



Greenhouse Gas Abatement Plan

Integrated Gas

ORIGIN BEETALOO EXPLORATION PROGRAM Greenhouse Gas Abatement Plan

Rev	Date	Reason for issue	Reviewer/s	Consolidator	Approver
0	08/12/2021	Issued for use	RU	TN	MK
1	08/07/2022	Update to include Amungee Delineation Scope	LP		MK
1.1	13/09/2022	Minor update to emission estimates	LP		MK
1.2	25/10/2022	Minor edits to Table 1	LP		MK

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1. Introduction

Origin Energy B2 Pty Ltd (Origin) is a registered holder and the operator of Exploration Permit (EP) 98, EP 76 and EP 117 located in the Beetaloo Sub-basin. Origin as a part of its ongoing exploration and appraisal (E&A) program, is proposing to undertake a series of activities over the 2022- 2026 period which is anticipated to result in emissions that exceed 100,000tCO₂^e in a financial year. In accordance with the Northern Territory Greenhouse Gas Emissions Management for New and Expanding Large Emitters (referred to herein as the Large Emitters policy) Origin is required to submit a Greenhouse Gas Abatement Plan (GGAP) to the Department of Environment and Water Security (DEPWS) outlining how Origin's proposed emissions will be mitigated and managed during the proposed activity.

This document fulfils the GGAP requirements and will be amended periodically to cover new scope proposed under new/ revised Environmental Management Plan (EMP) submissions.

2. Project overview

Origin Energy B2 Pty Ltd (Origin) is planning to undertake petroleum exploration and appraisal works within the Beetaloo Sub-Basin, to fulfil its commitments under its tenure work program. Over the 2022 to 2026 period, Origin proposes to drill, stimulation and well test up to 16 E&A wells to confirm the technical and commercial feasibility of the Velkerri shale.

The forward program is focused on collecting data from the Amungee Delineation Area (including the existing Amungee NW location) and the Velkerri 76 S2 locations. The Amungee delineation area is located in the dry gas window, with recent data acquired from the existing Amungee NW-1H E&A well confirming better than originally determined shale gas prospectively. The Velkerri 76 S2 site is located in the wet gas window, with indicative results collected during the drilling of Velkerri 76 S2-1 confirming the presence of wet gas.

This GGAP covers the proposed regulated activities required to enable Origin to continue to drill, stimulate, test, maintain and decommission the proposed E&A wells as outlined in the various approved Environmental Management Plans.¹

¹ Approved EMPs can be found on the DEPWS website at: <https://depws.nt.gov.au/onshore-gas/environment-management-plan/emp-decisions>

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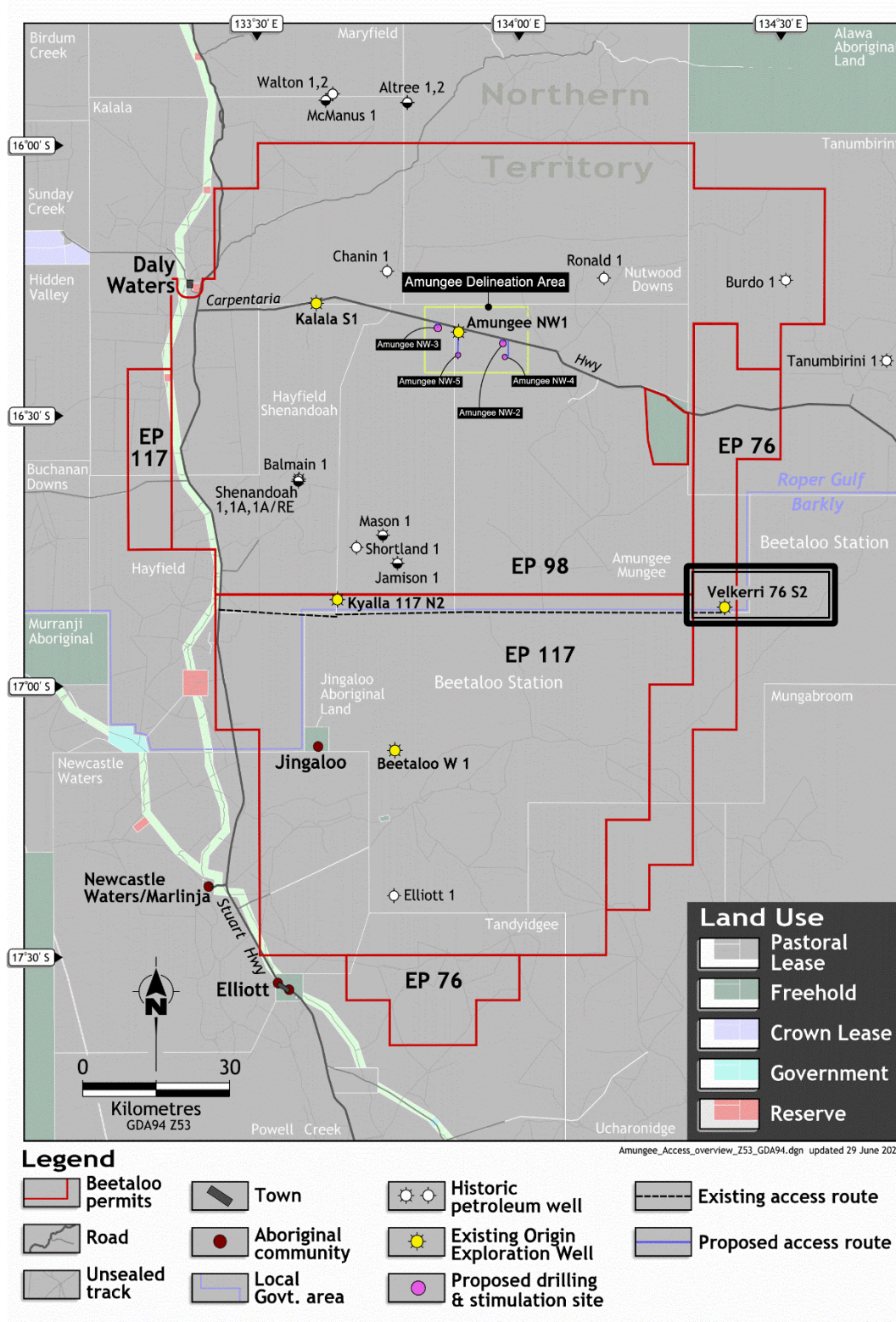


Figure 1 Location of the proposed Amungee Delineation Area and Velkerri 76 S2 locations

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3. Greenhouse Gas Abatement Plan

The requirements of the GGAP are described extensively in Origin’s Environment Management Plans. These include:

- Beetaloo Sub-basin Amungee Multiwell Drilling, Stimulation and Well Testing Program NT-2050-15-MP-041- covering up to 4 E&A wells
- Beetaloo Sub-basin Amungee NW Delineation Drilling, Stimulation and Well Testing Program NT-2050-15-MP-088- covering up to 12 E&A wells.

How Origin addresses the GGAP requirements are summarised in Table 1.

Table 1: GGAP summary

#	Requirement	Origin response
	Brief description of the project	<p>The scope of Origin’s Financial year (FY) 2023-26 campaign includes:</p> <ul style="list-style-type: none"> - Drilling, hydraulic fracture stimulation and well testing of 16 exploration and appraisal wells within Origin’s Beetaloo Tenure (exploration permit 76, 98 and 117) - Civil construction activities require to construct lease pads, camp pads, laydown areas, helipads, firebreaks, c lines and access tracks to support the drilling the proposed E&A wells. - Setup and operation of a temporary camps (70-person) and drilling mini-camp (8-person) at each of the sites - Flaring of gas and condensate and/or beneficial use of hydrocarbons where possible - Groundwater bore installation with groundwater extraction under WEL GRF 10285 - All other activities required to achieve the exploration program activities.
2	An estimate of the project’s net scope 1 emissions and how these emissions will contribute to the Territory’s overall emissions profile	<p>Scope 1 emissions are provided in Appendix A of this document.</p> <p>Emissions are estimated to peak at 172,815 tCO₂-e in FY 2024. This includes emission from other proposed Origin activities in the Beetaloo Sub-basin.</p> <p>Over 90% of the anticipated emissions are associated with flaring. Flaring of produced hydrocarbons is required under exploration tenure to evaluate the commercial viability of a resource as beneficial use of produced hydrocarbon is not permitted under the NT Petroleum Act.</p>

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#	Requirement	Origin response
		<p>The potential emissions of Origin’s activities represent between 0.69% (90 day well test average) and 0.99% (135 day well test average) of the total NT GHG emissions for 2019.</p> <p>Based upon the life cycle assessment analysis of a similar (but different) unconventional gas development in Australia completed by the Gas Industry Social and Environmental Research Alliance (GISERA) (Heinz 2019), the current net climate benefits of using natural gas in replacing coal for electricity generation is up to 50% less emissions (Heinz 2019).</p> <p>It is anticipated that a future shale gas development will be net zero scope 1 and 2 emissions, through the utilisation of world’s best practice emission reduction technology, such as field electrification, flare minimisation strategies, use of renewable energy sources and procurement of emission offsets. Scope 3 emissions will also be reduced through investigation in low emission technologies, such as carbon capture and sequestration (CCS) enable blue ammonia/ hydrogen and electricity export. This would further reduce the emission intensity of a future gas developments and highlights the role of natural gas as a transition or ‘firming’ fuel to support the roll out of large-scale renewables in the future. This is reflected by Origin’s ongoing commitment to invest in both renewable energy sources and firming fuels such as natural gas.</p>
3	An estimate of the project’s net scope 2 emissions and how these emissions will contribute to the Territory’s overall emissions profile	There are no scope 2 emissions associated with Origin’s Beetaloo exploration program.
4	An estimate of the project’s scope 3 emissions	Scope 3 emissions are restricted to the emission associated with the material and supply chains associated with Origin’s activities. The projects estimated Scope 3 emissions are 56,732 tCO ₂ e ⁻ . These emissions are predominantly associated with the steel casing and cement for the proposed 16 E&A wells which are generated outside of Australia (wastewater transportation is included in scope 1 emission estimates).
5	An overarching long-term emissions target for the project that represents a meaningful	Origin’s long-term target within the Beetaloo is to have a scope 1 and scope 2 neutral development.

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	contribution to the Territory's net zero emissions target	How Origin intends to use offsets to deal with residual emissions is discussed in item 9 of this plan.
6	Regular interim targets that establish a trajectory to achieving the overarching target and the methods that will be applied to achieve the interim targets	N/A- interim targets are not appropriate for exploration and appraisal projects. Offset targets are discussed in item 9 of this plan.
7	An explanation of, and justification for, the proposed long-term and interim targets and how these will make a meaningful contribution to the Territory's emissions target	Interim targets are not appropriate for exploration projects due to the high degree of uncertainty, the requirement to test and produce hydrocarbons to determine technical and commercial viability of a potential development and the inability to beneficially re-use hydrocarbons due to legislative constraints within the NT. Interim and long term targets are more appropriate where produced hydrocarbons have the ability to be utilised (i.e. through use or sale of product to minimise flaring) or where a project is in the operating phase where emission certainty is higher.
8	A demonstration that all reasonable and practical measures have been applied to avoid and mitigate emissions through best practice design, process, technology and management	Greenhouse gas emissions during well testing are required to be generated to prove the commerciality of a potential resource. Well testing data is utilised to generate a wells Estimated Ultimate Recovery (EUR), which determines how many wells are required to be drilled and how often replacement wells are required to be brought online to maintain production levels (i.e. as wells decline over time). The minimum required well testing (or Piloting) duration for unconventional gas development generally exceeds 2 years (730days) per geographic region. The more data on production, the lower the commercial risk of a development. This duration is based upon Origin's current experience in appraising and developing unconventional gas assets within Australia. The mitigation of emissions has been undertaken through: <ul style="list-style-type: none"> • Minimising well test durations: The proposed worst case well testing duration under this GGAP is an average of 135 well test days per well, significantly lower than the 730-day period typically utilised. • Utilisation of the best practice emission management controls outlined in the code of Practice: Onshore petroleum activities in the Northern Territory (Code of Practice)

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#	Requirement	Origin response
		<ul style="list-style-type: none"> • Inability to beneficially re-use hydrocarbons under Exploration Permits: Origin is currently legally not permitted to beneficially re-use produced hydrocarbons under NT law, which has resulted in flaring being the only technically feasible hydrocarbon management approach. Where beneficial use of appraisal gas becomes permitted, Origin will prioritise the beneficial use of appraisal gas to minimise scope 1 emissions.
9	A description of all strategies proposed to avoid, mitigate and offset the project’s scope 1 and scope 2 emissions	<ol style="list-style-type: none"> 1. Greenhouse gas emissions will be mitigated through the adoption of the mandatory requirements in the NT Code of Practice which requires <ul style="list-style-type: none"> - The development and implementation of a methane emission management plan (D5.1) - Restrictions on venting (D.5.9) - Use of a Reduced Emissions Completion (REC) (D.5.9) - Implementation on a routine Leak Detection and Repair (LDAR) program (D.5.3.) - Pressure and gas testing all in service equipment to ensure any leaks are identified and fixed prior to commission (D.5.9) - Flanges, valves and fittings are all API compliant and gas tight (D.5.9) - Equipment is appropriately sized and regularly maintained to minimise diesel wastage (D.5.9) - Routine site inspections and assurance undertaken to ensure equipment is maintained and operated as per manufacturers’ requirements. 2. Residual emissions shall be offset using credible carbon credit units approved by the Commonwealth Clean Energy Regulator. 3. Minimum offset levels shall increase year-on-year by 3.7% (based on a baseline financial year of 2023) to result in a linear decrease in residual emission levels to net zero by 2050 as per the following schedule: <ul style="list-style-type: none"> - Financial year 2023: 3.7% of total emissions offset

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#	Requirement	Origin response
		<ul style="list-style-type: none"> - Financial year 2024 7.4% of total emissions offset - Financial year 2025: 11.1% of total emission offset - Financial year 2026 14.8% of total emissions offset <p>4. Actual emission levels produced during a financial year will be estimated in accordance with the National Greenhouse and Energy Reporting Scheme (NGERS) reporting methodology.</p> <p>5. Offsets volumes shall be calculated retrospectively, by multiplying the actual emission volumes generated during a financial year with the corresponding financial year offset % requirement level.</p> <p>6. Offsets shall be secured and retired within 6 months of the end of a financial year</p>
10	Flexibility to review mitigation actions and abatement plans so they can be improved and updated to enable further emissions reductions going forward	Origin will continue to look for opportunities to mitigate carbon emissions throughout the project. Given the mandatory controls outlined in the Code of Practice and inability to beneficially re-use produced hydrocarbons, additional abatement measures are considered limited.
11	A schedule for periodic public reporting on implementation and progress against the interim and overarching targets and any changes that have had to be made to the strategies proposed in the GGAP to deliver on the targets	<ol style="list-style-type: none"> 1. Origin is required under condition D.6.2 of the Code of Practice to report its Greenhouse Gas emissions to the Department of Environment, Parks and Water Security on an annual basis. During this report, Origin assesses the level of greenhouse gas emissions against its EMP estimated levels to demonstrate it has met it has met its performance standards. 2. A report from the appropriately qualified independent person shall be provided to DEPWS by January 31 each year verifying the actual emission levels estimated and confirming the required offset for the previous financial year have been acquired and retired.
12	Information about the project's obligations under the Australian Government's National Greenhouse and Energy Reporting Act 2007 and any expected baseline determinations	Where Origin exceeds 100 ktCO ₂ in a reporting period (financial year), Origin will trigger the NGERS reporting threshold and safeguard mechanism. A baseline emission intensity will be generated for Origin's activities.

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#	Requirement	Origin response
13	A timetable for review that is considerate of the project's lifespan and the identified interim and overarching targets.	The emissions associated with the project will be reviewed annually.

4. References

Heinz Schandl, Tim Baynes, Nawshad Haque, Damian Barrett and Arne Geschke (2019). *Final Report for GISERA Project G2 - Whole of Life Greenhouse Gas Emissions Assessment of a Coal Seam Gas to Liquefied Natural Gas Project in the Surat Basin, Queensland, Australia.* CSIRO, Australia



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Appendix A Origin project scope 1 emissions estimate

Table 2 Summary of Origin’s scope 1 emissions estimates from FY 2023 to 2026

Activity	Anticipated volume	135-day average well test	Estimate methodology and assumptions
Diesel combustion – transport to cover seismic program	25 KL	68 t	<p>Diesel estimates multiplied by NGERs emission factor from NGER Determination: Division 2.4.2 Method 1 emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum-based oils or greases, section 2.41 Method 1—emissions of carbon dioxide, methane and nitrous oxide and Part 3—Fuel combustion—liquid fuels and certain petroleum-based products for stationary energy purposes item 40:</p> <p>Energy Content Factor (GJ/kg) 38.6 CO₂ Factor 69.9 kgCO₂-e/ GJ of diesel CH₄ Factor 0.1 kgO₂-e/ GJ of diesel N₂O Factor 0.2 kgCO₂-e/ GJ of diesel</p>
Diesel combustion – transport to cover drilling/stimulation mobilisation and transport activities (including offsite wastewater transport)	944 KL	2,565 t	<p>Diesel estimates multiplied by NGERs emission factor from NGER Determination: Division 2.4.2 Method 1 emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum-based oils or greases, section 2.41 Method 1—emissions of carbon dioxide, methane and nitrous oxide and Part 3—Fuel combustion—liquid fuels and certain petroleum-based products for stationary energy purposes item 40:</p> <p>Energy Content Factor (GJ/kill) 38.6 CO₂ Factor 69.9 kgCO₂-e/ GJ of diesel CH₄ Factor 0.1 kgO₂-e/ GJ of diesel N₂O Factor 0.2 kgCO₂-e/ GJ of diesel</p>
Diesel combustion - drilling	5,760 KL	15,608 t	<p>Diesel estimates multiplied by NGERs emission factor from NGER Determination: Division 2.4.2 Method 1 emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum-based oils or greases, section 2.41 Method 1—emissions of carbon dioxide, methane and nitrous oxide and Part 3—Fuel combustion—liquid fuels and certain petroleum-based products for stationary energy purposes item 40:</p> <p>Energy Content Factor (GJ/kill) 38.6</p>

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Activity	Anticipated volume	135-day average well test	Estimate methodology and assumptions
			CO ₂ Factor 69.9 kgCO ₂ -e/ GJ of diesel CH ₄ Factor 0.1 kgO ₂ -e/ GJ of diesel N ₂ O Factor 0.2 kgCO ₂ -e/ GJ of diesel
Diesel combustion-Drilling and stimulation camp	642 KL	1,741 t	Diesel consumption estimates multiplied by NGERs emission factor from NGER Determination: Division 2.4.2 Method 1 emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum-based oils or greases, section 2.41 Method 1—emissions of carbon dioxide, methane and nitrous oxide and Part 3—Fuel combustion—liquid fuels and certain petroleum-based products for stationary energy purposes item 40: Energy Content Factor (GJ/kill) 38.6 CO ₂ Factor 69.9 kgCO ₂ -e/ GJ of diesel CH ₄ Factor 0.1 kgO ₂ -e/ GJ of diesel N ₂ O Factor 0.2 kgCO ₂ -e/ GJ of diesel
Fugitive methane emissions – drill cuttings	10.872 t	304 t	Estimate by engineer based on gas saturation and core volume multiplied by NGERs Global Warming Potential (GWP) of 28 tCO ₂ e/tCH ₄ .
Fugitive emissions – completion (venting)	570 t methane	15,954 t	2 completion days anticipated per well. Table 5-23 Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Gas Industry; American Petroleum Institute (API), 2009 NGERs completion factor of 25.9 tonnes of methane per day multiple by NGERs Global Warming Potential (GWP) of 28 tCO ₂ -e/tCH ₄
Fugitive emission-wastewater storage	5 t methane	143 t	7.5 ML/ well wastewater (assumes 25 ML stim volume with a recovery of 30%). Emissions multiplied by Table 5-10 produced saltwater tank methane flashing emission factors - Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Gas Industry; American Petroleum Institute (API), 2009 emission factor of 0.11 tCH ₄ /ML (assuming 2% salinity, 250 psi separator pressure) multiplied by NGERs Global Warming Potential (GWP) of 28 tCO ₂ -e/tCH ₄ .
Well testing- flared natural gas emissions	7290 TJ of natural gas total	473,870 t	Flared estimate using forecasted P50 success case of 4.5 TJ/day per well. Estimated production rates multiplied by NGER Determination: Subdivision 3.3.2.2—

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Activity	Anticipated volume	135-day average well test	Estimate methodology and assumptions
			Oil or gas exploration and development (emissions that are flared) section 3.44 Method 1—oil or gas exploration and development item 1: CO ₂ Factor 2.8 tCO ₂ -e/ t unprocessed gas CH ₄ Factor 0.933 tCO ₂ -e/ t unprocessed gas N ₂ O Factor 0.026 tCO ₂ -e/ t unprocessed gas
Well stimulation – stationary sources (diesel combustion)	550 KL	1,490 t	Diesel consumption estimated from historical data and multiplied by NGERs emission factor from NGER Determination: Division 2.4.2 Method 1 emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum-based oils or greases, section 2.41 Method 1—emissions of carbon dioxide, methane and nitrous oxide and Part 3—Fuel combustion—liquid fuels and certain petroleum-based products for stationary energy purposes item 40: Energy Content Factor (GJ/kg) 38.6 CO ₂ Factor 69.9 kgCO ₂ -e/ GJ of diesel CH ₄ Factor 0.1 kgCO ₂ -e/ GJ of diesel N ₂ O Factor 0.2 kgCO ₂ -e/ GJ of diesel
Well testing- utilised for wastewater management, treatment and internal field transportation (diesel combustion)	810KL (0.5 KL per day)	2,195 t	Diesel consumption estimated from historical data and multiplied by NGERs emission factor from NGER Determination: Division 2.4.2 Method 1 emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum-based oils or greases, section 2.41 Method 1—emissions of carbon dioxide, methane and nitrous oxide and Part 3—Fuel combustion—liquid fuels and certain petroleum-based products for stationary energy purposes item 40: Energy Content Factor (GJ/kill) 38.6 CO ₂ Factor 69.9 kgCO ₂ -e/ GJ of diesel CH ₄ Factor 0.1 kgCO ₂ -e/ GJ of diesel N ₂ O Factor 0.2 kgCO ₂ -e/ GJ of diesel
Land clearing for site preparation and seismic surveys	106.86 ha land clearing (77 tCO ₂ e/ ha)	8,233 t	TAGG 2013 Appendix I vegetation clearing methodology, Table 6, assumed maximum potential biomass class = 1.
Total over 4 years		522,172 t	

[^] Based on Global Warming Potential (GWP) of 28 tCO₂-e/tCH₄ (Clean Energy Regulator 2020)

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