

## **Appendix H Methane Emission Management Plan**



**MEMP**

NT-2050-MP-15- 030

# BEETALOO EXPLORATION PROGRAM

## Methane Emission Management Plan

### Review record

Rev	Date	Reason for issue	Reviewer/s	Consolidator	Approver
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## 1. Purpose

This Methane Emissions Management Plan (MEMP) is designed to outline the measures as to how the risks of methane emissions associated with Origin Energy's Beetaloo Basin exploration activities will be managed. This Plan has been developed in accordance with the Code of Practice for Petroleum Activities in the Northern Territory.

## 2. Key Legislation

Key legislation and documents consulted in the development of this plan are provided below. A full list of applicable legislation is provided in the corresponding management plans.

- **Code of Practice for Petroleum activities in the Northern Territory:** Mandatory code of practice legislating the management of chemicals and wastewater onsite, including the use of secondary containment, lined tanks and spill management plan,
- **National Greenhouse and Energy Reporting Act 2007:** Regulates the reporting of greenhouse gas emissions, energy production and energy consumption associated with company activities. Data to be supplied annually to the regulator in accordance with emission/energy use guidance manuals.

## 3. Activity description

The activities undertaken as a part of this MEMP are summarised in Table 1. These activities are restricted to the drilling, stimulation, well testing and ongoing operation of exploration wells. They do not cover any production, compression or pipeline activities as these are currently not proposed.

**Table 1 Activity and emission description summary**

Activity	Emission Description	Controls	Emission monitoring
Drilling	Methane emissions are small (<1 tonne) and restricted to outgassing of hydrocarbon within intersected shales brought to surface.	<ul style="list-style-type: none"> <li>•Drilling is overbalanced, preventing gas influx into well bore</li> <li>•Shale formations have negligible permeability with limited influx of gas from target formations</li> </ul>	<ul style="list-style-type: none"> <li>•Due to low emission level, gas is qualitatively monitored in mud stream as a concentration (not flow rate).</li> <li>•Gas desorption data is collected from target reservoir allowing emission estimates.</li> </ul>
Stimulation	During stimulation, the well will be overbalanced restricting the flow of hydrocarbons to surface.	<ul style="list-style-type: none"> <li>•Well is kept overbalanced to prevent gas influx during and after stimulation.</li> <li>•Flowback kept within the formation after each stage.</li> </ul>	N/A
Well Testing	Well is unloaded to allow hydrocarbons and fluid to flow to surface. All fluids and hydrocarbons diverted to a separator and then a flare onsite. Small emissions (<1 tonne) of methane may be released prior to the onsite of flaring, as the hydrocarbon production rate may not be enough to sustain a flare initially. Small volumes (kg's/day) of methane is entrained within liquid hydrocarbons and flowback fluid and will be released to atmosphere	Well heads are designed in accordance with the NT Code of Practice and API standards to minimise loss of methane. A reduced emission completion will be utilised- where all gas is sent to a separator and then flared. Personal Gas Detector during all operational visits	<ul style="list-style-type: none"> <li>•Personal Gas Detector during well testing activities</li> <li>•All flared gas measured using flow meters</li> </ul>
Ongoing Well Operations/ suspension	Methane emissions restricted to unplanned leaks from well heads, including surface casing vents.	•Operation staff to carry personal calibrated gas detectors during every routine operational visit to well sites.	<ul style="list-style-type: none"> <li>•Personal Gas Detector during well testing activities</li> <li>•6 monthly leak detection</li> </ul>

Activity	Emission Description	Controls	Emission monitoring
		<ul style="list-style-type: none"> <li>•Routine wellhead maintenance as per well Integrity Management System</li> <li>•Each well and equipment on a well pad to be inspected every 6 months for leaks using a US EPA Method 21 compliance technique</li> </ul>	

#### 4. Equipment Selection and Activity Design

The uncontrolled emissions of natural gas during drilling, stimulation and well testing activities represents a potential hazard to workers and the environment. All equipment will be selected to minimise the emissions during production activities.

- Exploration wells and associated surface infrastructure shall be designed to mitigate leaks in accordance with the relevant standards. These Standards include:
  - ISO 16530-1-2017 Petroleum and natural gas industries- Well Integrity - Life cycle governance
  - API SPEC 5CT 2016 Casing and Tubing
  - API SPEC 16D 2013 Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment
  - API RP 59 2012 Well control operations
  - API SPEC 6A 2016 Wellhead and Christmas Tree equipment
  - NORSOK Standard D-010, Well integrity in drilling and well operations
- Leak detection implemented consistent with Codes of Practice.
- Ongoing well maintenance as per the Well Operations Management Plan.

#### 5. Flowback Activities

##### 5.1 Reduced emission Completion

- A Reduced Emission completions (REC) shall be used to minimise the amount of venting
- A REC for the purpose of the Beetaloo Exploration Project is a separator equipped with a flare.
- Venting shall only be used where the capture or flaring is not possible.
- The recovery or gas and hydrocarbons for sale will be prioritised (where practicable) to minimise flaring.

#### 6. Leak Detection Inspections.

The leak inspection programs will be implemented in accordance with Table 2.

**Table 2 Leak detection program**

Monitoring Program	Monitoring methodology	Frequency
Routine operational Inspections	Calibrated personal gas detector	During each operational visit
Mandatory inspection	US EPA Method 21	6-monthly

#### 7. Monitoring Methodology

- Mandatory inspections will be completed on all surface infrastructure (vents, flanges, valves, connections, drains, pressure relief vents, etc.) of the exploration well in accordance with the USEPA Method 21 requirements or a vehicle mounted cavity ring-down spectrometer (CRDS).

##### 7.1 Instrument Selection

- A Method 21 detector must be able to detect methane at the minimum detection range of 10 Parts Per Million (PPM), with an +/- accuracy of 50PPM.

- A vehicle mounted CRDS detectors shall have a 10 Parts Per Billion (PPB) minimum detection accuracy with an accuracy of +/- 10PPB
- The instrument shall be intrinsically safe (where used within hazardous areas) and equipped with an electrically driven pump, to ensure that a sample is provided to the detector at a constant flow rate.

## 7.2 Qualifications

- Inspections must be carried out by a suitably qualified person
- A suitably qualified person is defined as a person that has been specifically trained in leak detection or has at least 3 years industry experience in conducting leak detection activities.

## 7.3 Calibrations

- Gas detectors must be maintained and calibrated in accordance with the manufacturers instructions. Records of instrument calibration shall be retained.
- A two stage calibration shall be used, with an Air calibration and a 10PPM by volume CH<sub>4</sub> calibration gas used.
- The instrument response time shall be less than 30 seconds.

## 7.4 Testing procedure

### 7.4.1 Method 21

Method 21 inspections are used to survey individual pieces of equipment. These types of inspections require access to the surface of the equipment and are extremely effective at pinpointing leaks. The following procedure is to be followed when conducting method 21 inspections:

1. Ensure gas detector is calibrated and functioning properly
2. Ensure the appropriate permitting is obtained before entry into a hazardous area
3. Place the probe inlet at the surface of the component interface where leakage could occur.
4. Move the probe along the interface periphery while observing the instrument readout. If an increased meter reading is observed, slowly sample the interface where leakage is indicated until the maximum meter reading is obtained.
5. Leave the probe inlet at this maximum reading location for approximately two times the instrument response time (i.e. at least a minute).
6. If the maximum observed meter reading is greater than 500PPM at the surface of a piece of infrastructure, the leak is to be measured again at 150mm immediately above (and downwind) of the leak in an open-air environment
7. The leak shall be classified in accordance with section 7
8. The location of the leak shall be clearly documented and photographs taken (if safe to do so)
9. Any liquid petroleum leaks should also be identified, along with estimates of leak rate and volume released.

### 7.4.2 Vehicle mounted CRDS

Vehicle mounted CRDS uses highly sensitive, PPB level detectors to screen clumps of infrastructure for leaks. They are extremely effective at providing a rapid assessment and are used in combination of method 21 assessment to pin point leaks. The following procedure shall be followed when conducting vehicle mounted CRDS inspections:

1. The vehicle shall be driven within 20m up and downwind of the infrastructure at a speed below 20km/hour: it is advisable to drive around a piece of infrastructure in a circular motion to obtain up and down wind in the same pass.
2. Where a survey cannot be made within 20m downwind of a piece of infrastructure, a method 21 inspection shall be undertaken.
3. Downwind methane concentrations shall be compared to upwind (background) concentration.
4. Where an emission is identified at 5PPM above background, a method 21 inspection shall be undertaken
5. Where enrichment is recorded below 5PPM, the infrastructure has no material leaks present.

## 7.5 Leak Classification, Repair and Notification

Each leak shall be classified, repaired and reported in accordance with Table 3. It should be noted, that classification of leaks is only undertaken using a method 21 approach outlined in 7.4.1.

**Table 3 Leak classification and remediation summary**

Classification	Threshold	Response	Notification	Comments
Minor Leak	>500ppm measured at the surface of the component in accordance with section 6.4.1	All minor leaks must be documented and repaired as soon as practicable, but within 30 days. Where 30 days is unachievable, the reason for the delay and target date for completion must be submitted.	All minor leaks must be documented	A minor leak is an unplanned release that does not occur during commissioning or bringing equipment back into service. These leaks should be corrected immediately as a part of commissioning
Significant Leak	>5000ppm (or 10%of the Lower Explosive Limit) when measured at 150mm above the leak source. Or A Liquid Petroleum (condensate/oil) loss of containment that exceeds 200L. Or The leak is too large or not safe to measure.	<ol style="list-style-type: none"> <li>1. The activities safety management plan, risk assessment and emergency response requirements must be followed.</li> <li>2. Remediation work must only commence after a suitable risk assessment has been undertaken (at a level appropriate to the nature of the leak) and the relevant safety procedures are followed including the consideration of all the required Personal Protective Equipment and emergency response material.</li> <li>3. If safe to do so, the leak source should be isolated and repaired immediately. The response priority must be to make the site safe above all other actions.</li> <li>4. The leak shall be repaired or made safe as soon as practicable, as follows: <ol style="list-style-type: none"> <li>i) the leak must be isolated, repaired if possible, contained or otherwise made safe within 72 hours.</li> <li>ii) Where isolation and repair is not possible, an exclusion zone must be established around the leak and appropriate restrictions to on access to the exclusion zone imposed.</li> <li>iii) in the event the 72 hour deadline is unachievable, the reason for the delay and the target date for repair shall be submitted to DPIR before the deadline has passed.</li> </ol> </li> </ol>	<p>In the case of an emergency situation, DPIR must be notified within 24 hours via the emergency response hotline number 1300 935 250.</p> <p>Notification must include the date of identification, nature and level of the leak, infrastructure name, number and location as well as the initial actions to minimise the risk.</p> <p>The land owner or occupier of the property in which these leaks are occurring must be notified in the following circumstances:</p> <ol style="list-style-type: none"> <li>i) if the leak cannot be repaired immediately; and</li> <li>ii) if the leak is likely to affect any of the land owner's or occupiers facilities or activities.</li> </ol> <p>A written close-out report must be submitted within 5 business days of the remediation of the leak, specifying the date of identification, nature and level of leak, location and name of the operating plant, and the rectification actions taken.</p>	A significant leak is an unplanned release that does not occur during commissioning or bringing equipment back into service. These leaks should be corrected immediately as a part of commissioning

Classification	Threshold	Response	Notification	Comments
		<p>5. If it is contended that the risk of immediately repairing the leak exceeds the risk posed by the leak, an extension of the 72-hour deadline may be sought provided that other measures to mitigate the risk are undertaken (eg. ensuring an appropriate exclusion zone has been implemented)</p> <p>6. For leaks identified on well equipment, higher order controls such as containment by repair must be implemented wherever possible.</p> <p>7. For leaks identified on well casings or adjacent to the well casing (where a work over rig is necessary to effect repair) it must be determined whether the leak requires immediate repair, or whether the risk can be adequately managed via other control measures until a work over of the well is scheduled for normal operational reasons. The risk assessment to determine the above shall consider the location of the well, likely access to the well from landholders or the general public, and landholder/community concerns in relation to the leak.</p>	<p>If finalising the remediation is delayed more than 7 business days from the identification of the leak an update must be submitted on that day. The final close out report shall be provided when all work is completed.</p>	

## 8. Reporting

### 8.1 Flaring and Venting Emissions

- Where natural gas is vented or flared during exploration activities, these emissions shall be measured or estimated using methods consistent with those outline under the National Greenhouse and Energy Reporting (Measurement) Determination 2008. This include:
  - Leaks, venting and flaring during flowback activities
  - Equipment blowdowns, system upsets and accidental releases

### 8.2 Annual reporting

An annual report will be provided to the Northern Territory Government summarising the following:

1. The records of the stages of flowback activities including:
  - i. the date and time of the onset of flowback;
  - ii. the date and time of each attempt to route flowback fluid to the separator;
  - iii. the date and time of each occurrence in which the operator reverted to the initial flowback stage;
  - iv. the date and time of well shut in or connected into adjacent gathering lines;
  - v. the date and time that temporary flowback equipment is disconnected.
  - vi. the total duration of venting, combustion and flaring over the flowback period.
2. The results of leak detection surveys (in the annual report under the Act) outlining:
  - i. the extent of compliance with the leak management plan;
  - ii. a summary of monitoring undertaken during the period;
  - iii. a summary of minor and significant leaks identified during the reporting period, including the date of identification and repair for each leak and those leaks that could not be repaired; and
  - iv. an explanation of why any component could not be repaired and what actions will be taken to either decommission the component or otherwise remedy the problem.
  - v.
  - vi.
  - vii.

## Appendix I Water Monitoring Suites

Groundwater monitoring suite extracted from the [Code of Practice for Onshore Petroleum Activities in the Northern Territory](#)

Table 6: Minimum suite of analytes for groundwater monitoring.

General	LOR	Cations and Metals	LOR
pH	0.01 pH units	Calcium	1 mg/L
Electrical conductivity	1 $\mu$ S/cm	Chromium	0.001 mg/L
Total Dissolved Solids	10 mg/L	Copper	0.001 mg/L
Total Suspended Solids	1 mg/L	Iron	0.05 mg/L
Alkalinity	1 mg/L	Lead	0.001 mg/L
Gross Alpha	0.05 Bq/L	Magnesium	1 mg/L
Gross Beta	0.1 Bq/L	Manganese	0.001 mg/L
Water level	$\pm$ 10 cm (AHD)	Mercury	0.0001 mg/L
Groundwater pressure		Potassium	1 mg/L
<b>Anions</b>		Silver	0.001 mg/L
Chloride	1 mg/L	Arsenic	0.001 mg/L
Fluoride	0.1 mg/L	<b>Barium</b>	0.001 mg/L
Sulfate	1 mg/L	Boron	0.05 mg/L
Nitrate	0.01 mg/L	Cadmium	0.0001 mg/L
Nitrite	0.01 mg/L	Lithium	0.001 mg/L
<b>Petroleum</b>		Selenium	0.01 mg/L
TRH	100 $\mu$ g/L	Silica	0.1 mg/L
PAH Suite	0.5 $\mu$ g/L	<b>Strontium</b>	0.001 mg/L
BTEX	1 $\mu$ g/L	Sodium	1 mg/L
Diss. Methane	10 $\mu$ g/L	Zinc	0.005 mg/L
Diss. Ethane	10 $\mu$ g/L		
Diss. Propane	10 $\mu$ g/L		

**Wastewater characterisation suite (refer Code Table C.8)**

Parameter	Reporting Units	Limit of Reporting	Method
<b>Physical Parameters</b>			
Dissolved oxygen (DO)	mg/L	0.1	Field
Electrical Conductivity (EC)	us/cm	1	Field
Total Dissolved Solids (TDS)	mg/L	10	APHA 2540C
Total Suspended Solids (TSS)	mg/L	5	APHA 2540C
pH		0.1	Field
Sodium Adsorption Ratio	ratio	0.01	APHA 4500
Temperature	°C	0.1	Field
<b>Nutrients</b>			
Nitrate	mg/L	0.01	APHA VC13
Nitrite	mg/L	0.01	APHA 4500 NO2
Total Nitrogen	mg/L	0.1	APHA 4500 NORG
total Kjeldahl Nitrogen	mg/L	0.1	APHA NORG/TKN
Ammonia	mg/L	0.01	APHA NH4
Reactive Phosphorous	mg/L	0.01	APHA 4500P
Total Phosphorous	mg/L	0.01	APHA 4500P
<b>Anions</b>			
Sulfate	mg/L	1	APHA 4500-SO4-C
Chloride	mg/L	1	APHA 4500-Cl-C
Carbonate	mg/L	1	APHA 2320 B
Bicarbonate (as CaCO <sub>3</sub> equivalent)	mg/L	1	APHA 2310 B
Bicarbonate Alkalinity (as CaCO <sub>3</sub> equivalent)	mg/L	1	APHA 2320 B
Hydroxide Alkalinity (as CaCO <sub>3</sub> equivalent)	mg/L	0.01	APHA 2320 B
Total Alkalinity (as CaCO <sub>3</sub> equivalent)	mg/L	0.01	APHA 2320 B
Fluoride	mg/L	0.1	APHA 4500 F-C
Bromide	mg/L	0.01	APHA 4110B
Total Cyanide	mg/L	0.004	APHA 4500 CN-0
<b>Major Cations</b>			
Sodium	mg/L	1	APHA 4500 Na
Magnesium	mg/L	1	APHA 4500 Mg
Potassium	mg/L	1	APHA 4500 K
Calcium	mg/L	1	APHA 4500 Ca
<b>Metals and Metalloids (total and dissolved)</b>			
Aluminium	mg/L	0.001	USEPA 6010 ICP/AES

Parameter	Reporting Units	Limit of Reporting	Method
Antimony	mg/L	0.001	USEPA 6010 ICP/AES
Arsenic	mg/L	0.001	USEPA 6010 ICP/AES
Barium	mg/L	0.001	USEPA 6010 ICP/AES
Beryllium	mg/L	0.001	USEPA 6010 ICP/AES
Boron	mg/L	0.001	USEPA 6010 ICP/AES
Bromide	mg/L	0.001	USEPA 6010 ICP/AES
Cadmium	mg/L	0.001	USEPA 6010 ICP/AES
Chromium	mg/L	0.001	USEPA 6010 ICP/AES
Copper	mg/L	0.001	USEPA 6010 ICP/AES
Iron	mg/L	0.001	USEPA 6010 ICP/AES
Lead	mg/L	0.001	USEPA 6010 ICP/AES
Manganese	mg/L	0.001	USEPA 6010 ICP/AES
Mercury	mg/L	0.001	USEPA 6010 ICP/AES
Molybdenum	mg/L	0.001	USEPA 6010 ICP/AES
Nickel	mg/L	0.001	USEPA 6010 ICP/AES
Selenium	mg/L	0.001	USEPA 6010 ICP/AES
Silica	mg/L	0.1	USEPA 6010 ICP/AES
Silver	mg/L	0.001	USEPA 6010 ICP/AES
Strontium	mg/L	0.001	USEPA 6010 ICP/AES
Thorium	mg/L	0.001	USEPA 6010 ICP/AES
Tin	mg/L	0.001	USEPA 6010 ICP/AES
Uranium	mg/L	0.001	USEPA 6010 ICP/AES
Vanadium	mg/L	0.001	USEPA 6010 ICP/AES
Zinc	mg/L	0.001	USEPA 6010 ICP/AES
<b>Naturally Occurring Radioactive Material.</b>			
alpha radiation	Bq/L	0.05	ASTM D7283-06
beta radiation	Bq/L	0.05	ASTM D7283-06
<b>BTEX</b>			
Benzene	mg/L	0.001	USEPA 5030/8260 HS or P&T/GC/MS
Toluene	mg/L	0.001	USEPA 5030/8260 HS or P&T/GC/MS
Ethylbenzene	mg/L	0.001	USEPA 5030/8260 HS or P&T/GC/MS
M and p Xylene	mg/L	0.001	USEPA 5030/8260 HS or P&T/GC/MS
O Xylene	mg/L	0.001	USEPA 5030/8260 HS or P&T/GC/MS

Parameter	Reporting Units	Limit of Reporting	Method
Total Xylene	mg/L	0.001	USEPA 5030/8260 HS or P&T/GC/MS
<b>Hydrocarbons</b>			
TRH C6 - C10	mg/L	0.02	USEPA 5030/8260 HS or P&T/GC/MS
TRH C6 - C10 less BTEX	mg/L	0.02	USEPA 5030/8260 HS or P&T/GC/MS
TRH >C10 - C16	mg/L	0.02	USEPA 5030/8260 HS or P&T/GC/MS
TRH >C10 - C16 less Naphthalene	mg/L	0.02	USEPA 5030/8260 HS or P&T/GC/MS
TRH >C16 - C34	mg/L	0.01	USEPA 5030/8260 HS or P&T/GC/MS
TRH >C34 - C40	mg/L	0.01	USEPA 5030/8260 HS or P&T/GC/MS
Total TRH C6 - C40	mg/L	0.01	USEPA 5030/8260 HS or P&T/GC/MS
<b>Polycyclic Aromatic Hydrocarbons</b>			
3-Methylcholanthrene	mg/L	0.001	USEPA 3510/8270 GC/MS
7, 12-Dimethylbenz(a)anthracene	mg/L	0.001	USEPA 3510/8270 GC/MS
Acenaphthene	mg/L	0.001	USEPA 3510/8270 GC/MS
Acenaphthylene	mg/L	0.001	USEPA 3510/8270 GC/MS
Anthracene	mg/L	0.001	USEPA 3510/8270 GC/MS
Benzo (a) pyrene	mg/L	0.001	USEPA 3510/8270 GC/MS
Benzo (b) fluoranthene	mg/L	0.001	USEPA 3510/8270 GC/MS
Benzo (ghi) perylene	mg/L	0.001	USEPA 3510/8270 GC/MS
Benzo (k) fluoranthene	mg/L	0.001	USEPA 3510/8270 GC/MS
Benzo (a) anthracene	mg/L	0.001	USEPA 3510/8270 GC/MS
Chrysene	mg/L	0.001	USEPA 3510/8270 GC/MS
Dibenz (ah) anthracene	mg/L	0.001	USEPA 3510/8270 GC/MS
Fluoranthene	mg/L	0.001	USEPA 3510/8270 GC/MS
Fluorene	mg/L	0.001	USEPA 3510/8270 GC/MS
Indeno (1,2,3-cd) pyrene	mg/L	0.001	USEPA 3510/8270 GC/MS
Naphthalene	mg/L	0.001	USEPA 3510/8270 GC/MS
Phenanthrene	mg/L	0.001	USEPA 3510/8270 GC/MS
Pyrene	mg/L	0.001	USEPA 3510/8270 GC/MS
Carcinogenic PAHs (benzo[a]pyrene equivalents)	mg/L	0.001	USEPA 3510/8270 GC/MS
Total PAH	mg/L	0.001	USEPA 3510/8270 GC/MS
<b>Volatile Organic Compounds</b>			

Parameter	Reporting Units	Limit of Reporting	Method
2,3,4,6-Tetrachlorophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2,4,5-Trichlorophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2,4,6-Trichlorophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2,4-Dichlorophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2,4-Dimethylphenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2,4-Dinitrophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2,6-Dichlorophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2-Chlorophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2-Methyl-4,6-dinitrophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
2-Nitrophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
4-Chloro-3-methylphenol	mg/L	0.005	USEPA 3510/8270 GC/MS
4-Nitrophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
Dinoseb	mg/L	0.005	USEPA 3510/8270 GC/MS
Formaldehyde	mg/L	0.001	USEPA 3510/8270 GC/MS
Hexachlorophene	mg/L	0.005	USEPA 3510/8270 GC/MS
m- and p-Cresol	mg/L	0.005	USEPA 3510/8270 GC/MS
Pentachlorophenol	mg/L	0.005	USEPA 3510/8270 GC/MS
Phenol	mg/L	0.005	USEPA 3510/8270 GC/MS
<b>Organic Carbon</b>			
Dissolved Organic Carbon	mg/L	1	APHA 5310 B
Total Organic Carbon	mg/L	1	APHA 5310 B

## **Appendix J Land Condition Assessment Report**



# Land Condition Assessment

Amungee Delineation Area

08-Jul-2022  
Origin Stage 3

# Land Condition Assessment

Amungee Delineation Area

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Amungee Delineation Area


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Reviewed by Alana Court

### Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	08-Jul-2022	LCA for Amungee NW EMP Submission	Alana Court Associate Director – Environment	

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Acronym	Meaning
°C	Degrees Celsius
%	Percentage
AAPA	Aboriginal Areas Protection Authority
AS	Australian Standard
BOM	Bureau of Meteorology
CLA	Cambrian Limestone Aquifer
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DoH	Department of Health (NT)
DPIR	Department of Primary Industry and Resources (NT)
DEPWS	Department of Environment, Parks and Water Security (NT)
EPA	Environment Protection Authority (NT)
EP##	Exploration Permit (e.g. EP76, EP98 and EP117)
EMP	Environmental Management Plan
EPBC	Environmental Protection and Biodiversity Conservation
ESCP	Erosion and Sediment Control Plan
GPS	Global Positioning Device
Ha	hectare
IBA	Important Bird Area
ILUA	Indigenous Land Use Agreement
km	Kilometre
km <sup>2</sup>	Square Kilometres
km/hr	Kilometre per hour
LCA	Land Condition Assessment
m	metre
MD	Measured Depth
MNES	Matters of National Environmental Significance
mm	millimetre
NLC	Northern Land Council
NT	Northern Territory
OHS	Occupational Health and Safety
RWA	Restricted Work Area
TO	Traditional Owner
<i>TPWC Act</i>	<i>Territory Parks and Wildlife Conservation Act</i>
WoNS	Weed of National Significance

## 1.0 Introduction

### 1.1 Purpose of this Report

AECOM Australia Pty Ltd (AECOM) conducted a Land Condition Assessment (LCA) to support Origin Energy's (Origin) proposed 2D seismic exploration program and development of exploration well lease pads within Exploration Permit 98 (EP98) in the Beetaloo Sub-Basin, Northern Territory (NT).

The primary aim of the LCA is to identify and document site condition prior to the proposed activities occurring in the Amungee delineation area to inform the preparation of Origin's exploration programs Environmental Management Plan (EMP). This LCA report summarises the result of the survey and documents baseline conditions within the Amungee delineation area.

A baseline field survey was undertaken in September 2021 and May 2022 to record site conditions. The LCA report summarises the result of the surveys and documents baseline conditions of the land within the Amungee delineation area.

### 1.2 Project Boundary

The Amungee delineation area is located within the Amungee Mungee Perpetual Pastoral Lease (PPL) and Shenandoah East PPL and is covered by EP98 (Figure 1). The Amungee NW delineation area is located approximately 55 km east of the Stuart Highway turnoff, along the Carpentaria Highway.

The proposed Amungee delineation area covers a distance of approximately 19.7 km from east to west and 11 km from north to south (6,583 ha). A total of eleven 2D seismic lines are proposed with one line located along existing cleared fence lines and tracks (12,786 m) and ten lines within areas of uncleared land (44,782 m). The Amungee delineation area also covers the proposed exploration well lease pads (5 in total), two gravel pits and associated access tracks. Since completion of the field survey's only four exploration well lease pad are planned to progress.

The area where project activities are planned to occur is displayed in Figure 2 and will henceforth be referred to in this report as the project area or Amungee delineation area.

### 1.3 Origin's Proposed Activities

Origin proposes to undertake range of exploration activities within the Amungee delineation area. This includes:

- Acquisition of up to 60km of a 2D seismic survey along both cleared and uncleared area of the seismic line route. This will require clearing of native vegetation in uncleared land and widening of existing fence lines and tracks to allow Vibroseis truck access to the seismic survey area. Vibroseis source seismic survey will involve the following activities:
  - Surveying and line clearing with dozers and grader, clear all source lines to 5m in width.
  - Once the geophones are laid out, Vibroseis trucks are driven down the lines vibrating the ground at a set interval. In some areas, seismic charges may be utilised as the energy source. In these areas, charges will be drilled installed down to 15m.
  - Cleared lines are remediated by pulling fallen vegetation into the cleared area.
- Construction of four new well lease areas identified for development in the Amungee delineation area. Development of well lease areas will include clearing for a well pad, camp pad and helicopter landing pad (13.7 ha), placement of temporary camp, access tracks, gravel pits and all associated exploration infrastructure.

The total clearing footprint for the Amungee delineation area is detailed in Table 1.

**Table 1 Amungee delineation disturbance footprint**

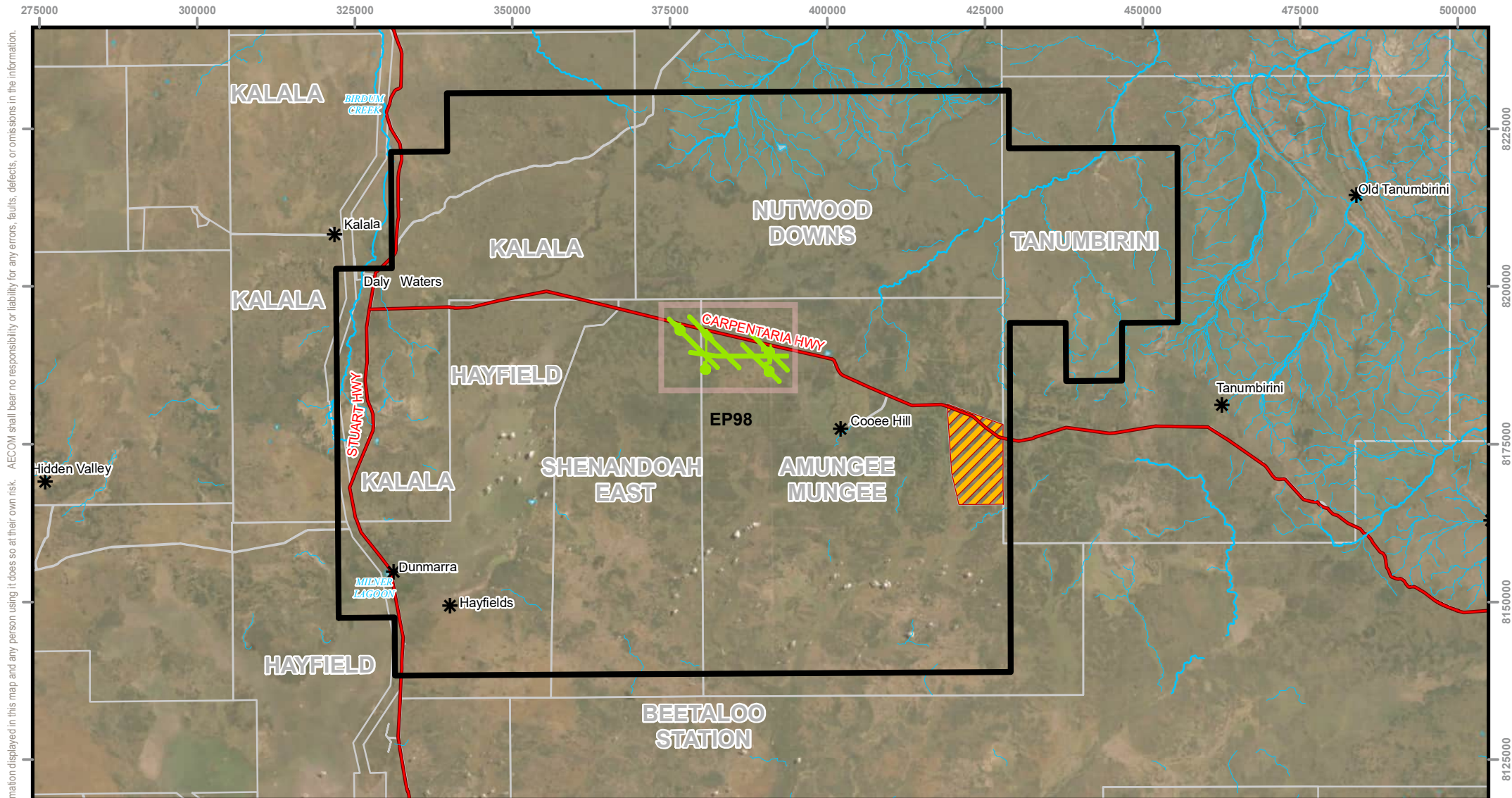
Details	Approximate Clearing area (ha)
10 seismic lines	31.66
4 well pads	54.8
Access Tracks	21
Amungee NW-2 Gravel Pit	3.5 (approved)
Amungee NW-3 Gravel Pit	3.5
<b>Total</b>	<b>110.96*</b>

\*excludes Amungee NW-2 Gravel Pit

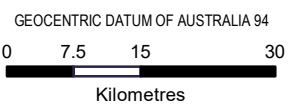
## 1.4 Scope of Works

The scope of work for the LCA involved:

- A review of historical data and reports prepared during the previous Beetaloo onshore oil and gas exploration programs
- A search of the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) Protected Matters database at 10 km and 50 km buffer (March 2022)
- A search of the Northern Territory (NT) Natural Resource Maps Database (flora and fauna Atlas database) (6/02/2022)
- Completion of LCA field survey of the proposed exploration program area (September 2021 and May 2022)
- Preparation of this report.



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- \* Populated Place
- Highway
- Drainage**
- Major
- Minor
- Amungee NW 2D Seismic Exploration Area
- Permit Area
- Pastoral Lease Boundary
- Bullwaddy
- Conservation Reserve
- Amungee Delineation Area

**LOCATION**



Data sources:  
 Permit Area, Cadastre - NT Gov 2022  
 Places, Vegetation - Aust Gov 2022  
 Highways, Roads, Drainage - StreetPro 2022

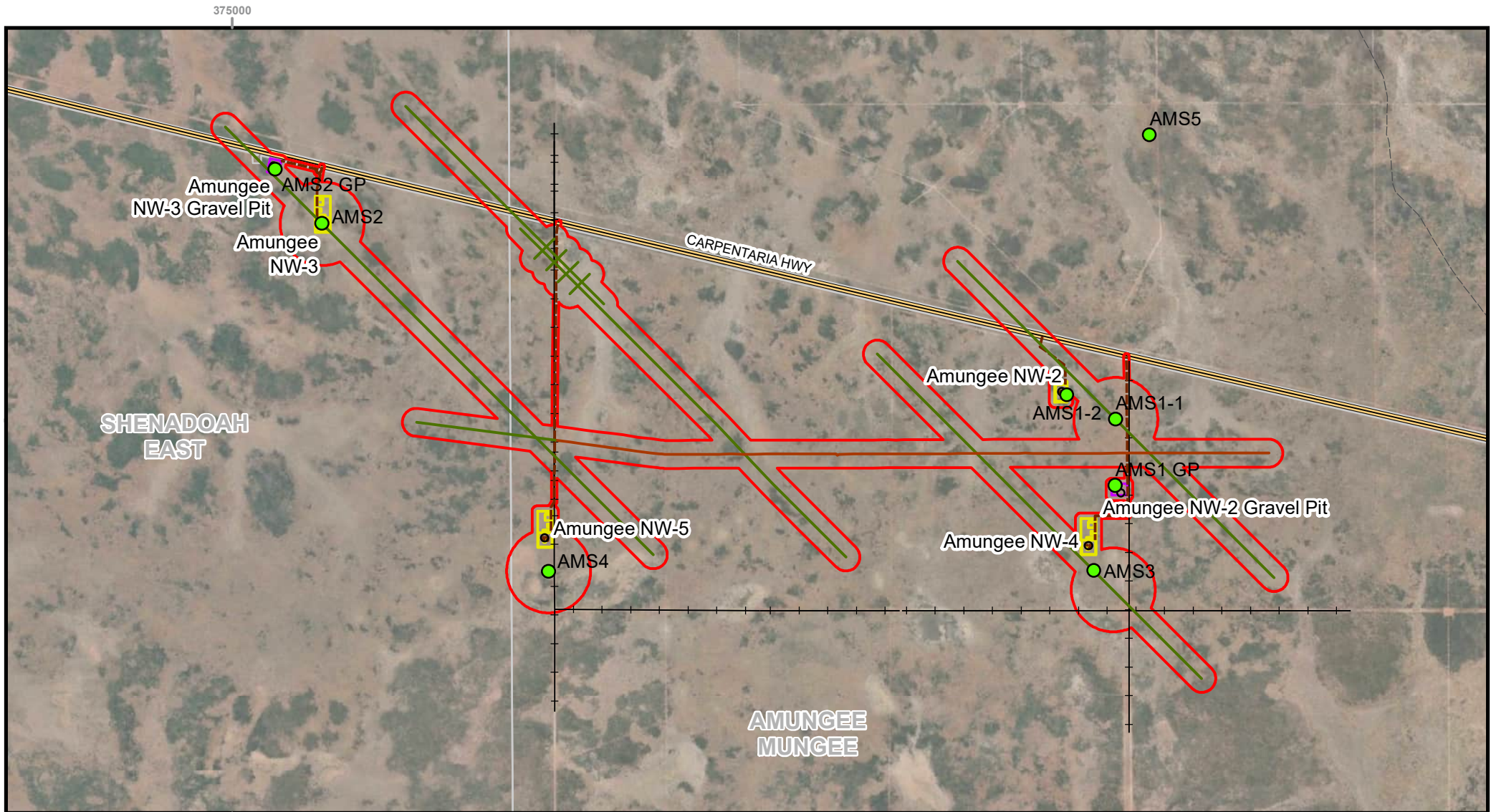
**ORIGIN ENERGY RESOURCES LIMITED**

**Amungee Delineation Area  
 2D Seismic Exploration Permit Area  
 and Land Tenure**

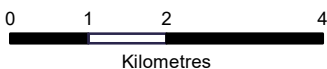
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**Figure  
 1**

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GEOCENTRIC DATUM OF AUSTRALIA 94



- Well Lease Pad Survey Sites
- Gravel Pits
- Highway
- Proposed Access Tracks
- Exploration Well Lease Pads
- Amungee NW 2D Seismic Exploration Survey Area
- Fence Lines and Tracks
- Pastoral Lease Boundary
- 2D Seismic**
- Fenceline
- Uncleared

Data sources:  
Permit Area, Cadastre - NT Gov 2022.  
Places, Vegetation - Aust Gov 2022  
Highways, Roads, Drainage - StreetPro 2022

**ORIGIN ENERGY RESOURCES LIMITED**

**Amungee Delineation Area  
2D Seismic Exploration Survey Area,  
Survey Sites, Proposed Access Tracks,  
Gravel Pit and Well Lease Pad Areas**

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Figure  
**2**

## 2.0 Assessment Method

### 2.1 Desktop Review

Field data collected between 2005 and 2022 within the permit areas was mapped based on image interpretation, with ground-truthing of the proposed survey areas being completed during field assessments (refer Section 2.2). This information was reviewed prior to the field work to identify the following:

- Vegetation types and flora and fauna species within the region that potentially occur within the Amungee delineation area, using previous reports and aerial / satellite imagery.
- *Environment Protection and Biodiversity Conservation Act* (EPBC Act) and *Territory Parks and Wildlife Conservation Act* (TPWC Act) listed threatened species or communities that potentially occur within the Amungee delineation area.
- Matters of national environmental significance or other matters protected by the EPBC Act that potentially occur within the Amungee delineation area.
- Weeds or feral animals listed under the EPBC Act or *Weeds Management Act* that potentially occur within the Amungee delineation area.

Table 2 provides a chronological list of reports (2004 - 2021), previously compiled in relation to environmental approvals and management support for petroleum exploration activities in the Beetaloo Sub-basin, NT.

The extent of work undertaken since 2004 has enabled a good understanding of the natural and cultural environment, which has been used in assessing the land condition of the project area.

**Table 2 Summary of existing Environmental Assessments and Reports for the Beetaloo Basin (2004 to 2022)**

Date	Report
<b>Sweetpea Petroleum</b>	
Jul- Aug 2004	Baseline land condition assessment (LCA)
	Site database established
Jul 2005	Exploration EMP finalised and approved
November 2019 to February 2020	LCA for EP136 (Seismic and Drilling Exploration Program)
<b>Petrohunter Australia (Partner to Sweetpea)</b>	
Dec 2006	Baseline vegetation assessment
Apr 2007	Drill site assessments
Apr 2007	Annual report
Jun 2007	Update of the existing EMP to include the new Exploration Permit areas
Jul 2007	Drill Site maps
Jul 2007	Supplemental Environmental Management Plan, Drilling Program 2007, Beetaloo Basin, NT
Jul 2007	Soil erosion assessment
Jul 2007	Groundwater quality
July 2007	Emergency Maps
Jul 2007	Environment & Heritage Induction Materials
<b>Falcon Oil and Gas</b>	
Dec 2010	Drill site condition assessments

Date	Report
Jan 2011	Archaeological survey
March 2011	Site-specific drilling EMP
2011	Falcon Shenandoah 1 Stimulation and Testing Groundwater Monitoring
2011/2012	Shenandoah 1 Re-Entry Environment Plan (EP)
July 2012	EP99 Archaeological Survey, Beetaloo Basin
2013	EP99 Seismic Exploration Environmental Management Plan
<b>Origin</b>	
2015 and 2016	Beetaloo Basin Environmental and Heritage Assessment and preparation of Approval documentation.
October 2018	LCA and Heritage Assessment of proposed lease area (Velkerri 76 S1-1, Velkerri 76 S2-1, Velkerri 117 E1-1, Velkerri 98 N1-2, Kyalla 117 N2-1 and Kyalla 117 W1-2, Kyalla 98 W1-1)
July 2019	Weed Survey of Kyalla 117 N2-1 and access tracks, including Kalala S1 and Amungee NW-1H
December 2019	LCA and Heritage Assessment of EP76, EP117 and EP98
June 2020	Beetaloo Exploration Program Annual Weed Survey Report 2020
September 2021	Land Condition Assessment and weed surveys for Velkerri 76 N1, Amungee NW and Beetaloo W
May 2022	Additional Land Condition Assessment field survey of this specific proposed exploration program

## 2.2 Field Assessment and Reporting

The aim of the LCA was to document site condition prior to activities occurring within the Amungee delineation area (seismic, lease pads, access tracks and gravel pits) and inform the preparation of the program's Environmental Management Plan (EMP).

The LCA field surveys completed for the Amungee delineation area used both an aerial rapid condition assessment method similar to previous assessments carried out by AECOM for past exploration activities. The method allows for large areas to be surveyed over a relatively short period of time through the use of a helicopter platform to assess proposed Amungee delineation area, as well access remote locations for on-ground-truthing.

The following site characteristics were recorded as part of the LCA:

- the presence of drainage lines and the direction of surface flows
- the distance to the nearest sensitive receptors (such as significant vegetation communities or fauna habitats)
- soil characteristics and intactness
- soil suitability for wastewater disposal
- vegetation communities (based on dominant species within each canopy strata)
- fauna habitat features, such as hollows, logs and burrows (the fauna habitat quality for each mapped vegetation community type would be assessed)
- incidental fauna sightings
- the presence or absence of Crested Shrike-tit (*Falcunculus frontatus whitei*) via call-playback surveys and active searches
- the presence or absence of Gouldian Finch (*Erythrura gouldiae*) via active searches

- the presence of weeds and/or feral animals (i.e. indication of scats, tracks, wallows etc.)
- general land use description.

The proposed program at Amungee delineation area sites requires a series of existing access tracks and boundary fence line tracks to be upgraded and gates installed, to allow for support vehicles to access the site.

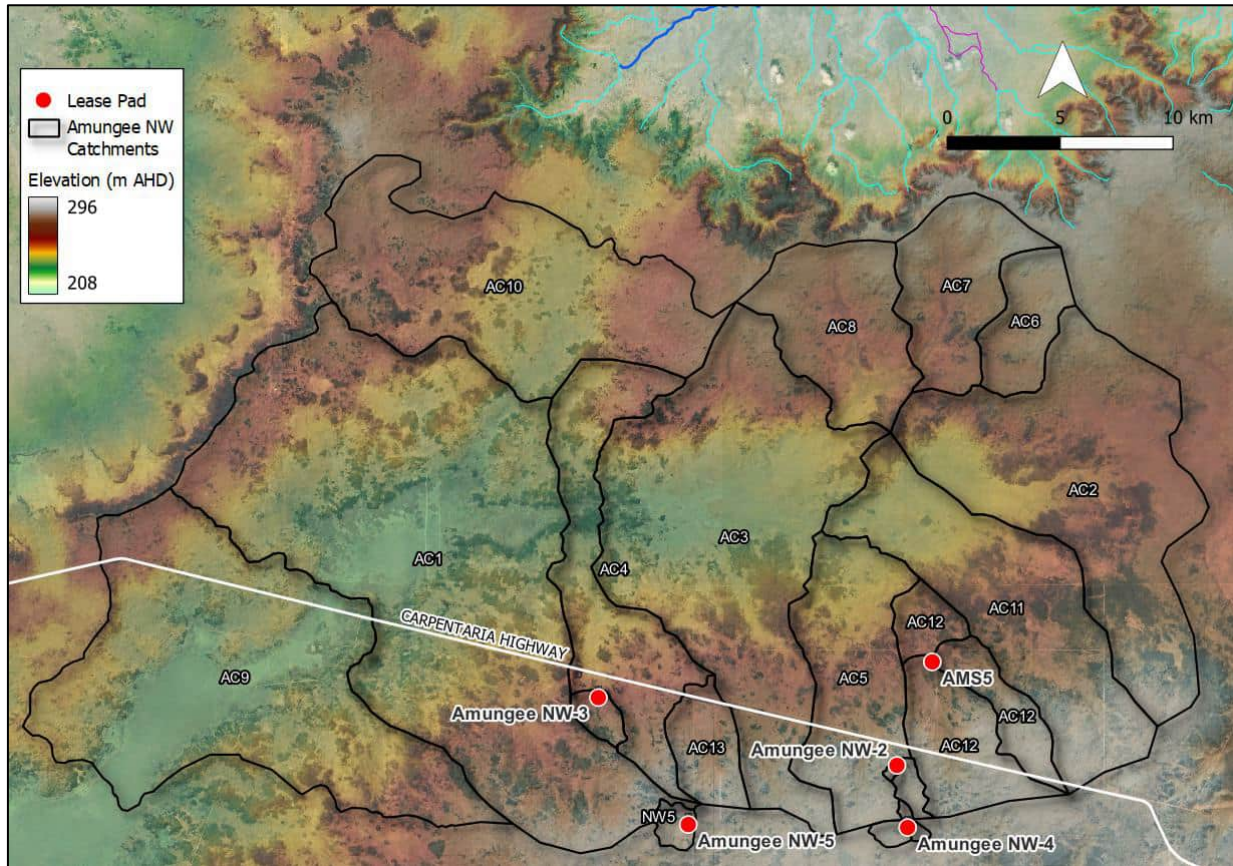
Site assessments locations were identified by Origin. Four of the six assessment sites were selected for exploration well lease pad development and one of the two gravel pit areas has already received approval for development. Two of the final proposed exploration areas have been moved around 500 m to the north to avoid a drainage depression at Amungee NW-4 and a significant archaeological site at Amungee NW-5 (refer Table 3 and Figure 2).

**Table 3 Field survey assessment site names and corresponding proposed well exploration areas**

Field ID	GDA94, zone 53		Corresponding Proposed Exploration Area	GDA94, zone 53	
	Easting	Northing		Easting	Northing
AMS1-1	390800	8189600	Site not selected for current development		
AMS1 Gravel Pit	390900	8188279	Amungee NW-2 Gravel Pit (approved)	390900	8188280
AMS1-2	376611	8193100	Amungee NW-2	389841.4	8190093
AMS2	390415	8186890	Amungee NW-3	376611	8193100
AMS2 Gravel Pit	375770	8194070	Amungee NW-3 Gravel Pit	375752	8188280
AMS3	380660	8186870	Amungee NW-4	390313.6	8187337
AMS4	390800	8188380	Amungee NW-5	380597.4	8187470
AMS5	389932	8190030	Site not selected for current development		

## 2.3 Flood Assessment

A hydraulic assessment has been conducted to inform potential risks of the identified exploration lease pads to flood and inform the design. The extent of inundation within the project area depends on the severity of the wet season and can range from remaining completely dry to widespread flooding. An assessment of the flood levels was completed for five of the six identified drill lease pads (Amungee NW-2, Amungee NW-3, Amungee NW-4, Amungee NW-5 and additional site AMS5 (Figure 3).



**Figure 3 Catchments of Amungee delineation area exploration well sites**

The methodology used for the hydraulic assessment is described in Table 4. For consistency, the same methodology previously used for the Amungee NW was adopted.

**Table 4 Hydraulic Assessment Methodology**

Item	Description
Topographical Data	Shuttle Radar Topography Mission (SRTM) ~1s (30 m)  There was no other available ground level survey and aerial Light Detection And Ranging (LiDAR) data available for the areas around the lease pads. This includes the LASer (LAS) LiDAR point cloud data of the Beetaloo Basin which also does not cover the proposed lease pad locations.
Catchment Flow Estimation	Queensland Urban Drainage Manual (QUDM) 2017 Rural rational method  The flow estimation method is consistent with the previous investigation used for the Amungee NW which was in the same catchment as the proposed new lease pads (Figure 3).
Hydraulic Assessment	One-dimensional (1D) Manning’s n open channel flow calculation using FlowMaster software: <ul style="list-style-type: none"> <li>• Channel cross sectional information – Taken from the available STRM data</li> <li>• Channel slope – Estimated from the available STRM data</li> <li>• Manning’s n roughness – Estimated for Google Earth© satellite photography</li> </ul>

It is noted that the vertical accuracy of SRTM data varies from 5 to 10 m and therefore the vertical accuracy of the flood levels in the investigation should be expected to have a similar order of accuracy. Further detailed surveys will be conducted of the lease pad areas to inform final placement of the lease pads within the landscape to avoid flood areas.

## 3.0 Physical Environment

### 3.1 Climate

The climate of the Amungee delineation area can be described as arid to semi-arid, with rainfall decreasing in frequency and quantity from north to south. The climate is monsoon influenced and has a distinctive wet and dry season. The wet season occurs in summer, between October and March and is characterised by hot and wet conditions. The dry season occurs during the winter months between May and August and is characterised by mild days and cool nights. September and April are transitional months, with occasional rainfall. Approximately 90% of the rainfall occurs during the Wet Season, and annual totals show moderate variability from year to year.

The maximum rainfall for the permit area occurs in January and February, coinciding with the northern Australian annual monsoon event. Daly Waters airstrip is on a similar latitude with the northern end of the permit area and recorded the highest average rainfall in the region at this time, with 163 mm falling in January and 183 mm in February. The May to September period is generally very dry, with average monthly rainfall ranging from 0.3 – 6.4 mm (BOM, 2022). The annual rainfall pattern within the area is highly variable. Drought conditions are known to occur in the region once every ten years (Holt & Bertram, 1981).

Land capability assessments were undertaken in late May 2022 during the start of the dry season.

The average annual rainfall experienced in the region (which includes the BOM data from Daly Waters Airstrip) is shown in Table 5.

**Table 5 Annual rainfall 2019 – 2021**

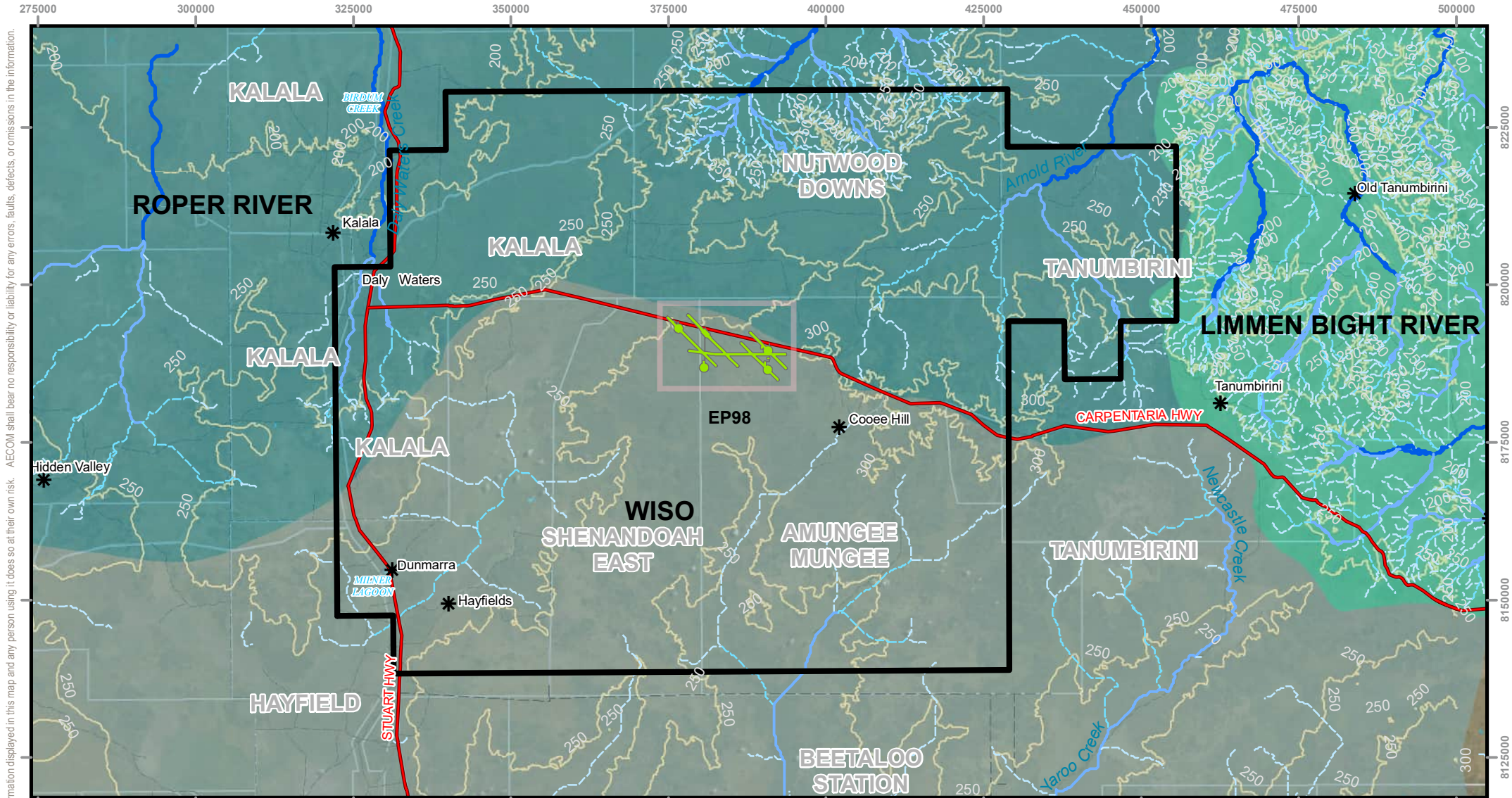
Year	Annual rainfall (mm)	Months during which rain was recorded
2016	608	12
2017	866	7
2018	752	7
2019	277	8
2020	951	9
2021	679	7

### 3.2 Topography, Surface Water and Drainage

The Amungee delineation area occurs within a topographic zone classified as laterite plains that predominantly slope in a south and south westerly direction (Tickell, 2003).

The Amungee delineation area is situated in the Wiso River Basin (Figure 4). The Wiso River Basin covers the southern half of EP98 (south of the Carpentaria Highway) and is internally drained by Newcastle Creek and a number of small ephemeral creeks. Newcastle Creek flows into Lake Woods, which is located south of Newcastle Waters Station, around 140 km south-west of the area.

Lake Woods covers an area of inundation of approximately 50,000 ha in normal rainfall years, extending to 80,000 ha in exceptionally wet years, after which it can retain water for several years (AECOM, 2015). Lake Woods is described as a major quasi-permanent surface water body in the region, although some semi-permanent and many ephemeral waterholes are located across the permit area (HLA, 2006) and is listed as a Site of Conservation Significance by the previous NT Government Department of Environment and Natural Resources (DENR) and is listed on the Directory of Important Wetlands in Australia. Lake Woods is listed as a wetland of national significance in the Directory of Important Wetlands in Australia (NRETAS, 2009)



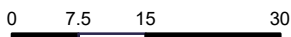
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Kilometres

- Highway
- Contours - 50m
- Amungee NW 2D
- Seismic Exploration Area
- Permit
- Pastoral Lease Boundary

Data sources:  
Permit Area, Cadastre - NT Gov 2022.  
Places, Vegetation - Aust Gov 2022  
Highways, Roads, Drainage - StreetPro 2022

**Stream Order**  
**Intermittant Streams**

- 1
- 2
- 3
- 4

**Creeks**

- 3
- 4

Amungee Delineation Area

**River Basins**

- Roper River
- Limmen Bight River
- Wiso

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**Amungee Delineation Area  
2D Seismic Exploration Permit Area  
Surface Water and Drainage**

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Figure  
**4**

Although Lake Woods is located outside of the exploration permit areas, it is fed principally by surface inflow of Newcastle Creek, originating more than 160 km north-east on Amungee Mungee Station (NTG, undated). During the period of inundation, Lake Woods supports over 100,000 waterbirds including internationally significant numbers of Plumed Whistling-Duck. Numerous bird species nest and feed in the diverse wetland habitat, and the conservation group 'Birdlife International' nominated Lake Woods as an 'Important Bird Area' (IBA). The lake also includes the largest area of lignum swamp in the Northern Territory and in tropical Australia (NRETAS, 2009).

There are no creeks or stream crossings intersecting proposed Amungee delineation area.

During the wet season it is likely the region would experience widespread surface flooding, to a depth of 30 cm, which has previously been identified by debris being collected on fence lines (HLA, 2005).

### 3.3 Flood Risk

The extent of inundation within the permit area depends on the severity of the wet season and can range from remaining completely dry to widespread flooding. As part of the preparation of the LCA, AECOM assessed the 1% Annual Exceedance Probability (AEP) flood depths and levels to determine the risk of flood inundation during the 100-year flood event from a local or regional flooding for each of the Amungee delineation area exploration well sites (Table 6).

**Table 6 1% AEP Results for Each Lease Pad**

Lease Pad	SRTM Ground Elevation (m AHD)	Maximum Water Depth (m)	Flood Level at Nearest Channel (m AHD)
Amungee NW-2	286.6	0.4	287.1
Amungee NW-3	253.5	0.1	253.6
Amungee NW-4	295.7	0.3	296.0
Amungee NW-5	284.3	<0.1	282.6
AMS5	260.5	<0.1	259.5

The greatest risk of flooding to the new exploration well sites is from local catchment sheet-flow (rainfall immediately over the area draining to the site). The local catchment runoff from major storm events will be the considering factor for the establishment of lease pad finish levels and the lease pad designs will take this into consideration for the final placement in the landscape.

**3.3.1 Well Site Amungee NW-2**

Table 7 provides a summary of the hydraulic assessment outcomes for the proposed Amungee NW-2 location.

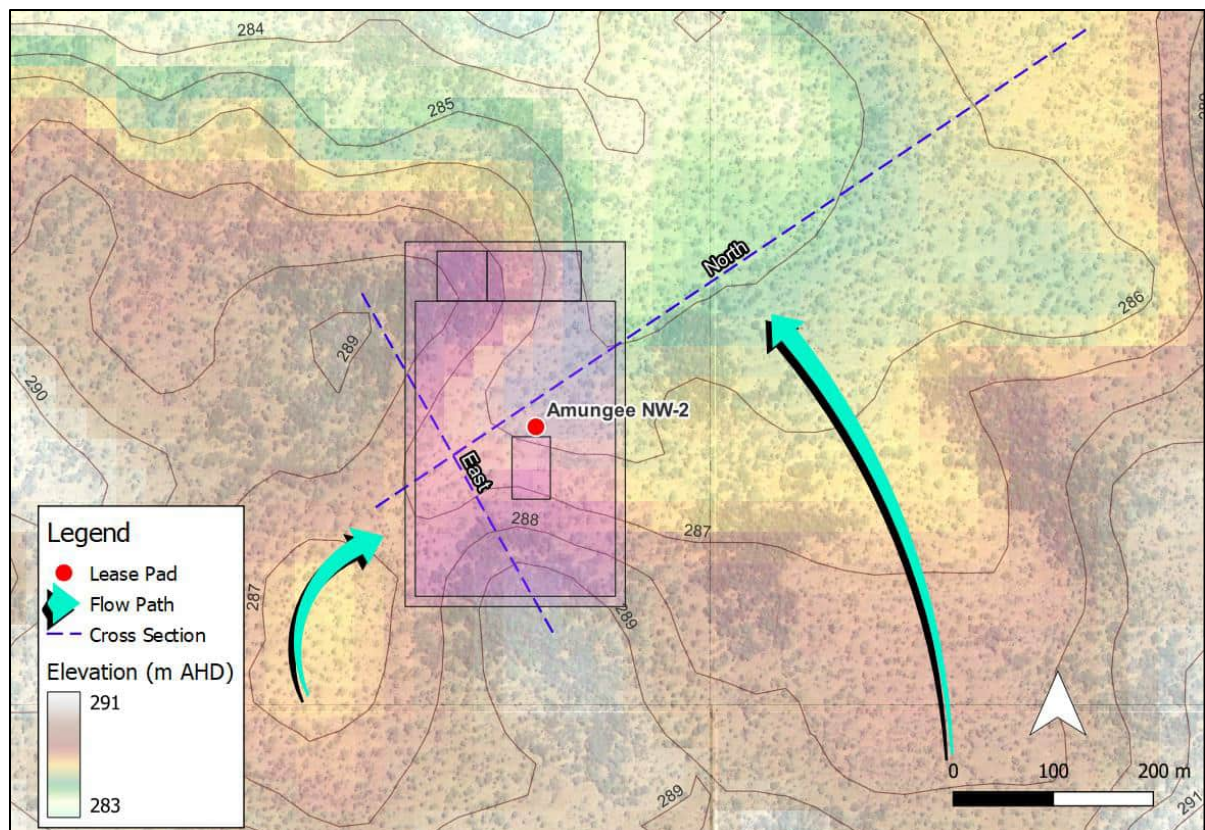
**Table 7 Amungee NW-2 Lease Pad Results Summary**

Item	Description
Location	Amungee NW-2 (Figure 5)
1% AEP Peak Flow	South to North flow path: 39.9 m <sup>3</sup> /s West to East flow path: 10.6 m <sup>3</sup> /s
Results	South to North flow path: Figure 6 West to East flow path: Figure 7

**Results Summary**

Figure 7 shows that the proposed lease pad potentially extends across a minor local catchment flow path and is at risk of inundation in the 1% AEP by up to 0.4 m. Figure 6 shows that the risk of inundation in the 1% AEP from the larger flow path to the east of the proposed lease pad is low.

It is recommended that the lease pad is raised more than 0.7 m above natural ground level. The lease pad will likely require flow diversion works along its western side to divert flows northwards. Alternately, piped drainage can be considered under the lease pad if there is a low risk of heavy load damage to the pipes.



**Figure 5 Amungee NW-2 Plan View**

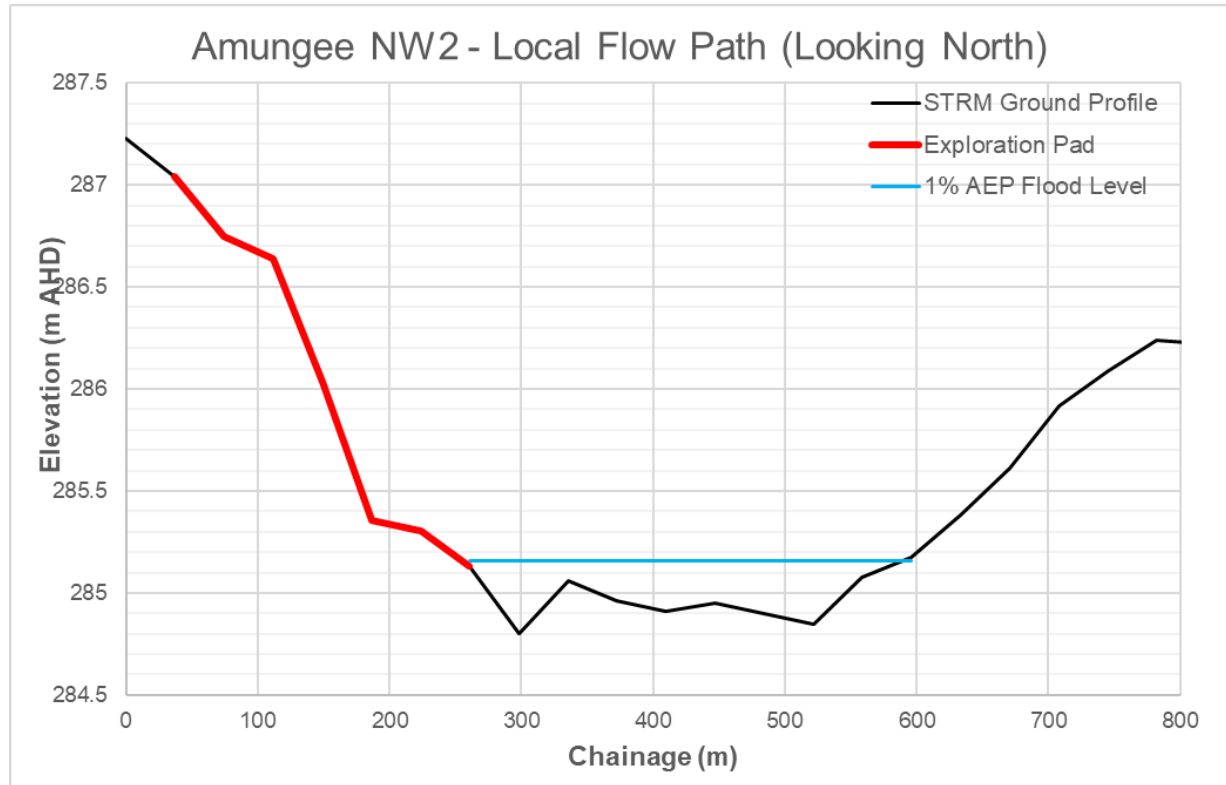


Figure 6 Amungee – Lease Pad NW-2 (Looking North) Local Flow Path

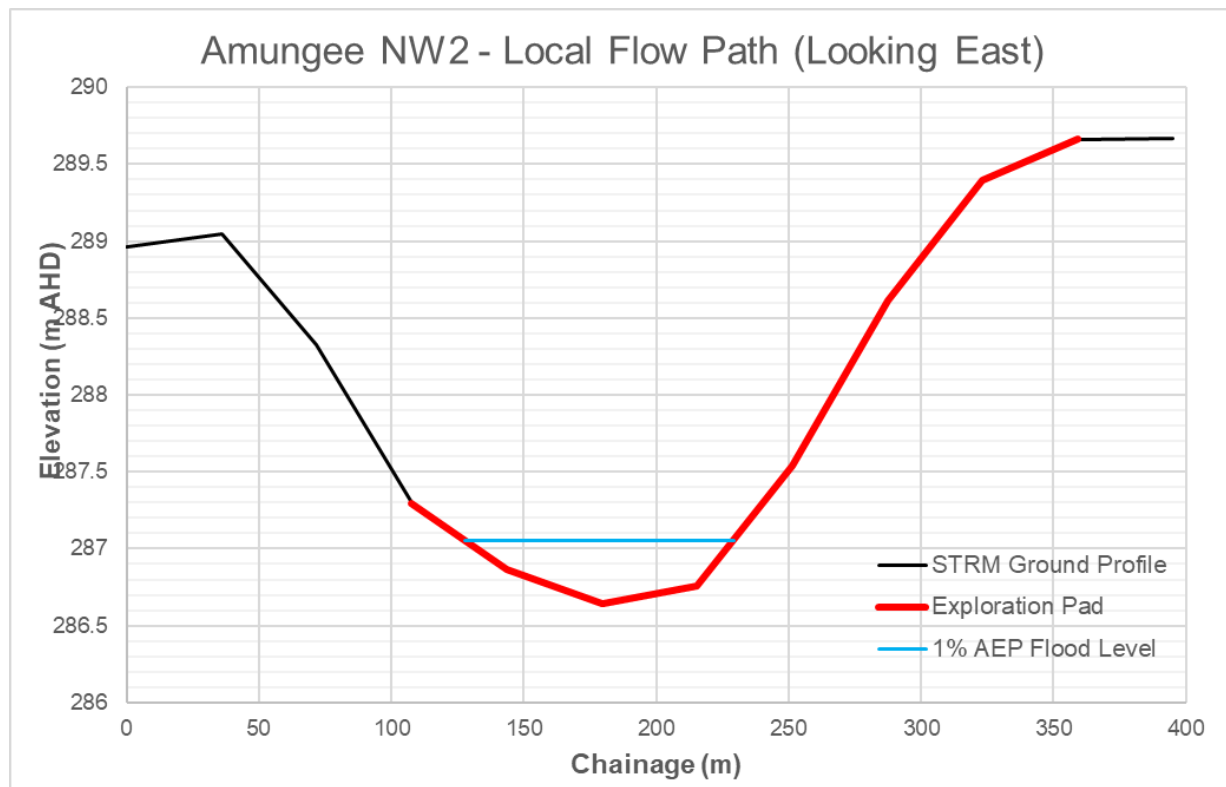


Figure 7 Amungee NW-2 (Looking East) Local Flow Path

**3.3.2 Well Site Amungee NW-3**

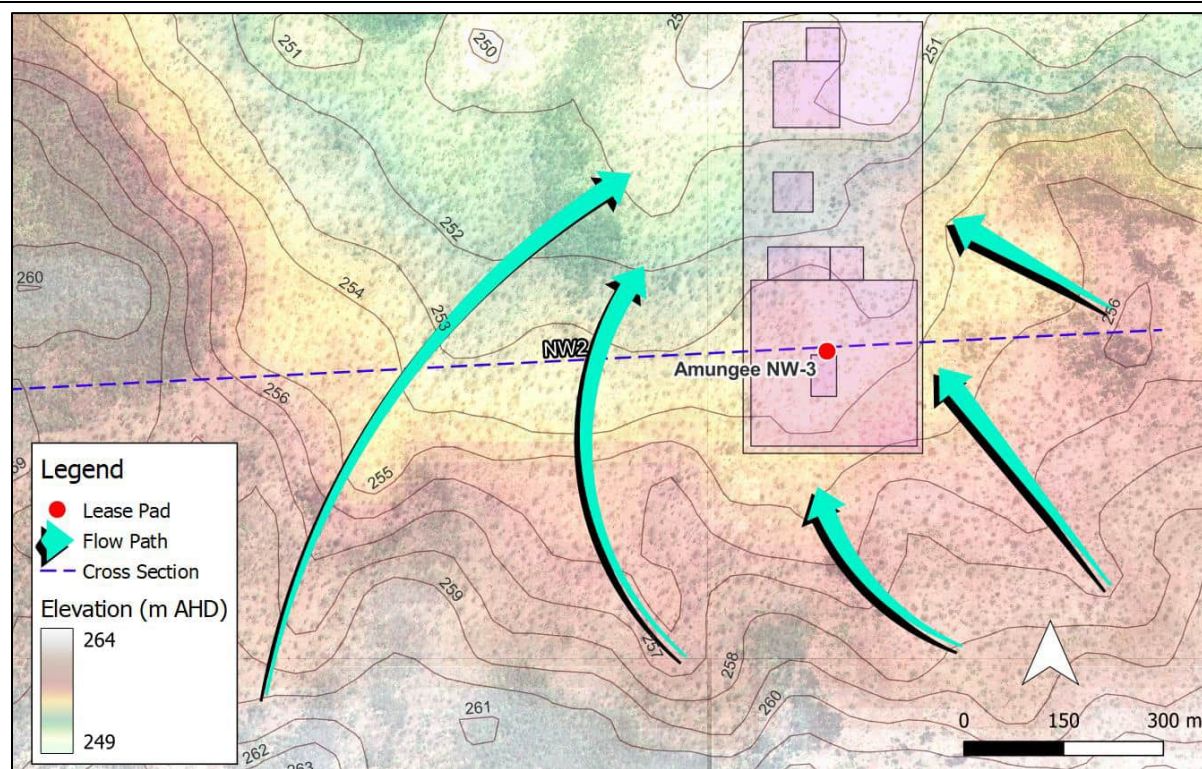
Table 8 provides a summary of the hydraulic assessment outcomes for the proposed Amungee NW-3.

**Table 8 Amungee NW-3 Results Summary**

Item	Description
Location	Amungee NW-3 (Figure 8)
1% AEP Peak Flow	South to North flow path: 56.5m <sup>3</sup> /s
Results	South to North flow path: Figure 9

**Results Summary**

Figure 9 shows there is a potential minor risk of the lease pad being inundated in the 1% AEP from flooding in the main local catchment flow path (chainage 600 – 1,100 m). However, the lease pad's potential location across several smaller local catchment flow paths will probably require a diversion drainage works along the south-eastern boundaries of the site to prevent minor flooding of the site.



**Figure 8 Amungee NW-3 Plan View**

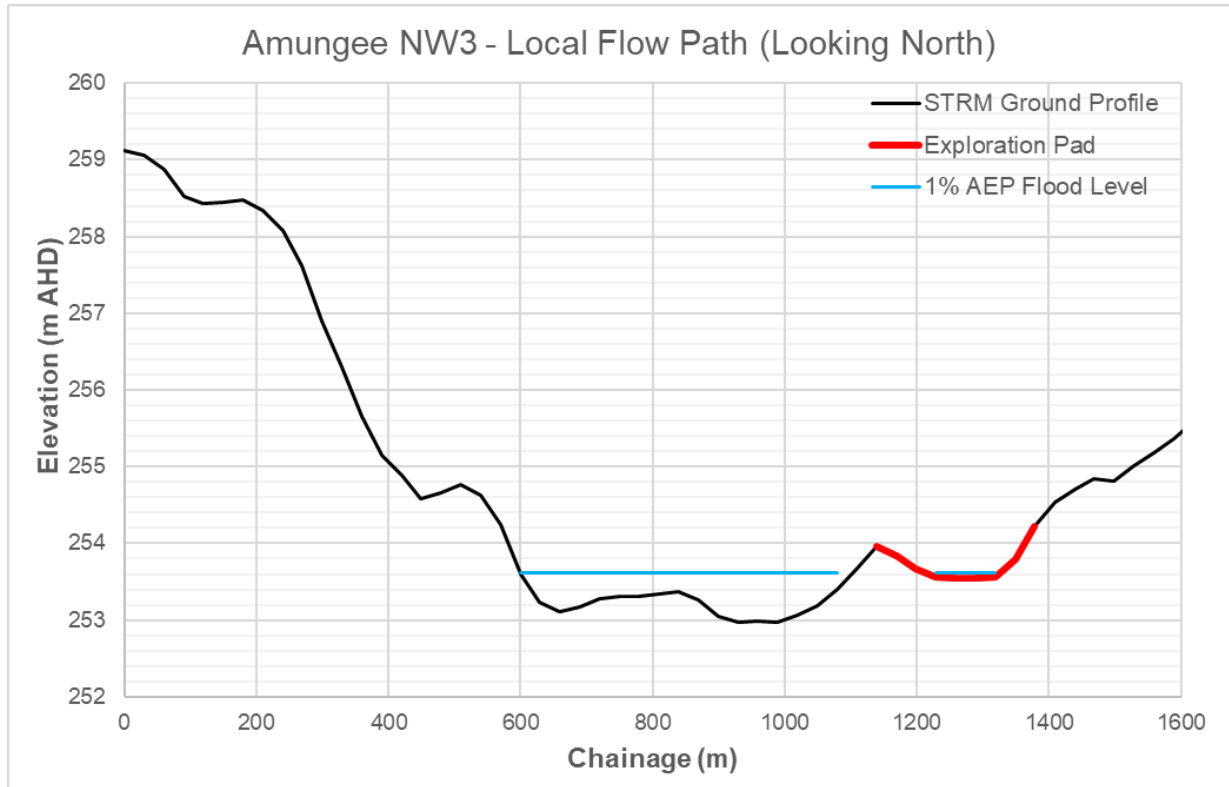


Figure 9 Amungee NW-3 Local Flow Path

### 3.3.3 Well Site Amungee NW-4

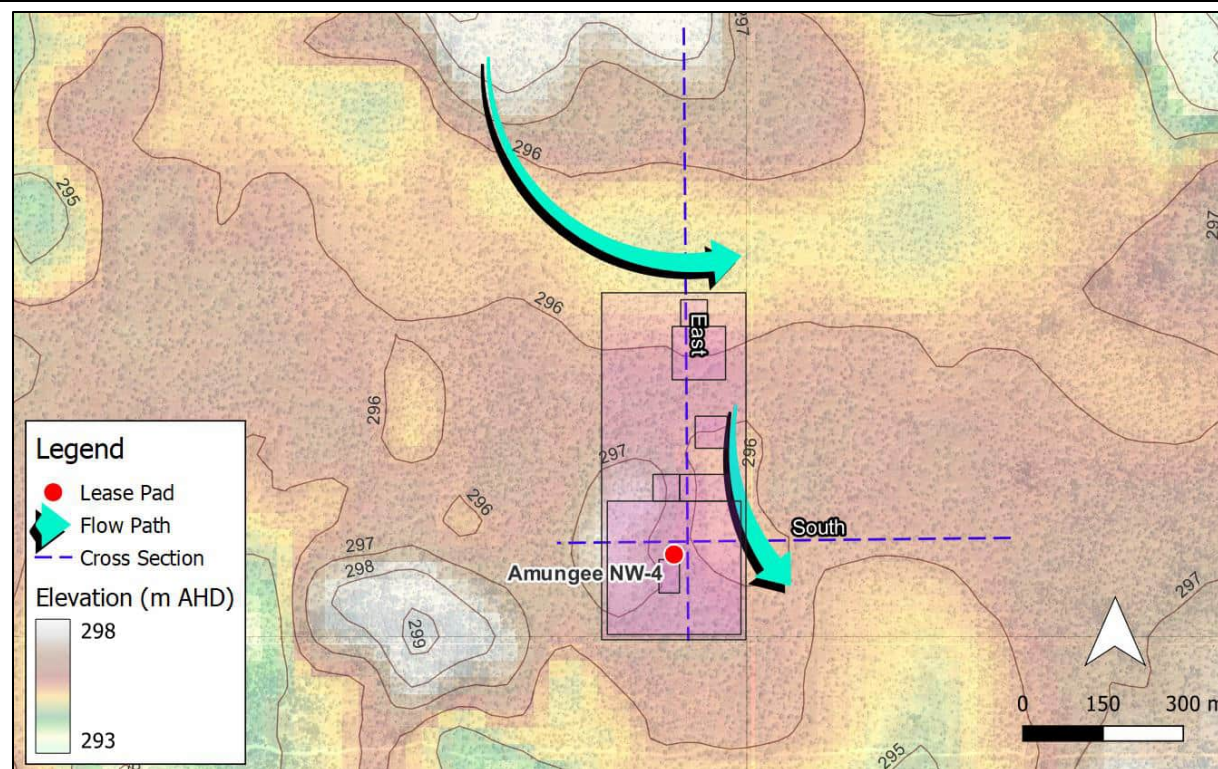
Table 9 provides a summary of the hydraulic assessment outcomes for the proposed Amungee NW-4.

**Table 9 Amungee NW-4 Results Summary**

Item	Description
Location	Amungee NW-4 (Figure 10)
1% AEP Peak Flow	West to East flow path: 10.9 m <sup>3</sup> /s North to South flow path: 7.0 m <sup>3</sup> /s
Results	West to East flow path: Figure 11 North to South flow path: Figure 12

#### Results Summary

Figure 11 and Figure 12 show that the lease pad is potentially located near a sag in the ground. This means that there is a potential risk of 0.3 m depth of flooding along the eastern side of the lease pad. It is recommended that the lease pad should be raised at least 0.6 m above natural ground level. Diversion works are also potentially required along the eastern boundary of the lease pad to divert local catchment runoff southwards.



**Figure 10 Amungee NW-4 Plan View**

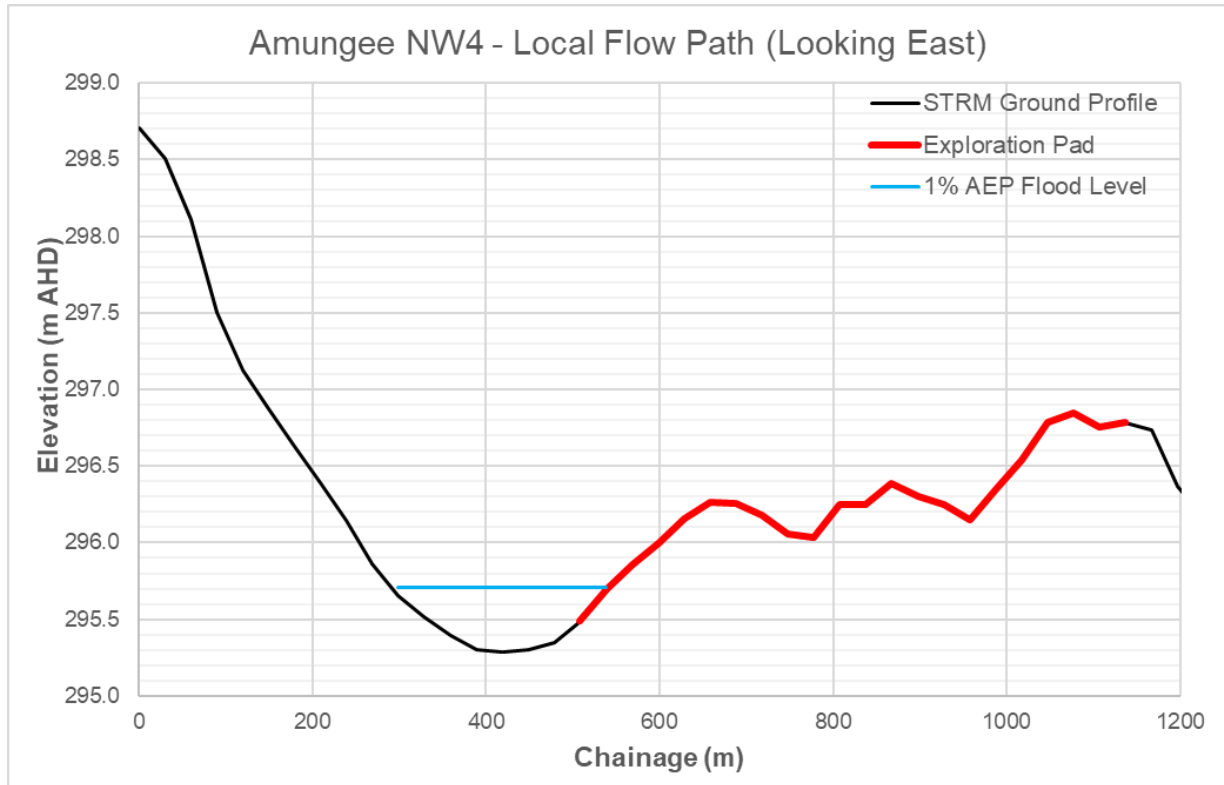


Figure 11 Amungee NW-4 (Looking East) Local Flow Path

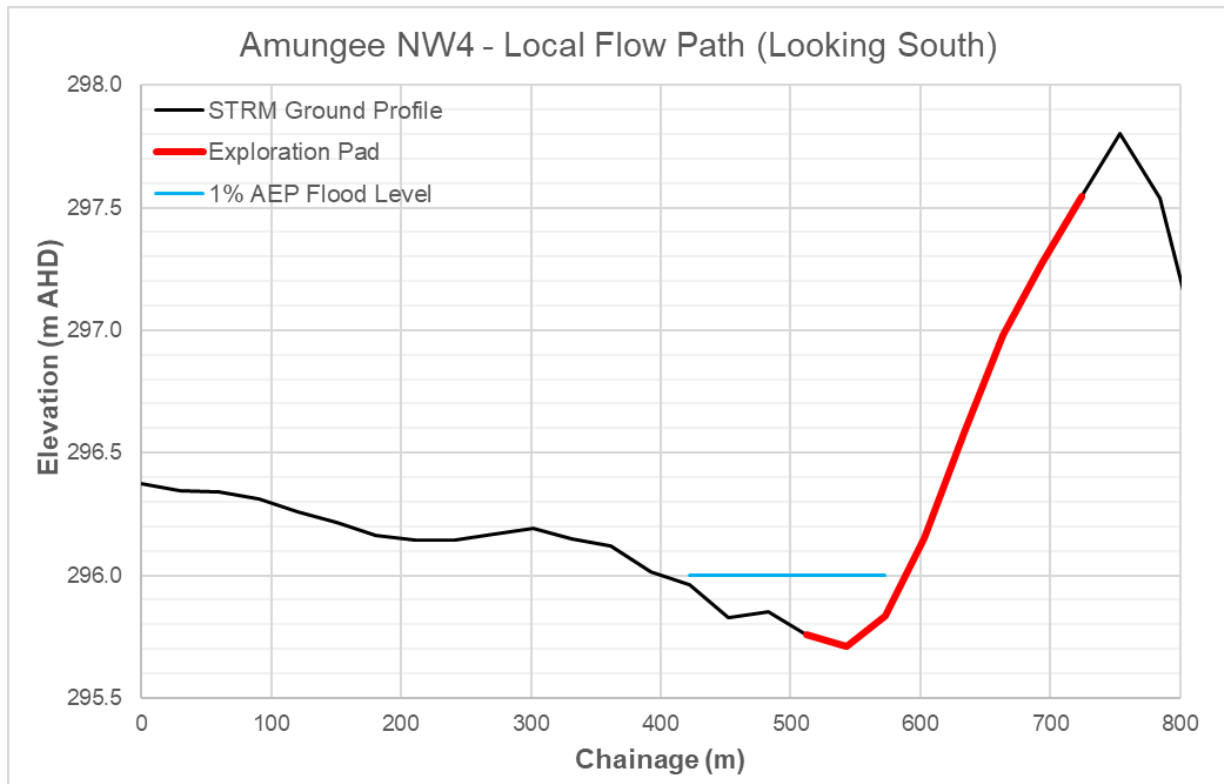


Figure 12 Amungee NW-4 (Looking South) Local Flow Path

**3.3.4 Well Site Amungee NW-5**

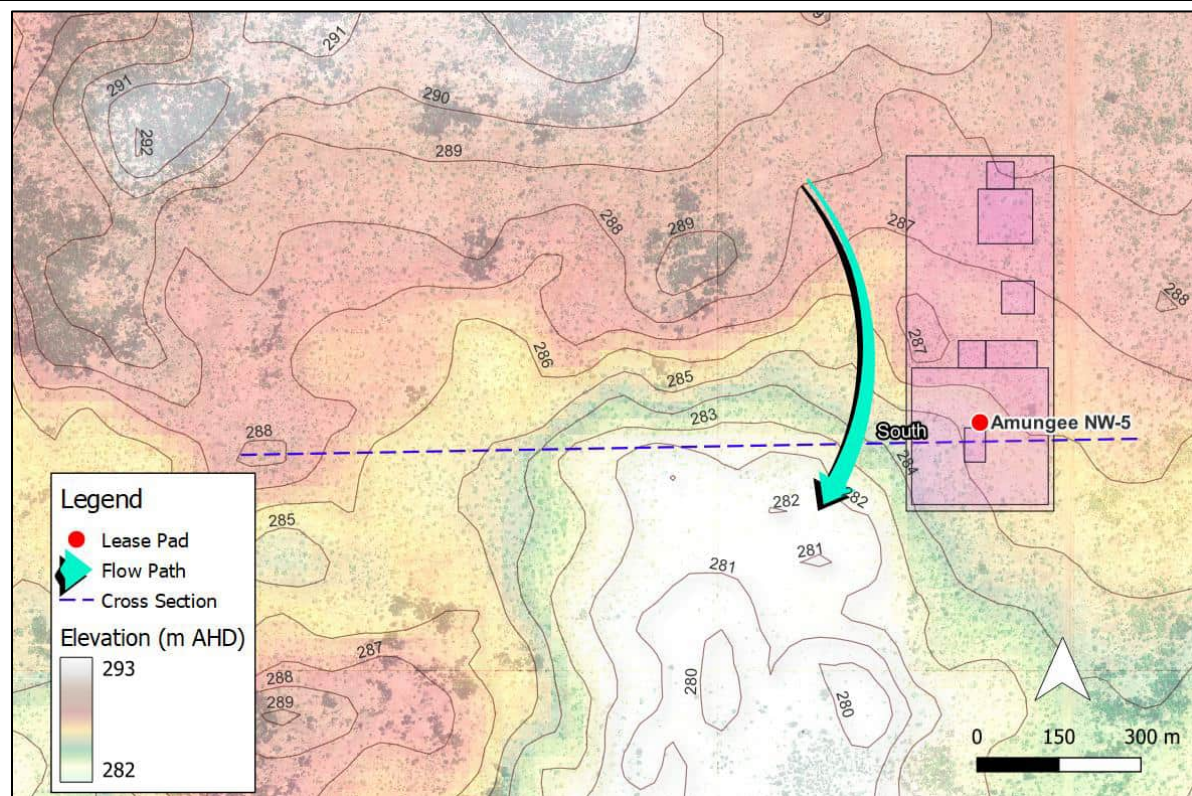
**Table 10** provides a summary of the hydraulic assessment outcomes for the proposed Amungee lease pad NW-5.

**Table 10 Amungee NW-5 Results Summary**

Item	Description
Location	Amungee NW-5 (Figure 13)
1% AEP Peak Flow	North to South flow path: 52.9 m <sup>3</sup> /s
Results	North to South flow path: Figure 14

**Results Summary**

Figure 14 shows that there is allow risk of flooding in the 1% AEP to the lease pad from flows in the largest nearby flow path (Figure 13). It is recommended that the lease pad is still raise above natural ground level and diversion works be provided along the north-eastern boundaries. This is due to the site still being subject to potential inundation from shallow sheet flow from runoff in the higher elevation areas located north of the site.



**Figure 13 Amungee NW-5 Plan View**

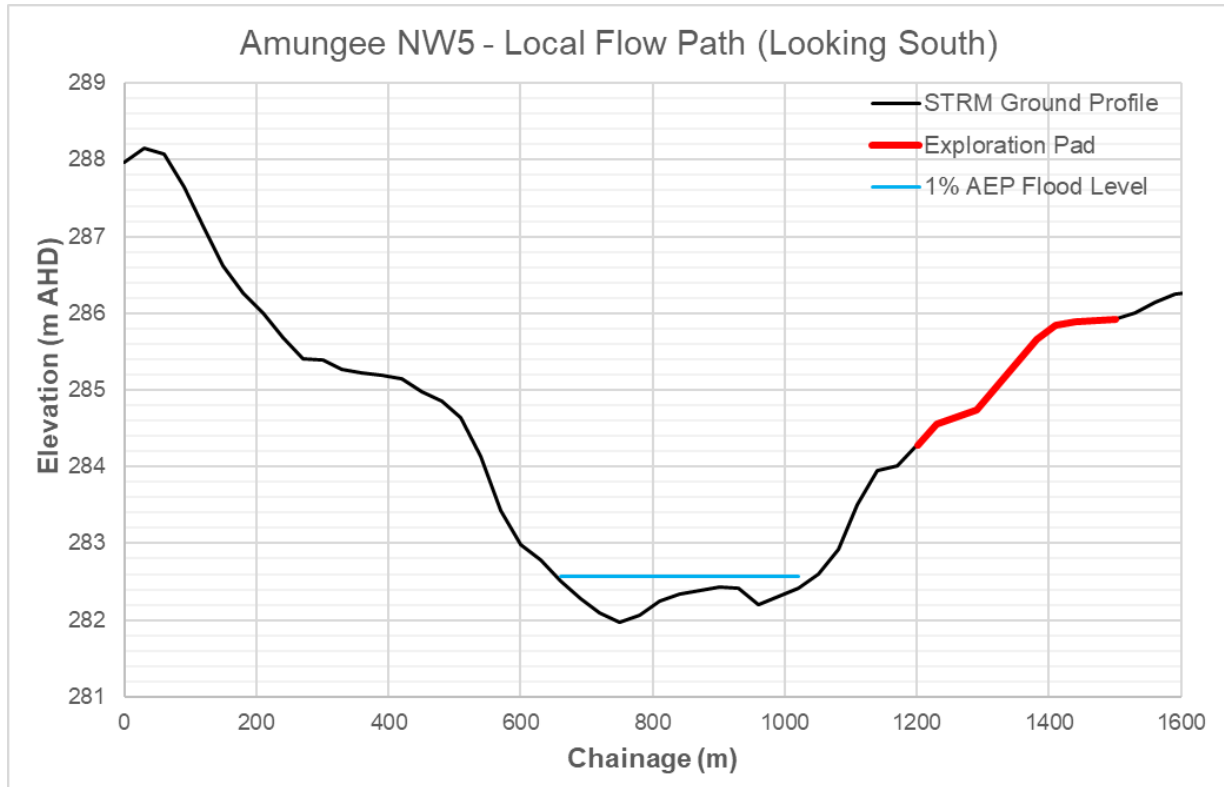


Figure 14 Amungee NW-5 Local Flow Path

**3.3.5 Site AMS5**

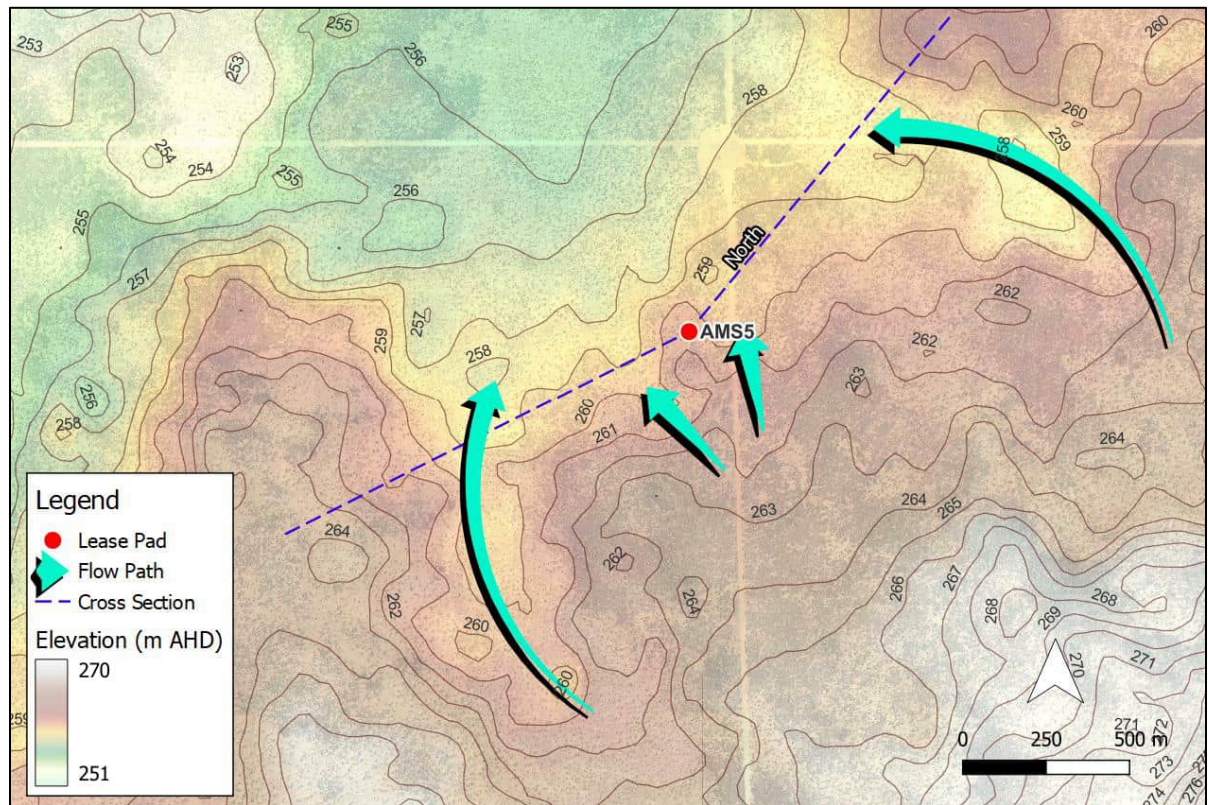
Table 11 provides a summary of the hydraulic assessment outcomes for AMS5 site.

**Table 11 AMS5 Results Summary**

Item	Description
Location	Amungee AMS5 (Figure 15)
1% AEP Peak Flow	South to North flow path: 155.7 m <sup>3</sup> /s
Results	South to North flow path: Figure 16

**Results Summary**

Figure 16 demonstrates that there is a low risk of inundation to the potential lease pad given that the selected location is on a high point (Figure 15) above the local catchment flood levels. The extent of the lease pad has not been provided for this investigation. It is likely that diversion works will be required along the southern side of the lease pad to divert the minor local catchment flow paths (Figure 15) around the site and towards the north.



**Figure 15 AMS5 Site Plan View**

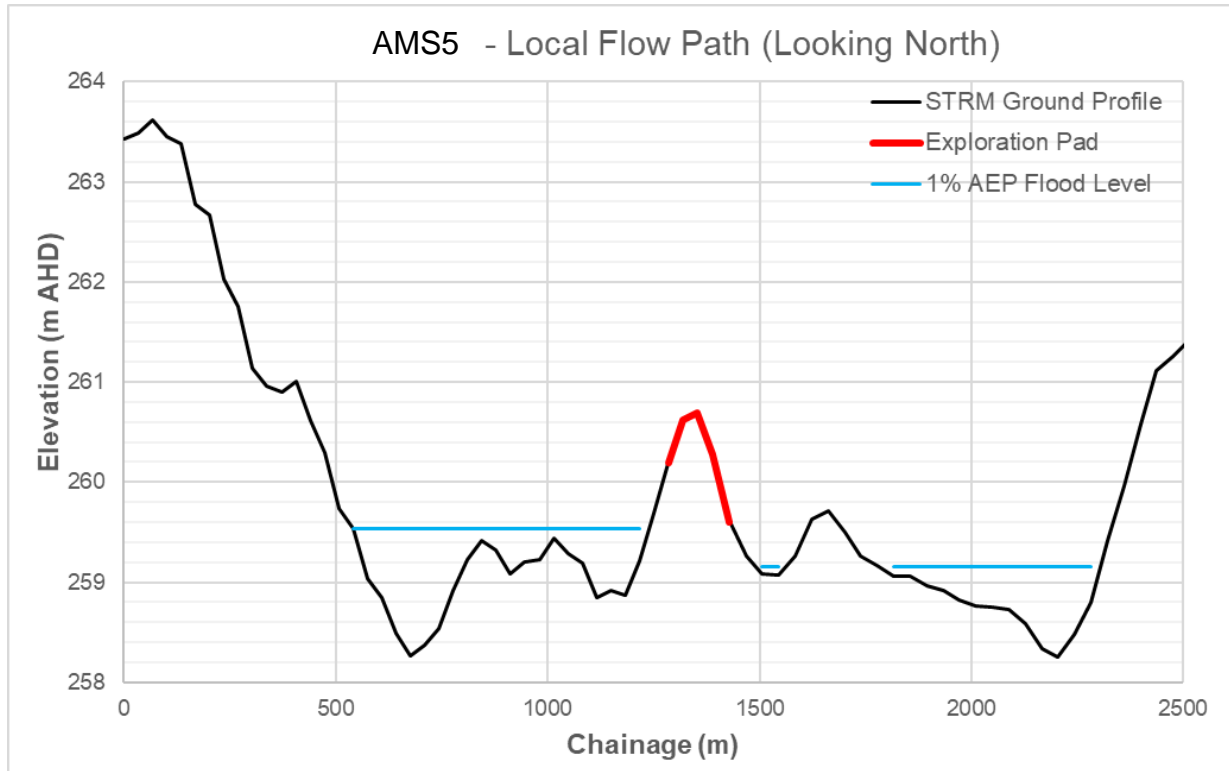


Figure 16 AMS5 Site Local Flow Path

### 3.4 Hydrogeology

Origin commissioned CloudGMS to undertake a desktop hydrogeological study of the Beetaloo Basin (CloudGMS, 2015) to compile a current understanding of the groundwater regime in the Beetaloo and adjacent groundwater basins. The conceptual hydrogeological model described below is from the Beetaloo Basin Hydrogeological Assessment.

The Beetaloo Basin comprises a thick sequence of flat-lying mudstone and sandstone formations (Roper Group) that were deposited between 1,500 and 1,430 million years ago (Ma) (Table 12). The Roper Group is estimated to reach 5,000 m in thickness in the centre of the basin, with the exception of the north and eastern margins occurs at an average depth of about 500 m. The Roper Group is overlain by the Georgina Basin (630 – 497 Ma), which includes widespread basalts and a thick limestone sequence that forms the Cambrian Limestone Aquifer (CLA), which is a significant water supply aquifer in the region. The Georgina Basin is capped by Cretaceous mudstone and sandstone (145 – 66 Ma) and recent alluvial and laterite deposits.

**Table 12 Summary of Beetaloo Basin Hydrostratigraphy**

Province	Period/Age	Formation	Aquifer Status	Thickness (m)	Yield (L/s)	Ave EC ( $\mu\text{s/cm}$ )	
CARPENTARIA BASIN	CRETACEOUS 145 – 66 Ma	Undifferentiated	<i>Local Aquifer</i>	0 - 130	0.3 - 4	1,800	
GEORGINA BASIN	CAMBRIAN 497-630 Ma	Cambrian Limestone Aquifer (CLA)	Anthony Lagoon Beds	REGIONAL AQUIFER	0 – 200	1 - 10	1,600
			Gum Ridge Formation	REGIONAL AQUIFER	0 – 300	0.3 - >20	1,400
		Antrim Plateau Volcanics	REGIONAL AQUITARD	0 – 440	0.3 - 5	900	
		Bukalara Sandstone	<i>Local Aquifer (not regionally connected)</i>	0 – 75	0.3 - 5	1,000	
BEETALOO BASIN (ROPER GROUP)	NOT KNOWN	Hayfield Mudstone	REGIONAL AQUITARD	0 – 450	-	32,000	
		Jamison Sandstone	<i>Local Aquifer (not regionally connected)</i>	0 – 150	-	138,000	
	MESO-PROTEROZOIC 1,430-1,500 Ma	Kyalla Formation	REGIONAL AQUITARD	0 – 800	-	-	
		Moroak Sandstone	<i>Local Aquifer (not regionally connected)</i>	0 – 500	0.5 - 5	131,000	
		Velkerri Formation	REGIONAL AQUITARD	700 – 900	-	-	
		Bessie Ck Sandstone	<i>Local Aquifer (not regionally connected)</i>	450	0.5 - 5	-	

Across parts of the Beetaloo Basin, undifferentiated Cretaceous deposits form the uppermost aquifer targeted for stock use. Notably, a basal sandstone unit immediately overlying the CLA produces yields of up to 5 L/s. Shallow groundwaters have also been recorded within the permit area between 1 and 2 metres below ground level.

The CLA, comprising the Gum Ridge Formation and the Anthony Lagoon Beds, is an extensive regional aquifer system that forms the principal water resource in the Beetaloo Basin. Limestone in the CLA is commonly fractured and cavernous; regionally bore yields of up to 100 L/s have been recorded from this aquifer. Approximately 80% of groundwater bores drilled in the basin screen the CLA and the aquifer supplies water for the pastoral industry and local communities including Elliot, Daly Waters, Larrimah and Newcastle Waters.

The CLA contains a significant but largely undeveloped groundwater resource with the sustainable yield from the Georgina Basin estimated to be in the order of 100,000 ML/year. Existing groundwater use in the Beetaloo Basin is estimated at 6,000 ML/year.

The regional groundwater flow direction in the CLA is north-west toward Mataranka, where the aquifer discharges into the Roper River and supports significant groundwater dependent ecosystems including the Roper River at Eley National Park and Red Lily/57 Mile Waterhole. These discharge features occur around 100 km north-west of the Beetaloo Basin. Dry season flow in the Roper River has been gauged at 95,000 – 126,000 ML/year and provides an estimate of the magnitude groundwater discharge from the CLA. Large decadal changes in the discharge to the Roper River suggest that most recharge input occurs close to the discharge zone (i.e. beyond the Beetaloo Basin region). Groundwater recharge mechanisms to the CLA are poorly characterised but are likely to be dominated by infiltration through sinkholes and preferential recharge through soil cavities.

Limited information exists on the hydrogeological characteristics of the Roper Group sequence as it occurs at depth within the Beetaloo Basin. Sandstone dominated formations may behave as aquifers, however, drilling results suggest these formations have limited permeability and will only form marginal, very local scale aquifers. Groundwater in the Roper Group is highly saline and contrasts with the shallower, utilised aquifers in which groundwater is generally of drinking water quality.

The Velkerri Formation represents the primary unconventional gas target in the Beetaloo Basin, although small hydrocarbons intersections have been encountered in other formations within the Roper Group. Vertical pressure gradients between the Roper Group and the CLA are not well characterised, however, previous exploration well formation tests indicate there is an upward pressure gradient from the Roper Group to the CLA. Over much of the basin the CLA is separated from these formations by multiple aquitards including the Antrim Plateau Volcanics and Hayfield Mudstone.

The Origin permit area currently falls within the Daly Roper Beetaloo Water Control District, that encompasses 175,580 km<sup>2</sup> and includes the Roper River and its tributaries as well as the Beetaloo Sub-basin (DENR, 2018). Legislation in Water Control Districts covers all aspects of sustainable water management, including the investigation, use, control, protection and allocation of water resources. Through the NT *Water Act*, water control districts and water allocation plans, allocation of water to various declared beneficial uses, including agriculture, aquaculture, public water supply, riparian and industry while ensuring that adequate provisions are made to maintain cultural and environmental requirements. Water control districts are geographical areas declared under the *Water Act* by the minister to allow for intensive management of water resources. Origin have an existing water extraction licence from DEPWS Water Resource Division in accordance with the *Water Act 1992* (Cloud GMS, 2015).

### 3.5 Land Systems

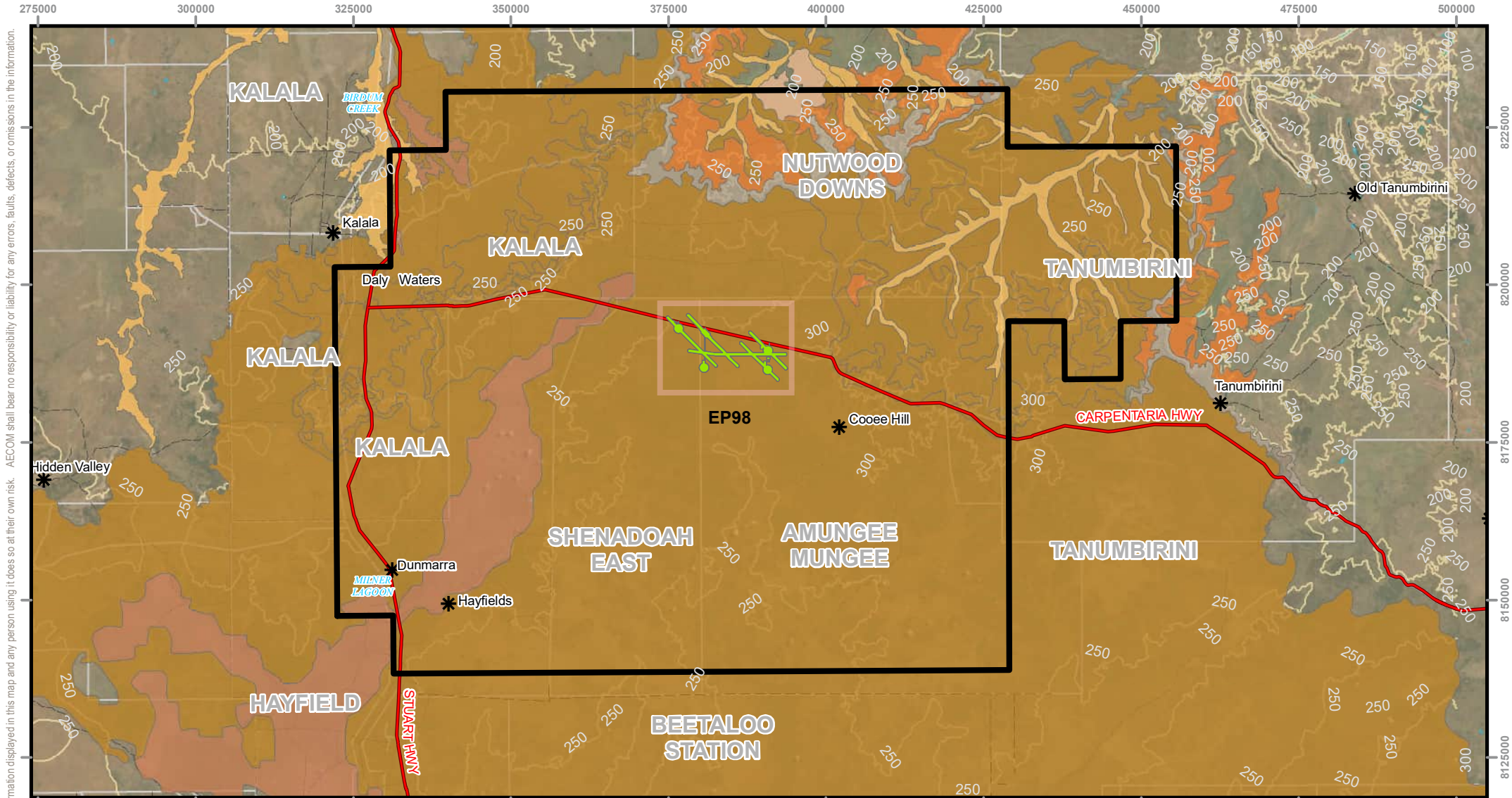
Land systems are defined because of their distinct differences from the surrounding areas and by the recurring pattern of geology, topography, soils and vegetation. Land system mapping for the project area is derived from *Land Systems of the Southern Part of the NT*, which is a compilation of three existing land system surveys and the Atlas of Australian Soils (scale 1:1,000,000). It covers the southern part (approximately 70%) of the Northern Territory. Published maps were made digital and edited to accommodate overlaps, gaps and mismatching boundaries. Where possible, the land system descriptions have been extrapolated into areas covered by the broader scale Atlas mapping (DLRM, 2013).

The Amungee delineation area occurs within the Beetaloo Land System, which is classified as lateritic plains and rises. This land system is characterised by plains and rises associated with deeply weathered profiles (laterite) including sand sheets and other depositional products, sandy and earth soils.

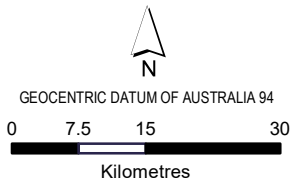
Land system mapping for the Amungee delineation area is summarised in Table 13 and Figure 17.

**Table 13 Beetaloo land system details**

Land System	Geological Zone	Class	Description
Beetaloo	Sturt Plateau	Lateritic plains and rises	Plains and rises associated with deeply weathered profiles (laterite) including sand sheets and other depositional products; sandy and earth soils



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- Highway
- Contours - 50m
- Amungee NW 2D
- Seismic Exploration Area
- Permit Area
- Pastoral Lease Boundary

Data sources:  
Permit Area, Cadastre - NT Gov 2022.  
Places, Vegetation - Aust Gov 2022  
Highways, Roads, Drainage - StreetPro 2022

- Landscape Class**
- lateritic plains and rises
  - clay plains
  - alluvial floodplains
  - sandstone plains and rises
  - lateritic plateaux
  - basalt plains and rises

Amungee Delineation Area

**ORIGIN ENERGY RESOURCES LIMITED**

**Amungee Delineation Area  
2D Seismic Exploration Permit Area  
Land Systems**

PROJECT ID 60623736  
 CREATED BY david.vandenhoeck  
 LAST MODIFIED 06-Jul-2022  
 VERSION 1

Figure  
**17**

### 3.6 Soils

Soils within the Sturt Plateau have been derived from ancient rock formations and ancestral soils that were formed during earlier weathering cycles. The soils have been deeply weathered, leached and are relatively infertile because they have not been enriched by any recent geological events (Orr & Holmes, 1984). The soil types located within the plateau range from the very strongly leached lateritic soils of the Tertiary land surface to the calcareous desert soils and desert loams in the southern drier areas.

The lateritic plains, which encompass the Amungee delineation area, are classed as very strongly leached soils of the Tertiary land surface. Three main soil types are located within this area, including:

- Tertiary Lateritic Red Earths (Red Kandosols), which occur on the gently undulating topography
- Tertiary Lateritic Red Sands (Red Tenosols), which occur on gently undulating to undulating topography of the Tertiary Lateritic Plain, formed from sandstones and complex parent materials of the deep sandy soils
- Tertiary Lateritic Podzolic Soils, formed on the gently undulating topography over a variety of rocks. These soils occur in the northern section of the Barkly Basin and the Gulf Falls.

Soil assessment were completed at six proposed exploration well sites. The results of the soil assessment is presented in Table 14.



Soils at proposed Amungee NW exploration well sites - Amungee NW-2, Amungee NW-3, Amungee NW-4 and Amungee NW-5 were found to comprise Kandosols, being reddish brown at a depth of ~0.5 m and would likely have graded to red Kandosols at greater depth. These soils increased in clay content with depth, grading from a loamy sand to a heavy sandy loam or sandy clay loam in the upper B horizon at 0.2 m to 0.5 m depth.



Soils at sites AMS1-1 and AMS5, which are currently not proposed to progress, were shallow, with lateritic bedrock being encountered at a depth of 0.25 m and 0.45 m respectively.



Soils within the project area had 20% to 60% gravel content, comprising sub-angular ironstone gravels of 1-5mm size, and were slightly acidic, ranging in pH from 5.7 to 6.6.

Soil material structure samples were collected at all of the exploration well sites and at the two gravel pit sites. Soil lab results are provided in Appendix A.

Table 14 Proposed exploration well sites soil

Horizon	Depth (m)	Texture	Colour	Coarse fragments	pH	EC (µS/cm)	Moisture	Emerson class no.	Photo
<b>AMS1-1 soil - not selected to progress</b>									
A1	0 – 0.1	Loamy sand	7.5YR 3/3 dark brown	60% fines, 25% 1-2mm subangular ironstone, 15% 2-5mm subangular ironstone	6.0	17	0.8%	2	
A3	0.1– 0.25	Sandy loam (light)	5YR 3/3 dark reddish brown	65% fines, 20% 1-2mm subangular ironstone, 10% 2-5mm subangular ironstone, 5% 5-10mm subangular ironstone	5.7	7	2.3%	2	
Lateritic bedrock @ 0.25m									
<b>AMS1-2 soil (Amungee NW-2)</b>									
A1	0-0.08	Sandy loam (light)	7.5YR 3/3 Dark brown	50% fines, 25% 1-2mm subangular ironstone, 25% 2-5mm subangular ironstone	-	-	-	-	
A3	0.08-0.2	Sandy loam	5YR 4/4 reddish brown	65% fines, 20% 1-2mm subangular ironstone, 15% 2-5mm subangular ironstone	5.7	9	3.6%	2	
B1	0.2-0.55	Sandy clay loam	2.5YR 3/4 dark reddish brown	60% fines, 25% 1-2mm subangular ironstone, 15% 2-5mm subangular ironstone	6.0	6	3.8%	2	

Horizon	Depth (m)	Texture	Colour	Coarse fragments	pH	EC (µS/cm)	Moisture	Emerson class no.	Photo
<b>AMS2 soil (Amungee NW-3)</b>									
A1	0 – 0.1	Sandy loam (light)	10YR 3/2 very dark greyish brown	60% fines, 30% 1-2mm subangular ironstone, 10% 2-5mm subangular ironstone	-	-	-	-	
A3	0.1 – 0.3	Sandy loam	10YR 5/2 greyish brown	50% fines, 40% 1-2mm subangular ironstone, 10% 2-5mm subangular ironstone	6.2	9	3.3%	2	
B1	0.3– 0.45	Silty clay loam	7.5YR 5/3 brown	40% fines, 30% 1-2mm subangular ironstone, 30% 2-5mm subangular ironstone	6.6	6	4.9%	2	
Lateritic bedrock @ 0.45m									
<b>AMS3 soil (Amungee NW-4)</b>									
A1	0 – 0.13	Loamy sand	7.5YR 2.5/3 very dark brown	45% fines, 30% 1-2mm subangular ironstone, 25% 2-5mm subangular ironstone	-	-	-		
A3	0.13– 0.2	Loamy sand (heavy)	5YR 3/3 dark reddish brown	40% fines, 30% 1-2mm subangular ironstone, 30% 2-5mm subangular ironstone	6.4	18	1.1%	7	
B1	0.2– 0.45	Sandy loam	2.5YR 3/4 dark reddish brown	40% fines, 25% 1-2mm subangular ironstone, 35% 2-5mm subangular ironstone	6.6	8	2.3%	2	

Horizon	Depth (m)	Texture	Colour	Coarse fragments	pH	EC (µS/cm)	Moisture	Emerson class no.	Photo
<b>AMS4 soil (Amungee NW-5)</b>									
A1	0 – 0.1	Loamy sand	5YR 3/3 dark reddish brown	80% fines, 15% 1-2mm subangular ironstone, 5% 2-5mm subangular ironstone	-	-	-	-	
A3	0.1 – 0.3	Sandy loam	5YR 3/4 dark reddish brown	70% fines, 25% 1-2mm subangular ironstone, 5% 2-5mm subangular ironstone	6.4	8	3.5%	2	
B1	0.3– 0.55	Sandy loam (heavy)	2.5YR 3/4 dark reddish brown	40% fines, 45% 1-2mm subangular ironstone, 15% 2-5mm subangular ironstone	6.6	6	4.9%	6	
<b>AMS5 soil – not selected to progress</b>									
A1	0 – 0.1	Loamy sand	5YR 2.5/2 dark reddish brown	60% fines, 40% ironstone, gravel	-	-	-	-	
A3	0.1– 0.25	Sandy loam	7.5YR 3/4 strong brown	65% fines, 25% 1-2mm subangular ironstone, 10% 2-3mm subangular ironstone	6.1	15	3.3%	2	
B1	0.25– 0.65	Sandy clay loam	5YR 4/4 reddish brown	65% fines, 20% 1-2mm subangular ironstone, 15% 2-5mm subangular ironstone	6.2	6	4.9%	2	

### 3.6.1 Erosion Susceptibility

Soil erosion susceptibility varies throughout the permit area, dependent upon soil types, slope and extent of ground disturbance. Apart from the erosive impact of climatic conditions, soil erosion is influenced mainly by the inherent properties of the soils and the processes which occurred during the formation of the landscapes (Aldrick & Wilson, 1990).

Erosion will occur in the permit area if the land is used beyond its capacity, as is seen if land is overstocked or vehicle movements not controlled, for example. The location of proposed lease pads and seismic lines have been examined to determine the risk of erosion occurring. Factors considered include the following:

- Soil type – soils with higher clay content are prone to generation of bulldust and are easily eroded by wind and water. The surface soils at the lease pad sites had low clay content in the upper 0.2m, ranging from loamy sands (5-10% clay) to sandy loams (10-20% clay). Gravelly soils tend to be more robust to disturbance on the scale expected during the lease exploration program. The lease pad areas were found to have high gravel content and generally non-dispersive soils as shown below:
  - Amungee NW-2 – Surface gravel 50%, subsurface gravel 35-40%, Emerson class number 2
  - Amungee NW-3 - Surface gravel 40%, subsurface gravel 50-60%, Emerson class number 2
  - Amungee NW-4 - Surface gravel 55%, subsurface gravel 60%, Emerson class number 2 and 7 (low potential for dispersion)
  - Amungee NW-5 - Surface gravel 20%, subsurface gravel 30-60%, Emerson class number 2 and 6 (low potential for dispersion)

The two sites currently not planned to progress

- AMS1-1 – Surface gravel 40%, subsurface gravel 35%, Emerson class number 2 (moderate potential for dispersion when inundated with water)
- AMS5 - Surface gravel 40%, subsurface gravel 35%, Emerson class number 2
- Slope – the slope of the site will determine the risk of erosion during rainfall events, with steeply inclined areas a higher risk than small undulations in the landform. All assessed sites were considered flat with a slope of  $\leq 1\%$ , with exception being AMS 1-1 which had a 2% gradient.
- Aspect – the position of the access track and pads in relation to the direction of the contour should be considered and creation of tracks across (as opposed to parallel with) the contour should be avoided.
- Rainfall – Table 15 presents the erosion risk rating based on average monthly rainfall using the rating system provided in the IECA (2008) for Daly Waters Aerodrome (located approximately 55 km to the west of Amungee delineation area). Construction activities for exploration well sites is planned for completion prior to the wet season, to minimise the risk of erosion resulting from rainfall impacts.

**Table 15 Erosion Risk Rating based on average monthly rainfall at Daly Waters Aerodrome**

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	163.2	182.7	107.5	20.7	6.4	2.8	1.7	0.3	1.9	21.8	49.4	118.1
Erosion Risk	H	H	H	VL	VL	VL	VL	VL	VL	VL	M	H

H = High (100+ to 225 mm); M = Moderate (45+ to 100 mm); L = Low (30+ to 45 mm); VL = Very Low (0 to 30 mm) Data sourced from Bureau of Meteorology, Climate Averages for Station 014626 Daly Waters Aerodrome recorded from 1939-2022.

### 3.7 Bushfire

Fire is a natural occurrence in most Australian ecosystems and plays an important ecological role. Fire is generally excluded from Mitchell grasslands by pastoral management in order to maintain forage throughout the dry season (HLA, 2005). Fire is more frequent in the Eucalypt and Acacia woodlands situated within the Sturt Plateau bioregion.

Historically most high intensity fires within EP98 occur during the dry season fires (June to September). (HLA, 2005). Wet season fires (October to May) have occurred within the permit area. These fires are likely to be patchy and of lower intensity, depending on the state of curing of the fuel load.

Fire sensitive Bullwaddy and Lancewood communities are located throughout the permit area. The impacts of hot fires can impact flora and fauna species and reduce habitat quality. Research suggests that hot fires may impact fauna diversity and in particular diurnal reptiles (e.g. Legge *et al.*, 2008).

Land condition assessments undertaken at Amungee NW 2022 recorded low intensity fire events occurring at all assessed sites in the previous 2-3 years, with minor scars on some trees and shrubs.

Fire data was acquired from the NAFI site and queried for the Amungee delineation area. Ten-year fire data (2012 to 2021) shows increased fire frequency, occurring between one and four years on the western side of the project area, situated on the Shenadoah East PPL.

Fire frequency reduced to between one and three years on the eastern side of the project area, situated on the Amungee Mungee PPL. Fire frequency was highest in areas of woodland and less frequent in areas of dense Lancewood and Bullwaddy shrubland. Figure 18 shows the fire frequency within the exploration areas over the past 10 years (2012 to 2021).

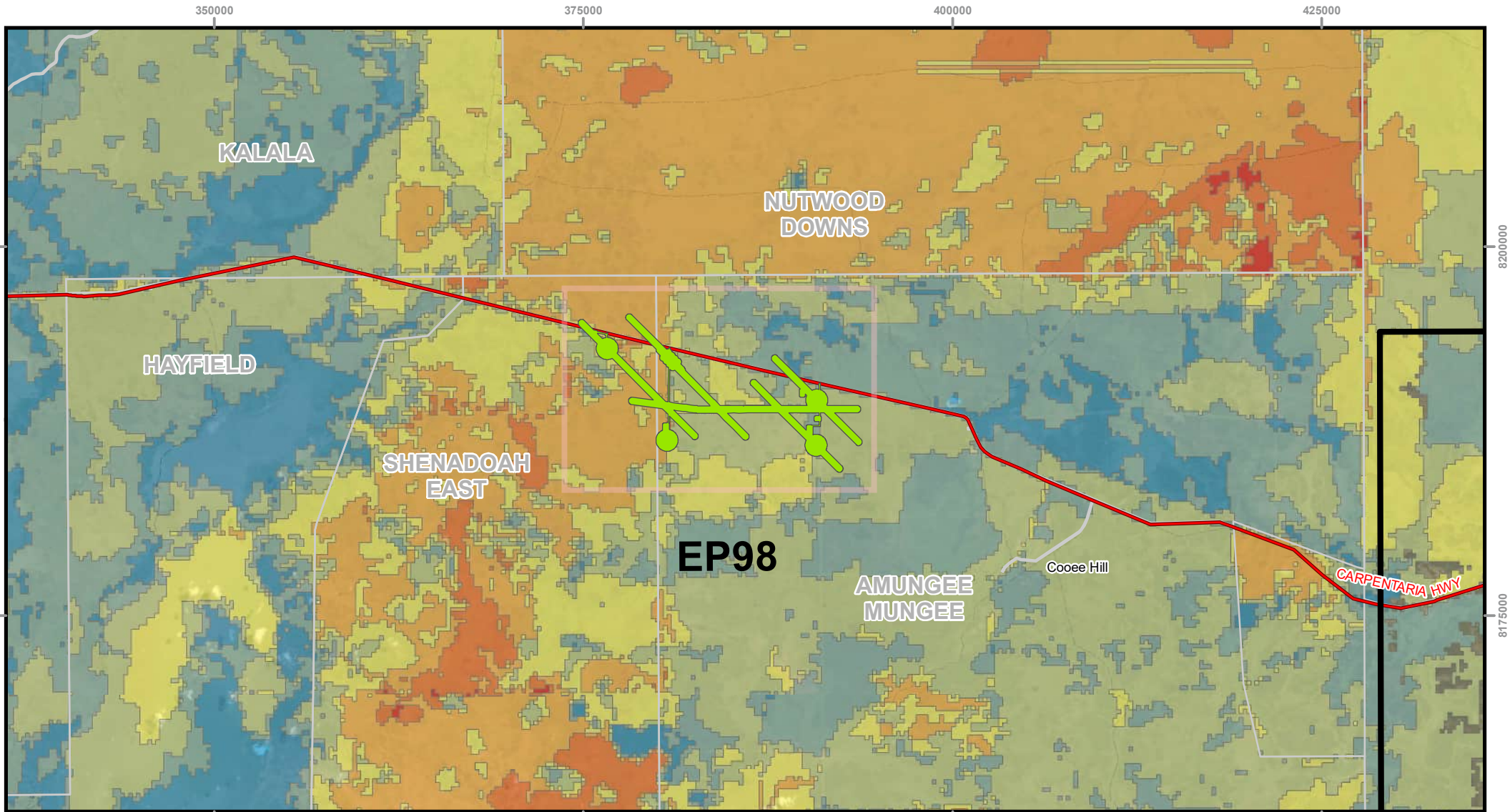
### 3.8 Land use and sensitive receptors

Approximate separation distances from the Amungee delineation area to the nearest environmental and community receptors is summarised in Table 16 and illustrated in Figure 19.

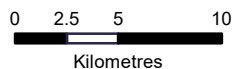
Table 16 Sensitive Receptors

Receptor	Amungee NW (existing)	Amungee NW 2	Amungee NW 3	Amungee NW 4	Amungee NW 5
<b>Closest pastoralist bore</b>	4 km	4 km	1.2 km	1.1 km	7.5 km
<b>Nearest homestead</b>	27 km	19 km	30 km	16 km	25 km
<b>Nearest community</b>	56 km (Daly Waters)	64 km (Daly Waters)	50 km (Daly Waters)	65 km (Daly Waters)	57 km (Daly Waters)
<b>Stuart Highway</b>	56 km	63 km	50 km	64 km	56 km
<b>Carpentaria Highway</b>	1 km	1 km	1 km	3.5 km	5.6 km
<b>Bullwaddy Conservation Reserve</b>	40 km	31 km	44 km	30 km	47 km
<b>Lake Woods</b>	161 km	154 km	154 km	153 km	150 km
<b>Nearest mapped major watercourse</b>	20 km	20 km	15 km	16.5 km	18 km
<b>Sacred site</b>	19 km	9.5 km	14.5 km	9.5 km	15 km

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GEOCENTRIC DATUM OF AUSTRALIA 94



- Highway
- Amungee NW 2D
- Seismic Exploration Area
- Permit Area
- Pastoral Lease Boundary
- Amungee Delineation Area

**Annual Fire Frequency**

- 0
- 1
- 2
- 3
- 4
- 5
- 6

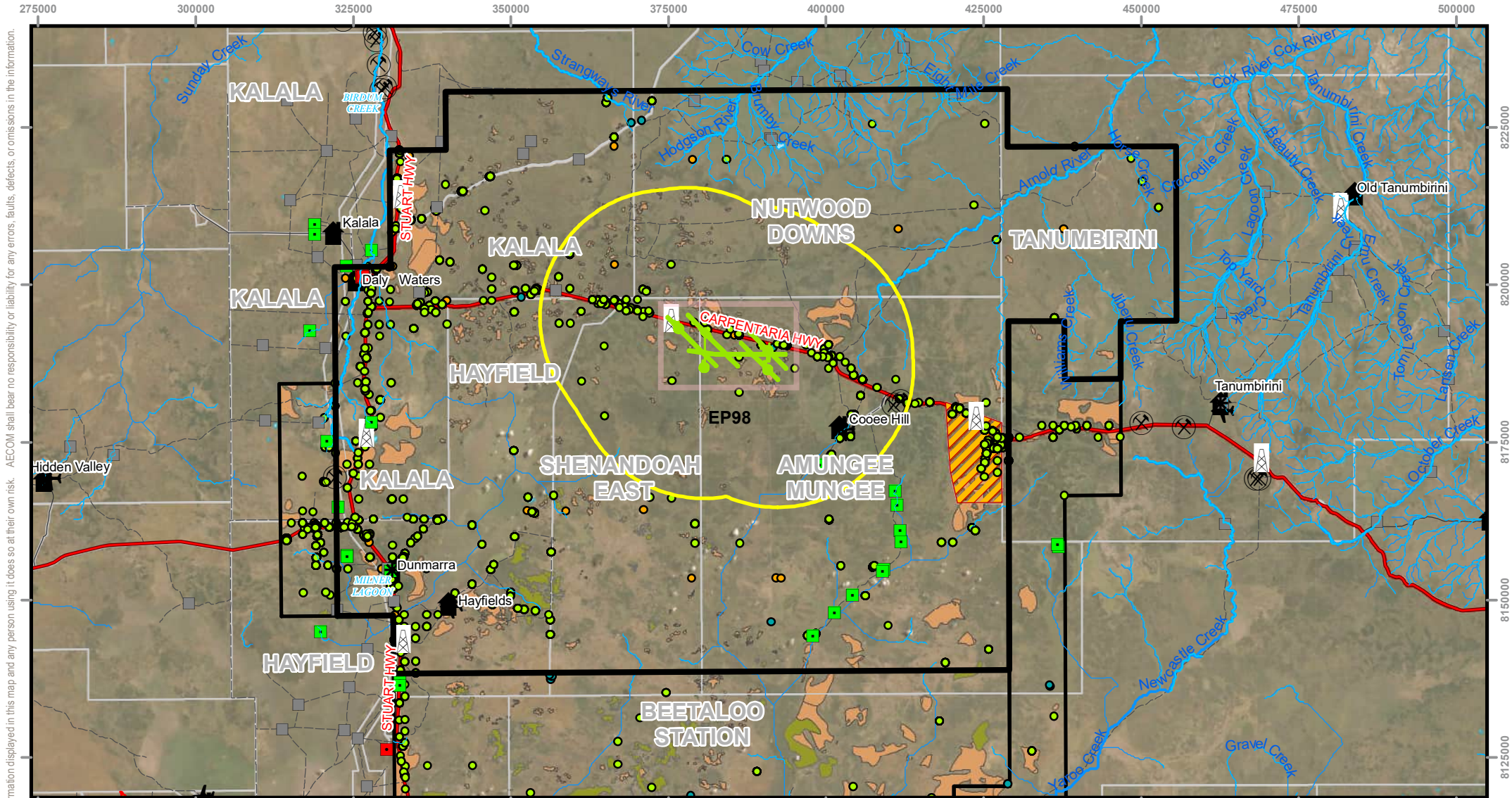
**ORIGIN ENERGY RESOURCES LIMITED**

**Amungee Delineation Area  
2D Seismic Exploration Permit Area  
Annual Fire Frequency  
10 Year 2012 - 2021**

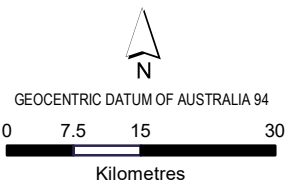
PROJECT ID 60623736  
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 VERSION 1

**Figure  
18**

Data sources:  
 Permit Area, Cadastre - NT Gov 2022.  
 Places, Vegetation - Aust Gov 2022  
 Highways, Roads, Drainage - StreetPro 2022



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- Homestead
- Place Name
- Populated Place
- Populated Place
- Highway
- Tower
- Mine
- Yard
- Archaeological Sites
- Threatened Flora
- Threatened Fauna
- Drainage**
- Major
- Minor
- 20km 2D Seismic Area Buffer
- Amungee NW 2D Seismic Exploration Area
- Permit Area
- Pastoral Lease Boundary
- Bullwaddy Conservation Reserve
- Aboriginal Communities
- Historic Heritage Sites
- Amungee Delineation Area

- VEGETATION OF INTEREST**
- Macropteranthes (mixed) low woodland/Chrysopogon (mixed) open tussock grassland
  - Macropteranthes low woodland/Panicum low open tussock grassland
  - Macropteranthes tall shrubland/Acacia sparse shrubland/Aristida (mixed) low open tussock grassland

**ORIGIN ENERGY RESOURCES LIMITED**

**Amungee Delineation Area  
2D Seismic Exploration Permit Area  
Sensitive Receivers and Features  
of Interest**

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Figure  
**19**

## 4.0 Natural Environment

### 4.1 Bioregions

The Interim Biogeographic Regionalisation of Australia (IBRA) classifies the Amungee delineation area as occurring within the Sturt Plateau Bioregion. The Sturt Plateau Bioregion comprises undulating plains on sandstone, with predominantly neutral sandy red and yellow earth soils. Dominant vegetation is eucalypt woodland (dominated by variable-barked bloodwood *Eucalyptus dichromophloia*) with spinifex understorey, as well as extensive areas of Lancewood (*Acacia shirleyi*) - Bullwaddy (*Macropteranthes kekwickii*) vegetation association and associated fauna, including the Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*). Land condition in the bioregion is moderate to good but is threatened by impacts from weeds, feral animals, pastoralism and changed fire regimes (Baker *et al*, 2005).


### 4.2 Vegetation Communities




The field assessment undertaken in September 2021 and May 2022 confirmed that the main vegetation communities identified within the Amungee delineation area scouting areas are woodlands, typically dominated by bloodwoods (*Corymbia* spp.) and Eucalypt and patches of tall shrubland / woodland of Lancewood (*Acacia shirleyi*) and Bullwaddy (*Macropteranthes kekwickii*) with open grassland understorey.

Vegetation communities surrounding the Amungee delineation area include *Corymbia* spp. open woodland and a mixed community supporting patches of Lancewood and Bullwaddy open forest surrounded by *Corymbia* spp. open woodland. Dominant species within the open woodland include *C. dichromophloia*, *Erythrophleum chlorostachys* and *C. chlorophylla* and in the upper strata, over *Petalostigma pubescens*, *Terminalia canescens* and *Hakea arborescens* dominant in the mid strata. The tussock grassland understorey supports grasses such as *Chrysopogon fallax*, *Sorghum plumosum* and *Schizachyrium fragile*.

During the survey, six vegetation communities were identified from 41 vegetation sites recorded within the project area. Vegetation communities are shown below in Table 17 and a map of vegetation community boundaries within the project area is shown in Figure 20. The area of each vegetation community and corresponding land types within the Amungee delineation area is provided in Table 18 and Table 19. Detailed vegetation community description are provided in (Appendix B).

**Table 17 Vegetation Community Descriptions**

Vegetation Community	Description	Survey Sites	Photo Reference
<i>Acacia shirleyi</i> , <i>Corymbia polycarpa</i> mid high woodland	<i>Acacia shirleyi</i> ± <i>Corymbia polycarpa</i> mid high woodland, over <i>Macropteranthes kekwickii</i> , <i>Terminalia volucris</i> , <i>Santalum lanceolatum</i> mid high shrubland, over <i>Scleria brownii</i> , <i>Chrysopogon fallax</i> , <i>Schizachyrium fragile</i> mid high tussock grassland.	<b>No of sites:</b> (10) VC6, VC7, VC24, VS9, VS10, VS14, VS17, VS19, VS23, VS26	 <p>Plate 1 <i>Corymbia dichromophloia</i> open woodland</p>

Vegetation Community	Description	Survey Sites	Photo Reference
<i>Corymbia dichromophloia</i> , <i>Erythrophleum chlorostachys</i> , <i>Eucalyptus chlorophylla</i> mid high open woodland	<i>Corymbia dichromophloia</i> , ± <i>Erythrophleum chlorostachys</i> , ± <i>Eucalyptus chlorophylla</i> mid high open woodland, over <i>Terminalia canescens</i> , <i>Petalostigma pubescens</i> , <i>Erythrophleum chlorostachys</i> mid high open shrubland, over <i>Chrysopogon fallax</i> , ± <i>Sorghum plumosum</i> , <i>Themeda triandra</i> mid high open tussock grassland	<b>No of sites:</b> (21) VC5, VC8, VC18, VC21, VC25, VC26, VC42, AMS1-1, Amungee NW-2 & Gravel Pit, Amungee NW-3, & Gravel Pit, Amungee NW-4, Amungee NW-5, AMS5, VS8, VS11, VS20, VS21, VS24	 <p><b>Plate 2</b> <i>Eucalyptus chlorophylla</i> and <i>Corymbia polycarpa</i> open woodland</p>
<i>Eucalyptus chlorophylla</i> , <i>Corymbia polycarpa</i> , and <i>Corymbia dichromophloia</i> mid high open woodland	<i>Eucalyptus chlorophylla</i> , <i>Corymbia polycarpa</i> , ± <i>Corymbia dichromophloia</i> mid high open woodland, over <i>Eucalyptus chlorophylla</i> , ± <i>Corymbia ferruginea</i> , ± <i>Terminalia canescens</i> , mid high open shrubland, over <i>Chrysopogon fallax</i> mid high open tussock grassland	<b>No of sites:</b> (6) VC19, VC20, VC22, VC23, VS18, VS22	 <p><b>Plate 3</b> <i>Erythrophleum chlorostachys</i> open woodland</p>
<i>Eucalyptus microtheca</i> low open woodland	<i>Eucalyptus microtheca</i> low open woodland, over <i>Terminalia volucris</i> , <i>Ehretia saligna</i> , mid high sparse shrubland, over <i>Aristida inaequiglumis</i> , <i>Eulalia aurea</i> mid high tussock grassland	<b>No of sites:</b> (1) VS12	 <p><b>Plate 4</b> <i>Acacia shirleyi</i>, <i>Corymbia dichromophloia</i> and <i>Erythrophleum chlorostachys</i> open woodland</p>



Vegetation Community	Description	Survey Sites	Photo Reference
<i>Eucalyptus microtheca</i> and <i>Macropteranthes kekwickii</i> low woodland	<i>Eucalyptus microtheca</i> , <i>Macropteranthes kekwickii</i> low woodland, over <i>Macropteranthes kekwickii</i> , <i>Eucalyptus microtheca</i> , <i>Brachychiton diversifolius</i> mid high open shrubland, over <i>Chrysopogon fallax</i> , <i>Sorghum plumosum</i> mid high open tussock grassland	<b>No of sites:</b> (2) VS13, VS15	 <p><b>Plate 5</b> <i>Terminalia canescens</i> and <i>Grevillea parallela</i> low woodland</p>
<i>Lophostemon grandiflorus</i> and <i>Macropteranthes kekwickii</i> low woodland	<i>Lophostemon grandiflorus</i> , <i>Macropteranthes kekwickii</i> low woodland, over <i>Acacia difficilis</i> , <i>Grewia retusifolia</i> mid high open shrubland, over <i>Chrysopogon fallax</i> , <i>Eulalia aurea</i> , <i>Themeda triandra</i> mid high open tussock grassland	<b>No of sites:</b> (1) VS16	 <p><b>Plate 6</b> <i>Acacia shirleyi</i> and <i>Macropteranthes kekwickii</i> woodland</p>

Table 18 Ground-truthed vegetation communities mapped within Amungee delineation area

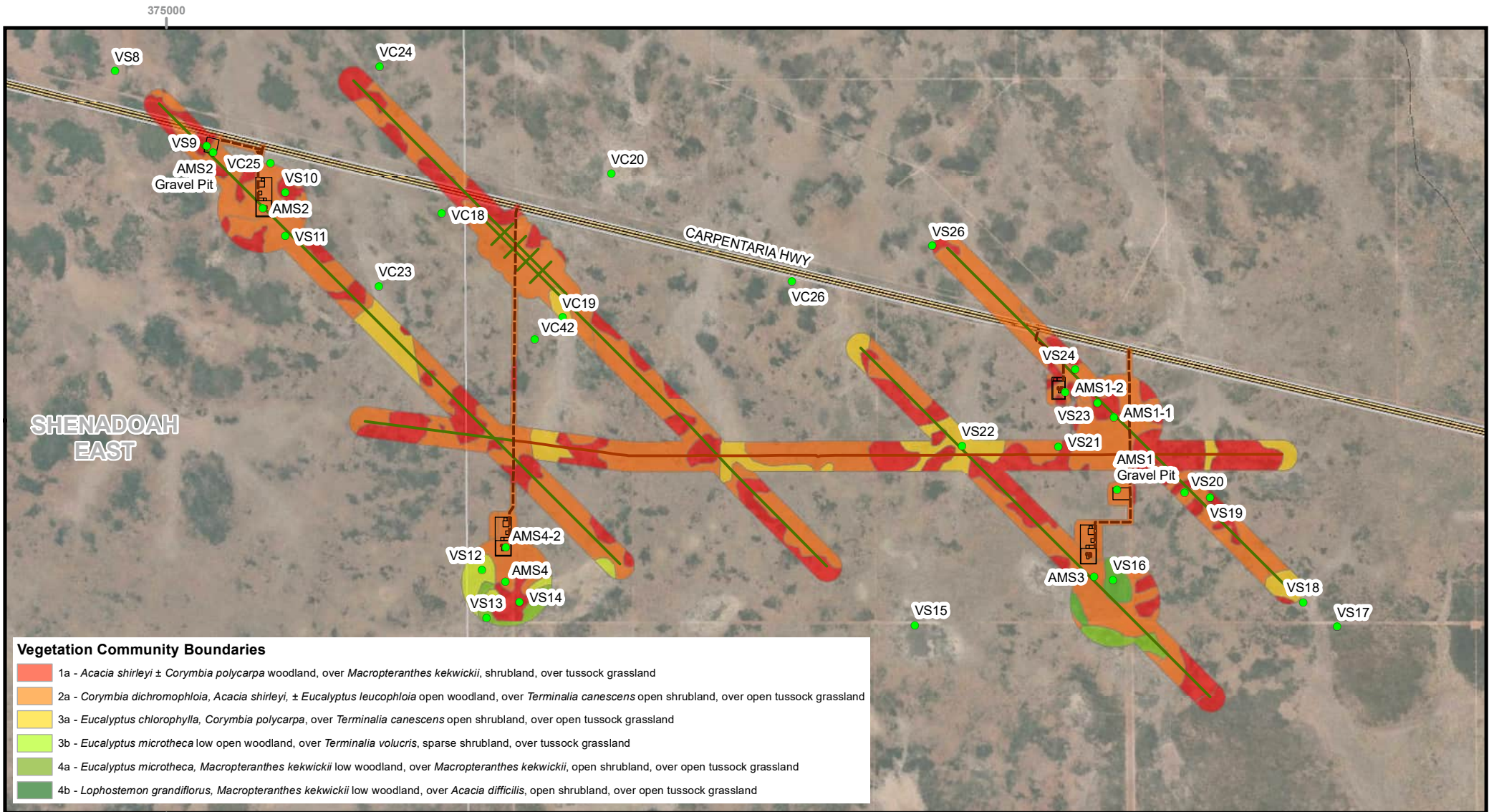
Vegetation Community	Area (ha) and % of Amungee delineation area
1a <i>Acacia shirleyi</i> ± <i>Corymbia polycarpa</i> mid high woodland, over <i>Macropteranthes kekwickii</i> , <i>Terminalia volucris</i> , <i>Santalum lanceolatum</i> mid high shrubland, over <i>Scleria brownii</i> , <i>Chrysopogon fallax</i> , <i>Schizachyrium fragile</i> mid high tussock grassland.	1,008.80 ha (30.7%)
2a <i>Corymbia dichromophloia</i> , ± <i>Erythrophleum chlorostachys</i> , ± <i>Eucalyptus chlorophylla</i> mid high open woodland, over <i>Terminalia canescens</i> , <i>Petalostigma pubescens</i> , <i>Erythrophleum chlorostachys</i> mid high open shrubland, over <i>Chrysopogon fallax</i> , ± <i>Sorghum plumosum</i> , <i>Themeda triandra</i> mid high open tussock grassland.	1,854.92 ha (56.4%)
3a <i>Eucalyptus chlorophylla</i> , <i>Corymbia polycarpa</i> , ± <i>Corymbia dichromophloia</i> mid high open woodland, over <i>Eucalyptus chlorophylla</i> , ± <i>Corymbia ferruginea</i> , ± <i>Terminalia canescens</i> , mid high open shrubland, over <i>Chrysopogon fallax</i> mid high open tussock grassland.	270.02 ha (8.2%)
3b <i>Eucalyptus microtheca</i> low open woodland, over <i>Terminalia volucris</i> , <i>Ehretia saligna</i> , mid high sparse shrubland, over <i>Aristida inaequiglumis</i> , <i>Eulalia aurea</i> mid high tussock grassland.	53.60 (1.6%)

Vegetation Community		Area (ha) and % of Amungee delineation area
4a	<i>Eucalyptus microtheca</i> , <i>Macropteranthes kekwickii</i> low woodland, over <i>Macropteranthes kekwickii</i> , <i>Eucalyptus microtheca</i> , <i>Brachychiton diversifolius</i> mid high open shrubland, over <i>Chrysopogon fallax</i> , <i>Sorghum plumosum</i> mid high open tussock grassland.	64.80 ha (2.0%)
4b	<i>Lophostemon grandiflorus</i> , <i>Macropteranthes kekwickii</i> low woodland, over <i>Acacia difficilis</i> , <i>Grewia retusifolia</i> mid high open shrubland, over <i>Chrysopogon fallax</i> , <i>Eulalia aurea</i> , <i>Themeda triandra</i> mid high open tussock grassland.	36.30 ha (1.1%)

Table 19 Land type within Amungee delineation area

Land Type Description			Area (ha) and % of Amungee delineation area
<b>Plains</b>			
1a/2a	Lateritic Plains and Rises	Associated with deeply weathered profiles (laterite) including sand sheets and other depositional products, sandy and earth soils.	2,863.7 ha (87.0%)
<b>Drainage</b>			
3a/3b	Clay Drainage Floors, Relic Drainages	Associated with clay and alluvial soils.	324.0 ha (9.9%)
4a/4b	Closed Drainage Depression	Associated with clay and alluvial soils.	101.1 ha (3.1%)

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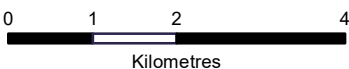


**Vegetation Community Boundaries**

- 1a - *Acacia shirleyi* ± *Corymbia polycarpa* woodland, over *Macropteranthes kekwickii*, shrubland, over tussock grassland
- 2a - *Corymbia dichromophloia*, *Acacia shirleyi*, ± *Eucalyptus leucophloia* open woodland, over *Terminalia canescens* open shrubland, over open tussock grassland
- 3a - *Eucalyptus chlorophylla*, *Corymbia polycarpa*, over *Terminalia canescens* open shrubland, over open tussock grassland
- 3b - *Eucalyptus microtheca* low open woodland, over *Terminalia volucris*, sparse shrubland, over tussock grassland
- 4a - *Eucalyptus microtheca*, *Macropteranthes kekwickii* low woodland, over *Macropteranthes kekwickii*, open shrubland, over open tussock grassland
- 4b - *Lophostemon grandiflorus*, *Macropteranthes kekwickii* low woodland, over *Acacia difficilis*, open shrubland, over open tussock grassland



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- Vegetation Survey Sites
- Highway
- Proposed Access Tracks
- Fenceline
- Uncleared
- Exploration Well Lease Pads
- Pastoral Lease Boundary

Data sources:  
 Permit Area, Cadastre - NT Gov 2022  
 Places, Vegetation - Aust Gov 2022  
 Highways, Roads, Drainage - StreetPro 2022

**ORIGIN ENERGY RESOURCES LIMITED**

**Amungee Delineation Area  
 2D Seismic Exploration Survey Area  
 Vegetation Community Boundaries**

PROJECT ID 60623736  
 CREATED BY david.vandenhoeck  
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Figure  
**20**

### 4.3 Flora

A search of the DCCEEW Protected Matters database of nationally significant fauna (PMST) and the NT Government flora atlas database was undertaken for the exploration area, with a 10 km buffer applied. No threatened vegetation communities are listed as likely to occur within the Amungee delineation area.

Field surveys undertaken in May 2022 recorded a total of 73 flora species within the Amungee delineation area scouting sites (Table 20). The survey focused on recording dominant species to describe vegetation communities rather than undertake a comprehensive floristic assessment.

**Table 20 Flora Species Recorded during the 2022 field survey**

Family	Genus	Species
APOCYNACEAE	<i>Carissa</i>	<i>lanceolata</i>
ASPARAGACEAE	<i>Lomandra</i>	<i>tropica</i>
BORAGINACEAE	<i>Ehretia</i>	<i>saligna</i>
CELASTRACEAE	<i>Denhamia</i>	<i>cunninghamii</i>
COMBRETACEAE	<i>Macropteranthes</i>	<i>kekwickii</i>
	<i>Terminalia</i>	<i>canescens</i>
	<i>Terminalia</i>	<i>carpentariae</i>
	<i>Terminalia</i>	<i>volucris</i>
CYPERACEAE	<i>Cyperus</i>	<i>haspan</i>
	<i>Fimbristylis</i>	sp.
	<i>Schoenus</i>	<i>punctatus</i>
	<i>Schoenus</i>	<i>sparteus</i>
	<i>Scleria</i>	<i>brownii</i>
DILLENIACEAE	<i>Dillenia</i>	<i>alata</i>
	<i>Hibbertia</i>	<i>oblongata</i>
ERIOCAULACEAE	<i>Eriocaulon</i>	sp.
ERYTHROXYLACEAE	<i>Erythroxylum</i>	<i>ellipticum</i>
FABACEA	<i>Acacia</i>	<i>calligera</i>
	<i>Acacia</i>	<i>difficilis</i>
	<i>Acacia</i>	<i>shirleyi</i>
	<i>Acacia</i>	<i>latescens</i>
	<i>Acacia</i>	<i>leptocarpa</i>
	<i>Acacia</i>	<i>multisiliqua</i>
	<i>Bauhinia</i>	<i>cunninghamii</i>
	<i>Erythrophleum</i>	<i>chlorostachys</i>
	<i>Glycine</i>	<i>tomentella</i>
	<i>Gompholobium</i>	<i>subulatum</i>
LAMIACEAE	<i>Mesosphaerum</i>	<i>suaveolens*</i>
MALVACEAE	<i>Brachychiton</i>	<i>diversifolius</i>
	<i>Brachychiton</i>	<i>paradoxus</i>

Family	Genus	Species
	<i>Grewia</i>	<i>retusifolia</i>
	<i>Helicteres</i>	<i>cana</i>
	<i>Sida</i>	<i>acuta</i> *
	<i>Waltheria</i>	<i>indica</i>
MYRTACEAE	<i>Calytrix</i>	<i>exstipulata</i>
	<i>Corymbia</i>	<i>confertiflora</i>
	<i>Corymbia</i>	<i>dichromophloia</i>
	<i>Corymbia</i>	<i>ferruginea</i>
	<i>Corymbia</i>	<i>polycarpa</i>
	<i>Corymbia</i>	<i>setosa</i>
	<i>Eucalyptus</i>	<i>chlorophylla</i>
	<i>Eucalyptus</i>	<i>microtheca</i>
	<i>Lophostemon</i>	<i>grandiflorus</i>
	<i>Melaleuca</i>	<i>cajuputi</i>
	<i>Melaleuca</i>	<i>viridiflora</i>
	<i>Petalostigma</i>	<i>pubescens</i>
OLEACEAE	<i>Jasminum</i>	<i>molle</i>
PHYLLANTHACEAE	<i>Flueggea</i>	<i>virosa</i>
POACEAE	<i>Aristida</i>	<i>calycina</i>
	<i>Aristida</i>	<i>contorta</i>
	<i>Aristida</i>	<i>holathera</i>
	<i>Aristida</i>	<i>inaequiglumis</i>
	<i>Aristida</i>	<i>latifolia</i>
	<i>Chrysopogon</i>	<i>fallax</i>
	<i>Eriachne</i>	<i>ciliata</i>
	<i>Eriachne</i>	<i>stipacea</i>
	<i>Eriachne</i>	<i>triseta</i>
	<i>Eulalia</i>	<i>aurea</i>
	<i>Germainia</i>	<i>grandiflora</i>
	<i>Heteropogon</i>	<i>contortus</i>
	<i>Sehima</i>	<i>nervosum</i>
	<i>Sorghum</i>	<i>plumosum</i>
	<i>Schizachyrium</i>	<i>fragile</i>
	<i>Themeda</i>	<i>triandra</i>
<i>Triodia</i>	<i>bitextura</i>	
PROTEACEAE	<i>Grevillea</i>	<i>parallela</i>
	<i>Grevillea</i>	<i>pungens</i>

Family	Genus	Species
	<i>Hakea</i>	<i>arborescens</i>
RESTIONACEAE	<i>Dapsilanthus</i>	<i>elator</i>
RHAMNACEAE	<i>Alphitonia</i>	<i>excelsa</i>
	<i>Alphitonia</i>	<i>oblata</i>
RUBIACEAE	<i>Spermacoce</i>	sp.
SANTALACEAE	<i>Santalum</i>	<i>lanceolatum</i>

\* Declared weed species

#### 4.4 Weeds

Previous surveys within the Origin Permit Areas have recorded a low number and density of weed species, indicating that land condition is generally good. Three declared weed species, *Calotropis procera* (Rubber bush), *Parkinsonia aculeata* (Parkinsonia) and *Mesosphaerum suaveolens* (Hyptis), have been recorded during surveys.

Table 21 provides a list of weed species that are known to occur or likely to occur within Amungee delineation area based on a desktop review of the following sources:

- Mapping data provided by the Weed Management Branch, DEPWS.
- Guidelines for the Management of the Weeds of Beetaloo 2018 (DLRM & CDU, 2018).
- Department of Climate Change, Energy, the Environment and Water (DCCEEW) EPBC Act Protected Matters Report database.
- Previous data collected by AECOM in the permit area.

Table 21 NT Listed Weeds known or likely to occur within Amungee delineation area

Scientific Name	Common Name	Status
<i>Alternanthera pungens</i>	Khaki Weed	Class B and C
<i>Andropogon gayanus</i>	Gamba Grass	Class A and C, WoNS
<i>Azadirachta indica</i>	Neem	Class B and C
<i>Calotropis procera</i>	Rubber Bush	Class B and C (south of 16°30' S latitude)
<i>Cenchrus ciliaris</i>	Buffel Grass	Not declared in NT
<i>Cenchrus echinatus</i>	Mossman River Grass	Class B and C
<i>Datura ferox</i>	Fierce Thornapple	Class A and C
<i>Mesosphaerum suaveolens</i>	Hyptis	Class B and C
<i>Jatropha gossypifolia</i>	Bellyache Bush	Class B and C, WoNS
<i>Parkinsonia aculeata</i>	Parkinsonia	Class B and C, WoNS
<i>Sida acuta</i>	Spinyhead Sida	Class B and C
<i>Sida cordifolia</i>	Flannel Weed	Class B and C
<i>Sida rhombifolia</i>	Paddy's Lucerne	Class B and C
<i>Tamarix aphylla</i>	Athel Pine	Class B and C, WoNS

Scientific Name	Common Name	Status
<i>Themeda quadrivalvis</i>	Grader Grass	Class B and C, WoNS
<i>Tribulus terrestris</i>	Caltrop	Class B and C
<i>Vachellia nilotica</i>	Prickly Acacia	Class A and C, WoNS

Note: Declarations under the Northern Territory Weeds *Management Act 2013*:

- a Class A weed is to be eradicated
- a Class B weed is to have its growth and spread controlled
- a Class C weed is not to be introduced to the NT.

\* All Class A and B weeds are also Class C.

In addition to the species listed in Table 21, a range of grassy weeds are known to occur along road corridors throughout the region. This includes Buffel Grass which was originally introduced for livestock feed and soil stabilisation but has subsequently shown to alter fire regimes and impact biodiversity.

The *Barkly Regional Weed Management Plan* (DLRM, 2015) provides additional information on regional weed management priorities and management actions to support landholders in their obligations to manage weeds on their land. The plan includes a list of 'alert' weed species that are not yet naturalised in the region but have the potential to have a high level of impact to the region should they become established. These alert species are listed in Table 22. If located, the program EMP requires the Weed Management Branch to be contacted for identification and disposal.

**Table 22 Alert Species identified in the Barkly Region (DLRM, 2015)**

Scientific Name	Common Name	Declaration
<i>Cenchrus setaceum</i>	Fountain grass	Class B and C
<i>Parthenium hysterophorus</i>	Parthenium	Class A and C, WoNS
<i>Cryptostegia grandiflora</i>	Rubber vine	Class A and C, WoNS

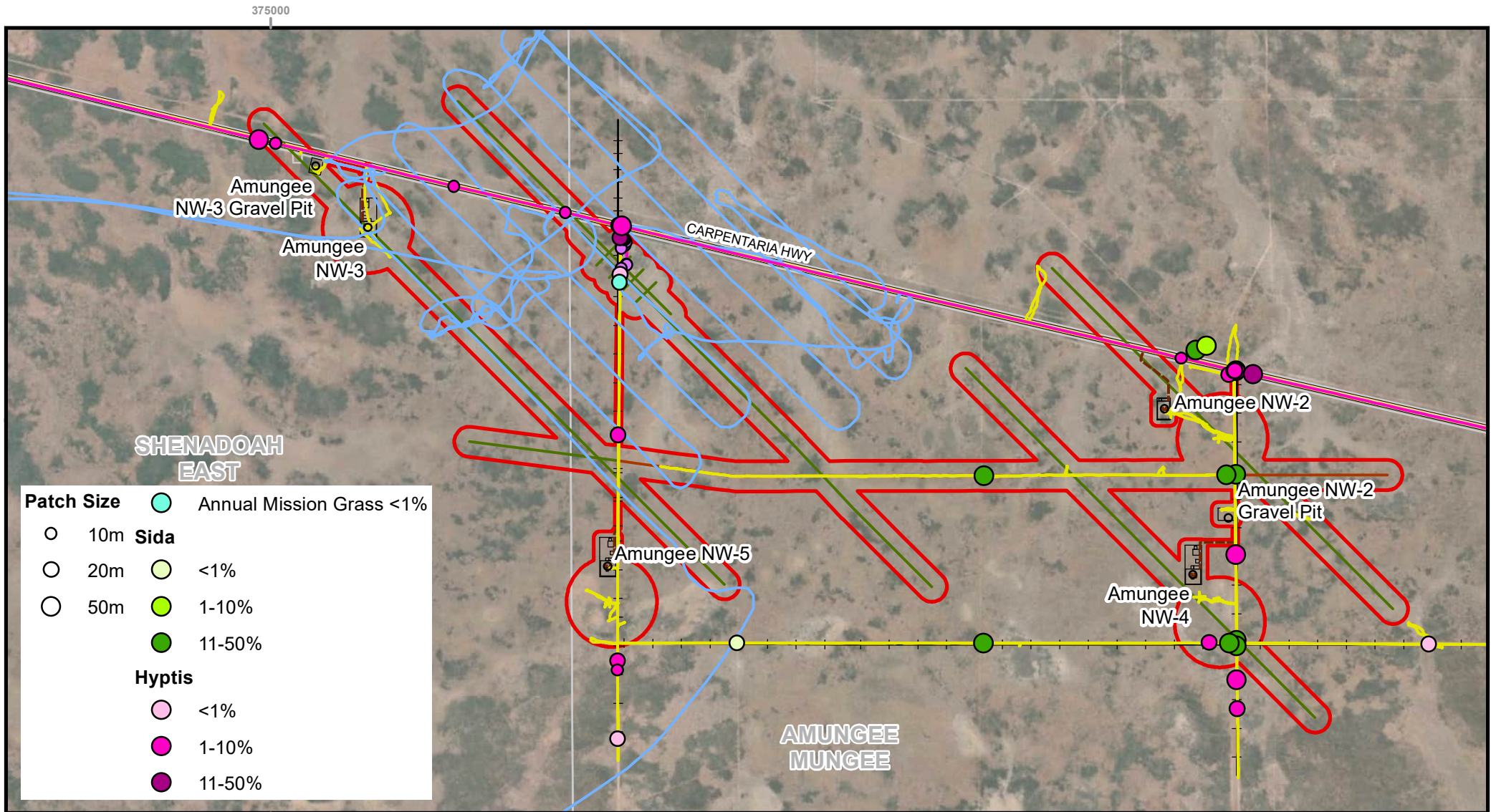
A weed survey was undertaken within the Amungee delineation area for the 2D seismic exploration area during the May 2022 field survey. Survey areas included the edge of tracks, disturbance areas and along the Carpentaria Highway. The following weeds were recorded during the May 2022 field survey:

- Hyptis (*Mesosphaerum suaveolens*)
- Sida (*Sida acuta*)
- Annual Mission grass (*Cenchrus pedicellatus*) - Environmental weed of concern

The class B weed Hyptis was observed along the Carpentaria Highway and along fence line tracks. Sida was observed predominantly in areas heavily disturbed by cattle, such as where drinking troughs were located. A single occurrence of Annual Mission grass was recorded on the proposed access track to Amungee NW-5.

A map showing the location, size and density of weed patches located within the Amungee NW 2D seismic exploration lease area is shown in Figure 21.

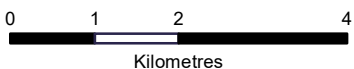
AECOM does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. AECOM shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.



Patch Size	Species	Percentage
10m	Sida	Annual Mission Grass <1%
20m		<1%
50m		1-10%
		11-50%
Hyptis		
		<1%
		1-10%
		11-50%



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Highway	Fence Lines and Tracks
October 2020 Ground Survey Tracks	Uncleared
Nov 2021 Helicopter Survey Track	Amungee NW 2D Seismic Exploration Survey Area
May 2022 Ground Survey Tracks	Exploration Well Lease Pads
Proposed Access Tracks	Pastoral Lease Boundary
Fence Lines and Tracks	

Data sources:  
 Permit Area, Cadastre - NT Gov 2022  
 Places, Vegetation - Aust Gov 2022  
 Highways, Roads, Drainage - StreetPro 2022

**ORIGIN ENERGY RESOURCES LIMITED**

**Amungee Delineation Area  
 2D Seismic Exploration Survey Area  
 Weed Surveys 2020 - 2022**

PROJECT ID 60623736  
 CREATED BY david.vandenhoeck  
 LAST MODIFIED 08-Jul-2022  
 VERSION 1

Figure  
**21**

## 4.5 Fauna and Habitat

A search of the Department of Environment, Parks and Water Security (DEPWS) Natural Resource Maps database reveals that a total of 88 fauna species have been recorded within 5 km of the Amungee delineation area comprising 76 species of bird, eight reptiles and four mammals.

A full list of recorded species is provided – Appendix C, Table 35 (Flora Atlas records) and Appendix D, Table 36 (Fauna Atlas records).

The Amungee delineation area primarily comprises open woodland consisting of mixed *Eucalyptus/Corymbia* species with a mixed tussock grass understorey. Often, scattered stands of Bullwaddy/Lancewood communities occur across the proposed sites and individuals of both species are dispersed throughout. In the wider landscape, including proposed access tracks, additional vegetation types include those associated with drainage lines, grasslands/floodplains and *Acacia sp.* shrublands.

*Eucalyptus/Corymbia sp.* woodland provides habitat for a range of species. The proposed sites had high native grass cover and included numerous species suitable for granivorous birds (seed eaters). Dense leaf litter and numerous logs provide suitable refuge and foraging sites for fauna such as reptiles. Although most of the species found in this vegetation type are widespread in the tropical savannas of the Northern Territory, some such as the threatened Crested Shrike-tit (*Falcunculus frontatus whitei*) are rare and known to utilise this habitat (Ward, 2008). Many of the sites have a high density of hollow-bearing trees that provide important habitat for many fauna species. Avoiding clearing large hollow-bearing trees will reduce the impact to native wildlife within the permit area.

Incidental fauna sightings were recorded within the exploration lease pad scouting during the May 2022 field survey. A total of 15 birds and one reptile were recorded during the field survey (Table 23).

**Table 23 Incidental fauna observations**

Scientific Name	Common name	Survey Site/s Identification
<b>Birds</b>		
<i>Aegotheles cristatus</i>	Owlet Nightjar	AMS4 (Amungee NW 5)
<i>Artamus superciliosus</i>	White-browed Woodswallow	VS19
<i>Colluricincla harmonica</i>	Grey Shrike-thrush	AMS3 (Amungee NW 4)
<i>Corvus orru</i>	Torresian Crow	AMS1 GP (Amungee NW 2 Gravel Pit)
<i>Cracticus nigrogularis</i>	Pied Butcherbird	VS8
<i>Falco berigora</i>	Brown falcon	AMS 2 GP (Amungee NW 3 gravel Pit)
<i>Gavicalis virescens</i>	Singing Honeyeater	VS14, VS18, VS19
<i>Haliastur sphenurus</i>	Whistling Kite	VS17
<i>Malurus melanocephalus</i>	Red-backed Fairy-wren	VS16
<i>Melanodryas cucullata</i>	Hooded Robin	VS20
<i>Pachycephala rufiventris</i>	Rufous Whistler	AMS2 (Amungee NW 3)
<i>Pardalotus striatus</i>	Striated Pardalote	VS8, VS18, VS20
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler	VS20
<i>Rhipidura leucophrys</i>	Willie Wagtail	VS20
<i>Smicromnis brevirostris</i>	Weebill	VS13
<b>Reptiles</b>		
<i>Aspidites melanocephalus</i>	Black-headed Python	AMS4 (Amungee NW 5)

#### 4.5.1 Threatened Fauna

A search of the DCCEEW Protected Matters database of nationally significant fauna (PMST) and records from the NT Government Fauna Atlas database (NR Maps) was undertaken at 10 km and 50 km of the proposed lease areas and access tracks. The search results indicate the potential presence of 15 fauna species listed as threatened under the EPBC Act and/or the TPWC Act. These included eight birds, five mammals and two reptiles.

The likelihood of occurrence assessment is based on the availability of suitable habitat within the permit area, records in the vicinity and distributional data. Therefore, many of the threatened and migratory fauna species indicated in databases as 'occurring' or 'likely to occur' have been assessed as unlikely to occur within the project area. As some areas in the proposed lease area have not been subject to intensive survey and some species are very cryptic, a conservative approach has been taken to assess species presence. A full description of each species, their distribution and habitat associations are outlined in Table 24 below.

No core habitat for threatened fauna was identified at the sites. However, some species may occur and are known to occur in the wider landscape. Threatened species that potentially occur include:

- Gouldian Finch *Erythrura gouldiae* (Endangered EPBC Act, Vulnerable TPWC Act)
- Grey Falcon *Falco hypoleucos* (Vulnerable EPBC Act and TPWC Act)
- Crested Shrike-tit (northern) *Falcunculus frontatus whitei* (Vulnerable EPBC Act)
- Painted Honeyeater *Grantiella picta* (Vulnerable EPBC Act and TPWC Act)
- Pale Field-rat *Rattus tunneyi* (Vulnerable TPWC Act)
- Common Brushtail Possum (northern) *Trichosurus vulpecula arnhemensis* (Vulnerable EPBC Act)
- Yellow-spotted Monitor *Varanus panoptes* (Vulnerable TPWC Act)

As records of species may be limited in remote areas the precautionary principle has been applied. There are some species that have been assessed as possibly occurring even though their primary habitat is not found within the proposed sites or access tracks. These include species that are associated with ephemeral wetlands, low lying areas that may be seasonally inundated and creeks. During the wet and early dry season these areas may sustain threatened species such as wetland birds (including migratory species).

The following provides summary of each threatened species that may potentially occur within the Amungee delineation area.

##### Gouldian Finch

Research has shown that critical components of suitable habitat for the Gouldian Finch include suitable nesting trees during the breeding season (particularly *Eucalyptus tintinnans*, *E. brevifolia* or *E. leucophloia*), a water source and a diverse range of favoured annual and perennial grasses (Dostine & Franklin, 2002).

No nesting habitat was recorded during the surveys and it is unlikely this species breeds in close vicinity to the exploration well sites within the Amungee delineation area. During the wet season, Gouldian Finches move from breeding habitat on hillsides with suitable trees down to lower lying areas where they forage on perennial grasses such as *Triodia sp.*, *Alloteropsis semialata*, and *Chrysopogon fallax* (Palmer *et al.* 2012). Some of the perennial grasses were recorded during recent surveys so potential foraging habitat is present; however, there are limited records in the vicinity.

The proposed exploration well sites, gravel pits and vegetation sites were surveyed for Gouldian Finch, congruent with the Crested Shrike-tit surveys. Call playback was not undertaken for Gouldian Finch. Primary nesting trees such as *Eucalyptus brevifolia*, *Eucalyptus leucophloia* and *Eucalyptus tintinnans* were not observed in the area. Corymbia and Eucalyptus trees that are potentially suitable for nesting and perennial grasses suitable for feeding were observed at several sites. Habitat in the Amungee delineation area was moderately suitable for Gouldian Finch but core habitat was absent. No Gouldian Finch were observed during the bird surveys.

### **Crested Shrike-tit**

The Crested Shrike-tit lives in dry Eucalypt forests and woodlands where it feeds on insects from the canopy and also under bark. It has been recorded in wet Melaleuca open woodlands and woodlands dominated by Nutwood (*Terminalia arostrata*) and Bloodwoods with flaky bark and ironwood (Ward, 2008). In the NT, nesting has been recorded from September through to January and nests are built in terminal branches at the top of trees (Ward *et al.*, 2009). The stronghold of this species is north of this location and only one old record exists near Borroloola.

Although it is possible the Crested Shrike-tit may be present in the area, it is unlikely to represent an important area for this species.

During the May 2022 field survey call-playback was undertaken for Crested Shrike-tit (northern subspecies). Call-playback was undertaken for approximately 5 minutes at all of the proposed exploration well sites (Amungee NW-2, Amungee NW-3, Amungee NW-4 and Amungee NW-5, and AMS 1-1 and AMS5), two proposed gravel pits and the vegetation survey sites (VS1 to VS28). Following 5 minutes of call playback the area was surveyed for approximately 10 minutes with binoculars. The search area was within 50 m of where call playback was undertaken, covering an approximate 0.8 ha search area. No Crested Shrike-tits were observed during these surveys.

The targeted call-playback surveys failed to detect the bird at the exploration well sites or the vegetation assessment sites. The overall estimated density of the *Corymbia* sp. has previously been recorded for the Amungee NW (AECOM, 2022) at 6 stems/ha, which based on the impact of the proposed activities of 110.96 ha represents 0.03% of the available *Corymbia* open woodland vegetation community within EP98 (estimated from NVIS of 359,950 ha). Based on the recorded stems/ha for Amungee delineation area it can also be estimated that within the 1,000 ha directly surrounding the disturbance area there would be up to 6,000 individual stems/ha of *Corymbia* sp. With additional vegetation clearing controls, such as timing of the clearing activities to avoid the preferred breeding and fledging times (October to March), as far as is practicable.

### **Grey Falcon**

The Grey Falcon (*Falco hypoleucos*) is a widespread species listed as Vulnerable in the NT and considered possibly present in the study area. The species occurs in low densities throughout arid and semi-arid areas of Australia (DEPWS, 2021a). The species is known to nest on repeater towers in the region, including one site located approximately 100 km south-west of the Amungee delineation area where the species bred in 2014 (Jonny Schoenjahn, personal communication, 2022). The species is also known to nest in the tallest trees along watercourses, such as Red River Gums (*Eucalyptus camaldulensis*) (TSSC, 2020). Grey Falcon may forage within the Amungee delineation area but is unlikely to be impacted by project activities because suitable nesting trees won't be cleared.

One repeater tower located within the lease area next to the Carpentaria Highway was surveyed for Grey Falcon. The species was not detected.

### **Painted Honeyeater**

The Painted Honeyeater (*Grantiella picta*) has been known to occur in region, however, given it does not breed in the NT it would only be present intermittently for foraging. Suitable habitat for the species potentially occurs within the Amungee delineation area. The area proposed for clearance is relatively small compared to available suitable habitat within the region.

### **Yellow-spotted Monitor**

The Yellow-spotted Monitor (*Varanus panoptes*) occurs across northern Australia where it occupies a variety of habitats, including grasslands and woodlands (Ward *et al.*, 2012). Most records of this species are from the Top End, though it has been recorded in the Barkly Tablelands. The species likely occurs close to wetlands and riparian habitats within the permit areas; however such habitat won't be impacted by proposed activities.

**Common Brushtail Possum**

Recent surveys have detected Common Brushtail Possum (*Trichosurus vulpecula arnhemensis*) on Kalala Station, located approximately 45 km from the Amungee delineation area (NTG Flora & Fauna, personal communication, 2022). Suitable woodland habitat is contiguous through the landscape; therefore the species potentially occurs within the Amungee delineation area. Given the large amount of suitable habitat within the region comparative to the project footprint the risk to regional populations of the species is small.

**Pale Field-rat**

The Pale Field-rat occurs in a wide range of habitats, including tall grasslands and woodlands (Cole & Woinarski, 2002). There are no recent records of the species within the region; however this may reflect a lack of survey effort. Suitable habitat for the species occurs within the Amungee delineation area. The proposed area of impact is relatively small compared to available suitable habitat within the region.

Table 24 EPBC and TPWC Listed Threatened Species and Likelihood of Occurrence within the Origin Amungee Delineation Area

Species	Status		Distribution	Habitat	Likelihood
	EPBC	TPWC			
<b>Birds</b>					
Curlew Sandpiper <i>Calidris ferruginea</i>	Marine Migratory	VU	In the NT this species occurs around Darwin, north to Melville Island and Cobourg Peninsula, and east and south-east to Gove. It has been recorded inland from Victoria River Downs and around Alice Springs (Higgins & Davies, 1996).	Coastal habitats, inland it has been found around lakes, dams and ephemeral/permanent waterholes.	Unlikely No suitable habitat within project area
Red Goshawk <i>Erythrotriorchis radiatus</i>	VU	VU	Found across most of Northern Australia, in the NT most records are from the Top End but there are records from central Australia (Pizzey & Knight, 2012).	Red Goshawks occupy a range of habitats, often at ecotones, including coastal and sub-coastal tall open forest, tropical savannahs crossed by wooded or forested watercourses. In the NT, it inhabits tall open forest/woodland as well as tall riparian woodland (Aumann & Baker-Gabb, 1991).	Unlikely No records and no suitable breeding habitat within the project area
Gouldian Finch <i>Erythrura gouldiae</i>	EN	VU	Formerly widespread across northern Australia. In the NT they are found in the Top End south past Daly Waters (Palmer <i>et al.</i> , 2012).	Gouldian Finches occupy different habitat types in the breeding and non-breeding season. Breeding habitat consists of hillsides with suitable nesting trees. Outside of the breeding season they are found in lowland drainages to feed on suitable perennial grasses (Dostine & Franklin, 2002).	Possible The closest record occurs 75 km east of the project area. Suitable foraging habitat is present
Grey Falcon <i>Falco hypoleucos</i>	VU	VU	This species has a widespread distribution and records occur throughout the NT. However, most records are from arid and semi-arid regions (Pizzey & Knight, 2012).	Grey Falcon is typically found on inland drainage systems in lightly treed lowland plains, pastoral lands, timbered watercourses and, occasionally, the driest deserts (DEPWS, 2021a).	Possible The species may forage within the project area but is unlikely to breed

Species	Status		Distribution	Habitat	Likelihood
	EPBC	TPWC			
Crested Shrike-tit (northern) <i>Falcunculus frontatus whitei</i>	VU	NT	This species has been recorded from widely scattered localities from near Timber Creek to the east Gulf Country, north to Kakadu National Park and in north-eastern Arnhem Land (DEPWS, 2021b).	Occupies wet and semi-arid melaleuca and eucalypt open woodlands. May be associated with bloodwoods with flaky bark and ironwood (Ward, 2008).	Possible  No records in the vicinity of the project area. Sub-optimal habitat is present. Call-playback surveys failed to detect the species
Painted Honeyeater <i>Grantiella picta</i>	VU	VU	This species is migratory based on seasonal variation in occurrence. They breed on the inland slopes of the Great Dividing Range. After the breeding season they sometimes occur in the north-eastern NT, south of the Roper River (Garnett & Baker, 2021).	Painted Honeyeater inhabits woodlands dominated by Acacia and/or Eucalyptus species and open forests but prefers habitats with abundant mature trees that host mistletoes. The species specialises on the fruit of mistletoes although it may also forage on nectar and insects (Garnett <i>et al.</i> , 2011).	Possible  No recent records occur close to the project area; however suitable habitat is present
Australian Painted Snipe <i>Rostratula australis</i>	CE	VU	Records of the species occur across the NT. More recent records come from McMinns Lagoon near Darwin, Yellow Waters in Kakadu, the Sturt Plateau, the Barkly and the Tanami (DEPWS, 2021c).	Australian Painted Snipe prefers a habitat of recently flooded temporary vegetated wetlands during the non-breeding period and brackish temporary freshwater wetlands with minimum vegetation during breeding periods. Birds usually forage in thick, low vegetated areas during the day (Curtis <i>et al.</i> , 2012).	Unlikely  Suitable habitat does not occur within the project area
Masked Owl (northern) <i>Tyto novaehollandiae kimberli</i>	VU	VU	The subspecies occurs in northern Australia, although its distribution is not well known. In the NT, occurs from Cobourg south to Katherine and the VRD and east to the McArthur River (DoE, 2014).	This species inhabits tall open eucalypt forest in the NT, especially those associated with <i>Eucalyptus miniata</i> and <i>E. tetradonta</i> (Woinarski, 2007). Also found in riparian and monsoonal forest and rainforest (DoE, 2014).	Unlikely  No recent records occur close to the project area and suitable habitat is not present

Species	Status		Distribution	Habitat	Likelihood
	EPBC	TPWC			
<b>Mammals</b>					
Northern Quoll <i>Dasyurus hallucatus</i>	CE	EN	The species once occurred throughout most of Northern Australia although it is has declined across much of its range (Woinarski & Hill, 2012). In the NT it is found in the Top End as far southeast as Borroloola.	Northern Quolls do not have highly specific habitat requirements although the most suitable appear to be rocky habitats. They occur in a variety of habitats across their range, including open forest and woodland. Daytime den sites provide important shelter. Shelter sites include rocky outcrops, tree hollows, hollow logs, termite mounds, goanna burrows and human dwellings (Woinarski & Hill, 2012).	Unlikely  No recent records, occur in the vicinity of the project area and habitat is sub-optimal
Ghost Bat <i>Macroderma gigas</i>	VU	NT	The species' range in northern Australia is from relatively arid conditions in the Pilbara region of Western Australia to humid rainforests of northern Queensland. A large colony occurs in a series of gold mine workings at Pine Creek, NT. This species has also been recorded throughout the mainland Top End north of approximately 17° latitude (DEPWS, 2021d).	The distribution of Ghost Bats is influenced by the availability of suitable caves and mines for roost sites. The species often roosts in a deep crack or cave during the day (DEPWS, 2021d).	Unlikely  Suitable habitat does not occur within the project area
Greater Bilby <i>Macrotis lagotis</i>	VU	VU	This species occurs in south-western Queensland and in arid north-western Australia (Western Australia and Northern Territory). This species was previously widespread in arid and semi-arid Australia (Pavey, 2006). The most northern records are from Newcastle Waters and Wave Hill (Southgate & Paltridge, 1998).	In the NT, this species is found on sandy soils dominated by spinifex. Also hummock grassland associated with low lying drainage systems and alluvial areas (Pavey, 2006). Recent surveys in the Beetaloo region have recorded Greater Bilby in Eucalyptus and Corymbia woodlands mixed tussock and hummock grasses in sandy/loam soils (Davis <i>et al.</i> , 2021).	Unlikely  No recent records, occur in the vicinity of the project area and suitable habitat is not present

Species	Status		Distribution	Habitat	Likelihood
	EPBC	TPWC			
Bare-rumped Sheath-Tailed Bat <i>Saccolaimus saccolaimus nudicluniatus</i>	CE	DD	Wide distribution from India through south-eastern Asia to the Solomon Islands, including north-eastern Queensland and the NT. Records of the species in the NT are sparsely scattered across the Top End (DEPWS, 2021e).	Previous specimens have been collected from Open <i>Pandanus</i> woodland fringing the sedgeland of the South Alligator River in Kakadu National Park, and from eucalypt woodlands and forests from coastal and adjacent inland areas (DEPWS, 2021e).	Unlikely  No recent records, occur in the vicinity of the project area and habitat is not suitable
Common Brushtail Possum <i>Trichosurus vulpecula arnhemensis</i>	VU	NT	The Common Brushtail Possum (northern subspecies) occurs discontinuously from the Gulf of Carpentaria hinterland near Borroloola, NT westward to the Kimberley, WA (TSSC, 2020b).	The species occurs mainly in tall eucalypt open forests with large hollow-bearing trees, particularly where the understorey includes some shrubs that bear fleshy fruits (TSSC, 2020b).	Possible  Recent records of the species occur at nearby Kalala Station and suitable habitat occurs within the project area
Pale Field-rat <i>Rattus tunneyi</i>	-	VU	Pale Field-rat inhabits higher rainfall areas of northern and eastern Australia, including the Top End of the NT (Menkhorst & Knight, 2011).	This species favours dense vegetation found along rivers where it occupies burrows in loose colonies (Cole & Woinarski, 2002). Pale Field-rat occurs within a variety of habitats including woodlands if a dense understorey of grasses is present (Menkhorst and Knight, 2011)	Possible  One record from 1999 occurs approximately 15 km from the project area. Suitable habitat occurs within the project area
<b>Reptiles</b>					
Gulf Snapping Turtle <i>Eseya lavarackorum</i>	-	EN	Gulf Snapping Turtle is restricted to rivers draining into the Gulf of Carpentaria, including the Calvert and Nicholson River systems (DEPWS, 2021f)	The species occurs in deep pools in the upper catchments of permanently flowing spring-fed river systems, particularly in areas with intact riparian vegetation (DEPWS, 2021f).	Unlikely  No rivers or large permanent water bodies occur within the project area

Species	Status		Distribution	Habitat	Likelihood
	EPBC	TPWC			
Yellow-spotted Monitor <i>Varanus panoptes</i>	-	VU	Occurs across a broad geographic range across northern Australia. In the NT most records are from the Top End but occurs as far south as Renner Springs (Ward <i>et al.</i> , 2012).	Occupies a variety of habitats including coastal beaches, floodplains, grasslands and woodlands (Ward <i>et al.</i> , 2012).	Possible A 2019 record occurs approximately 45 km from the project area and suitable habitat is present

#### 4.5.2 Migratory and Marine Species

The EPBC Protected Matters database (Appendix E) indicated the potential presence of 20 Migratory and Marine listed species within the Amungee delineation area (Table 25). Of these species, three are considered likely to occur, nine possibly occur and eight are unlikely to occur within the Amungee delineation area. Several migratory wetland bird would possibly occur within the area in ephemeral wetlands that would fill up following wet season rainfall. The Amungee delineation area does not contain critical habitat for any Migratory or Marine listed species.

**Table 25 Migratory listed species potentially occurring within the Amungee delineation area**

Scientific Name	Common Name	EPBC Act	Likelihood of Occurrence
<i>Actitis hypoleucos</i>	Common Sandpiper	Migratory, Marine	Possible
<i>Anseranas semipalmata</i>	Magpie Goose	Marine	Possible
<i>Apus pacificus</i>	Fork-tailed Swift	Migratory, Marine	Likely
<i>Ardea ibis</i>	Cattle Egret	Marine	Likely
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	Migratory, Marine	Possible
<i>Calidris ferruginea</i>	Curlew Sandpiper	Migratory, Marine	Possible
<i>Calidris melanotos</i>	Pectoral Sandpiper	Migratory, Marine	Possible
<i>Cecropis daurica (Hirundo daurica)</i>	Red-rumped Swallow	Migratory, Marine	Unlikely
<i>Charadrius veredus</i>	Oriental Plover	Migratory, Marine	Possible
<i>Chalcites osculans (Chrysococcyx osculans)</i>	Black-eared Cuckoo	Marine	Possible
<i>Crocodylus johnstoni</i>	Freshwater Crocodile	Marine	Unlikely
<i>Cuculus optatus</i>	Oriental Cuckoo	Migratory	Possible
<i>Glareola maldivarum</i>	Oriental Pratincole	Migratory, Marine	Possible
<i>Haliaeetus leucogaster</i>	White-bellied Sea-eagle	Marine	Unlikely
<i>Hirundo rustica</i>	Barn Swallow	Migratory, Marine	Unlikely
<i>Merops ornatus</i>	Rainbow Bee-eater	Marine	Likely
<i>Motacilla cinerea</i>	Grey Wagtail	Migratory, Marine	Unlikely
<i>Motacilla flava</i>	Yellow Wagtail	Migratory, Marine	Unlikely
<i>Pristis pristis</i>	Freshwater Sawfish	Migratory	Unlikely
<i>Rostratula benghalensis (Sensu lato)</i>	Australian Painted Snipe	Migratory, Marine	Unlikely

#### 4.5.3 Feral Animals

Feral animals known to occur within the region include:

- Pig (*Sus scrofa*)
- Wild Dog (*Canis lupus familiaris*)
- Feral Cat (*Felis catus*)
- Cane Toad (*Bufo marinus*)
- Horse (*Equus caballus*)
- Donkey (*Equus asinus*)

- Water Buffalo (*Bubalus bubalis*)
- Camel (*Camelus dromedarius*)
- Black Rat (*Rattus rattus*)
- Domestic Cattle (*Bos Taurus*)

During May 2022 field survey evidence of current cattle grazing or grazing within the last 1 to 2 years was recorded at the majority of assessed sites. Pig damage was also observed at some sites.

The Cane Toad is known to be present in the project area and the Commonwealth DCCEEW recognises this species as a 'key threatening process' related to their impacts on biodiversity through predation, competition, land degradation and poisoning. In the NT, the Cane Toad has been implicated in the decline of several species including a large number of reptiles such as the King Brown Snake (*Pseudechis australis*) and Varanus monitors (Smith & Phillips, 2006).

Pest predators such as Cats likely occur within the project area, though their abundance is difficult to assess due to their cryptic nature. Introduced predators such as Cats can impact many vertebrates (Dickman, 1996 & 2009). One of the primary concerns of introduced predators are the impacts on reptiles and ground-dwelling birds. Feral cats are also believed to be one of the factors that have led to the decline of the threatened ground-dwelling Partridge Pigeon (Woinarski *et al.* 2007).

There is potential for pest species to be attracted to increased site activities causing an increased abundance in the landscape. Pest species control should be considered when undertaking site activities. Care should be taken during project activities to ensure that rubbish is securely contained (i.e. with suitable lids) and removed from the site as soon as possible to discourage attracting feral animals.

## 4.6 Conservation Areas

There are no national or world heritage places, Commonwealth land or heritage places or reserves or critical habitat areas listed under the EPBC Act are located within or adjacent to the exploration area.

The Bullwaddy Conservation Reserve occurs approximately 40 km east of the Amungee delineation area along the Carpentaria Highway. The Reserve was declared in 2000 and is approximately 11,500 ha in area. It represents the only declared conservation area within the Sturt Plateau region to protect the Lancewood/Bullwaddy vegetation community. Less than 3% of this vegetation community is reserved nationally (PWCNT, 2005). The most significant values of the reserve are the flora and the associated fauna for which it provides habitat. This includes the Spectacled Hare-Wallaby (*Lagorchestes conspicillatus leichardtii*), the Northern Nailtail Wallaby (*Onychogalea unguifera*) and the Giant Frog (*Cyclorana australis*). It is also a valuable area for research on the ecology of Bullwaddy, particularly the effects of fire (PWCNT, 2005).

Lake Woods is located approximately 150 km south-west of the Amungee delineation area on Newcastle Waters Station. This wetland is listed as a Site of Conservation Significance by the Department of Land Resource Management and is listed in the Directory of Important Wetlands in Australia. Although Lake Woods is located outside of the project area, it is fed principally by surface inflow of Newcastle Creek, itself originating more than 160 km north-east on Amungee Mungee Station. During the period of inundation, Lake Woods supports over 100,000 waterbirds including internationally significant numbers of Plumed Whistling-Duck (*Dendrocygna eytoni*). Numerous bird species nest and feed in the diverse wetland habitat, and the conservation group 'Birdlife International' nominated Lake Woods as an 'Important Bird Area' (IBA). The lake also includes the largest area of lignum swamp in the Northern Territory and in tropical Australia (NRETAS, 2009).

## 4.7 Matters of National Environmental Significance

### 4.7.1 Potential EPBC Act Controlling Provisions

Actions such as the proposed 2022 Origin exploration program may require approval by the Commonwealth Minister for the Environment, under the *EPBC Act*. Approval is only required if the action is likely to result in significant impacts on Matters of National Environmental Significance (MNES) or if the action will have or is likely to have a significant impact on the environment.

Potential triggers under the EPBC Act include a significant impact on:

- The world heritage values of a declared World Heritage Property
- The national heritage values of a listed National Heritage Place
- The ecological character of a declared Ramsar wetland
- A listed Threatened Ecological Community, or its habitat
- The members of a listed threatened species
- The members of a listed migratory species or their habitat
- A water resource, in relation to coal seam gas development and large coal mining development.

### 4.7.2 Matters of National Environmental Significance

An EPBC Protected Matters Search was generated on the 2 June 2022 (refer to Appendix E) to identify whether MNES or other matters protected by the EPBC Act are likely to occur on or in the near vicinity of the project area. Results of the search are provided below in Table 26.

**Table 26 Summary of EPBC Aspects for Amungee Delineation Area**

Aspect	Located within the Amungee delineation area
<b>Matters of National Environmental Significance</b>	
World Heritage Properties	None
National Heritage Places	None
Wetlands of International Significance	None
Great Barrier Marine Park	None
Commonwealth Marine Area	None
Listed Threatened Ecological communities	None
Listed Threatened Species	13
Listed Migratory Species	13
<b>Other Matters Protected by the EPBC Act</b>	
Commonwealth Land	None
Commonwealth Heritage Places	None
Listed Marine Species	18
Whales and other Cetaceans	None
Critical Habitat	None
Commonwealth Reserves Terrestrial	None
Australian Marine Parks	None
Habitat Critical to the Survival of Marine Turtles	None

Aspect	Located within the Amungee delineation area
<b>Extra Information (Information that may also be relevant to the Exploration sites)</b>	
State and Territory Reserves	None
Regional Forest Agreement	None
Nationally Important Wetlands	None
EPBC Act Referrals	None
Key Ecological Features (Marine)	None
Biologically Important Areas	None
Bioregional Assessments	None
Geological and Bioregional Assessments	1

Section 4.5 provides details on threatened, migratory and marine fauna species that potentially occur within the project area. The threatened and migratory species that potentially occur within the Amungee delineation area are unlikely to be significantly impacted by the exploration activities.

## 5.0 Land Condition Assessment

AECOM undertook land condition assessments for the Amungee delineation area including 2D seismic exploration area and six proposed exploration well sites, access tracks and gravel pits during September 2021 and May 2022. It is understood that only four to the exploration well sites are currently progressing.

The aim of the assessment was to provide a baseline assessment of ecological conditions to support Origin's application to the NTG DEPWS to continue exploration activities. Information obtained during the LCA will assist in determining the effectiveness of site rehabilitation once exploration activities have ceased.

The overall vegetation disturbance within the Amungee delineation area is 31.66 ha for the seismic program and 79.30 ha for the drilling program as summarised in Table 27.

**Table 27 Area and % of Vegetation Disturbance Required with the Amungee Delineation Area**

Seismic Line	Seismic line coordinates				Total Length (km)	Vegetation Clearing Maximum Disturbance Area (ha)*	Best Case Vegetation Clearance Extent (ha)*
	Start of line		End of line				
	Lat	Long	Lat	Long			
001-SR	-16.32434	133.82875	-16.39386	133.89996	10.81	5.95	2.20
002-SR	-16.32112	133.85894	-16.35325	133.89186	5.00	2.75	1.83
003-SR	-16.34104	133.87802	-16.39438	133.93218	8.27	4.55	2.31
004-SR	-16.36162	133.93763	-16.41430	133.99165	8.20	4.52	1.18
005-SR	-16.34667	133.95114	-16.39806	134.00384	8.00	4.45	3.07
006-SR	-16.37223	133.86042	-16.37795	134.00306	15.29	8.44	7.05
007-SR	-16.34267	133.88364	-16.34584	133.88032	0.50	0.25	0.14
008-SR	-16.34459	133.88562	-16.34777	133.88229	0.50	0.25	0.10
009-SR	-16.34652	133.88759	-16.34970	133.88427	0.50	0.25	0.09
010-SR	-16.34845	133.88957	-16.35163	133.88624	0.5	0.25	0.09
<b>Total Seismic Program Clearing</b>					<b>57.57</b>	<b>31.66</b>	<b>18.04</b>
Lease Area, Access Track and Gravel Pits	Lease Pads			Total length (km)	Vegetation Clearing Maximum Disturbance Area (ha)*	Best Case Vegetation Clearance Extent (ha)*	
	Lat	Long					
Amungee NW-2	-16.367	133.968		-	13.70	13.70	
Amungee NW-3	-16.340	133.844		-	13.70	13.70	
Amungee NW-4	-16.393	133.973		-	13.70	13.70	
Amungee NW-5	-16.391	133.882		-	13.70	13.70	
Amungee NW-2 Gravel Pit (approved)	-16.381	133.977		-	0	0	
Amungee NW-3 Gravel Pit	-16.330	133.837		-	3.50	3.50	
Amungee Delineation Access Tracks	-	-		-	21.00	21.00	
<b>Total Drilling Program Clearing</b>					<b>-</b>	<b>79.30</b>	<b>79.30</b>
<b>Total Amungee Delineation Clearing Requirements</b>					<b>57.57</b>	<b>110.93</b>	<b>97.34</b>

The main vegetation community that will be disturbed by the Amungee delineation area exploration program for the 2D seismic and well exploration is summarised in Table 28. Community 2a, which is the most widespread vegetation community within the Amungee delineation area will result in only 3.37% of that vegetation in the immediate area.

**Table 28 % of Vegetation Community Disturbance for 2D Seismic and Exploration Well Area**

Vegetation Community	Ha	% of Vegetation Community within Amungee Delineation Area
<b>Community 1a</b> - <i>Acacia shirleyi</i> ± <i>Corymbia polycarpa</i> mid high woodland, over <i>Macropteranthes kekwickii</i> , <i>Terminalia volucris</i> , <i>Santalum lanceolatum</i> mid high shrubland, over <i>Scleria brownii</i> , <i>Chrysopogon fallax</i> , <i>Schizachyrium fragile</i> mid high tussock grassland.	7.1	0.38
<b>Community 2a</b> - <i>Corymbia dichromophloia</i> , ± <i>Erythrophleum chlorostachys</i> , ± <i>Eucalyptus chlorophylla</i> mid high open woodland, over <i>Terminalia canescens</i> , <i>Petalostigma pubescens</i> , <i>Erythrophleum chlorostachys</i> mid high open shrubland, over <i>Chrysopogon fallax</i> , ± <i>Sorghum plumosum</i> , <i>Themeda triandra</i> mid high open tussock grassland.	101.0	3.25
<b>Bare/Disturbed</b>	2.9	-

Potential environmental risks and impacts to the environment have been identified based on environmental conditions observed during the field survey. The overall disturbance footprint for the Amungee delineation area is 110.96 ha, however with the development of mitigation measures to minimise Origin's impact to the environment Origin could reduce its disturbance area to 97.34 ha.

During the survey the proposed exploration well sites, seismic lines, access tracks and gravel pits were assessed to be in generally good condition with minor evidence of weeds, erosion and disturbance from cattle.

EPBC and TPWC Act Listed Threatened species that have a potential to be encountered within the Amungee delineation area include:

- Gouldian Finch *Erythrura gouldiae*
- Grey Falcon *Falco hypoleucos*
- Crested Shrike-tit (northern) *Falcunculus frontatus whitei*
- Painted Honeyeater *Grantiella picta*
- Pale Field-rat *Rattus tunneyi*
- Common Brushtail Possum (northern) *Trichosurus vulpecula arnhemensis*
- Yellow-spotted Monitor *Varanus panoptes*

Due to a scarcity of records and lack of core habitat, it is unlikely that significant populations of these species occur within the Amungee delineation area. It is therefore unlikely threatened species will be significantly impacted from Origin's proposed exploration activities. No threatened ecological communities are listed within the area.

Mitigation measures are presented in Origin's Exploration Program [EMPs](#) and will assist in minimising the impacts from Origin's activities on the natural environment and threatened species that may occur within the project area.

Detailed land condition description and photographs of Amungee NW are provided in Table 29 to Table 34.

Table 29 Proposed Exploration Well Site AMS1- 1 Land Condition Description




Proposed Exploration Well Site AMS1-1			
<b>Location</b>	GDA94, Zone 53, 0390739E, 8189607N	<b>Vegetation community</b>	<i>Erythrophleum chlorostachys</i> and <i>Eucalyptus chlorophylla</i> open woodland
<b>Vegetation description</b>	<i>Erythrophleum chlorostachys</i> and <i>Eucalyptus chlorophylla</i> mid high open woodland, over <i>Petalostigma pubescens</i> mid high open shrubland, over <i>Chrysopogon fallax</i> sparse tussock grassland		
<b>Vegetation transect</b>	No canopy 61.3%, <i>Erythrophleum chlorostachys</i> 10.2%, <i>Petalostigma pubescens</i> 9.5%, <i>Terminalia canescens</i> 8.2%, <i>Corymbia ferruginea</i> 6.7%, <i>Acacia difficilis</i> 1.2%, <i>Terminalia volucris</i> 1.2%, <i>Bauhinia cunninghamii</i> 0.7%, <i>Hakea arborescens</i> 0.7%, <i>Grevillea parallela</i> 0.25%		
<b>Basal area (5 sweeps)</b>	17 ( <i>Macropteranthes kekwickii</i> 1.5, <i>Petalostigma pubescens</i> , <i>Corymbia dichromophloia</i> , <i>Erythrophleum chlorostachys</i> , <i>Terminalia canescens</i> , <i>Eucalyptus chlorophylla</i> , <i>Bauhinia cunninghamii</i> )	<b>Stand basal area (average)</b>	3.4 m <sup>2</sup> /ha
<b>Landform</b>			
Simple slope			
<b>Habitat</b>	Poor – scattered fallen logs, shallow leaf litter. Tree hollows, mistletoe and flowering plants absent		
<b>Slope</b>			
1%			
<b>Disturbance</b>	Fire damage > 2 years ago. No erosion. Cattle impacts		
<b>Vegetation Structure</b>	<b>Upper storey: 5 - 12 m</b>	<i>Erythrophleum chlorostachys</i> (8%) and <i>Eucalyptus chlorophylla</i> (2%)	
	<b>Mid-storey: 0.5 - 5 m</b>	<i>Petalostigma pubescens</i> (15%), <i>Terminalia canescens</i> (2%) and <i>Terminalia volucris</i> (1%)	
	<b>Understorey: 0 - 0.5 m</b>	<i>Chrysopogon fallax</i> (6%) and <i>Eriachne ciliaris</i> (2%) tussock grasses	
<b>Soil texture</b>	Loamy sand and sandy loam in upper 0.25 m.		
<b>Soil drainage</b>	Well drained		
<b>Soil colour</b>	5YR 3/3. Dark brown		
<b>Soil pH</b>	6.0 (0-0.1m), 5.7 (0.1-0.25m)		
<b>Termite mounds</b>	Sparse		
<b>Ground cover</b>	20% Vegetation, 10% Litter, 70% Bare Soil		

Table 30 Proposed Exploration Well Site – Amungee NW-2 Land Condition Description






Amungee NW-2 (Alternate Well Site)			
<b>Location</b>	GDA94, zone 53, 0389927E, 8190027N	<b>Vegetation community</b>	<i>Corymbia dichromophloia</i> and <i>Eucalyptus chlorophylla</i> open woodland
<b>Vegetation description</b>	<i>Corymbia dichromophloia</i> and <i>Eucalyptus chlorophylla</i> mid high open woodland, over <i>Erythrophleum chlorostachys</i> , <i>Acacia difficilis</i> and <i>Santalum lanceolatum</i> mid high open shrubland, over <i>Chrysopogon fallax</i> and <i>Sorghum plumosum</i> open tussock grassland		
<b>Vegetation transect</b>	No canopy 68.2%, <i>Eucalyptus chlorophylla</i> 7.6%, <i>Macropteranthes kekwickii</i> 5.9%, <i>Acacia difficilis</i> 5.6%, <i>Corymbia ferruginea</i> 3.8%, <i>Erythrophleum chlorostachys</i> 2.8%, <i>Terminalia canescens</i> 1%, <i>Brachychiton paradoxus</i> 0.8%, <i>Bauhinia cunninghamii</i> 0.8%		
<b>Basal area (5 sweeps)</b>	42 ( <i>Macropteranthes kekwickii</i> 10, <i>Acacia shirleyi</i> 10, Dead tree 9, <i>Corymbia ferruginea</i> 4, <i>Erythrophleum chlorostachys</i> 3.5, <i>Acacia difficilis</i> 3, <i>Eucalyptus chlorophylla</i> 2.5)	<b>Stand basal area (average)</b>	8.4m <sup>2</sup> /ha
<b>Landform</b>			
Simple slope			
<b>Habitat</b>			
Scattered tree hollows, common falling logs. Mistletoe and flowering plants absent.			
<b>Slope</b>			
1%			
<b>Disturbance</b>			
Fire damage > 2 years ago. No erosion. Cattle impacts			
<b>Vegetation Structure</b>	<b>Upper storey: 5 - 12 m</b>	<i>Corymbia dichromophloia</i> (7%), <i>Eucalyptus chlorophylla</i> (3%)	
	<b>Mid-storey: 0.5 - 5 m</b>	<i>Erythrophleum chlorostachys</i> (6%), <i>Acacia difficilis</i> (4%), <i>Santalum lanceolatum</i> (3%)	
	<b>Understorey: 0 – 0.5 m</b>	<i>Chrysopogon fallax</i> (16%), <i>Sorghum plumosum</i> (2%)	
<b>Soil texture</b>	Sandy loam grading to sandy clay loam at 0.2 m		
<b>Soil drainage</b>	Well drained		
<b>Soil colour</b>	2.5YR 3/4 dark reddish brown		
<b>Soil pH</b>	5.7 (0-0.2m), 6.0 (0.2-0.55m)		
<b>Termite mounds</b>	Sparse		
<b>Ground cover</b>	20% Vegetation, 10% Litter, 70% Bare Soil		

Table 31 Proposed Exploration Well Site – Amungee NW-3 Land Condition Description




Amungee NW-3			
<b>Location</b>	GDA94, zone 53, 0376604E, 8193091N	<b>Vegetation community</b>	<i>Corymbia dichromophloia</i> open woodland
<b>Vegetation description</b>	<i>Corymbia dichromophloia</i> mid high open woodland, over <i>Terminalia canescens</i> , <i>Petalostigma pubescens</i> and <i>Hakea arborescens</i> mid high sparse shrubland, over <i>Chrysopogon fallax</i> , <i>Schizachyrium fragile</i> open tussock grassland		
<b>Vegetation transect</b>	No Canopy 66%, <i>Corymbia dichromophloia</i> 22%, <i>Terminalia canescens</i> 6.5%, <i>Petalostigma pubescens</i> 2.75%, <i>Erythrophleum chlorostachys</i> 1.75%, <i>Hakea arborescens</i> 0.25%, <i>Grevillea parallela</i> 0.25%, <i>Ehretia saligna</i> 0.25%, <i>Erythroxyllum ellipticum</i> 0.25%		
<b>Basal area (5 sweeps)</b>	24 ( <i>Corymbia dichromophloia</i> 15.5, dead tree 2.5, <i>Petalostigma pubescens</i> 2, <i>Erythrophleum chlorostachys</i> 2, <i>Erythroxyllum ellipticum</i> 1, <i>Terminalia canescens</i> 1)	<b>Stand basal area (average)</b>	4.8m <sup>2</sup> /ha
<b>Landform</b>			
Simple slope			
<b>Habitat</b>	Common tree hollows and scattered fallen logs. Mistletoe and flowering plants absent.		
<b>Slope</b>			
1%			
<b>Disturbance</b>	Fire damage > 2 years ago. No erosion. Cattle impacts		
<b>Vegetation Structure</b>	<b>Upper storey:</b> 10 - 14 m	<i>Corymbia dichromophloia</i> (20%)	
	<b>Mid-storey:</b> 6.5 - 7 m	<i>Terminalia canescens</i> (4%), <i>Petalostigma pubescens</i> (2%), <i>Hakea arborescens</i> (1%)	
	<b>Understorey:</b> 0 - 0.5 m	<i>Chrysopogon fallax</i> (10%), <i>Hakea arborescens</i> sapling (8%), <i>Schizachyrium fragile</i> (2%)	
<b>Soil texture</b>	Sandy loam grading to silty clay loam at 0.3m		
<b>Soil drainage</b>	Imperfectly drained		
<b>Soil colour</b>	7.5YR 5/3 Brown		
<b>Soil pH</b>	6.2 (0 - 0.45m)		
<b>Termite mounds</b>	Common		
<b>Ground cover</b>	20% Vegetation, 5% Litter, 35% Bare Soil, 40% Gravel		

Table 32 Proposed Exploration Well Site – Amungee NW-4 Land Condition Description



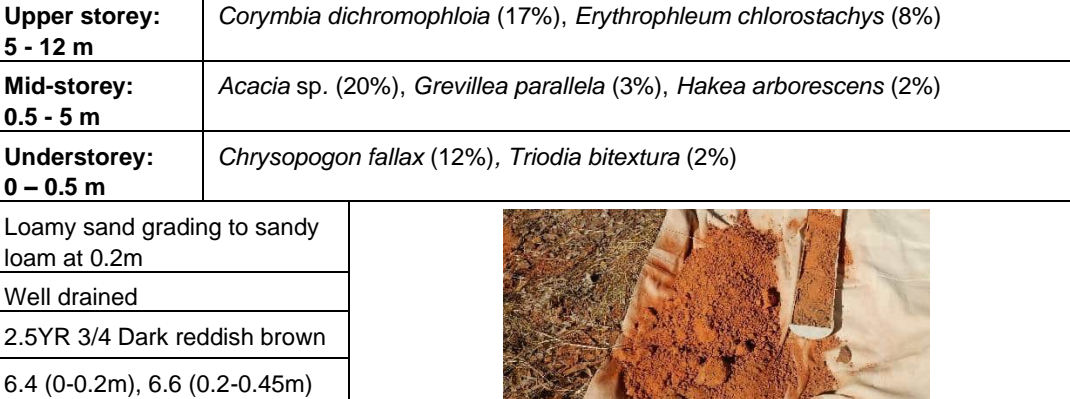


Amungee NW-4			
<b>Location</b>	GDA94, zone 53, 0390418E, 8186954N	<b>Vegetation community</b>	<i>Corymbia dichromophloia</i> and <i>Erythrophleum chlorostachys</i> woodland
<b>Vegetation description</b>	<i>Corymbia dichromophloia</i> and <i>Erythrophleum chlorostachys</i> mid high woodland, over <i>Acacia calligera</i> , <i>Grevillea parallela</i> and <i>Hakea arborescens</i> mid high open shrubland, over <i>Chrysopogon fallax</i> and <i>Triodia bitextura</i> open tussock grassland		
<b>Vegetation transect</b>	No Canopy 58%, <i>Corymbia dichromophloia</i> 34.75%, <i>Erythrophleum chlorostachys</i> 4.5%, <i>Hakea arborescens</i> 1.25%, <i>Grevillea parallela</i> 0.75%, <i>Terminalia canescens</i> 0.5%, <i>Denhamia cunninghamii</i> 0.25%		
<b>Basal area (5 sweeps)</b>	28.5 ( <i>Corymbia dichromophloia</i> 15, <i>Erythrophleum chlorostachys</i> 5.5, <i>Gardenia pyriformis</i> 3.5, dead tree 3, <i>Hakea arborescens</i> 1, <i>Eucalyptus chlorophylla</i> 0.5)	<b>Stand basal area (average)</b>	5.7m <sup>2</sup> /ha
<b>Landform</b>			
Simple slope			
<b>Habitat</b>			
Scattered tree hollows and fallen logs. Mistletoe and flowering plants absent.			
<b>Slope</b>			
<1%			
<b>Disturbance</b>			
Fire damage > 2 years ago. No erosion. Cattle impacts			
<b>Vegetation Structure</b>	<b>Upper storey: 5 - 12 m</b>	<i>Corymbia dichromophloia</i> (17%), <i>Erythrophleum chlorostachys</i> (8%)	
	<b>Mid-storey: 0.5 - 5 m</b>	<i>Acacia</i> sp. (20%), <i>Grevillea parallela</i> (3%), <i>Hakea arborescens</i> (2%)	
	<b>Understorey: 0 – 0.5 m</b>	<i>Chrysopogon fallax</i> (12%), <i>Triodia bitextura</i> (2%)	
<b>Soil texture</b>	Loamy sand grading to sandy loam at 0.2m		
<b>Soil drainage</b>	Well drained		
<b>Soil colour</b>	2.5YR 3/4 Dark reddish brown		
<b>Soil pH</b>	6.4 (0-0.2m), 6.6 (0.2-0.45m)		
<b>Termite mounds</b>	Sparse		
<b>Ground cover</b>	65% Litter, 15% Vegetation, 15% Gravel, 5% Bare Soil		

Table 33 Proposed Exploration Well Site – Amungee NW-5 Land Condition Description








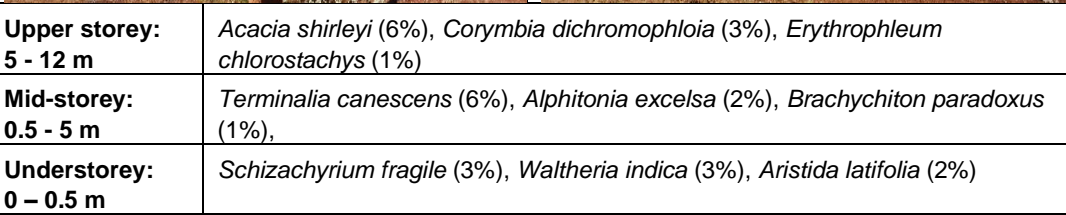
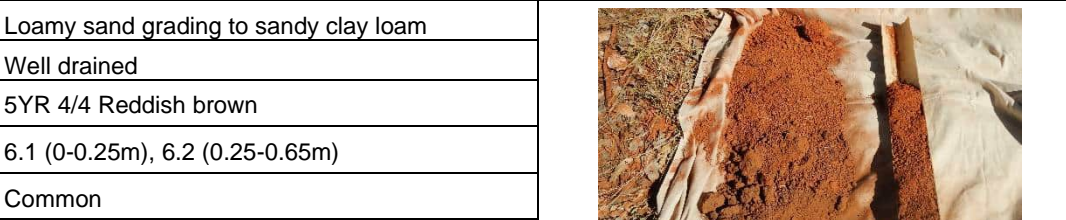

Amungee NW-5			
<b>Location</b>	GDA94, zone 53, 0380628E, 8186884N	<b>Vegetation community</b>	<i>Corymbia dichromophloia</i> and <i>Eucalyptus chlorophylla</i> open woodland
<b>Vegetation description</b>	<i>Corymbia dichromophloia</i> and <i>Eucalyptus chlorophylla</i> mid high open woodland, over <i>Erythrophleum chlorostachys</i> , <i>Petalostigma pubescens</i> and <i>Terminalia volucris</i> mid high open shrubland, over <i>Themeda triandra</i> , <i>Chrysopogon fallax</i> and <i>Schizachyrium fragile</i> tussock grassland		
<b>Vegetation transect</b>	No Canopy 70.25%, <i>Erythrophleum chlorostachys</i> 9.25%, <i>Corymbia dichromophloia</i> 6.25%, <i>Eucalyptus chlorophylla</i> 4.25%, <i>Terminalia canescens</i> 2.75%, <i>Terminalia volucris</i> 2.25%, <i>Petalostigma pubescens</i> 1.5%, <i>Corymbia polycarpa</i> 1.25%, <i>Acacia shirleyi</i> 1%, <i>Macropteranthes kekwickii</i> 0.75%, <i>Grevillea parallela</i> 0.5%		
<b>Basal area (5 sweeps)</b>	27 ( <i>Erythrophleum chlorostachys</i> 5, <i>Eucalyptus chlorophylla</i> 4.5, <i>Macropteranthes kekwickii</i> 4.5, <i>Acacia shirleyi</i> 3.5, <i>Corymbia dichromophloia</i> 2.5, <i>Terminalia volucris</i> 2, dead tree 2, <i>Petalostigma pubescens</i> 1, <i>Terminalia canescens</i> 1, <i>Grevillea parallela</i> 1)	<b>Stand basal area (average)</b>	5.4m <sup>2</sup> /ha
<b>Landform</b>			
Simple slope			
<b>Habitat</b>			
Scattered tree hollows and fallen logs. Mistletoe and flowering plants absent.			
<b>Slope</b>			
1%			
<b>Disturbance</b>			
Fire damage > 2 years ago. No erosion. Cattle impacts			
<b>Vegetation Structure</b>	<b>Upper storey: 7 - 12 m</b>	<i>Corymbia dichromophloia</i> (12%), <i>Eucalyptus chlorophylla</i> (3%)	
	<b>Mid-storey: 1 - 7 m</b>	<i>Erythrophleum chlorostachys</i> (12%), <i>Petalostigma pubescens</i> (5%), <i>Terminalia volucris</i> (2%)	
	<b>Understorey: 0 - 1 m</b>	<i>Themeda triandra</i> (20%), <i>Chrysopogon fallax</i> (15%), <i>Schizachyrium fragile</i> (5%)	
<b>Soil texture</b>	Loamy sand grading to sandy loam		
<b>Soil drainage</b>	Well drained		
<b>Soil colour</b>	2.5YR 3/4 Dark reddish brown		
<b>Soil pH</b>	6.4 (0-0.3m), 6.6 (0.3-0.55m)		
<b>Termite mounds</b>	Common		
<b>Ground cover</b>	40% Vegetation, 40% Bare Soil, 20% Leaf Litter		

Table 34 Proposed Exploration Well Site AMS5 Land Condition Description

Proposed Exploration Well Site AMS5			
<b>Location</b>	GDA94, zone 53, 0391354E, 8194713N	<b>Vegetation community</b>	<i>Acacia shirleyi</i> , <i>Corymbia dichromophloia</i> and <i>Erythrophleum chlorostachys</i> open woodland
<b>Vegetation description</b>	<i>Acacia shirleyi</i> , <i>Corymbia dichromophloia</i> and <i>Erythrophleum chlorostachys</i> mid high open woodland, over <i>Terminalia canescens</i> and <i>Alphitonia excelsa</i> mid high open shrubland, over <i>Schizachyrium fragile</i> , <i>Waltheria indica</i> and <i>Aristida latifolia</i> open tussock grassland		
<b>Vegetation transect</b>	No Canopy 82.5%, <i>Acacia shirleyi</i> 7.25%, <i>Terminalia canescens</i> 3%, <i>Erythrophleum chlorostachys</i> 2.25%, <i>Alphitonia excelsa</i> 1%, <i>Corymbia confertiflora</i> 0.75%, <i>Hakea arborescens</i> 0.5%, <i>Denhamia cunninghamii</i> 0.5%, <i>Santalum lanceolatum</i> 0.25%		
<b>Basal area (5 sweeps)</b>	23.5 (Dead tree 7, <i>Acacia shirleyi</i> 6.5, <i>Corymbia dichromophloia</i> 4, <i>Erythrophleum chlorostachys</i> 3, <i>Petalostigma pubescens</i> 1, <i>Terminalia volucris</i> 1, <i>Terminalia canescens</i> 0.5)	<b>Stand basal area (average)</b>	4.7m <sup>2</sup> /ha
<b>Landform</b>			
Flat			
<b>Habitat</b>			
Abundant fallen logs and flowering plants. Scattered tree hollows and mistletoe.			
<b>Slope</b>			
<1%			
<b>Disturbance</b>			
Fire damage > 2 years ago. No erosion. Significant grazing impacts			
<b>Vegetation Structure</b>	<b>Upper storey: 5 - 12 m</b>	<i>Acacia shirleyi</i> (6%), <i>Corymbia dichromophloia</i> (3%), <i>Erythrophleum chlorostachys</i> (1%)	
	<b>Mid-storey: 0.5 - 5 m</b>	<i>Terminalia canescens</i> (6%), <i>Alphitonia excelsa</i> (2%), <i>Brachychiton paradoxus</i> (1%),	
	<b>Understorey: 0 - 0.5 m</b>	<i>Schizachyrium fragile</i> (3%), <i>Waltheria indica</i> (3%), <i>Aristida latifolia</i> (2%)	
<b>Soil texture</b>	Loamy sand grading to sandy clay loam		
<b>Soil drainage</b>	Well drained		
<b>Soil colour</b>	5YR 4/4 Reddish brown		
<b>Soil pH</b>	6.1 (0-0.25m), 6.2 (0.25-0.65m)		
<b>Termite mounds</b>	Common		
<b>Ground cover</b>	50% Gravel cover, 36% Bare Soil, 3% Leaf Litter 1% Rock Cover		

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# Appendix A

## Soil Material Laboratory Results

## Appendix A Soil Material Laboratory Results

## CERTIFICATE OF ANALYSIS

**Work Order** : **ES2215956**  
**Client** : **AECOM AUSTRALIA PTY LTD**  
**Contact** : MS ALANA COURT  
**Address** : GPO BOX 3175  
 DARWIN NT, AUSTRALIA 0801  
**Telephone** : +61 08 8942 6200  
**Project** : 60623736  
**Order number** : 60623736  
**C-O-C number** : ----  
**Sampler** : WILLIAM RIDDELL  
**Site** : ----  
**Quote number** : EN/004/21  
**No. of samples received** : 12  
**No. of samples analysed** : 12

**Page** : 1 of 5  
**Laboratory** : Environmental Division Sydney  
**Contact** : Sepan Mahamad  
**Address** : 277-289 Woodpark Road Smithfield NSW Australia 2164  
**Telephone** : +61 2 8784 8555  
**Date Samples Received** : 11-May-2022 08:00  
**Date Analysis Commenced** : 13-May-2022  
**Issue Date** : 18-May-2022 15:21



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

**Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.**

### Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Dian Dao	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW



## General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.  
LOR = Limit of reporting  
^ = This result is computed from individual analyte detections at or above the level of reporting  
ø = ALS is not NATA accredited for these tests.  
~ = Indicates an estimated value.

- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H<sup>+</sup> + Al<sup>3+</sup>).



## Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Sample ID		AMS2_A3	AMS2_B1	AMS4_A3	AMS4_B1	AMS1-1_A1
		Sampling date / time		06-May-2022 00:00	06-May-2022 00:00	05-May-2022 00:00	05-May-2022 00:00	04-May-2022 00:00
Compound	CAS Number	LOR	Unit	ES2215956-001	ES2215956-002	ES2215956-003	ES2215956-004	ES2215956-005
				Result	Result	Result	Result	Result
<b>EA002: pH 1:5 (Soils)</b>								
pH Value	----	0.1	pH Unit	6.2	6.2	6.4	6.6	6.0
<b>EA010: Conductivity (1:5)</b>								
Electrical Conductivity @ 25°C	----	1	µS/cm	9	8	8	6	17
<b>EA055: Moisture Content (Dried @ 105-110°C)</b>								
Moisture Content	----	0.1	%	3.3	4.9	3.5	4.9	0.8
<b>EA058: Emerson Aggregate Test</b>								
Color (Munsell)	----	-	-	Gray (7.5YR 5/1)	Brown (7.5YR 5/2)	Reddish Brown (5YR 4/4)	Dark Red (2.5YR 3/6)	Dark Brown (7.5YR 3/4)
Texture	----	-	-	Medium Clay	Medium Clay	Light Medium Clay	Light Medium Clay	Medium Clay
Emerson Class Number	EC/TC	-	-	2	2	2	6	2
<b>ED007: Exchangeable Cations</b>								
Exchangeable Calcium	----	0.1	meq/100g	1.6	1.8	2.1	2.3	2.4
Exchangeable Magnesium	----	0.1	meq/100g	0.7	1.0	0.7	0.7	0.6
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	0.3	0.2	0.2
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	2.5	2.9	3.1	3.2	3.2
Exchangeable Sodium Percent	----	0.1	%	<0.1	<0.1	<0.1	<0.1	<0.1



## Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	AMS1-1_A3	AMS1-2_A3	AMS1-2_B1	AMS3_A3	AMS3_B1
				Sampling date / time	04-May-2022 00:00	04-May-2022 00:00	04-May-2022 00:00	03-May-2022 00:00	03-May-2022 00:00
Compound	CAS Number	LOR	Unit		ES2215956-006	ES2215956-007	ES2215956-008	ES2215956-009	ES2215956-010
				Result	Result	Result	Result	Result	
<b>EA002: pH 1:5 (Soils)</b>									
pH Value	----	0.1	pH Unit		5.7	5.7	6.0	6.4	6.6
<b>EA010: Conductivity (1:5)</b>									
Electrical Conductivity @ 25°C	----	1	µS/cm		7	9	6	18	8
<b>EA055: Moisture Content (Dried @ 105-110°C)</b>									
Moisture Content	----	0.1	%		2.3	3.6	3.8	1.1	2.3
<b>EA058: Emerson Aggregate Test</b>									
Color (Munsell)	----	-	-		Dark Reddish Brown (5YR 3/4)	Dark Reddish Brown (5YR 3/4)	Dark Red (2.5YR 3/6)	Dark Brown (7.5YR 3/3)	Reddish Brown (5YR 4/4)
Texture	----	-	-		Medium Clay	Medium Clay	Medium Clay	Clay Loam Sandy	Clay Loam Sandy
Emerson Class Number	EC/TC	-	-		2	2	2	7	2
<b>ED007: Exchangeable Cations</b>									
Exchangeable Calcium	----	0.1	meq/100g		1.5	1.6	1.5	1.7	1.0
Exchangeable Magnesium	----	0.1	meq/100g		0.4	0.6	0.6	0.6	0.5
Exchangeable Potassium	----	0.1	meq/100g		0.1	0.2	<0.1	0.4	0.2
Exchangeable Sodium	----	0.1	meq/100g		<0.1	<0.1	<0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g		1.9	2.4	2.2	2.7	1.8
Exchangeable Sodium Percent	----	0.1	%		<0.1	<0.1	<0.1	<0.1	<0.1



## Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	AMS5_A3	AMS5_B1 Received as ASS_B1	----	----	----
Sampling date / time				03-May-2022 00:00	03-May-2022 00:00	----	----	----	
Compound	CAS Number	LOR	Unit	ES2215956-011	ES2215956-012	-----	-----	-----	
				Result	Result	---	---	---	
<b>EA002: pH 1:5 (Soils)</b>									
pH Value	----	0.1	pH Unit	6.1	6.2	----	----	----	
<b>EA010: Conductivity (1:5)</b>									
Electrical Conductivity @ 25°C	----	1	µS/cm	15	6	----	----	----	
<b>EA055: Moisture Content (Dried @ 105-110°C)</b>									
Moisture Content	----	0.1	%	3.3	4.9	----	----	----	
<b>EA058: Emerson Aggregate Test</b>									
Color (Munsell)	----	-	-	Dark Reddish Brown (5YR 3/2)	Dark Red (2.5YR 3/6)	----	----	----	
Texture	----	-	-	Clay Loam Sandy	Light Medium Clay	----	----	----	
Emerson Class Number	EC/TC	-	-	2	2	----	----	----	
<b>ED007: Exchangeable Cations</b>									
Exchangeable Calcium	----	0.1	meq/100g	2.4	1.8	----	----	----	
Exchangeable Magnesium	----	0.1	meq/100g	0.7	0.7	----	----	----	
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.2	----	----	----	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	----	----	----	
Cation Exchange Capacity	----	0.1	meq/100g	3.5	2.6	----	----	----	
Exchangeable Sodium Percent	----	0.1	%	<0.1	<0.1	----	----	----	

## Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EA058: Emerson Aggregate Test

# Material Test Report

**Report Number:** 215285.00-1  
**Issue Number:** 1  
**Date Issued:** 13/05/2022  
**Client:** AECOM Australia Pty Ltd  
 PO Box 3175, Darwin NT 0801  
**Contact:** David van de Hoek  
**Project Number:** 215285.00  
**Project Name:** Project 60623736 - February  
**Project Location:** Not Supplied, - NT  
**Client Reference:** Project 60623736  
**Work Request:** 4176  
**Sample Number:** DW-4176A  
**Date Sampled:** 03/05/2022  
**Dates Tested:** 10/05/2022 - 12/05/2022  
**Sampling Method:** Sampled by Client  
*The results apply to the sample as received*  
**Sample Location:** AS5  
**Material:** Clayey Sandy Gravel



Accredited for compliance with ISO/IEC 17025 - Testing



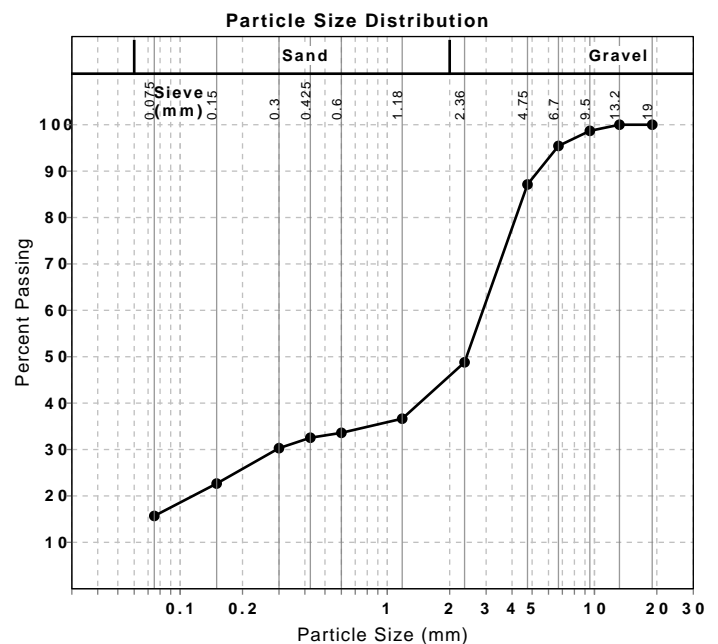
Approved Signatory: Sunil Sukhdeo  
 Laboratory Manager  
 Laboratory Accreditation Number: 828

Particle Size Distribution (AS1289 3.6.1)		
Sieve	Passed %	Passing Limits
19 mm	100	
13.2 mm	100	
9.5 mm	99	
6.7 mm	95	
4.75 mm	87	
2.36 mm	49	
1.18 mm	37	
0.6 mm	34	
0.425 mm	33	
0.3 mm	30	
0.15 mm	23	
0.075 mm	16	

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	24		
Plastic Limit (%)	12		
<b>Plasticity Index (%)</b>	<b>12</b>		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	5.0		
Cracking Crumbling Curling	Cracking		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	<b>8</b>		
Soil Description	Natural Soil		
Nature of Water	Demineralised Water		
Temperature of Water (°C)	25.6		



# Material Test Report

**Report Number:** 215285.00-1  
**Issue Number:** 1  
**Date Issued:** 13/05/2022  
**Client:** AECOM Australia Pty Ltd  
 PO Box 3175, Darwin NT 0801  
**Contact:** David van de Hoek  
**Project Number:** 215285.00  
**Project Name:** Project 60623736 - February  
**Project Location:** Not Supplied, - NT  
**Client Reference:** Project 60623736  
**Work Request:** 4176  
**Sample Number:** DW-4176B  
**Date Sampled:** 06/05/2022  
**Dates Tested:** 10/05/2022 - 12/05/2022  
**Sampling Method:** Sampled by Client  
*The results apply to the sample as received*  
**Sample Location:** AMS2 - Gravel Pit  
**Material:** Silty Sandy Gravel



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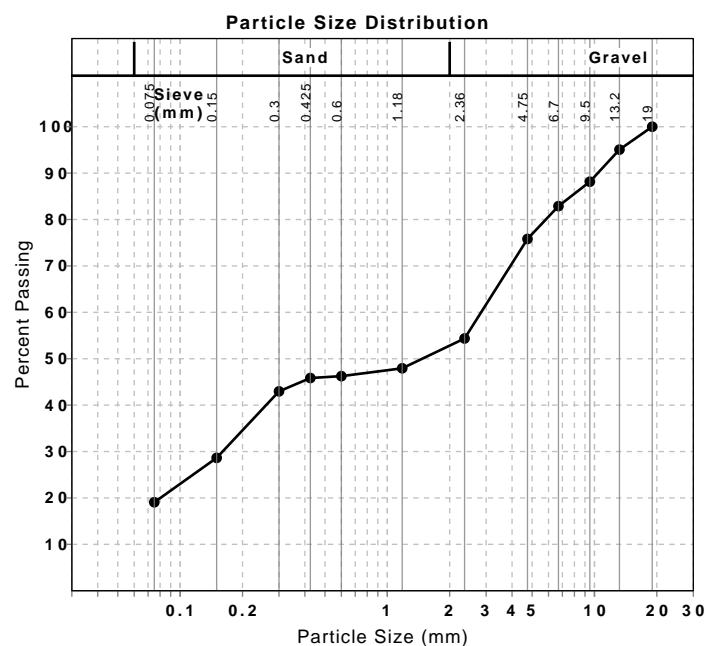
Approved Signatory: Sunil Sukhdeo  
 Laboratory Manager  
 Laboratory Accreditation Number: 828

Particle Size Distribution (AS1289 3.6.1)		
Sieve	Passed %	Passing Limits
19 mm	100	
13.2 mm	95	
9.5 mm	88	
6.7 mm	83	
4.75 mm	76	
2.36 mm	54	
1.18 mm	48	
0.6 mm	46	
0.425 mm	46	
0.3 mm	43	
0.15 mm	29	
0.075 mm	19	

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	Not Obtainable		
Plastic Limit (%)	Not Obtainable		
<b>Plasticity Index (%)</b>	<b>Non Plastic</b>		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	0.0		
Cracking Crumbling Curling	Cracking		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	8		
Soil Description	Natural Soil		
Nature of Water	Demineralised Water		
Temperature of Water (°C)	26.5		



# Material Test Report

**Report Number:** 215285.00-1  
**Issue Number:** 1  
**Date Issued:** 13/05/2022  
**Client:** AECOM Australia Pty Ltd  
 PO Box 3175, Darwin NT 0801  
**Contact:** David van de Hoek  
**Project Number:** 215285.00  
**Project Name:** Project 60623736 - February  
**Project Location:** Not Supplied, - NT  
**Client Reference:** Project 60623736  
**Work Request:** 4176  
**Sample Number:** DW-4176C  
**Date Sampled:** 06/05/2022  
**Dates Tested:** 10/05/2022 - 12/05/2022  
**Sampling Method:** Sampled by Client  
*The results apply to the sample as received*  
**Sample Location:** AMS2  
**Material:** Silty Gravel



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Approved Signatory: Sunil Sukhdeo

Laboratory Manager

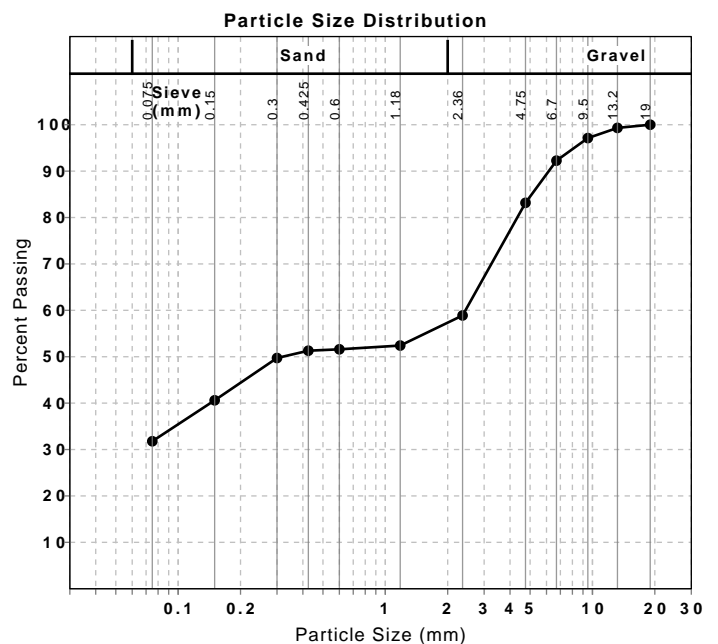
Laboratory Accreditation Number: 828

Particle Size Distribution (AS1289 3.6.1)		
Sieve	Passed %	Passing Limits
19 mm	100	
13.2 mm	99	
9.5 mm	97	
6.7 mm	92	
4.75 mm	83	
2.36 mm	59	
1.18 mm	52	
0.6 mm	52	
0.425 mm	51	
0.3 mm	50	
0.15 mm	41	
0.075 mm	32	

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	16		
Plastic Limit (%)	10		
<b>Plasticity Index (%)</b>	<b>6</b>		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	2.5		
Cracking Crumbling Curling	Cracking		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	2		
Soil Description	Natural Soil		
Nature of Water	Demineralised Water		
Temperature of Water (°C)	25.6		



# Material Test Report

**Report Number:** 215285.00-1  
**Issue Number:** 1  
**Date Issued:** 13/05/2022  
**Client:** AECOM Australia Pty Ltd  
 PO Box 3175, Darwin NT 0801  
**Contact:** David van de Hoek  
**Project Number:** 215285.00  
**Project Name:** Project 60623736 - February  
**Project Location:** Not Supplied, - NT  
**Client Reference:** Project 60623736  
**Work Request:** 4176  
**Sample Number:** DW-4176D  
**Date Sampled:** 03/05/2022  
**Dates Tested:** 10/05/2022 - 12/05/2022  
**Sampling Method:** Sampled by Client  
*The results apply to the sample as received*  
**Sample Location:** AMS3  
**Material:** Silty Sandy Gravel



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Approved Signatory: Sunil Sukhdeo  
 Laboratory Manager

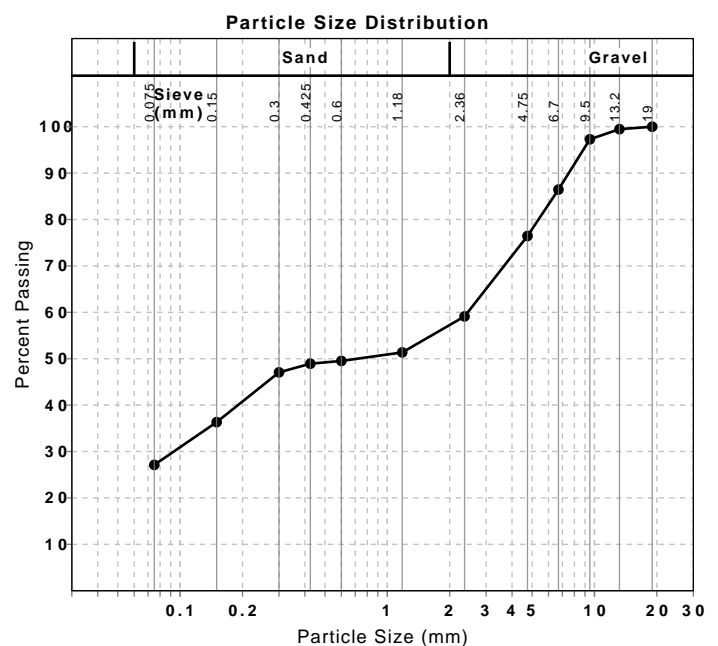
Laboratory Accreditation Number: 828

Particle Size Distribution (AS1289 3.6.1)		
Sieve	Passed %	Passing Limits
19 mm	100	
13.2 mm	99	
9.5 mm	97	
6.7 mm	86	
4.75 mm	76	
2.36 mm	59	
1.18 mm	51	
0.6 mm	50	
0.425 mm	49	
0.3 mm	47	
0.15 mm	36	
0.075 mm	27	

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	14		
Plastic Limit (%)	12		
<b>Plasticity Index (%)</b>	<b>2</b>		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	1.0		
Cracking Crumbling Curling	Cracking		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	<b>8</b>		
Soil Description	Natural soil		
Nature of Water	Demineralised Water		
Temperature of Water (°C)	26.6		



# Material Test Report

**Report Number:** 215285.00-1  
**Issue Number:** 1  
**Date Issued:** 13/05/2022  
**Client:** AECOM Australia Pty Ltd  
 PO Box 3175, Darwin NT 0801  
**Contact:** David van de Hoek  
**Project Number:** 215285.00  
**Project Name:** Project 60623736 - February  
**Project Location:** Not Supplied, - NT  
**Client Reference:** Project 60623736  
**Work Request:** 4176  
**Sample Number:** DW-4176E  
**Date Sampled:** 05/05/2022  
**Dates Tested:** 10/05/2022 - 12/05/2022  
**Sampling Method:** Sampled by Client  
*The results apply to the sample as received*  
**Sample Location:** AMS4  
**Material:** Clayey Sandy Gravel



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Approved Signatory: Sunil Sukhdeo  
 Laboratory Manager

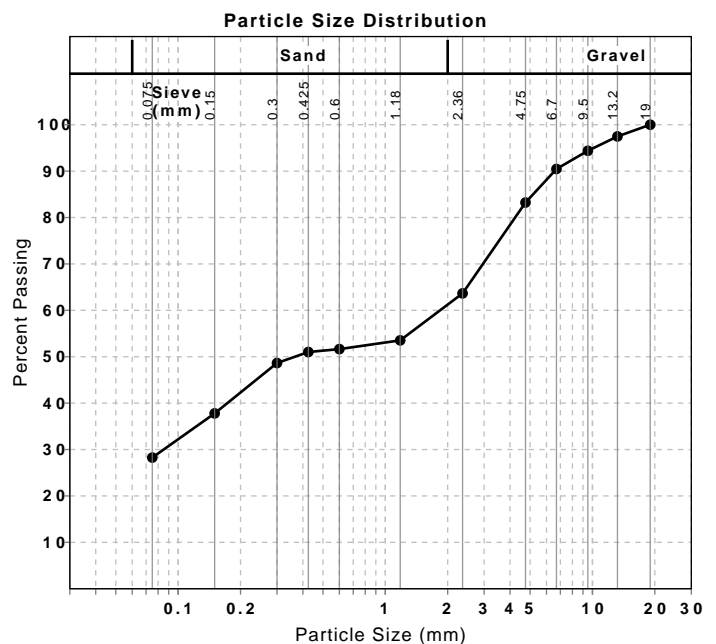
Laboratory Accreditation Number: 828

Particle Size Distribution (AS1289 3.6.1)		
Sieve	Passed %	Passing Limits
19 mm	100	
13.2 mm	97	
9.5 mm	94	
6.7 mm	90	
4.75 mm	83	
2.36 mm	64	
1.18 mm	54	
0.6 mm	52	
0.425 mm	51	
0.3 mm	49	
0.15 mm	38	
0.075 mm	28	

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	21		
Plastic Limit (%)	11		
<b>Plasticity Index (%)</b>	<b>10</b>		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	4.0		
Cracking Crumbling Curling	Cracking		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	2		
Soil Description	Natural Soil		
Nature of Water	Demineralised Water		
Temperature of Water (°C)	25.6		



# Material Test Report

**Report Number:** 215285.00-1  
**Issue Number:** 1  
**Date Issued:** 13/05/2022  
**Client:** AECOM Australia Pty Ltd  
 PO Box 3175, Darwin NT 0801  
**Contact:** David van de Hoek  
**Project Number:** 215285.00  
**Project Name:** Project 60623736 - February  
**Project Location:** Not Supplied, - NT  
**Client Reference:** Project 60623736  
**Work Request:** 4176  
**Sample Number:** DW-4176F  
**Date Sampled:** 04/05/2022  
**Dates Tested:** 10/05/2022 - 12/05/2022  
**Sampling Method:** Sampled by Client  
*The results apply to the sample as received*  
**Sample Location:** AMS1-1  
**Material:** Silty Sandy Gravel



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Approved Signatory: Sunil Sukhdeo  
 Laboratory Manager

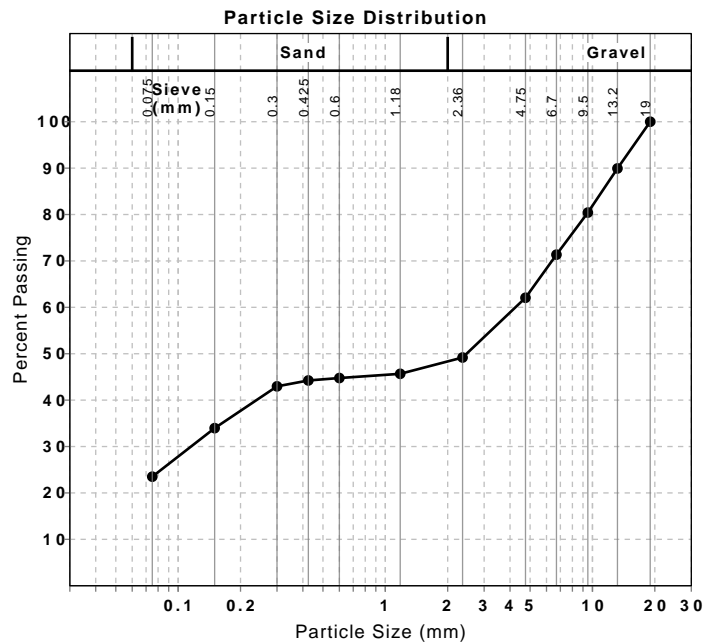
Laboratory Accreditation Number: 828

Particle Size Distribution (AS1289 3.6.1)		
Sieve	Passed %	Passing Limits
19 mm	100	
13.2 mm	90	
9.5 mm	80	
6.7 mm	71	
4.75 mm	62	
2.36 mm	49	
1.18 mm	46	
0.6 mm	45	
0.425 mm	44	
0.3 mm	43	
0.15 mm	34	
0.075 mm	24	

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	15		
Plastic Limit (%)	12		
<b>Plasticity Index (%)</b>	<b>3</b>		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	1.5		
Cracking Crumbling Curling	Cracking		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	6		
Soil Description	Natural Soil		
Nature of Water	Demineralised Water		
Temperature of Water (°C)	25.6		



# Material Test Report

**Report Number:** 215285.00-1  
**Issue Number:** 1  
**Date Issued:** 13/05/2022  
**Client:** AECOM Australia Pty Ltd  
 PO Box 3175, Darwin NT 0801  
**Contact:** David van de Hoek  
**Project Number:** 215285.00  
**Project Name:** Project 60623736 - February  
**Project Location:** Not Supplied, - NT  
**Client Reference:** Project 60623736  
**Work Request:** 4176  
**Sample Number:** DW-4176G  
**Date Sampled:** 04/05/2022  
**Dates Tested:** 10/05/2022 - 12/05/2022  
**Sampling Method:** Sampled by Client  
*The results apply to the sample as received*  
**Sample Location:** AMS1 - Gravel Pit  
**Material:** Silty Sandy Gravel



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Approved Signatory: Sunil Sukhdeo  
 Laboratory Manager

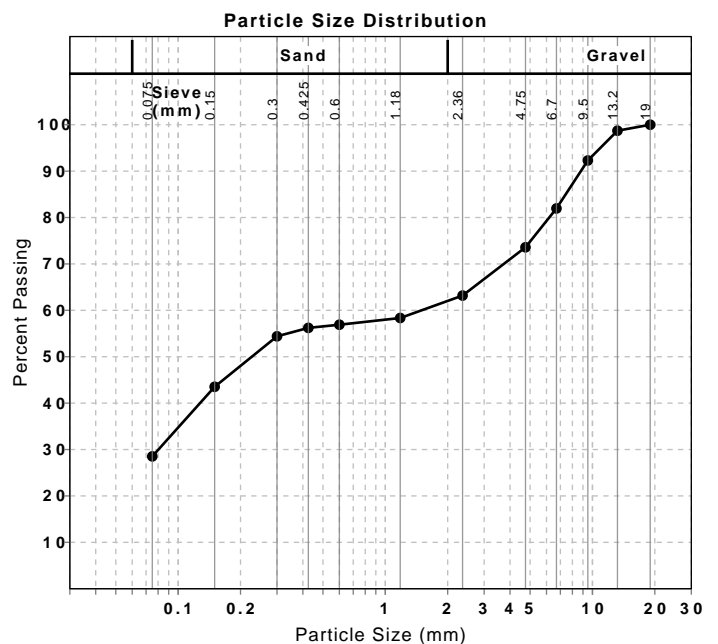
Laboratory Accreditation Number: 828

Particle Size Distribution (AS1289 3.6.1)		
Sieve	Passed %	Passing Limits
19 mm	100	
13.2 mm	99	
9.5 mm	92	
6.7 mm	82	
4.75 mm	74	
2.36 mm	63	
1.18 mm	58	
0.6 mm	57	
0.425 mm	56	
0.3 mm	54	
0.15 mm	44	
0.075 mm	29	

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	17		
Plastic Limit (%)	12		
<b>Plasticity Index (%)</b>	<b>5</b>		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	1.5		
Cracking Crumbling Curling	Cracking		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	7		
Soil Description	Natural Soil		
Nature of Water	Demineralised Water		
Temperature of Water (°C)	25.6		

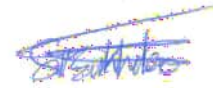


# Material Test Report

**Report Number:** 215285.00-1  
**Issue Number:** 1  
**Date Issued:** 13/05/2022  
**Client:** AECOM Australia Pty Ltd  
 PO Box 3175, Darwin NT 0801  
**Contact:** David van de Hoek  
**Project Number:** 215285.00  
**Project Name:** Project 60623736 - February  
**Project Location:** Not Supplied, - NT  
**Client Reference:** Project 60623736  
**Work Request:** 4176  
**Sample Number:** DW-4176H  
**Date Sampled:** 04/05/2022  
**Dates Tested:** 10/05/2022 - 13/05/2022  
**Sampling Method:** Sampled by Client  
*The results apply to the sample as received*  
**Sample Location:** AMS1-2  
**Material:** Gravelly Clay



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Approved Signatory: Sunil Sukhdeo  
 Laboratory Manager

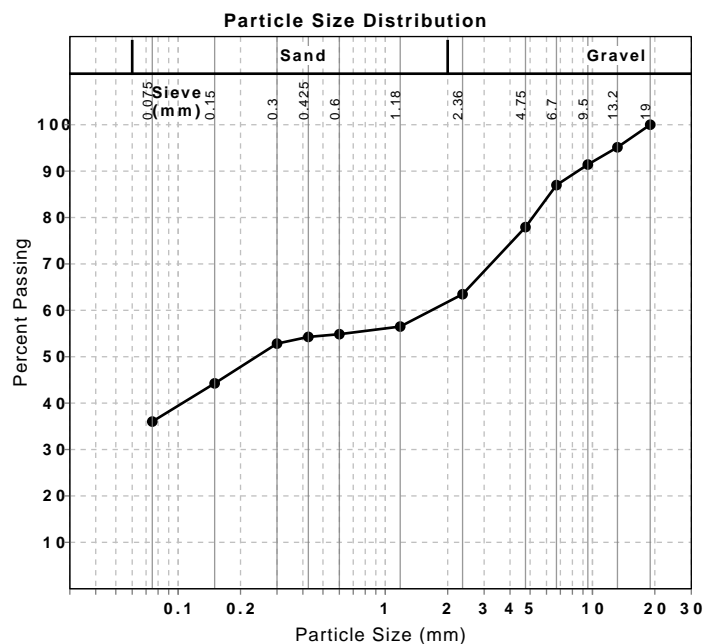
Laboratory Accreditation Number: 828

Particle Size Distribution (AS1289 3.6.1)		
Sieve	Passed %	Passing Limits
19 mm	100	
13.2 mm	95	
9.5 mm	91	
6.7 mm	87	
4.75 mm	78	
2.36 mm	63	
1.18 mm	56	
0.6 mm	55	
0.425 mm	54	
0.3 mm	53	
0.15 mm	44	
0.075 mm	36	

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	22		
Plastic Limit (%)	12		
<b>Plasticity Index (%)</b>	<b>10</b>		


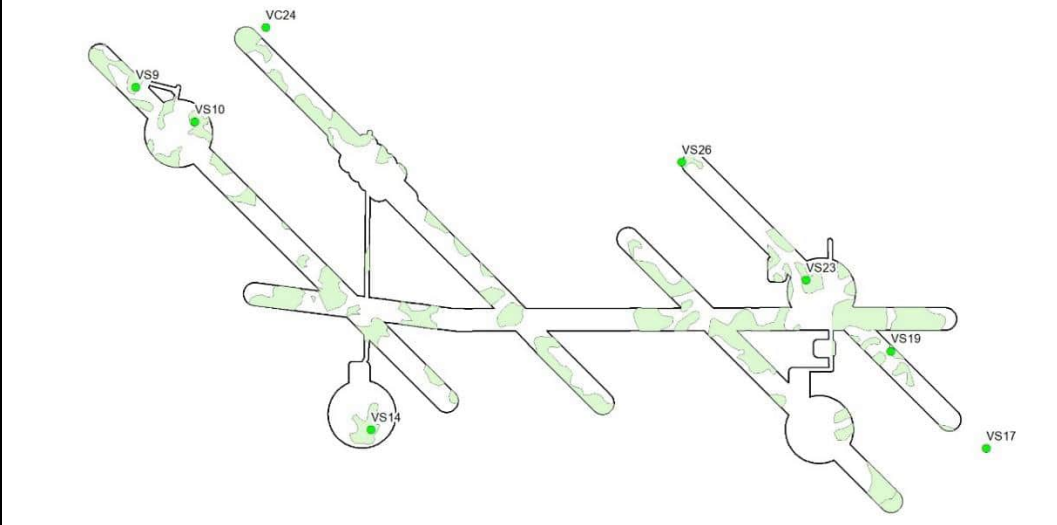
Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	4.0		
Cracking Crumbling Curling	Cracking		


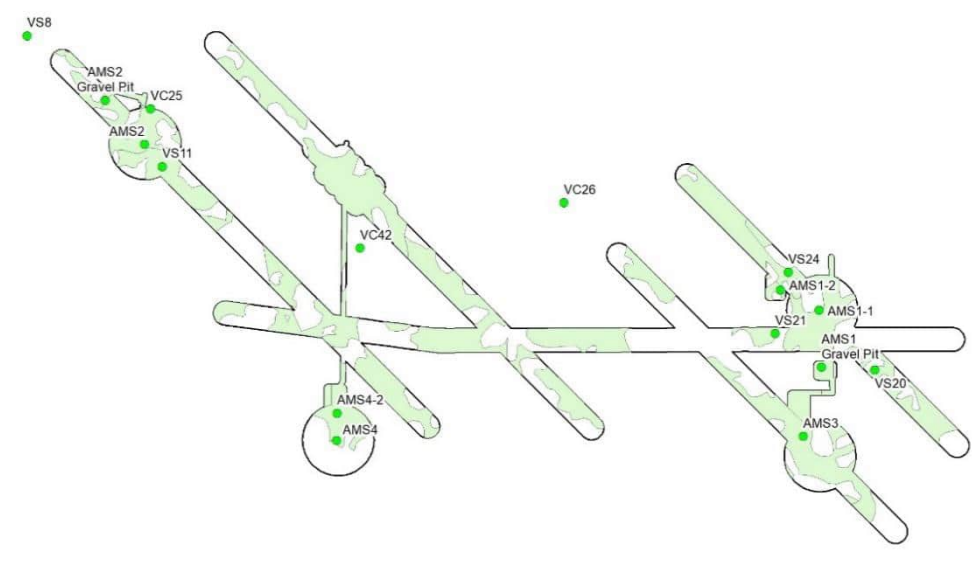
Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	6		
Soil Description	Natural Soil		
Nature of Water	Demineralised Water		
Temperature of Water (°C)	25		




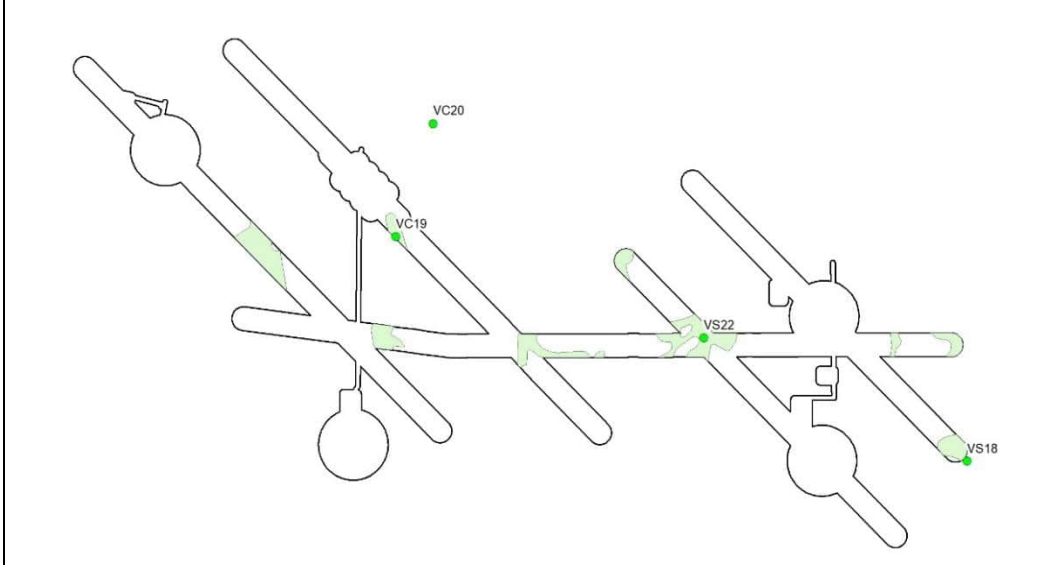
# Appendix B


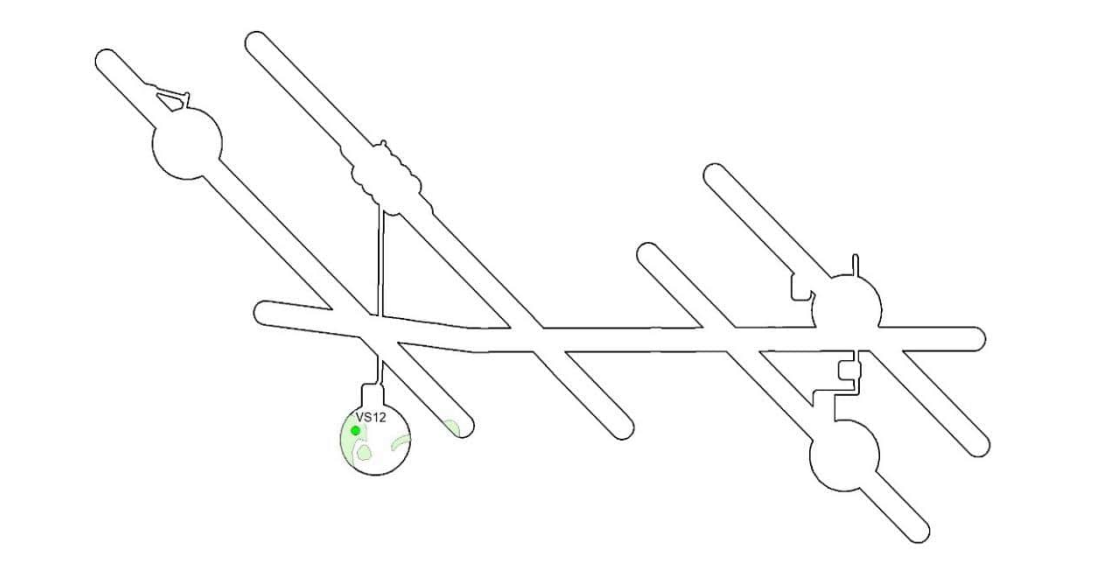
## Vegetation Community Description


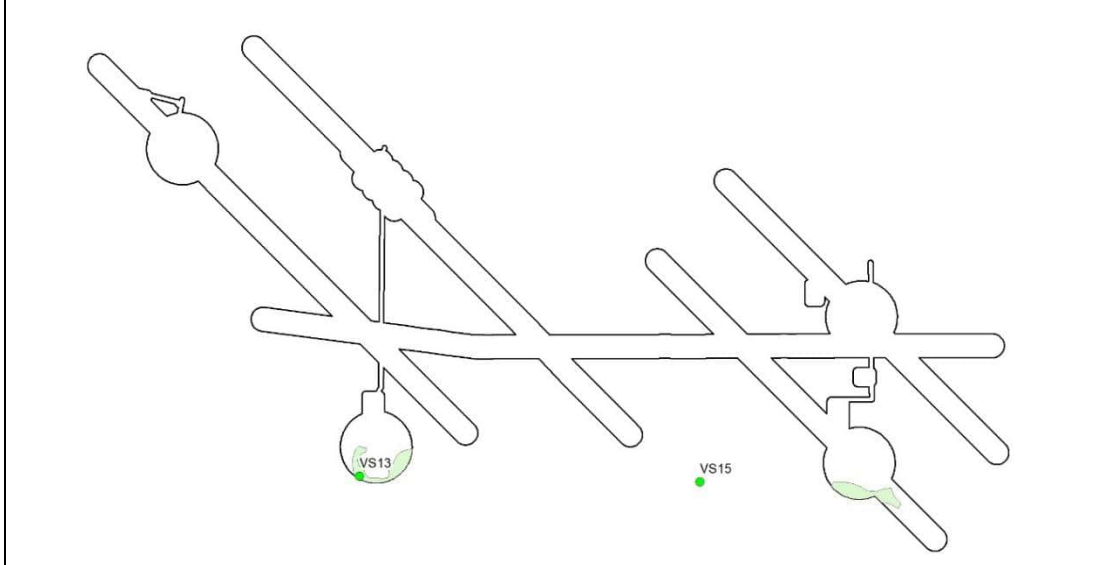
<b>Community 1a (NVIS Code: T7r) - <i>Acacia shirleyi</i> ± <i>Corymbia polycarpa</i> mid high woodland, over <i>Macropteranthes kekwickii</i>, <i>Terminalia volucris</i>, <i>Santalum lanceolatum</i> mid high shrubland, over <i>Scleria brownii</i>, <i>Chrysopogon fallax</i>, <i>Schizachyrium fragile</i> mid high tussock grassland.</b>					
<b>Upper 1:</b> Mid high open woodland dominated by <i>Acacia shirleyi</i> (fq 100%), <i>Corymbia polycarpa</i> (fq 20%), <i>Macropteranthes kekwickii</i> (20%)					
<b>Mid 1:</b> Mid high shrubland dominated by <i>Macropteranthes kekwickii</i> (fq 100%), <i>Terminalia volucris</i> (fq 100%), <i>Santalum lanceolatum</i> (fq 66%),					
<b>Ground 1:</b> Mid high open tussock grassland dominated by <i>Scleria brownii</i> (fq 50%), <i>Chrysopogon fallax</i> (fq 20%) <i>Schizachyrium fragile</i> (fq 20%)					
					
<b>No. of sites:</b>	(10) VC6, VC7, VC24, VS9, VS10, VS14, VS17, VS19, VS23, VS26				
<b>Other species:</b>	<b>Upper stratum (U1):</b> - <i>Macropteranthes kekwickii</i>	<b>Mid stratum (M1):</b> <i>Acacia shirleyi</i> (fq 10%), <i>Atalaya hemiglauca</i> (fq 10%)	<b>Ground stratum (G1):</b> <i>Bidens bipinnata</i> (fq 10%), <i>Eriachne armitii</i> (fq 10%), <i>Waltheria indica</i> (fq 10%), <i>Abutilon fraseri</i> (fq 10%), <i>Aristida calycina</i> (fq 10%), <i>Jasminum molle</i> (fq 10%)		
<b>Landform:</b>	Lateritic Plains and Rises -associated with deeply weathered profiles (laterite) including sand sheets and other depositional products, sandy and earth soils	<b>Soils:</b>	Brown sandy loam kandosol soils.	<b>Total area of the survey area:</b>	1857.305 ha (32.8 %)
<b>Community 1a Structural Summary</b>					
<b>Strata</b>	<b>Modal Growth Form</b>	<b>Mean Cover %</b>	<b>Mean Height (m)</b>	<b>NVIS code</b>	
Upper U1	Tree	36.9 (20–70)	10.9 (10-30)	T7r	
Mid M1	Shrub	33.5 (15– 70)	6.8 (5-8)	S2c	
Ground G1	Tussock grass	11.0 (5–20)	0.6 (0.5–1)	G2i	

<b>Community 2a (NVIS Code: T7r) - <i>Corymbia dichromophloia</i>, ± <i>Erythrophleum chlorostachys</i>, ± <i>Eucalyptus chlorophylla</i> mid high open woodland, over <i>Terminalia canescens</i>, <i>Petalostigma pubescens</i>, <i>Erythrophleum chlorostachys</i> mid high open shrubland, over <i>Chrysopogon fallax</i>, ± <i>Sorghum plumosum</i>, <i>Themeda triandra</i> mid high open tussock grassland.</b>			
<b>Upper 1:</b> Mid high open woodland dominated by <i>Corymbia dichromophloia</i> (fq 80%), <i>Erythrophleum chlorostachys</i> (fq 35%), <i>Eucalyptus chlorophylla</i> (fq 30%)			
<b>Mid 1:</b> Mid high open shrubland dominated by <i>Terminalia canescens</i> (fq 55%), <i>Petalostigma pubescens</i> (fq 45%), <i>Erythrophleum chlorostachys</i> (35%)			
<b>Ground 1:</b> Mid high open tussock grassland dominated by <i>Chrysopogon fallax</i> (fq 85%), ± <i>Schizachyrium fragile</i> (fq 20%), ± <i>Themeda triandra</i> (fq 15%)			
			
<b>No. of sites:</b>	(21) VC5, VC8, VC18, VC21, VC25, VC26, VC42, AMS1-1, AMS1-2, AMS1 GravelPit, AMS2, AMS2 GravelPit, AMS3, AMS4, AMS4-2, AMS5, VS8, VS11, VS20, VS21, VS24		
<b>Other species:</b>	<b>Upper stratum (U1):</b> <i>Acacia shirleyi</i> (20%), <i>Eucalyptus leucophloia</i> (fq 10%), <i>Terminalia canescens</i> (fq 5%), <i>Corymbia ferruginea</i> (fq 5%), <i>Grevillea parallela</i> (fq 5%)	<b>Mid stratum (M1):</b> <i>Acacia calligera</i> (fq 20%), <i>A. difficilis</i> (fq 5%), <i>Alphitonia excelsa</i> (fq 20%), <i>Hakea arborescens</i> (fq 20%), <i>Corymbia ferruginea</i> (fq 15%), <i>Grevillea parallela</i> (fq 15%), <i>Terminalia volucris</i> (fq 15%), <i>Macropteranthes kekwickii</i> (fq 10%), <i>Carissa lanceolata</i> (fq 5%), <i>Eucalyptus leucophloia</i> (fq 5%), <i>Calytrix exstipulata</i> (fq 5%), <i>Bauhinia cunninghamii</i> (fq 5%), <i>Santalum lanceolatum</i> (fq 5%)	<b>Ground stratum (G1):</b> <i>Sorghum plumosum</i> (15%), <i>Sehima nervosum</i> (fq 15%), <i>Eriachne ciliata</i> (fq 15%), <i>Triodia bitextura</i> (fq 15%), <i>Sorghum timorense</i> (fq 5%), <i>Waltheria indica</i> (fq 5%), <i>Aristida inaequiglumis</i> (fq 5%), <i>Hakea arborescens</i> (fq 5%)

<b>Landform:</b>	Lateritic Plains and Rises - associated with deeply weathered profiles (laterite) including sand sheets and other depositional products, sandy and earth soils.	<b>Soils:</b>	Brown sandy loam kandosol soils.	<b>Total area of the survey area:</b>	3104.08 ha (54.9%)
<b>Community 2a Structural Summary</b>					
<b>Strata</b>	<b>Modal Growth Form</b>	<b>Mean Cover %</b>	<b>Mean Height (m)</b>	<b>NVIS code</b>	
Upper U1	Tree	17.4 (6-30)	11.6 (7-14)	T7r	
Mid M1	Shrub	15.7 (5-30)	6.5 (5-8)	S2i	
Ground G1	Tussock grass	25 (5-50)	0.7 (0.5-1)	G2i	

<b>Community 3a (NVIS Code: T6r) - <i>Eucalyptus chlorophylla</i>, <i>Corymbia polycarpa</i>, ± <i>Corymbia dichromophloia</i> mid high open woodland, over <i>Eucalyptus chlorophylla</i>, ± <i>Corymbia ferruginea</i>, ± <i>Terminalia canescens</i>, mid high open shrubland, over <i>Chrysopogon fallax</i> mid high open tussock grassland</b>				
<b>Upper 1:</b> Mid high open woodland dominated by <i>Eucalyptus chlorophylla</i> (fq 83%), <i>Corymbia polycarpa</i> (fq 50%), ± <i>Corymbia dichromophloia</i> (fq 33%)				
<b>Mid 1:</b> Mid high open shrubland dominated by <i>Eucalyptus chlorophylla</i> (fq 66%), ± <i>Terminalia canescens</i> (fq 16%), ± <i>Corymbia ferruginea</i> (fq 16%)				
<b>Ground 1:</b> Mid high open tussock grassland dominated by <i>Chrysopogon fallax</i> (fq 83%)				
				
<b>No. of sites:</b>	(6) VC19, VC20, VC22, VC23, VS18, VS22			
<b>Other species:</b>	<b>Upper stratum (U1):</b> <i>Erythrophleum chlorostachys</i> (fq 16%), <i>Eucalyptus camaldulensis</i> (fq 16%)	<b>Mid stratum (M1):</b> <i>Acacia pellita</i> (fq 16%), <i>Grevillea parallela</i> (fq 16%), <i>Petalostigma pubescens</i> (fq 16%), <i>Terminalia volucris</i> (fq 16%), <i>Acacia difficilis</i> (fq 16%), <i>Ehretia saligna</i> (fq 16%),	<b>Ground stratum (G1):</b> - <i>Dichanthium fecundum</i> (fq 16%), <i>Eulalia aurea</i> (fq 16%), <i>Themeda triandra</i> (fq 16%), <i>Panicum sp</i> (fq 16%).	
<b>Landform:</b>	Drainage floors and relic drainages associated with clay and alluvial soils	<b>Soils:</b>	Reddish brown clay soils	<b>Total area of the survey area:</b> 325.32 ha (5.8%)
<b>Community 3a structural summary</b>				
<b>Strata</b>	<b>Modal Growth Form</b>	<b>Mean Cover %</b>	<b>Mean Height (m)</b>	<b>NVIS code</b>
Upper U1	Tree	16.8 (15 - 22)	10.3 (8 - 12)	T6r
Mid M1	Shrub	11.3 (6 - 20)	5.8 (5-8)	S2i
Ground G1	Tussock grass	13.3 (5 - 20)	0.8 (0.5 - 1)	G2i

<b>Community 3b (NVIS Code: T6r) - <i>Eucalyptus microtheca</i> low open woodland, over <i>Terminalia volucris</i>, <i>Ehretia saligna</i>, mid high sparse shrubland, over <i>Aristida inaequiglumis</i>, <i>Eulalia aurea</i> mid high tussock grassland.</b>					
<b>Upper 1:</b> Low woodland dominated by <i>Eucalyptus microtheca</i> (fq 100%), <i>Macropteranthes kekwickii</i> (fq 100%)					
<b>Mid 1:</b> Mid high Open shrubland dominated by <i>Macropteranthes kekwickii</i> (fq 100%), <i>Eucalyptus microtheca</i> (fq 100%), <i>Brachychiton diversifolius</i> (fq 50%).					
<b>Ground 1:</b> Mid high open tussock grassland dominated by <i>Chrysopogon fallax</i> (fq 100%), <i>Sorghum plumosum</i> (fq 100%).					
					
<b>No. of sites:</b>	(1) VS12		<b>Other common species:</b>	None	
<b>Landform:</b>	Drainage floors and relic drainages associated with clay and alluvial soils	<b>Soils:</b>	Reddish brown clay soils	<b>Total area of the survey area:</b>	103.50 ha (1.8%)
<b>Community 3b structural summary</b>					
<b>Strata</b>	<b>Modal Growth Form</b>	<b>Mean Cover %</b>	<b>Mean Height (m)</b>	<b>NVIS code</b>	
Upper U1	Tree	6	8	T6r	
Mid M1	Shrub	5	4	S3r	
Ground G1	Tussock grass	40	1	G2i	

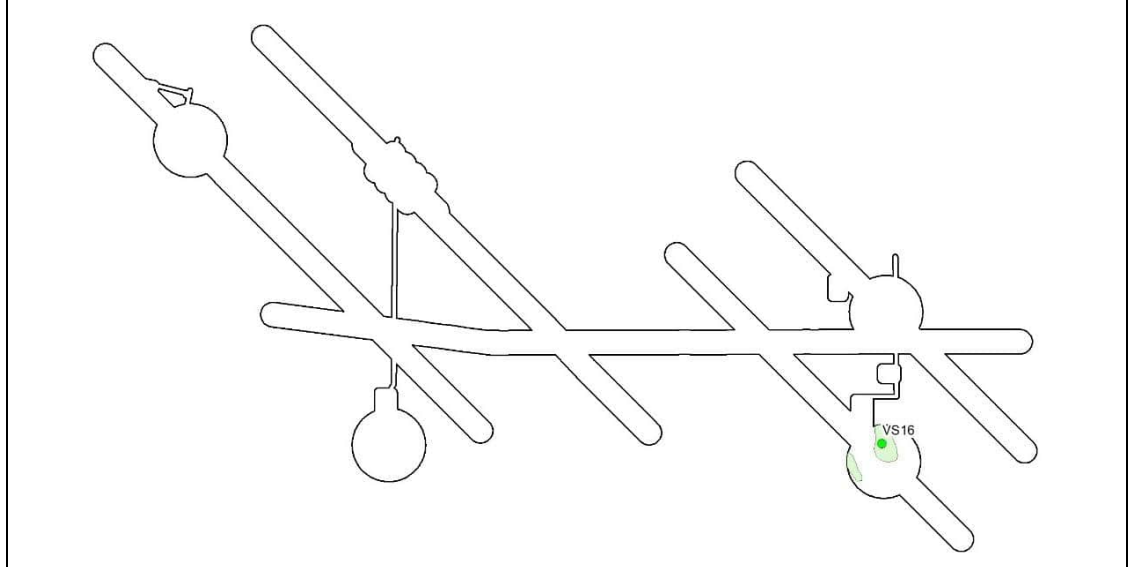
<b>Community 4a (NVIS Code: T6i) - <i>Eucalyptus microtheca</i>, <i>Macropteranthes kekwickii</i> low woodland, over <i>Macropteranthes kekwickii</i>, <i>Eucalyptus microtheca</i>, <i>Brachychiton diversifolius</i> mid high open shrubland, over <i>Chrysopogon fallax</i>, <i>Sorghum plumosum</i> mid high open tussock grassland.</b>					
<b>Upper 1:</b> Low woodland dominated by <i>Eucalyptus microtheca</i> (fq 100%), <i>Macropteranthes kekwickii</i> (fq 100%)					
<b>Mid 1:</b> Mid high Open shrubland dominated by <i>Macropteranthes kekwickii</i> (fq 100%), <i>Eucalyptus microtheca</i> (fq 100%), <i>Brachychiton diversifolius</i> (fq 50%).					
<b>Ground 1:</b> Mid high open tussock grassland dominated by <i>Chrysopogon fallax</i> (fq 100%), <i>Sorghum plumosum</i> (fq 100%).					
					
<b>No. of sites:</b>	(2) VS13, VS15		<b>Other common species:</b>	None	
<b>Landform:</b>	Closed drainage depression associated with clay and alluvial soils	<b>Soils:</b>	Reddish brown clay soils	<b>Total area of the survey area:</b>	227.80 ha (4.0%)
<b>Community 4a Structural Summary</b>					
<b>Strata</b>	<b>Modal Growth Form</b>	<b>Mean Cover %</b>	<b>Mean Height (m)</b>	<b>NVIS code</b>	
Upper U1	Tree	27.5 (20-35)	7.5 (7-8)	T6i	
Mid M1	Shrub	17.5 (15-20)	5	S3i	
Ground G1	Tussock grass	21 (2-40)	0.8 (0.5-1)	G3i	

**Community 4b (NVIS Code: T6i) - *Lophostemon grandiflorus*, *Macropteranthes kekwickii* low woodland, over *Acacia difficilis*, *Grewia retusifolia* mid high open shrubland, over *Chrysopogon fallax*, *Eulalia aurea*, *Themeda triandra* mid high open tussock grassland**

**Upper 1:** Low woodland dominated by *Lophostemon grandiflorus* (fq 100%), *Macropteranthes kekwickii* (fq 100%)

**Mid 1:** Mid high open shrubland dominated by *Acacia difficilis* (fq 100%), *Grewia retusifolia* (fq 100%).

**Ground 1:** Mid high open tussock grassland dominated by *Chrysopogon fallax* (fq 100%), *Eulalia aurea* (fq 100%), *Themeda triandra* (fq 100%).



<b>No. of sites:</b>	(1) VS16	<b>Other common species:</b>	None
<b>Landform:</b>	Closed drainage depression associated with clay and alluvial soils	<b>Soils:</b>	Reddish brown clay soils
		<b>Total area of the survey area:</b>	36.30 ha (0.6%)

**Community 4b Structural Summary**

Strata	Modal Growth Form	Mean Cover %	Mean Height (m)	NVIS code
Upper U1	Tree	35.0	8	T6i
Mid M1	Shrub	30	5	S3i
Ground G1	Tussock grass	20	0.5	G3i

# Appendix C

Flora Atlas Species  
Records

## Appendix C Flora Atlas Species Records

Table 35 Native flora recorded within 5 km of the project area

Family	Genus	Species
ACANTHACEAE	<i>Dicliptera</i>	<i>armata</i>
	<i>Hygrophila</i>	<i>angustifolia</i>
AMARANTHACEAE	<i>Achyranthes</i>	<i>aspera</i>
	<i>Alternanthera</i>	<i>denticulata</i>
	<i>Alternanthera</i>	<i>nana</i>
	<i>Alternanthera</i>	<i>nodiflora</i>
	<i>Ptilotus</i>	<i>fusiformis</i>
	<i>Ptilotus</i>	<i>polystachyus</i>
	<i>Ptilotus</i>	<i>spicatus</i>
APOCYNACEAE	<i>Carissa</i>	<i>lanceolata</i>
	<i>Cynanchum</i>	<i>viminale</i>
	<i>Marsdenia</i>	<i>australis</i>
	<i>Marsdenia</i>	<i>geminata</i>
	<i>Marsdenia</i>	<i>viridiflora</i>
	<i>Secamone</i>	<i>elliptica</i>
ASTERACEAE	<i>Bidens</i>	<i>bipinnata</i>
	<i>Pterocaulon</i>	<i>serrulatum</i>
	<i>Pterocaulon</i>	<i>sphacelatum</i>
BIGNONIACEAE	<i>Dolichandrone</i>	<i>heterophylla</i>
BORAGINACEAE	<i>Ehretia</i>	<i>saligna</i>
	<i>Heliotropium</i>	<i>ramulipatens</i>
CAPPARACEAE	<i>Capparis</i>	<i>lasiantha</i>
	<i>Capparis</i>	<i>umbonata</i>
CARYOPHYLLACEAE	<i>Polycarpaea</i>	<i>breviflora</i>
CELASTRACEAE	<i>Denhamia</i>	<i>cunninghamii</i>
	<i>Denhamia</i>	<i>obscura</i>
CLEOMACEAE	<i>Cleome</i>	<i>viscosa</i>
COMBRETACEAE	<i>Macropteranthes</i>	<i>kekwickii</i>
	<i>Terminalia</i>	<i>canescens</i>
	<i>Terminalia</i>	<i>volucris</i>
COMMELINACEAE	<i>Commelina</i>	<i>ciliata</i>
	<i>Cyanotis</i>	<i>axillaris</i>
CONVOLVULACEAE	<i>Bonamia</i>	<i>pannosa</i>
	<i>Evolvulus</i>	<i>alsinoides</i>

CONVOLVULACEAE	<i>Ipomoea</i>	<i>argillicola</i>
	<i>Ipomoea</i>	<i>diamantinensis</i>
	<i>Ipomoea</i>	<i>eriocarpa</i>
	<i>Ipomoea</i>	<i>gracilis</i>
	<i>Ipomoea</i>	<i>polymorpha</i>
	<i>Polymeria</i>	<i>longifolia</i>
	<i>Xenostegia</i>	<i>tridentata</i>
CUCURBITACEAE	<i>Cucumis</i>	<i>melo</i>
CYPERACEAE	<i>Bulbostylis</i>	<i>barbata</i>
	<i>Cyperus</i>	<i>carinatus</i>
	<i>Cyperus</i>	<i>tenuispica</i>
	<i>Eleocharis</i>	<i>atropurpurea</i>
	<i>Eleocharis</i>	<i>brassii</i>
	<i>Fimbristylis</i>	<i>depauperata</i>
	<i>Fimbristylis</i>	<i>laxiglumis</i>
	<i>Fimbristylis</i>	<i>microcarya</i>
	<i>Fimbristylis</i>	<i>phaeoleuca</i>
	<i>Schoenoplectiella</i>	<i>dissachantha</i>
	<i>Schoenoplectiella</i>	<i>laevis</i>
ELATINACEAE	<i>Bergia</i>	<i>pedicellaris</i>
ERIOCAULACEAE	<i>Eriocaulon</i>	<i>cinereum</i>
EUPHORBIACEAE	<i>Euphorbia</i>	<i>australis</i>
	<i>Euphorbia</i>	<i>bifida</i>
	<i>Excoecaria</i>	<i>parvifolia</i>
FABACEAE	<i>Abrus</i>	<i>preparatorius</i>
	<i>Acacia</i>	<i>ancistrocarpa</i>
	<i>Acacia</i>	<i>hammondii</i>
	<i>Acacia</i>	<i>lysiphloia</i>
	<i>Acacia</i>	<i>monticola</i>
	<i>Acacia</i>	<i>shirleyi</i>
	<i>Acacia</i>	<i>stenophylla</i>
	<i>Aeschynomene</i>	<i>indica</i>
	<i>Bauhinia</i>	<i>cunninghamii</i>
	<i>Chamaecrista</i>	<i>absus</i>
	<i>Crotalaria</i>	<i>medicaginea</i>
	<i>Crotalaria</i>	<i>montana</i>
	<i>Desmodium</i>	<i>muelleri</i>
	<i>Dichrostachys</i>	<i>spicata</i>

FABACEAE	<i>Erythrophleum</i>	<i>chlorostachys</i>
	<i>Flemingia</i>	<i>parviflora</i>
	<i>Galactia</i>	<i>tenuiflora</i>
	<i>Neptunia</i>	<i>gracilis</i>
	<i>Neptunia</i>	<i>monosperma</i>
	<i>Petalostylis</i>	<i>cassioides</i>
	<i>Rhynchosia</i>	<i>minima</i>
	<i>Sesbania</i>	<i>cannabina</i>
	<i>Sesbania</i>	<i>muelleri</i>
	<i>Tephrosia</i>	<i>brachyodon</i>
	<i>Vigna</i>	<i>lanceolata</i>
	<i>Vigna</i>	<i>sp. McDonald Downs Station</i>
	<i>Zornia</i>	<i>muriculata</i>
GOODENIACEAE	<i>Goodenia</i>	<i>byrnesii</i>
	<i>Goodenia</i>	<i>minutiflora</i>
	<i>Goodenia</i>	<i>strangfordii</i>
	<i>Goodenia</i>	<i>viscidula</i>
	<i>Scaevola</i>	<i>browniana</i>
	<i>Scaevola</i>	<i>ovalifolia</i>
HYDROLEACEAE	<i>Hydrolea</i>	<i>zeylanica</i>
LAMIACEAE	<i>Clerodendrum</i>	<i>floribundum</i>
LORANTHACEAE	<i>Amyema</i>	<i>sanguinea</i>
LYTHRACEAE	<i>Ammannia</i>	<i>multiflora</i>
	<i>Rotala</i>	<i>diandra</i>
MALVACEAE	<i>Abutilon</i>	<i>fraseri</i>
	<i>Abutilon</i>	<i>hannii</i>
	<i>Brachychiton</i>	<i>paradoxus</i>
	<i>Corchorus</i>	<i>aestuans</i>
	<i>Corchorus</i>	<i>sidoides</i>
	<i>Grewia</i>	<i>retusifolia</i>
	<i>Herissantia</i>	<i>crispa</i>
	<i>Hibiscus</i>	<i>meraukensis</i>
	<i>Hibiscus</i>	<i>sturtii</i>
	<i>Melhania</i>	<i>oblongifolia</i>
	<i>Sida</i>	<i>brachypoda</i>
	<i>Sida</i>	<i>rohlena</i>
	<i>Sida</i>	<i>spinosa</i>
<i>Triumfetta</i>	<i>micracantha</i>	

MALVACEAE	<i>Waltheria</i>	<i>indica</i>
MARSILEACEAE	<i>Marsilea</i>	<i>angustifolia</i>
MENISPERMACEAE	<i>Tinospora</i>	<i>smilacina</i>
MENYANTHACEAE	<i>Nymphoides</i>	<i>crenata</i>
	<i>Nymphoides</i>	<i>indica</i>
MYRTACEAE	<i>Corymbia</i>	<i>dichromophloia</i>
	<i>Corymbia</i>	<i>ferruginea</i>
	<i>Corymbia</i>	<i>flavescens</i>
	<i>Corymbia</i>	<i>polycarpa</i>
	<i>Corymbia</i>	<i>setosa</i>
	<i>Eucalyptus</i>	<i>chlorophylla</i>
	<i>Eucalyptus</i>	<i>cyanoclada</i>
	<i>Eucalyptus</i>	<i>microtheca</i>
	<i>Eucalyptus</i>	<i>tectifera</i>
	<i>Lophostemon</i>	<i>grandiflorus</i>
NYCTAGINACEAE	<i>Boerhavia</i>	<i>coccinea</i>
	<i>Boerhavia</i>	<i>dominii</i>
ONAGRACEAE	<i>Ludwigia</i>	<i>perennis</i>
PHRYMACEAE	<i>Mimulus</i>	<i>gracilis</i>
	<i>Uvedalia</i>	<i>linearis</i>
PHYLLANTHACEAE	<i>Breynia</i>	<i>cernua</i>
	<i>Flueggea</i>	<i>virosa</i>
	<i>Margaritaria</i>	<i>dubium-traceyi</i>
	<i>Phyllanthus</i>	<i>exilis</i>
	<i>Phyllanthus</i>	<i>hebecarpus</i>
	<i>Phyllanthus</i>	<i>maderaspatensis</i>
	<i>Synostemon</i>	<i>rhytidospemus</i>
	<i>Synostemon</i>	<i>trachyspermus</i>
PICRODENDRACEAE	<i>Petalostigma</i>	<i>pubescens</i>
PLANTAGINACEAE	<i>Bacopa</i>	<i>floribunda</i>
POACEAE	<i>Acrachne</i>	<i>racemosa</i>
	<i>Aristida</i>	<i>calycina</i>
	<i>Aristida</i>	<i>holathera</i>
	<i>Aristida</i>	<i>inaequiglumis</i>
	<i>Aristida</i>	<i>latifolia</i>
	<i>Aristida</i>	<i>pruinosa</i>
	<i>Aristida</i>	<i>queenslandica</i>
	<i>Brachyachne</i>	<i>convergens</i>

POACEAE	<i>Chrysopogon</i>	<i>fallax</i>
	<i>Cymbopogon</i>	<i>bombycinus</i>
	<i>Dactyloctenium</i>	<i>radulans</i>
	<i>Dichanthium</i>	<i>fecundum</i>
	<i>Dichanthium</i>	<i>sericeum</i>
	<i>Digitaria</i>	<i>brownii</i>
	<i>Digitaria</i>	<i>gibbosa</i>
	<i>Ectrosia</i>	<i>scabrida</i>
	<i>Elytrophorus</i>	<i>spicatus</i>
	<i>Enneapogon</i>	<i>decipiens</i>
	<i>Enneapogon</i>	<i>lindleyanus</i>
	<i>Enneapogon</i>	<i>oblongus</i>
	<i>Enneapogon</i>	<i>pallidus</i>
	<i>Enneapogon</i>	<i>polyphyllus</i>
	<i>Enneapogon</i>	<i>purpurascens</i>
	<i>Eragrostis</i>	<i>cumingii</i>
	<i>Eragrostis</i>	<i>tenellula</i>
	<i>Eriachne</i>	<i>armittii</i>
	<i>Eriachne</i>	<i>obtusa</i>
	<i>Eulalia</i>	<i>aurea</i>
	<i>Heteropogon</i>	<i>contortus</i>
	<i>Imperata</i>	<i>cylindrica</i>
	<i>Iseilema</i>	<i>macratherum</i>
	<i>Iseilema</i>	<i>membranaceum</i>
	<i>Iseilema</i>	<i>vaginiflorum</i>
	<i>Mnesithea</i>	<i>formosa</i>
	<i>Oryza</i>	<i>australiensis</i>
	<i>Oryza</i>	<i>rufipogon</i>
	<i>Panicum</i>	<i>decompositum</i>
	<i>Panicum</i>	<i>effusum</i>
	<i>Panicum</i>	<i>latzii</i>
	<i>Panicum</i>	<i>mindanaense</i>
	<i>Paspalidium</i>	<i>gracile</i>
	<i>Paspalidium</i>	<i>rarum</i>
<i>Schizachyrium</i>	<i>fragile</i>	
<i>Sehima</i>	<i>nervosum</i>	
<i>Sorghum</i>	<i>plumosum</i>	
<i>Sorghum</i>	<i>timorense</i>	

POACEAE	<i>Sporobolus</i>	<i>australasicus</i>
	<i>Themeda</i>	<i>avenacea</i>
	<i>Triodia</i>	<i>bitextura</i>
	<i>Urochloa</i>	<i>holosericea</i>
	<i>Whiteochloa</i>	<i>capillipes</i>
POLYGALACEAE	<i>Polygala</i>	<i>barbata</i>
	<i>Polygala</i>	<i>longifolia</i>
	<i>Polygala</i>	<i>pterocarpa</i>
PONTEDERIACEAE	<i>Monochoria</i>	<i>cyanea</i>
PORTULACACEAE	<i>Portulaca</i>	<i>bicolor</i>
	<i>Portulaca</i>	<i>filifolia</i>
PROTEACEAE	<i>Grevillea</i>	<i>parallela</i>
	<i>Hakea</i>	<i>arborescens</i>
PTERIDACEAE	<i>Cheilanthes</i>	<i>nudiuscula</i>
	<i>Cheilanthes</i>	<i>tenuifolia</i>
RHAMNACEAE	<i>Alphitonia</i>	<i>excelsa</i>
RUBIACEAE	<i>Spermacoce</i>	<i>argillacea</i>
	<i>Spermacoce</i>	<i>breviflora</i>
	<i>Spermacoce</i>	<i>dolichosperma</i>
	<i>Spermacoce</i>	<i>stenophylla</i>
SANTALACEAE	<i>Santalum</i>	<i>lanceolatum</i>
SAPINDACEAE	<i>Atalaya</i>	<i>hemiglauca</i>
	<i>Cardiospermum</i>	<i>halicacabum</i>
	<i>Dodonaea</i>	<i>hispidula</i>
	<i>Dodonaea</i>	<i>lanceolata</i>
	<i>Dodonaea</i>	<i>physocarpa</i>
	<i>Dodonaea</i>	<i>stenophylla</i>
SOLANACEAE	<i>Solanum</i>	<i>tumulicola</i>
STYLIDIACEAE	<i>Stylidium</i>	<i>adenophorum</i>
VITACEAE	<i>Cayratia</i>	<i>trifolia</i>
ZYGOPHYLLACEAE	<i>Tribulopsis</i>	<i>pentandra</i>
	<i>Tribulus</i>	<i>terrestris</i>

# Appendix D

## Fauna Atlas Species Records

## Appendix D Fauna Atlas Species Records

Table 36 Native fauna recorded within 5 km of project area

Scientific Name	Common Name
<b>Birds</b>	
<i>Accipiter fasciatus</i>	Brown Goshawk
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar
<i>Aprosmictus erythropterus</i>	Red-winged Parrot
<i>Apus pacificus</i>	Fork-tailed Swift
<i>Aquila audax</i>	Wedge-tailed Eagle
<i>Ardeotis australis</i>	Australian Bustard
<i>Artamus cinereus</i>	Black-faced Woodswallow
<i>Artamus minor</i>	Little Woodswallow
<i>Burhinus grallarius</i>	Bush Stone-curlew
<i>Calyptorhynchus banksii macrorhynchus</i>	Red-tailed Black-cockatoo (north-western)
<i>Chalcites osculans</i>	Black-eared Cuckoo
<i>Chlamydera nuchalis</i>	Great Bowerbird
<i>Cincloramphus mathewsi</i>	Rufous Songlark
<i>Circus assimilis</i>	Spotted Harrier
<i>Cissomela pectoralis</i>	Banded Honeyeater
<i>Climacteris melanurus</i>	Black-tailed Treecreeper
<i>Colluricincla harmonica</i>	Grey Shrike-thrush
<i>Conopophila rufogularis</i>	Rufous-throated Honeyeater
<i>Coracina maxima</i>	Ground Cuckoo-shrike
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike
<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike
<i>Corvus bennetti</i>	Little Crow
<i>Corvus orru</i>	Torresian Crow
<i>Coturnix ypsilophora</i>	Brown Quail
<i>Cracticus nigrogularis</i>	Pied Butcherbird
<i>Dacelo leachii</i>	Blue-winged Kookaburra
<i>Daphoenositta chrysoptera</i>	Varied Sittella
<i>Dicaeum hirundinaceum</i>	Mistletoebird
<i>Entomyzon cyanotis</i>	Blue-faced Honeyeater
<i>Eolophus roseicapilla</i>	Galah
<i>Eurystomus orientalis</i>	Dollarbird
<i>Falco berigora</i>	Brown Falcon
<i>Falco cenchroides</i>	Nankeen Kestrel

Scientific Name	Common Name
<i>Gavicalis virescens</i>	Singing Honeyeater
<i>Geopelia cuneata</i>	Diamond Dove
<i>Geopelia humeralis</i>	Bar-shouldered Dove
<i>Geopelia placida</i>	Peaceful Dove
<i>Gerygone olivacea</i>	White-throated Gerygone
<i>Grallina cyanoleuca</i>	Magpie-lark
<i>Gymnorhina tibicen</i>	Australian Magpie
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard
<i>Lalage tricolor</i>	White-winged Triller
<i>Lichmera indistincta</i>	Brown Honeyeater
<i>Malurus lamberti</i>	Variegated Fairy-wren
<i>Malurus melanocephalus</i>	Red-backed Fairy-wren
<i>Manorina flavigula</i>	Yellow-throated Miner
<i>Melanodryas cucullata</i>	Hooded Robin
<i>Melithreptus albugularis</i>	White-throated Honeyeater
<i>Melithreptus gularis</i>	Black-chinned Honeyeater
<i>Merops ornatus</i>	Rainbow Bee-eater
<i>Microeca fascinans</i>	Jacky Winter
<i>Milvus migrans</i>	Black Kite
<i>Myiagra nana</i>	Paperbark Flycatcher
<i>Myiagra rubecula</i>	Leaden Flycatcher
<i>Nymphicus hollandicus</i>	Cockatiel
<i>Ocyphaps lophotes</i>	Crested Pigeon
<i>Oreoica gutturalis</i>	Crested Bellbird
<i>Pachycephala rufiventris</i>	Rufous Whistler
<i>Pardalotus rubricatus</i>	Red-browed Pardalote
<i>Pardalotus striatus</i>	Striated Pardalote
<i>Philemon citreogularis</i>	Little Friarbird
<i>Podargus strigoides</i>	Tawny Frogmouth
<i>Poephila acuticauda</i>	Long-tailed Finch
<i>Poliocephalus poliocephalus</i>	Hoary-headed Grebe
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler
<i>Ptilotula flavescens</i>	Yellow-tinted Honeyeater
<i>Ptilotula keartlandi</i>	Grey-headed Honeyeater
<i>Ptilotula plumula</i>	Grey-fronted Honeyeater
<i>Rhipidura leucophrys</i>	Willie Wagtail
<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo

Scientific Name	Common Name
<i>Smicronis brevirostris</i>	Weebill
<i>Struthidea cinerea</i>	Apostlebird
<i>Taeniopygia bichenovii</i>	Double-barred Finch
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher
<i>Turnix pyrrhothorax</i>	Red-chested Button-quail
<i>Turnix velox</i>	Little Button-quail
<b>Mammals</b>	
<i>Lagorchestes conspicillatus</i>	Spectacled Hare-wallaby
<i>Leggadina lakedownensis</i>	Northern Short-tailed Mouse
<i>Onychogalea unguifera</i>	Northern Nailtail Wallaby
<i>Planigale maculata</i>	Common Planigale
<b>Reptiles</b>	
<i>Amalosia rhombifer</i>	Zig-zag Gecko
<i>Ctenotus spaldingi</i>	Straight-browed Ctenotus
<i>Heteronotia binoei</i>	Bynoe's Gecko
<i>Lucasium stenodactylum</i>	Sand-plain Gecko
<i>Rhynchoedura ornata</i>	Western Beaked Gecko
<i>Strophurus ciliaris</i>	Northern Spiny-tailed Gecko
<i>Suta punctata</i>	Little Spotted Snake
<i>Varanus tristis</i>	Black-headed Monitor

# Appendix E

Protected Matters  
Search Report  
10 km and 50 km

## Appendix E Protected Matters Search Report - 10 km



# EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 15-Mar-2022

[Summary](#)

[Details](#)

[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

[Acknowledgements](#)

# Summary

## Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

<a href="#">World Heritage Properties:</a>	None
<a href="#">National Heritage Places:</a>	None
<a href="#">Wetlands of International Importance (Ramsar)</a>	None
<a href="#">Great Barrier Reef Marine Park:</a>	None
<a href="#">Commonwealth Marine Area:</a>	None
<a href="#">Listed Threatened Ecological Communities:</a>	None
<a href="#">Listed Threatened Species:</a>	13
<a href="#">Listed Migratory Species:</a>	13

## Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at <http://www.environment.gov.au/heritage>

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

<a href="#">Commonwealth Lands:</a>	None
<a href="#">Commonwealth Heritage Places:</a>	None
<a href="#">Listed Marine Species:</a>	18
<a href="#">Whales and Other Cetaceans:</a>	None
<a href="#">Critical Habitats:</a>	None
<a href="#">Commonwealth Reserves Terrestrial:</a>	None
<a href="#">Australian Marine Parks:</a>	None
<a href="#">Habitat Critical to the Survival of Marine Turtles:</a>	None

## Extra Information

This part of the report provides information that may also be relevant to the area you have

<a href="#">State and Territory Reserves:</a>	None
<a href="#">Regional Forest Agreements:</a>	None
<a href="#">Nationally Important Wetlands:</a>	None
<a href="#">EPBC Act Referrals:</a>	None
<a href="#">Key Ecological Features (Marine):</a>	None
<a href="#">Biologically Important Areas:</a>	None
<a href="#">Bioregional Assessments:</a>	None
<a href="#">Geological and Bioregional Assessments:</a>	1

# Details

## Matters of National Environmental Significance

### Listed Threatened Species

[ [Resource Information](#) ]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.  
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text	Buffer Status
<b>BIRD</b>			
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Erythrotriorchis radiatus</a> Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Erythrura gouldiae</a> Gouldian Finch [413]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Falco hypoleucos</a> Grey Falcon [929]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Falcunculus frontatus whitei</a> Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Rostratula australis</a> Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Tyto novaehollandiae kimberli</a> Masked Owl (northern) [26048]	Vulnerable	Species or species habitat may occur within area	In feature area
<b>MAMMAL</b>			
<a href="#">Dasyurus hallucatus</a> Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area	In buffer area only

Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Macroderma gigas</a> Ghost Bat [174]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Macrotis lagotis</a> Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Trichosurus vulpecula arnhemensis</a> Northern Brushtail Possum [83091]	Vulnerable	Species or species habitat may occur within area	In feature area

## REPTILE

<a href="#">Elseya lavarackorum</a> Gulf Snapping Turtle [67197]	Endangered	Species or species habitat may occur within area	In feature area
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## SHARK

<a href="#">Pristis pristis</a> Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area
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## Listed Migratory Species

[ [Resource Information](#) ]

Scientific Name	Threatened Category	Presence Text	Buffer Status
<b>Migratory Marine Birds</b>			
<a href="#">Apus pacificus</a> Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area

## Migratory Marine Species

<a href="#">Pristis pristis</a> Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area
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## Migratory Terrestrial Species

<a href="#">Cecropis daurica</a> Red-rumped Swallow [80610]		Species or species habitat may occur within area	In feature area
<a href="#">Cuculus optatus</a> Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area	In feature area
<a href="#">Hirundo rustica</a> Barn Swallow [662]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Motacilla cinerea</a> Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
<a href="#">Motacilla flava</a> Yellow Wagtail [644]		Species or species habitat may occur within area	In feature area
<b>Migratory Wetlands Species</b>			
<a href="#">Actitis hypoleucos</a> Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
<a href="#">Calidris acuminata</a> Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Calidris melanotos</a> Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
<a href="#">Charadrius veredus</a> Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area	In feature area
<a href="#">Glareola maldivarum</a> Oriental Pratincole [840]		Species or species habitat may occur within area	In feature area

## Other Matters Protected by the EPBC Act

Listed Marine Species			[ <a href="#">Resource Information</a> ]
Scientific Name	Threatened Category	Presence Text	Buffer Status
<b>Bird</b>			
<a href="#">Actitis hypoleucos</a> Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Anseranas semipalmata</a> Magpie Goose [978]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Apus pacificus</a> Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
<a href="#">Bubulcus ibis as Ardea ibis</a> Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Calidris acuminata</a> Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Calidris melanotos</a> Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Cecropis daurica as Hirundo daurica</a> Red-rumped Swallow [80610]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Chalcites osculans as Chrysococcyx osculans</a> Black-eared Cuckoo [83425]		Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Charadrius veredus</a> Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Glareola maldivarum</a> Oriental Pratincole [840]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Haliaeetus leucogaster</a> White-bellied Sea-Eagle [943]		Species or species habitat may occur within area	In feature area
<a href="#">Hirundo rustica</a> Barn Swallow [662]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Merops ornatus</a> Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Motacilla cinerea</a> Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Motacilla flava</a> Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Rostratula australis as Rostratula benghalensis (sensu lato)</a> Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area overfly marine area	In feature area
<b>Reptile</b>			
<a href="#">Crocodylus johnstoni</a> Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		Species or species habitat may occur within area	In feature area

## Extra Information

### Geological and Bioregional Assessments

Name	State	Website	Buffer Status
Beetaloo GBA region	NT	<a href="#">GBA website</a>	In feature area

# Caveat

## 1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

## 2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

## 3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

## 4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

# Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [-Office of Environment and Heritage, New South Wales](#)
- [-Department of Environment and Primary Industries, Victoria](#)
- [-Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [-Department of Environment, Water and Natural Resources, South Australia](#)
- [-Department of Land and Resource Management, Northern Territory](#)
- [-Department of Environmental and Heritage Protection, Queensland](#)
- [-Department of Parks and Wildlife, Western Australia](#)
- [-Environment and Planning Directorate, ACT](#)
- [-Birdlife Australia](#)
- [-Australian Bird and Bat Banding Scheme](#)
- [-Australian National Wildlife Collection](#)
- Natural history museums of Australia
- [-Museum Victoria](#)
- [-Australian Museum](#)
- [-South Australian Museum](#)
- [-Queensland Museum](#)
- [-Online Zoological Collections of Australian Museums](#)
- [-Queensland Herbarium](#)
- [-National Herbarium of NSW](#)
- [-Royal Botanic Gardens and National Herbarium of Victoria](#)
- [-Tasmanian Herbarium](#)
- [-State Herbarium of South Australia](#)
- [-Northern Territory Herbarium](#)
- [-Western Australian Herbarium](#)
- [-Australian National Herbarium, Canberra](#)
- [-University of New England](#)
- [-Ocean Biogeographic Information System](#)
- [-Australian Government, Department of Defence](#)
- [Forestry Corporation, NSW](#)
- [-Geoscience Australia](#)
- [-CSIRO](#)
- [-Australian Tropical Herbarium, Cairns](#)
- [-eBird Australia](#)
- [-Australian Government – Australian Antarctic Data Centre](#)
- [-Museum and Art Gallery of the Northern Territory](#)
- [-Australian Government National Environmental Science Program](#)
- [-Australian Institute of Marine Science](#)
- [-Reef Life Survey Australia](#)
- [-American Museum of Natural History](#)
- [-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania](#)
- [-Tasmanian Museum and Art Gallery, Hobart, Tasmania](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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## Appendix E Protected Matters Search Report - 50 km



# EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 15-Mar-2022

[Summary](#)

[Details](#)

[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

[Acknowledgements](#)

# Summary

## Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

<a href="#">World Heritage Properties:</a>	None
<a href="#">National Heritage Places:</a>	None
<a href="#">Wetlands of International Importance (Ramsar)</a>	None
<a href="#">Great Barrier Reef Marine Park:</a>	None
<a href="#">Commonwealth Marine Area:</a>	None
<a href="#">Listed Threatened Ecological Communities:</a>	None
<a href="#">Listed Threatened Species:</a>	15
<a href="#">Listed Migratory Species:</a>	13

## Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at <http://www.environment.gov.au/heritage>

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

<a href="#">Commonwealth Lands:</a>	None
<a href="#">Commonwealth Heritage Places:</a>	None
<a href="#">Listed Marine Species:</a>	18
<a href="#">Whales and Other Cetaceans:</a>	None
<a href="#">Critical Habitats:</a>	None
<a href="#">Commonwealth Reserves Terrestrial:</a>	None
<a href="#">Australian Marine Parks:</a>	None
<a href="#">Habitat Critical to the Survival of Marine Turtles:</a>	None

## Extra Information

This part of the report provides information that may also be relevant to the area you have

<a href="#">State and Territory Reserves:</a>	1
<a href="#">Regional Forest Agreements:</a>	None
<a href="#">Nationally Important Wetlands:</a>	None
<a href="#">EPBC Act Referrals:</a>	1
<a href="#">Key Ecological Features (Marine):</a>	None
<a href="#">Biologically Important Areas:</a>	None
<a href="#">Bioregional Assessments:</a>	None
<a href="#">Geological and Bioregional Assessments:</a>	1

# Details

## Matters of National Environmental Significance

### Listed Threatened Species

[\[ Resource Information \]](#)

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.

Number is the current name ID.

Scientific Name	Threatened Category	Presence Text	Buffer Status
<b>BIRD</b>			
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Erythrotriorchis radiatus</a> Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Erythrura gouldiae</a> Gouldian Finch [413]	Endangered	Species or species habitat likely to occur within area	In feature area
<a href="#">Falco hypoleucos</a> Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area	In feature area
<a href="#">Falcunculus frontatus whitei</a> Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area	In feature area
<a href="#">Grantiella picta</a> Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area	In buffer area only
<a href="#">Rostratula australis</a> Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Tyto novaehollandiae kimberli</a> Masked Owl (northern) [26048]	Vulnerable	Species or species habitat may occur within area	In feature area
<b>MAMMAL</b>			

Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Dasyurus hallucatus</a> Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area	In buffer area only
<a href="#">Macroderma gigas</a> Ghost Bat [174]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Macrotis lagotis</a> Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area	In feature area
<a href="#">Saccolaimus saccolaimus nudicluniatus</a> Bare-rumped Sheath-tailed Bat, Bare-rumped Sheath-tail Bat [66889]	Vulnerable	Species or species habitat may occur within area	In buffer area only
<a href="#">Trichosurus vulpecula arnhemensis</a> Northern Brushtail Possum [83091]	Vulnerable	Species or species habitat likely to occur within area	In feature area

## REPTILE

<a href="#">Elseya lavarackorum</a> Gulf Snapping Turtle [67197]	Endangered	Species or species habitat may occur within area	In feature area
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## SHARK

<a href="#">Pristis pristis</a> Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area
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## Listed Migratory Species

[ [Resource Information](#) ]

Scientific Name	Threatened Category	Presence Text	Buffer Status
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### Migratory Marine Birds

<a href="#">Apus pacificus</a> Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
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### Migratory Marine Species

<a href="#">Pristis pristis</a> Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area
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### Migratory Terrestrial Species

Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Cecropis daurica</a> Red-rumped Swallow [80610]		Species or species habitat may occur within area	In feature area
<a href="#">Cuculus optatus</a> Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area	In feature area
<a href="#">Hirundo rustica</a> Barn Swallow [662]		Species or species habitat may occur within area	In feature area
<a href="#">Motacilla cinerea</a> Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
<a href="#">Motacilla flava</a> Yellow Wagtail [644]		Species or species habitat may occur within area	In feature area
<b>Migratory Wetlands Species</b>			
<a href="#">Actitis hypoleucos</a> Common Sandpiper [59309]		Species or species habitat known to occur within area	In feature area
<a href="#">Calidris acuminata</a> Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
<a href="#">Calidris melanotos</a> Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
<a href="#">Charadrius veredus</a> Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area	In feature area
<a href="#">Glareola maldivarum</a> Oriental Pratincole [840]		Species or species habitat may occur within area	In feature area

## Other Matters Protected by the EPBC Act

Listed Marine Species			[ Resource Information ]
Scientific Name	Threatened Category	Presence Text	Buffer Status
<b>Bird</b>			
<a href="#">Actitis hypoleucos</a> Common Sandpiper [59309]		Species or species habitat known to occur within area	In feature area
<a href="#">Anseranas semipalmata</a> Magpie Goose [978]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Apus pacificus</a> Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
<a href="#">Bubulcus ibis as Ardea ibis</a> Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Calidris acuminata</a> Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
<a href="#">Calidris ferruginea</a> Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Calidris melanotos</a> Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Cecropis daurica as Hirundo daurica</a> Red-rumped Swallow [80610]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Chalcites osculans as Chrysococcyx osculans</a> Black-eared Cuckoo [83425]		Species or species habitat known to occur within area overfly marine area	In feature area
<a href="#">Charadrius veredus</a> Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Glareola maldivarum</a> Oriental Pratincole [840]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Haliaeetus leucogaster</a> White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area	In feature area
<a href="#">Hirundo rustica</a> Barn Swallow [662]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Merops ornatus</a> Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Motacilla cinerea</a> Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Motacilla flava</a> Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area	In feature area
<a href="#">Rostratula australis as Rostratula benghalensis (sensu lato)</a> Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area overfly marine area	In feature area

Reptile

Scientific Name	Threatened Category	Presence Text	Buffer Status
<a href="#">Crocodylus johnstoni</a> Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		Species or species habitat may occur within area	In feature area

## Extra Information

### State and Territory Reserves [\[ Resource Information \]](#)

Protected Area Name	Reserve Type	State	Buffer Status
Bullwaddy	Conservation Reserve	NT	In buffer area only

### EPBC Act Referrals [\[ Resource Information \]](#)

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action <a href="#">Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia</a>	2015/7522	Not Controlled Action	Completed	In buffer area only

### Geological and Bioregional Assessments

Name	State	Website	Buffer Status
Beetaloo GBA region	NT	<a href="#">GBA website</a>	In feature area

# Caveat

## 1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

## 2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

## 3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

## 4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

# Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [-Office of Environment and Heritage, New South Wales](#)
- [-Department of Environment and Primary Industries, Victoria](#)
- [-Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [-Department of Environment, Water and Natural Resources, South Australia](#)
- [-Department of Land and Resource Management, Northern Territory](#)
- [-Department of Environmental and Heritage Protection, Queensland](#)
- [-Department of Parks and Wildlife, Western Australia](#)
- [-Environment and Planning Directorate, ACT](#)
- [-Birdlife Australia](#)
- [-Australian Bird and Bat Banding Scheme](#)
- [-Australian National Wildlife Collection](#)
- Natural history museums of Australia
- [-Museum Victoria](#)
- [-Australian Museum](#)
- [-South Australian Museum](#)
- [-Queensland Museum](#)
- [-Online Zoological Collections of Australian Museums](#)
- [-Queensland Herbarium](#)
- [-National Herbarium of NSW](#)
- [-Royal Botanic Gardens and National Herbarium of Victoria](#)
- [-Tasmanian Herbarium](#)
- [-State Herbarium of South Australia](#)
- [-Northern Territory Herbarium](#)
- [-Western Australian Herbarium](#)
- [-Australian National Herbarium, Canberra](#)
- [-University of New England](#)
- [-Ocean Biogeographic Information System](#)
- [-Australian Government, Department of Defence](#)
- [Forestry Corporation, NSW](#)
- [-Geoscience Australia](#)
- [-CSIRO](#)
- [-Australian Tropical Herbarium, Cairns](#)
- [-eBird Australia](#)
- [-Australian Government – Australian Antarctic Data Centre](#)
- [-Museum and Art Gallery of the Northern Territory](#)
- [-Australian Government National Environmental Science Program](#)
- [-Australian Institute of Marine Science](#)
- [-Reef Life Survey Australia](#)
- [-American Museum of Natural History](#)
- [-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania](#)
- [-Tasmanian Museum and Art Gallery, Hobart, Tasmania](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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**Appendix K Amungee 2D Seismic and Well LCA Heritage Assessment**

30 May 2022

Alana Court  
Environment Team Leader  
AECOM Australia Pty Ltd  
Level 3, 9 Cavenagh Street  
Darwin, NT 0800

**Re: Origin Amungee 2D Seismic and Well LCA Heritage Assessment**

Dear Alana,

## 1 Introduction

EMM Consulting Pty Ltd (EMM) was engaged by AECOM Australia Pty Ltd (AECOM) on behalf of Origin Energy Resources Limited (Origin) to undertake a heritage assessment of the proposed Amungee NW extension seismic survey area.

The Amungee NW extension seismic survey area is located within the Amungee Mungee and Hayfield pastoral leases and is covered by EP98 (Figure 2). Amungee NW extension area is located approximately 55 km east of the Stuart Highway turnoff along the Carpentaria Highway. The seismic survey area covers a distance of around 21.3 km from east to west and 13.3 km from north to south (6,583 ha), with a total of eight 2D seismic lines proposed along both existing cleared fence lines and tracks (69,392 m) and areas of uncleared land (63,221 m) (Figure 1.1).

Origin proposes to undertake a 2D seismic survey along both cleared and uncleared area of the seismic line route. This will require clearing of native vegetation in uncleared land and widening of existing fence lines and tracks to allow Vibroseis truck access to the seismic survey area. Vibroseis source seismic survey involving the following activities:

- Surveying and Line clearing with dozers and grader, clear all source lines to 5m in width.
- Once the geophones are laid out, Vibroseis trucks are driven down the lines vibrating the ground at a set interval. In some areas, seismic charges may be utilised as the energy source. In these area, charges will be installed down to 15m.
- Cleared lines are remediated by pulling fallen vegetation into the cleared area.

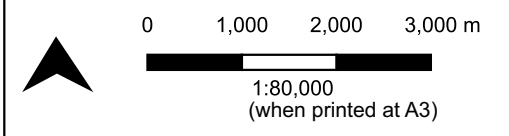
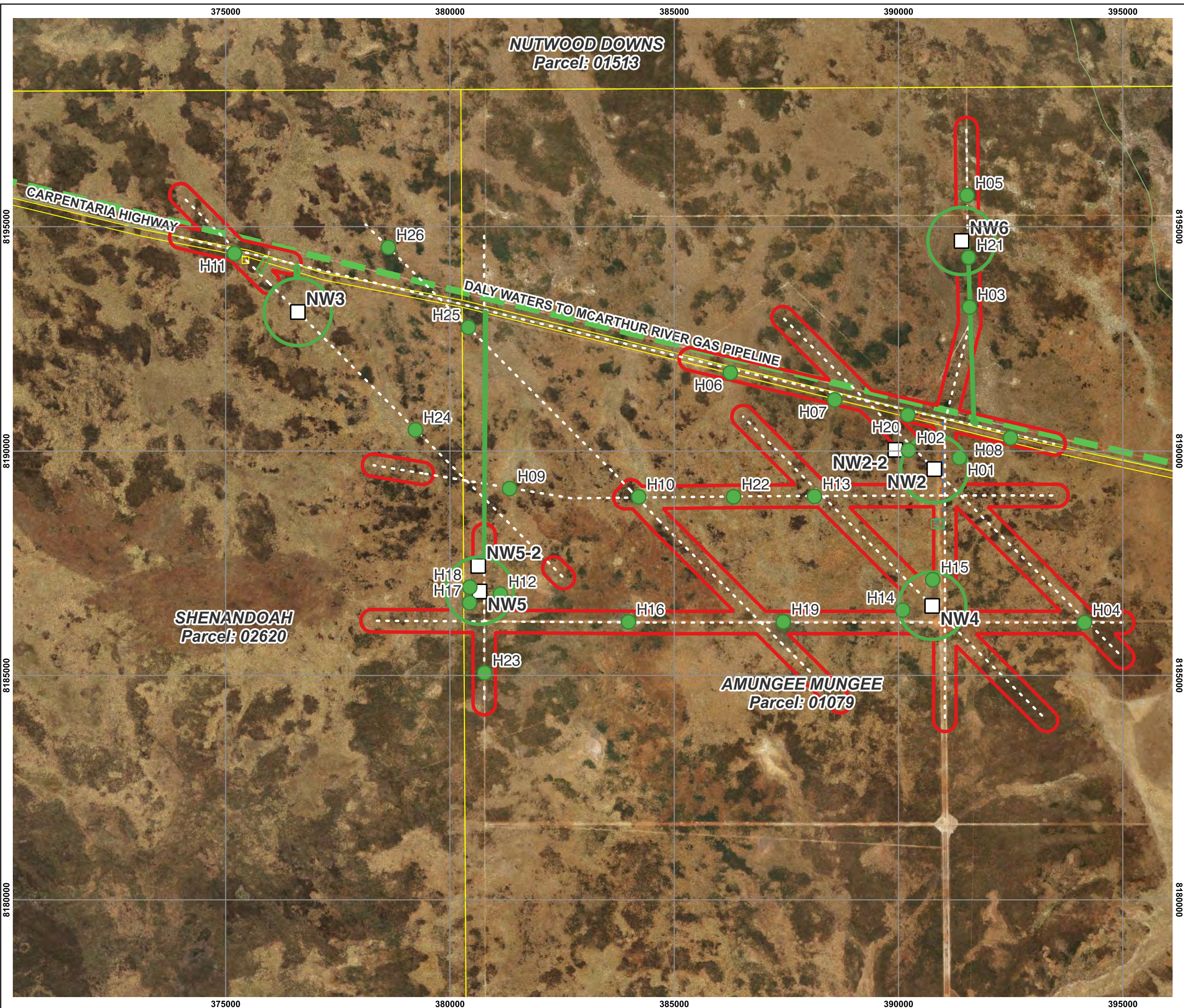
A total of five well lease areas have been identified for development of the Amungee NW extension area (Table 1.1). Development of well lease areas will include clearing for a well pad, camp pad and helicopter landing pad (12 ha), placement of temporary camp, access tracks, gravel pits and all associated exploration infrastructure.

**Table 1.1 Proposed Well Lease Areas and Alternative Siting Locations**

Well ID (Previous ID)	Easting <sup>a</sup>	Northing <sup>a</sup>
NW2 (AMS1)	390800	8189600
NW3 (AMS2)	376611	8193100
NW4 (AMS3)	390753	8186551
NW5 (AMS4)	380660	8186873
NW6 (AMS6)	391407	8194683

<sup>a</sup> GDA20 Zone 53

AECOM does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. AECOM shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.



- LEGEND**
- Heritage Scout Point
  - Well Pad Locations
  - 2D Seismic 250m Buffer
  - Well Scouting 750m buffer
  - NT - Cadastre

Data Sources:  
 Geoscience Australia  
 Bing Australia

**Amungee 2D Seismic and Well LCA  
 Heritage Assessment Report  
 Project Area**

PROJECT ID	E220390
CREATED BY	LK
LAST MODIFIED	08-7-2022
VERSION	2

**Figure  
1.1**

## 2 Existing Data Sources

Information on the location of heritage sites within the study area was obtained from:

- a review of Native Title claims and Indigenous Land Use Agreements over the proposed activity areas
- a review of relevant heritage databases including the Commonwealth Australian Heritage Database and the Northern Territory Heritage Register managed by the NT Heritage Branch
- a review of the Sacred Sites Register maintained by the Aboriginal Areas Protection Authority
- a review of past archaeological survey reports and assessments undertaken within the local area.

### 2.1 Native Title

The Proposal is covered by two determined Native Title Claims (Table 2.1). There are no current Indigenous Land Use Agreements (ILUAs) over the Proposal area.

**Table 2.1 Native Title**

Type	Well Location	NTD Claim Name	Summary
Native Title	NW3	NTD21/2010 Shenandoah (PPL 1141)	Native Title exists (non-exclusive) and is held by the Kinbininggu and Bamarrngganja group
Native Title	NW2 NW4 NW5 NW6	NTD17/2010 Amungee Mungee (PPL 1100)	Native Title exists (non-exclusive) and is held by the Karranjini and Bamarrngganja group

### 2.2 Australian Heritage Database

A search of the Australia Heritage Database identified that no Commonwealth statutory listed heritage places occur within the proposed impact areas.

### 2.3 NT Heritage Register

A search of NT Heritage Register identified a number of historic heritage sites within a 125 km by 125 km search area that encompasses the Beetaloo Basin. The closest item to the proposed Amungee NW extension area is the Daly Waters Aviation Complex, an airfield that once operated as an international airhub and has the oldest hangar in the Northern Territory dating back to 1930. The Aviation Complex is located 50km to the west of the Amungee NW extension area on the Stuart Highway.

No heritage places or artefacts are registered within the proposed impact areas.

### 2.4 Aboriginal Areas Protection Authority (AAPA)

Aboriginal Areas Protection Authority (AAPA) Authority Certificate C2019/014 and C2022/002 applies to Origin exploration activities at the Amungee NW exploration area. These AAPA certificate do not identify any sacred sites or Restricted Works Areas (RWAs) in proximity to either seismic survey area or proposed wells location covered as part of this assessment.

## 2.5 Previous Archaeological Investigations

The majority of archaeological investigations near the study area have been predominately associated with either linear infrastructure in an alignment parallel to the Carpentaria Highway or natural gas exploration activities associated with the Beetaloo Basin. Of the assessments of relevance to the study area, the majority of sites identified are artefact scatters composed of raw material commonly found in the immediate area (chert, quartz, silcrete and quartzite).

Table 2.2 provides a summary of previous archaeological investigations undertaken in the local area.

**Table 2.2 Previous Archaeological Assessments in the Local Area**

Researchers	Assessment Type	Locality	Key Findings
Smith (1986)	Excavation	Lake Woods	<i>In situ</i> artefacts dated to 6,000 years identified at the periphery of Lake Woods.
Hermes (1986)	Survey	Amadeus Basin to Katherine	Large scale survey for a proposed natural gas pipeline targeting areas of major cultural sensitivity from Daly Waters to Katherine. Thirty-two sites were identified with the majority being artefact scatters associated with watercourses.
Quaternary Archaeological Surveys (1998)	Survey	Stuart Highway to Mataranka Homestead	Large scale survey for a fibre optic cable corridor. Three isolated artefacts and one historic heritage site identified.
Heritage Surveys (1999)	Survey	Daly Waters to McArthur River	Nine archaeological sites identified as part of a survey for a gas pipeline including rockshelters and artefact scatters.
HLA-Envirosciences (2006c; 2006b; 2006d; 2006a; 2007)	Survey	Beetaloo Basin	Several archaeological sites identified across the exploration permits including artefact scatters, isolated artefacts and stone cairns. Assessments developed a preliminary predictive model based on site modelling and landform.
AECOM (2011; 2012c; 2012a; 2012b)	Survey	Beetaloo Basin	Several archaeological sites identified as part of seismic line clearance including large artefact scatters (>1 km), quarry sites and isolated artefacts. Predictive model refined and used in the field to identify 'hot spots' of Indigenous archaeological significance.
AECOM (2014)	Survey	Beetaloo Basin	One isolated artefact identified as part of an exploration drilling program clearance.
AECOM (2015)	Survey	Beetaloo Basin	Four archaeological sites (artefact scatters) were located on access tracks. Of these, two sites are determined to be of moderate significance, with the remaining two sites being of low significance.
AECOM (2016)	Survey	Beetaloo Basin	One isolated artefact identified on Newcastle Waters firebreak.
AECOM (2019)	Survey	Beetaloo Basin	Heritage assessment for proposed exploration lease areas Kyalla 117 N2-1 and Velkerri 76 S2- 1. No Aboriginal archaeological sites were identified in the Velkerri 76 S2-1 survey area.
Jung (2020)	Survey	Beetaloo Basin	Heritage assessment at Eva Downs Station. Three small artefact scatters were identified.

**Table 2.2** Previous Archaeological Assessments in the Local Area

Researchers	Assessment Type	Locality	Key Findings
AECOM (2021)	Survey	Beetaloo Basin	Survey of Amungee NW-1 and Velkerri 76 S2. Three artefact scatters and six isolated artefacts were identified within the Amungee NW-1 lease.
Shipton et al. (2021)	Survey & Excavation	Lake Woods	Survey and excavation of multiple sites around Lake Woods demonstrating a diverse distinctive stone assemblage including retouched artefacts and grindstones. The artefacts were dated to the late Holocene and suggested processing camps of grass seeds.

### 3 Heritage Assessment

A combined heritage and ecological scouting survey was undertaken by EMM heritage specialist Luke Kirkwood, Origin employee and traditional custodian Ben Ulamari and Jeremy Jackson (Traditional Custodian) for the proposal area from 3 to 6 May 2022. The archaeological inspection involved vehicular and pedestrian survey of the proposed exploration area and access tracks.

In addition to well locations, an additional 26 heritage inspection locations in areas of proposed disturbance (well locations and access tracks) were identified during the desktop assessment for further assessment as they had potential to be associated with culturally sensitive landforms (watercourses, gilgai, soaks, elevated locations etc)

During the inspection, notes were taken on landform, ground surface visibility and areas of exposure. The aim of the inspection was to identify any surface expressions of Aboriginal archaeological and cultural heritage values within the proposal area. Photographic records were taken at each proposed disturbance location.

Results of the inspection are provided in Table 3.1.

Appendix B provides details on ground surface visibility classes and subsurface archaeological potential assessment. Plate 1 to Plate 18 present the general context shots of the proposed exploration lease area.

**Table 3.1 Heritage Assessment Results**

Survey ID	Easting	Northing	Soil	Vegetation	GSV	Aboriginal Heritage	Sensitive Landforms	Heritage Clearance Obtained
NW2	390800	8189600	Various	Open woodland	0-80%	None	None	Yes
NW2-2	389932	8190029	Red sandy loam	Open woodland	20-60%	None	None	Yes
NW3	376611	8193100	Grey sandy loam	Open woodland	20-100%	Yes. An isolated chert distal flake, BB-22-IA1, was identified 140m north west of the survey centroid for NW3.	None	Yes
NW4	390753	8186551	White sandy loam	Bullwaddy and revegetated eucalyptus	90-100%	None	None	Yes
NW5	380660	8186873	White sandy loam to red laterite pea gravel	Bullwaddy and open woodland eucalyptus. Presence of circular soak/wetland feature	0-100%	Yes. A significant camp site, BB-22-AS1, south of the proposed well site around a large circular wetland system fringed by bullwaddy. A range of raw materials types demonstrating sophisticated artefact production including several broken grindstones and two Pirie points were identified. At least 100 artefacts were mapped. This potentially represents one of the largest Aboriginal archaeological sites documented within the Amungee NW area and is reflective of the adjacent wetland system and its importance to subsistence survival in the past.	Yes, two large wetland systems with potential for fringing camps are within the survey area	No
NW5-2	380632	8187442	White sandy loam to red laterite pea gravel	Open woodland	0-60%	None	None	Yes
NW6	391407	8194683	Reddy grey sandy loam	Open woodland	50-80%	None	None	Yes
Gravel Pit south of NW2	390890	8188370	Red laterite pea gravel	Open woodland	20-100%	None	None	Yes

Survey ID	Easting	Northing	Soil	Vegetation	GSV	Aboriginal Heritage	Sensitive Landforms	Heritage Clearance Obtained
Gravel Pit northwest of NW3	375828	8194120	Red laterite pea gravel	Open woodland	20-100%	Yes. An isolated quartzite complete flake, BB-22-IA2, was identified just south of an access track associated with an existing borrow pit.	None	Yes
H01	391360	8189850	Grey sandy loam	Open scrappy woodland	100%	None	None	Yes
H02	390224	8190020	Red laterite pea gravel	Mixed woodland	50-100%	None	None	Yes
H03	391583	8193210	Yellow to white sandy clay	Thick weedy-like scrub	50-100%	None	None	Yes
H04	394148	8186180	Grey sandy loam	Revegetated	80-100%	None	None	Yes
H05	391530	8195700	Grey sandy loam	Mixed woodland	50-100%	None	None	Yes
H06	386252	8191740	Sandy pea gravel	Revegetated	80-100%	None	None	Yes
H07	388579	8191140	Grey sandy loam	Revegetated	80-100%	None	None	Yes
H08	392500	8190290	White sandy clay	Open woodland	50-100%	None	None	Yes
H09	381329	8189160	Area previously inspected					
H10	384209	8188980	Yellow to white sandy clay	Thick weedy-like scrub	50-100%	None	None	Yes
H11	375197	8194400	Grey sandy loam	Open scrappy woodland	50-100%	None	None	Yes
H12	381125	8186810	Yellow sandy loam	Open scrappy woodland	100%	None. Despite presence of sensitive landforms and 100% ground surface visibility.	None	Yes
H13	388128	8188990	Sandy pea gravel	Revegetated	80-100%	None	None	Yes
H14	390094	8186450	Yellow sandy loam	Open scrappy woodland	100%	None. Despite presence of sensitive landforms and 100% ground surface visibility.	Established gilgai waterholes	Yes
H15	390764	8187130	Grey sandy loam	Open scrappy woodland	100%	None	None	Yes
H16	383982	8186190	Red laterite pea gravel	Open woodland	80-100%	None	None	Yes
H17	380436	8186620	Not inspected - high grass and low visibility					
H18	380441	8186970	Grey sandy loam	Fringe vegetation between woodland and waterhole's edge	50-100%	None	Waterhole in distance	Yes
H19	387432	8186200	White sandy clay	Open woodland	50-100%	None	None	Yes

Survey ID	Easting	Northing	Soil	Vegetation	GSV	Aboriginal Heritage	Sensitive Landforms	Heritage Clearance Obtained
H20	390210	8190800	Yellow sandy loam	Open scrappy woodland	100%	None. Despite presence of sensitive landforms and 100% ground surface visibility.	Established gilgai waterholes	Yes
H20	391562	8194320	Red laterite pea gravel	Open woodland	80-100%	None	None	Yes
H21	386324	8188980	Red laterite pea gravel	Mixed woodland	80-100%	None	None	Yes
H22	380772	8185060	Grey sandy loam	Mixed woodland	50-100%	None	None	Yes
H23	379231	8190470	Red laterite pea gravel	Mixed woodland	80-100%	None	None	Yes
H24	380411	8192760	Area previously inspected					
H25	378629	8194540	Area previously inspected					
H26	391360	8189850	Area previously inspected					

*a* GDA20 Zone 53; *b* GSV = Ground Surface Visibility; *c* GSI = Ground Surface Integrity



**Plate 1**      **NW2 looking south**



**Plate 2**      **NW2 alternative location looking north**



**Plate 3**      **NW3 looking south**



**Plate 4**      **NW4 looking east**



**Plate 5**      **NW5 looking east**



**Plate 6**      **NW5 alternative location looking east**



**Plate 7** NW6 looking east



**Plate 8** H01 looking north



**Plate 9** H03 looking south



**Plate 10** H04 looking east



**Plate 11** H07 looking west



**Plate 12** H08 looking west



**Plate 13**      **H10 looking east**



**Plate 14**      **H12 looking east**



**Plate 15**      **H14 looking south**



**Plate 16**      **H18 looking east**



**Plate 17**      **H19 looking north**



**Plate 18**      **H22 looking south**

## 4 Identified Archaeological Heritage

Three Aboriginal archaeological sites were identified during the field survey at Amungee NW-1, which includes one significant artefact scatter and two isolated artefact sites. Table 4.1 provides a summary of the Aboriginal archaeological sites recorded including reference to the target area survey transect that they were identified on. Figure 4.1 provides a map showing the location of each site within each survey area. Detailed site records for each of the recorded sites in the Amungee NW-1 survey area are provided in the sections that follow.

**Table 4.1** Identified archaeological heritage

Site ID	Site Type	Artefact Count	Easting	Northing
BB-22-AS1	Artefact Scatter	120+	██████	██████
BB-22-IA1	Isolated Artefact	1	██████	██████
BB-22-IA2	Isolated Artefact	1	██████	██████

### 4.1 BB-22-AS1 – Artefact Scatter

BB-22-AS1 (GDA20 Zone 53 ██████████) is a high-density artefact scatter found in the Amungee NW5 proposed well pad. The archaeological site is located on the fringes of a large grassed circular wetland feature associated with a large stand of bullwaddy (*Macropteranthes kekwickii*) (Plate 19 and Plate 20). The artefact scatter comprises over 120 artefacts: including three grindstone fragments and two pirri points (Plate 21 to Plate 26). Equivalent archaeological sites of this scale and complexity have not been recorded in the immediate vicinity with similar sites noted along major watercourses such as Newcastle Waters Creek.

A range of raw materials (quartzite, silcrete, chert, chalcedony, sandstone) were represented in the observed artefacts with quartzite dominating the assemblage. Artefacts were clustered around southern margin of the bullwaddy on exposed ground adjacent to the wetland system. GSV across the site extent ranged extensively between poor (20%) to very good (100%) while GSI was moderate with some disturbance likely caused by cattle using the areas for water.

The presence of a number of grindstone fragments and diverse tool types in proximity to a well grassed wetland system was also notable. Early pastoralist and drover Arthur C Ashwin noted the scale of grass seed harvesting on a muster past the Ashburton Range near Newcastle Waters in 1871:

There was a large mia-mia [hut], about seven feet high, in the middle and about 16 feet diameter. It was round and arched off to the ground. There were large bundles of spears stored there, and large wooden dishes four and five feet long filled with grass seed as large as rice with the husk or skin still on the seed. I think it was a species of rice which grows in the flooded country 40 or 50 miles in extent and north of Newcastle Waters. There must have been about a ton of seed stored there in 17 large dishes, full and all covered with paper-bark. The dishes were nearly all five feet long and a foot deep, scooped out of solid wood. There were more weapons and shields. (Ashwin 1927, 64)

Given the lack of ground surface visibility across much of the site, there is the possibility that the site may have more extensive subsurface archaeological deposits and additional unique tool types present.

In-field discussions with Jeremy Jackson (Traditional Custodian) and Ben Ulamari (Origin employee and Traditional Custodian) raised the importance of this archaeological site and the need to avoid impact. Initial agreement was reached on moving the well site and disturbance footprint to the north (but still within the provided 750m buffer) to a less sensitive area.



**Plate 19** View to east from BB-22-AS1 towards wetland system



**Plate 20** View to north from BB-22-AS1 towards bullwaddy stand



**Plate 21** A selection of artefacts and raw materials



**Plate 22** Grindstone fragment #1 (dorsal)



**Plate 23** Grindstone fragment #2 (dorsal)



**Plate 24** Grindstone fragment #3 (dorsal)



Plate 25 Pirri point #1 (dorsal)



Plate 26 Pirri point #2 (dorsal)

#### 4.2 BB-22-IA1 – Isolated Artefact

BB-22-IA1 (GDA20 Zone 53 [REDACTED]) is an isolated proximal chert flake located 140m northwest of the centroid for proposed well pad NW3 (Plate 27). Despite relatively good GSV in the immediate area surrounding the find, no further evidence of archaeology was noted (Plate 28). No specific sensitive landforms were noted in this area. In-field discussions with Jeremy Jackson (Traditional Custodian) and Ben Ulamari (Origin employee and Traditional Custodian) identified that it was appropriate to translocate the artefact to BB-22-AS1 prior to impact allowing for clearance of the site.



Plate 27 Proximal chert flake (ventral)



Plate 28 View to south from BB-22-IA1

#### 4.3 BB-22-IA2 – Isolated Artefact

BB-22-IA2 (GDA20 Zone 53 [REDACTED]) is an isolated complete quartzite flake located south of an access track associated with an existing borrow pit accessed from the Carpentaria Highway (Plate 29). The surrounding area showed evidence of significant impact from vegetation clearance (Plate 30). No specific sensitive landforms were noted in this area. Despite relatively good GSV in the immediate area surrounding the find, no further evidence of archaeology was noted. In-field discussions with Jeremy Jackson (Traditional

Custodian) and Ben Ulamari (Origin employee and Traditional Custodian) identified that it was appropriate to translocate the artefact to BB-22-AS1 prior to impact allowing for clearance of the site.

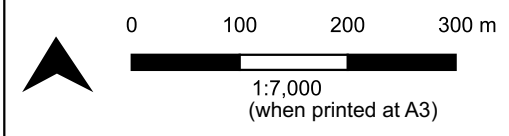
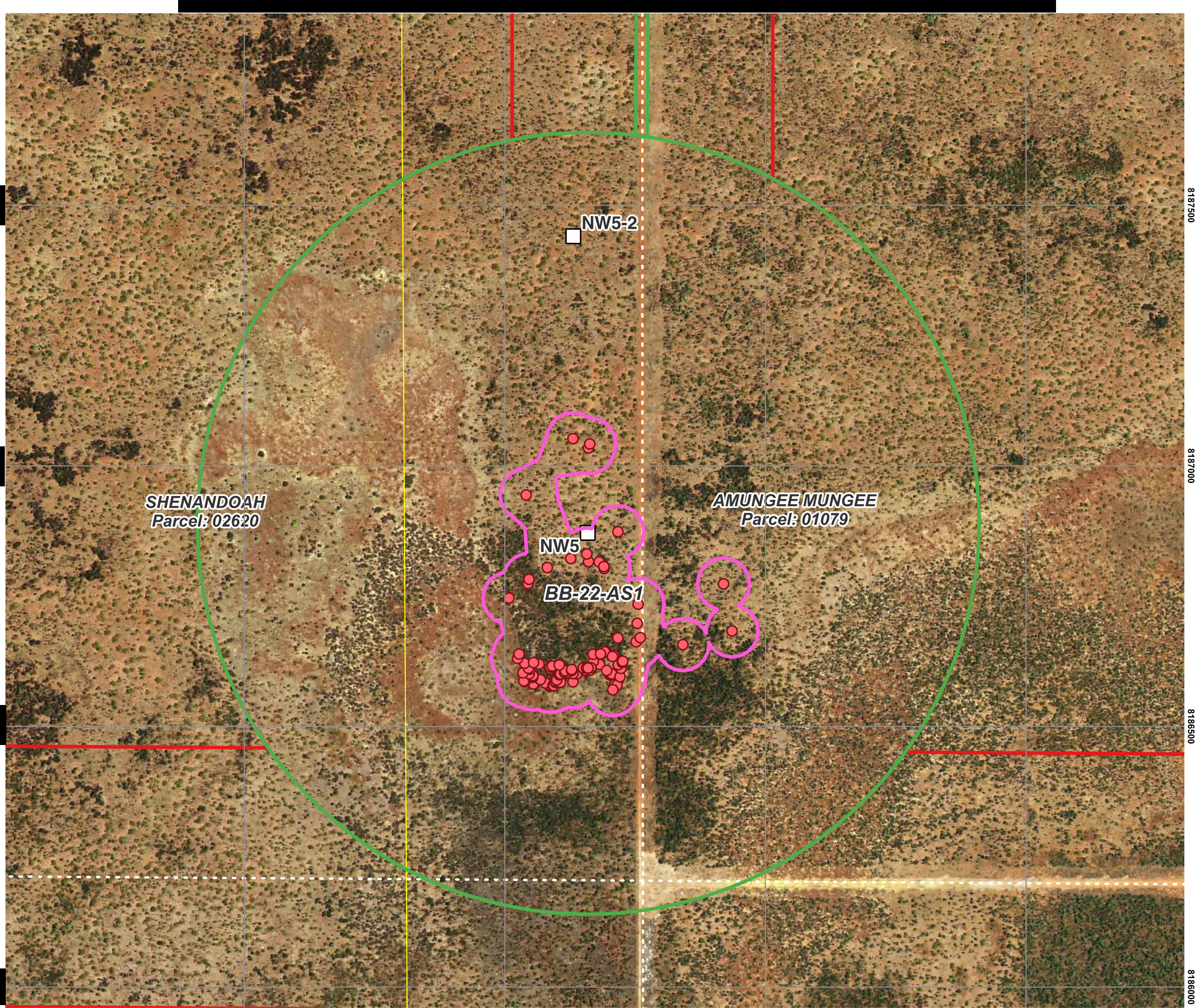


**Plate 29** Complete quartzite flake (dorsal)



**Plate 30** View to east from BB-22-IA2

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- LEGEND**
- Heritage - Artefacts
  - Well Pad Locations
  - 2D Seismic 250m Buffer
  - Well Scouting 750m buffer
  - NT - Cadastre

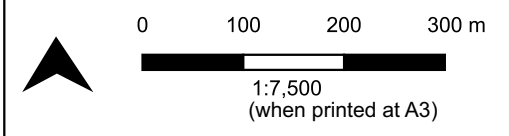
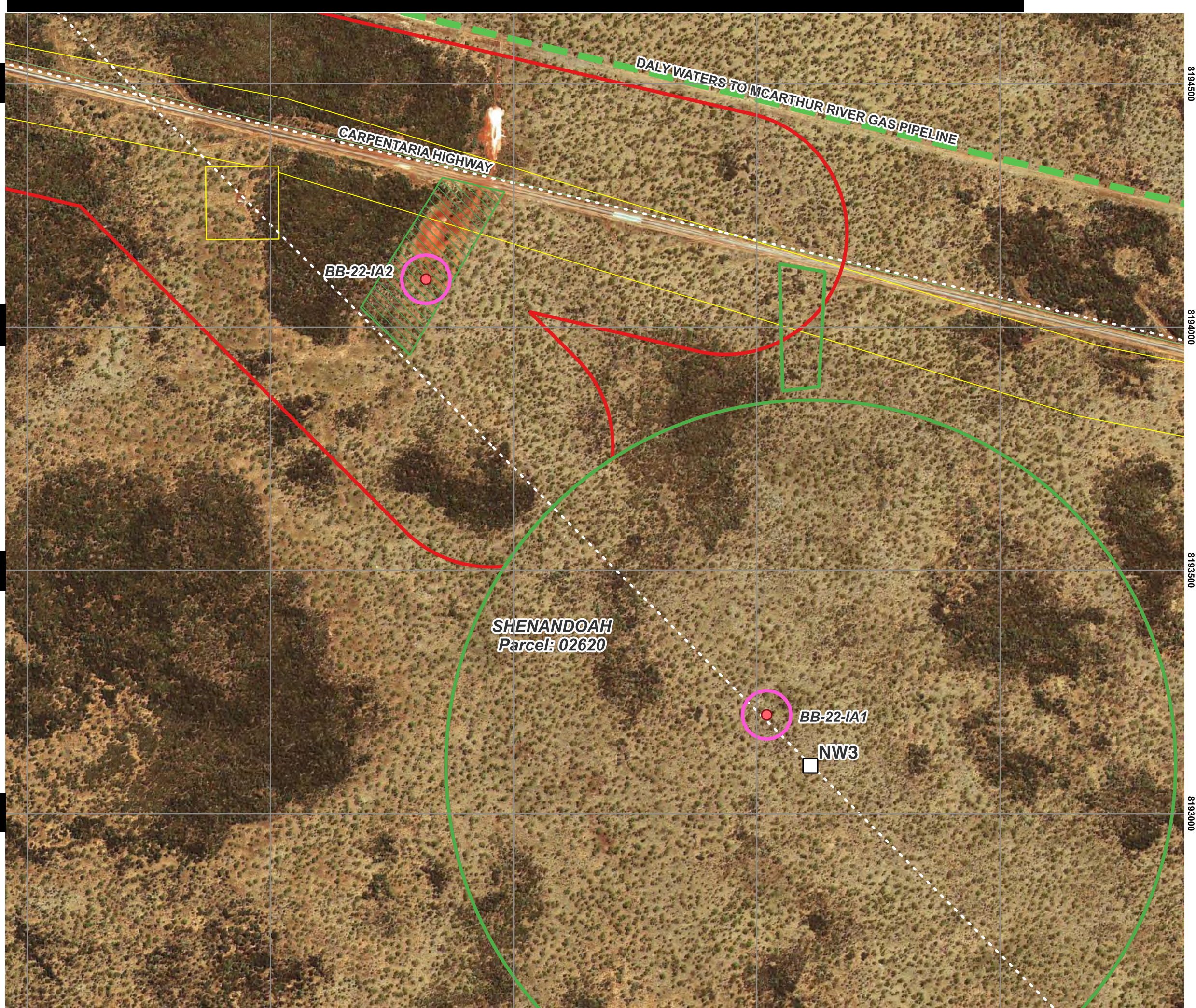
Data Sources:  
Geoscience Australia  
Bing Australia

**Amungee 2D Seismic and Well LCA  
Heritage Assessment Report  
BB-22-AS1**

PROJECT ID	E220390
CREATED BY	LK
LAST MODIFIED	08-7-2022
VERSION	1

**Figure  
4.1A**

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**LEGEND**

- Heritage - Artefacts
- Well Pad Locations
- 2D Seismic 250m Buffer
- Well Scouting 750m buffer
- Gravel Pits
- NT - Cadastre

Data Sources:  
Geoscience Australia  
Bing Australia

**Amungee 2D Seismic and Well LCA  
Heritage Assessment Report  
BB-22-IA1 & BB-22-IA2**

PROJECT ID	E220390
CREATED BY	LK
LAST MODIFIED	08-7-2022
VERSION	1

**Figure  
4.1B**

## 5 Significance Assessment

### 5.1 Scientific Significance

In the absence of formal State/Territory significance assessment guidelines and for the sake of consistency across Beetaloo Basin assessments, EMM has utilised AECOM's standard approach. This methodology utilises a standardised set of criteria developed for Australian contexts that address the principal factors involved in determining an archaeological site's scientific significance and as a consequence the level of management measures required.

For the current assessment, information on the scientific values of the seismic survey areas has been obtained through a review of existing environmental and archaeological data. The significance rating of 'scientific significance' is offered on the basis of an assessment of the place's complexity, rarity, representativeness, integrity/place condition and assigned low, moderate and high values. The criteria are explained in Appendix B.

Table 5.1 applies the criteria to each of the identified sites in the Amungee NW-1 seismic survey area. Of the three archaeological sites, one site was determined to be of high scientific significance, with the remaining two sites being of low or low-medium scientific significance.

**Table 5.1 Scientific Significance Assessment**

Site ID	Site Contents	Rarity	Site Integrity	Overall Scientific Significance
BB-22-AS1	High – 3 Artefact scatter has a large number of artefacts and diverse range of cultural heritage material	Medium – 2	High – 3 The site is in excellent condition with minimal or not disturbance	8 – High scientific significance
BB-22-IA1	Low – 1 Isolated Artefact	Low – 1 Isolated artefacts are a common occurrence across Australia	Low – 1 Site is an isolated surface find	3 – Low scientific significance
BB-22-IA2	Low – 1 Isolated Artefact	Low – 1 Isolated artefacts are a common occurrence across Australia	Low – 1 Site is an isolated surface find	3 – Low scientific significance

### 5.2 Cultural Significance

Cultural value refers to the spiritual, traditional, historical, and contemporary associations and attachments a place or area has for Aboriginal people and can only be identified through consultation with Aboriginal people. In-field discussions with Jeremy Jackson (Traditional Custodian) and Ben Ulamari (Origin employee and Traditional Custodian) highlighted the cultural importance of BB-22-AS1, BB-22-IA1 and BB-22-IA2. In particular BB-22-AS1 was considered a location of high value. Discussions were also had regarding opportunities for members of the local Aboriginal community to visit this site.

## 6 Key Findings and Recommendations

### 6.1 Key Findings

The key findings of this heritage assessment are:

- A review of existing heritage data and reports for the study area indicate that no previously recorded heritage sites are located within the propose seismic survey area.
- A total of twenty six target survey areas (five well sites and 21 heritage locations) were inspected during the scouting survey.
- Three Aboriginal archaeological sites (BB-22-AS1, BB-22-IA1 and BB-22-IA2) were located during the survey. Of these, archaeological site BB-22-AS1 has been identified as a high value

### 6.2 Recommendations

On the basis of the above findings, the following recommendations are made:

- A 100m avoidance buffer should be established for archaeological site BB-22-AS1 which includes the current proposed location for well site NW5.
- The proposed well location for NW5 should be relocated to the proposed NW5 alternative location (GDA20 Z53 380632mE 8187442mN)
- Where possible, archaeological sites BB-22-IA1 and BB-22-IA2 should be avoided. Should avoidance not be possible, the artefacts should be salvaged and translocated to archaeological site BB-22-AS1
- All heritage sites recorded as part of this survey should be reported to the NT Heritage Branch. Should these heritage items be declared a heritage object by the NT Heritage Council, a work order may be required for future impacts to the object.
- An unexpected heritage finds stop works procedure is to be implemented for the duration of the project (Appendix D).
- Induction of staff on site is to include reference to the wider area having Indigenous heritage values and the stop works procedure.

Yours sincerely



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# Appendix A

## Legislation

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## A.1 Legislation

### A.1.1 Commonwealth Legislation

#### i Environment Protection and Biodiversity Conservation Act

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) took effect on the 16 July 2000 (NSW Department of Urban Affairs and Planning, 2000). Under section 26 of the EPBC Act it is stated that:

A person must not take on Commonwealth land an action that has, will have or is likely to have a significant impact on the environment.

Under Section 28 of the EPBC Act it is stated that:

The Commonwealth or a Commonwealth agency must not take inside or outside the Australian jurisdiction an action that has, will have or is likely to have a significant impact on the environment inside or outside the Australian jurisdiction.

An action is defined as a project, development, undertaking, activity, series of activities, or alteration. An action will also require approval if:

It is undertaken on Commonwealth land and will have or is likely to have a significant impact;

It is undertaken outside Commonwealth land and will have or is likely to have a significant impact on the environment on Commonwealth land; and

It is undertaken by the Commonwealth and will have or is likely to have a significant impact.

The EPBC Act defines 'environment' as both natural and cultural environments and therefore includes Aboriginal and historic heritage items. Under the Act, protected heritage items are listed on the National Heritage List (items of significance to the nation) or the Commonwealth Heritage List (items belonging to the Commonwealth or its agencies). These two lists replaced the Register of the National Estate (RNE) which is no longer a statutory list.

#### ii Aboriginal and Torres Strait Islander Heritage Protection Act 1984

The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (the ATSIHP Act) provides for the preservation and protection of places, areas and objects of particular significance to Indigenous Australians. The stated purpose of the ATSIHP Act is the 'preservation and protection from injury or desecration of areas and objects in Australia and in Australian waters, being areas and objects that are of particular significance to Aboriginals in accordance with Aboriginal tradition' (section 4).

Under the Act, 'Aboriginal tradition' is defined as "the body of traditions, observances, customs and beliefs of Aboriginals generally or of a particular community or group of Aboriginals, and includes any such traditions, observances, customs or beliefs relating to particular persons, areas, objects or relationships" (Section 3). A 'significant Aboriginal area' is an area of land or water in Australia that is of 'particular significance to Aboriginals in accordance with Aboriginal tradition' (Section 3). A 'significant Aboriginal object', on the other hand, refers to an object (including Aboriginal remains) of like significance.

For the purposes of the Act, an area or object is considered to be injured or desecrated if:

- In the case of an area:
  - it is used or treated in a manner inconsistent with Aboriginal tradition;
  - the use or significance of the area in accordance with Aboriginal tradition is adversely affected;

- passage through, or over, or entry upon, the area by any person occurs in a manner inconsistent with
- Aboriginal tradition;
- In the case of an object:
  - it is used or treated in a manner inconsistent with Aboriginal tradition.

The ATSIHP Act can override state and territory laws in situations where a state or territory has approved an activity, but the Commonwealth Minister prevents the activity from occurring by making a declaration to protect an area or object. However, the Minister can only make a decision after receiving a legally valid application under the ATSIHP Act and, in the case of long-term protection, after considering a report on the matter. Before making a declaration to protect an area or object in a state or territory, the Commonwealth Minister must consult the appropriate Minister of that state or territory (section 13).

### iii [Native Title Act 1993](#)

The *Native Title Act 1993* provides for the recognition and protection of native title for Indigenous peoples. The Act recognises native title for land over which native title has not been extinguished and where persons able to establish native title are able to prove continuous use, occupation or other classes of behaviour and actions consistent with a traditional cultural possession of those lands. It also makes provision for Indigenous Land Use Agreements (ILUA) to be formed.

## A.1.2 [Northern Territory Legislation](#)

### i [Northern Territory Aboriginal Sacred Sites Act 1989](#)

The *Northern Territory Aboriginal Sacred Sites Act 1989* was established to provide a system that protects sacred sites whilst providing for the development of land. The Aboriginal Areas Protection Authority (AAPA) is a statutory authority established under the Sacred Sites Act and is responsible for overseeing the protection of sacred sites on land and sea across the whole of Australia's Northern Territory.

The Act establishes the protection of Aboriginal sacred sites through:

- Sacred site avoidance surveys and issuing authority certificates for any development proposals.
- Giving the public information about existing sacred sites through abstracts of Authority records and access to the registers the Authority maintains.
- Establishing and maintaining a Register of Sacred Sites
- Manages the rights of traditional custodians to access Sacred Sites.

The Act also establishes a range of offences and associated penalties that are aimed at protecting sacred sites. It is an offence to desecrate or disturb a site without the approval of the relevant custodians. A register of known sites exists to assist in identifying the likelihood of disturbance and potential need to obtain approval. The Act also establishes a duty-of-care to notify the AAPA of any potential disturbance to Aboriginal sacred sites.

### ii [Heritage Act 2011](#)

The *Heritage Act 2011* provides for the protection of both natural and cultural heritage (Aboriginal, historical and Macassan heritage) within the Northern Territory. The Act establishes the Heritage Council (consisting of

eleven members) and the NT Heritage Register. It sets the process by which places become heritage places and allows for interim protection of places.

It is an offence to remove or damage heritage places or objects or to mislead or obstruct heritage officers regarding the provision of requested information or entry to works, vehicles or premises that are likely to have been involved in an offence against the Heritage Act. Compliance with the requirements of the Act must be adhered to at all times.

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# Appendix B

## Archaeological Assessment Criteria

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## B.1 Archaeological Assessment Criteria

The following tables outline the criteria used to assess subsurface archaeological potential.

**Table B.1** Ground Surface Visibility (GSV) Rating

GSV Rating	Ground Surface Visibility %
Nil to Poor	0-25%
Poor to Good	26-50%
Good to Very Good	51-75%
Very Good to Excellent	76-100%

**Table B.2** Ground Surface Integrity (GSI) Rating

GSI rating	Definition
Low	Ground surface has been subjected to significant disturbance (e.g. earthworks, excavation). Little to no integrity remains.
Moderate	Ground surface has been subject to moderate disturbance (e.g. native vegetation clearance) but retains a reasonable degree of integrity.
High	An unmodified or minimally modified ground surface.

**Table B.3** Subsurface Archaeological Potential

Subsurface Archaeological Potential	Definition
Low	Areas in which subsurface archaeological materials are unlikely to occur. This may be due to unfavourable environmental conditions and/or prior disturbance(s).
Moderate	Areas in which subsurface archaeological materials may occur. Reasonable environmental conditions exist though high artefact counts/densities are unlikely. Subsurface evidence likely to be the product of random discard events as opposed to repeated or extensive activity by Aboriginal people in antiquity.
High	Areas known or highly likely to contain subsurface archaeological materials. Presence of archaeological materials typically reflects optimal environmental conditions and little to no prior landscape disturbance. High artefact counts/densities are likely.

## B.2 Scientific Significance Criteria

### B.2.1 Complexity

The *complexity* of a site refers primarily to the nature or character of the artefactual materials or features that constitute it but also includes site structure (e.g., the physical size of the site, spatial patterning in observed cultural materials).

**Table B.4 Scientific Significance – Complexity**

Criteria	Value
No cultural materials remain	None - 0
Place contains 1-10 artefacts with no evident archaeological deposit	Low – 1
Place contains more than 10 artefacts but limited range of cultural heritage materials and/or potential for archaeological deposit	Medium – 2
Place contains more than 10 artefacts and diverse range of cultural heritage material and/or likely potential for archaeological deposits	High – 3

### B.2.2 Rarity & Representativeness

Rarity and representativeness are related concepts. *Rarity* refers to the relative uniqueness of a site within its local and regional context. The scientific significance of a site is assessed as higher if it is unique or rare within either context.

The concept of *representativeness* refers to the question of whether or not an archaeological site is a ‘good example of its type’ (Burke & Smith 2004: 247). Representativeness is an important criterion as one of the primary goals of cultural heritage management is to preserve for future generations a representative sample of all archaeological site types in their full range of environmental contexts.

**Table B.5 Rarity & Representativeness Criteria**

Criteria	Value
Common occurrence within the geographical region	Low – 1
Irregular occurrence within the geographical region	Medium – 2
Rare occurrence within the geographical region	High – 3

### B.2.3 Integrity

*Integrity* refers to the extent to which a site has been disturbed by natural and/or anthropogenic phenomena and includes both the state of preservation of particular remains (e.g., animal bones, plant remains) and, where applicable, stratigraphic integrity. Assessments of archaeological integrity are predicated on the notion that undisturbed or minimally disturbed sites are likely to yield higher quality archaeological and/or environmental data than those whose integrity has been significantly compromised by natural and/or anthropogenic phenomena.

**Table B.6 Integrity Criteria**

Criteria	Value
Heritage site destroyed	None - 0
Site is a single isolated surface find or is in a deteriorated condition with high degree of disturbance but with some cultural material remaining	Low – 1
Site in a fair to good condition but with some disturbance	Medium – 2
Site in an excellent condition with little or no disturbance.	High – 3

### B.2.4 Overall Scientific Significance

An overall scientific significance rating is assigned to the site based on a cumulative score from the assessment. This results in one of the following ratings being assigned for scientific significance:

- 1-3 – Low Scientific Significance
- 4-6 – Moderate Scientific Significance
- 7-9 – High Scientific Significance

### B.3 Impact Assessment

The degree of impact an activity will have on a cultural heritage place is assessed in terms of the magnitude of change to the acknowledged heritage values of a place. These impacts may be direct, such as the demolition of heritage buildings, or indirect, such as changes to the views or setting of a cultural heritage place. In some cases, indirect impacts might also cause physical damage to a cultural heritage place, such as excessive vibration causing structural damage, or excessive pollution causing damage to surfaces.

**Table B.7 Heritage Impact Risk**

<b>Impact Risk</b>	<b>Definition</b>	<b>Management Action</b>
No Impact	Heritage objects will not be affected by the proposed activity.	Unexpected Finds Procedure
Low Impact	Unlikely to disturb, destroy, damage or deface a heritage object or objects.	Unexpected Finds Procedure
Moderate Impact	Reasonable potential to disturb, destroy, damage or deface a heritage object or objects.	Avoid area if possible. If avoidance not an option, test excavate area to determine nature and extent of potential archaeological deposits
High Impact	Will, or is highly likely to, disturb, destroy, damage or deface a heritage object or objects.	Avoid area if possible. If avoidance not an option, test excavate area to determine nature and extent of potential archaeological deposits

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# Appendix C

## Unexpected Heritage Finds Procedure

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## Integrated Gas

# UNEXPECTED HERITAGE FINDS PROCEDURE Beetaloo Asset (Northern Territory)

This documents details the Unexpected Heritage Finds Procedure for the Beetaloo Exploration Program.

Revision	Date	Description	Originator	Checked	Approved
0	31/03/2019	Unexpected Heritage Finds Procedure	Luke Kirkwood	Alana court	MK

# Unexpected Heritage Finds Procedure

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# Unexpected Heritage Finds Procedure

## 1. Purpose

The purpose of this procedure is to set out the actions to be undertaken by Origin staff and contractor if a suspected find of Aboriginal and non-Aboriginal cultural heritage is made during civil construction activities.

## 2. Scope

This procedure covers the requirements associated with:

- The identification of cultural heritage artefacts or areas within the Beetaloo Permit Area.
- The assessment of the risk and control measures to be taken if a suspected Indigenous and non-Indigenous cultural heritage find is discovered; including investigation, notification, recording and reporting, means of communication, measures to avoid cultural heritage and dispute resolution.

It applies to all fieldwork conducted in the Beetaloo Basin.

## 3. Responsibility

These personnel are responsible for the following activities:

<b>Corporate Affairs Manager</b>	Heritage specialist and regulator engagement
<b>Project Manager</b>	Procedure issue and maintenance
<b>Construction Superintendent</b>	Implementation of this procedure
<b>Heritage Specialist</b>	Third party engaged to provide specialist heritage advice.
<b>All Employees / Contractors</b>	Complying with this procedure

## 4. Requirements

The following management measures will be implemented for all unexpected heritage finds and are to be included as part of toolbox discussions during civil construction activities.

### 4.1 Unexpected Discovery- Aboriginal Cultural Heritage

Unexpected Aboriginal heritage finds can include the following:

- Stone artefacts (sharp edged rocks that have identifiable features demonstrating evidence of human modification. See attached information sheet)
- Scarred Trees (trees with symmetrical scars that might demonstrate evidence of removal of bark for use in coolamons, shields and huts. See attached information sheet)
- Grindstones (Large sandstone items (either fixed in bedrock or mobile) that have manmade grooves in them demonstrating use. See attached information sheet)
- Stone Axes (heavy hatchet head like stone items, typically with the leading edge sharpened. See attached information sheet)
- Bone, Shell and Charcoal (potential historical food waste dumps (also known as Middens). See attached information sheet)

If subsurface works encounter shell, charcoal and bone this will typically appear as lens ranging from a centimetre to several metres in depth. Stone artefacts may also be present and contractors must be vigilant for these finds at all times as all Aboriginal archaeological heritage is protected in the Northern Territory

Prior to surface works, civil construction teams should be aware of potential for surface finds of artefacts and avoid impacts to scarred trees. This procedure should be discussed as part of the project kick off meeting:

#### **Procedure in the event of Unexpected Aboriginal Heritage Finds**

If an object of potential Aboriginal cultural heritage value is uncovered:

## Unexpected Heritage Finds Procedure

1. All work to cease within 10 metres of the suspected find, and the area to be cordoned off using temporary fencing.
1. The project work crew must record the description, GPS location and photograph the suspect find.
2. Civil Construction Supervisor is to be immediately notified who will then notify the Corporate Affairs Manager.
3. The Civil Construction supervisor will assess where the project work crew can continue to work providing that an appropriate buffer to the site is maintained and that at all times the cultural heritage duty of care is observed.
4. The Corporate Affairs Manager will engage a qualified Heritage Specialist to assess the find and recommend any necessary management measures.
5. The Heritage specialists will provide further directions for managing the suspected find, in accordance with legislative requirements. This may include flagging the discovery, deviating project work around the suspected find (provided the deviation is covered within the existing Environmental Management Plan and AAPA Certificate) or relocating the work front to a new location removed from the suspected find.
6. If the find is determined to be Aboriginal heritage, the Corporate Affairs Manager will notify the relevant Heritage Department and the traditional custodians for the area.
7. Work is not to recommence in the vicinity of the find until direction is provided by the relevant Heritage Department.
8. If the project work cannot deviate around the suspected find and it is necessary to excavate, relocate, remove or harm the suspected find, Origin will seek the advice and consent of the traditional custodians for the area on developing management mitigation measures for the find.

### 4.2 Unexpected Discovery- Historical Cultural Heritage

Unexpected historical heritage finds can include the following:

- Glass (Coloured glass, bottles (complete or fragmentary etc.)
- Metal (identifiable metallic objects such as cutlery, buckles, farming equipment, woodworking and metal equipment etc.)
- Ceramic (Plates, cups, ink wells, pipes, etc.)
- Wood (identifiable human manufactured wooden items)
- Stone (identifiable human manufactured stone items)
- Bone, Shell and Charcoal (potential historical food waste dumps)

#### **Procedure in the event of Unexpected Historical Heritage Finds**

The following management measures are recommended for unexpected historic finds:

1. All work to cease within 10 metres of the suspected find, and the area to be cordoned off using temporary fencing.
2. The project work crew must record the description, GPS location and photograph the suspect find.
3. Civil Construction Supervisor is to be immediately notified who will then notify the Corporate Affairs Manager.
4. The Civil Construction supervisor will assess where the project work crew can continue to work providing that an appropriate buffer to the site is maintained and that at all times the cultural heritage duty of care is observed.
5. The Corporate affairs manager will engage a qualified Heritage Specialist to assess the find and recommend any necessary management measures.
6. The Heritage specialists will provide further directions for managing the suspected find, in accordance with legislative requirements. This may include flagging the discovery, deviating project work around the suspected find (provided the deviation is covered within the existing Environmental Management Plan and AAPA Certificate) or relocating the work front to a new location removed from the suspected find.

## Unexpected Heritage Finds Procedure

1. If the find is determined to be of heritage importance, work is not to recommence in the vicinity of the find until direction is provided from the relevant Heritage Department.

### 4.3 Unexpected Discovery-Human Remains

If any suspected human remains are discovered during any activity works, they must be initially assumed under the provisions of the relevant *Coroners Act* to be a crime scene and treated accordingly. The following procedure is to be applied:

1. Do not handle, photograph or collect the remains. Leave in-situ. You may be unwittingly contaminating a crime scene and leaving your DNA on a crime victim.
2. All activity in the vicinity must cease as the find may be part of a larger crime scene and the Site Supervisor to be notified immediately.
3. The Police must be notified immediately of the discovery by the Site Supervisor or appointed supervisor in charge of the works area.
4. The remains must be left in place and protected from harm or damage with a minimum of at least a 50m buffer. It is important to use best judgement and restrict all movement in the immediate vicinity around the discovery until directed otherwise by the Police as this could contaminate a potential crime scene. Likewise do not set up temporary fencing unless directed by the Police.

### 4.4 Heritage Awareness Training

1. Cultural heritage awareness training must be included in the induction/icebreakers for all Origin staff / contractors conducting project work that may have the potential to harm Aboriginal or historic cultural heritage
2. Origin staff / contractors must be made aware of the conditions set out in the relevant AAPA Certificate (AAPA C2019/039 or other relevant certificate) the obligations of all persons (who enter on, or carry out works or use land on which there is a sacred site) under Part IV of the *Northern Territory Aboriginal Sacred Sites Act 1989*.
3. All Origin staff/ contractors performing civil construction activities are to be made aware of this procedure to ensure any unexpected discoveries are promptly identified and reported

## 5. Records

The following records should be kept and maintained in order to demonstrate compliance with the requirements of this procedure:

- Staff Training records
- Unexpected Finds Incidents Reporting; records of all finds to be kept on file, including correspondence with the relevant Government Departments.

# Unexpected Heritage Finds Procedure

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## 6. Definitions

<b>Archaeological places or objects</b>	Archaeological places or objects exist within or in the vicinity of the Origin Permit Areas. All such materials are protected under the <i>Heritage Act 2011 (NT)</i> .
<b>Aboriginal Cultural Heritage</b>	Has the same meaning as in the relevant Aboriginal Cultural Heritage legislation. It includes pre-settlement and post-settlement significant Aboriginal areas and significant Aboriginal objects.
<b>Aboriginal Heritage Awareness Training</b>	Training may consist of any of: <ul style="list-style-type: none"><li>• Briefings on relevant Aboriginal Cultural Heritage</li><li>• Briefings on particular arrangements with Aboriginal parties</li><li>• Identification of aboriginal heritage artefacts</li><li>• Awareness sessions run for Origin staff by traditional owner/custodian groups</li></ul>
<b>Burial Sites</b>	Possibility of burial sites located within the Permit Area. Under the Northern Territory Criminal Code and <i>Coroners Act 1993 (NT)</i> it is an offence to interfere with remains of a deceased person.  Under the <i>Heritage Act 2011 (NT)</i> , it is an offence to interfere with historical human remains (both Aboriginal and non-Aboriginal) without authorization under this Act.
<b>Cultural Heritage Duty of Care</b>	Has the same meaning as due diligence as defined in Aboriginal Cultural Heritage legislation guidelines applicable to the relevant State in which activities are occurring.
<b>Find</b>	Means a significant Aboriginal object or, evidence of archaeological or historic significance of Aboriginal occupation of an area or Aboriginal human remains, found in the course of undertaking an activity covered by the guidelines.
<b>Traditional Custodian</b>	A descendant of an Aboriginal ethnic group that occupied a particular region before European settlement, recognised as being traditionally responsible for cultural heritage of that area
<b>Traditional Owners</b>	A descendant of the Aboriginal ethnic group that occupied a particular region before European settlement, as recognised by Australian law.

## 7. References

1. Northern Territory Aboriginal Sacred sites Act 1984
2. Northern Territory Heritage Act
3. Aboriginal Areas Protection Authority Certificate

## **Appendix L Risk Assessment**

# Risk Matrix

		IMPACT ON ORIGIN OPERATIONS					EXTERNAL RESPONSE		LIKELIHOOD						
		Conduct Business with Due Care		Create Value			Decisions are Subject to Scrutiny		1 REMOTE	2 HIGHLY UNLIKELY	3 UNLIKELY	4 POSSIBLE	5 LIKELY	6 HIGHLY LIKELY	
		People	Environment and Community	EBIT	Cash flow	NPV	Stakeholder Perceptions	Laws, regulation and civil actions	<1% chance of occurring within the next year. Only occurs as a '100 year event' or less frequent.	<10% chance of occurring within the next year. Could occur within decades.	<30% chance of occurring within the next year. Could occur within the next few years.	<60% chance of occurring within the next year. Could occur within months to years.	<90% chance of occurring within the next year. Could occur within weeks to months.	Likely to happen multiple times a year	
CONSEQUENCE	6 CATASTROPHIC	Multiple fatalities ≥4 or life threatening illness or total permanent disability to a large exposed group (10 or more people)	Extensive permanent damage to endangered species, habitats, ecosystems or area/s of cultural significance  Extensive irreversible loss of community livelihood. Long-term social unrest and outrage	>\$200m	>\$1b	>\$1.5b	Multiple stakeholder groups confirming coordinated action, as reflected in media channels with significant reach and influence (eg. scheduled blockade or boycott covered in media for more than 1 week).	Criminal charges against any director or senior executive involving jail or loss of right to manage the company. Public inquiry – requiring considerable resources and Executive Management time. Loss of licence to operate an asset	6 CATASTROPHIC	HIGH	HIGH	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH
	5 CRITICAL	1 – 3 fatalities or life threatening illness or total permanent disability to a small exposed group (<10 people)	Extensive long term partially reversible damage to vulnerable species, unique habitats, ecosystems or area/s of cultural significance  Extensive reversible loss of community livelihood. Prolonged community outrage.	>\$50m - \$200m	>\$250m - \$1b	>\$375m - \$1.5b	Multiple stakeholder groups mobilising and encouraging others to take action, as reflected in media channels with significant reach and influence (eg. social media campaign calling for protest, escalating over several days).	Criminal charges against any director, senior executive or senior manager not involving jail or loss of right to manage the company. Prolonged major litigation – exposure to significant damages / fines / costs. Suspension / restriction to operate an asset.	5 CRITICAL	MEDIUM	MEDIUM	HIGH	VERY HIGH	VERY HIGH	VERY HIGH
	4 MAJOR	Injury or illness to one or more persons, resulting in permanent partial disability	Long term reversible impacts to listed species, habitats, ecosystems or area of cultural significance  Significant impacts to community cost of living, business viability or social wellbeing. High levels of community tension.	>\$20m - \$50m	>\$100m - \$250m	>\$150m - \$375m	More than one stakeholder group's opinion or view influencing other stakeholders, reported through media channels with some reach and influence (eg. government comments in national media or in Parliament).	Criminal charges against any employee (not described above) Major litigation – exposure to damages / fines / costs.	4 MAJOR	MEDIUM	MEDIUM	MEDIUM	HIGH	VERY HIGH	VERY HIGH
	3 SERIOUS	Injury or illness to one or more persons resulting in hospitalisation, 5 or more days lost time or alternative / restricted duties for 1 month or more	Serious medium term reversible impacts to low risk species, habitats, ecosystems or area/s of cultural significance  Moderate impacts to community cost of living, business viability or social wellbeing. Moderate levels of community tension.	>\$5m - \$20m	>\$25m - \$100m	>\$37.5m - \$150m	More than one stakeholder group offering an opinion or view, reported through media channels with some reach and influence (eg. state based commentary lasting one 24 hour media cycle across internet, print, television, radio).	Non-compliance with conditions of licence to operate an asset or to conduct an activity. Litigation – exposure to damages / fines / costs.	3 SERIOUS	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH
	2 MODERATE	Injury or illness to 1 or more persons resulting in medical treatment, up to 5 days lost time or alternative / restricted duties for up to 1 month	Moderate short term impacts to common regional species, habitats, ecosystems or area of cultural significance Small scale impacts to cost of living, business viability or social wellbeing. Isolated examples of community tension.	>\$1m - \$5m	>\$500k - \$25m	>\$750k - \$37.5m	A single stakeholder group drawing attention to an incident, issue or approach, conveyed through media channels with potential reach and influence (eg. some social media complaints or local media reports).	Moderate non-compliance with external mandatory obligations or breach of contractual or other legal obligations (not described above). Litigation possible.	2 MODERATE	LOW	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM
	1 MINOR	Injury or illness requiring first aid to 1 or more persons, or no treatment (record only)	Minor environmental or community impact - readily dealt with	>\$100k - \$1m	<\$500k	<\$750k	A person or organisation within stakeholder group signaling an interest in an incident, event or approach, using channels with limited reach or influence (eg. letter of complaint/commendation).	Minor non-compliance with external mandatory obligations or breach of contractual or other legal obligations.	1 MINOR	LOW	LOW	LOW	MEDIUM	MEDIUM	MEDIUM

\* Cash Flow - change from expectation over the life of the exposure. EBIT change from expectation over 12 – 18 month period.

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures			Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
1	Groundwater	Changes in aquifer quality from subsurface (drilling and stimulation) activities impacting a receptor (groundwater user or Groundwater Dependent Ecosystem).	Contamination from drilling fluids. Drilling fluids used to drill through the Cambrian Limestone Aquifer (CLA) are water-based with clay inhibition in the form of KCl. This may result in temporary elevated levels of chlorides in the CLA immediately adjacent to the well bore during the drilling of the top hole section of the well. This risk also includes groundwater monitoring bore construction (Path 1)	B.4.10 Drilling fluids B.4.17 Groundwater monitoring	1	5	M	<ul style="list-style-type: none"> <li>Drilling fluids used to drill aquifers are low toxic, water-based with addition of bentonite and salt in the form of potassium chloride for clay inhibition. Low toxic synthetic based muds to be used for bore-hole stability from the Hayfield mudstone or below (i.e. synthetic based muds not used to drill through aquifers and all aquifers will be protected behind cement casing) (Engineering)</li> <li>Drilling Fluids included in chemical risk assessment and determined to be of low concern through adoption of standard chemical management practices (Administration)</li> <li>Results of existing exploration well will be used to optimise the drilling of all proposed new wells, with fluid systems modified where fluid loss zones are anticipated (Elimination)</li> <li>Impacted area likely to be localised around the immediate vicinity of each well bore (Elimination)</li> <li>Karst system likely to result in rapid dilution (Elimination)</li> <li>Site selection: No pastoralist extraction bores within 1 km. (Elimination)</li> <li>Groundwater monitoring bores constructed in accordance with the Minimum Construction Requirements for Water Bores in Australia utilising low toxicity drilling fluids and muds</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring of drilling fluid returns to identify fluid losses and modify fluid systems (Engineering)</li> <li>Impact groundwater monitoring bores constructed within 20m of exploration well, with any changes detected rapidly (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Use of loss of circulation material (such as fibres or dissolvable materials) to mitigate drilling fluid losses when drilling within aquifers (Engineering)</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	1	3	L	Yes	This risk consequence is managed through the COP requirements that only water based drilling fluids are to be used which will not result in a residual toxic effect to the aquifer. The consequence is anticipated to be "minor", with a locally restricted rapidly reversible impact. The likelihood is reduced by the type of drilling fluids used to drill through the aquifer, protection of aquifer by cement casing for drilling below aquifer depth, rapid dilution of karst formations and the 4km separation distance from the closest pastoral user. The likelihood of contamination at any receptor is considered remote- with a probability lower than 1%.	Yes	Low
2		Cross flow of formation through inappropriate well barrier design and construction. (Path 1)		B.4.3 Well design and barriers B.4.2 Aquifer Isolation B.4.7 Primary cementing B.4.17 Groundwater monitoring	3	1	L	<ul style="list-style-type: none"> <li>Each well designed and constructed with multiple (4) casing barriers and specifically-engineered cement in place to protect aquifers- this includes the 18.625" Conductor casing, 13.75" surface casing, 9.625" intermediate casing and 5.5" production casing.</li> <li>Casing shoe for the conductor and surface casing section to be located in the base of each aquifer unit, with cement returned to surface</li> <li>Any impacted area likely to be localised, around the immediate vicinity of the E&amp;A wells.</li> <li>No driving head between saline formations (below Gum Ridge) and surface aquifers- cross flow potential is limited</li> <li>No landholder bores within 1km.</li> <li>Groundwater monitoring bores constructed in accordance with the Minimum Construction Requirements for Water Bores in Australia</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Well Barrier Integrity Validated (WBIV) through casing pressure tests and Casing shoe integrity tests of test during the construction of each casing string</li> <li>Monitoring of cement returns to surface, with cement volume sand density as per programme</li> <li>Cement bond logs (CBL) completed on each well prior to stimulation to confirm integrity</li> <li>Each well designed, with a Well Barrier Integrity Validation report approved by DITT as part of Well Operations Management Plan (WOMP).</li> <li>Groundwater monitoring bores installed to detect and trigger response in the case of contamination.</li> </ul>	<ul style="list-style-type: none"> <li>2 stage cement job completed where fluid losses between the casing shoe and the base of the loss zone. 2nd stage places cement 30m above the zone of losses, using an inflatable casing packer coupled with a stage tool assembly.</li> <li>Cement repair jobs (such as squeeze jobs) to be performed to mitigate poor cement coverage.</li> <li>Plug and abandonment and re-drilling of new vertical/ horizontal well sections where required.</li> </ul>	3	1	L	Yes	The risk of cross formation flow is managed through the COP which provides specific well barrier design and validation requirements to mitigate the risk of aquifer interconnectivity. The well barrier design is submitted to DITT as a part of the WOMP and must be approved prior to the commencement of drilling. The integrity of each well is validated prior to the commencement of hydraulic fracture. The consequence of an interconnectivity event is likely to be "serious", with spatially restricted (to the vicinity of the well), medium term reversible impacts. The Likelihood of multiple casing and cement failures from occurring is considered remote, with a probability lower than 1%. This is confirmed by the NT inquiry that estimated the likely well failure rate (total failure of all barriers) to be less than 0.1%.	Yes	Low
3		Crossflow through fracture growth into aquifer from stimulation activities allowing the migration of fluid and gas. (Path 2)		B.4.3 Well design and barriers B.4.13 Hydraulic Stimulation and Flowback Operations B.4.17 Groundwater monitoring	3	1	L	<ul style="list-style-type: none"> <li>Each well designed and constructed with multiple (4) casing barriers and specifically-engineered cement in place to protect aquifers- this includes the 18.625" Conductor casing, 13.75" surface casing, 9.625" intermediate casing and 5.5" production casing.</li> <li>Casing shoe for the conductor and surface casing section to be located in the base (Aquifer) of each aquifer unit, with cement returned to surface</li> <li>Geomechanical data collected during drilling of existing wells used to understand fracture gradients.</li> <li>Geomechanical modelling validated from Amungee NW-1 stimulation results and ensure to appropriate fracture barriers are sufficient to contain the fracture propagation.</li> <li>Modelling to factor in results of existing wells to optimise stimulation design.</li> <li>Hydraulic fracture stimulation risk assessment completed prior to stimulation to determine fracture growth.</li> <li>Minimum 1400 m vertical separation distance between target formation and closest aquifer.</li> <li>Each horizontal well to be at least 2-400 m separated, with the separation distance determined through the Mechanical earth model and results from stimulation of existing wells.</li> <li>Overlying sequences have a higher fracturing pressure reducing the risk of fracture migration out of the target shale.</li> <li>Any impacted area likely to be localised, around the immediate vicinity of the E&amp;A wells.</li> <li>No driving head between saline formations (below Gum Ridge) and surface aquifers- cross flow potential is limited</li> <li>No landholder bores within 1 km.</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Well Barrier Integrity Validated (WBIV) through casing pressure tests and Casing shoe integrity tests of test during the construction of each casing string</li> <li>Monitoring of cement returns to surface, with cement volume sand density as per programme</li> <li>Cement bond logs (CBL) completed on each well prior to stimulation to confirm integrity</li> <li>A Well Barrier Integrity Validation report approved by DITT as part of Well Operations Management Plan (WOMP).</li> <li>Real time pressure monitoring of stimulation pressure to determine if a fracture has propagated outside the design operating envelope.</li> <li>Groundwater monitoring bores installed to detect and trigger response in the case of contamination.</li> </ul>	<ul style="list-style-type: none"> <li>Stimulation activities to cease and be reviewed where fracture propagation extends beyond the target formation (noting a 1400m separation between the closest regional aquifer). Where fracture growth is suspected to reach an aquifer, Stimulation activity on pad suspended until a go forward plan submitted by Origin and approved by DITT.</li> </ul>	3	1	L	Yes	The risk is managed through the COP requirements for well integrity, validation and stimulation modelling. The consequence of aquifer interconnectivity is further reduced through pressure monitoring during stimulation. Any uncontrolled fracture growth is likely to be detected rapidly using pressure monitoring and managed to prevent growth into aquifers. Management of any pressure indicating interconnection would be investigated and could result in a potential repair and/ or abandonment of the well.	Yes	Low
4		Stimulation activity induces seismic activity that enables cross formation flow between shallow aquifers. (Path 5)		B.4.13 Hydraulic Stimulation and Flowback Operations B.4.17 Groundwater monitoring	2	1	L	<ul style="list-style-type: none"> <li>Wells are located away from known geohazards, with no significant faults within proximity of activity (Elimination)</li> <li>Amungee NW-1 stimulation completed without inducing seismic activity (Elimination)</li> <li>Stimulation is not linked to major seismic events (rejection of wastewater is generally recognised as the main cause). No reinjection of wastewater proposed (Elimination)</li> <li>Stimulation stages deployment will be away from geohazards to reduce the loss of fluids into any encountered faults (Elimination)</li> <li>The Beetaloo is not prone to seismic activity and there is no evidence of recent earthquake activity as most faults and the major subsurface structure are confined to Cambrian or older strata. This is supported by the National seismic Hazard Assessments completed by Allen 2018 (Figure 33), which highlight the Beetaloo is located within a low hazard area (Elimination)</li> <li>Any faults encountered during drilling will be assessed to determine risk of stimulating with appropriate separation distances applied (Elimination).</li> <li>1400 m separation distance between target Velkerri formation and the Gum Ridge Aquifer. (Elimination)</li> <li>No landholder bores within 1 km (Elimination)</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring of stimulation pressure to detect and respond to anomalies which may indicate fluid being pumped to an open geological structure (Engineering)</li> <li>Geoscience Australia's Waramungu seismic array located approximately 300km from Amungee Delineation Area. Seismometer to be located adjacent to each well pad. It is likely that any material seismic events above a 2 MI will be detected via this array if they occur (Administration)</li> <li>An induced seismicity traffic light system has been adopted and outlined in the WOMP (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where seismic activity is recorded in Origin's tenure during hydraulic stimulation activities, the actions in the WOMP Traffic Light System will be enacted as summarised below: Green: Local Magnitude (MI) &lt;2.0- no action required Orange: ML 2.0- &lt;3.5MI- Report event to DITT and continue operations Red: ML&gt; 3.5- Stimulation activity on pad suspended until a go forward plan submitted by Origin and approved by DITT.</li> </ul>	2	1	L	Yes	The consequence of a induced seismicity, based upon evidence from the UK and US, indicates that the consequence is likely to be "moderate", with most events restricted to discrete areas at a size that generally cannot be detected at the surface (below 2 order of magnitude). Larger events are rare and generally a factor of the existing built up stress regime of the area- rather than a factor of the intensity of hydraulic fracturing or wastewater injection. The likelihood of a seismic event is reduced through the geological setting of the Beetaloo Basin itself and the safeguards implemented in the COP requiring geohazard assessment and avoidance. In the Beetaloo, there have been no earthquakes over magnitude 3 measured since records began. The area is not prone to seismic activity and there is no evidence of recent earthquake activity as most faults and the major subsurface structure are confined to Cambrian or older strata. This is supported by the National seismic Hazard Assessments completed by Allen 2018 (Figure 33), which highlight the Beetaloo is located within a low hazard area. The COP requires any geohazard (such as fault) identified prior to drilling (from existing seismic or interpreted data) or encountered during drilling to have a risk assessment to determine the potential for reactivation. Any faults identified would not be stimulated, with a risk-based buffer applied. Given the number of wells stimulated in the US without issue and geological setting of the Beetaloo basin, the likelihood is considered remote, with a probability less than 0.1%.	Yes	Low
5		Migration via fractures intersecting with offset wells (including the adjacent horizontal wells) or intersecting an existing geohazard. (Path 2 & 5)		B.4.13 Hydraulic Stimulation and Flowback Operations	2	1	L	<ul style="list-style-type: none"> <li>Amungee NW sites will be screened for geohazards using seismic before drilling</li> <li>Wells are located away from known geohazards, with no significant faults within proximity of activity (Elimination)</li> <li>Results from existing wells confirm the lack of significant faulting or other geohazards</li> <li>Amungee NW stimulation completed without any uncontrolled fracture growth (Elimination)</li> <li>Fracture modelling undertaken to determine maximum fracture growth prior to the commencement of stimulation activities.</li> <li>Any faults encountered during drilling will be assessed to determine risk of stimulating with appropriate separation distances applied (Elimination).</li> <li>Stimulation stages deployment will be away from geohazards to reduce the loss of fluids into any encountered faults (Elimination)</li> <li>Separation of at least 200 m between each horizontal well, with final separation distance determined through modelling. (Elimination)</li> <li>Each adjacent well designed and constructed with multiple (4) casing barriers and specifically-engineered cement in place to protect aquifers- this includes the 18.625" Conductor casing, 13.75" surface casing, 9.625" intermediate casing and 5.5" production casing. (Elimination)</li> <li>1400 m separation distance between target Velkerri formation and the Gum Ridge Aquifer (Elimination)</li> <li>No landholder bores within 1 km (Elimination)</li> <li>Closest legacy exploration well 15 km (well is abandoned).</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring of stimulation pressure to detect and respond to anomalies which may indicate fluid being pumped to an open geological structure or migrating away from target zone (Engineering)</li> <li>Pressure monitoring undertaken on adjacent wells</li> <li>Groundwater monitoring bores adjacent to exploration wells (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Stimulation activities to cease where fracture propagation is suspected to have interacted with an adjacent well. Stimulation activity on pad suspended until a go forward plan submitted by Origin and approved by DITT.</li> </ul>	2	1	L	Yes	If an integrity issue was to occur, leakage of gas and flowback (including recycled flowback) would be contained within the inner casing strings of the existing adjacent well , significantly reducing the consequence and likelihood of an event. The likelihood risk mitigated through the 1) design of adjacent E&A wells which are constructed in accordance with the COP using multiple, verified barriers (Cement and steel casing) 2) the location of the closest historic exploration well is located approximately 20km from the well pad and 3) Geohazards have not been identified during the drilling of the existing Amungee Delineation Area. The likelihood is considered Remote", with a probability lower than 1%.	Yes	Low

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures			Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
6		Crossflow/well integrity caused by the deviation of an E&A well into the adjacent well during drilling	B.4.3 Well design and barriers	B.4.1 Well Integrity Management B.4.3 Well design and barriers	3	1	L	<ul style="list-style-type: none"> <li>Separation distance between adjacent wells: Vertical separation of &gt;10m and horizontal separation of &gt;200m used to ensure appropriate well separation. (Engineering)</li> <li>Each adjacent well designed and constructed with multiple (4) casing barriers and specifically-engineered cement in place to protect aquifers- this includes the 18.625" Conductor casing, 13.75" surface casing, 9.625" intermediate casing and 5.5" production casing.(Engineering)</li> <li>1400 m separation distance between target Velkerri formation and the Gum Ridge Aquifer. (Elimination)</li> <li>Subsurface collision of a well during drilling is unlikely to result in formation cross flow, with collision likely at depth (below Aquifers) and flow restricted to the well being drilled. Well being drilled will have multiple barriers (at least the conductor casing and surface casing) and blow out prevention in place during drilling (Engineering/Elimination)</li> <li>Origin has conducted multiwell drilling operations across Australia, including the Cooper, Bowen and Surat Basins. Origin and their contractors experience is mature. (Engineering)</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Continuous GPS tracking of the drill bit to detect and respond to vertical and horizontal well deviations during drilling (Engineering)</li> <li>Pressure monitoring undertaken on adjacent wells (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Well orientation to be actively controlled to prevent deviations into adjacent wells (Engineering)</li> <li>Wells remediated in accordance with the code of practice (engineering)</li> <li>Well suspension and abandonment may be required where wells interact during drilling (Engineering)</li> </ul>	3	1	L	Yes	The consequence of the vertical or horizontal section of the well deviating into the adjacent well during drilling is primarily a destruction in asset value (potential plug and abandonment of both wells). Any cross flow is likely to be contained within both of the well bores- with casing and cement isolating the relevant aquifers. Given the continuous logging of GPS location of the bit, the likelihood is considered remote, with a probability less than 1%.	Yes	Low
7		Leakage of either flowback, produced water, or hydrocarbons (liquid and gaseous) from suspended or abandoned wells. (Path 1)	B.4.1 Well Integrity Management B.4.2 Aquifer Isolation B.4.3 Well design and barriers B.4.15 Well suspension and decommissioning B.4.17 Groundwater monitoring B.4.15.2 D.5.5 Leak Remediation and Notification	B.4.1 Well Integrity Management B.4.2 Aquifer Isolation B.4.3 Well design and barriers B.4.15 Well suspension and decommissioning B.4.17 Groundwater monitoring B.4.15.2 D.5.5 Leak Remediation and Notification	3	1	L	<ul style="list-style-type: none"> <li>Each well designed and constructed with multiple (4) casing barriers and specifically-engineered cement in place to protect aquifers- this includes the 18.625" Conductor casing, 13.75" surface casing, 9.625" intermediate casing and 5.5" production casing (Engineering)</li> <li>Casing shoe for the conductor and surface casing section to be located in the base of each aquifer unit, with cement returned to surface (Engineering)</li> <li>Well design and Well Barrier Integrity Validation reports submitted to DITT as part of Well Operations Management Plan (WOMP). (Administration)</li> <li>Cement plugs used to isolate hydrocarbon zones from aquifers</li> <li>Cement plugs to be tagged to test plug integrity</li> <li>Casing annuli pressure to be monitored to determine successful formation isolation.</li> <li>Any impacted area likely to be localised, around the immediate vicinity of the E&amp;A wells. (Elimination)</li> <li>No landholder bores within 1km. (Elimination)</li> <li>No major GDE linked to CLA within 20 km of extraction point, although eDNA indicates the presence of stygofauna in the Amungee NW1 bore</li> </ul>	<ul style="list-style-type: none"> <li>Integrity of isolation validated before and after stimulation and maintained throughout well life (Engineering)</li> <li>Monitoring of cement returns to surface, with cement volume sand density as per programme (Engineering)</li> <li>Cement bond logs (CBL) completed on each well prior to stimulation to confirm integrity (Engineering)</li> <li>A Well Barrier Integrity Validation report approved by DITT as part of Well Operations Management Plan (WOMP) (Administration)</li> <li>Routine (6 monthly) monitoring of well integrity in accordance with code of Practice (Engineering)</li> <li>Routine (6 monthly) well leak detection on all wells</li> </ul>	<ul style="list-style-type: none"> <li>Any contamination event to be characterised and have remediation plans developed and executed immediately in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	3	1	L	Yes	The risk is primarily reduced through the stringent well barrier design, construction and verification requirements outlined in the COP. If an integrity issue was to occur, leakage of gas and flowback (including recycled flowback) would be contained within the inner casing strings significantly reducing the consequence and likelihood of an event. A contamination event is likely to result in "serious", reversible moderate impacts (months to years) restricted to the vicinity of the lease pad. The likelihood is reduced by the presence of multiple casing strings, likely low leakage rate and rapid dilution of any contamination. The NT Inquiry concluding the likelihood of this scenario being very low, typically less than 0.1%. This likelihood of this risk is therefore considered to be "remote".	Yes	Low
8	Groundwater	Contamination of aquifer from surface activities (chemical and waste storage, handling, recycling and spills) impacting a receptor (groundwater user or GDE).	Surface contamination from storage and disposal of drilling fluids, additives, muds and cuttings on-site. (Path 3 & 7)	A.4.7 Containment of Contaminants B.4.13 Hydraulic Stimulation and Flowback Operations C.4.2 Management of produced water and flowback fluid C.5.1 Drilling Materials C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan C.8.1 Wastewater Management Plan	2	2	L	<ul style="list-style-type: none"> <li>Each well cellar to be concrete lined to contain drilling fluids with pumps to prevent overflow</li> <li>Synthetic based mud tanks and equipment to be located within secondary containment with all spills captured and recovered.</li> <li>Specialised pressure rated hoses and valves utilised to reduce risk of leaks during transfer of synthetic based muds</li> <li>Air dryer used to recover synthetic based muds from cuttings, eliminating onsite disposal of muds</li> <li>Drill cuttings and muds are not expected to contain high NORMs levels- with validation testing undertaken in accordance with the COP</li> <li>Open wastewater evaporation tanks and drill sumps to have a 1:1000ARI wet season freeboard (wet season freeboard 1.3m).</li> <li>Recycling of flowback to reduce wastewater volumes in accordance with the Code.</li> <li>Drilling sumps to be lined with an impermeable coletanche liner with a permeability of less than 6 x10-14 m/s</li> <li>Drilling sump to be designed and operated to handle the drilling of multiple wells</li> <li>Sump solid levels to be periodically removed from the sump between wells to maintain sump capacity</li> <li>Any removed drilling muds and cuttings from the sump will be stored on an impermeable liner with a permeability of less than 6 x10-14 m/s- any fluid captured and directed to the wastewater tank</li> <li>Drill cuttings and muds to be tested and either disposed of onsite in accordance with the Code of Practice or disposed of at a licenced waste management facility.</li> <li>Storage areas to be lined with an impermeable liner (with a permeability of less than 6 x10-14 m/s to prevent contamination</li> <li>Separation between sump and aquifer over 70 m, with interbedded clays present.</li> <li>Nearest landholder extraction bore 1 km.</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Inspections of storages to be undertaken daily during the wet season and weekly at other times to identify potential liner issues.</li> <li>Groundwater monitoring bores installed at each exploration well site to detect any potential contamination.</li> <li>Groundwater monitoring completed quarterly to detect changes in groundwater quality.</li> </ul>	<ul style="list-style-type: none"> <li>Any damage to sump liner to be repaired as soon as practicable.</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> <li>Any spills of drilling fluid and muds to be cleaned up as soon as practicable</li> </ul>	2	2	L	Yes	In accordance with the COP, the onsite storage and disposal of drilling fluids and cuttings can only occur if the activity does not represent an unacceptable environmental hazard. All drilling fluids, muds and cutting will be stored in a lined sump, with testing undertaken prior to final disposal. Sump liner failure is considered to be a low consequence event, with contamination likely to be restricted to the immediate vicinity of the sump due to a lack of hydrological head. Onsite disposal will only occur if determined to be safe by an independent third party. The consequences are therefore likely to be restricted to a Moderate short term reversible impacts. The likelihood of contamination through drilling fluid, mud and cuttings storage and failure is considered highly unlikely, with the probability below 10%. This largely due to the separation distance between the underlying aquifer, use of lined sumps and third party disposal suitability assessments.	Yes	Low
9		Storage, handling and transportation of produced hydrocarbons (condensate). (Path 3)	A.4.7 Containment of Contaminants C.8.2 Spill Management Plan	A.4.7 Containment of Contaminants C.8.2 Spill Management Plan	2	1	L	<ul style="list-style-type: none"> <li>Tanks to be compliant with AS 1692 and double-lined</li> <li>Spill Management Plan implemented to prevent, detect and respond to spills.</li> <li>Separation between condensate storages and closest aquifer over 70 m, with interbedded clays likely to limit any contaminant migration.</li> <li>Any condensate transportation to be undertaken by licenced transporters (for Dangerous goods or wastes)</li> <li>Flare pit to be lined and freeboard maintained to prevent contaminant releases or overflows.</li> <li>Nearest landholder extraction bore 1 km.</li> <li>Impact and control groundwater monitoring bores installed to of to detect any potential contamination.</li> <li>Spills and leaks to be cleaned up immediately.</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Weekly inspections to identify any potential leaks or spills from storage and handling areas.</li> <li>Daily level monitoring during production</li> <li>Quarterly groundwater monitoring</li> </ul>	<ul style="list-style-type: none"> <li>Spill management plan implemented outlining leak classification, response and reporting requirements</li> <li>All leaks to be cleaned up as soon as practicable</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	2	1	L	Yes	The regulatory regime legislating the storage, handling and transportation of dangerous goods and combustible liquids within Australia is mature. Double lined tanks will be used which will reduce the potential for spills/ leaks. Any spillage is likely to be locally restricted, small and rapidly detected. Consequences are considered moderate, with impacts spatially restricted to the lease pad, primarily located on the surface (condensate has low mobility) an likely to be of a short term (days to weeks). The likelihood of contamination is influenced by the lack of mobility of condensate, separation distance between aquifer and the surface and likely rapid detection of any spills. The likelihood of a groundwater event from condensate management is considered remote with a <1% probability	Yes	Low
10		Surface spills from storage, handling, recycling and transportation of flowback water. (Path 3 & 7)	A.4.7 Containment of Contaminants B.4.13 Hydraulic Stimulation and Flowback Operations C.4.2 Management of produced water and flowback fluid C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan C.8.1 Wastewater Management Plan	A.4.7 Containment of Contaminants B.4.13 Hydraulic Stimulation and Flowback Operations C.4.2 Management of produced water and flowback fluid C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan C.8.1 Wastewater Management Plan	2	1	L	<ul style="list-style-type: none"> <li>Tanks to be double-lined with impermeable liners with impermeable membrane with coefficient of permeability of less than 10-9 m/s</li> <li>Leak detection to be located within the interstitial space between the primary and secondary liner to detect any potential leaks.</li> <li>Chemical storage and handling areas to have secondary containment, with an impermeable membrane with coefficient of permeability of less than 10-9 m/s</li> <li>The site is earthen bunded to above 100kpa to achieve a permeability of approximately 1x10m-7/s</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control.</li> <li>The earthen bund is constructed in a manner to withstand a tank failure scenario with appropriate compacted and stabilisation applied.</li> <li>The site earthen bund has a bund wall height of 300 mm capable of managing at least 110% of the largest wastewater tank volume.</li> <li>Licensed waste transporters to be used for all listed waste transportation</li> <li>Chemical risk assessment confirms exposure from stimulation fluid (including recycled flowback) is considered a low concern</li> <li>Based on the Amungee NW-1H well, NORM levels are not anticipated to be significant- with characterisation of levels within drilling wastewater and flowback (including recycled flowback) undertaken to validate.</li> <li>Separation between chemical storages and closest aquifer over 70m, with interbedded clays likely to limit any contaminant migration.</li> <li>Nearest landholder extraction bore 1 km.</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Leak detection to be located within the interstitial space between the primary and secondary liner to detect any potential leaks. - Leak detection alarms to identify when a leak is potentially identified</li> <li>Daily inspections during wet season and weekly inspections during the dry season to identify any potential leaks.</li> <li>Impact and control groundwater monitoring bores installed within 20m of exploration wells to detect any potential contamination</li> <li>Quarterly groundwater monitoring</li> <li>Sampling for NORMs to characterise and assess levels within drilling wastewater and flowback (including recycled flowback) undertaken.</li> </ul>	<ul style="list-style-type: none"> <li>Liner leaks to be investigated and liners repaired as soon as practicable</li> <li>Spills and leaks to be cleaned up and rectified immediately</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	2	1	L	Yes	The consequence and likelihood of groundwater contamination are reduced by the duration of the activity, separation of underlying aquifer units for the surface, mandated use of double lined tanks with continuous leak detection and secondary containment for all chemical storage areas. Any spill onsite is therefore likely to be small, restricted to the chemical storage areas and rapidly detected. The potential consequence of ground water contamination event is likely to be "moderate", with potential spill consequences likely to be locally restricted, moderate-short term and reversible. The likelihood is reduced down to remote with a probability of less than 1%. This is primarily influenced by the lack of spill sources, separation distance between aquifers and the surface and spill management plan that will rapidly detect any spills.	Yes	Low

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures			Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
11		Storage, handling, recycling and transportation of chemicals, fuels and wastes. (Path 3)	A.4.7 Containment of Contaminants C.3.3 Wastewater management legislative requirements C.8.2 Spill Management Plan	2	2	L	<ul style="list-style-type: none"> <li>All chemical, fuel and waste storage, including synthetic based mud tanks and equipment, and high risk spill handling areas are to have secondary containment, with an impermeable liner with coefficient of permeability of less than 10-9 m/s</li> <li>Licensed waste transporters to be used to transport listed wastes.</li> <li>Chemicals to be transported in accordance with the Australian Dangerous Goods Code and NT Dangerous Goods Act.</li> <li>No chemical or wastewater transportation during wet season, unless a risk assessment determined the activity is safe and low risk</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10<sup>-7</sup>/s</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control.</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume. The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.</li> <li>All transportation of listed wastes and dangerous goods to be undertaken via licenced contractors.</li> <li>Area is remote with major urban areas to be avoided during the transportation of dangerous goods and wastes in accordance with the NT Dangerous Goods Act.</li> <li>Separation between chemical stores and closest aquifer over 70m, with interbedded clays likely to limit any potential contaminant migration.</li> <li>Nearest landholder extraction bore 1km.</li> <li>Origin has completed 100,000's of chemical and wastewater trucking movements in QLD without significant incident causing material environmental harm</li> <li>Depth of aquifers generally below known stygofauna distribution range (elimination)</li> <li>Transportation will not occur on tracks where the surface is not safe to allow transportation vehicles to drive upon</li> <li>Chemical risk assessment confirms exposure from stimulation fluid (including recycled flowback) is considered a low concern</li> <li>Wastewater/ chemical transportation will not be undertaken through flooded waterways</li> <li>The transportation of wastewater / chemicals during rainfall events will be avoided.</li> <li>Driving on unsealed access tracks will be avoided for 24 hours following a &gt;20 mm rainfall event</li> <li>Chemicals will not be unloaded during rain events.</li> </ul>	<ul style="list-style-type: none"> <li>Daily inspections during wet season and weekly thereafter to identify and respond to any potential leaks.</li> <li>Impact and control groundwater monitoring bores installed around exploration wells to detect any potential contamination.</li> <li>Groundwater monitoring of control and impact monitoring bores on a quarterly basis.</li> <li>Daily and weekly weather forecasts via Bom website.</li> <li>Review of road conditions after a rain event via Road Report NT</li> <li>After a &gt;20mm rain event, or when the integrity of any unsealed road may be compromised due to prolonged rainfall, each unsealed access track proposed to be used for wastewater/ chemical transportation will be inspected to ensure the integrity of the road surface is sufficient to allow the safe passage of the proposed transport vehicle</li> </ul>	<ul style="list-style-type: none"> <li>Liner leaks to be investigated and liners repaired as soon as practicable</li> <li>Spills and leaks to be cleaned up and rectified immediately</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	2	2	L	Yes	The storage, handling and management of chemicals is a standard activity that is managed through a mature nationally uniform regulatory setting. The COP further reduces the likelihood/consequence of chemical spills and contamination, through the mandated use of secondary containment, a spill management plan and groundwater monitoring. Any spills are likely to be locally restricted and rapidly detected (hours to days). The consequence of a spill/leak is therefore considered to be "moderate", with moderate short term (days). Given the requirement for a spill management plan, secondary containment requirements and 70m separation distance to aquifers, the likelihood of a spill/leak reaching an aquifer is considered remote with a probability of less than 1%.	Yes	Low	
12		Overtopping of drilling sumps and flowback tanks (including during wet season) (Path 7)	A.4.7 Containment of Contaminants C.6 Monitoring mandatory requirements C.8.2 Spill Management Plan	2	1	L	<ul style="list-style-type: none"> <li>Drilling sump to be designed and operated to handle the drilling of multiple wells</li> <li>Sump solid levels to be periodically removed from the sump between wells (or as required) to maintain sump capacity</li> <li>Covered tanks to be used to manage flowback storage, with enough enclosed storage onsite to manage all stored flowback</li> <li>Results from Amungee NW-1H well testing have been used to optimise available tank capacity to allow for multiple wells</li> <li>Additional tank capacity to be installed as required, with new tank capacity taking less than 14 days</li> <li>Open wastewater evaporation tanks and drill sumps to have a 1:1000ARI wet season freeboard (wet season freeboard 1.3m).</li> <li>All flowback wastewater to be transferred to enclosed tanks prior to the onsite of a "significant rainfall event" (&gt;300mm of forecasted rain over a 4 day period)</li> <li>Sufficient pumps available onsite to meet volume transfer requirements, with available pump redundancy in case of mechanical issues.</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10<sup>-7</sup>/s</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control.</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume.</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.</li> <li>Site is manned at all times or have telemetered level logging during wastewater storage, with helicopters to be used to fly in staff when road access is prevented.</li> <li>Separation between lease pad and closest aquifer over 70m, with interbedded clays likely to limit any potential contaminant migration.</li> <li>Nearest landholder extraction bore 1 km.</li> <li>Depth of aquifers generally below known stygofauna distribution range (elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Daily monitoring of tank and sump levels (along with available storage space) during the wet season and weekly at all other times</li> <li>Daily and weekly significant rainfall monitoring during the wet season</li> <li>Spill Management Plan implemented to prevent, detect and respond to spills.</li> <li>Impact and control groundwater monitoring bores installed within 20m of exploration wells to detect any potential contamination, with monitoring completed quarterly</li> </ul>	<ul style="list-style-type: none"> <li>Drilling fluids to be transferred to wastewater tanks or removed from site where maximum freeboard is exceeded</li> <li>New wastewater tanks to be constructed onsite if wastewater storage is insufficient</li> <li>Flowback to be transferred to enclosed tanks 8 hours before the onset of a significant rainfall event (defined as &gt;30mm of rain over a 4 day period)</li> <li>Operations (flowback and drilling) to cease if insufficient wastewater (sump or flowback storage) is available to meet freeboard and enclosed tank availability requirement.</li> <li>Spill Management Plan implemented to prevent, detect and respond to spills. implemented- this includes regular inspections of containment facilities.</li> <li>In the event of a major spill, a site assessment in accordance with the National Environmental Protection (Assessment of Site Contamination) Measure, including the assessment of NORMs will be undertaken</li> </ul>	2	1	L	Yes	The COP provides onerous regulatory requirements that essentially eliminate the risk of wastewater storage overtopping events. The consequences of an overtopping event are limited through the construction of earthen bunds and compaction of the lease pad. A wastewater management plan, spill management plan and emergency response plan is implemented to further ensure any overtopping events are prevented, detected and responded to. In the event of an overtopping incident, such spill is likely to be contained onsite and rapidly responded to. The consequence of an overtopping event is therefore considered to be "moderate", with moderate short term (weeks-months) contamination. Given the requirements for enclosed tanks and a 1"1000 wet season freeboard, the potential for overtopping are considered remote, with a probability less than 1%.	Yes	Low	
13		Failure of flowback storage tank. (Path4 & 7)	A.4.1 Site selection and planning C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan	3	1	L	<ul style="list-style-type: none"> <li>Wastewater Management Plan implemented in accordance with the Codes of Practice to mitigate the risk associated with wastewater generation and management.</li> <li>Spill Management Plan implemented to prevent, detect and respond to spills- including requirements for daily wastewater tank inspections during the wet season and weekly at all other times.</li> <li>Tanks designed and engineered to AS3990 Mechanical Equipment- Steel Work, AS 1170.1 Hydrostatic loading, AS1170.2 Wind Rating (cyclonic wind rating)</li> <li>Wastewater tank liner with impermeable membrane with coefficient of permeability of less than 10-9 m/s permeability, 120N picture resistance and 49N tear resistance</li> <li>Covered wastewater tanks and condensate tanks to have vents to prevent pressure build up.</li> <li>Sufficient pump capacity available to recover any spilled wastewater.</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10<sup>-7</sup>/s</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control.</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume.</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.</li> <li>Separation between lease pad and closest aquifer over 70m, with interbedded clays likely to limit any potential contaminant migration.</li> <li>Nearest landholder extraction bore 1 km.</li> <li>No major GDE linked to CLA within 20 km of extraction point, although stygofaunal eDNA has been detected in the Amungee NW1 bore; impact likely to be localised</li> </ul>	<ul style="list-style-type: none"> <li>Weekly wastewater tank integrity inspections during wastewater storage to detect</li> <li>Impact and control groundwater monitoring bores installed within 20m of exploration wells to detect any potential contamination.</li> <li>Quarterly groundwater monitoring completed to detect potential contamination.</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater tank structural defects to be rectified as soon as practicable.</li> <li>Wastewater to be transferred from defective tanks to alternative tanks onsite until repairs completed.</li> <li>Pumps located onsite to recover fluid and transfer into existing tanks, with spills and leaks to be cleaned up and rectified immediately</li> <li>Earth moving equipment available regionally to clean up spills</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	3	1	L	Yes	The consequences of a tank failure are negated through the use of double lined, engineered above ground tank which have continuous leak detection and alarms. Tanks and their liners are designed with sufficient structural integrity to withstand cyclonic winds, extreme temperatures and loading stress forces under a range of conditions. A spill management plan is in force to detect, prevent and respond to potential spills of wastewater. If a storage failure was to occur, the wastewater would be restricted to the lease pad. Flowback would be pumped into available enclosed and open tank storage, with contaminated soil removed from site. The consequences are likely to be "serious", being locally restricted, moderate duration (weeks) and reversible. The likelihood is reduced by the COP requirements, tank design separation distances to the underlying aquifer. The likelihood is considered Remote, with a probability less than 1%	Yes	Low	
14	Surface Water	Contamination of surface water from surface activities. (Path4 & 7)	A.4.1 Site selection and planning C.4.2 Management of produced water and flowback fluid C.5.2 Management of produced water from petroleum wells C.7.1 Wastewater Management Plan C.8.2 Spill Management Plan	3	1	L	<ul style="list-style-type: none"> <li>Wastewater Management Plan implemented in accordance with the Codes of Practice to mitigate the risk associated with wastewater generation and management.</li> <li>Recycling of flowback to reduce wastewater volumes in accordance with the Code.</li> <li>Spill Management Plan implemented to prevent, detect and respond to spills- including requirements for daily wastewater tank inspections during the wet season and weekly at all other times.</li> <li>Tanks designed and engineered to AS3990 Mechanical Equipment- Steel Work, AS 1170.1 Hydrostatic loading, AS1170.2 Wind Rating (cyclonic wind rating)</li> <li>Wastewater tank liner with impermeable membrane with coefficient of permeability of less than 10-9 m/s permeability, 120N picture resistance and 49N tear resistance</li> <li>Covered wastewater tanks and condensate tanks to have vents to prevent pressure build up.</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10<sup>-7</sup>/s</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control.</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume.</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.</li> <li>Separation between lease pad and closest major watercourse is ~15 km.</li> <li>No major wetlands, with closest ~150 km away (Lake Woods).</li> </ul>	<ul style="list-style-type: none"> <li>Weekly wastewater tank integrity inspections during wastewater storage to detect</li> <li>Routine level monitoring and alarms</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater tank structural defects to be rectified as soon as practicable.</li> <li>Wastewater to be transferred from defective tanks to alternative tanks onsite until repairs completed.</li> <li>Pumps located onsite to recover fluid and transfer into existing tanks, with spills and leaks to be cleaned up and rectified immediately</li> <li>Earth moving equipment available regionally to clean up spills</li> <li>Emergency response plan implemented.</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	3	1	L	Yes	The consequence and likelihood of a containment failure are negated through onerous wastewater management requirements stipulated in the COP. The lease pad is bunded, preventing the offsite release of wastewater in the event of a failure. A spill management plan is required to be implemented to prevent, detect and respond to spills to prevent offsite releases. The spill is therefore likely to be smaller, with any spillage restricted to the lease pad. The consequence of a spill is therefore considered to be "serious", with moderate short term (weeks-months) contamination. The area is not in close proximity to major watercourse with a 13km separation distance. Given the separation distance and bunding, the likelihood is considered remote, with the probability of occurring less than 1% .	Yes	Low	

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating		Risk mitigation Measures			Residual Risk Rating		ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking	
					Consequence	Likelihood	Prevent	Detect	Recover	Consequence	Likelihood					Risk Rating
15		Overlapping of drilling sumps and flowback tanks (including wet season operations) (Path 4 & 7)	A.4.7 Containment of Contaminants C.6 Monitoring mandatory requirements C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan	A.4.7 Containment of Contaminants C.6 Monitoring mandatory requirements C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan	3	1	<ul style="list-style-type: none"> <li>Drilling sump has been designed to accommodate the anticipated drilling waste volumes of multiple wells.</li> <li>Sump solids (cuttings and muds) to be periodically removed from the sump between the drilling of wells (or as required) to maintain sump capacity to prevent overflows</li> <li>Spill Management Plan implemented to prevent, detect and respond to spills- this includes daily inspections during wet season and weekly inspections during dry season.</li> <li>Covered wastewater tanks to be used to manage flowback storage- with enough capacity onsite to deal with</li> <li>Open wastewater evaporation tanks and drill sumps to have a 1:1000ARI wet season freeboard (wet season freeboard 1.3m).</li> <li>Monitoring of tank and sump levels daily when operational.</li> <li>Results from existing well testing have been used to optimise available tank capacity to allow for multiple wells</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10<sup>-7</sup>/s</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control.</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume.</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.</li> <li>Site is manned at all times or have telemetered level logging during wastewater storage, with helicopters to be used to fly in staff when road access is prevented.</li> <li>Area is flat with the separation between lease pad and closest major watercourse ~ 15 km.</li> <li>No major wetlands, with closest ~100km away (Lake Woods).</li> </ul>	<ul style="list-style-type: none"> <li>Daily monitoring of tank and sump levels (along with available storage space) during the wet season and weekly at all other times</li> <li>Daily significant rainfall monitoring during the wet season</li> </ul>	<ul style="list-style-type: none"> <li>Drilling fluids to be transferred to wastewater tanks or removed from site where maximum freeboard is exceeded</li> <li>New wastewater tanks to be constructed onsite if wastewater storage is insufficient</li> <li>Flowback to be transferred to enclosed tanks 8 hours before the onset of a significant rainfall event (defined as &gt;30mm of rain over a 4 day period)</li> <li>Operations (flowback and drilling) to cease if insufficient wastewater (sump or flowback storage) is available to meet freeboard and enclosed tank availability requirement.</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	2	1	L	Yes	The consequence and likelihood of a wastewater storage overflowing are minimised through the onerous wastewater management requirements stipulated in the COP. This includes lease pad bunding, tank level alarms, tank freeboard requirements and use of a wastewater management plan. Any overflow is likely to be restricted to the lease pad, rapidly detected and promptly cleaned up. The use of enclosed tanks, freeboard and lease pad bunding essentially eliminates the likelihood potential for a wastewater storage tank to overflow. Given the onerous regulatory requirements, the likelihood of an overtopping event is considered Remote, with a <1% probability of occurring.	Yes	Low
16		Transportation accident releasing chemical or wastewater (drilling fluid and flowback).	A.4.7 Containment of Contaminants C.8.2 Spill Management Plan	A.4.7 Containment of Contaminants C.8.2 Spill Management Plan	3	1	<ul style="list-style-type: none"> <li>Risk assessment completed for all wet season transportation of chemicals and wastes</li> <li>All wastes to be transported in accordance with the NT Waste Management and Pollution Control Act.</li> <li>All dangerous goods to be transported in accordance with the NT Dangerous Goods Act and Australian Dangerous Goods Code.</li> <li>Transportation route to avoid major urban areas</li> <li>All drivers to be appropriately licenced</li> <li>Fatigue management plan implemented, requiring journey management plans and drivers to rest every 2 hours</li> <li>Strict drug and alcohol policy implemented, with routine testing and 0 zero tolerance policy to alcohol (0.00% limit) and drugs</li> <li>Area is remote with major urban centres to be avoided.</li> <li>Risk to any receptor is identical to that of normal diesel or petroleum tankers.</li> <li>Training of Origin supervisors regarding chain of responsibility requirements to minimise the risk of driver fatigue</li> <li>Origin has completed 100,000's of chemical and wastewater trucking movements in QLD without significant incident causing material environmental harm</li> <li>The transportation of waste and chemicals across Australia is a standard practice with mature codes and legislation in place. the transportation of fuels, chemicals and wastes occurs every year in the NT to support existing industry's during the wet season.</li> </ul>	<ul style="list-style-type: none"> <li>Transport incident statistics collected and monitored.</li> <li>Onsite assurances and fit for work assessments completed periodically on transport companies.</li> </ul>	<ul style="list-style-type: none"> <li>Spill Management Plan and Emergency Response Plan implemented to prevent, detect and respond to spills.</li> <li>Contractor performance reviews completed where breaches in requirements are escalated and actions implemented to rectify defects.</li> </ul>	3	1	L	Yes	The transportation of wastes and chemicals is a tightly controlled industry with mature practices designed to prevent, detect and respond to transportation spills. Any accident is likely to be restricted to road corridors and result in "serious", short term (days-weeks) reversible impacts. All contractors must be appropriately licenced, with National uniform legislation in place to offer a high level of regulatory protection. This risk is considered identical to that of bulk diesel and other dangerous goods transportation- a common activity throughout Australia. Fuel and chemical transport accidents are rare given the number of transportation movements in Australia. The likelihood of an event occurring is therefore considered "remote", what a probability of less than 1%.	Yes	Low
17		Storage and handling of chemicals and fuel. (Path 4)	A.4.7 Containment of Contaminants C.8.2 Spill Management Plan	A.4.7 Containment of Contaminants C.8.2 Spill Management Plan	2	2	<ul style="list-style-type: none"> <li>All areas where chemicals and fuels are stored, including area for synthetic based mud tanks and equipment will have secondary containment with a coefficient of permeability of less than 10-9 m/s</li> <li>Secondary containment to be maintained in a good working order</li> <li>Spill Management Plan implemented to prevent, detect and respond to spills. implemented.</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10<sup>-7</sup>/s</li> <li>The site is earthen bunded to prevent offsite release of contaminants, with all stormwater directed to an onsite retention pond for testing prior to offsite release</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.</li> <li>Area is remote with closest homestead approximately 16 km away.</li> </ul>	<ul style="list-style-type: none"> <li>Daily inspections will be implemented during the wet season and spills rectified immediately</li> </ul>	<ul style="list-style-type: none"> <li>All spills to be cleaned up as soon as practicable (within the shift that spill was observed)</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	2	1	L	Yes	The storage, handling and management of chemicals is a standard activity that is managed through a mature regulatory setting. The COP further reduces the likelihood and consequence of chemical spills and contamination, through the mandated use of secondary containment, a spill management plan and groundwater monitoring. A spill event is likely to result in moderate, short term reversible impacts restricted to the existing lease pad. The likelihood is further reduced down to remote (<1% probability of occurring) based on the 13km separation distance to the closest watercourse.	Yes	Low
18		Release of stormwater from activities to surface water.	A.4.1 Site selection and planning A.4.3 Erosion and sediment control and hydrology	A.4.1 Site selection and planning A.4.3 Erosion and sediment control and hydrology	1	3	<ul style="list-style-type: none"> <li>Erosion and sediment controls implemented around the sites to minimise erosion and sediment releases (Engineering)</li> <li>Stockpiled debris to be used to discourage water concentration. (Engineering)</li> <li>Lease pad to be earthen bunded to prevent offsite release of stormwater from exposed surfaces (Engineering)</li> <li>Sites to be maintained, with vegetation cover on exposed bunds/ stockpiles established and erosion and sediment controls kept in working order (Elimination)</li> <li>Contaminated stormwater to be retained on-site, treated and disposed off-site at a licenced disposal facility (Administration/ Engineering)</li> <li>A sediment sock to be used to reduce sediment levels within stormwater releases. (Engineering)</li> <li>Clean stormwater to be reused or released off-site in a manner that reduces the risk of erosion (Elimination)</li> <li>Lease pad located away from watercourses or regional flow paths. (Elimination)</li> <li>Area is remote with closest major watercourse approximately 15 km away.(Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Pre-wet season site assessment completed to identify any maintenance requirements (Administration)</li> <li>Stormwater captured in sediment basin to be tested and released offsite in a controlled manner (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance to be undertaken on erosion and sediment controls to ensure ongoing functionality (Engineering)</li> </ul>	1	1	L	Yes	All stormwater retained onsite during well testing will be collected in a purpose built sediment basin and tested prior to release. Releases must comply with the stipulated criteria to ensure contaminants are not released from site. The release of stormwater will also be via a "Sediment sock", with a reasonable consequence of minor, localised reversible impacts. The likelihood is reduced down to remote (<1% probability of occurring) based on the 13km separation distance to the closest watercourse and routine testing requirements.	Yes	Low
19		Runoff from sewage treatment irrigation areas.	A.4.1 Site selection and planning	A.4.1 Site selection and planning	1	2	<ul style="list-style-type: none"> <li>Irrigation areas located away from watercourses (Elimination)</li> <li>A wastewater suitability acceptance assessment has been completed and a design approval for wastewater disposal received in accordance with the NT Department of Health code of Practice for On-site Wastewater Management (July 2014) (Engineering)</li> <li>Wastewater irrigation to comply with DOH requirement (Engineering)</li> <li>Areas appropriately sized to accommodate irrigation volume (Engineering)</li> <li>Area is remote with closest major watercourse approximately 15 km away (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater system performance to be monitored in accordance with the manufacturers requirements (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where wastewater specifications are exceeded, corrective actions will be implemented to ensure wastewater is returned back into specification (Engineering)</li> </ul>	1	1	L	Yes	The management of sewerage and greywater is mature with various NT wastewater management guidelines. Due to the temporary nature of the activity, the maximum contamination resulting from sewerage and grey water irrigation is likely to be minor, with any impacts locally restricted and temporary in nature. The closest watercourse is approximately 13km, with the potential contamination of these features considered remote (probability <1%).	Yes	Low
20	Surface Water	Changes in surface water hydrology resulting in vegetation dieback from ponding and diversions away from natural surface systems with environmental and cultural value.	Infrastructure located on regional flow path resulting in changes to surface water flow.	A.4.1 Site selection and planning A.4.3 Erosion and sediment control and hydrology	1	2	<ul style="list-style-type: none"> <li>Lease pad located away from watercourses and regional flow paths. (Elimination)</li> <li>Lease pads designed to divert stormwater around, without impeding natural surface water flows (Engineering)</li> <li>Stockpiled debris to be used to discourage water concentration, with vegetation establish on stockpiles to reduce exposed surfaces</li> <li>Area is remote with closest major watercourse located 15 km away (Elimination)</li> <li>The lease area is flat, with water to be diverted around the perimeter of the site. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Erosion and Sediment Control Plan in place with routine pre and post wet season inspection and maintenance (administration)</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance to be undertaken on erosion and sediment controls to ensure ongoing functionality (Engineering)</li> </ul>	1	2	L	Yes	Due to the lack of major water courses, and impact is likely to "minor", locally restricted and reversible. The likelihood is reduced down to highish unlikely (probability <10%) due to the absent of watercourses and controls implemented in accordance with NT Land Clearing Guidelines to avoid changes in the hydrological setting.	Yes	Low

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures			Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
21		Changes to terrestrial ground surface levels associated with seismic activity.		B.4.13 Hydraulic Stimulation and Flowback Operations	1	1	L	<ul style="list-style-type: none"> <li>Wells are located away from known geohazards, with no significant faults within proximity of activity (Elimination)</li> <li>Amungee NW-1H stimulation completed without inducing seismic activity (Elimination)</li> <li>Stimulation is not linked to major seismic events (reinjection of wastewater is generally recognised as the main cause). No reinjection of wastewater proposed (Elimination)</li> <li>Stimulation stages deployment will be away from geohazards to reduce the loss of fluids into any encountered faults (Elimination)</li> <li>The Beetaloo is not prone to seismic activity and there is no evidence of recent earthquake activity as most faults and the major subsurface structure are confined to Cambrian or older strata. This is supported by the National seismic Hazard Assessments completed by Allen 2018 (Figure 33), which highlight the Beetaloo is located within a low hazard area (Elimination)</li> <li>Any faults encountered during drilling will be assessed to determine risk of stimulating with appropriate separation distances applied (Elimination).</li> <li>Any induced seismicity likely to be minor (&lt;3 MI) and not at a level capable of altering earths surface.</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring of stimulation pressure to detect and respond to anomalies which may indicate fluid being pumped to an open geological structure (Engineering)</li> <li>Geoscience Australia's Waramungu seismic array located approximately 300km of the sites. Seismometer to be deployed at each site. It is likely that any material seismic events above a 2 MI will be detected via this array if they occur (Administration)</li> <li>An induced seismicity traffic light system has been adopted and outlined in the WOMP (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where seismic activity is recorded in Origin's response during hydraulic stimulation activities, the actions in the WOMP Traffic Light System will be enacted as summarised below: Green: Local Magnitude (MI) &lt;2.0- no action required Orange: MI 2.0- &lt;3.5MI- Report event to DITT and continue operations Red: MI&gt; 3.5- Stimulation activity on pad suspended until a go forward plan submitted by Origin and approved by DITT.</li> </ul>	1	1	L	Yes	The consequence of a induced seismicity, based upon evidence from the UK and US, indicates that the consequence is likely to be "minor", with most events restricted to discrete areas at a size that generally cannot be detected at the surface (below 2 order of magnitude). This limits the potential for changes in terrestrial surface level. Larger events are rare and generally a factor of the existing built up stress regime of the area- rather than a factor of the intensity of hydraulic fracturing or wastewater injection. The likelihood of a seismic event is reduced through the geological setting of the Beetaloo Basin itself and the safeguards implemented in the COP requiring geohazard assessment and avoidance. In the Beetaloo, there have been no earthquakes over magnitude 3 measured since records began. The area is not prone to seismic activity and there is no evidence of recent earthquake activity as most faults and the major subsurface structure are confined to Cambrian or older strata. This is supported by the National seismic Hazard Assessments completed by Allen 2018 (Figure 33), which highlight the Beetaloo is located within a low hazard area. The COP requires any geohazard (such as fault) identified prior to drilling (from existing seismic or interpreted data) or encountered during drilling to have a risk assessment to determine the potential for reactivation. Any faults identified would not be stimulated, with a risk-based buffer applied. Given the number of wells stimulated in the US without issue and geological setting of the Beetaloo basin, the likelihood is considered remote, with a probability less than 0.1%.	Yes	Low
22	Water usage	Unsustainable groundwater extraction impacts landholders and groundwater dependent ecosystems.	Over extraction of groundwater for civils, drilling and stimulation activities.  Over extraction of groundwater for 2D seismic activities.	B.4.17 Groundwater monitoring C.4.2 Management of produced water and flowback fluid	3	1	L	<ul style="list-style-type: none"> <li>Groundwater extraction for activities to be restricted to the minimum water required (220ML per site (110ML per well)) (Elimination)</li> <li>All water take licenced in accordance with NT Water Act under Water Extraction Licence (WEL) GRF 10285 (Administration)</li> <li>Drawdown from the activities and other users assessed by DEPWS as a part of WEL; impacts to closest receptor not anticipated (Administration/ Elimination)</li> <li>Karst system is under allocated, with sufficient available capacity to support proposed water extraction requirements. (Elimination)</li> <li>Closest pastoral bore is &gt;1 km from extraction point (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Continuous flow meters to monitor take and water balance implemented to ensure compliance with WEL (Administration)</li> <li>Groundwater monitoring completed to identify impacts associated with water extraction (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Groundwater extraction to cease where sustained drawdown post pumping exceeds 1 m (Administration)</li> </ul>	3	1	L	Yes	The extraction of groundwater for the proposed activities require all take to be licenced. The proposed take is assessed as a part of the licence application, with the assessment considering current and future water take levels. Based on this assessment, it was determined that the extraction rate would not impact upon adjacent users. The risk consequence is determined to be "serious"- given any impact is likely to cause pastoralist and broader community concern. The likelihood of such a consequence from occurring is considered remote (probability <1%) due to the quality of the Cambrian limestone aquifer, separation distance from surrounding users and under utilisation of the targeting aquifer.	Yes	Low
23	Soil	Loss in long-term soil productivity and viability.	Soil compaction from access tracks, leases and 2D seismic.	A.4.1 Site selection and planning	1	3	L	<ul style="list-style-type: none"> <li>Clearing within Amungee Delineation Area limited to minimum necessary to extend well lease pad, camp lease and install helipad, laydown yard and fence line/firebreak and seismic lines (Engineering)</li> <li>All lease pads, camp pads, helipads to be stripped of topsoil (Elimination)</li> <li>Areas to be rehabilitated to reduce impacts associated with compaction (Engineering)</li> <li>Disturbance area is small (&lt;0.01% of EP 98 and &lt;0.006% of total tenure area) (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Rehabilitation monitoring to assess soil productivity impacts (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Areas with poor rehabilitation will be maintained to reduce impact (Engineering)</li> </ul>	1	3	L	Yes	During the construction/operation of lease pads, access tracks, camp pads etc., these sites will be compacted. Long term impacts of this compaction will be addressed during the rehabilitation of the sites. A loss of productivity is anticipated in the earlier stages of rehabilitation, returning back to pre-disturbed state within ~10 years. This will be accelerated through removal of hard stand areas, ripping and scarifying compacted surface. The consequences is likely to be "moderate", being locally restricted, with a moderate- long (years) recovery time. The likelihood of long term productivity impairment is considered "unlikely" (probability <30%), given the observed rehabilitation from previous disturbance activities.	Yes	Low
24			Soil erosion from cleared areas (access tracks, lease pads, camp pads and 2D seismic).	A.4.3 Erosion and sediment control and hydrology	1	5	M	<ul style="list-style-type: none"> <li>Clearing within Amungee Delineation Area limited to minimum necessary to extend well lease pad, camp lease pad and install helipad, laydown yard and fence line/firebreak (Engineering)</li> <li>Erosion and Sediment Control Plan in place and maintained in functioning condition (Engineering)</li> <li>Sites to be maintained, with erosion and sediment controls kept in working order (Engineering)</li> <li>Stockpiled debris to be used to discourage water concentration. (Engineering)</li> <li>Areas to be rehabilitated to reduce impacts associated with compaction (Engineering)</li> <li>Disturbance area is small (less than 0.005% of total tenure area) (Elimination)</li> <li>Clearing of slopes &gt;2% will be avoided.</li> </ul>	<ul style="list-style-type: none"> <li>Pre and post wet season erosion and sediment control inspections.</li> <li>Rehabilitation monitoring to assess soil productivity impacts (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance completed on areas where erosion is occurring or where the controls are defective (Engineering)</li> <li>Areas with poor rehabilitation will be maintained to reduce impact (Engineering)</li> </ul>	1	3	M	Yes	The erosion and sediment release from cleared area is a well documented impact. The consequences of sediment releases are likely to be minor, a function of the low risk nature of the soils types, design of lease pads and ongoing inspection and maintenance programs. The likelihood of these minor locally restricted releases of sediment is considered likely (Probability 90%) .	Yes	Low
25		Long term surface disturbance from 2D seismic deontation charges	Soil erosion and instability from 2D seismic detonation charges	A.4.3 Erosion and sediment control and hydrology	1	1	L	<ul style="list-style-type: none"> <li>Charges are only laid within the designated seismic lines (Elimination)</li> <li>Charges are small and placed 15 - 20 m below the ground surface (Engineering)</li> <li>The blast zone is underground resulting in no visible surface disturbance (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Pre and post wet season erosion and sediment control inspections.</li> <li>Rehabilitation monitoring to assess soil productivity impacts (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance completed on areas where erosion is occurring or where the controls are defective (Engineering)</li> <li>Areas with poor rehabilitation will be maintained to reduce impact (Engineering)</li> </ul>	1	1	L	Yes	The charges are small and the detonation zone is subsurface, resulting in no long surface disturbance or blast impact sites.	Yes	Low
26		Soil contamination due to spills and leaks of chemicals, wastes or wastewater.	Spills/leaks from the on-site storing, handling and recycling of fuels, hydrocarbons, drilling additives, stimulation additives, flowback fluid, solid wastes, storage, transportation of wastes and during 2D seismic	A.4.7 Containment of Contaminants C.4.2 Management of produced water and flowback fluid C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan	2	2	L	<ul style="list-style-type: none"> <li>All chemical, fuel and waste storage, including synthetic based mud tanks and equipment, and high risk spill handling areas are to have secondary containment, with an impermeable liner with coefficient of permeability of less than 10-9 m/s</li> <li>Recycling of flowback to reduce wastewater volumes in accordance with the Code.</li> <li>Licensed waste transporters to be used to transport listed wastes.</li> <li>Chemicals to be transported in accordance with the Australian Dangerous Goods Code and NT Dangerous Goods Act.</li> <li>No chemical or wastewater transportation during wet season, unless a risk assessment determined the activity is safe and low risk</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10m-7/s</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control.</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume.</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.</li> <li>All transportation of listed wastes and dangerous goods to be undertaken via licenced contractors.</li> <li>Chemical risk assessment confirms exposure from stimulation fluid (including recycled flowback) is considered a low concern</li> <li>Area is remote with major urban areas to be avoided during the transportation of dangerous goods and wastes in accordance with the NT Dangerous Goods Act.</li> <li>Origin has completed 100,000's of chemical and wastewater trucking movements in QLD without significant incident causing material environmental harm</li> <li>Origin has completed 1000's of km of seismic in QLD without significant contaminant incident causing material environmental harm.</li> <li>All vehicles mechanically maintained and free of oil leaks.</li> <li>Portable storage bunding and spill kits on hand during seismic.</li> </ul>	<ul style="list-style-type: none"> <li>Daily inspections during wet season and weekly thereafter to identify and respond to any potential leaks.</li> </ul>	<ul style="list-style-type: none"> <li>Liner leaks to be investigated and liners repaired as soon as practicable</li> <li>Spills and leaks to be cleaned up and rectified immediately</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	2	2	L	Yes	The storage, handling and management of chemicals is a standard activity that is managed through a mature regulatory setting. The COP further reduces the likelihood and consequence of chemical spills and contamination, through the mandated use of secondary containment, a spill management plan and groundwater monitoring. A spill event is likely to result in moderate, short term reversible impacts restricted to the existing lease pad. The likelihood is further reduced down to highly unlikely (<10% probability of occurring) based on the use of secondary containment, rapid spill detection and rehabilitation requirements.	Yes	Low

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures			Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
27		Drill sump and flowback tank overflowing.		A.4.7 Containment of Contaminants C.5.1 Drilling Materials C.5.2 Management of produced water from petroleum wells C.6 Monitoring mandatory requirements C.8.2 Spill Management Plan	2	1	L	<ul style="list-style-type: none"> <li>Drilling sump has been designed to accommodate the anticipated drilling waste volumes of multiple wells. (Engineering)</li> <li>Sump solids (cuttings and muds) to be periodically removed from the sump between the drilling of wells (or as required) to maintain sump capacity to prevent overflows (Engineering)</li> <li>Covered wastewater tanks to be used to manage flowback storage- with enough capacity onsite to deal with (Engineering)</li> <li>Open evaporation tank and drilling sump freeboard to accommodate a 1:1000 ARI total wet season (Engineering)</li> <li>Monitoring of tank and sump levels daily when operational. (Administration)</li> <li>Results from Amungee NW-1H well testing to be used to optimise available tank capacity to allow for multiple wells (Engineering)</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10m-7/s (Engineering)</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control. (Engineering)</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume. (Engineering)</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied (Engineering)</li> <li>Sufficient transfer pump capacity onsite to transfer fluids prior to the onset of a significant rainfall event or major wastewater release</li> <li>Site is manned at all times or have telemetered level logging during wastewater storage, with helicopters to be used to fly in staff when road access is prevented. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Daily monitoring of tank and sump levels (along with available storage space) during the wet season and weekly at all other times (Administration/ Engineering)</li> <li>Daily significant rainfall monitoring during the wet season (Administration/ Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Drilling fluids to be transferred to wastewater tanks or removed from site where maximum freeboard is exceeded (Engineering)</li> <li>New wastewater tanks to be constructed onsite if wastewater storage is insufficient (engineering)</li> <li>Flowback to be transferred to enclosed tanks 8 hours before the onset of a significant rainfall event (defined as &gt;30mm of rain over a 4 day period) (Engineering)</li> <li>Operations (flowback and drilling) to cease if insufficient wastewater (sump or flowback storage is available to meet freeboard and enclosed tank availability requirement (Elimination)</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	2	1	L	Yes	The consequence and likelihood of a wastewater storage overflowing are minimised through the onerous wastewater management requirements stipulated in the COP. This includes lease pad bunding, tank level alarms, tank freeboard requirements and use of a wastewater management plan. Any overflow is likely to be restricted to the lease pad, rapidly detected and promptly cleaned up. The use of enclosed tanks, freeboard and lease pad bunding essentially eliminates the likelihood potential for a wastewater storage tank to overflow. Given the onerous regulatory requirements, the likelihood of an overtopping event is considered Remote, with a <1% probability of occurring..	Yes	Low
28		Chemical and waste transportation accident.		A.4.7 Containment of Contaminants C.8.2 Spill Management Plan	3	1	L	<ul style="list-style-type: none"> <li>Risk assessment completed for all wet season transportation of chemicals and wastes (Administration)</li> <li>All wastes to be transported in accordance with the NT Waste Management and Pollution Control Act. (Administration)</li> <li>All dangerous goods to be transported in accordance with the NT Dangerous Goods Act and Australian Dangerous Goods Code (Administration)</li> <li>Transportation route to avoid major urban areas</li> <li>All drivers to be approximately licenced (Administration)</li> <li>Fatigue management plan implemented, requiring journey management plans and drivers to rest every 2 hours (Administration)</li> <li>Access track maintained to allow periodic wet weather access</li> <li>Strict drug and alcohol policy implemented, with routine testing and 0 zero tolerance policy to alcohol (0.00% limit) and drugs (Administration)</li> <li>Area is remote with major urban centres to be avoided. (Elimination)</li> <li>Risk to any receptor is identical to that of normal diesel or petroleum tankers.</li> <li>Training of Origin supervisors regarding chain of responsibility requirements to minimise the risk of driver fatigue (Administration)</li> <li>Origin has completed 100,000's of chemical and wastewater trucking movements in QLD without significant incident causing material environmental harm (elimination)</li> <li>The transportation of waste and chemicals across Australia is a standard practice with mature codes and legislation in place. the transportation of fuels, chemicals and wastes occurs every year in the NT to support existing industry's during the wet season. (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Transport incident statistics collected and monitored. (Administration)</li> <li>Onsite assurances and fit for work assessments completed periodically on transport companies (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>All transport spills to be cleaned up immediately (engineering)</li> <li>Contractor performance reviews completed where breaches in requirements are escalated and actions implemented to rectify defects. (administration)</li> </ul>	3	1	L	Yes	The transportation of wastes and chemicals is a tightly controlled industry with mature practices designed to prevent, detect and respond to transportation spills. Any accident is likely to be restricted to road corridors and result in "serious", short term (days-weeks) reversible impacts. All contractors must be appropriately licenced, with National uniform legislation in place to offer a high level of regulatory protection. This risk is considered identical to that of bulk diesel and other dangerous goods transportation- a common activity throughout Australia. Fuel and chemical transport accidents are rare given the number of transportation movements in Australia. Origin has completed 100,000's of chemical and wastewater trucking movements in QLD without significant incident causing material environmental harm. The likelihood of an event occurring is therefore considered "highly unlikely", what a probability of less than 10%	Yes	Low
29		On-site disposal of drill muds and cuttings.		C.5.1 Drilling Materials	2	2	L	<ul style="list-style-type: none"> <li>Drilling muds, water based and synthetic based are low residual toxicity. (Elimination)</li> <li>Synthetic based drilling muds to be recovered from drill cuttings for reuse and removed from site for further reuse, removing the need for onsite disposal. Residual drill cuttings to be disposed of in sump (Engineering)</li> <li>Sodium and Chloride levels to be reduced through segregation of drilling fluids from muds and mixing with clean material onsite</li> <li>Drilling muds and cuttings from the sump maybe transferred and stored in a pit/sump on site that is compliant with C.4.1.2 for the storage of drilling muds and cuttings to dry the cuttings and reduce waste volumes.</li> <li>Drilling muds (water-based) to be tested and a disposal strategy developed by a suitably qualified third-party in a manner that minimises the risk to the environment.</li> <li>Drilling muds (water-based) removed from site where onsite disposal is unsafe.</li> <li>DEPWS engaged to confirm final disposal strategy.</li> <li>Rehabilitation monitoring to monitor ongoing site rehabilitation</li> </ul>	<ul style="list-style-type: none"> <li>Drilling muds (water based) to be tested and a disposal strategy developed by a suitably qualified third-party in a manner that minimises the risk to the environment.</li> <li>Rehabilitation monitoring completed on all disposal areas</li> </ul>	<ul style="list-style-type: none"> <li>Additional rehabilitation actions implemented where rehabilitation objectives are not being met.</li> </ul>	2	2	L	Yes	In accordance with the COP, the onsite storage and disposal of drilling fluids and cuttings can only occur if the activity does not represent an unacceptable environmental hazard. Aside from synthetic based drilling muds which will be recovered and reused all drilling fluids, muds and cuttings will be stored in a lined sump with testing undertaken prior to final disposal. Onsite disposal will only occur if determined to be safe by an independent third party. The consequences are therefore likely to be restricted to Moderate- short term reversible impacts. The likelihood of contamination through drilling fluid, mud and cuttings storage and failure is considered highly unlikely, with the probability below 10%. This is largely due to the separation distance between the underlying aquifer, use of lined sumps and third party disposal suitability assessments.	Yes	Low
30		Failure of a flowback tank.		A.4.1 Site selection and planning A.4.7 Containment of Contaminants C.8.2 Spill Management Plan	3	1	L	<ul style="list-style-type: none"> <li>Tanks designed and engineered to AS3990 Mechanical Equipment- Steel Work, AS 1170.1 Hydrostatic loading, AS1170.2 Wind Rating (cyclonic wind rating)</li> <li>Wastewater tank liner with impermeable membrane with coefficient of permeability of less than 10-9 m/s permeability, 120N picture resistance and 49N tear resistance</li> <li>Covered wastewater tanks and condensate tanks to have vents to prevent pressure build up.</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10m-7/s</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control.</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume.</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.</li> </ul>	<ul style="list-style-type: none"> <li>Weekly wastewater tank integrity inspections during wastewater storage to detect</li> <li>Routine level monitoring and alarms</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater tank structural defects to be rectified as soon as practicable.</li> <li>Wastewater to be transferred from defective tanks to alternative tanks onsite until repairs completed.</li> <li>Pumps located onsite to recover fluid and transfer into existing tanks, with spills and leaks to be cleaned up and rectified immediately</li> <li>Earth moving equipment available regionally to clean up spills</li> <li>Emergency response plan implemented.</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	3	1	L	Yes	The consequences of a tank failure are negated through the use of double lined, engineered above ground tank which have continuous leak detection and alarms. Tanks and their liners are designed with sufficient structural integrity to withstand cyclonic winds, extreme temperatures and loading stress forces under a range of conditions. A spill management plan is in force to detect, prevent and respond to potential spills of wastewater. If a storage failure was to occur, the wastewater would be restricted to the lease pad. Flowback would be pumped into available enclosed and open tank storage, with contaminated soil removed from site. the consequences are likely to be "serious", being locally restricted, moderate duration (weeks) and reversible. The likelihood is reduced by the COP requirements. tank design separation distances to the underlying aquifer. The likelihood is considered Remote, with a probability less than 1%.	Yes	Low
31		Soil contamination from the drift of saline wastewater offsite from mechanical evaporation units.		A.4.1 Site selection and planning	2	2	L	<ul style="list-style-type: none"> <li>Automated wind speed and direction cut offs to be implemented to prevent drift (Engineering)</li> <li>Evaporators located within the wastewater tank considering the predominant wind direction (from the SE) to avoid offsite drift (Engineering)</li> <li>Drift likely to be restricted to within the lease pad (Elimination)</li> <li>Chemical risk assessment confirms exposure from stimulation fluid (including recycled flowback) is considered a low concern</li> <li>No homesteads, sacred sites or sensitive environmental areas in the vicinity of the proposed lease pad (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Daily monitoring to detect drift (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Evaporation units to cease operation where drift identified (Engineering)</li> <li>Evaporators to be modified/ repositioned to control drift (Engineering)</li> </ul>	2	2	L	Yes	The use of enhanced evaporators to manage wastewater is a well-known technology used through multiple mining and wastewater treatment industries. Evaporators were used successfully on the Amungee NW-1H well to reduce fluid levels decreasing offsite trucking volumes. Offsite release of wastewater drift is restricted through wind speed and direction cut offs and the location of the evaporator within the wastewater storage. The sites are continuously manned during well testing, thus the risk of drift and associated impacts is anticipated to be moderate, with short term, reversible impacts. Given the aforementioned controls, the likelihood of moderate impacts is reduced to Highly unlikely, with a potential of lower than 10%	Yes	Low
32		Soil contamination from the disposal of greywater and sewerage from camp activities.		N/A	1	2	L	<ul style="list-style-type: none"> <li>Sewerage wastewater irrigated as per Department of Health code of Practice for On-site Wastewater Management (July 2014) (Engineering)(Elimination)</li> <li>A wastewater suitability acceptance assessment has been completed and a design approval for wastewater disposal received in accordance with the NT Department of Health code of Practice for On-site Wastewater Management (July 2014) (Engineering)</li> <li>Wastewater irrigation to comply with DOH requirement (Engineering)</li> <li>Areas appropriately sized to accommodate irrigation volume (Engineering)</li> <li>Area is remote with closest watercourse approximately 15 km away (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater system performance to be monitored in accordance with the manufacturers requirements (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where wastewater specifications are exceeded, corrective actions will be implemented to ensure wastewater is returned back into specification (Engineering)</li> </ul>	1	2	L	Yes	The management of sewerage and greywater is mature with various NT wastewater management guidelines. Due to the temporary nature of the activity, the maximum contamination resulting from sewerage and grey water irrigation is likely to be minor, with any impacts locally restricted and temporary in nature. The closest watercourse is approximately 15km, with the potential contamination of these features considered remote (probability <1%).	Yes	Low

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					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
33	Flora and fauna	Impact to listed threatened habitats and listed threatened flora and fauna, including non-listed fauna and livestock from exploration activities.	Activity (vehicle and machinery) noise and lighting on well pads and access tracks.	A.4.1 Site selection and planning A.4.2 Noise	1	3	L	<ul style="list-style-type: none"> <li>Site location avoids areas of high conservation value as a priority (Elimination)</li> <li>Areas are not considered high conservation value, are not threatened/endangered and not fragmented, with impacts unlikely to result in significant disturbance to threatened/endangered species. (Elimination)</li> <li>Impacts likely to be temporal, with fauna able to move to adjacent areas to escape impacts. (Elimination)</li> <li>Fauna monitoring at Amungee NW has not identified any impacts, with fauna identified in areas around operations. (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Anecdotal evidence from pastoralists and Traditional Owners (Administration)</li> <li>Impacts are likely to be temporal, with detection extremely difficult.</li> </ul>	<ul style="list-style-type: none"> <li>Where impacts are identified, practices will be reviewed and modified to reduce impact on fauna (Administration/ engineering)</li> </ul>	1	3	L	Yes	Fauna may be disturbed through transport movements along access tracks and drilling, stimulation and well testing activities around the lease pad. The consequence of activity nuisance is anticipated to be minor, with localised, short term impacts to areas immediately adjacent to access tracks. The likelihood of the risk is reduced through the isolated location (lack of sensitive receptors), regionally extensive vegetation communities (good outside refuge away from access tracks and limited transport movements during the evenings). The impact to fauna is considered highly unlikely given the ability of fauna to move to other areas of refuge away from E&A activities	Yes	Low
34			Failure of flowback storage tanks	A.4.1 Site selection and planning A.4.7 Containment of Contaminants C.4.2 Management of produced water and flowback fluid C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan	3	1	L	<ul style="list-style-type: none"> <li>Tanks designed and engineered to AS3990 Mechanical Equipment- Steel Work, AS 1170.1 Hydrostatic loading, AS1170.2 Wind Rating (cyclonic wind rating) (Engineering)</li> <li>Wastewater tank liner with impermeable membrane with coefficient of permeability of less than 10-9 m/s permeability, 120N picture resistance and 49N tear resistance (Engineering)</li> <li>Covered wastewater tanks and condensate tanks to have vents to prevent pressure build up. (Engineering)</li> <li>Recycling of flowback to reduce wastewater volumes in accordance with the Code.</li> <li>Leases to be compacted to above 100kpa to achieve a permeability of approximately 1x10m-7/s (Engineering)</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control. (Engineering)</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume. (Engineering)</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied.(Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Weekly wastewater tank integrity inspections during wastewater storage to detect (administration)</li> <li>Routine level monitoring and alarms (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater tank structural defects to be rectified as soon as practicable. (Engineering)</li> <li>Wastewater to be transferred from defective tanks to alternative tanks onsite until repairs completed. (Engineering)</li> <li>Pumps located onsite to recover fluid and transfer into existing tanks, with spills and leaks to be cleaned up and rectified immediately (Engineering)</li> <li>Earth moving equipment available regionally to clean up spills (Engineering)</li> <li>Emergency response plan implemented (Administration)</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	3	1	L	Yes	The consequences of a tank failure are negated through the use of double lined, engineered above ground tank which have continuous leak detection and alarms. Tanks and their liners are designed with sufficient structural integrity to withstand cyclonic winds, extreme temperatures and loading stress forces under a range of conditions. A spill management plan is in force to detect, prevent and respond to potential spills of wastewater. If a storage failure was to occur, the wastewater would be restricted to the lease pad. The consequences are likely to be "serious", being locally restricted, moderate duration (weeks) and reversible. The likelihood is reduced by the COP requirements, tank design, separation distances to sensitive places and the lease pad bunding. The likelihood is considered Remote, with a probability less than 1%.	Yes	Low
35			Introduction and spread of weeds in the area (including civil construction, seismic and E&A activities) .	A.4.5 Weed management	2	3	M	<ul style="list-style-type: none"> <li>All equipment and vehicles to be washed-down and to have a Biosecurity Declaration Certificate prior to access to site (Elimination)</li> <li>Areas of proposed exploration have been surveyed and are deemed to have low weed abundance (elimination)</li> <li>Activity will be restricted to defined lease pads and camp pads (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>6 monthly monitoring implemented around infrastructure to detect the spread/ introduction of weed species (administration)</li> <li>Origin assurance activities to target equipment wash-down certificates to ensure standards are being met. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where weed outbreaks are identified associated with Origin's activities, infestations will be treated in accordance with the Weed Management Plan. (elimination)</li> <li>Corrective actions implemented where ongoing biosecurity breaches are identified.</li> </ul>	2	3	M	Yes	The area in the vicinity sites is free of weeds. Weeds are present across the broader property. Any introduction of weeds is likely to result in localised impact, with weed management requirements likely to reduce the consequence down to "moderate, short term. Due to the inherent nature of weed prevention the risk likelihood is considered unlikely, with a probability less than <30%	Yes	Low
36			Accidental ignition of fire from exploration activities (drilling, stimulation, flaring, seismic and general access).	A.4.6 Fire management	3	2	M	<ul style="list-style-type: none"> <li>Bushfire management plan implemented to prevent and respond to bushfires- including establishment of communication and fire response protocols with pastoralists (Administration)</li> <li>Bushfire awareness included in site inductions. (Administration)</li> <li>Designated smoking areas on-site (Elimination)</li> <li>Firefighting equipment to be available to deal with fires (Engineering)</li> <li>Fire breaks have been constructed around the lease and camp pads (Engineering)</li> <li>Minimum of 45m separation distances between flares and surrounding vegetation (Engineering)</li> <li>Ignition sources placed outside of the hazardous area. (Elimination)</li> <li>Intrinsically safe equipment used in hazardous area. (Elimination)</li> <li>Hazardous area drawing will provide classification of hazardous zones while drilling. (Elimination)</li> <li>No flaring during periods of total fire ban (Elimination)</li> <li>Activities will comply with landholder and regional bushfire management plans. (Elimination)</li> <li>Area in the vicinity of leases have had recent (within 1-2 years) fire activity, reducing the fuel load (Elimination)</li> <li>Fire tender to be utilised during seismic clearing, with a spotter to identify and respond to any ignition events (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Annual fire preparedness assurance activities completed where activities are proposed during high fire risk periods (administration)</li> <li>Daily monitoring of bushfires in the region during periods of high fire danger (administration)</li> <li>Annual fire frequency mapping using the Northern Australia Fire Information fire history database (administration)</li> </ul>	<ul style="list-style-type: none"> <li>Fire hazard reduction strategies (such as back burning) to be implemented to reduce the risk of fire ignition/ impact as required (Elimination)</li> <li>Where a bushfire is started and cannot be controlled, Origin to engage with pastoralist to coordinate response activities</li> </ul>	3	2	M	Yes	Fire is a common occurrence within the Barkly Region. A fire is likely to have a serious impact, with moderate term reversible impacts (years). With the appropriate controls, such as separation distances, firebreaks, and adherence to total fire bans, the likelihood of causing a fire from drilling, stimulation and well testing is anticipated to be highly unlikely, with a predicted occurrence of <10%	Yes	Low
37			Poor rehabilitation of the site reduces regional habitat and promotes weed invasions (including civil construction, seismic and E&A activities)	A.4.8 Rehabilitation	1	3	L	<ul style="list-style-type: none"> <li>A site specific Rehabilitation Plan has been developed and will be implemented progressively (Engineering)</li> <li>Areas will have infrastructure and wastes removed, sumps and pits backfilled, topsoil respread and vegetation re-introduced. (Engineering)</li> <li>Rehabilitation timing will consider seasonal constraints, with rehab completed prior to the wet season to maximise revegetation chance (Engineering)</li> <li>Rehabilitation to commence within 4 weeks upon completion of seismic activities.</li> </ul>	<ul style="list-style-type: none"> <li>Rehabilitation monitoring to be undertaken to track rehabilitation progress (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance will be undertaken periodically to fix any defects (Engineering)</li> </ul>	1	3	L	Yes	Risks associated with rehabilitation are well known. Knowledge of rehabilitation within the Beetaloo Basin has been gained, based on previous seismic line rehabilitation programs.	Yes	Low
38			Trapping and drowning of fauna in storage tanks and sumps.	C.5.1 Drilling Materials	2	2	L	<ul style="list-style-type: none"> <li>Wastewater tank walls are 2m high with minimal risk of animals accessing tanks (elimination)</li> <li>Lease pads fenced to prevent stock access (engineering)</li> <li>Sump coletanche liner is rough, with fauna able to climb out of sump (Engineering)</li> <li>Sump fenced when not in use in a manner to reduce fauna access to sump (Engineering)</li> <li>Limited habitat for threatened fauna in area surrounding site (Elimination)</li> <li>Wastewater saline, with freshwater tanks to be preferred by birds</li> <li>Fauna cameras installed around lease pad have not detected significant wildlife presence in and around operating sites. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Weekly inspections during wastewater storage.</li> <li>Monitoring of fauna interaction with wastewater</li> </ul>	<ul style="list-style-type: none"> <li>Where ongoing fauna interactions with wastewater are identified through monitoring, additional controls shall be implemented as appropriate (such as additional fencing, deterrents etc.) (Engineering)</li> </ul>	2	2	L	Yes	Risks associated with potentially trapping and drowning fauna in storage tanks and sumps are well understood. Origin has extensive experience in managing sumps, ponds and tanks to prevent fauna ingress.	Yes	Low
39			Contaminants in water and soil from exploration activities (including chemical and wastewater storage, handling and recycling) pass through the food chain and bioaccumulate in fauna causing detrimental impacts to local species and communities	A.4.7 Containment of Contaminants C.4.2 Management of produced water and flowback fluid C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan	1	2	L	<ul style="list-style-type: none"> <li>All chemicals stored in designated areas with secondary containment (Engineering)</li> <li>Synthetic based drilling muds and equipment stored in secondary containment, with all spills captured and recovered (Engineering)</li> <li>Specialised pressure rated hoses and valves utilised to reduce risk of leaks during transfer of synthetic based muds (Engineering)</li> <li>Air dryer used to recover synthetic based drilling muds from cuttings and removed from site by drilling contractor for further reuse meaning no onsite disposal (Engineering/Elimination)</li> <li>Chemical risk assessments with no chemicals considered above low concern levels when used in accordance with standard procedures and controls (Elimination)</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control. (Engineering)</li> <li>Site earthen bunding will have a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume. (Engineering)</li> <li>The earthen bund will be constructed in a manner to withstand a tank failure scenario with appropriate compaction and stabilisation applied. (Engineering)</li> <li>Recycling of flowback to reduce wastewater volumes in accordance with the Code</li> <li>Wastewater evaporation to have drift controls to prevent offsite release (engineering)</li> <li>No offsite wastewater discharge (elimination)</li> <li>Chemical mixing units and operating procedures designed to mitigated the formation of chemical airborne particulate matter (Engineering/ Administration)</li> <li>Onsite burial of drilling waste can only occur where no material impacts to flora and fauna are anticipated (engineering)</li> <li>Chemical risk assessment confirms exposure from stimulation fluid (including recycled flowback)is considered a low concern</li> <li>Salt is the main hazard and does not bioaccumulate- UV and oxidation of organic compounds and metals in wastewater likely to degrade chemicals rapidly (within days) (Elimination)</li> <li>Lease pads fenced to prevent livestock accesses (engineering)</li> <li>Sump fenced to prevent fauna access. (engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Routine weekly inspections to identify poor chemical handling or wastewater storage practices (engineering)</li> <li>Monitoring of fauna interaction with wastewater tanks and area surrounding the site (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where ongoing fauna interactions with wastewater or chemicals are identified through monitoring, additional controls shall be implemented as appropriate to reduce the potential for exposure (such as additional fencing, deterrents etc.) (Engineering)</li> </ul>	1	1	L	Yes	A chemical risk assessment and flowback characterisation program for the Amungee NW 1H well ensures all potential chemicals that are persistent, bio accumulative and toxic at high concentrations are identified and appropriate management strategies implemented. The risks associated with fauna ingestion of chemicals is well known and measures to prevent ingestion (such as fences and separation distances to activity) are deployed as standard practice. Origin has extensive operational experience in drilling and stimulating 1000s of conventional and unconventional petroleum wells with no evidence of impacts on biota from chemicals.	Yes	Low

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures			Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
40			Vehicle and machinery collisions with fauna during civil and maintenance activities – fauna mortality results in a localised impact to listed threatened species.	A.4.4 Biodiversity protection	1	5	M	<ul style="list-style-type: none"> <li>Vegetation clearing at exploration sites to be conducted with visual checks to identify fauna/fauna habitat during clearing.</li> <li>Vehicle speed limited to 60 km/hr to be reduced around areas of high risk of fauna collision (Administration)</li> <li>Vehicle movements to avoid driving at night (Elimination)</li> <li>Fauna collisions observed during the existing activities have been minimal, with collision restricted to several wallabies along access track (Elimination)</li> <li>Absence of listed threatened species identified in the vicinity of the lease pad, access tracks and seismic lines.</li> <li>Large trees and habitat trees to be avoided during seismic clearing through line deviation.</li> <li>A minimum 300 m buffer will be maintained around any active Grey Falcon nests (or suspected nests) to reduce potential disturbance/impacts.</li> </ul>	<ul style="list-style-type: none"> <li>Fauna mortality data is collected as part of Origin's incident and observation management procedures (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where ongoing fauna collisions are reported, additional controls shall be investigated, such as reduced speed limits in high risk areas will be implemented. (Administration)</li> </ul>	1	3	L	Yes	Fauna collisions with vehicles are a commonly associated with roads. It is anticipated that a small number of fauna collisions will be experienced during the activity (1-2 animals per month), with minor, short term, reversible impacts to local fauna species. The likelihood of causing a localised decline in species abundance is considered remote.	Yes	Low
41			Encouragement of feral animals and other pest species increases leading to competition with native species. This includes the introduction of cane toads.	A.4.4 Biodiversity protection	1	3	L	<ul style="list-style-type: none"> <li>Camp wastes to be storage to be animal proof (Engineering)</li> <li>All food scraps to be removed from site and disposed of at a licenced facility (Elimination)</li> <li>Food scraps to be frozen and stored within freezer during wet season (Elimination)</li> <li>Experience from existing activities has not detected increased feral animal prevalence, with only 1 feral dog identified in 6 months of camp operations. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Feral fauna observation data is collected as part of Origin's incident and observation management procedures (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where ongoing feral animal presence is detected additional controls will be investigated in consultation with the pastoralist (such as fencing, removal of water sources etc.) (Engineering)</li> </ul>	1	3	L	Yes	Feral animals may be increased through the provision of access to water, food (camps) and hunting habitat (such as road corridors). The use of the existing site and access tracks limits the additional risk associated with provision of additional hunting habitat. Food scraps and waste will be frozen and disposed of offsite which will reduce the food availability for pests. Wastewater is too saline for cane toads to survive, with the design of the tanks likely to restrict toad habitat. The anticipated consequence is minor, with the potential pest species increase anticipated to be small. The likelihood is determined to be unlikely, with a probability of less than 30%.	Yes	Low
42			Activity (vehicle, machinery and seismic activity) noise & vibration during 2D seismic acquisition.	A.4.1 Site selection and planning A.4.2 Noise	1	3	L	<ul style="list-style-type: none"> <li>Seismic lines avoid areas of high conservation value as a priority (Elimination)</li> <li>Areas are not considered high conservation value, are not threatened/ endangered and not fragmented, with impacts unlikely to result in significant disturbance to threatened/ endangered species. (Elimination)</li> <li>Impacts likely to be temporal, with fauna able to move to adjacent areas to escape impacts. (Elimination)</li> <li>Avoid vegetation clearing as much as practicable</li> <li>In open woodlands, limit clearing to grasses and shrubs (Avoidance)</li> <li>During seismic surveys, detonations will not occur when cattle are in proximity (Elimination)</li> <li>Cattle will be mustered away from seismic area in consultation with pastoralist (Elimination)</li> <li>During detonation, a short sharp thud will be heard, and potential small level vibration field within 1 km of charge going off. Origin will work with pastoralist to ensure cattle are mustered away from the activity. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Anecdotal evidence from pastoralists and Traditional Owners (Administration)</li> <li>Impacts are likely to be temporal, with detection extremely difficult.</li> </ul>	<ul style="list-style-type: none"> <li>Where impacts are identified, practices will be reviewed and modified to reduce impact on fauna (Administration/ engineering)</li> </ul>	1	3	L	Yes	Fauna may be disturbed through transport movements along access tracks and seismic lines. The consequence of activity nuisance is anticipated to be minor, with localised, short term impacts to areas immediately adjacent to access tracks. The likelihood of the risk is reduced through the isolated location (lack of sensitive receptors), regionally extensive vegetation communities (good outside refuge away from access tracks, seismic activity and limited transport movements during the evenings. The impact to fauna is considered highly unlikely given the ability of fauna to move to other areas of refuge away from seismic activities and ongoing engagement with pastoralists re cattle.	Yes	Low
43			Introduction and spread of weeds in the area during 2D seismic.	A.4.5 Weed management	2	3	M	<ul style="list-style-type: none"> <li>All equipment and vehicles to be washed-down and to have a Biosecurity Declaration Certificate prior to access to site (Elimination)</li> <li>Areas of proposed exploration have been surveyed and are deemed to have low weed abundance (elimination)</li> <li>Activity will be restricted to defined seismic lines and camp sites (Elimination)</li> <li>Vegetation pushed during seismic line preparation will be placed back over cleared areas immediately after seismic recording (Engineering)</li> <li>Preparation of seismic lines will minimise the removal of vegetation, rootstock, topsoil and seed bank, increasing the rate of vegetation recovery (Engineering)</li> <li>Avoid seismic lines in water courses (unless co-located with an access track)</li> </ul>	<ul style="list-style-type: none"> <li>6 monthly monitoring implemented around infrastructure to detect the spread/ introduction of weed species (administration)</li> <li>Origin assurance activities to target equipment wash-down certificates to ensure standards are being met. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where weed outbreaks are identified associated with Origin's activities, infestations will be treated in accordance with the Weed Management Plan. (elimination)</li> <li>Corrective actions implemented where ongoing biosecurity breaches are identified.</li> </ul>	2	3	M	Yes	The area in the vicinity sites is free of weeds. Weeds are present across the broader property. Any introduction of weeds is likely to result in localised impact, with weed management requirements likely to reduce the consequence down to "moderate, short term. Due to the inherent nature of weed prevention the risk likelihood is considered unlikely, with a probability less than <30%	Yes	Low
44			Accidental ignition of fire during 2D seismic acquisition and general access.	A.4.6 Fire management	3	2	M	<ul style="list-style-type: none"> <li>Bushfire management plan implemented to prevent and respond to bushfires- including establishment of communication and fire response protocols with pastoralists (Administration)</li> <li>Bushfire awareness included in site inductions. (Administration)</li> <li>Designated smoking areas on-site (Elimination)</li> <li>Firefighting equipment to be available to deal with fires (Engineering).</li> <li>Vehicles to be equipped with fire extinguishers.</li> <li>Fire response to be implemented during seismic program, with spotters and fire trailers utilised to put out fires during work.</li> <li>Activities will comply with landholder and regional bushfire management plans. (Elimination)</li> <li>Area in the vicinity of the seismic activity have had recent (within 1-2 years) fire activity, reducing the fuel load (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Annual fire preparedness assurance activities completed where activities are proposed during high fire risk periods (administration)</li> <li>Daily monitoring of bushfires in the region during periods of high fire danger (administration)</li> <li>Annual fire frequency mapping using the Northern Australia Fire Information fire history database (administration)</li> </ul>	<ul style="list-style-type: none"> <li>Fire hazard reduction strategies (such as back burning) to be implemented to reduce the risk of fire ignition/ impact as required (Elimination)</li> <li>Where a bushfire is started and cannot be controlled, Origin to engage with pastoralist to coordinate response activities</li> </ul>	3	2	M	Yes	Fire is a common occurrence within the Barkly Region. A fire is likely to have a serious impact, with moderate term reversible impacts (years). With the appropriate controls, such as separation distances, firebreaks, and adherence to total fire bans, the likelihood of causing a fire from drilling, stimulation and well testing is anticipated to be highly unlikely, with a predicted occurrence of <10%	Yes	Low
45			Poor rehabilitation of the 2D seismic lines reduces regional habitat and promotes weed invasions	A.4.8 Rehabilitation	1	5	M	<ul style="list-style-type: none"> <li>A site specific Rehabilitation Plan has been developed and will be implemented progressively (Engineering)</li> <li>Vegetation pushed during seismic line preparation will be placed back over cleared areas immediately after seismic recording (Engineering)</li> <li>Preparation of seismic lines will minimise the removal of vegetation, rootstock, topsoil and seed bank, reducing the risk of erosion and increasing the rate of vegetation recovery (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Rehabilitation monitoring to be undertaken to track rehabilitation progress (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance will be undertaken periodically to fix any defects (Engineering)</li> </ul>	1	4	M	Yes	Risks associated with rehabilitation are well known. Knowledge of rehabilitation within the Beetaloo Basin has been gained, based on previous seismic line rehabilitation programs.	Yes	Low
46			Vehicle and machinery collisions with fauna during 2D seismic activities – fauna mortality results in a localised impact to listed threatened species	A.4.4 Biodiversity protection	1	5	M	<ul style="list-style-type: none"> <li>Pre-clearance site inspections (October - March) to minimise impacts to breeding / fledging of the Crested Shrike Tit. (Elimination)</li> <li>Vegetation clearing of seismic lines to be conducted with visual checks to identify fauna/fauna habitat during clearing.</li> <li>Vehicle speeds during seismic acquisition limited to &lt;60 km/hr and mostly occurring at walking pace (Administration)</li> <li>Vehicle movements to avoid driving at night (Elimination)</li> <li>Fauna collisions observed during the existing activities have been minimal, with collision restricted to several wallabies along access track (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Fauna mortality data is collected as part of Origin's incident and observation management procedures (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where ongoing fauna collisions are reported, additional controls shall be investigated, such as reduced speed limits in high risk areas will be implemented. (Administration)</li> </ul>	1	3	L	Yes	Fauna collisions with vehicles are a commonly associated with roads. It is anticipated that a small number of fauna collisions will be experienced during the activity (1-2 animals per month), with minor, short term, reversible impacts to local fauna species. The likelihood of causing a localised decline in common or listed threatened species abundance is considered remote.	Yes	Low
47	Cultural Heritage and Sacred Sites	Disturbance of sacred site or culturally sensitive area and decline in environmental value of area used for hunting, foraging and enjoyment.	Sites disturbed directly by exploration activities	A.4.1 Site selection and planning	3	1	L	<ul style="list-style-type: none"> <li>Exploration Agreements with Determined Traditional owners covering all proposed exploration activities.</li> <li>All areas of the proposed activity to be cleared by NLC. (Elimination)</li> <li>AAPA certificates for proposed work program have been granted (Elimination)</li> <li>The location of infrastructure has considered proximity to sacred sites (Elimination)</li> <li>Areas of cultural heritage to be avoided during construction (Elimination)</li> <li>Areas of cultural significance are not within 9.5 km of the proposed area of activity (Elimination)</li> <li>Implementation of the unexpected finds protocol (Administration).</li> </ul>	<ul style="list-style-type: none"> <li>Origin completes 6 monthly assurance programs to confirm access to sacred sites has not occurred.</li> </ul>	<ul style="list-style-type: none"> <li>N/A- no access to sacred sites anticipated. (Elimination)</li> </ul>	3	1	L	Yes	All sites of the proposed activity must have Traditional Owner clearance via the NLC. AAPA certificates are required for all activities to ensure sacred sites are not impacted by activities. The remote location of the activity, lack of sacred sites in the vicinity of the sites and contractual requirements prohibiting access reduce the likelihood down to "highly unlikely", with a probability lower than 10%.	Yes	Low
48			Accidental ignition by site activities (civil works, drilling, grinding) or site personnel.	A.4.6 Fire management	3	2	M	<ul style="list-style-type: none"> <li>Bushfire management plan implemented to prevent and respond to bushfires- including establishment of communication and fire response protocols with pastoralists (Administration)</li> <li>Bushfire awareness included in site inductions. (Administration)</li> <li>Designated smoking areas on-site (Elimination)</li> <li>Firefighting equipment to be available to deal with fires (Engineering).</li> <li>Fire breaks have been constructed around the lease and camp pads (Engineering)</li> <li>Minimum of 45m separation distances between flares and surrounding vegetation (Engineering)</li> <li>Ignition sources placed outside of the hazardous area. (Elimination)</li> <li>Intrinsically safe equipment used in hazardous area. (Elimination)</li> <li>Hazardous area drawing will provide classification of hazardous zones while drilling. (Elimination)</li> <li>No flaring during periods of total fire ban (Elimination)</li> <li>Activities will comply with landholder and regional bushfire management plans. (Elimination)</li> <li>Area in the vicinity of Amungee NW has had recent (within 2-3 years) fire activity, reducing the fuel load (Elimination).</li> </ul>	<ul style="list-style-type: none"> <li>Annual fire preparedness assurance activities completed where activities are proposed during high fire risk periods (administration)</li> <li>Daily monitoring of bushfires in the region during periods of high fire danger (administration)</li> <li>Annual fire frequency mapping using the Northern Australia Fire Information fire history database (administration)</li> </ul>	<ul style="list-style-type: none"> <li>Fire hazard reduction strategies (such as back burning) to be implemented to reduce the risk of fire ignition/ impact as required (Elimination)</li> <li>Where a bushfire is started and cannot be controlled, Origin to engage with pastoralist to coordinate response activities</li> </ul>	3	2	M	Yes	Fire is a common occurrence within the Barkly Region. A fire is likely to have a serious impact, with moderate term reversible impacts (years). With the appropriate controls, such as separation distances, firebreaks, and adherence to total fire bans, the likelihood of causing a fire from drilling, stimulation and well testing is anticipated to be highly unlikely, with a predicted occurrence of <10%	Yes	Low

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures			Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
49		Flowback tank structural failure.	A.4.1 Site selection and planning A.4.7 Containment of Contaminants C.4.2 Management of produced water and flowback fluid C.5.2 Management of produced water from petroleum wells C.8.2 Spill Management Plan	3	1	L	<ul style="list-style-type: none"> <li>Tanks designed and engineered to AS3990 Mechanical Equipment- Steel Work, AS 1170.1 Hydrostatic loading, AS1170.2 Wind Rating (cyclonic wind rating) (Engineering)</li> <li>Wastewater tank liner with impermeable membrane with coefficient of permeability of less than 10-9 m/s permeability. 120N picture resistance and 49N tear resistance (Engineering)</li> <li>Covered wastewater tanks and condensate tanks to have vents to prevent pressure build up. (Engineering)</li> <li>The leases is compacted to above 100kpa to achieve a permeability of approximately 1x10m-7/s (Engineering)</li> <li>The site is earthen bunded to prevent offsite release of flowback. This is considered an additional level of containment, as the primary and secondary containment is the principle spill risk control. (Engineering)</li> <li>The site earthen bund has a minimum bund wall height of 300mm capable of managing at least 110% of the largest wastewater tank volume. (Engineering)</li> <li>The earthen bund is constructed in a manner to withstand a tank failure scenario with appropriate compact and stabilisation applied.(Engineering)</li> <li>Sacred sites 9.5 km away from lease pads, areas mapped as restricted work areas with no access permitted (Elimination, Administration)</li> <li>Recycling of flowback to reduce wastewater volumes in accordance with the Code.</li> </ul>	<ul style="list-style-type: none"> <li>Weekly wastewater tank integrity inspections during wastewater storage to detect (administration)</li> <li>Routine level monitoring and alarms (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater tank structural defects to be rectified as soon as practicable. (Engineering)</li> <li>Wastewater to be transferred from defective tanks to alternative tanks onsite until repairs completed. (Engineering)</li> <li>Pumps located onsite to recover fluid and transfer into existing tanks, with spills and leaks to be cleaned up and rectified immediately (Engineering)</li> <li>Earth moving equipment available regionally to clean up spills (Engineering)</li> <li>Emergency response plan implemented (Administration)</li> <li>Any contamination event to be characterised and have remediation plans developed and executed in accordance with the process outlined in schedule A of the National Environmental Protection (Assessment of site Contamination) Measures (Engineering)</li> </ul>	3	1	L	Yes	The consequences of a tank failure are negated through the use of double lined, engineered above ground tank which have continuous leak detection and alarms. Tanks and their liners are designed with sufficient structural integrity to withstand cyclonic winds, extreme temperatures and loading stress forces under a range of conditions. A spill management plan is in force to detect, prevent and respond to potential spills of wastewater. If a storage failure was to occur, the wastewater would be restricted to the lease pad, limiting the impact on adjacent pastoral activities and community. Flowback would be pumped into available enclosed and open tank storage, with contaminated soil removed from site. The consequences are likely to be "serious", being locally restricted, moderate duration (weeks) and reversible (requiring rehabilitation). The likelihood is reduced by the COP requirements, tank design separation distances to the underlying aquifer. The likelihood is considered Remote, with a probability less than 1%.	Yes	Low	
50		Personnel unauthorised access to sacred site.	A.4.1 Site selection and planning	2	2	L	<ul style="list-style-type: none"> <li>Restricted work areas are not located in close proximity to explorational activities (Elimination)</li> <li>All staff to be inducted covering restricted work areas and cultural heritage (Administration)</li> <li>Access off lease not permitted. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Origin completes 6 monthly assurance programs to confirm access to sacred sites has not occurred.</li> </ul>	<ul style="list-style-type: none"> <li>N/A- no access to sacred sites anticipated. (Elimination)</li> </ul>	2	2	L	Yes	All sites of the proposed activity must have Traditional Owner clearance via the NLC. AAPA certificates are required for all activities to ensure sacred sites are not impacted by activities. The remote location of the activity, lack of sacred sites in the vicinity of the sites and contractual requirements prohibiting access reduce the likelihood down to "highly unlikely", with a probability lower than 10%.	Yes	Low	
51		Sites disturbed directly by 2D seismic activities	A.4.1 Site selection and planning	3	1	L	<ul style="list-style-type: none"> <li>Exploration Agreements with Determined Traditional owners covering all proposed exploration activities.</li> <li>All areas of the proposed activity to be cleared by NLC. (Elimination)</li> <li>AAPA certificates for proposed work program have been granted (Elimination)</li> <li>The location of seismic lines has considered proximity to sacred sites (Elimination)</li> <li>Areas of cultural heritage to be avoided during the activity (Elimination)</li> <li>Implementation of the unexpected finds protocol (Administration).</li> </ul>	<ul style="list-style-type: none"> <li>Origin completes 6 monthly assurance programs to confirm access to sacred sites has not occurred.</li> </ul>	<ul style="list-style-type: none"> <li>N/A- no access to sacred sites anticipated. (Elimination)</li> </ul>	3	1	L	Yes	All sites of the proposed activity must have Traditional Owner clearance via the NLC. AAPA certificates are required for all activities to ensure sacred sites are not impacted by activities. The remote location of the activity, lack of sacred sites in the vicinity of the sites and contractual requirements prohibiting access reduce the likelihood down to "highly unlikely", with a probability lower than 10%.	Yes	Low	
52		Accidental ignition during 2D seismic activities.	A.4.6 Fire management	3	2	M	<ul style="list-style-type: none"> <li>Bushfire management plan implemented to prevent and respond to bushfires- including establishment of communication and fire response protocols with pastoralists (Administration)</li> <li>Bushfire awareness included in site inductions. (Administration)</li> <li>Designated smoking areas on-site (Elimination)</li> <li>Firefighting equipment to be available to deal with fires (Engineering).</li> <li>Vehicles to be equipped with fire extinguishers.</li> <li>Fire response to be implemented during seismic program, with spotters and fire trailers utilised to put out small fires during work</li> <li>Activities will comply with landholder and regional bushfire management plans. (Elimination)</li> <li>Area in the vicinity of the seismic activity have had recent (within 1-2 years) fire activity, reducing the fuel load (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Annual fire preparedness assurance activities completed where activities are proposed during high fire risk periods (administration)</li> <li>Daily monitoring of bushfires in the region during periods of high fire danger (administration)</li> <li>Annual fire frequency mapping using the Northern Australia Fire Information fire history database (administration)</li> </ul>	<ul style="list-style-type: none"> <li>Fire hazard reduction strategies (such as back burning) to be implemented to reduce the risk of fire ignition/ impact as required (Elimination)</li> <li>Where a bushfire is started and cannot be controlled, Origin to engage with pastoralist to coordinate response activities</li> </ul>	3	2	M	Yes	Fire is a common occurrence within the Barkly Region. A fire is likely to have a serious impact, with moderate term reversible impacts (years). With the appropriate controls, such as separation distances, firebreaks, and adherence to total fire bans, the likelihood of causing a fire from drilling, stimulation and well testing is anticipated to be highly unlikely, with a predicted occurrence of <10%	Yes	Low	
53		Personnel unauthorised access to sacred site during 2D seismic activities.	A.4.1 Site selection and planning	2	2	L	<ul style="list-style-type: none"> <li>Restricted work areas are not located in close proximity to explorational activities (Elimination)</li> <li>All staff to be inducted covering restricted work areas and cultural heritage (Administration)</li> <li>Access off lease not permitted. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Origin completes 6 monthly assurance programs to confirm access to sacred sites has not occurred.</li> </ul>	<ul style="list-style-type: none"> <li>N/A- no access to sacred sites anticipated. (Elimination)</li> </ul>	2	2	L	Yes	All sites of the proposed activity must have Traditional Owner clearance via the NLC. AAPA certificates are required for all activities to ensure sacred sites are not impacted by activities. The remote location of the activity, lack of sacred sites in the vicinity of the sites and contractual requirements prohibiting access reduce the likelihood down to "highly unlikely", with a probability lower than 10%.	Yes	Low	
54	Community impact	Loss of visual amenity, experience and sense of place for landholder, community members and tourists.	Industrialisation of landscape.	A.4.1 Site selection and planning A.4.1.1 Well pad specific site selection	1	1	L	<ul style="list-style-type: none"> <li>Existing location used to reduce footprint, with multi- well pads needed to minimise the impact of a future development (if feasible)</li> <li>Site is located away from sensitive receptors and not clearly visible: slight glow may be experienced during well testing (similar to a small town) (Elimination)</li> <li>Level of clearing for infrastructure is small (Elimination)</li> <li>Progressive rehabilitation to occur when sites are no longer required for future operations (engineering)</li> <li>Activity intensity is restricted to specific periods, with most activity restricted to the lease pad.</li> <li>Workers are flown in and out of Daly waters from Darwin. Buses are used to limit vehicle transport movements between the Daly Waters airport and remote camps- there is limited Drive In/Drive Out workers into the Beetaloo- except where local or regional contractors are utilised.</li> <li>Camps utilised to minimise impact on local accommodation and tourism.</li> <li>2D seismic acquisition only occurs during daylight hours (Elimination)</li> <li>Clearing for 2D seismic lines is minimal (Avoid)</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing community engagement to monitor performance and identify potential impacts from activity on local amenity.</li> </ul>	<ul style="list-style-type: none"> <li>N/A- site location and activity intensity is unable to be changed.</li> </ul>	1	1	L	Yes	The proposed explorational activities are located away from major transport routes, homesteads and communities. The consequences of activities may result in minor changes in aesthetics through visibility of exploration activities (flare glows at night, presence of workers and vehicles). The probability that the activity will result in an industrialisation of the landscape is considered remote, with a probability less than 1%.	Yes	Low
55		Increased traffic.	A.4.1 Site selection and planning	2	1	L	<ul style="list-style-type: none"> <li>Traffic impact assessment completed assessing the increased traffic levels as negligible: reflective of limited size and scope of activity.</li> <li>Traffic impacts are expected to small and temporary with Rig located onsite or moved via internal road.</li> <li>Access route is away from Copee Hill and Hayfields Homesteads.</li> <li>Capacity of road and level of service will not be impacted materially.</li> <li>Workers are flown in and out of Daly waters from Darwin. Busses are used to limit vehicle transport movements between the Daly Waters airport and remote camps- there is limited Drive In/Drive Out workers into the Beetaloo- except where local or regional contractors are utilised.</li> <li>Traffic issues were not identified during the well drilling and stimulation campaigns for the existing wells.</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing community engagement to monitor performance and identify potential impacts from activity on traffic.</li> </ul>	<ul style="list-style-type: none"> <li>Complaints regarding traffic will be dealt through Origins complaint resolution process. Where valid complaints are received, additional controls will be implemented to address community complaints (such as changes to vehicle load movements etc.)</li> </ul>	2	1	L	Yes	The increased traffic from the activity is likely to be short term and within the Level of service of the existing roads. Increases in traffic are anticipated to have a "moderate" consequence (increase in traffic observable, but temporary). The likelihood of causing a loss of experience from the E&A activities is considered "Highly unlikely", with an anticipated probability of less than 10%.	Yes	Low	
56		Light emissions impact on sensitive receptor (such as pastoralist)	A.4.1 Site selection and planning	1	1	L	<ul style="list-style-type: none"> <li>Sites are located 20 km away the nearest homestead (Copee Hill) with Amungee Delineation area located adjacent to Carpentaria Highway may be visible during flaring. This is likely to be consistent with a small town and only visible during the night. (Elimination)</li> <li>Flaring is of short duration, generally less than 90 days. (Elimination)</li> <li>No complaints received from Amungee NW-1 flaring.</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing pastoralist engagement to monitor performance and identify potential impacts from activity on local amenity. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Complaints regarding light emissions will be dealt through Origins complaint resolution process. Where valid complaints are received, additional controls will be implemented to address community complaints (such as shrouds, changes to flare configuration etc.)</li> </ul>	1	1	L	Yes	The remote location and separation distances between receptors is likely to result in minor light emissions. Light may be visible from activities (such as flaring), but will not be of sufficient intensity to cause any material impact to the health and wellbeing of community members. The likelihood of impacts is a function of separation distance and is therefore predicted to be remote, with a probability less than 1%	Yes	Low	
57		Influx of workers to region		2	1	L	<ul style="list-style-type: none"> <li>Work temporary in nature and utilises existing regional contractors where available (Elimination)</li> <li>Engagement with the pastoralists and directly affected community completed to communicate scope of work (administration)</li> <li>Site camps utilised to minimise workers within local community (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing community engagement to monitor performance and identify potential impacts from activity on local communities.</li> </ul>	<ul style="list-style-type: none"> <li>Complaints regarding work influx are unlikely and will be dealt through Origins complaint resolution process. Where valid complaints are received, additional controls will be implemented to address community complaints.</li> </ul>	2	1	L	Yes	The limited scope and duration of activities reduces the risk and uncertainty associated with risk. Most workers will be located away from communities, meaning there is unlikely to be a major increase in people.	Yes	Low	

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures			Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
58		Noise emissions from activities.		A.4.1 Site selection and planning A.4.2 Noise	1	1	L	<ul style="list-style-type: none"> <li>Sites are located 20 km away from the nearest homestead (Copee Hill) with Amungee Delineation area located adjacent to Carpentaria Highway. Noise impacts will not reach sensitive receptors, with QLD experience on rig and stimulation noise indicating noise levels approaching background levels approximately &lt;2 km from the activity. (Elimination)</li> <li>No complaints received from Amungee NW-1 flaring (Administration).</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing pastoralist engagement to monitor performance and identify potential impacts from activity on local amenity. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Complaints regarding noise emissions will be dealt through Origins complaint resolution process. Where valid complaints are received, additional controls will be implemented to address community complaints (such as shrouds, changes to flare configuration etc.)</li> </ul>	1	1	L	Yes	The remote location and separation distances between receptors is likely to result in "minor" noise impacts. The likelihood of impacts is a function of separation distance and is therefore predicted to be remote, with a probability less than 1%	Yes	Low
59		Noise emissions and vibration from 2D seismic activities.		A.4.1 Site selection and planning A.4.2 Noise	1	1	L	<ul style="list-style-type: none"> <li>Seismic located &gt;15 km from pastoralist homestead.</li> <li>Noise impacts will not reach sensitive receptors (Elimination)</li> <li>During detonation, a short sharp thud will be heard, and potential small level vibration field within 1 km of charge going off.</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing pastoralist engagement to monitor performance and identify potential impacts from activity on local amenity. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Complaints regarding noise emissions will be dealt through Origins complaint resolution process</li> </ul>	1	1	L	Yes	The remote location and separation distances between receptors is likely to result in "minor" noise impacts. The likelihood of impacts is a function of separation distance and is therefore predicted to be remote, with a probability less than 1%	Yes	Low
60		Reduction in land productivity	Introduction and spread of weeds in the area.	A.4.5 Weed management	2	3	M	<ul style="list-style-type: none"> <li>All equipment and vehicles to be washed-down and to have a Biosecurity Declaration Certificate prior to access to site (Elimination)</li> <li>Areas of proposed exploration have been surveyed and are deemed to have low weed abundance (elimination)</li> <li>Activity will be restricted to defined lease pads and camp pads (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>6 monthly monitoring implemented around infrastructure to detect the spread/introduction of weed species (administration)</li> <li>Origin assurance activities to target equipment wash-down certificates to ensure standards are being met. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where weed outbreaks are identified associated with Origin's activities, infestations will be treated in accordance with the Weed Management Plan</li> </ul>	2	3	M	Yes	The area in the vicinity of the sites is free of weeds. Weeds are present across the broader property. Any introduction of weeds is likely to result in localised impact, with weed management requirements likely to reduce the consequence down to "moderate, short term". Due to the inherent nature of weed prevention the risk likelihood is considered unlikely, with a probability less than <30%	Yes	Low
61		Over extraction of groundwater.		A.4.1.1 Well pad specific site selection requirements B.4.17 Groundwater monitoring	1	1	L	<ul style="list-style-type: none"> <li>Groundwater extraction for activities to be restricted to the minimum water required. (Elimination)</li> <li>Groundwater bores are metered for groundwater take. (Engineering)</li> <li>All water take licenced in accordance with NT Water Act under Water Extraction Licence (WEL) GRF 10289 (Administration)</li> <li>Drawdown from the activities and other users assessed by DEPWS as a part of WEL; impacts to closest receptor not anticipated (Administration/ Elimination)</li> <li>Karst system is under allocated, with sufficient available capacity to support proposed water extraction requirements. (Elimination)</li> <li>Closest receptor is &gt;1 km from extraction point (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Continuous flow meters to monitor take and water balance implemented to ensure compliance with WEL (Administration)</li> <li>Groundwater monitoring completed to identify impacts associated with water extraction (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Groundwater extraction to cease where sustained drawdown post pumping exceeds 1 m (Administration)</li> </ul>	1	1	L	Yes	The extraction of groundwater for hydraulic fracturing activities requires all take to be licenced. The proposed take is assessed as a part of the licence application, with the assessment considering current and future water take levels. Based on this assessment, it was determined that the extraction rate would not impact upon adjacent users. The risk consequence is determined to be "serious"- given any impact is likely to cause pastoralist and broader community concern. The likelihood of such a consequence from occurring is considered remote (probability <1%) due to the quality of the Cambrian limestone aquifer, separation distance from surrounding users and under utilisation of aquifer.	Yes	Low
62		Impact to surface hydrology changes water flows impacting the land use/productivity		A.4.3 Erosion and sediment control and hydrology A.4.1 Site selection and planning	1	1	L	<ul style="list-style-type: none"> <li>Lease pad located away from watercourses and regional flow paths. (Elimination)</li> <li>Lease pads designed to divert stormwater around, without impeding natural surface water flows (Engineering)</li> <li>Stockpiled debris to be used to discourage water concentration, with vegetation establish on stockpiles to reduce exposed surfaces</li> <li>Area is remote with closest watercourse approximately 15 km away. (Elimination)</li> <li>The lease area is flat, with water to be diverted around the perimeter of the site. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Erosion and Sediment Control Plan in place with routine pre and post wet season inspection and maintenance (administration)</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance to be undertaken on erosion and sediment controls to ensure ongoing functionality and the controls are adequate (Engineering)</li> </ul>	1	1	L	Yes	The existing lease pad will be utilised for all activities, with no additional construction required. The existing lease pad has been located outside the major regional flow paths and designed to divert stormwater around the infrastructure. The consequence is anticipated to be minor, with the likelihood remote (based on the site being existing).	Yes	Low
63		Bushfire from accidental ignition by site activities (civil works, drilling, flaring grinding) or personnel.		A.4.6 Fire management	3	2	M	<ul style="list-style-type: none"> <li>Bushfire management plan implemented to prevent and respond to bushfires- including establishment of communication and fire response protocols with pastoralists (Administration)</li> <li>Bushfire awareness included in site inductions. (Administration)</li> <li>Designated smoking areas on-site (Elimination)</li> <li>Firefighting equipment to be available to deal with fires (Engineering).</li> <li>Fire breaks have been constructed around the existing lease and camp pads and will be constructed around the expanded Amungee NW lease pad (Engineering)</li> <li>Minimum of 45 m separation distances between flares and surrounding vegetation (Engineering)</li> <li>Ignition sources placed outside of the hazardous area. (Elimination)</li> <li>Intrinsically safe equipment used in hazardous area. (Elimination)</li> <li>Hazardous area drawing will provide classification of hazardous zones while drilling. (Elimination)</li> <li>No flaring during periods of total fire ban (Elimination)</li> <li>Activities will comply with landholder and regional bushfire management plans. (Elimination)</li> <li>Area in the vicinity of Amungee NW lease has had recent (within 1-2 years) fire activity, reducing the fuel load (Elimination).</li> </ul>	<ul style="list-style-type: none"> <li>Annual fire preparedness assurance activities completed where activities are proposed during high fire risk periods (administration)</li> <li>Origin assurance activities to target equipment wash-down certificates to ensure standards are being met. (Administration)</li> <li>Groundwater monitoring completed to identify impacts associated with water extraction (Engineering)</li> <li>Australia Fire Information fire history database (administration)</li> </ul>	<ul style="list-style-type: none"> <li>Fire hazard reduction strategies (such as back burning) to be implemented to reduce the risk of fire ignition/ impact as required (Elimination)</li> <li>Where a bushfire is started and cannot be controlled, Origin to engage with pastoralist to coordinate response activities</li> </ul>	3	2	M	Yes	Fire is a common occurrence within the Barkly Region. A fire is likely to have a serious impact, with moderate term reversible impacts (years). With the appropriate controls, such as separation distances, firebreaks, and adherence to total fire bans, the likelihood of causing a fire from drilling, stimulation and well testing is anticipated to be highly unlikely, with a predicted occurrence of <10%	Yes	Low
64		Poor rehabilitation of exploration infrastructure.		A.4.8 Rehabilitation	2	2	L	<ul style="list-style-type: none"> <li>A site specific Rehabilitation Plan has been developed and will be implemented progressively (Engineering)</li> <li>Areas will have infrastructure and wastes removed, sumps and pits backfilled, topsoil respread and vegetation re-introduced. (Engineering)</li> <li>Rehabilitation timing will consider seasonal constraints, with rehab completed prior to the wet season to maximise revegetation chance (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Rehabilitation monitoring to be undertaken to track rehabilitation progress (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance will be undertaken periodically to fix any defects (Engineering)</li> </ul>	2	2	L	Yes	Rehabilitation success will be determined through the timing of rehabilitation, with rehab activities undertaken before the wet season to maximise success. Ongoing monitoring and maintenance of rehabilitated areas will be critical to identify and repair areas where rehabilitation success is poor. Consequences are likely to be moderate, with impacts likely to have moderate, locally restricted and medium to long term (1-5 years). The likelihood is influenced by the requirement for security provisions, rehabilitation plan requirements and COP conditions. The likelihood is anticipated to be highly unlikely, with a probability below 10%.	Yes	Low
65		Disruption of agricultural operations due to ongoing access, traffic, helicopter movements etc.		A.4.1 Site selection and planning A.4.2 Noise	1	3	L	<ul style="list-style-type: none"> <li>All activities require engagement with pastoralists (Administration)</li> <li>Lease site has been located to avoid disruption to agriculture operations and infrastructure. (Elimination)</li> <li>Engagement will be undertaken in accordance with NT Petroleum (Environment) Regulations (Administration)</li> <li>Traffic levels are anticipated to be small- as per Traffic Impact Assessment.(Elimination)</li> <li>Helicopter movements to be restricted to wet season when landholder activities are minimal (Elimination)</li> <li>Helicopter movements to be undertaken in consultation with leaseholder to avoid impacts to livestock, cattle yards, watering points, homesteads and other sensitive areas as advised by leaseholder. (Elimination)</li> <li>2D seismic activities are of a limited size and scope of the activity (e.g. 10 vehicles for 30 - 45 days).</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing pastoralist engagement to monitor performance and identify potential impacts from activity on local amenity. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Complaints regarding Origin's activities will be dealt through Origins complaint resolution process. Where valid complaints are received, Origin will investigate if additional controls are needed and implement to address the complaint (such as shrouds, Changes to flare configuration etc.) (administration/engineering)</li> </ul>	1	3	L	Yes	Origin has extensive experience in co-existing its activities with agricultural users. Consultation with pastoralists is undertaken to ensure impacts on their activities are mitigated. These impacts are addressed in the compensation agreements and access guidelines. It is noted that there is an impact on stakeholder in regards to working with proponents to plan E&A activities. This is unavoidable and required to ensure the activities can be designed to accommodate the activities of both parties. Consequences are anticipated to be minor for E&A activities, with the likelihood unlikely. The likelihood is reduced through compensation agreements which consider the pastoralist time when negotiating agreements.	Yes	Low
66		Safety hazard to pastoralists, community and tourists from increased traffic levels	Increased risk of vehicle accident	A.4.1 Site selection and Planning	3	1	L	<ul style="list-style-type: none"> <li>Traffic impact assessment completed, with traffic levels are anticipated to be small (Elimination)</li> <li>Fatigue management policy implemented for transport companies, with breaks required every two hours (Administration)</li> <li>Alcohol and drug policy implemented with zero tolerance (0.00% BAC and no illicit substances) (Elimination)</li> <li>Workers are flown in and out of Daly waters from Darwin. Buses are used to limit vehicle transport movements between the Daly Waters airport and remote camps- there is limited Drive In/Drive Out workers into the Beetaloo- except where local or regional contractors are utilised. (Elimination)</li> <li>The camp is located away from major roads with most movements internal between camp lease and drill site (Elimination)</li> <li>Stuart highway intersection design approved by DIPL with appreciate line of site provided for vehicles to identify turning vehicles. (Engineering)</li> <li>Origin has completed 100,000's of transport movements each in QLD with transports incidents extremely rare. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing community engagement to monitor performance and identify potential impacts from activity on local amenity. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Complaints regarding Origin's activities will be dealt through Origins complaint resolution process. Where valid complaints are received, additional controls will be implemented to address community complaint (Administration)</li> </ul>	3	1	L	Yes	E&A activities will increase traffic levels up to 44 vehicles per day during the peak. This traffic volume is well below the Level of Service for the highway, which is estimated to be above 1100 vehicles per hour. Accidents from truck turning into access tracks or from general vehicle accidents are anticipated to have a serious consequence, with an injury to community members/ tourist requiring hospitalisation. Given Origin completed 100,000's of heavy vehicle movements each year with serious incidents extremely rare, smaller volume of traffic required for Beetaloo, the lack of road users, traffic management plan for the access track turn in, Zero tolerance for alcohol and drugs and use of trained drivers, the likelihood is considered Remote, with a probability less than 1%	Yes	Low

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					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating				
67		Labour competition with local businesses and agricultural procedures.	Exploration activities compete with agricultural industry for resources.		1	1	L	<ul style="list-style-type: none"> <li>Proposed activity is temporary with no major labour requirements- stakeholders engaged to ensure they know the temporal nature of work (Administration)</li> <li>Local and regional contractors will be utilised where available (Elimination)</li> <li>All work to be short-term with predominantly skilled workforce sourced regionally/interstate.</li> <li>Contracts will be structured to reduce 'boom and bust' cycle (clear understanding of limited scope of work).</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing community engagement to monitor performance and identify potential impacts from activity on local amenity. (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Complaints regarding Origin's activities will be dealt through Origins complaint resolution process. Where valid complaints are received, additional controls will be implemented to address community complaint (Administration)</li> </ul>	1	1	L	Yes	Labour competition is a consequence that may occur in a full scale shale development and is not anticipated to have a major impact during exploration. Exploration activities are generally short term campaigns and are completed similar to most small infrastructure projects (such as road upgrades). Local contractor are to be used where available, with a priority on using TN businesses. The consequence of labour competition during E&A is minor, with a likelihood of remote (<1% probability)	Yes	Low
68	Air Quality	Reduction in air quality associated with exploration emissions (Civil, Drilling, Stimulating and Well Testing).	Emissions from the combustion of diesel.	A.4.1 Site selection and planning D.5.1 Baseline assessment	1	2	L	<ul style="list-style-type: none"> <li>Low emission equipment to be utilised (Engineering)</li> <li>All equipment to be maintained in accordance with the manufacturer's recommendations (Engineering)</li> <li>Flares onsite to combust hydrocarbons (Engineering)</li> <li>No sensitive receptors within 15 km (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Equipment condition and maintenance to be built into contract (Administration)</li> <li>Routine site inspections and assurance undertaken to ensure equipment is maintained and operated as per manufacturers requirements. (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>All equipment defects identified by site inspection and assurances to be rectified promptly.(Engineering)</li> </ul>	1	1	L	Yes	Impacts to sensitive receptors are not anticipated, with the closest receptor over 20km away. Flares will be utilised to minimise the release of VOC's. The potential consequence from E&A activities is predicted to be minor. The likelihood is a function of source (lack of ) and separation distance between receptors. the likelihood of a sensitive receptor being exposed to emissions from E&A activities above the NEPM guidelines are remote (<1%).	Yes	Low
69		Air emissions from gas and condensate flaring.	A.4.1 Site selection and planning D.5.1 Baseline assessment B.4.13 Hydraulic Stimulation and flowback operations D.5.8 Venting and flaring	1	2	L	<ul style="list-style-type: none"> <li>Flares have been designed and will be operated in compliance with the US EPA 40 CFR § 63.18 to achieve a 98% combustion efficiency (Engineering)</li> <li>Emissions of NOx, CO and TVOC are small and not anticipated to reduce ambient air quality as there are no regional sources (Elimination)</li> <li>Vertical flare stack used for gas- maximising dispersion. (Engineering)</li> <li>Flares to be designed and operated to minimise smoking (Engineering)</li> <li>Site located away from receptors (Elimination)</li> <li>No sensitive receptors within 15 km (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Flares will be inspected as a part of weekly routine site inspection to rectify any excessive smoke production from flares (noting condensate flaring may produce small quantities of ongoing smoke due to the higher molecular weight of the hydrocarbons) (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where excessive smoking of flares is identified, the flare operating status will be reviewed and optimise to reduce particulate generation (Engineering)</li> </ul>	1	2	L	Yes	Risks associated with emissions from flares are well known with literature, and Australia and International policy/standards exist (such as NGERs and various US EPA technical guidance notes). The location of the activity is likely to limit the potential exposure to receptors, with consequences likely to be minor, localised and short term (days base on wind direction and atmospheric boundary conditions). The likelihood is predominantly reduced through the separation distance between the activity and receptors, with a likelihood of remote (<1% predicted)	Yes	Low	
70		Air emissions from chemical releases during drilling and stimulation activities.	A.4.1 Site selection and planning B.4.16 Well site layout and housekeeping b.4.13 Hydraulic Stimulation and flowback operations	1	1	L	<ul style="list-style-type: none"> <li>National Occupational Health and Safety Codes: Code of Practice for the Control of Workplace Hazardous Substances. (Administration)</li> <li>Chemical Risk Assessment completed on all chemicals used for stimulation (Elimination/Administration)</li> <li>Chemical handling and mixing practices to reduce particulate emissions. (Engineering)</li> <li>No sensitive receptors within 15 km. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Routine site inspections and assurance undertaken to ensure ongoing chemical handling and mixing practices do not result in an offsite release of substances (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Corrective actions implemented to address poor chemical handling and mixing practices. (Engineering)</li> </ul>	1	1	L	Yes	Risks associated with air emissions from petroleum activities are well known, with various risk assessment and emissions estimation technical guidance notes available within Australia and internationally (such as the National Pollutant Inventory and the US EPA). Due to overriding occupational health safety requirements to limit worker exposure and lack of local receptors the consequence is anticipated to be minor. The likelihood is reduced to remote, given the large separation distances between the activity and closest receptors.	Yes	Low	
71		Reduction in air quality associated with 2D seismic activities	Emissions from the combustion of diesel, detonation of charges and dust from clearing.	A.4.1 Site selection and planning D.5.1 Baseline assessment	1	2	L	<ul style="list-style-type: none"> <li>Low emission equipment to be used where practicable (Engineering)</li> <li>All equipment to be maintained in accordance with the manufacturer's recommendations (Engineering)</li> <li>No sensitive receptors within 20 km (Elimination)</li> <li>Short term activity (e.g. 10 vehicles for 30 - 45 days)</li> </ul>	<ul style="list-style-type: none"> <li>Equipment condition and maintenance to be built into contract (Administration)</li> <li>Routine site inspections and assurance undertaken to ensure equipment is maintained and operated as per manufacturers requirements. (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>All equipment defects identified by site inspection and assurances to be rectified promptly.(Engineering)</li> </ul>	1	1	L	Yes	Impacts to sensitive receptors are not anticipated, with the closest receptor over 20km away. Flares will be utilised to minimise the release of VOC's. The potential consequence from E&A activities is predicted to be minor. The likelihood is a function of source (lack of ) and separation distance between receptors. the likelihood of a sensitive receptor being exposed to emissions from E&A activities above the NEPM guidelines are remote (<1%).	Yes	Low
72		Increased nuisance from dust and particulate emissions associated with exploration activities caused impacts to regional ecosystems and fauna	Civil activities, drilling operations, well testing and 2D seismic activities.	A.4.1 Site selection and planning	1	5	M	<ul style="list-style-type: none"> <li>Water trucks will be used to decrease dust emissions. (Engineering)</li> <li>Roads maintained to prevent bull dust generation (Engineering)</li> <li>No sensitive receptors within 15 km (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Routine site inspections and assurance undertaken to identify and rectify high dust emissions (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Dust control to be implemented where unacceptable dust from transport activities occur (Engineering)</li> </ul>	1	5	M	Yes	Dust will be generated through transport movements along access tracks and around lease pads. The consequence of dust is anticipated to be moderate, with localised, short term impacts to areas immediately adjacent to access tracks. The likelihood of the risk is reduced through the isolated location (lack of sensitive receptors), regionally extensive vegetation communities (good outside refuge away from access tracks and use of dust suppression). As dust generation has been observed, and is commonly associated with dirt tracks, the likelihood of an impact is considered likely.	Yes	Low
73		Bushfire from accidental ignition by site activities (civil works, drilling, flaring, grinding), during 2D seismic clearing or by personnel.		A.4.6 Fire management	3	2	M	<ul style="list-style-type: none"> <li>Bushfire management plan implemented to prevent and respond to bushfires- including establishment of communication and fire response protocols with pastoralists (Administration)</li> <li>Bushfire awareness included in site inductions. (Administration)</li> <li>Designated smoking areas on-site (Elimination)</li> <li>Firefighting equipment to be available to deal with fires (Engineering).</li> <li>Fire breaks have been constructed around the existing lease and camp pads and will be constructed around the expanded Amungee NW lease pad (Engineering)</li> <li>Minimum of 45m separation distances between flares and surrounding vegetation (Engineering)</li> <li>Ignition sources placed outside of the hazardous area. (Elimination)</li> <li>Intrinsically safe equipment used in hazardous areas. (Elimination)</li> <li>Hazardous area drawing will provide classification of hazardous zones while drilling. (Elimination)</li> <li>No flaring during periods of total fire ban (Elimination)</li> <li>Activities will comply with landholder and regional bushfire management plans. (Elimination)</li> <li>Vehicles to be equipped with fire extinguishers.</li> <li>Fire response to be implemented during 2D seismic program, with spotters and fire trailers utilised to put out spot fires during work</li> <li>Activities will comply with landholder and regional bushfire management plans. (Elimination)</li> <li>Area in the vicinity of the 2D seismic activity have had recent (within 1-2 years) fire activity, reducing the fuel load (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Annual fire preparedness assurance activities completed where activities are proposed during high fire risk periods (administration)</li> <li>Daily monitoring of bushfires in the region during periods of high fire danger (administration)</li> <li>Annual fire frequency mapping using the Northern Australia Fire Information fire history database (administration)</li> </ul>	<ul style="list-style-type: none"> <li>Fire hazard reduction strategies (such as back burning) to be implemented to reduce the risk of fire ignition/ impact as required (Elimination)</li> <li>Where a bushfire is started and cannot be controlled, Origin to engage with pastoralist to coordinate response activities (Administration/ engineering)</li> </ul>	3	2	M	Yes	Fire is a common occurrence within the Barkly Region. A fire is likely to have a serious impact, with moderate term reversible impacts (years). With the appropriate controls, such as separation distances, firebreaks, and adherence to total fire bans, the likelihood of causing a fire from drilling, stimulation and well testing is anticipated to be highly unlikely, with a predicted occurrence of <10%	Yes	Low
74	Greenhouse Gas Emissions	Unsustainable greenhouse gas emissions from the activity.	Combustion of diesel for all exploration activities, including 2D seismic.	A.4.1 Site selection and planning	2	1	L	<ul style="list-style-type: none"> <li>Australian emission standards for equipment ensures minimum operating efficiency (Engineering)</li> <li>All equipment to be maintained in accordance with the manufacturer's recommendations (Engineering)</li> <li>No sensitive receptors within 15 km (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Equipment condition and maintenance to be built into contract (Administration)</li> <li>Routine site inspections and assurance undertaken to ensure equipment is maintained and operated as per manufacturers requirements. (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>All equipment defects identified by site inspection and assurances to be rectified promptly.(Engineering)</li> </ul>	2	1	L	Yes	The risks associated with Greenhouse Gas generation through diesel combustion are well documented in literature and domestic/international greenhouse policy (such as NGERs and IPCC). The consequences of GHG generation from exploration activities is moderate, with less than 1% of the NT emissions generated. The likelihood of the level of GHG production being unsustainable is considered remote, with a probability less than 1%	Yes	Low
75		Flaring of gas and condensate during well testing.	B.4.13 Hydraulic Stimulation and flowback operations D.5.8 Venting and flaring	2	2	L	<ul style="list-style-type: none"> <li>Venting to be minimised with all venting reported under NGERs.</li> <li>Flares have been designed and will be operated in compliance with the US EPA 40 CFR § 63.18 to achieve a 98% combustion efficiency.</li> <li>Emissions from source rock during drilling are negligible.</li> <li>Condensate will be flare and/or transported offsite for sale if permissible.</li> <li>Total worst case emissions from activity are not significant- being ~1.3% of NT's Total GHG emissions and 0.05% of Australia's GHG emissions</li> </ul>	<ul style="list-style-type: none"> <li>Flares will be inspected as a part of weekly routine site inspection to rectify any excessive smoke production from flares (noting condensate flaring may produce small quantities of ongoing smoke due to the higher molecular weight of the hydrocarbons) (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Where excessive smoking of flares is identified, the flare operating status will be reviewed and optimise to reduce particulate generation (Engineering)</li> </ul>	2	2	L	Yes	The risks associated with Greenhouse Gas generation through diesel combustion are well documented in literature and domestic/international greenhouse policy (such as NGERs and IPCC). The consequences of GHG generation from exploration activities is moderate, with less than 1% of the NT emissions generated. The likelihood of the level of GHG production being unsustainable is considered remote, with a probability less than 1%. The well testing will also allow for natural gas to be used as a transition fuel	Yes	Low	
76		Uncontrolled release of gas encountered during drilling, stimulation, barrier failure, operator error or vehicle collision under a multi-well scenario	B.4.1 Well integrity management B.4.3 Well design and barriers B.4.13 Hydraulic Stimulation and flow back operations D.5.8 Venting and flaring	2	2	L	<ul style="list-style-type: none"> <li>Drilling overbalanced to reduce the inflows of hydrocarbons (Engineering)</li> <li>Blow out prevention in place to manage well failure and uncontrolled gas influxes (Engineering)</li> <li>Blow out preventor pressure rating and testing</li> <li>All equipment will be API compliant to handle expected conditions (Engineering)</li> <li>Site manned during operation (Administration)</li> <li>Well suspended with multiple cement and casing barriers in place- with 4 casing section utilised (conductor, surface, intermediate and production).(Engineering)</li> <li>Barricading to be used to protect each exploration well from vehicle collision during multi-well drilling activities. (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Process monitoring to detect events that could potentially result in a uncontrolled release of gas (such as fluid balances, well head pressure etc.) (Engineering)</li> <li>Routine (monthly) well inspections (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>An emergency as diverter and flare to be used during drilling to manage gas ingress (Engineering)</li> <li>Contracts in place with emergency well intervention specialists (such as Boots and Cootes) (administration)</li> <li>Emergency response plan implemented (administration)</li> </ul>	2	2	L	Yes	The COP and standard drilling, stimulation and well testing safety controls are designed to prevent the uncontrolled release of hydrocarbons. Flares are used during drilling and well testing to manage any encountered hydrocarbons The consequence are anticipated to be moderate, with impacts likely to be moderate, restricted in duration (minutes to hours). The likelihood is considered highly unlikely with a occurrence probability less than 10%, based on the well designed, construction and operations requirements mandated by the COP.	Yes	Low	

Ref	Environmental Factor	Risk scenario description	Risk Source	Code of Practice	unmitigated (CoP implemented) Risk Rating			Risk mitigation Measures						Residual Risk Rating			ALARP criteria achieved?	Residual risk ALARP and Acceptable Statement	Acceptable criteria achieved?	Scientific Uncertainty Ranking
					Consequence	Likelihood	Risk Rating	Prevent	Detect	Recover	Consequence	Likelihood	Risk Rating							
77		Uncontrolled release of gas from well due to sabotage.		D.5.8 Venting and flaring	2	2	L	<ul style="list-style-type: none"> <li>Multiple barriers used during well suspension/operation- including downhole suspension plugs, suspension fluid and surface valves (Engineering)</li> <li>Sites manned during operation (Administration)</li> <li>Security cameras located on sites (Engineering)</li> <li>Sites locked (Engineering)</li> <li>Valves locked (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Routine (monthly) well inspections (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Contracts in place with emergency well intervention specialists (such as Boots and Cootes) Administration)</li> <li>Emergency response plan implemented (Administration)</li> </ul>	2	2	L	Yes	The risks associated with Greenhouse Gas generation through well sabotage is anticipated to be moderate, with impacts likely to be restricted in duration (hours to days). The likelihood is considered remote (probability <1%), with the site remote and multiple valves locked on the well to prevent tampering	Yes	Low			
78		Leak of gas from wells.		B.4.1 Well integrity management B.4.3 Well design and barriers D.5.4 Emission detection and management D.5.5 Leak remediation and notification	1	2	L	<ul style="list-style-type: none"> <li>Well design considers multiple (4) specifically-engineered cement and steel casing barriers in place between hydrocarbon-bearing zone and surface. This includes conductor casing, surface casing, intermediate casing and production casing intervals (Engineering)</li> <li>Well design and Well Barrier Integrity Validation reports submitted to DITT as part of Well Operations Management Plan (WOMP). (Administration/ engineering)</li> <li>Wells constructed and suspended with barriers in place and verified as per governing code (engineering)</li> <li>Limited gas production time only to extended production test. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Routine 6 monthly well leak detection (Engineering)</li> <li>Routine (monthly) well inspections (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Any leaking wells to be reported and remediated at a frequency consistent with the COP depending on severity (Engineering)</li> </ul>	1	2	L	Yes	The consequence of a well leak are anticipated to be minor with impacts likely to be small (<1000L/hour) and restricted in duration (days to weeks). The likelihood is considered highly unlikely with a occurrence probability less than 10%, based on the well designed, construction and operations requirements mandated by the COP. Leak detection and reporting requirements are also controls to ensure any leaks are promptly identified and fixed.	Yes	Low			
79	Cumulative Risk	Cumulative impacts on groundwater quantify.	Groundwater take from surrounding land users exceeds the natural recharge rate of the Basin.	Water extraction licences under the NT Water Act	2	1	L	<ul style="list-style-type: none"> <li>Groundwater extraction volumes to be monitored and kept below WEL (Elimination)</li> <li>Groundwater extraction assessments include an estimate of current extraction levels at a regional scale.</li> <li>No intensive users of groundwater within the region, with stock and domestic being the major usage. (elimination)</li> <li>Cumulative impacts considered in the water extraction licence under the NT Water Act. (Elimination)</li> <li>Strategic Regional Environmental Baseline Assessment (SREBA) completed to collected baseline environmental data, with Environmental Impact Assessments completed to address cumulative impacts from industry (Administration/ Engineering/ elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Groundwater monitoring of control and impact monitoring bores will detect localised groundwater depressurisation before regional impacts occur (Engineering)</li> </ul>	<ul style="list-style-type: none"> <li>Where sustained groundwater depletion is observed in regional aquifers, alternative water supplies may be required, such as deeper aquifers with limited extraction (Elimination)</li> <li>Water Act make good provisions to ensure any impacts on users from exploration activities are "made good"</li> </ul>	2	1	L	Yes	The regional understanding of the CLA is sufficient to understand the risks associated with groundwater extraction. The absence of users and small exploration take reduces the uncertainty of the activity. This risk has been assessed as a part of the WEL application and approval. Due to the lack of receptors, the consequence is considered moderate (i.e. 1 user within 16km) and likelihood remote (probability less than 1%)	Yes	Low			
80		Cumulative impacts on terrestrial ecology.	Impacts from exploration activities and existing agricultural activities results in impacts to vegetation communities, fragmentation and poses a threat to protected flora and fauna.	A.4.1 Site selection and planning A.4.1.1 Well pad specific site selection A.4.4 Biodiversity Protection	2	1	L	<ul style="list-style-type: none"> <li>Area has limited development with no widespread land clearing or other pressures from agriculture or other users. (Elimination)</li> <li>Petroleum activity is limited in scale and will not material decrease availability of habitat across the region (Elimination)</li> <li>Strategic Regional Environmental Baseline Assessment (SREBA) completed to collected baseline environmental data, with Environmental Impact Assessments completed to address cumulative impacts from industry (Administration/ Engineering/ Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>N/A- No increased risk to cumulative regional impacts.</li> </ul>	N/A.	2	1	L	Yes	The region has low land clearing pressure with no applications for large scale land clearing present. The level of disturbance proposed is small, with field ecological scouting confirming ecological communities present.	Yes	Low			
81		Cumulative impacts on amenity.	Exploration activities further reduces amenity (visual, noise, traffic and lighting) through additional landscape modification, dust, noise, light and traffic.	A.4.1 Site selection and planning A.4.1.1 Well pad specific site selection	1	2	L	<ul style="list-style-type: none"> <li>Wellsites are located in a remote/rural landscape, away from sensitive receptors (Elimination)</li> <li>Rig equipment located onsite/ within the adjacent property (Elimination)</li> <li>Flaring may create a visible hue on the horizon consistent with that of a small town.</li> <li>Traffic volumes are anticipated to be small and well below existing industries. (Elimination)</li> <li>A Traffic Management Plan covering the intersection upgrade work has been submitted to DPIL for approval. (Elimination)</li> <li>Low level of development activity within the region, with activity unlikely to cause declines in amenity. (Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>Community complaints regarding nuisance (including dust, traffic etc.) to be used to detect cumulative impacts (Administration)</li> </ul>	<ul style="list-style-type: none"> <li>Complaints are to be investigated and additional controls implemented where appropriate. (Administration/ engineering)</li> </ul>	1	2	L	Yes	The region is underdeveloped with the activity located away from major transportation routes, homesteads and communities. The activity is of a small size and unlikely to result in any loss of amenity. Any loss of amenity is therefore likely to be minor, with likelihood of highly unlikely.	Yes	Low			
82		Cumulative impacts on surface water quality.	Exploration activities in addition to existing surrounding land use (agriculture) reduces surface water quality.	A.4.1 Site selection and planning A.4.1.1 Well pad specific site selection A.4.3 Erosion and sediment control and hydrology	1	1	L	<ul style="list-style-type: none"> <li>Area has limited development with no widespread land clearing pressures from agriculture or other users likely to reduce water quality. (Elimination)</li> <li>No surface water take or wastewater releases permitted. (Elimination)</li> <li>Strategic Regional Environmental Baseline Assessment (SREBA) completed to collected baseline environmental data, with Environmental Impact Assessments completed to address cumulative impacts from industry (Administration/ Engineering/ Elimination)</li> </ul>	<ul style="list-style-type: none"> <li>N/A- no increased impact o surface waters anticipated</li> </ul>	<ul style="list-style-type: none"> <li>N/A- no increased impact o surface waters anticipated</li> </ul>	1	1	L	Yes	The region is underdeveloped with the activity located away from major flow pathways with limited topographic variation.. The activity is of a small size and unlikely to result in any material increase in sediment loads to surface waters.	Yes	Low			
83		Cumulative impacts- greenhouse gas emissions	Exploration activities materially increase Northern Territory's and Australia Greenhouse Gas emissions	B.4.1 Well integrity management B.4.3 Well design and barriers B.4.13 Hydraulic Stimulation and flow back operations D.5.8 Venting and flaring	2	1	L	<ul style="list-style-type: none"> <li>Activities required to prove up natural gas resources, with all available technology utilised to reduced emission intensity of exploration activities</li> <li>Flaring required to mitigate emissions from the activity (Engineering)</li> <li>Full development (if technically and commercially viable) likely to provide a viable transition fuel with up to 50% emissions of coal (Engineering)</li> <li>Total greenhouse gas emissions for the Beetaloo Sub-basin are low compared to total NT and Broader Australia Greenhouse gas emissions. The worst case percentage of total NT and Australian GHG emissions is estimated at 1.3% and 0.05% respectively.</li> <li>Strategic Regional Environmental Baseline Assessment (SREBA) completed to collected baseline environmental data, with Environmental Impact Assessments completed to address cumulative impacts from industry (Administration/ Engineering/ elimination)</li> </ul>	<ul style="list-style-type: none"> <li>N/A- Greenhouse gas emissions are approved prior to commencement of activity</li> </ul>	<ul style="list-style-type: none"> <li>N/A- Greenhouse gas emissions are approved prior to commencement of activity</li> </ul>	2	1	L	Yes	The role natural gas plays as a low carbon intensity transition fuel to support renewable energy use is well known. Broad adoption of natural gas within the US has replaced coal in energy production and has been responsible for a continued decline in carbon emissions. The use of natural gas is one of the low carbon intensity fuels required to reduce carbon emissions.	Yes	Low			