Yathong-Ivanhoe Trough Potential Strategic Release Area

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Executive Summary

In June 2016, the NSW Government introduced the NSW Strategic Release Framework for Coal and Petroleum Exploration. The Framework implements a new process for issuing prospecting titles and is overseen by the Advisory Body for Strategic Release. The Advisory Body will make recommendations to the Minister about release of areas for petroleum exploration based on consideration of geological, social, environmental, economic and operator capability factors.

The Geological Survey of NSW (GSNSW) identifies potential areas for release for petroleum exploration, based on geological resource assessments, for consideration by the Advisory Body.

The GSNSW recommends the Yathong-Ivanhoe Trough for consideration by the Advisory Body under the Strategic Release Framework. The Yathong-Ivanhoe Trough is a sedimentary sub-basin in the Darling Basin in Western NSW and the assessed petroleum prospectivity, relative to other underexplored basins and sub-basins, is in the highest tier. The Yathong-Ivanhoe Trough is predominantly prospective for tight gas and has some potential for conventional gas. There is no potential for coal seam gas.

Introduction

NSW contains ten main sedimentary basins that have known petroleum resources or prospectivity potential (Figure 1). There have been oil and gas shows from previous exploration in the main sedimentary basins and potential for discovery of conventional gas/oil, tight gas/oil, shale gas/oil and coal seam gas.

The relatively well explored coal bearing basins in the eastern one third of NSW have identified coal seam gas resources. In contrast, the basins in the western two thirds of NSW are relatively underexplored, but have potential for the discovery of petroleum resources.

The GSNSW has an ongoing program to acquire, analyse and deliver new precompetitive data to improve understanding of the prospectivity of the underexplored basins in the western two thirds of NSW. This program is a part of the New Frontiers Minerals and Energy Exploration Initiative and is expected to progressively identify additional areas for consideration for strategic release.

The GSNSW has identified the Yathong-Ivanhoe Trough for consideration by the Advisory Body for release as a new petroleum prospecting area (Figure 1).

This area was selected based on the current understanding of the level of prospectivity and history of petroleum exploration. The Yathong-Ivanhoe Trough is considered a “Frontier Basin” with respect to petroleum exploration – it is relatively underexplored.

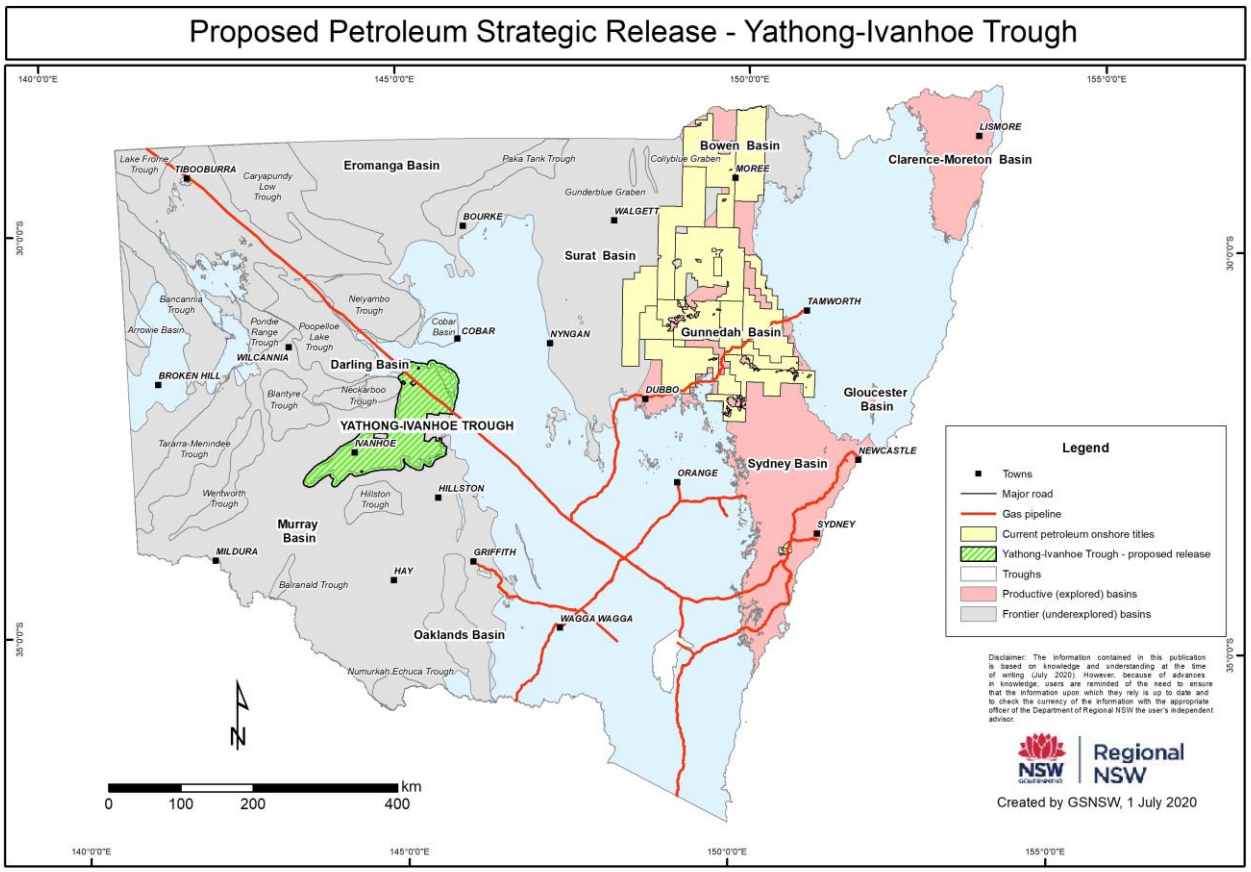

Figure 1 – Yathong-Ivanhoe Trough - potential strategic release area and current petroleum titles in NSW.

Yathong-Ivanhoe Strategic Release Area

The Yathong-Ivanhoe Trough is a sedimentary sub-basin within the Late Silurian to Early Carboniferous Darling Basin, located southwest of Cobar in central western NSW (Figure 2). The Yathong-Ivanhoe Trough is approximately 167 km from north to south, and 209 km east to west, at its greatest length. The Yathong-Ivanhoe Trough covers an area of approximately 13 750 km^2. The estimated maximum sediment thickness in the trough is between 5 500 and 6 000 m, comprising predominantly Devonian aged sandstone and siltstone. The Yathong-Ivanhoe Trough is mostly overlain by Cenozoic sediments of the Murray Basin.

Based on current understanding, the Yathong-Ivanhoe Trough is one of the more prospective areas for petroleum exploration in western NSW. The sub-basin has the potential to attract explorers, and pre-competitive data acquired by Geoscience Australia and the GSNSW over the last eight years has increased the understanding of the area. The Yathong-Ivanhoe Trough may contain conventional and unconventional gas resources. The location of the trough on the Moomba-Sydney gas pipeline, and its proximity to larger towns such as Griffith and Cobar as well as rail and road corridors provide relative ease of access for explorers.

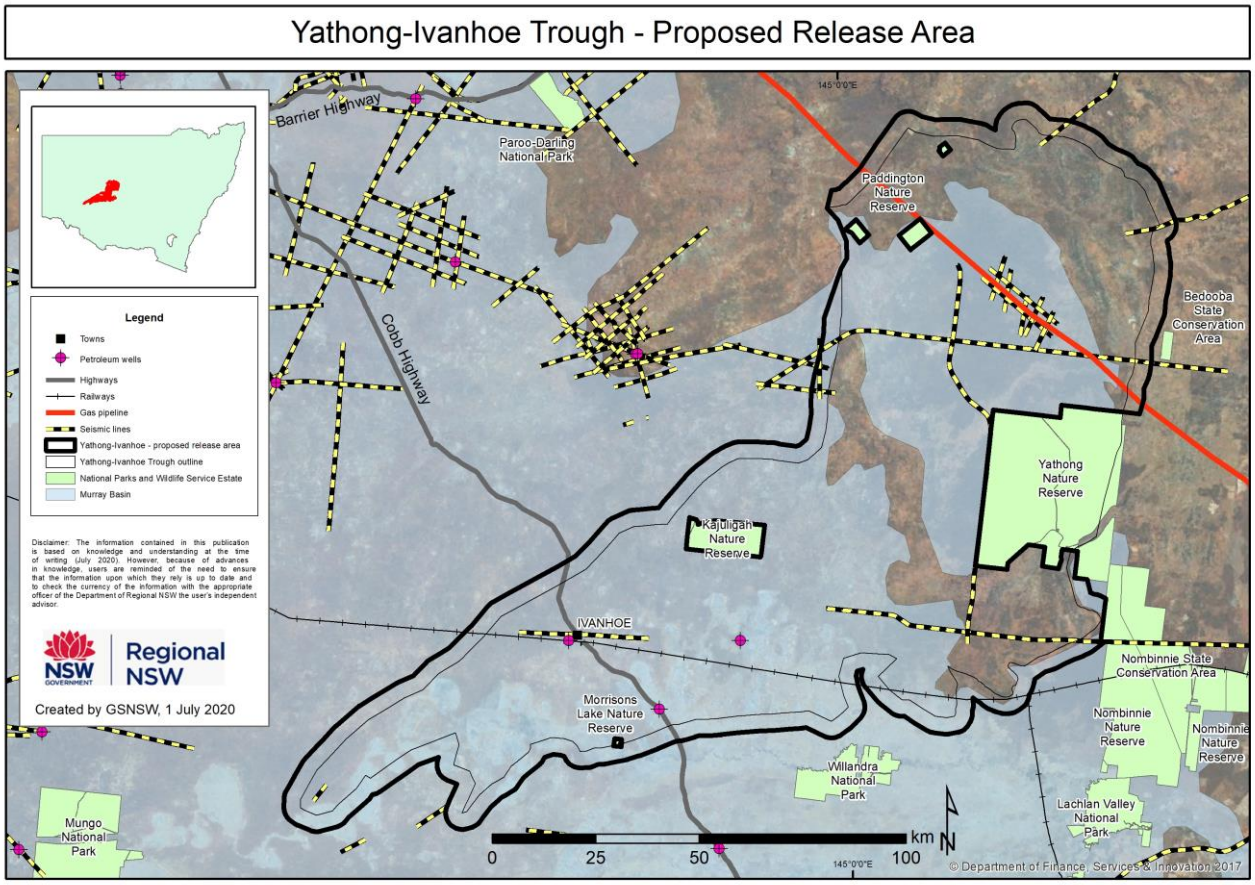

Figure 2 – Yathong-Ivanhoe Trough showing the proposed release area, seismic lines and wells. The proposed release excludes national parks and reserves and has a buffer of 4 km outwards from the interpreted geological boundary of the trough.

History of exploration

The first petroleum exploration licence over the Yathong-Ivanhoe Trough was granted in the 1950s to Frome Broken Hill Co. Pty Ltd. Since then, the sub-basin has been wholly or partially covered by 18 petroleum exploration titles (16 PELs and 2 PSPAUTHs) (Figure 3) and one exploration licence for geothermal substances (Table 1). There were short breaks in exploration activities in the late 1970s and early 1990s. The last petroleum title over the trough was relinquished in 2010.

Table 1 Historic titles covering or partially covering the Yathong-Ivanhoe Trough.

TITLE CODE	TITLE NO	TITLE HOLDER	ACT	APPROX. YEAR OF OPERATION	EXPLORATION HIGHLIGHTS	AREA
PEL	15	Frome Broken Hill Co. Pty Ltd	1955	1960-1963	Field mapping (PGR1958/05)	northwestern Yathong-Ivanhoe Trough

TITLE CODE	TITLE NO	TITLE HOLDER	ACT	APPROX. YEAR OF OPERATION	EXPLORATION HIGHLIGHTS	AREA
PEL	51	Exploration Drilling of Australia, Texam Oil Corporation	1955	1960-1968	Aeromagnetic survey: Ivanhoe (AM009); Gravity and magnetic interpretation (AM017); Gravity survey: Ivanhoe (GR025); Seismic survey: Ivanhoe (SS057) (outside of the trough); Drilling of 3 wells outside the Yathong-Ivanhoe Trough area.	northwestern Yathong-Ivanhoe Trough
PEL	56	Planet Exploration Company Pty Ltd	1955	1962-1966	Interpretation of magnetic survey (AM015); Gravity survey: East Darling (GR012); Seismic survey: Ivanhoe (SS057) (outside of the trough)	western margin of the Yathong-Ivanhoe Trough
PEL	68	Overland Australian Oil Ltd	1955	1962-1962	Desktop studies	eastern Yathong-Ivanhoe Trough
PEL	107		1955	1963-1966	No reports in DIGS	northern Yathong-Ivanhoe Trough
PEL	122	Texam Oil Corporation, Star Oil of Australia Ltd, Exploration Drilling of Australia Ltd	1955	1965-1967	Desktop studies	northern margin of Yathong-Ivanhoe Trough
PEL	138	Texam Oil Corp, Star Oil of Australia Ltd (Exploration Drilling of Australia Ltd)	1955	1966-1967	Desktop studies	northern margin of the Yathong-Ivanhoe Trough

TITLE CODE	TITLE NO	TITLE HOLDER	ACT	APPROX. YEAR OF OPERATION	EXPLORATION HIGHLIGHTS	AREA
PEL	166	North Star Oil of Australia Ltd (Energy Resource Corporation)	1955	1969-1973	Desktop studies	central-eastern part of the Yathong-Ivanhoe Trough
PEL	247	Comserv (No. 779) Pty Ltd (Claremont Petroleum NL), BHP Petroleum PL	1955	1980-1991	Desktop studies	eastern part of the Yathong-Ivanhoe Trough
PEL	248	Comserv (No. 779) Pty Ltd	1955	1982	Desktop studies	northwestern Yathong-Ivanhoe Trough
PEL	249	Comserv (No. 779) Pty Ltd	1955	1982	Desktop studies	northeastern Yathong-Ivanhoe Trough
PEL	252	Comserv (No. 779) Pty Ltd	1955	1982 -1983	Seismic survey: Darling (SS134) (outside of the trough)	northern margin of the Yathong-Ivanhoe Trough
PSPAUTH	4	Department of Mineral Resources	1991	1995-1996	Desktop studies	northern Yathong-Ivanhoe Trough
PEL	420	GO Resources (Aust. PL), Eastern Star Gas Ltd., Red Sky Exploration Pty. Ltd.	1991	1997-2008	Seismic survey: Taringo Downs (GS2008-0269)	northern Yathong-Ivanhoe Trough
PEL	421	First Sourcenergy Group Inc., Eastern Star Gas Ltd., Red Sky Exploration Pty. Ltd.	1991	1998-2001	Desktop studies	northern Yathong-Ivanhoe Trough margin
PEL	448	Red Sky Energy Ltd	1991	2006-2010	Desktop studies	northern Yathong-Ivanhoe margin Trough
PEL	451	Red Sky Energy Ltd	1991	2006-2009	Desktop studies	central Yathong-Ivanhoe Trough
PSPAUTH	32	Energetica Resources Pty Ltd	1991	2009-2010	Desktop studies	central Yathong-Ivanhoe Trough

TITLE CODE	TITLE NO	TITLE HOLDER	ACT	APPROX. YEAR OF OPERATION	EXPLORATION HIGHLIGHTS	AREA
EL	8065	Secretary of Regional NSW	1992	2013-present	Drilling: Tiltagoonah-1 (GS2015/0406) drilled outside of the trough: Desktop studies.	northern eastern Yathong-Ivanhoe Trough

Exploration data

The exploration data includes well completion reports, geochemical analyses, seismic surveys, gravity and magnetics surveys, and soil gas surveys (Figure 2). There are also interpretative geological reports available for the trough.

Three shallow stratigraphic wells have been drilled in the southwest part of the Yathong–Ivanhoe Trough the area formerly known as the Ivanhoe Trough (Table 2).

Table 2 – Summaries of drilling results and reasons for drilling in the Yathong-Ivanhoe Trough.

WELL NAME	REASON FOR DILLING
Conoble-1 (1963)	Drilled in PEL 51 (held by Exploration Drilling of Australia) by North Star Oil Corporation, both wholly owned subsidiaries of the Texam Oil Corporation of Midland, Texas. Conoble-1 was drilled as a stratigraphic test to correlate with the nearby Ivanhoe-1, also drilled in PEL 51. During coring, the drill pipe twisted off at 177 m, therefore core was not recovered. The well was abandoned immediately. The well intersected clay and sandstone, with fine-grained gypsum near the surface. Traces of pyrite were identified below 119 m. Early Cretaceous marine fauna were encountered between 119 m and 155 m.
North Star Ivanhoe-1 (1963)	Drilled in PEL 51 (held by Exploration Drilling of Australia) by North Star Oil of Australia, both wholly owned subsidiaries of the Texam Oil Corporation of Midland, Texas. Ivanhoe-1 is one of the stratigraphic holes planned by Texam to investigate shallow basement areas. The purpose of Ivanhoe-1 was to ascertain whether the "Palaeozoic slates", reported at shallow depth in water bores drilled within the permit, indicated shallow economic basement. Early Cretaceous and Early Permian fossils have been identified in the well. Good reservoir sands are present in the Permian. The Early Devonian is shale rich that has some source rock potential. No hydrocarbon shows were encountered.
Holey Box-1 (1967)	Drilled in PEL 117 (held by Texam Oil) by North Star as a first of three stratigraphic tests by Texam Oil Corporation in PEL 117 (Holey Box-1, Berangabah-1 and Dolmoreve-1). The well was drilled to evaluate a geologic province named the Ivanhoe uplift (PGR1967/01), with shallow 3350 - 5790 m /sec refractors.

Five seismic surveys comprising 13 lines totalling 545 km were acquired in the Yathong-Ivanhoe Trough. Three seismic surveys are excellent quality – Rankin Springs 2D Seismic Survey 2008 by Geoscience Australia, Yathong Trough 2D Seismic Survey 2013 by Geoscience Australia for NSW Trade and Investment, and Taringo Downs 2D Seismic Survey 2006 by Red Sky Energy. Two other seismic surveys partly cover the Yathong-Ivanhoe Trough are of poor and very poor quality.

Additionally, there are 310 water bores and 750 shallow mineral exploration drill holes within the trough.

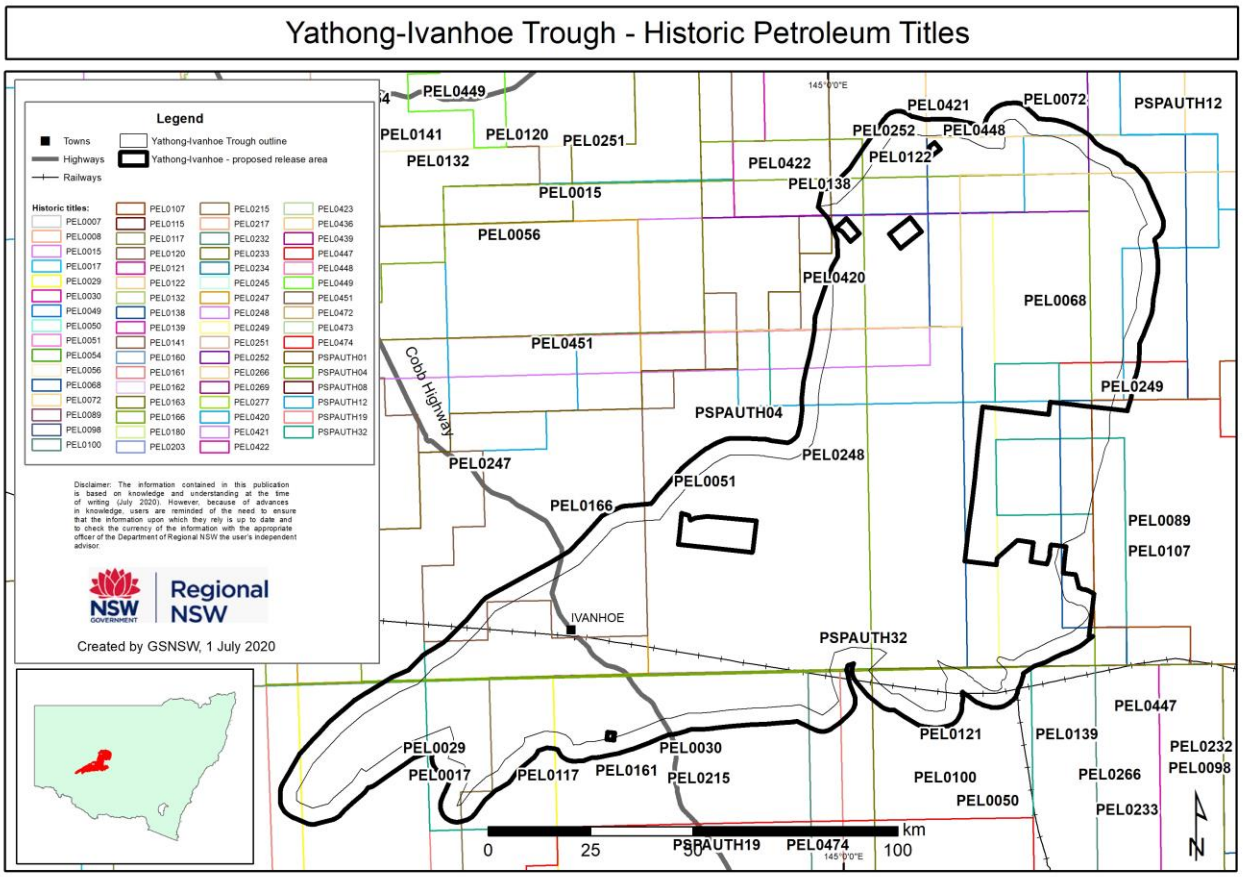

Figure 3 - Historic petroleum titles granted over parts of the Yathong-Ivanhoe Trough.

Petroleum Assessment Analysis – Yathong-Ivanhoe Trough

Name of area: **Yathong-Ivanhoe Trough**

Location: 1:250,000: SI/55-1 (Ivanhoe), SI/55-2 (Nymagee), SI/55-5 (Booligal), SI/55-6 (Cargelligo), SH/55-13 (Barnato), SH/55-14 (Cobar) and SI/55-**10 (Narrandera), nearest town: Hillston**

Factor	Issue	Considerations	Petroleum Rating [MEG to tick one in each column]	Analysis
Availability of Geological data	Data density and veracity	Is the data sufficient to define a resource or potential resource and inform decision making?	☐ Data are sufficient to define a petroleum resource. ☒ Data indicate the potential for the discovery of a petroleum resource. ☐ Data are insufficient to assess the exploration potential for the discovery of a petroleum resource. ☐No petroleum resource potential exists.	Historic data: 5 seismic surveys in total - 13 lines were acquired, for a total of approximately 545 km (3 seismic surveys – Rankin Springs 2D Seismic Survey 2008 by Geoscience Australia, Yathong Trough 2D Seismic Survey 2013 by Geoscience Australia for NSW Trade and Investment, and Taringo Downs 2D Seismic Survey 2006 by Red Sky Energy, 2 other seismic surveys partly cover the Yathong-Ivanhoe Trough) 3 wells drilled in the sub-basin 310 water bores and 750 shallow mineral exploration holes Gravity and magnetic surveys, Petroleum prospectivity indications: The soil gas survey undertaken by GSNSW in 2017 over parts of the Yathong–Ivanhoe Trough displayed elevated hydrocarbon signatures of thermogenic origin. Sandstones that could act as reservoirs

Factor	Issue	Considerations	Petroleum Rating [MEG to tick one in each column]	Analysis
				crop out on the eastern flank of the Yathong–Ivanhoe Trough. Potential seals are also present throughout the Devonian section. The Yathong-Ivanhoe Trough boundary has been redefined based on the recent seismic interpretation and the extent of outcropping Devonian rocks <u>Petroleum title history:</u> 16 PELs and 2 PSPAUTHs have been granted over parts of the trough. Last one relinquished in 2010 Current EL over part of the trough.
☒ Continue Resource Assessment if 'data are sufficient' or indicate the potential for resource discovery.				
Resource body characteristics	Resource type		☒ Conventional (oil, gas) ☒ Unconventional (oil, gas) • Shale (oil, gas) • Tight Sand / Carbonate (oil, gas)	Unconventional and the possibility of conventional systems.
	Resource quality	Does product quality meet the likely market/utilisation?	☐ Yes ☐ No	If gas is high percentage methane it will meet market requirements.

Factor	Issue	Considerations	Petroleum Rating [MEG to tick one in each column]	Analysis
			☒Cannot be determined	Unconventional and conventional petroleum - quality not tested
	Resource size	What is the resource size/potential resource size?	☐ Likely sufficient to support a stand-alone operation. ☐ Requires further appraisal or testing to assess resource size. ☒ Requires further exploration to identify resource potential.	Not able to determine without further exploration. Drilling required for testing of source rocks, seismic data required to determine structures, potential prospect size and geometry.
	Geological resource constraints	Do other geological considerations impact the potential development of the Resource?	☒ No significant resource constraints identified. ☐ Resource constraints are identified but unlikely to be detrimental to the development of the resource. ☐ Resource constraints indicate significant hurdles must be overcome if production were to proceed in the future.	No geological constraints currently identified.

Factor	Issue	Considerations	Petroleum Rating [MEG to tick one in each column]	Analysis
Ease of access	Existing infrastructure	Suitability of roads, power, water and outbound logistics (pipeline, rail or road)	☒ Would require little or no change to existing infrastructure. ☐ Would require some upgrade to existing infrastructure. ☐ Would require provision of new infrastructure.	Pipeline: Moomba to Sydney gas pipeline - runs through the northern part of the trough; Junee to Griffith gas pipeline connecting to Moomba-Sydney - less than 25 km SE away from the southern edge of the trough. Roads: Cobb Highway runs 35-80 km west of the trough connecting to Hay, Ivanhoe and Wilcannia, Barrier Highway runs 35 km to the north of the trough and connects to Wilcannia and Cobar, several well maintained roads run across the trough. Rail: Orange - Broken Hill Railway runs E-W through the centre of the trough. Towns: Hillston (1430 residents) is within the boundary of the trough; Cobar (4710 residents) about 50 km north; Ivanhoe (200 residents) is about 80 km west, Griffith (25,811 residents) about 28 km south, Lake Cargelligo (1,380 residents) about 40 km east.
	Proximity to existing operations	Ability to share or leverage infrastructure of existing operations	☐ Yes. Established petroleum district with local labour and service industry. ☒ Possibly. Potential synergies with existing operations and infrastructure. ☐ No. No synergies presently exist.	No existing petroleum operations in the region however, the Moomba-Sydney gas pipeline traverses the Yathong-Ivanhoe Trough.

Factor	Issue	Considerations	Petroleum Rating [MEG to tick one in each column]	Analysis
	Capital costs	Style of operation the resource would support and likely capital costs and lead times	☐ Potential conventional operations with relatively low capital and earliest product to market. ☐ Potential unconventional operations with likely favourable geological characteristics to facilitate resource flow with probable medium capital outlays. ☐ Potential unconventional operations with likely less favourable geological characteristics to facilitate resource flow, with probable significant capital outlays. ☒ Unable to reasonably determine at this time.	Will be able to be estimated upon results of further exploration.
	Distance from market and outbound logistics (e.g. pipeline, port, rail, road)	Distance of resource from pipeline, port or a domestic market.	☒ Close. ☐ Medium. ☐ Far.	Moomba to Sydney gas pipeline‑ crosses the northern part of the trough; Junee to Griffith gas pipeline connecting to Moomba-Sydney ‑ less than 25 km SE away from the southern edge of the trough.
		Level of establishment of pipeline, port or domestic market.	☒ Established. ☐ Mostly established. ☐ Not yet established.	Market in NSW is established with only 3.5% of gas supplied from NSW gas fields, with the sole operating field at Camden expected to cease production in 2023.
Market characteristics	Customer demand		☒ Current customer demand exists.	NSW requires approx. 140 PJ of gas annually. Only 3.5% of gas is produced within NSW.

Factor	Issue	Considerations	Petroleum Rating [MEG to tick one in each column]	Analysis
			☐ Current customer demand is moderate. ☐ Current customer demand is low or may not exist.	
Preliminary commercial viability assessment	Likely commercial viability as a stand-alone operation	Commercial viability of stand-alone operation at current market prices.	☐ Project is likely to be financially robust. ☐ Project is currently marginal. ☐ Project is marginal to not commercially viable at this time. ☒ Unable to reasonably determine.	Project requires extensive exploration to determine its value.
Other strategic matters Note that some of these issues will be further or more fully considered in DPE's strategic issues assessment	Existing land uses	Likelihood of competing land uses impacting on the resource.	☐ Existing land uses would not impact extraction of the resource. ☒ Existing land uses would have some impact on extraction of the resource but could be managed. ☐ Existing land uses would likely prohibit extraction of the resource.	Yathong Reserve is in the eastern part of the trough. Kajulingah Reserve is in the central part of the trough.
	Environment/ hydrology	Environmental/ hydrological constraints to the resource and likelihood to prohibit resource extraction	☒ Yes. Environmental constraints are likely. ☒ Some constraints that could be managed. ☐ No environmental constraints identified under current policy settings.	Nature reserves are present within the Yathong Trough. However, these areas are excluded from the proposed release area. Includes areas of known and predicted occurrence of Malleefowl an endangered species in NSW.

Factor	Issue	Considerations	Petroleum Rating [MEG to tick one in each column]	Analysis
	Accessibility to market		☒ Product can be delivered with no hindrance. ☐ Product can be delivered but with some issues. ☐ Product can only be delivered with major changes.	A gas pipeline is already within the area.
	Other constraints and critical risks	Other constraints that would prohibit or restrict further exploration or future extraction of the resource.	☐ Yes ☒ Possibly ☐ No	Land access may be difficult in some locations due to landholder opposition to petroleum exploration.
Additional comments				
END OF PETROLEUM RESOURCE ASSESSMENT TEMPLATE				