BEETALOO BASIN GROUNDWATER MONITORING BORE INSTALLATION PROGRAM- VELKERRI 76

Environmental Management Plan

EP76

Review record

Rev	Date	Reason for issue	Author	Reviewer	Approver
A	07/09/2018	Draft EMP released for comment	A.Court	M.Kernke	M.Hanson
0	09//11/2018	Revised to reduce sites	A.Court	M.Kernke	M.Hanson
1	22/11/2018	Revised to include AAPA Certificates	A.Court	M.Kernke	M.Hanson
1.1	12/03/2019	Revision to address DPIR comments	A.Court	M.Kernke	M.Hanson
1.2	10/06/2019	Minor revision to update Gravel Pit Locations and landholder feedback	M.Kernke	M.Hanson	M.Hanson

Environmental Management Plan

NT-2050-15-MP-0017

Table of contents

Table of figures

List of tables

List of appendices

Executive Summary

The Beetaloo Basin Groundwater Monitoring Bore Installation Environmental Management Plan (EMP) forms the basis of Origin Energy's (Origin) application to the Northern Territory (NT) Department of Primary Industry and Resources (DPIR) for the installation of environmental monitoring bores located adjacent to the proposed future exploration sites to collect baseline groundwater level and quality data prior to further exploration.

The proposed network of groundwater monitoring bores will be used to obtain baseline groundwater quality and quantity data adjacent to the proposed future drilling and stimulation lease sites to meet Recommendation 7.11 of the Inquiry and relevant guidelines published by NT Department of Environment and Natural Resources (DENR) on Groundwater Monitoring Bores required for petroleum exploration activities.

This EMP has been prepared with reference to the *NT Petroleum (Environment) Regulations 2016* and the Exploration Agreement between Origin, local Aboriginal groups and the Northern Land Council (NLC). The overall objective of the EMP is to ensure minimal environmental impact and minimise risk of any inadvertent adverse outcomes from Origin's activities. It is noted that this EMP does not seek approval for future exploration activities or potential hydraulic fracture stimulation activities. Should Origin seek to undertake further exploration, the company will prepare a separate submission and obtain approvals before conducting such activities.

The EMP covers a series of low impact activities proposed to expand Origin's existing, four-year, baseline groundwater monitoring program in preparation for its' 2019 exploration program. The groundwater monitoring program will involve the installation of monitoring bores sufficient to meet guidelines currently in development at the proposed Velkerri 76 S2 lease site within the Origin Beetaloo Exploration Area (refer Figure 1).

The activities subject to this EMP are:

- two 50 x 50 m groundwater monitoring bore lease sites, including provision for fire breaks totalling 0.5 hectares in disturbance.
- Establishment of up to four 100mx100m gravel pits to provide material for improving stability of the access tracks
- The installation of approximately 2km of access tracks (approximately 8 m wide) to connect the groundwater monitoring leases to the existing access track.
- Installation of approximately 3km of access track (approximately 8m wide) in total, to connect Gravel pit 4,5 and 6 to the existing access track.
- Grading and forming of 80km of existing tracks which involves the clearing of an average of 1m of vegetation along the length of the track,
- Installation of fencelines, gates, grids and firebreaks to access the groundwater monitoring bore lease sites.
- Groundwater monitoring bore drilling, completing and equipping of up to four groundwater water monitoring bores.

For the preparation of this EMP, a land condition assessment was completed in August 2018 to review the physical, natural and cultural heritage environment of the proposed lease areas for groundwater bore drilling and the associated access tracks.

The proposed groundwater monitoring bore sites is located within *Eucalyptus* low woodland with a tussock grass understorey. The proposed site 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 (DoTEE, 2014, Ward, 2008). Many of the sites surrounding areas 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.

There was no evidence of weeds observed during the survey. This suggests the primary controls for this program will therefore be focused on preventing the introduction of weeds and managing weeds promoted through site disturbance.

The archaeology assessment did not identify culturally sensitive landforms or artefacts within the proposed disturbance area. In addition, a sacred site clearance survey coordinated and carried out by the Northern Land

Council (NLC) in August and September 2018, was led by their anthropologist and included site visits and consultations with the Native Title holders / custodian. The Sacred Site Avoidance Survey Report / Anthropological Report has been provided to the Aboriginal Areas Protection Authority (AAPA) and informed the issuing of AAPA Certificate C2019/039.

The AAPA clearance certificates identified one restricted work areas (RWA's) within the vicinity of Origin's proposed activity. This RWA falls within the existing access track to the Velekrri 76 S2 lease site and outside of Origins proposed activities will not impact on any of the features of the protected area..

The environmental, heritage and social risks associated with the proposed groundwater monitoring bore drilling activities have been assessed utilising the Origin risk assessment framework. The detailed risk assessment presents the range of potentially impact-causing activities, corresponding mitigation measures and residual risk ratings based on their assessed worst-case consequence and likelihood of occurrence.

Key environmental impacts and risks identified for the program include:

- impacts on flora, fauna and habitat from clearing native vegetation

- risks to land and habitat from bushfire resulting from the activity

- risk to the land and surface water from erosion, in particular where access tracks cross small drainage channels

- risk to cultural heritage sites.

It was considered that with the appropriate controls implemented to mitigate the impacts, there were no residual risks above a medium, with 16 out of the 18 risks identified as being considered low. The medium risks identified were consistent with standard civil construction activities completed across the NT, being the potential spread of weeds and the ignition of bushfires from the proposed activities.

At completion of activities and once a determination has been made in relation to decommissioning, a site-specific rehabilitation plan will be developed for each site. Where the site is not able to be handed over to the pastoralists for beneficial use, the site will be rehabilitated back to a safe, stable landform consistent with surrounding land use.

Due to the nature of the activity, community engagement for the 2018 groundwater monitoring bore installation project has been with host Traditional Owners via the northern Land Council (NLC) and host Pastoralists directly affected by the proposed activity. Detailed community and stakeholder engagement is underway covering future exploration activities which are beyond the scope of this EMP.

Origin recognises the growing community interest in ensuring onshore natural gas development takes place in a safe and environmentally sound way. Origin are committed to delivering operational excellence (which encapsulates our health, safety and environmental performance). Further information on stakeholder engagement is provided in section 5.

It should be noted that the water bore monitoring installation network is a recommendation of the NT Inquiry and as such the broader NT community is expecting the work program to be executed swiftly.

1. Introduction

1.1 Background

Origin Energy (Origin), holds three petroleum exploration permits in the Barkly region under the Beetaloo Joint Venture with Falcon Oil and Gas. These permits consist of EP76, EP98 and EP117 which cover 18,512 square kilometres (km^2) of pastoral lease on the Sturt Plain, part of the Barkly Tableland, Northern Territory (Figure 1) and were originally granted by the NT Minister for Mines and Energy under the *Petroleum Act 2014*.

Origin drilled three vertical wells (Kalala S-1, Amungee NW-1, Beetaloo W-1) and one horizontal well (Amungee NW-1H) during 2015 and 2016. A successful hydraulic fracture stimulation and production test was undertaken on the Amungee NW-1H well in 2016, highlighting the potential of the Beetaloo Basin as a future unconventional shale development. Upon completion of the 2016 work program, Kalala S-1 and Beetaloo W-1 were suspended and a pressure monitoring commenced at Amungee NW-1H.

On 16 April 2018, the Northern Territory (NT) Government announced the lifting of the moratorium on hydraulic fracturing of onshore unconventional gas reservoirs within the NT. The lifting of the moratorium was made with the endorsement of the 135 recommendations handed down by the independent Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional Reservoirs in the Northern Territory (referred to herein as the Inquiry). One of the inquiry recommendations was for the collection of baseline groundwater level and quality data before the commencement of any future hydraulic fracturing activities.

A letter dated 31 August 2018, from the Minster of the Department of Primary Industries and Resources to Origin, confirmed that the installation of water bores has been deemed as a "low impact" enabling activity and therefore will be considered under an EMP prior to the implementation of the inquiry recommendations.

This Environmental Management Plan (EMP) forms the basis of Origin's application to the Northern Territory Department of Primary Industry and Resources (DPIR) for the installation of environmental monitoring bores located adjacent to the proposed future exploration sites to collect baseline groundwater level and quality data prior. This EMP progresses the Origin current 5-year work program, which is currently with the department for consideration of a proposed extension and revision.

1.2 Project Proponent

The proponent for the project is Origin as the operator. The key Operator contacts for this plan are provided below:

Name	Title	Contact number
Tracey Boyes	Asset Manger	[redacted]
Matthew Hanson	Project and Operations Manager	[redacted]
Stephanie Stonier	Corporate Affairs Manager	[redacted]
Matt Kernke	Environment Specialist	[redacted]

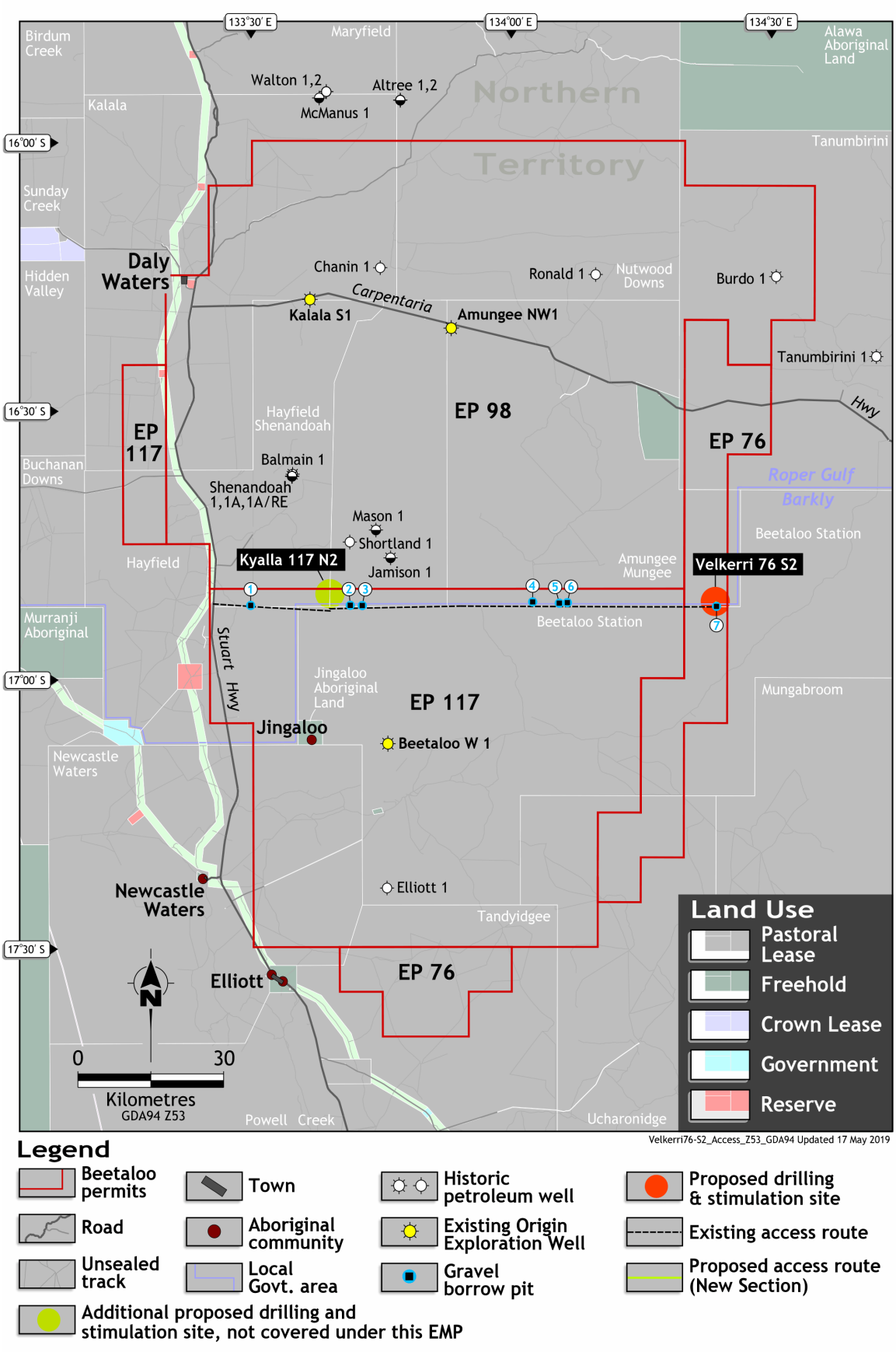

Figure 1 Location of Origin Permit Area and future proposed drilling and stimulation site where groundwater monitoring bores will be installed

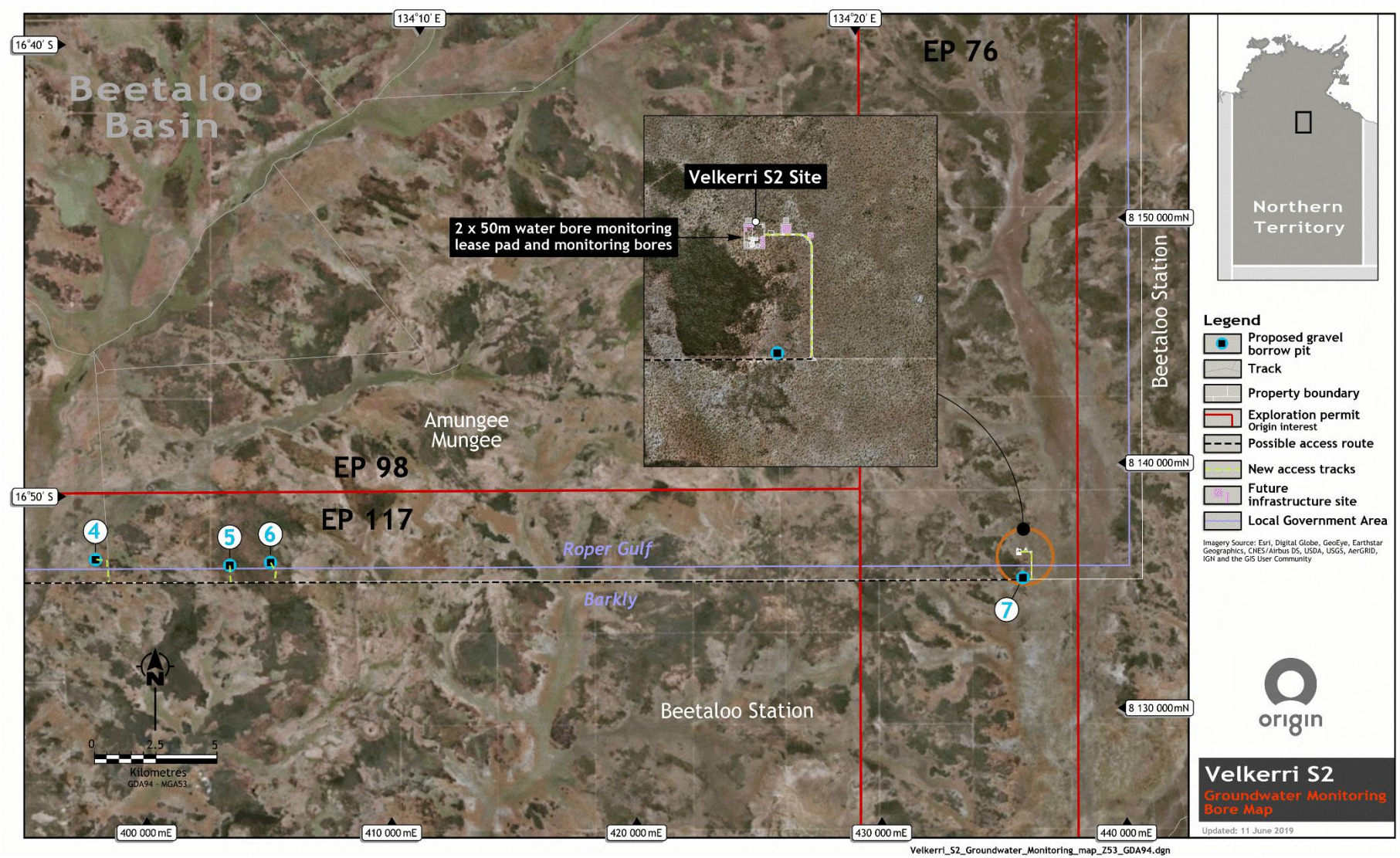

Figure 2 Site location map

1.3 Project Boundary

Origin are proposing to undertake a series of low impact activities required to expand its existing, four-year, baseline groundwater monitoring program in preparation for its' 2019 exploration program. The groundwater monitoring program will involve the installation of monitoring bores sufficient to meet guidelines currently in development at the proposed Velkerri 76 S2 lease sites within the Origin Beetaloo Exploration Area. For the purpose of this EMP, the project boundaries are defined as the area which may be affected by the groundwater monitoring bore installation project. This is includes

- two 50 x 50 m groundwater monitoring bore lease sites located on the future proposed Velekrri76 S2 site, including provision for fire breaks totalling 0.5 hectares in disturbance.
- The installation of approximately 2km of access tracks (approximately 8 m wide) to connect the groundwater monitoring leases to the existing access track.
- Establishment of up to four 100mx100m gravel pits to provide material for improving stability of the access tracks
- Installation of approximately 1.4km of access track (approximately 8m wide) to connect Gravel pit 4, 700m of access track to connect Gravel pit 5 and 900m of access track to the existing access track.
- Grading and forming of 80km of existing tracks which involves the clearing of an average of 1m of vegetation along the length of the track,
- Installation of fencelines, gates, grids and firebreaks to access the groundwater monitoring bore lease sites.
- Groundwater monitoring bore drilling, completing and equipping of up to four groundwater water monitoring bores.

Maps of the proposed location are provided in Figure 1 and Figure 2. Additional information on the locations is also provided in **Table 1** and **Table 2**.

Table 1 Proposed Lease Area for Water Monitoring Bores and Disturbance Areas

Exploration Permit	Infrastructure name	Station	Zone*	Approx Easting	Approx Northing	Disturbance Area (ha)
EP76	Velkerri 76 S2 Control monitoring bore	Amungee Mungee	53	435705	8136212	0.25
EP76	Velkerri 76 S2 Impact monitoring bore	Amungee Mungee	53	435609	8136283	0.25
2 km Access Track						2.4
Upgrade of existing 80km access track						8
					Total Disturbance Area (Ha)	**10.9 ha**

** Universal Transverse Mercator (UTM) geographic coordinate system is Geocentric Datum of Australia (GDA) 94.*

In addition, six proposed gravel pits locations have been identified and summarised in **Table 2**.

Table 2 Proposed Gravel

Exploration Permit	Gravel Pit	Station	Zone*	Approx Easting	Approx Northing	Disturbance Area (ha)
EP117	Gravel Pit 4	Amungee Mungee	53	397906	8136039	1
EP117	Gravel Pit 4 Access track	Amungee Mungee	3	398444	8135134	1.4

Exploration Permit	Gravel Pit	Station	Zone*	Approx Easting	Approx Northing	Disturbance Area (ha)
EP117	Gavel Pit 5	Amungee Mungee	53	403386	8135809	1
EP117	Gravel pit 5 Access track	Amungee Mungee	53	403431	8135150	0.7
EP 117	Gravel Pit 6	Amungee Mungee	53	406249	8135276	1
EP 117	Gravel pit 6 Access tracks	Amungee Mungee	53	405210	8135124	0.9
EP 117	Gravel pit 7	Amungee Mungee	53			1
Total Gravel Pit Disturbance Area (Ha)						**7.0 ha**

1.4 Purpose

Origin is required to provide a site-based Environmental Plan Management (EMP) for its proposed groundwater monitoring bore installation program to the Department of Primary Industry and Resources (DPIR). This EMP has been prepared with reference to the *NT Petroleum (Environment) Regulations 2016* and the Exploration Agreement between Origin, local Aboriginal groups and the Northern Land Council (NLC).

The overall objective of the EMP is to ensure minimal environmental impact and minimise risk of any inadvertent adverse outcomes from Origin's activities.

More specifically, this EMP aims to:

- be a practical and usable document, with environmental management principles that are easily implemented and effective
- address regulatory requirements
- provide a description of site-specific aspects of the existing environment (physical, biological, social and cultural)
- provide site-specific impact management strategies to assist Origin in maintaining a positive position in the local community throughout its program
- provide site-specific plans for review, monitoring and rehabilitation
- align with the principles of Ecological Sustainable Development (ESD) through the adoption of responsible development practices that are designed to maximize social benefit, whilst minimising the level of impact on the surrounding ecosystems.

The 'site' is defined as all the work areas including the groundwater monitoring bore pads and access tracks.

1.5 Structure of EMP

This EMP is structured to meet the requirements of an environmental management plan, as per Schedule 1 of the NT Petroleum (Environment) Regulations 2016. This EMP is divided into the following sections:

- Section 1 – provides background information to Origin's exploration program and the purpose of the EMP for water bore drilling program
- Section 2 – provides a detailed description of the proposed water bore installation activities
- Section 3 – provides a summary of the relevant environmental legislation and other requirements
- Section 4 - describes the existing environment in detail, including the site location, site history and the physical, natural and social environment of the permit area and specifically lease sites
- Section 5 – provides detail on stakeholder consultation
- Section 6 – provides the environmental management procedures for the civil construction activities. This section describes the potential impacts and risks associated with the program of works, how these can be

managed or mitigated, responsibilities for management, monitoring and performance measurement, resources required and the relevant legislation and guidelines for each aspect identified

- Section 7 – provides the implementation strategy
- References – an alphabetical list of all reference material referred to in this EMP
- Appendices – ancillary information in support of the EMP.

2. Project Description

2.1 Location and Proposed Operations

The exploration permits cover 18,512 square kilometres (km^2) of pastoral lease on the Sturt Plain, part of the Barkly Tableland, approximately 500 km south-east of Darwin (refer Figure 1). Origin, as the Operator of exploration permit areas EP76, EP98 and EP117, propose to install up to four groundwater monitoring bores in a cluster on Origin's proposed lease site within the Origin Beetaloo Exploration Area.

The network of groundwater monitoring bores sufficient to satisfy the relevant guidelines (currently in development) will be used to obtain baseline groundwater quality and quantity data adjacent to the proposed future drilling and stimulation lease sites to meet Recommendation 7.11 of the Inquiry and relevant guidelines published by NT DENR on Groundwater Monitoring Bores for Exploration Petroleum Wells in the Beetaloo Sub-Basin. As the guidelines are still in draft, the exact location of the monitoring bores at each of the proposed sites will be undertaken in consultation with the DENR Water Division to ensure any potential changes are incorporated in the program design.

The proposed number and aquifer monitoring zone has been selected based on the information presented in Table 3. These formations have been chosen based on their quality and importance as a local water source and are anticipated to include the following units:

- Perched alluvium aquifer (if present)
- Cretaceous aquifer (if present)
- Anthony Lagoon Beds
- Gum Ridge Limestone.

The screening interval of each groundwater monitoring bore will be determined by a suitably qualified hydrogeologist.

A schematic of the multi-level monitoring bores is provided in Figure 3.

It is noted that this EMP does not seek approval for future exploration activities or potential hydraulic fracture stimulation activities. Should Origin seek to undertake further exploration, the company will prepare a separate submission and obtain approvals before conducting such activities.

Table 3 Aquifer properties and monitoring rationale

Formation		Aquifer Status	Av. EC (uS/cm)	Yield (L/sec)	Thickness (m)	Proposed Monitoring
Shallow / Perched alluvium aquifer		Local aquifer - temporary storage after wet season	100 - 200	<0.1	<20	Yes- If present and containing water of sufficient quality and quantity to be of value for environmental or consumptive use
Undifferentiated Cretaceous		Local aquifer - unsaturated across much of the Beetaloo Basin	1,800	0.3 - 4	0 - 130	Yes- If present and of sufficient storage
Cambrian Limestone Aquifer	Anthony Lagoon Beds	Regional Aquifer	1,600	Up to 10	0 - 200	Yes – likely deepest subunit

Formation		Aquifer Status	Av. EC (uS/cm)	Yield (L/sec)	Thickness (m)	Proposed Monitoring
	Gum Ridge Formation	Regional Aquifer	1,400	Up to 20	0 - 300	Yes – likely deepest subunit
Antrim Plateau Volcanics		Regional Aquitard - *Local aquifer in the north-west of the Beetaloo Basin where it is fractured shallow*	900	0.3 - 5	0 – 440	No- Not used locally – Use North of Daly Water and West of the Stuart Hwy
Bukalara Sandstone		Local Aquifer - used only along the northeast margin of the Beetaloo Basin	1,000	0.3 - 5	0 – 75	No- Not used locally – Use Northern Nutwood Downs
Jamison Sandstone		Local Aquifer - outside the Beetaloo Basin only	138,000	NA	0 – 150	No
Moroak Sandstone		Local Aquifer - outside the Beetaloo Basin only	131,000	0.5 - 5	0 – 500	No
Bessie Creek Sandstone		Local Aquifer - outside the Beetaloo Basin only	NA	0.5 - 5	450	No

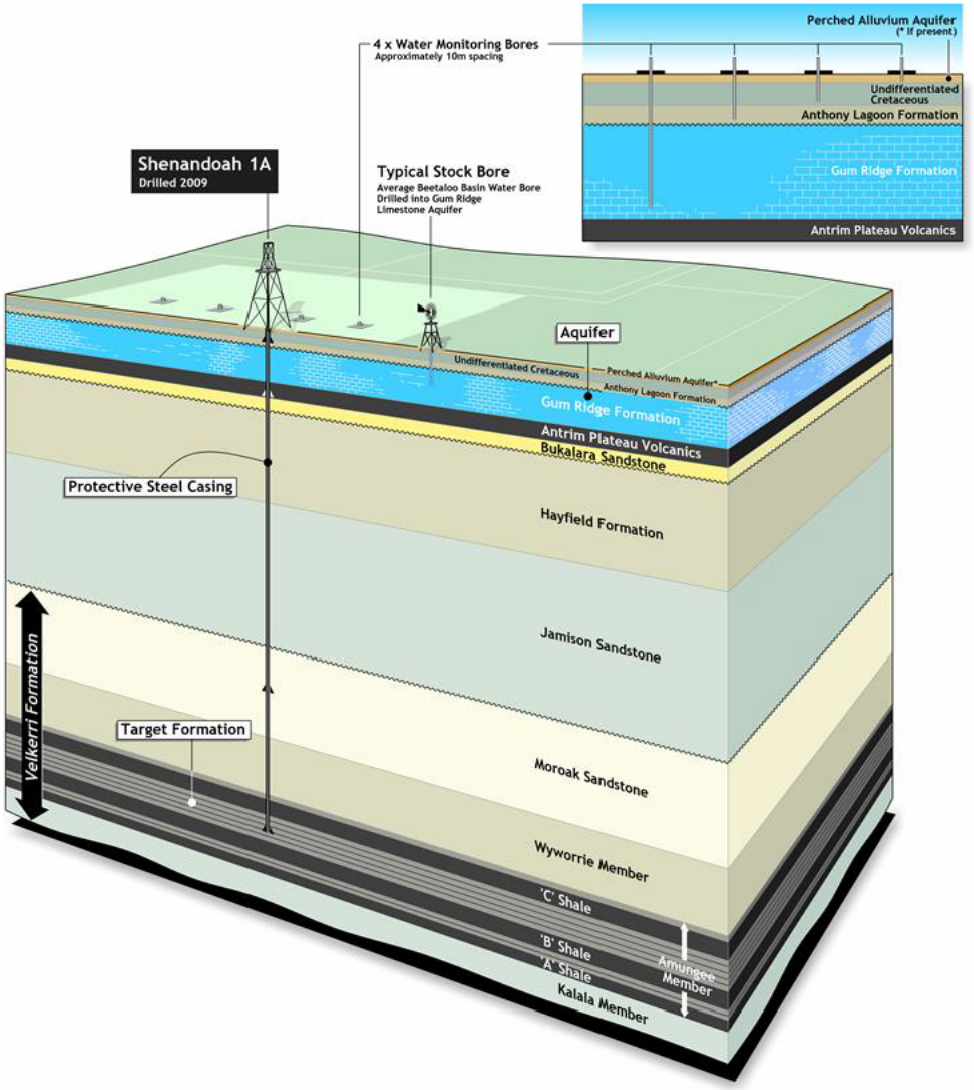

Figure 3 Geological schematic for the proposed multi-level groundwater monitoring bores

2.2 Civil Activities

The civil activities subject to this EMP are:

- two 50 x 50 m groundwater monitoring bore lease sites, including provision for fire breaks totalling 0.5 hectares in disturbance.
- Establishment of up to three100mx100m gravel pits to provide material for improving stability of the access tracks
- The installation of approximately 2km of access tracks (approximately 8 m wide) to connect the groundwater monitoring leases to the existing access track.
- Installation of approximately 1.4km of access track (approximately 8m wide) to connect Gravel pit 4, 700m of access track to connect Gravel pit 5 and 900m of access track to the existing access track.
- Grading and forming of 80km of existing tracks which involves the clearing of an average of 1m of vegetation along the length of the track,
- Installation of fencelines, gates, grids and firebreaks to access the groundwater monitoring bore lease sites.

Land clearance will be minimised to avoid disturbance of soils, vegetation and wildlife habitats and avoid interference or blockage of natural drainage patterns. Erosion control measures such as check banks will be used to minimise the effect of overland flow. The material for erosion control measures would be sourced locally from the proposed gravel pits identified. Long-term visual impact will be minimised by avoiding steep cuts and fills which may cause erosion and slump problems.

The proposed monitoring bore lease pad and associated access road (requiring clearing and construction) are located outside the major flow paths of the small intermediate streams and creeks. Of the existing farm access tracks/ firebreaks, three intermediate tributaries of the Newcastle Creek cross the proposed access track to Velkerri 76 S2-1. Where a crossing on the existing access tracks is required to be upgraded to allow rig access, a bed level crossing will be installed in accordance with the following:

- crossings will be aligned perpendicular to the water flow.
- crossing is to be constructed from clean rocks (minimal fine material) that are an equivalent or larger size than the natural bed material at the site.
- The surface is to be left rough and not to be over compacted (e.g. track-rolled finish or rougher).
- The lowest point of the bed level crossing must be installed at the level of the lowest point of the natural stream bed (preconstruction), within the footprint of the proposed crossing.
- There must be a height difference of at least 100 mm from the lowest point of the crossing to the edges of the low flow section of the crossing
- Where scour protection is required:
    - Scour protection must abut the surface edge of the crossing at the same level.
    - If the crossing is set below bed level then the surface of the scour protection must also be below bed level.
    - The stream bed must abut the scour protection at the same level.
    - The scour protection is installed at a gradient no steeper than 1 in 20 or the natural channel gradient, whichever is steeper.
    - Scour protection must incorporate a low flow channel. Clean rock to be used (with minimal fine material), at least 100 mm diameter.
    - Ensure the rock armouring is not over compacted but left proud and uneven (track-rolled finish or rougher).
    - Use clean rocks (minimal fine material), at least 100 mm diameter.
    - Ensure the rock armouring is not over compacted but left proud and uneven (track-rolled finish or rougher).
    - Use clean rocks (minimal fine material), at least 100 mm diameter. Ensure the rock armouring is not over compacted but left proud and uneven (track-rolled finish or rougher).

The groundwater monitoring bore lease pads will be constructed to accommodate the cluster of groundwater monitoring bores at each of the two lease locations. These lease pads will be 50mx50m and located to avoid major civil work requirements. These sites will require vegetation clearing to provide space for the water bore drilling rig and associated equipment.

The access track will be designed to minimise their environmental footprint. The existing access tracks connecting the proposed lease site to the Stuart highway is in good condition and will require minimal maintenance to allow the rig to access. A 1km access track connecting the existing access tracks to the proposed lease sites will be required. An example of the existing access tracks to be utilised during the program are provided in Figure 4.

The access tracks will be typically less than 8 m wide; with provisions for a six (6) metre formed surface and eight (8) metre shoulder as per the NTG Standard Drawings (CS3003) for Typical Cross Section for Rural Environment – Pastoral Access Road 2 (refer Appendix A). A 14m disturbance area is only likely to be utilised in areas identified as requiring specific controls to manage overland flow. Where vegetation clearing is required, mature trees and trees with hollows will be avoided where possible.

Where gravel is required to allow safe access, existing gravel borrow pits will be used where possible or, alternatively, borrow pits may need to be created. This is included in the scope of discussions with landholders and NLC.

Figure 4 Photographs of the existing ~100km of access track connecting the Sturt Highway with Velkerri 76 S2

2.3 Groundwater Monitoring Bore Drilling Activities

An indicative schematic of the water bore rig layout and final lease configuration is provided in Figure 5 and Figure 6.

All bores will be drilled and constructed by a licensed water bore driller and in accordance with the current version of the *Minimum Construction Requirements for Water bores in Australia.*

Location of the lease areas has considered the minimum offset distance of at least 1 km between site activities and pastoral water supply bores. Each aquifer intersected will be isolated from overlying aquifers with a cemented casing string. Drilling will be undertaken with air or mud rotary techniques. If mud rotary techniques are employed, the circulation fluid will be water based and will utilise standard water bore drilling polymer or bentonite-based density and viscosity modifying additives.

A qualified hydrogeologist will supervise drilling activities and will determine the appropriate screening depth of each the monitoring bores.

A survey of each monitoring bore would be established at each well pad monitoring bore in Australian Height Datum (AHD), accurate to ±10 cm, to accurately determine depth to water table during each sampling event.

Within 28 days of bore completion, it is the driller's responsibility to provide a statement of bore (Form 21), with registered number, to the Water Resource branch of the Department of Environment and Natural Resources (DENR).

All cuttings and drilling mud will be disposed of on site in accordance with the *Minimum Construction Requirements for Waters bores in Australia* for water bore drilling practices.

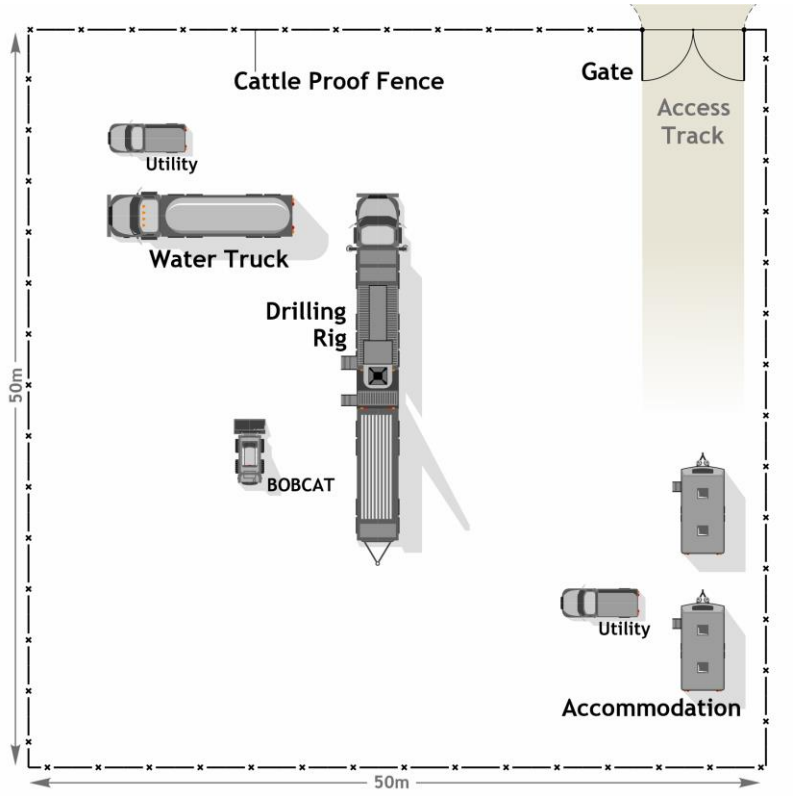

Figure 5 Proposed Water Bore Lease Area Layout (figures not to scale)

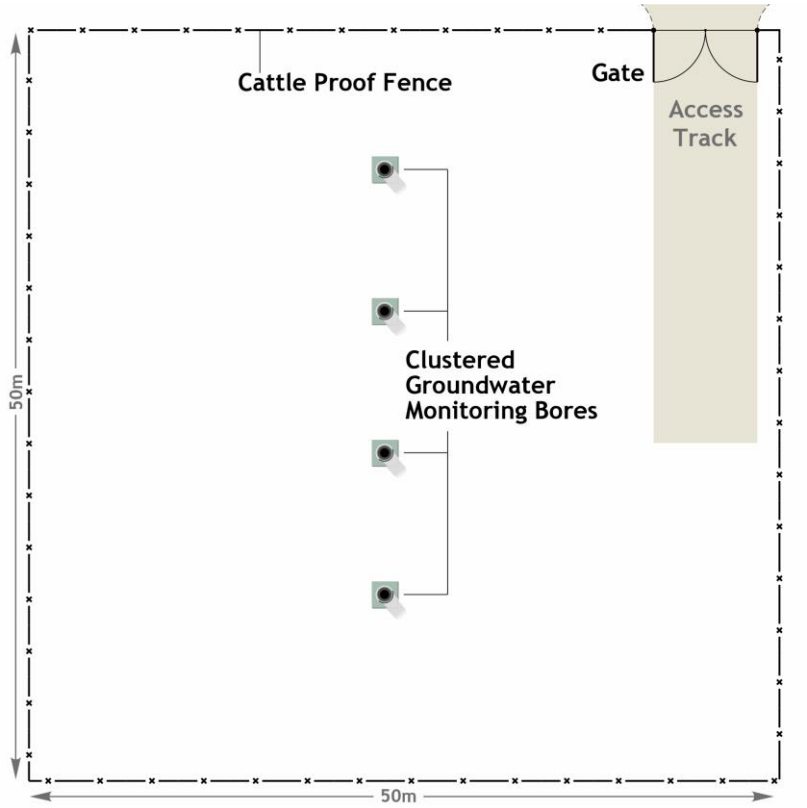

Figure 6 Indicative multi-level monitoring bore lease layout for each lease post drilling

2.4 Groundwater Monitoring Bore Sampling Activities

Following the installation of the groundwater monitoring bore sampling will be undertaken in consideration of standard industry practice including:

- the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (ANZECC Guidelines).
- AS/NZ5667.1: 1998. *Water Quality Sampling Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples*
- AS/NZ5667.11: 1998. *Water Quality Sampling Part 11: Guidance on Sampling of Groundwaters*.

Prior to the collection of water quality samples the following methods would be implemented:

1. The standing water level (SWL) will be measured and the bore volume calculated as described in the relevant standards.
2. Three bore volumes of water shall be removed from the bore to ensure a representative sample.
3. Measurements of groundwater pH, reduction potential (redox), temperature and electrical conductivity (EC) will be conducted during purging using a calibrated multi-parameter probe to assess whether physiochemical conditions have stabilised prior to sample collection.

The water samples will be collected in appropriate laboratory supplied sampling containers and placed in chilled eskies and transported under standard chain of custody (COC) procedures to a laboratory National Association of Testing Authorities (NATA) accredited for the analysis requested to ensure sample integrity is maintained.

Each sample collected would have a unique identification number that would be cross referenced to the monitoring location and time of sampling.

Groundwater samples will be dispatched to the laboratory for analysis of the parameters provided in Table 4. These parameters have been selected based on the draft Preliminary Guideline: Groundwater Monitoring Bores for Petroleum Wells in the Beetaloo Basin.

Groundwater monitoring will be undertaken at a frequency dictated within the NTG "Guideline: Groundwater Monitoring Bores for Petroleum Wells in the Beetaloo Basin" as revised from time to time. Monitoring may be undertaken at a frequency of up to monthly; contingent on weather and access.

Table 4 Groundwater Parameters for Laboratory Analysis

Parameter	Analyte
General Parameters	Electrical Conductivity, pH, Total Dissolved Solids, Total Suspended Solids, Alkalinity
Dissolved metals (filtered)	Arsenic, barium, boron, cadmium, chromium, copper, lead, lithium, iron, manganese, mercury, silver, selenium, silica, strontium, and zinc.
Major Ions	Sodium, calcium, magnesium, potassium, sulphate and alkalinity
Anions	Chloride, fluoride, sulphate, nitrate and nitrite
Petroleum	Total Petroleum Hydrocarbons, Benzene, toluene, ethylbene, xylene (BTEX), TRH*, polyaromatic hydrocarbons (PAHs), dissolved methane, ethane and propane.
Radioactive	Gross Alpha, Gross Beta

During the initial implementation of the sampling program, a review of the suite of analytes will be required once a stable baseline has been established for the monitoring bores.

The procedures to be implemented for the monitoring program would be undertaken to ensure that there is no cross-contamination between monitoring bores during gauging and sampling. A documented Quality Assurance/ Quality Control (QA/QC) plan will be prepared and implemented in accordance with the relevant standards.

Recommendation 7.11 of the Inquiry requires that during fracture stimulation operations, electrical conductivity (E.C.) in the monitoring bores should be measured in real-time as an indicator providing 'early warning' of contamination, with the results telemetered from the site to the regulator and made available to the public. Discussions are underway with the relevant departments to resolve how best to implement these recommendations. Results of all monitoring would be made available to DENR and DPIR on a minimum quarterly frequency as part of the projects reporting commitments.

2.5 Camps

All civil contractors performing work will be housed in local hotel accommodation avoiding the need for camps.

Temporary caravans/mobile dongas will be used to house water bore drillers on each lease for the duration of water bore drilling activities. This infrastructure is temporary and will be powered by diesel generators.

Wastewater, sewage and sullage generated by the domestic camp activities will be managed in accordance with the Department of Health (DoH) "Health requirements for mining and construction camps".

It is anticipated that all sewage will be removed from site. If a sewage treatment system is to be used, approval will be sought from DoH and onsite irrigation will be undertaken in accordance with the Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent.

2.6 Waste Management

Waste management methods for the proposed water bore installation and access track development are summarised in Table 5. For the size of the proposed program, all waste produced will be backloaded with the crew for appropriate disposal and or recycling. Waste transfer certificated will be retained and provided to DPIR upon completion of the project.

Table 5 Waste and disposal methods

Domestic Waste	**Disposal Method**
Sewage and grey water	Treated in portable treatment systems prior to discharge to an evaporation sump approximately 50 m beyond the camp or removed from site. Grey water disposed of on-site in accordance with Department of Health requirements Sludge removed from site and disposed of at an appropriately licenced facility
Food waste, paper and plastic	Collected in dedicated waste bins for back-loading to an approved landfill
Glass and cans	Collected in separate waste bins for recycling
Industrial Waste	**Disposal Method**
Chemical bags and cardboard packaging materials	Compacted and collected at rig site for disposal to approved landfill
Scrap metals	Collected in designated skip for recycling or to approved landfill
Used chemical and fuel drums	Collected in designated skip for recycling
Chemical wastes	Collected in approved containers for disposal at approved landfill or returned to supplier
Timber pallets (skids)	Recycled or to approved landfill
Vehicle tyres	Shredded and disposed to approved landfill
Drilling Activity Waste	**Management / Disposal Method**
Oily rags, filters	Collected in suitable containers for disposal at approved landfill
Drilling cuttings (cuttings mixed with drilling fluids)	All cuttings and drilling mud will be disposed of on site in accordance with the *Minimum Construction Requirements for Waters bores in Australia* for water bore drilling practices.
Associated water (groundwater mixed with drilling fluids)	All cuttings and drilling mud will be disposed of on site in accordance with the *Minimum Construction Requirements for Waters bores in Australia* for water bore drilling practices.

2.7 Water Supply and Use

It is estimated that approximately 0.5ML of water will be required for lease pad construction and water bore drilling related activities. An additional 15ML of water will be required for access track construction. Water will be sourced from the Kyalla 117 N2 water supply bore (not on this property), under an approved water extraction licence (in Accordance with the NT Water Act).

As per the preliminary DENR Groundwater Monitoring Guidelines, the proposed monitoring bores will be converted to a water supply bore for future drilling and stimulation activities. Approval prior to the commencement of Drilling and stimulation from the DENR Water Resources Department will be obtained.

Potable water will be sourced from Darwin and transported to the site.

Surface water will not be used for any activities proposed in this EMP.

All groundwater take will be recorded using an approved flow meter and records reported to DENR in accordance with the reporting requirements of the water extraction licence.

2.8 Weed Management

To ensure the risk associated with the introduction and spread of declared weeds is mitigated, Origin will comply with the regulatory and leaseholder biosecurity requirements for all activities associated with this project. This will ensure all potential risks to the Northern Territory (NT) economy, community, industry and environment from the introduction of weeds are mitigated.

The controls Origin will implement to prevent the introduction and spread of weeds are summarised in the attached Weed Management Plan (Appendix B). These include:

- Activities will adhere to the guidelines within the NT Weed Management Handbook (2018).
- Weed desktop and field-based surveys to be undertaken to identify existing weed areas.
- Weed management and control measures to be implemented in alignment with existing leaseholder biosecurity procedures.
- All equipment will have certified equipment wash-down completed prior to entry to the exploration permit.
- Activities will be planned to address prevention of weed or non-indigenous plant spread.
- Machinery to be preferentially sourced locally, with machinery sourced from surrounding areas or Queensland being the 2nd and 3rd preferred option respectively.
- Pre and post wet (February to May) inspections and periodic audits will be conducted to identify and report weed outbreaks.
- Weeds will be actively controlled in cleared/ hardstand areas.
- Major equipment moves will be planned from weed-free areas to infested areas and not the other way around.
- Staff members responsible for preventing, identifying and managing weeds to be appropriately trained.
- Contractors have procedures covering weed prevention and management.
- Ensuring all material imported to or between sites is free of weeds.

Further information on Weed risk management is outlined in Section 6.4.4 and in the Weed Management Plan provided in **Appendix B**.

2.9 Proposed contractors and equipment list

Preliminary estimates of the civil construction and water bore drilling crew and equipment are described in Table 6 below.

Table 6 Water bore drilling crew and equipment (estimate)

Task	Proposed Contractor	Crew List	Equipment and Machinery
Civil Construction	Arnhem Earthmoving and Mechanical Pty Ltd (AEM) ABN 49 134 418 670 10 Spencely Road Humpty Doo NT 0836	1 x Origin Supervisors (HSE + Construction) 1 x Project Manager/Project Engineer (Contractor) 6 x plant operators 2 x truck drivers 2 x water bore contractors 2 x fencing contractors 1 x Surveyor	- Excavator x 1 - Dozer x 1 - Grader x 2 - Water Cart x 2 - Haulage trucks (Water and/or gravel) - Bob cat (Fencing contractor) - 3 x Light 4wd vehicles
Water Bore Drilling	ALLWELL (NT) Pty Ltd ABN 69 605 851 358 PO Box 1821 Howard Springs NT 0835	1 x Origin Supervisors 1 x Rig Supervisors 2 x Drillers 1 x Assistant Drillers 1x water truck operator	- Truck mounted drill rig (Water bore) - Caravans/ dongas for accommodation x2 - Water Cart x1 - Cement truck x2
Groundwater monitoring	Origin Energy or other contractors	2x Samplers	- 1x light vehicle - 1x groundwater pump - 1x dip meter - 1x calibrated water quality meter (EC, pH, DO, REDOX) - Sampling equipment (Sample bottles, esky, field filters, decon etc.)

2.10 Timeframes

The key activity dates for the water bore drilling program are detailed as follows:

Activity	Estimate Start Date
Civil Works	July 2019
Groundwater Monitoring Bore Installation	July- September 2019

Subject to obtaining necessary approvals and consents, Origin is anticipating commencing the civil work and groundwater monitoring bore drilling activities in April 2019. Some or all of this work may be transferred to later in 2020 if required.

On-ground conditions, initial drilling results, wet weather, equipment and operator availability and delays in obtaining required approvals and consents may delay the commencement date and / or extend the duration of the planned works.

3. Environmental Legislation and other Requirements

3.1 Regulatory Framework

In the NT, the granting of exploration permits and approval to commence petroleum exploration activities rests with the Department of Primary Industry and Resources (DPIR), through its administration of the *Petroleum Act 2016* on behalf of the NT Minister for Primary Industry and Resources.

Alongside the DPIR approval process, the Northern Territory Environment Protection Authority (NT EPA) administers the *Environmental Assessment Act 2013*; which allows for all proposals to be assessed as to the level of significance of potential impacts.

The application to drill water monitoring bores and the required civil works on access tracks and leases will be submitted to DPIR, and they may engage the relevant authorities for advice, including the NT EPA.

It is not expected the proposed works will require referral to the NT EPA or the Commonwealth Department of the Environment (DOTEE), under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as amended 2013 due to the low impact activities proposed by the water bore drilling program.

A range of Territory and Commonwealth legislation, agreements, operating consents, guideline's and codes of practice are relevant to the activities described in this EMP. These are summarised in Table 7 , Table 8 and Table 9.

Table 7 Key Legislation

NT Legislation	Administered By:
Petroleum Act 1984, Petroleum (Environment) Regulations 2016 - Provides a framework for petroleum exploration and development to occur within the Territory. - Requires that petroleum activities are carried out in an ecologically sustainable manner and the environmental impacts and environmental risks of the activities are identified and reduced to an acceptable level. - Sets out the requirements for environmental management plans, which includes the Code of Practice for Onshore Petroleum Activities in the Northern Territory. - Considered when developing this EMP.	Department of Primary Industry and Resources and Department of Environment and Natural Resources Petroleum (Environment) Regulations
Aboriginal Land Act 2013 - Provides for access to Aboriginal land, certain roads bordered by Aboriginal land and the seas adjacent to Aboriginal land. - Provides that a person shall not enter onto or remain on Aboriginal land or use a road unless he has been issued with a permit to do so in accordance with *Part II Entry onto Aboriginal land* of the Act. - Land Council for the area in which Aboriginal land or a road is situated may issue a permit to a person to enter onto and remain on that Aboriginal land or use that road subject to such conditions as the Land Council thinks fit.	Land Council established by or under the Aboriginal Land Rights (Northern Territory) Act 1976 of the Commonwealth.
Bushfires Management Act 2016 and associated Regulations - Provides for the protection of life, property and the environment through the mitigation, management and suppression of bushfires, and for related purposes.	Bushfires NT, Department of

- The Regulations outline infringement notices and prescribed amounts for certain acts relating to lighting fires.	Environment and Natural Resources
Control of Roads Act 2018 - Provides for the administration and control of roads, including the maintenance of roads, construction and opening and closing of roads. - The use of Road Bores will require a permit to work within a road reserve from the Department of Transport.	Department of Infrastructure, Planning and Logistics
Dangerous Goods Act 2012 and Regulations - Provides for the safe storage, handling and transport of certain dangerous goods.	NT Worksafe, Department of the Attorney-General and Justice
***Environmental Assessment Act 2013* and associated Regulations** - Provides for the assessment of the environmental effects of development proposals and for the protection of the environment. - Ensures to the greatest extent practicable that each matter which could reasonably have a significant effect on the environment is fully examined and considered. - Defines environment as being "all aspects of the surroundings of man including the physical, biological, economic, cultural and social aspects".	Northern Territory Environmental Protection Authority, Department of Environment and Natural Resources
***Heritage Act 2016* and associated Regulations** - Protects the Territory's cultural and natural heritage. - Establishes the Heritage Council (consisting of eleven members). - Establishes the NT Heritage Register. - Sets the process by which places become heritage places. - Allows for interim protection of places. - Sets out the process for getting permission to do work to heritage places. - Allows for fines and imprisonment for offences against the Act. - Declares classes of places and objects of heritage significance to be protected. - Provides for heritage agreements to encourage the conservation, use and management of heritage places and objects. - Regulates work on heritage places and objects. - Establishes enforcement and offence provisions.	Heritage Branch, Department of Tourism and Culture
***Northern Territory Aboriginal Sacred Sites Act 2013* and associated Regulations** - Provides a practical balance between the recognized need to preserve and enhance Aboriginal cultural tradition in relation to certain land in the Territory, and the aspirations of the Aboriginal and all other peoples of the Territory for economic, cultural and social advancement. - Establishes a procedure for the protection and registration of sacred sites, through: • providing entry onto sacred sites and the conditions to which such entry is subject • procedures for avoidance of sacred sites when developing and using land • establishing an Authority for the purposes of the Act • procedures for the review of decisions of the Authority by the Minister, and for related purposes.	Aboriginal Areas Protection Authority (AAPA); Minister for Environment and Natural Resources
Public and Environmental Health Act 2016 and Associated Regulations - To monitor, assess and control environmental conditions, factors and agents, facilities and equipment and activities, services and products that impact on or may impact on public and environmental health. - Outlines requirements for camps, specifically waste and wastewater (sewage and greywater)management	Department of Health
Territory Parks and Wildlife Conservation Act 2014 (TPWC Act) and associated Regulations - provides for the protection, conservation and sustainable utilisation of wildlife. - Provides protection of CEEVNT listed species.	Flora and Fauna Division of the Department of Environment and Natural Resources
Waste Management and Pollution Control Act 2016 and associated Regulations	Northern Territory Environmental Protection

- Provides for the protection of the environment through encouragement of effective waste management and pollution prevention and control practices and for related purposes. - To protect, and where practicable to restore and enhance the quality of the NT environment - To encourage ecologically sustainable development - To facilitate the implementation of National Environment Protection Measures established by the National Environment Protection Council (Northern Territory) Act. - Section 12 of the Act places obligation on a person to ensure they take all practicable measures to prevent or minimise pollution when undertaking an activity that could cause pollution and environmental harm.	Authority, Department of Environment and Natural Resources
Water Act 2016 - Provides for the investigation, allocation, use, control, protection, management and administration of water resources, including extraction of groundwater, waste water management and water pollution. - Provides for water allocation plans, beneficial uses within Water Control Districts, drilling licences, bore construction permits, water extraction licences, waste discharge licences, fees and charges, and penalties for offences against the Act. - Provides for water allocation plans, beneficial uses within Water Control Districts, drilling licences, bore construction permits, water extraction licences, waste discharge licences, fees and charges, and penalties for offences against the Act. - The use of groundwater for stimulation activities (including supporting works) within the Beetaloo Basin is required to comply with the Water Act. - Act prohibits wastewater reinjection and surface water extraction for stimulation activities.	Water Resources Division, Department of Environment and Natural Resources
Weeds Management Act 2013 - Protects the Territory's economy, community, industry and environment from the adverse impact of weeds. - Identifies declared weeds (those which must be controlled) and provides a framework for weed management.	Weed Management Branch, Department of Environment and Natural Resources
Work Health and Safety (National Uniform Legislation) Act 2014 - Provides for a balanced and nationally consistent framework to secure the health and safety of workers and workplaces.	NT WorkSafe
Commonwealth Legislation	**Administered By:**
Aboriginal and Torres Strait Islander Heritage Protection Act 1984 - Provides for the preservation and protection of places, areas and objects from injury or desecration of particular significance to Aboriginal people in accordance with Aboriginal tradition.	Department of the Environment and Energy
Aboriginal Land Rights (Northern Territory) Act 1976 - Provides for the granting of Traditional Aboriginal Land in the Northern Territory for the benefit of Aboriginals, and for other purposes.	Department of Prime Minister and Cabinet
Australian Heritage Council Act 2003 - Establishes the Australian Heritage Council which is the principal adviser to the Australian Government on heritage matters. - The Council's major role is to assess the heritage values of places nominated for the National Heritage List and the Commonwealth Heritage List, and to advise the Minister on promotion, research, education, policies, grants, conservation and other matters. - The Council also makes assessments under the EPBC *Act*, and performs any other functions conferred on the Council by the *EPBC Act.*	Department of the Environment and Energy
Environment Protection and Biodiversity Conservation Act 1999 - Provides for the protection of the environment and conservation of biodiversity, particularly species and places of national significance. - Invoked only if a development is likely to have environmental impacts of national significance.	Department of the Environment and Energy

National Greenhouse and Energy Reporting Act 2007 - An Act to provide for the reporting and dissemination of information related to greenhouse gas emissions, greenhouse gas projects, energy consumption and energy productions of corporations.	Department of the Environment and Energy
Native Title Act 1993 - Provides for the recognition and protection of native title for Indigenous peoples. - Establishes ways in which future dealings affecting native title may proceed and to set standards for those dealings. - Establishes a mechanism for determining claims to native title. - Provides for the validation of past acts, and intermediate period acts, that have been invalidated because of the existence of native title.	Prime Minister and Cabinet

Table 8 Codes of Practice and Relevant Guidelines

Codes of Practice
Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent (NT Department of Health, 2014) - Provides guidance of the management of effluent. - It is noted that Territory Health Services will issue any amendments to the above Code on an annual basis.
Code of Practice for Onshore Petroleum Activities in the Northern Territory Mandatory Code of Practice for the Petroleum industry to ensure that petroleum activities in the Northern Territory are managed according to minimum acceptable standards to ensure that risks to the environment can be managed to a level that is as low as reasonably practical (ALARP) and acceptable.
Guidelines
AS 1940: The storage and handling of flammable and combustible liquids, 2004 - Provides guidance for the operation and handling of flammable and combustible liquids.
Best Practice Erosion and Sediment Control (International Erosion Control Association, 2008) - Facilitates the identification of those issues that should be considered when formulating and evaluating strategies for best practice erosion and sediment control. - Facilitates best practice stormwater management. - Facilitates active avoidance or minimisation of soil erosion resulting construction activities. - Facilitate best practice soil and sediment control management on sites.
Bores, drilling and dams - Provides information on water drilling licences, bore construction permits, licensed drillers and other information regarding drilling water bores in the NT. - https://nt.gov.au/environment/waterhttps://nt.gov.au/environment/water/bores-drilling-and-dams/about-water-drilling-licences
Guideline for the Preparation of an Environmental Management Plan (NT EPA, 2015) - Details the environmental protection measures to be included in Environmental Management Plans.
Northern Territory Natural Resource Management Plan 2016-2020 (Territory Natural Resource Management, 2016) - Describes the management direction for the NT's natural resources for the five year period and beyond. - Four regional plans provide an overview of the current land condition, use and threats, key areas to monitor and improve approaches, and the level of coordination that occurs across key organisations responsible for implementing actions.
ISO 19011: Guidelines for auditing management systems, 2018 - Provides guidance on environmental auditing to a certifiable standard.

Leading Practice Sustainable Development Program for the Mining Industry (Australian Government, 2016) - The LPSDP provides guidance to the mining industry through a series of handbooks including: - Airborne Contaminants, Noise and Vibration - Biodiversity Management - Community Engagement and Development - Hazardous Materials Management - Risk Management - Water Stewardship - Working with Indigenous Communities.
Minimum Construction Requirements for Water Bores in Australia (National Water Commission, 2012) - Developed by the National Uniform Drillers Licensing Committee, this document outlines the minimum requirements for constructing, maintaining, rehabilitating, and decommissioning water bores in Australia.
Northern Territory Land Clearing Guidelines (NRETAS, 2010) - Although clearing for roads or tracks is a significant cause of erosion on pastoral leases, there is no requirement to obtain formal approval from the Pastoral Land Board. Instead, clearing must be carried out in accordance with Land Clearing Guidelines.
Northern Territory Noise Management Framework Guideline (NT EPA, 2018) - Provides guidance to the community and industry about the noise regulatory framework as it applies in the NT.
Weed Management Planning Guide - Onshore Shale Gas Development Projects (DENR, 2018) - Provides guidance to the industry about the weed management planning required to undertake Onshore Shale Gas Developments in the NT.

Table 9 Relevant agreements and operating consents

Agreements	Administered By:
Native Title Petroleum Exploration Agreement (between NLC and Origin [Falcon Energy]) - Includes clauses for the protection of Sacred Sites, objects and sensitive areas related to Aboriginal activities in the area, including cultural, hunting and foraging activities. Site clearance will occur prior to any on ground activities. The Native Title Agreement also includes clauses for the protection of the environment and rehabilitation.	Northern Land Council
Exploration Permits - Details the environmental protection measures to be included in Exploration EPs. - Permit EP76, 98 and 117 applies to this scope of work.	Department of Primary Industry and Resources
AAPA Certificates The most current clearance certificates issued for the Origin exploration program include: - AAPA C2019/039 provides approval of Origin's 2018/19 Monitoring bore drilling program	Aboriginal Areas Protection Authority
Apply for permit to work within a road reserve - Road bores are usually used for road construction and maintenance work, however application to access water in the bores can be made to the Department of Transport for approval. - Approval to access the bore will be dependent if the bore has sufficient capacity to meet future needs for road construction and maintenance.	Department of Infrastructure, Planning and Logistics (DIPL)

3.2 Referral Assessment

Approval for the proposed action has considered the need for referral under the NT Environmental Assessment Act and the Commonwealth Environmental Protection and Biodiversity Conservation Act. Impacts associated with the proposed activity will be largely centred on vegetation clearing, bushfires, introduction of weeds and erosion and sediment control.

3.2.1 NT Environmental Assessment Act

In the NT, proposed actions that have the potential to have a significant effect on the environment require environmental impact assessment (EIA) under the Environmental Assessment Act. In such cases, a Notice of Intent (NOI) is required to be submitted to the NT Environmental Protection Agency outlining the relevant information to allow a decision on whether the proposed action requires a Public Environmental Report (PER) or an Environmental Impact Statement (EIS). Where the environmental impacts of the proposed activity are not significant, a PER or EIS will not be required.

An assessment of whether the proposed activity requires a NOI was undertaken in accordance with the NT *Referring a Proposal to the NT EPA* guideline. This is summarised in Table 10.

Three project specific factors were applicable to the proposed activity covered under this EMP. These included:

- Potential risks to terrestrial flora and fauna associated with vegetation clearing activities, bushfire and introduction of weeds;
- Potential risks to Terrestrial Environmental Quality associated with access track construction and erosion and sediment control; and
- Potential risk to inland waters associated with monitoring bore drilling and sediment releases

Due to the low impact nature associated with the proposed groundwater monitoring bore work program, no significant impacts on any of the NT Environmental factors and objectives are anticipated. Origin does not believe referral to the NT EPA is required.

3.2.2 Commonwealth Environmental Protection and Biodiversity Conservation Act

Under the Commonwealth Environmental Protection and Biodiversity Conservation Act (EPBC) an action that has, will have or is likely to have a significant impact on Matters of National Environmental Significance (MNES) must be referred to the Australian Government Minister for the Environment (the Minister) for assessment.
A self-assessment in accordance with the EPBC Act was undertaken under this EMP. The environment and heritage assessment confirmed significant impacts to EPBC listed threatened species or threatened ecological communities were unlikely. The proposed program will not require referral under the EPBC Act.

Table 10 Assessment against environmental factors and objectives

Environmental Factors	Project Specific Environmental Factors	Environmental Objectives at Risk	Receiving Environment	Potential Impacts	Mitigation Measures	Potential significant effect on an environmental factor?	Assumptions
Land	Terrestrial Flora and Fauna	Protect NT's flora and fauna so that biological diversity and ecological integrity are maintained.	Refer Section 4.2	Vegetation clearing resulting in: •Disturbance to environmentally sensitive areas and/or flora and fauna species • Loss or endangerment of Threatened species • Loss of habitat • Introduction or spread of weeds.	Section 6.4.3 and 6.4.4	No- Assessment summarised in section 6.4 indicates activity unlikely to result in significant impacts on threatened flora and fauna or areas essential habitat.	Assessment based upon field surveys. Threatened fauna may be present in the area which were not identified during the surveys
Land	Terrestrial Environmental Quality	Maintain the quality of land and soils so the environmental values are protected	Refer Section 4.2	Land disturbance through access track construction resulting in soil erosion and sediment releases	Section 6.4.1	No- Assessment summarised in 6.4.1 indicates activity unlikely to result in significant impacts from increased erosion and sediment releases	Assumes international accepted erosion and sediment controls are sufficient to manage risk of erosion within the NT
Water	Inland Water Environmental Quality	Maintain the quality of groundwater and surface water so that environment values including ecological health, land uses, and the welfare and amenity of people area protected.	Refer Section 4.1	Contamination of groundwater and surface waters resulting from water bore drilling and sediment releases	Section 6.4.2	No- Assessment summarised in section 6.4.2 indicates activity unlikely to result in significant impacts to surface and ground water	Assumes groundwater bore standard sufficient manage groundwater risk

3.3 Alignment with the Principles of Ecological Sustainable Development (ESD)

This EMP aims to align with the principles of ESD through the adoption of responsible practices that are designed to maximise social benefit, whilst minimising the level of impact on the surrounding ecosystems. Ecological Sustainable Development (ESD) is defined by the NT EPA as:

"Using, conserving and enhancing the communities' resources so that ecological processes, on which life depends, are maintained, and the total quality of life now and in the future is increased. ESD is development that aims to meet the needs of Australians today, while conserving our ecosystems for the benefit of future generations."

The proposed water bore drilling program aim is to obtain baseline groundwater quality and quantity data within the proposed future drilling and stimulation lease sites to meet Recommendation 7.11 of the *Scientific Inquiry into Hydraulic Fracturing in the Northern Territory*. This is a key component of demonstrating all future petroleum exploration and development activities will not adversely impact on current and future groundwater users.

4. Environment Description

4.1 Physical Environment

4.1.1 Climate

The climate of the permit areas is arid to semi-arid, with rainfall decreasing in frequency and quantity from north to south. The climate is monsoon influenced, with a distinctive wet and dry season experienced through the year.

The average annual rainfall in the north of the permit area is listed at 680 mm at Daly Waters. The southern portion of the permit area records an average annual rainfall of 535 mm at Newcastle Waters and 608 mm listed at Elliott. Approximately 90% of the rainfall occurs during the Wet Season.

4.1.2 Geology

The geology within and surrounding the permit areas (Plate 1) was primarily formed over three main periods – the Precambrian (> 550 million years ago), the Cambrian (500 million years ago) and the Cretaceous (100 million years ago) (refer Plate 1).

Pre-Cambrian rock formations, known as the Roper Group, are located at depth across the permit areas, beneath the younger formations, and are exposed only in the bedrock hills located to the north east of EP98 (Tickell, 2003).

Cambrian formations are expressed only in the south west region of the study area. They predominantly fall outside of the identified permit areas, and comprise of limestone, siltstone and sandstone. The rock formation is near flat, rarely cut by faults and forms distinct layers. The Cambrian sediments contain the sub-artesian water storage, pedocalcic soils, Cambrian dolomite, limestone, and tertiary alluvium (Tickell, 2003).

The majority of the permit area is located within the McArthur Basin, which was formed during the Mesoproterozoic period, over 1,000 million years ago. Soft clays and sandstone are the primary rock formation in the basin and overly the older Pre-Cambrian and Cambrian rocks. Small and patchy occurrences of freshwater limestone accumulations, formed during the Miocene Period (15 million years ago) when erosion and the gradual sinking of some areas produce isolated fresh-water lakes.

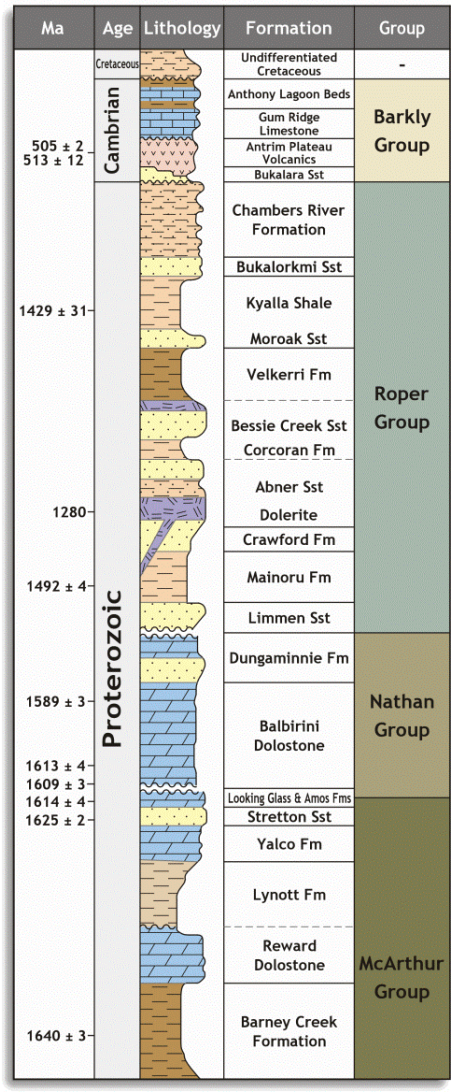

Plate 1 Beetaloo Sub-Basin Stratigraphic Column

Following the deposition of Cretaceous sediments, a period of geomorphic activity occurred during the Tertiary period. This resulted in the area, being gently folded and warped, which exposed it to a long period of erosional forces (Christian et al.,

1951). These forces resulted in the area being dominated by undulating plains that contain extensive swampland and lakes.

Following a period of lateritization during the end of the Tertiary period, rivers were at grade and erosion was reduced to a state that allowed deep stable soil profiles to be established and be preserved (Christian et al., 1951), resulting in the 'black' soil clay plains and the lateritic and non-lateritic rises that are in the region today (Randal, 1967). With the onset of a more arid climate during the post–Miocene period, lakes and swamps dried up, resulting in high concentrations of lime and silica deposits that were leached from the lateritic soils into the ground and surface waters, which in turn formed a number of Tertiary limestone outcrops within the permit area. During the Quaternary period, which occurred less than 2 million years ago, the minor alluvial and lake deposits throughout the permit area were formed.

The target formations for the water bore drilling program are described below:

- Undifferentiated Cretaceous (if present) – The Cretaceous claystone located near the surface in the Beetaloo Basin can be extremely unstable and may be very wet under the surface, retaining water from the previous wet season. The formation poses a risk during the spudding of the well due to its propensity to slough into the hole and wash out.
- Anthony Lagoon Beds - The Anthony Lagoon Beds are made up of dolomitic siltstones and limestones. They pose no specific drilling risk.
- Gum Ridge Limestone - The Gum Ridge formation is described as a cavernous limestone. It is the regional aquifer for local domestic and commercial use and is therefore extremely important to isolate from any potential cross-flow contamination. Given its description as a cavernous limestone, it is highly likely that total losses would be taken during drilling.

4.1.3 Soils

The Sturt Plateau bioregion covers an area of 103,857 km and comprises undulating plains on sandstones, with mostly neutral sandy red and yellow earth soils (ANRA, 2008).

The 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 and Holmes, 1984). The distribution and diversity of soils in the plateau have been influenced by:

- the past wetter conditions of the region that formed relict Tertiary plains which comprise of highly leached and generally lateritic soils
- extensive areas of Post-Tertiary Alluvia on which a variety of mature soils formed
- the dissected hilly country which is dominated by skeletal soils or rocky outcrops
- the range of parent materials of residual soils, ranging from basic volcanic and highly calcareous rocks to granitoid rocks and sandstones (Christian *et al*, 1951).

The soil types located within the plateau range from the very strongly leached lateritic soils of the Tertiary land surface to the calcareous deserts soils and desert loams in the southern drier areas.

The lateritic plains, located within EP98 and the northern part of EP117, 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, which occur on the gently undulating topography
- Tertiary Lateritic Red Sands, 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 are located in the northern section of the Barkly Basin and the Gulf Falls.

Other areas of Black Soil Plains are located within the Barkly Tablelands, including EP76, the southern part of EP117 and a small section of EP98. The soils usually crack widely in the upper profile upon drying and have a loose, self-mulching surface. The soils are neutral to alkaline, calcareous and commonly have depths to one metre (Fisher, 2001). The cracking clay soils occur mostly on flat or gently undulating plains ('downs') and are associated with the exposure and weathering of sedimentary or basic volcanic rocks. The Black soils also occur on the more recent depositional landscapes in the form of alluvial clays associated with drainage lines and major river systems.

Only a small section of the existing southern access tracks indicated the presence of Northern Heavy Grey Pedocals, also known as the black cracking clays, which are described as soils with poorer structure in the

surface and fine manganiferous concretions throughout the profile. They occur in high rainfall areas or poorly drained areas.

The soil erosion susceptibility is generally considered None/Slight erosion risk. This was confirmed during the field survey in August 2018 which reported no evidence of erosion within the proposed lease areas.

Soil samples collected during the field survey indicated the soils were slightly acidic (ph range of 5.0 to 6.2) across the permit area. A dispersion test was also undertaken on the samples which indicated that the soils were non-dispersive and maintained their shape when submerged in water. Results from the soil testing is provided in the Land Condition Report in **Appendix C**.

Certain sections of the proposed access tracks are likely to encounter more erosion susceptible soils, such as the access track to the southern sites and where streams and Newcastle Creek are crossed. Mitigation measures will need to be established to minimise the risk for erosion along the track and are stabilised leading up to the wet season. Overall, the main issues to be managed in relation to soils during exploration activities in the permit areas include:

- the generation of bull dust along the access tracks. Noting previous observations have indicated bull dust had formed where the surface crust had been disturbed and then subjected to repeated ground disturbance (AECOM 2015). This was primarily in grassland areas.
- The formation erosion gullies along inappropriately placed tracks and fence lines, where a slope was present. Scolding to bedrock has previously been observed in other areas of the permit, as well as pooling of water in areas of compaction and subsidence.

4.1.4 Hydrology

The proposed lease sites all fall within the Wiso River Basin. The Wiso River Basin covers the southern half of EP98 (south of the Carpentaria Highway) and the majority of EP76 and EP117 and is internally drained by Newcastle Creek and a number of small ephemeral creeks. Newcastle Creek ultimately flows into Lake Woods, which is located south of Newcastle Waters Station. 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 (HLA, 2005). 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, 2006b).

The only major creek in the permit area that could potentially be impacted by the proposed activities is Newcastle Creek (Stream Order 4) and a number of small ephemeral streams (Stream Order 1 and 2) located along the proposed access tracks (refer **Appendix C**). The streams only flow for a short period during the wet season, with waterholes forming at the beginning of the dry season. If the wet season is poor, the waterholes will often remain dry, whereas, during heavy wet seasons, large areas of the internal drainage systems are flooded. The stream banks are often lined with a scatter of small trees which highlights them from the surrounding plains.

Only one intermediate stream crosses the Beetaloo Access track at one location and three intermediate and Newcastle Creek cross the proposed access track to Velkerri 76 S2-1. The retention of vegetation buffers, as outlined in the NTG Land Clearing Guidelines – Northern Territory Planning Scheme 2010, as they relate to stream order should be considered for the preparation of access tracks and pads. Gravel pits located nearby would be utilised to provide stability where creeks and streams are crossed.

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).

4.1.5 Hydrogeology

Origin commissioned CloudGMS to undertake a desktop hydrogeological study of the Beetaloo Basin (CloudGMS, 2015). The study objective was to compile an up to date summary of the hydrogeology of Beetaloo and adjacent groundwater basins, including geological setting, previous studies, aquifer characterisation, groundwater use and the regulatory framework. 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 11). The Roper Group is estimated to reach of 5,000 m in thickness in the centre of the basin and 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), a significant water supply aquifer. The Georgina Basin is capped by Cretaceous mudstone and sandstone (145 – 66 Ma) and recent alluvial and laterite deposits.

Table 11 Summary of Beetaloo Basin Hydrostratigraphy

Province	Period/Age	Formation		Aquifer Status	Thickness (m)	Yield (L/s)	Ave EC (µs/cm)
CARPENTARIA BASIN	CRETACEOUS 145 – 66 Ma	Undifferentiated		*Local Aquifer*	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		*Local Aquifer (not regionally connected)*	0 – 75	0.3 - 5	1,000
BEETALOO BASIN (ROPER GROUP)	NOT KNOWN	Hayfield Mudstone		REGIONAL AQUITARD	0 – 450	-	32,000
		Jamison Sandstone		*Local Aquifer (not regionally connected)*	0 – 150	-	138,000
	MESO-PROTEROZOIC 1,430-1,500 Ma	Kyalla Formation		REGIONAL AQUITARD	0 – 800	-	-
		Moroak Sandstone		*Local Aquifer (not regionally connected)*	0 – 500	0.5 - 5	131,000
		Velkerri Formation		REGIONAL AQUITARD	700 – 900	-	-
		Bessie Ck Sandstone		*Local Aquifer (not regionally connected)*	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 mbgl.

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 (NALWTF, 2009). 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 Elsey 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/yr 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.

4.2 Biological Environment

4.2.1 Bioregions

The Interim Biogeographic Regionalisation of Australia is a nationally recognised ecosystem classification system (Environment Australia, 2000). Bioregions are large, geographically distinct ecosystems that are distinguished by broad physical and biological characteristics, which can be further classified into Subregions. These regions and subregions are used as the basis for regional comparisons and conservation of flora and floristic communities.

Of the 85 bioregions mapped nationally, 20 occur within the Northern Territory and only two within the Origin permit areas, the Sturt Plateau bioregion and the Mitchell Grass Downs bioregion. The 2018 proposed lease sites all fall within the Sturt Plateau Bioregion which comprises undulating plains on sandstone, with predominantly neutral sandy red and yellow earth soils. Dominant vegetation associations included extensive areas of Lancewood (*Acacia shirleyi*) - Bullwaddy (*Macropteranthes kekwickii*) vegetation 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.

4.2.2 Vegetation Communities

Vegetation communities within the permit areas have been ground-truthed during baseline assessments in 2004, 2006 (HLA, 2006; 2006c), 2010, 2014, 2016 (AECOM, 2011; 2014; 2016) and more recently in August 2018, along with assessments of weeds, habitat, erosion and land condition. The August 2018 survey focused on the proposed lease areas for water bore drilling and the associated access tracks. The methodology used for the assessments is presented in Appendix C.

The existing vegetation at the proposed sites have been evaluated through detailed habitat assessments. Habitat assessments included identification of vegetation community, dominant flora species at each strata, habitat condition, disturbance factors (fire, weeds, erosion, feral fauna species), and fauna attributes (e.g. tree hollows, logs, grass cover, mistletoe abundance).

The main vegetation communities within the exploration permit areas are woodlands, typically dominated by Bloodwoods (*Corymbia spp*.) and tall shrublands and woodlands of Bullwaddy and Lancewood with open grassland understorey (Cofinas and Creighton, 2001; ANRA, 2008). Other less common vegetation communities within the area include Acacia shrubland over spinifex and Bullwaddy-dominated woodland.

Lancewood/Bullwaddy communities are important as they represent Gondwanan remnants of the once dominant rainforests of the Australian tertiary period and are limited in distribution (PWCNT, 2005). Lancewood forests are the most extensive acacia dominated communities across northern NT. The Lancewood/Bullwaddy communities typically have a dense shady shrub layer, a few vines and creepers and a sparse grass understorey, compared to the sparse canopy and tall grass understory of other tall dense grasslands (PWCNT, 2005).

Bullwaddy is a unique plant with a multi-stemmed habit, very small leaves crowded along the branches and a very dense and heavy wood. Whilst technically being a shrub it can grow up to six metres tall with massive individual stems (PWCNT, 2005).

The Lancewood/Bullwaddy vegetation associations are fire sensitive. Inappropriate fire regimes may result in a community succession from Bullwaddy through Lancewood to a Eucalypt dominated open woodland (PWCNT, 2005). This process may be accelerated by the invasion of exotic pasture grasses such as Buffel Grass (*Cenchrus ciliaris*).

Detailed condition description and photographs of each of the proposed water bore sites and access are provided in Appendix C.

4.2.3 Flora

A total of 805 plant species have been recorded within the wider region, during the August 2018 survey 28 dominant flora species were identified across the proposed lease areas. As the survey was conducted during the late dry season, grasses and other annual species were difficult or impossible to identify due to the lack of inflorescence or because they had already died-back.

No Commonwealth or NT threatened plant species were identified as occurring by the Protected Matters Searches or NRM Infonet search. One species, the prostrate, herbaceous vine *Ipomoea argillicola*, is listed as Near Threatened under Section 29 of the *Territory Parks and Wildlife Conservation Act 2000* (TPWC Act) and could potentially occur in the project sites, although has not been reported in previous and current surveys. NT flora data base shows that this species has been recorded from the Bullwaddy Conservation Reserve and at locations surrounding the area in previous searches (AECOM, 2015).

The region supports fragmented stands of Bullwaddy, which is listed under the TPWC Act as 'Least Concern', which refers to species that are either widespread or common and cannot be categorised as Critically Endangered, Endangered, Vulnerable, Near Threatened or Data Deficient. However, Bullwaddy is significant in terms of the habitat it provides for a range of native species. The extent of Bullwaddy in the permit area is far more extensive than that indicated by the NT Herbarium records.

4.2.4 Weeds

Weed baseline surveys were completed by AECOM in August 2018 covering all proposed access tracks and lease pad areas. This section provides a summary of weed related information pertinent to the project, with detailed information provided as a part of the Land Condition Assessment in **Appendix C**.

Weed prevention and control within the NT is regulated under the *Weeds Management Act*. The aim of the Act is 'to protect the Territory's economy, community, industry and environment from the adverse impact of weeds'. The act identifies several weed declaration classes, designed to eradicate, control or prevent the introduction of certain weed species in the NT. These declaration classes are:

- 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.

Regional Weed Management Plans (RWMP) have been developed for areas of the NT, with the Barkley and the Katherine RWMP overlapping Origin's Beetaloo exploration tenure. The aim of these regional plans is to assist in prioritising weed management by:

- identifying the region's priority weeds and associated pathways of spread to inform management priorities
- identifying landscapes that may need prioritised protection from weed impacts like river corridors or sacred Aboriginal sites
- containing information on alert weeds that are not yet found in the region, but could become major issues if they establish

The weeds species of high risk of introduction or spread through Origins activities are listed in Table 12. These high-risk weeds have been determined through consideration of the following criteria:

- Weed species that has been confirmed in the area within the relevant RWMP or through field surveys
- Weed species listed in a RWMP that is in close proximity to Origin tenure
- Weed species is at risk of introduction through the use of machinery sourced from other regions in the NT or from other states.

A survey undertaken in August 2018 and previously in 2014,15 and 16 did not detect any priority weeds in the area surrounding the proposed activity.

The low level of weed abundance suggests good habitat condition in the areas of the proposed sites. Primary controls for this program will therefore be focused on preventing the introduction of weeds and managing weeds promoted through site disturbance. The proposed weed control measures to prevent and manage weed infestations are outlined in Section 6.4.

Additional information on the full list of weeds and control measures for the development are provided in the Weed Management Plan in **Appendix B.**

Table 12 High priority weeds to be managed or prevented within the permit area

Scientific Name	Common Name	Status	Priority reason
Acacia nilotica	Prickly Acacia	Class A, WoNS	Mapped in the exploration lease within the Katherine RWMP
Andropogon gayanus	Gamba Grass	Class A WoNS	Mapped in the exploration lease within the Katherine RWMP
Calotropis procera	Rubber Bush	Class B and C	Mapped in the exploration lease within the Barkly RWMP
Hyptis suaveolens	Hyptis	Class B and C	Confirmed within exploration lease during previous weed Origin surveys
Jatropha gossypiifolia	Bellyache Bush	Class A, WoNS	Mapped in the exploration lease within the Katherine RWMP
Parkinsonia aculeata	Parkinsonia	Class B and C, WONS	Confirmed within exploration lease during previous weed Origin surveys and Mapped in the exploration lease within the Katherine RWMP
Prosopis pallida	Mesquite	Class A and C, WONS	Mapped in the area surrounding exploration lease within the Katherine and Barkly RWMP
Themeda quadrivalvis	Grader Grass	Class B and C, WoNs	Mapped in the area surrounding exploration lease within the Katherine RWMP. High potential introduction through sourcing of equipment from Katherine area.
Xanthium occidentale	Noogoora Burr	Class B and C	Weed Management Branch – Mapping data DLRM databases (DLRM *et al* 2018)
Parthenium hysterophorus	Parthenium	Class A and Class C, WoNS	Potential introduction through equipment sourced from QLD.

4.2.5 Fauna

Previous surveys and database searches indicate that the exploration area is an important area for a diverse array of fauna. The NT Fauna database provides records for the following fauna species (excluding migratory birds): 32 species of mammal, 198 species of birds, 96 species of reptiles and 19 species of frogs. Surveys undertaken elsewhere within the region have recorded:

- 78 bird, 33 reptile, 11 mammal and six frog species in the Bullwaddy Conservation Reserve (PWCNT, 2005)
- 148 bird, 47 reptile, 21 mammal and six frog species in the Junction Stock Reserve and nearby Newcastle Waters (Fleming *et al*., 1983)
- 157 bird species within the project area as determined by a search of the Birds Australia bird atlas database (Birds Australia, 2010).

The proposed monitoring bore sites are all located within similar habitat types consisting primarily of open *Eucalyptus*/*Corymbia* woodland with a tussock grass understorey. There are Bullwaddy/Lancewood communities around 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 shrublands.

Eucalypt/Corymbia 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 (DoTEE,

2014, 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.

Savanna grasslands and open woodland provide suitable habitat for species such as Emu (*Dromaius novaehollandiae*) and Australian Bush Turkey (*Ardeotis australis*. Drainage lines and seasonally inundated grasslands may also provide habitat for migratory species during the wet season and are breeding areas for frogs. Limiting disturbances in these areas and avoiding these areas during the wet season would limit impacts on fauna.

4.2.6 Significant Fauna

A search of the DotEE Protected Matters database of nationally significant fauna (PMST), the NT Government fauna database (NRM Infonet), and records from the Atlas of Living Australia (ALA) was undertaken for the proposed lease areas and access tracks. The search results indicate the potential presence of 20 fauna species listed as threatened under the EPBC Act and/or the TPWC Act. These included ten birds, eight mammals and two reptiles.

The likelihood assessment of species occurrence 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 proposed water bore lease areas. 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 Appendix C.

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

- Gouldian Finch *Erythrura gouldiae* (E-EPBC Act, VU-TPWC Act)
- Crested Shrike-tit (northern) *Falcunculus frontatus whitei* (VU-EPBC Act, NT-TPWC Act)

Research has shown that critical components of suitable habitat for the Gouldian Finch include suitable nesting trees during the breeding season (particularly *E. tintinnans*, *E. brevifolia* or *E. leucophloia*), a water source and a diverse range of favoured annual and perennial grasses (DoE, 2015). No nesting habitat was recorded during the surveys and it is unlikely this species breeds in close vicinity of the sites. 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 of the sites suggesting it is not an important area for this species.

The Crested Shrike-tit lives in dry Eucalypt forests and woodland where it feeds on insects from the canopy and also under bark (Ward, 2008). It has been recorded in wet Melaleuca open woodlands, woodlands dominated by Nutwood (*Terminalia arostrata*), Bloodwoods with flaky bark and ironwood (DoE, 2014, 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 this species may be present in the area, it is unlikely to represent an important area for this species and the impact of the proposed activities, given their size, would be small.

The Grey Falcon (*Falco hypoleucus*) is a widespread species listed as Vulnerable in the NT that is considered possibly to be present in the study area. The Painted Honeyeater (*Grantiella picta*) has been known to occur in the study area, however, given it does not breed in the NT it would only be present intermittently for foraging. Based on the field assessment there was no breeding habitat recorded, and depending on grass seed and water availability it is unlikely the study area comprises core habitat for this species.

4.2.7 Feral and Pest 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 the August 2018 survey evidence of cattle grazing in present or 1-2 years previously was recorded and in previous surveys of the permit area cat tracks were observed as the only non-native species recorded but based on records many species, especially Dogs/Dingo, Pigs and Cane Toads will be present in permit area. The disturbance from cattle within the proposed sites were considered to have resulted in less than 5% damage or no damage at all.

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

Pest predators such as the Cat are most likely common although their abundance is difficult to assess due to their cryptic nature. Introduced predators such as Cats can impact many vertebrates (e.g. Dickman, 2009 &1996). One of the primary concerns of introduced predators in the site is the impact on EPBC listed species such as reptiles, and ground-dwelling birds. Feral cats are believed to be one of factors that have led to the decline of threatened ground-dwelling bird the Partridge Pigeon (Woinarski et al. 2007)

Species could be attracted to the increased activities at the site potentially increasing their abundance in the landscape, and their control should be taken into consideration during the proposed activities on site. It is of key importance during all phases of the project that care is taken to ensure that rubbish is securely contained (i.e. with suitable lids) and removed from the site as soon as possible to discourage attracting any feral animals.

4.3 Fire Regime

Fire is a natural occurrence in most Australian ecosystems and plays an important role in their ecology. Fire is generally excluded from Mitchell grasslands by pastoral management in order to maintain forage throughout the dry season (HLA, 2005) whereas fire is more frequent in the Sturt Plateau.

Based on field data, fire disturbance was determined as follows:

- Vekerri 76 S2-1 – Fire Frequency 2-3 years previous, Intensity 1 (minor scars on some trees/shrubs and Height <1m.

4.4 Environmental and Cultural Sensitivities

4.4.1 Native Title

Three Native Title claims have been determined as non-exclusive and one Indigenous Land Use Agreement (ILUA) are current over the permit areas (see Table 13).

Table 13 Native Title and IULA Agreements Current for the Permit Areas

Type	Well	Name	Summary
	Velkerri 76 S2-1	NTD17/2010 Amungee Mungee Pastoral Lease	Native title exists in parts of the determination area and is held by The Karranjini group; the Bamarrnganja group
Indigenous Land Use Agreement	All Sites	D12004/014 Jingaloo CLA ILUA	Registered for Community Living Area and Tenure resolution

The Native Title Petroleum Exploration Agreement between Origin and the NLC includes clauses for the protection of Sacred Sites, objects and sensitive areas related to Aboriginal activities in the area, including cultural, hunting and foraging activities. Site clearance will occur prior to any on ground activities. The Native Title Agreement also includes clauses for the protection of the environment and rehabilitation.

4.4.2 Archaeology Assessment

An archaeological assessment, involving searches of the NT Heritage Register and Australia Heritage Database and a field survey, has been carried out by AECOM archaeologist, Luke Kirkwood for the proposed water bore sites and associated tracks. The archaeological inspection involved a combination of both pedestrian and helicopter survey of the proposed lease areas and tracks. During the inspections 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 exploration area. Photographic records were taken at each proposed location.

A search of the Northern Territory Heritage Register identified 41 Aboriginal archaeological sites within a 125 km by 125 km area that encompasses the full Proposal area. No archaeological sites are recorded within proximity of the proposed lease area covered under this EMP.

A search of the Australia Heritage Database identified that no statutory listed heritage places within the proposed impact areas. Three sites listed on the now non-statutory Register of the National Estate are located within a 125 km x 125 km search area that encompasses the full permit area. None of these heritage places are located within 10 km of the proposed lease area.

No culturally sensitive landforms were identified during the August 2018 survey of the lease sites covered under this EMP.

The archaeological assessment is provided in Appendix D.

4.4.3 Areas of Cultural Significance

Sacred sites in the study area are primarily associated with drainage lines; natural landform features and stock routes, but there are also concentrations of sites nearby to old homesteads. The distribution of these sites may reflect historical patterns of Indigenous movements along drainage lines and subsequent development of stock routes on old Indigenous walking trails, or they may merely be indicative of the site clearance work undertaken along roads and tracks in the area. It is suspected that there will be a range of other sites also within the area, either not yet recorded, or known but not reported for cultural reasons.

Clearance survey by AAPA anthropologist and traditional owners have been completed. The AAPA clearance certificate AAPA C2019/039 is provided in Appendix E.

The APPA certificates identify 1 Restricted Work Area (RWA) along the access track to the Velkerri 76 S2 well. The RWA excludes the proposed access track footprint and will therefore not be impacted by Origin's work program. All conditions of the AAPA will be followed.

4.4.4 Natural Resources

In addition, previous cultural heritage surveys of the permit areas were undertaken with representatives of the traditional owners who identified a number of natural resources of importance to Aboriginal people of the area (Table 14).

Table 14 Natural Resources of Importance in the Permit Areas

Scientific Name	Common Name	Usage
Grewia retusifolia	Emu-berry/Dog's Balls, Turkey Bush and Diddle Diddle	Fruit eaten. Leaves can be boiled, and body bathed in the liquid for treatment of a number of ailments
Marsdenia australis	Bush Banana/Gillibi	Bush 'fruit' eaten when young, as it matures 'fruit' seeds becomes feathery for dispersal in the wind and are not eaten
Pterocaulon sp.		Used for treating flu
Acacia sp.	Acacia	Leaves boiled and used to treat the flu
Acacia holosericea	Soapbush Wattle or strap wattle	Leaves used for washing
	Termite (unknown species)	Mounds pulverised and mixed with water, used to treat diarrhoea

4.4.5 Non-Indigenous Heritage

In 1860 explorer John McDougall Stuart was the first European to penetrate the area now known as the Centre. The first written descriptions of the area come from Stuart during his second attempt to cross the continent from south to north (HLA, 2005).

Development in the area began as pastoral lands with an increased interest in land settlement following the completion of the Overland Telegraph Line in 1873. Most attempts were unsuccessful with the Lancewood-Bullwaddy vegetation found to be impenetrable and the lack of surface water making the land unsuitable for cattle. Daly Waters was thus recognised as one of the last watering stops on the Murranji Stock Route.

It wasn't until the 1930s to 1950s, that the area saw regional economic growth with Daly Waters becoming a significant hub of air and mail services into the territory. The wartime years saw this role increase with Daly Waters again playing a major role in cross country transport and communication. This role continued until the early 1970s when the airport was closed to commercial traffic. The town and surrounding areas subsequently reverted to a primarily agriculture-based existence following the decline of air travel, but has in recent times seen

commercial interest from the exploration for gas in the Beetaloo Sub-basin and the growth of the ‘grey nomad’ tourism market.

4.4.6 Historic Heritage Assessment

A search of relevant historic heritage registers identified a number of historic heritage sites within a 125 km by 125 km area that encompasses the full Proposal area. No previously identified sites are located within 20 km of the proposed 2018 lease areas. No new sites of historic heritage were identified during the August 2018 survey.

4.4.7 Protected or Conservation Areas

There are no conservation areas within proximity to the proposed activities. 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 areas (EP76, EP98 and EP117).

4.5 Social Environment

4.5.1 Social Context

The proposed water bore drilling program occurs within the Barkly Regional Council area, which covers 323,514 km^2. The approximate population is estimated for the Barkly Region of 8,137 people (Barkly Regional Council, 2018).

The potential social and economic impacts within the region where the exploration permits are located are varied. Considered at a regional level the impacts on the community from the proposed groundwater monitoring bore drilling program would be negligible. Origin's future activities within the permit area will likely contribute to broad socio-economic changes within the region which have potential for both positive and negative impacts.

The major communities which are in proximity to Origin's activities include Tennant Creek, Elliott, Daly Waters, Newcastle Waters, Mayfield, Dunmarra, various pastoral properties and Aboriginal outstations.

In 2014, the Tennant Creek Regional Economic Development Committee (REDC) released the *Tennant Creek and Barkly Region Strategic Action Plan (2014-2016)* which addressed social issues and economic development within the region, including oil and gas development.

4.5.2 Pastoral Activity

The current land use in the project area is pastoral with varying stocking rates and varying management practices. Within the permit area there are nine pastoral properties as shown in Table 15. All of the land within the permit area is Leasehold Land. There are no areas of Aboriginal Freehold land.

Table 15 Pastoral properties in the Permit Area

Pastoral Property	Permit Areas			Contact Details
	EP76	EP98	EP117	
Amungee Mungee	✓	✓	✓	[redacted]
Kalala		✓	✓	
Tanumbirini	✓	✓		
Beetaloo	✓		✓	
Hayfield/Shenandoah		✓	✓	
Ucharonidge	✓		✓	
Tandyidgee	✓	✓		
Nutwood Downs		✓		
Newcastle Waters			✓	

The project area has been subject to pastoral activities for over 150 years (AECOM, 20). The average size of a Station in the Barkly Region is 8,186 km^2 (Bubb, 2004), which is large by global standards.

The proposed water bore drilling activities conducted on the proposed Velkerri 76 S2 lease located on the Amungee Mungee Property.

4.5.3 Other Land Uses in the Area

A range of other land-uses exists in the permit area or in the larger region, including a range of public utilities and facilities. These include the following:

1. Tourism- Tourism is an important regional industry with the Sturt Highway being a major thoroughfare for tourists travelling in the area during the dry season. The local townships of Daily Waters, Dunmarra and

Elliot provide consumables (food, fuel etc.) and accommodation. A number of heritage areas of importance to regional tourism are located in the broader region, including Elliott, Newcastle Waters and other heritage listed homesteads.

2. Road networks – The Stuart Highway and Carpentaria Highway will be used to access the sites. In addition, there are numerous gravel roads connecting properties, and internal property tracks. All properties also have firebreaks on their boundaries and internally.
3. Alice Springs to Darwin Railway - The railway line runs to the west of the gas pipeline and Stuart Highway, and does not cross into any of the permit areas.
4. Townships - The township of Daly Waters and Dunmarra lie within EP98.
5. Conservation areas – including the Bullwaddy Conservation Reserve, which lies within EP98 and Lake Woods and the Junction Stock Reserve just outside the permit area.
6. Heritage – there are seven heritage sites within the exploration permit area. There are also number of heritage areas of importance to regional tourism are located in the broader region, including Elliott, Newcastle Waters and other heritage listed homesteads. These sites have been identified as part of the environmental assessment, and the proposed water bore drilling sites will not impact on these.
7. Archaeological sites - the permit areas have a long history of Aboriginal association and 41 archaeological sites have previously been recorded within the permit areas, as well as 25 registered Sacred Sites.

5. Stakeholder / Community Consultation

The NT *Petroleum (Environment) Regulations 2016* defines *stakeholder* as meaning:

(a) a person or body whose rights or activities may be directly affected by the environmental impacts or environmental risks of the regulated activity proposed to be carried out; or

(b) an agent or representative of a person or body mentioned in paragraph (a).

Origin's local and directly impacted / affected stakeholders have, and continue to be, consulted in a respectful, open and consistent manner. This has been the case since 2014, when Origin has assumed operatorship of EP98, EP117 and EP76.

Origin's consistent approach to stakeholder engagement has been to ensure that those persons and / or groups most directly impacted / affected and / or influenced by permit commitments have received Origin's full attention. Origin views the social acceptance and informed consent of these primary stakeholders of critical important and relevance during this stage of low impact and small-scale exploration activities.

For the purpose of this EMP, Origin identifies it stakeholders, in compliance with the NT *Petroleum (Environment) Regulations 2016* as:

- **host Traditional Owners** recognised as the Native Title holders and / or claimants and their representative, the Northern Land Council, as described in Exploration Agreements between the parties for EP98, EP117 and EP76; and
- **host pastoralists** recognised as the landholders of the nine Pastoral Lease Stations in Table 15, with particular engagement with the landholder of Amungee Mungee as the stakeholder most impacted by Origin's relevant permit commitments the subject of this EMP.

Origin also recognises and engages, where appropriate and acceptable, with the following list of stakeholders:

- Northern Territory community and residents;
- Federal Government, including Departments, Members of Parliament and Opposition Spokespersons;
- Local Government Agencies, including:
    - Katherine Town Council;
    - Barkly Regional Council;

    - Roper Gulf Regional Council; and
    - Regional Economic Development Committees;
- Northern and Central Land Councils;
- Environmental Protection Authority;
- Aboriginal Areas Protection Authority (AAPA);
- National, State and Local Media (Print, TV and Radio);
- Australian Petroleum, Production and Exploration Association (APPEA);
- Northern Australia Development Office (NADO);
- Northern Territory Cattlemen's Association (NTCA);
- Industry Capability Network (ICN);
- Chamber of Commerce NT;
- Business Council of Australia;
- Minerals Council of Australia;
- CSIRO / GISERA;
- NGOs;
- Darwin Major Business Group (DMBG);
- Energy Club Northern Territory (ECNT);
- Indigenous Business Network NT (NTIBN);
- Katherine Mining Services Association (KMSA).

The collection of baseline groundwater monitoring data proposed under this EMP, extending the groundwater monitoring network Origin has had in place since 2014, is of importance and relevance to all parties including community members, pastoralists, Traditional Owners and Origin. It provides interested stakeholders the ability to assess impacts given a data set will exist before, during and after Hydraulic Fracturing Stimulation (HFS) activity. For Origin, it is equally important to be able to demonstrate to the pastoralists, Traditional Owners and regulators that our extraction processes are robust, measurable and environmentally disciplined.

Stakeholder and community engagement for the 2019 work programme has been held with host pastoralists and Traditional Owners directly affected by the proposed activities. Origin's proposed exploration program has been clearly communicated to interested parties, with several written submissions and video presentations prepared by Origin for 'The Scientific Inquiry into Hydraulic Fracturing in the Northern Territory'. Information included in Origin's submission to the Inquiry is publicly available at https://frackinginquiry.nt.gov.au/submission-library.

Activities performed under EP98, EP117 and EP76 will be conducted in a manner consistent with the 'Code of Practice: Onshore Petroleum Activities in the Northern Territory', which Origin considers an appropriate reference for ensuring Origin's activities are in line with community expectations.

5.1 Pastoralist Stakeholder Engagement

Origin has engaged with the pastoralist stakeholders identified in Table 15 above on an ongoing basis, including engagement with the landholder of Amungee Mungee Station regarding the low impact and small-scale exploration activities. Key engagement efforts Origin has undertaken with the landholder of Amungee Mungee Station include:

- engaging in consultation for and agreeing on early works access to Amungee Mungee Station in preparation of low impact and small-scale exploration activities;

- providing the landholder with draft copies of this EMP and the EMP for civil construction works for the Velkerri 76 S2 well and providing opportunity for the landholder to comment;
- providing the landholder with copies of Beetaloo Basin Exploration Project – Weed Management Plan (**Appendix B**) and Trafficwerx NT Traffic Management Plan (**Appendix H**) for works Origin proposes to undertake as part of the broader Beetaloo Basin Exploration Project, which outline Origin's environmental risk management and outcome achievement policies; and
- ongoing engagement and consultation meetings regarding Origin's proposed exploration activities, including demonstration of the scope and activities part of Origin's Beetaloo Basin project (**Appendix J**).

Appendix K summarises Origin's compliance with Origin's obligation to engage with the landholder of Amungee Mungee Station as a relevant stakeholder and provide information in accordance with section 7(2)(a) of the *Petroleum (Environment) Regulations 2016*.

Appendix L provides the correspondence between Origin and the landholder and representatives of Amungee Mungee Station in fulfilment of the stakeholder engagement obligations under the *Petroleum (Environment) Regulations 2016*.

5.2 Traditional Owner Engagement

Origin has undertaken detailed engagement with the relevant Traditional Owners through the Northern Land Council to facilitate an ongoing relationship between Origin and the Traditional Owners. Engagement efforts undertaken by Origin include:

- ongoing consultation regarding Origin work programs and proposed exploration activities, including the locations of all areas of disturbance across the area of EP98, EP117 and EP76.
- in person consultation between Origin and the Northern Land Council regarding Origin's proposed exploration activities on 3 September 2018;
- ongoing communication between Origin and the Northern Land Council; and
- performance of a Sacred Site clearance survey on land with the relevant Traditional Owners between 10 September and 19 September 2018. A formal Northern Land Council Sacred Site Avoidance and Anthropological Report was provided to AAPA to assist with the certification process for Origin's exploration areas and associated infrastructure.

The Northern Land Council has provided Origin with Traditional Owner consent for the activities and AAPA provided Origin certification AAPA C2019/039 on 30 November 2018 (**Appendix E**).

5.3 Northern Territory Community Engagement

Broader engagement has occurred with local and regional business within the local communities of Daly Waters, Elliot, Katherine and the broader Northern Territory region. Northern Territory businesses have been engaged on the scope of Origin's activities through tender opportunities covering a range of material supply and support services, such as:

- people transport and logistics;
- accommodation and food;
- provision of temporary camps and camp services;
- civil construction work;
- freight and transport;
- water bore drilling;
- water carting and waste management;

- site maintenance and inspections;
- weed management and control;
- equipment and materials storage;
- oil country tubular goods;
- environmental and civil consulting;
- surveying and geotechnical assessments; and
- general provisions of goods and services (such as personal protective equipment and hire cars).

5.4 Ongoing Stakeholder and Community Engagement

Origin is committed to continuing to engage with stakeholders regarding the exploration activities under EP98, EP117 and EP76 and any associated environmental outcomes prior to, during and after performance of the low impact and small-scale exploration activities. For example, Origin made an express offer for further and ongoing consultation with the landholder of Amungee Mungee Station by letter on 5 June 2019 (**Appendix L**).

Origin recognises the growing community interest in ensuring onshore natural gas development takes place in a safe and environmentally sound way and are committed to delivering operational excellence (which encapsulates our health, safety and environmental performance standards).

Origin has further committed to ongoing engagement with the relevant Traditional Owners, including annual work plan meetings and provision of draft work programmes for future years of activity.

Detailed community and stakeholder engagement is underway covering future exploration activities which are beyond the scope of this EMP.

6. Environmental Risks and Impacts, Description and Assessment

6.1 Origin's Risk Management Approach

Origin utilises a robust risk management process for all its activities to achieve the following key outcomes:

- Risks are understood, eliminated or reduced and controlled to an acceptable level.
- Controls are owned, assured and continuously reviewed for effectiveness.
- All activities are compliant with regulatory standards and are guided by best practice, and
- Origin and its stakeholders are confident in the way activities are conducted to manage risks.

Risk management processes are mandated through the Origin Risk Management Policy and Directive, which includes a risk rating toolkit that is utilised from the Board through to frontline activity owners (Figure 7). The toolkit considers the requirements of ISO 31000 and addresses risk identification, assessment and management.

Assessment of risk are completed using Origin's Risk Matrix (Figure 8) to assess and rate risks by assessing the combination of frequency of occurrence and the severity of the outcome of an event. This allows quantification of the risk and determination can then be made about whether the risk can be accepted, or whether further mitigation is required.

Origin risk management processes requires regular assessment of underlying (unmitigated) risk from an activity, the residual risk once controls are applied, the effectiveness of controls and the likelihood and consequence of a risk event. A risk is either accepted in accordance with strict delegations of authority or the activity does not proceed.

6.2 Risk Acceptance threshold- ALARP

A risk can be considered to have been reduced to ‘as low as reasonably practicable’ (ALARP) when all reasonably practicable control measures (both preventative and mitigative) have been identified and implemented to reduce the risk of identified events. A key element of demonstrating ALARP is that good practice is followed, where good practice is defined as the recognised risk management practices and measures that are used by competent organisations to manage well understood hazards arising from their activities. This definition incorporates good practice as defined in codes and standards, and a consensus of good practice within the industry. ALARP is not a final position over the life of an asset or project.

The practicability and the reasonability of control measures can change over time due to changes in technology (that can make measures more readily available or less expensive), industry standards (that can commoditise once-cutting-edge technology) and the socio-technical landscape (that can modify societal expectations).

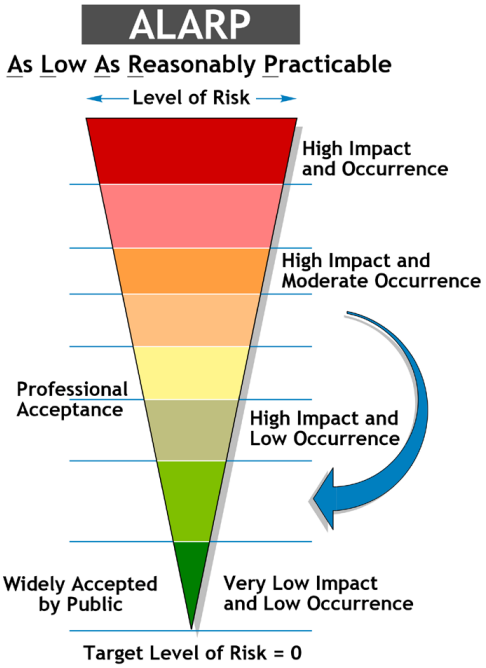

Figure 7 Origin's risk tool kit which describes the approach to identify, assess, control, treat and accept risks

Origin Risk Rating Toolkit

How to use this toolkit

Step A – describe the risk
Identify and describe the risk in terms of what could happen, its causes and potential effect/impact on Origin's objectives.

Step B – identify and assess controls
Identify and assess existing controls using the Control Assessment Ratings. Consider any related significant incidents, near miss events and assurance activities when assessing controls.

Step C – assess the level of consequence
Decide on the level of consequence that best represents the risk. Determine the highest credible consequence level in all relevant consequence categories in the Risk Matrix, taking into account current control assessment.

Step D – assess the likelihood of the risk
Determine the likelihood level in the Risk Matrix that represents the chance of the risk occurring at each consequence level identified, taking into account current control assessments.

Step E – determine a level of risk
Use the Risk Matrix to determine the level of risk.

Step F – determine the priority for risk treatment and approval
Using the Risk Treatment and Acceptance Criteria, determine the risk treatment required and who can approve/accept the risk at its current level.

Step G – assess the potential maximum consequences
Estimate the potential maximum consequence (plausible worse case level assuming all current controls fail) using the consequence categories.

Control Assessment Ratings

Rating	Explanation
Effective	▪ All controls are well designed and address the root cause/s of the risk. ▪ All controls operate to the required level. ▪ Ongoing monitoring required.
Can be improved	▪ Majority of controls are well designed and address the root cause/s of the risk. ▪ Majority of controls operate to the required level. ▪ Certain controls can be improved. ▪ Ongoing monitoring required.
Needs to be improved	▪ Majority of controls are not well designed and do not address root cause/s of the risk. ▪ Majority of controls do not operate to the required level. ▪ Majority of controls require improvement.

Risk Treatment and Acceptance Criteria

Level of risk	Action required	Acceptance authority
VERY HIGH	▪ Risk treatment must be in place immediately ▪ Review risk quarterly at a minimum	EMT member*
HIGH	▪ Risk treatment must be considered (having regard to current business priorities) ▪ Review risk annually at a minimum	General Manager
MEDIUM	▪ Risk treatment may be considered ▪ Review risk two yearly at a minimum	Group/Asset/ Project Manager
LOW	▪ No risk treatment required ▪ No ongoing review required unless determined by the relevant Group Manager	Site/Activity Manager

* Managing Director acceptance required for risks with a Catastrophic consequence and Likely or above Likelihood

Figure 8 Origin's Risk Matrix

Risk Matrix

CONSEQUENCE	IMPACT ON ORIGIN OPERATIONS – Conduct Business with Due Care: People	IMPACT ON ORIGIN OPERATIONS – Conduct Business with Due Care: Environment and Community	IMPACT ON ORIGIN OPERATIONS – Create Value: EBIT	IMPACT ON ORIGIN OPERATIONS – Create Value: Cash flow	IMPACT ON ORIGIN OPERATIONS – Create Value: NPV	EXTERNAL RESPONSE – Decisions are Subject to Scrutiny: Stakeholder Perceptions	EXTERNAL RESPONSE – Decisions are Subject to Scrutiny: Laws, regulation and civil actions
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
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.
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.
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.
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 though 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.
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.

CONSEQUENCE	LIKELIHOOD – 1 REMOTE (<1% chance of occurring within the next year. Only occurs as a '100 year event' or less frequent.)	2 HIGHLY UNLIKELY (<10% chance of occurring within the next year. Could occur within decades.)	3 UNLIKELY (<30% chance of occurring within the next year. Could occur within the next few years.)	4 POSSIBLE (<60% chance of occurring within the next year. Could occur within months to years.)	5 LIKELY (<90% chance of occurring within the next year. Could occur within weeks to months.)	6 HIGHLY LIKELY (Likely to happen multiple times a year)
6 CATASTROPHIC	HIGH	HIGH	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH
5 CRITICAL	MEDIUM	MEDIUM	HIGH	VERY HIGH	VERY HIGH	VERY HIGH
4 MAJOR	MEDIUM	MEDIUM	MEDIUM	HIGH	VERY HIGH	VERY HIGH
3 SERIOUS	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH
2 MODERATE	LOW	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM
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.

6.3 Risk Assessment Outcomes

The environmental, heritage and social risks associated with the proposed water bore drilling activities have been assessed utilising the Origin risk assessment framework described in Section 6.1. The detailed risk assessment presents the range of potentially impact-causing activities, corresponding mitigation measures and residual risk ratings based on their assessed worst-case consequence and likelihood of occurrence.

There were no residual risks above a medium, with 16 out of the 18 risks identified as being considered low. The medium risks identified were consistent with standard civil construction activities completed across the NT, being the potential spread of weeds and ignition of bushfires from the proposed activities.

Table 16 provides a count of the post-treatment environmental risks associated with the water bore drilling program. A copy of the risk assessment is provided in Appendix F.

Table 16 Count of Post-Treatment Environmental Risks for the Water Bore Drilling Program

	Post-treatment Environmental Risk Level			
	Low	Medium	High	Very High
Count	16	2	0	0

6.4 Environmental Risk Management Summary

The following section provides a summary of how the risks associated with each environmental aspect will be managed. For aspects with multiple individual risks, these are summarised in the relevant aspect table with the highest residual risk being used. The risk assessment provided in Appendix F should be consulted where an overview of each individual risk is required.

The risk management summary tables include an overview of the environmental values, management objectives, activities, potential impacts, management controls, performance measures and monitoring and records. In addition, the residual risk rating and a statement on the effectiveness of the proposed controls to manage the environmental risk is also provided. The rationale for how each risk control effectiveness has been determined is provided in Table 17.

Table 17 Risk control effectiveness definition

Rating	Explanation
Effective	• Controls are well designed and address the root cause/s of the risk • Controls are recognised industry best practice • All controls operate at the required level • All controls are within the power of Origin, with few external factors beyond control • Ongoing monitoring required
Can Be Improved	• Majority of controls are well designed and address the root cause/s of the risk • Majority of controls operate at the required level • Some controls are outside the power of Origin, with multiple external factors beyond control • Ongoing monitoring required • Certain controls can be improved or have elements below industry best practice.
Must Be Improved	• Most controls are not well designed and do not address the root cause/s of the risk. • Most controls are not operating to the required level. • A large number of controls are outside the power of Origin, with multiple external factors • The majority of controls require improvement and are well below industry best practice.

6.4.1 Soils and erosion

Table 18 Environmental Values and Objectives – Land

Environmental Values	• Suitability and stability of land for existing uses (Erosion and Sediment Controls implemented). • Stability of land to preserve existing water quality, landscapes and ecosystems.	
Management Objectives	• Minimise disturbance to land and land use (including soils and terrain, flora and fauna). • Protection of waterways. • Avoid site contamination and remediate land areas disturbed by water bore drilling activities, including contaminated land. • Optimise (in order of most to least preferable) waste avoidance, reduction, reuse, recycling, treatment and disposal and remove and disposal of regulated waste as soon as practicable to a licensed waste disposal facility or recycling facility. • Return disturbed areas to a stable condition such that they are returned to a condition as close as practicable to the surrounding area (or pre-disturbance state) within an acceptable time frame.	
Activity	**Potential impacts without management controls**	**Management Controls**
• Civil works • Water bore drilling activities • Storage and transportation of wastes • Sewerage treatment and disposal • Disposal of drill cuttings and muds to excavated sumps • Fuel and chemical handling and storage	• Localised soil contamination • Soil erosion and sedimentation	• Ecological assessment undertaken to identify environmentally sensitive areas. • Erosion control measure to be implemented and maintained as per the project erosion and sediment control plan. • The retention of vegetation buffers surrounding streams and creek, as outlined in the NTG Land Clearing Guidelines 2010 • Bed level creek crossings as per section 2.2. • Regular inspections will be conducted to identify erosion and repair where observed. • Fuel, lubricants and chemicals will be stored appropriately in lined and bunded areas and transported, handled and used in accordance with the relevant MSDS. • Spill kits will be in place and clean-up equipment will be onsite and available in relevant areas. • No off lease or off-road driving. • All solid and regulated waste to be removed offsite. • Following completion of works, disturbed areas to be restored and/or rehabilitated. • Gravel borrow pits to have topsoil returned and re-profiled; • All compacted areas will be ripped and scarified to promote regeneration of vegetation. • Disturbed areas to be restored will be monitored for weed infestation, and progress towards specified rehabilitation goals.
Performance Measures	• Land disturbance equal to or less than planned. • Minimum incidences of erosion and sedimentation occurring. • Areas left safe, stable and non-polluting.	

Monitoring and Records	• The extent of disturbances will be measured and uploaded to the Origin's Geographic Information System (GIS).
	• Monitoring for soil erosion and related issues is best undertaken at critical stages, such as:
	- During siting of access track and water bore areas– this is when there is greatest opportunity to avoid erosion problems.
	- After completion of a specific phase of activity all areas disturbed should be inspected for early signs of compaction, erosion and soil degradation (generation of bulldust).
	- When accessing the site after the wet season look for signs of erosion. If significant impacts are identified remediation works may need to be conducted prior to continued vehicular access.
	- After more than 20 mm of rainfall.
	• Where rehabilitation of a site is undertaken, rehabilitation monitoring will be undertaken annually to assess the rehabilitation success and determine where additional remedial works are required. Success criteria is defined as:
	  • Safe for humans and wildlife
	  • Non polluting
	  • Stable, with appropriate vegetation cover and erosion and sediment controls in place and functioning
	  • Land condition suitable for existing pastoral land use	

Residual Risk	**Low**	**Risk control effectiveness** **Effective**

6.4.2 Surface Water and Groundwater

Table 19 Environmental Values and Objectives – Surface Water and Groundwater Resources

Environmental Values	• Suitability for agricultural use. • Suitability for human consumption (where applicable).	
Management Objectives	• Minimise impacts to groundwater and maintain surface and groundwater values. • Minimise erosion and sedimentation of waters as a result of water bore drilling activities.	
Activity	**Potential impacts without management controls**	**Management Controls**
• Equipment failure • Groundwater monitoring bore design • Down hole problems • Casing failure • Cement failure • Drill pipe failure • Leak or loss of containment onsite • Disposal of waste – cuttings, associated water and produced water • Groundwater usage	• Aquifer contamination • Loss of aquifer pressure • Contamination of soil, shallow groundwater or surface water body	• Adherence to the Minimum Construction Requirements for Water bores in Australia. Monitoring bore designed and drilled as per requirements and suit the hydrogeological conditions on the site, be appropriate to protect aquifer and suitable for intended purpose as a monitoring bore. • Licensed drilling to be engaged. • Spill response measures shall be implemented for spills or leaks. Spills of dangerous goods will be collected for treatment and disposal at an approved facility. • Spill kits will be made available where hazardous materials are used and personnel will be trained in correct use. • Emergency response systems shall be in place for responding to contaminant release. • Dangerous goods will be stored, handled, separated and signed as required by the Flammable and Combustible Liquids Regulations and AS1940. • Hazardous goods will be stored in bunded areas away from watercourses. • Refuelling of equipment will not occur within 100m of a water course. • Waste which cannot be recycled will be transported to a designated, approved disposal site. • All refuelling of equipment will have spill kits available. • Plant and equipment shall be inspected and maintained regularly to detect and prevent leakage of liquid contaminants. • Earthworks disturbance to drainage lines will be minimised/avoided wherever possible. Bed level crossing constructed in accordance with section 2.2. • The retention of vegetation buffers surrounding streams and creeks, as outlined in the NTG Land Clearing Guidelines – Northern Territory Planning Scheme 2010. • Stablise stream and creek crossings where unavoidable. • A buffer of 2 km will be maintained between operations and stock water bores. • Surface water will not be used for activities. • No discharges to watercourses. • All grey and treated sewerage waste will be appropriately managed. • Agreements to be reached with land holders and/or Department of Transport for the use of groundwater resources. • Sustainable use of groundwater measures will be implemented including the monitoring and recording of water used for any approved construction, drilling and stimulations.
Performance Measures	• Water usage for civils and water bore drilling below 15.5ML • No unacceptable decline in groundwater resources, as defined as a sustained (12 month +) drawdown of greater than 1m measured at the extraction point • No release of site stormwater or wastewater exceeding baseline surface water quality • No long-lasting change in soil and surface water quality from base line conditions. • Stream and creek crossings disturbance minimised.	
Records	• Records of releases, leaks and associated clean ups are to be managed using Origins Incident Management System (OCIS). • Groundwater use data recorded and reported to DENR as per water extraction licence. • Rectification work requirements and actions will be recorded in OCIS.	

Residual Risk	Low	Risk control effectiveness	Effective

6.4.3 Vegetation, Flora, Fauna and Habitat

Table 20 Environmental Values and Objectives – Vegetation, Flora, Fauna and Habitat

Environmental Values	• Maintain the integrity of significant ecosystems and agriculture productivity. • Maintain habitat elements for native flora and fauna, including species protected by EPBC Act and TPWC Act. • Avoid clearing high value habitat.	
Management Objectives	• Minimise disturbance to flora and fauna. • Minimise disturbance to sensitive areas.	
Activity	**Potential impacts without management controls**	**Management Controls**
• Vehicle and water bore Rig movements • Clearing of vegetation • Rehabilitation	• Disturbance to environmentally sensitive areas and/or flora and fauna species • Disturbance of fauna • Loss or endangerment of Threatened species • Loss of habitat • Vehicle collisions with fauna – fauna mortality	• Ecological assessment to be undertaken to identify environmentally sensitive areas (flora and fauna habitat). • Clearing to avoid large habitat trees. • Spotter catcher or equivalent to be present when clearing vegetation. • No off-lease driving, stay to approved access tracks. • Personnel will be prohibited from bringing firearms or traps into the lease areas. • Water bore leases will be fenced. • Personnel will be prohibited from interfering with wildlife. • Personnel will be prohibited from bringing domestic pets onto the Program area. • Adequate fire breaks shall be maintained around Monitoring bores to protect asset. • Appropriate fuel and chemical handling and storage measures will be implemented. • Fire extinguishers and firefighting equipment will be provided at each site and for vehicles. • Fire bans will be complied with. • Driving at dawn and dusk to be avoided in accordance with Origin Travel Management Plan. • Rehabilitate back to sites natural state once activities are completed (if required). Monitoring post-disturbance.
Performance Measures	• Monitoring bore lease located to minimise impacts to fauna habitat and sensitive vegetation. • No native fauna impacts (injury or fatality) reported in OCIS during civil and water bore drilling related activities. • Security bond maintained until such time DPIR is satisfied remediation of site. • No loss of sensitive vegetation resulting from Origin's activities.	
Records	• Records of disturbance will be maintained within Origin's GIS. • Records of inspections will be maintained. • All incidents will be reported in Origin's OCIS and corrective action initiated.	
Residual Risk	**Low**	**Risk control effectiveness** / **Effective**

6.4.4 Weeds

Table 21 Environmental Values and Objectives – Weeds (Biosecurity)

Environmental Values	• Maintain the integrity of significant ecosystems and agricultural productivity	
Management Objectives	• Avoid the introduction of weeds • Avoid the spread of existing weeds	
Activity	**Potential impacts without management controls**	**Management Controls**

• Vehicle and water bore Rig movements • Civil construction activities	• Introduction or spread of weeds.	• Activities will adhere to the guidelines within the NT Weed Management Handbook • Weed desktop and field-based surveys undertaken to identify existing weed areas. • Weed management and control measures to be implemented in alignment with existing landholder biosecurity procedures. • All equipment will have certified equipment wash-down completed prior to entry to the field. • Activities will be planned to address prevention of weed or non-indigenous plant spread. • Machinery to be preferentially sourced locally, with machinery sourced from surrounding areas or Queensland being the 2nd and 3rd preferred option respectively. • Pre and post wet (February to May) inspections and periodic audits will be conducted to identify and report weed outbreaks. • Weeds will be actively controlled in cleared/ hardstand areas. • Major equipment moves will be planned from weed-free areas to infested areas and not the other way around. • staff members responsible for preventing, identifying and managing weeds to be appropriately trained. • Ensuring all material imported to or between sites is free of weeds.	
Performance Measures	• No introduction or spread of declared weeds resulting from Origins activities.		
Records	• Records of weed distribution will be maintained within Origin's GIS and if required provided to the Weeds Officer at DENR. • Records of weed inspections will be maintained. • All weed outbreak incidents will be reported in Origin's OCIS and corrective action initiated. • It is noted that under the Weeds Management Act that: *'The owner and occupier of land must… within 14 after becoming aware of a declared weed that has not previously been, or known to have been, present on the land, notify and officer of the presence of the declared weed'.*		
Residual Risk	**Medium**	**Risk Control Effectiveness**	**Effective**

6.4.5 Waste Management

Table 22 Environmental Values and Objectives – Waste

Environmental Values	• Maintain the integrity of ecosystems and agricultural productivity. • Minimise the amount of waste generated.	
Management Objectives	• To minimise impacts on soil, surface water, groundwater, sensitive habitat and air quality. • To minimise creation of food sources or habitat for pest species. • To minimise waste generation through reduce, reuse, recycle programs.	
Activity	**Potential impacts without management controls**	**Management Controls**
• Civil construction works • Water bore drilling and camp operations	• Contaminated land • Encouragement of pest species to waste sites	• Designated waste storage and handling area to be provided onsite. • Consider recycling capabilities when awarding waste contract for civil construction and drilling program. • Removal and disposal of hazardous wastes to be in accordance with NT hazardous waste disposal requirements. • Ensure the availability of spill clean-up equipment for operations. • Undertake inspection of waste storage areas regularly, or after significant rainfall event (greater than 20 mm in 24-hour period). • Grey water from kitchen and showering facilities will be managed in accordance with Part 6 of the DoH *Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent, 2014.* • Domestic refuse to be disposed of in accordance with NT waste guidelines. No incineration of wastes on site. • Identify and remediate the affected area where applicable in accordance with the National Environmental Protection Measure (NEPM) requirements. • Drilling fluids considered acceptable for water bore drilling include water-based drilling fluids and air-based drilling fluids • The makeup water shall be fresh non-polluted water for all water bore drilling fluid preparations. • Mud tanks will be utilised, instead of pits. • Waste (excluding muds and cuttings) to be removed off site for appropriate disposal at licensed landfill facility. • Waste Contractors to be used to be listed on the NT EPA waste handling contractors register (http://www.ntepa.nt.gov.au/waste-pollution/approvals-licences/ep-licences).
Performance Measures	The outcomes of waste management practices can be assessed against the performance criteria for: • The absence of wastes remaining on site at completion of operations (i.e. general rubbish, waste chemicals, workshop wastes including oily rags, containers etc.). • Waste registers maintained for the duration of the project. • Pest species not encouraged to the site.	
Records	• Waste disposal records to be kept for audit purposes and to be provided to DPIR.	
Residual Risk	**Low**	**Risk control effectiveness** **Effective**

6.4.6 Air Quality – Dust and Emissions

Table 23 Environmental Values and Objectives – Air Quality (Dust and Emissions)

Environmental Values	• Rural air environment with qualities conducive to suitability for the life, health and wellbeing of humans.		
Management Objectives	• Minimise environmental nuisance due to dust for sensitive receptors resulting from Origin's activities. • Minimise greenhouse gas emissions.		
Activity	**Potential impacts without management controls**	**Management Controls**	
• Civil construction works • Water bore drilling and camp operations	• Dust emissions • Release of atmospheric contaminants from exhausts • Aesthetic impacts	• Reducing the speed of vehicles on dirt tracks • Monitor road conditions to ensure deterioration with possible increase in dust creation, does not occur and undertake road rehabilitation as required. • Watering of roads when appropriate and agreed with landholders. • All equipment and machinery to be in good working order to minimise vehicle exhaust emissions	
Performance Measures	• Minimal complaints regarding dust/air quality. • Amicable resolution of complaints.		
Records	• All complaints and subsequent actions are to be recorded in Origin's OCIS incident management system.		
Residual Risk	**Low**	**Risk control effectiveness**	**Effective**

6.4.7 Lighting, noise, vibration and visual amenity

Table 24 Environmental Values and Objectives – Lighting, noise, vibration and visual amenity

Environmental Values	• A rural acoustic, lighting, vibration and visual amenity environment conducive to the wellbeing of the community, including its social and economic amenity, and an individual, including the opportunity to have sleep, relaxation and conversation without unreasonable interference from civil works and water bore drilling operations.		
Management Objectives	• Minimise the environmental nuisance for sensitive receivers as a result of civil and water bore activities, including Tourist visual amenity.		
Activity	**Potential impacts without management controls**	**Management Controls**	
• Civil works • Water bore drilling activities	• Noise generation causing and environmental nuisance • Light pollution impacting sensitive receptors • Visual amenity impacts on tourism	• Low impact water bore drilling activity surrounded by vegetated areas. • Drill sites selected to minimise noise and visual amenity impacts on sensitive receptors/ local community. • 6am to 7pm work, with no night time drilling anticipates. • Complaints shall be recorded in OCIS, investigated and responded to appropriately.	
Performance Measures	• Minimal nuisance-related complaints received from sensitive receptors, including landowners. • Amicable resolution of complaints.		
Records	• All complaints and subsequent actions are to be recorded in OCIS		
Residual risk	**Low**	**Risk Control Effectiveness**	**Effective**

6.4.8 Bushfires

Table 25 Environmental Values and Objectives – Bushfire

Environmental Values	• Maintain a natural fire regime of the region. • Protection of public, private infrastructure and equipment.
Management Objectives	• Minimise the risk of causing bushfires from Origin's activities.

	• To minimise impacts on environmental habitat and fauna, soil erosion, impacts on stakeholders, impacts on culturally significant sites, public infrastructure and community lands. • To ensure proper health and safety plan for activities. • To prevent accidental fire risk and ensure safe storage of chemicals to prevent fire damage.		
Environmental Aspects	**Potential impacts without management controls**	**Management Controls**	
• Civil works • Water bore drilling	• Increased incident and intensity of bushfires can lead to vegetation degradation and habitat modification • Damage to or loss of public infrastructure, private infrastructure and equipment or community lands • Damage to or loss of culturally significant sites	• Fire extinguishers to be fitted to all vehicles. • Fire trailer to be on hand to respond to fire. • Emergency response plan developed and implemented to deal with fire. • Establish firebreaks around water bore infrastructure (4 m fire break in accordance with NT requirements. • Firebreaks around production wells must be maintained for life of the lease area. • Access tracks and roads will serve as firebreaks to limit the spread of fire and the availability of water and firefighting equipment on site will assist in fire control.	
Performance Measures	• Successful fire management will be indicated by having no uncontrolled fires occurring as a result of civil works and water bore drilling activities.		
Records	• All incidents of fire to be recorded in OCIS		
Residual Risk	**Medium**	**Risk control effectiveness**	**Effective**

6.4.9 Cultural Heritage and Sacred Sites

Table 26 Environmental Values and Objectives – Cultural Heritage and Sacred Sites

Environmental Values	• Maintain cultural heritage values of the region, both Indigenous and non-Indigenous	
Management Objectives	• To avoid disturbance of or damage to Aboriginal or cultural heritage artefacts or Sacred Sites. • To minimise impacts upon or disruption to activities of Indigenous stakeholders in culturally significant areas. • To ensure adequate background information and training is provided to employees and contractors working in culturally significant areas. • To ensure that the health and safety of exploration workers and the community is not compromised through management of cultural and environmental awareness.	
Environmental Aspects	**Potential impacts without management controls**	**Management Controls**
• Civil works • Water bore drilling	• Disturbance to cultural heritage sites	• Cultural Heritage Clearance (and identification of sites of Aboriginal significance in conjunction with NLC and AAPA) will be conducted prior to commencement of disturbance activities or operations • Activities will be conducted in accordance with the NLC Agreement. • Prepare a Code of Conduct for employees and contractors to assist in the prevention of any possible anti-social behaviour that will affect the local residents. • Identify location of culturally sensitive areas and ensure design avoids these areas where applicable. • Where avoidance is not possible, such as in the case of existing access tracks, an artefact collection protocol is to be implemented in collaboration with traditional owners and NLC. • An unexpected heritage finds stops related work activities within the vicinity of the find (within a 500 m radius) for assessment and direction by an NLC representative. • Ensuring appropriate behaviours are employed outside of work hours. • Site inductions are to ensure that all personnel are aware of the Code of Conduct prepared for social interactions with the community.
Performance Measures	• No incidences of disturbance of archaeological sites or sites of cultural significance, or if disturbance is required, an application to disturb is submitted and approved prior to disturbance	

Records	• A register should be kept of all occurrences of archaeological sites identified during the Project for provision to the NLC, the AAPA and Heritage Branch within DLPE. • Ensure that site personnel and contractors report all new discoveries of archaeological or cultural artefacts, as per Origin's Unexpected Aboriginal Cultural Heritage Find procedure (OEUP-Q1000-PRO-BUS-001). Cease work and effect practical protection measures until the area can be assessed by DLRM personnel.		
Residual Risk	**Low**	**Risk Control Effectiveness**	**Effective**

6.4.10 Community

Table 27 Environmental Values and Objectives – Community

Environmental Values	• Livelihood and well-being of local communities and towns.		
Management Objectives	• Minimise impacts upon environmental values of the local community. • Minimise impacts on cultural heritage. • Minimise safety risks to the public and other third parties. • Maintain and enhance partnerships with the local community, including using local contractors.		
Activity	**Potential impacts without management controls**	**Management Controls**	
• Civil activities • Water bore drilling activities	• Damage to third party infrastructure • Loss of visual amenity-landholder and tourists • Possible danger to health and safety of the community • Increased traffic within the region impacts landholder and tourists	• All areas to be located away from sensitive receptors with lease layouts designed to minimise visual amenity impacts. • Emergency response systems will be in place. • All personnel and site visitors will complete the appropriate inductions. • All activities to be undertaken in accordance with "Code of Practice: Onshore Petroleum Activities in the Northern Territory" (and any land access agreement negotiated between Origin and a landholder at later date) • Use of contractors that have high Indigenous participation in their workforce. • An approved DIPL Traffic Management Plan or exemption to be provided to DPIR prior to commencement of activities.	
• Performance Measures	• An absence of issues arising, which have the potential to affect the work program, is a good indication of successful communications • No unresolved reasonable complaints • An overall social and economic benefit as compared to perceived adverse impacts as derived from consultations with community advisory groups • High level of satisfaction with complaint outcomes and complaint resolution processes. • Where suitable, include Aboriginal employment in the proposed program.		
Records	• Register should be kept of all incidences relating to access issues, unauthorised access and requirements of pastoralists, recognising that these requirements may change seasonally • OCIS complaint register • Land access agreements closed out at completion.		
Residual Risk	Low	**Risk Control Effectiveness**	**Effective**

7. Implementation Strategy

7.1 Corporate Environmental Policy

Origin's activities are governed by the Origin Health, Safety and Environment Management System (HSEMS). This system is underpinned by Origins Health, Safety and Environment (HSE) Policy (Figure 9) which is designed to:

> *"Conduct our business sin a way that causes no harm to the health and safety of people and has no unforeseen impacts to the environment.*

7.2 Environment, Health, and Safety Management Systems

Origin has a mature Health, Safety and Environment Management System (HSEMS) which contains the systems, policies and procedures that Origin has in place to manage and minimise the impact from its activities. In addition to meeting legal requirements, Origin's activities are also governed by several additional internal directives and risk control directives designed to ensure best practice in environmental risk management.

An overview of the Origin HSEMS and the associated directives is provided in Figure 10.

OUR HEALTH, SAFETY AND ENVIRONMENT POLICY

origin

OUR PRINCIPLE OF DUE CARE

We care about the wellbeing of our people and our impact on the environment.

OUR HSE ASPIRATION

To conduct our business in a way that causes no harm to the health and safety of people and has no unforeseen impacts to the environment.

OUR HSE ACTIONS

We all believe that our HSE aspiration is achievable and we embrace our responsibility for supporting it by:

Always mindful of risk

Recognising that risk is present in every task we do and taking the time to identify and understand these risks and manage them safely and responsibly.

Enabled and accountable

Taking ownership and using our authority, resources, systems and competencies to manage the risks associated with our work. We stop work when confronted by an unknown hazard and proceed only when satisfied we can continue safely and responsibly.

Continuously learning

Being open and transparent about how well we are doing and relentless in learning from our experience to manage our risks. We work together effectively, welcome any feedback and recognise that we can always do better.

Our Compass and HSE Management System set out how we will implement this policy.

Frank Calabria
CEO
Origin Energy

ORG-HSE-POL-001 November 2016

Figure 9 Origins Health, Safety and Environment (HSE) Policy

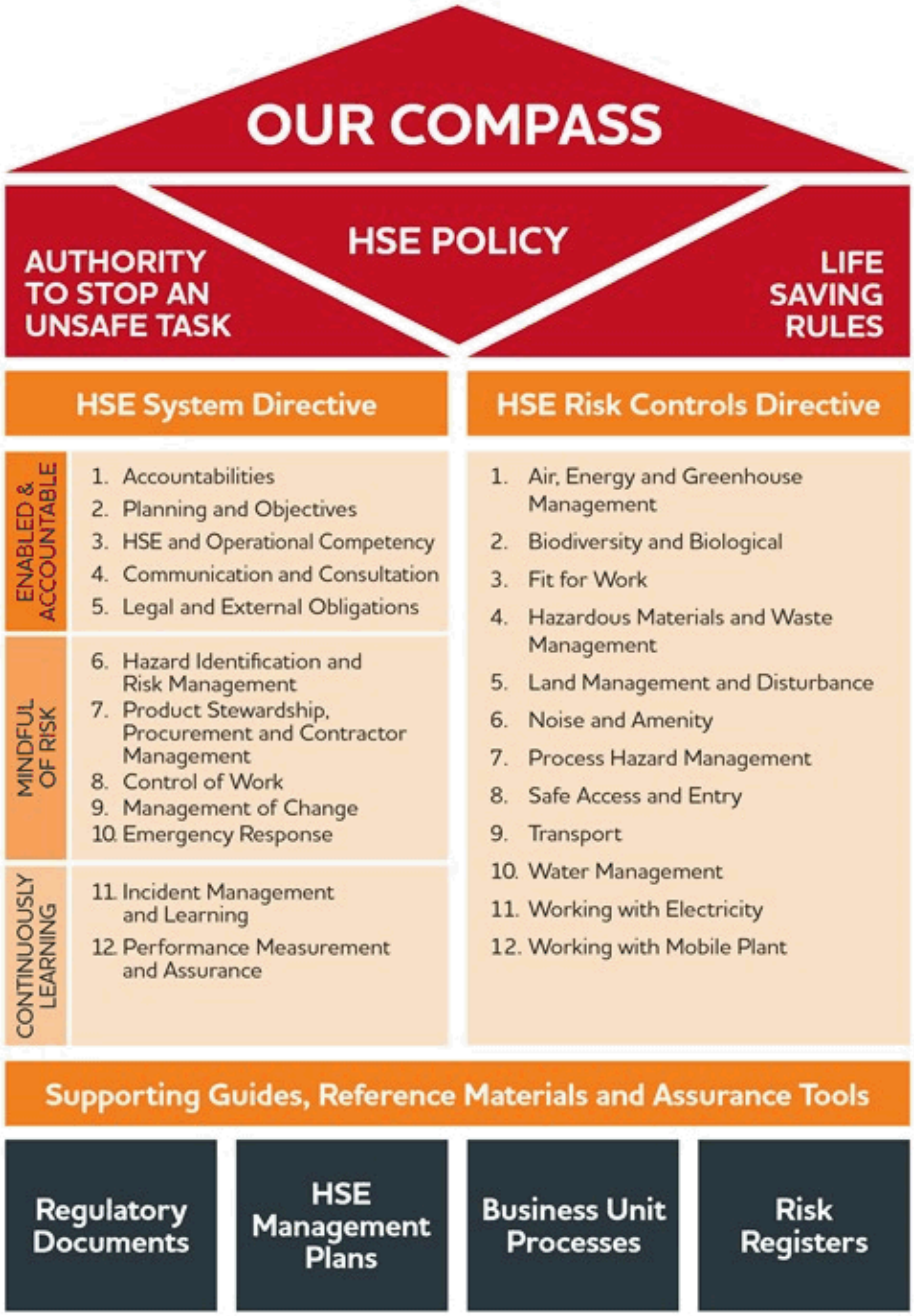

Figure 10 Origins HSEMS Structure

7.3 Roles and Responsibility

The following sections describe in detail the management strategies for specific components of the landscape, such as soil, ground water and vegetation, and the cultural and social environment, in relation to the different impact-causing activities that may occur.

Each management area has been assigned to specific positions within the exploration team, as follows:

- **Asset Manager** – responsible for the overall operations in the Origins activities in the exploration permit area.
- **Project Manager** – oversees the whole planning and execution of the exploration program and is the person ultimately responsible for ensuring all other parties are working within the HSE guidelines. The Project Manager's role is predominantly office-based.

- **Civil Construction Superintendent** – person based in the field responsible for ensuring all areas of operations and construction are carried out in accordance with the EMP and Origin' HSE Policy. All contractors report to this position, who is responsible to the Project Manager.

  This role will also cover the role of the weeds officer, who will be responsible for:

- Planning and execution of weed monitoring requirements, including baseline weed assessments and ongoing monitoring both during periods of gas related activities as well as during the target identification period of February to May.
- Facilitate training all workers (including contractors) in weed management requirements, with support from the Northern Territory Government Regional Weed Officer - Onshore Shale Gas Development.
- Oversight of implementation of weed control mechanisms including but not limited to wash-downs and proactive weed control programs.
- Ensuring all reporting requirements are met.
- Act as the designated point of contact for and rapidly responding to any weed related complaints and incidents in accordance with the pre-determined strategies in this WMP and additional strategies as required developed in consultation with the Regional Weed Officer - Onshore Shale Gas Development and affected landholders.
- Review and update of WMP's to remain effective in communication with relevant landholders and Regional Weed Officer - Onshore Shale Gas Development in consideration of monitoring results and emerging weed issues for both gas and pastoral operations.
- **Water Bore Driller** – Water Bore contractor responsible for contractor's equipment and personnel, adherence to the current version of the *Minimum Construction Requirements for Water bores in Australia* National Uniform Drillers Licensing Committeeto minimise impact of activities on the environment and in accordance with this EMP.
- **Civil Design Consultant** – An individual or organisation that provides professional or expert advice in the field of civil engineering and design. They determine the best locations, design, materials and construction techniques for undertaking a project to ensure it meets the needs of the end user.
- **Health Safety and Environment Representative (HSE Representative)** – Origin representative providing guidance and advice to site personnel on the day-to-day management of the environment. This role is the will also support the nominated weeds officer, specifically in the planning and reporting phases.
- **Field Personnel** – All staff including Origin and contractors that are working on in the exploration permit areas.

7.4 Training and Awareness

Origin HSEMS outlines the policies and procedures governing the training and competency of all personnel (staff and contractors) to ensure they can fulfil their obligations under this EMP and the broader Origin HSEMS.

These systems include:

- General Origin HSE induction
- Contractor HSE prequalification process
- Contractor management system-
- Site specific inductions
- Task specific training and competency requirements

As most activities completed under this EMP will be implemented by contractors, contractors will be required to demonstrate they have appropriate systems, procedures and training to manage specific risks covered under this EMP prior to award. The following aspects will be considered during tender award:

- Maturity of HSE systems and process.
- Previous HSE performance
- Existing procedures and training:
  - Weed identification and management

- Refuelling procedures
- Procedures for avoidance of potential fauna habitat and any identified heritage sites
- Hazardous material and waste management procedures
- Incident notification and management processes

- Internal training programs
- Internal auditing processes.

All staff and contractors entering the site will be required to attend a site-specific induction. The induction covers the following aspects:

- Regulatory requirements, for the area, including specific conditions on the exploration permits and agreements with the NLC.
- Environmental considerations and special procedures to be used for environment protection, as well as, protection of archaeological and cultural sites within the permit areas.
- Safety procedures covering the safe use of vehicles, equipment and explosives first aid and
- HSE in remote area operations.
- Landowner sensitivities, including Aboriginal communities and their specific cultural requirements.
- Procedures for handling any culturally or archaeologically sensitive materials that may be discovered.
- Provide training in safe storage and handling of flammable and combustible liquids.

7.5 Environmental Commitment Summary

The responsibility for general environmental monitoring rests with all personnel engaged on the project. More specifically the Origin Project Manager shall ensure each element of the groundwater monitoring bore drilling programs are monitored to ensure that appropriate environmental protection/procedures are in place.

The program environmental commitments are outlined in Appendix G and are sourced from the risk management controls specified in Section 6.4. The implementation and compliance against these risk controls will be assessed as part of the annual environmental report (refer Section 7.9).

Specific commitments will be to:

- recording of information to track performance, including non-conformances and corrective actions.
- inspection and monitoring of operational controls on site via regular environmental monitoring
- assessing the level of conformance with objectives and targets detailed in this EMP.

The Operating Company Representative shall undertake random site inspections and direct such action as may be considered necessary to protect, minimise or rectify any environmental concerns.

7.6 Incident Reporting

Incident reporting and investigation provides the mechanism to prevent a recurrence. Personnel are required to proactively report all incidents, near-misses and identification of potential hazards.

Origin utilises an online incident management and reporting system. Any environmental incident, near miss or observation is reported through the online incident reporting system. All personnel are encouraged to report minor events to act as an alert to environmental risks and to maintain a program of continual improvement.

7.6.1 Recordable incidents

The Regulations define a recordable incident as an incident arising from the activity that breaches an environmental objective or performance standard in the EMP that applies to the activity, and is not a reportable incident.

7.6.2 Reportable Environmental Incident Reporting

As per Part 3, Division 1 of the Petroleum (Environment) Regulations, a reportable incident means an incident arising from a regulated activity that has caused, or has the potential to cause, material environmental harm or serious environmental harm as defined under the Petroleum Act. The interest holder must notify (this may be oral or in writing) DPIR of a reportable incident as soon as practicable but no later than 2 hours after the first occurrence of the incident or after the time the interest holder becomes aware of the incident

DPIR will be notified through the DPIR Operations Term Emergency number 1300 935 250.

The verbal report to DPIR will be followed up by a written report from the Project Manager within 3 days in accordance with the NT Petroleum Act.

7.7 Monitoring, assurance and Non-conformance management

In addition to regular monitoring as set out in this document, audits assessing compliance with this EMP will be undertaken by a suitably qualified person during the commencement of the activity. System deficiencies, adverse or potentially adverse environmental conditions arising from site activities may be subject to the issue of Environmental Non-conformances or Corrective Action Requests. These non-conformances or corrective actions shall be logged, and remedial actions identified and implemented. The status of corrective actions will be tracked and reported annual in the annual environmental report.

Due to the limited scope of the works within this EMP, it is proposed that audits will be restricted to weekly site/compliance inspections during the construction of access tracks and drilling of monitoring bores. Assurance audits of implementation of the EMP commitments will be completed annually and included in the annual environmental report.

Table 28 EMP Audit Schedule

Audit Type	Scope of Audit	Frequency	Responsibility
Site Inspections	Significant issues to be inspected as required with results recorded on checklist. Items to be actioned as required	Weekly	HSE Representative, Civil Construction Supervisor and Operating Company Representative
Annual Assurance	Compliance against EMP commitments and risk management controls	Annually	OE HSE Representative

Origin shall also comply with any auditing regime set by relevant external Authorities.

7.8 Emergency Response Plan

An Emergency Response Plan (ERP: OEUP-NT2000-PLN-SAF-001) has been developed covering the proposed activities within the EMP. The ERP provides a broad framework for managing potential emergency incidents to minimise the potential risk to human safety and the environment.

The ERP covers the following aspects pertinent to the drilling of groundwater monitoring bores and associated infrastructure:

- Spills and loss of containment
- Bushfires
- Medical emergencies.
- Emergency incident reporting

7.9 Reporting

Internal and government reporting on performance standards will be carried out by the Origin authorised representative, and distributed to Origin management and the DPIR, in accordance with condition 11 and 35 of the NT Petroleum (Environment) Regulations 2016. Quarterly and annual reports shall be completed to summarise the compliance with this EMP, whether the environmental outcomes and performance standards in the plan were met and summarise the details of any recordable and reportable incidents.

Table 29 EMP Reporting Schedule

Frequency	Report name	Recipient
Quarterly	Quarterly incident report summarising recordable incidents during the period	DPIR
Annual	An annual environmental report shall be prepared and submitted to the regulator covering the following: - Summary of the works completed under the EMP during the reporting period.	Origin management DPIR

Frequency	Report name	Recipient
	- Compliance against performance criteria and standards. - A summary of environmental incidents that occurred during the year (i.e. reportable and recordable incidents that occurred). - Any environmental studies or research associated with the activity. - Technical improvements. - Consultation undertaken. - Results of related research or of an ongoing monitoring program, etc.	

7.10 Record Keeping

The following records shall be retained within Origins Document Management system for a period of 5 years

- records linked to measurement criteria, commitments and statutory reporting requirements;
- induction records;
- waste records;
- hazardous goods manifests;
- fuel usage;
- weed inspections;
- non-compliances and corrective action records;
- internal audits and inspection records; and
- management of change records.

7.11 Rehabilitation

The proposed leases and water bores will form a part of Origin's ongoing Exploration program.

Once a determination has been made to decommission an asset, a site-specific rehabilitation plan shall be developed for each disturbed area. Transfer of ownership of an asset to a landholder for beneficial use will be the priority. A transfer of ownership shall be

  - Assessment of the current status of the asset and whether it can be beneficially used by the local landholder
  - Where a beneficial use is anticipated, identify works required to be undertaken to ready asset for transfer (i.e. any repairs, site remediation, equipment removal etc.)
  - Obtain written consent with landholder to take ownership of asset and any stipulated liabilities. accepts all ongoing liabilities (which will be documented)
  - Where an asset cannot be beneficially utilised, the site shall be rehabilitated using assisted natural regeneration back to a safe, stable landform consistent with surrounding land use. This may include
- Removal of all weeds and contaminated materials/ wastes
- Re-spreading of stockpiled topsoil
- Reshaping the site to as close to natural form as possible
- Ripping or scarifying any compacted surface
- Spreading seed of suitable local native species.

Where rehabilitation of a site is undertaken, rehabilitation monitoring will be undertaken annually to assess the rehabilitation success and determine where additional remedial works are required.

7.12 EMP Review

Implementation of this EMP will be continually monitored and revised as required based on monitoring and audit results, complaints, employee and stakeholder feedback, change to the proposed work program or a material increase in risk level.

A formal review, update and resubmission of this EMP will be undertaken every 5 years.

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9. Acronyms & Abbreviations

Acronym	Meaning
ºC	Degrees Celsius
%	Percentage
AAPA	Aboriginal Areas Protection Authority
ABS	Australian Bureau of Statistics
AICS	Australian Inventory of Chemical Substances
ALA	Atlas of Living Australia
ANZECC	Australian and New Zealand Environment Conservation Council
API	American Petroleum Institute
APPEA	Australian Petroleum Production and Exploration Association
AS	Australian Standard
CAS number	Chemical Abstracts Services number
CDEP	Community Development Employment Program
CEEVNT	Critically Endangered, Endangered, Vulnerable and Near Threatened
CLA	Cambrian Limestone Aquifer
CLC	Central Land Council
Cth	Commonwealth
DoH	Department of Health (NT)
DOTEE	Department of The Environment and Energy (Cmwlth)
DPIR	Department of Primary Industries and Resource (NT)
DLPE	Department of Lands, Planning and the Environment (NT)
EPA	Environment Protection Authority (NT)
EIS	Environment Impact Statement
EP##	Exploration Permit (e.g. EP76, EP98 and EP117)
EMP	Environmental Management Plan
EPBC	Environmental Protection and Biodiversity Conservation
ERS	Emergency Response Plan
GPS	Global Positioning Device
Ha	hectare
HSE	Health, Safety and Environment
HSEMPs	Health, Safety and Environmental Management Plans
HSEMS	Health, Safety and Environment Management System
IBA	Important Bird Area
ILUA	Indigenous Land Use Agreement
ISO	International Organisation for Standardisation
JV	Joint Venture
Km	Kilometre

Acronym	Meaning
km^2	Square Kilometres
km/hr	Kilometre per hour
LAG	Local Aboriginal Group
m	metre
MD	Measured Depth
MNES	Matters of National Environmental Significance
MSDS	Material Safety Data Sheet
mTVD	metre True Vertical Depth
Mm	millimetre
NATA	National Association of Testing Authorities
NEPM	National Environmental Protection Measure
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NLC	Northern Land Council
NORMs	Naturally Occurring Radioactive Materials
NT	Northern Territory
OHS	Occupational Health and Safety
PER	Public Environment Report
RWA	Restricted Work Area
SIA	Social Impact Assessment
SMS	Safety Management System
SWL	Standing Water Level
TDS	Total Dissolved Solids
TMP	Traffic Management Plan
TO	Traditional Owner
TPWC Act	*Territory Parks and Wildlife Conservation Act*
TRH	Total Recoverable Hydrocarbons
TSS	Total Suspended Solids
UCS	Unconfined Compressive Strength
VOCs	Volatile Organic Compounds
WoNS	Weed of National Significance