



BENNETT RESOURCES

Valhalla Gas Exploration and Appraisal Program

Section 38 Referral – Supporting Information Document

[BNR_ENV_RE_002]

VERSION HISTORY

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Acronyms/Definitions

Acronym	Expansion/Definition
AICS	Australian Inventory of Chemical Substances
ALARP	As Low As Reasonably Practicable
AQMS	Air Quality Monitoring Station
ATU	Aerobic Treatment Units
bbl	Barrel, a unit of volume for crude oil and petroleum products
BC Act	(WA) <i>Biodiversity Conservation Act 2016</i>
BCF/ sq km	Billion cubic feet of gas per square kilometre
BME	Black Mountain Exploration Pty Ltd
BNR	Bennett Resources Pty Ltd
BTEX	BTEX compounds and found in crude oil and include: Benzene, Toluene, Ethylbenzene and Xylene
CH ₄	Methane
COPC	Contaminants of Potential Concern
CO ₂	Carbon dioxide
DAWE	(Commonwealth) Department of Agriculture, Water and the Environment
dBA	A-weighted decibels. These are an expression of the relative loudness of sounds in air as perceived by the human ear
DBCA	(WA) Department of Biodiversity, Conservation and Attractions
DMIRS	Department of Mines, Industry Regulation and Safety
DO	Dissolved Oxygen
DRF	Declared Rare Flora
DWER	Department of Water and Environmental Regulation
EIA	Environmental Impact Assessment
EP	Environment Plan
EP 371	Exploration Permit 371
EP Act	(WA) <i>Environmental Protection Act 1986</i>
EPA	(WA) Environmental Protection Authority



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Acronym	Expansion/Definition
EPBC Act	(Commonwealth) <i>Environment Protection and Biodiversity Conservation Act 1999</i>
ERD	Environmental Review Document
ESA	Environmentally Sensitive Area
GHG	Greenhouse Gas
HF	Hydraulic Fracturing
HFC	Hydrofluorocarbons
HFS	Hydraulic Fracturing Stimulation
IBRA	Interim Biogeographic Regionalisation for Australia
ILUA	Indigenous Land Use Agreement
LAUA	Land Access and Use Agreement
mS/m	milliSiemens per metre is a measure of electrical conductivity of a solution or soil and water mix that provides a measurement of salinity
NATA	National Association of Testing Authorities
NGER	National Greenhouse and Energy Reporting
NGER Act	(Commonwealth) <i>National Greenhouse and Energy Reporting Act 2007</i>
NORM	Naturally Occurring Radioactive Material
N ₂ O	Nitrous oxide
NO _x	Nitrogen Oxides
NT	Northern Territory
OSCP	Oil Spill Contingency Plan
PDWSA	Public Drinking Water Source Areas
PEC	Priority Ecological Communities
PFC	Perfluorocarbons
PGER	Petroleum and Geothermal Energy Resources
PGER(E)R	Petroleum and Geothermal Energy Resources (Environment) Regulations 2012
PGER Act	(WA) <i>Petroleum and Geothermal Energy Resources Act 1967</i>
PMST	Protected Matters Search Tool



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Acronym	Expansion/Definition
PM _{2.5}	Fine Particulate Matter of diameter of 2.5 micrometres or less
PM ₁₀	Particulate Matter of a diameter of 10 micrometres or less
ppbv	Parts per billion by volume, a unit used to measure concentration in air. This represents the number of molecules of pollutant per billion molecules of air
QA / QC	Quality Assurance / Quality Control
SF ₆	Sulfur hexafluoride
SO ₂	Sulfur dioxide
t CO ₂ -e	Tonnes of carbon dioxide equivalent
TEC	Threatened Ecological Communities
TDS	Total Dissolved Solids
TRH	Total Recoverable Hydrocarbons
VOC	Volatile Organic Compounds
WA	Western Australia
WMO	World Meteorological Organization

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1 Introduction

1.1 Purpose

This document has been prepared to support the formal referral of Bennett Resources Pty Ltd Valhalla Gas Exploration and Appraisal Program (the Proposal), under Section 38 of the *Environmental Protection Act 1986* (EP Act). It provides supplementary information on the Proposal characteristics (Section 2), potential environmental impacts and proposed mitigation measures (Sections 5 and 6), and other key environmental and regulatory approvals (Section 1.4). This document has been prepared in accordance with the Environmental Protection Authority's (EPA) Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures (EPA 2016a) and Procedures Manual (EPA 2020a).

1.2 Proposal Summary

The Proposal is to complete an unconventional exploration and appraisal drilling and Hydraulic Fracture Stimulation (HFS) program within Petroleum Exploration Permit EP 371 (EP 371) in the Canning Basin, within the Shire of Derby-West Kimberley in Western Australia (WA).

The intent of the Proposal is to evaluate the large tight gas resource in the region which has the potential to offer long-term energy security to Australia. The onshore Canning Basin is an early Ordovician to early Cretaceous aged geological basin that covers approximately 430,000 km² in the West Kimberley region. The Proposal is targeting hydrocarbons in the Laurel Formation, with hydrocarbon shows present at depths in the order of 2,000 m to 4,000 m below ground level.

The Development Envelope is located approximately 123 km south east of the town of Derby (Figure 1-1 and Figure 1-2). The Proposal comprises the construction of up to 20 wells in a region of the Canning Basin that has previously been surveyed and explored for petroleum purposes. Following well construction, HFS will be undertaken to appraise the hydrocarbon flow rates.

The Proposal includes the following activities: site preparation operations, drilling operations, HFS operations and site reinstatement. These activities are proposed to be undertaken in a staged manner over a period of seven years. The overall expected disturbance footprint within the Development Envelope is approximately 109 hectares (ha).

The Traditional Owners within the Proposal have a good understanding of and experience with HFS activities. They support the current Proposal and the ongoing appraisal and development of the resource (Figure 1-3).

1.3 Proponent Details

The instrument holder and operator of EP 371 is Bennett Resources Pty Ltd (BNR), a wholly owned subsidiary of Black Mountain Exploration Pty Ltd (BME). BNR is the nominated operator for EP 371 and the proponent for the Proposal. Contact details are provided in Table 1-1.

Table 1-1: Proponent contact details

Name	Ashley Zumwalt-Forbes
Position	Co-Founder, President and Chief Operating Officer
Organisation	Bennett Resources Pty Ltd
Address	Level 9, 40 The Esplanade, Perth WA 6000
Email	perthoffice@bennettresources.com.au



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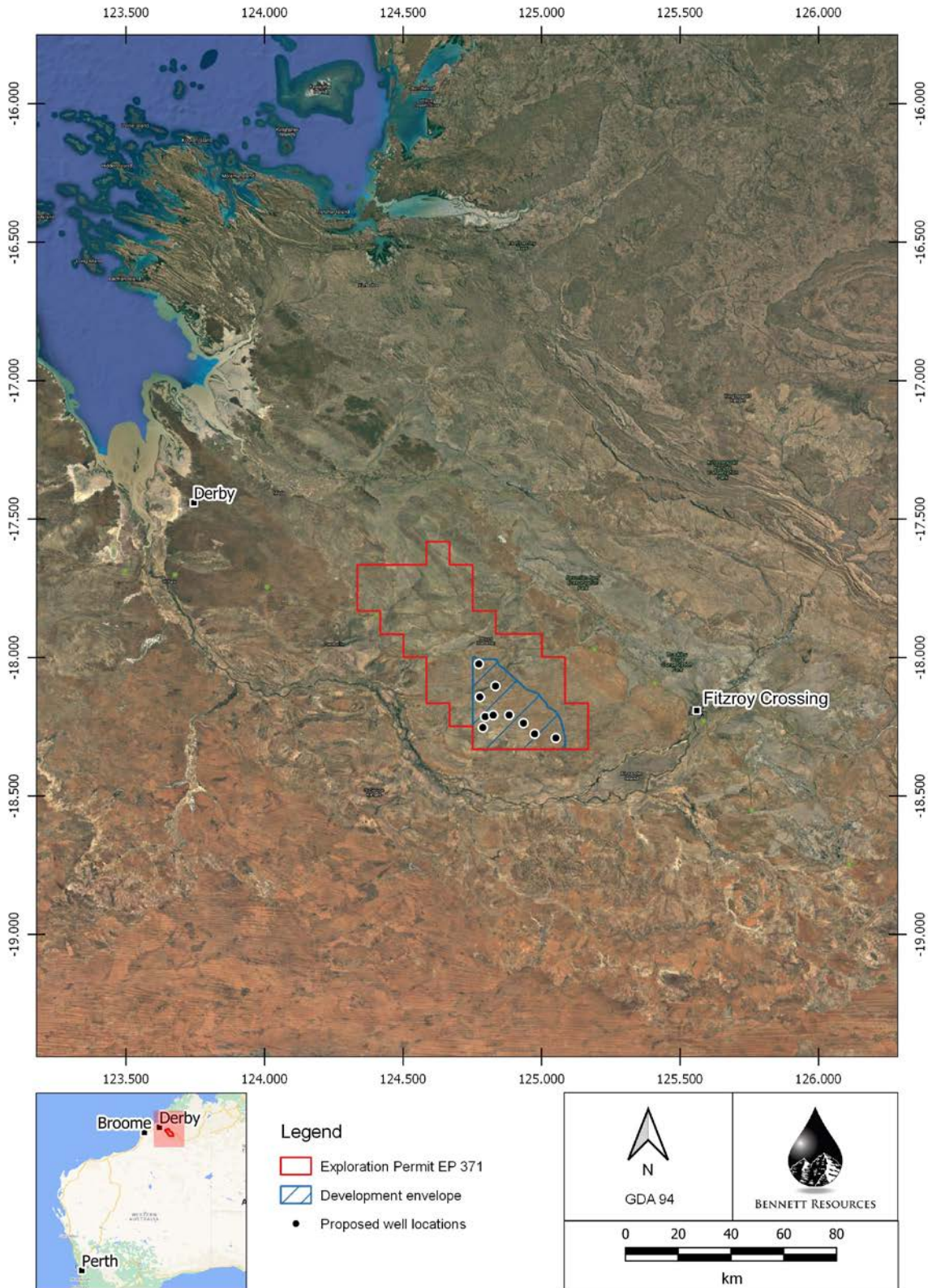


Figure 1-1: Regional location of the Development Envelope



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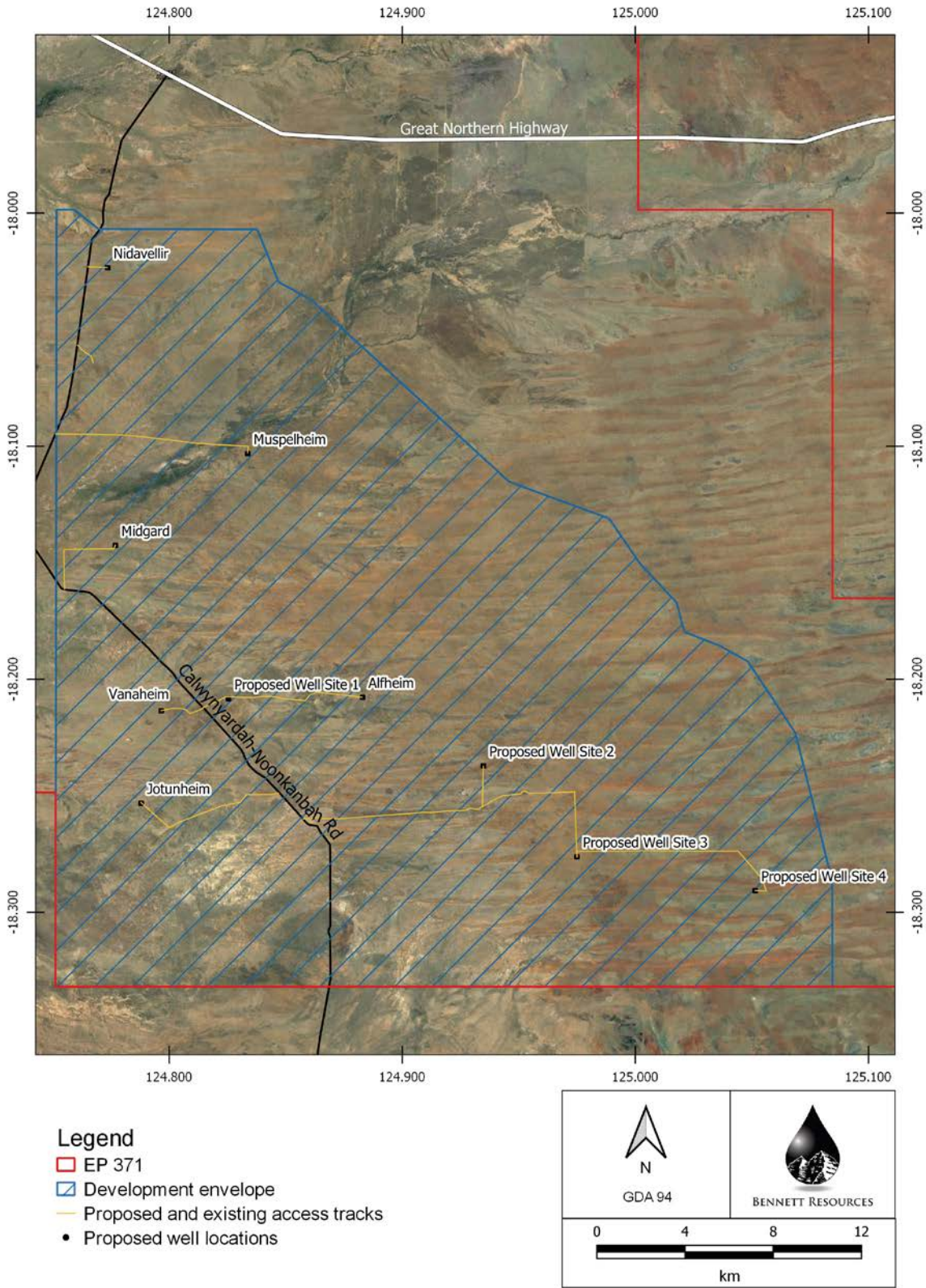


Figure 1-2: Proposed well site locations



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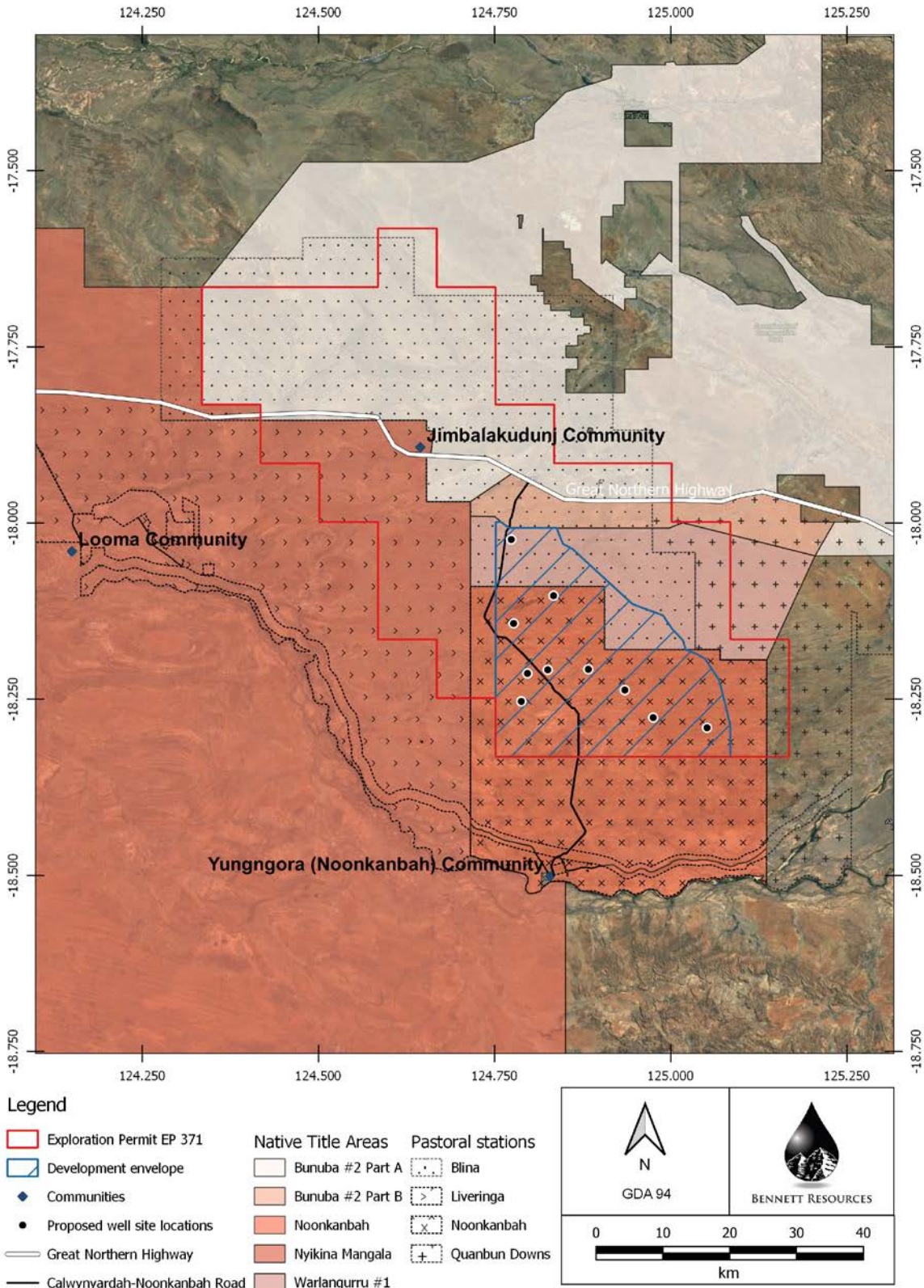



Figure 1-3: Native Title areas, pastoral stations and nearest communities within EP 371

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1.4 Other Approvals and Regulations

In addition to the required approvals under Part IV of the EP Act, a summary of the other key environmental and regulatory approvals required to be in place for the Proposal is provided in Table 1-2.


Table 1-2: Summary of key regulatory approval requirements for the Proposal

Proposal activities	Land tenure / access	Type of approval	Regulatory agency	Legislation regulating the activity
Drilling and well testing	EP 371	Environment Plan	DMIRS	<i>Petroleum and Geothermal Energy Resources (PGER) Act 1967</i>
		Oil Spill Contingency Plan		PGER (Environment) Regulations 2012
		Well Management Plan		PGER (Resource Management and Administration) Regulations 2012
		Safety Management System – Health and Safety Management Plan		PGER (Management of Safety) Regulations 2010
		Emergency Response Plan		
Land use within a Native Title claim and determined areas	Native Titles	Native Title agreements via an Indigenous Land Use Agreement and a Land Access and Use Agreement	National Native Title Tribunal	<i>Native Title Act 1993</i> Native Title (Indigenous Land Use Agreements) Regulations 1999 Native Title (Prescribed Body Corporate) Regulations 1999
Water extraction from bores	Surficial aquifer underlying Development Envelope	26D Licence to construct a well / bore 5C Licence to take water	DWER	<i>Rights in Water and Irrigation Act 1914</i>
Accommodation and associated infrastructure	EP 371	Development / Planning Approval	Shire of Derby-West Kimberley	<i>Planning and Development Act 2005</i>
		Building Permit		<i>Building Act 2011</i>
		Permit to install an apparatus for the treatment of sewage		<i>Health Act 1911</i> Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974

1.4.1 Petroleum and Geothermal Energy Resources Act 1967

The WA Department of Mines, Industry Regulation and Safety (DMIRS) is responsible for the administration of various acts including the *Petroleum and Geothermal Energy Resources Act 1967* (PGER Act). Under this act, various subsidiary legislation has been enacted, which require BNR to seek additional approvals from DMIRS prior to implementation of the Proposal.

Under the Petroleum and Geothermal Energy Resources (Environment) Regulations (PGER(E)R) 2012, an Environment Plan (EP) must be accepted by DMIRS for petroleum related activities, before such activities can commence. The EP must evaluate all impacts and risks that are associated with an activity, and demonstrate that with the management measures identified, the impacts and risks are reduced to levels that are 'As Low As Reasonably Practicable' (ALARP). Further to this, the EP must demonstrate that the environmental impacts and

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risks are acceptable. Included as part of an EP is the requirement to submit an Oil Spill Contingency Plan (OSCP) for approval. An EP cannot be accepted without an approved OSCP. The OSCP covers all spill scenarios associated with the activity.

Under the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015, a Well Management Plan (WMP) that describes the history of all well activities relating to the planning, design, construction, integrity and management of a well throughout its life cycle must be approved by DMIRS. Among other requirements, the WMP is required to explain the philosophy of, and criteria for, the design, construction, operational activity and management of the well and the possible production or injection activities of the well. The WMP covers the drilling and HFS program and identifies the operational risks. The WMP adopts a risk-based approach for the exploration of petroleum and ensures operations are undertaken in accordance with good oilfield practice and minimises the risk of aquifer contamination.

The WMP will, at a minimum:

- Identify and assess all risks associated with the well activity and their resultant impacts;
- Establish specific environmental performance objectives and standards against identified risks (including measurement criteria to assess performance of those standards); and
- Detail mitigation measures for identified risks, including those where the likelihood of occurrence is low.

Reporting arrangements to DMIRS are also specified in the WMP, including the results of well logging and pressure tests undertaken during well construction and prior to HFS activities. This approach for managing well activities aims to reduce the risks and impacts to a level that is ALARP.

1.4.2 Review of the HFS Scientific Inquiry

On 5 September 2017, the WA Government announced an independent scientific panel inquiry to assess and report on the potential impacts arising from the implementation of HFS on the onshore environment of Western Australia. The inquiry was established under Section 25 of the *Environmental Protection Act 1986*. Following input from stakeholders, a final report was submitted to the Western Australian Government in September 2018. A key finding of the inquiry was, based on the evidence presented and the international standards for the design, construction and operation of an individual petroleum well incorporating HFS, if properly executed and located, generally limit risks to the environment and people to a low level. To further reduce these risks, respond to community concerns and regulate HFS and its activities, the report identified 44 recommendations aimed at government departments, regulators and HFS proponents.


BNR have reviewed all recommendations arising from the HFS Scientific Inquiry, and have used relevant recommendations to inform mitigation and monitoring requirements of the Proposal. A summary of how these recommendations have been considered or applied to the Proposal is provided in Appendix A.

1.4.3 Western Australian Code of Practice

An enforceable Code of Practice for HFS was a key recommendation of the WA Scientific Inquiry Report (Section 1.4.2). The Code of Practice will include necessary prescriptive requirements and standards across the entire development lifecycle of HFS programs, and ensure that all activities are brought to an acceptable and high standard across the industry. The HFS WA Code of Practice will therefore close out the prescriptive and technical recommendations (Appendix A) published in the WA HFS Scientific Inquiry's final report.


At the time of referring the Proposal to the EPA, the HFS WA Code of Practice was not yet complete. In the current absence of a WA Code of Practice, based on advice from government, BNR have also used relevant sections of the Northern Territory's (NT) Code of Practice for Onshore Petroleum Activities in the NT (Northern Territory Government 2019) to inform mitigation and monitoring requirements of the Proposal.

Approved in May 2019, the NT Code of Practice addresses the management of environmental risks and impacts, combined with safety and operational risks associated with the conduct of regulated conventional and unconventional petroleum activities. Standards and processes are outlined through a series of mandatory requirements, to ensure that public and environmental risks and impacts are reduced to a level that is acceptable

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and ALARP. The NT Code of Practice, moreover, ensures that regulated activities are carried out in a manner consistent with the principles of ecologically sustainable development.

BNR will comply with the WA Code of Practice once it is finalised.

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2 Proposal Overview

2.1 Background

The previous operator of EP 371 conducted an initial HFS exploration program in 2015. This program included HFS of two wells named Asgard 1 and Valhalla North 1, previously drilled in 2012. In the lead up to, and during, the 2015 HFS program, a large amount of scientific data was collected. This data demonstrated that HFS activities in this location could be done safely and with low risk to the environment. Studies and surveys conducted during the previous program that are relevant to the Proposal have been included as appendices and summarised / referenced within the relevant sections of this document.

The initial exploration program within EP 371 considered differences in flow rates between vertical zones of the Laurel Formation to identify those formations that provide the best flow rates of hydrocarbons. The program demonstrated that the Laurel Formation produces high quality wet gas that may offer long-term energy security to Western Australia.

2.2 Justification

BNR is proposing to undertake an unconventional exploration and appraisal drilling program with HFS within EP 371, with the purpose of further appraising the tight gas resources in the Laurel Formation.


The Proposal covers the drilling and HFS of up to 20 wells within EP 371 to enable the extent of the reservoir to be further appraised and mapped. Although well locations at the time of writing the Proposal are accurate, it is expected that once additional data is gathered and interpreted, these well locations may be further optimised within the Development Envelope.

Consequently, the Proposal boundary or development envelope for this referral has been defined as the "Development Envelope" in accordance with the EPA instructions on how to define the key characteristics of a proposal.

The coordinates of the Development Envelope are included in Table 2-1 and the area shown in Figure 1-2. The coordinates of the indicative well site locations are provided in Table 2-2 and shown in Figure 1-2. For the purpose of this Proposal, two wells are planned to be located on each well site. An overview of how the well locations are selected is provided in Section 2.2.1.

Table 2-1: Coordinates of the Development Envelope (GDA 94, Zone 51)

ID	Latitude	Longitude
1	-17.99853	124.75168
2	-17.99854	124.75926
3	-18.00684	124.76969
4	-18.00698	124.83774
5	-18.02966	124.84703
6	-18.03715	124.86095
7	-18.05179	124.87666
8	-18.11532	124.94590

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9	-18.13102	124.98873
10	-18.15030	125.00193
11	-18.16707	125.01764
12	-18.17973	125.02107
13	-18.18563	125.03620
14	-18.19241	125.04833
15	-18.22311	125.06868
16	-18.26023	125.07796
17	-18.28700	125.08449
18	-18.33193	125.08459
19	-18.33193	124.75126

Table 2-2: Coordinates of the indicative well site locations (GDA 94, Zone 51)

Well	Latitude	Longitude
Jotunheim	-18.253224	124.787923
Midgard	-18.14258	124.776958
Alfheim	-18.207772	124.882912
Muspelheim	-18.103233	124.833622
Proposed Well 1	-18.208448	124.825451
Proposed Well 2	-18.237182	124.934808
Proposed Well 3	-18.276184	124.974959
Proposed Well 4	-18.290737	124.051452
Vanaheim	-18.213578	124.796585
Nidavellir	-18.023477	124.773575

2.2.1 Site Selection

Consideration is given to multiple constraints when locating well sites. These constraints include environmental sensitivities, proximity to social receptors, Native Title boundaries, and geological prospectivity. The geological prospectivity of an area is identified through the acquisition and interpretation of seismic data. Seismic data

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enables geological prospects to be mapped and the subsequent well locations and appropriate design to be identified.

For the Proposal, the underlying geological formations have been studied to understand the depth and thickness of the target Laurel Formation as well as their depth to recognised useable aquifers. This information is calibrated to data collected from petroleum wells drilled in proximity to the Development Envelope which provides more accurate information on the formation depths.

As stated in Section 2.2, it is expected that once additional data is gathered and interpreted, these well locations may be optimised. In accordance with the approach outlined in the EPA Guidance – Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures (EPA 2016a) and Procedures Manual (EPA 2020a), this document considers impacts in relation to the proposed well locations within the Development Envelope and includes the requirements for a number of verification studies to enable the assumptions and basis for the Proposal to be verified prior to any disturbance activities occurring.

2.3 Key Proposal Characteristics

The Development Envelope is situated in the West Kimberley district. The closest Public Drinking Water Source Areas (PDWSA) are the Camballin Water Reserve and Fitzroy Crossing Water Reserve, approximately located 60 km west and 51 km east, respectively.

HFS activities within the Development Envelope are supported by the Traditional Owners on whose land the Proposal is situated. This is based on their understanding of HFS activities on their country and the environment as informed by their first-hand experience of HFS activities, independent advice received from their experts and the economic benefits the Proposal would bring to the Yungngora and Warlangurru groups.

Further information regarding relevant stakeholders is provided in Section 5.5. Table 2-3 and Table 2-4 summarise the key elements of the Proposal. An activity overview is provided in Section 2.4.

Table 2-3: Summary of the Proposal

Proposal Title	Valhalla Gas Exploration and Appraisal Program
Proponent Name	Bennett Resources Pty Ltd (BNR)
Short Description	<p>The Proposal is to undertake an unconventional exploration and appraisal drilling program within EP 371, located in the Canning Basin, West Kimberley of Western Australia. The Proposal includes the construction of up to 20 exploration wells within 10 well sites.</p> <p>The intent of the Proposal is to further appraise the extent of the tight gas reservoir in the Laurel Formation with hydrocarbon shows present at depths in the order of 2,000 m to 4,000 m below ground level.</p> <p>The total area of the physical disturbance footprint for the Proposal is ~109 ha, including some previously disturbed areas and a proposed clearing envelope.</p> <p>The clearing envelope comprises:</p> <ul style="list-style-type: none"> • Well sites ~ 40.1 ha, • Access Tracks ~59.1 ha, • Camps ~2.8 ha. <p>The estimated maximum clearing envelope for the Proposal is approximately 102 ha.</p> <p>The exploration and appraisal program is expected to commence in 2022.</p>

Table 2-4: Location and proposed extent of physical and operational elements

Element	Location	Proposed extent
Physical elements		



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Element	Location	Proposed extent
Construction of up to 10 well sites ¹	Within the Development Envelope. Indicative well sites provided in Figure 1-2.	Clearing of vegetation will be required for the development of the well sites. The cleared areas for the well sites comprise an area of 200 m x 200 m and include the well sites themselves 180 m x 180 m. Well sites are cleared, graded then sheeted with locally sourced material (such as gravel).
Access tracks	Within the Development Envelope.	Clearing of vegetation will be required for the access to the well sites. To reduce the overall clearing / disturbance footprint, pre-existing access tracks to main roads will be utilised where possible. Access tracks are anticipated to be in the order of 10 m wide.
Main workers camp / laydown	Within the Development Envelope.	Location of the main workers camp(s) is not yet known, but it will be located within the Development Envelope. An area of approximately 0.5 ha is required for the camp which includes all accommodation, kitchen, amenity and recreation buildings. Although only one camp will likely operate at a time, the need for camps within proximity of the well sites means that multiple locations have been identified. Mobile Aerobic Treatment Units (ATU) will be utilised to manage wastewater generated from the rig camp and the main workers camp in accordance with regulatory requirements.
Operational elements		
Well design	N/a	Wells are currently designed for horizontal HFS (Figure 2-1). The Proposal allows for wells to be plugged and side-tracked. BNR expect that the horizontal section of the wellbore will be in the order of 1,500 m during Phase I and up to 3,000 m during Phase II (refer to Section 2.4.1).
HFS intervals (per well)	N/a	Currently the Proposal includes varying HFS intervals for each of the wells. They are expected to range from 2 m to 100 m on the horizontal lateral well section.
Number of HFS intervals (per well)	N/a	The horizontal wells may have up to 50 HFS intervals.
Planned fracture height	N/a	The top of the Laurel Formation zones of interest for HFS treatment is more than 2,400 m deep. Currently BNR's planned fracture heights vary between 50 m and 150 m.
Water extraction	Within each well site	At least two groundwater extraction bores and two monitoring bores will be constructed per well site in accordance with the Department of Water and Environmental Regulation (DWER) requirements. No additional clearing of vegetation is required for their construction. It is expected that a volume of approximately 40 ML of groundwater will be required to support the drilling and HFS treatment of each well.
Water retention ponds	Within each well site	The water retention ponds have been designed with a total holding capacity able to hold the volume of water required for the drilling and HFS operations. The water retention ponds used post HFS treatment have also been designed to hold formation water produced from the well testing operations. The ponds will be

¹ In the event of technical or operational issues during the drilling activity, contingency activities may be required including re-starting the well (re-spudding) or side-tracking the well. A side-track involves drilling a secondary well-bore away from the original wellbore and may result in a horizontal well. This may be done to avoid an unusable section of the original wellbore, or if it is otherwise inaccessible.



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Element	Location	Proposed extent
		lined and designed with sufficient freeboard in accordance with DWER guidelines. Specifically, at the time of writing the Proposal, it is estimated that the water retention ponds could have a total holding capacity in the order of ~160,000 m ³ .
Proppant storage area	Within each well site	It is anticipated that the volume of proppant required for HFS activities (per HFS operation) is in the order of 200,000 kg to 10,000,000 kg respectively for a horizontal HFS treatment. This will be stored in designated areas on the well site. The proppant storage area will comprise a semi-enclosed area to provide a wind break for prevailing winds and minimise associated dust emissions.
Drilling fluid and cuttings "mud sump"	Within each well site	The mud sumps are designed with a total design holding capacity to hold all of the drill cuttings and mud / water generated during drilling operations, as well as providing sufficient capacity to hold water from rainfall events with an allowance for freeboard. Specifically, at the time of writing the Proposal, it is estimated that the mud sumps will have a holding capacity of approximately 5,135 m ³ (26,000 bbl).
Well test flare pit	Within each well site	During well testing, flaring of small amounts of condensate will occur. A well test flare pit will be located adjacent to the retention pond, with overflow pipes running from the flare pit to the pond. The flare pit will be constructed of concrete, coated metal or engineered soils and will be impermeable as per DWER requirements.
Camp and amenities	Rig camp at each well site & main workers camp	A rig camp is provided on the site where operations are conducted and will only be used by key personnel who may be required for immediate response to emergencies or to oversee critical operations. The rig camp may comprise a number of sleeper units, a generator skid, a lunchroom, a training room, a toilet block, a mud lab / service contractor office and offices for key personnel. Leach drains will be installed or mobile ATU will be utilised to manage wastewater generated from the rig camp. The main workers camp will be used by the remainder of the workforce and will include accommodation, a kitchen, laundry, dining room, utility (with water storage), ablutions and gym facilities. Water for the camp will be either supplied from town supplies, trucked in and stored onsite, or sourced from groundwater bores on site and treated through on site reverse osmosis units. Leach drains will be installed at the main workers camp or mobile ATU utilised to manage generated wastewater.
Power generation	Within each well site	All electricity is generated on site for drilling, HFS and ancillary activities using diesel (or gas if practicable) powered generators. As operations during certain phases of the Proposal are conducted on a 24-hour basis, portable lighting towers will be erected on site to ensure a safe working environment.
Atmospheric emissions (well testing)	Within each well site	During well testing operations, baseline air quality monitoring will be conducted and atmospheric emissions (including methane) will be recorded and monitored using static gas samplers.
Waste management	Within the Development Envelope / Waste disposal facility	Disposal of treated septic waste will either be through off-site surface irrigation or through leachate drains, in accordance with the Department of Health requirements. All other waste will be disposed of either at a local landfill or at an appropriately licensed waste disposal facility, in accordance with the Environmental Protection (Controlled Waste) Regulations 2004.



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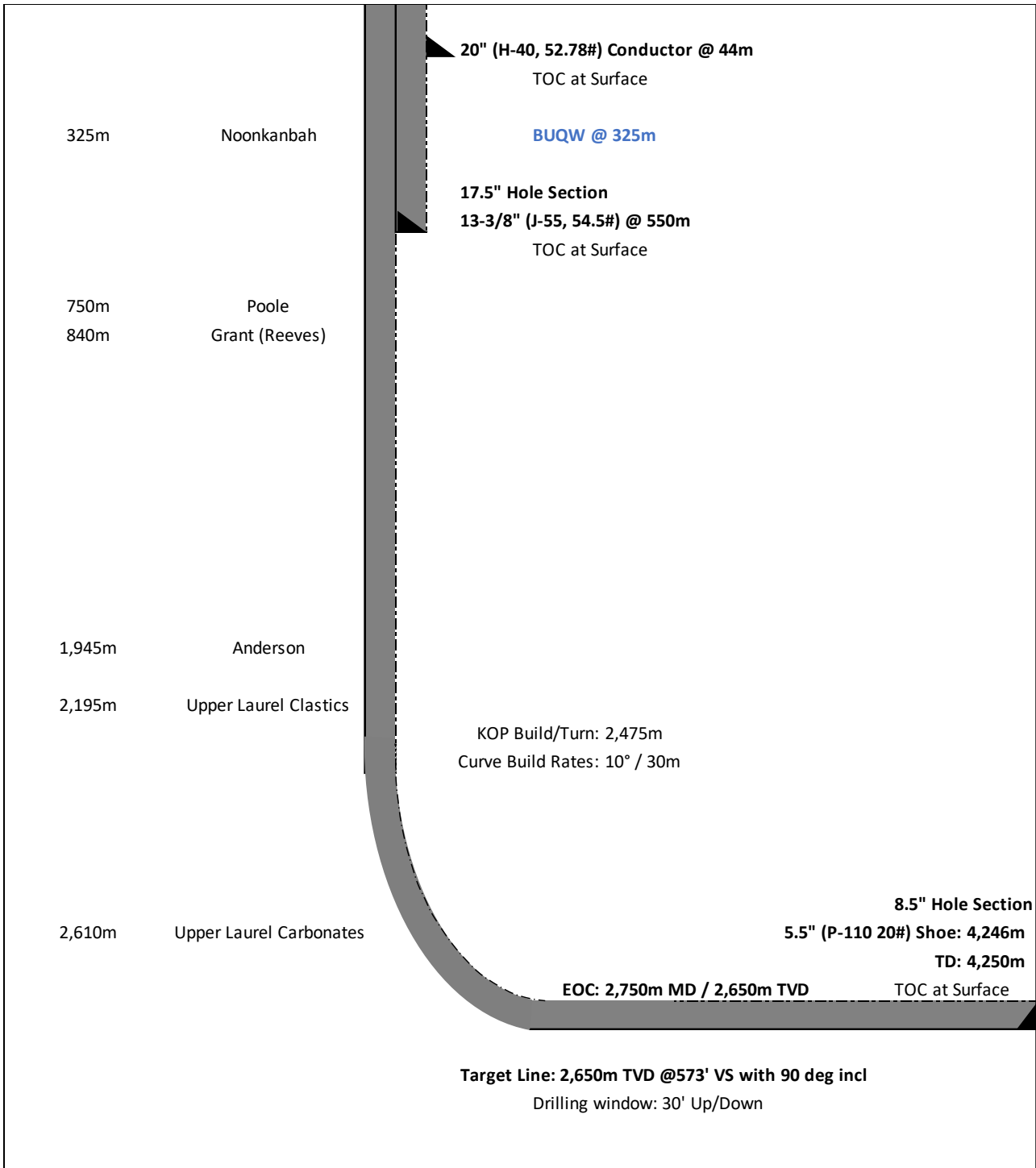



Figure 2-1: BNR indicative horizontal well design

2.4 Activity Overview

BNR plan to conduct the activities as detailed in this proposal over a couple of phases. Specifically, BNR will conduct an initial exploration and appraisal phase associated with the initial six wells, and a further exploration and appraisal phase associated with an additional 14 wells. Although the activities themselves are very similar, an overview of these two phases is provided in Section 2.4.1. Key stages of works and associated tasks are set out in Section 2.4.5-Section 2.4.6. Machinery and equipment, personnel and supplies will be mobilised to the well sites and associated camp site.

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2.4.1 Phases

2.4.1.1 Phase I - Initial Exploration and Appraisal

The purpose of the initial exploration and appraisal phase is to confirm and appraise the positive results from previous exploration activities within EP 371. BNR expect that the initial six well program is sufficient to achieve the following key objectives:

- 1) Acquire quality geological data and confirm the validity of target zones for new or further testing;
- 2) Evaluate the continuity of the regional stratigraphy and integrate information into seismic data;
- 3) Use the collected data to inform vertical completion and/or horizontal targeting; and
- 4) Perform extended production testing on the selected zone(s) to determine economic viability of an ongoing drilling program.

The initial six well locations have been selected to the basis they are believed to be the most prospective for dry-gas production, and strategically located to de-risk Phase II drilling activities. Following completion of Phase I, if the outcomes of the exploration and appraisal program and subsequent economic modelling indicate commercial production is not feasible, Phase II of this program will be terminated.

2.4.1.2 Phase II – Exploration and Appraisal

If the initial six well program indicates commercial production is likely to be economically feasible, it will be followed by the Phase II drilling program that will continue to appraise the reservoir and further delineate the productive limits of the Development Envelope. Specifically, BNR expect that a 14 well program is sufficient to achieve the following objectives:

- 1) Prove continuity of productive tests from the Phase I program to further develop the economic model of the resource;
- 2) Test intervals that showed promise in Phase I, but for any variety of reasons were not able to be tested. Given the productive stratigraphic column is in excess of 2000 metres, it is possible that not all zones of significant interest may be adequately tested during Phase I; and
- 3) Test and evaluate zones of interest in Phase I that were unable to be adequately assessed for technical reasons, e.g. drilling or completion issues, timing, weather, logistics, etc.

2.4.2 Site Preparation Operations


Site preparation operations comprise:

- Civil activities including vegetation clearing and well site construction;
- Construction of well site ponds, pits, sumps and well cellars;
- Installation of groundwater extraction and monitoring bores.

Native vegetation will be cleared for each well site, associated access track and for the main workers camp. As native vegetation is cleared, the vegetation and associated topsoil will be stockpiled and used for future site rehabilitation. Once cleared, the well sites will be levelled (or graded), sheeted with gravel (or similar stabilising material) to support compressive loads or stabilised using cement. Well sites will have a firm subgrade and will be flat with a slight taper to allow for adequate site drainage. Civil works will be undertaken using a combination of heavy and light vehicles. A vehicle-mounted diesel tank will be used to refuel these vehicles.

The below mentioned ponds, sumps and pits will be constructed following the preparation of the well site and prior to drilling activities commencing:

- Ponds and sumps:

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- Water retention ponds;
- Drilling fluid and cuttings “mud sump”;
- Pits:
 - Well test flare pit;
 - Vertical seismic profile pit;
- Well cellars.

Ponds and sumps will be constructed adjacent to the constructed hardstand and lined with a synthetic membrane, as per the Department of Water – Water Quality Protection Note 26 (DoW 2013). Pits will be constructed within the wellsite and are expected to comprise either concrete, coated metal or engineered soils and will be impermeable as per DWER requirements.

Well cellars are cavities below ground level where the wellhead is installed. The well cellar is used to competently hold back the surrounding soils around the wellhead area so personnel can safely work inside this area during drilling and well intervention operations.

At least two groundwater extraction bores and two monitoring bores will be constructed on each of the well sites under the Proposal. These extraction bores will provide water, as required, for the entire drilling and HFS operations. All bores will be installed on the edge of the well sites, with the monitoring bores planned to be installed down the hydraulic gradient of the well sites, as per the Guideline for Groundwater Monitoring in the Onshore Petroleum and Geothermal Industry (DMP and DoW 2016).

2.4.3 Drilling Operations

Drilling operations will comprise:

- Mobilisation of drilling package, ancillary services, rig camp, personnel and supplies;
- Conducting drilling activities;
- Logging activities;
- Well suspension.


Once the well sites are prepared, various equipment, packages and supplies will be mobilised to site. A small rig camp comprising a small number of sleeper units housing up to 8 people, a generator skid, a lunchroom, a training room, a toilet block, a mud lab / service contractor office and offices for key personnel will be established on the well site.

The main workers camp, which will host the majority of the workforce for the duration of activities under the Proposal, will also be established. The main workers camp will comprise accommodation units, a kitchen, laundry, dining room, utility (with water storage), ablutions and gym facilities.

All electricity on site will be generated using diesel powered generators or natural-gas powered generators.

Potable drinking water will either be trucked to location and stored onsite, or sourced from groundwater bores onsite and treated onsite using reverse osmosis units. Two water extraction bores per well site will be constructed and utilised to provide water, as required, for the Proposal. Any spoil generated during the construction of the water bores will be spread in-situ, with this practice being no different to installing water extraction or monitoring bores in other industries.

Toilet facilities will either comprise mobile ATU or septic and leach drains systems. The anticipated daily wastewater volume is estimated to be on average <400 L/day at the well site camp and <2,000 L/day at the main accommodation camp. Where ATU are utilised, treated wastewater will be disposed of through sprinkler surface irrigation systems and sewage sludge stored and disposed of in accordance with regulatory requirements.

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To support drilling and HFS operations, diesel will be stored in bulk on the well site. It is expected that storage on site will be in the vicinity of 75,000 L. A trailered tank or skid-mounted fuel cell will be used for mobile refuelling of equipment (e.g. generators and lighting towers) around the well site.

A designated storage area will be set up on each well site for the storage of chemicals and hazardous materials. In accordance with the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007, a bunded area will be used to store oil, fuel, and hazardous liquid chemicals.

When drilling the petroleum wells, each hole section will be drilled using conventional drilling techniques and a low-toxicity mud system. The cuttings produced from the drilling operation will be stored in the mud sump. As each well section is drilled to the section total depth, a casing string will be run and cemented in place. Once the casing string is run and cemented in place, pressure tests are undertaken to verify the integrity of the casing string. Both the casing and cement are designed to withstand the environmental conditions they are exposed to over the life of the well, including following well decommissioning. The indicative well design is included as Figure 2-1. Drilling operations will be conducted 24 hours per day.

Once the petroleum wells reach total depth, casing integrity will be evaluated using cement bond logs with the target formation evaluated using wireline logging. This method measures the downhole properties and attributes of the Laurel Formation. In the event of technical or operational issues during the drilling activity, contingency activities may be required, these include re-starting the well (re-spudding) or side-tracking the well. A side-track involves drilling a secondary wellbore away from the original wellbore. This may be done to avoid an unusable or inaccessible section of the original wellbore.

Once complete, the wells will be prepared for perforation, HFS treatment, and well testing operations. Prior to these activities being conducted however, the wells will be suspended. During suspension, the well sites will be regularly inspected, and maintenance works undertaken as necessary.

2.4.4 HFS Operations

HFS operations comprise:

- Mobilisation of HFS spread, personnel and supplies;
- Well perforation and clean-up;
- HFS treatment;
- Well testing operations; and
- Well suspension.

Once the wells are constructed and integrity independently validated, HFS equipment, packages and supplies are mobilised to site including the HFS spread. Typical surface infrastructure that may be required for the Proposal is shown in Figure 2-2. Approximately 70 personnel are expected to be located at a single wellsite during HFS operations. The HFS spread is comprised of high-pressure pumps, mixing unit (to blend water, proppant and chemicals), the command centre and coil tubing unit (or equivalent). All high-pressure surface lines and equipment used (including the wells) will be pressure tested during rig-up to ensure integrity before HFS operations commence.



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Figure 2-2: Typical HFS layout

Once the integrity of equipment has been verified, any plugs which have been placed into the well to suspend the well will be removed with any remnant fluid or cement returned to surface and stored in the mud sump, and the casing perforated to provide access to the target formation. The casing will be perforated at selected intervals currently expected to be between 2 and 100 m apart.


Once well perforations are complete, and the well is cleaned up, then HFS operations will commence. Water from the water retention pond is pumped into the blenders where the proppants (sand) and chemical additives are mixed. Chemical additives typically comprise approximately 2% of the HFS fluid composition, and the system proposed to be used is described in Section 2.4.4.1. In accordance with the PGER(E) Regulations 2012, the chemical composition of the downhole fluid system will also be assessed by DMIRS.

Once mixed, the downhole fluid system water will be directed into high-pressure pumps where it is then pumped down the well. Each HFS treatment will create hairline fractures in the target formation with the proppant holding these fractures open, allowing gas to flow to the wellbore. Depending on the well design, well location, reservoir response following testing, the horizontal wells will receive up to 50 treatments for horizontal wells.

Following HFS treatment, the wellbore may be cleaned out with coil tubing with any remnant fluids or proppant returned to surface, and stored in the mud sump. This prepares the well for well testing operations.

During well testing operations, reservoir fluids, including produced gas, are flowed back to the surface and directed through three-phase separators whereby water, condensate (if present) and gas can be separated into their respective phases (Figure 2-3). The entire well testing manifold from the well to a water retention pond and flare comprise a closed piping system. The fate of the three reservoir fluid phases are:

- Gas: Any gas is routed to the well test flare pit, where it is flared off;

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- Condensate (liquid): Based upon previous characterisation of fluids low volumes of condensate are expected to be produced (<25 bbl). The condensate will be routed through to the well test flare pit and flared off;
- Water: Formation water produced from well testing operations is stored in a designated lined water retention pond and left to evaporate.

Well testing operations are 24-hour operations and are expected to be undertaken for a number of months. However, at any time during the operation, activities may cease to enable equipment to be serviced or a change in operations to occur.

The volume and type of fluid coming back to surface will be monitored and recorded, as they will be essential in determining the quality of the reservoir. More information regarding the characterisation of formation water produced from well testing operations is provided in Section 5.4, Section 6.4 and Appendix G.

Once well testing operations are complete, the well will be suspended or shut-in, and well test equipment, ancillary services and personnel will be demobilised from site.

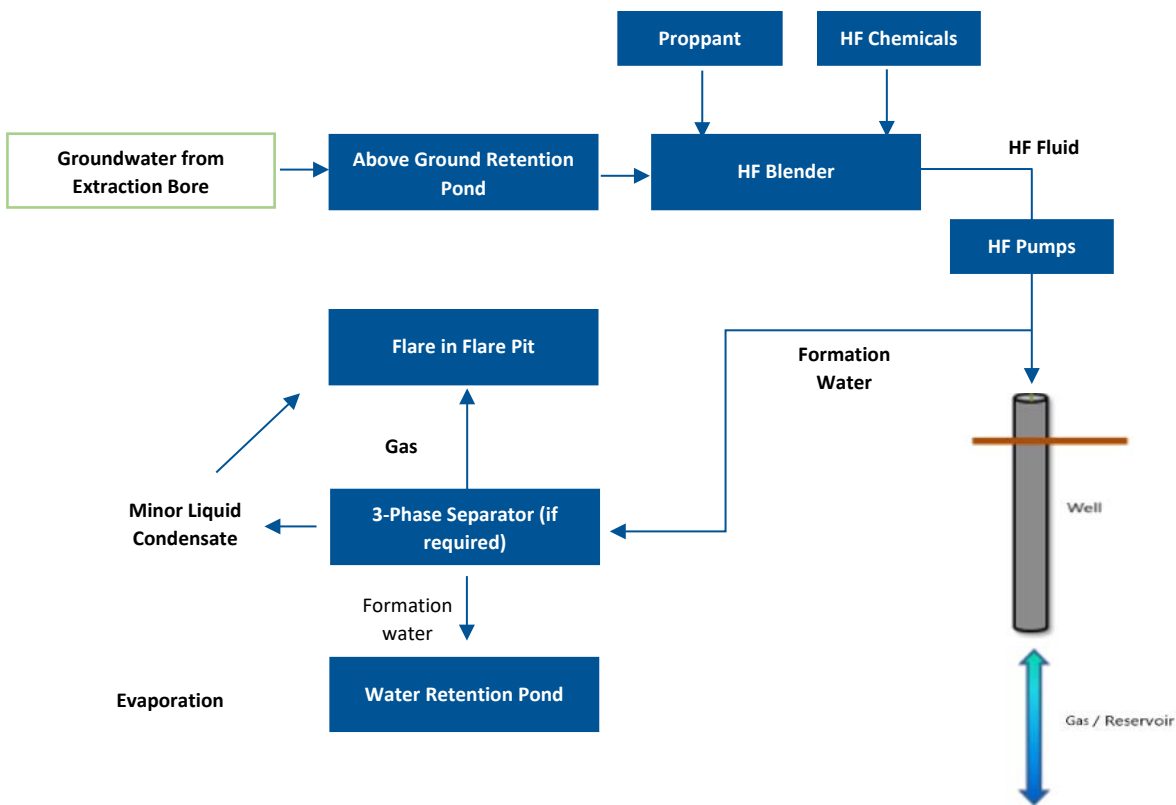



Figure 2-3: Fluids and gas cycle during HFS operations

2.4.4.1 HFS Fluid Composition

The types and use of HFS fluids has evolved greatly over the last 60 years and continues to evolve due to the investment of significant research effort. This has led to the development of “green” HFS fluids that optimise operational objectives and environmental outcomes. One of these fluid systems is Halliburton’s CleanStim Aus® HFS fluid system which is proposed to be used for this program. A chemical risk assessment undertaken for this HFS fluid system has determined that none of the chemicals in the fluid system are classified in their downhole form as carcinogens or teratogens, are not persistent in the environment and do not bioaccumulate. Ecotoxicity testing of the combined fluid system has also previously been undertaken and demonstrated that the fluid system is of very low toxicity.

A chemical disclosure for the fluid system is included as Appendix J.

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2.4.5 Site Reinstatement

Site reinstatement comprises:

- Sampling of pond and sump contents (liquids and solids);
- Sampling of soil beneath pond liners following their removal;
- Evaporation, draining if necessary, and backfilling of ponds, sumps and pits;
- Ripping and contouring hardstands as required;
- Re-spreading of topsoil and stockpiled vegetation.

If installed site infrastructure is no longer required upon completion of all site operations, then where appropriate, infrastructure will be demobilised and sections of the Development Envelope may be reinstated.

Prior to reinstatement, BNR will sample and analyse pond and sump contents. Residual drilling fluid solid waste and drill cuttings subsoils will be sampled for Contaminants of Potential Concern (COPC). Soil samples will also be analysed from beneath the water retention pond and sump liners and from the well testing flare pits to verify no contamination from COPC has occurred.

Soil samples will be compared to site baseline results and ecological screening levels, in accordance with Section 5.2.3.2. During reinstatement, any soil that does not meet landfill guidelines will be removed and disposed of at an appropriate waste disposal facility.

Prior to the liner being removed, fluid contained within water retention ponds, sumps and pits will be left to naturally evaporate. Any previously excavated areas will be reinstated using backfilled stockpiled topsoil, and any remaining vegetation will be spread over this area.

2.5 Waste Characterisation

All aspects of the Proposal were examined to identify and characterise waste products generated from each well site. All waste will be stored, transported and disposed of in accordance with the Environmental Protection (Controlled Waste) Regulations 2004. A summary of the various types of waste generated from each well site is provided in Table 2-5.

Table 2-5: Waste characterisation for each well site

Waste product	Method of disposal
Waste oil	Placed into empty oil drums within a bunded area and removed from site for disposal at an appropriately licensed facility by licenced waste disposal contractor.
Wastewater	Where there is a risk of contamination, wastewater generated from clean down of equipment will be contained and transferred to the mud sump. Where there is no risk of contamination and fresh water is used, it may be released to grade.
General waste including food waste, plastics and rubber products, empty mud and cement product sacks etc.	Placed into rubbish skips with lids or net covers and removed from site for disposal at an appropriately licensed facility by licenced waste disposal contractor.
Steel scrap (including steel casing protectors and drill line)	Stored in one central area after use. Subsequently placed into steel bins and removed from site for disposal at an appropriately licensed facility by licenced waste disposal contractor.
Cuttings and muds	<p>Stored onsite in the mud sump. At completion of drilling operations, cuttings and muds will be tested prior to site reinstatement. Disposal options will be informed by the presence of contaminants in comparison with acceptable regulatory limits.</p> <p>If concentrations of contaminants exceed threshold levels for reuse on site, the material will be disposed of to the appropriate class of landfill or treated until suitable for disposal to lower class landfill or reuse on site.</p>



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Waste product	Method of disposal
	<p>Where no significant volumes of formation water / mud filtrate are present during well testing, BNR may circulate the liquid contents of the mud sump through the flare to incinerate this waste residue from the drilling program. This provides a solution that minimises any waste legacy issues and one which is both environmentally and economically beneficial compared with other options available, consequently reducing any impacts and risks associated with legacy waste sumps to ALARP.</p>
HFS wastes, including formation water, gas and condensate	<p>Once passed through three-phase separators, gas and liquid condensate will be flared off in the well test flare pit.</p> <p>Formation water produced during well testing operations will be stored in lined water retention ponds on site and left to evaporate.</p>
Wooden pallets and other timber goods	<p>Recycled where suitable, otherwise will be placed into rubbish skips and removed from site for disposal at an appropriately licensed facility.</p>
Sewage	<p>Sewage will be managed and treated using ATU or a septic system with leachate drains.</p> <p>Disposal of the treated effluent will either be through off-site surface irrigation or through the leachate drains in accordance with Department of Health requirements.</p> <p>Sewage sludge will be stored on site in sealed tanks and removed from site for disposal by licensed waste disposal contractor.</p>
Metal drums	<p>Placed in central location and removed from site for disposal at an appropriately licensed facility by a licenced waste disposal contractor.</p>

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3 Stakeholder Engagement

3.1 Methodology

In accordance with the Department of Mines, Industry Regulation and Safety's Guideline for the Development of Petroleum and Geothermal Environment Plans in Western Australia (DMP 2016), BNR apply the following methodology to undertake consultation for both their wider operations and activities associated with the Proposal:

- Identify relevant stakeholders;
- Determined how to undertake meaningful engagement;
- Provide sufficient information to ensure the stakeholder is informed;
- Address any objections or claims raised.

BNR have developed an engagement plan based upon this methodology that includes all identified relevant stakeholders to ensure they remain informed and aware of ongoing activities within EP 371. The engagement plan documents the contact frequency and contact details for each stakeholder. Each relevant engagement will be recorded to summarise issues and actions as they arise.

3.2 Relevant Stakeholders

The Development Envelope is located within the Shire of Derby-West Kimberley within the broader West Kimberley region. The Development Envelope is characterised by semi-arid rangelands which are areas of open country used for cattle grazing and by indigenous people for hunting and the collection of bush foods.

A description of the Social Context, Surrounding Land Use and Indigenous and Non-indigenous communities is included in Section 5.5 – Social Surroundings. In summary, the Development Envelope overlays:

- Two pastoral stations (leased Crown Land); the Blina Station and the Noonkanbah Station,, leased for pastoral grazing;
- Two registered Native Title groups, the Warlangurru People (claim application WAD509/2015, also known as the Warlangurru 1 Claim) and the Yungngora (Noonkanbah) People (determination application WAD6229/1998, also known as the Yungngora Native Title Determination) (Figure 1-3).


Based upon the definition of relevance provided by DMIRS (DMP 2016):

any person or organisation whose functions, interests or activities may be affected by the proposed activities

BNR believe that these stakeholders are relevant to the proposal given their functions, interests, or activities have the potential to be directly affected by the Proposal. BNR will therefore continue to engage closely with these stakeholders regarding the Proposal through the remainder of the planning phase and into execution.

BNR also actively engages with relevant government departments, industry associations and those stakeholders who operate in the broader region. These stakeholders include:

- Office of the Environmental Protection Authority (OEPA);
- Department of Mines, Industry Regulation and Safety (DMIRS);
- Commonwealth Department of Agriculture, Water and the Environment (DAWE);
- Department of Water and Environmental Regulation (DWER);
- Department of Primary Industries and Regional Development (DPIRD);
- Commonwealth Scientific and Industrial Research Organisation (CSIRO);
- Shire of Derby West Kimberley (SDWK);

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- Other oil and gas operators;
- Kimberley Development Commission (KDC);
- Regional Development Australia (RDA);
- Kimberley Pilbara Cattleman's Association (KPCA);
- Pastoralists and Graziers Association (PGA).
- Derby Chamber of Commerce and Industry (DCCI);
- Fitzroy Crossing Business Network; and
- Australian Petroleum Production and Exploration Association (APPEA).

3.3 Pastoral Stations

3.3.1 Overview

The Canning Basin is covered by rangeland ecosystems. Key land uses within the Fitzroy River Catchment include 95% pastoralism (cattle grazing), with nature conservation and Indigenous Protected Areas covering the remaining area. In 2018, the gross value of agricultural production was \$77 million/year, predominantly from cattle (Merrin *et al.* 2018). Most rangeland grazing properties are managed as pastoral leases on government owned land (crown land). The average size of cattle stations in the Kimberley is 230,406 ha (DPIRD 2019), with cattle typically grazing on native and introduced vegetation that is rarely cleared for pasture or cropping.

The Development Envelope overlays two pastoral stations (leased Crown Land); the Blina Station and the Noonkanbah Station, that are leased for pastoral grazing purposes.

3.4 Native Title Groups

3.4.1 Overview


The Development Envelope is overlapped by two registered Native Title groups, the Warlangurru People (claim application WAD509/2015, also known as the Warlangurru 1 claim) and the Yungngora (Noonkanbah) People (determination application WAD6229/1998, also known as the Yungngora Native Title Determination).

3.4.2 Native Title Group Engagement

Consultation with relevant Native Title groups has occurred at its own pace and has included the use of translators, where required. This has allowed Traditional Owners time to digest provided information, discuss the provided information with their family and community and make informed decisions. Engagement with the Noonkanbah Community (Yungngora and Warlangurru members) started in 2012 and has followed two engagement phases:

- Planning phase;
- Inform / Consult phase.

During the planning phase, a 'Gas Roadmap' document was developed with the community. This document sought to set environmental, cultural / social and economic objectives for the Native Title groups through the exploration, appraisal and development of the tight gas resource. The Gas Roadmap process was used to guide community engagement through the various stages of field development including exploration and appraisal. An example of the Gas Roadmap as it relates to economic development (training, employment and contracting) with the Noonkanbah Community is provided in Figure 3-1 below.

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Training, Employment and Contracting

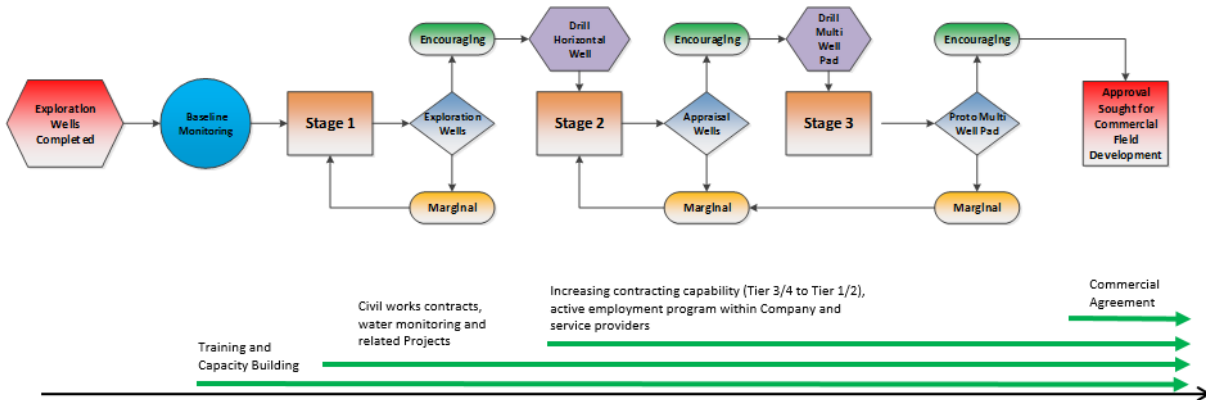


Figure 3-1: Example of Yungngora Community Gas Roadmap relating to economic development opportunities

During the Inform / Consult phase of engagement, an independent specialist review process was supported to enable the Noonkanbah Community to make an informed decision in relation to HFS activities on the permit. The process provided access to advice from independent experts in the fields of groundwater, petroleum engineering, HFS specific risks and community engagement with first nations peoples.

The Noonkanbah People selected their own independent specialists with the specialists having access to all relevant approvals documents and reviewed the proposed activities and specifically HFS. While the previous operator provided funding for the review, the reviews were undertaken independent of the petroleum Company unless requested by the community. The process ran for approximately seven months and included collaborative risk workshops, community meetings and information sessions with the community.

Independent specialist reviewers presented the outcomes of their review to the community and demonstrated that the Project will have very low risk to Country. After the presentation was complete, the community voted overwhelmingly to support the tight gas program which included HFS activities.


Ongoing engagement has been formalised through separate land use agreements with NT groups. Specifically, BNR have separate land use agreements in place with Yungngora and Warlangurru Native Title groups. Amongst other things, these agreements provide for the support of the Yungngora and Warlangurru People in the future grant of tenure required for the further development of gas resources in the area. The agreements include financial and other benefits to the Native Title groups and include structured processes for managing cultural, heritage and environmental matters. The agreement also focuses on employment and training opportunities for Traditional Owners.

BNR continue to engage with NT Groups regarding the HFS activities associated with the Proposal throughout the Inform / Consult phase of engagement. This ongoing engagement is undertaken by a community liaison person who is based in Noonkanbah community for approximately two weeks a month. This person is responsible for providing regular updates to Yungngora Aboriginal Corporation, Warlangurru members and the general community. This is done in a way that is consistent, culturally appropriate and respectful.

3.5 Interested Stakeholders

BNR have engaged with a number of community organisations, government departments and industry bodies regarding the Proposal. These are outlined in Section 3.2 above:


Meeting in person is the preferred method of engagement with stakeholders. However, this has not always been possible during Q2, Q3 and Q4 2020 due to the COVID-19 pandemic and associated travel restrictions. As such, engagement to date has been primarily via telephone, videoconference, and email. Following the WA Government’s release of the Phase 3 easing of COVID-19 restrictions, follow up meetings with those people based in the Kimberley region occurred in July 2020.

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Effective engagement is supported by maps along with information relating to the scope of the referral and the potential environmental risk / impact of the Proposal, when implemented. A feedback form is also provided to stakeholders so they have the opportunity to formally provide input to the proposal.

At the time of writing this document, no objections to the Proposal have been raised by consulted stakeholders.

BNR will continue to inform these, and other community organisations, government departments and industry bodies about the Proposal and BNR's other activities in the region.

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4 Environmental Principles and Factors

4.1 Principles

Section 4A of the EP Act establishes the object and principles of the Act. In accordance with the EPA Statement of Environmental Principles, Factors and Objectives (EPA 2018), this section describes how each of the five principles of the EP Act has been applied to the Proposal (Table 4-1).

Table 4-1: Summary of the Proposal against the Environmental Protection Act Principles

Principle	Summary of the Proposal Against EP Act Principles
<p><u>Precautionary principle</u></p> <p>Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decision should be guided by:</p> <p>a. Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and</p> <p>b. An assessment of the risk-weighted consequences of various options.</p>	<p>The Proposal has a disturbance footprint of approximately 109 ha. Previous baseline and targeted flora and fauna surveys have been undertaken within the Development Envelope and indicate that although conservation significant flora and fauna have the potential to be present, no Threatened flora, fauna or vegetation communities are likely to be present. Assessments for all preliminary key factors including noise, dust and atmospheric emissions indicate impacts arising from the Proposal are not significant and are manageable through the implementation of good practice mitigation measures.</p> <p>The review of previous HFS data within EP 371 also indicates there is scientific and historic evidence to indicate that such activities can be undertaken in a manner that will not cause serious or irreversible damage to the environment. BNR plan to leverage this wealth of environment data and conduct similar studies for the Proposal to demonstrate that these activities can be undertaken in a manner that is safe with minimal impact to the environment.</p>
<p><u>Inter-generational equity</u></p> <p>The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.</p>	<p>Significant environmental impacts are not expected from the Proposal. The Proposal has minimised environmental disturbance where practicable to ensure the health, diversity and productivity of the environment are maintained. Further evaluation of other factors including human health indicate that impacts arising from the Proposal (refer to Section 6 for specific detail) are not significant and will be manageable through the implementation of good practice mitigation measures.</p>
<p><u>Conservation of biological diversity and ecological integrity</u></p> <p>Conservation of biological diversity and ecological integrity should be a fundamental consideration.</p>	<p>The areas of vegetation to be disturbed are representative of the surrounding vegetation community and the wider bioregion. Previous and recent baseline and targeted flora and fauna surveys have been undertaken within the Development Envelope which indicate no Threatened flora, fauna or vegetation communities are likely to be present.</p> <p>A focused evaluation on groundwater has been undertaken. This included a review of previous HFS data within EP 371 that indicates the Proposal will not threaten biological diversity or ecological integrity.</p>



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Principle	Summary of the Proposal Against EP Act Principles
<p><u>Principles relating to the improved valuation, pricing and incentive mechanisms</u></p> <p>a. Environmental factors should be included in the valuation of assets and services.</p> <p>b. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.</p> <p>c. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.</p> <p>d. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and / or minimise costs to develop their own solutions and responses to environmental problems.</p>	<p>Throughout the Proposal development process, environmental factors have been considered during decision making and design. For example, the disturbance footprint has been reduced to ALARP. In siting the final well locations BNR have considered impacts to fauna and stakeholders and operational efficiency.</p> <p>The emissions and wastes arising from the Proposal have been identified, and BNR acknowledge that the cost associated with the management of these emissions and wastes forms part of the Proposal.</p> <p>Justification for the Proposal includes incentives to balance impacts of emissions through promoting and contributing to increased economic activity and benefits in the region (Section 5.5.5.4). BNR believe that programs such as these are particularly important for the development of the West Kimberley region as unconventional resources occur away from regional centres, in areas where meaningful employment opportunities are central to addressing economic disadvantages.</p>
<p><u>Waste minimization</u></p> <p>All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.</p>	<p>Key waste streams have been evaluated and management techniques identified to minimise environmental impacts.</p>

4.2 Identification of Environmental Factors

Fourteen environmental factors and respective objectives have been defined by the EPA, organised into five themes: Sea, Land, Water, Air and People. With respect to the Valhalla Gas Exploration and Appraisal Program, BNR has classified each of the environmental factors as either ‘preliminary key’, ‘other’ or ‘not applicable’ (Table 4-2), where:

- ‘Preliminary key environmental factors’ are those parts of the environment that may be impacted by an aspect of the Proposal;
- ‘Other preliminary environmental factors’ are parts of the environment that the Proposal may interact with, but are unlikely to cause any impacts;
- ‘Not applicable’ are those parts of the environment that are not relevant to any aspect of the Proposal.

The assessment of potential environmental impacts is focussed on the preliminary key environmental factors identified by BNR, which are further discussed in Section 5.1 to Section 5.5. The Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia (2018) presents the potential risks arising from the implementation of HFS on the onshore environment of Western Australia and recommendations that may be employed to mitigate these risks.

The environmental assessments presented in the following sections have considered the outcomes of the inquiry and identified mitigation measures that are considered sufficient to satisfy these expectations. For completeness of the assessment, additional relevant factors are included from the EPA Statement of Guideline for Environmental Principles, Factors and Objectives (EPA 2020b); these other preliminary environmental factors are presented in Section 6.



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Table 4-2: Identification of preliminary key environmental factors for the Proposal

Factor	Preliminary classification of factor	Further information
Theme: Sea		
Benthic communities and habitats	Not applicable	Not applicable
Coastal processes	Not applicable	Not applicable
Marine environmental quality	Not applicable	Not applicable
Marine fauna	Not applicable	Not applicable
Theme: Land		
Flora and vegetation	Preliminary key environmental factor	Section 5.1
Landforms	Not applicable	Not applicable
Subterranean fauna	Other preliminary environmental factor	Section 6.1
Terrestrial environmental quality	Preliminary key environmental factor	Section 5.2
Terrestrial fauna	Preliminary key environmental factor	Section 5.3
Theme: Water		
Inland waters	Preliminary key environmental factor	Section 5.4
Theme: Air		
Air quality	Other preliminary environmental factor	Section 6.2
Greenhouse Gas Emissions	Other preliminary environmental factor	Section 6.2
Theme: People		
Human health	Other preliminary environmental factor	Section 6.4
Social surroundings	Preliminary key environmental factor	Section 5.5

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5 Preliminary Key Environmental Factors

5.1 Flora and Vegetation

5.1.1 EPA Objective

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

5.1.2 Legislation, Policy and Guidance

- *Environmental Protection Act 1986;*
- *Environmental Protection (Clearing of Native Vegetation) Regulations 2004;*
- *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act);*
- *Biodiversity Conservation Act 2016 (BC Act);*
- *Biosecurity and Agriculture Management Act 2007;*
- *Bush Fires Act 1954;*
- *Bush Fires Regulations 1954;*
- *Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016b);*
- *Environmental Factor Guideline Flora and Vegetation (EPA 2016c);*


5.1.2.1 Application of EPA Guidance

The Environmental Factor Guideline – Flora and Vegetation (EPA 2016c) identifies the considerations for conducting an Environmental Impact Assessment (EIA) of this factor. The Proposal meets the guideline's considerations as demonstrated in Table 5-1.

Table 5-1: Environmental factor guideline – flora and vegetation considerations

Considerations for EIA	Section
Application of the mitigation hierarchy to avoid and minimise impacts to flora and vegetation, where possible.	Table 5-6
The flora and vegetation affected by the proposal.	Section 5.1.3 Appendix B
The potential impacts and the activities that will cause them, including direct and indirect impacts.	Section 5.1.4
The implications of cumulative impacts.	N/a ²
Whether surveys and analyses have been undertaken to a standard consistent with guidance.	Section 5.1.3
The scale at which impacts to flora and vegetation are considered.	Section 5.1.5 Section 5.1.5.1
The significance of the flora and vegetation, and the risk to the flora and vegetation.	Section 5.1.5

² The scope of the Proposal is limited to an exploration and appraisal program within the Proposal Area. No industry / industrial presence or social receptors are present in this area. Subsequently, no additional cumulative impacts are present.

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Considerations for EIA	Section
	Section 5.1.5.1
The current state of knowledge of flora and vegetation and the level of confidence underpinning the predicted residual impacts.	Section 5.1.3 Section 5.1.5
Whether proposed management and mitigation approaches are technically and practically feasible.	Table 5-6
Whether the Development Envelope will be revegetated in a manner that promotes biological diversity and ecological integrity.	Table 5-6 Table 5-16

5.1.3 Receiving Environment

The flora and vegetation composition of the Development Envelope is well understood given the numerous surveys that have been conducted for previous petroleum activities within EP 371.

The flora and vegetation studies relevant to the Proposal are provided in Table 5-2, with survey locations shown in Figure 5-1. The reports of all baseline studies confirmed that the surveys were conducted in accordance with the relevant technical EPA sampling and survey guidance. The most recent flora and vegetation survey conducted for the Development Envelope (Low Ecological Services 2020) has been attached in Appendix B.

In accordance with the Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016b), further flora and vegetation surveys will be undertaken prior to the commencement of the proposed activities.

Table 5-2: Baseline studies – flora and vegetation

Year	Consultant	Survey name / reference	Location	Survey outcomes
2007	Woodman Environmental Consulting	Woodman Environmental Consulting (2007). Valhalla – 01 Well Site Flora and Vegetation Survey. Woodman Environmental Consulting. July 2007. Report prepared for Arc Energy Limited.	EP 371 687206m E 8000998m N (GDA 94, zone 51)	<ul style="list-style-type: none"> Three Priority flora species were identified. <i>Triodia acutispicula</i>³ (P1) was recorded and an additional survey revealed that this species is common in the surrounding vegetation. <i>Goodenia bymesii</i> (P3) was recorded, with no additional plants of this species recorded outside of the well site area. <i>Goodenia sepalosa</i> var. <i>glandulosa</i> (P3) was collected and recorded in the areas adjacent to the proposed well site; No introduced weed species were recorded in the survey area; One structural plant community was recorded within the survey area: W1 – Woodland. The site was an open woodland of <i>Eucalyptus chlorophylla</i> and <i>Erythrophleum chlorostachys</i> with occasional <i>Corymbia dampierii</i> over Grassland of <i>Aristida holothera</i> var. <i>holothera</i> and <i>Eriachne obtusa</i> with occasional shrub and herbaceous species; No Threatened Ecological Communities (TEC) have been located within the survey area. The plant community described in this report extended outwards from the survey area in all directions and appears to not be restricted locally.

³ At the time of writing the Proposal, *Triodia acutispicula* is now listed as a P3 Priority species.



Year	Consultant	Survey name / reference	Location	Survey outcomes
2011	Low Ecological Services	Low Ecological Services (2011b). Valhalla East-1 Exploration Well: Flora and Fauna Survey. September 2011. Report prepared for Buru Energy.	EP 371 691813m E 8002857m N (GDA 94, Zone 51).	<ul style="list-style-type: none"> No Priority flora species were identified during the survey; One introduced weed species, <i>Stylosanthes hamata</i>, was found at the well site and along the access route; The vegetation associations are locally and regionally widespread and are very similar to those predicted using the vegetation maps produced by Shepherd <i>et al.</i> (2002); Neither of the vegetation types are classed as TEC or Priority Ecological Communities (PEC).
2011	Low Ecological Services	Low Ecological Services (2011a). Flora and Vegetation Survey: Valhalla North. October 2011. Report prepared for Buru Energy.	EP 371 683112m E 8006107m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> Only nine species from six families were able to be identified at Valhalla North-1; No introduced species were found at Valhalla North-1; <i>Calotropis procera</i> (Rubber Bush), a Declared Pest, was present along the main Calwynyardah-Noonkanbah Road; <i>Sida cordifolia</i> (Flannel weed) and <i>Cenchrus ciliaris</i> (Buffel grass) were noted at a disused bore along the minor access track to the Valhalla North-1 site; The site was an open shrubland of primarily <i>Grevillea</i> spp., with the occasional <i>Acacia</i> sp. and scattered trees, over hummock grassland; The vegetation is unlikely to be a type classed as TEC or PEC.
2012	Low Ecological Services	Low Ecological Services (2012a). Asgard-1 Exploration Well: Flora, Vegetation and Fauna Survey. Report prepared for Buru Energy.	EP 371 714726m E 7981294m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> The desktop review identified nine conservation significant flora species likely to be found within the site; however, none of these were identified during the survey; One introduced plant species, <i>Cucumis argenteus</i>, was recorded; The vegetation associations in the area were typical of Pindan vegetation associations. They are regionally widespread and are very similar to those predicted using the vegetation maps produced by Shepherd <i>et al.</i> (2002); None of these vegetation types are classified as TEC or PEC.
2012	Low Ecological Services	Low Ecological Services (2012b). Asgard 2D Seismic Survey: Flora, Vegetation and Fauna Survey. Report prepared for Buru Energy.	EP 371 -18.255566, 125.055461 -18.284348, 125.135494 -18.104218, 125.044064 -18.145749, 124.951130 - 18.110725, 124.809457 - 18.332103, 124.981419 - 18.321484, 124.951740	<ul style="list-style-type: none"> Flora surveys were conducted at a total of ten sites. Two listed Priority species were identified. <i>Trianthema kimberleyi</i> (P1) was recorded along the Calwynyardah-Noonkanbah Road. <i>Goodenia virgata</i> (P3) was recorded on one site; Seven introduced species were recorded at the survey sites. One of these, <i>Calotropis procera</i>, is a Declared Pest; Each of the ten sites surveyed within the survey area differed in vegetation type. Several of these communities were very similar, only varying slightly in species composition; Vegetation associations in the area were locally and regionally widespread and were quite similar to those predicted using the vegetation maps produced by Shepherd <i>et al.</i> (2002), but varied in time since last burnt, suite of species and degree of cover.



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Year	Consultant	Survey name / reference	Location	Survey outcomes
			- 18.295856, 124.906641 - 18.290406, 124.895847 - 18.247001, 125.030820 (GDA 94, Zone 51)	
2014	Buru Energy and Outback Ecology	Buru Energy and Outback Ecology (2014). Ophir, Paradise, Valhalla, Eden and Ellendale Flora, Vegetation and Fauna Survey Report. August 2014.	Of relevance to the Proposal: EP 371 681471m E 8003803m N 681532m E 8000656m N 686496m E 8004817m N 686141m E 8001639m N 695595m E 8003148m N 690276m E 7999424m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> No flora species of conservation significance were recorded in the survey area. However, Priority flora species have been recorded in the survey area during previous studies, and a further Priority species may be present based on suitable habitat that occurs within the survey area; One introduced flora species was recorded, <i>Stylosanthes</i> sp.; Vegetation recorded broadly represented vegetation associations described and mapped by Beard (1979); Vegetation was dominated by open Acacia shrublands over tussock or hummock grasslands comprised of <i>Chrysopogon fallax</i> or <i>Triodia</i> spp. with an overstorey of scattered <i>Corymbia</i> spp.; None of the vegetation communities described during the survey were representative of TEC or PEC.
2016	Eco Logical Australia	Eco Logical Australia (2016). Level 1 Vegetation, Flora and Fauna Survey of Kurradjong, Yakka Munga and Valhalla Central Well Sites. Prepared for Buru Energy limited.	EP 371 Valhalla Central (of interest): 694310m E 7992800m N and 8 km access track (GDA 94, Zone 51)	<ul style="list-style-type: none"> One Priority flora species, <i>Pterocaulon intermedium</i>⁴ (P3), was recorded approximately 100 m from the Valhalla Central access track; No introduced weed species were identified; Although the Valhalla Central site is within the North Fitzroy Plains 700 vegetation association, vegetation recorded in the survey is more analogous to the Dampierland_64 vegetation association which is described as 'Grasslands, tall bunch grass savanna low tree; baobabs (<i>Adansonia gregorii</i>), bauhinia & beefwood (<i>Grevillea striata</i> over ribbon grass)'; None of the vegetation communities were likely to represent any TEC or PEC.
2018	Eco Logical Australia	Eco Logical Australia (2018). Valhalla Central 4 Flora and Fauna Survey. August 2018.	EP 371 689310m E 7998098m N	<ul style="list-style-type: none"> No conservation significant flora species were identified during the survey; One introduced species, <i>Stylosanthes scabra</i>, was recorded;

⁴ At the time of writing the Proposal, *Pterocaulon intermedium* is no longer Threatened and thus no longer listed as a Priority species.



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Year	Consultant	Survey name / reference	Location	Survey outcomes
		Prepared for Buru Energy Limited.		<ul style="list-style-type: none"> The survey's vegetation association contains broad elements consistent with Beard's (1979) pre-European vegetation mapping of the area, described as Dampierland_699; None of the vegetation communities described during the survey were representative of TEC or PEC.
2019	Low Ecological Services	Low Ecological Services (2020). Flora and Fauna Assessment – Odin 2D and 3D seismic survey, Fitzroy Basin, Western Australia. Report prepared for Bennett Resources Pty Ltd. Report drafted in March 2020. Refer to Appendix B.	EP 371 17 sites within the survey area. The 3D seismic survey area is the same as the Development Envelope mentioned in the Proposal.	<ul style="list-style-type: none"> No conservation significant flora species were identified during the survey; Two introduced species, <i>Calotropis procera</i> (Declared Pest) and <i>Cenchrus ciliaris</i>, were recorded; Three species of important indigenous bush foods were recognised within the Development Envelope: <i>Adansonia gregorii</i> (Boab Tree), <i>Carissa lanceolata</i> (Conker Bush) and <i>Cyperus bulbosus</i> (Bush Onion).



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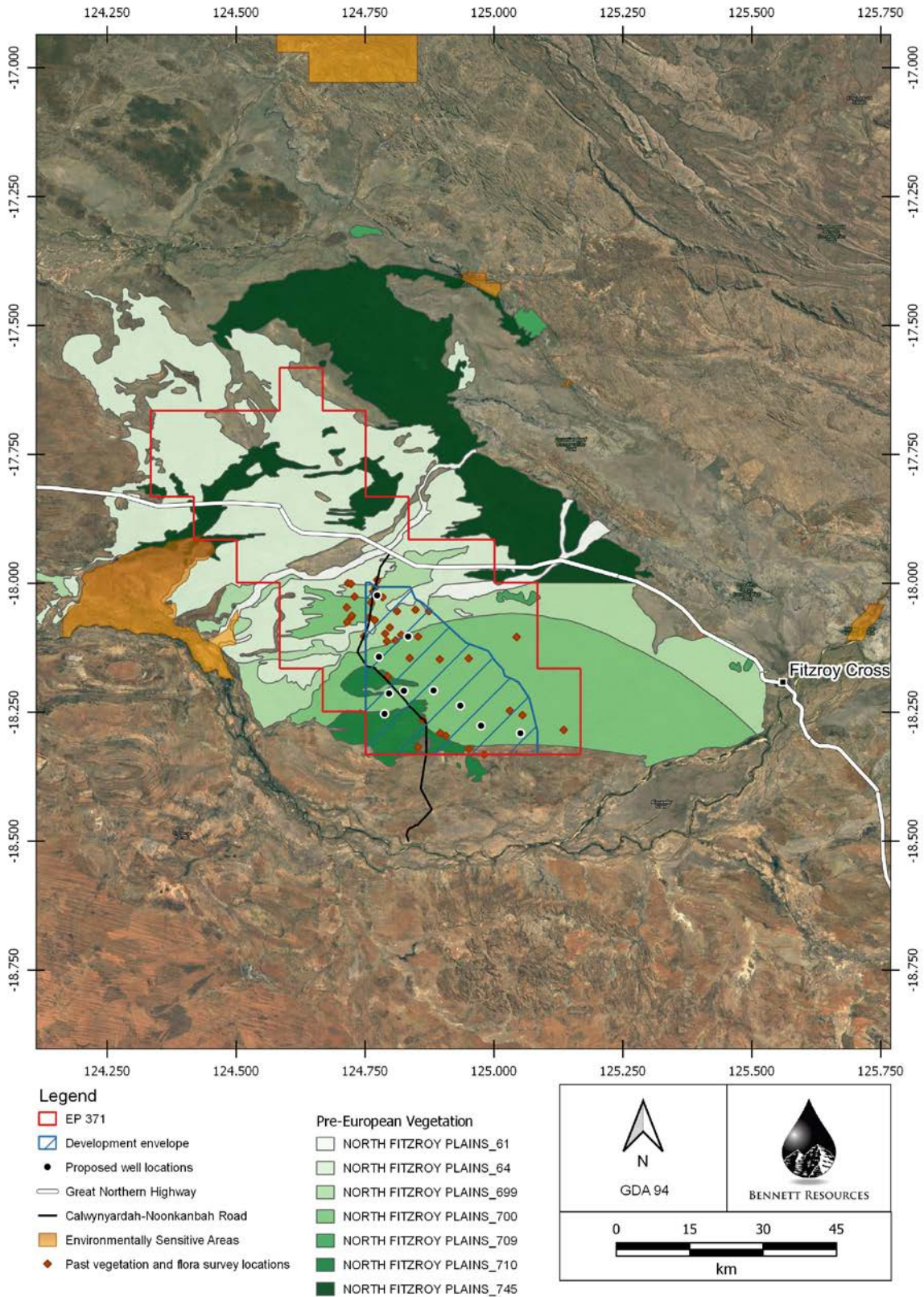



Figure 5-1: Location of flora surveys, Environmentally Sensitive Areas and vegetation communities

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5.1.3.1 Regional Biogeography

The Proposal is located within the West Kimberley's Dampierland Interim Biogeographic Regionalisation for Australia (IBRA) bioregion (DAWE 2020a).

Dampierland is a region distinguished by the domination of sand sheets and sandy rises occasionally dissected by alluvial and lacustrine features associated with surface waters. The vegetation of the bioregion is relatively uniform and characterised by the pindan assemblage that develops on sand plains. Acacia thickets with scattered trees, areas of grasslands and savannas (Bastin and the ACRIS Management Committee 2008) are present on these extensive plains, rangelands and gorges. In the West Kimberley region, rangelands, or areas of open country used for cattle grazing or Indigenous hunting of animals, are the dominant ecosystems.

The Development Envelope specifically occurs within the Fitzroy Trough (Dampierland DAL1) IBRA subregion (Figure 5-2). The subregion is located in the semi-arid northern edge of the Canning Basin containing the middle and lower catchments of the Fitzroy River. The Fitzroy Trough comprises Quaternary alluvial plains from the river associated with Permian and Mesozoic sediments. These sediments support *Eucalyptus microtheca* and *Lysiphyllum cunninghamii* tree savannas over *Chrysopogon-Dichanthium* grasslands with scattered riparian forests of river red gum (*Eucalyptus camaldulensis*) and Cadjeput (*Melaleuca spp.*) along fringe drainage lines. The subregion also includes sandplains and eroded dune surfaces derived from the Canning Basin. Devonian limestones are present in the north and east of the Trough supporting tree steppes with understoreys of *Triodia intermedia* and *T. wiseana* hummock-grass (Graham 2001; McKenzie *et al.* 2003).

The Development Envelope is located within the Valhalla province, a colloquial term used to describe the area that lies along the north eastern flank of the Fitzroy Trough where the targeted Laurel Formation shows promise of hydrocarbons at depths in the order of 2,000 m to 4,000 m below ground level. The Valhalla province is located within the dune areas outside the floodplains, with the Fitzroy River located approximately 16 km south of the Development Envelope.

5.1.3.2 Environmentally Sensitive Areas

An Environmentally Sensitive Area (ESA) is defined as a landscape element or place which is vital to the long-term maintenance of biological diversity, soil, water or other natural resources. An ESA is declared under section 51B of the EP Act 1986. The nearest ESA is the Camballin Floodplain located approximately 27 km west of the Development Envelope, which is associated with a Nationally Important Wetland, Le Lievre Swamp (Iijamalkarda) (DEC 2009). The wetland area is a major breeding area for water birds as well as a migration stop-over area for shorebirds. The floodplain is contiguous with the Fitzroy River floodplain.

To date, flora and vegetation surveys undertaken within the Development Envelope have not identified the presence of any Declared Rare Flora (DRF), TEC or PEC (Table 5-2). Figure 5-1 provides details on the Development Envelope within the regional environmental values and sensitivities.



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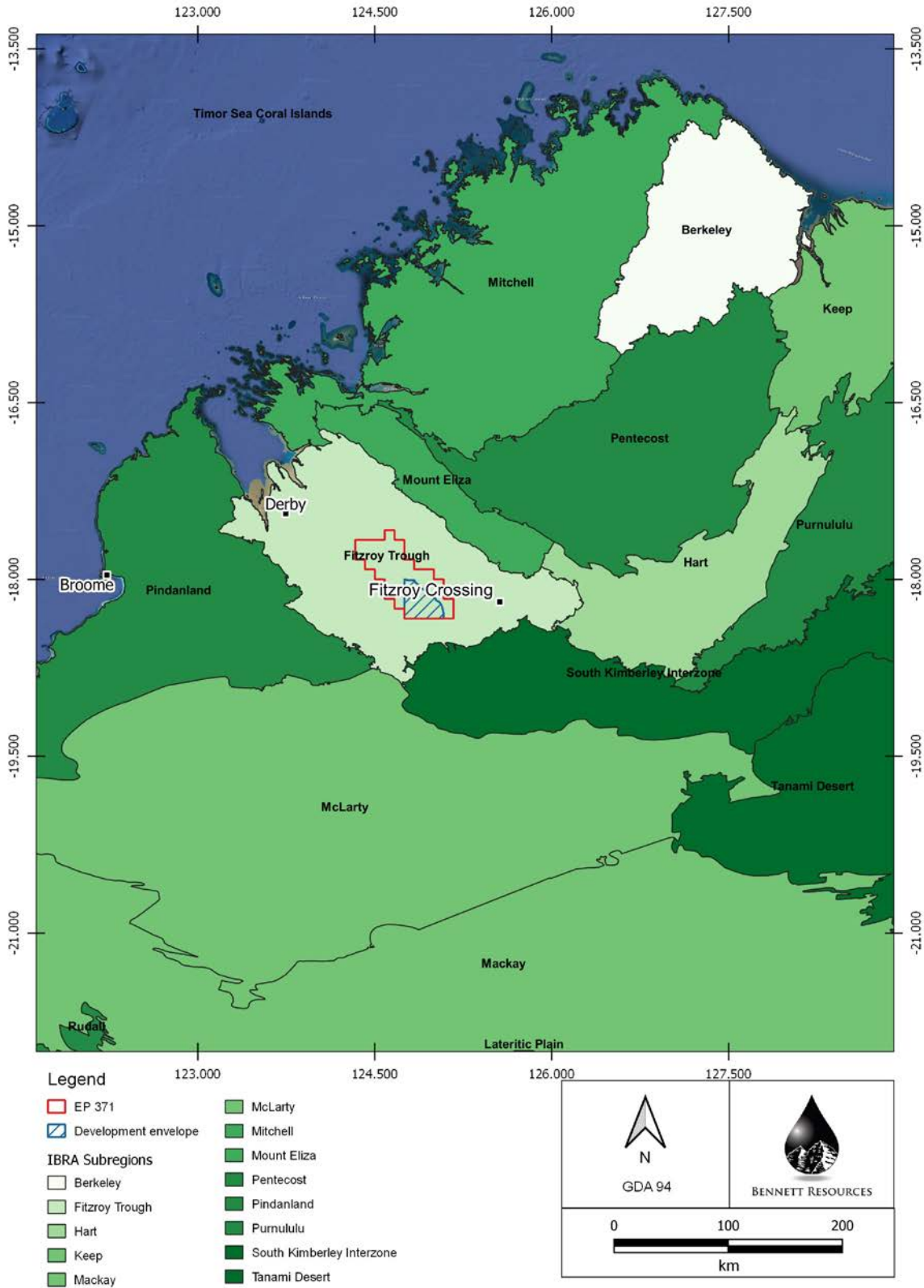



Figure 5-2: IBRA subregions of the Kimberley

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5.1.3.3 Vegetation Communities

Within the Dampierland bioregion, the vegetation is characterised by the pindan assemblage that occurs on sandplains. Vegetation on pindan plains is relatively uniform with the same species occurring in very predictable patterns. Pindan is described by Beard (1979) as a “grassland wooded by a sparse upper layer of trees and a dense, thicket-forming middle layer of unarmed, phyllodal Acacia”.

Based upon Beard (1979) and Shepherd *et al.* (2002), three predominant and two less predominant vegetation communities (vegetation systems) are present within the Development Envelope, shown in Figure 5-1 and detailed in Table 5-3. Detailed flora and vegetation surveys undertaken within sites surrounding the Development Envelope have verified that the vegetation within the Development Envelope is reflective of these communities (Table 5-2).

Table 5-3: Extent of the vegetation systems within the Development Envelope in the Fitzroy Trough IBRA subregion (Government of Western Australia 2019a, 2020a)

Vegetation system	Description	Pre-European Extent (ha)	IBRA region current Extent (ha)	Percentage of Pre-European extent remaining
North Fitzroy Plains_64	Mainly ribbon grass with low woodland or scattered trees e.g. <i>Eucalyptus terminalis</i> over <i>Chrysopogon</i> spp., <i>Dichanthium</i> spp.	320,517.39	320,294.62	99.93 %
North Fitzroy Plains_699	Shrublands, pindan; <i>Acacia eriopoda</i> shrubland with scattered low Bloodwoods (<i>Corymbia</i> spp.) over Soft Spinifex (<i>Triodia pungens</i>) and Curly Spinifex (<i>Triodia bitextura</i>) on sandplain,	124,361.43	124,246.13	99.91 %
North Fitzroy Plains_700	Pindan with low trees; Acacia thicket with scattered low trees over spinifex <i>Acacia eriopoda</i> , <i>Corymbia dichromophloia</i> , <i>Triodia pungens</i> , <i>T. bitextura</i> .	185,328.30	185,328.30	100.00 %
North Fitzroy Plains_710	Mosaic: Grasslands, tall bunch grass savanna low tree; boabs, bauhinia and beefwood over ribbon grass / Hummock grasslands, grass steppe (<i>Triodia pungens</i>) and (<i>Plectrachne pungens</i>).	25,596.64	25,596.64	100.00 %

5.1.3.4 Threatened / Declared Rare Flora


Flora species that have been formally recognised as Threatened or DRF are protected under State legislation under Part 2 of the BC Act 2016, and under Commonwealth legislation under the EPBC Act 1999. Previous and recent flora and vegetation surveys conducted within the Development Envelope revealed that no Threatened or DRF species were identified in the surrounding region.

A desktop search of the Department of Biodiversity, Conservation and Attractions (DBCA) NatureMap and of the DAWE Protected Matters Search Tool (PMST) database identified no Threatened or DRF species to be present within a 5 km buffer around the Development Envelope. These reports are included as Appendix H.

5.1.3.5 Priority Flora

A desktop search of NatureMap identified only *Goodenia byrnesii* (P3) within a 5 km buffer around the Development Envelope (Appendix H). However, previous flora and vegetation surveys conducted within the Development Envelope identified five (current) Priority flora taxa known to occur within the Development Envelope:

- *Goodenia byrnesii* (P3);
- *Goodenia sepalosa* var. *glandulosa* (P3);

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- *Goodenia virgata* (P2);
- *Trianthema kimberleyi* (P1);
- *Triodia acutispicula* (P3).

5.1.3.6 Introduced and Invasive Species

The DAWE PMST desktop search identified that weed species may be present, listing three weeds as potentially occurring within a 5 km buffer around the Development Envelope, being:

- *Cenchrus ciliaris* (Buffel Grass);
- *Jatropha gossypifolia* (Cotton-leaved Physic-nut, Bellyache Bush);
- *Parkinsonia aculeata* (Parkinsonia, Jerusalem Thorn) – Declared Pest

Previous and recent on-ground flora surveys undertaken in the Valhalla province (Table 5-2) identified several introduced species as being present within the Development Envelope, including:

- *Stylosanthes spp.* (*S. hamata* and *S. scabra*);
- *Calotropis procera* (Rubber Bush) – Declared Pest;
- *Sida cordifolia* (Flannel Weed);
- *Cucumis spp.* (*C. argenteus* and *C. ? melo*);
- *Parkinsonia aculeata* – Declared Pest;
- *Cenchrus ciliaris*.

Of all the weeds recorded, *Parkinsonia aculeata* has been declared as a Weed of National Significance, and along with *Calotropis procera* is listed as a Declared Pest under the *Biosecurity and Agriculture Management Act 2007*.

5.1.4 Potential Impacts

A summary of the potential impacts associated with the Proposal is provided below.

5.1.4.1 Direct Impacts

The Proposal will cause the following direct impacts to vegetation and flora:

- Clearing of approximately 102 ha of vegetation.

5.1.4.2 Indirect Impacts

The Proposal may cause the following indirect impacts to vegetation and flora:


- Degradation of vegetation ecology and biodiversity as a result of the introduction of non-indigenous species (weeds);
- Habitat loss or degradation as a result of an unplanned fire event; and
- Dust generation.

5.1.5 Assessment of Impacts

5.1.5.1 Clearing of Approximately 102 ha of Vegetation

The Proposal will result in a direct loss of native vegetation and flora through clearing to construct the well sites and the required access tracks. Based upon the indicative well locations at the time of writing the Proposal, Table 5-4 provides a breakdown of the expected clearing envelope and associated vegetation systems.

Table 5-4: Vegetation clearing envelope

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Clearing envelope (ha)	Vegetation system	Current extent (ha)	Impact of clearing at a regional scale
~12.2	North Fitzroy Plains_699	124,246.13	~0.01 %
~76	North Fitzroy Plains_700	185,328.30	~0.04 %
~12.7	North Fitzroy Plains_710	25,596.64	~0.05 %
~1.1	North Fitzroy Plains_64	320,294.62	~0.0003 %
~102 ha	-	655,465.69	~0.1 %

5.1.5.1.1 Regional and Local Significance


The direct impact of the clearing is limited to no more than 0.05 % of a single vegetation system. Having regard to the extent and distribution of these systems regionally, the removal of 0.05 % of a vegetation system is not considered to be significant.

The vegetation systems within the Development Envelope are well represented locally. Figure 5-1 shows the regional extent of the pre-European vegetation systems present within and surrounding the Development Envelope. The five vegetation systems identified within the Development Envelope are only present in and adjacent to EP 371. However, mapping of other vegetation systems outside of EP 371 shows that these systems possess the same or very similar vegetation and flora species (Beard *et al.* 2013) as those present within the Development Envelope. This reflects the domination of pindan vegetation which is found all over the West Kimberley region. This is reflective of previous surveys undertaken at various locations within EP 371 (Table 5-2 and Figure 5-1). With the small scale and low impact of the Proposal, the loss of vegetation within the well site locations and the access tracks is not considered to result in significant local or regional impacts.

5.1.5.1.2 Conservation Significant Flora

As described in Table 5-2, a number of flora and vegetation surveys have been undertaken in the Development Envelope. These surveys indicate that DRF, TEC or PEC, as listed under the BC Act or EPBC Act, are not expected to occur within the Development Envelope. As the areas surveyed are considered indicative and representative of the expected flora and vegetation composition within the Development Envelope, no DRF, TEC or PEC are expected to be impacted by the Proposal.

As described in Section 5.1.3.5, five Priority taxa have been recorded in past surveys: *Goodenia byrnesii* (P3), *Goodenia sepalosa* var. *glandulosa* (P3), *Goodenia virgata* (P2), *Trianthema kimberleyi* (P1), and *Triodia acutispicula* (P3).

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Goodenia byrnesii

A search of NatureMap indicates that a single Priority species, *Goodenia byrnesii* (P3), has the potential to occur within the Development Envelope. *Goodenia byrnesii* is known to be present throughout the Dampierland, Northern Kimberley, Ord Victoria Plain and Victoria Bonaparte IBRA regions (FloraBase in Western Australian Herbarium 1998-) indicating that it is widespread throughout Northern Western Australia. Although there are only 32 individuals identified in the species' records (Figure 5-3), they occur within a remote area of WA of which a large area has not been surveyed. The species is known to favour sandy habitat along the edge of creeks. Although a single water way, the Mount Hardman Creek, intersects the Development Envelope and the Calwinyardah-Noonkanbah Road, the creek is ephemeral and dry for most of the year. The non-perennial state of Mount Hardman Creek therefore does not support riparian vegetation. BNR do not on locating any well site within 1 km of the creek (Table 5-19). Consequently, riparian vegetation, including *Goodenia byrnesii*, is not expected to be impacted by the Proposal.

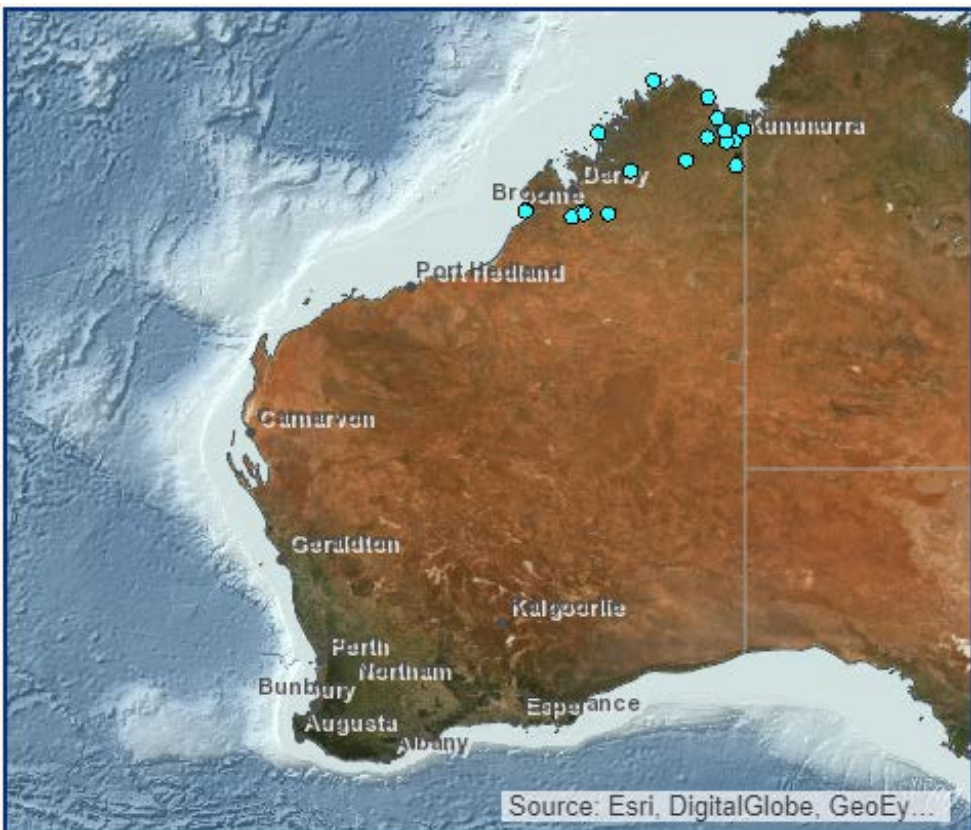



Figure 5-3: NatureMap records for *Goodenia byrnesii* (DBCA 2020)

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Goodenia sepalosa var. glandulosa

Goodenia sepalosa var. glandulosa (P3) is known to be present throughout the Dampierland, Northern Kimberley and Victoria Bonaparte IBRA regions (FloraBase in Western Australian Herbarium 1998-), indicating that it is relatively widespread throughout Northern Western Australia. Although there are only 8 individuals identified in the species' records (Figure 5-4), they occur within a remote area of WA of which a large area has not been surveyed. The species is known to favour red sandy or loamy habitat.

As the Development Envelope is located within floodplain and sandplain zones, comprising clayey and sandy soils (Section 5.2.3.1), habitat may be favourable for the species. Given the limited extent of vegetation clearing required for the Proposal, any disturbance is not expected to be significant.

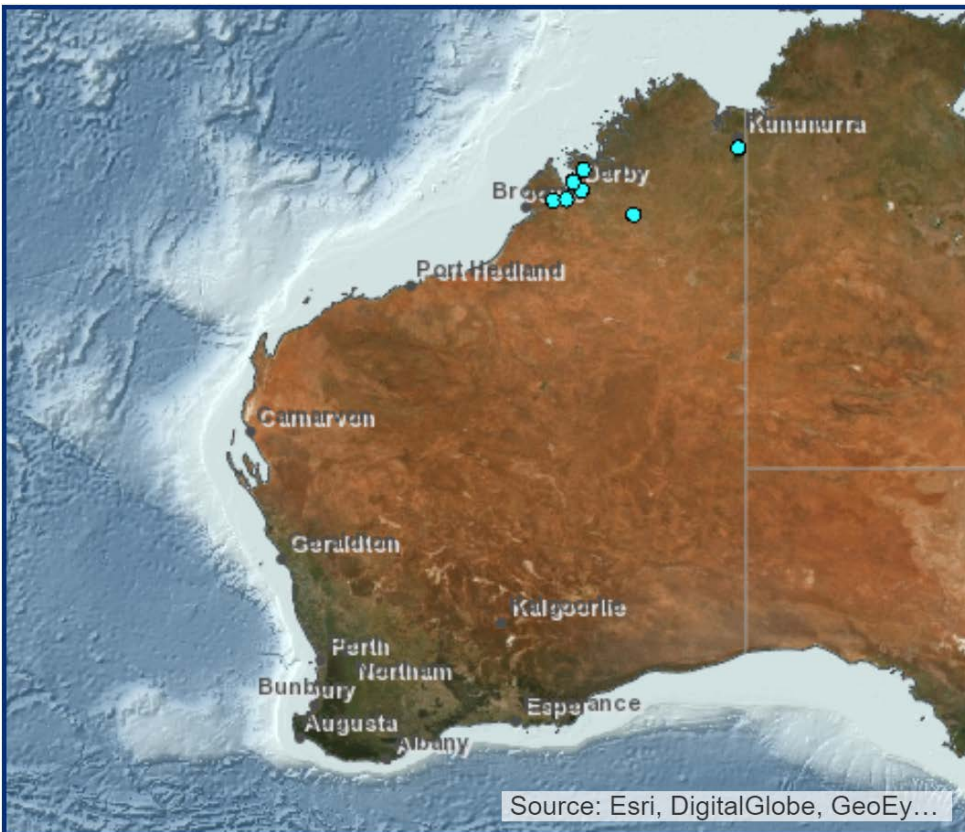



Figure 5-4: NatureMap records for *Goodenia sepalosa var. glandulosa* (DBCA 2020)

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Goodenia virgata

Goodenia virgata (P2) is known to be present throughout the Gascoyne, Gibson Desert, Great Sandy Desert and Little Sandy Desert IBRA regions (FloraBase in Western Australian Herbarium 1998-), indicating that it is distributed throughout WA's central desert regions. Although there are only 17 individuals identified in the species' records (Figure 5-5), they occur within remote central areas of WA of which a large area has not been surveyed. The species is known to favour red sandy loam habitat near salt pans. Salt pans, or salt flats, are often found near estuaries, coastal areas, in deserts and around salt lakes.

The Development Envelope is located far from the coast (approximately 123 km from Derby) and the Fitzroy River estuary. The closest desert, the Great Sandy Desert, is situated approximately 55 km south, and no inland salt lakes have been identified within EP 371. As no salt pans have been recorded during past on-ground surveys, these are not expected to occur within or in close proximity to the Development Envelope (Schoknecht and Payne 2011), consequently *Goodenia virgata* is not expected to be impacted by the Proposal.

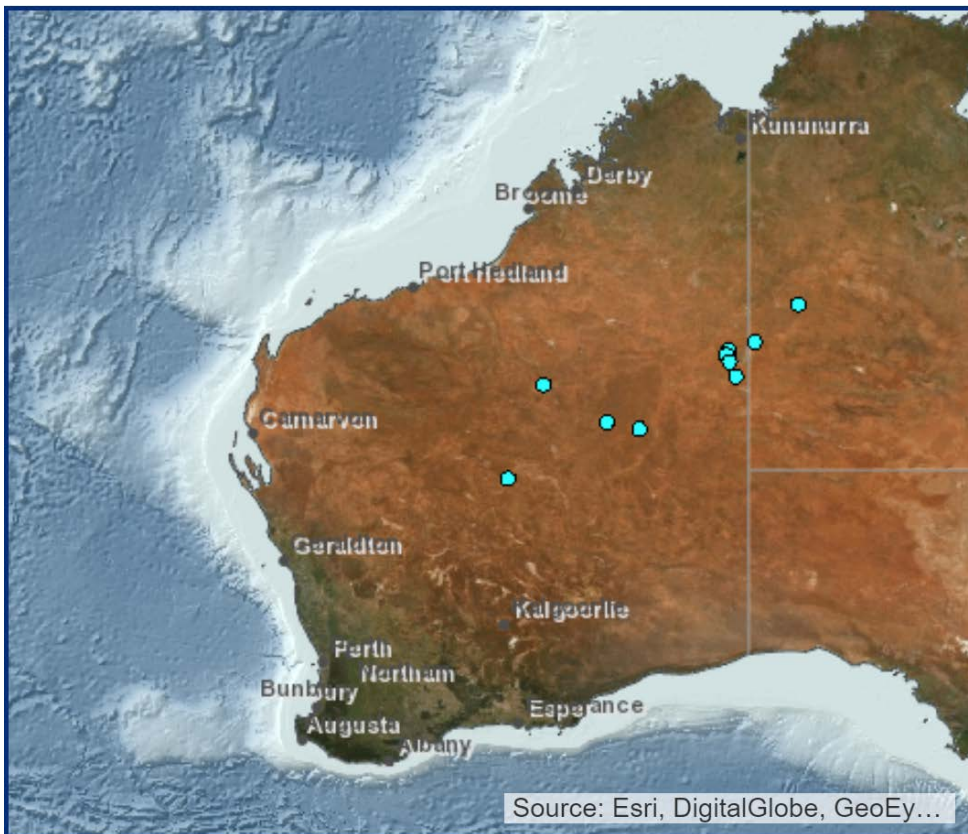



Figure 5-5: NatureMap records for *Goodenia virgata* (DBCA 2020)

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Trianthea kimberleyi

Trianthea kimberleyi (P1) is known to be present throughout the Ord Victoria Plain IBRA region (FloraBase in Western Australian Herbarium 1998-), indicating that its distribution is limited in WA. Although there are only 6 individuals identified in the species' records (Figure 5-6), they occur within a remote area of WA of which a large area has not been surveyed. The species is known to favour schistous (laminated, crystalline and rock-based) soils.

Under certain geological circumstances, schistous soils have the potential to become clayey due to natural breakdown processes. As the Development Envelope is located within floodplain and sandplain zones, comprising clayey and sandy soils (Section 5.2.3.1), clayey schistous soils may be present in the area, and habitat may be suitable for the species. However, given the limited extent of vegetation clearing required for the Proposal, any disturbance is not expected to be significant

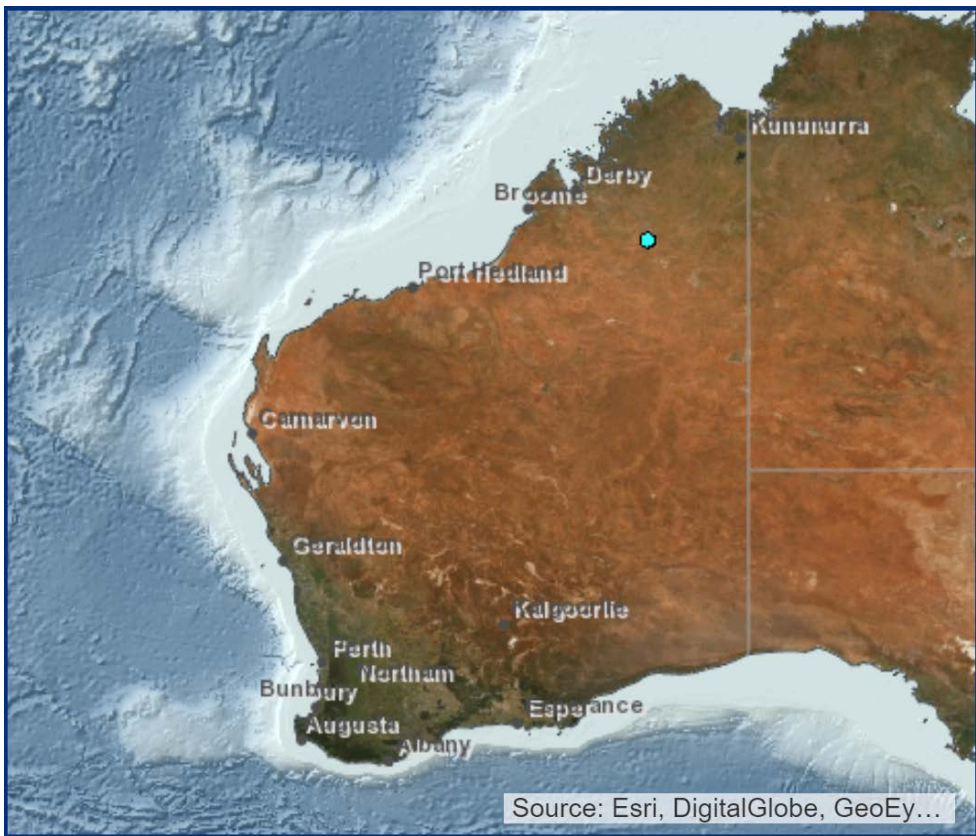



Figure 5-6: NatureMap records for *Trianthea kimberleyi* (DBCA 2020)

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Triodia acutispicula

Triodia acutispicula (P3) is known to be present throughout the Dampierland and Northern Kimberley IBRA regions (FloraBase in Western Australian Herbarium 1998-), indicating that it is relatively well distributed in Northern Western Australia. Although there are only 33 individuals identified in the species' records (Figure 5-7), they occur within a remote area of WA of which a large area has not been surveyed. The species is known to favour sandy soils on river levees, pindan plains, and rocky hillslopes and outcrops.

As the Development Envelope is located within floodplain and sandplain zones, comprising clayey and sandy soils (Section 5.2.3.1) and pindan vegetation assemblages, habitat may be favourable for the species. Given the limited extent of vegetation clearing required for the Proposal, any disturbance is not expected to be significant.

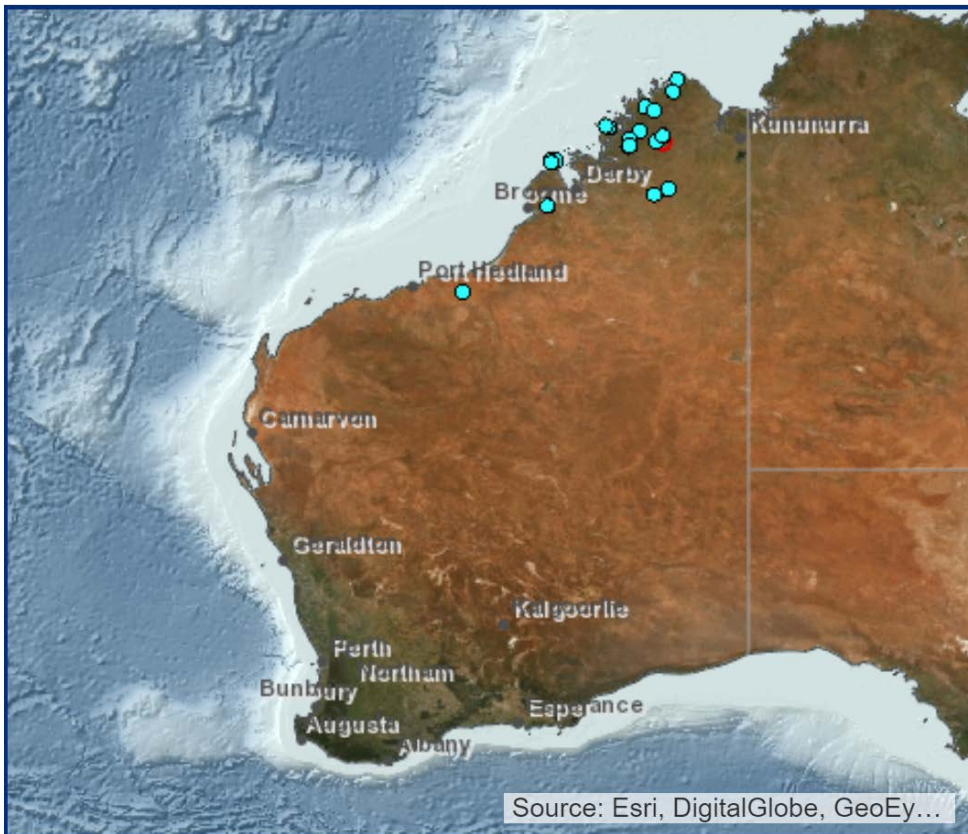



Figure 5-7: NatureMap records for *Triodia acutispicula* (DBCA 2020)

5.1.5.2 Degradation of Vegetation Ecology and Biodiversity as a Result of the Introduction of Non-Indigenous Species (Weeds)

The introduction of non-indigenous species (weeds) is an indirect impact that is a standard risk for projects within and adjacent to native vegetation. Spreading weed species that are already present within the Development Envelope would be expected to result in short-term effects to ecosystem function. However, the introduction of new weed species to well sites within the Development Envelope has the potential to result in significant impacts, where the new species out compete native species, causing local vegetation communities and ecosystems to be significantly altered.

The incidences of spreading weed species around and introducing new weed species to the Development Envelope can be suitably managed through standard mitigation measures and hygiene procedures. As weed and hygiene management are part of a standard suite of measures that can be easily and effectively applied to the Proposal, BNR do not expect these indirect impacts to cause a significant environmental impact.

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5.1.5.3 Habitat Loss or Degradation as a Result of an Unplanned Fire Event

Site operations, including site preparation, may have the potential to cause a fire resulting in habitat loss and vegetation degradation. As described in Table 5-3 and Section 5.1.5.1, the general habitat and vegetation system surrounding the Development Envelope have a very large extent and distribution within West Kimberley.

The most substantial risk of ignition in the Development Envelope is posed by grass fires. Such grass fires are a regular occurrence in the Canning Basin during the dry season. Fire frequency varies, but typically occurs every two to four years (NAFI 2020). Weather conditions, fire history and vegetation fuel load all contribute to grass fire patterns and intensity. Additional values and sensitivities at risk from fire events include Priority flora species and potential DRF within the wider region. Should the proposed activities cause a fire event to occur, impacts to vegetation communities and species diversity in the surrounding region is unlikely to be significant given the frequent occurrence in which fires pass through the landscape. Studies into the recovery of pindan vegetation systems following fire events conclude that pindan vegetation structural recovery took 4–5 years indicating that recovery could be expected over a shorter period of time (Radford and Fairman 2015).

The incidences of fire can be suitably managed through standard mitigation measures that are enacted under the *Bush Fires Act 1954* and Bush Fires Regulations 1954. As prevention of fire events can be managed through a standard suite of measures that can be easily and effectively applied to the Development Envelope, BNR do not expect these indirect impacts to cause a significant environmental impact.

5.1.5.4 Dust Generation

Generation of dust from vegetation clearing and driving on unsealed roads is anticipated to be produced during the proposed activities. A long-term monitoring program that investigated impacts of dust on vegetation for a significant development in the Pilbara over a 5-year period, where significantly higher volumes of vehicles (heavy and light) and earthworks were present, determined that no adverse impacts occurred to plant health or vegetation communities as a result of construction dust loads (Gorgon Gas Development and Jansz Feed Gas Pipeline: Five-year Environmental Performance Report (August 2015) [Chevron Australia 2015]). Consequently, BNR do not believe that dust generation will result in a credible impact to vegetation, therefore have not considered it further.

Further information regarding dust impacts to human health is evaluated in Section 5.5.5.1.

5.1.5.5 Application of Legislation, Policy and Guidance

Approval to clear native vegetation and flora is regulated under Part V of the EP Act, the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. The Native Vegetation Regulations provide exemptions for clearing native vegetation. The Native Vegetation Regulations define item 24 (as a prescribed purpose) – Clearing that is the result of carrying out exploration under an authority under the PGER Act 1967 – as being prescribed under Section 51 C of the EP Act. As this activity is a petroleum exploration activity, within EP 371 and not in an ESA (defined under Section 51B of the EP Act) (refer to Section 3.4.4), no permit for native vegetation clearing is required for the Proposal.

Under the PGER (Environment) Regulations 2012, a DMIRS accepted Environment Plan is required to manage both direct and indirect impacts on flora and vegetation associated with the proposed activities. Specifically, the EP has to consider impact significance and demonstrate that impacts and risks are reduced to a level that is ALARP and acceptable prior to acceptance by DMIRS. No activities covered in the Proposal can commence until an EP is accepted by DMIRS.

Consequently, as impacts associated with this preliminary key environmental factor will not be significant, they are able to be suitably managed under other regulatory requirements.

5.1.6 Impact Validation and Verification

Throughout the planning phase, BNR have reviewed studies undertaken by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, once the well locations are finalised, BNR plan to conduct a range of studies to validate the assumptions in the Proposal. The assumptions and verification studies are documented in Table 5-5. The complete monitoring, verification and validation program for the Proposal is included in Section 7.


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Table 5-5: Assumptions and verification studies for the Proposal


Assumptions	Verification studies during activity	Timing
No DRF, TEC or ESA are located within the individual well sites.	Flora and vegetation reconnaissance survey (with fauna habitat / opportunistic fauna observation) within the disturbance footprint.	Prior to site preparation operations.
Vegetation communities to be impacted comprise well represented communities that match broadscale vegetation mapping.		
No weeds of significance are located within the proposed wells sites.		

5.1.7 Mitigation

A summary of the mitigation measures and their mitigation hierarchy that will be included in the DMIRS Environment Plan for assessment and acceptance by DMIRS is included in Table 5-6.

Table 5-6: Proposed mitigation measures – flora and vegetation

Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Avoid	Demarcation of clearing area	Demarcation of the proposed clearing area by a surveyor reduces the chance of unplanned clearing outside of the proposed footprint to the smallest possible extent.
Avoid	Fire breaks	In accordance with Section A.3.7 of the NT Code of Practice, it is industry best practice, and required by local shire regulations, to ensure clearances between vegetation and the industrial activities are installed and maintained to reduce the risk of causing a fire outside of the site.
Avoid	Bush Fires Regulations 1954 and exemptions	The site preparation and construction activities (hot work and off-road activities) and the operational activities (i.e. gas flaring) are prescribed activities in the Bush Fires Regulations 1954. As such, a range of management measures under the Regulations are required to be implemented.
Minimise	Topsoil windrows <2 m	Following clearing, it is a generally accepted industry standard that windrows should be no higher than 2 m. The reason for this is that temperature in the centre of a windrow will get higher where the height / quantity of material increases. As seed viability is reduced where temperatures are increased, the quality / outcomes of revegetation using the topsoil and associated seedbank is reduced. Topsoil will moreover be segregated from the subsoil.
Minimise	Fill verified as having low weed risk	In accordance with the Department of the Environment's Arrive Clean, Leave Clean guidance (Commonwealth of Australia 2015), it is considered good industry practice for the prevention of spreading weeds to ensure that any fill used onsite such as gravel, limestone marl, soil or sand has been verified to have a low weed risk.
Minimise	Hygiene requirements management	It is considered good industry practice for the prevention of spread of weeds to ensure that civil earthmoving machinery is subject to a clean-down prior to arrival on site and commencement of ground disturbing activities.
Rehabilitation	Progressive rehabilitation	In accordance with Section A.3.9 of the NT Code of Practice, once drilling and HFS activities are complete, cleared areas that are not required to support the maintenance of infrastructure will be progressively rehabilitated to minimise rehabilitation legacy at the end of asset life. Topsoil is to be re-spread and

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		rehabilitation sites actively monitored to ensure they meet required completion criteria.
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5.1.8 Predicted Outcomes

The outcomes of the Proposal are predicted to be:

- No impacts to DRF, ESA, TEC or PEC;
- No significant impacts (if any) to priority flora species;
- No significant reduction in pre-European vegetation community extent;
- No detrimental impacts flora and vegetation values will occur through the implementation of a DMIRS accepted Environment Plan; and
- No impact to the overall biological diversity and ecological integrity of flora and vegetation within the Development Envelope.

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant impact to flora and vegetation. The environmental mitigation measures intended to manage and minimise impacts on flora and vegetation are considered effective. Consequently, BNR believes that the EPA’s objective to;

“Protect flora and vegetation so that biological diversity and ecological integrity are maintained”

can be met.

BNR have considered the WA Environmental Offsets Policy, however BNR do not believe actions to offset the predicted outcomes of the Proposal are required as the Proposal is not expected to have a significant impact on flora and vegetation.

5.2 Terrestrial Environmental Quality

5.2.1 EPA Objective

To maintain the quality of land and soils so that environmental values are protected.

5.2.2 Policy and Guidance


- Environmental Factor Guideline Terrestrial Environmental Quality (EPA 2016d);
- Environmental Protection (Controlled Waste) Regulations 2004;
- Department of Water – Water Quality Protection Notice (WQPN) 26 (liners for containing pollutants, using synthetic membranes) (DoW 2013).

5.2.2.1 Application of EPA Guidance

The Environmental Factor Guideline – Terrestrial Environmental Quality (EPA 2016d) identifies the information required for conducting an EIA of this factor. The Proposal meets the guideline’s requirements as demonstrated in Table 5-7.

Table 5-7: Environmental factor guideline – terrestrial environmental quality requirements

Information required for EIA	Section
Baseline information on soil quality.	Section 5.2.3 Appendix C
Chemical and physical characterisation of waste materials.	Table 2-5

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Information required for EIA	Section
	Section 5.2.5.2
<p>The mitigation, management, and rehabilitation practices at a catchment and local level which may include:</p> <ul style="list-style-type: none"> Strategies to address salinity, such as the protection of native vegetation, rehabilitation of degraded native vegetation and reforestation and tree planting, particularly in areas of high recharge, pasture maintenance, cropping management, and management of salinity affected areas; Current site contamination classification, or acid sulfate soil risk information and proposed avoidance, management or remediation methods; and Proposed amelioration of damage to soil structure. 	Table 5-11

5.2.3 Receiving Environment

5.2.3.1 Soil Landscape Systems

The Development Envelope is located within the 331 – North Fitzroy Plain Zone, that covers an area of 17,925 km² (Tille 2006). The North Fitzroy Plain Zone is comprised of floodplains and sandplains (with alluvial plains and undulating plains) on Permian sedimentary rocks of the Canning Basin with self-mulching cracking clays, Red deep sands, Red sandy earths and Red / brown non-cracking clays. The Development Envelope covers four soil landscape systems (Figure 5-8) which are described by the Government of Western Australia (2020b) as:

- 331Cm: Camelgooda System: Sandplains, swales and linear sand dunes supporting low pindan woodlands of acacias and low woodlands of bauhinia and bloodwood with curly spinifex and ribbon grass;
- 331Cy: Calwynyardah System: Alluvial plains with scalded tracts downslope from lateritic remnants with yellowish loamy soils supporting patchy beefwood-bauhinia low woodlands with curly spinifex and ribbon grass; also minor hard spinifex grasslands;
- 331Dj: Djada System: Active flood-plains with levees and levee back slopes supporting ghost gum open woodlands with frontage grasses, and cracking clay back plains supporting ribbon grass-blue grass and Mitchell grass grasslands.
- 331Ma: Mamilu System: Plains and sandplains, deep red sands and yellowish loamy soils on lateritised sedimentary rocks supporting beefwood-bauhinia low woodlands and pindan acacia shrublands with curly spinifex and ribbon grass.



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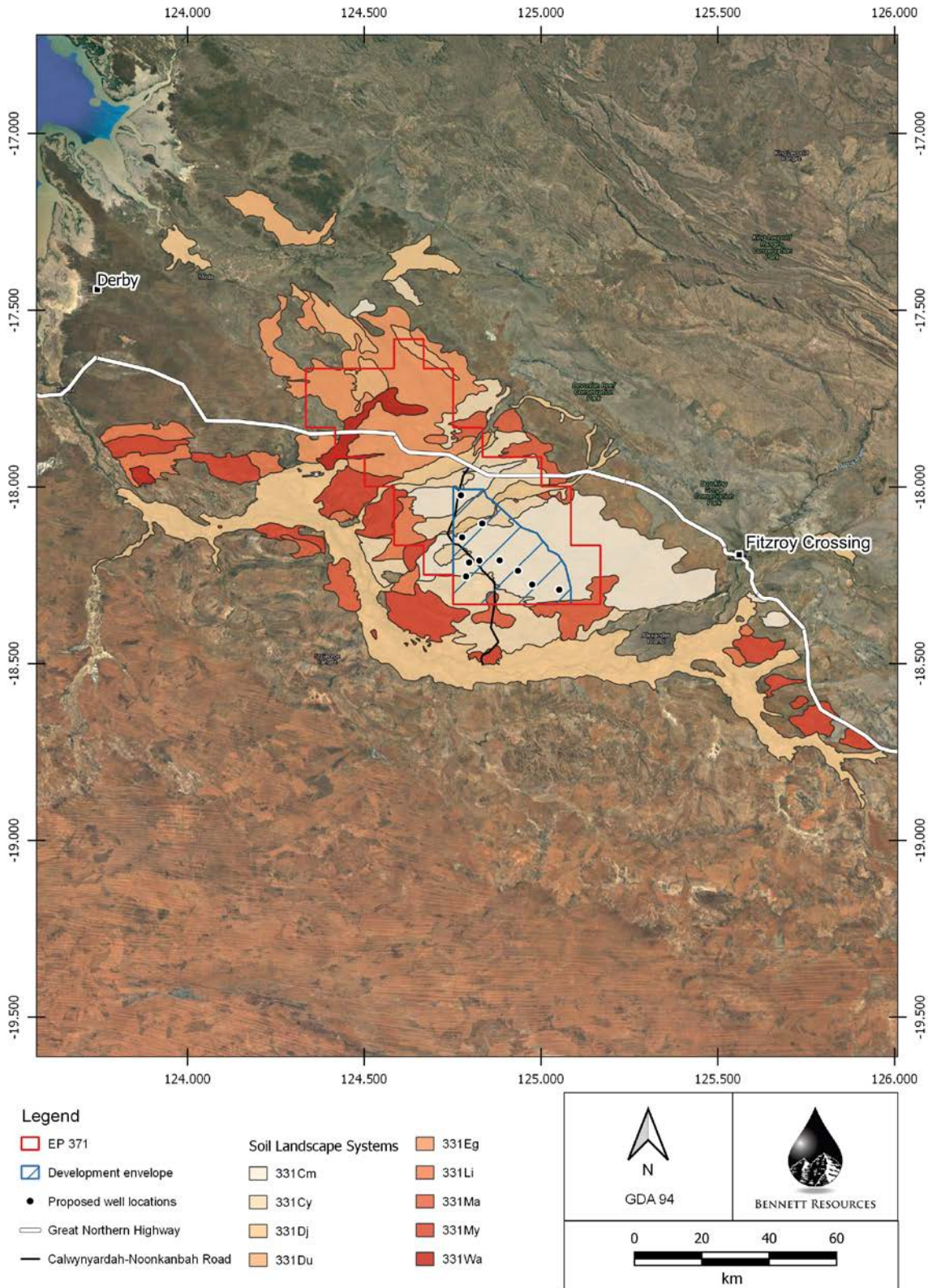



Figure 5-8: Regional extent of the soil landscape systems within the Development Envelope

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5.2.3.2 Soil Quality Characteristics

Baseline soil quality sampling was conducted in 2012 for a previous well location: Valhalla 1. Samples were collected from the drill site and mud sump locations prior to the drilling of the well. These comparisons will provide site specific guidance where exceedance with baseline and screening levels are observed. Given that screening levels are subject to change depending on various legislation and best scientific information at the time of the sampling, these have not been provided.

The soil samples prior to conducting the HFS activities are useful for providing an indication of soil quality more generally within EP 371. Parameters that will likely be tested during soil sampling are included in Table 5-8. The outcomes of the 2012 baseline soil quality analysis are included in Appendix C.

Table 5-8: Soil sampling parameters

Parameters	
BTEXN	Benzene
	Toluene
	Ethylbenzene
	m+p Xylenes
	o- Xylenes
	Naphthalene
TRH	C6-C10
	C6-C10 (less BTEX)
	>C10-C16
	>C10-C16 (less naphthalene)
	>C16-C34
	>C34-C40
Soil characteristics	Soil moisture
	pH
	Electrical conductivity (us/c,)
Metals, metalloids and non-metals	Aluminium (Al)
	Arsenic (As)
	Barium (Ba)
	Beryllium (Be)
	Boron (B)

**Parameters**

Cadmium (Cd)
Chromium (Cr)
Hexavalent Chromium (CrVI)
Cobalt (Co)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Lithium (Li)
Manganese (Mn)
Mercury (Hg)
Molybdenum (Mo)
Nickel (Ni)
Selenium (Se)
Strontium (Sr)
Titanium (Ti)
Uranium (U)
Vanadium (V)
Zinc (Zn)

5.2.4 Potential Impacts**5.2.4.1 Direct Impacts**

No direct impacts are expected to arise as a result of the Proposal.


5.2.4.2 Indirect Impacts

A surface spill event from the Proposal may indirectly result in:

- Erosion or scouring from reduction in soil stability during civil works; and
- Contamination of soils.

5.2.5 Assessment of Impacts**5.2.5.1 Potential Erosion or Scouring from Reduction in Soil Stability during Civil Works**

When soils contain significant organic matter, compaction can be very difficult to achieve. For the purposes of the Proposal, given the well site needs to provide a suitable stable foundation for heavy equipment and

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machinery, once the site is cleared, organic material is removed (through removal of topsoil) and placed to one side. Once complete the well site is either stabilised through importing construction fill material such as gravel or using cement to stabilise the subgrade sands. This material is then compacted to provide a suitable foundation.

As both erosion and scouring are common construction risks for all large-scale civil activities, there are well understood mitigations that will be applied to reduce the likelihood that such impacts will occur. Provided that soil materials on the site are well compacted following the removal of topsoil organics, and these hardstands are protected from excessive stormwater ingress, any erosion impacts arising from the Proposal would be localised and easily remediated, and therefore are not expected to be significant.

5.2.5.2 Spills Causing Potential Contamination of Soils

Soil quality sampling was undertaken at Valhalla North 1 and Valhalla 1, following completion of HFS activities during the previous operator's HFS program. A comparison to ecological and health investigation levels (DEC 2010) showed that following HFS activities, all parameters are below these accepted health screening levels. With the exception of manganese, all parameters are below the accepted ecological screening levels. The soil quality 2016 monitoring data is presented in Appendix D.

A spill characterisation scoping exercise was undertaken for the Proposal to determine the spill risk and potential impacts arising from a spill event. The outcomes of the scoping exercise are included as Table 5-9.



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Table 5-9: Proposal spill risk characterisation

Spill event	Activity				Event summary
	Site preparation operations	Drilling operations	HFS operations	Site reinstatement	
Loss of diesel during refuelling	X	X	X	X	A spill event such as this is anticipated to result in a volume of less than 100 L being released to the ground.
Loss of diesel from onsite diesel storage tank	X	X	X		Based upon the volumes of hydrocarbon and hazardous material types anticipated for utilisation for the Proposal; the impact evaluation is based upon a full release of a 75 m ³ diesel tank.
Loss of minor volumes of hydrocarbon or chemicals during storage and handling around the wellsite		X	X		Various hydrocarbons and chemicals are required for the Proposal. These will generally be stored in 10 L tins, 200 L drums, and 1000 L intermediate bulk containers. Based upon the loss of an entire container during transport or handling, this type of spill event is anticipated to result in a volume of less than 1000 L being released to ground.
Lost circulation of drilling fluids		X			During drilling activities, a small amount of the drilling fluid and associated chemical additives may be lost to the environment down hole as a fugitive discharge (filtrate loss). There is also a risk that during drilling, fluid returns may be lost to the formation where porous / cavernous geological formations are intersected and where the casing has not yet been installed and cemented in place.
Loss of formation water produced during well testing operations			X		Formation water sourced from the Laurel Formation has been characterised by the previous operator of EP 371 through the analysis of multiple water samples at a National Association of Testing Authorities (NATA) accredited laboratory. The results of the sampling program are included as Appendix G. In summary, the formation water in the water retention ponds is very high in salt at 3-5 times the salt concentration of seawater, not toxic to fauna or humans, and heavy metals are at very low levels. To understand the potential release volumes associated with a release of formation water, BNR have evaluated the formation water system and identified that the piping or connection points were the most likely source for a release of this fluid. Based upon guidance for understanding the magnitude of other similar events, and given the HFS activities are continuously supervised, a maximum credible spill volume was based upon the transfer rate × 15 minutes. Based upon pumping rates, this equates to an instantaneous spill volume in the order of 50 m ³ .

To understand the potential extent and subsequent impact on terrestrial environmental quality from a spill event associated with the Proposal, the worst credible spill event (associated with the complete failure of an onsite diesel storage tank) was evaluated further.

Diesel has medium viscosity and consequently upon release it will start spreading over and soaking into porous soils surrounding the hardstand area which, as detailed per Section 5.2.3.1, will be comprised of deep sands, sandy earths and clays. Based upon Grimaz *et al.* (2008), it is anticipated that a large diesel release of 75 m³ could result in an area in the order of ~18,900 m² being contaminated where site containment and recovery was

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not in place. Based upon the viscosity of diesel and assuming this large area is contaminated, there is the potential that hydrocarbons may seep through to a depth of approximately 0.4 m.

A spill event such as this has the potential to affect an area of ~18,900 m² with no management or mitigation barriers in place. However, given standard construction and petroleum measures would be applied to this activity, the likelihood of a spill event such as this occurring is extremely low, and containment and recovery measures would ensure that any soil contamination event would be minimised and remediated quickly.

Spill events from formation water produced during well testing operations, or spill events from chemicals during handling and transport are expected to behave in a similar manner to diesel upon release, but any spill volume is expected to be much smaller. As these materials will be stored within bunded areas, the likelihood of an event that results in a large volume that reaches the environment is very low. As a result, the extent of soil contamination associated with a 75 m³ spill of diesel is considered to provide a conservative assessment of any spill event arising from the Proposal.

As spill management including bunding requirements and appropriate disposal methods are considered part of a standard suite of measures that can be easily and effectively applied to the Proposal, BNR do not expect these indirect impacts to cause a significant environmental impact.

5.2.5.3 Application of Legislation, Policy and Guidance

Under the PGER (Environment) Regulations 2012, a DMIRS accepted Environment Plan is required to manage both direct and indirect impacts on terrestrial environmental quality associated with the Proposal. Specifically, the EP is to include an Oil Spill Contingency Plan. These plans will identify credible worst-case spill scenarios, identify mitigation actions that are in place to prevent these events from occurring, and identify mitigation strategies to determine how these events will be managed should they occur. The OSCP will demonstrate that the operator has sufficient arrangements to implement an appropriate response.

The EP and OSCP consider impact significance and demonstrate that impacts and risks are reduced to a level that is ALARP and acceptable prior to acceptance by DMIRS. No activities covered in the Proposal can commence until an EP and OSCP are accepted by DMIRS.

5.2.6 Impact Validation and Verification

Throughout the planning phase, BNR have reviewed studies undertaken by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, once the well locations are finalised, BNR plan to conduct a range of studies to validate the assumptions in the Proposal and verify the impacts of the activity. The assumptions and verification studies are documented in Table 5-10. The complete monitoring, verification and validation program for the Proposal is included in Section 7.

Table 5-10: Assumption and verification studies for the Proposal

Assumptions	Verification studies during activity	Timing
Verify baseline soil quality prior to the activity.	Baseline soil quality sampling within the disturbance footprint.	Prior to drilling operations.
No soil parameters are above ecological screening levels attributable to the Proposal following completion of the activity.	Soil quality sampling.	Following site reinstatement.

5.2.7 Mitigation

A summary of the mitigation measures and their mitigation hierarchy that will be included in the Environment Plan for assessment and acceptance by DMIRS is included in Table 5-11.



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Table 5-11: Proposed mitigation measures – terrestrial environmental quality

Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Avoid	HFS spread integrity assessment	All high-pressure surface lines and equipment used (including the wells) will be pressure tested during rig-up to ensure integrity before the HFS operations commence.
Minimise	Water retention pond design	As per the Department of Water – Water Quality Protection Note 26 – Liners for containing pollutants, using synthetic membranes (DoW 2013), all lined storage compounds should have sufficient freeboard (at least 500 mm) maintained to prevent unintended overflow of water from storms with an average return frequency of at least 20 years, plus capacity to store rainfall resulting from a 90 percentile wet season, after allowance for any evaporative water loss and the effects of any water reuse recovery system.
Minimise	Water retention pond design	In accordance with Section B.4.16 of the NT Code of Practice, and as per the Department of Water – Water Quality Protection Note 26 – Liners for containing pollutants, using synthetic membranes (DoW 2013), surface ponds used to contain wastewater or solids that may leach contaminants for short-term containment, require synthetic membranes and need to meet specific requirements, which include: <ul style="list-style-type: none"> All synthetic drilling fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s; and A minimum thickness of 0.75 mm.
Minimise	Spill protection during refuelling	It is standard industry practice for contractors to have and implement a refuelling procedure. Refuelling procedures include the requirement for refuelling in a designated area and using drip trays. BNR will ensure that, in accordance with the contractors refuelling process, refuelling will only be undertaken on the well site hardstand, and drip trays will be utilised during this activity.
Minimise	Chemical and hazardous liquid material storage	In accordance with Section A.3.8 of the NT Code of Practice, and as per the Australian Standards (AS 1940[2004]) recommendations: <ul style="list-style-type: none"> Secondary containment for hazardous materials, chemicals and hydrocarbons comprise a volume that equals 110% of the largest container within the contained area or 25% percent of the combined tank volumes; or Tanks are double skinned.
Minimise	Chemical disclosure	In accordance with Recommendation 6 of the HFS Scientific Inquiry, composition of the proposed HFS fluid system is included in Appendix J. In accordance with Sections B.4.10 and B.4.13 of the NT Code of Practice, and as per the requirements of Regulation 9 of the PGER(E)R 2012, chemicals or substances must be disclosed for acceptance by DMIRS prior to commencing activities where they are: <ul style="list-style-type: none"> in, or added to, any treatment fluids to be used for the purposes of drilling or hydraulic fracturing undertaken in the course of the activity, or otherwise introduced into a well, reservoir or subsurface formation in the course of the activity. In addition to this, all chemicals to be used downhole under the Proposal are included on the Australian Inventory of Chemical Substances (AICS) or are otherwise approved for use in Australia. The chemicals will be used solely for the activity purpose they will serve as stated under the EP. The constituents, toxicity, ecotoxicity and bioaccumulation data of each chemical product or system will be disclosed.

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Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Minimise	Oil Spill Contingency Plan (OSCP)	Regulation 15 of the PGER(E)R 2012 requires that an OSCP will be developed for the Proposal and accepted by DMIRS prior to conducting any petroleum activities.
Minimise	Spill kits	To support the first strike / immediate response actions in the event of a spill as directed by the OSCP, spill kits will be made available onsite.
Minimise	Appropriately licensed waste contractor	<p>Waste generated during the Proposal, including potential spill-contaminated soils and materials, will be separated, and stored until an appropriately licensed waste contractor disposes of the waste at a licensed facility. Specifically, any controlled waste will be managed in accordance with the Environmental Protection (Controlled Waste) Regulations 2004.</p> <p>This reduces the risk of other accidental release events given they will be experienced in transfer and transport of waste.</p>

5.2.8 Predicted Outcomes

The outcomes of the Proposal are predicted to be:

- No detrimental impacts from erosion, scouring or drainage through the implementation of an EP; and
- No significant nor permanent impacts arising from spill events through the implementation of activity specific spill management measures.

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant impact to terrestrial environment quality. The environmental mitigation measures intended to manage and minimise impacts on terrestrial environmental quality are considered effective. Consequently, BNR believes that the EPA's objective to:

“To maintain the quality of land and soils so that environmental values are protected”

can be met.

BNR have considered the WA Environmental Offsets Policy, however BNR do not believe actions to offset the predicted outcomes of the Proposal are required as the Proposal is not expected to have a significant impact on terrestrial environmental quality.


5.3 Terrestrial Fauna

5.3.1 EPA Objective

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

5.3.2 Legislation, Policy and Guidance

- *Biodiversity Conservation Act 2016;*
- Biodiversity Conservation Regulations 2018;
- *Environment Protection and Biodiversity Conservation Act 1999;*
- Environmental Factor Guideline Terrestrial Fauna (EPA 2016e);
- Technical Guidance Sampling methods for Terrestrial Vertebrate Fauna (EPA 2016f);
- Technical Guidance Terrestrial Fauna Surveys (EPA 2016g).

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5.3.2.1 Application of EPA Guidance

The Environmental Factor Guideline – Terrestrial Fauna (EPA 2016e) identifies the considerations for conducting an EIA of this factor. The Proposal meets the guideline’s considerations as demonstrated in Table 5-12.

Table 5-12: Environmental factor guideline – terrestrial fauna considerations

Considerations for EIA	Section
Application of the mitigation hierarchy to avoid or minimise impacts to terrestrial fauna, where possible.	Table 5-16
The terrestrial fauna affected by the proposal.	Section 5.3.3
The potential impacts and the activities that will cause them, including direct and indirect impacts.	Section 5.3.4
The implications of cumulative impacts.	N/a ²
Whether surveys and analyses have been undertaken to a standard consistent with EPA technical guidance.	Section 5.3.3
The scale at which impacts to terrestrial fauna are considered.	Section 5.3.5
The significance of the terrestrial fauna and the risk to those fauna.	Section 5.3.5
The current state of knowledge of the affected species / assemblages and the level of confidence underpinning the predicted residual impacts.	Section 5.3.3 Section 5.3.5
Whether proposed management approaches are technically and practically feasible.	Table 5-16

5.3.3 Receiving Environment

Fauna presence within the Development Envelope is well understood given the numerous surveys that have been conducted for previous petroleum activities within EP 371. Previous studies relevant to the Proposal are provided in Table 5-13. The reports of all baseline studies confirmed that the surveys were conducted in accordance with the relevant technical EPA sampling and survey guidance. The most recent fauna survey conducted for the Development Envelope (Low Ecological Services 2020) has been attached in Appendix B.

In accordance with the Technical Guidance for Terrestrial Fauna Surveys (EPA 2016g), further fauna and habitat reconnaissance surveys will be undertaken prior to the start of the proposed activities.

Table 5-13: Baseline studies – terrestrial fauna

Year	Consultant	Survey Reference	Name / Location	Survey outcomes
2011	Low Ecological Services	Low Ecological Services (2011). Valhalla East-1 Exploration Well: Flora and Fauna Survey. September 2011. Report prepared for Buru Energy.	EP 371 691813m E 8002857m N (GDA 94, Zone 51).	<ul style="list-style-type: none"> The only sign of fauna of conservation significance was the Australian Bustard (<i>Ardeotis australis</i>, P4)⁵; Habitat at the proposed well site has the potential to support other species of conservation significance, but no signs of these species were present.

⁵ At the time of writing the Proposal, the Australian Bustard (*Ardeotis australis*) is no longer listed as a Priority species.



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Year	Consultant	Survey Name / Reference	Location	Survey outcomes
2011	Low Ecological Services	Low Ecological Services (2011). Flora and Vegetation Survey: Valhalla North. October 2011. Report prepared for Buru Energy.	EP 371 683112m E 8006107m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> There was no evidence of utilisation (diggings, dung or prints) of the site by listed mammals such as the Bilby (<i>Macrotus lagotis</i>); The Rainbow Bee-Eater (<i>Merops ornatus</i>), listed as a Migratory⁶ bird species under the Japan Australia Migratory Bird Agreement, was observed at Vahalla North-1.
2012	Low Ecological Services	Low Ecological Services (2012a). Asgard-1 Exploration Well: Flora, Vegetation and Fauna Survey. Report prepared for Buru Energy.	EP 371 714726m E 7981294m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> No species of conservation significance were recorded at the Asgard-1 well site. Diggings were identified at the well, but these were identified as originating from a non-listed species (<i>Varanus</i> sp.).
2012	Low Ecological Services	Low Ecological Services (2012b). Asgard 2D Seismic Survey: Flora, Vegetation and Fauna Survey. Report prepared for Buru Energy.	EP 371 -18.255566, 125.055461 -18.284348, 125.135494 -18.104218, 125.044064 -18.145749, 124.951130 - 18.110725, 124.809457 - 18.332103, 124981419 - 18.321484, 124.951740 - 18.295856, 124.906641 - 18.290406, 124.895847 - 18.247001, 125.030820 (GDA 94, Zone 51)	<ul style="list-style-type: none"> Two species of conservation significance were recorded during the survey; the Australian Bustard (<i>Ardeotis australis</i>, P4)⁵, and the Rainbow Bee-eater (<i>Merops ornatus</i>) listed as a Migratory⁶ and Marine species under the EPBC Act 1999. A burrow observed with similar characteristics to that of a Greater Bilby (<i>Macrotis lagotis</i>) burrow. This could not be confirmed, as diggings scats or tracks were not observed in the surrounding area; Signs of non-native animals were widespread. As the project area was located on a pastoral station, cattle and their impact were present and widespread throughout area, especially near water sources. Horse, camel and dogs / dingo tracks were also observed; Within the project area, ten different vegetation types and the Calwynyardah-Noonkanbah Road were surveyed. This covered the majority of the habitat types in the area, missing only potential microhabitats that were not noted from the air; The habitats visited had the potential to support other species of conservation significance, but no signs of other fauna of conservation significance were present.
2014	Buru Energy and Outback Ecology	Buru Energy and Outback Ecology (2014). Ophir, Paradise, Valhalla, Eden and Ellendale Flora, Vegetation and	Of relevance to the Proposal: EP 371 681471m E 8003803m N	<ul style="list-style-type: none"> Two conservation significant birds were recorded during the on-ground survey, <i>Ardeotis australis</i> (Australian Bustard (P4)⁵) and <i>Merops ornatus</i> (Rainbow Bee-eater (Migratory)⁶); Three introduced fauna species were recorded during the on-ground survey: <i>Bos taurus</i> (Cattle), <i>Felis catus</i>

⁶ At the time of writing the Proposal, the Rainbow Bee-Eater (*Merops ornatus*) is no longer listed as a Migratory species. It is now only listed as a Marine species under the EPBC Act.



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Year	Consultant	Survey Name / Reference	Location	Survey outcomes
		Fauna Survey Report. August 2014.	681532m E 8000656m N 686496m E 8004817m N 686141m E 8001639m N 695595m E 8003148m N 690276m E 7999424m N (GDA 94, Zone 51)	(Domestic Cat) and <i>Camelus dromedarius</i> (Dromedary camel); • Five broad fauna habitats occur within the survey area. The habitats are widespread regionally and it is unlikely that conservation significant fauna is specifically reliant on habitats within the survey area.
2016	Eco Logical Australia	Eco Logical Australia (2016). Level 1 Vegetation, Flora and Fauna Survey of Kurrajong, Yakka Munga and Valhalla Central Well Sites. Prepared for Buru Energy limited.	EP 371 Of relevance to the Proposal: Valhalla Central: 694310m E 7992800m N and 8 km access track (GDA 94, Zone 51)	<ul style="list-style-type: none"> • No Threatened or Priority fauna species were recorded from the study sites. One Migratory⁶ bird species, <i>Merops ornatus</i> (Rainbow Bee-eater), was recorded at Valhalla Central well site. This species was observed opportunistically foraging at these sites; • One introduced fauna species was recorded during the field survey, <i>Bos taurus</i> (Cattle); • Three major fauna habitats were described across the Valhalla Central site: <ul style="list-style-type: none"> ◦ <i>Corymbia</i> and <i>Adansonia</i> low open woodland over <i>Hakea</i> tall open shrubland over scattered <i>Triodia</i> hummock grassland and open tussock grassland on sand sheet / plain; ◦ <i>Corymbia</i> low trees over <i>Bauhinia</i> and <i>Acacia</i> tall shrubland over tussock grassland on dunes; ◦ <i>Adansonia</i> scattered low trees over mixed shrubland over <i>Triodia</i> hummock grassland and scattered tussock grasses on sheet flood fans.
2017	Buru and Dawson S.J (Murdoch University PhD project)	Dawson, S.J. (2017). Disturbance of ecology of the Greater Bilby (<i>Macrotis lagotis</i>). PhD Thesis, School of Veterinary and Life Sciences, Murdoch University. A preliminary unpublished report was additionally prepared for Buru in 2016: Murdoch University. (2016). Targeted Bilby survey of proposed well site 'Valhalla Central' and immediate area. Report prepared by Murdoch University, September 2016.	EP 371 694310m E 7992800m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> • Within the Valhalla Central survey area, no sign of recent bilby activity was recorded; • One burrow resembled an old bilby burrow (>2 years since used), which has since been occupied by a <i>Varanus panoptes</i> (Yellow-spotted monitor); • Habitat is potentially suitable for bilbies, based on other surveys of bilby habitat in the West Kimberley.

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Year	Consultant	Survey Name / Reference	Location	Survey outcomes
2018	Eco Logical Australia	Eco Logical (2018). Valhalla Central 4: Flora and Fauna Survey. Report prepared for Buru Energy Limited. August 2018.	EP 371 689310m E 7998098m N	<ul style="list-style-type: none"> No Threatened or Priority fauna species were recorded; One introduced fauna species, <i>Bos Taurus</i> (Cattle), was recorded as occurring throughout the study area; One broad fauna habitat type was recorded in the study area: <i>Eucalyptus coolabah</i> and <i>Corymbia greeniana</i> open woodland over mixed sparse shrubland over <i>Triodia ?schinzii</i> open hummock grassland over <i>Sorghum stipoideum</i> and <i>Eriachne obtusa</i> tussock grassland on floodplain (not frequently active) with light brown sand-clay.
2019	Low Ecological Services	Low Ecological Services (2020). Flora and Fauna Assessment – Odin 2D and 3D seismic survey, Fitzroy Basin, Western Australia. Report prepared for Bennett Resources Pty Ltd. Conducted in 2019, Report drafted in March 2020. Refer to Appendix B.	EP 371 17 sites within the survey area. The 3D seismic survey area is the same as the Development Envelope mentioned in the Proposal.	<ul style="list-style-type: none"> No Threatened or Priority fauna species were recorded; A range of animal tracks, scats, diggings, burrows, and remains were recorded, and identified with the help of a Traditional Owner; Potential Greater Bilby foraging excavation could not be confirmed. Northern Quoll scats could not be confirmed; Observations of non-native species (and scats and tracks) were mainly of cattle and feral cats, but some evidence of camels, dogs and / or dingoes was also recorded.

5.3.3.1 Protected Fauna

Fauna species that have been formally recognised as threatened with extinction or as having special conservation value are protected by International, Commonwealth and State legislation. At national level, fauna species are protected under the EPBC Act. Within Western Australia, Threatened and Priority fauna are listed under the BC Act and the Biodiversity Conservation Regulations 2018.

A desktop search of the DBCA NatureMap database identified no Threatened and Priority fauna species within a 5 km buffer around the Development Envelope. A search of the DAWE PMST identified that nine conservation significant species had the potential to occur within a 5 km buffer around the Development Envelope. These species are listed in Table 5-14, along with their likely of occurrence in the Development Envelope.


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Table 5-14: PMST search of conservation significant fauna species with the potential to occur around the Development Envelope

Conservation status				
Scientific name	Common name	Conservation status		Preferred habitat description (DAWE 2020b)
		Federal (EPBC Act)	WA (BC Act)	
Birds				
<i>Calidris ferruginea</i>	Curlew Sandpiper	Critically Endangered, Listed Marine, Listed Migratory under international agreements	Threatened	<p>In Australia, curlew sandpipers occur around the coasts and are also widespread inland, though erratic in their appearance across much of the interior. They occur mainly on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast (Watkins 1993). They are also recorded inland, though less often, including around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand. They occur in both fresh and brackish waters.</p> <p>NatureMap (2020) lists 2246 records for the species (none of these in the Development Envelope), with observations suggesting the species displays a strong preference to coastal habitat. The species' preferred habitat is not present in the Development Envelope, consequently the species is unlikely to be encountered during the Proposal.</p>
<i>Erythrura gouldiae</i>	Gouldian Finch	Endangered	Priority 4	<p>Gouldian finches are sparsely distributed across northern Australia in the Kimberley. The species inhabits open woodlands that are dominated by Eucalyptus trees and support a ground cover of Sorghum and other grasses. The critical components of suitable core habitat for the Gouldian finch appear to be the presence of favoured annual and perennial grasses (especially Sorghum), a nearby source of surface water and, in the breeding season, unburnt hollow-bearing Eucalyptus trees.</p> <p>NatureMap (2020) lists 466 records for the species (none of these in the Development Envelope). Although the species' preferred habitat is present in the Development Envelope (Section 5.1.3.3), this species has not been observed during previous fauna surveys, and consequently is considered unlikely to be encountered during the Proposal.</p>



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Conservation status


Scientific name	Common name	Federal (EPBC Act)	WA (BC Act)	Preferred habitat description (DAWE 2020b)
<i>Pezoporus occidentalis</i>	Night Parrot	Endangered	Critically Endangered	<p>The Night Parrot is a highly elusive nocturnal ground dwelling parrot found in the arid and semi-arid zones of Western Australia. The variation between reports and observations may be due to actual variation in the species' ecology across its range (TSSC 2016a). Night parrots were recorded drinking water in north-western Western Australia (Higgins 1999), although they may not rely on surface water, and instead may derive sufficient metabolic water from foraging on succulent plants, such as <i>Sclerolaena</i> spp. (Murphy 2015). This indicates that access to water may not be required in some circumstances. Roosting and nesting sites are consistently reported as within clumps of dense vegetation, primarily old and large Spinifex clumps, but sometimes other vegetation types (Higgins 1999, Murphy 2015).</p> <p>NatureMap (2020) lists 14 records for the species (none of these in the Development Envelope). Although the species' preferred habitat is present in the Development Envelope (Section 5.1.3.3), this species has not been observed during previous fauna surveys, and consequently is considered unlikely to be encountered during the Proposal.</p>
<i>Polytelis alexandrae</i>	Princess Parrot, Alexandra's Parrot	Vulnerable	Priority 4	<p>The Princess Parrot is confined to arid regions of Western Australia, in the north near the Fitzroy River. The species inhabits sand dunes and sand flats. It occurs in open savanna woodlands and shrublands that usually consist of scattered stands of Eucalyptus trees, an understorey of shrubs such as Acacia, and a ground cover dominated by <i>Triodia</i> species. It also frequents Eucalyptus or <i>Allocasuarina</i> trees in riverine or littoral areas. The population size, extent of occurrence and area of occupancy of the Princess Parrot are all believed to fluctuate as it is thought to breed in response to rainfall, which is an irregular event in the arid zone (Forshaw and Cooper 2002).</p> <p>NatureMap (2020) lists 121 records for the species (none of these in the Development Envelope). Although the species' preferred habitat is present in the Development Envelope (Section 5.1.3.3), this species has not been observed during previous fauna surveys, and consequently is considered unlikely to be encountered during the Proposal.</p>



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Conservation status				
Scientific name	Common name	Federal (EPBC Act)	WA (BC Act)	Preferred habitat description (DAWE 2020b)
<i>Rostratula australis</i>	Australian Painted Snipe	Endangered	Threatened	<p>The Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum <i>Muehlenbeckia</i> or canegrass or sometimes tea-tree (<i>Melaleuca</i>).</p> <p>NatureMap (2020) lists 113 records for the species (none of these in the Development Envelope). The species' preferred habitat is not present in the Development Envelope, consequently the species is unlikely to be encountered during the Proposal.</p>
Mammals				
<i>Dasyurus hallucatus</i>	Northern Quoll	Endangered	Endangered	<p>The Northern Quoll, a small nocturnal mammal, occupies a diversity of habitats across its range which includes rocky areas, eucalypt forest and woodlands, rainforests, sandy lowlands and beaches, shrubland, grasslands and desert (TSSC 2005). Dens are made in rock crevices, tree holes or occasionally termite mounds. Rocky habitats support higher densities and / or longer-lived individuals within the species range. Northern Quolls sometimes occur around human dwellings and campgrounds. Northern Quolls appear to be most abundant in habitats within 150 km of the coast (Braithwaite and Begg 1995).</p> <p>NatureMap (2020) lists 8172 records for the species (none of these in the Development Envelope). Although the species' habitat is present in the Development Envelope (Section 5.1.3.3 and Section 5.2.3.1), this species has not been observed during previous fauna surveys. However, scats that resembled the species were identified and as it is a ground dwelling species, there is a possibility that it could be encountered during the Proposal.</p>
<i>Macroderma gigas</i>	Ghost Bat	Vulnerable	Vulnerable	<p>Ghost bats move between a number of caves seasonally or as dictated by weather conditions (TSSC 2016b), and require a range of cave sites (Hutson <i>et al.</i> 2001).</p> <p>NatureMap (2020) lists 903 records for the species (none of these in the Development Envelope). The species' habitat is not believed to be present in the Development Envelope. BNR would furthermore not select its well site locations on or near cave sites. Consequently, the species is unlikely to be encountered during the Proposal.</p>

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Conservation status				
Scientific name	Common name	Federal (EPBC Act)	WA (BC Act)	Preferred habitat description (DAWE 2020b)
<i>Macrotis lagotis</i>	Greater Bilby	Vulnerable	Vulnerable	<p>Greater bilbies are currently known to occur within three major vegetation types: open tussock grassland on uplands and hills; mulga woodland / shrubland on ridges and rises; and hummock grassland growing on sand plains, dunes, drainage systems and other alluvial areas (Pavey 2006, TSSC 2016c).</p> <p>NatureMap (2020) lists 3303 records for the species (none of these in the Development Envelope). The species' habitat is present in the Development Envelope (Section 5.1.3.3 and Section 5.2.3.1), and consequently may be encountered during the Proposal.</p>
Sharks				
<i>Pristis pristis</i>	Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish	Vulnerable, Listed Migratory	Priority 3	<p>It is a marine / estuarine species that spends its first three–four years in freshwater. Juveniles and sub-adult Freshwater Sawfish predominantly occur in rivers and estuaries, while large mature animals tend to occur more often in coastal and offshore waters. The preferred habitat of this species is mud bottoms of river embayments and estuaries, but they are also found well upstream (Allen 1997). They are usually found in turbid channels of large rivers over soft mud bottoms, but will move into shallow waters when travelling upstream or while hunting prey.</p> <p>NatureMap (2020) lists 57 records for the species (none of these in the Development Envelope). The species' habitat is not present in the Development Envelope. The nearest creek is located approximately 1 km away from a proposed well site (Section 5.4.3.2) and is ephemeral for most of the year. Consequently, the species is unlikely to be encountered during the Proposal.</p>


Based upon the information provided in Table 5-14 to determine the likelihood of listed species being present in the Development Envelope, terrestrial fauna considered most likely to be encountered during Proposal were identified as ground dwelling mammals.

5.3.3.2 Introduced Species

The *Biosecurity and Agriculture Management Act 2007* allows pest animals that have a negative impact on agricultural production and the environment to be Declared. The Declared species are listed with a corresponding category which determines the level of management required to control this species.

The DAWE PMST report lists the following seven pest species as likely to occur within a 5 km radius of the well locations:

- *Canis lupus familiaris* (Domestic dog);
- *Equus asinus* (Donkey, Ass);
- *Equus caballus* (Horse);
- *Felis catus* (Domestic cat);
- *Rhinella marine* (Cane toad);
- *Sus scrofa* (Pig);
- *Vulpes vulpes* (Red fox, Fox).

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All of these species have been Declared under state legislation.

Bos taurus (Cattle) has also been recorded in many of the on-ground surveys. Given the location of the Development Envelope within pastoral stations, with lands used for cattle grazing, cattle are likely to be present within and surrounding the Development Envelope.

5.3.4 Potential Impacts

5.3.4.1 Direct Impacts

Direct impacts from the Proposal's activities may include:

- Death or displacement of native fauna species;
- Habitat destruction; and
- Habitat fragmentation.

5.3.4.2 Indirect Impacts

In addition to potential direct impacts to fauna and fauna habitat arising from the Proposal, the following indirect impacts to terrestrial fauna may arise:

- Habitat degradation as a result of the introduction and / or spread of non-indigenous species (weeds);
- Habitat degradation as a result of an unplanned fire event.


5.3.5 Assessment of Impacts

5.3.5.1 Death or Displacement of Native Fauna Species

Throughout all phases of the Proposal there are the two common sources of fauna interaction: entrapment and fauna strike. These interactions have the potential to cause death or injury to fauna. The fauna assemblage of the Development Envelope is considered intact, relatively diverse and representative of the West Kimberley region. Conservation significant fauna with the potential to be present are mobile with wide-ranging distributions. Given the limited extent of disturbance and duration of the Proposal, although mobile fauna has the potential to be encountered, interactions with fauna (if any) are expected to be low in numbers.

The temporary increase in impacts such as noise and vibration resulting from the Proposal were also considered. Such impacts may have the potential to displace fauna species. As the Development Envelope is situated within three pastoral stations, where pastoral, petroleum activities and vehicle movements associated with the local community are common, fauna are likely to be accustomed to noise and traffic movement. Additionally, noise impacts are restricted to short periods of loud operations, including mobilisation and demobilisation of personnel and equipment. It is consequently expected that fauna would avoid the area during site operations. The death or displacement of native fauna species as a result of the Proposal remains possible, however the Development Envelope is comprised of similar habitat throughout, and any displacement would be limited to the activity causing only short-term and temporary impacts. Noise impacts to social surroundings are further evaluated in Section 5.5.5.2.

As pathways for fauna interactions are well understood, the mitigation measures for preventing / reducing these interactions are well established. These risks are well managed through existing good practice mitigation measures which are well understood and implemented by the industry. The likely interaction and the significance of the Proposal's interaction with fauna of conservation significance is provided below.

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5.3.5.1.1 Northern Quoll

As described in Table 5-14, the Endangered *Dasyurus hallucatus* (Northern Quoll) is a small nocturnal mammal with the potential to occur within 5 km of the Development Envelope. Northern Quolls are known to occur in regional populations across Northern Western Australia, with Kimberley records being scattered discontinuously from just south of Derby across to Wyndham (DAWE 2020c).

This species has 8172 documented occurrences (Figure 5-9), across a widespread area throughout Northern Western Australia. The species are known to occupy a range of habitats which include rocky areas, eucalypt forests and woodlands, sandy lowlands and beaches, shrubland, grasslands and desert (TSSC 2005). Prime habitat for the Northern Quoll is habitat found in the northern regions of the Kimberley such as the sandstone escarpments. DAWE (2020b) identifies rocky areas as providing habitat critical to the survival of the species. These habitats have not been identified within the Development Envelope from previous flora and fauna surveys.

The Development Envelope is not known to comprise critical habitat for this species. As the vegetation and fauna habitat to be impacted is ubiquitous, it is unlikely that large numbers of the species would be encountered, displaced or impacted by the Proposal.

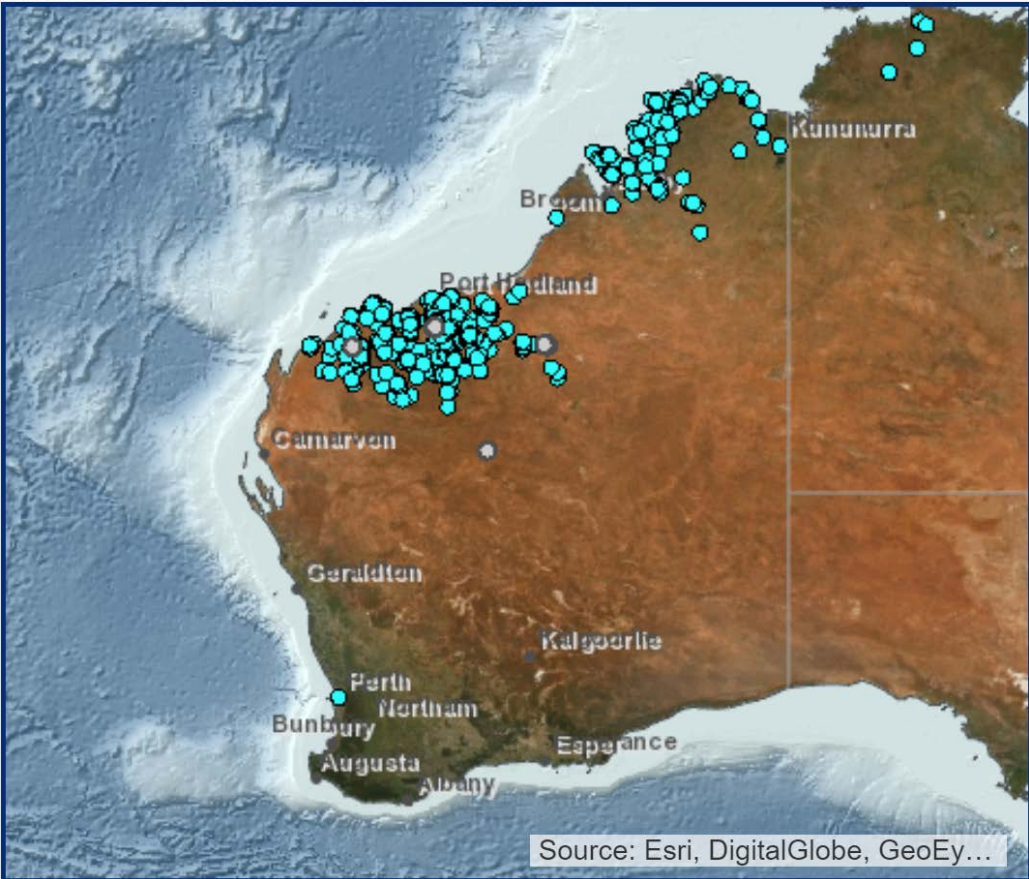



Figure 5-9: NatureMap records for *Dasyurus hallucatus* (Northern Quoll) (DBCA 2020)

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5.3.5.1.2 Greater Bilby

The lack of information regarding bilby habitat preference in north-western Australia has resulted in some ambiguity in management (Dawson 2017). In the West Kimberley region, Greater Bilbies (*Macrotis lagotis*) have been associated with red sands and dune fields, as well as Pindan woodlands and hummock and tussock grasslands (Cramer *et al.* 2016). This species has 3303 documented occurrences (Figure 5-10) across a widespread area throughout WA, with a large population presence around the Broome area. While no bilbies (or recent burrows) were recorded or identified during the most recent surveys within the Development Envelope, the definite presence of the species was recorded in other areas of the bioregion (Dawson 2017), outside of EP 371. The vegetation within and surrounding the Development Envelope could be considered as appropriate bilby habitat, however suitable habitat is also widely available throughout the wider region. Although this species may be present in the Development Envelope, any impacts would be expected at an individual level rather than a population level. Consequently, this species is unlikely to be significantly impacted due to the magnitude and duration of the Proposal and its widespread distribution throughout Western Australia.

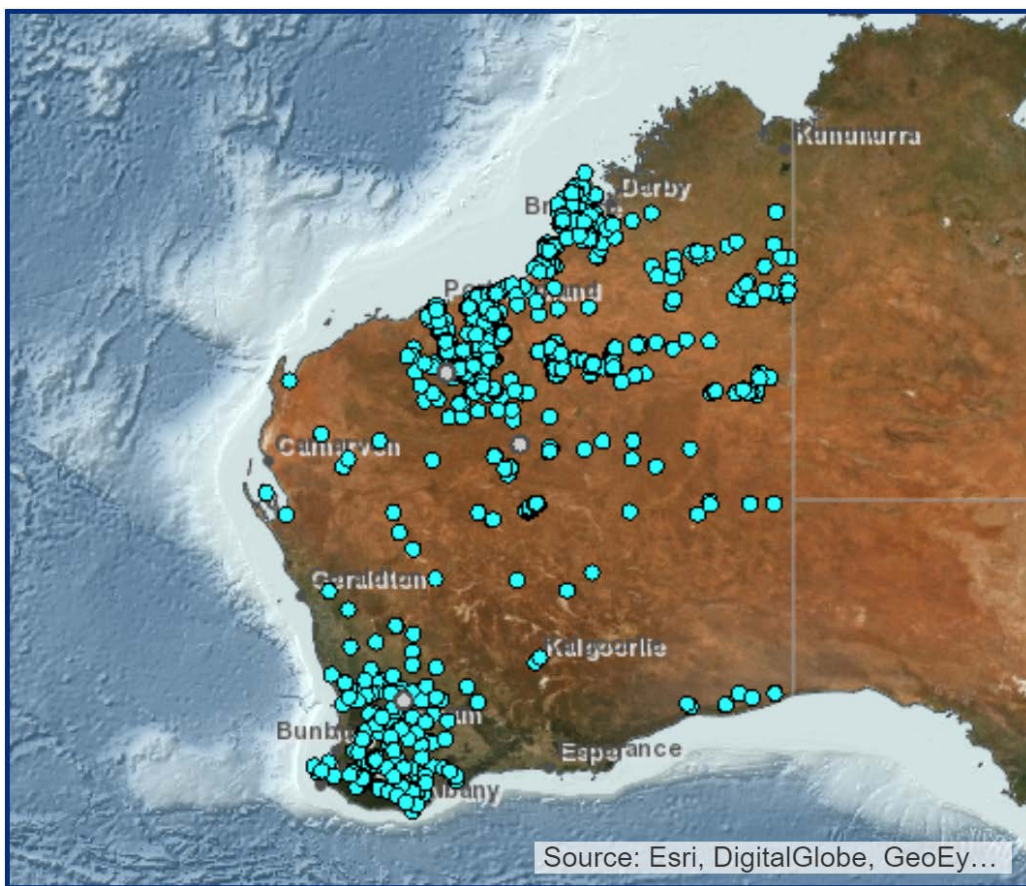



Figure 5-10: NatureMap records for *Macrotis lagotis* (Greater Bilby) (DBCA 2020)

5.3.5.2 Habitat Destruction

Habitat destruction is listed as a specific threat under the National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*) (Hill and Ward 2010) and the National Recovery Plan for the Greater Bilby (*Macrotis lagotis*) (Pavey 2006). Both species are known to have a wide distribution, and localised impacts from the Proposal are limited to clearing ~102 ha of vegetation. As described in Section 5.1.3.3, vegetation communities identified within the Development Envelope are well represented within pre-European extents indicating that the extent of impact associated with the Proposal is unlikely to be significant given that similar vegetation and thus habitat is present throughout the Development Envelope and the wider region.

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No habitat critical for the survival of the species has been previously identified within the Development Envelope. The vegetation and fauna habitat to be impacted is ubiquitous, therefore it is unlikely that large numbers of the species would be encountered, displaced or impacted by the Proposal.

5.3.5.3 Habitat Fragmentation in the Immediate Area of Clearing

Fragmentation, or the breaking up of large areas of intact vegetation, may have negative impacts on overall ecosystem functioning and fauna and flora community structure (pollination, seed dispersal etc). Examples of impacts from fragmentation including the disturbance to / or interruption of fauna movements, foraging and hunting behaviours. Approximately half of Australia's species currently listed as Threatened under the EPBC Act are considered to be at risk from habitat fragmentation (Jackson *et al.* 2016). However, habitat fragmentation is not listed as a specific threat under the National Recovery Plan for the Northern Quoll (Hill and Ward 2010) or the National Recovery Plan for the Greater Bilby (Pavey 2006). Both species are known to have wide ranging movement patterns which indicates that the magnitude of disturbance for each well site associated with the Proposal is unlikely to hinder these species moving through the landscape.

5.3.5.4 Habitat Degradation as a Result of the Introduction and / or Spread of Non-Indigenous Species (Weeds)

The presence and introduction of weeds is listed as a specific threat under the National Recovery Plan for the Northern Quoll (Hill and Ward 2010). Specifically, the recovery plan indicates that an increased presence of weeds may inhibit ground movements and hunting by quolls, or foster fire regimes that are more intense which are more likely to cause direct mortality, reduce availability of shelter and reduce habitat heterogeneity.

As pathways for spreading or introducing weed species are well understood, the mitigations measures for preventing / reducing these interactions are well established. These risks are well managed through existing good practice mitigation measures which are well understood and implemented by the industry. With standard industry management measures in place, no significant impacts are expected.

5.3.5.4.1 Habitat Loss or Degradation as a Result of an Unplanned Fire Event

Inappropriate fire regimes are listed as a specific threat under the National Recovery Plan for the Northern Quoll (Hill and Ward 2010) and under the National Recovery Plan for the Greater Bilby (Pavey 2006). Fire events have the potential to cause a number of impacts, including direct mortality and injury, or indirect mortality through alteration of habitat and reduction of food abundance, breeding cycles and recruitment and increased predation due to a reduction in ground cover (Hill and Ward 2010).


Grass fires occur regularly in the Canning Basin during the dry season. Although fire frequency varies, grass fires typically occur every two to four years (NAFI 2020). Weather conditions, fire history and vegetation fuel load all contribute to grass fire patterns and intensity.

As sources of fire events are well understood, the mitigations measures for preventing / reducing these events are well established. These risks are well managed through existing good practice mitigation measures which are well understood and implemented by the industry. With standard industry management measures in place, no significant impacts are expected.

5.3.5.5 Application of Legislation, Policy and Guidance

Approval to clear native vegetation and flora is regulated under the Part V of EP Act and impacts to vegetation, flora and terrestrial fauna are also regulated under the PGER (Environment) Regulations 2012. The Environmental Protection (Clearing of Native Vegetation) Regulations 2004 provide exemptions for clearing vegetation. Under Regulation 5, Item 24, which covers exemption for activities conducted under the PGER Act, the activity is exempt from requiring a native vegetation clearing permit.

Under the PGER (Environment) Regulations 2012, a DMIRS accepted Environment Plan is required to manage both direct and indirect impacts on terrestrial fauna associated with the Proposal. Specifically, the EP must consider impact significance and demonstrate that impacts and risks are reduced to a level that is ALARP and acceptable prior to acceptance by DMIRS. No activities covered in the Proposal can commence until an EP is accepted by DMIRS.

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Consequently, as impacts associated with this preliminary key environmental factor will not be significant, they are able to be suitably managed under these other regulatory requirements.

5.3.6 Impact Validation and Verification

Throughout the planning phase, BNR have reviewed studies undertaken by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, once the well locations are finalised, BNR plan to conduct a range of studies to validate the assumptions in the Proposal and verify the impacts of the activity. The assumptions and verification studies are documented in Table 5-15. The complete monitoring, verification and validation program for the Proposal is included in Section 7.

Table 5-15: Assumptions and verification studies for the Proposal


Assumptions	Verification studies during activity	Timing
No significant fauna habitat will be disturbed by the Proposal.	Flora and vegetation reconnaissance survey (with fauna habitat / opportunistic fauna observation) within the disturbance footprint.	Prior to site preparation operations.

5.3.7 Mitigation

A summary of the mitigation measures and their mitigation hierarchy that will be included in the Environment Plan for assessment and acceptance by DMIRS is included in Table 5-16.

Table 5-16: Proposed mitigation measures – terrestrial fauna

Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Avoid	Fauna exclusion and egress	In accordance with Section B.4.16 of the NT Code of Practice and the Fauna Egress Matting and Ramps guidance (DMP 2012), the implementation of fauna exclusion and egress management measures where lined ponds / fauna traps are present is considered good practice to reduce likelihood of entrapment, whilst providing means of egress if the initial exclusionary barriers fail. As such, water retention ponds will be fenced with 1.0 m high feral ring lock mesh fencing with small animal mesh attached to the base of the fence to help prevent ingress of small animals. During drilling activities, one section of the mud sumps will be unfenced in front of the shakers to allow the cuttings chute to be directed into the sumps.
Avoid	Speed limits	Vehicle speed limit signage will be installed along the access tracks and well sites. By reducing speed limits where limits are not set by law, the number of fauna strike incidents are expected to be reduced.
Avoid	Fire breaks	In accordance with Section A.3.7 of the NT Code of Practice, it is industry best practice, and required by local shire regulations, to ensure clearances between vegetation and the petroleum activities are installed and maintained to reduce the risk of causing a fire outside of the site.
Avoid	Bush Fires Regulations 1954	Under the Bush Fires Regulations 1954, site preparation and construction activities (hot work and off-road activities) and operational activities (i.e. gas flaring) are considered prescribed activities. As such, a range of management measures under the Regulations are required to be implemented.
Minimise	Site inspections of fauna traps	It is a generally accepted good industry practice to conduct routine inspections of areas considered to be potential fauna traps throughout operations.

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Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Minimise	Weed management measures	<p>According to the Department of the Environment – Arrive Clean, Leave Clean guidance (Commonwealth of Australia 2015), it is considered good industry practice for the prevention of spreading weeds to ensure that fill for civil works such as gravel, limestone marl, soil or sand has been verified to have a low weed risk.</p> <p>It is also considered good industry practice to ensure that good hygiene measures are implemented. Prior to entering the well sites, earthmoving machinery and equipment will be checked for weeds or weed contaminated materials, and cleaned if necessary.</p>
Rehabilitate	Progressive rehabilitation	<p>In accordance with Section A.3.9 of the NT Code of Practice, once drilling and HFS activities are complete, cleared areas that are not required to support the maintenance of infrastructure will be progressively rehabilitated to minimise rehabilitation legacy at the end of asset life. Topsoil and vegetation are to be re-spread and rehabilitation sites actively monitored to ensure they meet required completion criteria.</p>

5.3.8 Predicted Outcomes

The outcomes of the Proposal are predicted to be:

- No impact to listed fauna species' populations; and
- No significant degradation, loss or fragmentation of habitat surrounding the Development Envelope.

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant impact to terrestrial fauna. The environmental mitigation measures intended to manage and minimise impacts on terrestrial fauna are considered effective. Consequently, BNR believes that the EPA's objective to:

"To protect terrestrial fauna so that biological diversity and ecological integrity are maintained."

can be met.

BNR have considered the WA Environmental Offsets Policy, however BNR do not believe actions to offset the predicted outcomes of the Proposal are required, as the Proposal is not expected to have a significant impact on terrestrial fauna.


5.4 Inland Waters

5.4.1 EPA Objective

To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.

5.4.2 Policy and Guidance

- Environmental Key Factor Guideline – Inland Waters (EPA 2016h);
- Australian and New Zealand Environment and Conservation Council (ANZECC) Guidelines for Water Quality Management (2000);
- Department of Water – Water Quality Protection Notice (WQPN) 26 (liners for containing pollutants, using synthetic membranes) (DoW 2013);
- Department of Mines and Petroleum / Department of Water (2016). Guideline for groundwater monitoring in the onshore petroleum and geothermal industry.

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5.4.2.1 Application of EPA Guidance

The Environmental Factor Guideline – Inland Waters (EPA 2016h) identifies the information required for conducting an EIA of this factor. The Proposal meets the guideline's requirements as demonstrated in Table 5-17.

Table 5-17: Environmental factor guideline – inland waters requirements

Information required for EIA	Section
Description of studies and surveys of surface water and / or groundwater systems and proposed buffers.	Table 5-18
Characterisation of the surface water and / or groundwater systems, including climatic influences on water availability and, where relevant, location, hydrology, water quality, catchment boundaries, geology, hydrogeology, and connectivity, locally and regionally.	Section 5.4.3
Description of the environmental values of the surface or groundwater systems.	Section 5.4.3
Information on the water to be used in the proposal or scheme, and other current and potential water use in the area.	Table 2-4 Section 2.4 Section 5.4.3.5
Description of how excess water is to be disposed of and how this might impact the environment.	Section 2.4.3
Characterisation of the waste generated, the pathways for potential contamination, and quantification of how the proposal or scheme will impact water quality, where necessary through the use of models.	Table 2-5 Section 5.4.5.2 Section 5.4.5.3 Section 5.4.5.4
Modelling the impact of water abstraction and use for the proposal or scheme on water regimes and other users, including the assumptions and uncertainties of the modelling and supporting data.	Section 5.4.5.1 Appendix E Table 5-24
Predictions of the changes to surface and groundwater water regimes as a result of the proposal or scheme.	Section 5.4.5.1
The potential consequences of any hydrological or water quality changes on downstream waters such as estuaries or the marine environment.	N/a
Predictions of the likely impacts of water use and changing water quality on water dependent ecosystems and other environmental values.	N/a
Evaluation of the significance of the potential impacts (direct, indirect and cumulative ²) of the proposal or scheme on inland waters in a local and regional context.	Table 5-21 Section 5.4.5.1
Description of the approach to maintaining well integrity for wells which intercept multiple aquifers.	Section 5.4.5.5 Table 5-25
Description of monitoring, mitigation, management, closure and rehabilitation arrangements.	Table 5-24 Table 5-25



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Information required for EIA	Section
Information on the predicted outcome of the proposal or scheme against the environmental objective for inland waters and discuss whether there is likely to be a significant residual impact.	Section 5.4.4 Section 5.4.5
Description of the adaptive management and / or contingency planning in the instance that predictions are incorrect.	Table 5-24 Table 5-26

5.4.3 Receiving Environment

Water quality within the Development Envelope is well understood given the sampling programs that have been conducted for previous petroleum activities within EP 371. Previous studies relevant to the Proposal are provided in Table 5-18. Monitoring sites within the Development Envelope are shown in Figure 5-11.

Table 5-18: Baseline studies – water quality

Year	Consultant / operator	Study	Location	Study outcomes
2012 and 2013	Buru Energy in partnership with Noonkanbah Rangers	Baseline groundwater monitoring in prospective tight gas areas	EP 371 Valhalla North 1 well site: 683112m E 8006107m N (GDA 94, Zone 51) Asgard 1 well site: 714726m E 7981294m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> Groundwater samples collected from the production water bores on site were initially used to characterise groundwater quality for the future 2015 HFS program areas. This was supplemented by sampling of nearby pastoral bores to further characterise groundwater quality (Figure 5-11); Provided 2 years of baseline data from extraction bores on site.
2014 and 2015	Buru Energy in partnership with Noonkanbah Rangers	Groundwater monitoring program for the 2015 program	EP 371 Valhalla North 1 well site: 683112m E 8006107m N (GDA 94, Zone 51) Asgard 1 well site: 714726m E 7981294m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> Six groundwater monitoring bores (combination of shallow and deep) were installed at each well site in 2014. The monitoring bores included a combination of upgradient (reference) and downgradient ('impact') monitoring bores. The deep bore adjacent to the well head at each site (AB2D and VNB1D) provides the most suitable location for monitoring for any impacts on groundwater associated with the petroleum well; All 12 bores were sampled on a six-weekly basis, and increased to a four-weekly basis in the 3 months leading up to the commencement of the HFS operations; Provided 12 months of baseline data from dedicated environmental monitoring bore, for over 65 parameters including anions, cations, metals and hydrocarbons. Chloride was selected as a key indicator of impacts from HFS operations; Chloride levels during this period ranged from 810 mg/L to 1,000 mg/L at AB2D and 258 mg/L to 308 mg/L at VNB1D.
2016-2018	Buru Energy	Post-operational groundwater monitoring	EP 371 Valhalla North 1 well site: 683112m E 8006107m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> All 12 monitoring bores were monitored quarterly until October 2016 (one year post 2015 HFS program); Given that the monitoring determined no impacts of the 2015 HFS program on groundwater, monitoring



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Year	Consultant / operator	Study	Location	Study outcomes
			Asgard 1 well site: 714726m E 7981294m N (GDA 94, Zone 51)	<p>was rescheduled to six-monthly from October 2016, in consultation with DMIRS;</p> <ul style="list-style-type: none"> Chloride levels during this period ranged from 700 mg/L to 970 mg/L at AB2D and 290 mg/L to 310 mg/L at VNB1D.
2019-present	Buru Energy and Bennett Resources	Post-operational groundwater monitoring	EP 371 Valhalla North 1 well site: 683112m E 8006107m N (GDA 94, Zone 51) Asgard 1 well site: 714726m E 7981294m N (GDA 94, Zone 51)	<ul style="list-style-type: none"> Six-monthly monitoring of all 12 bores continued until November 2019; From November 2019, monitoring focussed on the deep bore adjacent to the well head at each site (AB2D and VNB1D); Chloride levels during this period ranged from 940 mg/L to 950 mg/L at AB2D and 290 mg/L to 300 mg/L at VNB1D; Most recent monitoring occurred in November 2020 (laboratory results consistent with previous sampling results).



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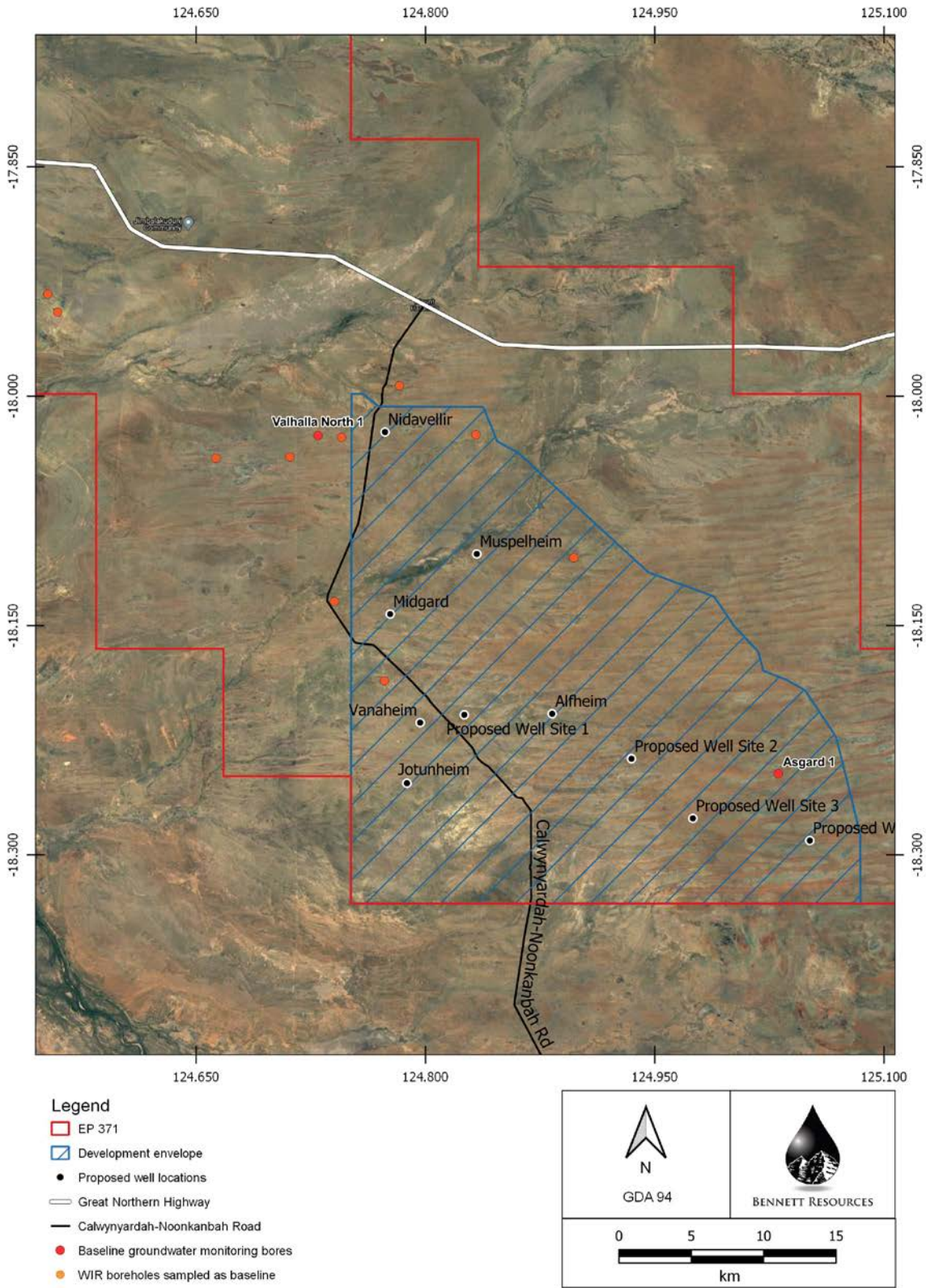



Figure 5-11: Proximity of groundwater sampling bores monitored during the previous HFS program

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5.4.3.1 Climate

The climate of the Canning Basin varies from semi-arid to dry tropical with distinct wet and dry periods and an average annual total rainfall of 600-900 mm. There are two main broad-scale influences on climate in the Kimberley region: the band of high pressure known as the sub-tropical ridge to the south, and the monsoon which delivers moist air from the warm tropical waters to the north. Over 75% of the average annual rainfall falls from January to March associated with thunderstorms and tropical lows or cyclones. Figure 5-12 shows the mean monthly rainfall at Fitzroy Crossing (approximately 51 km east of the Development Envelope) and demonstrates the distinct wet and dry seasons.

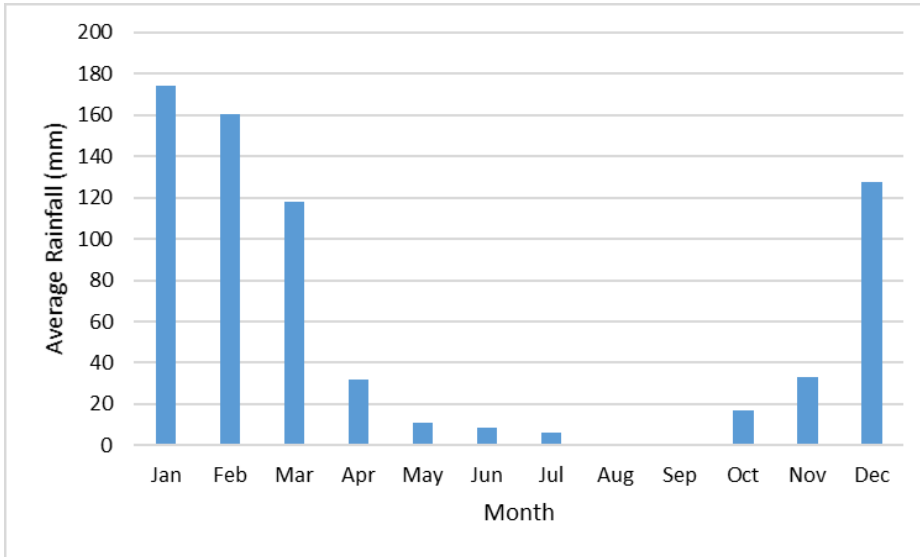


Figure 5-12: Average rainfall figures for Fitzroy Crossing (BoM 2020)

5.4.3.2 Surface Waters

Within or surrounding the Development Envelope, three recognised surface water bodies are present. These are the:

- Fitzroy River, located approximately 16 km from the Development Envelope;
- Mount Hardman Creek, crossing the Development Envelope; and
- Mount Wynne Creek, situated North of the Development Envelope.

The proximity of these features to the proposed well locations is provided in Table 5-19 and shown in Figure 5-13.

Table 5-19: Surface water bodies

Well site name	Catchment	Closest surface water body
Jotunheim	Fitzroy River	Approximately 15 km south of Mount Hardman Creek Approximately 26 km north of Fitzroy River
Midgard		Approximately 2.5 km south east of Mount Hardman Creek
Alfheim		Approximately 13.5 km south east of Mount Hardman Creek
Muspelheim		Approximately 1 km south east of Mount Hardman Creek
Vanaheim		Approximately 10 km south of Mount Hardman Creek



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Well site name	Catchment	Closest surface water body
Nidavellir		Approximately 7 km south east of Mount Wynne Creek Approximately 10 km north of Mount Hardman Creek
Proposed well site 1		Approximately 10.7 km south / south east of Mount Hardman Creek
Proposed well site 2		Approximately 18.7 km south east of Mount Hardman Creek
Proposed well site 3		Approximately 25 km south east of Mount Hardman Creek Approximately 27 km north of Fitzroy River
Proposed well site 4		Approximately 24 km north of Fitzroy River

The Fitzroy River generally flows between November and May following seasonal rainfall and has large but short duration floods (less than two months in a wet year). Due to the long dry season present in the Development Envelope, many of the tributaries of the surface fluvial system draining into the Fitzroy River are ephemeral streams or swale washes. These ephemeral water bodies may occur in clay pans. The surface water lines shown within the Development Envelope (Figure 5-13) all consist of such ephemeral water bodies. The river contracts to pools with very low flows from about June to October (DoW 2006). Ecologically, permanent pools are important refuges for aquatic species, enabling them to survive the harsh dry season.

Salinity levels in the Fitzroy River have not been routinely measured; however, some records are available from five stations from 1996 to 2005. Wet season salinity levels are usually less than 250 mg/L compared to dry season levels which range up to 900 mg/L (Vogwill 2015). The river is fresh (< 500 mg/L) between Fitzroy Crossing and Noonkanbah, it is marginal (500–1000 mg/L TDS) between Noonkanbah and Myroodah Station (approximately 51 km west of the Development Envelope), and fresh from Myroodah to Willare (20 km south of Derby). Dry season salinity of the river water can be interpreted to reflect the salinity of the groundwater, as contribution from surface runoff is negligible and river flows are supported by baseflow. The brackish stretch of river at Noonkanbah may reflect the baseflow contribution both from the alluvial aquifer, and possibly from the Noonkanbah Formation, over which the river flows along that section. There may also be an influence of the Blina Shale upstream from Noonkanbah (Lindsay and Commander 2005). The results from the five sampling stations show that the salinity of river water often exceeds the desirable potable water limit of 500 mg/L during the dry season.



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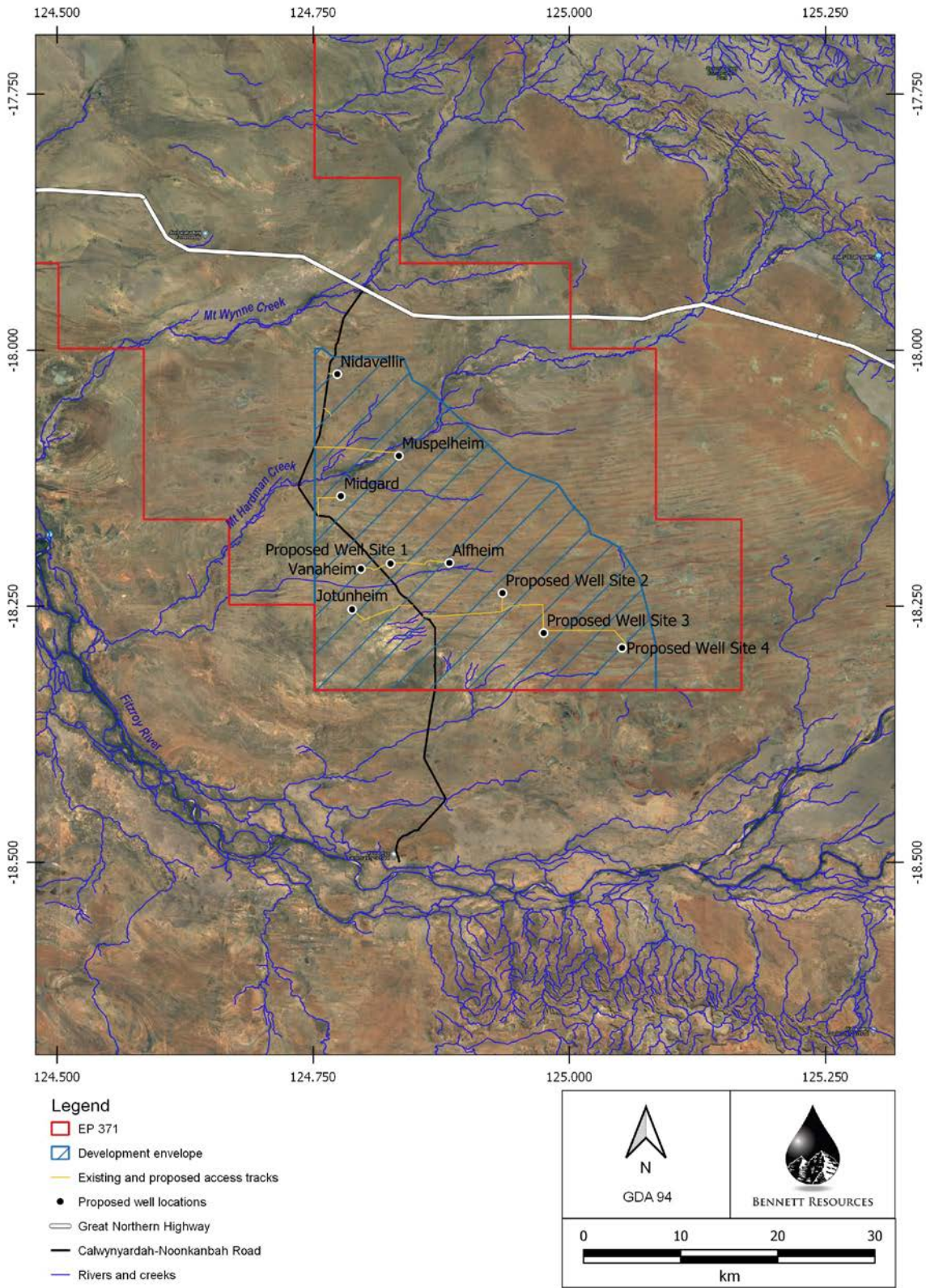


Figure 5-13: Surface waters within and surrounding the Development Envelope



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5.4.3.3 Hydrogeology

The Proposal is situated in the Canning Basin region. The Canning Basin is considered the second largest groundwater resource in Australia after the Great Artesian Basin. It is a large sedimentary basin covering an onshore area of more than 450,000 km² (DoW 2012). The major regional aquifer systems in the Canning Basin are (in order of decreasing age) the Grant Formation, Liveringa Formation, Wallal Sandstone and Broome Sandstone. These sandstone aquifers have very large stores of fresh to saline groundwater with variable total dissolved solids (TDS) content.

Data of three Valhalla province wells acquired from the previous operator of EP 371 (Table 5-20) has provided a detailed two-dimensional cross section of the aquifers, shown in Figure 5-14.

Table 5-20: Regional aquifer data acquired from Valhalla province wells

Formation	Dominant lithology	Classification	Elevation – base of formation (m AHD)			Thickness	Total Dissolved Solids (mg/L)
			Valhalla 2	Valhalla North 1	Asgard 1		
Liveringa	Carbonate / shale	Minor aquifer, Aquitard	-84	-196	-171	84 to 196 m	500 to 12,400
Noonkanbah	Shale	Aquiclude	-441	-635	-579	357 to 439 m	550 to 800
Poole Sandstone	Sandstone and Shale	Aquifer or Aquitard	-524	-715	-695	80 to 116	300
Grant Group	Sandstone	Aquifer	-1,332	-1,499	-1,240	545 to 808	800-1,000
Reeves	Sandstone	Aquifer	-1,588	-1,826	-1,606	270 to 366	
Anderson	Sandstone, siltstone, shale	Minor aquifer, Aquitard	-1,858	-2,105	-1,790	184 to 279	70,000 to 100,000(?)
Laurel	Limestone, shale, siltstone and sandstone	Minor aquifer, Aquitard	<-3,350	<-3,241	<-3,400	1136 to 1610	70,000 to 100,000(?)



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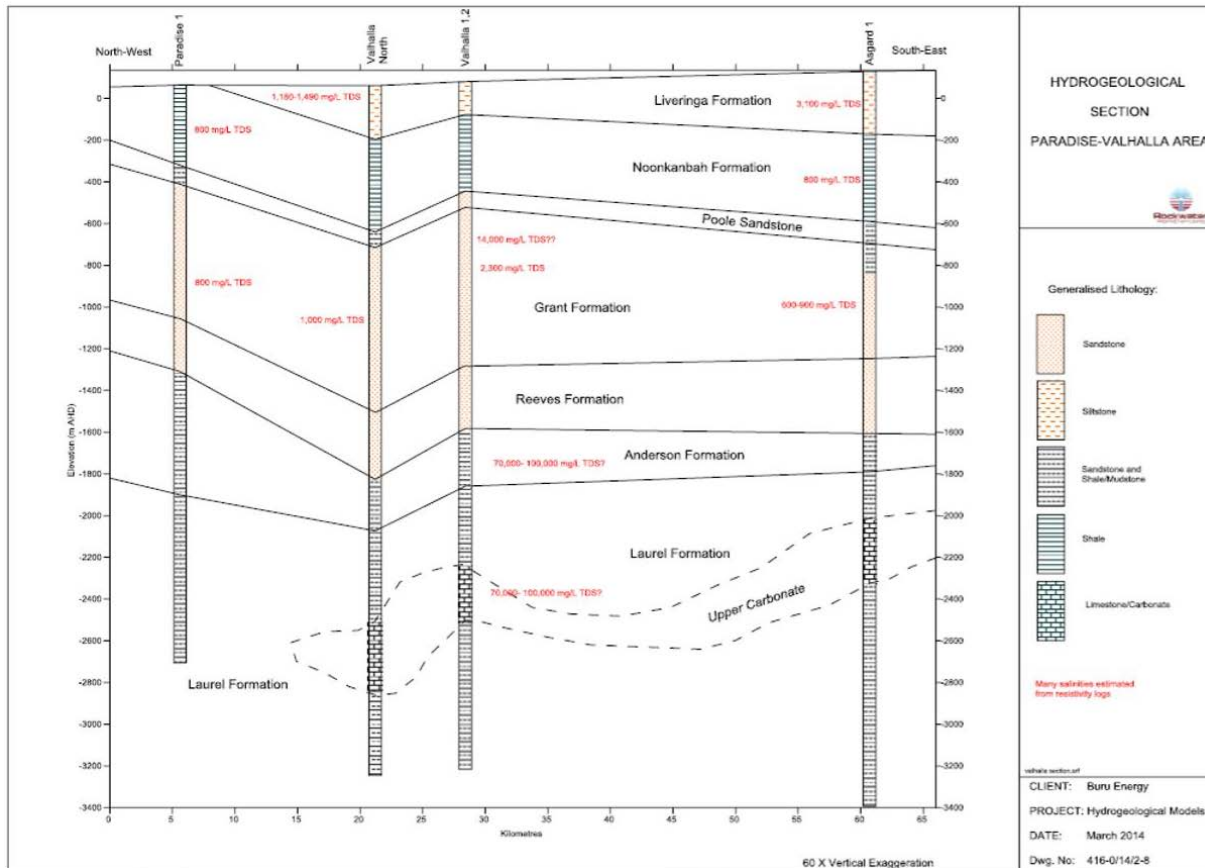



Figure 5-14: Hydrogeological cross section for the Valhalla province

The Livinginga Formation consists of interbedded sandstones, siltstones with lenses and minor beds of claystone and shale, varying in thickness between 320 m to 900 m (Harrington and Harrington 2015). Salinities, where recorded in DWER’s Water Information Reporting (WIR) database and by the previous operator, are generally less than 1,000 mg/L TDS in the Livinginga Formation, but may range from 500 to 12,400 mg/L TDS (Appendix E [Rockwater 2016]). Salinities for water bores located around EP 371 well sites that are screened in the Livinginga Formation range from 450 to 1,600 mg/L TDS (Appendix E [Rockwater 2016]). Monitored groundwater levels in the region surrounding the Development Envelope indicate predominantly stable trends, suggesting that the groundwater system is in dynamic equilibrium. Seasonal fluctuations of groundwater levels in the region are between 0.2 m and 1 m (Appendix E [Rockwater 2016]). Based upon groundwater flow rates in the Livinginga Aquifer, Rockwater (2016) predicted that the duration of groundwater migration from the western part of the Development Envelope to the Fitzroy River (approximately 32 km) would take around 16,000 years. BNR have access to data from the large number of water sampling programs that have been conducted within EP 371 (Table 5-18). The outcome of the most recent water quality monitoring program within EP 371, conducted in 2018 for bores screened within the Livinginga Formation and located within the Development Envelope is provided in Appendix I. These studies indicate that methane levels within the Livinginga group vary between 0.01 mg/L and 0.05 mg/L⁷.

The Noonkanbah Formation is generally thought of as an aquitard, comprising siltstone, limestone and minor sandstone (Lindsay and Commander 2005). Consequently, the Noonkanbah Formation is considered to provide the first natural geological barrier between useable aquifers and the targeted tight gas containing Laurel Formation. The Noonkanbah Formation comprises mainly shale with minor fine-grained sandstone in the Valhalla province and is thought to be 400 to 450 m thick. For bores screened in the Noonkanbah Formation

⁷ This is considered to meet the HFS Scientific Inquiry Recommendation Number 5 – refer to Appendix A

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(WIR database, pastoral and previous operator bores), salinity levels were identified to range from 550 to 800 mg/L TDS, but are up to 2,300 mg/L TDS.

The Poole Sandstone lies directly above the Grant Formation however the two are considered to be hydrogeologically similar, regarded as good aquifers because of their combined thickness and widespread distribution (Lindsay and Commander 2005). The Poole Sandstone is mainly fine-grained with some medium to coarse sandstone towards the base. The Grant Formation is much thicker than the Poole Sandstone. The three salinities available from the WIR database for the Poole Sandstone range from 200 to 325 mg/L TDS. The one bore recorded on the WIR database that is screened in the Grant Formation had a salinity of 860 mg/L TDS. However, in other areas of the Grant Formation, oil accumulations are known to occur with hydrocarbons having previously been produced from the Grant Formation from the Sundown, Boundary and West Terrace wells at Blina Oilfield to the north of the Project Area (Jonasson 2001).

The dominantly sandstone Reeves Formation is also an aquifer that is generally considered as part of the Grant Aquifer (formerly described as the Lower Grant Formation). Below, the Anderson and Laurel Formations are considered to be aquitards and minor aquifers. The sandstone and limestone of these formations generally have low permeability. The sediments in the Laurel Formation are predominantly sandstone, carbonate and shale of shallow water marine, deltaic and fluvial origin. Within the Laurel Formation, the permeability and porosity decreases with depth providing the constraining mechanism for gas accumulation. Located directly above the Laurel Formation, the Anderson Formation has a shale layer that acts as a confining seal.

5.4.3.4 Groundwater Recharge

Groundwater recharge to the surficial Liveringa Group is believed to be mainly from rainfall on outcrop areas (Lindsay and Commander 2005). During the 'Fitzroy River integrated ground and surface water hydrology assessment' conducted between 2008-2011, monitoring of the Liveringia Aquifer and surface alluvial waters associated with the Fitzroy River indicated a strong connection between the river and the aquifer. This project was led by the Department of Water (DoW at the time) with funding provided by National Water Commission under the Raising National Water Standards (RNWS) program. The multi-level piezometers that were installed at three sites on Noonkanbah Station as part of the DoW / RNWS project showed a groundwater response to high river flow events (Lindsay and Commander 2005). This, and comparatively low groundwater salinities measured in these piezometers compared with other regional bores, suggests some recharge to the aquifer by floodwaters.

Infiltration to the Liveringa Group (and subsequent aquifers) from rainfall will be retarded by clay, shale and siltstone layers, both above and below the water table. Water is likely to take between 70 and 300 days to travel from the ground surface to the water table (Appendix E [Rockwater 2016]).

5.4.3.5 Groundwater Use

Groundwater is used for licensed and unlicensed extraction in the region. The latter is likely to include domestic and stock watering which extract relatively minor volumes of groundwater. In accordance with the *Rights in Water and Irrigation Act 1914*, DWER allocates water use via licences within the sustainable volume available for a groundwater resource. DWER have determined that the Canning-Kimberley groundwater area (Figure 5-15) has an allocated limit of over 300,000 ML/year (DoW 2014), of which only 0.9 GL (4.3%) is licenced within the Liveringa Aquifer (Harrington and Harrington 2015). A search for licenced users within the Development Envelope identified five other water licences as detailed in Table 5-21. The nearest physical licensed groundwater user is the Yungngora community, located approximately 19 km south of the Development Envelope.

Table 5-21: Summary of groundwater extraction licences

Number	Issue date	Expiry date	Allocation (ML)	Owner	Targeted aquifer
174685	05/10/2020	04/10/2030	309	Main Roads	Liveringiga
165723	14/09/2020	13/09/2030	99	Main Roads	Grant



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Number	Issue date	Expiry date	Allocation (ML)	Owner	Targeted aquifer
174785	19/11/2019	18/11/2029	40.5	Buru Energy Limited	Wallal
180003	29/09/2016	17/03/2021	20	Buru Energy Limited	Erskine
181107	18/01/2017	15/01/2027	10	Buru Energy Limited	Grant

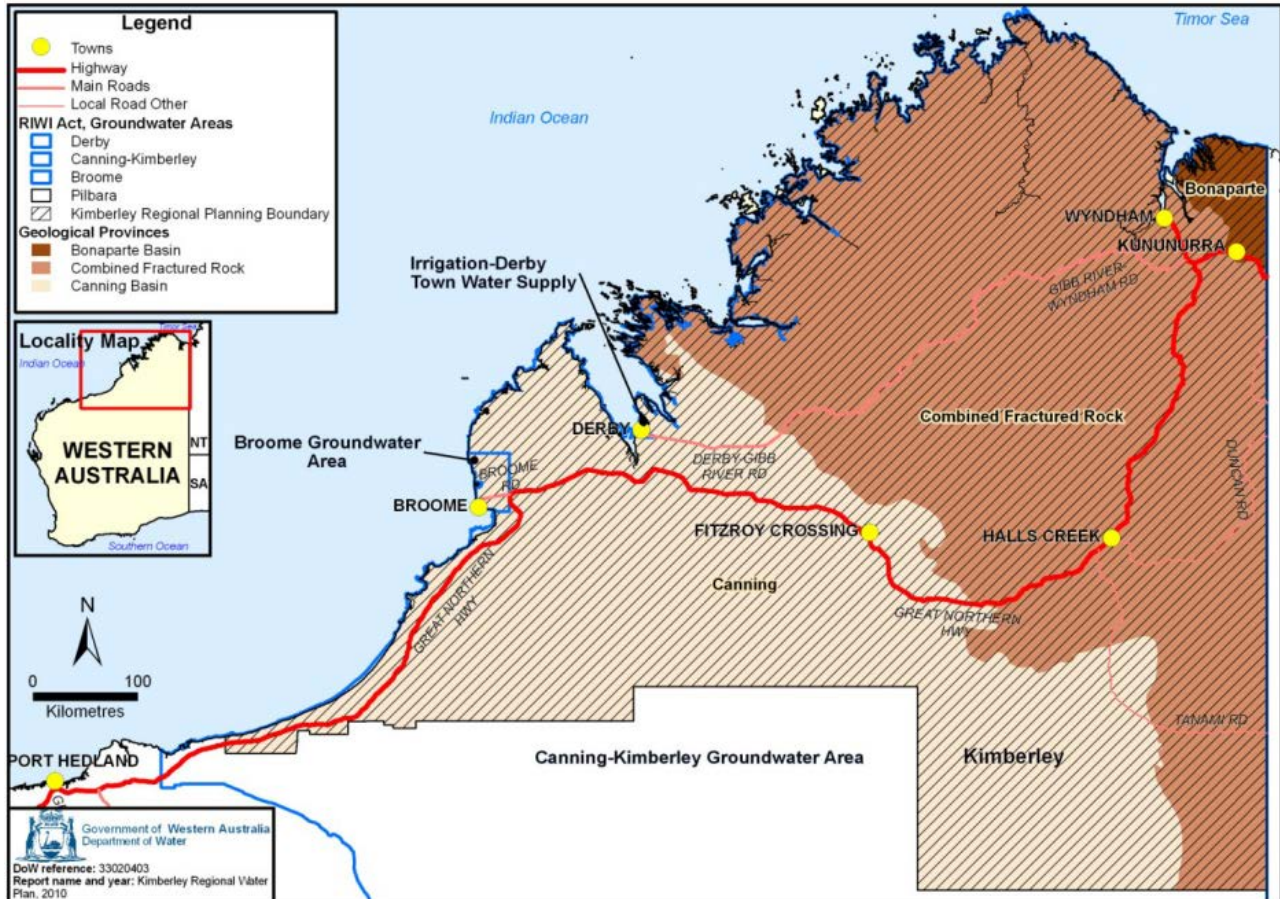


Figure 5-15: Canning-Kimberley groundwater area (DoW 2010)

5.4.3.6 Public Drinking Water Source Areas

PDWSA are surface water catchments and groundwater areas that provide drinking water to cities, towns and communities throughout the state. PDWSA are proclaimed under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*. The closest PDWSA to the Development Envelope are the:

- Camballin Water Reserve (located approximately 60 km west of the Development Envelope); and
- Fitzroy Crossing Water Reserve (located approximately 51 km east of the Development Envelope).

BNR note that, although not gazetted as a PDWSA, the Yungngora Community water supply is located around 19 km south of the Development Envelope.

The PDWSA for Camballin is supplied from groundwater within the Poole Sandstone (DoW 2006). The water quality (range and median values) for these groundwater sources are provided in Table 5-22. All values are in milligrams per litre (mg/L) unless stated otherwise.


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Table 5-22: Camballin groundwater quality (DoW 2006)


Parameter	BORE 3	BORE 3/73	BORE 1/04
	Min – Max Median	Min – Max Median	
Salinity (Total filterable solids by summation, less CO ₂)	180 - 232 200	186 - 221 202	Not Tested (NT)
Hardness (CaCO ₃)	35 - 75.4 45	40 - 65.3 42.5	45 ⁸
Turbidity	Not Detected (ND) - 160 0.8	ND - 60 0.8	0.4 ⁸
pH	6.43 - 8.4 6.6	6.42 - 8.4 6.6	6.5 ⁸
Aluminium (unfiltered)	ND - 0.03 ND	ND - 0.02 ND	ND ⁸
Arsenic	ND - 0.004 ND	ND - 0.002 ND	NT
Barium	0.038 - 0.42 0.1	0.04 - 0.095 0.095	NT
Boron	ND - 0.08 0.063	0.06 - 0.07 0.06	NT
Fluoride	0.2 - 0.3 0.25	0.2 - 0.35 0.3	NT
Iron (unfiltered)	ND - 15 0.55	ND - 5.5 0.7	0.183 ⁸
Manganese (unfiltered)	ND - 0.16 0.032	ND - 0.103 0.03	0.026 ⁸
Nitrate + Nitrite (as N)	ND - 1.13 ND	ND - 0.28 ND	0.011 ⁸

The public drinking water source for the Fitzroy Crossing Water Reserve is supplied from groundwater within the Grant group (DoW 2008). The water quality of this groundwater source (range and median values) is provided in Table 5-23. All values are in mg/L unless stated otherwise.

Table 5-23: Fitzroy Crossing groundwater quality (DoW 2008)

Parameter	BORE 3 Min – Max Median
Conductivity at 25°C (mS/m)	37 - 50 42
Turbidity (Nephelometric turbidity unit)	<0.1 - 6.6 <0.1
pH (pH units)	6.75 - 7.07 6.91
Aluminium (unfiltered)	<0.008 – 0.67 <0.008
Barium	0.095
Boron	0.1
Dieldrin	<0.001 - 0.02 0.008
Fluoride	0.2 - 0.25 0.25
Iron (unfiltered)	<0.003 - 0.34 <0.003
Manganese (unfiltered)	<0.002 - 0.065 <0.002
Nitrate as nitrogen	0.63 - 0.75 0.7
Nitrite as nitrogen	<0.002 - 0.005 <0.002

⁸ One test result only.

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Parameter	BORE 3 Min – Max Median
Uranium	0.001

5.4.3.7 Local Micro-seismic Events

The previous operator of EP 371 conducted more than two years of baseline micro-seismic monitoring to understand natural seismic activity within the petroleum title (Appendix F). The monitoring involved the deployment of eight surface seismic monitoring stations in two arrays across four stations. The monitoring program shows the region to be “seismically quiet” (Appendix F).

5.4.4 Potential Impacts

5.4.4.1 Direct Impacts

Direct impacts from the Proposal’s activities may include:

- Groundwater drawdown of surficial aquifers associated with water extraction; and
- Contamination of surficial aquifers due to well integrity failure.

5.4.4.2 Indirect Impacts

In addition to potential direct impacts to aquifers and formations arising from the Proposal, the following indirect impacts to inland waters may arise:

- Contamination of surficial aquifers through unplanned fracture heights;
- Contamination of surficial aquifers from an accidental release at the surface of drilling fluids, HFS chemicals, liquid hydrocarbons or formation water.

5.4.5 Assessment of Impacts

5.4.5.1 Groundwater Drawdown of Surficial Aquifers Associated with Water Extraction

Groundwater use is expected to be very similar to the previous HFS program undertaken within EP 371, using water from new extraction bores on each well site. Water extraction will be licensed and the volume extracted will be within the allocated licence volumes, with a conservative estimate of approximately 40 ML to be used per well. BNR’s water use for the Proposal per well represents a negligible portion of the Canning Basin allocation limit (<0.02%), and will be far less than water used by the other sections in the region, such as communities and pastoralists.

Since 2012, during the previous HFS program within EP 371, groundwater drawdown was monitored during water extraction activities (Buru Energy 2012). Continuous depth loggers were installed in 2015 in two deep environmental monitoring bores at each well site, allowing the depth of the water table to be monitored over time. The depth loggers were installed at varying distances away from each water extraction bore, allowing any cone of depression formed during groundwater extraction to be readily detected. The occurrence and extent of any cone of depression is dependent upon the volumes of water extracted from the extraction bore relative to the volumes available in the aquifer.

The monitoring program indicated that a short-term drawdown of 0.07 m and 0.08 m (Figure 5-16) was experienced at the environmental monitoring bores located 55 m and 27 m away respectively from the extraction bore. The data provided no evidence that a cone of depression occurred at either well site. Given that seasonal fluctuations of groundwater levels in the region are between 0.2 m and 1 m (Appendix E [Rockwater 2016]), any short-term drawdown is expected to remain within the extent of natural variability, and therefore would be indistinguishable from normal seasonal fluctuations.



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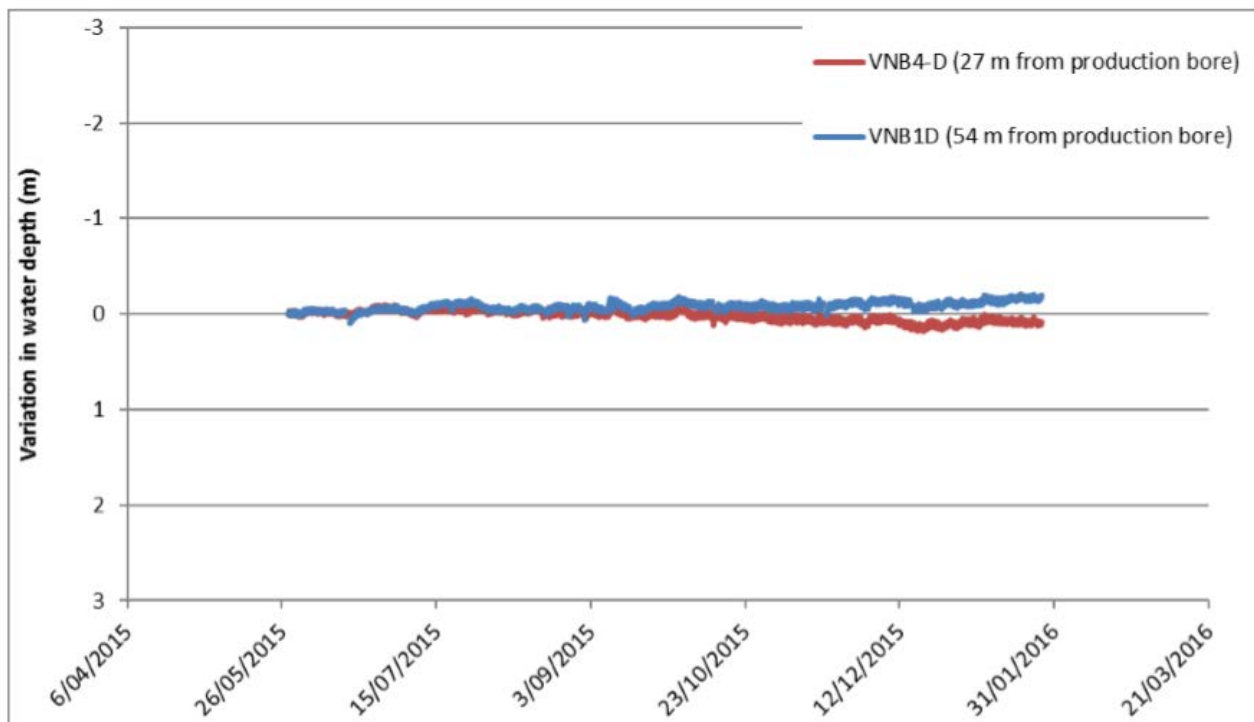


Figure 5-16: Variation in groundwater levels recorded at the Valhalla North 1 well site during the 2015 program

Results from site-based monitoring during the previous HFS program were used to develop a numerical model to determine the impact of groundwater extraction on the surrounding environment. This numerical model used the MODFLOW groundwater modelling software and was used to understand drawdown impacts for considerably larger volumes of water extraction. Using a similar water extraction volume (per well) of 33 ML, the model predicted that a short-term drawdown of 1 m or more could extend up to 410 m from the extraction water bore at the (deep) level of the screens in the extraction bore, but smaller drawdowns would occur in the top 50 m of the Liveringa Formation: 1.2 m close to the bore decreasing to 1 m at a distance of about 56 m from the bore, and 0.1 m at a distance of 690 m (Appendix E [Rockwater 2016]).


The model also predicted that groundwater levels would be expected to recover rapidly to within 0.2 m of baseline levels within hours following the cessation of extraction and to fully recover within weeks. Consequently, even extracting larger volumes than those required for the Proposal is expected to result in temporary drawdown that is within natural variability. Further to this, extraction of groundwater for the Proposal is not expected to result in any impacts to other groundwater users given the limited extent of impact, and distance to other licenced users. Consequently, BNR do not believe that water extraction for the purposes of the Proposal would result in a significant impact to inland waters or associated receptors.

5.4.5.2 Potential Contamination of Surficial Formations due to Well Integrity Failure

During all drilling activities, the most sensitive well sections are the surface hole sections as these sections penetrate through surficial aquifers that generally have low salinities and consequently are most suited for other uses (such as potable or agricultural uses).

Given that the risk of soil and groundwater contamination from these activities is well understood with conventional onshore exploration and appraisal drilling undertaken regularly, there is a standard suite of management measures that ensure that even should a spill occur, any impacts to groundwater quality are negligible. These include:

- Drilling fluid systems for the surface hole sections comprising low-toxicity mud systems; and
- Installing and cementing a surface casing in place across the useable aquifers to isolate these from deeper formations and aquifers.

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As detailed in Figure 2-1, the surface hole sections (26 inch and 17.5 inch hole sections) will be installed to 550 m, well below the Liveringa Group Formation. This will ensure that sufficient isolation exists before drilling the next hole section.

Rockwater (2016) was engaged to predict duration of groundwater migration to key sensitivities based upon hydraulic conductivity, hydraulic gradients and specific yields. The study (Appendix E) concluded that groundwater would take about 16,000 years to move approximately 32 km. Based upon the unlikely event that a release of drilling fluids whilst drilling the top hole sections resulted in groundwater contamination, it is extremely unlikely that due to the migration timeframe and the nature of the low-toxicity mud system used that any change to groundwater quality would be observed in PDWSA or by other licenced groundwater users (located at least 19 km from the Development Envelope, refer to Section 5.4.3.5).

5.4.5.3 Potential Contamination of Surficial Aquifers through Unplanned Fracture Heights

International, peer reviewed studies have found that hydraulic fracturing in shale and tight gas formations affects a very limited portion of the entire thickness of the overlying bedrock and is unable to create direct hydraulic communication between target zones and shallow aquifers through induced fractures (Fisher and Warpinski 2012; Davies *et al.* 2012). The review by Davies *et al.* (2012) was based on the analysis of data acquired from several thousand shale gas HFS operations in the USA. This data reported a maximum vertical fracture length of 588 m (Davies *et al.* 2012).

Nearly four thousand micro-seismic fracture top comparisons to maximum groundwater depths across four major US shale plays showed that in no cases did the fracture zone even approach overlying aquifers with over 800 m from the local aquifers (Fisher and Warpinski 2012) and that the height of only 1% of these fractures was greater than 350 m (Davies *et al.* 2012). A further study by Green *et al.* (2012) in the United Kingdom found that hydraulic fractures remain well confined to the target interval, even in the presence of faults.

Well analysis of the stratigraphy (rock layering) (Table 5-20) indicates that within EP 371:

- The top of the Laurel Formation zones of interest for HF treatment is more than 2,400 m deep;
- There is approximately 1,800 m separation between the targeted Laurel Formation and the surface Liveringa Aquifer / Formation of which approximately 1,100 m is impermeable hard rock;
- Located directly above the Laurel Formation, the Anderson Formation has a shale layer that acts as a confining geological seal for hydrocarbon migration and would therefore act as an immediate thick containment barrier of impermeable hard rock to unplanned vertical growth of fractures;


The proposed vertical extent of the fracture envelope is expected to be in the region of 150 m. Given that there is approximately 1,800 m separation between the targeted Laurel Formation and the surface Liveringa Aquifer / Formation and as the predicted vertical extent of fractures for the activities is 150 m, the risk to aquifers is extremely low.

Like much of the Australian continent, micro-seismic monitoring in the Development Envelope has demonstrated the region to be seismically quiet (Section 5.4.3.7, Appendix F, Leonard *et al.* 2013). Based on available seismic data and previous reviews of the area, the potential for geo-mechanical hazards in the Development Envelope is considered to be low though this will be verified with the most up to date seismic information once the well locations are finalised. Consequently, based on the available scientific information, and given the significant separation between the targeted Laurel Formation and the Liveringa Aquifer, BNR does not believe that contamination of surficial aquifers through unplanned fracture heights is a credible risk for the Proposal.

5.4.5.4 Potential Contamination of Surficial Aquifers from an Accidental Release at the Surface of Drilling Fluids, HFS Chemicals, Liquid Hydrocarbons or Formation Water

A spill from one of the water retention ponds used to store formation water produced during well testing operations, drilling fluids, or a spill from a chemical or chemical additive (unmixed) to the ground will result in a varying level of exposure dependant on the volume of release.

As described in Table 5-9, formation water from the Laurel Formation that was produced during well testing operations has been characterised by the previous operator of EP 371 through taking multiple water samples and analysing them at a NATA accredited laboratory. The results of the sampling program are included as

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Appendix G. In summary, formation water from the water retention ponds is very high in salt at 3 to 5 times the salt concentration of seawater, not toxic to fauna or humans, and comprise very low levels of heavy metals. Given the characterisation of the formation water, a release is not expected to result in a significant change to soil or water quality that could not be managed with standard industry controls.

As detailed in Section 5.2.5.2, a large spill event (such as a 75 m³ of diesel) would only be expected to seep through soils to a depth of approximately 0.4 m. Consequently, it is extremely unlikely that any release would cause the groundwater to be contaminated. As described in Section 5.4.3.4, based upon the depth to groundwater, any surface release is expected to take between 70 and 300 days to travel from the ground surface to the water table (Appendix E [Rockwater 2016]). Given that surface spill events are well understood, there is a standard suite of preventative and management measures including spill response and recovery arrangements, that would ensure that should a spill occur, impacts to groundwater quality (if any) are negligible.

If standard management measures are implemented, BNR do not expect these events to occur in the first place, but should they, any indirect impacts are not expected to cause a significant environmental impact.

5.4.5.5 Application of Legislation, Policy and Guidance

The management of impacts and risks associated with petroleum activities are managed and regulated under the PGER (Environment) Regulations 2012 and the PGER (Resource Management and Administration) Regulations 2015. Under the PGER (Environment) Regulations 2012, a DMIRS accepted Environment Plan (EP) is required to manage environmental impacts arising from planned emissions and unplanned releases associated with all petroleum activities. Specifically, the EP has to consider impact significance and demonstrate that impacts and risks are reduced to a level that is ALARP and acceptable prior to acceptance by DMIRS. No activities covered in the Proposal can commence until an EP is accepted by DMIRS.

Operational aspects are regulated under the PGER (Resource Management and Administration) Regulations 2015 to ensure that exploration activities are carried out in a way that reduces the risk of aquifer contamination. The well design and construction details of the well are described in the WMP, which will be approved by DMIRS under the PGER (Resource Management and Administration) Regulations 2015 prior to construction. Specific design requirements that are documented in the WMP and managed under these regulations include:

- Ensuring the casing grade is selected in accordance with API Grades;
- The well is designed with a minimum required casing strings;
- Integrity tests are undertaken throughout the drilling process including;
 - Casing pressure test;
 - Formation pressure integrity test;
 - Cement bond logs.


In addition to seeking approval on the well design construction methodology, as per the recommendation of the HFS Scientific Inquiry, BNR will ensure that well integrity will be assessed by an independent and certified well examiner. BNR will also report to DMIRS on the results of integrity tests (undertaken during well construction, prior to HFS activities as well as during and post HFS).

Any extraction of groundwater within a proclaimed groundwater area is subject to a licence issued by DWER under the *Rights in Water and Irrigation Act 1914* where a cumulative assessment of all extraction in the groundwater area is complete to ensure allocation limits are not exceeded – this is done independent of the applicant - such that local and regional cumulative impacts are considered.

Under the RIWI Licence, volumes extracted are required to be monitored and reported to DWER annually to confirm compliance with the licence and confirm that extraction above licence allocation does not occur.

Various guidelines exist in relation to drilling and HFS management that provide a list of industry requirements that must be implemented. These will be highlighted in the Environment Plan as relevant management measures and a suitable level of performance set for these management measures. Specific industry guidance includes:

- Code of Practice: Onshore Petroleum Activities in the Northern Territory (Northern Territory Government 2019) (Section 1.4.3);

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- Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia (2018);
- Guidelines for the protection of surface and groundwater resources during exploration and appraisal drilling (DMPR 2002);
- Western Australia Water Quality Protection Notice (WQPN) 26 (liners for containing pollutants, using synthetic membranes) (DoW 2013);
- Department of Mines and Petroleum / Department of Water (2016). Guideline for groundwater monitoring in the onshore petroleum and geothermal industry.

5.4.6 Impact Validation and Verification


Throughout the planning phase, BNR have reviewed studies undertaken by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, once the well locations are finalised, BNR plan to conduct a range of studies and modelling to validate the assumptions in the Proposal and verify the impacts of the activity. The assumptions and proposed verification studies are documented in Table 5-24. The complete monitoring, verification and validation program for the Proposal is included in Section 7.

Table 5-24: Assumptions and verification studies for the Proposal

Assumptions	Verification studies during activity	Timing
No significant drawdown from water extraction activities.	Groundwater drawdown modelling.	Prior to site preparation operations.
Verify baseline water quality and groundwater level prior to the activity.	Groundwater level and quality (drilling) monitoring within the Development Envelope.	Prior to drilling operations.
No significant drawdown from water extraction activities.		Following drilling operations.
No significant changes to groundwater quality (including methane composition) arising from the Proposal.		
No significant drawdown from water extraction activities.	Groundwater level and quality (HFS) monitoring.	During HFS operations.
No significant changes to groundwater quality (including methane composition) arising from the Proposal.		Following HFS operations.
		Annually following HFS operations.
At least 600 m vertical separation from the nearest useable aquifer will be maintained for the Proposal.	Fracture trajectory modelling.	Prior to HFS operations.
No geo-mechanical risks present at the well locations.	A geo-mechanical risk analysis to be completed at each of the well sites.	Prior to site preparation operations.

5.4.7 Mitigation

A summary of the mitigation measures and their mitigation hierarchy that will be included in the Environment Plan for acceptance by DMIRS is included in Table 5-25.

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Further to this, BNR have developed a suite of draft trigger and threshold criteria to enable proactive and procedural adaptive management throughout the activity. The response actions (trigger level and contingency actions) that will be undertaken if the environmental criteria are exceeded are included in Table 5-26.

Table 5-25: Proposed mitigation measures – inland waters

Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Avoid	No geo-mechanical risks present at the well locations	In accordance with HFS Scientific Inquiry Recommendation 7, a comprehensive geo-mechanical risk analysis will be conducted prior to undertaking HFS operations. Further seismic data interpretation will be conducted to verify that no geo-mechanical risks are present at the well location.
Avoid	HFS operations not located within 2,000 m of a PDWSA	As identified by HFS Scientific Inquiry Recommendation 9, the wells are not located within 2,000 metres of a PDWSA (Section 5.4.3.6).
Avoid	HFS treatment will have more than 600 m vertical separation to the nearest useable aquifer.	In accordance with Section B.4.16 of the NT Code of Practice, HFS operations must not be conducted in a formation that does not have more than 600 m vertical separation to the nearest useable aquifer unless it can be demonstrated that the risks of connectivity is ALARP and acceptable (Northern Territory Government 2019).
Avoid	Surface casing cemented across all useable freshwater aquifers	In accordance with Section B.4.2 and B.4.3 of the NT Code of Practice, and the Guidelines for the protection of surface and groundwater resources during exploration and appraisal drilling (DMPR 2002), the potential for contamination of groundwater resources is to be managed through the installation of casing which is secured / sealed by the use of a sealing material such as cement.
Avoid	Well Management Plan	In accordance with Regulation 10 of the PGER (Resource Management and Administration) Regulations 2015, a new well is required to have a WMP in place to ensure the well is designed and managed in accordance with sound engineering principles and industry good practice, including identification of risks. The WMP specifically describes and addresses well integrity risks and includes the requirements for the operator to manage these accordingly. Specifically, the WMP will address casing integrity management that will then be assessed and accepted by DMIRS prior to undertaking HFS operations.
Avoid	Well integrity assessment	In accordance with Section B.4.1 of the NT Code of Practice, and as identified by HFS Scientific Inquiry Recommendation 33, to further ensure well integrity and thus environmental protection and public safety, well design, construction and testing will be assessed by an independent / certified expert well examiner.
Minimise	Water retention pond design	In accordance with Section B.4.16 of the NT Code of Practice, and as per the Department of Water – Water Quality Protection Note 26 – Liners for containing pollutants, using synthetic membranes (DoW 2013), surface ponds used to contain wastewater or solids that may leach contaminants for short-term containment, require synthetic membranes and need to meet specific requirements, which include: <ul style="list-style-type: none"> All synthetic drilling fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s; and A minimum thickness of 0.75 mm.
Minimise	Chemical disclosure	In accordance with Recommendation 6 of the HFS Scientific Inquiry, composition of the proposed HFS fluid system is included in Appendix J. In accordance with Sections B.4.10 and B.4.13 of the NT Code of Practice, and as per the requirements of Regulation 9 of the PGER(E)R 2012, chemicals or substances must be disclosed for acceptance by DMIRS prior to commencing activities where they are:



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Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
		<ul style="list-style-type: none"> In, or added to, any treatment fluids to be used for the purposes of drilling or hydraulic fracturing undertaken in the course of the activity; or Otherwise introduced into a well, reservoir or subsurface formation in the course of the activity, <p>In addition to this, all chemicals to be used downhole under the Proposal are included on the AICS or are otherwise approved for use in Australia. The chemicals will be used solely for the activity purpose they will serve as stated under the EP. The constituents, toxicity, ecotoxicity and bioaccumulation data of each chemical product or system will be disclosed.</p>
Minimise	Low-toxicity mud system	In accordance with Section B.4.10 of the NT Code of Practice, BNR plan to use a low-toxicity mud system for the top-hole section that, if lost to the environment, is not expected to result in environmental impacts.
Minimise	Fugitive discharges are monitored and reported	As per Regulation 15 of the PGER(E)R 2012, BNR will monitor and record fugitive volumes of fluids not recovered during circulation.
Minimise	Groundwater licences for extraction bores	In accordance with the <i>Rights in Water and Irrigation Act 1914</i> , as the Development Envelope is located within a proclaimed groundwater area (DoW 2010), all water extraction must be licensed prior to take.
Minimise	Meter calibration and monitoring for extraction bores	As described in the Department of Water – Measuring the taking of water guidelines (DoW 2016), Clause 46 of Schedule 1 of the <i>Rights in Water and Irrigation Act 1914</i> expressly contemplates licensees being subject to metering because it is recognised as an accurate and reliable measuring technique.
Monitor	Site water audit	<p>As identified by HFS Scientific Inquiry Recommendation 8, all water wastes and emissions, including formation water produced during well testing operations, resulting from the Proposal will be recorded and monitored.</p> <p>A site water audit on completion of the HFS operation at each well site will be undertaken, accounting for water produced, evaporated and disposed, to detect significant leakage of fluids and determine whether remedial action to track any contaminants is warranted.</p>
Monitor	Monitoring of fluid volumes and pressures during HFS activities	In accordance with Section B.4.13 of the NT Code of Practice, volumes of injected hydraulic fracturing fluid and pumping pressure will be accurately monitored and recorded.
Monitor	Monitoring of groundwater bores	<p>In accordance with Section B.4.17 of the NT Code of Practice, as per the Guideline for Groundwater Monitoring in the Onshore Petroleum and Geothermal Industry (DMP and DoW 2016), and as defined by HFS Scientific Inquiry Recommendation 8, where petroleum activities (such as exploration and appraisal drilling) pose low risks to groundwater, they are required to conduct water quality monitoring to verify that water quality is unaffected by the activity. Groundwater sampling will include verification of baseline methane concentrations.</p> <p>The suite of parameters that will be monitored will include:</p> <ul style="list-style-type: none"> Inorganic compounds (including metals); Organic compounds; Total recoverable hydrocarbons (TRH); Benzene, toluene, ethylbenzene and xylene (BTEX compounds); pH;



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Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
		<ul style="list-style-type: none">• Total dissolved solids;• Methane.



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Table 5-26: Draft key performance environmental criteria (outcome based)

ID	Environmental criteria	Response actions	Monitoring	Reporting
1	<p>Trigger criteria</p> <p>Groundwater level measured at defined monitoring locations (yet to be determined) exceed historical average groundwater level values 1 day after completion of extraction activities.</p> <p>Threshold criteria</p> <p>Groundwater level measured at defined monitoring locations (yet to be determined) exceed historical average groundwater level values over two consecutive monitoring events.</p>	<p>Trigger contingency actions</p> <ul style="list-style-type: none"> Determine whether the changes observed in the impact sites are comparable to baseline sampling; Re-examine monitoring results (Quality Assurance / Quality Control [QA / QC]) to validate data. Re-monitor if required; Increase monitoring frequency (within three weeks of the previous sample); Identify the reason for the change and determine direct correlation to construction / operational activities or natural variation and review management measures with an adaptive management response. <p>Threshold contingency actions</p> <ul style="list-style-type: none"> Initiate implementation of contingency measures including: <ul style="list-style-type: none"> Re-examine monitoring results (QA / QC) to validate data. Re-monitor if required; Ground truth the monitoring results to validate findings of the assessment and / or determine / identify what may be causing the exceedance. Where cause is identified during ground truthing and can be rectified, undertake action immediately. For actions which require alternate resources, schedule works to be undertaken as soon as possible. Where the threshold exceedance was not caused by the activities, resume standard monitoring frequency; Where the threshold exceedance of Environmental Criteria (1) can be attributed to the Proposal activities: <ul style="list-style-type: none"> Modified extraction methods using adaptive management. This may include a reduction in extraction volumes or sourcing water from other sources. Once management actions have been completed, extend the monitoring program to include an additional recharge event to determine if groundwater quality and level values recover; Continue to implement actions to remediate the exceedance until approval to cease has been given by the relevant regulator. 	Refer to Section 7, Table 7-1	Annual report
2	<p>Trigger criteria</p> <p>Changes to groundwater quality (including methane) at defined monitoring locations (yet to be determined) exceed baseline averages.</p> <p>Threshold criteria</p> <p>Changes to groundwater quality (including methane, and using chloride as key indicator) at defined monitoring locations (yet to be determined) exceed baseline averages over two consecutive monitoring events.</p>			

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5.4.8 Predicted Outcomes

Throughout the planning phase, BNR have reviewed studies undertaken by the previous operator of EP 371 and analysed geological records to understand the potential impacts associated with the Proposal. Based upon this information, the outcomes of the Proposal are predicted to be:

- No impacts to hydrological regimes or groundwater quality demonstrated by:
 - No significant drawdown of the aquifer following completion of the Proposal considered outside of seasonal fluctuations;
 - No change to groundwater quality attributable to the Proposal.

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant impact to inland waters. The environmental mitigation measures intended to manage and minimise impacts on inland waters are considered effective. Consequently, BNR believe that the EPA's objective to:

"To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected"

can be met.

BNR have considered the WA Environmental Offsets Policy, however BNR do not believe actions to offset the predicted outcomes of the Proposal are required as the Proposal is not expected to have a significant impact on inland waters.

5.5 Social Surroundings

5.5.1 EPA Objective

To protect social surroundings from significant harm.

5.5.2 Legislation, Policy and Guidance

- Environmental Factor Guideline Social Surroundings (EPA 2016i);
- Environmental Protection (Noise) Regulations 1997 (Noise Regulations);
- *Aboriginal Heritage Act 1972*;
- *Native Title Act 1993*;
- Petroleum and Geothermal Energy Resources (Environment) Regulations 2012.

5.5.2.1 Application of EPA Guidance

The Environmental Factor Guideline – Social Surroundings (EPA 2016i) identifies the information required for conducting an EIA of this factor. The Proposal meets the guideline's requirements as demonstrated in Table 5-27.

Table 5-27: Environmental factor guideline – social surroundings requirements

Information required for EIA	Section
Aboriginal heritage and cultural surveys, which may include anthropological and / or archaeological surveys, as well as proposed impact avoidance and mitigation measures.	Table 5-28 Section 5.5.3.3.2 Figure 5-17 Table 5-36 Table 5-37



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Information required for EIA	Section
A description of natural and historical heritage values that may be impacted, as well as proposed avoidance and mitigation measures.	Section 5.5.3.3 Section 5.5.3.4 Table 5-37
Landscape and visual impact assessment studies based on recognised methodology.	Section 5.5.4
Analysis, modelling and predictions of impacts from odour, dust and noise, including likely impacts during, worst, best and most likely case scenarios.	Section 5.5.5.1 Section 5.5.5.2 Section 5.5.5.3
Characterisation of proximity to sensitive receptors.	Section 5.5.3.1 Section 5.5.3.2
Summary of proposed technologies, emission reduction equipment and management practices.	Table 5-37
Description of proposed management and monitoring arrangements.	Table 5-36 Table 5-37
Analysis of cumulative impacts, including existing and reasonably foreseeable emission sources.	N/a ²

5.5.3 Receiving Environment

A number of relevant surveys have been conducted for previous petroleum activities within EP 371 that inform the baseline receiving environment described in this section. Previous studies relevant to the Proposal are provided in Table 5-28. The location of some heritage survey lines from past seismic surveys within the Development Envelope is presented in Figure 5-17.

Table 5-28: Previous heritage surveys

Date	Survey name	Location	Heritage status
August 2007	Heritage survey for the Paradise / Noonkanbah 2D seismic survey	Blina, Liveringa, and Noonkanbah pastoral stations	Cleared
July 2009	Heritage survey for the Paradise 2D seismic survey	Blina and Liveringa pastoral stations	Cleared with conditions
October 2011	Heritage survey for the Valhalla North A, B & C, Valhalla East well sites	Blina and Liveringa pastoral stations	Cleared
February 2012	Heritage survey for the Valhalla North A, Valhalla East 1 well sites	Noonkanbah pastoral station	Cleared
May 2012	Heritage survey for Asgard 2D seismic	Blina and Noonkanbah pastoral stations	Cleared with conditions
May 2012	Heritage survey for Eden 2D, Asgard 2D, Valhalla 2D seismic and Asgard 1 well site seismic	Blina, Liveringa and Noonkanbah pastoral stations	Cleared

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5.5.3.1 Social Context

The Kimberley region has a sparsely distributed population of approximately 40,000 people across a region twice the size of the state of Victoria. There are six towns, about 160 Aboriginal communities and numerous homesteads in the region. Broome is the largest town with a population of approximately 16,000 people (ABS 2016), while Kununurra is the next largest town with a population of approximately 5,300 people (ABS 2016).

There are two main population centres in the Fitzroy River catchment: Derby (population approximately 3,500) and Fitzroy Crossing (population approximately 1,300), and 57 smaller Indigenous communities combining to a total catchment population of about 7,500 people (Merrin *et al.* 2018). Much of the catchment is subject to Native Title (Figure 1-3). The population is one of very high socio-economic disadvantage, with high unemployment. There is a lack of settlement, communications or transport infrastructure in the Fitzroy River catchment, with no rail network and a sparse road network, with most of the catchment accessed by unsealed minor roads.

Traditional Owners relevant to the Proposal are the Yungngora People (represented by the Yungngora Aboriginal Corporation RNTBC) and the Warlangurru 1 Native Title Claimants. The locations of the proposed well sites to the nearest communities and towns are presented in Table 5-29.

The majority of the Yungngora People live in the Yungngora Community, also known as the Noonkanbah Community. The Community is located approximately 28 km from the nearest well site (Jotunheim) and is located approximately 170 km by road from Fitzroy Crossing, with limited road access and communications (Figure 1-3). The majority of Warlangurru 1 Claimants also live in Yungngora Community with other members living in Jimbalakudunj Community located approximately 20 km north west of the proposed Nidavellir well site. As outlined in Section 3, close consultation and engagement has occurred with the Yungngora and Warlangurru People regarding petroleum activities on their native title areas. This has occurred over many years and includes the proposed activities.

5.5.3.2 Surrounding Land Use

The Canning Basin is covered by rangeland ecosystems. Key land uses within the Fitzroy River Catchment include 95% pastoralism (cattle grazing), with nature conservation and Indigenous Protected Areas covering the remaining area. In 2018, the gross value of agricultural production was \$77 million/year, predominantly from cattle (Merrin *et al.* 2018). Most rangeland grazing properties are managed as pastoral leases on government owned land (crown land). The average size of cattle stations in the Kimberley is 230,406 ha (DPIRD 2019), with cattle typically grazing on native and introduced vegetation that is rarely cleared for pasture or cropping.

The Development Envelope overlays two pastoral stations (leased Crown Land); the Blina Station and the Noonkanbah Station, who lease the land for pastoral grazing purposes. Both stations have been informed of the Proposal and BNR will continue to liaise closely with the pastoralists to keep them informed of activities both as they occur and upcoming.

The well locations are located remote from residential developments, local tourist attractions and main roads. The closest receptors to the Development Envelope include a limited number of station homesteads and Indigenous Communities (Figure 1-3) which are located tens of kilometres from the Development Envelope. Table 5-29 below provides information on well site locations relative to the nearest town or community.

Table 5-29: Pastoral station, Native Title area and closest community to the Development Envelope

Well site name	Pastoral station	Native Title area	Closest town or community
Jotunheim	Noonkanbah	Noonkanbah	Yungngora Community, approximately 28 km south Fitzroy Crossing, approximately 82 km east
Midgard	Noonkanbah	Noonkanbah	Jimbalakudunj Community, approximately 31 km north west
Alfheim	Noonkanbah	Noonkanbah	Yungngora Community, approximately 33 km south / south east



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Well site name	Pastoral station	Native Title area	Closest town or community
Muspelheim	Noonkanbah	Noonkanbah	Jimbalakudunj Community, approximately 31 km north west
Vanaheim	Noonkanbah	Noonkanbah	Yungngora Community, approximately 32 km south
Nidavellir	Blina	Warlangurru	Jimbalakudunj Community, approximately 20 km north west Camballin Town, approximately 62 km west
Proposed Well Site 1	Noonkanbah	Noonkanbah	Yungngora Community, approximately 32 km south
Proposed Well Site 2	Noonkanbah	Noonkanbah	Yungngora Community, approximately 32 km south / south west Fitzroy Crossing, approximately 66 km east
Proposed Well Site 3	Noonkanbah	Noonkanbah	Yungngora Community, approximately 30 km south west Fitzroy Crossing, approximately 66 km east / north east
Proposed Well Site 4	Noonkanbah	Noonkanbah	Yungngora Community, approximately 33 km south west Fitzroy Crossing, approximately 55 km east / north east

5.5.3.3 Indigenous and Non-Indigenous Cultural Heritage

5.5.3.3.1 Native Title

The Development Envelope is overlapped by two registered Native Title groups, the Warlangurru People (claim application WAD509/2015, also known as the Warlangurru 1 Claim) and the Yungngora (Noonkanbah) People (determination application WAD6229/1998, also known as the Yungngora Native Title Determination) (Figure 1-3).

Given the Proposal occurs within the boundaries of the Warlangurru and Noonkanbah Native Title areas, members of these native title groups are key stakeholders for the proposal. BNR closely consult and engage with these stakeholders and will continue to do so throughout the development of the Proposal (Section 3). An Indigenous Land Use Agreement (ILUA) and a Land Access and Use Agreement (LAUA) are in place respectively with the Yungngora (Yungngora Aboriginal Corporation RNTBC) and Warlangurru People.


Under these ILUA and LAUA, the Yungngora People and Warlangurru People support the further appraisal and development of the gas resources in the area, and support future grants of tenure as required. The agreements include structured processes for managing cultural, heritage and environmental matters in relation to BNR's proposed exploration activity within these Native Title areas.

5.5.3.3.2 Heritage Sites

A search of the Aboriginal Heritage Inquiry System (AHIS) identified that two Registered Aboriginal heritage sites are located within the Development Envelope (Figure 5-17). These are the:

- Dunggaba Complex 1 (Mythological – site 14215); and the
- Walgidee Hills 4 (Mythological – site 14224).

Two sites listed as Other Heritage Places are also present within the Development Envelope (DPLH 2020). These are the:

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- No. 19 bore (Mythological – site 13851);
- No. 20 bore (Mythological – site 13852).

None of the wells are located within any known heritage sites. As the proposed access track to the Alfheim well site crosses the Other Heritage Place No. 19 bore, the pre-disturbance heritage survey with the Traditional Owners will determine if the location of the access track is to be modified.

Although located outside of the Development Envelope, the mythological Registered Aboriginal Site 14229 is associated with the Mount Hardman Creek (DPLH 2020). Given the nature and ambiguity of the extent of this site, the pre-disturbance heritage survey will also determine if the location of the access track to the Muspelheim well site is to be modified.

A number of heritage surveys have been undertaken by previous oil and gas operators throughout EP 371 (Table 5-28). A number of these surveys were conducted within the Development Envelope, as shown in Figure 5-17. In addition to these, one heritage survey was recorded within the Development Envelope by the AHIS (DPLH 2020) (Table 5-30).

Table 5-30: Aboriginal Heritage Inquiry System recorded surveys

Year	Survey name	Location	Survey outcomes
1981	Heritage Survey Area 18280 (1) A Catalogue of Ethnographic and Archaeological Sites found during Exploration in Permits 97,101,102 & 103. 1981 [OWE]. Report author: Mike Capelle.	Across the Development Envelope - covering the Nidavellir, Muspelheim and Midgard well site locations.	Unavailable

5.5.3.4 Natural Heritage

A search of the InHerit Western Australia database did not identify any registered natural heritage sites (statutory heritage listings) within or adjacent to the Development Envelope (Heritage Council 2020). No sites listed on the National Heritage List occur within EP 371 (DAWE 2020d). The nearest National Heritage List site is the West Kimberley (Listed Place – Heritage Place no. 18769) and is located approximately 7.5 km south of the Development Envelope (Figure 5-18). The West Kimberley Heritage Place no. 18769 is important due to its great biological richness and contains important geological and fossil evidence of Australia’s evolutionary history. Given the distance of the Development Envelope from this listed Heritage Place, it has not been considered further.

A search of the Australian Heritage Database identified one site within the Development Envelope classed as a Natural, Indicative Place under the Register of the National Estate (non-statutory archive), being the Walgidee Hills Lamproite Site (Place ID: 101095). The Walgidee Hills Lamproite Site is located on the Noonkanbah Pastoral Station, approximately 11 km south of the Alfheim well site. Although it possesses no statutory heritage listing, the Walgidee Hills Lamproite Site is classified as a ‘Landscape’ by the National Trust since 1991 (Heritage Council 2020).

5.5.3.4.1 Iconic Natural Heritage Places

The Government of Western Australia has identified, in line with the guiding identification principles (Government of Western Australia 2019b), two proposed iconic natural heritage places for consultation with the Western Australian community. These are the Fitzroy River and the Camballin Floodplain iconic natural heritage places.

The Proposal is not located within any of the proposed iconic natural heritage places (Figure 5-18).



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5.5.3.4.2 World and Commonwealth Heritage

No World Heritage Sites or Commonwealth Heritage Sites occur within EP 371 (DAWE 2020d).

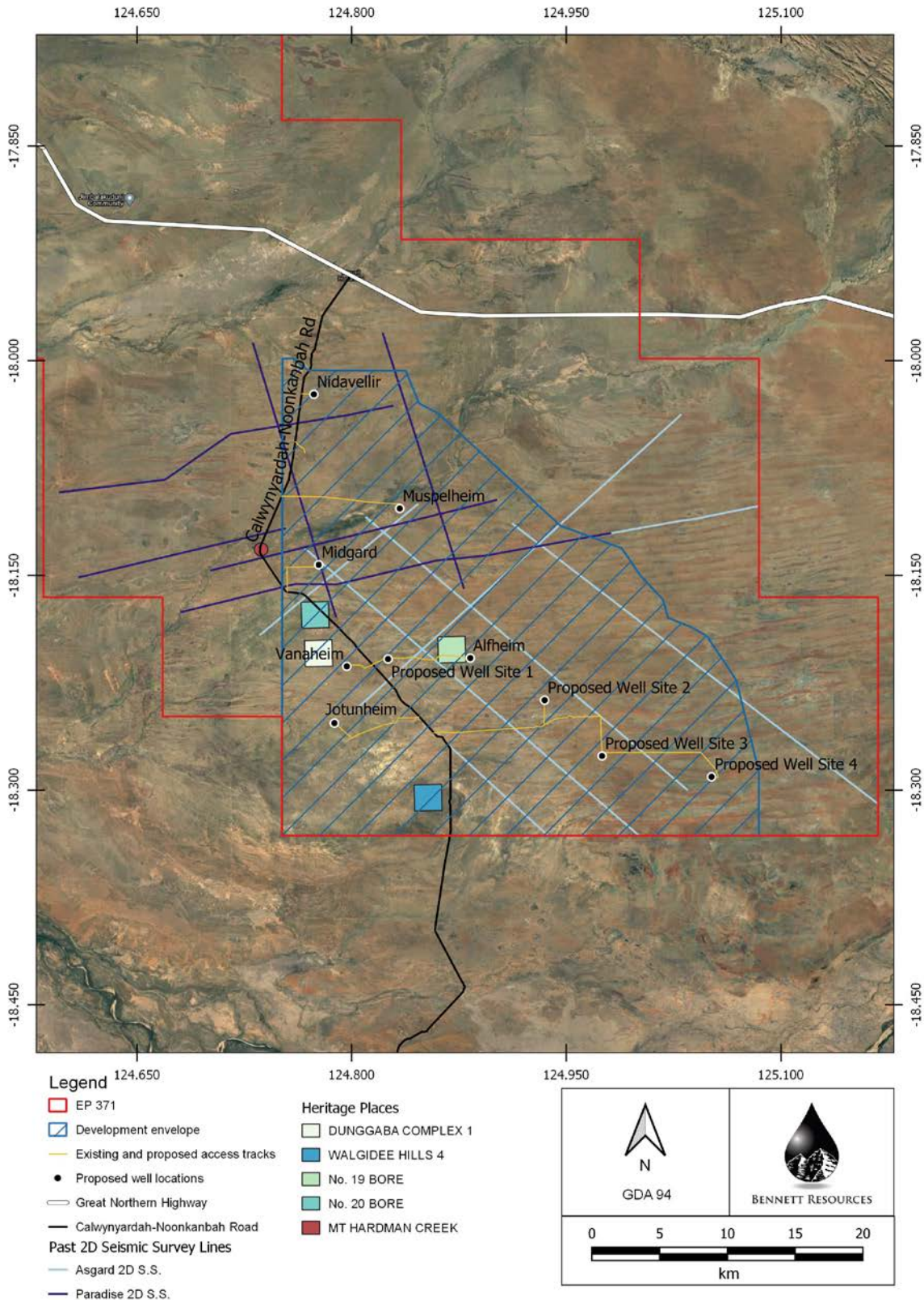


Figure 5-17: Location of Heritage Places and past heritage survey lines within the Development Envelope



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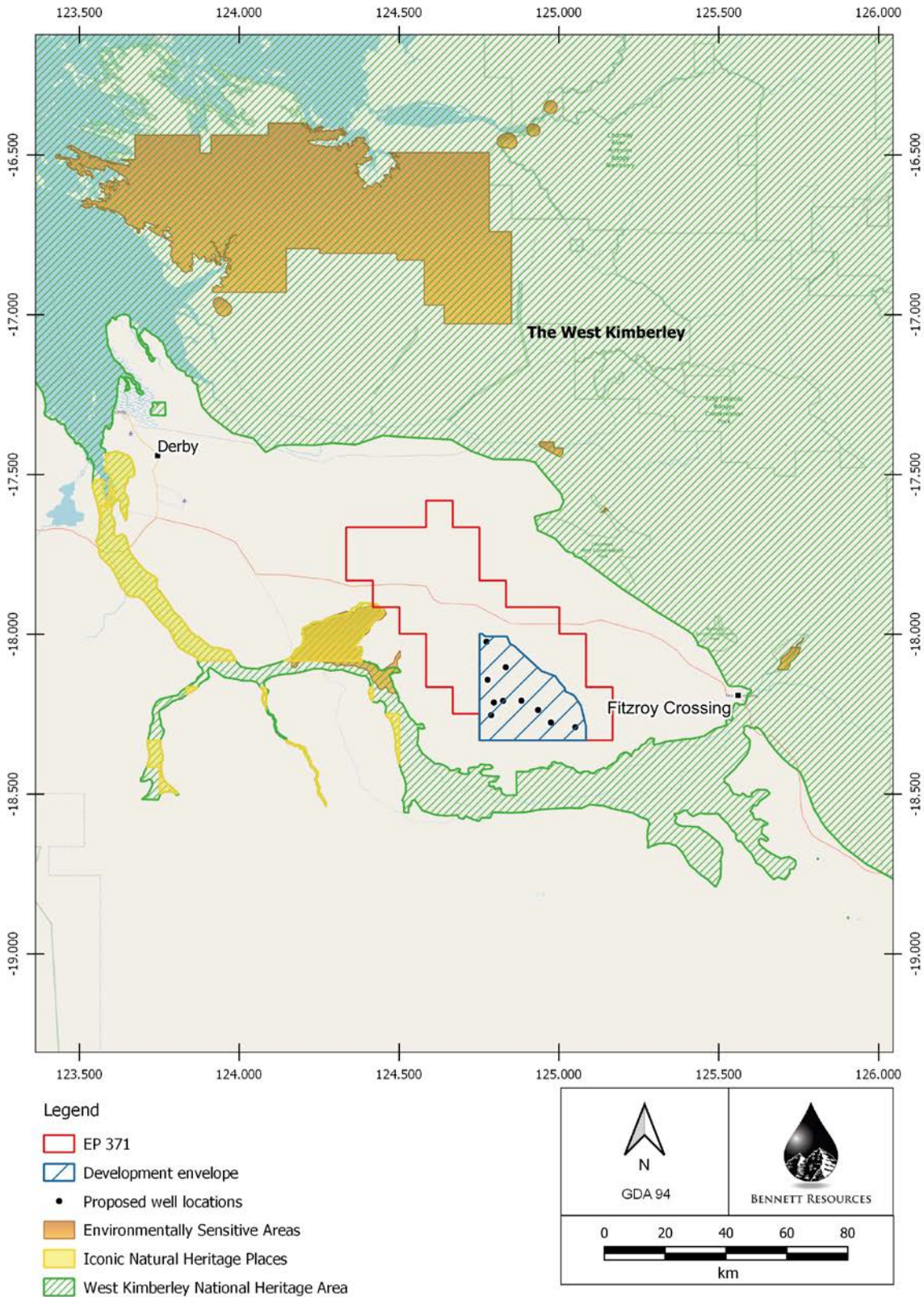



Figure 5-18: Natural Heritage areas in the vicinity of EP 371

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5.5.3.5 Dust

Dust is the generic term used to describe solid airborne particles generated and dispersed into the air by processes such as handling, crushing and grinding of organic or inorganic materials such as rock, ore and wood (DEC 2011). The movement of vehicles and heavy machinery on unsealed surfaces, along with the stockpiling of materials contribute to the generation of dust and dispersal of particulate matter.

Ambient air quality in the region is strongly influenced by season. During the winter dry season between June and August, south-easterly winds predominate. Dust storms blowing in from the Great Sandy Desert region may occur, however these are rare. The Dampierland bioregion has had a mean dust storm index of 0.5 between 1992-2010 (McTainsh *et al.* 2011), which is considered very low compared with all other rangeland bioregions (Bastin and the ACRIS Management Committee 2008). For comparison, the Great Sandy Desert bioregion's dust storm index is over three times this value (1.7).

5.5.3.6 Noise

Given the remoteness of the region, baseline (or background) noise within the Development Envelope and surrounds prior to the commencement of operations is expected to be very low. The closest main road is the Great Northern Highway, located approximately 4.5 km north of the Development Envelope. Some smaller roads such as the Calwinyardah-Noonkanbah Road and tracks are present within the wider region around the well sites, but traffic is rare. Road traffic noise is not expected to be heard in such a region isolated from the main towns. Further to this, no airstrips are located nearby to the proposed well site locations, therefore no substantial aircraft noise is expected. A review of previous noise monitoring programs was completed to understand the ambient / natural noise levels within the Development Envelope. Ambient noise measurements have been recorded off the Great Northern Highway for an access road associated with a mining development. This study (inland, away from the coast and other industrial noise sources) provides an indication of the ambient noise levels within the Development Envelope with the outcomes of that study summarised in Table 5-31.

Table 5-31: Ambient noise levels within the Kimberley

Source	Location	Comments	LA90 dB ⁹	LA10 dB ¹⁰	L _{Amax} dB ¹¹
Sheffield Resources (2016)	On an access road off Great Northern Hwy	No traffic	23	26	30
		With Traffic	27	50	62

5.5.3.7 Traffic Use


Main Roads (2020) summarises the average number of vehicles and heavy vehicles travelling at locations within Western Australia. Specifically, statistics are provided regarding traffic volumes and percentage of heavy vehicles for the latest available six years for key roads within the Kimberley region.

The Development Envelope is located approximately 4.5 km south from the closest main road being the Great Northern Highway. It is expected that equipment and machinery would be mobilised along the Great Northern Highway and then onto the rural Calwinyardah-Noonkanbah Road as the main access road to the well sites. The Calwinyardah-Noonkanbah road is an approximately 72.5 km long road between Great Northern Highway and Yungngora Community. As a public road listed within the Shire of Derby-West Kimberley's RAMM database and classified as an access road, the unsealed road is well maintained by the Shire (SDWK 2020) who use local contractors to grade the road between one and two times per year. Traffic volumes on the Calwinyardah-

⁹ LA10 – The noise level exceeded for 10% of the sample period. This is commonly referred to as the average maximum noise level.

¹⁰ LA90 – The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

¹¹ L_{Amax} – The maximum instantaneous noise level occurring during the sample period.

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Noonkanbah Road are known to be low. Local traffic data from the Shire of Derby-West Kimberley show that the annual average daily traffic is between 20-100 vehicles (SDWK 2020).

Regional statistics for the Great Northern Highway are also provided in Table 5-32 to understand potential traffic impacts at a regional level. It should be noted that the Great Northern Highway east of Derby Highway provides the most accurate traffic information for access into EP 371.

Table 5-32: Road-use statistics for key transport routes in the Kimberley (Main Roads 2020)

Road name	Location	Continuous monitoring	2014/15		2015/16		2016/17		2017/18		2018/19		2019/20	
			No. ¹²	% ¹³	No.	%	No.	%	No.	%	No.	%	No.	%
Great Northern Highway	South of Broome Rd	Yes	340	31.1	440	29.4	-	-	-	-	490	27.2	430	29.9
	East of Derby Hwy	Yes	-	-	-	-	-	-	-	-	470	32.8	-	-
	West of Derby Hwy	Yes	540	20.6	570	18.7	570	18.1	590	19.5	570	20.2	570	20.6
	East of Derby Hwy		-	-	540	33.5	-	-	-	-	-	-	-	-
	East of Fitzroy Crossing	Yes	350	23.4	370	19.6	360	19.2	400	19.6	400	20.3	390	21.6
	East of Halls Creek	Yes	-	-	-	-	-	-	-	-	430	24.7	340	24.1
	South of Lissadell Rd		550	25.9	-	-	-	-	-	-	-	-	-	-
	South of Victoria Hwy	Yes	340	30.7	350	23.6	330	21.3	330	23.0	340	24.6	360	30.4
	South of Victoria Hwy		650	30.2	-	-	-	-	-	-	-	-	-	-
	North of Gibb River Wyndham Rd	Yes	300	22.9	280	17.7	-	-	-	-	410	22.4	310	24.2
West of Foreshore Rd		1,030	15.4	-	-	-	-	-	-	-	-	-	-	

5.5.4 Potential Impacts

5.5.4.1 Direct Impacts

As no sensitive receptors were identified for the Proposal, the activities are not expected to result in landscape and visual impacts. Direct impacts from the Proposal's activities may include:


- Increased dust emissions;
- Increased noise and vibration emissions;
- Increased traffic movement; and
- Social and economic benefits.

5.5.4.2 Indirect Impacts

Unplanned events may lead to indirect impacts including:

¹² The average number of vehicles at each location for a typical day.

¹³ Percentage of Heavy Vehicles.

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- Potential impacts to heritage sites that have not previously been identified.

5.5.5 Assessment of Impacts

5.5.5.1 Increased Dust Emissions


Dust emissions resulting from the Proposal can affect human health, as well as decreasing amenity in surrounding areas, due to reduced visibility and settling on surfaces causing soiling and staining (DEC 2011). Typically, during early stages of site preparation and construction operations, dust is generated from vegetation clearing and activities on unsealed surfaces. Dust can be present as a PM_{2.5} (fine Particulate Matter of diameter of 2.5 micrometres or less) or PM₁₀ pollutant (Particulate Matter of a diameter of 10 micrometres or less), which can cause reduced air quality, acute and chronic health effects. The potential impact of dust is determined by particle size, chemicals composition and concentration (DEC 2011). The total suspended solid fraction of dust is typically responsible for nuisance or loss of amenity, whereas the smaller PM₁₀ and PM_{2.5} fractions are more commonly associated with the potential for health impacts due to their ability to penetrate the lungs (DEC 2011).

A dust risk assessment / classification for activities covered under the Proposal was completed in accordance with the DEC (2011). This is included as Table 5-33.

Table 5-33: Dust risk assessment

Item	Score options				Allocated score
Part A					
1. Nuisance potential of soil, when disturbed	Very low (1)	Low (2)	Medium (4)	High (6)	4
2. Topography and protection provided by undisturbed vegetation	Sheltered and screened (1)	Medium screening (6)	Little screening (12)	Exposed and wind prone (18)	18
3. Area of site disturbed by the works	Less than 1 ha (1)	Between 1 and 5 ha (3)	Between 5 and 10 ha (6)	More than 10 ha (9)	6
4. Type of work being done	Roads or shallow trenches (1)	Roads, drains and medium depth sewers (3)	Roads, drains, sewers, and partial earthworks (6)	Bulk earthworks and deep trenches (9)	1
TOTAL score for Part A					29
Part B					
1. Distance of other land uses from site	More than 1 km (1)	Between 1 km and 500 m (6)	Between 100 m and 500 m (12)	Less than 100 m (18)	1
2. Effect of prevailing wind direction (at time of construction) on other land uses	Not affected (1)	Isolated land uses affected by one wind direction (6)	Dense land uses affected by one wind direction (9)	Dense / sensitive land uses highly affected by prevailing winds (12)	1
TOTAL score for Part B					2
SITE CLASSIFICATION SCORE (A x B)					58

Based upon the assessment criteria, the Proposal is considered to be classified under Site Classification 1. This classification is considered to provide a negligible risk with no specific provisions or contingency arrangements

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required (DEC 2011). This is consistent with the remote nature of the Development Envelope and the proximity to receptors. Consequently, the Proposal is not expected to cause a significant environment and health impact associated with dust generation.

5.5.5.2 Increased Noise and Vibrations

Noise monitoring studies have indicated that for an average well construction site, noise emissions are approximately 65 dBA at 150 m from the drilling operation's location (Radtke *et al.* 2017).

The previous operator of EP 371 conducted a noise monitoring program during HFS activities. Noise loggers were installed approximately 1 m from the noise source and approximately 800 m from the well site where HFS operations were being undertaken. Monitoring was undertaken over two days during start-up, warm-up and shutdown of equipment and engines. Noise loggers located approximately 1 m from the source recorded noise levels of between 89 and 106 dB(A) during engine warm-up / idling and between 95 and 108 dB(A) during pumping (Buru Energy 2014).

Given the nature and scale of the development, simple noise attenuation calculations (in accordance with ISO 9613 standards) were also undertaken to provide an indication of how far from the source it would be before levels returned to ambient levels. Using ambient levels provided in Table 5-31, and the source levels as identified from the previous noise monitoring program within EP 371, noise levels may be above ambient for up to 3,000 m from the well site. However, no noise sensitive receptors are known to be present within 3 km of the wells (Table 5-29). Further to this, noise levels recorded by the previous operator during HFS activities indicate that noise levels are typically less than 65 dB(A) 800 m away from the source.

In accordance with the definitions provided in the Environmental Protection (Noise) Regulations 1997, no noise sensitive premises, commercial or industrial premises are located within the Development Envelope. With no fixed sensitive receptors within close proximity that can be exposed to the Proposal's increased noise levels, noise emissions from the Proposal operations are not expected to result in a significant impact to social surroundings.

5.5.5.3 Increased Traffic Movement

While the remoteness of the areas may present logistical and operational challenges, it does mean that impacts to amenity are mitigated through the absence of nearby receptors. Increased traffic in the area may present a possible impact on amenity. However, the region where the Proposal is to occur is sparsely populated with the surrounding area used for pastoral activities. Additionally, vehicle movements on the roads in the region are infrequent, even on the nearest major road, the Great Northern Highway (Table 5-32).

To understand the potential impacts associated with traffic for the Proposal, a brief breakdown of traffic movements expected to be required for each of the activities covered in the Proposal is provided in Table 5-34.

Regionally speaking, on the expectation that the average number of moves per day could be as high as 17 loads (during the HFS stage), with the increase to road traffic along the Great Northern Highway is calculated to be less than 6 % of the total number of vehicles that would be expected to be encountered on an average day. Consequently, the increased traffic on major transport routes is not expected to result in significant impacts to the border region.

Currently, local shire traffic data show that the annual average daily traffic is between 20-100 vehicles (SDWK 2020) along the Calwinyardah-Noonkanbah Road. As mobilisation periods are expected to be minimal (in the order of two weeks), any increased traffic attributable to the Proposal is not likely to significantly impact the road users as the road is of suitable quality to facilitate two directions of travel. Further to this, BNR plan to conduct local traffic monitoring along Calwinyardah-Noonkanbah Road to inform any future impacts to road users by activities within the Development Envelope.

Table 5-34: Indicative traffic requirements per well for the Proposal



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Activity	Vehicle	Qty	Mobilisation / Operation Period (days)	Average number of moves per day
Site preparation operations	Flatbed truck (heavy machinery)	6	2	3
	Dump trucks (materials for hard stand construction)	40	14	~3
Drilling operations	Flatbed trucks (for drilling rig, mobile camp, bulk material and related equipment)	50	7	7
	Service vehicles (heavy vehicles) during operations	50	40	~2
HFS operations	HFS equipment, mobile camp etc	40	4	10
	Triple road train - proppant sand	64	14	7
	Service vehicles (heavy vehicles) during operations	50	25	~3
Site reinstatement	Flatbed truck (heavy machinery)	6	2	3

5.5.5.4 Social and Economic Benefits

During the HFS Scientific Inquiry, the Yungngora People and Warlangurru People voiced their support for HFS activities on their native title areas which are located within EP 371. A link to specific letters of support from these stakeholders can be found in Table 5-35.

Table 5-35: Letters of support for HFS during the HFS Scientific Inquiry

Stakeholder	Link to letters of support
Yungngora People	
Yungngora Aboriginal Corporation	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/yungngora_aboriginal_community_152_redacted.pdf
Neil Ewart (retired CEO of the Yungngora Association Incorporated)	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/ewart_neil_52_redacted.pdf
Germaine Muller (Chairperson Yungngora Association Incorporated)	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/muller_germaine_142.pdf
Warlangurru People	
Michael Costain	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/costaine_michael_147.pdf
Lazarus Costain	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/costain_lazarus_144.pdf
Benjamin Laurel	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/laurel_benjamin_133.pdf
Ronnie Lormada	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/lormada_ronnie_149.pdf



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Stakeholder	Link to letters of support
Anthony Mulligan	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_anthony_308.pdf
Audrey Mulligan	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_audrey_140.pdf
Gabriella Mulligan	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_gabriella_135.pdf
Judy Mulligan	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_judy_137.pdf
Lucas Mulligan	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_lucas_310.pdf
Rosie Mulligan	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_rosie_150.pdf
Tojoe Mulligan	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_tojoe_312.pdf
Leroy Nargoodah	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/nargoodah_leroy_138.pdf
Patrick Nargoodah	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/nargoodah_patrick_139.pdf
Audrey Milligan (Director of Warlangurru Aboriginal Corporation)	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_audrey_140.pdf
Frankie Wangyella	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/wangyella_frankie_134.pdf
Natalie Wardsmith	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/wardsmith_natalie_311.pdf
Morrison Wulgarrie	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/wulgarrie_morrison_148.pdf
Douglas Yamera	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/yamera_douglas_136.pdf
Eric Yamera	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/yamera_eric_309.pdf
Kuminjay Yamera	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/yamera_grayton_143.pdf
Madeline Yamera	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/yamera_madeline_146.pdf

Support for petroleum activities amongst the Yungngora Community is based on individual community members sound knowledge of HFS informed by an independent specialist review process that was undertaken by the previous operator of EP 371. The outcomes of the independent specialist review are included with the Yungngora Aboriginal Corporation submission to the HFS Scientific Inquiry as included in Table 5-35. The community also has first-hand experience of the HFS process through their active involvement and participation in the 2015 HFS program on the permit. Equally important has been the trust between Yungngora Community members and the operators of EP 371 that has been developed by the transparent sharing of information and maximising the employment and contracting opportunities for community members during operations on site.

During the 2015 HFS program, 33 workers from the community worked more than 14,000 hours on the program. Work was in the following areas:

- Security and Access Control – Noonkanbah community members were responsible for providing security and access control at all sites for the whole program, in partnership with security specialists. This involved maintaining a 24-hour ranger presence across operational areas;

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- HFS Spread – Noonkanbah workers were seconded to service companies during the program and worked alongside service company personnel doing equipment maintenance, loading sand, refuelling and related jobs;
- Civil Works – Noonkanbah community members were responsible for maintaining the access tracks and well sites during the program. This included watering of operational areas for dust suppression;
- Camp Services – Community members worked in the temporary camp during the program.

During the program, the Kimberley Training Institute were on site during the operations to train, assess and certify community members. Fifteen people were trained and ticketed in security, the operation of excavators, water carts, dump trucks, front end loaders and bobcats with 32 tickets awarded during the program

Approximately 400 people live in Yungngora Community (ABS 2016) with a median age of 22 years old. Of the approximately 240 people who are of working age, over 80% of people are either unemployed or are supported through the Commonwealth funded Community Development Program. As such, the Proposal will provide an important source of employment and socio-economic opportunities to the Yungngora Community as well as the Shire of Derby-West Kimberley and the West Kimberley region generally.

BNR have ILUA and LAUA in place with the Yungngora People and Warlangurru People respectively (Section 5.5.3.3.1). These include a focus on employment and training opportunities and programs, particularly for young people. BNR will continue to work closely with the Yungngora People and Warlangurru People to maximise the opportunities the Proposal brings to the communities.

5.5.5.5 Potential Impacts to Heritage Sites

As described in Section 5.5.3.2, the Development Envelope is situated within two Native Title areas. Two registered heritage sites and two 'other heritage sites' are present within the Development Envelope. No wells are located within any known heritage sites.

A heritage survey will be conducted with Native Title representatives prior to clearing and site construction to identify if any heritage sites are present within the proposed disturbance footprint. Once the survey is complete, BNR will review existing well locations as required to ensure that no damage to identified heritage sites or Aboriginal heritage values will occur from the Proposal. This will be achieved through close communication and engagement with the Yungngora (Noonkanbah) and Warlangurru Traditional Owners. Once well locations are finalised, the Yungngora (Noonkanbah) and Warlangurru Traditional Owners will also be invited to the well sites to monitor ground disturbing activities. Participation of Traditional Owners and community members in operations (Section 5.5.5.4) will be encouraged and supported.


To prevent disturbance outside of cleared areas, following the completion of site preparation activities, vehicles and personnel access will be limited to the well sites, main workers camp and access tracks. Given the current understanding of local heritage, the Proposal is not expected to have a significant impact on the cultural heritage of the region.

5.5.5.6 Application of Legislation, Policy and Guidance

The management of impacts to social surroundings is regulated under various legislation including the:

- *Aboriginal Heritage Act 1972*;
- *Native Title Act 1993*;
- Environmental Protection (Noise) Regulations 1997 (Noise Regulations); and
- PGER (Environment) Regulations 2012.

The *Aboriginal Heritage Act 1972* protects all Aboriginal heritage sites in Western Australia, whether or not they are registered with the Department of Planning, Lands and Heritage. Consent is required from the Minister for Aboriginal Affairs for any activity which will negatively impact Aboriginal heritage sites.

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Under the PGER (Environment) Regulations 2012, a DMIRS accepted Environment Plan is required to manage impacts to relevant stakeholders associated with all construction and operational activities. Specifically, the EP has to consider impact significance and demonstrate that impacts and risks are reduced to a level that is ALARP and acceptable prior to acceptance by DMIRS. No activities covered in the Proposal can commence until an EP is accepted by DMIRS.

5.5.6 Impact Validation and Verification

Throughout the planning phase, BNR have reviewed studies undertaken by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, once the well locations are finalised, BNR plan to conduct a range of studies to validate the assumptions in the Proposal and verify the impacts of the activity. These are documented in Table 5-36. The complete monitoring, verification and validation program for the Proposal is included in Section 7.

Table 5-36: Assumptions and verification studies for the Proposal


Assumptions	Verification studies during activity	Timing
No heritage sites will be impacted by the Proposal.	Pre-disturbance heritage surveys of the disturbance footprint with Traditional Owners.	Prior to site preparation operations.
Verify ambient noise levels prior to the activity.	Noise monitoring within the Development Envelope.	Prior to drilling operations.
No significant noise impacts to local communities.		During drilling operations.
		During HFS operations.
Verify ambient air quality levels prior to the activity.	Air quality monitoring for volatile organic compounds (HFS Scientific Inquiry Recommendation 15).	Prior to site preparation operations.
No air quality impacts to local communities.		During HFS operations.
No significant impact to existing road users of the Calwynyardah-Noonkanbah Road.	Monitoring of traffic volumes on Calwynyardah-Noonkanbah Road within the development envelope.	Prior to site preparation operations.
		During the HFS program.

5.5.7 Mitigation

A summary of the mitigation measures and their mitigation hierarchy that will be included in the Environment Plan for assessment and acceptance by DMIRS is included in Table 5-37.

Table 5-37: Proposed mitigation measures – social surroundings

Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Avoid	Demarcation of clearing area	Demarcation of the proposed clearing area by a surveyor reduces the chance of unplanned clearing and potential damage to heritage sites outside of the proposed footprint to the smallest possible extent.
Avoid	Heritage survey	Conducting a survey with Traditional Owners for presence of heritage material will help identify if any sites have the potential to be impacted by the Proposal.

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Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Minimise	Complaints management system	BNR will record and investigate any complaints over the course of the activity and record these in the Proposal's action tracking system.
Minimise	Dust management techniques	Implementing dust management techniques, such as water carts, ensures that dust generation can be prevented and reduced if necessary.
Minimise	Consultation	Consultation with relevant Indigenous groups will help determine the risk of heritage material being present on-site. Consultation with other stakeholders will ensure that issues related to the Proposal are identified and addressed.
Minimise	Heritage monitors during disturbance of the topsoil	Heritage monitors will be onsite during disturbance of the topsoil to ensure that in the event that heritage material is uncovered, activities cease, and discovery of the material immediately reported to the Noonkanbah and Warlangurru Traditional Owners to verify if it is a heritage artefact subject to protection under the <i>Aboriginal Heritage Act 1972</i> .
Minimise	Inductions	BNR have a comprehensive induction process that considers environmental impacts and risks. As identified by HFS Scientific Inquiry Recommendation 29, to prevent potential damage to heritage sites or artefacts should they be uncovered, BNR will provide cultural awareness and orientation to operational and field staff involved with ground disturbance activities.
Monitor	Traffic monitoring	As per HFS Scientific Inquiry Recommendation 27, traffic volumes on Calwinyardah-Noonkanbah Road will be monitored prior to and during the HFS program.

5.5.8 Predicted Outcomes

The outcomes of the Proposal are predicted to be:


- No impacts to the nearest receptors;
- No impacts to heritages sites or artefacts; and
- Direct and indirect economic benefits to the local communities of the Shire of Derby-West Kimberley.

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant impact to social surroundings. The mitigation measures intended to manage and minimise impacts on social surroundings are considered effective. Consequently, BNR believe that the EPA's objective to:

"To protect social surroundings from significant harm"

can be met.

BNR have considered the WA Environmental Offsets Policy, however BNR do not believe actions to offset the predicted outcomes of the Proposal are required as the Proposal is not expected to have a significant impact on social surroundings.

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6 Other Preliminary Environmental Factors

6.1 Subterranean Fauna

6.1.1 EPA Objective

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

6.1.2 Policy and Guidance

- Environmental Factor Guideline Subterranean Fauna (EPA 2016j);
- Technical Guidance Subterranean fauna survey (EPA 2013).

6.1.2.1 Application of EPA Guidance


The Environmental Factor Guideline – Subterranean Fauna (EPA 2016j) identifies the considerations for conducting an EIA of this factor. The Proposal meets the guideline’s considerations as demonstrated in Table 6-1.

Table 6-1: Environmental factor guideline – subterranean fauna considerations

Considerations for EIA	Section
Application of the mitigation hierarchy to avoid or minimise impacts to subterranean fauna, where possible.	Table 5-25
The subterranean fauna affected by the proposal.	Section 6.1.3
The potential impacts and the activities that will cause them, including direct and indirect.	Section 6.1.4
The implications of cumulative impacts.	N/a ²
Whether surveys and analyses have been undertaken consistent with EPA technical guidance.	Appendix E
The basis used to determine subterranean fauna habitat connectivity and species distributions and the level of confidence underpinning the predictions.	Section 6.1.3
The scale at which impacts to subterranean fauna are considered.	Section 6.1.5
The significance of the subterranean fauna values and the risk to those values.	Section 6.1.3 Section 6.1.5
The current state of knowledge of the affected species / assemblages of subterranean fauna and the level of confidence underpinning the predicted residual impacts.	Section 6.1.3 Section 6.1.5
Whether proposed management and mitigation approaches are technically and practically feasible.	Section 6.1.7 Table 5-25

6.1.3 Receiving Environment

Western Australia’s subterranean fauna is recognised as being globally significant because of its extraordinarily high species richness and high levels of endemism. Subterranean fauna assemblages may be significant as they have been recognised through the listing of some WA TEC and PEC, and may have important ecosystem service functions, such as the maintenance of water quality in groundwater aquifers.

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As such, the presence of subterranean fauna is strongly linked to the geology and hydrology of the area, in addition to the availability of suitable microhabitats, such as non-hypersaline aquifers for stygofauna and air-filled voids or caves for troglofauna.

The Liveringa Group Formation forms the upper-most aquifer in the Development Envelope (refer to Figure 5-14) and consists of mainly fine-grained sediments (siltstone and shale) with more-permeable sandstone beds being less common (Section 5.4.3.3). The shallow shale and siltstone sediments of the formation provide a potential habitat for stygofauna, although bore yields in the Development Envelope suggest that permeability is low, and so it is less likely that stygofauna would be present. Groundwater salinity in the Liveringa Formation is within a range that stygofauna are known to occur, with salinities of local bores ranging from 450 to 1,600 mg/L TDS (Appendix E [Rockwater 2016]).

The absence of caves or significant voids in the fine-grained sediments within the immediate surrounding region indicates that there is unlikely to be suitable habitat for troglofauna. Further analysis of subterranean fauna presence including a review of previous records and sampling undertaken within proximity of the Development Envelope is provided by Rockwater (2016) in Appendix E.

Based on results of previous sampling, it appears that sandstone aquifers of the Kimberley region contain moderately diverse stygofauna communities with very few stygofauna species restricted to small (project level) scales. The range of groundwater salinities are within the tolerance levels recorded for stygofauna, and the shale and siltstone of the Liveringa Formation could potentially provide habitats for stygofauna. However, the reported low yields from bores screened in this formation suggest that suitable voids within sediments may be limited. The absence of more permeable sandstone lithologies previously reported to support stygofauna communities in the Kimberley region may indicate that the potential for stygofauna is moderate to low. The regional extent of aquifers in the Development Envelope, and absence of any geological barriers that may prevent dispersal, suggest that any stygofauna community is unlikely to have a restricted distribution.

6.1.4 Potential Impacts

6.1.4.1 Direct Impacts

The Proposal may cause the following local changes to habitat which have the potential to result in impacts to subterranean fauna:

- Groundwater drawdown of surficial aquifers associated with water extraction.

6.1.4.2 Indirect Impacts


- Contamination of surficial aquifers from an accidental release at the surface of drilling fluids, HFS chemicals, liquid hydrocarbons or formation water.

6.1.5 Assessment of Impacts

6.1.5.1 Groundwater Drawdown of Surficial Aquifers Associated with Water Extraction

A detailed impact evaluation for groundwater drawdown is provided in Section 5.4.5.1. In summary, predictive modelling based upon in-field monitoring results for previous HFS programs indicate that an extraction 33 ML (per well) would result in a short-term drawdown of 1 m or more (Appendix E [Rockwater 2016]), and such drawdowns could extend up to 410 m from the extraction water bore at the (deep) level of the screens in the extraction bore. There would however be smaller drawdowns in the top 50 m of the Liveringa Formation: 1.2 m close to the bore decreasing to 1 m at a distance of about 56 m from the bore, and 0.1 m at a distance of 690 m (Appendix E [Rockwater 2016]). As seasonal fluctuations of groundwater levels in the region are between 0.2 m and 1 m (Appendix E [Rockwater 2016]), any drawdown is likely to be similar to existing natural variation.

The model also predicted that groundwater levels would be expected to recover rapidly to within 0.2 m of baseline levels within hours following the cessation of extraction and to fully recover within weeks. Based upon the volumes proposed to be extracted for the Proposal (approximately 40 ML per well), the impacts from the extraction will be similar to those previously modelled.

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Consequently, any impacts to groundwater levels attributed to the Proposal will be highly localised and temporary, therefore are not expected to result in a significant impact to subterranean fauna values, their diversity or abundance within the Development Envelope.

6.1.5.2 Potential Contamination of Surficial Aquifers from an Accidental Release at the Surface of Drilling Fluids, HFS Chemicals, Liquid Hydrocarbons or Formation Water

A spill from one of the water retention ponds used to support the Proposal, or a spill from a chemical or chemical additive (unmixed) to the ground will result in a varying level of exposure dependent on the volume of release. However, as described in Section 5.4.3.4, based upon the depth to groundwater, any surface release is expected to take between 70 and 300 days to travel from the ground surface to the water table (Appendix E [Rockwater 2016]).

As detailed in Section 5.2.5.2, a large spill event (such as a 75 m³ of diesel) would only be expected to seep through soils to a depth of approximately 0.4 m. Consequently, it is extremely unlikely that any release would cause the groundwater to be contaminated. Given that surface spill events are well understood, there is a standard suite of management measures including spill response and recovery arrangements, that would ensure that should a spill occur, impacts to groundwater quality (if any) are negligible.

If standard mitigation measures are implemented, BNR do not expect this indirect impact to cause a significant environmental impact and thus an impact to subterranean fauna and their values.

6.1.6 Impact Validation and Verification


Throughout the planning phase, BNR have reviewed studies undertaken by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, BNR plan to conduct a range of studies to validate the assumptions in the Proposal and verify the impacts of the activity. The assumptions and verification studies are documented in Table 6-2. The complete monitoring, verification and validation program for the Proposal is included in Section 7.

Table 6-2: Assumptions and verification studies for the Proposal

Assumptions	Verification studies during activity	Timing
No significant drawdown from water extraction activities.	Groundwater drawdown modelling	Prior to site preparation operations
Verify baseline water quality and groundwater level prior to the activity.	Groundwater level and quality (drilling) monitoring within the Development Envelope	Prior to drilling operations
No significant drawdown from water extraction activities.		Following drilling operations
No significant changes to groundwater quality (including methane composition) arising from the Proposal.		
No significant drawdown from water extraction activities.	Groundwater level and quality (HFS) monitoring	During HFS operations
No significant changes to groundwater quality (including methane composition) arising from the Proposal.		Following HFS operations
		Annually following HFS operations

6.1.7 Mitigation

Refer to Section 5.4.7 for a list of mitigation measures relevant to this factor.

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6.1.8 Predicted Outcomes

The outcomes of the Proposal are predicted to be:

- No impacts to subterranean fauna demonstrated by:
 - No significant drawdown of the aquifer following completion of the Proposal, considered outside of seasonal fluctuations; and
 - No change to groundwater quality attributable to the Proposal.

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant impact to subterranean fauna. The environmental mitigation measures intended to manage and minimise impacts on subterranean fauna are considered effective. Consequently, BNR believe that the EPA's objective to:

"To protect subterranean fauna so that biological diversity and ecological integrity are maintained"

can be met.

BNR have considered the WA Environmental Offsets Policy, however BNR do not believe actions to offset the predicted outcomes of the Proposal are required as the Proposal is not expected to have a significant impact on subterranean fauna.

6.2 Air Quality

6.2.1 EPA Objective

To maintain air quality and minimise emissions so that environmental values are protected.

6.2.2 Legislation, Policy and Guidance


- Environmental Factor Guideline Air Quality (EPA 2020c);
- *Environmental Protection Act 1986*;
- *National Greenhouse and Energy Reporting Act 2007* (NGER Act).
- National Environment Protection Measures (Ambient Air Quality).

6.2.2.1 Application of EPA Guidance

The Environmental Factor Guideline – Air Quality (EPA 2020c) identifies the information required for conducting an EIA of this factor. The Proposal meets the guideline's requirements as demonstrated in Table 6-3.

Table 6-3: Environmental factor guideline – air quality requirements

Information required for EIA	Section
Characterisation of the feedstock and the pollutants and contaminants that are likely to be emitted.	Section 6.2.5.1
Characterisation of and proximity to sensitive receptors.	Section 6.2.3.1 Section 6.2.3
Background ambient air modelling and the impact of emissions on sensitive receptors, including likely impacts during worst, best and most likely case scenarios.	Section 6.2.3.1 Section 6.2.5.1
Assessment against published standards and criteria.	Section 6.2.5.1 Section 6.3.5.2

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Information required for EIA	Section
Identification of emission reduction equipment and proposed technologies, and where relevant, demonstration of the use of proven technologies.	Table 6-7 Section 6.3.7
Description of proposed management and monitoring arrangements.	Table 6-6 Table 6-7

6.2.3 Receiving Environment

As detailed in Section 5.5.3.2, the Development Envelope is located at least 20 km from any public residential area. The Nidavellir well site is located approximately 20 km from the remote Jimbalakudunj Community and the Proposed Well Site 4 approximately 55 km from the nearest town, Fitzroy Crossing.

6.2.3.1 Air Quality

There is currently no publicly available data on background air quality in Derby, but it is expected to generally be good, although elevated particulate levels would likely arise from bushfires and dust storms.


The previous operator of EP 371 commissioned AECOM to undertake an air quality study during previous HFS activities. However, the background upwind sample point did not detect methane during the sampling period (AECOM 2016). Consequently, for the purposes of the Proposal, published literature by the World Meteorological Organisation (WMO) can be used to represent background methane concentrations. The WMO states that globally averaged background methane concentrations are approximately 1,869 parts per billion by volume (ppbv) (WMO 2019; Rubino *et al.* 2019).

BNR also reviewed publicly available information from suitable reference sites to validate ambient air quality within the Development Envelope. DWER monitors air quality at several Air Quality Monitoring Stations (AQMS) located in both regional and metropolitan locations within Western Australia in accordance with the National Environment Protection (Ambient Air Quality) Measure (NEPM), which is used as the national standard to monitor ambient air quality (DWER 2016). Only two sites monitoring the pollutants of interest were identified that were not in a densely populated area and were not under the strong direct influence of a large polluting source: Caversham (NE suburbs of Perth) and Rolling Green (outer east rural site) (DWER 2019). BNR selected Caversham to provide an indication of air quality within the Development Envelope as it is expected to have higher concentrations of most pollutants, allowing a suitably conservative assessment to be undertaken.

DWER's 2018 Western Australian air monitoring report (DWER 2019) provides annual air quality data for Caversham, as presented in Table 6-4.

Table 6-4: Air quality from Caversham (DWER 2019)

Pollutant	Averaging period	Statistic	Average air quality NEPM standard
CO (Carbon monoxide)	8-hours	1.1 ppm (highest)	9 ppm
O ₃ (Ozone)	4-hours	0.056 ppm (highest)	0.08 ppm
SO ₂ (Sulfur dioxide)	Annual average	-	0.02 ppm
NO ₂ (Nitrogen dioxide)		0.005 ppm	0.03 ppm
PM ₁₀ (suspended particulate matter)		16.3 µg/m ³	25 µg/m ³

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Pollutant	Averaging period	Statistic	Average air quality NEPM standard
PM _{2.5} (suspended particulate matter)		8 µg/m ³	8 µg/m ³

6.2.4 Potential Impacts

The potential impacts associated with this environmental factor are limited to:

- Reduction in air quality causing impacts to sensitive social receptors; and
- Contribution to greenhouse gas emissions.

6.2.5 Assessment of Impacts

6.2.5.1 Reduction in Air Quality Causing Impacts to Sensitive Social Receptors;


The operation of diesel-powered vehicles, heavy equipment and power generation during all phases of the Proposal will result in the generation of combustion emissions. Emissions generated will include Nitrogen Oxides (NO_x), SO₂, PM₁₀ and volatile organic compounds (VOC), however given their limited nature they are expected to rapidly disperse upon release. The combustion emissions associated with the types of vehicles, machinery and equipment required during construction operations are not expected to be significantly different from other sources in the region.

With the nearest receptors (Section 5.5.3.2) located at least 20 km from the Development Envelope, based upon the receptors' substantial distance from the well sites, and the surrounding rural land use, air emissions arising from vehicles, heavy equipment and generator use are not considered to represent a significant or long-lasting impact to air quality, human health or aesthetics during the site operations.

Air quality, specifically methane, was sampled during previous HFS activities within EP 371 across nine sample locations within 100 m of a well head (AECOM 2016). The outcomes of this 2015 sampling program are included as Table 6-5.

Table 6-5: Outcomes from previous 2015 air quality sampling program during HFS activities

Sample ID	Date / Time	Methane (ppbv)	Residual methane concentration (without background) (ppbv)
A11	09/09/2015 04:02 PM	1,900	100
A12	09/09/2015 04:02 PM	-	-
A21	09/09/2015 04:02 PM	2,100	300
A22	09/09/2015 04:02 PM	1,900	100
A32	09/09/2015 03:30 PM	2,200	400
A41	09/09/2015 03:28 PM	2,100	300
A61	09/09/2015 03:30 PM	1,800	Negligible
A72	09/09/2015 03:20 PM	-	-
A81	09/09/2015 02:45 PM	-	-
A82	09/09/2015 03:23 PM	-	-

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Sample ID	Date / Time	Methane (ppbv)	Residual methane concentration (without background) (ppbv)
A91 Background sample	09/09/2015 03:16 PM	¹⁴	-

The data presented in Table 6-5 shows that the concentration of methane generated from a HFS activity is marginally above the atmospheric global background level of 1,869 ppbv (WMO 2019; Rubino *et al.* 2019), ranging from negligible concentrations (sample A61) through to 400 ppbv (sample A32). To put these concentrations into context, methane fluxes of around 2400 ppbv have been measured approximately 1 km downwind of large cattle feedlots (Day *et al.* 2015). The negligible concentrations of methane generated from a HFS activity are typical of values that can be experienced within 5 km from a landfill site (Mønster *et al.* 2015).

Sources of methane that may have contributed to the concentrations recorded at the wellsite during the 2015 program include:

- Point source emissions from equipment and activities along the production and processing chain and vehicles;
- Diffuse source emissions as a result of extraction activities;
- Diffuse source background emissions from natural seepage;
- Natural sources of background emissions such as:
 - Biogenic sources: pastoral stations with cattle feedlots, landfills and wetlands;
 - Thermogenic sources: bush fires.

6.2.5.2 Contribution to Greenhouse Gas Emissions

The contribution to greenhouse gas emissions has been discussed in the environmental factor Greenhouse Gas Emissions, in Section 6.2.


6.2.6 Impact Validation and Verification

Throughout the planning phase, BNR have reviewed studies undertaken by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, BNR plan to conduct a range of studies to validate the assumptions in the Proposal and verify the impacts of the activity. The assumptions and verification studies are documented in Table 6-6. The complete monitoring, verification and validation program for the Proposal is included in Section 7.

Table 6-6: Assumptions and verification studies for the Proposal

Assumptions	Verification studies during activity	Timing
Verify ambient air quality levels prior to the activity.	Air quality monitoring for volatile organic compounds (HFS Scientific Inquiry Recommendation 15) within the Development Envelope.	Prior to site preparation operations.
No air quality impacts to local communities.		During HFS operations.

¹⁴ Methane levels for A91 were below the limit of detection, however, published literature states that although variable, global methane atmospheric concentrations are approximately 1,869 ppbv (WMO 2019).

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6.2.7 Mitigation

A summary of the mitigation measures and their mitigation hierarchy that will be included in the Environment Plan for assessment and acceptance by DMIRS is included in Table 6-7.

Table 6-7: Proposed mitigation measures – air quality

Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Minimise	Use of pilot flame during flaring, thereby minimizing cold venting of methane	In accordance with Section D.5.9 of the NT Code of Practice, by ensuring that cold venting is prevented during well test flaring operations, methane emissions associated with this activity are significantly reduced. Cold venting results in the release of methane, carbon dioxide, volatile organic compounds, sulfur compounds and gas impurities to the atmosphere, whereas flaring causes these gases to oxidise and form carbon dioxide, which has a global warming potential 21 times lower than methane.
Minimise	Dust management techniques	Implementing dust management techniques, such as dust suppression, ensures that dust generation is minimised.
Monitor	Monitoring and reporting of emissions (including diesel consumption)	As per Regulation 15 of the PGER(E)R, BNR will monitor and record the atmospheric emissions (including diesel consumption) associated with these activities.
Monitor	Complaints management system	BNR will record and investigate any atmospheric emission complaints over the course of the activity and record these in the Proposal's action tracking system.
Monitor	NGER reporting	BNR will maintain emissions records to enable GHG emissions reporting as required under the <i>National Greenhouse and Energy Reporting Act 2007</i> .

6.2.8 Predicted Outcomes

The outcomes of the Proposal are predicted to be:

- No reduction in air quality causing impacts to sensitive social receptors.

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant impact to air quality. The environmental mitigation measures intended to manage and minimise impacts on air quality are considered effective. Consequently, BNR believes that the EPA's objective to:

"To maintain air quality and minimise emissions so that environmental values are protected"

can be met.

BNR have considered the WA Environmental Offsets Policy, however BNR do not believe actions to offset the predicted outcomes of the Proposal are required as the Proposal is not expected to have a significant impact on air quality.


6.3 Greenhouse Gas Emissions

6.3.1 EPA Objective

To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change.

6.3.2 Legislation, Policy and Guidance

- Environmental Factor Guideline Greenhouse Gas Emissions, April 2020 (EPA 2020d);

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- United Nations Framework Convention on Climate Change (UNFCCC) Reporting Guidelines on Annual Inventories (UNFCCC 2014);
- *Environmental Protection Act 1986 (WA)* (EP Act);
- *National Greenhouse and Energy Reporting Act 2007* (NGER Act).

6.3.2.1 Application of EPA Guidance

The Environmental Factor Guideline – Greenhouse Gas Emissions (EPA 2020d) identifies the information required for conducting an EIA of this factor. The Proposal meets the guideline’s requirements as demonstrated in Table 6-8. Consistent with the EPA Factor Guideline – Greenhouse Gas Emissions (EPA 2020d), Greenhouse Gases are considered as a factor distinct from Air Quality.

Table 6-8: Environmental factor guideline – greenhouse gas emissions requirements

Information required for EIA	Section
Credible estimates of scope 1, scope 2 and scope 3 GHG emissions (annual and total) over the life of a proposal.	Section 6.3.5.2 Table 6-9
A breakdown of GHG emissions by source inclusive of, but not limited to, stationary energy, fugitives, transport, emissions associated with changes to land use.	Table 6-9
Projected emissions intensity (emissions per unit of production) for the proposal and benchmarking against other comparable projects.	N/a ¹⁵

6.3.3 Receiving Environment

Six categories of Greenhouse Gases (GHG) are covered by the United Nations Framework Convention on Climate Change (UNFCCC) Reporting Guidelines on Annual Inventories (UNFCCC 2014). These gases are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and the synthetic GHG – sulfur hexafluoride (SF₆), Hydrofluorocarbons (HFC) and Perfluorocarbons (PFC).

The amounts of CO₂, CH₄ and N₂O in the atmosphere show significant seasonal and year-to-year variabilities, but all show ongoing upward trends. The impact of all GHG can be converted to an equivalent CO₂ (CO₂-e) atmospheric concentration. The Australian Government publishes the National Greenhouse Gas Inventory as part of the commitments made under the Kyoto Protocol. Australia’s total greenhouse gas emissions were 537.4 million tonnes (Mt) of carbon dioxide equivalent (CO₂-e) in 2018 (National Greenhouse Gas Inventory Report 2018, (DISER, May 2020). Western Australia’s GHG emissions for the year 2018 was of 91.5 million tonnes of CO₂-e (State and Territory Greenhouse Gas Inventories 2018 [DISER 2020]). The State Greenhouse Gas Inventory shows a steady increase in GHG emissions in WA from the early 1990s (DISER 2017), and generally, emissions growth in WA is expected to continue in the short to medium term. Currently, except for emissions of PFC in aluminium and SF₆ in magnesium, due to lack of data, emissions of synthetic GHG are not included in Australia’s annual inventory of greenhouse gas emissions.


6.3.4 Potential Impacts

Due to the nature of the Proposal, emissions mainly occur at the outset of production and exploration emissions are likely very small when amortized over the general producing life of a gas field.

The potential impacts associated with this environmental factor are limited to:

- Reduction in air quality causing impacts to sensitive social receptors; and

¹⁵ The Proposal is limited to exploration and appraisal activities with no production / processing of hydrocarbons within this scope.

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- Contribution to greenhouse gas emissions.

6.3.5 Assessment of Impacts

6.3.5.1 Reduction in Air Quality Causing Impacts to Sensitive Social Receptors

Impacts to air quality are discussed in the preliminary key environmental factor Air Quality, in Section 6.2.

In summary, air quality was sampled during previous HFS activities within EP 371 in 2015. Results showed that the concentration of residual methane generated from an HFS activity ranged from negligible concentrations through to 400 ppbv (AECOM 2016), without the atmospheric global background level of 1,869 ppbv (WMO 2019; Rubino *et al.* 2019).

Given the distance to the nearest receptors (Section 5.5.3.2) and surrounding rural land use, air emissions arising from the Proposal's equipment and vehicle use are not considered to represent a significant or long-lasting impact to air quality, human health or aesthetics during the site operations.

For further information, refer to Section 6.2.5.1.

6.3.5.2 Contribution to Greenhouse Gas Emissions

During the previous HFS program in 2015, a comprehensive gas sampling program was carried out. This has confirmed that the produced gas is of high quality. Produced gas samples were surface samples obtained from commingled zones including both dry gas and liquid rich zones, but on average the composition is 87% methane, 5.5% ethane, 2.7% propane and low inert gases (2% to 5% CO₂) (ASX 2016). The CO₂ content of <5% is of pipeline quality.

Maximum operational GHG emissions from the Proposal are expected to be comparable to previous HFS activities within the Development Envelope which recorded gas flow rates in the order of approximately 13 MMCFGPD (million cubic feet of gas per day) (averaged over a 1.5 hour period) (ASX 2016).

BNR have estimated the Scope 1 emissions per well in Table 6-9. Using the State's GHG emissions for the year 2018 of 91.5 million tonnes of CO₂-e (DISER 2020), each well is expected to represent a conservative maximum 0.02% of the state's annual greenhouse gas emissions. Combined, the emissions associated with the Proposal are expected to comprise <0.4% of the State's greenhouse gas emissions.

There are no Scope 2 emissions associated with the Proposal as all electricity is generated onsite through diesel generation.

Scope 3 emissions that can be linked to the Proposal are limited to transport of equipment to and from site and manufacturing of equipment. As these are no different to any other exploration or construction program, BNR have not provided additional information.

6.3.5.3 Greenhouse Gas Emissions Reporting Obligations and Safeguard Mechanism

The National Greenhouse and Energy Reporting (NGER) legislative regime establishes a single national reporting framework for energy and emissions reporting and managing emissions. The NGER regime also contains the safeguard mechanism that applies to 'designated large facilities' with emissions over 100,000 t CO₂-e in a financial year as defined in Section 22XJ of the *National Greenhouse and Energy Reporting Act 2007* (Commonwealth).

The proposal is for a temporary exploration activity at a number of different well locations, and accordingly, each well site does not meet the threshold of a "designated large facility". Specifically, this exploration stage will further appraise the economic viability for future development. Subsequent development and operation of any future processing facilities may constitute a designated large facility under the NGER Act.


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Table 6-9: Scope 1 GHG calculations per well

Activities	Emission source	Volume estimates (per well)		Total Scope 1 emissions per well (t CO ₂ -e)
Site preparation operations	Combustion emissions from diesel	20 m ³		54
Drilling operations	Combustion emissions from diesel during mobilisation	10 m ³		27
	Combustion emissions from diesel during Drilling operations	379 m ³		1,023
HFS operations	Combustion emissions from diesel during mobilisation	20 m ³		54
	Combustion emissions from diesel during HFS operations	300 m ³		809
	CH ₄ emissions during well testing	Gas Flow rate ~2.5 MMCFGPD	Period of Flaring ~90 days	<15,000
Site reinstatement	Combustion emissions from diesel	20 m ³		54
Total				17,021 t CO₂-e

BNR do not believe that greenhouse gas impacts arising from the Proposal are significant as:


- Well testing emissions are similar to conventional exploration programs which are not generally considered to result in significant greenhouse gas impacts; and
- Emissions from the Proposal conservatively account for less than <0.4% of the State's greenhouse gas emissions.

6.3.6 Impact Validation and Verification

Throughout the planning phase, BNR have reviewed studies by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, BNR plan to conduct the following study to validate the assumptions in the Proposal and verify the impacts of the activity. The assumptions and verification studies are documented in Table 6-10. The complete monitoring, verification and validation program for the Proposal is included in Section 7.

Table 6-10: Assumptions and verification studies for the Proposal

Assumptions	Verification studies during activity	Timing
GHG emissions from each well site for the duration of the Proposal would not exceed 100,000 t CO ₂ -e.	Monitoring of Scope 1 GHG emissions within the Development Envelope.	For the duration of the Proposal.

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6.3.7 Mitigation

As the Proposal is an exploration stage activity, BNR will flare, and not vent, produced gas during well testing as flaring converts methane to carbon dioxide and water, thus significantly reducing methane emissions. Carbon dioxide has a global warming potential 25 times lower than methane over a 100-year span, therefore the removal of methane is preferable. This is a standard industry approach, and when combined with the correct flaring technology, is an economically and environmentally sound approach for managing these types of emissions during an exploration program. Flaring during early stage exploration is aligned with Recommendation 12 of the HFS Scientific Inquiry (Appendix A).

Given the nature of the Proposal (which is limited to an exploration and appraisal program), options for carbon capture and reinjection are not feasible given the lack of available infrastructure. Carbon capture (or reinjection) requires wells that are suitable for injection, dedicated treatment facilities to treat and compress the gas and a transport network of pipelines.

Further to this, a significant amount of work is required to assess the feasibility of such measures (e.g. evaluation of zone of injection, distance from producing reservoir so that production rates are not impacted). This pre-work is significant and may take several years to complete (resulting in significant financial costs not detailed here).

As the purpose of the Proposal is to appraise the extent of the formation, the wells are located far away from each other on the periphery of the target formation. Given the distance between each well site, such a carbon capture / reinjection program is not feasible given the vast pipeline network that would need to be built for a well that may (or may not) be successful in finding gas. The level of disturbance for the Proposal would then be much higher.

Other options for reducing greenhouse gas emissions that have been considered include capture of liquid hydrocarbons (condensate), storage onsite and trucking offsite for use. Based upon the previous HFS program within EP 371, the volumes of condensate that were produced during well testing were within the maximum of 4 m³ of condensate per day (Buru Energy Limited 2016). However, as the volume of condensate is low, there is negligible benefit in capturing and storing it onsite, given the emissions associated with transporting it offsite.

For specific mitigation and management measures, refer to Section 6.2.7

6.3.8 Predicted Outcome

The outcomes of the Proposal are predicted to be:

- No reduction in air quality causing impacts to sensitive social receptors;

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant contribution to GHG emissions. The environmental mitigation measures intended to manage and minimise impacts to GHG emissions are considered effective. The Proposal will enable BNR to gain a better understanding of the existing geology, including the mitigation measures that may be implemented during future field development.

6.4 Human Health

6.4.1 EPA Objective

To protect human health from significant harm.

6.4.2 Policy and Guidance

- Environmental Factor Guideline Human Health (EPA 2016k);

6.4.2.1 Application of EPA Guidance

The Environmental Factor Guideline – Human Health (EPA 2016k) identifies the information required for conducting an EIA of this factor. The Proposal meets the guideline's requirements as demonstrated in Table 6-11.


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Table 6-11: Environmental factor guideline – human health

Information required for EIA	Section
Radiological exposure assessments and modelling of radiation exposure risk to the public and workers.	Section 6.4.5.1
Establish an appropriate baseline for model input, including natural variation.	Section 6.4.3
Consideration of appropriate conversion factors and modelling of absorbed doses.	N/a
Management of radiological impacts during transport of hazardous materials, including measures to limit risk of spills in the event of a transport accident.	N/a
Radiation management measures that would be implemented to minimise emissions or radionuclide-containing dust and radon decay products	N/a
Monitoring, management and contingency procedures to reduce exposure.	Section 6.4.7
Health risk assessment, using evidence-based information for health impacts.	Section 6.4.5.1

6.4.3 Receiving Environment

The geological formations that contain oil and gas deposits also contain naturally occurring radionuclides, which are referred to as Naturally Occurring Radioactive Material (NORM). These include uranium, thorium and potassium, which can produce a range of other elements known as decay products such as radon and radium. NORM is found everywhere in the environment including soil, rocks, water, air and vegetation. It is also present in the human body and all living tissues, typically in very low concentrations (SA EPA 2017).]

In 2015, the previous operator analysed formation water produced during well testing operations from the previous HFS program. The sampling program comprised individual samples prior to storage in the water retention ponds and samples within water retention ponds to provide characterisation of the entire formation water volume. The results of this program are included as Appendix G.

On the basis that exposure to formation water is limited to the water retention pond (given the water is contained in a close loop system [Figure 2-3]), sampling undertaken by the previous operator indicates formation water stored in all water retention ponds was well below the exposure concentrations as identified by the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ 2000) and the Australian Drinking Water Guidelines (NHMRC and NRMCMC 2011).

6.4.4 Potential Impacts

The potential impacts associated with this environmental factor are limited to:


- Industrial processes that result in the build-up and release of radioactive substances or emissions.

6.4.5 Assessment of Impacts

6.4.5.1 Industrial processes that result in the build-up and release of radioactive substances or emissions

During the process of gas extraction, NORM may be brought to the surface resulting in the potential for human exposure. As the Proposal consists in a small-scale exploration and appraisal program within a short timeframe, occupational exposure to radiation is very limited. The potential for human exposure to NORM is limited to formation water storage within the water retention pond as the water is produced in a closed system (Figure 2-4).

Human exposure to formation water is limited to the water retention pond given formation water is contained in a closed loop system until it is stored in the water retention ponds (Figure 2-4).

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Monitoring of Laurel Formation water produced during well testing operations indicate that, on average, NORM levels for samples taken from the water retention pond are low and well below the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ 2000) and the Australian Drinking Water Guidelines (NHMRC and NRMCC 2011) levels (Appendix G).

Given the potential levels of NORM in formation water, and the mitigation measures in place to contain formation water on site (Table 6-13), BNR do not expect any NORM contaminated material to be released to the environment causing exposure to humans and risking human health.

However, should an accidental release from the water retention pond occur, impacts to human health are not expected given NORM concentrations in the ponds are below the levels set out by industry guidelines.

6.4.6 Impact Validation and Verification

Throughout the planning phase, BNR have reviewed studies by the previous operators of EP 371 to understand the potential impacts associated with the Proposal. Although these studies have formed the basis of this assessment, BNR plan to conduct the following study to validate the assumptions in the Proposal and verify the impacts of the activity. The assumptions and verification studies are documented in Table 6-12. The complete monitoring, verification and validation program for the Proposal is included in Section 7.

Table 6-12: Assumptions and verification studies for the Proposal


Assumptions	Verification studies during activity	Timing
Verify formation water within water retention ponds comprise NORM concentrations below Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ 2000) and the Australian Drinking Water Guidelines (NHMRC and NRMCC 2011).	NORM formation water sampling.	Following HFS operations.

6.4.7 Mitigation

A summary of the mitigation measures and their mitigation hierarchy that will be included in the Environment Plan for assessment and acceptance by DMIRS is included in Table 6-13.

Table 6-13: Proposed mitigation measures – human health

Mitigation hierarchy	Mitigation measure	Source of good practice mitigation measure
Minimise	Water retention pond design	As per the Department of Water – Water Quality Protection Note 26 – Liners for containing pollutants, using synthetic membranes (DoW 2013), all lined storage compounds should have sufficient freeboard (at least 500 mm) maintained to prevent unintended overflow of water from storms with an average return frequency of at least 20 years, plus capacity to store rainfall resulting from a 90 percentile wet season, after allowance for any evaporative water loss and the effects of any water reuse recovery system.
Minimise	Water retention pond design	In accordance with Section B.4.16 of the NT Code of Practice, and as per the Department of Water – Water Quality Protection Note 26 – Liners for containing pollutants, using synthetic membranes (DoW 2013), surface ponds used to contain wastewater or solids that may leach contaminants for short-term containment, require synthetic membranes and need to meet specific requirements, which include: <ul style="list-style-type: none"> All synthetic drilling fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s; and A minimum thickness of 0.75 mm.

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6.4.8 Predicted Outcomes

The outcomes of the Proposal are predicted to be:


- No impacts to human health by:
 - Industrial processes that result in the build-up and release of radioactive substances or emissions.

Based upon the predicted outcomes for the Proposal, BNR do not believe that the Proposal will result in a significant impact to human health. The environmental mitigation measures intended to manage and minimise impacts to human health are considered effective. Consequently, BNR believe that the EPA's objective to:

"To protect human health from significant harm"

can be met.

BNR have considered the WA Environmental Offsets Policy, however BNR do not believe actions to offset the predicted outcomes of the Proposal are required as the Proposal is not expected to have a significant impact on human health.

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7 Monitoring, Verification and Validation Studies, and Reporting

As detailed throughout Section 5 and Section 6, the assessment of impacts arising from the Proposal have been informed by a number of existing studies undertaken by the previous operators of EP 371. BNR plan to validate the outcomes of these studies over the course of the Proposal and report on the results accordingly.

Table 7-1 provides a summary of the verification and validation studies that are proposed to be undertaken over the course of the Proposal. BNR understands that the outputs of the studies will be included in several different reports with the key reports being the:

- DWER Annual Report; and
- DMIRS Environment Plan Annual Environmental Report.



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Table 7-1: Summary of monitoring, verification and validation studies for the Proposal

Verification studies	Assumptions to verify	Timing	Location	Monitoring parameters
Flora and vegetation reconnaissance survey (with fauna habitat / opportunistic fauna observation)	<ul style="list-style-type: none"> No DRF, TEC or ESA are located within the individual well sites. Vegetation communities to be impacted comprise well represented communities that match broadscale vegetation mapping. No weeds of significance are located within the proposed wells sites. No significant fauna habitat will be disturbed by the Proposal. 	Prior to site preparation operations	At all well sites.	<ul style="list-style-type: none"> Flora species: <ul style="list-style-type: none"> Native; Introduced; Fauna species: <ul style="list-style-type: none"> Native; Introduced; Vegetation type and associations.
Baseline soil quality sampling	Verify baseline soil quality prior to the activity.	Prior to drilling operations	At all well sites.	<ul style="list-style-type: none"> Inorganic compounds: <ul style="list-style-type: none"> Metals / metalloids; Other inorganics; Organic compounds, including: <ul style="list-style-type: none"> Total petroleum hydrocarbons.
Soil quality sampling	No soil parameters are above ecological screening levels attributable to the Proposal following completion of the activity.	Following site reinstatement	At all well sites.	
Groundwater drawdown modelling	No significant drawdown from water extraction activities.	Prior to site preparation operations	A single location – in closest proximity to existing communities.	<ul style="list-style-type: none"> Groundwater level.
Groundwater level and quality (drilling) monitoring	Verify baseline water quality and groundwater level prior to the activity.	Prior to drilling operations	At all well sites.	<ul style="list-style-type: none"> Groundwater level; Groundwater quality: <ul style="list-style-type: none"> Inorganic compounds (including metals);
	No significant drawdown from water extraction activities.	Following drilling operations	At all well sites.	


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Verification studies	Assumptions to verify	Timing	Location	Monitoring parameters
	No significant changes to groundwater quality (including methane composition) arising from the Proposal.			<ul style="list-style-type: none"> ○ Organic compounds; ○ TRH; ○ BTEX compounds; ○ pH; ○ Electrical conductivity; ○ TDS; ○ Methane.
Groundwater level and quality (HFS) monitoring	No significant drawdown from water extraction activities.	During HFS operations	At all well sites.	
	No significant changes to groundwater quality (including methane composition) arising from the Proposal.	Following HFS operations	At all well sites.	
		Annually following HFS operations	At all well sites.	
NORM formation water sampling	Verify formation water within water retention ponds comprise NORM concentrations below Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ 2000) and the Australian Drinking Water Guidelines (NHMRC and NRMCC 2011).	Following HFS operations	At all well sites.	<ul style="list-style-type: none"> ● Presence of NORM; ● Inorganic compounds: <ul style="list-style-type: none"> ○ Metals / metalloids; ○ Other inorganics; ○ Organic compounds.
Fracture trajectory modelling	At least 600 m vertical separation from the nearest useable aquifer will be maintained for the Proposal.	Prior to HFS operations	At all well sites.	N/a
A geo-mechanical risk analysis to be completed at each of the well sites	No geo-mechanical risks present at the well locations	Prior to site preparation operations	At all well sites.	N/a
Pre-disturbance heritage surveys with Traditional Owners	No heritage sites will be impacted by the Proposal.	Prior to site preparation operations	At all well sites.	<ul style="list-style-type: none"> ● Indigenous heritage sites and artefacts; ● Flora and vegetation species of Indigenous importance.



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Verification studies	Assumptions to verify	Timing	Location	Monitoring parameters
Noise monitoring	Verify ambient noise levels prior to the activity.	Prior to drilling operations	A single location – in closest proximity to existing communities.	<ul style="list-style-type: none"> Noise levels.
	No significant noise impacts to local communities.	During drilling operations	A single location – in closest proximity to existing communities.	
		During HFS operations	A single location – in closest proximity to existing communities.	
Monitoring of traffic volumes on Calwynyardah-Noonkanbah Road	No significant impact to existing road users of the Calwynyardah-Noonkanbah Road.	Prior to site preparation operations During the HFS program	Along the Calwynyardah-Noonkanbah Road'	<ul style="list-style-type: none"> Traffic frequency recorded through traffic surveys.
Air quality monitoring for volatile organic compounds (HFS Scientific Inquiry Recommendation 15)	Verify ambient air quality levels prior to the activity.	Prior to site preparation operations	A single location – in closest proximity to existing communities.	<ul style="list-style-type: none"> Gas concentrations, including: <ul style="list-style-type: none"> GHG; VOC; BTEX compounds; Particulate matter.
	No air quality impacts to local communities.	During HFS operations	A single location – in closest proximity to existing communities.	
Monitoring of Scope 1 GHG emissions	GHG emissions from each wellsite will not exceed 100,000 t CO ₂ -e.	For the duration of the Proposal	At all well locations.	<ul style="list-style-type: none"> Greenhouse gas concentrations.
Mud sump cuttings analysis	Contaminants exceed threshold levels for reuse on-site.	Prior to site reinstatement	At all mud sumps.	Cuttings analysis: <ul style="list-style-type: none"> Inorganic compounds: <ul style="list-style-type: none"> Metals / metalloids; Other inorganics; Organic compounds.

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8 References / Associated documents

AECOM (2016). Fugitive Air Emissions Characterisation – Well Completion Emissions. Report for Buru Energy. March 2016.

Allen, G.R. (1997). Marine Fishes of Tropical Australia and South-East Asia - A field guide for anglers and divers. Third Revised Edition. Perth, Western Australia: Western Australian Museum.

ASX (2016). ASX Release from Buru Energy: Operations Update and Update on Laurel Formation Tight Gas Pilot Exploration Program (TGS). 16 May 2016. Available from: <https://www.asx.com.au/asxpdf/20160516/pdf/43786rk7yxjz1c.pdf>

Australian and New Zealand Environment and Conservation Council (ANZECC) Water Quality Guideline (2000).

Australian Bureau of Statistics (ABS) (2016). 2016 Census Quickstats. Government of Australia.

Bastin, G. and the ACRIS Management Committee (2008). Rangelands 2008 — Taking the Pulse, published on behalf of the ACRIS Management Committee by the National Land & Water Resources Audit, Canberra.

Beard, J.S., Beeston, G.R., Harvey, J.M., Hopkins, A.J.M. and Shepherd, D.P. (2013). The vegetation of Western Australia at the 1:3,000,000 scale. Explanatory memoir. Second edition. Conservation Science Western Australia 9: 1-152.

Beard, J.S. (1979). Vegetation Survey of Western Australia: Kimberley. 1:1000,000 Vegetation Series. Map and Explanatory Notes. Perth, Western Australia: University of Western Australia Press.

Braithwaite, R.W. and Begg, R.J. (1995). Northern quoll *Dasyurus hallucatus* Gould, 1842. In: Strahan, R., (ed.). The Mammals of Australia: National Photographic Index of Australian Wildlife. Page(s) 65-66. Sydney: Reed Books.

Bureau of Meteorology (BoM) (2020). Climate data online – Fitzroy Crossing Aero climate statistics. Available from <http://www.bom.gov.au/climate/data/?ref=fr>

Buru Energy (2012). Groundwater monitoring program (including groundwater quality, depth using continuous water logging).

Buru Energy (2014). Noise monitoring program during HFS activities. Unpublished report.

Buru Energy and Outback Ecology (2014). Ophir, Paradise, Valhalla, Eden and Ellendale Flora, Vegetation and Fauna Survey Report. August 2014.

Buru Energy Limited (2016). Laurel Formation Tight Gas Pilot Exploration Program (TGS) End of Activity Report – Asgard 1 and Valhalla North 1 Exploration Wells, Located in EP 371. July 2016.

Chevron Australia (2015). Gorgon Gas Development and Jansz Feed Gas Pipeline: Five-year Environmental Performance Report (August 2010 – August 2015).


Commonwealth of Australia (2015). Arrive Clean, Leave Clean Guidance. Available from: <https://www.environment.gov.au/system/files/resources/773abcad-39a8-469f-8d97-23e359576db6/files/arrive-clean-leave-clean.doc>

Cramer, V.A., Dziminski, M.A., Southgate, R., Carpenter, F., Ellis, R.J. and van Leeuwen, S. (2016). A conceptual framework for habitat use and research priorities for the greater bilby (*Macrotis lagotis*) in the north of Western Australia. Australian Mammalogy.

Davies, R.J., Mathias, S.A., Moss, J., Hustoft, S. and Newport, L. (2012). Hydraulic fractures: how far can they go? Marine and Petroleum Geology 37: 1-6.

Dawson, S.J. (2017). Disturbance of ecology of the Greater Bilby (*Macrotis lagotis*). PhD Thesis, School of Veterinary and Life Sciences, Murdoch University.

Day, S., Ong, C., Rodger, A., Etheridge, D.M., Hibberd, M., *et al.* (2015). Characterisation of Regional Fluxes of Methane in the Surat Basin, Queensland. Phase 2: Pilot study of methodology to detect and quantify methane

 BENNETT RESOURCES	Document No:	BNR_ENV_RE_002
	Revision:	1
	Issue Date:	24/12/2020

sources. Report for the Gas Industry Social and Environmental Research Alliance (GISERA), Project No, GAS1315. CSIRO, Australia.

Department of Agriculture, Water and the Environment (DAWE) (2020a). Maps: Australia's bioregions. Available at: <http://www.environment.gov.au/parks/nrs/science/bioregionframework/ibra/index.html>

Department of Agriculture, Water and the Environment (DAWE) (2020b). Species Profile and Threats Databas. Australian Government. Available from: <https://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>

Department of Agriculture, Water and the Environment (DAWE) (2020c). Species Profile and Threats Database: Dasyurus hallucatus – Northern Quoll. Australian Government.

Department of Agriculture, Water and the Environment (DAWE) (2020d). Australian Heritage Database. Australian Government. Available from: <https://www.environment.gov.au/cgi-bin/ahdb/search.pl>

Department of Biodiversity, Conservation and Attractions (DBCA) (2020). NatureMap database. Available from: <https://naturemap.dbca.wa.gov.au/>

Department of Environment and Conservation (DEC) (2009). Resource Condition Report for a Significant Western Australian Wetland. Government of Western Australia.

Department of Environment and Conservation (DEC) (2010). Assessment levels for Soil, Sediment and Water. Contaminated Sites Management Series, Version 4 Revision 1, February 2010. Government of Western Australia. Available from: <https://esdat.net/Environmental%20Standards/Australia/WA/Assessment%20Levels%20-%202010.pdf>

Department of Environment and Conservation (DEC) (2011). A guideline for managing the impacts of dust and associated contaminants from land development Sites, contaminated Sites, remediation and other related activities. Government of Western Australia.

Department of Industry, Science, Energy and Resources (DISER) (2020). State and Territory Greenhouse Gas Inventories 2018. Australian Greenhouse Emissions Information System. Government of Australia. Available from: <https://www.industry.gov.au/data-and-publications/state-and-territory-greenhouse-gas-inventories-2018>

Department of Mineral and Petroleum Resources (DMPR) (2002). Guidelines for the protection of surface and groundwater resources during exploration drilling. Government of Western Australia. November 2002.

Department of Mines and Petroleum (DMP) (2012). Fauna Egress Matting and Ramps. Available online from: <http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-212.pdf>

Department of Mines and Petroleum (DMP) (2016). Guideline for the Development of Petroleum and Geothermal Environmental Plans in Western Australia. Government of Western Australia, November 2016.

Department of Mines and Petroleum (DMP) and Department of Water (DoW) (2016). Guideline for groundwater monitoring in the onshore petroleum and geothermal industry. Government of Western Australia, July 2016.


Department of Planning, Lands and Heritage (DPLH) (2020). Aboriginal Heritage Inquiry System. Government of Western Australia.

Department of Primary Industries and Regional Development (DPIRD) (2019). The Western Australian Beef Industry. Government of Western Australia. Available from: <https://www.agric.wa.gov.au/industry-development/western-australian-beef-industry?page=0%2C2>

Department of Water (DoW) (2006). Camballin Water Reserve: Drinking Water Source Protection Plan – Camballin Town Water Supply. Government of Western Australia, Water Resource Protection Series Report No. WRP 59.

Department of Water (DoW) (2008). Fitzroy Crossing Water Reserve: Drinking Water Source Protection Plan – Fitzroy Crossing Town Water Supply. Government of Western Australia, Water Resource Protection Series Report No. WRP 94.

Department of Water (DoW) (2010). Kimberley regional water plan: Strategic direction and actions 2010-2030. Draft for public comments. Department of Water, Perth, Western Australia.

 BENNETT RESOURCES	Document No:	BNR_ENV_RE_002
	Revision:	1
	Issue Date:	24/12/2020

Department of Water (DoW) (2012). Broome Water Reserve drinking water source protection plan. Government of Western Australia, December 2012.

Department of Water (DoW) (2013). Water Quality Protection Note 26 – Liners for containing pollutants, using synthetic membranes. Government of Western Australia, August 2013.

Department of Water (DoW) (2014). Water resources inventory 2014: Water availability, quality and trends. Government of Western Australia.

Department of Water (DoW) (2016). Measuring the taking of water guidelines. Government of Western Australia, January 2016.

Department of Water and Environmental Regulations (DWER) (2016). Air Quality Monitoring in Perth Region – Air Quality Fact Sheet. Government of Western Australia, July 2016.

Department of Water and Environmental Regulations (DWER) (2019). 2018 Western Australian air monitoring report – Annual report under the National Environment Protection (Ambient Air Quality) Measure. Government of Western Australia, October 2019. Available from: https://www.der.wa.gov.au/images/documents/your-environment/air/monitoring_reports/2018_WA_Air_monitoring_report.pdf

Eco Logical Australia (2016). Level 1 Vegetation, Flora and Fauna Survey of Kurrajong, Yakka Munga and Valhalla Central Well Sites. Prepared for Buru Energy limited.

Eco Logical Australia (2018). Valhalla Central 4: Flora and Fauna Survey. Reported prepared for Buru Energy Limited. August 2018.

Environmental Protection Authority (EPA) (2013). Technical Guidance Subterranean fauna survey. EPA, Western Australia, June 2013.

Environmental Protection Authority (EPA) (2016a). Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016. Government of Western Australia.

Environmental Protection Authority (EPA) (2016b). Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment. EPA, Western Australia.

Environmental Protection Authority (EPA) (2016c). Environmental Factor Guideline: Flora and Vegetation. EPA, Western Australia.

Environmental Protection Authority (EPA) (2016d). Environmental Factor Guideline: Terrestrial Environmental Quality, EPA, Western Australia.

Environmental Protection Authority (EPA) (2016e). Environmental Factor Guideline: Terrestrial Fauna. EPA, Western Australia.

Environmental Protection Authority (EPA) (2016f). Technical Guidance – Sampling Methods for Terrestrial Vertebrate Fauna. EPA, Western Australia.

Environmental Protection Authority (EPA) (2016g). Technical Guidance – Terrestrial Fauna Surveys. EPA, Western Australia.


Environmental Protection Authority (EPA) (2016h). Environmental Factor Guideline: Inland Waters. EPA, Western Australia.

Environmental Protection Authority (EPA) (2016i). Environmental Factor Guideline: Social Surroundings. EPA, Western Australia.

Environmental Protection Authority (EPA) (2016j). Environmental Factor Guideline: Subterranean Fauna. EPA, Western Australia.

Environmental Protection Authority (EPA) (2016k). Environmental Factor Guideline: Human Health. EPA, Western Australia.

Environmental Protection Authority (EPA) (2020a). Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual, EPA, Western Australia.

	Document No:	BNR_ENV_RE_002
	Revision:	1
	Issue Date:	24/12/2020

Environmental Protection Authority (EPA) (2020b). Statement of Environmental Principles, Factors and Objectives. EPA, Western Australia.

Environmental Protection Authority (EPA) (2020c). Environmental Factor Guideline: Air Quality. EPA, Western Australia.

Environmental Protection Authority (EPA) (2020d). Environmental Factor Guideline: Greenhouse Gas Emissions. EPA, Western Australia.

Fisher, K. and Warpinski, N. (2012). Hydraulic-fracture-height growth: Real Data. Society Petroleum Engineers (SPE-145949).

Forshaw, J.M. and Cooper, W.T. (2002). Australian Parrots, 3rd edition. Robina, Queensland: Alexander Editions.

Government of Western Australia (2019a). 2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of March 2019. WA Department of Biodiversity, Conservation and Attractions, Perth.

Government of Western Australia (2019b). Proposed Iconic Natural Heritage Places – Public Consultation Paper. Implementation of the Government’s response to the independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia. December 2019.

Government of Western Australia (2020a). Pre-European Vegetation (DPIRD-006) dataset. Available from: <https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006>

Government of Western Australia (2020b). Soil Landscape Mapping – Systems (DPIRD-064) dataset. Available from: <https://catalogue.data.wa.gov.au/dataset/soil-landscape-mapping-systems>

Graham, G. (2001). Dampierland 1 (*DL1 – Fitzroy Trough subregion*). In May, J.E. and McKenzie, N.L. (editors) (2003). A biodiversity audit of Western Australia's biogeographical subregions in 2002. Department of Conservation and Land Management, Kensington, WA.

Green, C.A., Styles, P. and Bapti, B.J. (2012). Preese Hall Shale Gas Fracturing: Review and Recommendations for Induced Seismic Mitigation. Induced Seismic Mitigation Report, April 2012.

Grimaz, S., Allen, S., Stewart, J.R. and Dolcetti, G. (2008). Fast prediction of the evolution of oil penetration into the soil immediately after an accidental spillage for rapid-response purposes. In Proceeding of 3rd International Conference on Safety & Environment in Process Industry, CISAP–3, Rome (I) (pp. 11-14).

Harrington, G.A. and Harrington, N.M. (2015). Lower Fitzroy River Groundwater Review. A report prepared by Innovative Groundwater Solutions for Department of Water, 15 May 2015.

Hasting Micro-Seismic Consulting (2013). Yulleroo and Valhalla Passive Seismic Monitoring Report, Days 166 to 329, 2012. February 2013.


Heritage Council (2020). InHerit – State Heritage Office database. Government of Western Australia. Available from: <http://inherit.stateheritage.wa.gov.au>

Higgins, P.J. (Ed.) (1999). Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbird. Oxford University Press, Melbourne.

Hill, B.M. and Ward, S.J. (2010). National Recovery Plan for the Northern Quoll *Dasyurus hallucatus*. Department of Natural Resources, Environment, The Arts and Sport, Darwin.

Hutson, A.M., Mickleburgh, S.P. and Racey, P.A. (2001). Microchiropteran Bats - Global Status Survey and Conservation Action Plan. IUCN/SSC Chiroptera Specialist Group, Gland, Switzerland and Cambridge, U.K. Koopman, K. (1984). Taxonomic and distributional notes on tropical Australian bats. American Museum Novitates 2778, 1-48.

Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia (2018). Final Report to the Western Australian Government, September 2018.

 BENNETT RESOURCES	Document No:	BNR_ENV_RE_002
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Jackson, W.J., Argent, R.M., Bax, N.J., Bui, E., Clark, G.F. *et al.* (2016). Overview: Land-use change, and habitat fragmentation and degradation threaten ecosystems and resilience. In: Australia State of the Environment (2016). Australian Government, Department of the Environment and Energy, Canberra. Available from: <https://soe.environment.gov.au/theme/overview/topic/land-use-change-and-habitat-fragmentation-and-degradation-threaten-ecosystems>

Jonasson, K.E. (2001). Western Australia Atlas of Petroleum Fields, Onshore Canning Basin: Petroleum Division, Mineral and Petroleum Resources Western Australia. Volume 2, Part 1, 72p.

Leonard, M., Burbidge, D. and Edwards, M. (2013). Atlas of Seismic Hazard Maps of Australia – Seismic hazard maps, hazard curves and hazard spectra. Record 2013/41. Geoscience Australia: Canberra.

Lindsay, R.P and Commander, D.P. (2005). Hydrogeological assessment of the Fitzroy alluvium, Western Australia, Department of Water, Hydrogeological Record Series HG 16.

Low Ecological Services (2011a). Valhalla East-1 Exploration Well: Flora and Fauna Survey. September 2011. Report prepared for Buru Energy.

Low Ecological Services (2011b). Flora and Vegetation Survey: Valhalla North. October 2011. Report prepared for Buru Energy.

Low Ecological Services (2012a). Asgard-1 Exploration Well: Flora, Vegetation and Fauna Survey. Report prepared for Buru Energy.

Low Ecological Services (2012b). Asgard 2D Seismic Survey: Flora, Vegetation and Fauna Survey. Report prepared for Buru Energy.

Low Ecological Services (2020). Flora and Fauna Assessment – Odin 2D and 3D seismic survey, Fitzroy Basin, Western Australia. Report prepared for Bennett Resources Pty Ltd. March 2020.

Main Roads (2020). Kimberley Traffic Digest 2014/15 – 2019/20. Main Roads Western Australia. Government of Western Australia.

McKenzie, N.L., May, J.E., McKenna, S. and eds. (2003). Bioregional Summary of the 2002 Biodiversity Audit for Western Australia. Department of Conservation and Land Management, Kensington, WA.

McTainsh, G.H., O’Loingsigh, T. and Strong, C. (2011). Update of Dust Storm Index (DSI) maps for 2005 to 2010 and re-analysis and mapping of DSI for 1992–2005, 1992–2008 and 1992–2010 for the Australian Collaborative Rangeland Information System (ACRIS). Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: <http://www.environment.gov.au/resource/updated-dust-storm-index-dsi-maps-2005-2010>

Merrin, L., Addison, J., Austin, J. *et al.* (2018). Chapter 3: Living and built environment of the Fitzroy catchment. In: Petheram C., Bruce C., Chilcott C. and Watson I. (eds) (2018). Water resource assessment for the Fitzroy catchment. A report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments. CSIRO, Australia.


Mønster, J., Delre, A. and Scheutz, C. (2015). Quantification of the methane emission from three UK landfills. Kgs. Lyngby: Technical University of Denmark, DTU Environment.

Murdoch University (2016). Targeted Bilby survey of proposed well site ‘Valhalla Central’ and immediate area. Report prepared by Murdoch University for Buru Energy Limited, September 2016.

Murphy, S. (2015). Shining a light: The research unlocking the secrets of the mysterious Night Parrot. Australian Birdlife 4, 30-35.

NHMRC and NRMCC (2011). Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

North Australia & Rangelands Fire Information (NAFI) (2020). Fire History. Charles Darwin University.

 BENNETT RESOURCES	Document No:	BNR_ENV_RE_002
	Revision:	1
	Issue Date:	24/12/2020

Northern Territory Government (2019). Code of Practice: Onshore Petroleum Activities in the Northern Territory. Department of Primary Industry and Resources, and the Department of Environment and Natural Resources, May 2019.

Pavey, C. (2006). National Recovery Plan for the Greater Bilby *Macrotis lagotis*. Northern Territory Department of Natural Resources, Environment and the Arts.

Radford, I.J. and Fairman, R. (2015). Fauna and vegetation responses to fire and invasion by toxic cane toads (*Rhinella marina*) in an obligate seeder-dominated tropical savanna in the Kimberley, Northern Australia. *Wildlife Research* 42, 302-314.

Radtke, C., Autenrieth, D.A., Lipsey, T. and Brazile, W.J. (2017). Noise characterization of oil and gas operations, *Journal of Occupational and Environmental Hygiene*, 14:8, 659-667. DOI: 10.1080/15459624.2017.1316386.

Rockwater (2016). Hydrogeological Assessment of Paradise-Valhalla-Asgard Project Areas. Report for Buru Energy. Report No. 416.0/16/04b. September 2016.

Rubino, M., Etheridge, D.M., Thornton, D.P., Howden, R., Allison, C.E., Francey, R.J., Langenfelds, R.L., Steele, L.P., Trudinger, C.M., Spencer, D.A., Curran, M.A.J., van Ommen, T.D., and Smith, A.M. (2019). Revised records of atmospheric trace gases CO₂, CH₄, N₂O, and δ¹³C-CO₂ over the last 2000 years from Law Dome, Antarctica, *Earth Syst. Sci. Data*, 11, 473–492, <https://doi.org/10.5194/essd-11-473-2019>

Schoknecht, N. and Payne, A. L. (2011). Land systems of the Kimberley region, Western Australia. Department of Agriculture and Food, Western Australia, Perth. Technical Bulletin 98.

Sheffield Resources (2016). Environmental Noise Impact Assessment: THUNDERBIRD MINERAL SANDS PROJECT MINE SITE DEVELOPMENT ENVELOPE. Available from: http://www.epa.wa.gov.au/sites/default/files/PER_documentation/A13%20Mine%20Site%20Development%20Envelope%20Noise%20Assessment_0.pdf

Shepherd, D.P., Beeston, G.R. and Hopkins, A.J.M. (2002). Native vegetation in Western Australia: extent, type and status. Department of Agriculture and Food, Western Australia, Perth. Report 249.

Shire of Derby-West Kimberley (SDWK). Road Management Strategy 2020-25 – Sealed Roads, April 2020. Available from: <https://www.sdwk.wa.gov.au/documents/187/road-management-strategy-2020-25-sealed-roads-april-2020>

South Australian Environmental Protection Authority (SA EPA) (2017). Radiation Information Sheet, Naturally occurring radioactive material (NORM). South Australia Environment Protection Authority.


Threatened Species Scientific Committee (TSSC) (2005). NON-APPROVED Conservation Advice on Northern Quoll (*Dasyurus hallucatus*). Available from: <http://www.environment.gov.au/biodiversity/threatened/species/dasyurus-hallucatus.html#conservation>

Threatened Species Scientific Committee (TSSC) (2016a). Conservation Advice *Pezoporus occidentalis* Night Parrot. Department of the Environment, Canberra, ACT. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/59350-conservation-advice-15072016.pdf>

Threatened Species Scientific Committee (TSSC) (2016b). Conservation Advice *Macroderma gigas* ghost bat. Canberra: Department of the Environment. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/174-conservation-advice-05052016.pdf>

Threatened Species Scientific Committee (TSSC) (2016c). Conservation Advice *Macrotis lagotis* greater bilby. Canberra: Department of the Environment. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/282-conservation-advice-15072016.pdf>

Tille, P.J. (2006). Soil-landscapes of Western Australia's rangelands and arid interior. Department of Agriculture and Food, Western Australia, Perth. Report 313.

	Document No:	BNR_ENV_RE_002
	Revision:	1
	Issue Date:	24/12/2020

United Nations Framework Convention on Climate Change (UNFCCC) 2014. UNFCCC reporting guidelines on annual inventories. Available from: <https://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf>

Vogwill, R. (2015). Water resources of the Mardoowarra (Fitzroy River) Catchment. The Wilderness Society, Perth, Western Australia.

Watkins, D. (1993). A national plan for shorebird conservation in Australia. RAOU Report Series. 90.

Western Australian Herbarium (1998–). FloraBase – the Western Australian Flora. Department of Biodiversity, Conservation and Attractions. Available from: <https://florabase.dpaw.wa.gov.au/>

Woodman Environmental Consulting (2007). Valhalla – 01 Well Site Flora and Vegetation Survey. Woodman Environmental Consulting. July 2007. Report prepared for Arc Energy Limited.

World Meteorological Organization (WMO) (2019). WMO Greenhouse Gas Bulletin (GHG Bulletin) - No. 15: The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2018. WMO, November 2019.