine generator set (genset) as shown in Plate 4-5, process safety valve, control and power cabinet and piping material;
- High-density polyethylene (HDPE) gas and water gathering lines will be installed. The gathering lines as shown in Plate 4-6 and Plate 4-7 will range from 160 mm to 1000 mm nominal diameter and will include Low Point Drains (LPD) and High Point Vents (HPV) as shown in Plate 4-8; and
- Gas-fired generators located on the well-pad is the preferred option for providing power to the wells.
- There may be a requirement for telecommunications infrastructure including buried fibre cable and telecommunications towers.

1.2.2.1 Groundwater

The PL253 area includes the former Underground Coal Gasification (UCG) site located on Lot 40 DY85, where historical UCG operations undertaken by Linc Energy resulted in residual hydrocarbon contamination and other UCG by-products within the groundwater system.

Arrow has conducted groundwater monitoring, numerical modelling, and annual reporting in and around the former UCG site since 2018 to characterise groundwater conditions, contaminant behaviour, and potential risks to surrounding receptors.

To support this EA amendment application , updated groundwater modelling to assess the potential impacts of Arrow's proposed activities on groundwater flow, contaminant migration, and long-term groundwater recovery associated with the former UCG site has been undertaken and included in Section 5.9 and in Appendix E.

1.3 Currently Authorised Environmentally Relevant Activities (ERAs)

The ERAs currently authorised under the Hopeland EA (EA0001401), as per the *Environmental Protection Regulation 2019* (Qld), are:

- Schedule 3, ERA 3: A petroleum activity that is likely to have a significant impact on a category A or B Environmentally Sensitive Area (ESA);
- Schedule 3, ERA 6: A petroleum activity carried out on a site containing a high consequence dam or a significant consequence dam if the dam forms part of the activity; and
- Incidental activities that are otherwise specified relevant activities.

1.4 Current Disturbance

Disturbance within the Hopeland EA area has been limited to the exploration and appraisal wells, gathering and Hopeland Dam confined to Lots 2DY94 and 34DY94. Monitoring bores have also been installed on the former UCG site on Lot 40DY85 as required under the Hopeland EA. This data will be consistent with the Annual return for EA0001401.

1.5 Proposed Development

The application seeks approval for 55 new production wells on PL253 as included in this EA amendment application. The exact number and timing of these wells will be phased to optimise gas production to meet Arrow's gas supply obligations and opportunities. The rate of development will be influenced primarily by subsurface performance (i.e. gas volumes extracted from each well over time).

The proposed field development plan for Hopeland Stage 2 (see Figure 4) , including well and gathering locations included in this EA amendment application is appropriate to assess site specific impacts because it has been refined after a number of surface and sub-surface engineering assessments, field surveys and reviews including the pre and post wet season ecological surveys undertaken in 2023 and 2025, data from the groundwater monitoring bore program and the Groundwater Characteristics Monitoring Program and from discussions with landholders over the past several years.

As with all gas production wells, workovers will continue for the entirety of the Project or until the gas reserves extracted by the well are depleted. Gathering lines will be installed from each well to transport the gas and water to the delivery point, being predominantly the Jammat Field Compression Facility (FCS).

The following principles in terms of development will be applied where possible:

- Closest to the delivery point facility first;
- Closest to the previous wells to minimise new gathering;
- Preference for areas adjacent to existing well fields; and
- Avoiding where practicable, environmental, landholder, cultural and geographical constraints.

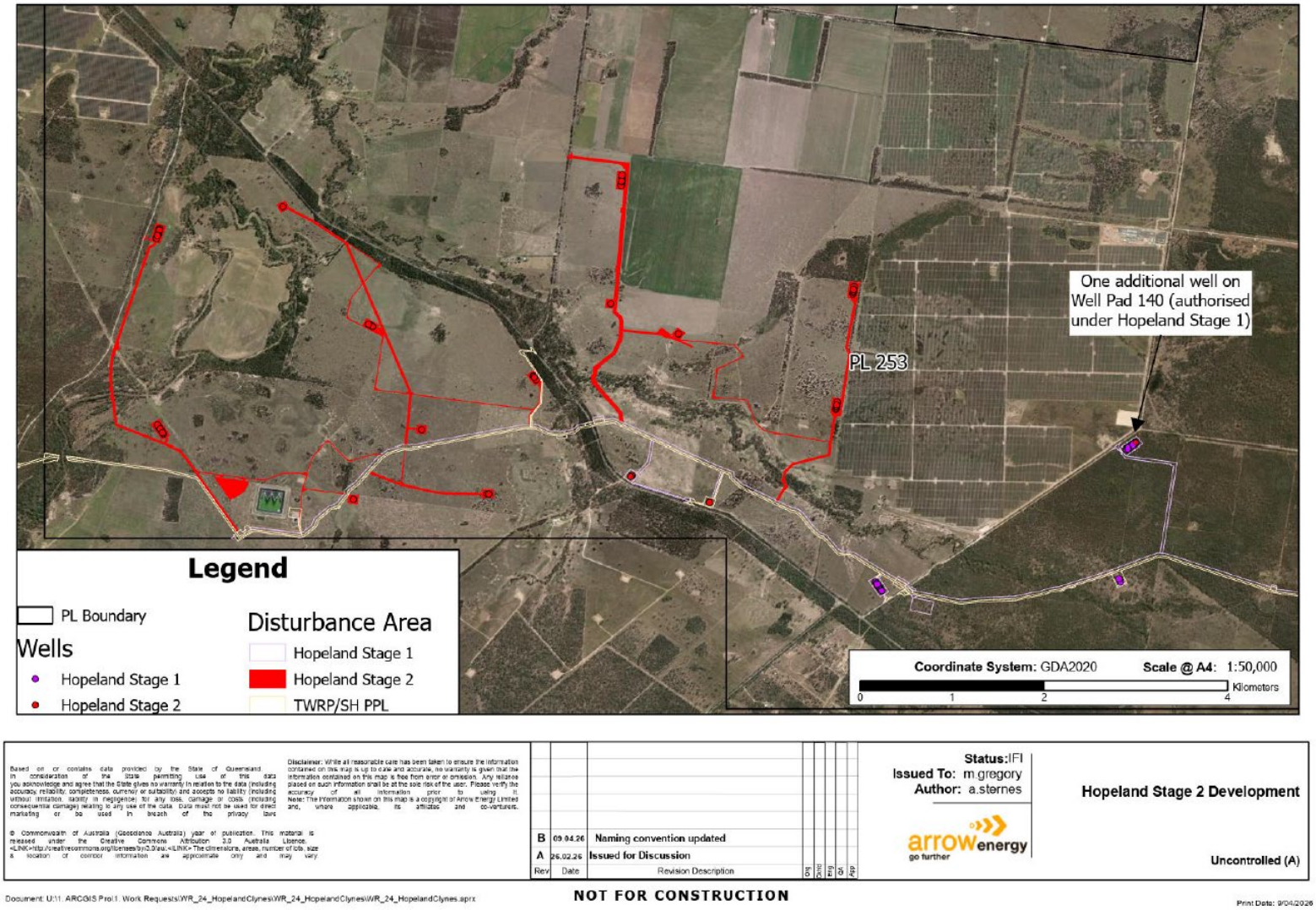


Figure 4 Hopeland Development Stage 2 – Field Development Plan

1.6 Scale of Disturbance for Proposed Development

The total disturbance area for Stage 2 of the Hopeland Development, which will involve the drilling and completion of an additional 55 wells, associated gathering lines and access tracks, is provided in **Table 1-2**.

Table 1-2 Hopeland Development Stage 2 – Wells and access tracks, and pipeline corridor Disturbance

Infrastructure	Location	Quantity	Proposed/estimated and Approved Land Disturbance
Wells pads	PL253	14 well pads for 55 wells	19 ha
Pipeline corridor	PL253	NA	45 ha
Additional access tracks outside the pipeline corridor RoW	PL253	21km	N/A
Incidental activities (EWAs, laydowns)	PL253	NA	6 ha
		Total	**70 ha**

Figure 4 provides an indicative layout of the proposed 55 wells and associated access track/gathering line network for the purposes of this EA amendment application. This layout generally represents the field development which Arrow's expects to deliver however the final layout may be influenced by further landholder inputs during Conduct and Compensation Agreements (CCAs) negotiations. As such the layout proposed may be subject to further refinement. Any such refinement will however be subject to 'in-field ecological values assessments' to avoid and if avoidance is not possible minimise our potential impacts.

This proposed EA amendment seeks to include within the Hopeland EA's additional petroleum activities. The corresponding environmental impact assessments from these activities and an update to the authorised activities in environmentally sensitive areas (ESAs) and to Prescribed Environmental Matters (PEMs) have been conducted (refer to Section 5).

Existing roads will be utilised used where possible, with only minor upgrades required, to existing roads and access tracks required for the majority of the proposed works.

Pre-clearance surveys will be conducted prior to disturbance to validate disturbance limitations against:

- the proposed impacts to Prescribed Environmental Matters (PEMs) in this EA amendment (refer to Appendix C), and
- offsets requirements.

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 5 and Section 6) and the

original EA application, as the environmental risks associated with the Project activities, as assessed in the SGPEIS, the SGPREIS, and the original EA application have not materially changed.

Appendix D provides the spatial data for the development of the Hopeland Stage 2.

1.7 Details of the Proponent

Arrow CSG (Australia) PTY LTD is an integrated energy company with interests in natural gas developments, pipeline infrastructure and electricity generation.

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

1.8 Legislative Context

The EP Act and the *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act) provide the principle legislative frameworks for facilitating resource projects in Queensland, including Hopeland.

Arrow Energy requires an amendment to the existing Hopeland EA under the EP Act to enable the construction of key infrastructure to support development of the subsequent stages of Hopeland. Further details regarding legislative requirements and compliance with the requirements under the EP Act are provided in Section **7.**.

As referred to in Section 3.5.1, Arrow Energy has a long history of community engagement, through the SGPEIS and the SREIS processes, through its consultation group, the *Arrow Surat Community Reference Group* (ASCRG), Area Wide Planning (AWP) (refer to Section 4.1) meetings, and local community drop-in information sessions. Over many years, the ASCRG provided local representatives a consultative forum with regard to Arrow Energy's development of coal seam gas resources within its tenements in the Surat Basin, designed to:

- effectively identify issues;
- provide feedback; and
- consider improvement opportunities and initiatives.

Arrow continues to keep the local community updated on its activities through its community newsletter, local advertising, ongoing Area Wide Planning, engagements with stakeholders through community events and local economic development organisations.

The consultation activities that Arrow Energy has developed, and continues to develop, are in line with the principles as set out under the *Human Rights Act 2019* (Qld), as they enable all people the freedom of expression (*Human Rights Act 2019*, s21). All engagement with Arrow Energy is conducted under privacy rules and regulations to protect stakeholder privacy and reputation (*Human Rights Act*, s25).

Arrow Energy is committed to respecting and upholding the cultural rights of Indigenous people (*Human Rights Act 2019*, s28), and holds Indigenous Land Use Agreements across much of its operational areas. Arrow Energy also has Cultural Heritage Management Plans with relevant Indigenous Groups and undertakes Cultural Heritage surveys prior to any on-ground activity, to ensure any areas of cultural significance are identified and protected.

Where required Arrow Energy will enter into Approved Cultural Heritage Management Plans with the appropriate Native Title Parties over the Project Area.

1.9 Purpose and Scope of this Document

The purpose of this report is to support an amendment application to the Department of Environment, Science, Tourism and Innovation (DETSI) to seek an amendment to Arrow Energy's site-specific EA0001401, and to provide sufficient information to enable DETSI to decide on the 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 DETSI guideline *Major and minor amendments* (ESR/2015/1684), version 11.00, of 26 September 2023.

1.10 Plan of Operations

Arrow Energy anticipates that the Project will likely commence in 2028. An updated PoO addressing the development activities will be submitted to the DETSI as required under Section 293 of the EP Act.

1.11 Estimated Rehabilitation Cost

In accordance with Section 297 of the EP Act, Arrow Energy has an estimated rehabilitation cost (ERC) decision in place.

A revised ERC calculation as necessary and applicable in accordance with the EP Act will be submitted to the administering authority for disturbance resulting from the additional activities, which will be lodged prior to commencement.

2. Proposed EA Amendments

2.1 Hopeland Stage 2

With this EA amendment, Arrow Energy is proposing to develop an additional 55 wells and their associated gathering and access and incidental activities over PL253. For the purposes of Arrow Energy's internal planning and this application this is known as the Hopeland Development Stage 2.

To help facilitate the development, Arrow Energy is also seeking approval for:

- Additional infrastructure, as described in Section 1.5
- Replace Waste Condition 11 to facilitate STP release for low capacity (less than 50EP) systems with low risk of adverse impacts;
- An update to biodiversity conditions, as described in Section 2.2 and Section 5.6; and
- Administrative changes, as described in Section 2.3 including specifying additional ERAs required to conduct work authorised by the existing EA conditions.

A summary of all proposed EA amendments is provided in Appendix A and the detail of this Stage 2 infrastructure, and the estimated proposed land disturbance is provided in **Table 2-1**.

Table 2-1 Hopeland Stage 2 additional infrastructure and estimated proposed land disturbance

Additional Infrastructure	Estimated proposed land Disturbance Hopeland Stage 2
Well pads (single well pads)	6 ha
Well pads (multi well pads)	13 ha
Gathering RoW	45 ha
Access tracks	Approximately 22km of additional track
Extra work areas and laydowns	6 ha
Total estimated proposed additional infrastructure disturbance	**70 ha**

The estimated disturbance of the additional infrastructure of approximately 70 ha, as shown in **Table 2-1,** is approximately 25% of the approximately 265 ha of the total footprint already authorised under the existing Hopeland EA for wells, access tracks, and the pipeline corridor (i.e., gathering) (refer to Section 1.2.2).

2.2 Update to Biodiversity Conditions

Impacts to biodiversity currently authorised under the Hopeland EA (EA0001401) are based on concept level design and layouts and are not inclusive of all disturbances necessary for the Project's development. As contemplated, the proposed amendments reflect updates to the Project as well as updates to species distribution and habitat mapping.

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 Condition (Biodiversity 8b) and Condition (Biodiversity 10) under the EA are required.

Further details of the proposed amendments and inclusions to biodiversity values are specified in Section 5.6 and the detailed Biodiversity Impact Assessment conducted by Attexo Consulting is provided in Appendix B.

2.3 Administrative Changes

In addition to the amendments mentioned above, Arrow Energy also proposes to amend the EA to allow for some minor administrative changes. These are described in detail in Appendix A.

3. Description of land on which the activity is located

3.1 General Location

Arrow Energy has interests in more than 65,000 km^2 of petroleum tenures, mostly within Queensland's Surat and Bowen basins.

The EA amendment is relevant to PL253 a 21,300-ha area of land approximately 1 km south of Chinchilla and 4.6 km north of Kogan (refer to **Figure 5**). The surrounding area has two primary uses and two secondary uses. These are:

- Agricultural use (primary use)
- Cattle grazing (primary use)
- Infrastructure (secondary use)
- Gas exploration and production (secondary use).

PL253 is comprised of 71 sub-blocks. The sub-blocks which are the subject of this EA amendment application and the location of new and previously unauthorised petroleum activities (the subject of this EA amendment application) are shown in **bold**.

The Hopeland EA area is solely located on PL253. This tenure is located within the Western Downs Regional Council (WDRC) Local Government Area and is located south east of the town of Chinchilla in Southern Queensland

Table 3-1 identifies the blocks and sub-blocks of PLs within the Hopeland EA which are administered under the P&G Act.

Table 3-1 Blocks and Sub-blocks of the Project Area

Petroleum Authority	Block Description	Sub-blocks
PL253	BRIS2456	a, b, c, f, g, h, j, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z
	BRIS2457	q, v, w
	BRIS2528	a, b, c, d, e, f, g, h, **j,** k, **l, m, n, o, p**, **q, r, s, t, u**, z
	BRIS2529	a, b, c, f, g, h, j, l, m, n, o, q, r, s, t, u, v, w, x, y, z
	BRIS2530	q, r, v, w

Figure 5 shows the relevant blocks and sub-blocks within PL253.

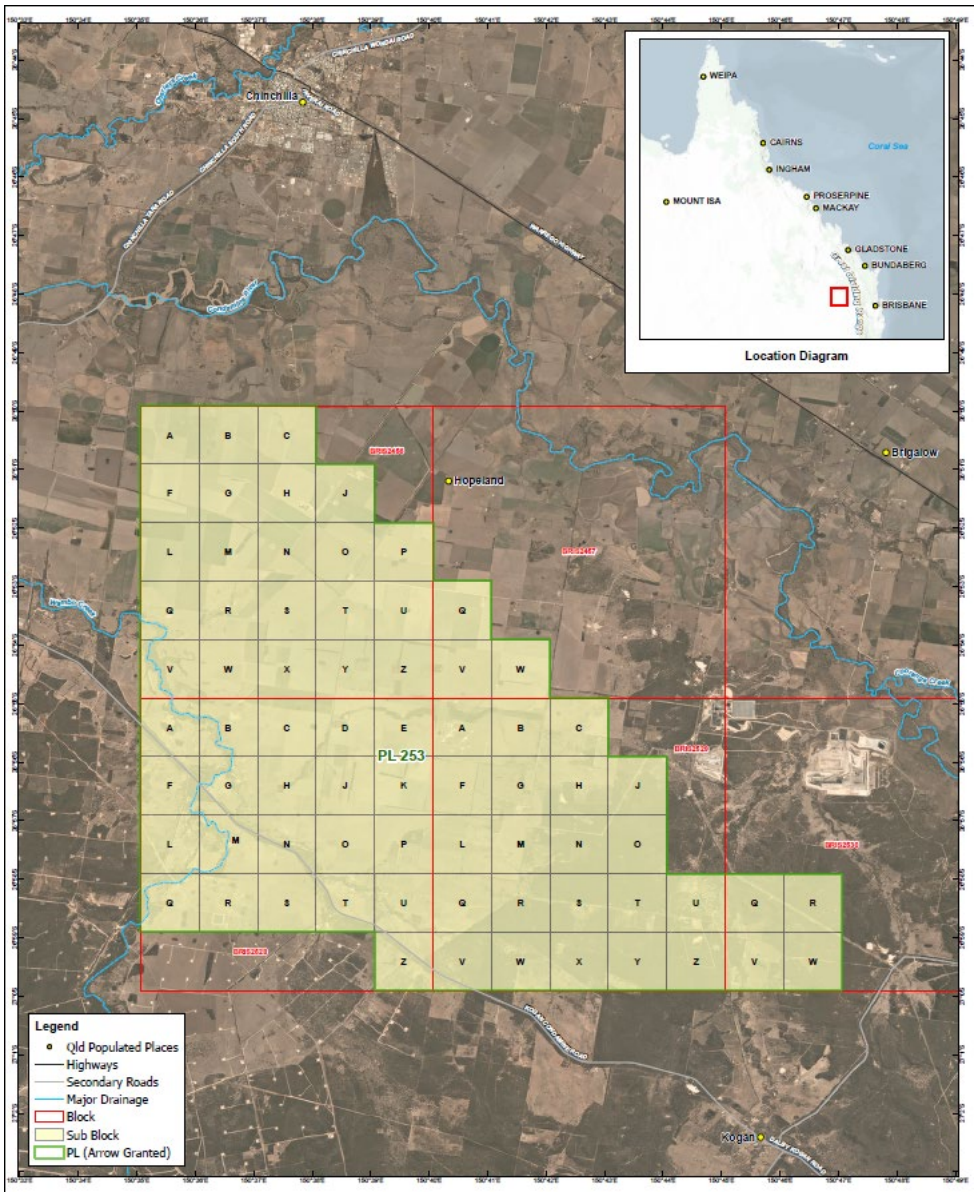


Figure 5 **Blocks and Sub-blocks granted under PL253 for the Hopeland EA**

3.2 Land Use

Land use across the Project area and the broader surrounds is predominantly characterised by cleared grazing land and bushland.

Key industries in the wider region surrounding the Project area include CSG exploration and agriculture. The Western Downs Green Power Hub is located adjacent the Project also located on land associated with PL253, however there is no overlap between Project works and the Green Power Hub.

The *Regional Planning Interest Act 2014* (Qld) identifies and protects areas of regional interest throughout Queensland, manages the impact of resource activities, supports resource activities to cohabitate with other activities, for example highly productive agricultural activities and assists in resolving land use conflicts. There are four areas of regional interest defined: priority agricultural areas (PAAs), priority living areas (PLAs), strategic environmental areas (SEAs) and strategic cropping area (SCA).

No PLAs are located on PL253 with the closest being the town of Chinchilla, north of the upper tenement boundary of PL253. No SEAs are located within the Project area.

The majority of the proposed infrastructure is located on land that is SCA and PAA covers the majority of the petroleum infrastructure that is unauthorized and proposed by this EA amendment.

Where Arrow Energy's resource activities are carried out in areas of regional interest, a Regional Interest development Approval (RIDA) will be sought where required.

3.3 Surrounding Resource Activities

The Surat Basin is a coal and coal seam gas resource area. Therefore, there are other active mining and exploration tenures in the region, however none occurring in close proximity to PL253. The Kogan Creek Coal Mine and Kogan Creek Power Station are located to the East of PL253 and will not be impacted by the proposed development.

3.4 Relationship to Overlapping Tenure

PL253 overlaps with a Mineral Development Licence (MDL335) held by Aberdare Collieries Pty Ltd in the eastern most extent of PL253 containing authorised infrastructure. No overlapping tenures impact the proposed petroleum activities subject of this EA amendment application.

3.5 Community and Stakeholders

3.5.1 Local representatives

For the purpose of this EA amendment application, stakeholders are individuals or organisations who are directly or indirectly affected by the proposed development. These include landowners of properties on which, or adjacent to where Arrow Energy proposes to undertake activities. It also includes nearby communities, Traditional Owners, contractors, local business, local, state, and national government departments, policy makers, advocacy groups and NGOs who have an interest in the development.

Public consultation on the SGP has been extensive (refer to Section 1.8). During the development of the SGP Environmental Impact Statement (EIS), Arrow Energy consulted with representatives of the following entities and/or groups:

- Government departments;
- Government-owned corporations;
- Registered property owners across the entire SGP development area;
- Leaseholders of properties across the entire SGP development area that made themselves known through participation in consultation activities;
- The communities of Dalby, Cecil Plains, Chinchilla, Miles, and Wandoan;
- Indigenous groups;
- Local industry, business associations and agricultural associations;
- Environmental groups / associations and community / interest groups; and
- Schools.

Consultation post-EIS has included:

- Government: Arrow Energy meets with the Queensland Department of Resources (DOR) on a monthly basis to provide project updates; and also engages with relevant local government authorities and elected officials.
- Indigenous stakeholders: The Indigenous group of the Hopeland area are part of the Western Downs Unclaimed Area Native Title Group, with which Arrow Energy has an existing Cultural Heritage Protocol. As per agreements, Arrow Energy meets with the Group's Committee on (at least) an annual basis and engages Western Downs' field crews to undertake cultural assessment surveys in areas of proposed disturbance.
- Community engagements: The community of particular relevance to this application is Chinchilla and its surrounding area. Arrow has undertaken considerable project engagement across the years with information sessions held both in the community and online. Arrow continues to engage with the community through its regular community newsletter, support for and attendance at community events, through engagements with local community economic development groups, local businesses and the ongoing Area Wide Planning process.

In addition, all potentially affected stakeholders have the opportunity to obtain information and consult with Arrow Energy via the following platforms:

- Arrow Energy Website for the public domain at Arrow Energy;
- The 1800 Community line or e-mail info@arrow.com.au.

3.5.2 Sensitive Places

The DETSI guideline *Streamlined Model Conditions for Petroleum Activities* (DESI, 2024) defines a sensitive places which mean:

- a dwelling (including residential allotment, mobile home or caravan park, residential marina, or other residential premises, motel, hotel, or hostel);
- a library, childcare centre, kindergarten, school, university, or other educational institution;
- a medical centre, surgery, or hospital;
- a protected area;
- a public park or garden that is open to the public (whether or not on payment of money) for use other than for sport or organised entertainment;
- a work place used as an office or for business or commercial purposes, which is not part of the petroleum activity(ies) and does not include employees accommodation or public roads; and
- for noise, a place defined as a sensitive receptor for the purposes of the Environmental Protection (Noise) Policy 2008.

The majority of sensitive places across PL253 are private residential dwellings. The final locations of infrastructure consider the proximity to these dwellings and potential impact to occupants as described in the Area Wide Planning and CCA process noted previously.

Potential impacts on other sensitive places (such as schools, churches, hospitals and libraries) has been taken into consideration when siting infrastructure. In terms

of the field development plan, the only sensitive receptors within 990 m of proposed infrastructure are residential dwellings. This separation distance is relevant to the noise generated by drill rigs (see Section 5.3 for details).

4. Description of Proposed Project Activities

The Project will involve three distinct phases covering construction, operation, and decommissioning and rehabilitation.

Project activities will include:

- Well pads, gathering lines and access roads; and
- Ancillary activities.

The anticipated activities to be undertaken at each stage of the Project are outlined in this chapter.

4.1 Construction phase

Construction activities for the Project include:

- Development of natural gas wells, including the construction of well pads and access tracks, drilling and completion of wells, installation of down-hole and surface facilities and potential flare or vent;
- Installation of gas and water gathering pipelines;
- Installation of incidental, ancillary and support infrastructure including, but not limited to, access roads, electrical and communications infrastructure, laydown areas, borrow pits, temporary and mobile camps; and
- Re-instatement and progressive rehabilitation of infrastructure not required for ongoing operations. This includes but is not limited to reinstatement and rehabilitation of wells pads and rehabilitation of gathering Right of Ways (RoW).

Final well and infrastructure locations and route selection for gathering pipelines and access tracks within the Project area will be determined in accordance with Arrow Energy's Area Wide Planning process (AWP).

The AWP process is a program that Arrow Energy has developed to incorporate landholders' knowledge and constraints into the company's wellfield development and infrastructure plans. It includes engaging with landholders to talk through any potential preferences regarding the wells development where it applies in relation to their own current infrastructure or planned infrastructure within the property. Landholders and Arrow Energy work together to identify locations for infrastructure, such as well pads, pipelines, and access tracks, across farming districts and on flood plains. Planning occurs on a 'one-on-one' basis with landholders and, where appropriate, in local area meetings. This process helps Arrow Energy to identify the best locations for gas infrastructure, potentially reduces the timeframes required to negotiate landholder agreements, and to meet Arrow Energy's commitments to coexist with agriculture. This process has commenced and will continue throughout the SGP as the project development footprint expands.

4.2 Operational phase

Operational activities for the Project include:

- Well operation and maintenance, workovers, and flaring and venting where required;

- Gathering system operation and maintenance including High Point Vents (HPVs) and Low Point Drains (LPD);
- Maintenance of ancillary infrastructure, such as access roads; and
- Undertaking all necessary and incidental activities to facilitate operation.

Natural gas and produced water (i.e., CSG water) extracted from the development will be transported to the QGC's Jammat FCS and Kenya Water Treatment Plant for further processing and distribution. These activities are already authorised under related QCLNG approvals and are not included within the scope of this EA amendment application. No new gas or water storage/processing infrastructure is required as part of this application.

4.3 Decommissioning and rehabilitation phase

4.3.1 Land disturbance strategy

Arrow Energy's strategy regarding land disturbance is to avoid and minimise overall environmental impact to vegetation, land, native flora and fauna, farmland, and infrastructure (including crops, pastures, and stock), and to facilitate that the smallest practicable area of land is cleared. Where significant disturbance cannot be avoided, land is rehabilitated, is non-polluting and can sustain the current land use with no further mitigation or management measures required once construction or operations have ceased.

In compliance with the conditions under *Rehabilitation Conditions* of the Hopeland EA, rehabilitation objectives are to facilitate the return of land to a stable, non-polluting state where either the former land use or another specified use as agreed with the State and landowner, and in accordance with the EA conditions, can be resumed.

Rehabilitation is managed under Land Management in Arrow Energy's HSE Compendium Standards for the management of Health, Safety and Environment (ORG-ARW-HSM-STA00001), and applies to stabilisation of operating areas, decommissioning, and final closure rehabilitation to stabilise the land following decommissioning of infrastructure (e.g., plugged and abandon wells), as follows:

4.3.2 Stabilisation

Where land disturbance is undertaken, Arrow Energy ensures that sites are progressively maintained in an appropriate stable condition following completion of construction activities.

Stabilisation, or progressive or interim rehabilitation of disturbed areas is undertaken as practicable as possible following land disturbance. The period of time between construction and rehabilitation of disturbed land that is not required for operations will be minimised to prevent degradation and loss of exposed soils.

Surface structures, equipment and waste materials not required for the operational phase will be removed prior to rehabilitation.

Ongoing monitoring and maintenance is undertaken to ensure the site remains in a stable condition and site records document the areas, volumes, methods, and locations.

4.3.3 Progressive rehabilitation activities

These activities typically include, but may not be limited to, the following rehabilitation measures:

- Backfilling of flowline trenches after pipe laying;
- Remediation of compacted areas by mechanical means;
- Remediation and backfill of drilling sumps;
- Regrading, stabilisation, and re-establishment of vegetation around completed wells (i.e., reducing the size of the well pad);
- Implementing erosion and sediment control measures, where required;
- Assessment and remediation of impacted soils, if applicable;
- Re-profiling significantly disturbed land to a stable landform similar to the original land contours;
- Re-establishing surface drainage lines on significantly disturbed land; and
- Re-establishing vegetation diversity and cover and appropriate fauna habitat.

4.3.4 Decommissioning

Following completion of activities, or when it is no longer required, infrastructure is decommissioned, and above ground infrastructure is removed. This is subject to alternative arrangements being made with landowners and authorised under the EA.

Subsurface infrastructure will generally remain in situ.

Any contaminated soils will be remediated or removed to a licensed and authorised disposal facility.

Site-specific decommissioning plans are developed as necessary for large infrastructure such as dams, pipelines and gathering networks.

4.3.5 Final land rehabilitation and use

Sites that are rehabilitated, including regular monitoring and timely maintenance of stabilisation and rehabilitation of sites to ensure rehabilitation integrity, are:

- non-polluting;
- provide a stable landform; and
- can sustain the current use of the land with no further mitigation or management measures required beyond the normal management of the land to achieve final rehabilitation acceptance criteria.

Final decommissioning and rehabilitation will occur at the end of individual infrastructure life, taking into consideration a variety of final land use options. The final land use will be determined by considering a number of factors, including but not limited to the following:

- Relevant legislative and regulatory requirements, including EA conditions;
- Surrounding land uses;
- Landowner requirements;
- Surrounding sensitive receptors and receiving environment; and

- The environmental, social, and cultural values of the area.

Site-specific rehabilitation plans will be developed as necessary.

4.4 Estimated Disturbance Area

The total land disturbance proposed for the Project, includes an additional disturbance of approximately 81 ha (refer to **Table 1-2**), , bringing the total authorised disturbance of approximately 256 ha across the tenure area. This area represents 1.17% of the Hopeland EA tenure (approximately 21,800 ha).

Based on the annual return report and data[5] for the period 1 January 2025 to 31 December 2025, only 18.36 ha of land has been disturbed as at the 31 December 2025, and no disturbance to MSES has been reported (refer to Section 1.4).

An assessment of impacts from the proposed disturbance has been done predominately utilising surveyed ground-truthed data over proposed infrastructure locations and indicative proposed locations based on constraints mapping (i.e. topography, environmental, landholder etc). This is then assessed where it overlays ground-truthed ecology data or mapped ecology data to predict impacts. In instances where ground-truthed data for impacts on ecology are unable to carried out due to land access and landholder constraints, predicted impacts have occurred utilising constraints mapping to locate location infrastructure to avoid and minimise impacts. The final layout and location of infrastructure will only be known subject to a signed Conduct and Compensation Agreement (CCA) with the landholder, prior to that exact final disturbance limits cannot be determined and would only be predicted. Pre-clearance surveys will be carried out in accordance with the EA before disturbance to validate and verify disturbance limits against authorisations within the EA, which will then be used to validate against PEMs impacts and offset requirements as approved in the EA.

4.5 Well pads, drilling and well development

4.5.1 Well pads

Most surface production facilities will comprise a well pad hosting the wellhead, pump drive head, gas engine generator, metering skid including pipework, valves, fittings, and instrumentation.

In general, well construction and operation activities will be undertaken in the following order:

- identification of well location;
- construction of necessary access tracks and well pads;
- construction of accommodation camps for drilling staff (if needed and agreed with the landowner);
- drill site preparation;
- drilling and well completion (setting casing in the well bore and placing a pump down hole);

[5] Refer to Annual Return for EA0001399, RET-100343170.

- installation and operation of well pad infrastructure;
- progressive rehabilitation; and
- monitoring and maintenance.

Arrow Energy's standard for the development wells use steel casing. However, in certain locations, glass-reinforced epoxy (GRE) casings may be used. Each stage of well construction is detailed in the following sections.

The majority of natural gas wells are typically drilled as a single well per well pad, with each well pad having a disturbance area of approximately 1 ha. Wells are spaced approximately 750 m to 1000 m apart with the final number, spacing and phasing depending on field development optimisation, production performance, landholder consultation and management of other surface constraints, particularly including, environmental constraints.

Arrow Energy have optimised the proposed well layout to include deviated wells and multi-well pads which would result in well spacing being approximately 1,000 m apart and reduce the overall total number of wells pads to be developed across the Project area.

After drilling of the well is completed, a portion of the well pad will be partially rehabilitated to ensure stability of the area following installation of well pad infrastructure.

4.5.2 Well site selection

Development areas are selected based on a combination of geological analysis, reservoir modelling and engineering, each of which will be determined by on-going appraisal activities.

In particular, the factors considered include:

- Landform and topography – a relatively firm and level pad is required;
- Environmental, social, cultural heritage and tenure constraints – avoiding environmentally and culturally sensitive areas, using previously disturbed areas to minimise potential environmental impacts and considering tenure in accordance with the AWP process;
- Landholder disturbance – the location of houses and existing land use will be considered to reduce impacts to landholders and ongoing land use or overlapping tenure requirements;
- Existing site access – upgrading existing landholders' tracks, locating sites close to existing tracks and adjacent to fence lines, where practicable, to minimise impacts associated with access and disturbance to primary production; and
- Constructability for gas and water gathering systems to the well location.

4.5.3 Drill site preparation

Depending upon the type of drill rig used, pre-drill work may include installation of and provision for:

- A hardstand area for the well pad of approximately 100 m x 100 m (1 ha) to facilitate drilling and maintenance activities and infrastructure placement on

site. Where wells are constructed on slopes, some cutting may be required to establish a level base which may increase the workspace required for the well pad. This is to allow the correct batters and sediment and erosion control measures to be put in place. In addition areas that are either heavily timbered may have vegetation windrowed on the edge of the lease pad for use in rehabilitation at completion and also to form habitat for species. Or pads could be located in intensely farmed land;

- A drill cutting pit (also referred to as drill sump) is required for storage of drilling cuttings and cement for drilling.
- Recirculation of water into the drilling rig mud system and collection of drill cuttings. Where possible, sump-less drilling techniques may be adopted;
- Fuel storage in accordance with Australian Standard AS1940 *Storage and Handling of Flammable and Combustible Liquids*;
- Transportable buildings for drill equipment, storage, lighting towers, site offices and amenities;
- Drill rig and sub base, generators, mud tank casing racks and pipe trailer loading bays and entry and exit points for vehicles; and
- New access tracks, where required.

When drilling is complete, semi-permanent fencing will be erected around the well site. Appropriate signage relating to restricted entry, fire hazards and protective clothing requirements will be displayed prominently to warn of hazards and required controls. A typical drill site layout during drilling is provided in **Figure 6**.

Vegetation and topsoil will be graded and stockpiled separately for use during partial hardstand rehabilitation.

Well sites will be located principally on flat ground clear of vegetation (i.e. trees and shrubs). Some vegetation may be cleared but tall trees (including hollow-bearing trees) will be avoided as far as possible.

Any clearing will be in accordance with existing relevant conditions.

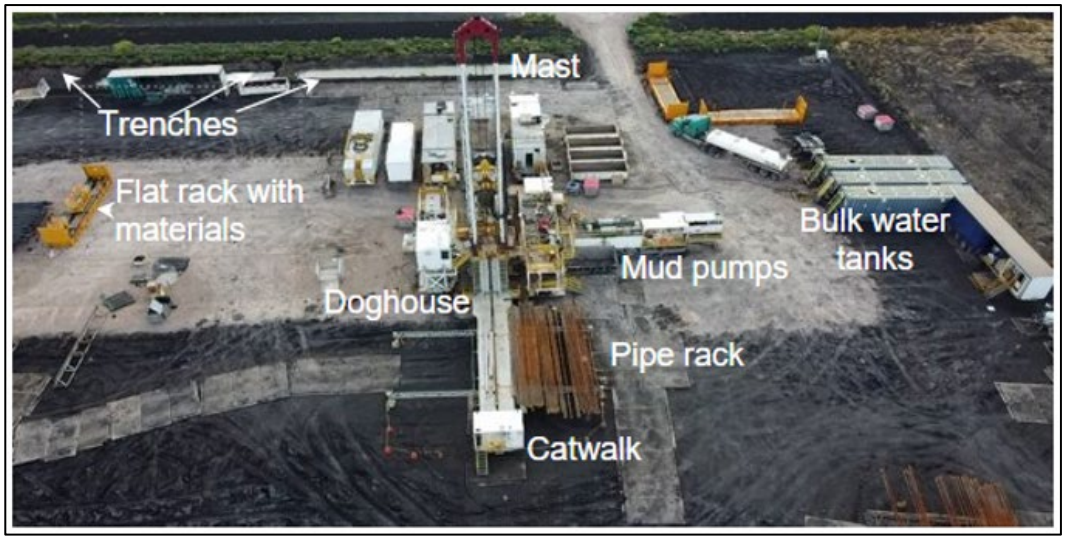


Figure 6 Typical well site layout during drilling

4.5.4 Drilling and well development

Once site preparation is complete, drilling and well completion will be undertaken. Each section of the drill hole will use progressively smaller drill bits, such that deeper sections have a smaller diameter than the section immediately above it. Refer to **Figure 7** for a photo showing a typical drilling rig. A different drilling rig may be used for each stage of the hole.

Figure 7 Typical Drilling Rig

Drilling will be carried out in stages. To construct a vertical well, a conductor pipe is typically installed to about 6 m with an auger rig. This will be followed by a smaller diameter hole to between 60 m to 500 m in depth by a drilling as shown in **Figure 7**. Steel or glass-reinforced epoxy casing will then be run into the open hole and cement pumped in to fill the gap around the casing. Well control equipment will be installed at the surface and tested to verify integrity. A blow-out preventer (BOP) will prevent gas or water leakage while drilling operations are conducted.

The final section is then drilled to the required depth to intersect the target coal seams. Drilling muds, or drilling fluids, being a suspension of solids and additives (e.g. potassium chloride (KCl) solution to aid hole condition through inhibiting the swelling of clay) in a base of water, will be used to aid drilling. Arrow Energy sometimes may use lost circulation materials to cure high fluid losses situation to prevent pipe getting stuck as part of drilling process. Arrow Energy but does not use oil-based or synthetic drilling muds.

In some instance, deviated well drilling practise is employed. The overall well process is similar to that of a vertical well with the exception of directional drilling equipment. More information can be found in the next sections.

Cuttings are removed from the drilling fluids at the rig location using shale shakers. Other dewatering technology may be implemented. The fluids are re-used in the drilling process or disposed of at an appropriately authorised facility once the fluid is beyond standard solids control equipment conditioning capability. Where appropriate, Arrow Energy will reuse drilling mud material in our site rehabilitation or construction activities in accordance with our regulatory requirements.

With regards to preservation of aquifer isolation, Arrow Energy complies with the Code of Practice for the construction and abandonment of coal seam gas wells and associated bores in Queensland. This includes measures to preserve aquifer isolation.

On completion of initial drilling, the formation will be logged with electric logging tools to determine the formation composition. Well-drilling operations are conducted 24 hours a day and generally take up to 3 to 4 days.

Each drill rig will be powered by diesel generators. Depending on the type of drill rig and engine, about 2,000 L of fuel is required per day. Approximately 25,000 L of fuel is anticipated to be stored on each site, with typical individual stored volumes ranging between 10,000 and 20,000 L. All fuel will be stored in accordance with Australian Standard AS1940 *Storage of Flammable and Combustible Liquids*.

A final casing will be installed to cover the reservoir section and to provide additional zonal isolation from aquifers. The well will then be suspended and a cap at the surface to prevent fluid leakage prior to preparation for production.

After the drilling rig leaves the location, the completion rig will arrive on location to finalise the well for production. The completion rig will clean the well and then run the pump, tubing, permanent downhole gauge, and rod string into the well.

The completion rig will finalise the wellhead installation, pressure test it to confirm integrity and then move off site to enable the production surface equipment to be installed. In some cases, the production surface equipment may be installed prior to the arrival of the completion rig.

When the well is ready to begin producing, surface equipment will be connected to the well. Gas and water pipelines will be run from the surface equipment and the separator to a flare stack and/or the Jammat FCS, and QGCs Kenya East pond. The produced water will either flow or be pumped to the surface, thereby lowering hydrostatic pressure in the coals, and allowing gas to desorb from the coal seam and flow into the well. The gas then flows to the surface.

A gas, diesel or electric powered hydraulic unit connected to the top of the wellhead will rotate the pump rods in the wellbore. When pumping is required to remove water, a dewatering pump will be set in the well bore with water transferred up an inner tubing string with gas produced through a surrounding annulus.

The proposed dewatering method will use either Progressive Cavity Pump (PCP) or Electric Submersible Pump (ESP), driven by gas or electric powered surface units. Once at the wellhead, the natural gas and produced water are piped to a separator.

Once separated from the water, the natural gas is piped to the Jammat FCS.

4.5.5 Drill water management

Water, or drilling fluids and muds (including water, solids, and additives with about 2 to 4% potassium chloride) will be used for primary well control, transportation of cuttings and conditioning of the well hole. Water sourced from untreated or treated produced water or from groundwater bores will be used for drilling purposes and will be delivered in tanker trucks or via the pipeline network. It is anticipated that the volume required will be up to 150,000 L per well.

The water is stored on site either in water trucks, tanks or in constructed drill pits or sumps. Where drill pits are used, they are constructed with upslope drainage to divert stormwater run-off around the pit. The drill cuttings are collected and stored on site in drill pits. Most often, fluid sumpless drilling techniques are used where all fluids are stored in tanks.

4.5.6 Workovers

Wells may be 'worked over' to improve production. Generally, a workover is required to clean out the well bore or to maintain or change out down-hole pumps used to provide artificial lift to remove water from the coal seams. Some pumping wells may be converted to free-flowing wells for a period of time. Free-flowing wells require workovers far less frequently.

Workovers generally require a workover rig, which are similar to, but smaller than a drilling rig, to enable well flushes, pump installation or changes and other necessary work. The procedure allows field operators to enhance well productivity or maintain downhole equipment. Once the hole is completed by a workover rig, the production wellhead will be re-installed.

A workover rig consists of a derrick, a workover platform with hydraulic powered tongs, a pump, and a BOP. In addition to the initial workover following drilling to complete the well for production, workovers are also carried out on individual wells roughly every two years and each workover takes about three days per well. The actual frequency of workovers on any well depends on well design and well performance.

4.5.7 Deviated or Multi-well pad drilling

Arrow Energy may use deviated or high angle drilling for field development of multiple wells from a single drill pad (refer to **Figure 8**). Use of a single pad for multiple wells is likely to decrease the number of well pads required for project development and increase spacing between pads. Some change in drilling pad layout would be required, but the overall project disturbance footprint would likely be reduced.

The target coal measures consist of multiple coal seams separated by non-coal intervals. To tap into all coals, a well needs to be vertical or deviated (i.e., drilled at an angle) so that they intersect multiple seams. In certain circumstances, multiple wells may be drilled from the same pad. Multi-well pad drilling requires wells to be deviated so that each well drains a separate area of the coals. However, because the target coal measures are shallow, well interception points with the top coals may be too close together for optimum drainage and too far apart in relation to the lowermost coals.

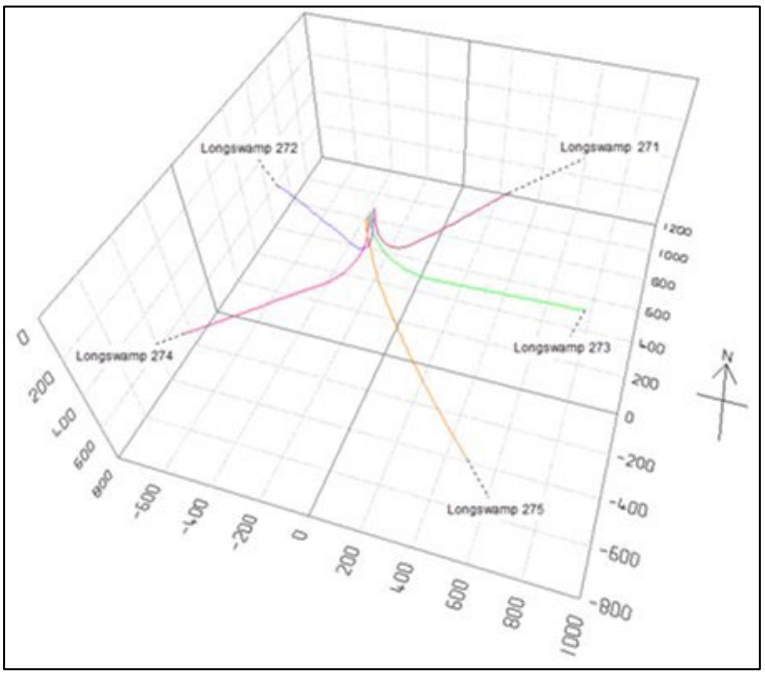


Figure 8 Deviated or MWP General Layout

4.5.8 Wellhead production infrastructure

As mentioned in Section 4.5.1, surface production facilities will typically consist of a well pad fitted out with the wellhead, gas-fired generator(s), pumps, pipe work, valves and fittings, instrumentation, and telemetry package (refer to **Figure 9**). Some wells will also require a small well-site pump to transfer water to water storage. Arrow Energy may use gas or electric drives as appropriate, depending on final design and layout.

A wellhead seals casing strings and isolates the underground fluids (gas and water) from the surface. The separator is provided with safety devices as protection against overpressure, with vessel design pressure specified to provide a safe margin for the downstream gathering network rating.

The pump is powered by a gas-fired generator to pump water from the wells. Where a diesel engine is present, approximately 2,000 L of diesel may be stored in tanks on site. One or more two-phase (i.e., water and gas) separators may be fitted to channel water and gas into separate gathering lines.

Wells are equipped with instrumentation and telemetry to transmit information including production and gas flow data to Arrow Energy's control rooms. The control rooms' primary function is to manage and balance gas production against demand, as well as provide a central point for managing and responding to field based process issues. Shutdown triggers are typically due to downstream production constraints but could also include potential well leaks or incidents.

Figure 9 Typical well configuration

4.6 Gathering Network

Gas gathering connects wells to the QGCs Jammat FCS and QGCs Kenya East pond under their relevant EAs. The connection to these facilities is via PPL2047 and EA0002166 which is already authorised.

4.6.1 Gas and water gathering lines

Typical gathering systems will utilise High-density polyethylene (HDPE) pipes as per Australian Standard AS4130 *Polyethylene Pipes for Pressure Applications and installed in accord*ance with APGA Code of Practice (CoP) for Upstream Polyethylene Gathering Networks in the Coal Seam Gas Industry.

APGA CoP will provide requirements for the safe design, construction and operation of a Gathering Network that carries CSG and water.

Low point drains (LPD) skids are installed on gas gathering lines to remove any free water condensed from the gas. High-point vents (HPV) are installed on water gathering lines to release free gas from the water. HDPE pipe sizes used by Arrow Energy range from 110 mm up to 900 mm.

4.6.2 Gathering route selection

Route selection for gas and water gathering is undertaken in consultation with affected landholders and uses previously cleared or disturbed areas where practicable. AWP and constraints mapping will inform route selection of areas of environmental, cultural, or social significance so they can be avoided where practicable. Pre-construction surveys will be undertaken to verify known constraints and provide additional information where necessary.

4.6.3 Gathering line installation

Arrow Energy's preferred method of laying gas and water gathering lines is by direct installation using standard pipeline trenching methodologies. This involves the following:

- Right of way (RoW) clearance, including vegetation clearing and topsoil stripping;
- Pipe stringing: small diameter pipe (up to 160 mm) via coils, large diameter pipe via 21 m lengths;
- Pipe welding to join supplied lengths into networks;
- Trenching, pipe lowering and trench backfilling/compaction;
- Pneumatic pressure and leak testing;
- RoW rehabilitation including top soil re-instatement;
- Regular communication with affected landholders and patrols to monitor any subsidence for repair.

Construction will be executed progressively by multiple work crews. Depth of pipe burial will comply with the requirements in the APGA Code of Practice for Upstream Polyethylene Gathering Networks – Coal Seam Gas Industry. Gas and water pipelines are collocated as much as possible.

Generally, an average typical RoW width of 22 - 30 m is required to allow vegetation clearing, mulching, and stockpiling, stockpiling of subsoils and topsoils, and safe access and movement of personnel and heavy machinery (including trenching machines) and access tracks to the wells. The RoW width is dependent upon the number of gathering lines in the RoW (trenching required), stock piling of additional vegetation clearing, permanent access tracks to wells and work space during construction and/or operational phases.

4.6.4 Gathering line maintenance

Surface structures including manifolds, low point drains, high point vents, end-of-line risers and isolation valves will be inspected as per Arrow Energy's Network Integrity Management Plan Surat Basin (S00-ARW-PPL-PLA-0003).

4.7 Water Handling

4.7.1 Water Supply and Management

Water supply and volumes required

Water will be required for short term construction activities and ongoing use for drilling, minor use for dust suppression (minor), for hydrostatic testing of pipelines, and for human consumption.

Potable water will be required for camps during construction, which will be sourced and trucked from existing town water supplies, or treated from groundwater from bores.

Water for construction and dust suppression for the proposed activities may come from a number of potential water sources. These water sources may be from:

- Off-site commercial suppliers (i.e., water service providers) and trucked from Chinchilla, or other nearby locations;
- Reused treated effluent;
- Produced water, or CSG water, from production wells and installed water gathering lines; or
- Existing Arrow Energy owned water dams.

The use of CSG water will be compliant with the relevant conditions under the Hopeland EA or the End of Waste Codes. Water sourced from dams or groundwater wells will be authorised for water supply, i.e., from service providers with the relevant water licences where applicable.

The expected volume of water consumed during construction and operations will be approximately 7 ML per annum and 18 ML per annum, respectively.

Approximate volumes of water required for construction activities are detailed below **Table 4-1**.

Table 4-1 Indicative construction water requirements

Water Requirement	Water Quantity Requirement	Water Source (s)
Wells	1,000 kL per well	Treated water / untreated CSG water of appropriate quality / groundwater / overland flow water
Gathering	1,000 kL/km	Treated water / untreated CSG water of appropriate quality / groundwater / overland flow water
Access tracks	50 kL/km	Treated water / untreated CSG water of appropriate quality / groundwater / overland flow water
Dust suppression	As required to meet environment obligations	Treated water / untreated CSG water of appropriate quality / groundwater / overland flow water

Operational activities will require about 1 ML of water per day over the operational life of the development for the following facilities:

- Potable water supplies at camps for workovers;
- Dust suppression;
- Washdown facilities; and
- Emergency services.

It is generally expected that operational water requirements will be met through the use of treated and untreated produced water. However, should produced water be unavailable due to geographical or timing issues, alternative sources such as groundwater and overland flow/runoff may be sourced for operational requirements.

Water gathering system

The water gathering system will convey water from the wells to a centralised facility (i.e, the QGC Kenya East Pond), and will follow the path of the gas gathering system.

HDPE water gathering lines will be installed, ranging from 110 mm to 1000 mm nominal diameter and will include Low Point Drains (LPD) and High Point Vents (HPV).

Where practicable, water lines, gas lines, fibre optic cables and power cables will be installed in a common Right of Way (RoW). The RoW width for the co-located facilities will be up to 40 m.

Generally, the gathering network will be installed by conventional trenching with a trenching machine. Where the gathering network is required to be installed below existing roads or infrastructure, other trenchless technologies such as horizontal directional drilling (HDD) , thrust boring or micro tunnelling may be used.

Conventional trenching involves an open trench as deep and as long as needed to install, inspect, or maintain piping, conduits, or cables. After the pipeline installation is completed, the trench is backfilled with soil, compacted equivalent to surrounding soils, reinstated in the same order it was removed and the topsoil spread across the surface.

High point vents

High Point Vents (HPVs) will be constructed along the water gathering network to catch and remove gas accumulating in the gathering system and to maintain the hydraulic performance of the lines as shown in **Figure 10**.

Figure 10 High point vent (HPV)

HPVs are typically vented to the atmosphere however some areas may have sufficient waterline pressure to be able to inject the gas to the gas gathering system. The required location of HPVs is dependent on the topography of each trunkline and will be determined as the gathering network is refined. The number of HPVs is subject to preliminary studies and optimally most of the accumulated gas will be released in the first one or two HPVs from each well site.

The design criterion for HPVs are:

- Minimise physical footprints aboveground;
- Atmospheric vents on water lines are to be used in rural locations only, preferably away from landholder properties;
- Not Normally Manned; and
- Automated operation.

Low point drains

Low Point Drains (LPDs) will be constructed to manage liquid accumulation in the gas gathering system. A LPD consists of an oversized tee piece on the pipeline to catch liquid and transfer it to the water line. There is also a surface pump for injection of the removed water into the adjacent water pipeline or an above ground tank that will be emptied periodically back into produce water storages.

The design criteria for LPDs are:

- Environmental – eliminate discharge of CSG water to grade;
- Health, Safety, Regulatory Compliance;
- Stakeholder and land access – minimising surface impacts and footprints;
- The location of LPD pad and associated infrastructure will be carefully selected with consideration to factors such as terrain slope, ground disturbance, proximity to water courses, flood levels during wet seasons, and the presence of rock;
- Not Normally Manned; and
- Automated operation.

4.7.2 Temporary Mobile Drilling Camps

Mobile drilling camps will be required within the Project area, which will be located in close proximity to the wells and in existing disturbed areas where possible, or on the well pads.

The temporary drilling camps consist of demountable buildings which are packed up and moved to the next site to support the drilling campaign but also to support well work overs and ultimately plug and abandonment and decommissioning. These self-contained camps will be sized appropriately for the workforce and will generally provide accommodation, kitchen facilities, communications, mobile sewage treatment facilities, bunded fuel storage areas, and waste collection and segregation facilities.

Power supply to the mobile drilling camps will be provided via diesel generators and potable water will be supplied by tankers.

Sewage from these temporary drilling camps will be managed in accordance with the EA conditions.

The additional area required for the temporary camps would only be in place for a short duration during the construction of the wells. These mobile drilling camps would then move to the next area to service the next lot of well construction.

4.8 Communications

Telecommunications for the development will include the following systems:

- Well site telemetry systems;
- Telecommunications towers and connections via a combination of Microwave and fibre optic cables (FOC);
- Mobile (wireless) communication (e.g., mobile phones and two-way voice communications such as hand-held radios and vehicle mounted radios);
- Vehicle tracking systems (e.g., vehicle location, speed, braking force, etc.);
- CCTV for security and site monitoring (e.g., dam water levels); and
- Access to Arrow Energy's corporate voice and data network from manned locations and remote offices.

These systems will be supported by a combination of a high-speed networks and secure wireless solutions. The high-speed network would interconnect the production wells and production facilities.

A fibre optic system backbone will be installed to transmit data for monitoring and remotely controlling all wellheads and CSG facilities (e.g., a Supervisory Control And Data Acquisition (SCADA) system)). It is planned this will be installed at the same time as the gathering lines and in the same right of way (RoW).

The secure wireless system will provide coverage across the gas field and provide telecommunications to the wells for telemetry and CCTV.

4.9 Ancillary Activities

4.9.1 Environmentally Relevant Activities

The amendment to the Hopeland EA considers the inclusion of new ERAs under the EP Act 1994 and the EP Regulation 2019, to support the treated STP effluent release to land that is already authorised via the Waste 11 – Waste 14 conditions of the existing EA. These changes are considered administrative in nature due to the activity already being authorised, with the changes only proposed to ensure that the ERA is authorised in the ERA table as indicated in **Table 4-2**.

Table 4-2 Additional ERAs to be included in the Hopeland EA(EA0001401)

Ancillary ERA[6]	Threshold	Facility (ies)
Schedule 2 Part 13 Water treatment services – **63 Sewage treatment 1, (a-i)**	Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of 21 to 100EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	Temporary Mobile Drilling Camps (MDCs)

[6] Environmentally Relevant Activities as per Schedule 2, *Environmental Protection Regulation 2019* (Qld).

4.9.2 Notifiable activities

The EP Act enables listing of land on the environmental management register (EMR) if either a notifiable activity has been or is being conducted, or the land is contaminated land. The DETSI will consider the need to list land on the EMR where a notifiable activity is being carried out on the land.

Currently there have been no notifiable activities undertaken by Arrow which require notification pursuant to the EP Act. Arrow will continue to review whether there are properties on the EMR/CLR within the Hopeland EA area which may be required to be notified and included on the environmental management register (EMR).

4.9.3 Roads and access tracks

Roads

Minor upgrades to unsealed roads and intersections will be conducted within the Project area. The standard for roads will follow the 'typical road' design as per the WDRC standard for rural access roads[7] where applicable. There will be some widening of existing roads to support the facilities and well delivery access which will be determined during the design phase.

Wells and gathering access tracks

Access tracks will be required for all proposed activities, including well sites, and gathering line ROWs. Wherever possible, existing (gazetted) roads and tracks (farm and landholder tracks) will be used. Actual access routes will not be determined until the final well sites and pipeline routes have been chosen. The location of access tracks and upgrading of existing tracks will be completed in consultation with the relevant landholders with a view to minimising environmental impacts. As a result, access tracks may potentially provide a beneficial use for the landholder by allowing additional access to and on the property or providing an upgraded all weather access track.

Additional working space may also be required to facilitate creek crossings and safe vehicle movement (e.g. for additional sediment and erosion control at creeks and for turning and passing bays for vehicles).

In some locations, all weather access tracks will be constructed, or existing roads upgraded to ensure access to facilities are accessible during wet weather conditions. In these instances, this may be in the form of sealed dual carriageway roads.

Additional working space may also be required within ESAs or their associated protection zones to facilitate creek crossings and safe vehicle movement (e.g. for additional sediment and erosion control at creeks, vegetation, and soil stockpiles and for turning and passing bays for heavy vehicles).

4.9.4 Laydown areas and workspaces

Additional laydowns are required to support construction and operational activities proposed. Should temporary project office structures be required, these will be collocated within associated development footprints, such as laydown areas.

[7] Typical road design is 7 m formation with 5 m gravel traffic width, and 1 m shoulders either side of the formation

Laydowns will be required to the temporary storage of equipment such as piping, building materials as well as for machinery. Additional workspaces may be required for the temporary stockpiling of vegetation, topsoil and subsoil.

4.9.5 Gravel pit

Quarry materials are required throughout the life of the Project, with its initial use being for short term construction of roadworks, hardstands and concrete works during the construction and commissioning phase.

Quarries and/or gravel pits are also the source of material such as foundation aggregate for the construction of well pads and access tracks as is reasonably required.

For the purposes of this EA amendment, the material will be sourced from either authorised quarries or an on-site gravel pit.

The location of gravel pits depends on a variety of factors including:

- Whether a source of suitable quarry material can be identified from within Arrow Energy's tenements, or failing this, within the local area or region;
- The significance of impacts to the local environment; and
- The significance of impacts on roads and traffic from transporting quarry material if this is to be sourced from local or regional sources.

When determining the location of gravel pits, potential sites will be assessed on a case by case basis using Arrow Energy's AWP process and utilising the findings of the geotechnical investigation, to determine the appropriate size and depth of the gravel pit. The aim of this undertaking is to minimise the environmental disturbance and impacts resulting from gravel pit development by identifying the maximum amount of available material at that location.

No changes to the existing authorisation for gravel pits is proposed as a result of this amendment application.

4.9.6 Waste generation and management

Waste generation

The construction, operation, and decommissioning and rehabilitation of the Project is expected to produce solid, liquid, and gaseous waste streams. Depending on the waste characteristics, these can be classified as general waste, inert or organic waste, recyclable waste, or regulated waste.

The anticipated typical wastes expected to be generated from the Project during construction, operation, and decommissioning and rehabilitation are presented in **Table 4-3**.

Table 4-3 Expected Waste streams and examples of waste types from the Project during construction, operation, and decommissioning and rehabilitation

Project Activity	Waste Stream / Characteristic	Examples of waste Type (s)
Construction of wells, gathering systems, and facilities	Solid / Regulated	• Contaminated soils • Drill cuttings and residual muds • Used lubricating oil and filters

Project Activity	Waste Stream / Characteristic	Examples of waste Type (s)
		• Debris from pipe blow-outs (i.e., cleaning)
	Liquid / Regulated	• Chemicals (spent/unused solvents, paints, oils, etc.) • Drilling fluids • Wastewater (greywater and sewage) • Contaminated hydrostatic test water
	Solid / Organic	• Cleared vegetation
	Solid / Inert	• Soil
	Solid / Recyclable	• Empty drums and containers • Wood pallets • Scrap metal • Paper and cardboard • Scrap swarf (high definition PE fillings) • Unused composite pipe
	Gaseous / Air contaminants	• Nitrogen oxide • Sulfur dioxide • Carbon monoxide • Particulate matter
Operation of pipelines and facilities	Solid / Regulated	• Crystalised salt / brine • Activated carbon filters • Filter cartridges • Batteries • Oily rags and sorbents • Contaminates empty drums and containers • Grease • Sewage sludge
	Solid / Inert	• Concrete • Cut and fill materials
	Solid / General waste	• Office consumables • Kitchen refuse
	Solid / Recyclable	• Paper, plastics, glass • Packaging materials • Non-contaminated empty containers • Plastic pipe cutoffs/scrap • Electric cable waste • Steel cutoffs and scrap metal • Rubber and tyres
	Solid / Organic	• Wooden pallets and timber
	Liquid / Regulated	• Produced water (or CSG water) • Wastewater (greywater and sewage) • Domestic cleaners • Fuels • Oils • Chemicals, paints, and cleaning acids • Contaminated stormwater runoff • Pigging waste (water and sludge) • Pesticides and herbicides • Wash out liquids
Decommissioning and rehabilitation	Solid / Regulated	• Debris • Chemical or oil contaminated soil • Sludge

Project Activity	Waste Stream / Characteristic	Examples of waste Type (s)
	Solid / Inert	• Concrete
	Solid / Recyclable	• Electrical cables • Fencing • Gas compressors • Gas pipelines • Production wellheads • Power generators • Pumps • Sewage treatment plants and tanks • Storage tanks

Details for the proposed management practices for the waste streams as per **Table 4-3** are described in Section 5.12.

Regulated waste management

The storage of produced water (or CSG water) as regulated waste is currently authorised under the Hopeland EA. This includes CSG water stored in dams authorised under the Hopelands EA (refer to **Table 1-1**).

CSG water is gathered via a network of buried HDPE low pressure pipelines to a series of aggregation dams (refer to **Figure 11**). Arrow Energy defines its dams as follows:

Aggregation Dams

These dams are used to contain CSG water from the gathering network and provide a buffer to address variations in CSG water production and water treatment capacity. The Hopeland Water Dam is the only authorised and existing Dam under the Hopeland EA. No new dams to store CSG water are planned as part of the Project.

Treated Water Dams

These dams contain treated CSG water. Treated water dams provide a buffer between treatment plant output and beneficial use demand. There will be no treated CSG water dams located within the Project area.

Brine Dams

These dams contain brine produced from the reverse osmosis water treatment process. There will be no brine dams located within the Project area.

As there will not be a gas processing facility within the Project area under this amendment, there will be no dams to contain waste lubricants and chemicals used in treatment and compression systems.

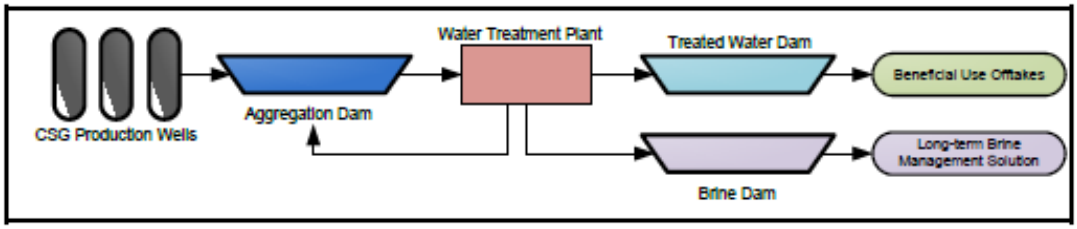


Figure 11 Conceptual diagram of CSG water management

CSG water produced from the CSG production wells and associated water gathering system from the Project will be transported through the water gathering pipeline to QGC's Kenya East Pond and then to QGC's water treatment facilities. These facilities are located outside the Project area.

Further details regarding the management of CSG water is described in Section 5.12.5 and in Coal Seam Gas Water Management Plan (refer to Appendix G).

Other regulated waste are potentially anticipated to be produced, which includes spent hydrotest water, used batteries, waste water from vehicle wash downs, plant and equipment oils, and lubricants aggregated in Intermediate Bulk Containers (IBCs) with bunding. These wastes will be collected and transferred offsite via an authorised regulated waste contractor.

Temporary storage of other regulated waste may be required to be undertaken as an incidental activity for this development, should regulated waste be produced.

Sewage from temporary drilling camps will be treated through Sewage Treatment Plants (STPs), and the treated sewage effluent will be managed in accordance with proposed Hopeland EA conditions.

Other waste management

Waste is managed by Arrow Energy in accordance with the requirements of the *Environmental Protection (Waste Management) Regulation 2000* (Qld) and the *Waste Reduction and Recycling Act 2011* (Qld) and waste management measures detailed in Section 5.12.5, which applies to both construction and operational activities.

Waste management practice throughout Arrow Energy's operations is routine collection of solid waste, solid recyclables, and liquid waste, contracted to established mainstream waste management contractors. Post collection, the waste contractors manage each material via their procedures.

5. Assessment of Environmental Impacts

5.1 Air Quality

5.1.1 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)): 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).

5.1.2 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.

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 (refer to Section 3.5.2).

Regulatory air quality parameters, objectives, and environmental values relevant to the project are provided in Section 5.1.4.

5.1.3 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 3.6°C in winter (June to August) to 21°C in summer (December to February)
- Mean monthly maximum temperatures range from 17°C in winter to 35°C in summer
- Rainfall displays a consistent pattern and ranges from an average of 20 to 40 mm in winter to 70 to 100 mm summer
- Evaporation rates are up to approximately five times higher in summer months than in winter months
- Wind patterns across the area are characterised by easterly/westerly flow in the afternoons. There is a high frequency of calm (less than 0.5 m/s) and very light winds across the region. Calm winds form 19% of morning winds (at 9:00 am) and 9% of afternoon winds (at 3:00 pm)
- Mean daily solar exposure changes throughout the year in line with the seasons, with values ranging from 12.1 MJ/m² in winter (June) to 25.3 MJ/m² in summer (January). Evaporation rates are highest during the summer months because of higher temperatures and solar radiation. Daily evaporation rates range from 3.2 mm in winter to 7.8 mm in summer
- Relative humidity varies with season, increasing through summer and autumn before reaching a maximum in winter (June) and falling in spring. The lowest relative humidity occurs in September and October (spring). Relative humidity is generally higher at 9 am (56 % to 74 %) and lower at 3 pm (38 % to 49 %)
- Around 20 thunderstorm days per year occur within the study area, often involving strong winds, heavy rainfall and flooding.

Existing Air Quality

Table 5-1 provides the existing maximum ground level concentrations of pollutants modelled within the study area (as per the SGP EIS; Arrow Energy 2013 and updated air quality assessment completed by SLR Consulting Australia Pty Ltd in 2018). Health-based EPP (Air) objectives are provided for reference and indicate that existing ground level concentrations of all key pollutants within the study area would be below the objectives.

Table 5-1 Background Levels of Key Air Pollutants

Pollutant	EPP (Air) Objective ($\mu g/m^3$)	Averaging Period	Existing Concentration ($\mu g/m^3$)
Nitrogen dioxide (NO_2)	164	1 hr	85
	31	Annual	10
Ground level ozone (O_3)	210	1 hr	136
	171	4 hr	123
Sulfur dioxide (SO_2)	286	1 hr	40.0
	57	24 hr	5.7
	21	Annual	2.9
Carbon monoxide (CO)	11,000	8 hr	2,840
Particulate matter (PM_{10})	50	24 hr	25.7
Particulate matter ($PM_{2.5}$)	25	24 hr	6.8
	8	Annual	3.6

Relevant Air Pollutants

The main air pollutant sources will be combustion emissions from wellhead gas-driven gensets, power generation for diesel-driven drill rigs and construction activities. Air pollutants released from these sources are:

- oxides of nitrogen (NOx);
- carbon monoxide (CO); and
- particulate matter (PM).

Emissions of sulfur dioxide and volatile organic compounds from these sources are negligible.

Ozone is a regional air pollutant that is formed from photochemical reactions between NOx 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 (SGP EIS 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, nuisance impacts from odour at the production testing wells are not expected from the project emissions.

The main air pollutant of concern from combustion (flaring and drill rigs) is nitrogen dioxide (NO_2). Nitrogen dioxide is formed in gas engines through 'thermal NO_x'. Thermal NOx is the process of thermal dissociation and subsequent reaction of nitrogen (N_2) and oxygen (O_2) 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 diesel and gas engines is so high, and background levels of CO are so low, potential impacts from CO emissions are negligible.

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).

The key pollutants identified under applicable legislation that are relevant to CSG activities are described in Table 5-2.

Table 5-2 Overview of assessment approaches for each Activity/Source

Emission Source	Relevant Air Pollutants	Air Impact Assessment Approach
Construction		
Construction of new wells through drilling and completion rigs	Combustion products, mainly NOx and CO	Generic assessment of rig emissions (NO_2 and CO) to identify off-set distances based on rig emission rates
Construction of access tracks and gathering lines	Construction dust (TSP (total suspended particles), PM_{10} and $PM_{2.5}$)	Site specific qualitative construction dust assessment
Operation of small diesel generators (camp power, pumps stations)	Combustion products, mainly NOx and CO	Screened as negligible based on larger rig diesel combustion assessment
Operation		
Operation of new wells	Combustion products, mainly NOx and CO	Generic modelling assessments of NOx and CO of emissions from CSG fired gensets located on well pads

5.1.4 Air quality objectives and indicators

Regulatory air quality parameters, objectives, and environmental values relevant to the Project area are provided in **Table 5-3**.

Table 5-3 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 hour

Substance		Queensland Objective	Air NEPM Objective	Environmental Value	Time Period
		(µg/m³)			
		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 DESI, have adopted them as air quality impact assessment criteria for use in AQIAs.

5.1.5 Assessment of environmental impacts

The key emission sources for the activities addressed in this amendment application are:

- CSG combustion emissions from well head gensets

- Drill rig diesel combustion emissions
- construction activities (e.g. clearing, grading, excavation, vehicles travelling on unpaved roads).

Operational impacts

Emissions from larger diesel rig engines have negligible impact of air quality values. Likewise, emissions from small diesel generators, used for camps and pump stations, which are much lower than rig engines, will also have negligible impact on air quality values.

The main source of air pollutant emissions from drilling activities is from diesel power generation for drilling operations. NOx emissions from diesel combustion are of most relevance to air quality impacts.

Updated air quality modelling and assessment for the Surat Gas Project by SLR Consulting Pty Ltd in 2018 shows that the maximum predicted incremental NO2 concentrations are below the 1-hour average ground level NO2 concentration of 250 µg/m³ within approximately 200 metres of the rig. These predictions do not include background NO2 levels, which have been conservatively estimated at 85 µg/m3. However, the rigs only operate for limited time periods at each well location (approximately 3 - 5 days). The potential for adverse air quality impacts is therefore not considered a significant risk.

The large majority of wells are located much greater than 200 m from a sensitive receptor, with almost all located greater than 400 m from a sensitive receptor. In addition, noise impacts from drilling activities constrains how close drill rigs can operate to sensitive receptors, with unacceptable operational noise impacts predicted for sensitive receptors located less than 400 metres from a well site. Given this, drill rig air assessment results for NO2 do not indicate a significant risk for adverse air quality impacts.

Given that the CO emissions from the drill rigs are less than 20% of the NO_X emissions and the CO guideline is much higher than those for NO_2, the assessment indicates there is no significant risk associated with CO emissions from the drill rig.

Construction impacts

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 heath and nuisance impacts from fugitive dust emissions associated with construction of the major infrastructure sites proposed as part of the SGP, concluded that there is a negligible risk of any adverse impacts due to the large separation distances between these sites and nearby sensitive receptors. The fugitive dust risk assessment also concluded that there is a negligible risk of

adverse air quality impacts associated with the construction of well pads, gathering pipeline and access roads associated with the SGP. Nonetheless, Arrow implements a range of dust mitigation measures to ensure that adverse air quality impacts do not occur during construction activities, including the use of water carts and minimising the extent of disturbed areas.

To improve Arrow's dust management practices, SLR Consulting Pty Ltd were also commissioned to conduct air quality modelling and assessment of wheel generated dust due to unpaved road travel associated with a typical rig movement (~ 40 trucks per day and 10 light vehicles per day travelling on an unpaved road). The air quality assessment shows that short term air quality goals for PM_{10}, $PM_{2.5}$ and dust deposition are achieved within 50 metres offset distance from the unpaved road.

Similar to the management of infrastructure construction dust emissions, Arrow implements a range of dust mitigation measures to further ensure that adverse air quality impacts do not occur during rig movements, including use of water carts, limiting speed near identified sensitive areas and route optimisation to avoid nearest sensitive receptors.

5.1.6 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;
- 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 5-4** 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.

Modelling of emissions from CSG-fired generators that would be installed at well pads as part of the SGP, as presented in this report, indicates that to ensure that ground-level NO_2 concentrations meet guideline criteria, well pads should be located no closer than 200 m from sensitive receptors.

Table 5-4 Air Quality Impact Mitigation measures

Project Phase	Mitigation Measures
Operational Phase	• 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 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.

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 to suppress dust emissions, and minimising the extent of disturbed areas to minimise wind erosion. A mulcher/shredder may also be required to process any cleared vegetation.

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.

5.2 Greenhouse Gas Emissions Assessment

The National environmental objective for greenhouse gas (GHG) emissions is to mitigate emissions by achieving net zero GHG emissions by 2050, consistent with efforts to limit global temperature increase.

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

- A 43% reduction below 2005 levels by 2030;
- 62 - 70% reduction below 2005 levels by 2035; and
- net-zero emissions by 2050.

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

In accordance with Section 3.1 of the *Greenhouse Gas Emissions Guideline* published by DETSI in January 2026 [8], applications for activities with expected GHG emissions must include details of GHG emissions likely to be generated by each relevant activity.

Section 3.2 of the Guideline defines GHG emission categories as follows:

- applications with expected GHG emissions (Scope 1 and Scope 2) of 25,000 tonnes CO_2-e or more per year (at any time during the life of the project) are considered medium to high emitters; and
- applications with expected GHG emissions (Scope 1 and Scope 2) of less than 25,000 tonnes CO_2-e per year are considered low emitters.

5.3 Assessment of Potential Environmental Impacts

5.3.1 GHG Emission Sources

GHG emissions associated with the construction and commissioning of the proposed 55 wells as part of Jammat Phase 1 are expected to result from:

- diesel consumption in:
  - construction plant, drilling rigs and light utility vehicles during construction
  - completion rigs during commissioning.
- mud (drilling fluid) degassing during drilling activities
- venting during well completions.

GHG emissions associated with the operation of the proposed 55 wells are expected to result from:

[8] Greenhouse gas emissions

- fuel gas combustion in wellhead engines used to power the water pumps for coal seam dewatering (representing the majority of operational emissions), noting that wellpads will not be connected to the electricity grid
- produced water
- well workover venting
- wellhead leaks
- gas gathering pipeline leaks.

The relevant GHGs that will be emitted are methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O).

5.3.2 Scope 1 Operational Emissions

Forecast GHG emissions (i.e. 2027 to 2047) were estimated using the estimation techniques from the following documents:

- National Greenhouse and Energy Reporting (NGER) Measurement Determination published in July 2025
- NGER Regulations published in July 2025
- American Petroleum Institute (API) Compendium 2009.

Peak Scope 1 operational emissions are estimated to reach approximately 11,000 t CO_2-e per annum in 2031. Accordingly, the amendment is categorised as a low emitter in line with Section 3.2 of the DETSI *GHG Guideline*.

Based on operations from 2027 until 2047, total Scope 1 emissions over the life are forecast to be approximately 75,000 t CO_2-e.

5.3.3 Scope 3 Emissions

Construction activities will be undertaken by a third-party Contractor and will not be under Arrow Energy's operational control. Construction emissions are therefore considered Scope 3 emissions.

As per Section 3.1.1 of the *GHG Emissions Guideline*, 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 CO_2-e per annum.

5.3.4 Emissions Materiality and Exclusions

Emissions due to land use change are not included in this assessment on the basis that:

- The EA includes a commitment/ requirement to minimise land disturbance and clearing, and a commitment to rehabilitate land to its original condition. As such, over the life of the activity, GHG emissions due to land use change are forecast to be net zero.

- These GHG emissions are not required to be reported under the NGER scheme.

Emissions from commissioning activities are expected to be insignificant relative to operational emissions.

Average annual operational emissions from the Project are estimated to be approximately 3,600 t CO_2-e per annum, which is equivalent to 14% of the 25,000 t CO_2-e per annum threshold for medium-to-high emitters.

Given the relative scale of the amendments estimated direct GHG emissions, the likely impact on Queensland's environmental values is not anticipated to be material.

5.3.5 Coverage under the Safeguard Mechanism

The proposed wells will be connected to Arrow Energy's existing Arrow Surat Operations Safeguard facility. Accordingly, associated Scope 1 emissions will be subject to a Safeguard Mechanism baseline, with declining baselines applying in line with Australian Government emissions reduction targets.

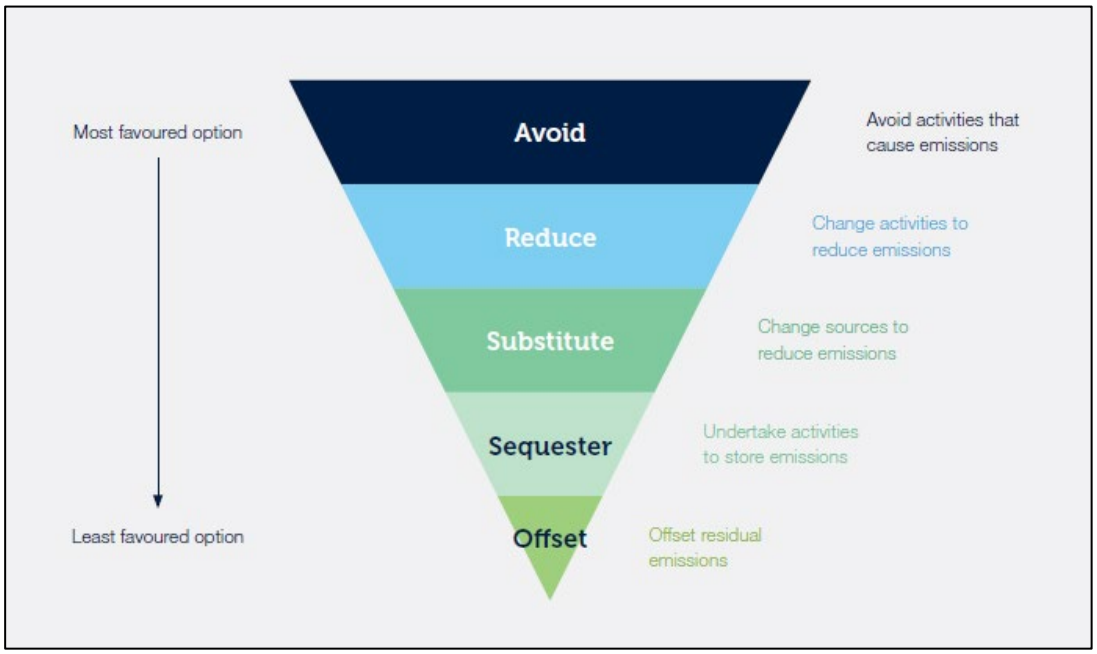
Where direct emissions reductions are not technically feasible, compliance with the Safeguard Mechanism will be achieved through the purchase and surrender of eligible carbon credit units.

5.4 Proposed management practices and continual improvement

Arrow Energy's carbon management approach is underpinned by a well-established hierarchy of GHG emissions controls, which prioritises avoidance, reduction, substitution and offsetting. Carbon reduction opportunities are systematically evaluated in accordance with this hierarchy, as illustrated in Figure 12.

This approach is currently applied, and will continue to be applied, across Arrow Energy's operational portfolio to manage and progressively reduce GHG emissions, where feasible.

Consistent with Section 3.2 of the DETSI *GHG Emissions Guideline*, the Project is classified as a low emitter. As such, a formal GHG abatement plan is not required to be submitted as part of this application.



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

Figure 12 Hierarchy of Carbon Management

5.5 Noise

5.5.1 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.

5.5.2 Description of environmental values

The development area is situated primarily in a rural area which, in general, has low background noise levels that follow a typical diurnal pattern. That is, the noise levels generally reduce during the evening and night-time when rural farming activities, bird and insect calls, and road traffic activity is reduced.

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.

5.5.3 Sensitive Receptors

As described in section 3.5.2, the DETSI guideline *Streamlined model conditions for petroleum activities* (DESI 2024) defines sensitive receptors as per Schedule 2 of the of the *Environmental Protection (Noise) Policy 2008*, and means and area or place where noise is measured.

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).

All identified noise sensitive receptors surrounding the proposed works associated with this amendment application are dwellings/residential premises.

5.5.4 Existing noise environment

The Project area is situated primarily in a rural area which, in general, has low background noise levels that follow a typical diurnal pattern. That is, the noise levels generally reduce during the evening and night-time when rural farming activities, bird and insect calls, and road traffic activity is reduced.

The deemed minimum background noise levels as stated in the DETSI Guideline *Streamlined Model Conditions for petroleum activities* have been applied for the basis of this assessment (refer to **Table 5-5**). The deemed minimum background noise levels are considered applicable given the rural nature that the Project area is located within and the expected low background noise levels within this area.

Table 5-5 Deemed background noise levels as per Streamlined Model Condition (DESI, 2024)

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 the Project area, including sources relevant for this amendment are summarised in **Table 5-6**.

Table 5-6 Overview of Noise Sources and Assessment Approaches

Noise Source	Description of noise source	Noise Impact Assessment Approach
Construction		
Construction of new wells through drilling and completion rigs	Drilling and other rig activities, which typically involves drilling, workovers, completions, and flaring activities. Rig activities can operate on a 24 hour basis and can last from anywhere between two days up to a month depending on the depth of the well, type of well and the geology of the area. Rig activities can produce impulsive noise (e.g., impacts of drill tools) as well as constant noise. Noise from diesel engines vary according to load and speed, but the main component of the sound is the fundamental rotation speed. Flaring or venting can occur during rig activities to dispose of gas that cannot be processed in a safe manner. Typically, flaring or venting is a minor source of noise relative to the total noise of drilling activities and is only discernible in the context of other well pad construction noise within relatively short distances from the flare.	Noise assessments are conducted on each rig contractor, and these are used to determine required separation distances to achieve Arrow Energy's noise limits. Each well and rig activity is assessed to determine whether activity restrictions are required (e.g., noisy rig activities restricted to daytime only)
Construction of access tracks and gathering lines	General construction activities undertaken on Arrow Energy tenure 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.	Noise assessments have been conducted using conservative operating assumptions to derive a 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 (e.g., reduced equipment operating at a time, site specific assessment and monitoring).
Operation		
Operation of wells/well pad noise	The operation of wells is a long term noise event that occurs on a 24-hour	Arrow Energy has conducted detailed noise assessments of well pad noise levels and

Noise Source	Description of noise source	Noise Impact Assessment Approach
	basis. The main noise impacts from the operation of wells relate to: • Gas fired generators – contained within an enclosure on the well pad • Well drive heads • Well head motors • Gas flows especially through pressure control valves (PCV) and across orifice plates where there is significant differential pressure and turbulent flow Noise levels generated by operating well pads are dependent on a number of factors including: • number of generators, • generator loads, • well pump type, • drive head type, and • well pad gas flow rate.	associated separation distances to achieve required noise levels. Well pads are located and/or configured with noise attenuation features to achieve Arrow Energy's nighttime noise limit under maximum load and worst case weather conditions.
Operation of gathering lines	Noise from high point vents is intermittent and highly variable due to varying water pressures and volumes of gas in the water lines over time.	Noise measurements have been made from a sample of high emitting high point vents in Arrow Energy's operating gas fields. Separation distances have been derived to achieve < 25 dBA under worst case HPV operation and worst case weather conditions Where these separation distances cannot be achieved noise attenuated HPVs can be used.
Operation of temporary drill camps and other incidental activities	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.

5.5.5 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 Project area are presented in **Table 5-7**. Project operations require continuous operation of plant as such this Assessment has referenced the 1-hour L_{Aeq} and L_{A1} AQO to assess the noise emissions from Project noise sources.

Table 5-7 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 DETSI has published a noise assessment guideline entitled *Prescribing noise conditions for environmental authorities for petroleum activities* (DESI, 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 (DESI, 2016, DESI, 2022) for each of the specified daily time periods are provided in **Table 5-8**. These noise limits closely align with the 'Streamlined Conditions' contained within the DESI *Streamlined model conditions for petroleum activities* (DESI, 2016), effective 5 May 2016 (hereafter referred to as SMC).

Table 5-8 Best Practice Measured Outdoor Noise Emission Limits (DESI, 2016)

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

5.5.6 Assessment of environmental impacts

Arrow has been operating rigs in the Surat Basin since 2001 and is experienced in the understanding of noise generated by well development activities. To complement this understanding, a noise and vibration impact assessment was undertaken in 2018-19 to assess the potential impacts on the ambient noise and vibration environments at the sensitive receptor locations surrounding the SGP in accordance with the requirements outlined in the DES guideline Application requirements for petroleum activities (DES 2013).

Environmental noise impacts are informed by various studies conducted by Arrow Energy and management is achieved through implementation of Arrow's Environment Noise and Vibration Management Plan (ORG-ARW-HSM-PLA-00043).

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 temporary drill 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.

Well Pad Operation

A detailed noise study was also undertaken in 2019 to characterise noise emissions from Arrow's operational well pads. Noise assessment was completed through noise measurement and modelling on a variety of well pad configurations in order to understand the required separation distances from the entire range of operational well pads under varying loads to achieve relevant noise criteria.

The required separation distances from multi-well pads to achieve the night-time noise criteria of 28 dBA varies depending on the well pad design type, required number of gensets and well pad load.

5.5.7 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):

- 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 EA conditions are suitable for controlling noise impact from the proposed project.

5.6 Biodiversity

5.6.1 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.

5.6.2 Description of environmental values

Description of general ecological values and assessment methodology

Arrow Energy initially identified the ecological values through a combination of desktop and field-based assessments as part of the Surat Gas Project EIS (SGPEIS) and Supplementary EIS (SGPREIS) process for the broader Surat Gas Project (SGP) between 2009 and 2013. Follow up surveys were conducted by EcoSmart in 2016 and 2017 (refer to Appendix F**).**

In addition, number of other ecological surveys have been undertaken across parts of the SGP since 2021 up until 2023 to support various State and Commonwealth approvals, including field verification of proposed infrastructure locations undertaken by Arrow Energy ecologists. Most recently comprehensive Project Environmental Clearance (PEC) Reports have been prepared in late 2025 following ecological surveys to field verify environmental values within the proposed project footprint and

to support this amendment application. These surveys have provided Arrow Energy with a comprehensive understanding of the ecological values, flora and fauna assemblages, characteristics of vegetation communities and habitats in the broader SGP area as well as the specific project footprint relevant to the Hopeland EA area and this amendment application.

Where there has been a difference between baseline surveys and targeted surveys, Arrow Energy's ecological data and corporate database has been updated to reflect the most current ecological survey. The ground-truthing surveys have helped to support the baseline data and has significantly increased the local knowledge of ecological values.

A Biodiversity Impact Assessment (BIA) was prepared to support this amendment application and has been provided in Appendix B. The BIA discusses environmental values and impacts have been reported using a Study area around the development footprint, which is based on a 500 m buffer of the proposed infrastructure using the compilation of ecological data collected across the Project area as described above.

A comprehensive desktop assessment was undertaken between October 2025 and March 2026 to identify ecological values potentially relevant to the Study area. The intent of this desktop assessment was to identify ESAs and PEMs relevant to the Study area, including threatened and migratory species of conservation significance (MNES) that have been listed since the EPBC approval was granted in 2020 (EPBC 2018/8223). The following desktop resources were reviewed as part of this assessment:

- DCCEEW Species Profile and Threats Database (SPRAT)
- Queensland Government mapping products including certified Regional Ecosystem Mapping (Version 13) and Protected Plants Trigger Mapping
- Essential habitat mapping
- Project-specific ground-truthed regional ecosystem (GTRE) and ESA mapping for the Study area
- Threatened flora and fauna records sourced from historical SGP ecological surveys and available online resources including Atlas of Living Australia (https://www.ala.org.au/) and eBird (https://ebird.org/map)
- Soils and land resource area mapping
- Wetland values (MNES – high ecological significance wetlands mapping and wetland protection areas)
- Catchment and waterway values (Queensland major watercourses mapping)
- Connectivity values (Brigalow Belt Biodiversity Planning Assessment), and
- Available published ecological information for threatened flora and fauna species where available.

A Likelihood of Occurrence Matrix (LoOM) was utilised during project specific ecological surveys most recently conducted for the Project to support consistency in habitat assessments. This assessment refined the potentially occurring flora and fauna species based on suitable habitat availability, the proximity of known records

and the species-specific habitat mapping rules develop by Arrow Energy for the broader SGP and determined to be applicable to the Study area.

The following categories were applied in this assessment:

- **Known to Occur**: The species has been recorded within the Study area.
- **Likely to Occur**: Suitable habitat for the species is present within the Study area and historical records exist within 10 km of the Study area (and are less than 20 years old).
- **Possibly Occurring**: Suitable habitat for the species is present within the Study area and historical records occur within 10-50 km.
- **Unlikely to Occur**: Whilst the Study area contains suitable habitat, the nearest historical record is greater than 50 km away, or whilst historical records exist within 50 km of the Study area no suitable habitat is present.

Flora survey efforts

Vegetation surveys relevant to the Project were undertaken in 2021 and again in October 2025 as part of an ecological survey of the Project footprint and surrounds. The PEC survey reports are provided in the BIA (Appendix B). The surveys were conducted in accordance with a previous version of the Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland (Neldner, et al., 2023).

Terrestrial fauna surveys

The habitat types in the Study area are widely distributed across the Brigalow Belt and have been extensively sampled as part of a substantial and sustained fauna survey effort across the broader SGP Project area between 2016 and 2026. Resultantly, fauna assemblages and characteristic microhabitats associated with the broad vegetation communities and habitats are well understood. As the fauna survey effort presented in this report represents a subset of the survey effort for the wider SGP, all sites within 15 km of the Study area have been regarded as relevant and have been included in overall effort.

The primary Project-specific field assessments that inform the description of terrestrial fauna habitats and fauna assemblages in the Study area are derived from CHEC Environmental 2025 fauna surveys (See Appendix B) and Surat Gas Project Terrestrial Ecology Report (See Appendix F). Since 2017, these fauna surveys have been supplemented by habitat assessments, Koala Spot Assessment Technique (SAT) surveys and opportunistic fauna observations undertaken by Arrow field ecologists.

Main fauna survey effort

In addition to the CHEC Environmental 2025 fauna surveys, areas for field survey were identified based on the results of desktop searches and interpretation of aerial photography to select patches of remnant and non-remnant vegetation for targeted fieldwork. As part of the terrestrial fauna surveys conducted by EcoSmart in 2016-2017, the following methodology was applied to select sites for further assessment:

- areas with little or no historic survey effort were identified by overlaying the locations of previous fauna work on pre-existing RE mapping to identify focus areas for the fauna survey;

- Broad Vegetation Group (BVG) mapping prepared by the Queensland Herbarium was used to identify the location and extent of BVGs at the 2 million scale. The contribution of each BVG to the extent of remnant vegetation was calculated and theoretical trap effort distributed accordingly;
- a five-day pilot study was conducted in August 2016 to visually inspect focus areas, identify survey constraints and located possible detailed fauna trap surveys;
- detailed survey sites were selected on the basis of spatial and BVG stratification, taking into consideration landholder access constraints, travel logistics and limitations, notable geomorphological features such as rock outcrops and caves, habitats likely to support specially protected species and vegetation condition (in particular, fire scarring).

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 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.

Further details of the fauna survey effort are provided in the BIA in Appendix B, which includes description of the survey techniques adopted in accordance with the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland* (Eyre, et al., 2022).

In addition to the main survey efforts undertaken by EcoSmart during the 2016-2017 survey period, several other supplementary fauna survey programs have also been undertaken in the vicinity of the Project and were identified as being relevant to this BIA report. The most recent Project specific fauna survey is the CHEC Environmental survey conducted in in 2025. For the purposes of the BIA, a species is considered 'cryptic' if it is unlikely to be detected using standard survey techniques (trapping, searching or spotlighting).

Of the fauna species considered 'likely' or 'possibly occurring' within the Study area, the following were difficult to detect using these survey methods:

- Brigalow Woodland Snail, *Adclarkia cameroni*
- Dulacca Woodland Snail, *Adclarkia dulacca*
- Dunmall's Snake, *Furina dunmalli*, and
- Grey Snake, *Hemiaspis damelii*.

Both snake species are subterranean by nature (i.e. they spend most of their time underground) and are recognised as difficult to detect in relevant conservation guidelines. Similarly, the brigalow woodland snail required moist environments (typically along watercourses) where there is sufficient coarse woody debris to provide shaded and moist microhabitats. These species are typically associated with Brigalow and/or riparian habitats which are limited in extent within the Study area. Whilst no specific surveys have focused on the detection of these species, the microhabitat features noted within each of the PEC reports has allowed for the

development of relatively reliable habitat mapping that has been used to inform this impact assessment.

Habitat Assessments

In addition to the direct survey methods used to detect fauna species, habitat assessments were also conducted. The focus of these assessments was to collect sufficient microhabitat information to inform the development of habitat mapping rules that have subsequently been adopted across the broader SGP.

Project area vegetation types and Environmentally Sensitive Areas (ESAs)

The Project is located approximately 12 km to the northwest of Kogan in the Inglewood Sandstones subregion of the Brigalow Belt bioregion. The Study area contains both cleared grazing land and eucalypt and brigalow woodlands either usually dominated by a mixture of river redgum (*Eucalyptus tereticornis*) and/or poplar box (*E. populnea*) or brigalow (*Acacia harpophylla*) and belah (*Casuarina cristata*).

Melonhole gilgai on clay plains are present in the cleared grazing land (east of Wambo Creek) along the eastern section of the Study area. Small patches of brigalow (*Acacia harpophylla*) also occur on the clay plains and the road reserves in the areas such as the Kogan Condamine Road. A narrow riparian open woodland dominated by forest red gum (*E. tereticornis*) is associated with Wambo Creek and occurs to the east of Clynes Road.

A Regional Terrestrial biodiversity corridor is mapped along Wambo and Sixteen Mile Creeks that traverse the Study area (refer to Appendix B).

A summary of the ESAs as defined in the *Environmental Protection Regulation 2019* (EP Reg) (for Category A & B ESAs), and recent definitions of Category C ESAs to include Protected Wildlife Habitat (PWH) has been used that are relevant to the Project have been provided in Table 5-9.

Table 5-9 ESAs within the Project Area

ESA Category	ESA Type	Occurrence in Hopeland EA amendment area
Category A	A National Park, Conservation Park, Special Wildlife Reserve, or a Forest Reserve.	None.
	The Wet Tropics Area under the Wet Tropics World Heritage Protection and Management Act 1993.	None
Category B	A coordinated conservation area, an area of critical habitat for major intersect identified under a conservation plan or an area subject to an interim conservation order.	None
	An area subject to the 'Convention on the Conservation of Migratory Species of Wild Animals', the 'Convention on Wetlands of International Importance, especially as Waterfowl Habitat' or the 'Convention Concerning the Protection of the World Cultural and Natural Heritage'.	None
	Under the *Queensland Heritage Act 1992*, a place of cultural heritage significance or a	None

ESA Category	ESA Type	Occurrence in Hopeland EA amendment area
	Queensland Heritage place, unless there is an exemption certificate issued under the Act.	
	An area recorded in the Aboriginal and Torres Strait Islander Cultural Heritage Database and Register established under the *Aboriginal Cultural Heritage Act 2003*, section 46, other than the area known as the 'Stanbroke Pastoral Development Holding', leased under the *Land Act 1994*.	None
	A feature Protection Area, State Forest Park or Scientific area under the *Forestry Act 1959*.	None
	A declared fish habitat area under the *Fisheries Act 1994*.	None
	An 'Endangered Regional Ecosystem' identified in the REDD database (by Biodiversity Status)	There are two (2) 'endangered' REs in the Study area (RE 11.4.3 and 11.3.1).
Category C	Nature refuges as defined in the conservation agreement for that refuge under the Nature Conservation Act 1992 Guideline Streamlined model conditions for petroleum activities.	None
	State forests or timber reserves as defined under the Forestry Act 1959	None
	Regional parks (previously known as resource reserves) under the Nature Conservation Act 1992	None
	An area validated as from ground-truthing surveys as 'essential habitat' on the Queensland Government essential habitat map in accordance with section 20AC of the Vegetation Management Act 1999 for a species of wildlife listed as critically endangered, endangered, vulnerable under the Nature Conservation Act 1992	Mapped essential habitat for Pale Imperial Hairstreak and Golden Tailed Gecko; As only essential habitat for critically endangered, endangered and vulnerable wildlife is considered as an ESA, no further assessment is made of essential habitat mapping for Golden-tailed Gecko.
	An area validated from ground-truthing surveys as 'protected wildlife habitat' that is category A, B or C on the remnant vegetation management map, in accordance with section 20A of the Vegetation Management Act 1992, for a species of wildlife listed as critically endangered, endangered or vulnerable under the Nature Conservation Act 1992.	Protected wildlife habitat for endangered and vulnerable species occurs within the amendment area. Refer to **Appendix B**.
	'Of concern regional ecosystems' that are remnant vegetation and identified in the database called 'RE description database' containing regional ecosystem numbers and descriptions.	There are four 'of concern' REs in the Study area (RE 11.3.25 and 11.3.27f, 11.3.2 and 11.3.4). Refer to Appendix B.

An assessment of the impacts on Protected Wildlife Habitat that is a Category A, B or C area shown on the regulated vegetation map (RVM) for a species of wildlife listed

as critically endangered, endangered, vulnerable under the *Nature Conservation Act 1992* is further discussed in Appendix B).

For further details and mapping please refer to Appendix B which provides a detailed description of environmental values (i.e., terrestrial flora and fauna) used for the assessment of impacts to biodiversity from the Project activities.

Terrestrial Flora

Terrestrial vegetation and flora values have been derived from both desktop assessments and field surveys undertaken since the original SGPEIS (for further details refer to Appendix B.

Current vegetation mapping prepared by the Department of Resources (DOR) identifies 7 REs within the Hopeland EA amendment. The descriptions for mapped REs are provided in Table 3.2 of Appendix B, and include:

- Two classified as 'Endangered';
- One classified as 'Of concern'; and
- Four classified as 'Least concern'.

Ground-truthed RE mapping prepared for the Hopeland EA amendment area has been based on the consolidated survey efforts undertaken across the Project footprint by CHEC Environmental and Arrow Ecologists from 2021 and 2025. (refer to Appendix B).

Of the 7 REs originally mapped by the DOR for the Project area, most were confirmed to be present. One, RE 11.9.5 was mapped under DoR but were not found in the Study area during ecological surveys. Descriptions for ground-truthed REs within he Study Area are provided in Table 3.3 of Appendix B and include:

- Two classified as 'Endangered';
- Four classified as 'Of Concern'; and
- Five classified as 'Least Concern'.

Ground-truthed REs for the Hopeland EA amendment area include RE11.4.3 which corresponds to the Brigalow threatened ecological community (TEC) as listed under the EPBC Act. Impacts on Brigalow TEC are managed under Arrow Energy's EPBC approval (EPBC 2010/5344) and do not require further consideration as PEMs for the EA amendment application. Activities in these 'endangered' REs are restricted by the Hopeland EA (Biodiversity 8B) which restricts activities within the ESAs and their protection zones.

There are no 'high risk' areas shown on the Protected Plants Flora Survey Trigger Map in the Study area.

It is noted that habitat for a near threatened species does not constitute an ESA, nor is it a PEM under the EO Act. The presence or potential presence of a near threatened species triggers requirements under the NC Act that are approved and managed separately to the EA. Therefore, the occurrence or potential occurrence of near threatened species or their habitat does not trigger any requirement to amend the EA however, the presence of these species is noted.

Terrestrial Fauna

The Hopeland EA amendment area dominated by riparian woodland habitats on watercourses and gilgaied clay plains with isolated patches of Brigalow to the east of Wambo Creek. Remnant vegetation is mostly restricted to road reserves and riparian areas. Most remnant vegetation have been impacted by logging activities (either broadscale or selective) or other forms of disturbance. The majority of the Study area has been almost completely cleared to support pastoral activities, however patches of brigalow vegetation (RE 11.4.3) have been retained within these areas. Additionally, the Project is located within an area of existing CSG infrastructure.

The vegetation communities that have been ground-truthed across the Study area represent the following broad habitat types:

- Eucalypt woodlands to open forests: A few of eucalypt communities have been identified within the Study area, including RE 11.5.1, RE 11.5.1a, and RE 11.5.20. This habitat type represents approximately 4.0% of the total Study area. Of these communities RE 11.5.20 and RE 11.5.1 are the most abundant communities and are dominated by grey box (*Eucalyptus moluccana*), narrow-leaved ironbark (*E. crebra*) and poplar box (*E. populnea*). Regrowth patches of these communities have also been incorporated into this habitat type.
- Riparian woodlands: Several eucalypt woodland communities were identified along mapped watercourses within the Study area and are predominately RE 11.3.18, RE 11.3.25 and RE 11.3.4. This habitat type represents approximately 5.3% of the total Study area. These communities are dominated by forest red gum (E. tereticornis) and poplar box. No regrowth communities were identified within the Study area.
- Acacia woodlands: Several isolated patches of remnant and regrowth RE 11.4.3 and RE 11.3.1 dominated by brigalow (*Acacia harpophylla*) have also been identified within the study area. These patches represent approximately 4.3% of the total Study area and are located east of Wambo Creek.
- Cleared and/or non-remnant: The remaining areas within the Study area have been described as cleared and/or non-remnant. This habitat type represents approximately 86.1% of the total Study area. Whilst these areas contain no little to no vegetation, they do contain large areas of highly disturbed gilgai.

Watercourses

Major watercourses are important landscape elements which act as significant migratory and dispersal pathways for many fauna species, contain important habitat resources (including food, water, sheltering, roosting and nesting sites) as well as provide refugia during periods of drought. Unlike other parts of the Brigalow Belt bioregion where waterways often provide the only remaining landscape connectivity, the Study area retains a significant amount of native vegetation and landscape connectivity. Despite this, the major creek systems (Wambo Creek and Sixteen Mile Creek) identified within the Study area does represent habitat that are often less impacted by historical clearing and are more likely to contain large trees due to their position in the landscape.

The drainage in the Study area generally flows in a northernly direction, eventually draining into the Condamine River. Wambo Creek and Sixteen Mile Creek are the major drainage systems in the Study area, with several tributaries of Sixteen Mile

Creek occurring in the eastern portion of the Study area. Wambo and Sixteen Mile Creek that intersect with the Project Footprint are ephemeral and only likely to contain water following substantial rainfall events. The Project has a crossing on Wambo Creek and two (2) crossings on Sixteen Mile Creek. These watercourses are generally buffered by riparian vegetation (RE 11.3.25).

Wetlands

There are no wetlands of high ecological significance mapped within the Project Area.

Conservation-significant fauna

Of the 34 species initially considered as part of the LoOM assessment as potentially occurring within the Study area, 10 species were ultimately identified as 'known to occur' or 'likely to occur' based on the proximity to nearby records and the availability of suitable microhabitat features within the Study area. These are:

- Glossy Black Cockatoo (south-eastern), *Calyptorhynchus lathami lathami* – Known to occur
- Diamond Firetail, *Stagonopleura guttata* – Likely to occur
- Southern Whiteface – *Aphelocephala leucopsis* – Likely to occur
- Brigalow Woodland Snail, *Adclarkia cameroni* – Likely to occur
- Koala, *Phascolarctos cinereus* – Likely to occur
- Short-beaked Echidna, *Tachyglossus aculeatus* – Likely to occur
- Dunmall's Snake – *Furina dunmalli* – Likely to occur
- Grey Snake – *Hemiaspsis damelii* – Likely to occur
- Golden- tailed Gecko, *Strophurus taenicauda* – Known to occur

For further information and details on the above species, please refer to Appendix B.

One (1) fauna species listed as near threatened under the NC Act are known to occur within the Project area, namely, the Golden-tailed Gecko, *Strophurus taenicauda*.

Habitat for a near threatened species does not constitute an ESA, nor is it a PEM under the EO Act. The presence or potential presence of a near threatened species triggers requirements under the NC Act that are approved and managed separately to the EA. Therefore, the occurrence or potential occurrence of near threatened species or their habitat does not trigger any requirement to amend the EA however, the presence of these species is noted.

The majority of the mapped essential habitat in the area that is subject of the Hopeland EA amendment is associated with records for the Golden-tailed Gecko. This species is listed as Near Threatened under the NC Act; as such, mapped essential habitat for this species does not constitute an ESA or a PEM for the purposes of the EA.

The short-beaked echidna can be found across most of Australia, where they live in forests and woodlands, heaths, grasslands and arid environments (BHA, 2024). Considering the broad range of habitats that the Echidna could occupy, they could occur anywhere across the wider SGP area. For the purposes of BIA to support this application (Appendix B), habitat has been mapped by buffering known records by 1

km as set out in the Method for mapping matters of state environmental significance, Version 7 (DESI, 2024). Whilst several records of the short-beaked echidna have been identified in the surrounding landscape, the nearest record is approximately 5 km to the north-west (ALA 2008). Following the guidance outlined in (DESI, 2024), there is no mapped habitat for the short-beaked echidna within the Study area.

5.6.3 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 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 proposed well locations and the gathering / access track alignment has been designed using the management hierarchy as described above. The project is co-located adjacent to existing linear infrastructure as much as possible to avoid fragmenting vegetated areas which also allows for a narrower RoW during construction due to being able to use the existing tracks or RoWs for access. Many of the construction workspaces and activities such as laydowns, access tracks and extra workspaces use gas field infrastructure or have been located in areas previously disturbed as part of the development of the gas field and are already approved under existing EAs.

The Project also propose to use of deviated wells (instead of traditional vertical wells) as a key method of reducing the disturbance area and managing surface constraints to avoid high value ecological areas. A total of 55 wells are planned for this Project on 15 well pads with up to 8 wells located on a single well pad.

Refinement of the project infrastructure locations and design has minimised the Project's impact by co-locating with other pipelines and in or adjacent to previously disturbed areas. This has resulted in a comparatively small construction footprint for a project of this size.

Project development has also considered the hierarchical management principles for primary and secondary protection zones of Category B and C ESAs as set out in conditions of the Hopeland EA.

Proposed Project impacts have been compared against the standard criteria, standard conditions, and variation conditions within the Hopeland EA to identify any impacts that are not consistent with approved conditions.

Planning of facilities and waterways crossing methodologies

A range of pipeline construction methods are available for watercourse crossings, including standard 'open cut' trenching, watercourse flow diversion and trenchless technology. A brief description of each and the associated advantages and disadvantages is provided below:

- Standard 'open cut' trenching involves in-stream construction of a trench using excavators or backhoes to stockpile trench spoil away from the streambed. The prefabricated pipe is placed across the waterway, lowered in and the trench and backfilled immediately. This method is often applied in dry or shallow low flow watercourses but may also be applied in sensitive watercourses where rapid construction is the best means of minimising environmental impacts.
- Watercourse flow diversion techniques involve construction of temporary dams up and downstream of a crossing and the diversion of water around the crossing site to create a dry construction area between the dams. This method is generally applied at crossings where water flow is required to be maintained for ecological, social or engineering reasons.
- Trenchless options, such as horizontal directional drilling (HDD) can cause less disruption to the surface environment and can be a viable alternative where there are significant surface constraints that exclude standard open cut trenching as a construction methodology. However, the cost of HDD is significantly higher compared to standard trenching and there are technical constraints and environmental risks (e.g. HDD failure, accidental release of drilling muds where geology is incohesive, etc) that also need to be considered. A cleared area equivalent to the length of the HDD is also required to 'string' the pipe length (i.e. welding together all sections of the pipe that are then pulled through the HDD). Other technical considerations include are not limited to, ground conditions and depth of channels.

All crossings for the Project are proposed to be standard 'open cut' with a bed level access track where required.

Overview of impacts

Direct impacts

Vegetation clearing impacts

The most significant impact associated with the construction of the Project is the direct loss vegetation through clearing of the RoW, which includes impacts on 0.75 ha of remnant vegetation and 2.66 ha of regrowth vegetation. Given the often linear nature

of remaining vegetated areas, clearing of remnant vegetation and associated habitat is an unavoidable aspect of the Project development. Despite this however, most of the clearing proposed is in relatively widespread, least concern vegetation types (predominantly RE 11.3.25) or regrowth vegetation.

Habitat fragmentation and landscape connectivity impacts

Habitat fragmentation occurs when continuous areas of habitat are subdivided into several smaller, separate components. This term encompasses two interrelated components: habitat loss (i.e. a reduction in the amount of habitat) and fragmentation (i.e. the breaking apart of habitat which increases 'edge effects'). The impacts of habitat fragmentation are also scale-dependent and may differ depending on the species or community under consideration. For example, loss of small areas of habitat that do not present a significant barrier to movement by highly mobile species (e.g. birds of prey) may represent a much greater barrier to dispersal of less mobile or far-ranging species (e.g. amphibians or small reptiles).

To help determine whether the development of the Project will result in an SRI on connectivity (a recognised PEM under the EO Act), the Landscape Fragmentation and Connectivity (LFC) Tool was used. This tool performs a desktop assessment of development impacts on connectivity areas containing remnant vegetation to determine whether these developments are likely to result in a significant impact to regional and local vegetation connectivity. The analysis of the LFC on connectivity areas from the Project were identified as **not** significant, based on DETSI RE mapping and based on Arrow's GTRE mapping. The LFC outputs have been included in the BIA in Appendix B.

Impacts to hollow bearing trees

The Glossy Black-cockatoo is a species assessed as known or likely to occur in the Study area which can be described as hollow-dependant species.

The location of wells and alignment of other infrastructure such as gathering RoWs and access tracks have been designed to minimises impact to vegetation where possible and there is particular emphasis on minimising impacts to riparian vegetation through RoW minimisation and locating any temporary workspaces outside of these areas.

The importance of riparian vegetation along the major creek systems represent habitats that are often less impacted by historical clearing and are more likely to contain large trees due to their position in the landscape.

Habitat trees with notes on their size and hollows have been captured during the ecological survey with six (6) habitat trees identified within the Project footprint. Based on the PEC reports (Appendix B) the riparian vegetation associated with Sixteen Mile Creek and the road reserve of Clynes road are where the project footprint intersects large mature trees that contain hollows or potential nest sites. This data allows the identification of Glossy Black-cockatoo habitat which requires large hollows suitable for nesting.

During construction hollow bearing trees, beyond the essential clearing footprint, identified from ecological survey data are flagged for retention and exclusion zones established to avoid potential impacts. Where required, clearing of hollows will be undertaken in accordance with the Arrow Energy Species Management Program

(SMP) (Doc. No. ORG-ARW-HSM-PLA-00070) which authorises activities if it will impact on breeding places of protected animals, which includes relocation of hollows if breeding fauna are observed.

Indirect impacts

Indirect impacts on ecological values that may arise during the construction and ongoing operation of the Project include:

- edge effects resulting from the creation of smaller patches of vegetation with a greater edge to surface ratio, including increased exposure to weed invasion, light and wind penetration (which can alter microclimate features) potentially resulting changes in community structure and composition over time
- dust generation during construction, which has the potential to smother plants, reducing photosynthesis and resulting in decreased vegetation health and condition
- increased noise from the vegetation clearing operations, the operation of machinery and vehicle traffic which may affect the behaviour of wildlife (typically limited to the construction period)
- increased lighting during construction and operation, with the potential to disrupt the behaviour of nocturnal species, and
- mortality resulting from vehicle collision.

Indirect impacts on the ecological values of the Project will be managed in accordance with Arrow's existing Environmental Management Framework.

Impacts on State Forests

There will be no impact to State Forests.

Impacts on terrestrial flora values

No conservation significant flora species were identified during field surveys and will not be impacted by the Project.

- No 'Endangered' REs by VM Status will be impacted by the Project. There is 50.50 ha of Endangered RE 11.4.3 and 5.66 ha of RE 11.3.1 within the study area that has been avoided.
- Two 'Of concern' REs 11.3.2 and 11.3.4 by VM Status were found to occur in the Study area but will not be impacted by the Project. Impacts on RE 11.3.25 and RE 11.3.27f (listed as 'Of concern' by BD status) will be captured as an impact under the Environmentally Sensitive Area PEM as they qualify as a Category C ESA.

Impacts on watercourse vegetation

Impacts on regulated vegetation within a defined distance from the defining banks of As part of the ecological survey the high banks of watercourses associated with the Project were mapped. The Project footprint will impact 0.14 ha of RE 11.3.25 watercourse vegetation associated with the Wambo Creek and Sixteen Mile Creek crossings.

Impacts on terrestrial fauna values

The Project will have an impact on protected wildlife habitat for the species identified as 'known to occur' or 'likely to occur. Whilst the Project will impact suitable habitat

for the Golden-tailed Gecko (as mapped by Arrow), this species is listed as Near Threatened and does not constitute a PEM under the EO Act and has been excluded from this summary table.

Terrestrial fauna species being potentially impacted by the development the Project, and the area of impact are the following:

- *Adlcarkia cameroni*, Brigalow Woodland Snail – 0.16 ha
- *Phascolarctos cinereus*, Koala – 3.00 ha
- *Hemiaspis damelii,* Grey Snake – 0.41 ha
- *Furina dunmalli*, Dunmall's Snake – 0.41 ha
- *Stagonopleura guttata*, Diamond Firetail – 3.00 ha
- *Aphelocephala leucopsis*, Southern Whiteface – 3.00 ha.

SRI Assessments have been undertaken in accordance with the SRI Guidelines (DEHP, 2014) for endangered, vulnerable and special least concern fauna species and are documented in detail in Appendix B

Impacts on mapped essential habitat

There are no impacts to 'essential habitat' on the Queensland Government Essential Habitat Map in accordance with section 20AC of the Vegetation Management Act 1999 for a species of wildlife listed as critically endangered, endangered, vulnerable under the Nature Conservation Act 1992.

Impacts to fish passage

The construction of the Project will involve crossing one Green (low impact) and one Purple (major impact) waterway crossings.

The two creek crossings associated with the Project will be bed level crossings that will comply with the 'Accepted development requirements for operational work that is constructing or raising waterway barrier works" (ADR (DAF 2018). There will be no culvert crossings or other structures placed in the waterways. Pipe crossing works and the use of bed-level crossings will be undertaken in accordance with the accepted development requirements (ADR) of the waterway barrier (WWB) self-assessable code or the temporary WWB code.

Specific EA amendments to the Hopeland EA

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

- The inclusion of the following to the definition of Category C ESAs in the Hopeland EA definitions schedule:
    - an area validated from ground-truthing surveys as 'protected wildlife habitat' that is category A, B or C on the Regulated Vegetation Management Map, in accordance with section 20A of the Vegetation Management Act 1992, for a species of wildlife listed as critically endangered, endangered or vulnerable under the Nature Conservation Act 1992.

- the inclusion of Category C ESAs that are Protected Wildlife Habitat to *Biodiversity 8A, Table 1 – Authorised petroleum activities in environmentally sensitive areas and their protection zones.*
- the inclusion of conditions or authorisations through 'despite clauses' the impacts to ESAs where the petroleum activities proposed are inconsistent with *Biodiversity 8B, Table 2 Authorised petroleum activities in environmentally sensitive areas and their protection zones.*
- amendments to *Condition Biodiversity 10, Table 3 Impacts to prescribed environmental matters* to include disturbance to PEMs that have been assessed as resulting in an SRI (refer Appendix B) and require inclusion in the PEMs despite table.

Inclusion of Protected Wildlife Habitat as a Category C ESA

Arrow proposes to amend definition of Category C ESAs in the definitions to include the Protected Wildlife Habitat (PWH) as described above to align with Arrows other EA's and DETSI revised definition for PWH. This would also include the associated amendment of *Condition Biodiversity 8A, Table 1*, to include a category for activities that are authorised and constrained within areas of vegetation that have been assessed as Protected Wildlife Habitat. This would bring the Hopeland EA in line with other recently amended or approved EAs.

Impacts to Environmentally Sensitive Areas (ESAs)

In accordance with the Hopeland EA, only low impact petroleum activities may be undertaken in Category A ESAs or Category B ESAs or Category C ESAs other than state forests or timber reserves, or within the ESAs' Primary Protection Zones (PPZs). However, Arrow has identified occasions where petroleum activities are required to be within ESAs or their protection zones. The Hopeland EA includes conditions with a 'despite' clause that authorise Extra Work Areas (EWAs) within primary protection zones, secondary protection zones and significant disturbance at the location and maximum extent specified in 'Table 2'. Conditions with 'despite' clauses that are relevant to the Project include:

- Biodiversity 7: Despite condition (Biodiversity 8A), Extra Work Areas (EWAs) are authorised in areas clear of vegetation, including primary protection zone (PPZ) and secondary protection zone (SPZ).
- Biodiversity 8B: Despite condition Biodiversity 8A, significant disturbance is authorised to be undertaken at the location and maximum extent of impact in Protecting Biodiversity Values, Table 2—Authorised petroleum activities in environmentally sensitive areas and their protection zones.

Non-essential petroleum activities proposed within ESAs for the Hopelands EA amendment area include:

- extra work areas, such as those required to accommodate well pads on sloping topography; and
- pipe yard and laydown areas.

It is proposed that Biodiversity 8B, Table 2 is amended to include the following previously unauthorised disturbance:

- 0.41 ha of disturbance within Category B ESA

- 24.61 ha of disturbance within a Category B PPZ
- 1.13 ha of disturbance within a Category B SPZs
- 0.78 ha of disturbance within a Category C ESA that is Of Concern vegetation.
- 3.41 ha of disturbance within a Category C ESA that is Protected Wildlife Habitat
- 0.47 ha of disturbance within a Category C PPZ.

The inclusion of the above disturbance has not limited Condition Biodiversity 4 which outlines principles in which site selection is to conducted that aims to minimised disturbance to areas of environmental value. Where possible Arrow has located infrastructure in areas of pre-disturbance.

Impacts to PEMS

The values given in Appendix B, Table 5.2, incorporate impacts to Protected Wildlife Habitat that is a ground verified Category A, B or C area shown on the Regulated Vegetation Management Map (RVMM) for a species of wildlife listed as critically endangered, endangered, vulnerable under the Nature Conservation Act 1992.

It is proposed to authorise impacts to the identified PEMs values via amendments to Condition Biodiversity 10, Table 3 –Impacts to prescribed environmental matters. The impacts for the activities have been divided into those that have been previously authorised (Stage 1) and those that are the subject of this EA amendment application (Stage 2).

For offsets related to the proposed EA amendments refer to Section **Error! Reference source not found.**.

5.6.4 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 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.

5.7 Biosecurity

5.7.1 Applicable legislation

The following legislation are relevant to identifying values and mitigating and managing impacts on biosecurity matters:

- *Biosecurity Act 2014* (Qld) and Regulation 2016: Biosecurity matters are defined in Section 15 as *Prohibited matters* and *Restricted matters*, and include: high risk weeds, pest animals, disease, viruses, fungi, insects, and parasites.
- *Local Government Act 2009* (Local Government Act) (Qld): Other weeds are declared under this act as local law.

- *Australian Weeds Strategy 2017-2027* (Cwlth): Further the identifies introduced plants that are agreed by Australian governments to be Weeds of National Significance (WONS).

5.7.2 Description of environmental values

High risk biosecurity matters identified within the Western Downs Regional Council local government area and of relevance to Arrow Energy are included in **Table 5-10**.

Table 5-10 High risk biosecurity matters

Biosecurity Matter	Categories
Pest Plants	
African boxthorn *(Lycium ferocissimum)*	WONS, Restricted matter category 3
African love grass *(Eragrostis curvula)*	Local Law (BSC)
Asparagus fern (*Asparagus aethiopicus, A.africanus and A.plumosus, A. scandens*)	WONS, Restricted matter category 3
Athel pine (*Tamarix aphylla*)	WONS, Restricted matter category 3
Broad-leaved pepper tree *(Schinus terebinthifolius)*	Restricted matte category 3
Cabomba *(Cabomba caroliniana)*	WONS, Restricted matter category 3
Cactus: (*Cylindropuntia*) Snake cactus (*C. spinosior*) Coral cactus (C. *fulgida*) Jumping cholla (*C. prolifera*) Devils rope pear (*C.imbricata*)	WONS, Restricted matter category 3
Cactus: (*Harrisia*) Harrisia cactus *(H. martinii, H. tortuosa and H.pomanensis syn. Cerus pomanensis)*	Restricted matter category 3
Cactus: (*Opuntia*) Bunny ears (*O. microdasys*) *O. elata*	WONS, Restricted matter category 2,3,4,5
Cactus: (*Opuntia*) Prickly pear *(Opuntia stricta syn. O.inermis)* Velvet tree Pear *(O.tomentosa)* Tiger pear (*O.aurantiaca)* Drooping tree pear *(O.monacantha syn. O.vulgaris)* *Westwood pear (O.streptacantha)*	WONS, Restricted matter category 3
Camphor laurel (*Cinnamomum camphora*)	Restricted matter category 3
Cats claw creeper *(Dolichandra unguis-cati)*	WONS, Restricted matter category 3
Chinese celtis (*Celtis snensis*)	Restricted matter category 3
Fire weed *(Senecio madagascariensis)*	WONS, Restricted matter category 3
Giant parramatta grass (*Sporobolus fertilis*)	Restricted matter category 3

Biosecurity Matter	Categories
Giant rats tail grass and other weedy Sporobolus species (*Sporobolus pyramidalis, S.natalensis, S.jacquemontii, S.fertilis*)	Restricted matter category 3
Groundsel bush *(Baccharis halimifolia)*	Restricted matter category 3
Hymenachne or Olive hymenachne *(Hymenachne amplexicaulis and hybrids)*	WONS, Restricted matter category 3
Karroo thorn (Vachellia Karoo)	Prohibited matter
Lantana (*Lantana camara*), Creeping lantana (*L. montevidensis*)	WONS, Restricted matter category 3
Leucaena *(Leucaena leucocephala)*	Local law (BSC & RRC)
Madeira vine (*Anredera cordifolia*)	WONS, Restricted matter category 3
Mesquite (*all Prosopis spp*. And hybrids other than *P. glandulosa, P.pallida and P.velutina*)	WONS, Prohibited matter
Mother-of-millions *(Bryophyllum delagoense syn. B. tubiflorum, Kalanchoe delagoensis, hybrid Bryophyllum x houtonii)*	Restricted matter category 3
Parkinsonia *(Parkinsonia aculeata)*	WONS, Restricted matter category 3
Parthenium weed *(Parthenium hysterophorus)*	WONS, Restricted matter category 3
Privet: (*Ligustrum*) Broad-leaf privet (*L. lucidum*) Chinese privet *(L. sinense)*	WONS, Restricted matter category 3
Rubber vine *(Cryptostegia grandiflora)*	WONS, Restricted matter category 3
Serrated tussock grass *(Nassella trichotoma)*	WONS, Prohibited matter
Silver-leaf nightshade (*Solanum elaeagnifolium*)	WONS, Restricted matter category 3
Water hyacinth *(Eichhornia crassipes)*	WONS, Restricted category 3
Yellow bells *(Taecoma stans)*	Restricted matter category 3
Pest Animals	
Carp (Cyprinus carpio)	Restricted matter category 3,5,6,7
Dingo (*Canis lupus dingo*)	Restricted matter category 3,4,5,6
European rabbit (*Oryctolagus cuniculus*)	Restricted matter category 3,4,5,6
European red fox (*Vulpes vulpes*)	Restricted matter category 3,4,5,6
Feral cat (*Felis catus and Prionailurus bengalensis x Felis catus*), other than a domestic cat	Restricted matter category 3,4,6
Feral deer Chital axis deer (*Axis axis*)	Restricted matter category 3,4,6

Biosecurity Matter	Categories
Fallow deer (*Dama dama*) Rusa deer (*Rusa timorensis, syn. Cervus timorensis*) Red deer (*Cervus elaphus*)	
Feral pig (*Sus scrofa*)	Restricted matter category 3,4,6
Wild dog (*Canis lupus familiaris*), other than a domestic dog	Restricted matter category 3,4,6
Disease and Virus (Pathogens)	
Bacterial blight (*Xanthomonas axonopodis*)	Prohibited matter
Verticillium wilt (*Verticillium dahlia*)	Prohibited matter

Three exotic flora species, all of which are classified as weeds, are considered to have a high potential for impact within the project development area due to the favourable climatic conditions and habitats available:

- African lovegrass (*Eragrostis curvula*) is an aggressive and difficult-to-control, grassy weed that is widely established on road verges. The species has the long-term potential to displace native pasture grasses and decrease grazing productivity. African lovegrass provides a potential threat to the integrity of native grassland and associated listed species.
- Parthenium (*Parthenium hysterophorus*) colonises weak pastures with disturbed ground cover. A few widely scattered occurrences have been recorded on roadsides within and in the vicinity of the project development area; however, no major infestations are known.
- Mesquite (*Prosopis glandulosa* var. *glandulos*, *Prosopis velutina*), which forms dense impenetrable thickets in riparian areas that can outcompete native vegetation, is known from a few scattered records around Brookstead and Millmerran on heavy soils.

Fauna species considered to have a moderate potential for increased distribution as a result of project activities include:

- Cane toad (Rhinella marina).
- European red fox (Vulpes vulpes).
- Feral cat (*Felis catus*).
- Wild dog (Canis familiaris).
- Feral pig (*Sus scrofa*).

The European rabbit does not pose a threat within the area due to unfavourable ecological conditions.

5.7.3 Assessment of environmental impacts

If exotic plants are not managed, the project has the potential to increase their abundance and facilitate dispersal which may have negative economic and social effects as well as negative impacts on native vegetation and biodiversity. Mechanisms of weed dispersal and spread of pathogens from project activities are generally associated with:

- Movement of equipment and machinery, particularly machinery sourced from adjacent regions.
- Ground disturbance, such as grading, removal, and relocation of topsoil.

Project-related activities have the potential to increase pest fauna abundance, which could lead to increased competition with and predation of native fauna and habitat degradation (e.g., through wallowing and foraging by feral pigs). In particular, pest fauna abundance and distribution may increase due to:

- The construction of linear infrastructure, which may create pathways and increase dispersal capability.
- The construction of dams, which can provide a permanent water source for feral animals, thereby increasing their abundance and distribution. In addition, dams may attract cane toads, increasing the risk of toxic ingestion in predatory species, such as grey snake, common death adder and black-necked stork.
- Putrescible waste dumps, which can become a food resource for a variety of pest fauna species, leading to an increase in their abundance.

5.7.4 Proposed management practices

Arrow Energy implements its Biosecurity Procedure (ORG-ARWE-HSM-PRO-00187) to manage biosecurity risks and to facilitate compliance with obligations under the *Biosecurity Act 2014*. This procedure adopts a risk-based approach to managing biosecurity, which allows greater flexibility and more responsive approaches to manage each specific circumstance.

Arrow Energy's Vehicle, Machinery, Equipment and Load Hygiene Procedure (ORG-ARW-HSM-PRO-00138) is implemented to minimise the likelihood of introducing biosecurity matters when undertaking a journey, transporting loads, and moving equipment.

During project planning, a preliminary ecology survey is undertaken to identify the presence, abundance, and distribution of biosecurity matter. The records of biosecurity matter findings are uploaded to Arrow Energy's GIS spatial repository. Any relevant findings are used to inform future management requirements and, subject to the biosecurity matters identified, whether a location specific biosecurity plan is required.

Pre-disturbance biosecurity surveys are undertaken prior to construction and updated information captured. Commensurate with risk, monitoring for biosecurity matters on site is ongoing during construction. Specific actions undertaken during construction to avoid, mitigate and manage biosecurity impacts include (as necessary):

- Progressive clearing and rehabilitation as soon as practicable.
- Training and inductions to ensure all relevant personnel are made aware of the location and extent of biosecurity matters in the vicinity of the work area and the risks involved in moving from one site or property to another.
- When sourcing materials, ensure that such materials as bedding sand, topsoil, straw bales, and sand bags are only brought to site after it is ascertained that the materials are not contaminated with weeds and plant or animal pathogens.
- Washdown facilities will ensure that runoff is contained on site and does not transfer weed seeds, spores, or infected soils to adjacent areas. No wash down

of vehicles is permitted in watercourses. Wash down of vehicles and equipment that have potentially been in contact with weeds and pathogens will be undertaken before entering new work sites.

- Disposal, storage and management of food scraps and general waste in appropriate storage facilities or containers that prevent animal access.

Vehicle, Machinery, Equipment and Load Hygiene

Arrow Energy is required to minimise the likelihood of introducing biosecurity matters when undertaking a journey, transporting loads, and moving equipment and must comply with the obligations in Section 15 of the Land Access Code 2016. Refer to the Vehicle, Machinery, Equipment and Load Hygiene Procedure (ORG-ARW-HSM-PRO-00138) for obligations and management requirements.

5.8 Surface Water

5.8.1 Applicable legislation

The following legislation, policy and guidelines are relevant to identifying values and mitigating and managing impacts on water 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, and it governs the management of surface water in regard to coal seam gas fields. 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 (Water and Wetland Biodiversity) Policy 2019* (EPP (Water and Wetland Biodiversity)): This policy sits under the EP Act, and its purpose is to achieve the object of the EP Act in relation to waters and wetlands, that is, protecting Queensland's water environment while allowing for development that is ecologically sustainable.
- *Coal Seam Gas Water Management Policy 2012* (Qld) (CSG Water Policy): This policy was developed to give direction to CSG operators for the treatment and disposal of coal seam gas water and to the role the government wishes to play in facilitating greater beneficial use of CSG water.
- *Water Act 2000* (Qld): This act provides the framework to deliver sustainable water planning, allocation management and supply processes to ensure the improved security of water resources. The project is within the region covered by the Water Resource (Condamine and Balonne) Plan 2004, which lies under the Water Act. The plan sets a requirement for the taking of or interfering with overland flow; therefore, such activities need an operational works approval under Schedule 3, Table 4 of Sustainable Planning Regulation 2009.
- *Environment Protection and Biodiversity Act 1999* (Cwlth) (EPBC Act): This Commonwealth act provides for the protection of matters of national environmental significance, including listed aquatic species and Ramsar sites. Changes to surface water systems have the potential to impact aquatic species and Ramsar sites. Any action with the potential for a significant impact on these must be referred to the Minister for the Department of Sustainability, Environment, Water, Population and Communities and may require approval under this act.

- *Fisheries Act 1994* (Qld): This act provides for the management, use and protection of fisheries resources in Queensland. In the event that Arrow needs to establish waterway barriers during watercourse crossings, approval must be sought under the Fisheries Act. The Fisheries (Freshwater) Management Plan 1999 under this act lists noxious species.

5.8.2 Description of environmental values

The regional surface water environment within the Project area is the Condamine-Balonne which forms part of the Murray-Darling drainage division. The main watercourse is the Condamine River flowing to the east to the north of the Project Area.

The hydrology of the surface waters flowing through the Project area has been extensively modified by land clearance, dams, weirs, and pumping infrastructure. Overland flow characteristics also vary, with vast areas of low-gradient floodplains or terraced surfaces generating little runoff except when saturated or under intense rainfall. When runoff is generated, expansive areas may be inundated.

Major floods occur on an average of every two years and generally in the months of late spring, summer, and autumn.

5.8.3 Surface water quality objectives and indicators

The environmental protection objectives for surface waters are:

- To avoid or minimise any degradation to water quality, water access, and the physical and biological characteristics of the watercourses and wetlands; and
- To maintain surface water amenity for the local community.

5.8.4 Assessment of environmental impacts

Potential impacts on surface water environmental values from the project's construction, operation and decommissioning activities include:

- Changes to physical form;
- Changes to hydrology; and
- Surface water quality degradation.

While the SGP EIS and SREIS, available on Arrow Energy's website, provide details on potential impacts, the following is an overview. Most importantly, the planning for CSG development in regard to development on floodplains must consider the RPI Act Statutory Guideline (02/14) *Carrying out resource activities in a Priority Agricultural Area* (July 2017), given that a significant portion of lands in the Project area has been designated as a Priority Agricultural Area (PAA).

During construction, operation, and decommissioning of wells, gathering lines and associated facilities such as access roads, the following impacts could occur:

- Changes to physical form and diminished water quality from the removal of riparian vegetation and subsequent reduced bank stability and increased erosion and sediment mobilisation.
- Diminished water quality from the removal of terrestrial vegetation leading to increased runoff and sedimentation in the watercourses.

- Diminished water quality from controlled and uncontrolled releases of hydrotest fluids.
- Diminished water quality from spills of hazardous materials or drilling muds.
- Damage to farmers' assets (including cropland) from placement of infrastructure in floodplains.
- Diminished water quality from earthmoving and soil stockpiling leading to increased sedimentation in watercourses.
- Flooding, changes to physical form and changes to hydrology by placing infrastructure in surface water flow paths.
- Changes to physical form and diminished water quality from pipeline or vehicle watercourse crossings causing bed and bank erosion and subsequent mobilisation of sediment.
- Changes to hydrology due to blockages in streams from pipeline watercourse crossings.

Potential impacts from flooding are the inundation of infrastructure and diversion of overland flows caused by inappropriately sited well production facilities. Diverted flows can cause erosion, loss of topsoil and prolonged inundation of crops leading to losses. As there are no processing facilities proposed for the development area, floodplain management for this EA report is focussed on the effects of wells and gathering lines and associated infrastructure.

5.8.5 Proposed Management practices

Primary mitigation measures to manage impacts to surface waters will include the following:

- Avoid permanent pools, chains of ponds, and alluvial islands, where practicable, when selecting watercourse crossing points.
- When siting facilities, avoid wetlands and consider the following:
  - Stream processes that may result in channel migration (either over time or as a result of project activities) and areas that are highly susceptible to erosion.
  - Downstream values of nearby watercourses or wetlands.
  - Minimising changes to natural drainage lines and flow paths.
  - Flooding regimes and areas subject to inundation.
  - Implement a 100 m wide buffer zone from the high bank of all watercourses to ensure that no development or clearance occurs within these buffers (other than construction of watercourse crossings for roads and pipelines and associated stream monitoring equipment).
  - Minimise watercourse crossings, where practicable, during route selection. Where required, select crossing locations to avoid or minimise disturbance to aquatic flora, waterholes, watercourse junctions and watercourses with steep banks.
  - Construct watercourse crossings in a manner that minimises sediment release to watercourses, stream bed scouring (e.g., the crossing location will be at low-velocity, straight sections, with the pipeline or road orientated

as near to perpendicular to water flow as practicable), obstruction of water flows and disturbance of stream banks and riparian vegetation. Avoid, where practicable, the use of rock gabions, as they are unsuited to watercourses of the region.

- Minimise the disturbance footprint and vegetation clearing.
- Clear areas progressively and implement rehabilitation as soon as practicable following construction and decommissioning activities.
- Grade soil away from watercourses.
- Control sediment runoff from stockpiles.
- Apply appropriate industry standards and codes of practice for the handling of hazardous materials (such as chemicals, fuels, and lubricants).

The following measures address potential impacts to stream hydrology:

- Check for flood warnings or subscribe to flood warning services where relevant during construction of watercourse crossings.
- Plan construction of watercourse crossings to occur during periods of low rainfall and low flow, where practicable.
- Avoid disrupting overland natural flow paths, and where avoidance is not practical, maintain connectivity of flow in watercourses.

Degradation to surface water quality will be minimised with the following measures:

- Develop an erosion and sediment control plan and install and maintain appropriate site specific controls.
- Locate soil stockpiles away from watercourses to minimise potential for sediment runoff to enter the watercourse.
- Use CSG water for dust suppression on roads or for construction and operations activities in accordance with the water quality parameters described in the EA.

Monitoring of surface water quality will be implemented to verify the residual impacts throughout the life of the project and to ensure mitigation measures are effective. Monitoring will be undertaken to demonstrate achievement of objectives and compliance with commitments.

Inspection and monitoring measures will include:

- Routinely monitor buffer zones and project footprint.
- Visually inspect physical form and monitor hydrology, turbidity, and pH upstream and downstream of crossings immediately prior to, during and after construction of watercourse crossings.
- Inspect erosion and sediment control measures following significant rainfall events to ensure effectiveness of measures is maintained.
- Routinely inspect spill containment controls and spill response kits.

A Coal Seam Gas (CSG) Water Management Plan (CWMP) for the SGP has been developed in accordance with Section 126 of the EP Act and is provided in Appendix G. Information to satisfy Section 126 and 126A of the EP Act which is specific to the Hopeland tenure is presented in Section 3.

5.9 Groundwater

5.9.1 Applicable legislation

The following legislation, policy and guidelines are relevant to identifying values and mitigating and managing impacts on groundwater quality or availability 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, and it governs the management of groundwater in regard to coal seam gas fields. 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.
- *Water Act 2000* (Qld): This act provides the framework to deliver sustainable water planning, allocation management and supply processes to ensure the improved security of water resources. The project is within the region covered by the Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017 and the Water Plan (Condamine and Balonne) 2019, both of which lie under the Water Act.
- *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.
- *Petroleum and Gas (Production and Safety) Act 2004* (Qld): The purpose of this Act is to facilitate and regulate the carrying out of responsible petroleum activities and the development of a safe, efficient, and viable petroleum and fuel gas industry, including the management of underground water resources.

Current approvals for groundwater management under which Arrow Energy operates, in addition to the PL253 EA, are:

- The Underground Water Impact Report (UWIR) 2025 for the Surat Cumulative Management Area (Surat CMA) [9], prepared by the Office of Groundwater Impact Assessment (OGIA) under the Water Act 2000 (Qld); and
- The EPBC Approval 2010/5344, Water Resource Monitoring and Management Plan 2025 (WRMMP)[10], under the EPBC Act.

5.9.2 Exercise of underground water rights

As indicated in this amendment application, a total of 55 new production wells (Section 1.5) are proposed to be constructed in addition to the production wells already authorised under EA0001401 (Section 1.2.2). The CSG water production over the life of the 55 new production wells will be in the order of 6.4GL with a peak rate of approximately 5.6ML/day in year 1 (2030) and diminishing through the project period. The total CSG water production for the authorised and new wells will be in the order of 17.3GL with a peak rate of approximately 10.1ML/day in 2030.

[9] Refer to the Surat CMA UWIR and its groundwater systems supporting reports, December 2025.
[10] Refer to the SGP Water Resource Monitoring and Management Plan, June 2025.

Arrow provides its water production volumes and forecasts to OGIA for inclusion in the Surat CMA UWIR.

A report to satisfy the provisions of Section 126A of the EP Act for the exercise of underground water rights for a resource project for this EA Amendment Application is provided in **Appendix E**, with abbreviated information provided in the following sections.

5.9.3 Description of environmental values

PL253 lies within the Surat Basin, a highly heterogeneous mix of alternating layers of sandstones, siltstones, mudstones and coal of Jurassic and Early Cretaceous age which attains a maximum thickness of approximately 1,000 m in the southwest of the tenure. The Surat Basin here sits unconformably over basement rocks, whilst generally relatively thin accumulations of unconsolidated Cenozoic sediments overly much of the Surat Basin sediments in the lower relief terrain.

The topographical relief of the area of PL253 is generally flat, with elevations between 310 (toward the northern and western edges) and 320 mAHD (through the centre), with steeper gradients to the southeast (up to approximately 370 m AHD). The majority of the area drains toward the south and west into Sixteen Mile and Wambo Creeks, while a small portion of the northern area drains to the north into the Condamine River. The elevated terrain in the southeast is bisected by the northerly flowing Kogan Creek.

The Cenozoic sediments consist of floodout and sheet sand with some alluvium, formed as a result of movement of sediments from higher ground in the east to lower ground in the west, toward Wambo Creek and the Condamine River. Drill logs in the area indicate that these Cenozoic sediments attain a maximum thickness of approximately 30 m closer to the creeks, thinning toward the east where it does not exist on the elevated terrain. The sediments comprise sand, red sandy soil, silt and some gravel, and can contain small local unconfined to semi-confined aquifers in the more permeable sediments. The physical aspects of these alluvial aquifers within the shallow groundwater system make them highly resilient to depressurisation impacts from CSG. The shallow groundwater system is dynamic, and is predominantly recharged from surface or diffuse drainage.

The Jurassic aged Gubberamunda Sandstone, Westbourne Formation, and Springbok Sandstone of the Surat Basin are the main units that outcrop in the development area and subcrop under the Cenozoic sediments, and overlie the Walloon Coal Measures, Eurombah Formation, Hutton Sandstone, Evergreen Formation and Precipice Sandstone which outcrop further to the northeast of the development area. The Westbourne Formation, Eurombah Formation and Evergreen Formation are considered tight aquitards, the Gubberamunda Sandstone, Springbok Sandstone and Hutton Sandstone are partial or tight aquifers, and the Precipice Sandstone is a regional aquifer as described by OGIA[11]. The Walloon Coal Measures are considered an interbedded aquitard, where the coal seams are thin, spatially limited water yielding zones interbedded in an otherwise tight aquifer.

An initial assessment of groundwater environmental values was undertaken as part of the SGP EIS and SREIS. Further studies and sampling since the EIS was approved

[11] Refer to the Surat CMA UWIR and its groundwater systems supporting reports, December 2025.

have provided Arrow a comprehensive understanding of groundwater in the area the subject of this EA amendment, including:

- Groundwater Monitoring Plan activities:
  - The sampling and reporting undertaken at 35 groundwater monitoring sites on and around Lot 40 DY85 (i.e. the former UCG site).
  - Groundwater modelling, using available and Arrow collected data, undertaken by third party suitable qualified experts. Arrow has completed three prior models of the EA area, firstly using the Office of Groundwater Impact Assessment (OGIA) Underground Water Impact Report (UWIR) model, and subsequently developing refined local scale models. The key elements of the current model, which includes hydraulic groundwater movement predictions and contaminant fate and transport predictions, are presented in this chapter and detailed in Appendix E.
- Groundwater modelling of the area conducted by the OGIA to inform their Surat Cumulative Management Area (Surat CMA) UWIR. This model is typically reviewed annually and updated every three years. The UWIR assesses the potential impacts on groundwater from CSG extraction in the Surat Basin CMA taking into account all existing and proposed CSG and coal mining projects.
- Groundwater monitoring undertaken as part of the UWIR water monitoring strategy at the Hopeland Pilot site and on adjacent tenures.
- Development of a Water Resource Monitoring and Management Plan for the SGP under the EPBC Act approval, including desktop review and field assessment of potential groundwater dependent ecosystems (GDEs).
- Baseline and bore assessment (47 and 24 respectively) of landholder bores conducted by Arrow within PL253.
- Geological, seismic and pilot production data collected by Arrow.

The studies above have established that limited environmental values for groundwater are present in the Hopeland area. A full description of groundwater environmental values is presented in Appendix E. The limited environmental values for groundwater in the area are:

- There is one spring in the area (the Orana spring), which is a spring with a local alluvial source aquifer and is not linked to the Great Artesian Basin formations and therefore not subject to impact from resource development in the Walloon subgroup. The depth to groundwater indicates that it has some limited environmental value with regards to intermittently supporting terrestrial groundwater dependent ecosystems from Cenozoic sediments.
- Desktop assessment and field investigations of potential terrestrial groundwater dependent ecosystems (GDEs) have been conducted in the east of PL253 around Kogan Creek. These areas have been identified as potentially at risk in the 2025 Surat CMA UWIR. The result of the investigations are either that the identified sites are not terrestrial GDEs, or are reliant on a shallow perched groundwater system which is disconnected from the regional system, and are therefore unlikely to be impacted by CSG development.
- The findings of the EIS / SREIS indicates that groundwater has no identified environmental value with regards to cultural heritage significance.

- There is some groundwater extraction for livestock watering and crop spraying from the Springbok Sandstone, Walloon Coal Measures, and Hutton Sandstone. The most accessible aquifers to landholders in this area (i.e. the Springbok Sandstone and coal seams in the Walloon Coal Measures) are brackish (~3,300 – 29,000 µS/cm and ~2,500 – 14,500 µS/cm respectively) and not suitable for drinking (drinking water is typically below 2,000 µS/cm). Treatment to drinking water quality due to the salinity would simultaneously remove potential contaminants of concern and hence there would not be a potential impact to human health through this potential pathway. Therefore, groundwater in the area has farming value to those landholders that can access it. However, the OGIA UWIR identifies the area will be within the immediately affected area (IAA) and long term affected area (LAA) for both the Springbok Sandstone and the Walloon subgroup. Therefore landholder bores where groundwater levels are or potentially will be affected by CSG activities triggers a requirement on proponents to enter 'make good' agreements with these landholders. Within PL253, there are 24 water bores predicted to be impacted by the exercise of underground water rights across the life of the development. Where it is determined from the bore assessment conducted as part of the 'make good' process that these landholder bores are or will be affected, these bores would be plugged and abandoned and alternative water sources, or appropriate compensation, provided. Therefore no pathway to these receptors would remain for potential groundwater contaminants of concern.

Table 5-11 provides a summary of the values which relate to the groundwater system where impacts are predicted from the identified resource activities on the respective tenure. Based on this, any impacts to environmental values will be in line with that presented in the SGPEIS, the UWIR 2025, and the WRMMP.

Table 5-11 Existing environmental values that may be affected by the exercise of underground water rights

Existing Environment/ Groundwater System	Intrinsic Characteristics and Hydrogeological Processes
Springbok Sandstone	• Groundwater from this system is of moderate biological importance due to generally brackish water quality. • There are no known areas of physical connection between this groundwater system and surface features within the tenement. • This aquifer is not known to support specific areas of cultural or spiritual significance. • This aquifer can provide a supply generally suitable for agricultural uses, excluding irrigation. • This aquifer forms a regional aquifer system across the GAB, and equivalent aquifers are common in many areas. • There are multiple recharge mechanisms producing a moderately resilient system that can recover over the medium term. • Rehabilitation can be achieved when impacts are removed.

Existing Environment/ Groundwater System	Intrinsic Characteristics and Hydrogeological Processes
WCM	• Groundwater from this system is of moderate biological importance due to generally brackish water quality. • There are no known areas of physical connection between this groundwater system and surface features within the project development area. • The aquifers in the WCM groundwater system provide a quality and supply generally suitable for agricultural uses, excluding irrigation. • The WCM groundwater system is a regional aquifer system across the GAB, and equivalent aquifers are common in many areas • The WCM groundwater system is less dynamic than other shallower systems, with limited recharge mechanisms. The aquifers within the WCM are recharged through rainfall only where outcropping and through inter-aquifer leakage and can recover from groundwater drawdown slowly. • Rehabilitation can be achieved when impacts are removed.

Groundwater Dependant Ecosystems (GDE)

Assessment of potential impacts to GDEs as part of the SGPEIS/SREIS has been updated to inform the Water Resource Monitoring and Management Plan (CSG WMMP[12]) to address the approval conditions. The assessments included:

- Identification of potential GDEs in the vicinity of the SGP.
- Use of numerical groundwater modelling to predict areas of potential impact.
- Correlation of potential GDEs with areas of potential impact to identify potentially at risk GDEs. This included consideration of:
  - Direct observation during site visits to confirm the presence or otherwise of groundwater dependent vegetation.
  - Site conceptualisation, including stratigraphy, depth to groundwater (including historical variability), characteristics of vegetation present and position in landscape.
  - Interpreted GDE source aquifer.
  - Ecosystem resilience and adaptability.

Within PL253 a spring has been identified which discharges to a small tributary off Wambo Creek, with the location shown in **Figure 13**. 3D Environmental investigated this spring (referred to as the 'Orana' spring in the 2025 Surat CMA UWIR and the 'Trebilco Spring' for Arrow's then Water Monitoring and Management Plan[13]) and found that it is an ephemeral spring which is fed by groundwater stored intermittently in the sandy ridge located west of the creek and is not likely sourced from the underlying GAB aquifers subject to potential impact through Arrow's activities. The groundwater in the sand is perched on low permeability clay and discharges where the phreatic surface intersects the lower slope of the creek bank at an elevation of approximately 301 m AHD. This is supported by the quality of the water which

[12] SGP Water Resource Monitoring and Management Plan, June 2025.
[13] Refer to Appendix D of the WMMP, September 2018

discharges from the spring, which is fresh and slightly acidic, with a dissolved solids of 146 mg/L and a sodium-chloride type. The source aquifer is attributed to Cenozoic sediments, and the 2025 Surat CMA UWIR spring risk assessment has identified this spring as a Category D (previously at risk) as the revisions to the conceptual understanding or impact predictions have reduced or eliminated the risk. It is considered unlikely that there will be any ecological impact to this sole non-GAB spring GDE as a result of the exercise of underground water rights.

Riparian vegetation that represents terrestrial groundwater dependent ecosystems (GDEs) may be present along significant reaches of some watercourses and their tributaries. Regional mapping, derived with varying levels of confidence from assessment of vegetation types and geology, indicates that the alluvial deposits associated with creek systems and the sandy plains of the Cenozoic sediments overlying the Westbourne Formation may support terrestrial GDEs (**Figure 13**). These GDE are described as ecosystems intermittently connected to aquifers with brackish to saline salinity and near neutral to alkaline pH in sandy plains or unconsolidated alluvia (https://wetlandinfo.detsi.qld.gov.au/wetlands/facts-maps/). The majority of the terrestrial GDE areas are predicted to experience less than 0.2m drawdown in the 2025 Surat CMA UWIR, and therefor are not considered to be at risk. However there are small areas of potentially 'low' and 'high' long-term at-risk terrestrial GDEs in the eastern third of PL253 around Kogan Creek.

A desktop assessment for Arrow's EPBC Act approval considered mapped vegetation, geology mapping and data, position in the landscape, depth to groundwater data and predicted groundwater drawdown to identify the potential for a site to be a terrestrial GDE. The assessment identified two areas associated with Kogan Creek and its tributaries within PL253 requiring further investigation through a field survey. The field survey, completed by 3D Environmental, utilised a methodology which aims to provide a consistent framework against which the likely degree and nature of groundwater dependence can be inferred including:

- An initial measurement of leaf water potential (LWP) used to infer the degree of moisture availability to a tree from either soil moisture or groundwater.
- Measuring soil moisture potential (SMP) from soil profiles collected at individual assessment sites which allows calibration of LWP results (i.e. can the reported moisture availability in the shallow soil profile explain LWP values?).
- Application of stable isotopes (oxygen 18 (δ18O) and deuterium (δ2H)) to trace moisture interactions between trees and the potential available moisture sources, including soil moisture or groundwater.
- Collection of surface water samples for analysis of 222Radon to assess the level of groundwater contribution to the water body.

Preliminary field inspections of one site identified that groundwater dependence is unlikely due to the site being located on a lateritic escarpment with a surrounding apron of sandy colluvial sediments, and vegetation at the site (*Eucalyptus crebra* and *Angophora leiocarpa*) are confirmed to have shallow rooting systems and are unlikely to be facultative phreatophytes (ie not terrestrial GDEs). This site is therefore not considered at risk from CSG induced groundwater.

The results of data collected at the second site indicated the riparian vegetation is predominantly utilising a mix of shallow groundwater and surface water, noting that

the groundwater is hosted in a perched system disconnected from the deeper regional groundwater system, namely:

- The average LWP value was -0.3 MPa, indicating extremely high moisture availability at this assessment locality.
- SMP values overlapped with LWP values in the upper 0.5 m of the soil profile.
- The stable isotope biplot of twig xylem, soil moisture, surface water and groundwater stable isotope samples indicates the riparian vegetation is utilising a mix of shallow (perched) groundwater and surface water.
- Radon activity on Kogan Creek has background levels of radon activity (0 to 0.071 bq/l), indicating the limited likelihood of groundwater discharge into surface water.

Results of the field investigation at the second site indicate that, while the site is a terrestrial GDE it is reliant on a shallow perched groundwater system which is disconnected from the deeper regional system, and therefore is unlikely to be impacted by CSG depressurisation.

Based on these assessments, there are no springs or terrestrial GDEs at risk of impact on PL253.

Figure 13 Drainage, tenure and mapped groundwater dependent ecosystems

Subsidence

Arrow Energy undertakes a subsidence monitoring program involving use of both Interferometric Synthetic Aperture Radar (InSAR) and Light Detection and Ranging (LiDAR) which provides baseline data and a regular interpretation of ground movement over the area of CSG extraction or planned extraction. InSAR technology provides high temporal resolution and wide coverage of change in elevation, while LiDAR provides high spatial resolution targeted coverage of terrain including slopes. Arrow Energy also collect geodetic measurement of ground movement at selected locations by conventional survey as well as at continually operating reference stations (CORS) to provide a ground-truthing check on subsidence.

Arrow's Water Resource Monitoring and Management Plan includes a subsidence assessment[14], as does the 2025 Surat CMA UWIR. Both these assessments cover PL253. The assessments include modelling of predicted subsidence for different regions within areas potentially affected by CSG drawdown, and risk assessment to identify if environmental values are likely to be adversely affected by ground subsidence resulting from CSG extraction activities. Review of potential impacts on various assets indicates that differential settlement or change in slope is more relevant than total subsidence. Predicted subsidence within PL253 in the 2025 Surat CMA UWIR is predicted to be less than 100mm for most of the tenure, with a small area along the western extent predicted to be up to 150mm, with change in regional ground slopes generally predicted to be less than 0.001% (10 mm over 1 km). As the topography is gently undulating, the potential for material impact from subsidence is low. However, where the CSG-related subsidence exceeds the investigation levels in the WRMMP, further assessment will be carried out to assess the site-specific infrastructure that may be impacted and identify whether an impact has occurred as a result of the Arrow operations.

5.9.4 Groundwater contamination associated with former Linc Energy UCG site Lot 40 DY85

Residual contamination from historical Underground Coal Gasification (UCG) by Linc Energy activities is present in the groundwater at Lot 40 DY85 within PL253. Contaminants include phenolic compounds, polynuclear aromatic hydrocarbons, BTEX compounds (benzene, toluene, ethylbenzene and xylene), and other hydrocarbon or organic compounds. The UCG operation has caused connection and enhanced permeability between the target of the UCG operation, the Macalister seam package, and the overlying Springbok Sandstone. The connection between the Springbok Sandstone and the Macalister seam package may result in movement of the contaminants as a result of the exercise of underground water rights within the WCM, by either increasing or changing the flow within or between units.

Since 2020, Arrow Energy has undertaken quarterly groundwater monitoring, annual reporting and hydrogeological modelling. These activities, together with historical studies (e.g., AECOM, 2018; DNRME, 2020) and published literature (McKellar, 1999; Camp and White, 2015; Mallants et al., 2018; OGIA, 2016, 2021; Scott et al., 2004) have supported the development of a robust understanding of the groundwater

[14] Refer to Appendix H of the WRMMP, June 2025

system, enabled characterisation of the extent of contamination, and improved understanding of contaminant fate and transport within and surrounding Lot 40 DY85.

The initial site conceptual model (SCM) and groundwater flow and contaminant transport models for Lot 40 DY85 and its surrounding were developed by GHD (2019 and 2020). These were subsequently refined and further advanced by AGE (2020 and 2023) to incorporate later data and uncertainty analysis. A comprehensive technical review on groundwater modelling and management in Arrow's previous EA amendment application was undertaken by CSIRO (2023) for the then Department of Environment and Science (DES). Based on this work, DES issued Environmental Authority EA0001401 (DES, 2023), dated 25 May 2023, for an initial 55 production wells (Kogan Creek batch) within PL253. Recommendations from CSIRO's review are incorporated in the EA conditions, including:

- Ongoing groundwater monitoring data coupled with updates in groundwater modelling to predict changes in groundwater water quality,
- Extending the simulation period and density of particle tracking in the models, and
- Installation of additional monitoring wells, with core collected and analysed for residual contamination, to better characterise the contaminant source term and use in the transport model.

Arrow Energy further developed a Groundwater Monitoring Plan (GMP) which includes a groundwater monitoring program, a SCM for Lot 40 DY85, groundwater flow and contaminant transport models, and an uncertainty analysis conducted by Intera (2024). The goal of the GMP is to fulfill the requirements of the condition Water 2 in the existing EA to ensure that potential impacts of Arrow's activities on groundwater systems are properly understood, predicted, and managed. Specifically, it aims to assess and model changes to groundwater flow, pressure, and contaminant behaviour; establish a robust conceptual and numerical understanding of the site; implement monitoring for early detection of any adverse changes; and define clear procedures for reporting and responding to groundwater impacts.

Arrow installed the four new Springbok Sandstone groundwater monitoring wells (Hopeland 34–37) in 2024 and collected 12 months of monitoring data from Q3 2024 to Q2 2025, with ongoing monitoring continuing since installation.

In 2025, Arrow updated the GMP (Arrow, 2025) and advanced the groundwater assessment and previous modelling (Intera 2024). This included updating the SCM to improve understanding of potential contaminant migration from Lot 40 DY85, revising and calibrating the groundwater flow model using all available data (including new monitoring from Hopeland 34–37), and incorporating uncertainty analysis to account for hydrogeological variability. In addition, particle tracking and contaminant transport modelling were undertaken and calibrated against observed water quality data, followed by predictive simulations to assess future contaminant behaviour with the 55 approved production wells (Kogan Creek batch). The updated GMP and modelling report (Intera, 2025), and the annual report (Arrow, 2025) were submitted to DETSI in December 2025.

5.9.4.1 Groundwater monitoring network

The staged groundwater monitoring network, comprising a total of 35 monitoring bores, as shown in **Figure 14**, includes:

- 11 monitoring bores installed by DETSI in 2018 (HSMB1 to HSMB5 series bores within Lot 40 DY85) and now operated by the Department of Natural Resources and Mines, Manufacturing, and Regional and Rural Development (DNRMMRRD),
- 8 monitoring bores installed by Arrow in 2019 (Hopeland 20 to 27 bores outside Lot 40 DY85),
- 10 monitoring bores installed by DNRMMRRD in 2020 (HSMB6 series and NB01 to NB05 series bores within Lot 40 DY85, and HSMB7 series outside Lot 40 DY85),
- 4 monitoring bores installed by Arrow between March and May 2024 (Hopeland 34 outside Lot 40 DY85, and Hopeland 35–37 bores within Lot 40 DY85), and
- 2 pre-existing landholder bores with Department of Regional Development, Manufacturing and Water (DRDMW) groundwater database (GWDB) numbers RN147004 and RN160158.

5.9.4.2 Monitoring completed

Groundwater monitoring has been undertaken by DETSI and DNRMMRRD (or predecessor departments) on their installed monitoring bores since 2018, with Arrow commencing monitoring of its installed monitoring bores since 2020. Arrow assumed monitoring responsibility for the DNRMMRRD owned monitoring bores from Q1 2024, with all previous data for these bores provided to Arrow.

Following each monitoring event, an investigation report was prepared and provided to DETSI, supporting a clearer understanding of the current status and historical trends of the contaminants, including how concentrations have changed over time. The investigation reports confirm that groundwater conditions at Lot 40 DY85 reflect a stable, legacy impacted system associated with historical UCG activities, with no evidence of continuing contaminant mobilisation or off site migration. Groundwater flow remains regionally east to west, with localised depressions within the former UCG area that continue to hydraulically contain contaminants. UCG related contaminants concentrations in the Springbok Sandstone and Macalister coal seam are consistent with historical trends and are generally stable or declining over time. Importantly, no UCG contaminants have been identified in the deeper Wambo coal seam package.

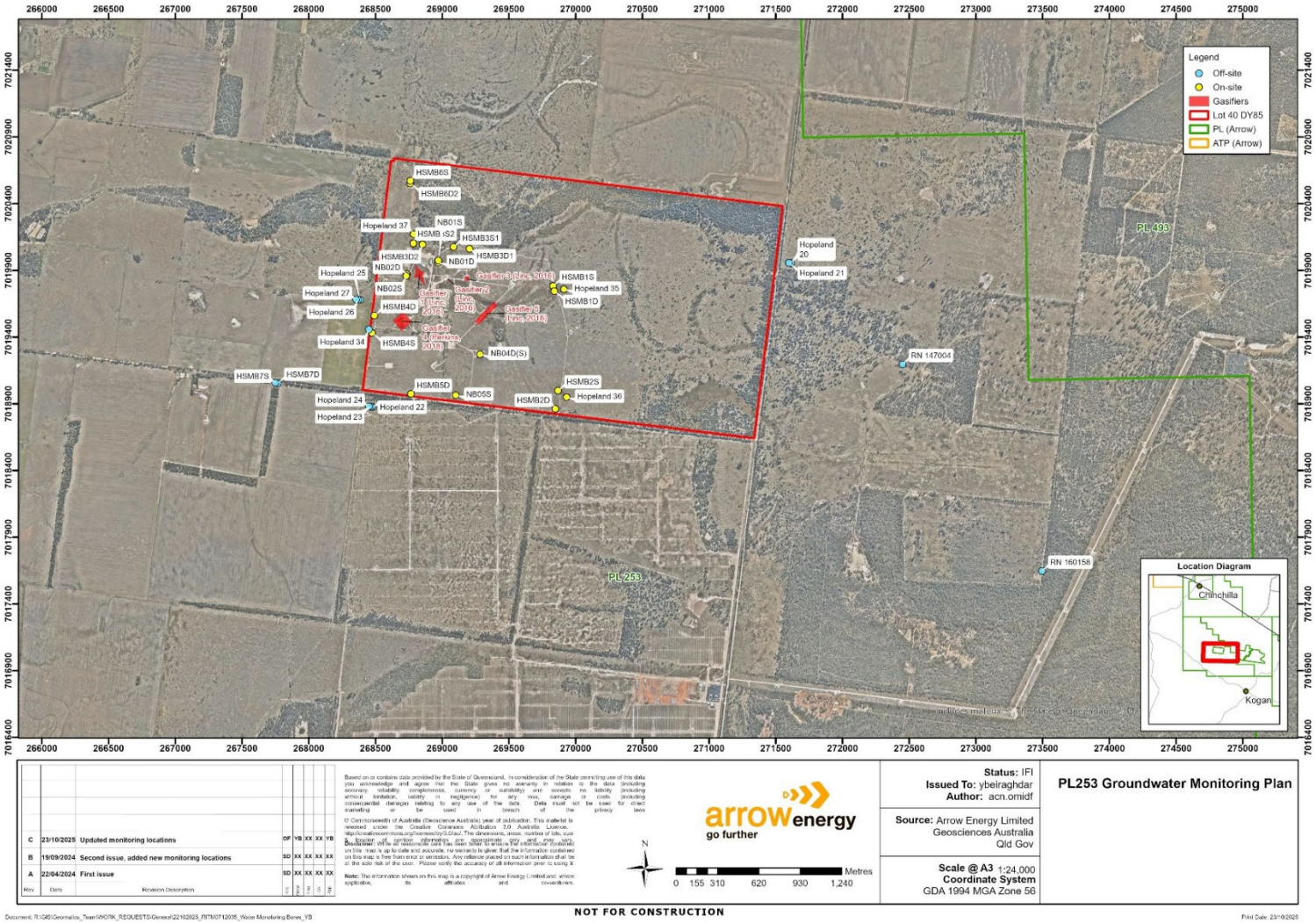


Figure 14 Groundwater monitoring network on and around Lot 40 DY85

5.9.4.3 Groundwater levels, pressures and flow

Regionally in PL253, groundwater flows to south and west in all Surat Basin aquifers and coal seams following the overall dip direction of the strata as documented in the 2025 Surat CMA UWIR. The coal seams are bedded between aquitards (e.g., siltstone), which limits the vertical movement of groundwater between each aquifer unit.

Due to the effects of gasification of coal and dewatering induced desorption of methane from coal during UCG operations, gas has been liberated in the area of Lot 40 DY85 leading to dual phase conditions, with a 'bubble' of free gas in and around the gasifiers restricting the groundwater flow into the gasifiers. As such, consideration of groundwater level and reservoir pressure (combination of groundwater level and gas pressure) is necessary to describe groundwater flow for the site.

Springbok Sandstone

Time series plots of Springbok Sandstone groundwater level and reservoir pressure are shown in **Figure 15**. Groundwater level and reservoir pressure contours for the Springbok Sandstone, prepared using data from the most recent monitoring event (Q1 2026), are shown in **Figure 16** and **Figure 17**, respectively.

The time series plots indicate permeability of the Springbok Sandstone is low, consistent with in-situ testing during drilling and ex-situ testing of core, with groundwater levels and reservoir pressure taking up to 12 months to stabilise following installation in 2018.

The time series plot and contours show a groundwater depression and reservoir pressure depression in the northern area of the site around monitoring bores HSMB3S1, HSMB3S2, NB01S and Hopeland 37. These monitoring bores also have the greatest difference between groundwater level and reservoir pressure, indicating the presence of free gas in the Springbok Sandstone in the same area, with the highest gas pressure measured in NB01S. This depression of groundwater levels and reservoir pressure, and presence of free gas, reflects the impacts of UCG operation with connectivity created between the gasifiers in the Macalister coal seam and the overlying Springbok Sandstone, with consequential loss of containment of syngas as described in the GMP (Arrow, 2024). Flow of groundwater in the Springbok Sandstone continues to be in towards the area of the gasifiers in this formation.

The Springbok Sandstone pressures are higher than those in the underlying Macalister coal seam, indicating a downward vertical pressure gradient between these two units, with the connectivity between the units controlled by the relative vertical permeability including any ongoing communication through UCG induced fracturing.

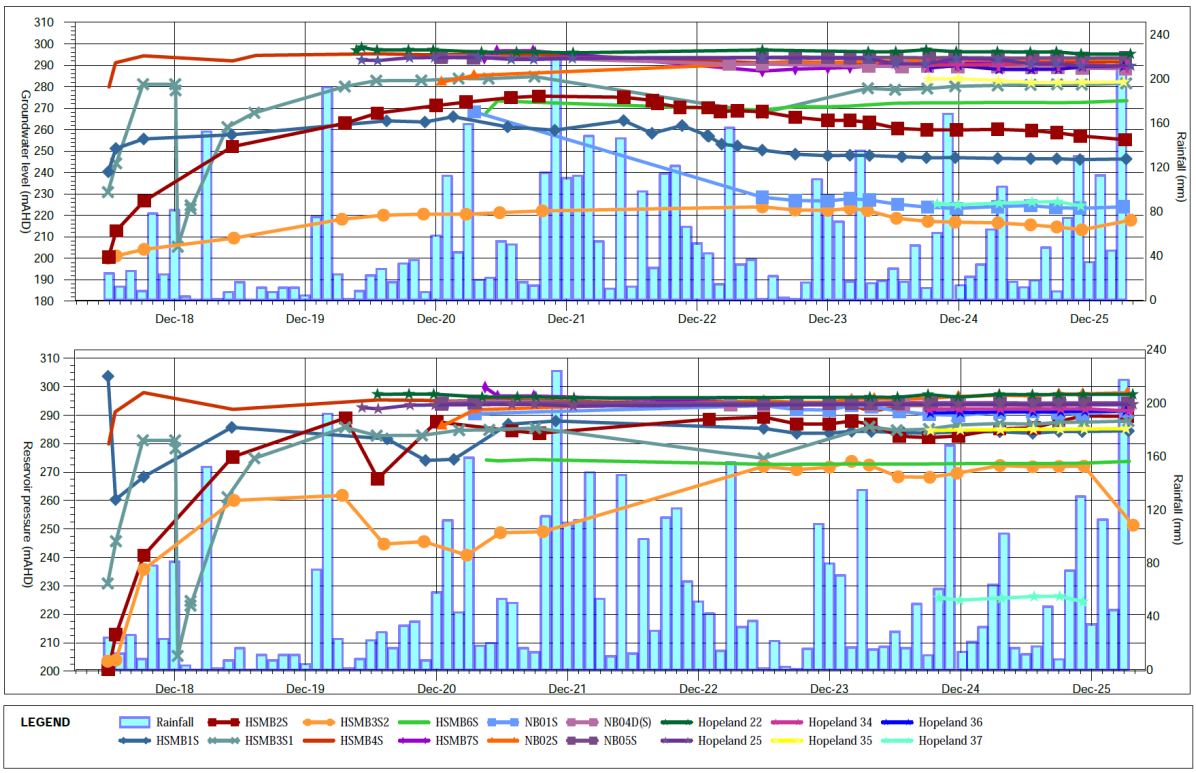


Figure 15 Springbok Sandstone groundwater level and reservoir pressures time series

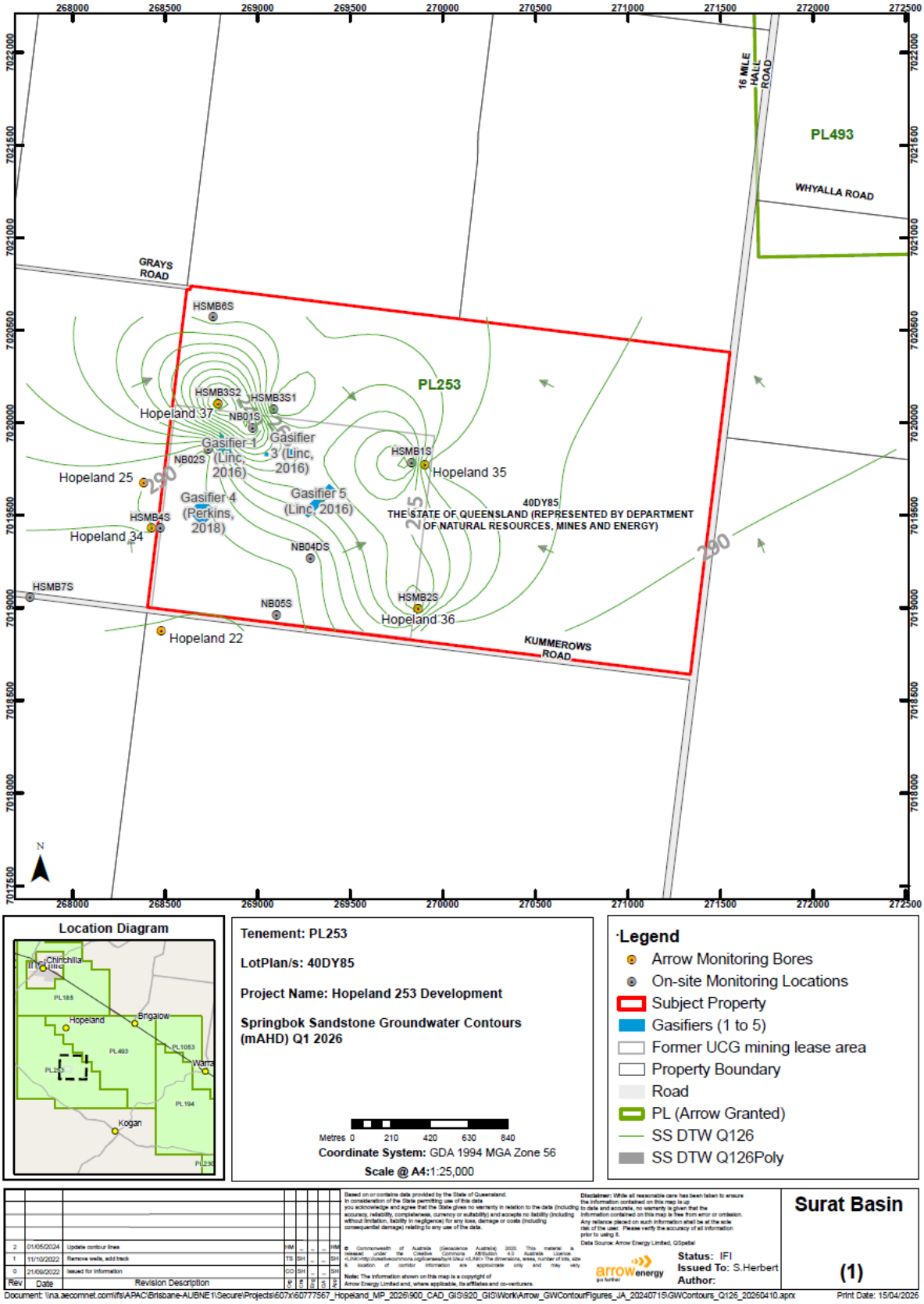


Figure 16 Springbok Sandstone groundwater level contours (mAHD) Q1 2026

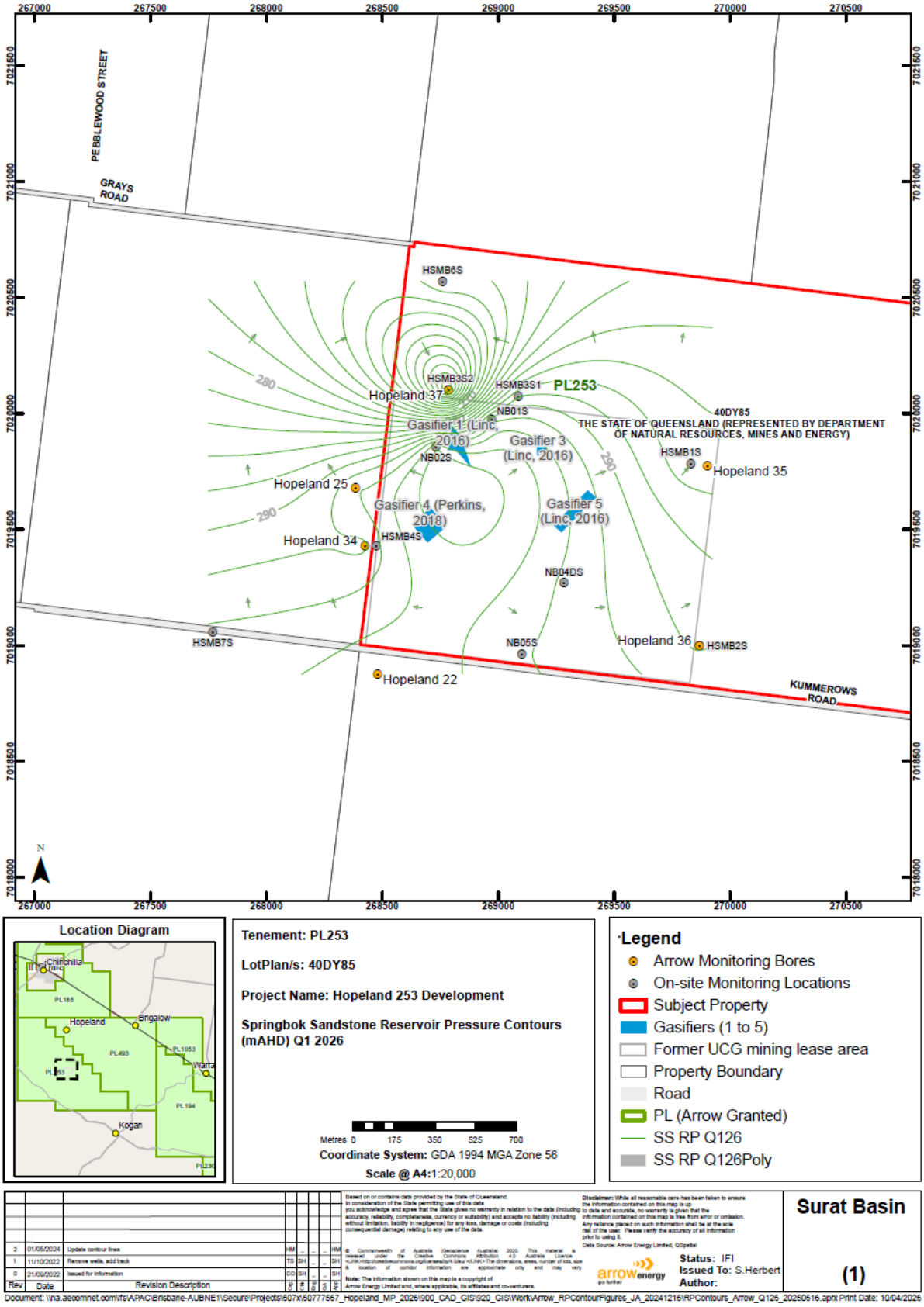


Figure 17 Springbok Sandstone reservoir pressure contours (mAHD) Q1 2026

Macalister coal seam

Time series plots of Macalister coal seam groundwater level and reservoir pressure are shown in **Figure 18**. Groundwater level and reservoir pressure contours of the Macalister coal seam for Q1 2026 are shown in **Figure 19** and **Figure 20**, respectively.

The time series plots and contours show a groundwater depression and reservoir pressure depression in the central area of the site between monitoring bores NB01D, NB02D and south towards HSMB5D. This depression is pronounced in the groundwater levels, but less so in the reservoir pressure where remnant syngas and desorption of methane from the coal contributes to a higher gas pressure component of the pressure. This is consistent with previous studies as described in the GMP (Arrow, 2024), which indicate the consumption of water during UCG operation resulted in dewatering of the coal, with limited groundwater flow (reduced recovery) subsequent to the UCG operation due to the remnant syngas and effects of methane desorption from the coal leading to dual phase conditions, with a 'bubble' of free gas in and around the gasifiers restricting the groundwater flow into the gasifiers. Potential flow gradient of groundwater in the Macalister coal seam continues to be in towards the area of the gasifiers, however with dry or near dry conditions close to and within the gasifiers, the 'bubble' of free gas present, and the limited pathways for the gas pressure to decrease (DNRMMRRD has undertaken plugging of UCG bores with integrity issues, UCG induced fractures have closed up, the Springbok Sandstone has relatively low permeability, and the coal is relatively flat lying with low potential for buoyancy driven migration), the rate of groundwater recovery is slow despite the steep hydraulic gradient. This suggests that any existing site contamination in the area of the UCG gasifiers is not currently migrating off-site via groundwater.

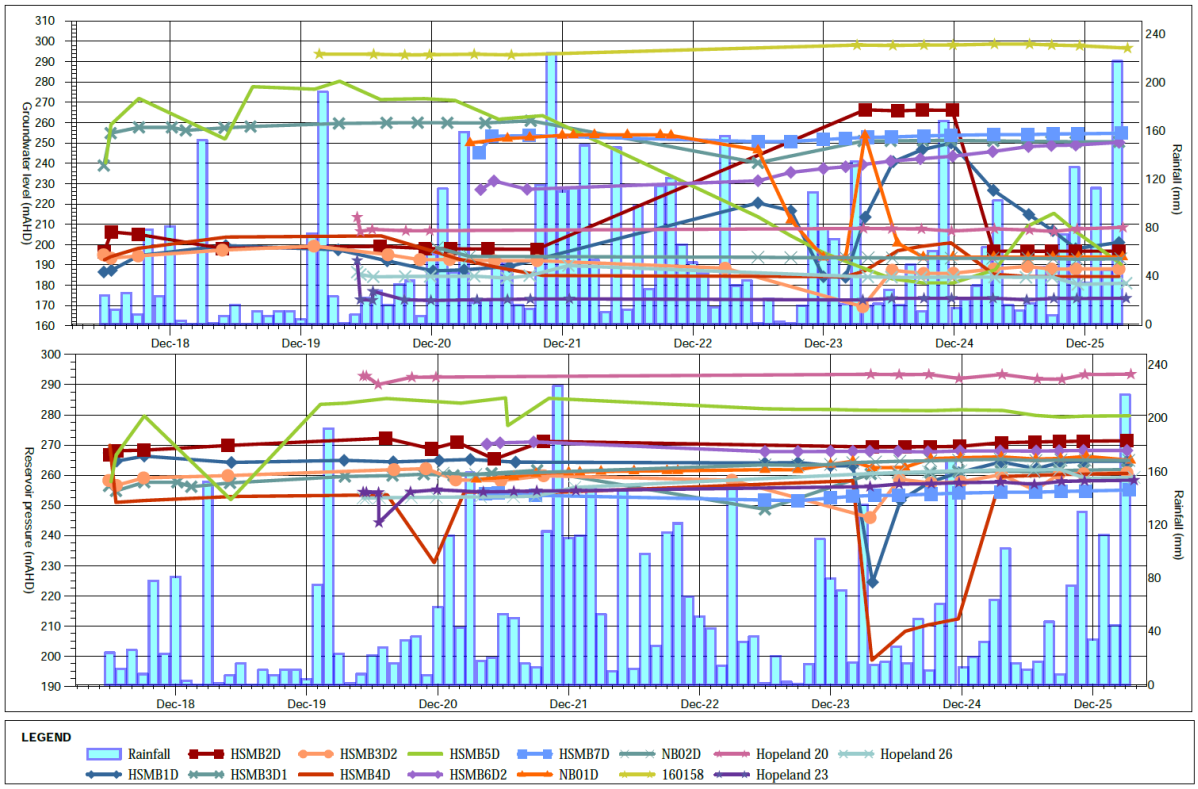


Figure 18 **Macalister coal seam groundwater level and reservoir pressures time series**

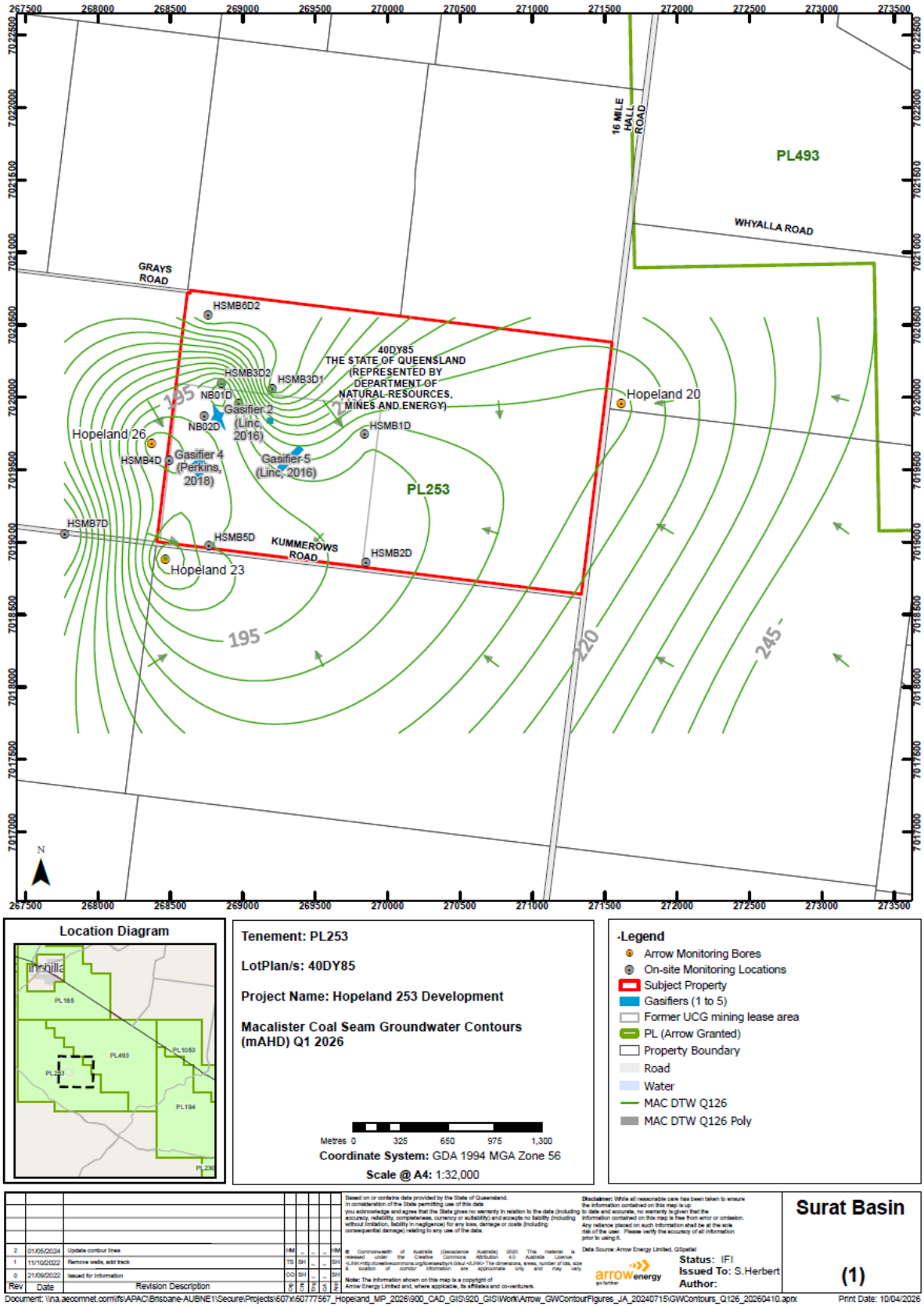


Figure 19 Macalister coal seam groundwater level contours (mAHD) Q1 2026

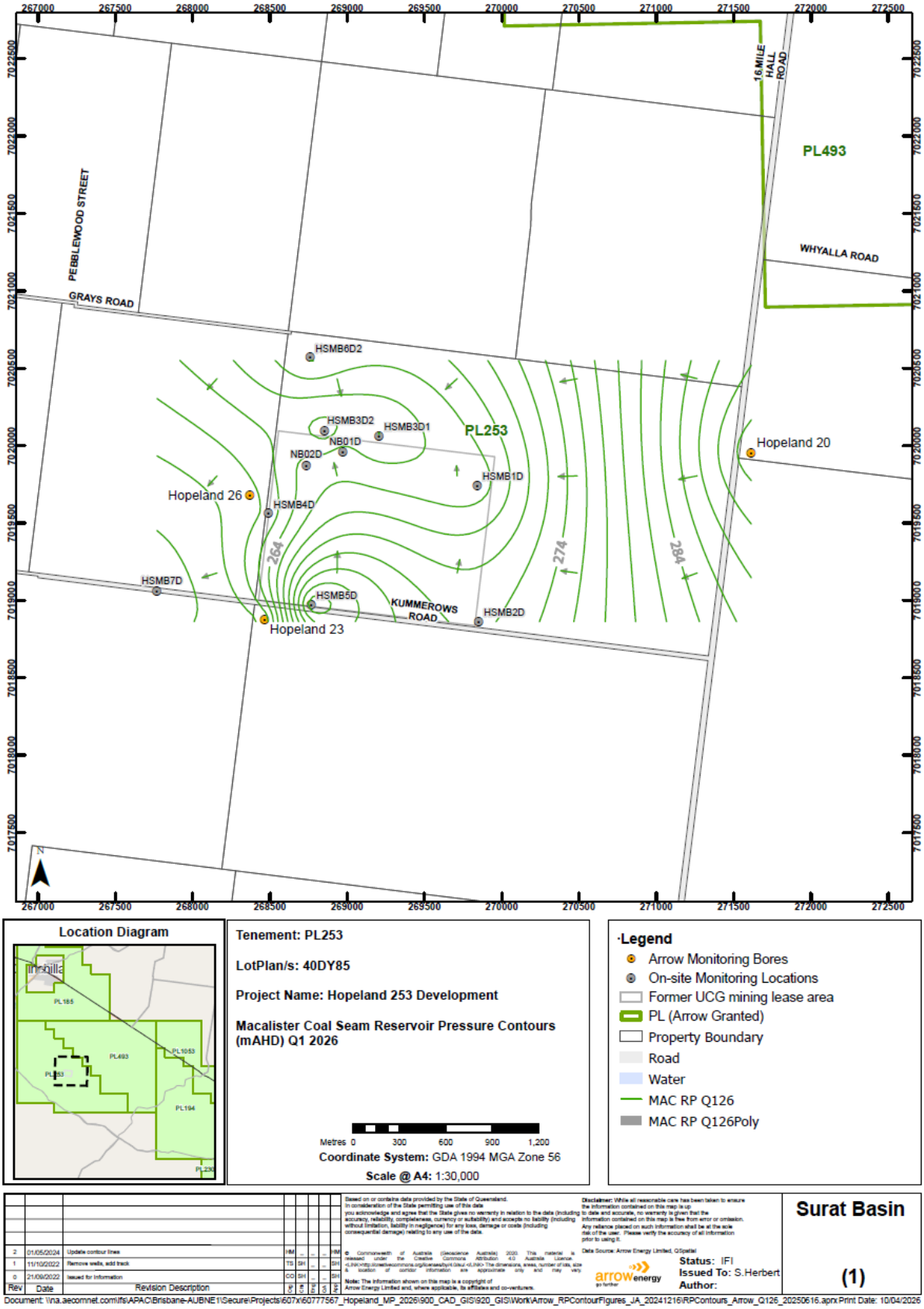


Figure 20 Macalister coal seam reservoir pressure contours (mAHD) Q1 2026

Wambo coal seam

Time series plots of Wambo coal seam groundwater level and reservoir pressures are shown in **Figure 21**. Groundwater level and reservoir pressure contours of the Wambo coal seam for Q1 2026 are shown in **Figure 22** and **Figure 23**, respectively.

The Wambo coal seam lies below the Macalister coal seam and is separated from the Macalister coal seam by low permeability material. The pressures in the Wambo coal seam are higher than pressures in the overlying Macalister coal seam, which is depressurised in the area of the gasifiers, indicating that flow potential is upward toward the UCG cavities within the Macalister coal seam on Lot 40 DY85. The pressure difference between the Wambo and Macalister coal seams indicates that the interburden is effectively separating the seams and will limit pressure transmission from underlying layers to the Macalister coal seam and the potential for contaminant migration downward from the Macalister coal seam.

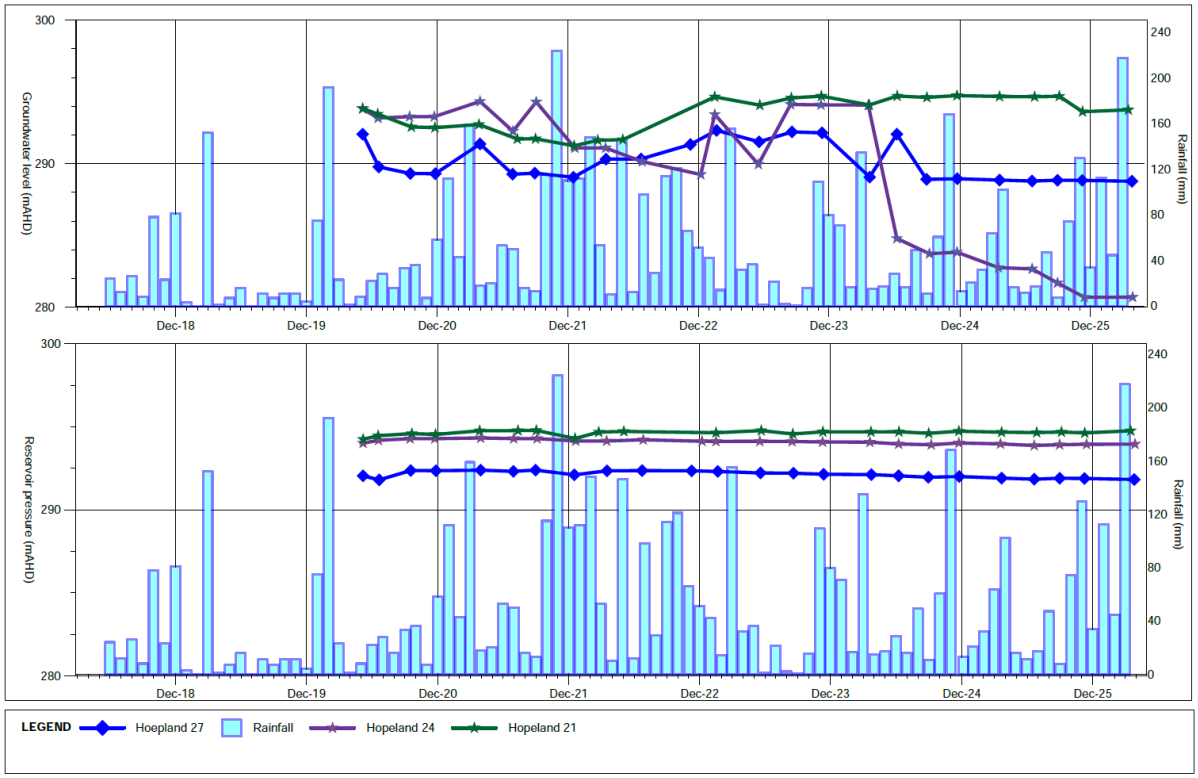


Figure 21 **Wambo coal seam groundwater level and reservoir pressures time series**

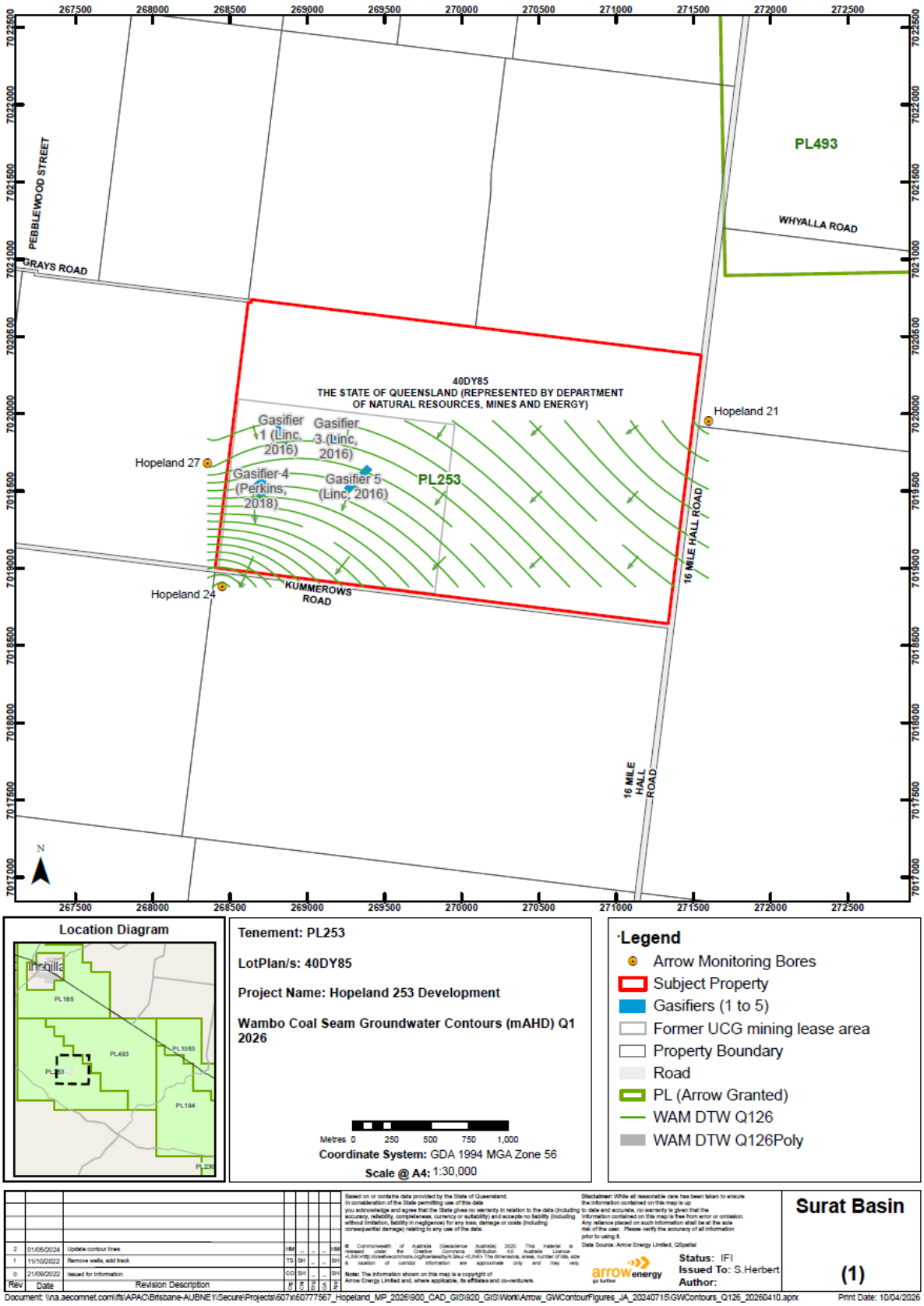


Figure 22 **Wambo coal seam groundwater level contours (mAHD) Q1 2026**

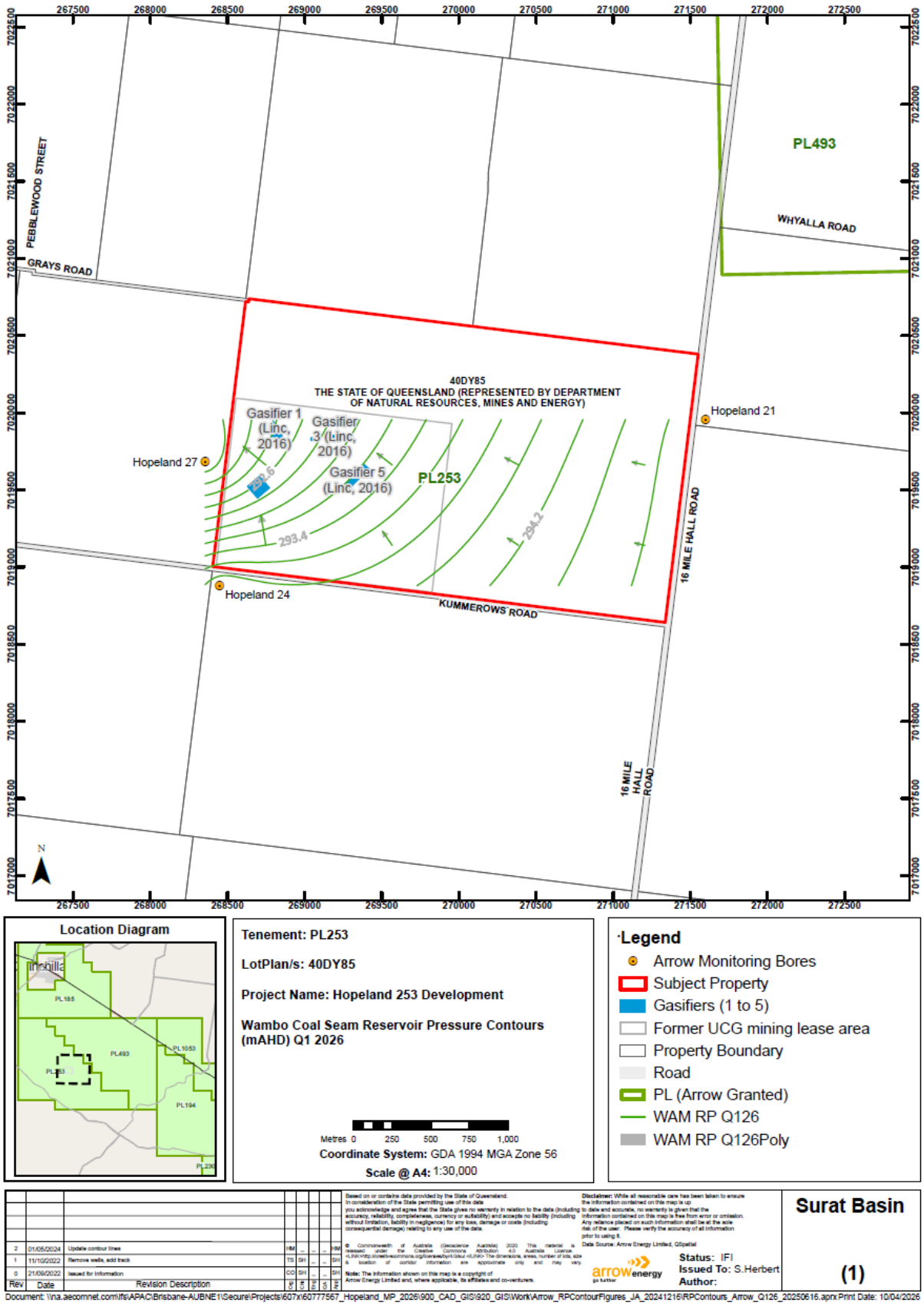


Figure 23 **Wambo coal seam reservoir pressure contours (mAHD) Q1 2026**

5.9.4.1 Groundwater quality

A high-level summary of groundwater data from DNRMMRRD-operated and Arrow monitoring bores, as well as landholder bores, is presented here, including field measurements and laboratory analytical results. Groundwater chemistry within the Springbok Sandstone and the Macalister and Wambo coal seams is presented graphically as Piper diagrams in the following sections.

Springbok Sandstone

Groundwater sampled from the Springbok Sandstone is typically brackish (EC: 1,600 – 4,800 µS/cm) to saline (EC > 4,800 µS/cm). Field EC values range from approximately 4,500 µS/cm at Hopeland 36 (brackish water) to 31,000 µS/cm at Hopeland 37 (saline water), with an average of about 14,000 µS/cm. The pH of groundwater from the Springbok Sandstone tended to be variable between monitoring bores, with some (Hopeland 25 and HSMB3S1) tending to be mildly acidic, with the remainder mildly alkaline apart from NB02S and NB05S which are strongly alkaline. This strong alkalinity in these two bores may be due to effects of UCG operation, or the cement contamination through the perforations of these monitoring bores.

Major ion chemistry for Springbok Sandstone, presented as a Piper diagram in **Figure 24**, shows that the groundwater within this formation is typically of a sodium-potassium-chloride type.

Concentrations of UCG contaminants—including phenolic compounds (e.g. phenol, 2-methylphenol, and 3- and 4-methylphenol), polynuclear aromatic hydrocarbons (PAHs) (e.g. naphthalene), total recoverable hydrocarbons (TRH; silica gel clean-up fractions such as >C16–C34 and >C34–C40), total cyanide, and BTEXN (e.g. benzene, toluene, ethylbenzene, and xylene)—have generally been below the investigation limits or show no increasing trend outside Lot 40 DY85. These contaminants are largely confined to Lot 40 DY85, where concentrations in monitoring bores have remained stable or are generally decreasing over time.

GHD (2020) identified benzene and naphthalene as the primary contaminants associated with UCG operations. Other organic constituents, such as toluene, have been detected at generally low concentrations, well below their respective investigation limits. Accordingly, benzene and naphthalene are presented here as representative contaminants of concern (COCs), as they are sufficient to delineate the extent of groundwater impacts and were also adopted in the contaminant transport modelling.

Benzene, a known carcinogen, is the most mobile of the BTEX compounds due to its high solubility and low adsorption potential (Odermatt, 1994), while naphthalene is the most water-soluble PAH (Bayard et al., 2020). Both compounds exhibit the highest concentrations within their respective groups in the site dataset and have been used in previous studies (AGE, 2023). In addition, benzene degrades more slowly than other BTEX compounds (Prommer et al., 2002, 2003), making it a reliable indicator of the spatial extent of groundwater contamination.

Figure 25 and **Figure 26** present benzene and naphthalene concentration time series for Springbok Sandstone monitoring bores in and around Lot 40 DY85. The data indicate naphthalene already attenuated to below the limit of reporting (LOR = 1 µg/L,

Investigation Limits > LOR) in the Springbok Sandstone. There are clear and consistent declining trends in contaminant concentrations across the site, reflecting gradual attenuation over time consistent with ongoing natural attenuation processes.

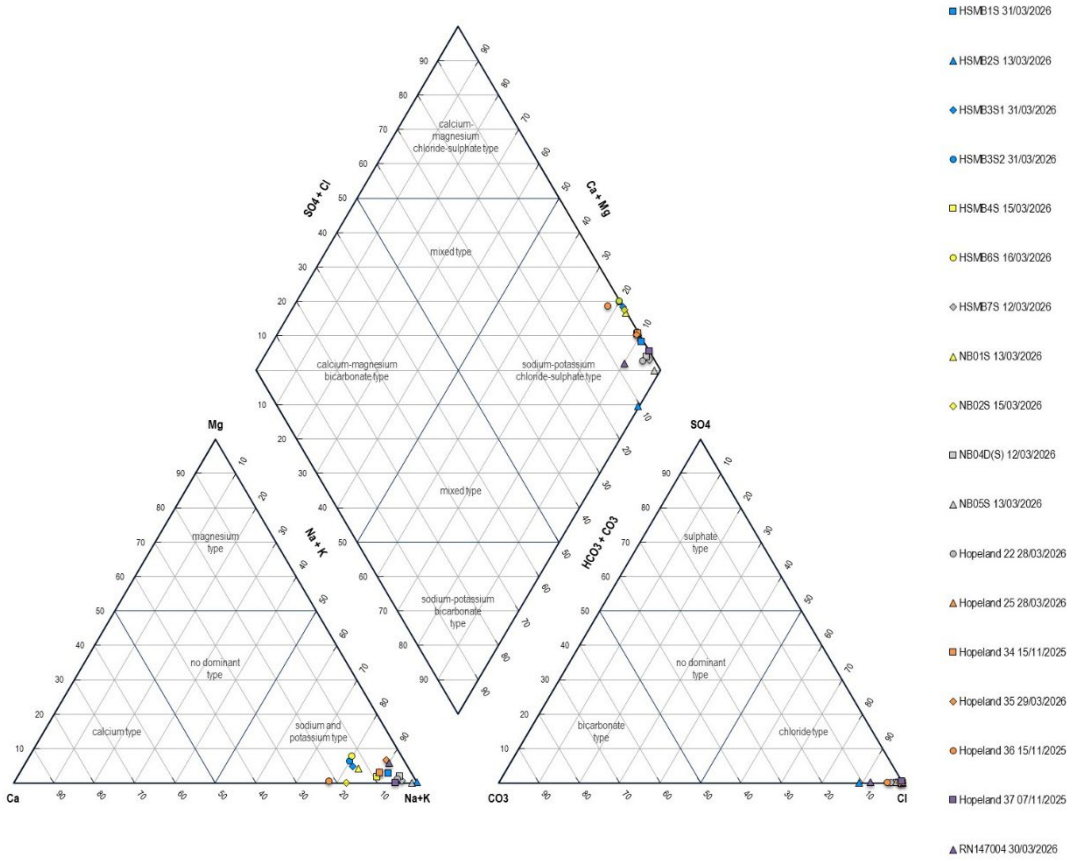


Figure 24 Piper diagram for Springbok Sandstone groundwater constructed using Q1 2026 data (Hopeland 34, 36, and 37 data were not available in this quarter; Q4 2025 data were used instead)

Elevated concentration of benzene remains localised in the specific monitoring bore, NB01S, indicating proximity to residual source areas (i.e., gasifiers). However, this impact is spatially constrained and does not indicate plume expansion. It should be noted that benzene concentration at this location was initially increasing from 2021 to 2024, followed by a stabilising or declining trend since 2024.

Importantly, benzene and naphthalene have not been detected in off-site monitoring bores, including downgradient locations. This provides additional confidence that contamination is not migrating beyond the site boundary and confirms that groundwater impacts remain contained within Lot 40 DY85.

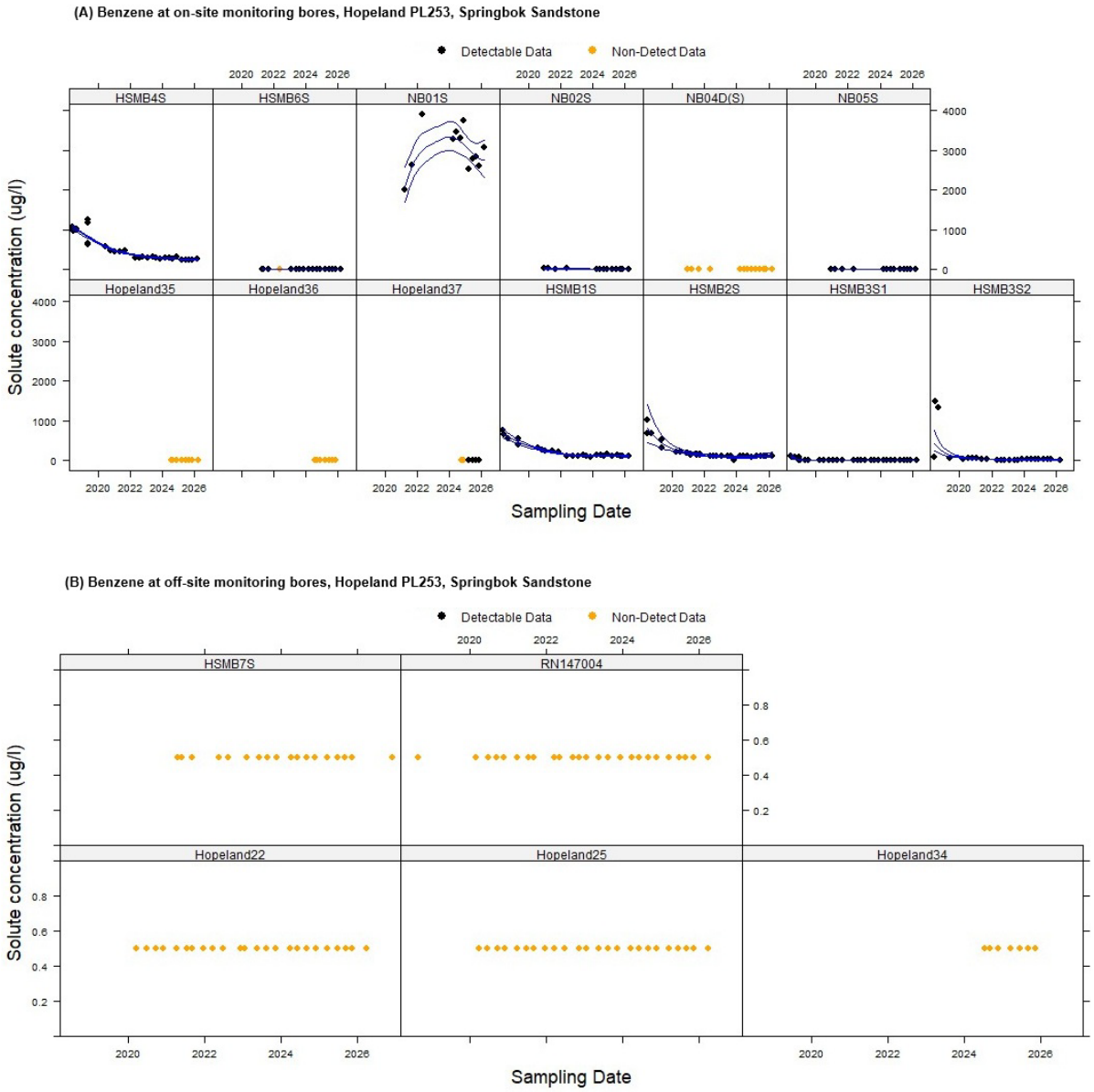


Figure 25 Benzene concentration time series at monitoring bores screened in Springbok Sandstone, Hopeland PL253. (A) on-site monitoring bores, and (B) off-site monitoring bores

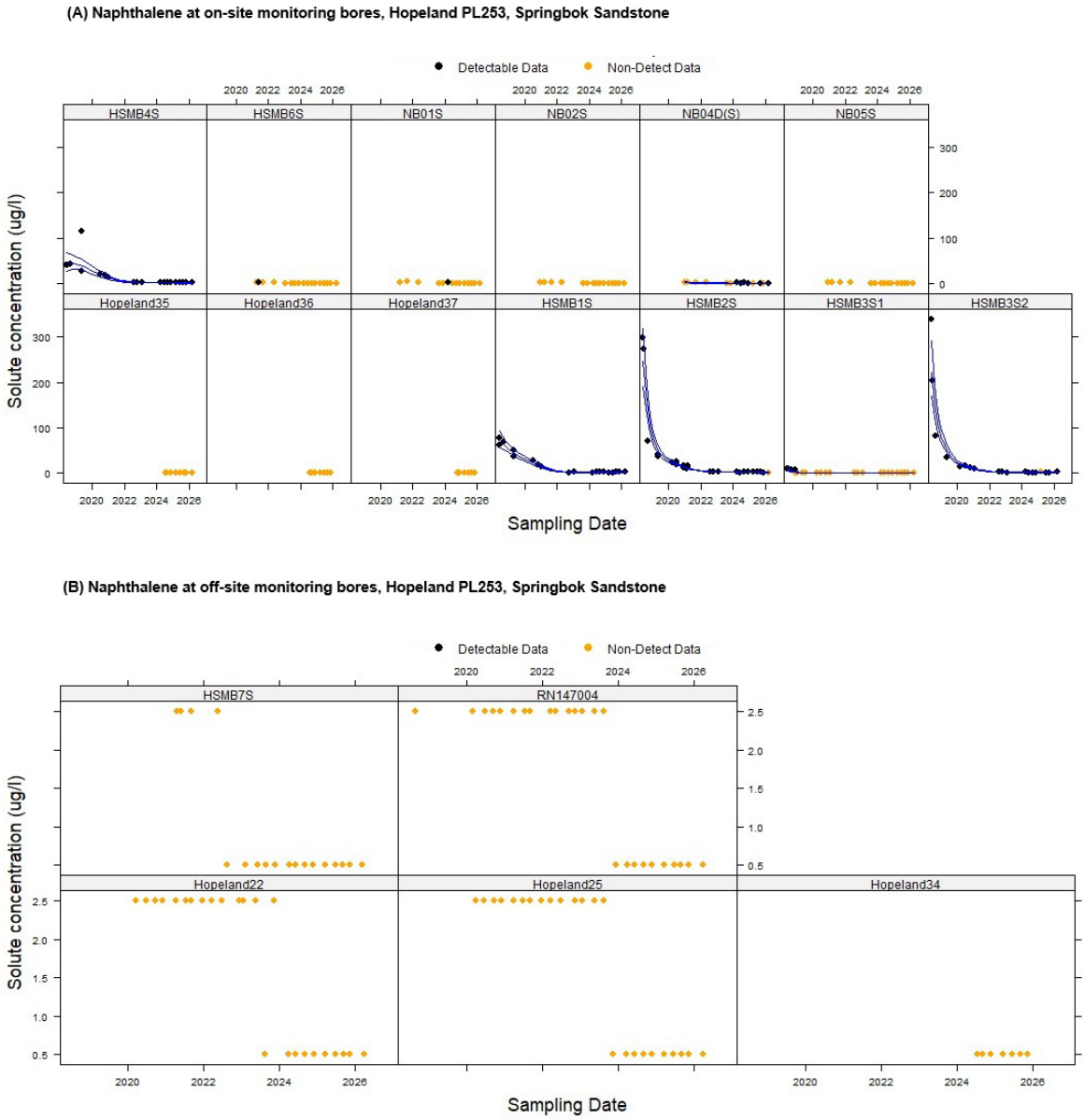


Figure 26 Naphthalene concentration time series at monitoring bores screened in Springbok Sandstone, Hopeland PL253. (A) on-site monitoring bores, and (B) off-site monitoring bores

Macalister coal seam

Groundwater from the Macalister coal seam is predominantly brackish to saline in character. EC measurements obtained during the monitoring programs ranged from approximately 2,000 µS/cm at HSMB5D to 18,000 µS/cm at HSMB4D, with a mean EC of approximately 5,500 µS/cm. In comparison with Springbok Sandstone, the pH of the Macalister coal seam tends to be consistently mildly alkaline to alkaline.

Major ion chemistry is shown in **Figure 27**, with the Piper diagram indicating groundwater within this formation is typically of a sodium-potassium-chloride type to sodium-potassium-bicarbonate type.

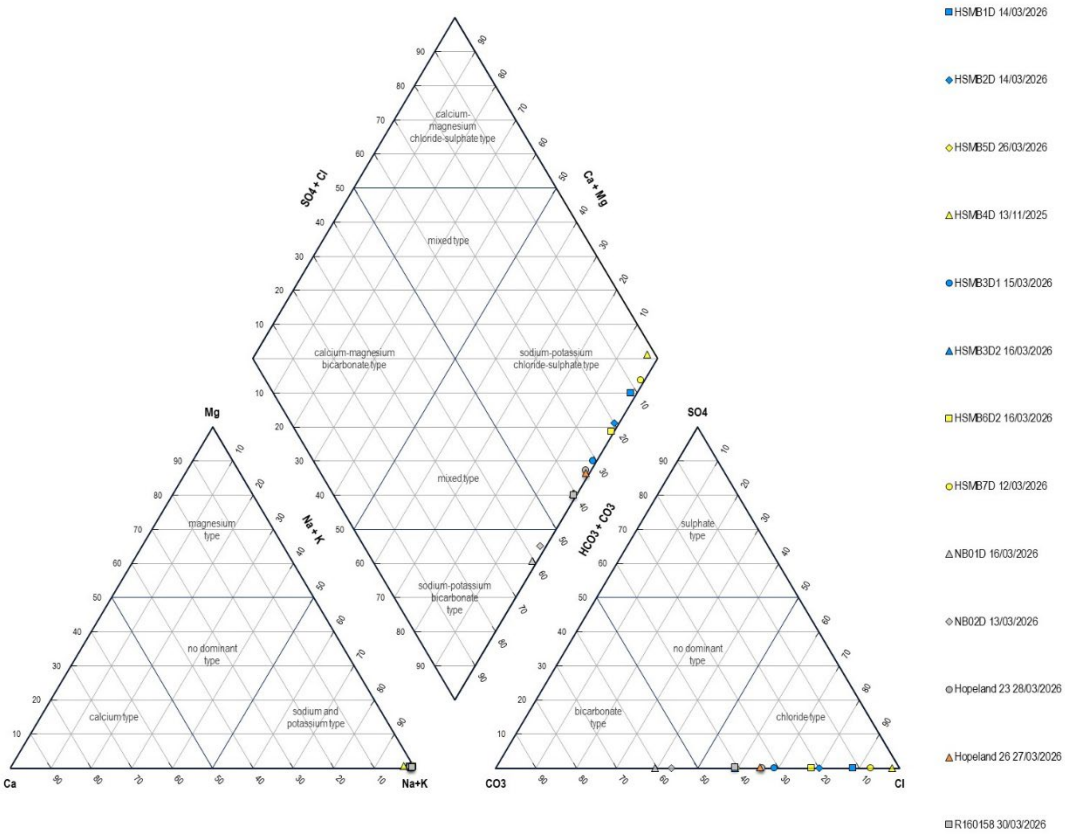


Figure 27 Piper diagram for Macalister coal seam groundwater constructed using Q1 2026 data (HSMB4D data were not available in this quarter; Q4 2025 data were used instead)

Figure 28 and **Figure 29** present benzene and naphthalene concentration time series for Macalister coal seam monitoring bores in and around Lot 40 DY85. Similar to the Springbok Sandstone, naphthalene has attenuated to below the detection limit in the Macalister coal seam. Benzene has undergone long-term exponential attenuation, with concentrations in the majority of bores falling below detection limits in recent years.

It is noted that benzene was detected above the investigation limit in only one monitoring bore outside Lot 40 DY85 (HSMB7D).

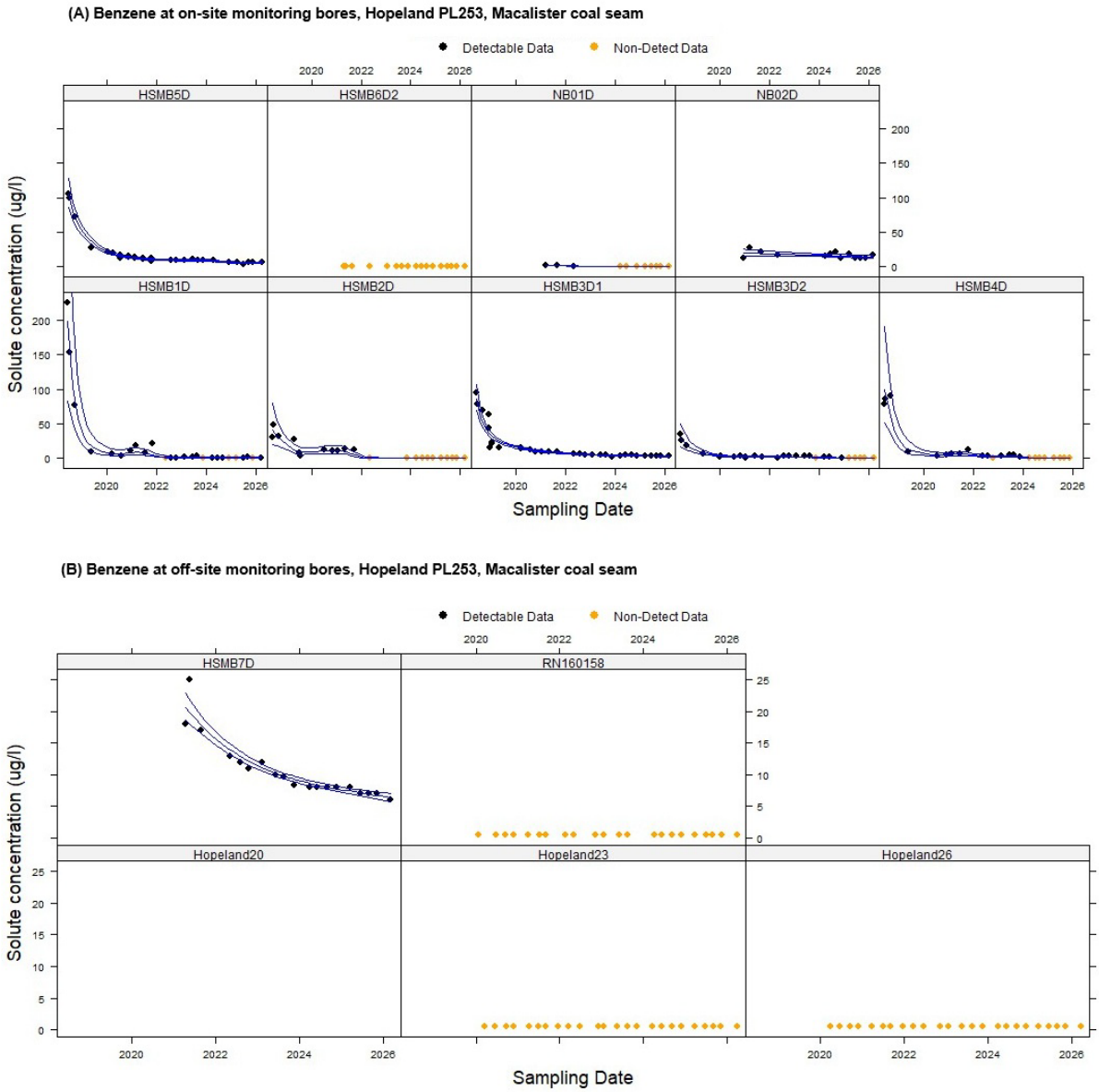


Figure 28 Benzene concentration time series at monitoring bores screened in Macalister coal seam, Hopeland PL253. (A) on-site monitoring bores, and (B) off-site monitoring bores

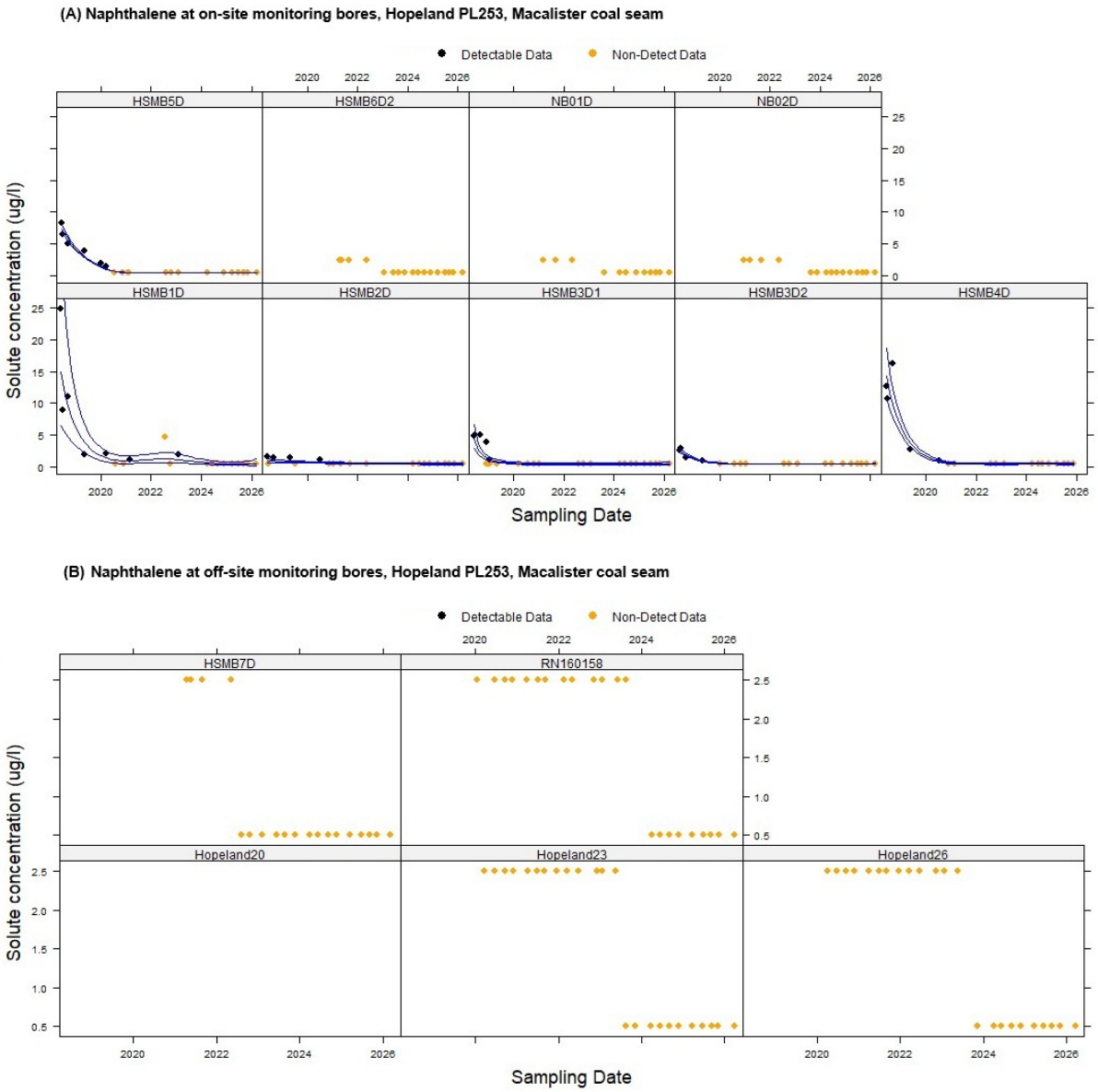


Figure 29 Naphthalene concentration time series at monitoring bores screened in Macalister coal seam, Hopeland PL253. (A) on-site monitoring bores, and (B) off-site monitoring bores

Wambo coal seam

The groundwater sampled from the Wambo coal seam is typically of brackish salinity, with a narrow range around approximately 3,500 µS/cm for the three monitoring bores. Similar to the Macalister coal seam, the pH of the Wambo coal seam ranges from mildly alkaline to alkaline.

Major ion chemistry is shown in **Figure 30**, with the Piper diagram indicating groundwater within the Wambo coal seam is typically of a sodium-chloride type to sodium-bicarbonate type.

No benzene or naphthalene above the LOR have been reported in the monitoring bores installed in the Wambo coal seam.

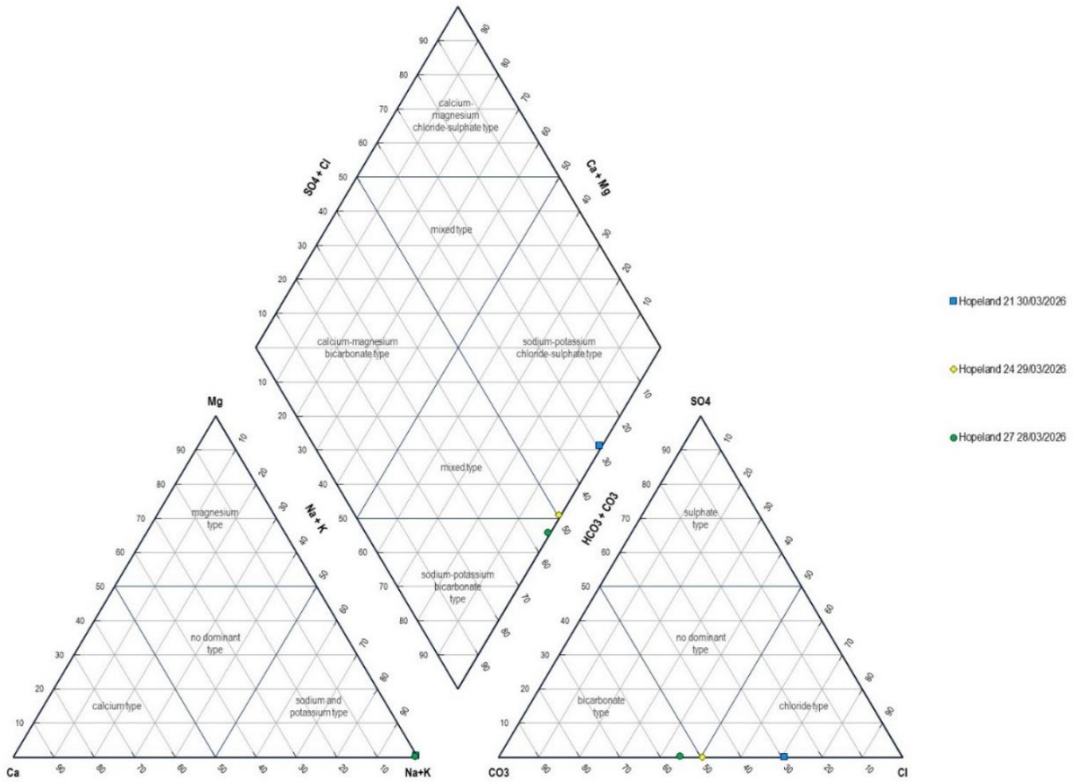


Figure 30 **Piper diagram for Wambo coal seam groundwater constructed using Q1 2026 data**

5.9.4.2 Site conceptual model

A high-level summary of the site conceptual model (SCM) is presented below, with further details provided in **Appendix E**.

The SCM synthesises geological, hydrogeological, operational, and monitoring information to describe how groundwater flows and how residual contaminants behave at the former UCG site (Lot 40 DY85) within PL253. It provides the foundation for groundwater flow and contaminant transport modelling and subsequent impact assessment.

Geological and hydrostratigraphic framework

Of primary hydrogeological importance are the Springbok Sandstone and the underlying WCM, particularly the Macalister coal seam. These units form the major aquifer and coal bearing interval influencing groundwater flow and contaminant behaviour at and around the former Lot 40 DY85 UCG site.

Although UCG activities have locally altered hydraulic properties near gasifiers, there is no evidence of laterally extensive faults or preferential pathways that would facilitate rapid off site groundwater flow. Indeed, analysis of well logs (e.g., FMI) and cores at from monitoring bores at the site (Intera, 2025) indicates that conductive fractures are primarily confined to interburden shales and siltstones, while coal seams and deeper sandstones are largely unfractured. The Macalister coal seam exhibits the highest fracture density, whereas the Springbok Sandstone and Wambo coal

seam remain mostly intact. Small faults and partially conductive fractures in the Kogan and Wambo coal seams may locally enhance vertical connectivity but are unlikely to form permanent preferential pathways for groundwater or contaminant transport from the Macalister coal seam to shallower units.

Historical UCG influences

UCG operations conducted between 1999 and 2013 caused localised modifications to the hydrogeological system within Lot 40 DY85. Thermal alteration, gasification voids, and depressurisation led to increased permeability and the introduction of hydrocarbon related contaminants in proximity to gasifier locations. These impacts were spatially restricted to the immediate UCG footprint and did not propagate regionally.

Following cessation of UCG activities, pressures have progressively recovered and monitoring data indicate stabilisation and improvement in groundwater conditions. The conceptual model concludes that UCG impacts as discrete, legacy features with finite contaminant mass and diminishing influence through time, rather than as ongoing or expanding sources.

Groundwater flow regime

Groundwater flow at the regional scale, in PL253, is directed predominantly toward the south to southwest, consistent with Surat Basin hydraulic gradients and the cumulative influence of long term coal seam gas production. These regional controls dominate groundwater behaviour beyond the immediate site.

At the local scale, groundwater flow near Lot 40 DY85 reflects a combination of residual UCG effects and regional depressurisation. In the Springbok Sandstone, hydraulic heads tend to define inward directed gradients toward the site, promoting hydraulic containment of the affected area. Within the Macalister coal seam, groundwater flow is mainly directed west to southwest, in alignment with broader WCM flow patterns.

Vertical hydraulic connectivity

Vertical groundwater movement between the Springbok Sandstone and the Macalister coal seam is constrained by intervening low permeability strata and is governed by a consistent downward hydraulic gradient. Monitoring data indicate that groundwater levels in the Springbok Sandstone remain higher than those in the Macalister coal seam across the site and surrounding area.

This downward gradient reduces the likelihood of upward contaminant migration from the coal seams into the overlying aquifer. Importantly, the conceptual model identifies no sustained or widespread upward gradients under historical, current, or proposed development conditions, reinforcing the understanding that vertical contaminant transfer is limited.

Groundwater contamination at Lot 40 DY85

Long term groundwater monitoring demonstrates that elevated concentrations of contaminants are largely confined to the site and that off site monitoring bores generally report concentrations below laboratory limits of reporting, except for HSMB7D, where benzene concentrations have been detected above applicable investigation limit but exhibit an exponential attenuation trend. Temporal trends show

a sustained decline in detected concentrations—particularly since 2018–2020—indicating plume stability and attenuation rather than expansion.

Natural attenuation and source depletion

The conceptual model incorporates natural attenuation processes as a key mechanism governing the long term behaviour of residual contamination. These processes include sorption to coal and fine grained sediments, biodegradation, and dispersion within a low velocity groundwater system.

Residual contaminant sources are conceptualised as finite and progressively depleting. While small areas near former gasifiers may retain detectable concentrations for extended periods, the available evidence indicates that these zones do not act as strong or persistent drivers of plume migration beyond the site boundary.

Conceptual risk understanding

Integration of geological controls, groundwater flow patterns, monitoring data, and historical operational context leads to a conceptual understanding that overall groundwater risk is low and diminishing. Hydraulic gradients favour containment, vertical connectivity is limited, and contaminant sources are finite and attenuating.

Key conceptual risk conclusions are that:

- off site lateral migration is slow and restricted,
- upward vertical migration is unlikely,
- concentrations are declining with time, and
- proposed CSG development by Arrow Energy does not fundamentally alter the controlling hydrogeological processes.

This conceptual understanding provides a strong and coherent foundation for the numerical groundwater flow and contaminant transport modelling and supports the conclusion that long term risks to surrounding groundwater resources are minimal.

Arrow engaged Worley Consulting to undertake groundwater flow, contaminant transport, and particle tracking modelling, and uncertainty analysis. This work (**Appendix E**) was carried out to assess potential changes to the groundwater flow regime and drawdown, as well as the likelihood of UCG-related contaminants migrating from the former UCG site at Lot 40 DY85 in response to Arrow's proposed field development plan. The outcome of this work is summarised in **Section 5.9.6**.

5.9.5 Groundwater quality objectives and indicators

A water monitoring strategy (WMS) is included in the 2025 Surat CMA UWIR. The WMS includes an integrated regional groundwater monitoring network to collect data on water pressure and water quality in the Surat CMA across a network of monitoring points and sites, monitoring all major aquifers and aquitards in the Surat CMA. The purposes of the WMS are to:

- Identify past groundwater impacts from CSG, conventional oil and gas, and coal mining in the Surat Basin;
- Improve knowledge about the groundwater flow system, which in turn improves ability to predict future impacts; and

- Support the evaluation of impact management strategies.

The WMS assigns requirements to petroleum tenure holders to establish the regional monitoring network, undertake routine monitoring and reporting of results and report water production data from petroleum and gas wells. The OGIA will routinely assess the monitoring results and report on these annually. Arrow is compliant with the water monitoring strategy and spring impact management strategy as prescribed in the 2025 Surat CMA UWIR. This process has resulted in the collection of a significant data set describing baseline groundwater pressure and quality for reference purposes as required for the larger area and not limited to PL253. The monitoring network requirements are adaptive, and reviewed and updated every three years by OGIA as part of the UWIR cycle under Chapter 3 of the Water Act. Arrow will continue to implement the elements of the UWIR WMS in future versions of the UWIR.

5.9.6 Assessment of environmental impacts

Potential groundwater impacts of the Project have been assessed in the SGPEIS and the SREIS[15] while the 2025 Surat CMA UWIR has assessed potential impacts on groundwater levels arising from CSG extraction. The 2025 Surat CMA UWIR identifies aquifers where groundwater levels are predicted to fall by more than the trigger threshold as determined in the Water Act 2000 due to the exercise of underground water rights by all petroleum tenure holders. The areas are defined as the Immediate Affected Areas (IAA) where within 3 years the water level drawdown exceeds trigger thresholds of 5 m in consolidated and 2 m in unconsolidated aquifers. The Long Term Affected Area (LAA) is defined as areas where water levels are to decline by more than the trigger thresholds at any time.

The 2025 Surat CMA UWIR model, which included all future well development proposed by Arrow and other CSG operators, produced outcomes that indicate that all of the PL253 tenure area is within the IAA for the WCM and part of PL253 is within the IAA for the Springbok Sandstone (**Figure 31**). The former Linc UCG site is not within the IAA of the Springbok Sandstone. All of PL253 is within the LAA for the WCM, and most of PL253 is within the LAA for the Springbok Sandstone as shown in (refer to **Figure 31**).

Within PL253, there are 24 water bores predicted to be impacted by the exercise of underground water rights, within the IAA and LAA of the 2025 Surat CMA UWIR. The location of water bores that Arrow has made good as a result of this or previous UWIR are shown in **Figure 31**. There are 3 remaining bores for which Arrow will conduct bore assessments and make best endeavours to negotiate make good agreement with affected bore owners.

UCG operations were conducted on Lot 40 DY85 within the area of PL253 by Linc Energy between 1999 and 2013 before the company went into liquidation. The site is now managed by the DNRMMRRD. Contamination of the groundwater in the Springbok Sandstone and WCM is evident in data available for the site and groundwater monitoring conducted by Arrow for the Groundwater Monitoring Plan developed for the existing EA0001401 conditions. Contaminants include phenolic compounds, polynuclear aromatic hydrocarbons, BTEX compounds (benzene,

[15]Refer to SGPEIS Chapter 14. Groundwater and to SGPSREIS Chapter 8. Groundwater, and associated appendices.

toluene, ethylbenzene and xylene), and other hydrocarbon or organic compounds. The UCG operation has caused connection and enhanced permeability between the target of the UCG operation, the Macalister seam package, and the overlying Springbok Sandstone. The connection between the Springbok Sandstone and the Macalister seam package may result in movement of the contaminants as a result of the exercise of underground water rights within the WCM, by either increasing or changing the flow within or between units. Groundwater flow modelling and contaminant fate and transport modelling has been undertaken to assess the risk of migration of contaminants as a result of Arrow's proposed development, as presented in the report by Worley Consulting (2026) in **Appendix E**. Collectively, results from groundwater level predictions, hydraulic gradient assessments, particle tracking, and contaminant transport modelling demonstrate that the proposed 55 wells result in minor localised incremental changes to groundwater within and around Lot 40 DY85 relative to the already approved development. No material changes are predicted in groundwater flow directions, vertical gradients, contaminant migration, or contaminant depletion timing. The ensemble of 364 contaminant transport predictions indicate continued decline in benzene and naphthalene concentrations across both the Springbok Sandstone and Macalister coal seam formations, with concentrations predicted to remain confined to areas proximal to former gasifier locations on Lot 40 DY85, consistent with the observed monitoring data. Predicted depletion timing indicates that, at the ensemble median (P50), benzene concentrations fall below detectable limits by approximately 2049 in the Springbok Sandstone and approximately 2035 in the Macalister coal seam, while naphthalene concentrations fall below detectable limits by approximately January 2027 and April 2024, respectively. Upper-bound (P95) predictions indicate that it is very unlikely for benzene depletion to extend beyond approximately 2053 for Springbok Sandstone or 2042 for Macalister coal seam, and for naphthalene beyond approximately 2037 and mid-2024, respectively. The assessment indicates that the proposed development is unlikely to increase the risk of contaminant migration off-site of Lot 40 DY85 or compromise long-term groundwater recovery and containment of residual contamination associated with the former Hopeland UCG site.

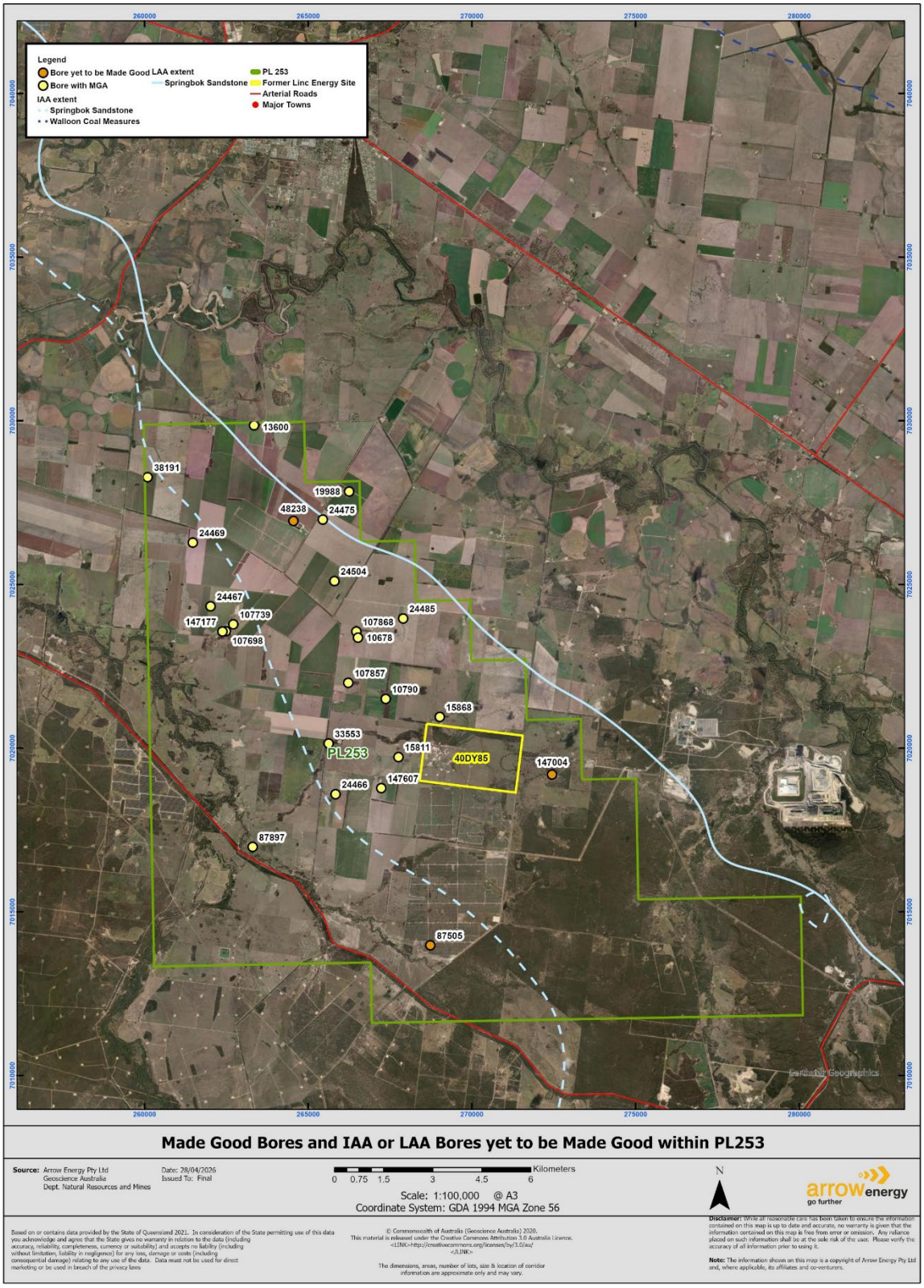


Figure 31 **Extent of the IAA and LAA relative to PL253, and status of bores with a make good agreement or yet to be made good**

In summary, the extraction of CSG will result in depressurisation of the Walloon Coal Measures which will lower aquifer pressures, which could potentially result in the following direct impacts:

- Reduced groundwater supply to existing or future groundwater users accessing groundwater from the Walloon Coal Measures.
- Subsequent indirect depressurisation of adjacent aquifers has the potential to cause aquifer interflow and groundwater drawdown, resulting in the following indirect impacts:
  - Diminished groundwater quality in aquifers above and below the Walloon Coal Measures. This relates to groundwater mixing as drawdown in the Walloon Coal Measures aquifers induces flow across deeper and shallower aquifers.
  - Reduced groundwater flow to groundwater-dependent ecosystems or areas of cultural and spiritual importance fed by the adjacent aquifers (unlikely as no GDEs or areas of cultural or spiritual significance have been identified connected to the regional groundwater systems).
  - Reduced groundwater supply to existing or future groundwater users accessing groundwater from the adjacent aquifers.
- Land subsidence and changes to surface water flow regimes and landforms.
- Surface activities that can impact groundwater values include:
  - Leaks and spills of chemicals, fuels and oils stored at the surface in association with CSG production facilities may result in contamination of the intersected aquifers.
  - Discharges of liquid domestic wastes and effluent to land have the potential to contaminate groundwater systems.
- Reduced rain water infiltration and subsequent reductions in aquifer recharge from the surface due to:
  - Construction of impervious surface coverings associated with CSG production facilities.
  - Land disturbance activities resulting in reduced porosity and permeability of surface profiles.

5.9.7 Proposed management practices and monitoring

Potential impacts on groundwater systems for PL253 will be managed through a hierarchy of mitigation, monitoring and management options that form the basis for an adaptive management framework.

Arrow Energy will implement the commitments it made in the EIS and updated in the SREIS in order to effectively manage and monitor the effects of CSG water extraction on local and regional groundwater values. These commitments are consistent with the existing legislative framework, specifically Chapter 3 of the Water Act and the EPBC Act Water Trigger.

These legislative requirements are further detailed in the UWIR (Part IV, where applicable to the SGP) and Arrow's WRMMP. The commitments summarised below

will be adapted to allow management decisions to be made based on an increased knowledge base developed over time.

Management practices during design and planning

The following measures have been developed to manage the potential impacts on groundwater values during the design and planning phase of the project.

- Apply appropriate international, Australian and industry standards and codes of practice for the handling of hazardous materials (such as chemicals, fuels, and lubricants).
- A baseline assessment plan to establish benchmark data in registered third party bores (where possible) prior to the commencement of Arrow Energy CSG extraction activities in the project area in accordance with the Water Act 2000, including the preparation and implementation of a groundwater monitoring and investigation strategy.
- Consider local biological, groundwater and surface water conditions when identifying sites for CSG infrastructure including storages.
- Consider local groundwater conditions when identifying sites and routes for the installation of buried infrastructure (e.g. gathering lines).
- Avoid unnecessary impervious surface coverings and minimise land footprint and vegetation clearing when designing facilities.
- Develop make-good agreements that include the outcome of bore assessments and implementation of make-good measures in the event that impaired capacity occurs.
- Ongoing collection of relevant geological and hydrogeological data from existing and future production wells, monitoring bores and registered third party bores (where possible) together with information collated collaboratively with other proponents and regulatory authorities.
- Maintain water balance models for long-term planning and management of CSG water. Review and update modelling in alignment with the production forecasting schedule.

Management practices during construction

The following mitigation, monitoring and management measures have been developed to address the potential impacts on groundwater values during the construction phase of the project:

- Avoid disturbance of contaminated soil and groundwater when it is identified or observed during intrusive works;
- Manage contaminated soil or groundwater that cannot be avoided through physical investigation; manage quantification of the type, severity, and extent of contamination; and remediate or manage in accordance with the relevant Queensland Government legislation and guidelines;
- Construct all monitoring bores, water bores or production wells in accordance with the latest version of the *Minimum Construction Requirements for Water Bores in Australia,* the *Minimum Standards for the Construction and Reconditioning of Water Bores that Intersect the Sediments of Artesian Basins in Queensland*, or the *Code of Practice for the Construction and Abandonment of Petroleum Wells and Associated Bores in Queensland,* as appropriate;

- Select drilling fluids to minimise potential groundwater impacts. Oil based drilling fluids will not be used; and
- Ensure well drilling is monitored by a suitably qualified personnel to ensure aquifers are accurately identified for correct well construction and aquifer isolation.

Management practices during operations

The following measures have been developed to address the potential impacts on groundwater values during the operational phase of the project:

- Carry out corrective actions immediately upon the identification of any contamination of soil or groundwater that has occurred as a result of project activities.
- Manage potential impacts to identified spring complexes by:
  - Supporting the identification of specific aquifers that serve as a groundwater source for discharge springs;
  - Assessing springs that are predicted to be subject to unacceptable impacts through the source aquifer;
  - Developing monitoring and mitigation strategies to avoid or minimise unacceptable impacts;
- Implement a well integrity management system during commissioning and operation of production wells;
- Minimise impacts of groundwater depressurisation on sensitive areas (e.g. groundwater dependent ecosystems);
- Implement a procedure for investigating any impaired capacity of third party bores that may become evident through monitoring and landholder liaison;
- If impaired capacity is confirmed (bore can no longer produce quality or quantity of groundwater for the authorised purpose, and the impact is due to CSG activities), implement make-good measures in accordance with the Water Act; and
- Incorporate procedures into an emergency response plan or water management plan for the controlled discharge of CSG water under emergency conditions. Procedures will include water balance modelling, weather monitoring and forecasting, stream flow data, notification, and reporting.

Management practices during decommissioning

All production wells and monitoring bores will be repaired (in the event of a failed integrity test) or decommissioned (at the end of their operating life span) in accordance with either the Petroleum and Gas (Production and Safety) Act 2004 and Water Act 2000 and relevant regulations, as appropriate. Should production wells or monitoring bores be converted to other uses, it will be done in accordance with relevant regulations.

Regional groundwater and subsidence monitoring program

The 2025 Surat CMA UWIR sets out regional monitoring requirements for groundwater pressure and quality in a water monitoring strategy (WMS), springs in a spring impact management strategy (SIMS), as well as for subsidence. Arrow, where assigned as Responsible Tenure Holder, is compliant with the WMS, SIMS and

subsidence obligations as prescribed in the 2025 Surat CMA UWIR. This process has resulted in the collection of a significant data set for reference purposes as required for the larger area and not limited to PL253, the subject of this EA Application. Arrow is also compliant with its Make Good obligations as set out in the 2021 Surat CMA UWIR.

The WMS includes an integrated regional monitoring network to collect data on water pressure and water quality in the Surat CMA across a network of monitoring points and sites, monitoring all major aquifers and aquitards in the Surat CMA. The purposes of the WMS are to:

- Identify past groundwater impacts from CSG, conventional oil and gas, and coal mining in the Surat Basin;
- Improve knowledge about the groundwater flow system, which in turn improves ability to predict future impacts; and
- Support the evaluation of impact management strategies.

The WMS assigns requirements to petroleum tenure holders to establish the regional monitoring network, undertake routine monitoring and reporting of results and report water production data from petroleum gas and wells. The OGIA will routinely assess the monitoring results and report on these annually. The monitoring network requirements are adaptive, and reviewed and updated every three years by OGIA as part of the UWIR cycle under Chapter 3 of the Water Act.

Arrow Energy has installed a comprehensive regional groundwater monitoring network (that satisfies Arrow Energy's obligations as described in the groundwater impact reports in the SGPEIS/SREIS and confirmed in the WMS of the 2025 UWIR) to:

- Establish baseline groundwater level and groundwater quality conditions;
- Assess natural variation (i.e. seasonal variations) in groundwater levels;
- Monitor groundwater levels during the operations phase;
- Establish suitable datum levels for each aquifer system;
- Target sensitive areas where more frequent monitoring and investigation is required (e.g. groundwater dependent ecosystems);
- Monitor groundwater drawdown as a result of CSG extraction;
- Monitor impacts in accordance with the Water Act and regulations;
- Provide an 'early warning system' that identifies areas potentially impacted by project activities to allow early intervention; and
- Comply with the commitments presented in the adaptive management framework described above.

Arrow Energy will implement the elements of the management and monitoring strategies for which it has been assigned responsibility. Groundwater monitoring and LiDAR surveys will be conducted to collect ongoing site specific data during production, which will allow for future comparisons to be made and evaluated against the presented baseline data for PL253.

Commitments in relation to Lot 40 DY85

Modelling allows Arrow to explore potential impacts in the future under different scenarios in order to assess the risk posed by its activities. It is important to understand that models do not represent a prediction of what may happen in the future. Rather, they determine the potential outcomes under a set of assumed conditions and are therefore a powerful tool to assess potential change, to indicate risk and to identify scenarios that have a low likelihood of occurring. The model work undertaken by Worley Consulting (**Appendix E**) shows that:

- groundwater movement away from Lot 40 DY85 is slow as it has been in all simulations since 2018
- Arrow's proposed development on PL253 will have no significant impact on either the rate of groundwater movement or the quality of groundwater.

Given the above, the focus of Arrow's future management of groundwater on PL253 is appropriately placed on managing risk, consistent with the existing EA0001401 conditions. The following will be undertaken:

- Arrow will maintain and sample on a quarterly basis the groundwater monitoring bores on- and off-site of Lot 40 DY85. These bores are appropriately placed to operate as an early warning trigger mechanism.
- If the sampling results from any of the 35 monitoring bores on- or off-site of Lot 40 DY85 exceed any of the trigger limits specified in the EA, Arrow will:
  - notify DETSI within forty-eight (48) hours of receiving the results
  - complete an investigation into the potential for environmental harm
  - provide a written report of the investigation to DETSI within 10 days of receiving the results for the quarterly event, with the report outlining details of the investigation conducted and proposed actions to prevent environmental harm.
- Groundwater will continue to be sampled and reported to DETSI on an annual basis as per the existing Groundwater Monitoring Plan.
- The groundwater model will be updated on an annual basis to include the current year of sampling results and predictions with regards to groundwater movement and particle tracking in the Springbok Sandstone and Macalister. This information will be included in the above-mentioned Groundwater Monitoring Plan.

5.10 Geology, Landform and Soils

5.10.1 Applicable legislation

The following legislation, policy and guidelines are relevant to identifying values, mitigating, and managing impacts on geology, landform, and soils, and to management of potential impacts associated with land contamination during construction, operations and decommissioning of the Project.

- *Environmental Protection Act 1994* (Qld): protects Queensland's environment while allowing for development that improves total quality of life, both now and in the future. It also includes provisions for the management of land that is contaminated, or that has supported land uses that may have resulted in land contamination, or that supports activities that could result in land contamination. Generally, activities that could result in land contamination are notifiable. Land

parcels where notifiable activities have been or are conducted are listed on the Environmental Management Register (EMR). Land parcels that are proven to be significantly contaminated are listed on the Contaminated Land Register (CLR).

- *Vegetation Management Act 1999* (Qld): aims to ensure that vegetation clearance does not lead to land degradation, and to manage the environmental effects resulting from clearance.

Relevant industry guidelines and codes of practice include:

- *Best Practice Erosion and Sediment Control Manual (IECA, 2008)*: This manual outlines how to manage erosion and sedimentation through the planning and construction stages of development.
- *Code of Environmental Practice - Onshore Pipelines (APGA 2022))*: This code provides information on methods and techniques to manage environmental impacts associated with construction of onshore pipelines.
- *Draft Guidelines for the Assessment and Management of Contaminated Land 1998* (Qld) (DE, 1998): These guidelines establish the processes for all aspects of the assessment and management of contaminated land and serve to facilitate compliance with the Environmental Protection Act. Although the guidelines remain in draft form, they set an industry-accepted standard for works on contaminated lands.

5.10.2 Description of environmental values

The Project area is characterised by typically low topographical relief, with elevation across the petroleum leases ranging between 305 and 345 mAHD. The landscape is strongly linked to the underlying geology and geomorphological evolution of the area. Other landscape features in the project area are alluvial systems (land zone 3), clay deposits (land zone 4) loamy and sandy plains and plateaus (land zone 5) and ironstone jump-ups (land zone 7). Topography throughout the project area is typically flat to gently undulating, with some low hills, jump-ups, and excised river/creek banks.

Geologically, the tenures are underlain by the Surat Basin, the surface geology of which comprises the following stratigraphic units (from youngest to oldest):

- Quaternary-aged alluvial deposits associated with the Condamine River:
- Jurassic-aged Kumbarilla Beds consisting of the Westbourne Formation overlying the Springbok Sandstone; and
- Jurassic-aged Walloon Coal Measures.

Of these, the Quaternary alluvium, Kumbarilla Beds, and Walloon Coal Measures are the most relevant in the context of impacts from seepage. Shallow aquifers tend to exist within the Quaternary alluvium and Kumbarilla Beds.

A review of the dominant soil order mapping shows that the dominant soil across the project development area is Sodosols with some Vertosols to the east.

Soil types across the development 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. Generally poorly drained areas. Limited in extent.

- Cracking Clays: Common in cropland in the north of the Project area on gently undulating terrain.
- Uniform Non-cracking Clays: Occurring on undulating plains and rises, and mid to upper slopes of hills.
- Texture Contrast Soils: Sharp textural contrast between surface and subsoil horizons of low agricultural value. Common throughout southern portion of the Project area.
- Sands and Sandy Loams: Consists of alluvial and residual sands found on plains, commonly near larger watercourses.
- Skeletal, Rocky or Gravelly Soils: Occur adjacent to rocky outcrops.

Soils have been mapped in the SGP EIS. Further delineation of soil types and implications for project development and rehabilitation will be undertaken prior to wellfield development.

Land can become contaminated through a range of activities and land uses. The Queensland Government defines such activities as notifiable activities under the EP Act. Although many of the listed notifiable activities are 'industrial' in nature, a significant number may be reasonably expected in an environment where agricultural activities predominate.

EMR and CLR searches may be undertaken for the land parcels the subject of this EA application within which disturbance is proposed. It is possible that sites where notifiable activities have occurred may not have been reported and/or are not included in the applicable registers. In addition to the specified notifiable activities, uncontrolled and otherwise unidentified activities may also have contributed to contamination of land within the project development area. Such uncontrolled activities may include but are not necessarily limited to:

- Dumping of waste materials in rural areas;
- Unreported spillage of agricultural chemicals, fuels, or lubricants;
- Broad acre application of persistent organic chemicals; and
- Bulk disposal of stock carcasses after disease, flood, or drought.

As Arrow develops land for the project, areas of contamination caused by uncontrolled activities may potentially be encountered.

5.10.3 Assessment of environmental impacts

As described in the SGPEIS, Potential impacts on geology, landform and soils values from project activities include:

- Land degradation – erosion and associated sedimentation, dust generation and reduction in soil quality; and
- Land contamination - through disturbance of existing contaminated land. and the potential to cause land contamination through project activities.

Activities with the potential to cause these adverse impacts on geological, landform and soils values during the construction, operations and decommissioning phases of the project are described below:

Construction

- Increased erosion resulting from ground disturbance, vegetation clearance, alteration of natural drainage and flow concentration due to construction activities (i.e., excavation, trenching, drilling, earthmoving) during any activity that disturbs the ground (e.g., the construction of production wells, gathering lines and associated infrastructure);
- Deposition downslope or downstream of eroded sediment as flow velocities decrease as an indirect result of project activities that cause erosion (e.g., construction of production wells, gathering lines and associated infrastructure);
- Topographic alteration from the construction of borrow pits for the use of material in construction activities; and
- Leaks or spills from fuel storage and handling leading to soil contamination.

Operations

- Increased surface or subsurface erosion and waterlogging resulting from flow concentration due to differential settlement of pipeline backfill and padding; and
- Leaks or spills from fuel storage and handling or overflow leading to soil contamination.

Decommissioning

- Reprofiling of microrelief leading to patchy exposure of sodic and saline subsoils from inversion of the soil profile during backfill of materials during rehabilitation.

Contaminated land

The following mechanisms may contribute to the realisation of impacts associated with contaminated land:

- The siting of project infrastructure over contaminated land;
- Disturbance of contaminated soil and/or groundwater during the drilling of coal seam gas wells, excavation of trenches for the installation of gathering infrastructure, gas pipelines and other utilities associated with the development or during civil works;
- Uncontrolled movement of contaminated soil and/or groundwater after disturbance by project activities; and
- Transport to the surface of groundwater that has become contaminated through notifiable or uncontrolled activities (creating an exposure pathway that would otherwise not exist).

Impacts that may be realised through the above mechanisms include:

- Exposure of the public, wildlife, stock or native or cultivated vegetation to contaminants;
- Exposure of project workers to contaminants; and
- Contamination of land and water resources (including surface water and groundwater) that are otherwise unaffected by contamination and accordingly have high environmental value.

Various aspects of the proposed project activities have the potential to result in land contamination. The potential for project activities to result in the contamination of land from notifiable activities includes, but may not be limited to:

- Leaks and spills from onsite fuel storage tanks;
- Leaks and spills (fuels and lubricants) from the operation of earthmoving, drilling, and associated equipment;
- Leaks and spills (chemicals) from the operation of coal seam gas water treatment and transfer facilities; and
- Waste generated through the drilling of coal seam gas wells (e.g., waste drilling muds).

5.10.4 Proposed management practices

The primary means by which avoidance is achieved for potential geological-, landform- and soil-related impacts is through design and site selection. Arrow's framework approach focuses on early identification of sensitive locations that should be avoided by project activities.

For activities that involve disturbance to land, vegetation and soil, Arrow undertakes activities in accordance with its Land Disturbance Procedure. This procedure outlines mandatory environmental requirements to avoid, minimise or mitigate environmental harm associated with land disturbance activities and covers vegetation clearing, soil management, site preparation and erosion and sediment control for all Arrow controlled activities during exploration, drilling, construction, and operating phases. Site stabilisation and rehabilitation are undertaken in accordance with Arrow's Land Rehabilitation Procedure (Section 4.3)

The guiding principles for land disturbance include:

- Avoid disturbing sensitive environmental values (for example - flora, fauna, watercourses, wetlands); and disturbing land outside the approved area;
- Minimise the footprint (area) of the site (i.e. the total area of land disturbance within the approved area); the duration of soil disturbance; water movement across the site; and removing vegetation, especially native woody vegetation/grasses (i.e. utilise previously disturbed areas);
- Mitigate impacts by developing and implementing effective Erosion and Sediment Control Plans (ESCPs) and soil management measures based on anticipated soil type, scale of disturbance, weather and construction conditions, and time/length of disturbance; maintaining all erosion and sediment control (ESC) measures in proper working order; stabilising and/or rehabilitating sites promptly; and providing biodiversity offsets where required (Section 5.6); and
- Manage contaminated soil or groundwater that cannot be avoided through physical investigation; manage quantification of the type, severity, and extent of contamination; and remediate or manage in accordance with the Queensland Auditor Handbook for Contaminated Land (DEHP, 2016), previously the Queensland Government's Draft *Guidelines for the Assessment and Management of Contaminated Land* (DE, 1998).

5.11 Cultural Heritage

5.11.1 Applicable legislation

The following legislation is relevant to identification, protection and management of Indigenous and non-Indigenous cultural heritage during construction, operation, and decommissioning of the Project.

- *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act): Provides consequence to causing significant impact on the National Heritage values or Indigenous Heritage values, of a National Heritage place.
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cwlth): Protects Cultural Heritage objects on land or in Australian waters that are of particular significance to Indigenous peoples and their traditions.
- *Queensland Heritage Act 1992* (Qld): Provides a legislative base for recording identified heritage, managing heritage and protecting Queensland's cultural heritage.
- *Aboriginal Cultural Heritage Act 2003* (Qld) (ACH Act): provides an effective legislative framework for recognition, protection and conservation of Indigenous cultural heritage. The ACH Act 'duty of care' guidlines outlines specifics of protection and management of *Indigenous* cultural heritage. Arrow Energy demonstrates compliance with the *Aboriginal Cultural Heritage Act 2003* by operating under an approved cultural heritage management plan (CHMP).
- *The Burra Charter*: The Australian International Council on Monuments and Sites (ICOMOS) Charter for Places of Cultural Significance 2013 provides guidance for the conservation and management of places of cultural significance, including retaining the setting of cultural heritage if it contributes to the place.

5.11.2 Description of environmental values

Within the Surat Gas Project footprint the key Indigenous cultural values are associated with either archaeological cultural significance (i.e., including physical evidence) or Intangible or ethnographic significance (i.e., of significance to indigenous peoples for cultural, spiritual, or historical reasons). All engagement with Indigenous people on new development is based on the principles of free, prior and informed consent.

Aspects that contribute to Indigenous cultural heritage values included the following:

- Places that are included in the Queensland Aboriginal and Torres Strait Islander Cultural Heritage Database and Register recorded by Arrow Energy, other proponents and Aboriginal Parties;
- Places, objects, and areas of cultural heritage value identified during previous investigations conducted by Aboriginal parties in conjunction with Arrow Energy. Where Aboriginal parties have allowed it, the details of these sites are retained on Arrow Energy's GIS database; and
- Potential for places, objects and areas of cultural heritage value that are currently not identified, including those that become known through preconstruction field site assessments.

In relation to non-Indigenous heritage, no sites of national or world heritage significance were identified within the project area. Sites identified in the region with

state heritage values are all located within town centres and will not be impacted by the Project. A number of regionally known sites listed on local council registers hold historical interest to the local community and comprise infrastructure (settlements, homesteads, industry, and places of worship), schools and former schools sites, cemeteries, war-related sites and memorials. No local heritage locations have been identified within the Hopeland EA construction footprint.

5.11.3 Assessment of environmental impacts

Potential impacts to Indigenous heritage places and values are considered to be most significantly associated with construction activities and, to a lesser extent, operations and, to an even lesser extent, decommissioning activities. Without the implementation of appropriate management controls clearing activities associated with construction of the project have the potential to impact on Indigenous cultural heritage. Arrow Energy assesses all construction areas for Indigenous and non-Indigenous heritage. During these assessments no historical sites of world heritage, national, State, or local significance have been identified within the development area of this EA amendment application.

Potential impacts to non-Indigenous sites could occur through chance-find discoveries of previously unknown sites that are uncovered during construction activities. These sites are protected through 'chance find' conditions that are applied to all construction activities.

5.11.4 Proposed management practices

Arrow Energy operates on an 'Avoidance Principal' in relation to impacts on cultural heritage and management of heritage sites, whether Indigenous or non-Indigenous, and aims to avoid impacts or provide mitigation measures to ensure the least amount of impact.

Arrow Energy has agreed Cultural Heritage Protocols, with relevant Aboriginal Parties in the Hopeland EA footprint, under a Cultural Heritage Management Plan that determines how cultural heritage in the Project area will be managed. The Hopeland EA area has no current or previous Native Title claims, therefore Arrow has an agreement with a collaboration of all surrounding regional Aboriginal Parties.

To manage potential impacts in relation to chance finds, site inductions provide cultural heritage awareness and guidance on the appropriate process to follow should there be any new discoveries. Arrow Energy implements a 'chance finds' procedure for the discovery of unknown sites during construction. This includes a stop work requirement upon initial discovery, appropriate reporting and recording, and management measures.

5.12 Waste

5.12.1 Applicable legislation

The following legislation, policy and guidelines are relevant to identifying values and mitigating and managing impacts on waste 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 EP Act regulates the impacts to groundwater, surface

waters, and biodiversity environmental values. The storage, tracking, and disposal of waste is regulated under a State environmental authority granted under the EP Act. 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 Environmentally Sensitive Areas (ESAs).

- *Environmental Protection (Waste Management) Regulation 2000* (Qld): This regulation provides a mechanism to enforce the EP Act and aims to protect the environment by minimising the impact of waste on the environment, including, in particular, the impact of waste so far as it affects human health. The regulation establishes an integrated framework for minimising and managing waste under the principles of ecologically sustainable development.
- *Waste Reduction and Recycling Act 2011*(Qld) (Waste Act): This act regulates additional obligations (e.g., reporting obligations) regarding to the management of waste (e.g., salt or brine disposal), and the beneficial use of salt and brine through an End of Waste (EOW) Approval or EOW Code.
- *Environmental Protection (Waste Management) Policy 2000 (Qld):* This policy aims to achieve the objectives of the EP Act in relation to waste management by providing a framework for minimising waste generation, maximising the usage of waste, efficient use of resources and maintaining ecologically sustainable principles. The policy also provides the framework for waste management programs.
- *Coal Seam Gas Water Management Policy 2012*: This 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.

5.12.2 Description of environmental values

The proposed project activities expected to generate waste and the types of waste are outlined in Chapter 4 (refer to Section 4.9.6).

The environmental values to be protected from the waste streams through the management of waste, including the management of CSG water are:

- Biodiversity. The diversity of ecological processes and associated ecosystems and suitability of flora and fauna habitats (refer to 5.6.2).
- Water resources. Quality of surface waters and groundwater. Water quality that is suitable for sustaining human health, visual amenity, and suitability of aquatic ecosystems (refer to Section 5.8.2 and Section 5.9.2).
- Land and soils. Land use capability, having regard to economic consideration, habitat for flora and fauna, and quality of land to guarantee environmental sustainability. Soils quality, including structural and chemical properties (refer to Section 5.10.2).
- Visual amenity. Features of the existing environment that are important for visual amenity.
- Health and safety. The life, health, and wellbeing of people including the Project workers.

5.12.3 Waste management objectives

Potential waste management issues associated with the Project activities include uncontrolled and/or controlled releases of waste or emissions.

Failure to properly manage waste storage and containment systems could potentially result in soil and water contamination and impacts on visual amenity.

The discharge of wastewater and air emissions could potentially lead to adverse health and ecological impacts, e.g., discharge of raw sewage and the generation of air pollutants.

Arrow Energy aims to minimise the release of any harmful substances to the air, water, or the land, through the responsible management of its wastes. Potential impacts from the Project waste streams will be managed with the implementation of the standard waste hierarchy of avoidance, reuse, recycling, and disposal.

The environmental protection objectives that Arrow Energy is committed to for waste management are:

- The implementation of a waste management hierarchy;
- Minimising resource utilisation by reuse and recycling of waste;
- Reducing impacts to the environment from the management of waste;
- Reducing the quantity of waste that is sent to landfills by the recycling and reuse of waste.

Specific waste management objectives depending on the waste stream and type of waste and the Project phase are provided in **Table 5-12**.

Table 5-12 Waste Management Objectives

Project Activity	Waste Stream / Characteristic	Waste Management Objectives
Construction of wells, gathering systems, and incident activities	Solid and Liquid / Regulated	Authorised final disposal[16] Bioremediation or landfarming where applicable Reuse or recycle where possible Irrigate with treated sewage
	Solid / Organic & Inert	Stockpile[17] on-site for use in rehabilitation
	Solid / Recyclable	Reuse or Recycle[17]
Operation of pipelines and incidental activities	Solid / Regulated	Authorised final disposal[16]
	Liquid / Regulated	Authorised final disposal[16] No unauthorised and/or unplanned CSG water releases Reuse of treated CSG water for dust suppression, construction activities, irrigation, town water supply where appropriate of quality, agricultural use, or injection into aquifers Irrigate with treated sewage[17]
	Solid / Regulated	Authorised final disposal[16]

[16] Collection and disposal through an authorised waste contractor to an offsite authorised regulated waste facility
[17] In compliance with per current applicable legislation.

Project Activity	Waste Stream / Characteristic	Waste Management Objectives
Decommissioning and rehabilitation	Solid / Inert	Recycle or reuse[17], or bury on site
	Solid / Recyclable	Recycle[17]

5.12.4 Assessment of environmental impacts

Potential impacts from waste can come from the construction of production wells, gas and water gathering systems, the construction and operation of incidental activities, and from decommissioning and land rehabilitation. These potential impacts may be:

- Loss of biodiversity values and associated ecosystems;
- Loss of water quality;
- Loss of land use and soil quality; and
- Loss of visual amenity, and impacts to health and safety.

5.12.5 Waste management

Waste will be managed through the application of the waste management hierarchy as shown in **Figure 32**.

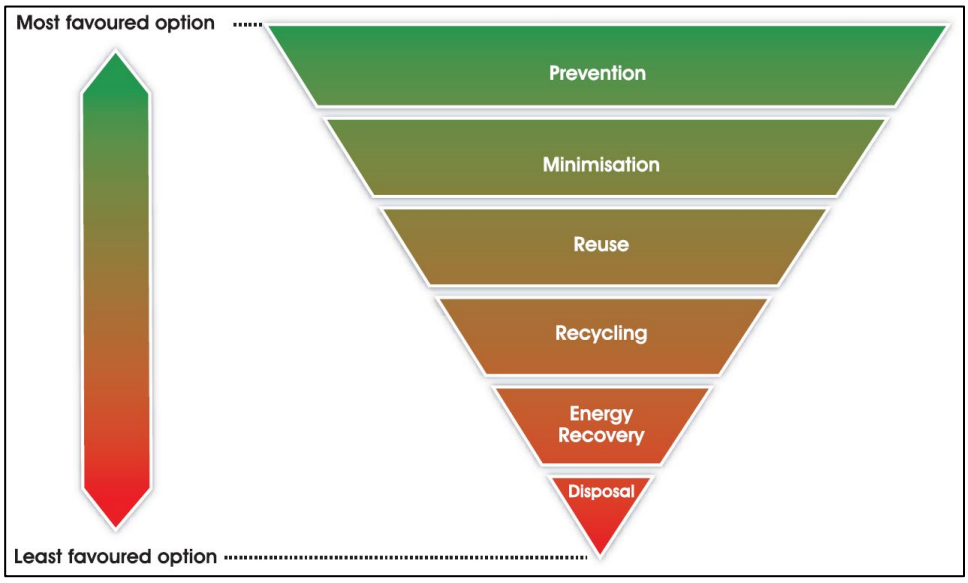


Figure 32 Waste Management Hierarchy

Reduction of waste sources

Waste avoidance and source reduction is achieved primarily in the design phase of the project through cleaner production. Production technologies will be designed, and production practices implemented to minimise resource consumption and increase production efficiency. Materials will be procured in bulk, where practicable, to minimise containers and movement of material.

Waste reuse

The reuse of waste will be determined largely by the salvage value of the material. Reuse requires onsite segregation and storage and will include the following measures:

- Reuse of cleared vegetation for mulch and soil erosion control.
- Segregation of wastewater streams, i.e., contaminated stormwater, waste waters and coal seam gas water.
- Reuse of treated waste water for dust suppression, construction activities or irrigation.
- Reuse of hydrotest water.
- Reuse of treated water for agricultural use, industrial use, potable water supply.
- Treatment and reuse of solid wastes, such as drilling muds and cuttings, where practicable.

Waste recycling

Recycling is a central element of waste management for the Surat Gas Project. The marketability of the waste is the primary driver for recycling. Arrow will maximise marketable volumes of recyclable waste to local and regional businesses. Highly marketable wastes include oil, metals, lead acid batteries and process vessels that have been decommissioned. Lower marketable waste includes aluminium cans, paper and box board and pipes.

Waste disposal

General waste will be segregated, treated if necessary and stored onsite prior to disposal.

Segregation will include the separation of liquid from solid waste, separation of regulated from non-regulated waste, and separation of reusable and recyclable from non-reusable and nonrecyclable waste.

Solid waste segregation will be achieved by the allocation of bins for different waste streams.

Appropriate domestic waste disposal facilities will be provided at designated work sites to assist in segregation of waste.

Contaminated soil or groundwater that cannot be avoided through physical investigation will be managed through quantification of the type, severity, and extent of contamination, and remediated or managed in accordance with the Queensland Government's Draft Guidelines for the Assessment and Management of Contaminated Land (DE, 1998).

Onsite waste treatment will be used for such purposes as sewage, coal seam gas water and other specified wastes.

Sewage will be treated in packaged sewage treatment plants and generally temporary in nature where they are located with Drilling Camps. Coal seam gas water will be contained in dams for treatment through reverse osmosis. The storage capacity of coal seam gas water will be designed to be sufficient to manage waste liquids until such time that permanent disposal options are operational.

Onsite waste storage areas will be developed in accordance with industry practice and relevant waste management regulations.

Waste that cannot be reused or recycled will be disposed of at appropriately licensed facilities. Potential waste facilities close to the Project Area may be used.

Liquid waste generated (other than coal seam gas water and sewage) will be stored and periodically removed for disposal or recycling. All waste fluids and muds resulting from drilling activities will be contained in properly lined dams or storage tanks for in situ treatment or disposal. Putrescible solid waste will be stored in covered containers to prevent odours, public health hazards and access by fauna.

Arrow will comply with Queensland Government waste tracking requirements. Regulated wastes will be handled, stored, and disposed of in accordance with relevant standards and *the Environmental Protection (Waste Management) Regulation 2000*.

Project activities are likely to generate solid, liquid, and gaseous waste streams. The main waste streams generated by the Project activities and the management objectives are provided in **Table 4-3** and **Table 5-12**.

Produced water (CSG Water) management

CSG Water is defined as waste under the EP Regulation 2019, as category 2 regulated waste. It can be approved as a resource through an EOW code or approval issued by DETSI. If CSG Water is not used in accordance with the EOW code or approval, it remains a waste and it's use, including beneficial use, is regulated under the EP Act.

Planning for the management of CSG Water from the Project requires forecasting of production rates, storage volumes, and quality of the CSG Water for the life of the Project. Arrow Energy has developed a strategy for the management of CSG Water (**Appendix G**), which outlines the management of CSG Water resulting from activities arising from the development of the SGP gas fields. This strategy provides a basis for compliance with government policy, and sets out the method for managing produced water for Arrow's Surat Basin tenements.

Arrow Energy aims to conduct an effective containment of CSG water throughout its transmission via pipelines from the wells to beneficial use or final disposal. Regular monitoring and maintenance of pipelines will be conducted in accordance with Arrow Energy's Plant Maintenance Data Management Manual. Process safety will be applied in the design of the pipelines and in the implementation of controls, so no reportable unplanned releases of CSG water occur.

Forecasting of CSG Water

The forecast of CSG Water that will be produced by the Hopeland Development is presented in **Figure 33**. It is noted that the full field development water forecast had been assessed under the EIS and SEIS including through the EPBC approval (EPBC2010/5344). Whilst only 55 wells are currently authorised under the EA, and this amendment seek an additional 55 wells, the full field development volume of CSG water produced has already been assessed for impacts to groundwater and is accounted for under the Arrow-QGC Water Services Agreement. This is where the majority of Arrows CSG water will be transferred to QGC for treatment and beneficial use through the Condamine Alluvium Substitution Scheme (CASS).

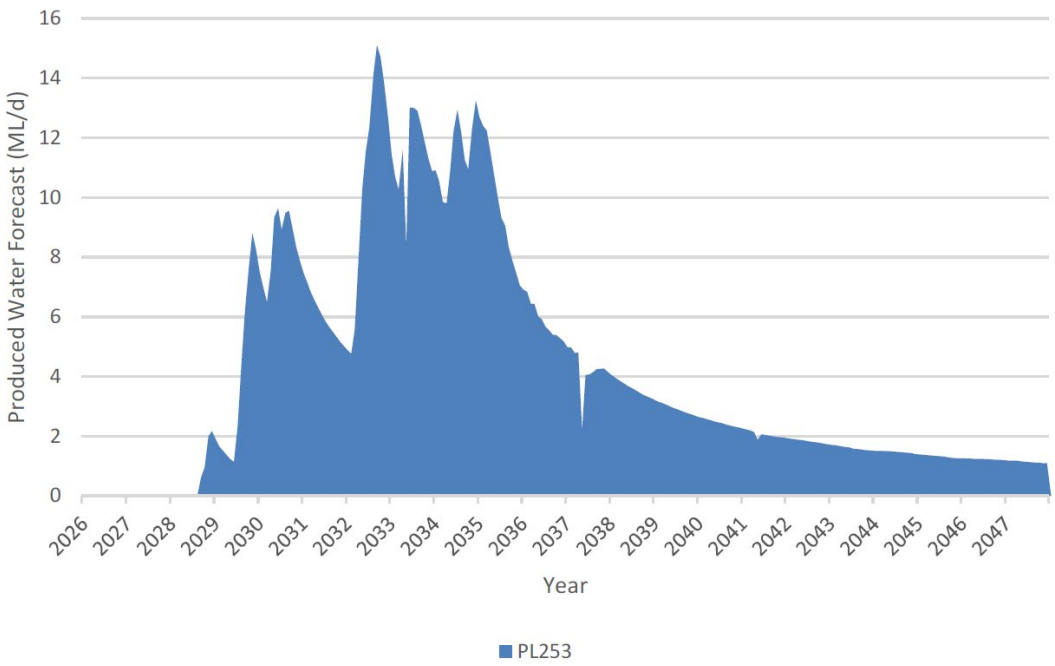


Figure 33 Forecast of CSG Water Production Hopeland Development Area

Storage of CSG Water

The storage of CSG water in dams (regulated) will also be operated and maintained in accordance with regulatory approvals to effectively contain CSG water, including activities such as:

- annual dam integrity inspections;
- groundwater monitoring programs;
- scheduled maintenance of infrastructure and facilities;
- implementation of dams operational plans; and
- conducting a water balance modelling to develop the dams' operating philosophy and strategy.

A CSG Water Management Plan for the project has been developed in accordance Section 126 of the EP Act and is included in **Appendix G.**

Quality of CSG Water

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 µS/cm (i.e. brackish);
- Suspended solids that will usually settle out over time;
- Trace metals and low levels of nutrients.

Table 5-13 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. Further information is available in Appendix G.

Table 5-13 Expected CSG water quality

Parameter	Unit	Average Quality for CSG Water[18]
Electrical Conductivity @ 25°C	µS/cm	7070
pH Value	pH Unit	9.14
Suspended Solids (SS)	mg/L	34
Total Dissolved Solids @180°C	mg/L	4620
Dissolved Organic Carbon	mg/L	16
Total Organic Carbon	mg/L	22
Silicon as SiO2	mg/L	18.2
Reactive Silica	mg/L	16.6
Nitrite as N	mg/L	<LOR
Nitrate as N	mg/L	<LOR
Nitrite + Nitrate as N	mg/L	<LOR
Total Phosphorus as P	mg/L	0.55
Total Hardness as CaCO3	mg/L	41
Dissolved Oxygen	mg/L	1.91

CSG water produced by PL253 will be transferred to QGC's Kenya East Pond for management under the Arrow-QGC Water Services Agreement. Treatment of produced water originating from the Hopeland development will occur at the QGC operated Kenya Water Treatment Plant (WTP).

Treated water is being provided to third parties to promote the beneficial use of CSG water. Supply will primarily be for irrigation of cropping land, but water may also be supplied for other authorised beneficial uses (e.g., domestic, stock, stock intensive). Supply of water for beneficial use will also address Arrow Energy's commitment to offset its impact to the Condamine Alluvium.

The management of CSG water, or produced water, is not proposed to be amended as part of this application to what is already authorised under EA0001401.

Appendix G provides detail regarding the management of CSG water for the SGP, including relevance to the management of CSG Water for the Project.

Brine management

Arrow Energy's CSG Water Management Strategy includes options for the treatment and disposal of brine, which is a byproduct of water treatment using reverse osmosis.

[18] CSG Water quality data based on available data from Arrow Energy's Surat Bason tenures.

Arrow Energy is currently exploring a range of brine management options, as specific measures are required to manage the storage, use, and/or disposal of brine. Until a specific brine management option is selected, Arrow Energy will store brine in its regulated dams which have been constructed in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (DESI, 2016). All treatment of CSG water originating from the Project will occur off-tenure at QGC's Kenya WTP, and Brine stored in the associated dams already authorised under EA0001540. No new brine dams are proposed subject of this EA amendment application.

Base case for the brine management option is disposal to a suitably licensed landfill.

Other regulated waste management

Appropriate international, Australian and industry standards and codes of practice will be applied for the design and installation of infrastructure associated with the storage and management of hazardous materials such as chemicals, fuels, and lubricants, where applicable.

Regulated waste generated by the Project activities will be managed through the utilisation of an authorised waste management contractor, and handled, stored, and disposed of in accordance with relevant standards under the *Environmental Protection (Waste Management) Regulation 2000*.

Emergency response and spill response procedures will be developed and implemented to minimise any impacts that could occur as a result of releases of hazardous materials or any loss of containment of storage equipment.

Sewage management

Sewage from temporary camp facilities to support drilling will be carted off site for treatment, or treated through Sewage Treatment Plants and the treated effluent will be irrigated as per the proposed EA conditions.

5.13 Landscape and Visual Amenity

5.13.1 Applicable legislation

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

- *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.

- *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.

5.13.2 Description of 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. Limited agricultural activity exists in areas of higher elevation and within state forests.

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 5-14**.

Table 5-14 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. • The Western Downs Green Power Hub is located adjacent the project area.
Stakeholders, sensitive receptors, and commercial places	• The closest towns to the Project Area are Kogan and Chincilla, which are located approximately 5km and 17km (respectively) from the Project Area. • Stakeholders include the Western Downs Regional Council (WDRC), 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[19]	Mainly pastural land with scattered stands of lowland native forest. Landscape characteristics include:

[19]Source: SGPEIS Chapter 18 Landscape and Visual Amenity

Environmental Values	Description
	• Smoothly undulating landform incised by several narrow dry gullies and creeks. • Creek valleys contain a muddy character, with distinctive rocky outcrops and well-treed valley sides. • Sparsely settled character with homesteads and cottages. • Generally comprises a high level of naturalness with a strong sense of remoteness away from major roads.

The landscape around the Project Area has been shaped by variations in geology, soils, landform, vegetation, and the settlement and use by people. As mentioned in **Table 5-14**, the topography, or landscape character type, of the Project Area is mainly cleared pastural land with fragmented stands of lowland forest.

5.13.3 Assessment of environmental impacts

Impact assessment method and pre-mitigation impact assessment

In order to assess the impacts on landscape and visual amenity from the Project activities, the following aspects need to be considered.

- Analysis and description of the landscape character, including landscape features, and visual amenity;
- Identification of the sensitivity of the landscape resource and viewers (i.e., visual receptors) in relation to the Project;
- Identification of the potential impacts on the landscape character and visual amenity of the viewers during project activities; and
- Identification of options for design, mitigation, and management of potential landscape and visual impacts associated with the Project activities.

An assessment of landscape effects deals with the effects of change and development on landscape as a resource, and how the Project will affect the elements that make up the landscape, the aesthetic, and the perceptual aspects of the landscape and its distinctive character.

The evaluation of overall potential impacts from the Project activities on landscape and amenity is based on the sensitivity to change of the existing landscape and the magnitude of change that is likely to occur[20].

The landscape sensitivity and the extent to which it can accept change of a particular type and scale without adverse effects on its character must be assessed.

Landscape sensitivity can vary according to the type of development proposed and the nature of the landscape, including:

- Its inherent landscape value (its condition, perceptual qualities, cultural importance, and any specific values that may apply, e.g., planning designations based on scenic amenity).

[20]There are no prescribed or existing methods for assessing the significance of landscape impacts, therefore professional judgement and experience are applied to identify the level of significance.

- The likely congruency of the proposed change (i.e., the extent to which the proposal may fit or be 'visually absorbed' into the scale, landform, land use, pattern, texture of the existing landscape).

Sensitivity can be described as: high, medium, low, or negligible (refer to **Table 5-15**).

Table 5-15 Landscape Sensitivity Categories Definitions

Attributes of Landscape Sensitivity Categories	Landscape Sensitivity
A landscape protected by national designation and/ or widely acknowledged for its quality and value; a landscape with distinctive character and low capacity to accommodate the type of change envisaged.	High
A moderately valued landscape, perhaps a regionally important landscape and / or protected by regional/state designation, or where its character, land use, pattern and scale may have some capacity to accommodate a degree of the type of change envisaged.	Medium
A landscape valued to a limited extent, perhaps a locally important landscape or where its character, land use, pattern and scale is likely to have the capacity to accommodate the type of change envisaged.	Low
A landscape which is not valued for its scenic quality or where its character, existing land use, pattern and scale are tolerant of the type of change envisaged, and the landscape has capacity to accommodate change.	Negligible

The magnitude of change affecting a landscape or visual receptor (refer to **Table 5-16**) depends on the nature, scale and duration of the particular change that is expected to occur. In a landscape, the magnitude of change will depend on the loss, change or addition of any feature, or any change in the backdrop to, or outlook from a landscape that affects its character.

The effect on a view will depend on the extent of visibility, degree of obstruction of existing features, degree of contrast with the existing view, angle of view, duration of view and distance from the development.

Magnitude of change can be described as: dominant, considerable, noticeable, and imperceptible.

Table 5-16 Landscape Magnitude of Change Definition

Attributes of Landscape Magnitude of Change Categories	Landscape Sensitivity
Dominant change: A clearly evident and frequent/continuous change in landscape characteristics affecting an extensive area, which is likely to fundamentally change the character of the landscape.	High
Considerable change: A considerable change in landscape characteristics, frequent or continuous and over a wide area or a clearly evident change, but over a restricted area.	Medium
Noticeable change: A noticeable change in landscape characteristics over a wide area or a considerable change over a restricted area but will not fundamentally change the character of the landscape.	Low
Imperceptible change: An imperceptible, barely, or rarely perceptible change in landscape characteristics.	Negligible

The significance level of potential visual impacts due to activities from the Project is then derived from the definitions as per **Table 5-15** and **Table 5-16**. Visual impacts are then classified as major, high, moderate, low, or negligible.

As per the SGPEIS, the landscape and visual amenity value sensitivity of this topography characteristic type was assessed as 'Medium'. The magnitude of the impact, pre-mitigation measures was assessed as 'noticeable' to 'considerable', which final impact was assessed as 'Moderate'.

Potential impacts to visual amenity from dust during construction and operation are covered in Section 5.1. Traffic impacts, including road safety impacts, resulting from the Project are outside the scope of the EP Act, except in so far as the Project's traffic movements may result in environmental impacts.

Mitigation measures to reduce the impact from the Project to landscape and visual amenity are provided in Section 5.13.4 and **Table 5-17**.

5.13.4 Proposed management practices

Arrow Energy Standards

Arrow Energy has a number of existing management and mitigation strategies designed to manage actual and potential impacts to landscape and visual amenity. Arrow Energy's Amenity Standard is in place to ensure that amenity impacts from Arrow Energy's activities are managed appropriately.

The requirements under Arrow Energy's Amenity standard include:

- Processes must be implemented to ensure compliance with relevant legislation and regulatory requirements associated with amenity management.
- Ensure that the appropriate amenity risk assessments are conducted, and controls implemented to reduce risks to as low as reasonably practicable. Assessments shall consider noise, light, odour, landscaping, and visual intrusion impacts, and shall be undertaken at the design phase of an activity as well as at subsequent stages as relevant.
- Where identified as part of the risk assessment:
  - locate, design, and operate infrastructure to minimise amenity impacts;
  - determine potential noise impacts and implement controls to manage the impacts of noise associated with activities;
  - minimise the extent of disturbed areas that are visible from public roads, residences, and towns;
  - minimise the visual contrast between equipment and structures and the surrounding landscape;
  - avoid making permanent changes to natural landforms where practical
  - document amenity impact control measures;
  - develop appropriate monitoring programs; and
  - maintain management and monitoring records.
- All personnel associated with amenity management shall receive awareness training, and all personnel carrying out monitoring activities shall be trained and competent to do so.

- Landholder requirements for amenity management, as documented in land access conditions, shall be complied with.
- Sensitive receptors shall be identified where there is potential for impact from Arrow's activities.
- Ensure that stakeholders are consulted to identify and understand local environmental values to be protected, prior to commencing activities that have the potential to cause impacts.
- Ensure all complaints associated with amenity are managed in accordance with Arrow's Complaints Management System.

Avoidance, mitigation, and management measures

Environmental and social protection objectives for landscape and visual amenity include:

- Avoiding or minimising the impact on sensitive viewsheds within the project area.
- Avoiding or minimising moderate to high impacts to landscape character.

Avoidance, mitigation, and management measures are proposed to be implemented for each phase of the Project to minimise potential impacts to changes in landscape character and visual amenity.

Project activities and post-mitigation measures

Project activities likely to cause impacts on landscape and visual amenity values can be described depending on the project phase, i.e., during construction, operation, and decommissioning.

Planning is also considered an important project phase, as adequate planning will determine the most appropriate location of infrastructure in order to minimise visual disturbance on visual receptors.

The impact from the construction activities on landscape and visual amenity will vary, depending on its nature (e.g., construction of a production well versus construction of a gas production facility), and the type of landscape and location of visual receptors. Construction activities will involve:

- Excavation, trenching, drilling, earthmoving, vegetation clearance/trimming and temporary lighting; and
- Presence of workforce, construction camps and associated transport (e.g., large trucks, 4WD vehicles, graders, excavators, and tractors, etc.).

During operations, the nature of the impact will largely be determined by the size of the infrastructure and type of landscape. The following project activities could impact upon landscape and visual amenity values:

- The presence and operation of production wells, gathering lines and incidental activities; and
- The presence of maintenance crew, their temporary drilling camps and associated transport.

During decommissioning the potential impacts upon landscape and visual amenity values include:

- Decommissioning, deconstruction, and removal of production wells, gathering lines and associated infrastructure; and
- The presence of workforce, possible construction camps, and associated transport (e.g., large trucks, 4WD vehicles, graders, excavators, and tractors, etc.).

Mitigation measures to reduce the potential impacts to landscape and visual amenity are presented in Table 5-17.

Table 5-17 Summary of Landscape and visual amenity impacts mitigation measures

Project phase	Mitigation measures
Planning/Design	• Where practicable, locate project infrastructure in the landscape of lowest sensitivity and maintain the maximum distance practicable from (and minimise visual disturbance on) the most sensitive visual receptors. • Avoid visually sensitive locations and landscapes, where practicable. • Where appropriate to the landscape sensitivity, hide or screen project infrastructure using natural landscape elements. • Consult with potentially impacted visual receptors in locating project infrastructure.
Construction	• Restrict lighting to the minimum required for safety and security during drilling. • Minimise footprint disturbance and vegetation clearing to reduce the magnitude of change on the affected landscape. • Implement progressive rehabilitation as soon as practicable following construction. • Locate topsoil and spoil mounds in visually unobtrusive locations. • Where practicable, use existing roads. • Maximise alignment of roads with existing landscape features such as fencing and natural drainage. • Minimise the length and width of roads. • Implement erosion control measures during construction of well pads and access roads. • Minimise construction time near sensitive visual receptors.
Operation	• Maintain erosion control measures. • Minimise dust and rutting along roads. • Ensure screening barriers adhere to required vegetation heights at different distances for fire mitigation measures.
Decommissioning	• Remove surface infrastructure and reinstate disturbed areas as soon as practicable to pre-disturbance landscape characteristics; or consult with landowners regarding reinstatement objectives.

With the implementation of the mitigation measures, the magnitude and significance of the residual impact for the topography landscape type of the Project (i.e., Lowland native forest) was assessed as imperceptible and low, respectively.

6. Impact Assessment Matters of State Environmental Significance

6.1 Summary of Matters of State Environmental Significance

Table 6-1 also describes MSES identified as relevant to the proposed activity based on surveyed and indicative alignments, and assesses potential impacts to identified MSES Environmental Values.

Table 6-1 Assessment of potential for proposed activities to affect MSES

MSES	Presence	Impact
Regulated Vegetation	Please refer to Section 3.1.1 of the BIA (refer to Appendix B), for a description of regional ecosystems at the locations of proposed activities.	Please refer to Section 4.2.1 of the attached third-party report (refer to Appendix B) for a description of potential impacts to regulated vegetation at the locations of proposed activities. Activities with an SRI on 'endangered' and 'of concern' Regional Ecosystems that have not been previously authorised have been added to proposed amendments to EA Condition Biodiversity 10 (refer to Appendix C).
Connectivity Areas	DETSI's Landscape Fragmentation and Connectivity (LFC) tool was used to assess potential for the proposed activity to affect remnant ecosystem connectivity.	The output from the LFC tool indicates that there is no significant residual impact on connectivity areas as a result of the activities proposed in this application.
Wetland and Watercourses	The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* 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	The proposed activity does not impact on any wetlands. Impacts on waterways are generally restricted to watercourse crossings for linear infrastructure ROWs. Erosion and sediment control would be appropriately managed, in accordance with the existing EA and Arrow's management plans. The proposed activity would comply with existing EA conditions regarding the watercourse 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.

MSES	Presence	Impact
	Dawson River Sub-basin Environmental Values and Water Quality Objectives: • Protection of aquatic ecosystems; • The suitability of the water for agricultural purposes • Suitability for visual recreational use; and • Cultural and spiritual values of the water. 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.	
Protected Wildlife Habitat	Please refer to Section 3.1.1 of the BIA (refer to Appendix B), for a description of regional ecosystems at the locations of proposed activities.	Please refer to Section 4 of the attached third-party report (refer to Appendix A) for a description of potential impacts to protected wildlife habitat at the locations of proposed activities. Impact areas for affected species have been included in the proposed amendments to Condition Biodiversity 10, Table 3 – Impacts to prescribed environmental matters. Arrow Energy would implement the management strategies and mitigation measures described in the Species Impact Management Plan. Planned actions include: marking of adjacent no-go zones; the presence of a suitably qualified fauna spotter during vegetation clearing; and slow sequential clearing to allow movement of wildlife away from activities and avoid habitat fragmentation.
Koala Habitat in SEQ	The surveyed area of the proposed activities is not within SEQ.	None.

MSES	Presence	Impact
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 activities 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 Field surveys by suitably qualified persons confirmed all proposed activities are located outside wetland, lake, spring, and watercourse buffers.	Arrow is committed to working in waterways in accordance with the Accepted Development Requirements (ADRs) for raising Waterway Barrier Works. The ADRs have been developed by the Department of Fisheries as a methodology which does not require additional approval and is considered low impact activity not requiring consideration for offset. Should the ADRs be unable to be complied with, Arrow will fulfill its legal obligations pursuant to the Planning Act 2016.
Marine Plants	The surveyed area of the proposed activities is terrestrial and inland.	None.
Offset Areas	No legally secured offset areas were identified within the surveyed area of the proposed activities.	None.

7. Legislative Requirements

7.1 Assessment Level Decision

Arrow Energy is applying to amend its Hopeland EA (EA0001401) as per Section 224 of the EP Act as it proposes to carry out additional resource activities as part of the Jammat Phase 1 Development 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 7-1**.

Table 7-1 Threshold criteria for an amendment to an EA

Amendment Threshold Criteria (EP Act Section 223)	This EA Amendment Application
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 include changes to standard conditions.
b) does not significantly increase the level of environmental harm caused by the relevant activity; and	The proposed amendment ***may*** lead to an increase in the risk of environmental harm, although the environmental risks associated with the Project activities, as assessed in the SGPEIS, have not materially changed. This EA amendment seeks to update the maximum disturbance areas within Environmentally Sensitive Areas (ESAs) and Prescribed Environmental Matters (PEMs) to facilitate the development of the Hopeland Stage 2 wells and infrastructure.
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.

Amendment Threshold Criteria (EP Act Section 223)	This EA Amendment Application
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 SGPEIS and SREIS. This application seeks to authorise an additional 55 wells, associated gathering and access and incidental activities. In addition, the application seeks to update the ESAs and impact to PEMs to support the development of the proposed infrastructure.
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 increase the surface area for the relevant activity greater than 10% of the existing area.**
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 statutory requirements for amending an EA are set out in sections 226 and 226A of the EP Act.

Table 7-2 summarises the statutory requirements under Section 226 and the responses from Arrow Energy to each of these requirements.

Table 7-2 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 DETSI which is the administering authority for this EA (EA0001401).
(b) be in the approved form; and	The Approved form is provided as supporting information to this 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 to DETSI's.
(d) describe the proposed amendment; and	Full details of this proposed EA amendment are included in this EA Amendment Supporting Document (refer to Section 2, Appendix A), so the administering authority, can clearly determine the requested changes to the Hopeland EA (EA0001401). This document and its Appendices provides the supporting information documentation to the Hopeland 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 Hopeland EA on PL253. No new areas will be included. Maximum disturbance to ESAs and PEMs are discussed and provided in Section 5.6.3 and Appendix B.
(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 Error! Reference source not found.).

Table 7-3 summarises the statutory requirements under Section 226A and the responses from Arrow Energy to each of these requirements.

Table 7-3 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.

Statutory requirement under s226A of the EP Act	Arrow Energy's Response
(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 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	(i) See Section 5.
(ii) details of emissions or releases likely to be generated by the proposed amendment; and	(ii) See Section 5.1 (Air) and Section 5.8 (Surface water).
(iii) a description of the risk and likely magnitude of impacts on the environmental values; and	(iii) See Section 5.
(iv) details of the management practices proposed to be implemented to prevent or minimise adverse impacts; and	(iv) See Section 5.
(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	(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 Hopeland EA and the SGPEIS and SREIS. See Section 4.9.6 and Section 5.12.
(h) include details of any site management plan or environmental protection order that relates to the land the subject of the application.	Not applicable.

7.2 Requirements for Amendment Application for CSG Activities

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 7-4** and the CSG Water Management Plan provided in Appendix G.

Table 7-4 - 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 does not propose any changes to the existing 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 (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	Yes. The application relates to a site-specific environmental	Applicable.

Amendment application for CSG activities	Arrow Energy's response	
licence, mining lease or petroleum lease; and	authority for which the relevant tenure is a petroleum lease.	
(b) the proposed amendment involves changes to the exercise of underground water rights.	The proposed amendments may involve changes to the exercise of underground water rights (refer to Section 5.9 and Appendix E).	Applicable. The application includes an assessment pursuant to Section 126A of the EP Act.

Appendix A. Draft EA (EA0001401 with marked-up changes), Table of changes and justification

EA Section	EA Condition / Table / Location of change	Proposed changes	Justification and Report Section(s) where applicable
Cover Page – Environmental Authority Number: EA0001401			
EA Cover Page	Cover page	**Insert** date (DD Month YYYY) on which the EA takes effect.	EA take effect date required.
Cover Page – Environmentally relevant activity and location details			
Environmentally relevant activity/activities	Environmentally Relevant Activities (ERAs) Table	**Add** the following ERA: • **Schedule 2, Ancillary ERA 63 – Sewage Treatment, 1:** Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of – **(a-i)** 21 to 100EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme.	Administrative change. To include the relevant ERA in the ERA table in relation to activities that the existing EA conditions allow for (i.e. Sewage treatment conditions included in Condition Waste 11 – 14). As the Hopeland EA already authorises the release of treated sewage effluent or greywater to land through existing condition Waste 11, this is, STPs with release limits defined for camp sizes up to 1500EP. As such, Arrow Energy believes that ERA 63(1)(a) and (b) was unintentional not shown in the ERA list and should already be listed in the EA.
Schedule A – General			
General Conditions	Condition (A1)	**Amend** condition by adding the text in **bold**: (A1) This environmental authority authorises the carrying out of the following resource activity(ies): a) The petroleum activities listed in Schedule A, Table 1 – Authorised petroleum	To include: • ERA for already authorised sewerage treatment works.

<table>
<tr><th>EA Section</th><th>EA Condition / Table / Location of change</th><th>Proposed changes</th><th>Justification and Report Section(s) where applicable</th></tr>
<tr><td></td><td></td><td>activities to the extent they are carried out in accordance with the activity's corresponding scale and intensity (or both, where applicable);

b) The following specified relevant activities:

(i) Resource Activity, Schedule 3 – 06: A petroleum activity carried out on a site containing a high hazard dam or a significant hazard dam;

(ii) Resource Activity, Schedule 3 – 03: A petroleum activity that is likely to have a significant impact on a category A or B environmentally sensitive area.

c) The following specified environmentally relevant activities (ERAs):

i. Sewage treatment – operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (a-i) 21 to 100EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme.

d) Incidental activities that are not otherwise specified relevant activities.</td><td></td></tr>
<tr><td>General Conditions</td><td>Condition (A1)</td><td>Amend Table 1 – Authorised Petroleum Activities to include the text in bold below and remove the struckout text:

<table>
<tr><th rowspan="2">Petroleum Activities and Infrastructure</th><th colspan="2">Scale</th></tr>
<tr><th>Intensity (Extent)</th><th>Maximum</th></tr>
<tr><td>Existing Wells</td><td>6 ha</td><td>6 wells</td></tr>
</table></td><td>To include the proposed 55 wells access and gathering required to construct the proposed Hopeland Stage 2 Development.

Streamlining to remove specificity in Table 1 and simplify Authorised activities to the number of wells that are authorised.
Removing gathering and access quantification from Table 1 would remove incidental activities from Table 1 and also remove duplication of approved limits</td></tr>
</table>

EA Section	EA Condition / Table / Location of change	Proposed changes			Justification and Report Section(s) where applicable
			See definition of Essential Petroleum Activities for well pad disturbance size (in hectares)		within the EA which could create conflicts or additional constraints. Listing ever piece of infrastructure length or hectare is extremely prescriptive and would not allow any flexibility if there was design or engineering changes, where there was no other EA constraint except for the length within the authorised activity table. Disturbance limits to environmental values such as impacts to ESAs and PEMs have been quantified and included in the relevant tables in the EA and amendments to these tables are included in this application for consideration. These limits provide the appropriate constraint to protect environmental values. This would also bring the Hopeland EA into alignment with other recently approved Arrow EAs and ensures consistency when managing compliance across Arrows EA as they are operated as single integrated project.
		Stage 1 Wells	55 ha See definition of Essential Petroleum Activities for well pad disturbance size (in hectares)	55 **wells**	
		Stage 2 Wells		**55 wells**	
		Existing and additional Water Monitoring Bores	0.03 ha for shallow monitoring bores 1 ha for deep monitoring bores	30	
		~~Gathering and Raw Water Pipelines~~	~~155 ha~~	~~N/A~~	
		~~Access Tracks~~	~~74 km~~	~~74 km~~	
		Borrow Pits	3 ha	6 borrow pits	
		Sediment Ponds	0.76 ha	2 sediment ponds	

EA Section	EA Condition / Table / Location of change	Proposed changes	Justification and Report Section(s) where applicable
		Hopeland Water Dam (regulated structure) — 21 ha — 1 dam	
Waste Conditions			
Condition Waste 11	Condition Waste 11	**Remove** condition (Waste 11).	Remove condition as per proposal to include new conditions linked to STP release limits. As such, propose to delete references to secondary treated class B standards and class C standards. This will also link to similar STP limits across industry and STP suppliers.
Condition Waste 12	Condition (Waste 12)	**Change** condition (Waste 12) to Waste (11) and include the following (**add** wording in **bold** and **remove** crossed out text): (Waste 12) ~~The release of t~~ **T**reated sewage effluent or greywater **from a treatment system with a daily peak design capacity of less than 50EP may be released to land provided it:** ~~authorised in condition (Waste 11) must:~~ (a) **is** to a fenced and signed contaminant release area(s)**;** (b) **does** not result in pooling or run-off or aerosols or spray drift or vegetation die-off; **(c) minimises deep drainage below the root zone of any vegetation;** **(d) does not adversely affect the quality of shallow aquifers;**	To authorise temporary drilling camps which may be up to a max 50EP, to be able to release treated sewage or grey water to land for irrigation as long as they comply with the conditions in this new proposed condition Waste 11. As it is currently under the Hopeland EA, STPs with less than 21EP are authorised to release these type of effluents to land without any release limits due to

EA Section	EA Condition / Table / Location of change	Proposed changes	Justification and Report Section(s) where applicable
		(e) does not adversely impact soil quality; and **(f) is** to a contaminant release area(s) that is kept vegetated with groundcover, that is: i. not a ~~prohibited matter, restricted matter species of weed of national significance~~ **declared <u>pest</u> species**; ii. kept in a viable state for transpiration and nutrient uptake; and iii. grazed or harvested and removed from the contaminant release area as needed, but not less than every three <u>months</u>.	the low risk nature based on the DETSI risk assessment for petroleum activities and the short term duration of the release (i.e. drilling campaign operate for a few weeks or workover rig), before they are demobilised to another site. Arrow Energy proposes to increase this from 21EP to 50EP through this new condition (replacement Waste 11), consistent with the other recently approved Arrow EA conditions, only for temporary drilling camps to allow for operational flexibility whilst reducing HSSE exposure from increased driving from rig camps to another rig camp or towns because of the restriction on the maximum camp EP for the duration of the drilling campaign.
Condition Waste 14	Condition (Waste 14)	**Remove** Condition Waste 14	Removing condition to adopt outcome focused approach and reduce specificity. The EA contains conditions that adequately protect environmental values that Arrow Energy is committed to complying with.
Biodiversity			

<table>
<tr><th>EA Section</th><th>EA Condition / Table / Location of change</th><th>Proposed changes</th><th>Justification and Report Section(s) where applicable</th></tr>
<tr><td>Condition Biodiversity 8A</td><td>Condition Biodiversity 8A</td><td>Add to Condition Biodiversity 8A, Table 1 the definition for ESA that are protected ‘wildlife habitat’ and the condition in columns ‘Within the ESA’ and ‘Primary protection zone of the ESA’ as per below in bold (also refer to Draft EA (marked-up EA0001401).

The modified Table 1 would look like the following:
<table>
<tr><th>Environmentally Sensitive Area</th><th>Within the Environmentally Sensitive Area</th><th>Primary protection zone of the Environmentally Sensitive Area</th><th>Secondary protection zone of the Environmentally Sensitive Area</th></tr>
<tr><td>Category A environmentally sensitive areas</td><td>No petroleum activities permitted.</td><td>Only low impact petroleum activities permitted.</td><td>Only essential petroleum activities permitted.</td></tr>
<tr><td>Category B environmentally sensitive a reas that are other than ‘endangered' regional ecosystems</td><td>Only low impact petroleum activities permitted.</td><td>Only low impact petroleum activities permitted.</td><td>Only essential petroleum activities permitted.</td></tr>
<tr><td>Category B environmentally sensitive a reas that are ‘endangered’ regional ecosystems</td><td>Only low impact petroleum activities permitted.</td><td>Only essential petroleum activities permitted.</td><td>Only essential petroleum activities permitted.</td></tr>
</table></td><td>Proposed change to Table 1 and to add the condition to protected wildlife habitat is to align with DETSI letter to AEP on 13 May 2024 on the departments approach to condition protected wildlife habitat.</td></tr>
</table>

EA Section	EA Condition / Table / Location of change	Proposed changes				Justification and Report Section(s) where applicable
		Category C environmentally sensitive areas that are 'nature refuges' or 'koala habitat'	Only low impact petroleum activities permitted.	Only low impact petroleum activities permitted.		
		Category C environmentally sensitive areas that are 'essential habitat', 'essential regrowth habitat', or '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.**	**Only essential petroleum activities permitted.**		
		Category C environmentally sensitive areas that are 'regional parks' (previously known as 'resources reserves')	Only essential petroleum activities permitted.	Only essential petroleum activities permitted.		

<table>
<tr><th>EA Section</th><th>EA Condition / Table / Location of change</th><th>Proposed changes</th><th>Justification and Report Section(s) where applicable</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><td>Category C environmentally sensitive areas that are ‘state forests’ or ‘timber reserves’</td><td>Only essential petroleum activities permitted.</td><td>Petroleum activities permitted.</td></tr>
<tr><td>Areas of vegetation that are ‘critically limited’</td><td>Only low impact petroleum activities permitted.</td><td>Only essential petroleum activities permitted.</td></tr>
</table>
</td><td></td></tr>
<tr><td>Condition Biodiversity 8B</td><td>Condition Biodiversity 8B</td><td>
Remove: Existing Biodiversity 8b Table 2 and replace with the new Table 2 below.

Table 2 – Authorised petroleum activities in environmentally sensitive areas and their protection zones
<table>
<tr><th>Environmentally Sensitive Areas</th><th>Location of impact</th><th>Maximum Disturbance (ha) (Stage 1)</th><th>Maximum Disturbance (ha) (Stage 2)</th></tr>
<tr><td>Category B environmentally sensitive areas that are 'endangered' regional ecosystems</td><td>PL253</td><td>0.79</td><td>0.41</td></tr>
</table>
</td><td>Replacement of Table 2 would allow for the inclusion of the disturbance for proposed Stage 2 wells and petroleum infrastructure. As Protected Wildlife Habitat was not included as an ESA at the time of authorisation, Staging has been included to demonstrate that disturbance within Category C ESAs that are protected wildlife habitat and its protection zones is only applicable to Stage 2 infrastructure.</td></tr>
</table>

EA Section	EA Condition / Table / Location of change	Proposed changes				Justification and Report Section(s) where applicable
		Category C environmentally sensitive areas that are 'essential habitat', 'essential regrowth habitat', or 'of concern' regional ecosystems	PL253	9.78	0.78	
		Category C environmentally sensitive areas that are protected wildlife habitat*	PL253	2.08	3.41	
		Category B environmentally sensitive area primary protection zones	PL253	0	To the extent they are required for authorised activities within the Hopeland Stage 2 maximum boundary, outlined in Condition Biodiversity 8C, Figure 1 – Stage 2 maximum boundary.	
		Category B environmentally sensitive area secondary protection zones	PL253	0		
		Category C environmentally sensitive area primary protection zones	PL253	0		
		*only applies to Stage 2 wells and infrastructure as Protected Wildlife Habitat was not an ESA at the time of authorisation of Stage 1.				

EA Section	EA Condition / Table / Location of change	Proposed changes	Justification and Report Section(s) where applicable
Condition Biodiversity 8B	***After*** condition (Biodiversity 8B)	**Add** condition (Biodiversity 8C) (all wording): (Biodiversity 8C) Despite condition (Biodiversity 8A) and (Biodiversity 8B), petroleum activities are permitted in ESAs, as well as their primary protection zones (PPZs) and secondary protection zones (SPZs), if they satisfy the following: a) Do not exceed the maximum area for each environmentally sensitive area as shown in Biodiversity 8B, Table 2 – Authorised petroleum activities in environmentally sensitive areas and their protection zones; and b) are undertaken within the footprint prescribed in Biodiversity 8C, Figure 1 – Hopeland Stage 2 Maximum Boundary.	Proposed change is to provide a linkage to the authorised limit/ pool to be drawn down on through Table 2, and a despite clause to *Biodiversity 8B Table 2 – Authorised petroleum activities in environmentally sensitive areas and their protection zones*, to allow essential petroleum activities to occur in relevant ESA without the need to go through numerous EA amendments to authorise. These authorisations would also be linked to PEMs disturbance limits, offsets, and SRI assessments. The inclusion of the Figure and provision of spatial data to DETSI is to facilitate DETSI compliance to check against the limits. i.e., by Arrow Energy providing spatial data consistent with Annual returns, ERC, and Plan of Operations. DETSI can then do periodic checks as to where disturbance has occurred in ESAs and have the disturbance limits set out in the EA (including PEMs) been complied with including annual ESA reporting conditions.

EA Section	EA Condition / Table / Location of change	Proposed changes	Justification and Report Section(s) where applicable
			This approach is also consistent with other recently approved Arrow EAs (i.e. EA0001399).
Condition Biodiversity 10	Condition Biodiversity 10 Table 3 — Impacts to prescribed environmental matters	**Changes** to Prescribed Environmental Matters (PEMs) table maximum disturbance numbers from biodiversity impact assessment provided in Appendix B (external consulting company) and detail of changes as provided in Appendix A (marked-up EA) and Appendix C, with specific changes to PEMs table numbers provided in the marked-up EA.	To include impacts to biodiversity and changes to PEMs table due to proposed Stage 2 activities not previously authorised (refer to Section 5.6 and Appendix B for detailed biodiversity impact assessment and to Appendix C for detail of maximum extent of impact to PEMs for the Project.
Condition Biodiversity 10	Condition Biodiversity 10 Table 3 — Impacts to prescribed environmental matters	**Add** the following wording immediately after Table 3 – Impacts to prescribed environmental matters: Matter(s) of National Environmental Significance (MNES) have been prescribed and will be offset in accordance with the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Species Impact Management and Offset Plans, specifically the EPBC approval for the Surat Gas Project Environment Impact Statement (EPBC Approval 2010/5344, Tables 1 and 2).	Administrative change to clarify that impacts to MNES that have been included in the existing SGP EPBC Approval (2010/5344) will be offset in accordance with the provisions of the EPBC. This would be consistent with other recently approved Arrow EAs.
Condition Biodiversity 14	Condition Biodiversity 14	**Remove** Biodiversity 14.	Proposed removal of these conditions is to provide more flexibility if a new stage is proposed to be commenced prior to completion of the previous stage. The EA contains Condition Biodiversity 17 which still requires the submission of a final report providing analysis of impacts to
Condition Biodiversity 15	Condition Biodiversity 15	**Remove** Biodiversity 15	

EA Section	EA Condition / Table / Location of change	Proposed changes	Justification and Report Section(s) where applicable
			PEMs and the Notice of Election (if required). SRIs and impacts to PEMs are still required to be assessed and authorised prior to disturbance with maximum disturbance limits already defined and included in the EA. This would be consistent with other recently approved Arrow EAs.
Schedule K - Definitions			
	Category C Environmentally Sensitive Area	**Add** wording (in **bold** below) • **an area validated from as from ground-truthing surveys as 'protected wildlife habitat' that is category A, B or C on the Remnant Vegetation Management Map, in accordance with section s0A of the *Vegetation Management Act 1992*, for a species of wildlife listed as critically endangered, endangered, vulnerable under the *Nature Conservation Act 1992***	Administrative change. Minor administrative amendment to update to most recent condition approach from DETSI with regards to Protected wildlife habitat and essential habitat.
	secondary treated class A standards	**Remove** definition.	Proposal is to move to discharge limits as proposed with the addition of Condition (Waste 11).
	secondary treated class B standards	**Remove** definition.	Proposal is to move to discharge limits as proposed with the addition of Condition (Waste 11).

EA Section	EA Condition / Table / Location of change	Proposed changes	Justification and Report Section(s) where applicable
	secondary treated class C standards	**Remove** definition.	Proposal is to move to discharge limits as proposed with the addition of Condition (Waste 11).

Appendix B. Biodiversity Impact Assessment (Attexo Consulting)

Appendix C. Proposed Prescribed Environmental Matters (PEMs) EA table

This EA amendment proposes the following changes to Condition Biodiversity 10, *Table 3 - Impacts to prescribed environmental matters*

Prescribed Environmental Matter	Location of impact	Maximum extent of impact (ha) – Stage 1	SRI and Offsets required – Stage 1	Maximum extent of impact (ha) - Stage 2	SRI and Offsets required – Stage 2
REGULATED VEGETATION					
Endangered regional ecosystem					
RE 11.4.3	PL253	0.75	Yes	0	No
Of concern regional ecosystem					
RE 11.3.4	PL253	0.58	Yes	0	No
Regional ecosystems (not within an urban area) within the defined distances from the defining banks of a relevant watercourse on the vegetation management watercourse map					
RE 11.3.25 (BVG 16a)	PL253	0.41	Yes	0.14	Yes
RE 11.5.1 (BVG 18b)	PL253	0.65	Yes	0	No
RE 11.3.4 (BVG 16c)	PL253	0.02	Yes	0	No
Essential habitat (not in an urban area) on the essential habitat map for endangered wildlife					
Phascolarctos cinereus (Koala)	PL253	0	No	0	No
Petaurus australis (Yellow-Bellied Glider - southern subspecies)	PL253	2.76	Yes	0	No
Philotheca sporadica (Kogan Waxflower)	PL253	8.37	No	0	No
Essential habitat (not in an urban area) on the essential habitat map for vulnerable wildlife					

Prescribed Environmental Matter	Location of impact	Maximum extent of impact (ha) – Stage 1	SRI and Offsets required – Stage 1	Maximum extent of impact (ha) - Stage 2	SRI and Offsets required – Stage 2
Jalmenus eubulus (Pale Imperial Hairstreak)	PL253	0.23	Yes	0	No
CONNECTIVITY AREAS					
Connectivity area that is a regional ecosystem (not in an urban area)	PL253	0	No	0	No
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	PL253	In accordance with the protected plant clearing framework and relevant protected plant clearing permit under the *Nature Conservation Act 1992*			
An area not shown as a high risk area on the flora survey trigger map that contains plants that are endangered or vulnerable wildlife	PL253	In accordance with the protected plant clearing framework and relevant protected plant clearing permit under the *Nature Conservation Act 1992*			
Habitat for an animal that is endangered wildlife					
Hemiaspis damelii (Grey snake)	PL253	17.65	Yes	0.41	Yes
Phascolarctos cinereus (Koala)	PL253	66.84	Yes	3.00	Yes

Prescribed Environmental Matter	Location of impact	Maximum extent of impact (ha) – Stage 1	SRI and Offsets required – Stage 1	Maximum extent of impact (ha) - Stage 2	SRI and Offsets required – Stage 2
Petauroides volans (Greater Glider)	PL253	40.37	Yes	0	No
Adclarkia cameroni (Brigalow Woodland Snail)	PL253	N/A	No	0.16	Yes
Habitat for an animal that is vulnerable wildlife					
Acanthophis antarcticus (Common Death Adder)	PL253	40.65	Yes	0	No
Calyptorhynchus lathami (Glossy Black Cockatoo)	PL253	3.92	Yes	0	No
Jalmenus eubulus (Pale Imperial Hairstreak)	PL253	0.75	Yes	0	No
Furina dunmalli (Dunmall's Snake)	PL253	39.42	Yes	0.41	Yes
Nyctophilus corbeni (South-Eastern Long-Eared Bat)	PL253	39.44	Yes	0	No
Stagonpleura guttata (Diamond Firetail)	PL253	N/A	No	3.00	No
Aphelocephala leucopsis (Southern Whiteface)	PL253	N/A	No	3.00	No
Habitat for an animal that is special least concern wildlife					
Tachyglossus aculeatus (Echidna)	PL253	3.75	Yes	0	No

Prescribed Environmental Matter	Location of impact	Maximum extent of impact (ha) – Stage 1	SRI and Offsets required – Stage 1	Maximum extent of impact (ha) - Stage 2	SRI and Offsets required – Stage 2
WATERWAY PROVIDING FOR FISH PASSAGE					
Fish passage (not in an urban area)	PL253 - Kogan Creek, Sixteen Mile Creek	0.15	No	0	No

Matter(s) of National Environmental Significance (MNES) have been prescribed and will be offset in accordance with the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Species Impact Management and Offset Plans, specifically the EPBC approval for the Surat Gas Project Environment Impact Statement (EPBC Approval 2010/5344, Tables 1 and 2).

Appendix D. Spatial data – Hopeland Stage 2 Maximum Boundary

Appendix E. Groundwater Assessment Report and s126A assessment

Appendix F. SGP Terrestrial Ecology Report (Ecosmart, 2017)

Appendix G. Arrow CWMP