BENNETT RESOURCES

Valhalla Gas Exploration and Appraisal Program

Section 38 Assessment – Environmental Review Document

EPA Assessment Number 2281

BNR_HSE_MP_013

VERSION HISTORY				
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Approved for release	Name		Position	Signature
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INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this Proposal.

Bennett Resources Pty Ltd (BNR; Proponent) proposes to undertake an unconventional exploration drilling and hydraulic fracture stimulation (HFS) program within Petroleum Exploration Permit EP 371 (EP 371) within the Shire of Derby / West Kimberley.

The Proposal area is ~123 km southeast of the town of Derby. The Proposal involves constructing up to 20 wells in a region of the Canning Basin that has been previously surveyed and explored for petroleum purposes. The Proposal is targeting hydrocarbons present from the Laurel Formation through to the Devonian Formation, at depths ranging from 2,000 m to 5,000 m. The main target is the Laurel Formation, with hydrocarbons present between 2,000 m and 4,000 m below ground level. The Proposal will require an overall disturbance footprint of ~112 ha, with a clearing footprint of <110 ha.

The Environmental Review Document (ERD) has been prepared in accordance with the EPA's Procedures Manual (Part IV Divisions 1 and 2). The ERD is the report by the proponent on their environmental review; it describes this Proposal and its likely effects on the environment.

The ERD is available for a public review period of 8 weeks from 12 August 2024.

Information / submissions on the Proposal from the public may assist the EPA to prepare an assessment report in which it will make recommendations on the Proposal to the Minister for Environment.

WHY WRITE A SUBMISSION?

The EPA seeks information that will inform the EPA's consideration of the likely effect of the Proposal, if implemented, on the environment. This may include relevant new information that is not in the ERD, such as alternative courses of action or approaches.

In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses, and other relevant information.

Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the Western Australian (WA) *Freedom of Information Act 1992*.

WHY NOT JOIN A GROUP?

It may be worthwhile joining a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

DEVELOPING A SUBMISSION

You may agree or disagree with, or comment on information in the ERD.

When making comments on specific elements in the ERD:

- clearly state your point of view and give reasons for your conclusions
- reference the source of your information, where applicable
- suggest alternatives to improve the outcomes on the environment.

WHAT TO INCLUDE IN YOUR SUBMISSION

Include the following in your submission to make it easier for the EPA to consider your submission:

- your contact details – name and address
- date of your submission
- whether you want your contact details to be confidential
- summary of your submission if your submission is long

- list points so that issues raised are clear, preferably by environmental factor
- refer each point to the page, section, and if possible, paragraph of the ERD
- attach any reference material, if applicable. Make sure your information is accurate.

The closing date for public submissions is: 7 October 2024.

The EPA prefers submissions to be made electronically via the EPA's Consultation Hub at https://consultation.epa.wa.gov.au.

Alternatively, submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bag 10, Joondalup DC WA 6919, or
- delivered to: Environmental Protection Authority, Prime House, 8 Davidson Terrace, Joondalup WA 6027.

If you have any questions on how to make a submission, please contact the EPA Services at the Department of Water and Environmental Regulation on 08 6364 7000.

ACKNOWLEDGEMENT OF TRADITIONAL CUSTODIANS

BNR would like to acknowledge the Traditional Owners of the land on which BNR works. BNR pays its respects to Elders past, present, and emerging.

Disclaimer

Information presented in this document is correct at the time of writing.

Scoping – required work checklist

An Environmental Scoping Document (ESD) checklist is provided below to demonstrate that the ESD requirements have been met and lists where the relevant ESD information is located in this Environmental Review Document (ERD).

Environmental Scoping Document (ESD) checklist

ESD requirement	Description	Further information
1.	Characterise the surface water and groundwater systems in a local and regional context and describe recharge and discharge mechanisms, aquifer connectivity, surface water/groundwater interaction and water chemistry. This should include identification and mapping of groundwater and surface water dependent ecosystems, and detail of the location of wells in relation to surface water features (e.g. Le Lievre Swamp, permanent/semi-permanent pools etc.).	Section 5.4.3 Appendix M
2.	Undertake baseline groundwater level and water quality monitoring at representative sites that reflect the expected conditions of each well, including a comprehensive list of analytes including geogenic chemicals, radon and methane concentrations, for a minimum of 24 months prior to commencing the Proposal that is at least consistent with the Guideline for groundwater monitoring in the onshore petroleum and geothermal industry (Department of Mines and Petroleum and Department of Water, 2016).	Section 5.4.3.3 Appendix M
3.	Analyse, describe and assess surface water and groundwater impacts, including direct, indirect and cumulative impacts, from the project. This should include, but not be limited to: a. changes to groundwater levels and surface water flows associated with the Proposal; b. changes to water quality; c. the nature, extent and duration of impacts; and d. impacts on environmental values of ground and surface water dependent ecosystems.	Section 5.4.5 Section 7.1
4.	Discuss the proposed management, monitoring and mitigation to ensure impacts on inland water quality and environmental values are not greater than predicted as a result of implementing the Proposal. This should include but not be limited to: a. ecotoxicology testing on produced or flowback water to better assess the potential impacts; b. a groundwater level and groundwater quality monitoring plan for the duration of the petroleum development activity and post closure, including concentrations of methane and of chemical constituents that are indicative of brine incursions; c. surveillance monitoring of groundwater level and groundwater quality for the duration of petroleum development activity; d. testing for, and assessment of the risk from a comprehensive list of analytes in groundwater, likely in produced and flowback water, including geogenic chemicals, technologically enhanced naturally occurring radioactive materials and radon; e. a site water balance, accounting for water produced, evaporated, and disposed of, to enable detection of significant leakage of fluids and determine whether remedial action to track any contaminants is warranted; and f. proposed management of flowback water, including volumes of water that can be expected to be produced. If open air pits are proposed, risks to groundwater and surface water resources arising from leaky pit membranes or other pond failures should be addressed, and the monitoring required to identify and remediate leakages. If re-injection is proposed, the depth of re-injection and detailed construction details of injection wells should be provided.	Section 5.4.6 Appendix F Appendix M
5.	**Chemicals** Identify all chemicals intended to be used as ingredients in drilling and hydraulic fracture fluids.	Appendix A
6.	Provide the Chemical Abstracts Service (CAS) number for the chemicals, and evidence that the chemicals are approved for their intended use in Australia and listed on the: a. Australian Inventory of Chemical Substances (AICS); b. Australian Pesticides and Veterinary Medicines Authority (APVMA); c. Therapeutic Goods Administration (TGA); or d. Food Standards Australia and New Zealand (FSANZ) inventories.	Appendix A

ESD requirement	Description	Further information
7.	Provide material safety data sheets (SDS) for the chemicals identified.	Appendix A
8.	Confirm whether any chemicals intended to be used contain Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) or Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS).	Appendix A
9.	Identify if chemicals proposed to be used are known or suspected carcinogens, mutagens, developmental toxicants, and endocrine disruptors. Use of chemicals with these properties should be minimised or avoided in all operations.	Appendix A
10.	Identify the cumulative, short and long-term public health and environmental risks from chemicals used in drilling and fracturing fluids and chemicals expected to be present in produced and flowback water.	Section 3.4 Appendix N
11.	The Western Australian Department of Health (DoH) should review and provide advice on the information and risk assessments provided for chemicals proposed to be used in hydraulic fracture stimulation, or expected to be present in produced or flowback water.	Section 5.8 Appendix N
12.	**Geotechnical risks** Undertake and provide a comprehensive geotechnical risk analysis, including: a. definition of subsurface state of stress; b. definition of the structural context; c. identification of any hydrogeologically active faults or fracture zones; d. assessment of well-seal effectiveness; e. appropriate expertise; and f. delineation of potential high-risk zones	Section 5.4.5 Appendix B
13.	Provide details of an appropriate early warning system mechanism to prevent adverse geo-mechanical events reaching a size of any consequence to land or hydrogeology.	Section 5.4.6 Appendix B
14.	**Well Integrity** Well design, construction, stimulation, operation, and decommissioning are all addressed by International Standards Organisation (2017; ISO 165301), which encompasses each phase of the life of any oil and gas well. The Proposal must meet or exceed ISO 165301. The following should be provided: a. details of the well integrity management system over the entire Proposal lifecycle; b. a risk assessment process for well barrier integrity, identifying appropriate remedial action should a well barrier be compromised; and c. details of a well integrity testing and validation program.	Section 1.4.3.2 Section 2.5 Section 5.4.6
15.	Provide confirmation that well design, construction, and testing will be assessed by an independent, certified well examiner, reporting to the regulator as a required part of commissioning, licensing, and decommissioning.	Section 5.4.6
16.	Demonstrate how the mitigation hierarchy of avoid, minimise, mitigate has been applied during the planning and design stages of the Project.	Section 5.4.6
17.	Demonstrate and document in the ERD how the EPAs objective for this factor can be met.	Section 5.4.7
18.	**Decommissioning** Include details of the entire life cycle of oil and gas wells, from establishment to decommissioning, including all supporting activities related to hydraulic fracture stimulation. Rehabilitation, decommissioning and well-monitoring post-decommissioning should include evaluating factors such as: a. life cycle of well from establishment to decommissioning; b. land use post-decommissioning, developed in consultation with relevant stakeholders; c. disposal of contaminated wastes, including the management of potentially radioactive drill cuttings and wastewater in a manner that is consistent with the requirements of the Radiological Council; d. storage pond and site rehabilitation; e. well-monitoring and groundwater monitoring post-decommissioning to ensure no leakage, fugitive emissions, contamination; and f. monitoring trigger-levels for intervention and commitment to immediate remediation if contamination is detected.	Section 2.4.5 Section 2.5 Section 2.6 Monitoring Program (Appendix E)

ESD requirement	Description	Further information
19.	In accordance with the requirements of EPA Guidance, conduct a desktop study to identify and characterise the fauna and fauna habitats to inform local and regional context; and based on the results of the desktop study: a. conduct a Basic survey and fauna habitat assessment; and/or b. conduct a Detailed survey; and/or c. conduct targeted surveys for significant fauna that may be directly or indirectly impacted. *Note: The desktop study, surveys and ERD should consider vertebrates and short-range endemic, and/or other significant, invertebrates. Survey design should ensure that adequate local and regional contextual data are collected and should consider cumulative impacts. Surveys should include sites in both impact and non-impact (reference) areas.*	Section 5.3.3 Appendix C
20.	Demonstrate how surveys are relevant, representative, and consistent with current EPA policy and guidance and this Environmental Scoping Document.	Appendix C
21.	Provide a map of the survey effort applied in relation to the fauna habitats, the study area, Development Envelope, identifying the direct and indirect impact areas.	Figure 5-1
22.	Identify and describe the fauna assemblages present and likely to be present within the Development Envelope that may be impacted by the Proposal.	Section 5.3.3
23.	Identify and describe the characteristics of the fauna habitats identified by the desktop study and surveys, including a map their extents in relation to the study area, the project area, and direct and indirect impact areas. Describe significant habitats, including but not limited to: refugia, breeding areas, key foraging habitat, movement corridors, and linkages.	Section 5.3.3.1 Appendix C
24.	Identify significant fauna and describe in detail their known ecology, likelihood of occurrence, habitats, and known threats. Map the locations of significant fauna records in relation to the fauna habitats, the study area, the Development Envelope, and direct and indirect impact areas.	Section 5.3.3.1 Section 5.3.3.2 Section 5.3.3.3 Figure 5-8
25.	Identify, describe and quantify the potential residual impacts (direct, indirect and cumulative) to fauna assemblages, habitats, and significant species that may occur following implementation of the Proposal, after considering and applying avoidance and minimisation measures, in a local and regional context. Provide a table of the proportional extents of each habitat within the study area and Development Envelope, and the predicted amount to be directly and indirectly impacted.	Section 5.3.5 Table 5-16 Figure 5-11 Figure 5-12 Section 7.2
26.	Outline and justify the proposed avoidance and mitigation measures to reduce the potential impacts of the Proposal. If any significant species are expected to be impacted, include proposed management and/or monitoring plans that will be implemented pre- and post-construction to demonstrate and ensure residual impacts are not greater than predicted. Management and/or monitoring plans may be required and if so, are to be presented in accordance with the EPAs Instructions.	Section 5.1.6
27.	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (p. 11) and Western Australian Environmental Offsets Template (Appendix 1) in the *WA Environmental Offsets Guidelines* (2014) and include reference to the Commonwealth Assessment Guide for any Matters of National Environmental Significance (MNES).	Section 5.3.7 Section 5.11.2
28.	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and WA Environmental Offsets Guidelines and, where impacts relate to EPBC Act-listed taxa, the Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy. Spatial data defining the area of significant residual impacts should be provided.	Section 5.3.7 Section 5.11.2
29.	Demonstrate and document in the ERD how the EPAs objective for these factors can be met.	Section 5.3.7
30.	Identify and characterise the flora and vegetation of areas that may be directly or indirectly impacted by the Proposal, in accordance with Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment. Surveys should be designed to inform local and regional context. Specimens of significant flora collected during surveys should be vouchered at the WA Herbarium.	Section 5.1.3 Appendix C
31.	Demonstrate how surveys are relevant, representative, and demonstrate consistency with current EPA policy and guidance. Ensure database searches and taxonomic identifications are up to date. If multiple surveys have been undertaken to support the assessment, a	Section 5.1.3 Appendix C

ESD requirement	Description	Further information
	consolidated report should be provided including the integrated results of the surveys. All surveys should be appended to the environmental review documentation.	
32.	Provide a figure depicting survey effort applied in relation to the study area and Development Envelope, identifying the direct and indirect impact areas.	Figure 5-1
33.	Determine whether any flora species recorded are significant, and provide an analysis of local and regional context, (refer to *Environmental Factor Guideline – Flora and Vegetation* for definition of significant flora).	Section 5.1.3.6 Section 5.1.3.6
34.	Determine whether any vegetation identified is significant, and provide an analysis of local and regional context, (refer to *Environmental Factor Guideline – Flora and Vegetation* for definition of significant vegetation).	Section 5.1.5.1
35.	Provide figures depicting the recorded locations of flora and vegetation in relation to the Development Envelope in accordance with EPA *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment*.	Figure 5-2 Appendix C
36.	Assess the potential direct and indirect impacts of the construction and operational elements of the Proposal on identified environmental values. Describe and assess the extent of cumulative impacts as appropriate.	Section 5.1.5 Section 7.3
37.	Provide a quantitative assessment of impact: a. For significant flora, this includes: i. number of individuals and populations in a local and regional context; ii. numbers and proportions of individuals and populations directly or potentially indirectly impacted; and iii. numbers/proportions/populations currently protected within the conservation estate (where known). b. For all vegetation units (noting threatened and priority ecological communities and significant vegetation) this includes: i. area (in hectares) and proportions directly or potentially indirectly impacted; and ii. proportions/hectares of the vegetation unit currently protected within conservation estate (where known).	N/A refer to Section 5.1.5.1
38.	Describe the application of the mitigation hierarchy in the Proposal design, construction, operation, and decommissioning. Detail actions undertaken to avoid, minimise, and mitigate Proposal impacts. If any conservation significant species are expected to be impacted include management and/or monitoring plans to be implemented pre and post-construction to demonstrate that residual impacts are not greater than predicted.	Section 5.1.6
39.	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and the Western Australian Environmental Offsets Template (Appendix 1) in the *WA Environmental Offsets Guidelines* (2014) and include reference to the Commonwealth Assessment Guide for any MNES.	Section 5.1.7 Section 5.11
40.	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the *WA Environmental Offsets Policy* and *Guidelines*. Spatial data defining the area of significant residual impacts for each environmental value should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).	Section 5.1.7 Section 5.11
41.	Demonstrate how the EPAs objective for this factor has been addressed.	Section 5.1.7
42.	Characterise the surrounding land use and amenity values in, and adjacent to the Proposal Area with a focus on the sensitive receptors and important areas for human use that could be affected by noise and dust emissions, traffic, and amenity issues. Include relevant maps to show the locations of the sensitive receptors likely to be affected by the Proposal.	Section 5.5.3
43.	Provide a collation of baseline information and processes to ensure the documentation and systematic monitoring of matters relating to amenity and aesthetics.	Section 5.5.3.3 Section 5.5.6
44.	**Noise** Undertake a site-specific noise assessment in accordance with EPA and contemporary guidance. Demonstrate that noise can be managed such that it complies the Environmental Protection (Noise) Regulations 1997 at sensitive receptor locations.	Section 5.5.5.2 Appendix P
45.	Undertake and provide baseline site-specific noise level data.	Section 5.5.3.8 Appendix O

ESD requirement	Description	Further information
46.	Provide predictive modelling of noise emissions and impacts.	Section 5.5.5.2 Appendix P
47.	Provide ongoing monitoring and management covering the entire lifecycle of the Proposal.	Section 5.5.6
48.	Include an assessment of the cumulative impact of noise from hydraulic fracture stimulation and associated activities, on places within proximity to people and domestic animals and provide management options to minimise noise.	Section 5.5.5.2 Section 7.4
49.	**Traffic** Identify the types and sizes of trucks, the road upgrades required to accommodate operations and ensure the safety of other road users. Describe how BNR will engage with local government to ensure public roads are maintained to provide for the ongoing safety of road users	Section 5.5.5.4 Section 5.5.6
50.	Provide baseline road-use statistics measuring volumes of vehicle movement and type and provide details of monitoring of road use, throughout the lifecycle of the Proposal.	Section 5.5.3.9
51.	Reduce emissions from traffic by ensuring the regular maintenance of all vehicles.	Section 5.5.6
52.	**Health** Provide a peer-reviewed, site-specific human health risk assessment, addressing potential short and long-term health impacts of the Proposal that addresses health risks from: a. airborne chemicals; b. chemicals proposed to be used in drilling and hydraulic fracture stimulation; c. fluids and those expected to be present in produced or flowback water; d. storage and handling of drilling and hydraulic fracture fluids; and e. storage and disposal of drilling and hydraulic fracturing flowback fluids (including wastewater). *Note: Peer-reviewed, site-specific human health risk assessments will be provided to the Department of Health for comment.*	Section 3.4 Section 5.8 Appendix N
53.	Undertake a comprehensive local social impact analysis prior to commencement of activities, to understand and measure the social dimensions of change and its links to mental health and wellbeing, due to impacts from changes to the physical or biological surroundings.	Section 5.5.5.8
54.	Determine impacts to human health in relation to worker accommodation (particularly dust, water supply, wastewater disposal etc.) by using the Department of Health scoping tool.	Section 5.5.5
55.	**Dust** Undertake and provide baseline dust monitoring [minimum 12 months] prior to regulated activities.	Section 5.5.3.7
56.	Identify cumulative impacts from dust on local and regional ecosystems and public health.	Section 5.1.5.4 Section 5.5.5.1 Section 7.4
57.	Propose measures to minimise the generation of dust throughout all operations when compared to baseline monitoring.	Section 5.5.6
58.	**Heritage** Characterise and describe the social, cultural and heritage values within the Proposal area and any sensitive receptors that may be directly or indirectly impacted as a result of this Proposal. Identify sites of social significance within a regional context, in consultation with the Traditional Owners.	Section 5.5.3.1 Section 5.5.3.2 Section 5.5.3.5 Section 5.5.3.6
59.	Conduct investigations, including ethnographic, ethnobotanic, and archaeological surveys in consultation with the Traditional Owners, to determine the significance of potential impacts (direct, indirect and cumulative) to social surroundings as a result of this Proposal.	Section 5.5.3.5.2 Section 7.40
60.	Proposals likely to impact on Aboriginal heritage or significant sites must include an Aboriginal Heritage Management Plan developed in consultation with the Traditional Owners and the Department of Planning, Lands and Heritage. The Aboriginal Heritage Management Plan must: a. include input from Traditional Owners whose land is under consideration for petroleum development;	N/A no management plan required, refer to Section 5.5.3.5.2

ESD requirement	Description	Further information
	b. detail the role of the Traditional Owners in monitoring the condition and protection of their cultural heritage and significant sites; and c. be reviewed and deemed acceptable by the Department of Planning, Lands and Heritage.	
61.	Detail how cultural orientations will be made available to the Proposal employees and contractors to raise cultural awareness, including issues specific to Aboriginal heritage, and be undertaken by local Traditional Owner groups or their approved cultural awareness providers.	Section 5.5.6
62.	Describe and assess the potential impacts (direct, indirect and cumulative) to social surroundings as a result of changes to the environment from the Proposal giving consideration to Traditional Owners and Pastoral Stations and their activities on the land.	Section 5.5.5 Section 7.40
63.	Apply the mitigation hierarchy and discuss proposed objectives/outcomes, monitoring, management and mitigation measures including decommissioning and rehabilitation outcomes to be implemented to appropriately avoid and minimise impacts to social surroundings.	Section 5.6.6
64.	Demonstrate and document how the EPA's objective for this factor can be met.	Section 5.5.7
65.	Present a desktop soil quality assessment within the vicinity of the well pads.	Section 5.2.3
66.	Include in the ERD, figures of the mapped soil units and soil profile.	Figure 5-8 Figure 5-9 Appendix F Appendix G
67.	Describe the proposed management, monitoring and mitigation methods to be implemented to address direct and indirect impact on soils/lands/receiving environment. This description is to include soil handling methods to mitigate erosion, compaction, and contamination and soil quality monitoring to inform site reinstatement activities.	Table 5-10 Appendix E
68.	Develop a suitable soil quality monitoring program for each well, documented within the ERD that includes: • A comprehensive list of analytes proposed to be collected, • A scientifically justified baseline monitoring program (including extent and duration of the program), • Trigger and threshold contingency actions	Appendix E
69.	Predict residual impacts after considering the mitigation hierarchy.	Section 5.2.5 Section 5.2.7
70.	Provide a waste management strategy, including methods for segregating wastes and appropriate disposal arrangements with licensed facilities. Wastes associated with hydraulic fracture stimulation requiring evaluation and management include drilling fluid, rock cuttings, flowback fluid, and produced formation water.	Section 2.6 Table 2-8
71.	Undertake and provide baseline air quality monitoring for volatile organic compounds and dust for a minimum of 12 months prior to commencing the Proposal.	Section 5.6.3 Appendix H
72.	Provide a site-specific air quality risk assessment.	Section 5.6.5
73.	Describe the proposed management, monitoring and mitigation methods to be implemented to address direct and indirect impact on air quality, including undertaking ongoing monitoring of dust and volatile organic compounds.	Section 5.6.6 Appendix E
74.	Provide credible estimates of scope 1, scope 2 and scope 3 greenhouse gas emissions (annual and total) in tonnes of carbon dioxide equivalent (CO_2-e) over the life of the Proposal. Detail methods used to estimate emissions.	Section 5.7.5.1 Appendix R
75.	Provide a breakdown of estimated scope 1 and scope 2 greenhouse gas emissions in tonnes of CO_2-e by all sources. Consider all proposed activities in determining the sources of emissions (e.g. clearing of land, site preparations, drilling operations, hydraulic fracture stimulation operations including flaring, potential leakage etc.).	Section 5.7.5.1
76.	Provide calculations and calculation methodology for determining estimated emissions of CO_2-e for all sources.	Section 5.7.5.1 Appendix R

ESD requirement	Description	Further information
77.	Benchmark the Proposal's emissions against other hydraulic fracture stimulation exploration projects. Information which supports that the identified projects are comparable to the Proposal should be included.	Section 5.7.5.1
78.	Provide a greenhouse gas management plan, in accordance with EPA guidance, which demonstrates the Proposal's trajectory towards net zero emissions by 2050. The plan should include at a minimum: a. information required by 74 to 77 above. b. a graph and table showing regular targets reflecting an incremental reduction in emissions towards net zero emissions by 2050. Where the proposed emissions reduction targets do not demonstrate a trajectory towards net zero by 2050, articulate clearly a compelling reason why it is not possible to achieve this. c. mitigation (avoidance, reduction, offset) measures to be implemented with associated timeframes and evidence to demonstrate that the interim and long-term targets will be met. Where it is proposed that, following implementation of the avoidance and reduction measures, authorised offsets will be applied to meet the targets, evidence which supports that the mitigation measures are capable of achieving the stated targets is still required. d. analysis of other potential abatement measures (e.g. renewables) relevant to the Proposal that are not proposed to be implemented which provides the rationale to support that these measures are unable to be implemented. e. reporting requirements for publicly and periodically reporting against the stated targets.	Appendix R
79.	Undertake and provide baseline measurements and monitoring for greenhouse gases, for a minimum of 12 months prior to any regulated activities.	Section 5.7.3
80.	Provide a monitoring and reporting program measuring atmospheric concentrations and process leakage of methane over every well's entire life cycle, with recognition that any detected leaks must be fixed by the operator.	Appendix E Appendix R
81.	Conduct a desktop assessment of the radionuclides and metals likely to be present in the geology of the Proposal area based on an interpretation of the site geology, exploration drilling data previously collected, and publicly available geophysical mapping. The assessment should explain if naturally occurring radionuclides and metals are likely to be of environmental significance or detrimental to human health during the development of the project and throughout operations.	Section 5.8.3
82.	Conduct an assessment of potential impacts to human health.	Section 5.8.5.1
83.	Outline the outcomes/objectives, management, monitoring, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Appendix E
84.	Provide information on wastewater management on site.	Section 5.8.6 Section 2.6
85.	Discuss the proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on human health.	Section 5.8.6 Appendix E
86.	Provide a statement of how the proponent considers the EPA's objective for this factor has been addressed.	Section 5.8.7
87.	Conduct a desktop assessment of the subterranean fauna and their habitat to inform local and regional context.	Section 5.9.3
88.	Undertake an assessment of potential impacts to Subterranean Fauna in accordance with EPA guidance.	Section 5.9.5
89.	Conduct an assessment of potential impacts from HFS activities to subterranean fauna. The assessment should explain if drill fluids or other chemicals of environmental significance are detrimental to subterranean fauna or their habitat.	Section 5.9.5
90.	Discuss the proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on subterranean fauna.	Section 5.9.6
91.	Outline the outcomes/objectives, management, monitoring, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Appendix E Section 5.4

ESD requirement	Description	Further information
92.	Provide a statement of how the proponent considers the EPA's objective for this factor has been addressed.	Section 5.9.7

This ERD was developed prior to the current versions of "Instructions: How to prepare an Environmental Review Document" (March 2024) and "Template: Environmental Review Document" (June 2023). Therefore, the structure of the document is slightly different. The below table lists the current instructions requirement and the relevant section in this document that covers that requirement.

ERD requirements as per Template: Environmental Review Document summary table

ERD Requirement	Section and Page
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Document Control	Cover Page
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Scoping - required work ESD	Page 3
Executive Summary	Section 1, Page 25-30
1.1 Proposal Content	Section 2, Page 53
1.2 Proposal Alternatives	Section 2.2.1, Page 53
1.3 Local and regional context	Section 2.7, Page 71
2. Legislative Context	Section 1.4, Table 1-2, Page 45
2.1 Environmental impact assessment process	Section1.4.1, Page 45
2.2 Other Approvals and regulation	Section 1.4.2– 1.4.7, 35 -52
3.1 Key Stakeholders	Section 3.2, Page 72
3.2 Stakeholder identification and engagement process	Section 3, Page 72
3.3 Stakeholder consultation outcomes	Section 3.4, Table 3-1, Page 75
4. Object and principals of the EP Act	Table 4-1, Page 63
5. Environmental factors and objectives	Section 4.2, Table 4.2 Page 80
5.1 EPA environmental factors and objectives	Section 5.1 and 5.1.1 Page 82 Section 5.2 and 5.2.1, Page 105 Section 5.3 and 5.3.1, Page 117 Section 5.4and 5.4.1, Page 132 Section 5.5 and 5.5.1, Page 171 Section 5.6 and 5.6.1, Page 198 Section 5.7 and 5.7.1, Page 207 Section 5.8 and 5.8.1, Page 212 Section 5.9 and 5.9.1, Page 215
5.2 Relevant policy and guideline	Section 5.1.2, Page 82 Section 5.2.2 Page 105 Section 5.3.2, Page 117 Section5.4.2, Page 132 Section 5.5.2, Page 171 Section5.6.2, Page 198 Section 5.7.2, Page 207 Section 5.8.2, Page 212 Section 5.9.2, Page 215
5.3 Receiving Environment	Section 5.1.3, Page 83 Section 5.2.3, Page 106 Section 5.3.3, Page 118

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11.2 Appendices	Appendix A – T, 245-265
11.3 Disclaimers	N/A
11.4 Index of Biodiversity Surveys for Assessments (IBSA) and Index of Marine Surveys for Assessment	IBSA Data packages have been prepared and submitted following EPA Guidance

EXECUTIVE SUMMARY

Overview of the Proposal

The Proposal is to undertake an unconventional exploration and appraisal drilling program within Petroleum Exploration Permit EP 371, located in the Canning Basin, West Kimberley of Western Australia (WA). The Proposal includes constructing up to 20 exploration and appraisal wells within 10 well sites.

The intent of the Proposal is to explore and further appraise the extent of the tight gas (natural gas produced from reservoir rocks with very low permeability requiring HFS) reservoirs present from the Laurel through to the Devonian Formations, at depths ranging from 2,000 m to 5,000 m below ground level. The main target is the Laurel Formation, with hydrocarbons present at below-ground depths between 2,000 m and 4,000 m.

The total area of the physical disturbance footprint for the Proposal is ~112 ha, which includes some previously disturbed areas. Conservatively, clearing of <110 ha is required for the Proposal, comprising:

- well sites ~41 ha
- access tracks ~62 ha (includes some pre-disturbed tracks)
- camps ~3 ha.

The estimated maximum amount of clearing for the Proposal is 110 ha. The exploration and appraisal program is expected to commence in the location and have the proposed extent of physical and operational elements, as listed below.

Element	Location	Proposed extent
Physical elements		
Clearing for well sites, access tracks and accommodation camps	Figure 1-2	No more than 110 ha
Gas exploration wells	Figure 1-2	No more than 20 wells at 10 well sites
Operational elements		
Water abstraction for process water and camp supply	Figure 1-2	100 ML per well via groundwater extraction bores
Gas exploration method	Not applicable (N/A)	Unconventional (hydraulic fracture stimulation [HFS])
Well design	N/A	Vertical wells with horizontal HFS wellbore sections
Hydraulic fracture stimulation intervals	N/A	Up to 70 intervals per well
Water retention pond	Figure 1-2	One pond per well site with a capacity of ~114,400 m^3, to hold raw bore water, then produced formation water
Well test flare pit	Figure 1-2	One per well site. Based upon availability of equipment at the time of undertaking operations, there is the option for a flare stack to combust gas off the separator
Project life	N/A	7 years

Summary of the environmental review

The EPA has defined 14 environmental factors and respective objectives, organised into 5 themes: Sea, Land, Water, Air, and People. With respect to the Valhalla Gas Exploration and Appraisal Program, and in accordance with the EPA's ESD, BNR has classified each environmental factor as either 'key' or 'not applicable' (Table 4-2), where:

- 'Key environmental factors' are those parts of the environment that may be impacted by an aspect of the Proposal
- 'Not applicable' are those parts of the environment that are not relevant to any aspect of the Proposal.

The assessment of potential environmental impacts focuses on the key environmental factors identified by BNR, which are further discussed in Sections 5.1 to 5.9. The Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia (Independent Scientific Panel Inquiry, 2018) presents the

potential risks arising from implementing HFS on the onshore environment of WA and recommendations that may be used 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.

Factor	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	Key environmental factor	Section 5.1
Landforms	Not applicable	Not applicable
Subterranean fauna	Key environmental factor	Section 5.9
Terrestrial environmental quality	Key environmental factor	Section 5.2
Terrestrial fauna	Key environmental factor	Section 5.3
Theme: Water		
Inland waters	Key environmental factor	Section 5.4
Theme: Air		
Air quality	Key environmental factor	Section 5.6
Greenhouse gas emissions	Key environmental factor	Section 5.7
Theme: People		
Human health	Key environmental factor	Section 5.8
Social surroundings	Key environmental factor	Section 5.5

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ACRONYMS/DEFINITIONS

Acronym	Expansion/Definition
%	Percentage
%w/w	Percent weight per weight
~	Approximately
<	Less than / fewer than
>	Greater than / more than
µm	Micrometre. 1 µm = 10^{-6} metre = 0.000001 metre or one millionth of a metre
µS/cm	Microsiemens per centimetre
4WD	Four-wheel drive (vehicle)
ABS	Australian Bureau of Statistics
AHD	Australian Height Datum
AICS	Australian Inventory of Chemical Substances
ALARP	As Low As Reasonably Practicable
ANZECC	Australian and New Zealand Environment and Conservation Council
API	American Petroleum Institute
APVMA	Australian Pesticides and Veterinary Medicines Authority
AQ	Air Quality
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS	Australian Standard
ATU	Aerobic Treatment Unit
bbl	Barrel, a unit of volume for crude oil and petroleum products
BC Act	(WA) *Biodiversity Conservation Act 2016*
BDAC	Bunuba Dawangarri Aboriginal Corporation
BNR	Bennett Resources Pty Ltd
BoM	Bureau of Meteorology
Bq/L	Becquerel per litre; a measure of radioactive activity. In the case of drinking water, it is usual to talk about the radioactive concentration
BTEX	Compounds found in crude oil: benzene, toluene, ethylbenzene, and xylene
$CaCO_3$	Calcium carbonate
CAS	Chemical Abstracts Service
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CoPC	Contaminants of Potential Concern
COVID-19	Coronavirus disease 2019
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWE	(Commonwealth) Department of Agriculture, Water and the Environment
dB	Decibels
dB(A)	A-weighted decibels
DBCA	(WA) Department of Biodiversity, Conservation and Attractions
DCCEEW	(Commonwealth) Department of Climate Change, Energy, the Environment and Water (formerly DAWE)

Acronym	Expansion/Definition
DEC	Former (WA) Department of Environment and Conservation; now DBCA and DWER
DEMIRS	(WA) Department of Energy, Mines, Industry Regulation and Safety (from 1 December 2023)
DMIRS	Former (WA) Department of Mines, Industry Regulation and Safety
DMP	Former (WA) Department of Mines and Petroleum; now DEMIRS
DMPR	Former (WA) Department of Mineral and Petroleum Resources; now DEMIRS
DoH	(WA) Department of Health
DoIW	Directory of Important Wetlands
DoW	Former (WA) Department of Water (now DWER)
DPIRD	(WA) Department of Primary Industries and Regional Development
DPLH	(WA) Department of Planning, Lands and Heritage
DRF	Declared Rare Flora
DWER	(WA) Department of Water and Environmental Regulation
e.g.	For example
EC	Electrical Conductivity
EMP	Environmental Management Plan
EP	Environment Plan
EP Act	(WA) *Environmental Protection Act 1986*
EP 371	Exploration Permit 371
EPA	(WA) Environmental Protection Authority
EPBC Act	(Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999*
ERD	Environmental Review Document
ESA	Environmentally Sensitive Area
ESD	Environmental Scoping Document
etc.	Et cetera
FSANZ	Food Standards Australia and New Zealand
GDA	Geocentric Datum of Australia
GDE	Groundwater Dependent Ecosystems
GHG	Greenhouse Gas
GHGEMP	Greenhouse Gas Environmental Management Plan
GL	Gigalitre
GWMP	Groundwater Management Plan
ha	Hectare
HFC	Hydrofluorocarbon
HFS	Hydraulic Fracture Stimulation
HHRA	Human Health Risk Assessment
i.e.	That is
IBRA	Interim Biogeographic Regionalisation for Australia
ILUA	Indigenous Land Use Agreement
ISO	International Organization for Standardization
km	Kilometre
km/h	Kilometres per hour

Acronym	Expansion/Definition
km^2	Square kilometre
kWh	Kilowatt hour
L	Litre
L/s	Litres per second
LAUA	Land Access and Use Agreement
LoR	Limit of Reporting
m	Metre
m/s	Metres per second
m^2	Square metre
m^3	Cubic metre
mg/kg	Milligrams per kilogram
mg/L	Milligrams per litre
mg/m^3	Milligrams per cubic metre
ML	Megalitre (1,000,000 litres)
mm	Millimetre
mmscf/d	Million standard cubic feet per day, a unit of measurement for gases
MNES	Matters of National Environmental Significance (also referred to as matters of NES)
mS/m	Millisiemens per metre; a measure of electrical conductivity of a solution or soil and water mix that provides a measurement of salinity
MSDS	Material Safety Data Sheet (now referred to as SDS)
N	Nitrogen
N/A	Not applicable
N_2O	Nitrous oxide
NAFI	Northern Australian Fire Information
NATA	National Association of Testing Authorities
ND	Not Detected
NES	(matters of) National Environmental Significance
NGER	National Greenhouse and Energy Reporting
NGER Act	(Commonwealth) *National Greenhouse and Energy Reporting Act 2007*
NHMRC	National Health and Medical Research Council
NORM	Naturally Occurring Radioactive Material
NOx	Nitrogen oxides
NRMMC	Natural Resource Management Ministerial Council
NT	Not Tested
OM	Organic Matter
OSCP	Oil Spill Contingency Plan
PDWSA	Public Drinking Water Source Areas
PEC	Priority Ecological Community
PER	Public Environmental Review
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substance
PFC	Perfluorocarbon

Acronym	Expansion/Definition
PGER	Petroleum and Geothermal Energy Resources
PGER Act	(WA) *Petroleum and Geothermal Energy Resources Act 1967*
PGER(E)R	(WA) Petroleum and Geothermal Energy Resources (Environment) Regulations 2012
pH	Measure of acidity or basicity of a solution
PM	Particulate Matter
PM_{10}	Particulate Matter with a diameter of 10 µm or less
$PM_{2.5}$	Particulate Matter with a diameter of 2.5 µm or less
PMST	Protected Matters Search Tool
Proponent	Bennett Resources Pty Ltd
Proposal	Valhalla Gas Exploration and Appraisal Program
PSD	Particle Size Distribution
RIWI	Rights in Water and Irrigation
RNTBC	Registered Native Title Bodies Corporate
RNWS	Raising National Water Standards
SDS	Material Safety Data Sheet (formerly MSDS)
SDWK	Shire of Derby / West Kimberley
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
SRE	Short-range Endemic (species)
tCO_2-e	Tonnes of carbon dioxide equivalent
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
TGA	Therapeutic Goods Administration
TOC	Total Organic Carbon. This refers specifically to the organic carbon fraction of soil
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
VOC	Volatile Organic Compound
WA	Western Australia
WAM	Western Australian Museum
WIR	Water Information Reporting
WMP	Well Management Plan
WoNS	Weeds of National Significance
WQPN	Water Quality Protection Note
YAI	Yungngora Association Inc. (leaseholder of Noonkanbah Station)
α	alpha
β	beta
γ	Gamma

1 Executive Summary

1.1 Purpose and scope

This Environmental Review Document (ERD) has been prepared to support the assessment of Bennett Resources Pty Ltd's (BNR) Valhalla Gas Exploration and Appraisal Program (the Proposal), under Section 39a of the Western Australian (WA) *Environmental Protection Act 1986* (EP Act). It provides information on environmental and regulatory approvals required (Section 1.4), Proposal characteristics (Section 2), potential environmental impacts and proposed mitigation measures (Section 5), and a cumulative (holistic) impact assessment (Section 5.6). This ERD has been prepared in accordance with the Environmental Protection Authority's (EPA) Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021a), Procedures Manual (EPA, 2021b), and Environmental Review Document Instructions (EPA, 2024).

The Proposal is to complete an unconventional exploration and appraisal drilling and hydraulic fracture stimulation (HFS) program on Petroleum Exploration Permit EP 371 (EP 371) in the Canning Basin, within the Shire of Derby / West Kimberley (SDWK) in 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 ~430,000 km^2 in the West Kimberley region. The Proposal is targeting hydrocarbons present from the Laurel through to the Devonian Formations, at depths ranging from 2,000 m to 5,000 m below ground level. The main target is the Laurel Formation, with hydrocarbons present at depths between 2,000 m and 4,000 m below ground level.

Note, this Proposal does not cover gas production. It is an exploration and appraisal program only to be undertaken in two phases, being exploration then field appraisal (field appraisal being dependant on successful outcomes from exploration). Should a commercially viable resource be identified, BNR will seek additional approvals as required under both Federal and State Government legislation.

To note, all distances in this ERD are presented as straight-line geographic distances, unless otherwise stated.

The Development Envelope is ~123 km southeast of the town of Derby (Figure 1-1 and Figure 1-2). The Proposal involves constructing 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, if required, to appraise the hydrocarbon flow rates.

The Proposal includes these activities:

- site preparation
- drilling
- HFS
- site reinstatement (including ongoing management of the wells).

These activities are proposed to be undertaken in two stages over seven years. The overall expected disturbance footprint within the Development Envelope is ~112 hectares (ha).

The Traditional Owners of the land within the Development Envelope have a good understanding of and experience with HFS activities. They support the current Proposal and the ongoing appraisal and development of the resource. Section 3.2.3 provides additional information on the history of engagement with Traditional Owners. The boundaries of native title areas and community locations are shown in Figure 1-3.

1.2 Proponent details

The instrument holder and operator of EP 371 is Bennett Resources Pty Ltd (BNR), a wholly owned subsidiary of Black Mountain Energy Pty Ltd. 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

Position	Chief Operating Officer
Organisation	Bennett Resources Pty Ltd
Address	Level 4, 225 St Georges Terrace, Perth WA 6000
Email	perthoffice@blackmountainenergy.com

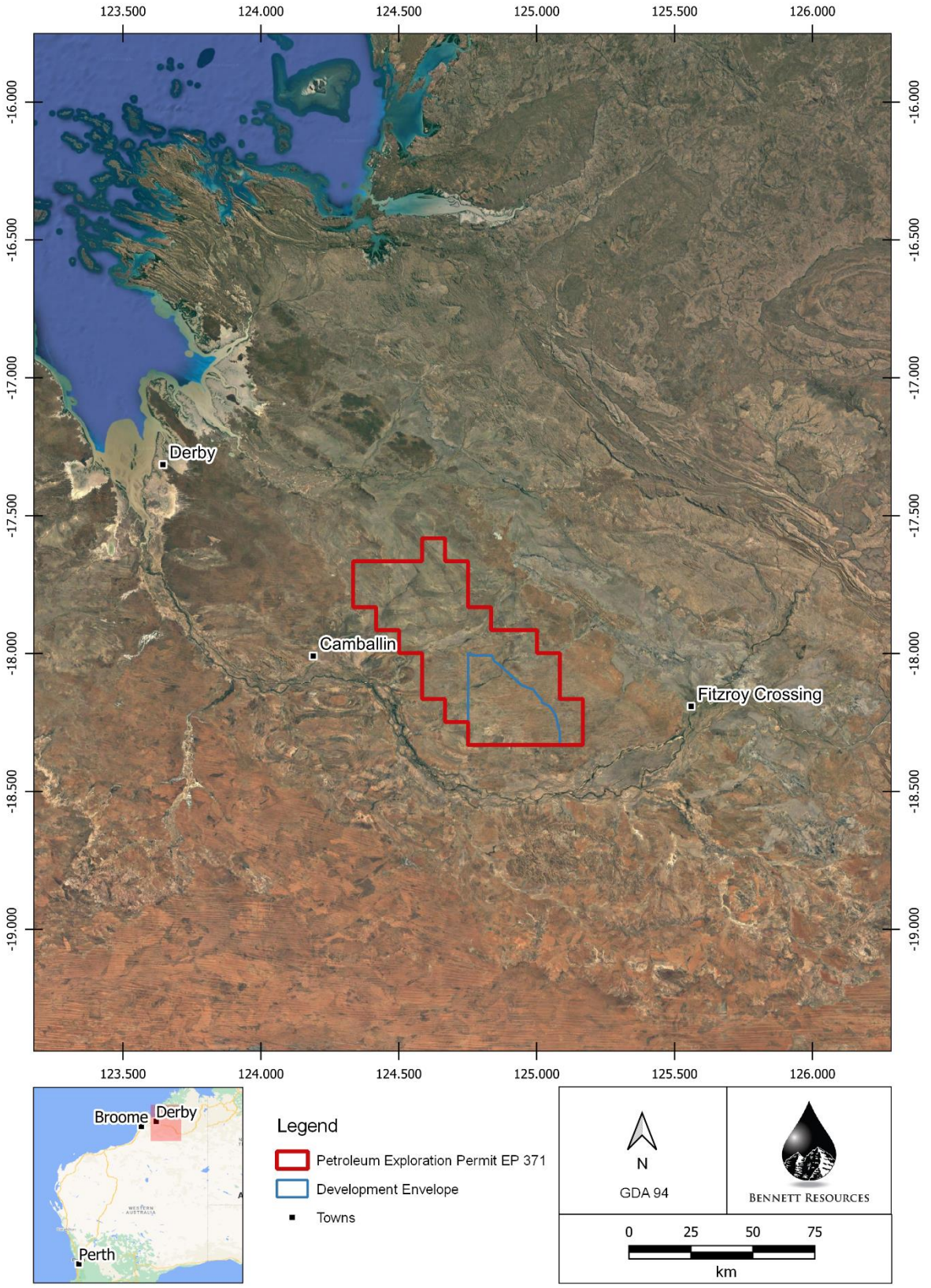


Figure 1-1: Regional location of the Development Envelope

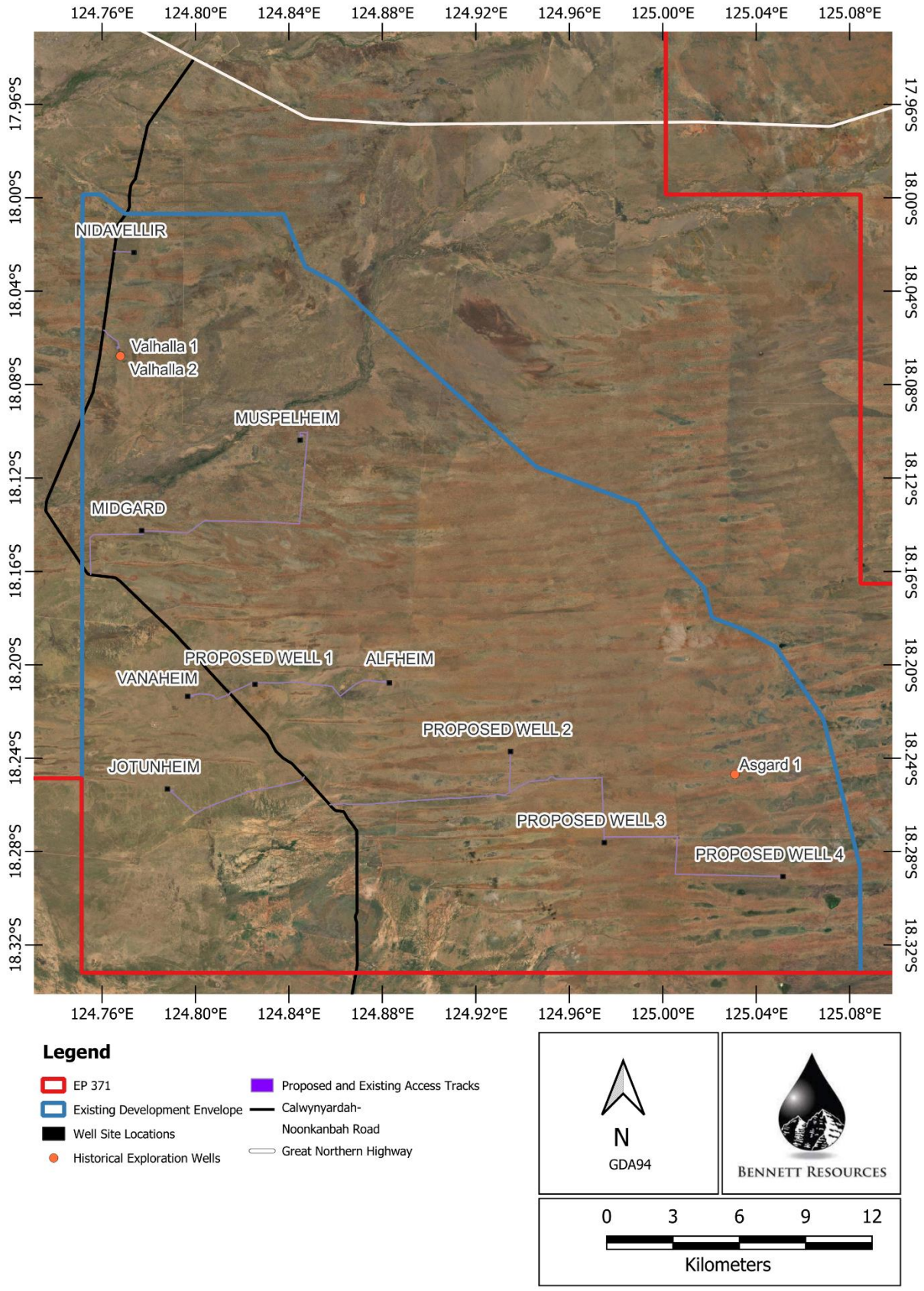


Figure 1-2: Proposed well site locations

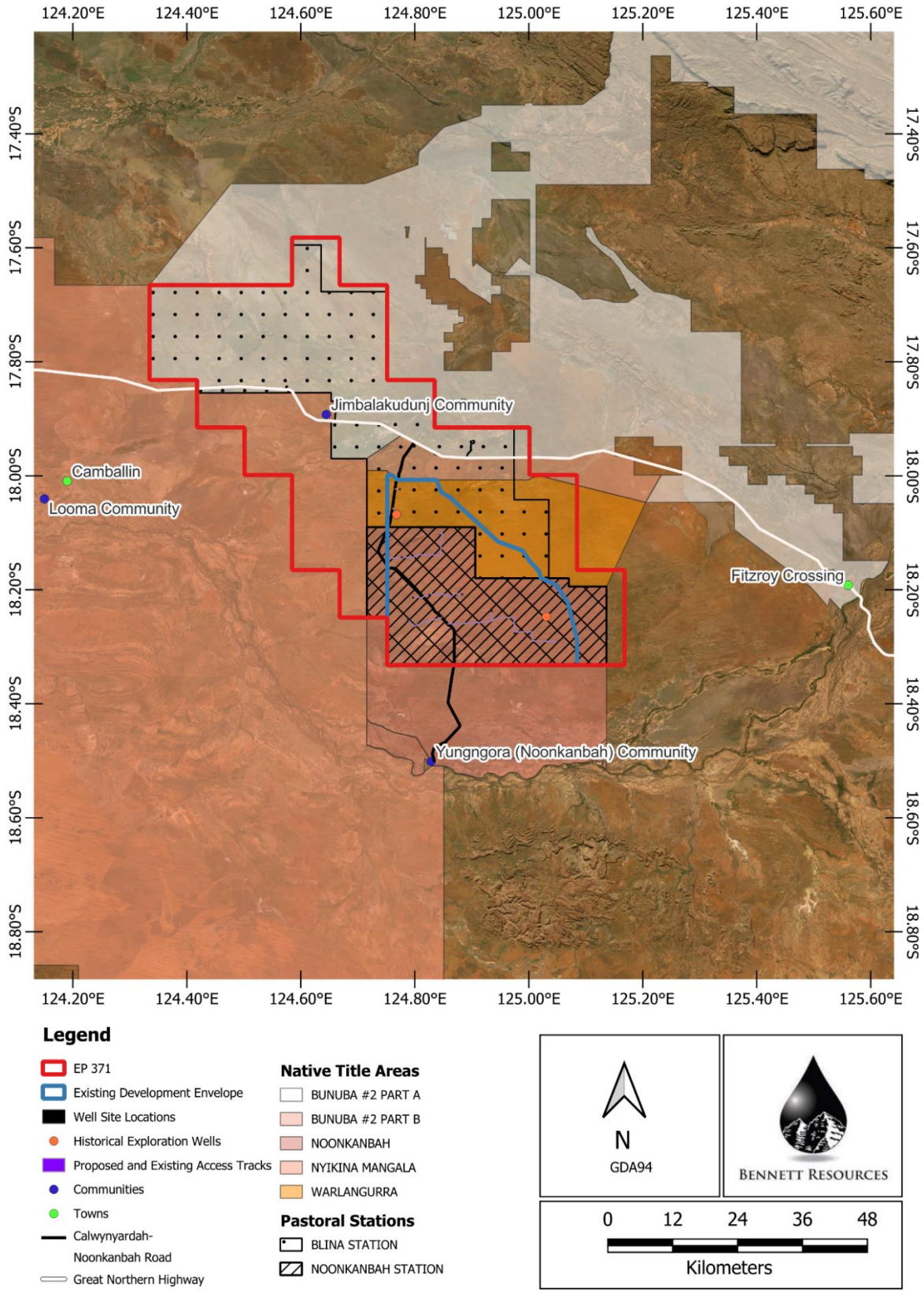


Figure 1-3: Native title areas, pastoral stations and nearest communities within EP 371

1.3 Key Environmental Factor Summary table

Table 1-2: Summary of potential impacts, proposed mitigation and proposed environmental outcomes for the Key Environmental Factors

Key Environmental Factor 1: Flora and Vegetation (For detailed information refer to Section 5.1, Page 82)	
Potential impacts	**Direct impacts:** • loss and fragmentation of native vegetation from clearing. **Indirect impacts:** • degradation or loss of vegetation ecology and biodiversity as a result of the introduction of non-indigenous species (weeds) • degradation or loss of vegetation ecology and biodiversity as a result of an unplanned fire event • degradation or loss of vegetation ecology and biodiversity as a result of dust.
Mitigation hierarchy	**Avoidance:** • demarcation of the proposed clearing area by a surveyor reduces, to the smallest possible extent, the chance of unplanned clearing outside the proposed footprint • as required by local shire regulations, BNR is required to ensure clearances between vegetation and industrial activities are created and maintained to reduce the risk of causing a fire outside the site • site preparation, construction and activities (e.g. hot work, off-road activities) (e.g. gas flaring) are prescribed activities in the Bush Fires Regulations 1954. As such, a range of management measures under the Regulations must and will be implemented. **Minimisation:** • with seeds and roots mainly conserved within the topsoil, topsoil will be removed and stockpiled into windrows following clearing, with subsoil left in place. It is a generally accepted industry standard that windrows should be no higher than two metres. The reason for this is that temperature in the centre of a windrow will get higher where the height / quantity of material increases. Because seed viability is reduced if temperatures increase, the quality / outcomes of revegetation using the topsoil and associated seedbank also reduces • in accordance with DAWE's Arrive Clean, Leave Clean guidance (Commonwealth of Australia, 2015), it is considered good industry practice to prevent the spread of weeds by ensuring that any fill used on site (e.g. gravel, limestone marl, soil, sand) has been verified to have a low weed risk. BNR will follow this industry practice • it is considered good industry practice to prevent the spread of weeds by ensuring that civil earthmoving machinery is subject to an inspection and if required a clean-down before arriving on site and before starting ground-disturbing activities, and BNR will require its operators follow this practice. **Rehabilitation:** • as required under the PGER(E)R, 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 environmental liability at the end of asset life. Topsoil is to be respread and rehabilitation sites actively monitored to ensure they meet the required completion criteria. Specifically, completion criteria will be developed to ensure that rehabilitation is conducted to enable long-term land use to continue. These completion criteria will be documented in the EP for acceptance by DEMIRS.
Residual impacts including assessment of significance	Loss and fragmentation of native vegetation from clearing • clearing of up to 105 ha

	Regional • having regard to the extent and distribution of these systems regionally, the loss of 0.054 per cent of a vegetation association is not considered to be significant at a regional scale. Local Significance • given that none of the vegetation associations mapped by Eco Logical are considered to be rare, nor do they match communities that have insufficient information available on them, BNR does not believe that the direct impact to each of the local vegetation communities, as detailed by Eco Logical , will result in a significant localised impact. Conservation Significance • BNR does not believe that the Proposal poses a risk to significant flora or vegetation values planned to be impacted within the disturbance footprint. Degradation or loss of vegetation ecology and biodiversity as a result of the introduction of non-indigenous species (weeds) • as weed and hygiene management are part of a standard suite of measures that can be effectively applied to the Proposal, BNR does not expect these indirect impacts to cause a significant environmental impact. Habitat loss or degradation as a result of an unplanned fire event • 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 does not expect these indirect impacts to cause a significant environmental impact. Degradation or loss of vegetation ecology and biodiversity as a result of dust • BNR does not believe that dust generation from the Proposal will result in a credible impact to vegetation • because the dominant vegetation type within the Development Envelope is the same as that associated with the long-term monitoring program conducted in the Pilbara, BNR does not believe that dust deposition poses a significant impact to flora or vegetation. Impacts from dust on vegetation is also discussed in the flora and vegetation environmental factor in Section 5.1.5.4.
Proposed environmental outcomes	• no impacts to listed flora species • no significant reduction in pre-European vegetation association extent • no detrimental impacts to flora and vegetation values • no impact to the overall biological diversity and ecological integrity of flora and vegetation within the Development Envelope.
Assessment of offsets (if relevant)	No offsets required under the Residual Impact Significance Model (Figure 3 in WA Environmental Offsets Guidelines).
Key Environmental Factor 2: Terrestrial Environmental Quality (For detailed information refer to Section 5.2, Page 105)	
Potential impacts	**Direct impacts:** • no direct impacts to terrestrial environmental quality are expected to arise as a result of the Proposal. **Indirect impacts:** • erosion or scouring as a result of reduction in soil stability during civil works • contamination of land and soils from surface spills • inadequate rehabilitation arising from compaction.
Mitigation hierarchy	**Avoidance:**

- all high-pressure surface lines and equipment used (including the wells) will be pressure tested during rig-up to ensure their integrity before the HFS commences.

Minimisation:

- as per WQPN 26 (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 90th percentile wet season, after allowance for any evaporative water loss and the effects of any water re-use recovery system
- as per WQPN 26 (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:
  - all fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s
  - a minimum thickness of 0.75 mm
  - dual liners
  - leak detection
- it is standard industry practice, which BNR will meet, 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 a refuelling process, drip trays will be used for this activity
- as per Australian Standard AS 1940:2004 recommendations, BNR will ensure that:
  - secondary containment for hazardous materials, chemicals, and hydrocarbons comprise a volume that equals 110% of the largest container within the contained area or 25% of the combined tank volumes
  - tanks are double-skinned

  in accordance with ESD Items 5, 6, and 8, a summary of all chemicals that may be used as ingredients in drilling and hydraulic fracture is included in Appendix A. As per the requirements of Regulation 9 of PGER(E)R 2012, chemicals or substances must be disclosed for acceptance by DEMIRS before commencing activities where they are:
  - in, or added to, any treatment fluids to be used for drilling or hydraulic fracturing undertaken in the course of the activity
  - otherwise introduced into a well, reservoir, or subsurface formation in the course of the activity

  In addition, all chemicals to be used downhole under the Proposal must be 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
- Regulation 15 of PGER(E)R 2012 requires that an OSCP be developed for the Proposal and accepted by DEMIRS before conducting any petroleum activities
- as directed by the OSCP, spill kits will be made available onsite to support the first strike / immediate response actions in the event of a spill

  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. Employing an appropriately licensed waste contractor reduces the risk of other accidental release events given the contractor will be experienced in transfer and transport of waste
- waste will be managed in accordance with Table 2 8 to ensure suitable disposal

  as detailed in Appendix E, BNR will implement a soil sampling and monitoring program. Specifically, additional local baseline samples, as required, will be collected from the well sites once they are established (i.e. post vegetation clearing and prior to well site sheeting) and will be used to verify the baseline sampling that has already taken place. Surveillance samples will also be undertaken prior to site reinstatement in accordance with Appendix E,

	and the trigger and threshold actions implemented as detailed. Appropriate site reinstatement activities and soil handling methods will also be undertaken, in accordance with the soil monitoring program, to ensure any potential soil erosion, compaction and contamination are mitigated • BNR will manage waste in accordance with Table 2-8. **Rehabilitation:** **N/A**
Residual impacts including assessment of significance	**Erosion or scouring from a reduction in soil stability during civil works** • if soil materials on the site are well compacted after topsoil organics are removed 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. **Contamination of land and soils from surface spills** • contamination of soils and the immediate surrounding land may occur from an unplanned surface spill event. Standard construction, petroleum storage, and petroleum use mitigation measures (Table 5-11) will be applied to this activity; therefore, the likelihood of such a spill event occurring is extremely low, and containment and recovery measures will ensure that any soil contamination would be minimised and remediated quickly and is not deemed significant. **Inadequate rehabilitation arising from compaction** • based on the vegetation associations impacted, the small quantity of vegetation affected under the Proposal is not regionally or locally significant • further, rehabilitation completion criteria will be included in the EP for submission and acceptance by DEMIRS to ensure any residual impacts are appropriately addressed.
Proposed environmental outcomes	• no significant or permanent impacts arising from contamination events • no long-term impacts to the terrestrial environment or detrimental impacts from erosion, scouring, or drainage.
Assessment of offsets (if relevant)	No offsets proposed.
Key Environmental Factor 3: Terrestrial Fauna (For detailed information refer to Section 5.3, Page 117)	
Potential impacts	**Direct impacts:** • death or displacement of native fauna species • habitat destruction • habitat fragmentation. **Indirect impacts:** • 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.
Mitigation hierarchy	**Avoidance:** • in accordance with the Fauna Egress Matting and Ramps guidance (DMP, 2012), BNR will implement fauna exclusion and egress management measures where lined ponds / fauna traps are present to reduce likelihood of entrapment and allow egress if the initial exclusionary barriers fail • water retention ponds will be fenced with 1 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

	• at least 6 months prior to clearing activities commencing, a targeted survey will be undertaken to identify any active and non-active bilby burrows throughout the Disturbance Footprint. Where evidence of species presence exists, specific bilby management measures (detailed below) will be implemented
	• in accordance with local shire regulations, firebreaks will be installed and maintained to ensure clearances between vegetation and the petroleum activities reduce the risk of causing a fire
	• under the Bush Fires Regulations 1954, site preparation, construction and activities (hot work and off-road activities) (i.e. gas flaring) are considered prescribed activities. As such, a range of management measures under the Regulations will be implemented, including the clearing of flammable material from around buildings, creating firebreaks and ensuring firefighting equipment is kept and well maintained at each well site.
	Minimisation:
	to mitigate potential impacts to bilbies during site preparation, these steps will be implemented if a bilby burrow is identified within the disturbance footprint:
	• the disturbance footprint will be scouted for new burrows (within a range of ~75 m)
	• no clearing will be undertaken within 50 m of any identified burrows
	• no clearing will be undertaken within 75 m of identified active burrows
	• vehicle speed limits will be reduced from dusk to dawn to:
	  • 20 km/h in areas where bilbies have been recorded
	  • 40km in areas where bilbies have not been recorded
	• vehicle speed limit signage will be installed along access tracks and at well sites. By reducing speed limits where limits are not set by law, the number of fauna strike incidents are expected to be reduced
	• BNR will conduct routine inspections of areas considered to be potential fauna traps. These include open excavations or well cellars, if they need to be left open. Egress paths from ponds will also be regularly inspected to ensure their useability
	• BNR will comply with the Arrive Clean, Leave Clean guidance (Commonwealth of Australia, 2015), to prevent spread of weeds by ensuring that fill for civil works (e.g. gravel, limestone marl, soil, or sand) has been verified to have a low weed risk
	Good hygiene measures will also be implemented, as prior to entering the well sites, earthmoving machinery and equipment being checked for weeds or weed-contaminated materials and cleaned if necessary
	• BNR will provide all records of introduced predatory species opportunistically observed over the course of the activity to DBCA. Where consistently high numbers are observed, and in consultation with DBCA, BNR will identify and implement measures that are considered suitable and commensurate to the nature of the activity.
	Rehabilitation:
	• in accordance with the PGER(E)R requirements, 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 environmental liability at the end of asset life. Topsoil and vegetation will be respread, and rehabilitation sites actively monitored to ensure they meet required completion criteria. Completion criteria will be documented in the EP and approved by DEMIRS.

Residual impacts including assessment of significance	**Wetlands and waterways** • as the Proposal will not result in clearing of vegetation within a wetland, creek or river, the residual impacts are not expected to be significant. **Conservation Areas**

	• as detailed in Section 5.1.3.2, the Development Envelope does not intersect any conservation areas. Consequently, the residual impacts are not expected to be significant. **High Biological diversity** • because the Proposal will not impact any fauna species or habitat that is known to have high biodiversity values, the residual impacts are not expected to be significant.
Proposed environmental outcomes	• no impact to listed fauna species' populations • no significant degradation, loss, or fragmentation of habitat surrounding the Development Envelope.
Assessment of offsets (if relevant)	No offsets required under the Residual Impact Significance Model (Figure 3 in WA Environmental Offsets Guidelines).
Key Environmental Factor 4: Inland Waters (For detailed information refer to Section 5.4, Page 132)	
Potential impacts	**Direct impacts:** • changes to groundwater levels (groundwater drawdown) associated with water extraction • contamination of surficial aquifers due to lost circulation. **Indirect impacts:** • changes to surface water flow due to the construction of well sites and access tracks • contamination of useable aquifers through unplanned fracture heights or well integrity failure (including casing failure).

Mitigation hierarchy	**Avoidance:**
	• in accordance with ESD Item 13, an early warning system for detecting geomechanical events has been developed and will be implemented for the Proposal. The detection system is described in Appendix B. and includes monitoring for one-month pre and post any HFS activities
	• the wells are not located within 2,000 m of a PDWSA (Section 5.4.3.7)
	• as is good industry practice (in the absence of a state Code of Practice), BNR will ensure that HFS will not occur in formations that have <600 m vertical separation to the nearest useable aquifer. This will be checked and confirmed once each well has been constructed, along with a geotechnical risk analysis
	• in accordance with the Guidelines for the protection of surface and groundwater resources during exploration and appraisal drilling (DMPR, 2002), the potential for contaminating groundwater resources will be managed by installing casing that is secured/sealed by a sealing material such as cement
	• in accordance with ESD Item 14 and Regulation 10 of the PGER (Resource Management and Administration) Regulations 2015, every 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 DEMIRS before HFS commences. Therefore, well management plans will be developed and approved prior to each well being constructed
	A summary of well integrity management is provided in Section 1.4.1.2.
	• as required by the ESD Item 4, BNR has developed a GWMP (Appendix M) that documents the groundwater monitoring requirements along with management actions associated with trigger and threshold criteria that must be implemented
	  • BNR believes that with the triggers detailed in the GWMP, groundwater sensitivities (such as subterranean fauna) will be protected
	  • BNR will ensure the location of all monitoring bores is completed in consultation with DWER and DEMIRS

- BNR will complete all groundwater monitoring (including local baseline sampling) in accordance with the Part IV Groundwater Management Plan.

Minimisation:

- as per WQPN 26 (DoW, 2013), all lined storage compounds will 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 90th percentile wet season, after allowing for any evaporative water loss and the effects of any water re-use recovery system. All water storage ponds will be designed to meet these requirements
- installation and drilling of all water bores (including abstraction bores) will be hydro stratigraphically logged in detail and geophysical interpretation of groundwater quality collected, for the interval where fresh aquifers are known to be present (including through the Grant formation)

  BNR will conduct validation water samples (along with QA/QC samples of any fluids or water used for the bore installation process) at a point of discharge from the circulation system to understand if cross contamination may be occurring as evidenced by fluid constituent presence associated with bore installation. This may involve the use of tracer dyes, but these specifics are subject to local conditions, aquifer depths and will be directed by a hydrogeologist during bore installation
- BNR will hydrostratigraphically log the petroleum well during drilling activities and collect a geophysical interpretation of groundwater aquifers
- in accordance with WQPN 26 (DoW, 2013), surface ponds used for short-term containment of wastewater or solids that may leach contaminants, require synthetic membranes and need to meet specific requirements, including:
  - all fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s
  - a minimum thickness of 0.75 mm
  - dual liners
  - leak detection

  All surface ponds will be constructed to meet these requirements
- in accordance with ESD Items 5, 6, 7, 8, and 9, a chemical inventory has been developed for the Proposal (Appendix A)
- BNR plans 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
- as per Regulation 15 of the PGER(E)R 2012, BNR will monitor, and record volumes of fluids not recovered during circulation.

Water meters will be installed as required on all groundwater abstraction wells

Monitor:

- as required by ESD Item 4, all water wastes and emissions, including formation water produced during well testing, resulting from the Proposal will be recorded and monitored
- a site water audit on completion of HFS 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
- as required by ESD Item 4, Ecotoxicology testing of produced formation waters at each wellsite will be conducted by an independent NATA endorsed laboratory, either through the sea urchin fertilization test using Heliocidaris tuberculate or other appropriate methodology. Reporting will be done in accordance with annual compliance reporting to DMAs.

Rehabilitation:

N/A

Residual impacts including assessment of significance	**Changes to groundwater levels (groundwater drawdown) associated with water extraction** • 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, noting that the closest groundwater user is at least 18 km from the project area. **Changes to surface water flow due to the construction of well sites and access tracks** • with the proposed mitigations in place, changes to surface water flow is not expected to result in regional impacts, and any localised impacts are not expected to be significant. **Potential contamination of aquifers through unplanned fracture heights** • BNR does not believe that contamination of useable aquifers through unplanned fracture heights is a credible risk for the Proposal. **Potential contamination of surficial aquifers from an accidental release at the surface of drilling fluids, HFS chemicals, liquid hydrocarbons, or produced formation water** • if standard management measures are implemented, BNR does not expect these events to occur, but if they do, any indirect impacts are not expected to cause a significant environmental impact. **Potential risk to site activities and infrastructure due to extreme rainfall events** • the GWMP will be implemented to demonstrate that residual impacts are not greater than predicted, which are not deemed to be significant after analysis of local rainfall and flooding events.
Proposed environmental outcomes	No impacts to hydrological regimes or groundwater quality, demonstrated by: • no significant drawdown of the aquifer following completion of the Proposal that is considered outside seasonal fluctuations • no change to groundwater quality attributable to the Proposal.
Assessment of offsets (if relevant)	No offsets proposed.
Key Environmental Factor 5: Social Surroundings (For detailed information refer to Section 5.5, Page 171)	
Potential impacts	**Direct impacts:** • increased dust emissions • increased noise and vibration emissions • increased traffic movement • disruption to existing land users • social and economic benefits • impacts to workers' health. **Indirect impacts:** • potential impacts to heritage sites • amenity and aesthetics • local social impact arising from mental health and wellbeing, due to impacts from changes to the physical or biological environment.

Mitigation hierarchy	**Avoidance:** • demarcation of the proposed clearing area by a surveyor reduces—to the smallest possible extent—the chance of unplanned clearing and potential damage to heritage sites outside the proposed footprint • no specific upgrades to the Calwynyardah–Noonkanbah Road are required for the activities. However, for the safety of other road users, BNR will monitor the condition of the gravel road throughout the Proposal's activities. BNR will liaise directly with SDWK and YAI regarding the frequency of road maintenance. **Minimisation:** • BNR will record and investigate any complaints over the course of the activity and record these in the Proposal's action tracking system. This includes any complaints provided by the public regarding impacts to amenity and aesthetics • BNR will conduct an amenity and aesthetics assessment during site activities. This will comprise a visual assessment of the activity within the landscape to confirm that visual impacts, noise emissions and any other emissions do not reduce amenity at key points along the Calwynyardah–Noonkanbah Road • implementing dust management techniques, such as water carts, ensures that dust generation can be prevented and reduced if necessary • consultation with relevant Traditional Owner 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 • Traditional Owners will be invited to partake in the Proposal as heritage monitors during ground-disturbing activities. Heritage monitors will be onsite during disturbance of the topsoil to ensure that activities cease if heritage material is uncovered, and discovery of the material is immediately reported to the Noonkanbah and Warlangurru Traditional Owners to verify if it is a heritage artefact subject to protection under the *Aboriginal Heritage Act 1972* (WA) • BNR has a comprehensive induction process that considers environmental impacts and risks • as required by ESD Item 61, BNR will provide cultural awareness and orientation to staff involved in ground-disturbance activities. BNR will conduct these in accordance with the Yungngora ILUA that specifically requires induction material to be developed in consultation with the Traditional Owners. Under the agreement, Yungngora has the right to select community members to deliver the induction package in accordance with the terms of the agreement • to reduce emissions from traffic, BNR will monitor vehicles and maintain these, as required, throughout the Proposal • after completing the Proposal activities, and as required under the PGER Act, BNR will submit and implement a decommissioning EP. **Rehabilitation:** • in accordance with the PGER(E)R requirements, 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 will be respread, and rehabilitation sites actively monitored to ensure they meet required completion criteria. Completion criteria will be documented in the EP.
Residual impacts including assessment of significance	**Natural Heritage** • a search of the WA Government's InHerit database did not identify any registered natural heritage sites (statutory heritage listings) within or adjacent to the Development Envelope • although located within a single heritage site – impacts have been avoided through realignment. Even though impacts have been avoided, s16 approval under the AH Act will be required • the Proposal is not located within any of the iconic natural heritage places • no world heritage sites or Commonwealth heritage sites occur within EP 371.

	Impacts assessed • (increased dust) Based on the assessment criteria, the Proposal is considered to be classified under Site Classification 1; i.e. considered a negligible risk with no specific provisions or contingency arrangements required (DEC, 2011) • (increased noise and vibrations) 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 nearby that can be exposed to the Proposal's increased noise levels, noise emissions from the Proposal are not expected to result in a significant impact to social surroundings • (disruption to existing land users) The Traditional Owners are made aware of all BNR presence and activities on site, and discussions are ongoing regarding the participation and employment of community members in the Proposal's activities. The community supports current and future work opportunities on EP 371 • (increased Traffic) Vehicle movements associated with the Proposal are unlikely to result in impacts to traffic on local dirt tracks within the Development Envelope given that these (with the exception of one currently existing access track) are planned to be constructed specifically for the Proposal and only to access the proposed well sites • (impact to workers health) BNR has not conducted a detailed assessment of impacts to worker health as this will be managed under the Work Health and Safety Act 2020 (WA) • (potential impacts to heritage sites) With the current understanding of local heritage, the Proposal is not expected to have a significant impact on the cultural heritage of the region • (potential impacts to heritage sites) Apart from additional vehicles and dust in remote places, it was felt by the Yungngora Aboriginal Corporation and Warlangurru Aboriginal Corporation representatives that the impacts on their aesthetic, cultural, economic and social surroundings would be minimal • (amenity and Aesthetics) the short duration of the Proposal activities and the nature of the landscape, impacts to amenity (if any) are expected to be limited with no long-term impacts expected.
Proposed environmental outcomes	• no impacts to heritage sites or artefacts • no significant disruption to existing land users • direct and indirect economic benefits to the local communities of the SDWK.
Assessment of offsets (if relevant)	No offsets proposed
Key Environmental Factor 6: Air Quality (For detailed information refer to Section 5.6, Page 198)	
Potential impacts	**Direct impacts:** N/A **Indirect impacts:** • reduction in air quality causing impacts to sensitive social receptors • increased dust generation resulting in deposition impacts to flora and vegetation.
Mitigation hierarchy	**Avoidance:** • BNR is considering using green completions, which allow gas produced during well completions to be separated for offtake to a sales gas pipeline. Given the distance of the well sites to existing gas markets, the emissions associated with transport offsite will also need to be considered

	Because of the complexities of negotiating an offtake agreement with a gas supplier, the green completions option will be considered closer to the time of the activity.
	Minimisation:
	• throughout the planning phase, BNR has conducted baseline air quality monitoring in accordance with EPA guidance and in consultation with DWER. Although the initial program formed the basis of this assessment, BNR plans to continue with a range of both baseline and surveillance monitoring programs to verify the Proposal activities can be undertaken in a way that has no significant impacts to the environment. A summary of the proposed air quality monitoring program to be undertaken for the Proposal is included in Appendix E. Specifically, the air quality monitoring planned for the Proposal includes:
	  • continuing ambient air quality monitoring
	  • verifying that ambient air quality levels near the communities (~2.5 to 5 km away) remain unaffected by the activity
	• BNR will reduce cold venting during well test flaring to ALARP, which will significantly reduce methane emissions associated with this activity. Cold venting results in the release of methane, carbon dioxide, VOCs, sulphur compounds and gas impurities to the atmosphere, whereas flaring causes these gases to oxidise and form carbon dioxide, which has a global warming potential 25 times lower than methane
	• BNR will implement dust management techniques, such as dust suppression, to ensure that dust generation is minimised
	• 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.
	Rehabilitation:
	N/A

Residual impacts including assessment of significance	**Reduction in air quality causing impacts to sensitive social receptors** • based on these distances and the surrounding rural land use, air emissions arising from using vehicles, heavy equipment and generators are not considered to represent a significant or long-lasting impact to air quality, human health, or aesthetics during site activities. **Increased dust generation resulting in deposition impacts to flora and vegetation** • because the dominant vegetation type within the Development Envelope is the same as that associated with the long-term monitoring program conducted in the Pilbara, BNR does not believe that dust deposition poses a significant impact to flora or vegetation. Impacts from dust on vegetation is also discussed in the flora and vegetation environmental factor in Section 5.1.5.4.
Proposed environmental outcomes	• no reduction in air quality that results in impacts to sensitive.
Assessment of offsets (if relevant)	No offsets proposed
Key Environmental Factor 7: Greenhouse Gas (For detailed information refer to Section 5.7, Page 207)	
Potential impacts	**Impacts:** • contribution to GHG emissions.
Mitigation hierarchy	**Avoidance/Reduce:** • as required by the ESD Item 78, BNR has developed a GHG EMP that documents the mitigation and management measures associated with the Proposal. A summary of the proposed GHG monitoring to be undertaken in accordance with the GHG EMP is provided in Appendix R • throughout the planning phase, BNR has conducted baseline GHG emissions monitoring (limited to methane) in accordance with EPA guidance and in consultation with DWER. Although the initial program formed the basis of this assessment, BNR plan to continue its methane monitoring program with

	baseline and surveillance monitoring to verify the impacts of the Proposal's activities. Monitoring will continue until a trend *back to baseline levels has been demonstrated **and** at least two consecutive results reflect no significant deviation from ambient (baseline) samples* (Appendix E). **Minimisation:** • BNR will maintain emissions records to enable GHG emissions reporting as required under the NGER Act. **Rehabilitation:** N/A
Residual impacts including assessment of significance	**Based on the predicted outcome for the Proposal, BNR does not believe that the Proposal will result in a significant contribution to GHG emissions** • no Scope 2 emissions are expected • no Scope 3 emissions are expected • the GHG EMP will be implemented to demonstrate that residual GHG impacts from the Proposal (Scope 1 emissions) are not greater than predicted.
Proposed environmental outcomes	• GHG emissions minimised to ALARP to mitigate the risk of environmental harm associated with climate change.
Assessment of offsets (if relevant)	BNR acknowledges that carbon offsets may be necessary to meet the environmental outcomes defined within this GHG EMP. Where and when required, BNR will acquire carbon offsets that meet the contemporary Australian acceptability standards (e.g., they should meet offset integrity principles and be based on clear, enforceable, and accountable methods.
Key Environmental Factor 8: Human Health (For detailed information refer to Section 5.85.1, Page 212)	
Potential impacts	**Impacts:** • industrial processes that result in the build-up and release of radioactive substances or emissions.

Mitigation hierarchy	**Minimisation:**
	• as detailed in Appendix E, BNR will sample produced formation water (from within water retention ponds) and drill cuttings (from the mud sumps) for CoPC, including NORMs
	• as per WQPN 26 (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 90th percentile wet season, after allowing for any evaporative water loss and the effects of any water re-use recovery system
	• in accordance with WQPN 26 (DoW, 2013), surface ponds used for short-term containment of wastewater or solids that may leach contaminants, require synthetic membranes and need to meet specific requirements, which include:
	  • all fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s
	  • a minimum thickness of 0.75 mm
	  • dual liners
	  • leak detection
	• all produced formation water will be managed in accordance with the principles detailed in Table 2-8.
	Rehabilitation:
	N/A

Residual impacts including assessment of significance	**Industrial processes that result in the build-up and release of radioactive substances or emissions** • BNR does not expect any NORM-contaminated material to be released to the environment that causes exposure to humans and risks human health. If an accidental release from the water retention pond or drilling sump did occur, impacts to human health are not expected because the NORM concentrations from the Laurel Formation have proven to be low and below the levels set out by industry guidelines.
Proposed environmental outcomes	• no impacts to human health by industrial processes that result in the build-up and release of radioactive substances or emissions.
Assessment of offsets (if relevant)	No offsets proposed
Key Environmental Factor 9: Subterranean Fauna (For detailed information refer to Section 5.9, Page 215)	
Potential impacts	**Direct impacts:** • groundwater drawdown of surficial aquifers associated with water extraction. **Indirect impacts:** • contamination of surficial aquifers from an accidental release (of drilling fluids, HFS chemicals, liquid hydrocarbons, or produced formation water) at the surface.
Mitigation hierarchy	**Avoidance:** • in accordance with the Guidelines for the protection of surface and groundwater resources during exploration and appraisal drilling (DMPR, 2002), the potential for contaminating groundwater resources will be managed by installing casing that is secured/sealed by a sealing material such as cement. **Minimisation:** • as required by the ESD Item 4, BNR has developed a GWMP (Appendix M) that documents the groundwater monitoring requirements along with management actions associated with trigger and threshold criteria that must be implemented BNR believes that with the triggers detailed in the GWMP, groundwater sensitivities (such as subterranean fauna) will be protected As per Australian Standard AS 1940:2004 recommendations, BNR will ensure that secondary containment for hazardous materials, chemicals, and hydrocarbons comprise volumes that equal 110% of the largest container within the contained area or 25% of the combined tank volumes, and that tanks are double-skinned • as per WQPN 26 (DoW, 2013), all lined storage compounds will 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 90th percentile wet season, after allowing for any evaporative water loss and the effects of any water re-use recovery system. All water storage ponds will be designed to meet these requirements • installation and drilling of all water bores (including abstraction bores) will be hydro stratigraphically logged in detail and geophysical interpretation of groundwater quality collected, for the interval where fresh aquifers are known to be present (including through the Grant formation) • annulus seals and gravel packs will be used, where necessary, to isolate the zone being monitored and prevent potential cross contamination via the bore casing as required by the Minimum Requirements for Water Bores in Australia (National Uniform Drillers Licensing Committee, 2011) required to be followed as detailed in the Groundwater monitoring in the onshore petroleum and geothermal industry guideline (DMP & DoW, 2016). BNR will conduct validation water samples (along with QA/QC samples of any fluids including water used for the bore installation process) at a point of discharge from the circulation system to understand if cross contamination may be occurring as evidenced by fluid constituent presence associated with bore installation. This may involve the use of tracer dyes, but these specifics are subject to local conditions, aquifer depths and will be directed by a hydrogeologist during bore installation • in accordance with WQPN 26 (DoW, 2013), surface ponds used for short-term containment of wastewater or solids that may leach contaminants

	• BNR plans 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. **Rehabilitation:** N/A
Residual impacts including assessment of significance	**High biological diversity / habitat for fauna** • given the impacts from these activities are limited, any indirect impacts to subterranean fauna would not be expected. Consequently, the residual impacts from this Proposal are not expected to be significant.

Proposed environmental outcomes	• no impacts to subterranean fauna demonstrated by:
	  • no short-term significant drawdown of the aquifer
	  • no change to groundwater quality.

Assessment of offsets (if relevant)	No offsets proposed

1.4 Legislative Context

1.4.1 Environmental impact assessment process

The Proposal was referred to the EPA under Section 38 of the EP Act on 24 December 2020. On 3 February 2021, the EPA determined that the Proposal should be assessed under section 39a of the EP Act at the level of assessment of Public Environmental Review (PER).

On 4 August 2021, the EPA issued the Environmental Scoping Document (ESD) for public review, which contained the requirements that should be included in this ERD. This ERD has been prepared to meet the requirements of the final ESD, which was issued by the EPA on 8 November 2021. In preparing this ERD, BNR completed engagements and studies to address the key environmental factors determined by the EPA, including:

- flora and vegetation
- terrestrial environmental quality
- terrestrial fauna
- inland waters
- social surroundings
- air quality
- greenhouse gas emissions
- human health
- subterranean fauna.

Once the EPA is satisfied that this ERD meets the requirements of the ESD, the EPA will approve the release of the ERD for public review for an eight-week period. Following this public review process, the EPA will provide BNR with a copy of all submissions received, which BNR will address in a Response to Submissions document. This will be prepared to the satisfaction of the EPA and will constitute part of the assessment documentation for the Proposal.

The EPA will then prepare its report and recommendations and submit this to the WA Minister for Environment for consideration as part of the Minister's decision process on Proposal approval or otherwise.

This ERD content, format and environmental assessment have considered the following EPA guidance:

- Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures (GoWA 2021) (Administrative Procedures)
- Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual (EPA 2021a) (Procedures Manual)
- Statement of Environmental Principles, Factors and Objectives and Aims of EIA (EPA 2021c)]
- Instructions – How to identify the content of a Proposal (EPA 2021c)
- Instructions – How to prepare an Environmental Review Document (EPA 2021d)
- Instructions – Environmental outcomes and outcomes-based conditions (EPA 2021e)
- Instructions for preparing data packages for the Index of Biodiversity Surveys for Assessments (IBSA) (EPA 2020a)
- Instructions on how to prepare EP Act Part IV Environmental Management Plans (EMPs) (EPA 2020b).

In addition to the required approvals under Part IV of the EP Act, Table 1-3 and further sections below summarise other key environmental and regulatory approvals required to be in place for the Proposal.

Table 1-3: Other statutory decision-making processes which can mitigate potential impacts on the environment

Environmental Factor	Environmental impact	How is the impact regulated by other decision-making processes?	Limit(s) of the decision-making process(es) to regulate the impact e.g. time limits, excluded operations	Likely environmental outcome of decision-making process(es) and consistency with EPA objective	Conditions, enforcement, and review process required by decision-making process(es)	Stakeholder engagement in decision-making process(es)
Inland Waters	Potential impact to groundwater from drilling and well testing	DEMIRS approvals required: • Environment Plan • Well Management Plan (individual for each well), as covered in *Petroleum and Geothermal Energy Resources (PGER) Act 1967* (WA) • PGER (Environment) Regulations 2012 (PGER(E)R)	DEMIRS oversees all drilling activities, with daily reporting required, ensuring immediate response in the event of an environmental impact	Daily reporting ensures any impacts can be immediately addressed, protecting environmental values of groundwater	Environment Plans and Well Management Plans include actions and commitments, overseen and regulated by DEMIRS	Ongoing consultation with TOs and pastoral station owners, as well as DEMIRS
Terrestrial Environmental Quality	Potential surface spill	DEMIRS approvals required: • Oil Spill Contingency Plan (OSCP), as covered in Petroleum and Geothermal Energy Resources (PGER) Act 1967 (WA) • Environment Plan - PGER (Environment) Regulations 2012 (PGER(E)R)	DEMIRS oversees all drilling activities, with daily reporting required, ensuring immediate response in the event of an environmental impact	Daily reporting ensures any impacts can be immediately addressed, protecting environmental values of the surface and groundwater	All spills must be immediately reported to DEMIRS and actions as approved in the OSCP undertaken to mitigate any potential impacts.	Ongoing consultation with TOs and pastoral station owners, as well as DEMIRS
Flora and Vegetation	Potential impact to vulnerable/endangered flora or fauna	The project is being referred under the *Environment Protection and Biodiversity*	Targeted surveys of all species listed by DCCEEW will be undertaken	Environmental values will be protected as BNR has committed to ensuring	Commitments made will be monitored by Commonwealth and State Government agencies	Ongoing consultation with TOs and pastoral station owners, as

Environmental Factor	Environmental impact	How is the impact regulated by other decision-making processes?	Limit(s) of the decision-making process(es) to regulate the impact e.g. time limits, excluded operations	Likely environmental outcome of decision-making process(es) and consistency with EPA objective	Conditions, enforcement, and review process required by decision-making process(es)	Stakeholder engagement in decision-making process(es)
Terrestrial Fauna		*Conservation Act 1999*, regulated by DCCEEW		buffers to exclude areas with listed active species		well as DWER and DCCEEW
Social Surroundings	Potential impacts to cultural heritage	Under the National Native Title Tribunal, and regulated through *Native Title Act 1993* (Commonwealth) Native Title (Indigenous Land Use Agreements) Regulations 1999 Native Title (Prescribed Body Corporate) Regulations 1999	Native title agreements via an Indigenous Land Use Agreement and a Land Access and Use Agreement have been put into place	Environmental and cultural heritage values protected through ongoing engagement with TOs at all stages of the operation, in particular when clearing land	Ongoing monitoring by TOs, consistent with the Land Access and Use Agreements and other agreement mechanisms	Ongoing consultation with TOs and pastoral station owners, as well as the National Native Title Tribunal
Social Surroundings	Potential impacts to cultural heritage sites	Aboriginal Heritage Act 1972 S16 authorisation required	No Aboriginal Heritage sites will be impacted; however a single site intersects the Disturbance Footprint	Environmental and cultural heritage values protected through ongoing engagement with TOs and already completed realignment of the disturbance footprint.	s 16 authorisation to enter, excavate, examine or remove anything on an Aboriginal site will be required	Consultation with TOs has been undertaken and the disturbance footprint realigned to avoid impacts to the site. Although not yet engaged – DPLH will be engaged following completion of the impact assessment process and a s16 application lodged
Inland Waters	Potential impacts to groundwater levels	Regulation by DWER through 26D Licence to construct a well/bore 5C Licence to take water under the *Rights in Water and*	Abstraction rates are regulated and monitoring bores provide additional checks for regulators	Groundwater values protected through licensed abstraction limits and ongoing monitoring	Groundwater values protected through licensed abstraction limits and ongoing monitoring	Prior to the provision of a groundwater licence to abstract water, and due to the volume of water, licence

Environmental Factor	Environmental impact	How is the impact regulated by other decision-making processes?	Limit(s) of the decision-making process(es) to regulate the impact e.g. time limits, excluded operations	Likely environmental outcome of decision-making process(es) and consistency with EPA objective	Conditions, enforcement, and review process required by decision-making process(es)	Stakeholder engagement in decision-making process(es)
		Irrigation Act 1914 (WA) (RIWI Act)				applications will be subject to public comment
Terrestrial Environmental Quality	Potential impact from accommodation and associated infrastructure	Regulated by the Shire of Derby – West Kimberley through development/planning approvals, building permits and a permit to install an apparatus for treating sewage, through the *Planning and Development Act 2005*, the *Building Act 2011*, *Public Health Act 2016*, *Health (Miscellaneous Provisions) Act 1911* and the Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974	All operations are regulated by the Department of Health and/or local government with no exclusions	Environmental values protected through extensive local government regulation	BNR must comply with all regulations	Ongoing consultation with TOs and pastoral station owners, as well as the Department of Health and local government

1.4.2 Environmental Protection and Biodiversity Act 1999

Matters of National Environmental Significance Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth of Austraila, 2013) - provides basis for consideration of what constitutes a significant impact to a matter of environmental significance.

Matters of national environmental significance known or likely to occur within or adjacent to the Development Envelope include:

- National Heritage Place (the West Kimberley National Heritage Area (WKNHA))
- Nationally threatened species
- Migratory species
- Water resource in relation to large coal mining development or coal seam gas.

On 15 December 2023, the EPBC Act Water Trigger was amended to include consideration of likely significant impacts on water resources in relation to all types of unconventional gas, for example, shale and tight gas related developments.

The Proposed Action involves HFS, whereby groundwater is mixed with sand and chemical additives prior to the pumping of this mix down each well, to create hairline fractures in the target formation and allowing gas to flow to the wellbore. Thus, this trigger is now of relevance to the Proposed Action. BNR continues to consult with DCCEEW during the preparation (and submission of) referral documentation.

1.4.3 Petroleum and Geothermal Energy Resources Act 1967

The WA Department of Mines, Energy, Industry Regulation and Safety (DEMIRS) is responsible for administering various acts including the *Petroleum and Geothermal Energy Resources Act 1967* (PGER Act). Under this Act, various subsidiary legislation has been enacted, which requires BNR to seek additional approvals from DEMIRS before implementing the Proposal. This includes Safety Management Systems and Emergency Response Plan, covered by the PGER (Management of Safety Regulations) 2010 which, while not having a direct relation to potential impacts on the environment, nevertheless assist in mitigating potential impacts through regulating the safety of the site and personnel.

1.4.3.1 Petroleum and Geothermal Energy Resources (Environment) Regulations 2012

Under the Petroleum and Geothermal Energy Resources (Environment) Regulations (PGER(E)R) 2012, an Environment Plan (EP) must be accepted by DEMIRS 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 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.

1.4.3.2 Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015

In accordance with ESD Item 14, BNR will manage its wells throughout their lifecycle under a well integrity management system, which includes meeting or exceeding all requirements set forth in the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015, as required by DEMIRS. Under the Regulations, 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 DEMIRS. Among other requirements, the WMP must explain the philosophy of, and criteria for, the design, construction, activities and management of the well. The WMP covers the drilling and HFS program and identifies the risks. The WMP adopts a risk-based approach for petroleum exploration and ensures appraisal activities are undertaken in accordance with good oilfield practice to minimise the risk of aquifer contamination.

At a minimum, the WMP will:

- identify and assess all risks associated with the well activity and their resulting impacts

- establish specific environmental performance objectives and standards against identified risks (including measurement criteria to assess performance of those standards)
- detail mitigation measures for identified risks, including those where the likelihood of occurrence is low.

Specific design requirements that are documented in the WMP and managed under these regulations include:

- ensuring the casing grade is selected in accordance with American Petroleum Institute (API) grades
- designing the well with a minimum required casing string
- undertaking integrity tests throughout the drilling process including:
  - casing pressure test
  - formation pressure integrity test
  - cement bond logs
- reporting arrangements to DEMIRS, including the results of well logging and pressure tests undertaken during well construction and prior to HFS activities. Reporting of integrity tests will also occur during and after HFS
- highlighting casing failure / well integrity issues as a potential risk, while recognising that all wells will be constructed to ensure there are two barriers present at all times during drilling activities. Should a well barrier be compromised, the well activity would be suspended, and integrity measures, as documented in the DEMIRS-accepted Well Management Plan, implemented to ensure risk of contamination is ALARP.

In addition to WMPs and seeking approval on the well design construction methodology, BNR will ensure that well integrity is assessed by an independent and certified well examiner approved by DEMIRS. BNR will follow the relevant Australian and international standards related to well integrity including ISO 165301 and NORSOK D-010. Further information on BNR's well integrity management system is detailed in Section 2.5.

1.4.4 Rights in Water and Irrigation Act 1914

Any extraction of groundwater within a proclaimed groundwater area is subject to a licence issued by the WA Department of Water and Environmental Regulation (DWER) under the *Rights in Water and Irrigation Act 1914* (RIWI Act). A cumulative assessment of all extraction in the groundwater area must be completed to ensure allocation limits are not exceeded; this assessment is done independent of the applicant such that local and regional cumulative impacts are considered.

Under a RIWI Act groundwater licence, volumes extracted must be monitored and reported to DWER annually to confirm compliance with the licence and confirm that extraction above the licence allocation does not occur.

1.4.5 Aboriginal Heritage Act 1972

Aboriginal Heritage Act 1972 is the regime for the protection and preservation of Aboriginal cultural heritage in Western Australia. BNR is required to ensure that any ground disturbance is undertaken in accordance with the WA *Aboriginal Heritage Act 1972*. Unless acting with the authorisation of the Registrar under section 16 or the consent of the Minister under section 18, it is an offence under the AH Act for any person to excavate, destroy, damage, conceal or in any way alter any Aboriginal site.

While the bulk of the ERD was prepared in 2021, BNR has noted developments with the Aboriginal Heritage Act (including the enactment and subsequent repeal of the *Aboriginal Cultural Heritage Act* 2021) to ensure consistency with the Proposal and this environmental factor. On 15 November 2023 the *Aboriginal Cultural Heritage Act 2021* (WA) was repealed, meaning that the previous *Aboriginal Heritage Act 1972* (WA) was restored, with amendments.

1.4.6 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 implementing HFS on the onshore environment of WA. This inquiry was established under Section 25 of the EP Act. Following input from stakeholders, a final report was submitted to the WA Government in September 2018 (Independent Scientific Panel Inquiry, 2018). Based on the evidence presented and the international standards for designing, constructing, and operating an individual petroleum well incorporating HFS, the inquiry found that HFS activities generally pose low-level and limited risks to the environment and people, if properly carried out and located. 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 has reviewed all recommendations arising from this HFS inquiry and has used relevant recommendations to inform mitigation and monitoring requirements of the Proposal.

1.4.7 Western Australian code of practice

An enforceable Code of Practice for HFS was a key recommendation of the Independent Scientific Inquiry Report (Independent Scientific Panel Inquiry, 2018). The Code of Practice will include necessary prescriptive requirements and standards across the entire development lifecycle of HFS programs and ensure that all activities comply with an acceptable and high standard across the industry. Therefore, the HFS WA Code of Practice will close out the prescriptive and technical recommendations published in the Independent Scientific Inquiry's final report.

At the time of writing this document, the HFS WA Code of Practice was not yet complete. In the absence of a WA Code of Practice, BNR understands (from engagement with the EPA) that the prescriptive requirements of the Code of Practice have been included in the ESD.

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

2 Proposal content

2.1 Background

The Proposal was referred to the EPA under section 38 of the WA EP Act on 24 December 2020. Section 1.4.1 details the timeline and stages of the environmental impact assessment process. This ERD has been prepared to meet the requirements of the Final ESD, which was issued on 8 November 2021.

Modifications to the Proposal since the Referral include modifying and optimising the proposed Muspelheim site, camp and track, the Alfheim and the Proposed Well Site 4 tracks to avoid damp land / marshland and creek lines, to prevent impacts to priority listed flora species and to avoid a heritage site.

Note that the Development Envelope is larger to encompass horizontal drilling of up to five kilometres in length, although they are unlikely to extend beyond three kilometres. The actual surface disturbance footprint will be approximately 112 ha. The disturbance footprint is also fixed at the proposed locations (Figure 1-2) and BNR does not seek flexibility in the proposed disturbance footprint under this Proposal.

2.2 Justification

The previous operator of EP 371 conducted an initial HFS exploration program in 2015. This program included HFS of two wells (Asgard 1 and Valhalla North 1) previously drilled in 2012. In the lead up to, and during, this 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.

The initial exploration program within EP 371 considered differences in hydrocarbon flow rates between vertical zones of the Laurel Formation to identify those formations that provide the best flow rates. The program demonstrated that the Laurel Formation produces high quality wet gas.

The purpose of this Proposal is to further appraise the tight gas resources of the Laurel Formation, in addition to other resources present in the Devonian Formation within EP 371. 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.

The Proposal boundary 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. However, it should be noted that the surface disturbance area, or footprint, will comprise approximately 112 hectares with the disturbance locations fixed as per Figure 1-2.

2.2.1 Proposal alternatives

Several exploration concepts were considered in the final selection and design of this Proposal, including:

- vertical versus horizontal well design
- staging the program
- well testing philosophy
- well site selection.

2.2.1.1 Vertical wells versus horizontal well design

The benefit of horizontal well design is in reducing surface impact—multiple wells can be clustered on a single well site, which allows multiple subsurface targets to be tested. BNR has chosen horizontal well design to limit the environmental footprint associated with this Proposal. As a result, BNR has halved the surface impact by using up to 10 well sites for up to 20 exploration and appraisal wells. However, should a vertical well be considered preferable for appraisal purposes, horizontal drilling may not occur at all well sites or for all wells.

2.2.1.2 Staged approach

As detailed in Section 2.4.1, BNR has separated the Proposal into two phases. The initial phase (Phase I) is to identify the minimum number of wells and spacing throughout the Development Envelope to confirm that commercially viable resources are present. This should be achieved through the drilling of six wells. At the

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 (up to 14 wells) will not be done. By minimising the number of wells required to achieve Phase I objectives, BNR has minimised the potential impacts if Phase II is not implemented.

2.2.1.3 Well testing philosophy

The main options or alternatives to reduce environmental impact associated with this Proposal relate to the well testing operations and the ability to prevent or reduce flaring activities. As detailed in the Greenhouse Gas Environmental Management Plan (GHGEMP) and in Section 5.7, BNR is continuing to investigate alternatives to flaring gas during well testing. The practicability and feasibility of implementing these alternatives will be further clarified as the design of the Proposal progresses.

2.2.1.4 Well site selection

Multiple constraints must be considered when locating well sites, including environmental sensitivities, proximity to social receptors, native title boundaries, and geological prospectivity. BNR conducted ecological surveys to understand the potential environmental sensitivities that have the potential to be impacted. Based on this data, BNR has re-aligned access tracks to prevent impacts to conservation significant species. Optimal well site selection enables environmental impacts to be minimised, as they have been for this Proposal. The entire area of proposed surface disturbance has been covered by flora and fauna surveys. In addition, BNR intends to undertake further pre-construction surveys to ensure that priority flora or fauna will not be adversely affected by this Proposal.

The geological prospectivity of an area is identified by acquiring and interpreting seismic data. This data enables geological prospects to be mapped and the subsequent well locations and appropriate design to be identified. For this Proposal, the underlying geological formations were studied to understand the depth and thickness of the target Laurel Formation, as well as the depth of various formations to useable aquifers. This information is calibrated to data collected from petroleum wells drilled near the Development Envelope, which provides more accurate information on the formation depths.

In accordance with the approach outlined in the EPA Guidance – Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021a) and Procedures Manual (EPA, 2021b), this ERD considers impacts in relation to the proposed well locations within the Development Envelope and includes requirements for continued baseline and ongoing surveillance monitoring at the specific well locations before any disturbance activities occur.

2.3 Proposal location

Table 2-1 lists the coordinates of the Development Envelope; the area is shown in Figure 1-2. Table 2-2 lists the coordinates of the well site locations; these are shown in Figure 1-2. For this Proposal, 2 wells are planned for each well site.

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
9	−18.13102	124.98873
10	−18.15030	125.00193
11	−18.16707	125.01764

ID	Latitude	Longitude
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 well site locations (GDA 94, Zone 51)

Well	Latitude	Longitude
Alfheim	−18.207772	124.882912
Jotunheim	−18.253224	124.787923
Midgard	−18.14258	124.776958
Muspelheim	−18.103833	124.844723
Nidavellir	−18.023477	124.773575
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	125.051452
Vanaheim	−18.213578	124.796585

The Development Envelope is situated in the West Kimberley district. The closest public drinking water source areas (PDWSA) are the Camballin and Fitzroy Crossing water reserves, approximately 60 km west and 51 km east, respectively, of the Development Envelope.

HFS activities within the Development Envelope are supported by the Traditional Owners on whose land the proposed activity 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	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 constructing up to 20 exploration wells within 10 well sites. The intent of the Proposal is to further explore and appraise the extent of the tight gas reservoirs present from the Laurel through to the Devonian Formations, at depths ranging from 2,000 m to 5,000 m below ground level. The main target is the Laurel Formation with hydrocarbon shows present at depths between 2,000 m and 4,000 m below ground level. The total area of the physical disturbance footprint for the Proposal is ~112 ha, which includes some previously disturbed areas. The estimated maximum amount of clearing for the Proposal is <110 ha and comprises: • well sites ~41 ha • access tracks ~62 ha • camps ~3 ha. The exploration and appraisal program is expected to commence in 2024 or 2025.

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

Element	Location	Proposed extent
Physical elements		
Clearing for wells, access tracks and accommodation camps	Figure 1-2	No more than 110 ha
Gas exploration wells	Figure 1-2	No more than 20 wells at 10 well sites
Operational elements		
Water abstraction for process water and camp supply	Figure 1-2	Up to 100 ML per well via groundwater extraction bores
Gas exploration method	N/A	Unconventional (hydraulic fracture stimulation)
Well design	N/A	Vertical wells with horizontal HFS wellbore sections
Hydraulic fracture stimulation intervals	N/A	Up to 70 intervals per well
Water retention pond	Figure 1-2	One pond per well site with a capacity of 114,400 m^3, to hold raw bore water and produced formation water
Well test flare pit	Figure 1-2	One per well site. Based upon availability of equipment at the time, there is the option for a flare stack to combust gas off the separator
Project life	N/A	7 years

2.4 Activity overview

BNR plans to conduct the activities detailed in this Proposal over two phases. Phase I is an initial exploration and appraisal phase with six wells, and Phase II is a further exploration and appraisal phase with up to an additional 14 wells. Section 2.4.1 summarises the activities, which are very similar, in each phase. Sections 2.4.2 to 2.4.5 detail the key work stages and their associated tasks. Machinery and equipment, personnel, and supplies will be mobilised to the well sites and associated camp site.

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 expects that the initial 6-well program is sufficient to achieve these key objectives:

- acquire quality geological data and confirm the validity of target zones for new or further testing
- evaluate the continuity of the regional stratigraphy and integrate information with seismic data

- use the collected data to inform vertical completion and/or horizontal targeting
- perform extended appraisal and testing on the selected zone(s) to determine economic viability of an ongoing drilling program.

The initial six well locations selected are believed to be the most gas prospective and are 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 not proceed.

2.4.1.2 Phase II – Exploration and appraisal

If Phase I indicates commercial production is economically feasible, it will be followed by the Phase II drilling program that will continue to appraise the reservoir and its potential. BNR expects that up to a 14-well program is sufficient to achieve these objectives:

- prove continuity of productive tests from the Phase I program to further develop the economic model of the resource
- test the intervals that showed promise in Phase I but were not able to be fully or definitively tested for any variety of reasons. Given the productive stratigraphic column is >2000 m, it is possible that not all zones of significant interest may be adequately tested during Phase I
- test and evaluate zones of interest in Phase I that were unable to be adequately assessed for various reasons (e.g. drilling or completion issues, timing, weather, logistics, etc.)
- evaluate the operational feasibility and productivity of longer horizontal sections.

2.4.2 Site preparation

Site preparation comprises:

- civil activities including clearing vegetation and constructing well sites
- constructing well site ponds, pits, sumps, and well cellars
- installing groundwater extraction and monitoring bores.

Following pre-construction flora and fauna surveys, native vegetation will be cleared for each well site, associated access track, and for the main workers' camp. Cleared 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 various heavy and light vehicles. A vehicle-mounted diesel tank will be used to refuel these vehicles.

At least two groundwater monitoring bores will be constructed at each site, and data collected prior to drilling activities commencing. This data will be analysed with the baseline data presented in this ERD, in order to inform an updated baseline specific to each well site. The monitoring bores are 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 & DoW, 2016).

Ponds, sumps, and pits will be constructed after the well site is prepared and before drilling activities commence, including:

- ponds and sumps:
  - water retention and produced water evaporation pond
  - 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 (WQPN) (DoW, 2013). All lined storage compounds will have sufficient freeboard (at least 500mm) 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 90th percentile wet season, after allowing for any evaporative water loss and the effects of any water re-use recovering system. Pits will be constructed within the well sites; these 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 hold back the surrounding soils around the wellhead area so personnel can safely work inside this area during drilling and well intervention activities.

Under this Proposal, BNR intends to construct at least two groundwater extraction bores close to or on the edge of each well site. The extraction bores will provide water, as required, for the entire drilling and HFS activities.

2.4.3 Drilling activities

Drilling activities will comprise:

- mobilising the drilling package, ancillary services, rig camp, personnel, and supplies
- conducting drilling activities
- logging activities
- casing and suspending the well or, if required, plugging it.

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

A main workers' camp will also be established. The main workers' camp will house most of the workforce for the duration of activities under the Proposal, and 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. Any spoil generated during the construction of the water bores will be spread in situ—this practice is identical to installing water extraction or monitoring bores in other industries.

Toilet facilities will either comprise mobile anaerobic treatment units (ATU) or septic and leach drain systems. The anticipated average daily wastewater volume is estimated to be <400 L/day at the well site camp and <2,000 L/day at the main workers' camp. If ATU are used, treated wastewater will be disposed of through sprinkler surface irrigation systems; sewage sludge will be stored and disposed of in accordance with regulatory requirements.

To support drilling and HFS activities, diesel will be stored in bulk at the well site. It is expected that storage volumes on site will be ~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 storing chemicals and hazardous materials. In accordance with the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007, a bunded area will 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 drilling 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, then pressure tests will be done to verify the integrity of the casing string. Both the casing and cement will be designed to

withstand the environmental conditions they are exposed to over the life of the well, including following well decommissioning. Figure 2-1 and Figure 2-2 illustrate the indicative well designs for Phase I and Phase II wells, respectively. The vertical depth may change for each well depending on the formation structure and the target interval chosen, and the horizontal length of any laterals may vary up to 5,000 m maximum length, although they are unlikely to be longer than 3000 m. Drilling is likely to be conducted 24 hours per day.

Throughout the drilling process, data relating to the subsurface geology will be constantly collected, reviewed and assessed to better understand the geology and to inform drilling decisions. Through this process, specific fault zones concerns will be identified and steps taken, including if required, the cessation of drilling and the shutting in of that well, to ensure potential adverse impacts to the environment are kept ALARP.

Once the petroleum wells reach total depth and the target formation evaluated using wireline logging, the final casing string is cemented in place. This method measures the downhole properties and attributes of the Laurel Formation. If technical issues occur during the drilling activity, contingency activities may be required, which may include restarting (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 and if required, the wells will be prepared for perforation, HFS treatment, and well testing. The wells will be suspended before any of these activities are conducted. During suspension, the well sites will be regularly inspected and maintenance works undertaken as necessary.

While this project covers exploration and appraisal only, should a commercially viable resource be found, it is recognised that any of these wells may form part of a production program in the future. ISO Standard 16530-1:2017 will be adhered to throughout the planning, construction, testing and decommissioning phases to effectively manage well integrity during the well life cycle. All conditions placed on the approved well management plans and drilling approvals will be met, including daily reporting to DEMIRS of pressures and drilling fluids during well activities. This would ensure that well integrity would be continuously monitored so that any well integrity anomalies or failures could be immediately identified and addressed. The well management plans will address:

- organizational structure and tasks related to well integrity management
- well barriers / performance standards
- monitoring and surveillance requirements
- annulus pressure management
- well barrier maintenance requirements
- risk assessments for well barrier failures
- reporting and documentation of well integrity activities
- periodic well reviews.

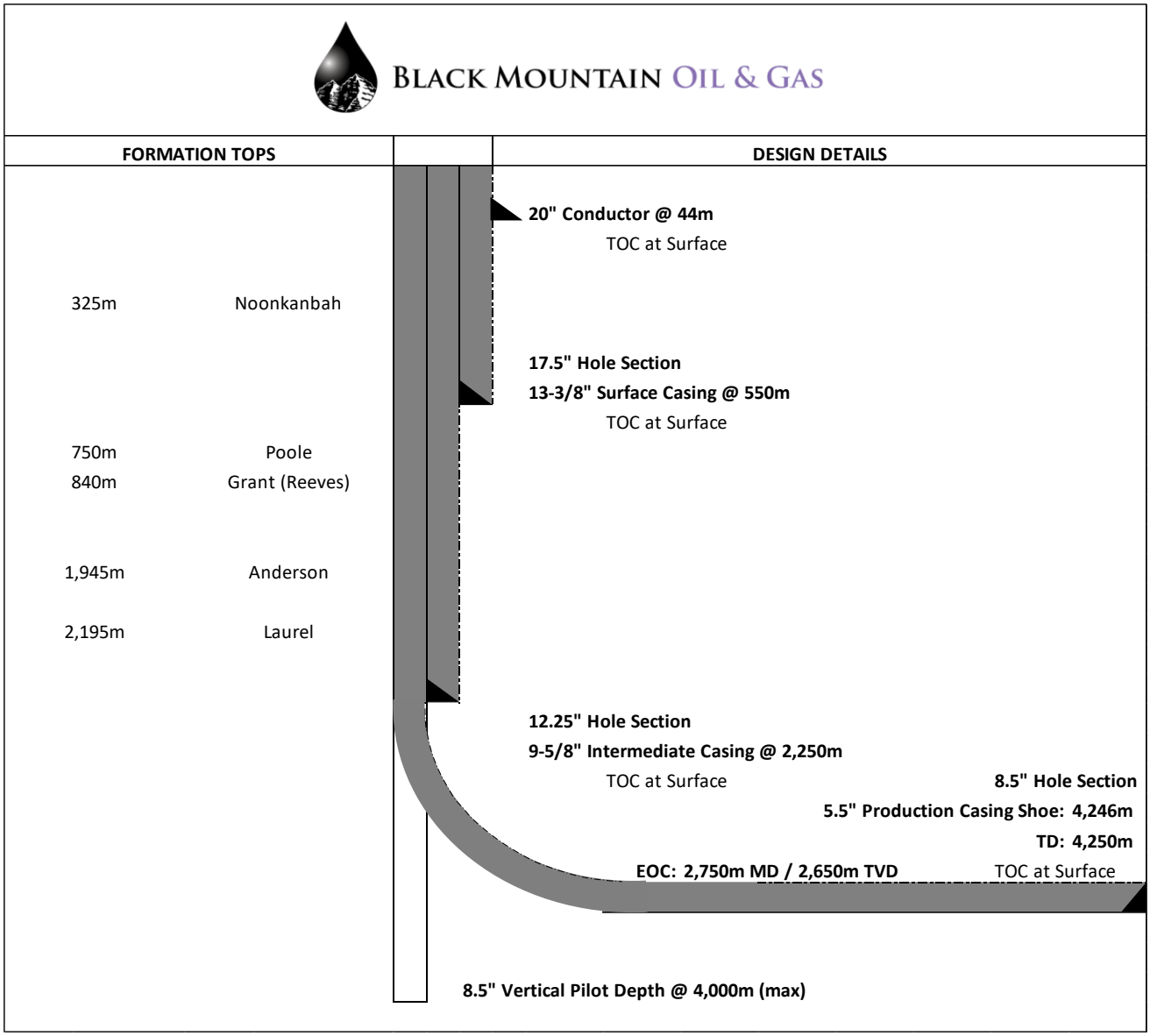


Figure 2-1: BNR Phase I indicative well design

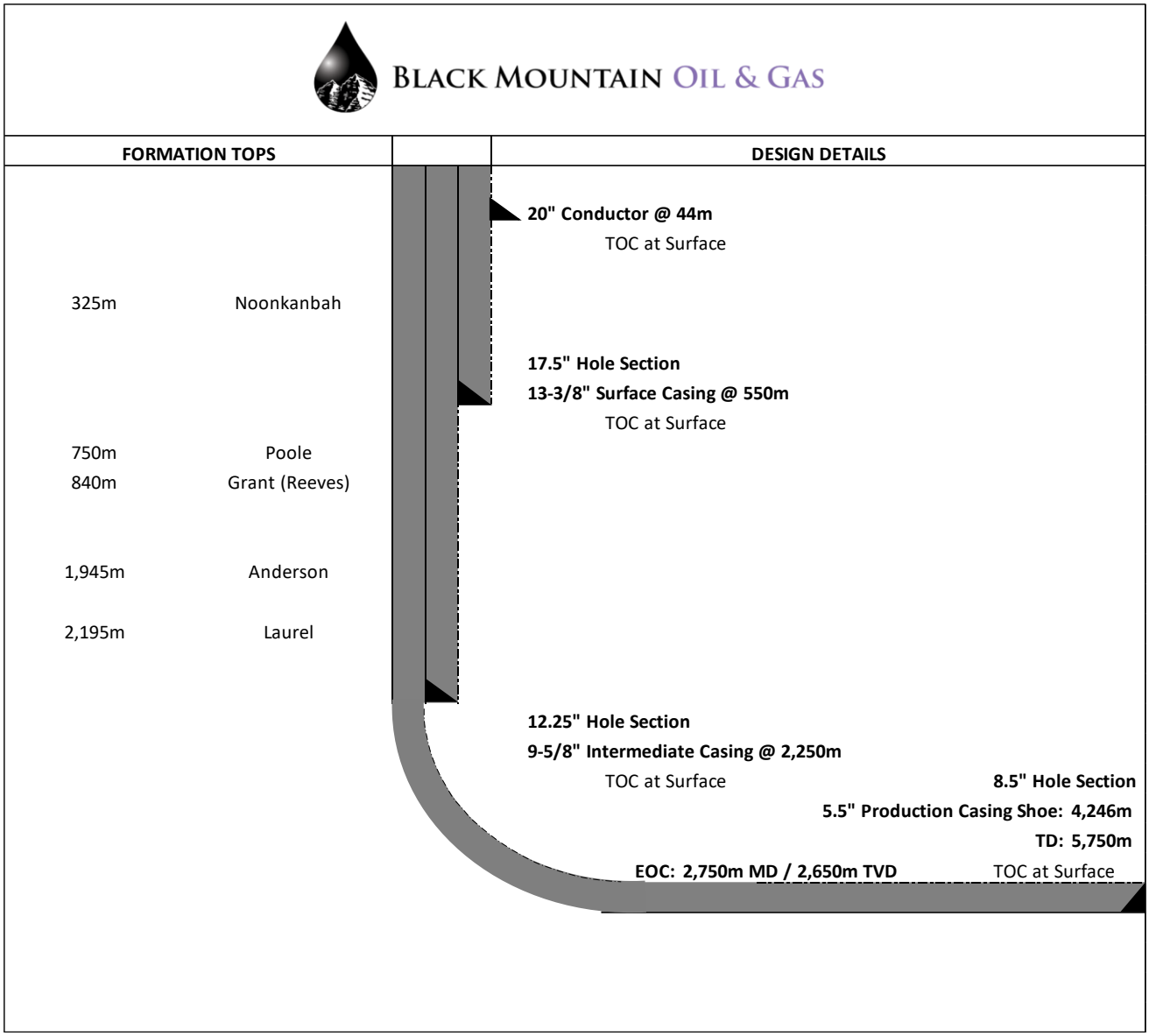


Figure 2-2: BNR Phase II indicative well design

2.4.4 HFS activities

HFS activities comprise:

- mobilising HFS spread (equipment), personnel and supplies
- well perforation and clean-up
- HFS treatment
- well testing
- well suspension.

Once the wells are constructed and their integrity is independently validated, the HFS spread, packages, and supplies are mobilised to site. Figure 2-3 shows typical surface infrastructure that may be required for the Proposal. Approximately 70 personnel are expected to be located at a single well site during HFS activities. The HFS spread comprises 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 their integrity before HFS commences.

Figure 2-3: Typical HFS layout

Once the integrity of equipment has been verified, any plugs that 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. If required, the casing will be perforated at selected intervals, which are currently expected to be 2–100 m apart.

After well perforations are complete and the well is cleaned up, HFS can 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 ~2% of the HFS fluid composition—the system proposed to be used is described in Section 2.4.4.1 and detailed in Appendix A. In accordance with the PGER(E)R, the chemical composition of the downhole fluid system will also be assessed by DEMIRS.

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, the well location and the reservoir response following testing, the wells may receive up to 70 treatments.

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

The entire well testing manifold—from the well to a water retention pond and flare—are a closed piping system. During well testing, reservoir fluids, including produced gas, are flowed back to the surface, and directed through 3-phase separators (if required) where water, condensate (if present), and gas are separated into their respective phases (Figure 2-4). The fate of the three reservoir fluid phases is:

- gas: any gas is routed to the well test flare, where it is flared off

- condensate (liquid): based upon previous characterisation of fluids, low volumes of condensate are expected to be produced (<25 bbl); this will be routed to the well test flare and flared off
- water: formation water produced from well testing is stored in a designated lined water retention pond and left to evaporate.

The volume of flowback / produced water is estimated to be in the order of 8 ML per well during the testing phase, however for the purposes of planning pond sizes, extremely conservative figures have been used by assuming a 70 per cent recovery of approximately 57 ML per well. An overview of water volumes and proposed uses (site balance) is included in Section 2.4.5.

Well testing runs for 24-hours a day and is expected to continue for several months. However, at any time during testing, activities may cease to allow equipment to be serviced or a change to occur. BNR has estimated that to collect the required data the well must flow during the period of maximum gas concentration for up to 90 days, which may also occur in stages.

The volume and type of fluid coming back to surface will be monitored and recorded—these data will be essential for determining the quality of the reservoir. Sections 5.4 and 5.8 have more information about the characterisation of formation water produced from well testing.

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

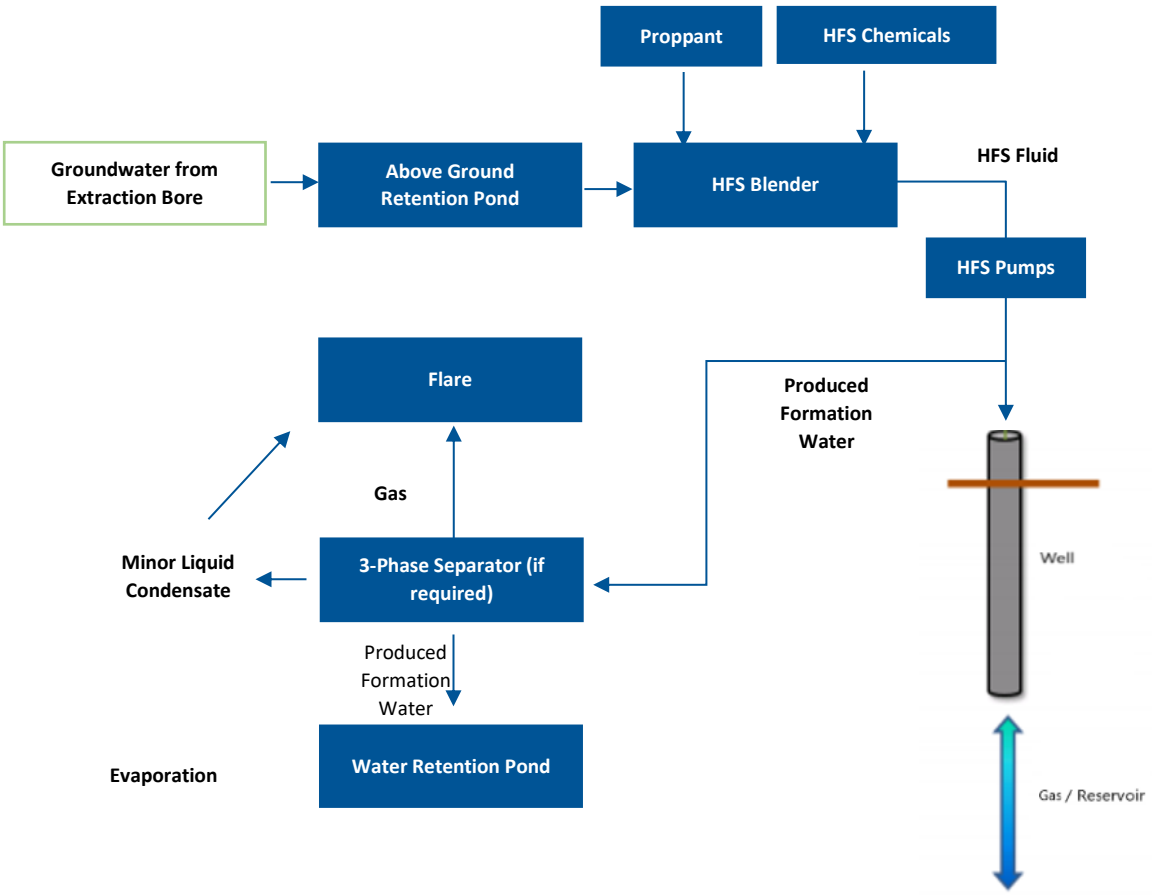


Figure 2-4: Fluids and gas cycle during HFS

2.4.4.1 HFS fluid composition

The types and use of HFS fluids have evolved greatly over the last 60 years and continue to evolve due to the investment of significant research effort. This has led to the development of 'green' HFS fluids that optimise environmental objectives and outcomes. One of these is Halliburton's CleanStim Aus® HFS fluid system, which is proposed to be used for this program. Ecotoxicity testing of the combined fluid system was

previously undertaken by the previous operator and demonstrated that the fluid system is of very low toxicity (Buru Energy, 2018).

A chemical inventory for the HFS fluid system is included as Appendix A.

2.4.5 Water Balance

BNR has developed a simple site water balance table to inform the risk assessment documented in Section 5. This water balance is simply divided into three tables that detail water use on a per well basis (Table 2-5), per well site basis (Table 2-6) and on a program basis (Table 2-7).

On the expectation that BNR plans to execute up to four wells in a single year:

- the total groundwater abstraction per year up to 400 ML (using a conservative estimate of 100 ML/well)
- the total volume of flowback / produced water managed per year would be up to 32 ML (8 ML/well), however for the purposes of this water balance, a 70 per cent recovery rate has been used, of up to 228 ML/year (this level of recovery normally takes around three years).

Water use figures have been conservatively estimated to be:

- 2000 ML total water use for the full exploration Proposal (calculated at 1820 ML, rounded up to 2000 ML for a conservative estimate)
- average water use per annum: 260 ML (on the basis that, while four wells can be constructed in one year, that will not be the case every year)
- maximum water use per HSF event: 1.6 ML per stage
- maximum water use per well: 100 ML (calculated at 91 ML, rounded up to 100 ML for a conservative estimate)
- camp use (potable, dust suppression, processing, etc, per well): 0.6 ML
- total maximum water use per well site: 182 ML, rounded up to 200 ML for a conservative estimate
- total produced water and flowback water volumes per well / well site: 8 ML/16 ML (however, for the purposes of this site water balance, a 70 per cent produced water recovery has been used, so 57/114 ML)
- total produced water and flowback water volumes for the whole project during the testing phase: 160 ML (although using the conservative figure of 1140 ML)
- site water balance: 317 ML per site, using conservative figures (see below).

Table 2-5: Site total water balance (per well)

Element	Initial Storage	Initial Volume	Expected final volume (for design purposes)	Final storage
Drilling water	Water retention pond [1]	100 ML	100 ML	Mud sump
Flowback / produced water during HFS Stimulation	Assuming 1 ML of groundwater (Liveringa) + 0.1 ML of produced water (Laurel) (per stimulation event and 70 stimulation events per well			
	Water retention pond	8 ML	57 ML	Water retention pond
Camp	Assuming 160 L per person per day, 50 people onsite for a period of 75 days per well			
	Onsite / offsite storage tanks	0.6 ML	0	N/a
Dust suppression / other	Water retention pond	< 1 ML	0	N/a

[1] Water used during the drilling phase is transferred from the water retention pond to the mud sump during drilling activities (where drill cuttings and drill fluids are stored).

Element	Initial Storage	Initial Volume	Expected final volume (for design purposes)	Final storage
Site total water balance for a single well at a single wellsite		158.6 ML (conservative)		

Table 2-6: Site total water balance (per wellsite x 2)

Element	Initial Storage	Initial Volume
Drilling water	Water retention pond [2]	200 ML
Flowback / produced water during HFS Stimulation	Produced water pond	114 ML[5]
Camp	Onsite/offsite storage tanks	1.2 ML
Dust suppression / other	Water retention pond	<2 ML
Site total water balance for two wells over multiple years		317 ML

Table 2-7: Site total water balance (entire program x 20)

Element	Initial Volume (per well/one year)	Total Volumes (for 20 wells over 7 years)
Drilling water	100 ML	2,000 ML
Flowback / produced water during HFS Stimulation[3]	8 ML	1140 ML[4]
Camp	0.6 ML	12 ML
Dust suppression / other	1 ML	20 ML
Site water balance over 7 years and 20 wells		3172 ML[5]

2.4.6 Site reinstatement/decommissioning

Site reinstatement/decommissioning comprises:

- suspending or shutting in the wells
- plugging decommissioned wells permanently with multiple concrete plugs (in accordance with DEMIRS accepted Well Management Plan) to ensure the reservoir is sufficiently separated from aquifers and the surface (Section 2.5.1.2)
- removing all infrastructure from the sites (with the exception of any material as requested by, and agreed with, the pastoral station landholders)
- sampling pond and sump contents (liquids and solids) to ensure contamination has not occurred, and to address any contamination issues
- sampling soil beneath pond liners following their removal, to ensure contamination has not occurred, and to address any contamination issues
- evaporating, draining if necessary, and backfilling ponds, sumps, and pits
- ripping and contouring hardstands as required

[2] The second wellsite will only be drilled where the pond has capacity to support an additional well. Wells (on the same wellsite) may be drilled 1-2 years apart to enable water contents to evaporate. Ponds are designed to sufficiently manage water requirements from a single horizontal well.

[3] Flowback water will include water present in the reservoir, but mostly comprise water initially pumped into the reservoir during HFS process. Although this water has been "double counted" here in reality, the site balance will likely comprise Drilling water (2000 ML) – Flowback water (1140 ML).

[4] Note, this figure provides for a 70% recovery over the life of the Program.

- respreading topsoil and stockpiled vegetation.

If installed site infrastructure is no longer required after all site activities are completed, then where appropriate, infrastructure will be demobilised and any areas of disturbance will be reinstated in accordance with any land access agreements (as required under Section 20 of the PGER Act). Specifically, it is expected that sites be returned to the pre-industry land use of the pastoral stations dedicated to cattle rearing and as agreed with the pastoral station landholders.

Prior to decommissioning/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 flare to verify contamination from CoPC has not occurred.

Soil samples will be compared to site baseline results and relevant screening levels, in accordance with Section 5.2.3.2. During decommissioning/reinstatement, any soil, drilling fluid solid waste, drill cutting subsoils, etc. that do not meet landfill guidelines will be removed and disposed of at an appropriate waste disposal facility.

Before liners are removed, fluid contained within water retention ponds, sumps, and pits will be left to naturally evaporate with any remaining residue removed and disposed of at an appropriate water disposal facility. Any previously excavated areas will be reinstated using backfilled stockpiled topsoil, with any remaining vegetation spread over this area.

2.5 Well lifecycle and well integrity

2.5.1 Well lifecycle

Figure 2-5 summarises the lifecycle of an indicative well. No production phase is proposed under this Proposal. At the end of the activity, the wells will either be decommissioned (provided for within this Proposal) or suspended to enable for future development. While this project covers exploration and appraisal only, should a commercially viable resource be found, it is recognised that any of these wells may form part of a production program in the future. ISO Standard 16530-1:2017 will be adhered to throughout the planning, construction, appraisal and decommissioning phases in order to effectively manage well integrity during the well life cycle. Any and all conditions placed on the approved well management plans and drilling approvals will be met, including daily reporting to DEMIRS of pressures and drilling fluids.

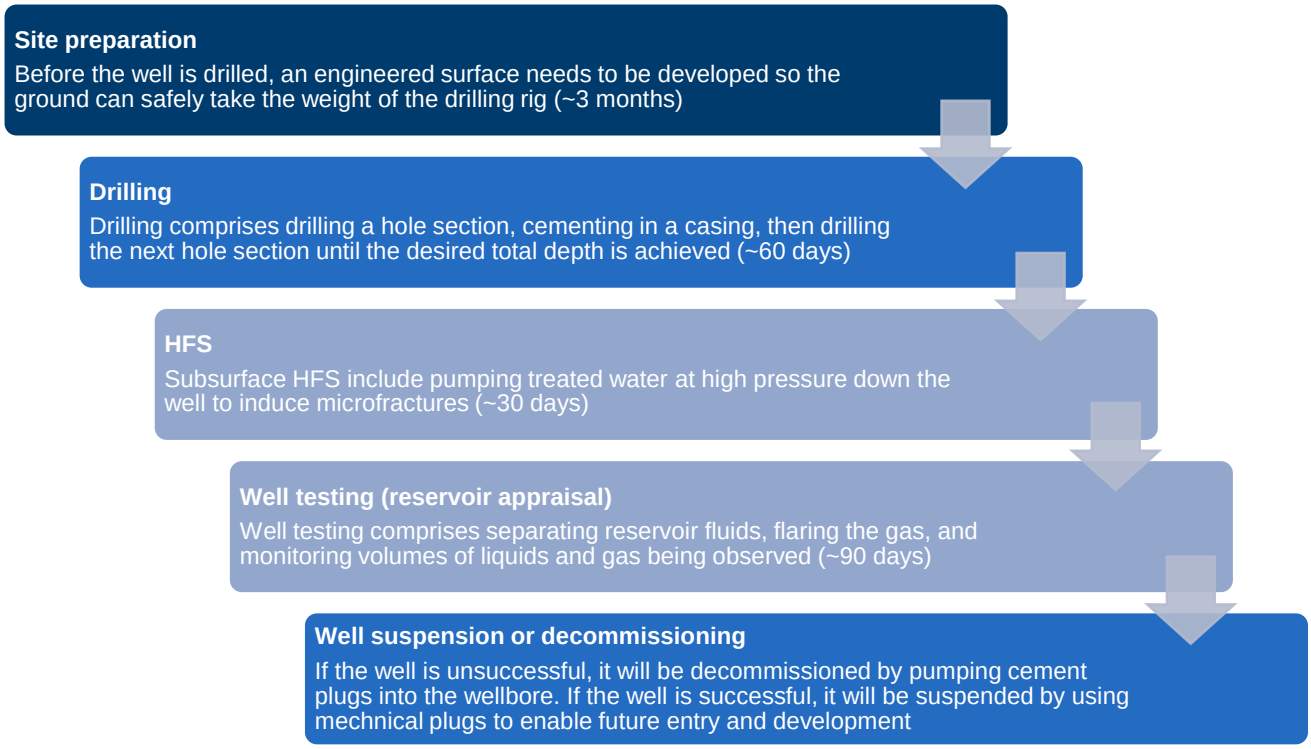


Figure 2-5: Well lifecycle under this Proposal

2.5.1.1 Well suspension

If the evaluation confirms the well is successful, the well will be suspended (casing will be installed and cemented to the surface) to enable potential future reservoir evaluation and other activities. The well site will enter into a care and maintenance phase until the future works program is developed and approved under separate and subsequent Part IV EP Act Ministerial Approvals.

As all site infrastructure may be retained, a care and maintenance regime will ensure the integrity of existing equipment is maintained. During this phase the well site will be monitored and inspected at least annually to ensure ongoing compliance with the site risk management commitments of the well integrity plan and any other environmental approvals under the *Petroleum and Geothermal Energy Resources Act 1967*. Site inspection will typically involve a visual inspection of all infrastructure on site including the mud sump liner integrity. Should any issues of non-compliance be identified during the site inspection, the required actions to remedy such non-compliance issues will be documented and tracked until closure.

2.5.1.2 Well decommissioning

If the evaluation confirms the well is not successful, the well will be plugged back with cement as per the regulatory approved well decommissioning program. A preliminary well decommissioning plan will be included in the Well Management Plan, with the final plan approved by DEMIRS under the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 based on the actual results of the drilled well prior to commencement of the well decommissioning process. Specifically, the well decommissioning objectives and activities that would be undertaken under a typical scenario include the following:

- install the barrier cement plug (plug #1) above the top of any zones containing moveable hydrocarbons to isolate the well above from the hydrocarbon zone
- install an intermediate cement plug (plug #2) to isolate any open annulus in the well from the surface
- install a surface cement plug (plug #3) to permanently isolate the well from the surface environment.

Cement plug thickness is normally a minimum of 30 m for a single barrier and 60 m for common / combination barrier (excluding any length across the zone with flow potential). Once the well is plugged with cement, the wellhead and cellar are left in place, and the drilling package demobilized from site. Removal of the wellhead and cellar will occur following departure of the rig to coincide with other civil works activity being undertaken at the site.

2.5.2 Well integrity

As previously mentioned in Section 1.4.3.2, and in accordance with ESD Item 14, BNR will manage its wells throughout their lifecycle under a well integrity management system ISO Standard 16530-1:2017).

The lifecycle of a petroleum well comprises several stages, which may be conducted at any time depending on the well status and the outcomes of the petroleum activities. A risk assessment will be undertaken for each of BNR's wells during each stage of the well lifecycle to ensure well integrity is maintained. This risk assessment will include a multidisciplinary team of personnel with different perspectives and knowledge of the Proposal activities and the Development Envelope. The risk assessment team will include personnel with drilling, environmental, health and safety expertise. The risk assessment process will be detailed in the WMPs and will involve:

- identifying the potential well integrity risks associated with the wells, including casing failure
- reviewing the causes of each risk as they apply to the well along with the preventative controls. The preventative controls for each well will be determined based on a review of available information as described in each well's well integrity workbook. The consequences of each risk event will be defined along with recovery controls should the risk eventuate
- determining the likelihood of each risk occurring through company and industry experience along with the consequences should the risk eventuate. Risks will be considered in terms of health and safety, environment, community and heritage, well activities and financial and reputational criteria with the highest risk from these criteria adopted
- an assessment to determine if each risk will be ALARP will also be undertaken, based on the current well status and the BNR's safety management system.

The following performance objectives will be in place for well integrity for each phase of the well's lifecycle:

- no contamination of recognised aquifers with reservoir fluids
- no release of reservoir fluids at surface.

These performance objectives will be met through the requirement to ensure that two barriers are in place in the wells through useable aquifers at all times. Should one of the barriers be breached, the following actions will occur:

- well will be shut-in immediately upon determining a well barrier element has failed
- well will be monitored by the field team and well pressures and surface conditions will be documented
- a risk assessment will be performed and well barriers will be reviewed
- in line with industry regulations, DEMIRS will be notified
- DEMIRS and BNR will determine an agreed upon path forward for remediation or decommissioning of the wellbore
- remediation will occur (and will vary in nature depending on which specific well barrier element has failed), it's expected that this will include:
    - isolation of the failed well barrier element
    - installation and test of temporary barrier (to maintain dual barriers)
    - removal or remediation of failed well barrier element, such as (but not limited to):

        - removing failed surface valve and installing a replacement valve
        - pumping a cement squeeze
        - installing a casing patch
        - pulling, and replacing wellhead seal assemblies
    - pumping kill weight fluid and bull heading the well
    - verifying and testing the remediated / new barrier
    - removing temporary barrier
- should the remediation be deemed unsuccessful or if the system no longer meets well integrity requirements, the well will be decommissioned
- should the remediation be successful, the well will be returned to its previous state (shut-in, producing, etc.)

In addition, geotechnical risk assessments will form part of the core workload during the Proposal. While earlier seismic surveys have highlighted the presence of faults and fractures, it is expected that additional ones, that are not able to be identified through seismic surveys, may be found as the wells are constructed. As the wells are being constructed, the subsurface geology will be constantly reviewed and assessed against other data sources. BNR will utilise collected data to ensure well seal effectiveness in providing a suitable geological seal between useable aquifers and targeted formations.

Given the information gathered to date through seismic surveys and earlier well construction, it appears that faults in this area are closed and strike in a direction that is approximately orthogonal to the maximum horizontal stress. Although they may negatively impact on fracture propagation, they pose no geomechanical hazard for upward propagation of fracturing fluids or hydrocarbons into the recognised aquifers as the activation energy required to delate faults or fractures in tension will be higher than overburden, which means the fracture growth would rotate to horizontal before opening such faults in tension (Appendix B).

2.6 Waste characterisation and management process

BNR is committed to ensuring that all Proposal activities have minimal impact on the environment and existing land users. Waste is defined as any substance that is rejected, unwanted, surplus, or abandoned and is discarded, emitted, or deposited to the environment. It is BNR's legal responsibility to minimise and appropriately manage all wastes generated by its activities. As such, BNR has defined and will apply a waste management process for the duration of the Proposal.

As part of its waste management strategy, a waste characterisation was undertaken, where all aspects of the Proposal were examined to identify and characterise waste products generated from each well site. Any controlled waste will be stored, transported, and disposed of in accordance with the Environmental Protection (Controlled Waste) Regulations 2004 and *Radiation Safety Act 1975* (WA). Table 2-8 summarises the various types of waste generated from each well site and the management methods and controls that BNR intends to implement.

BNR has an Indigenous Land Use Agreement (ILUA) and a Land Access and Use Agreement (LAUA) in place with the landowners, the Yungngora and the Warlangurru People, respectively. The land use agreements state that BNR should keep each activity site clean, tidy and free from waste, and that BNR agrees to take all reasonable precautions to avoid any contamination, pollution, or material environmental harm to the landowners' countries, including to any groundwater or watercourse on the owners' land. BNR will continue to comply with conditions set out in these agreements.

In addition, given seasonal rainfall patterns, all on site waste prior to disposal at an appropriately licensed facility, will be stored in such a way that risk of contamination through a major flood event will be reduced to ALARP. An assessment of flood risk to the project identified that the proposed well sites are higher in the landscape than Fitzroy River flood levels in a 1:100-year event, such as that which occurred in January 2023.

Table 2-8: Well site waste characterisation

Proposal waste products	Landfill class[5] (DWER, 2019)	Proposed management, storage, and disposal methods
Oily waste (liquid and solid)	Hazardous waste	As controlled waste, oily waste will be placed into empty oil drums within a bunded area and removed from site for disposal at an appropriately licensed facility by a licensed waste disposal contractor, in accordance with the Environmental Protection (Controlled Waste) Regulations 2004.
Wastewater	N/A	If there is a risk of contamination, wastewater generated from clean-down of equipment will be contained and transferred to the mud sump. If there is no risk of contamination and fresh water is used, it may be released to the environment.
General waste including food waste, plastics and rubber products, empty mud and cement product sacks, etc.	Putrescible waste Inert waste (Recyclable material[6])	Placed into general waste rubbish skips with lids or net covers and removed from site for disposal at an appropriately licensed facility by a licensed waste disposal contractor.
Hydrocarbon waste (oily rags, empty hydrocarbon containers etc.)	Hazardous waste	As controlled waste, hydrocarbon waste will be placed into hydrocarbon waste rubbish skips with lids and removed from site for disposal at an appropriately licensed facility by a waste contractor, in accordance with the Environmental Protection (Controlled Waste) Regulations 2004.
Steel scrap (including steel casing protectors and drill line)	(Recyclable material[4])	Stored in a central area after use. Subsequently placed into steel bins and removed from site for disposal at an appropriately licensed facility by a licensed waste disposal contractor.
Wooden pallets and other timber goods	Putrescible waste	Recycled where practicable. These will be stacked onsite or placed into timber-waste rubbish skips (as appropriate) and removed from site for disposal at an appropriately licensed facility.
Sewage	Putrescible waste	Sewage will be managed and treated using ATU or a septic system with leachate drains, in accordance with the Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974. Disposal of the treated effluent will either be through offsite surface irrigation or through the leachate drains, in accordance with WA Department of Health (DoH) requirements. Sewage sludge will be stored on site in sealed tanks and removed from site for disposal by a licensed waste disposal contractor.
Metal drums (uncontaminated)	(Recyclable material[4])	Stored in a centralised location as well as in a steel-waste skip and removed from site for disposal at an appropriately licensed facility by a waste contractor.
Cuttings and muds	Inert waste	Stored onsite in the mud sump. When drilling is completed, cuttings and muds will be tested before the site is reinstated. Disposal options will be informed by the presence of contaminants in comparison with acceptable regulatory limits. BNR will sample for chemicals of potential concern (CoPC). These concentrations will be assessed to understand the potential for contamination on site against existing baseline samples, consistent with the National Environmental Protection (Assessment of Site Contamination) Measure 2013, and considers ecological investigation levels and waste concentration thresholds (Section 4 of the Landfill Waste Classification and Waste Definitions 1996 (DWER, 2019). Where evidence shows that the waste will not pose an unacceptable risk to human or ecological receptors, or environmental values in the nearby vicinity (as provided by an independent subject matter expert), this material may be used as fill in situ by interring beneath a minimum of 2 m of clean overburden. If no significant volumes of produced 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

[5] As per the Landfill Waste Classification and Waste Definitions 1996 under the EP Act.

[6] Although recyclable material is not defined in the Landfill Waste Classification and Waste Definitions 1996 under the EP Act, BNR has included it in this table for consideration.

Proposal waste products	Landfill class[5] (DWER, 2019)	Proposed management, storage, and disposal methods
		available, consequently reducing any impacts and risks associated with legacy waste sumps to ALARP.
Produced formation water (HFS waste)	Hazardous waste	Formation water produced during well testing will be stored in lined water retention ponds on site and left to evaporate.
Gas and condensate (HFS waste)	Hazardous waste	Once passed through 3-phase separators, it is expected that gas and liquid condensate be flared off.
Radioactive waste	Hazardous waste	Drill cuttings and produced formation water produced during drilling, well testing and HFS activities have the potential to contain naturally radioactive substances. Concentrations of CoPC will be sampled and monitored to determine if cuttings can be disposed to the environment, produced formation water evaporated, or if other disposal options such as removal from site are required. Management of these wastes will be managed in accordance with the requirements of the Radiological Council and the Radiation Safety (General) Regulations 1983.

2.7 Local and regional context

As detailed in Figure 5-1, the Development Envelope does not overlap any environmental sensitivities (such as Ramsar wetlands, conservation estates, or PDWSAs). As detailed in Section 5.5.3, the Development Envelope overlays two pastoral stations (leased Crown land)—Blina Station and Noonkanbah Station—that are leased 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 current and upcoming activities.

The well locations are 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 Aboriginal communities (Figure 1-3), which are tens of kilometres from the Development Envelope.

BNR has searched for and found no other proposed development activities near the project area.

Given the remote location of the Proposal and distance from highly sensitive environmental factors, BNR believes that the Proposal fits within the regional land use and complements future development in the Kimberley. It will provide employment opportunities for the local community and the local community fully supports the project.

3 Stakeholder engagement

3.1 Stakeholder identification and engagement process

In accordance with DEMIRS' Guideline for the Development of Petroleum and Geothermal Environment Plans in Western Australia (DMP, 2021), BNR applies the following consultation methodology for all of its activities associated with the Proposal:

- identify relevant and interested stakeholders
- determine how to undertake meaningful engagement
- provide sufficient information to ensure the stakeholder is informed
- address any objections or claims raised.

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

3.2 Key stakeholders

The Development Envelope is within the SDWK in the broader West Kimberley region. It is characterised by semi-arid rangelands, which are areas of open country used by pastoralists and Traditional Owners for various activities, including grazing cattle and hunting and collecting bush foods.

Section 5.5 describes the social context, surrounding land use, Aboriginal communities and regional towns. In summary, the Development Envelope overlays:

- two pastoral stations (leased Crown land)—Blina Station and Noonkanbah Station
- two registered native title groups, the Warlangurru people and the Yungngora people (Figure 1-3).

DEMIRS provides the following definition of stakeholder relevance to support stakeholder engagement for petroleum activities (DMP, 2021):

> *'any person or organisation whose functions, interests or activities may be affected by the proposed activities'*.

Consequently, BNR believes that relevant stakeholders are those whose functions, interests, or activities have the potential to be directly affected by the Proposal; therefore, the stakeholders for this Proposal are limited to:

- Blina Station
- Noonkanbah Station
- Warlangurru People
- Yungngora (Noonkanbah) People.

3.2.1 Pastoral stations

The Canning Basin is covered by rangeland ecosystems. Land uses within the Fitzroy River catchment include 95 per cent pastoralism (cattle grazing), with nature conservation and Indigenous Protected Areas covering the remaining areas. In 2018, the gross value of agricultural production was $77 million/year, predominantly from cattle (Merrin, Addison, & Austin, 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, 2014), 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)—Blina Station and Noonkanbah Station—that are leased for pastoral grazing purposes.

3.2.2 Pastoral station engagement

Consultation with both stations has occurred consistently over the life of EP 371. BNR continues to keep the station owners informed of activities undertaken onsite and those planned for the future. Specifically, notifications are provided prior to accessing the pastoral station(s).

Engagement to date has identified a couple of key themes of interest including:

- Proposal footprint (and impact to grazing land)
- water source / contamination
- impacts to mustering
- ability to utilise infrastructure on completion of the activity (such as bores).

BNR continues to address these themes during engagement with the station owners in accordance with the assessments provided in this document.

3.2.3 Native title groups

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).

3.2.3.1 Native title group engagement

Consultation with relevant native title groups has occurred at a pace dictated by the Traditional Owners and translators have been used where required. This has allowed Traditional Owners time to digest the information provided, discuss it with their community, and make informed decisions. Engagement with the Yungngora Community (Yungngora and Warlangurru people) 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 Yungngora 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. Figure 3-1 is an example of the Gas Roadmap as it relates to economic development (training, employment, and contracting) with the Yungngora Community.

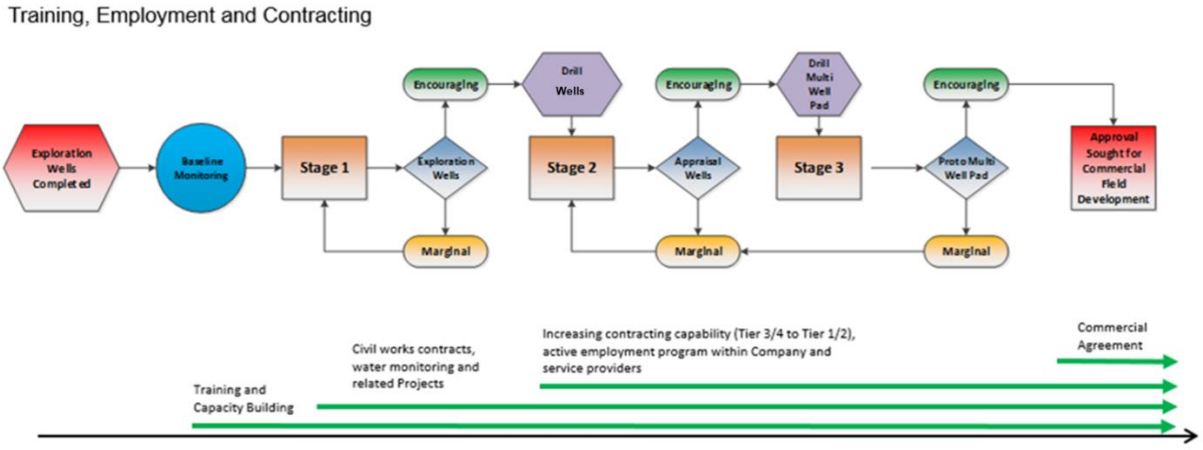


Figure 3-1: Example of Yungngora Community gas roadmap relating to economic development opportunities

During the Inform/Consult phase of engagement, an independent specialist review process was used to enable the Yungngora Community to make an informed decision about HFS activities on EP 371. This process provided access to advice from independent experts in the fields of groundwater, petroleum engineering, HFS-specific risks, and community engagement with Traditional Owners.

The Yungngora people selected their own independent specialists, who were given access to all relevant approvals documents and who reviewed the proposed activities, specifically HFS activities. The previous operator provided funding for the review, but the reviews were undertaken independent of that 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 2015 HFS program would have very low risk to the environment and social values. 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 the native title groups. Specifically, BNR has 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 agreements also focus on employment and training opportunities for the Traditional Owners.

BNR continues to engage with the native title groups regarding the HFS activities associated with the Proposal throughout the Inform/Consult phase of engagement. BNR provides regular updates to Yungngora Aboriginal Corporation, Warlangurru Aboriginal Corporation, and the general community. This is done in a way that is consistent, culturally appropriate and respectful to the Traditional Owners, and as required by the Traditional Owners.

As detailed above, the operators of EP371 have had a long history of engaging with the Traditional Owners. All of the engagements over this time have not been summarised in this document, however this should be acknowledged given the engagement over this period has been foundational to support the strong relationships and subsequent support for the Proposal. A summary of the most recent engagement (relating to this proposal) is provided in Section 3.4.

3.3 Interested stakeholders

BNR also actively engages with relevant government departments, industry associations, and other stakeholders who operate in the broader region, including:

- WA Environmental Protection Authority (EPA)
- WA Department of Mines, Energy, Industry Regulation and Safety (DEMIRS)
- Commonwealth Department of Climate Change, Energy the Environment and Water (DCCEEW), formerly the Department of Agriculture, Water and the Environment (DAWE)
- WA Department of Water and Environmental Regulation (DWER)
- WA Department of Primary Industries and Regional Development (DPIRD)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Shire of Derby / West Kimberley (SDWK)
- other oil and gas operators
- Kimberley Development Commission
- Regional Development Australia
- Kimberley Pilbara Cattlemen’s Association
- Pastoralists and Graziers Association

- Derby Chamber of Commerce and Industry
- Fitzroy Crossing Business Network
- Australian Petroleum Production and Exploration Association.

Meeting in person is the preferred method of engagement with stakeholders. However, this was not always possible during 2020 and 2021 due to the COVID-19 pandemic and associated travel restrictions. Therefore, engagement was primarily by phone, videoconference, and email. After the WA Government eased COVID-19 restrictions, follow-up meetings were held with those based in the Kimberley region.

Effective engagement is supported by maps and other information relating to the scope of the referral and the potential environmental risk or 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 had been raised by consulted stakeholders. On the contrary, the Traditional Owners are keen to see this Proposal implemented.

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

3.4 Engagement throughout the ESD process

Given the nature of the Proposal, and as this assessment is the first of its kind since the moratorium on hydraulic fracturing was lifted in September 2019, BNR has engaged closely with government agencies and decision-making authorities in developing monitoring programs, frameworks and processes that form the basis of this ERD. Table 3-1 summarises the engagements that have occurred since February 2021. Further Stakeholder engagement since 2023 has also been included in Table 3-1.

Table 3-1: Recent engagements with various stakeholders

Stakeholder	Method of engagement	Date of engagement	Summary of engagement
YAC	In person	28 March 2023, YAC Board meeting and AGM	Participation in the meetings and provision of a project update.
EPA Services	Teams meetings	2 Feb 2023 8 Feb 2023 1 Mar 2023 5 July 2023	Discussions on components of draft ERD to be updated and improved, including options to revise DE size and address flora and fauna survey requirements. BNR advised to demonstrate uniformity of vegetation associations to better validate survey results (covering the whole proposed disturbance footprint) and reduce uncertainty.
DWER	In person meeting	12 June 2023	Validation of groundwater monitoring data. BNR advised that data already provided from monitoring bores AB1S, AB1D, VNB4S and VNB4D, plus data from the YG2/18 well, would be acceptable providing drilling and completion data or results from a camera down hole could be provided.
DCCEEW	Teams meeting	10 Aug 2023	Earlier advice from the Commonwealth had been that this project was not required to be referred. BNR has continued to engage with DCCEEW to reiterate that the environmental impacts associated with the Proposal do not result in any direct or indirect mechanisms that would cause a significant impact to matters of NES protected under the EPBC Act.
DoC	Email	5 Sep 2023	Authorisation for data from bore YG2/18 to be disclosed to DWER.
DEMIRS	Teams meeting In person meeting	13 April 2023 19 September 2023	Discussion on project and approval processes.
DoH	Email	03 Jan 2022	BNR requested a brief review of the HHRA that was internally prepared while waiting for the consultant peer review.

Stakeholder	Method of engagement	Date of engagement	Summary of engagement
		10 Jan 2022	DoH responded and agreed with BNR's conclusion that no further HHRA is required.
Shire of Derby-West Kimberley	Email	23 Dec 2021	BNR provided an overview of petroleum activities planned to be undertaken within EP371 in 2022. Offered the opportunity to provide more information should it be required
Blina station pastoralists	Email	23 Dec 2021	BNR provided an overview of petroleum activities planned to be undertaken within EP 371 in 2022. Offered the opportunity to provide more information should it be required
WAC AGM	In Person	6 – 8 Dec 2021	BNR attended the WAC Annual General Meeting BNR discussed various regulatory approvals including Valhalla exploration drilling Program. BNR thanked WAC and YAC for their support during the Heritage Survey. BNR provided an overview of the new Covid Policy. General community sponsorship and future ranger programs and other sponsorship opportunities.
EPA	Email	25 Nov 2021	Formally notified that the subsidiary BNR had changed address and that the parent company had changed name and address.
EPA	Meeting	24 Nov 2021	Discussed ERD structure with EPA Services, including the new EPA ERD and Environmental Management Plan (EMP) guidelines, and the development of the human health risk assessment (HHRA). EPA stated that BNR should address worker accommodation/health and provide justification whether it is in scope of this referral or not. Actions included: • BNR to formally notify the EPA of BNR's address change • BNR to keep the current structure of the ERD, and address the guideline changes where necessary • BNR to arrange peer review of the HHRA • BNR to address worker health.
YAC AGM	In Person	22 – 24 Nov 2021	BNR attended the YAC Annual General Meeting and discussed various regulatory approvals including the Valhalla exploration drilling program. BNR thanked YAC for their support during the Heritage Survey. BNR provided an overview of the new Covid Policy. General community sponsorship and future ranger programs and other sponsorship opportunities.
EPA	Email	12 Nov 2021	EPA Services confirmed a HHRA was required and that it should come to one of two outcomes: • identifies health risks, receptors etc. and their mitigation; or • identifies there are no health risks/receptors etc.
Department of Communities	Email	08 Nov 2021	Enquired if the Yungngora Community groundwater bore data for the Poole Sandstone aquifer (provided by the Department) could be made publicly available in the ERD. The Department declined. As an action, BNR have compared the data and instead summarised similarities/differences without disclosing any data.
EPA	Meeting	22 Oct 2021	Discussed ESD progress with EPA Services. No actions arose.
DAWE	Meeting	20 Oct 2021	Provided an update on the referral and provided the results from the flora and fauna survey to confirm that no significant impacts to matters NES would occur as a result of the Proposal. Presented the proposed Odin seismic survey.
DoH	Email	19 Oct 2021	Discussed the requirement for a HHRA. DoH stated that if the Proposal is not within two km (end of lateral extent in all directions) of a potable water source or sensitive receptor, then a HHRA is not needed.

Stakeholder	Method of engagement	Date of engagement	Summary of engagement
EPA	Phone	13 Oct 2021	Discussed progress of the ESD and relevant decision-making authorities to discuss HHRA.
WAC & YAC	In Person	12 – 18 Oct 2021	Part 2 – Cultural, ethnographic and archaeological heritage survey via transects and helicopter by Deep Woods Surveys personnel with YAC & WAC representatives
WAC & YAC	In Person	10 -16 Sep 2021	Part 1 – Cultural, ethnographic and archaeological heritage survey. The survey was completed by Deep Woods Surveys personnel with YAC & WAC representatives
EPA	Phone	08 Jul 2021	Provided comments on EPA's final draft of the ESD.
Department of Planning, Lands and Heritage (DPLH)	Email	18 Jun 2021	Received approval from DPLH for the temporary installation of an air quality monitoring station within an Aboriginal heritage site.
SDWK	Phone	16 Jun 2021	Requested if Shire approval was required for installing traffic monitoring equipment on the gravel Calwynyardah–Noonkanbah Road. Shire confirmed via email that BNR could install the equipment. BNR action included sharing the baseline traffic monitoring with the Shire post-survey.
Blina Station manager	Phone and email	14 Jun 2021	BNR provided locations of proposed air quality monitoring stations for the air quality and GHG monitoring program, prior to site installation that month.
YAC	Email	14 Jun 2021	BNR requested approval to install air quality monitoring stations within the Noonkanbah Station as part of the Valhalla baseline air quality and GHG monitoring program. Approval granted.
Department of Communities	Email	09 Jun 2021	Requested drinking water data from the groundwater bores monitored at the Yungngora Community, to obtain information from the deeper aquifers.
DWER	Meeting	09 Jun 2021	Continued discussion regarding the proposed groundwater monitoring program. DWER requested that background information on the underlying Poole Sandstone and Grant Group aquifers should be included in the ERD.
YAC Noonkanbah station WAC	In person	7-10 Jun 2021	Provided an update on the Proposal and discussed heritage survey requirements for the Proposal. Discussed ranger program and sponsorship opportunities (including sponsoring local football team)
YAC and WAC	In person	7-10 Jun 2021	Provided an overview of unconventional drilling activities with independent experts, supported a question-and-answer session.
EPA	Phone	04 Jun 2021	Discussed baseline monitoring requirements from the draft ESD and requested to remove the requirement to sample at each well site for a period of 24 months and change to sampling representative control sites for a period of 24 months.
DWER	Phone	03 Jun 2021	Arranged a meeting to discuss DWER's feedback on the proposed Valhalla baseline groundwater monitoring program.
DPLH	Phone	03 Jun 21	Sought advice on the location of a proposed air quality monitoring station on a mythological Aboriginal heritage site (heritage site associated with an Aboriginal myth).
DWER	Email	26 May 2021	Discussed the suitability of the Valhalla baseline groundwater monitoring program, with regard to monitoring control sites only within the Liveringa Aquifer. Questioned that the other deeper aquifers must be discussed.

Stakeholder	Method of engagement	Date of engagement	Summary of engagement
WA Police	Phone	24 May 2021	Confirmed approval to enter the Yungngora Community to stay overnight during COVID-19 restrictions.
Blina Station manager	Phone and email	19 May 2021	BNR discussed the installation of air quality monitoring stations on Blina Station as part of the air quality and GHG baseline monitoring program. Station manager approved the installation of the equipment on Blina Station and suggested providing help to install these.
Noonkanbah Station manager	Phone	13 May 2021	Discussed the availability of bore logs from pastoral bores on the station; unofficial bore logs could be made available. Re-confirmed that BNR could sample water from the pastoral bores by unscrewing pipes or opening taps. Mentioned that access roads and fence line tracks would be graded at the end of May, and mustering activities would commence early June.
EPA	Meeting	05 May 2021	Met the new EPA Chair and discussed the draft EPA-prepared ESD and BNR's response comments.
EPA	Email	27 Apr 2021	EPA requested a meeting with Matthew Tonts (new EPA Chair) to discuss the Valhalla draft ESD.
EPA	Email	27 Apr 2021	Verified the status on EPA Services' processing of the Valhalla Draft ESD.
Bunuba Dawangarri Aboriginal Corporation (BDAC)	Meeting	31 March 2021	BNR mobilised independent experts from a groundwater and technical perspective to present an overview of HFS activities to the board and answer any questions they had.
Blina Station manager	Phone and email	23 Mar 2021	Discussed sampling station bores for the baseline groundwater monitoring program – station accepted. Discussed the availability of a bore log for a bore located on Blina Station. Confirmed that BNR could sample water from that bore by opening the tap.
DWER	Email	22 Mar 2021	Reviewed sampling methodology and locations for baseline control site groundwater monitoring program. Enquired about availability of bore logs and any existing data for any pastoral bores.
Noonkanbah Station manager	Phone and email	08 Mar 2021	Discussed sampling station bores for the baseline groundwater monitoring program – station accepted. Enquired about the availability of bore logs from pastoral bores on the station. Confirmed that BNR could sample water from the pastoral bores.
BDAC	Meeting	17 Feb 2021	BNR met to discuss the project subcommittee, provide an overview of the project and discussed the opportunity for BNR to provide independent experts to provide information in the form of a community session.
EPA	Email	15 Feb 2021	Discussed monitoring frameworks for dust, volatile organic compounds (VOC), and greenhouse gas (GHG) monitoring. EPA enquired about the justification for the monitoring locations.
EPA	Meeting	08 Feb 2021	Discussed next steps with the EPA and to confirm the baseline monitoring frameworks. BNR action included sending the monitoring frameworks to the EPA with the aim of individually engaging with the relevant EPA branches to confirm each monitoring approach.
EPA	Phone	02 Feb 2021	Discussed baseline air quality monitoring. EPA waiting on suitable branch / personnel to review GHG baseline and confirmation of the objectives of air quality studies that have not progressed. Level of assessment likely released over the next week.

4 Object and principles of the EP Act

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, 2021c), Table 4-1 describes how each of the five principles of the EP Act has been applied to the Proposal.

Table 4-1: Summary of the Proposal against the EP Act principles

Principle	Summary of the Proposal against EP Act principles
1.Precautionary principle *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:* *a. Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and* b. *An assessment of the risk-weighted consequences of various options.*	The Proposal has a disturbance footprint of ~112 ha. Previous detailed and targeted flora and fauna baseline 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, threatened fauna, or threatened vegetation associations are expected to be impacted. Assessments for all key factors including noise, dust and atmospheric emissions indicate impacts arising from the Proposal are not significant and are manageable by implementing standard mitigation measures and good practice measures. The review of previous HFS data within EP 371 also indicates there is scientific and historic evidence that such activities can be undertaken in a way that will not cause serious or irreversible damage to the environment. BNR plans to leverage this wealth of environmental data and conduct similar studies for the Proposal to demonstrate that these activities can be undertaken safely with minimal impact to the environment. As part of its commitment to this principle, BNR commits to undertaking pre-construction flora/fauna surveys to ensure that priority flora or fauna will not be adversely impacted by the Proposal. In addition, groundwater monitoring bores will be installed, and data collected prior to drilling activities commencing. Ongoing monitoring throughout the life of the project (and for an agreed period beyond project cessation) will quickly identify any issues so that mitigation measures can be undertaken.
2. Intergenerational equity *The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.*	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. Evaluation of the key environmental factors including human health indicates that impacts arising from the Proposal are not significant and will be manageable by implementing standard mitigation measures and good practice measures. As stated above, pre-construction surveys are planned to ensure that priority flora or fauna will not be adversely impacted by the Proposal, and that local groundwater monitoring will occur well in advance of drilling activities.
3. Principles relating to the improved valuation, pricing, and incentive mechanisms *a. environmental factors should be included in the valuation of assets and services* *b. the polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement* *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.* *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.*	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 has considered impacts to fauna and stakeholders The emissions and wastes arising from the Proposal have been identified and plans put into place to manage them. BNR acknowledges that the cost associated with managing these emissions and wastes forms part of the Proposal. Justification for the Proposal includes incentives to balance impacts of emissions by promoting and contributing to increased economic activity and benefits in the region. BNR believes that programs such as these are particularly important for developing the West Kimberley region as unconventional resources occur away from main regional towns, in areas where meaningful employment opportunities are central to addressing economic disadvantages.

Principle	Summary of the Proposal against EP Act principles
4. Conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integrity should be a fundamental consideration.*	The areas of vegetation to be disturbed are representative of the surrounding vegetation associations and the wider bioregion. Historical and recent detailed and targeted flora and fauna baseline surveys have been undertaken within the Development Envelope and indicate no threatened flora, fauna, or vegetation associations are likely to be impacted. The whole area of the proposed surface disturbance footprint has been recently surveyed and the disturbance footprint is also fixed at the proposed locations (Figure 1-2). BNR does not seek flexibility in the proposed disturbance footprint under this Proposal. In addition, further pre-construction surveys are planned be undertaken to ensure priority flora or fauna will not be adversely impacted by the Proposal. A focused evaluation on groundwater has been undertaken. This included a review of previous HFS data within EP 371, which indicates the Proposal will not threaten biological diversity or ecological integrity.
5. Waste minimisation *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*	Key waste streams have been evaluated and management techniques identified to minimise environmental impacts through appropriate site planning to ensure minimal impact from potential flooding and waste disposal to licensed facilities (Section 2.6).
Description of how the object of the EP Act has been considered The object of the EP Act is 'to protect the environment of the State', having regard to the five principles outlined above. BNR has considered and/or addressed each of the principles in regard to the Proposal and has therefore considered the object of the EP Act.	

4.2 Environmental factors and objectives

The EPA has defined 14 environmental factors and respective objectives, organised into five themes: Sea, Land, Water, Air, and People.

With respect to the Valhalla Gas Exploration and Appraisal Program, and in accordance with the ESD, BNR has classified each environmental factor as either 'key' or 'not applicable' (Table 4-2), where:

- 'key environmental factors' are those parts of the environment that may be impacted by an aspect of the Proposal
- 'not applicable' are those parts of the environment that are not relevant to any aspect of the Proposal.

The assessment of potential environmental impacts focuses on the key environmental factors identified in the ESD, which are further discussed in Sections 5.1 to 5.9.

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

Factor	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	Key environmental factor	Section 5.1
Landforms	Not applicable	Not applicable
Subterranean fauna	Key environmental factor	Section 5.9
Terrestrial environmental quality	Key environmental factor	Section 5.2
Terrestrial fauna	Key environmental factor	Section 5.3
Theme: Water		
Inland waters	Key environmental factor	Section 5.4
Theme: Air		

Factor	Classification of factor	Further information
Air quality	Key environmental factor	Section 5.6
Greenhouse gas emissions	Key environmental factor	Section 5.7
Theme: People		
Human health	Key environmental factor	Section 5.8
Social surroundings	Key environmental factor	Section 5.5

5 Key environmental factors and objectives

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* (WA)
- Environmental Protection (Clearing of Native Vegetation) Regulations 2004
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Commonwealth)
- *Biodiversity Conservation Act 2016* (WA) (BC Act)
- *Biosecurity and Agriculture Management Act 2007* (WA)
- *Bush Fires Act 1954* (WA)
- 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 the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing and procedure of the environmental review, as required by Section 40(3) of the EP Act. Table 5-1 lists the ESD requirements specific to flora and vegetation.

Table 5-1: ESD checklist – flora and vegetation

Flora and vegetation		
Required work		**BNR response**
30	Identify and characterise the flora and vegetation of areas that may be directly or indirectly impacted by the Proposal in accordance with *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment*. Surveys should be designed to inform local and regional context. Specimens of significant flora collected during surveys should be vouchered at the WA Herbarium.	Appendix C Section 5.1.3
31	Demonstrate how surveys are relevant, representative, and demonstrate consistency with current EPA policy and guidance. Ensure database searches and taxonomic identifications are up to date. If multiple surveys have been undertaken to support the assessment, a consolidated report should be provided including the integrated results of the surveys. All surveys should be appended to the environmental review documentation.	Appendix C Section 5.1.3
32	Provide a figure depicting survey effort applied in relation to the study area and Development Envelope, identifying the direct and indirect impact areas.	Figure 5-1
33	Determine whether any flora species recorded are significant, and provide an analysis of local and regional context, (refer to *Environmental Factor Guideline – Flora and Vegetation* for definition of significant flora).	Section 5.1.3.6 Section 5.1.3.6
34	Determine whether any vegetation identified is significant, and provide an analysis of local and regional context, (refer to *Environmental Factor Guideline – Flora and Vegetation* for definition of significant vegetation).	Section 5.1.5.1
35	Provide figures depicting the recorded locations of flora and vegetation in relation to the Development Envelope in accordance with *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment*.	Figure 5-2 Appendix C
36	Assess the potential direct and indirect impacts of the construction and operational elements of the Proposal on identified environmental values. Describe and assess the extent of cumulative impacts as appropriate.	Section 5.1.5 Section 7.3

Flora and vegetation		
Required work		**BNR response**
37	Provide a quantitative assessment of impact: For significant flora, this includes: i. number of individuals and populations in a local and regional context ii. numbers and proportions of individuals and populations directly or potentially indirectly impacted iii. numbers/proportions/populations currently protected within the conservation estate (where known). For all vegetation units (noting threatened and priority ecological communities and significant vegetation) this includes: i. area (in hectares) and proportions directly or potentially indirectly impacted ii. proportions/hectares of the vegetation unit currently protected within conservation estate (where known).	N/A refer to Section 5.1.5.1
38	Describe the application of the mitigation hierarchy in the Proposal design, construction, operation, and decommissioning. Detail actions undertaken to avoid, minimise, and mitigate Proposal impacts. If any conservation significant species are expected to be impacted include management and/or monitoring plans to be implemented pre- and post-construction to demonstrate that residual impacts are not greater than predicted.	Section 5.1.6 N/A
39	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and Western Australian Offsets Template (Appendix 1) in the *WA Environmental Offsets Guidelines* (2014) and include reference to the Commonwealth Assessment Guide for any MNES.	Section 5.1.7 Section 5.11
40	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the *WA Environmental Offsets Policy* (2011) and *Guidelines* (2014). Spatial data defining the area of significant residual impacts for each environmental value should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).	Section 5.1.7 Section 5.11
41	Demonstrate how the EPA's objective for this factor has been addressed.	Section 5.1.7

5.1.3 Receiving environment

The flora and vegetation composition of the Development Envelope is well understood from the numerous surveys that were conducted for previous petroleum activities within EP 371 as well as the surveys undertaken specifically for this Proposal.

Note, the surveys undertaken specifically for this Proposal cover the whole of the proposed surface disturbance footprint. The disturbance footprint is also fixed at the proposed locations (Figure 1-2) and BNR does not seek flexibility in the proposed disturbance footprint under this Proposal.

Table 5-2 lists the flora and vegetation studies relevant to the Proposal. The location of all survey efforts is shown in Figure 5-1, with the location of any significant flora species (including species no longer listed) identified from all previous surveys shown in Figure 5-2. The reports of all baseline studies confirmed that the surveys were designed and conducted in accordance with the relevant technical EPA sampling and survey guidance.

The most recent flora and vegetation survey conducted specifically for the proposed well sites, access tracks, and camp locations within the Development Envelope is attached in Appendix C. It should be noted that the commissioned survey was completed as a detailed and targeted level survey in accordance with the EPA technical guidance. As noted by Eco Logical regarding the limitations of the survey, some areas were inaccessible. However, based upon the number of historic studies completed within the Development Envelope, and a detailed post-survey flora likelihood of occurrence assessment, Eco Logical believes that the level of survey effort was suitable and in line with the EPA guidelines as no Threatened flora species are considered as being likely or having the potential to occur.

As detailed within the EPA Guidelines, a targeted survey is not required where areas are considered as having well defined flora and vegetation values and are not considered likely to support significant flora or vegetation species. BNR believes that based upon the survey effort to date and high confidence in the data, no additional survey effort is required to support the assessment of environmental impacts.

Table 5-2: Baseline studies – flora and vegetation

Author	Report	Distance to Development Envelope	Significant flora	Significant ecological communities	Declared pests / WoNS
(Eco Logical Australia, 2021)	Valhalla Flora and Fauna Survey	Within the Development Envelope – survey specifically undertaken for the Valhalla Gas Exploration and Appraisal Program	*Nymphoides beaglensis* (P3) found on seasonally inundated depressions – outside the Proposal's disturbance footprint	Nil	*Calotropis procera*
(Low Ecological Services, 2020)	Flora and Fauna Assessment – Odin 2D and 3D seismic survey, Fitzroy Basin, Western Australia	Within and immediately surrounding the Development Envelope	Nil	Nil	*Calotropis procera*
(Eco Logical Australia, 2018)	Valhalla Central 4 Flora and Fauna Survey	Within Development Envelope along creek line	Nil	Nil	Nil
(Eco Logical Australia, 2016)	Level 1 Vegetation, Flora and Fauna Survey of Kurrajong, Yakka Munga, and Valhalla Central Well Sites	Valhalla Central A is the only site within Development Envelope	*Pterocaulon intermedium* (no longer listed)	Nil at Valhalla Central A	Nil
(Murdoch University, 2016)	Targeted bilby survey of proposed well site 'Valhalla Central', and immediate area	Within Development Envelope, central	Nil	Nil	Nil
(Buru Energy and Outback Ecology, 2014)	Ophir, Paradise, Valhalla, Eden, and Ellendale Flora, Vegetation and Fauna Survey Report	Adjacent, to the west	Nil	Nil	Nil
(Low Ecological Services, 2012a)	Asgard-1 Exploration Well: Flora, Vegetation and Fauna Survey	Within Development Envelope	Nil	Nil	Nil
(Low Ecological Services, 2012b)	Asgard 2D Seismic Survey: Flora, Vegetation and Fauna Survey	Similar if not overlapping	*Trianthema kimberleyi* (P1), *Goodenia virgata* (P2)	Nil	Nil
(Low Ecological Services, 2011a)	Flora and Vegetation Survey: Valhalla North	Adjacent to the northwest, ~2 km away from the Development Envelope	Nil	Nil	*Calotropis procera*
(Low Ecological Services, 2012b)	Valhalla East-1 Exploration Well: Flora and Fauna Survey	Within Development Envelope, centre north, about 5 km south from northern extent	Nil	Nil	Nil
(Woodman Environmental Consulting, 2007)	Valhalla – 01 Well Site Flora and Vegetation Survey	Within Development Envelope to the northwest	*Goodenia byrnesii* (P1), *Triodia acutispicula* (P3), *Goodenia sepalosa* var. *Glandulosa* (P3)	Nil	Nil

Notes:

P1, P2, P3 = Priority species level

WoNS = Weeds of National Significance

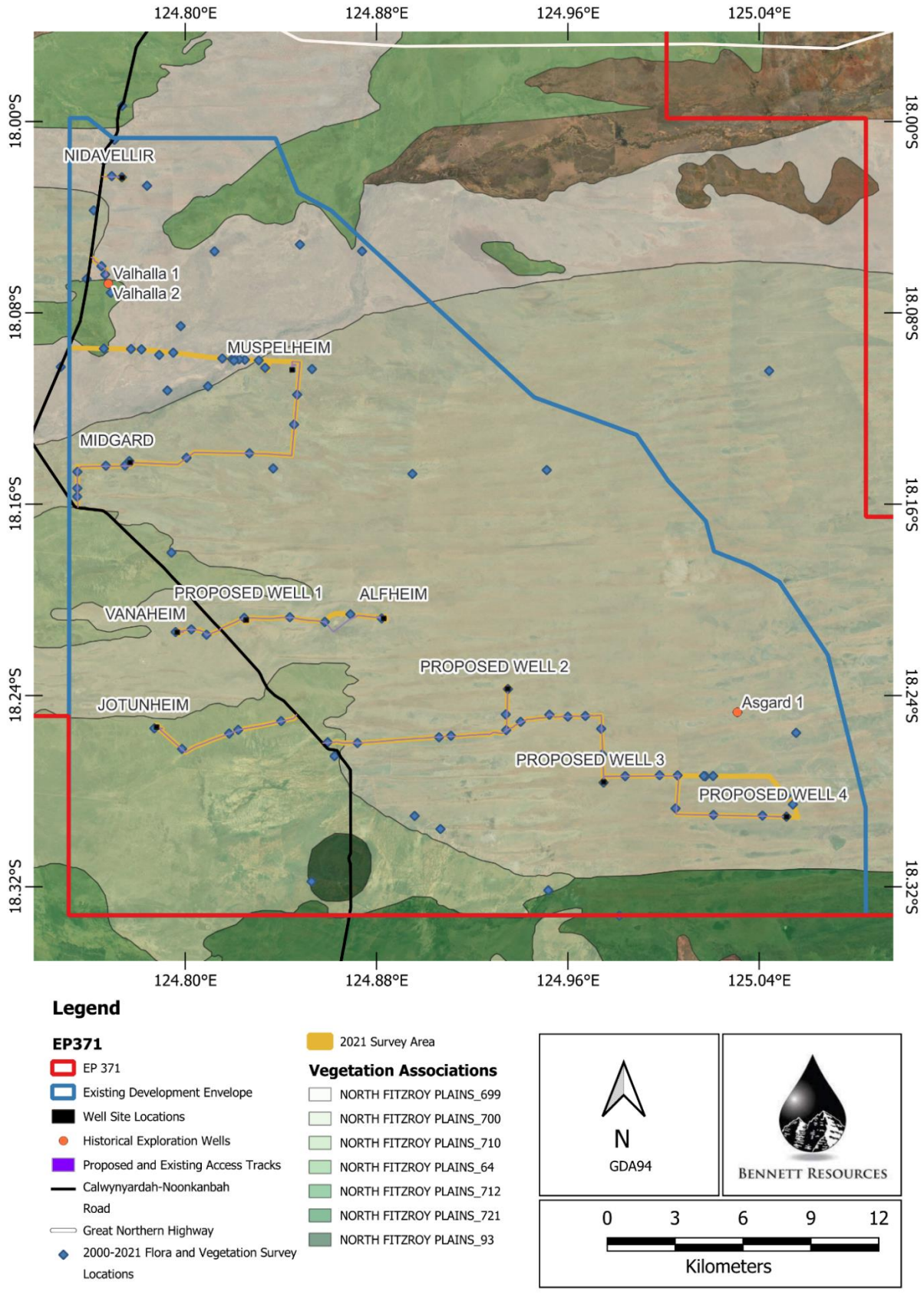


Figure 5-1: Location of flora survey efforts within and surrounding the Development Envelope

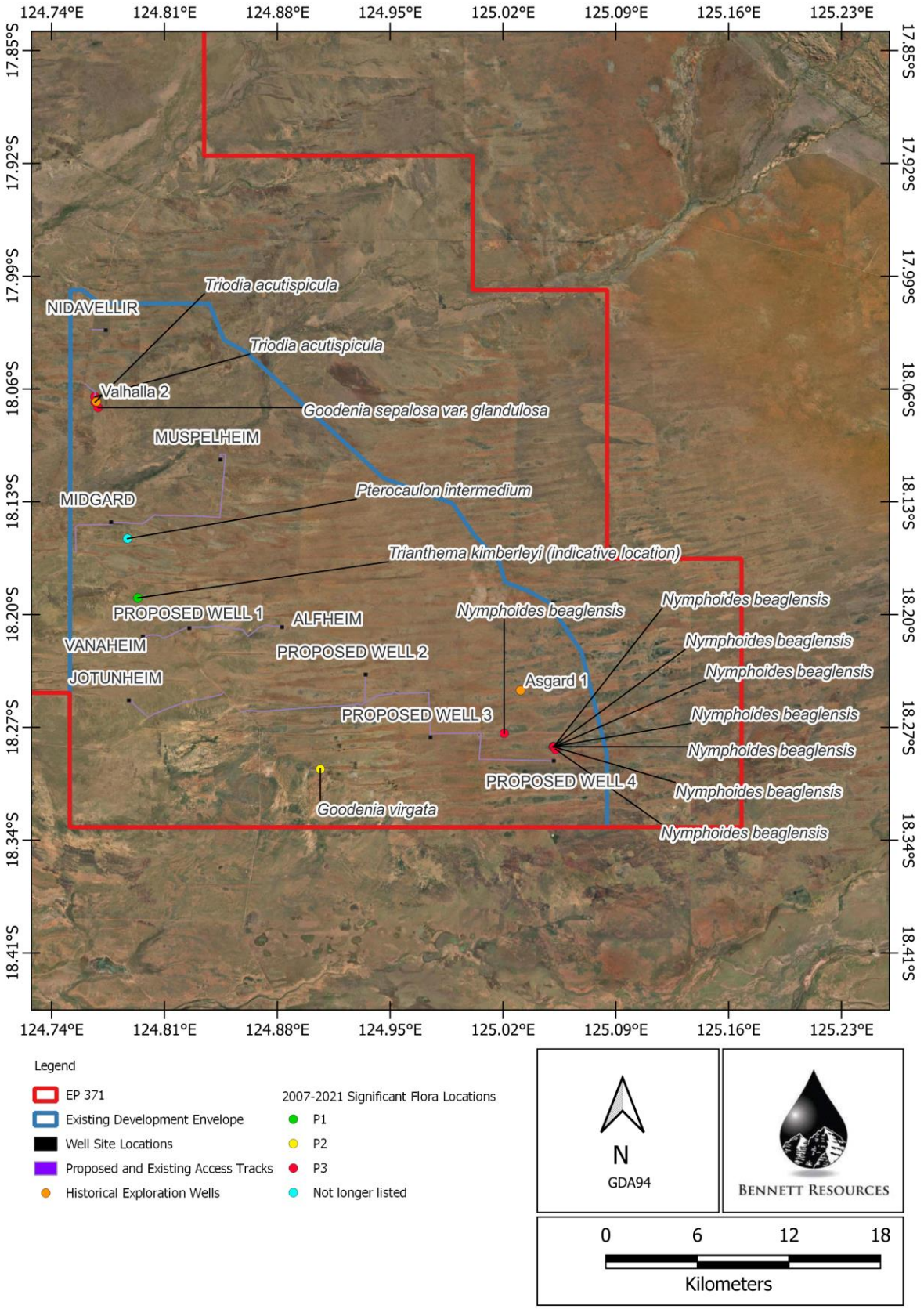


Figure 5-2: Location of previously recorded listed flora species within and surrounding the Development Envelope. Some species are no longer listed–refer to Table 5-2

5.1.3.1 Regional biogeography

The Proposal is located within the West Kimberley's Dampierland Interim Biogeographic Regionalisation for Australia (IBRA) bioregion (DAWE, 2021a).

The Dampierland bioregion is dominated by sand sheets and sandy rises, occasionally dissected by alluvial and lacustrine features associated with surface waters. Its vegetation is relatively uniform and characterised by the Pindan assemblage that develops on sandplains. Acacia thickets with scattered trees, areas of grassland, and savannas (Bastin & 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 animal hunting by Traditional Owners, are the dominant ecosystems.

The Development Envelope occurs within the Fitzroy Trough (Dampierland DAL1) IBRA subregion (Figure 5-3), which 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 that are 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 Fitzroy Trough supporting tree steppes with understoreys of *Triodia intermedia* and *T. wiseana* hummock-grass (Graham, 2001; McKenzie, May, & McKenna, 2003).

The Development Envelope is located within the Valhalla province, a colloquial term used to describe the area that lies along the northeastern flank of the Fitzroy Trough where the targeted Laurel Formation shows promise of hydrocarbons at depths between 2,000 m and 4,000 m below ground. 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 Conservation areas

The Development Envelope does not intersect any conservation areas (Figure 5-3).

5.1.3.3 Environmentally sensitive areas

An Environmentally Sensitive Area (ESA) is defined as a landscape element or place that 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. The nearest ESA is the Camballin Floodplain, approximately 27 km west of the Development Envelope, which is associated with a nationally important wetland—Le Lievre Swamp (Iljamalkarda) (DEC, 2009). The Lievre Swamp is listed in the Directory of Important Wetlands (DoIW) and was nominated for listing as a wetland of international significance under the Ramsar Convention (Jaensch & Watkins, 1999). This wetland is a major breeding area for waterbirds and a migration stopover 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), Threatened Ecological Communities (TEC), or Priority Ecological Communities (PEC) (Table 5-2). Figure 5-3 depicts the regional environmental values and sensitivities surrounding the Development Envelope.

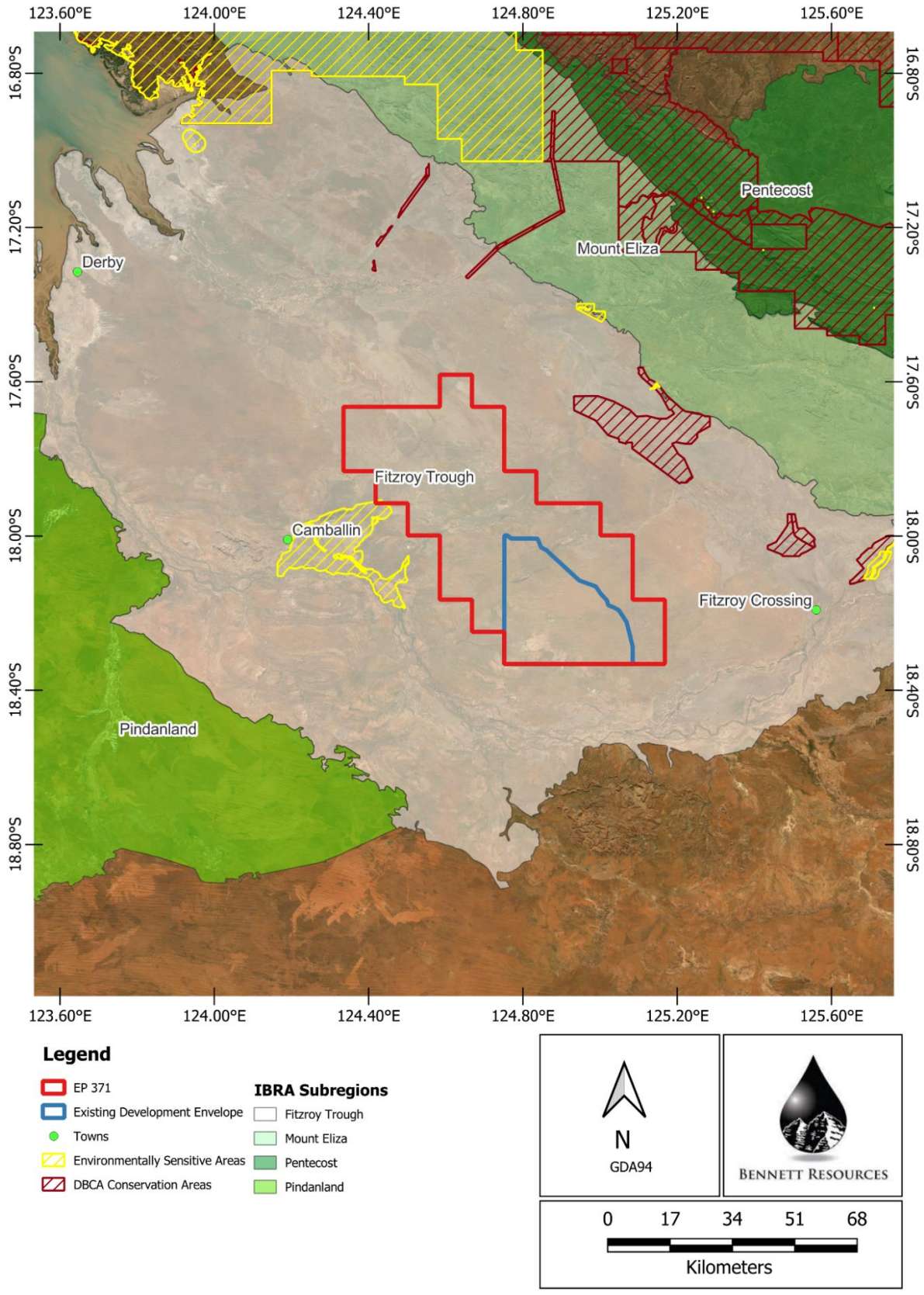


Figure 5-3: IBRA subregions and environmental values of the Kimberley

5.1.3.4 Vegetation associations

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 as a 'grassland wooded by a sparse upper layer of trees and a dense, thicket-forming middle layer of unarmed, phyllodal Acacia' (Beard J. , 1979).

Based upon Beard (Beard J. , 1979) and Shepherd et al. (Shepherd, Beeston, & Hopkins, 2002), four predominant vegetation associations are present within the Development Envelope, as shown in Figure 5-1.Detailed flora and vegetation surveys undertaken within the Development Envelope have verified that the vegetation within the Development Envelope reflects these associations (Table 5-2).

Eco Logical delineated and mapped a total of 13 vegetation communities within the project area (Figure 5-4 and Appendix C). The vegetation code, description and extent within the disturbance footprint is detailed in Table 5-3.

Table 5-3: Local Scale Vegetation associated within the disturbance footprint, as detailed by Eco Logical

Vegetation code	Description	Extent (ha) within the disturbance footprint (% total)
AgCgEc	*Adansonia gregorii* mid isolated trees and *Corymbia greeniana, Erythrophleum chlorostachys, Bauhinia cunninghamii* low open woodland over *Acacia colei, Grevillea pyramidalis, Carissa lanceolata* mid sparse shrubland over *Triodia bitextura* low open hummock grassland and *Sorghum plumosum, Chrysopogon fallax* tall open tussock grassland.	11.44 (10.18)
EmEcAg	*Eucalyptus microtheca, Eucalyptus camaldulensis, Adansonia gregorii* tall open woodland and *Bauhinia cunninghamii, Atalaya hemiglauca* low open woodland over *Acacia colei, Terminalia platyphylla, *Vachellia farnesiana* tall open shrubland over *Corchorus fascicularis* low sparse shrubland and *Aristida latifolia, Sehima nervosum* tall open tussock grassland.	1.15 (1.02)
CgAgBc	*Corymbia greeniana*, *Adansonia gregorii* mid open woodland and *Bauhinia cunninghamii* low open woodland over *Acacia colei*, *Hakea arborescens*, *Hakea chordophylla* tall sparse shrubland over *Sorghum plumosum* tall open tussock grassland and *Eriachne obtusa*, *Aristida hygrometrica* low sparse grassland.	14.24 (12.66)
CbEc	*Corymbia bella*, *Eucalyptus coolabah* mid open woodland over *Acacia colei*, *Lophostemon grandiflorus* subsp. *riparius*, *Sesbania cannabina* tall sparse shrubland over *Triodia bitextura* low open hummock grassland and *Aristida hygrometrica*, *Eriachne obtusa* low sparse grassland.	1.77 (1.58)
CgCzBc	*Corymbia greeniana*, *Corymbia zygophylla*, *Bauhinia cunninghamii* low open woodland over *Acacia platycarpa*, *Grevillea pyramidalis*, *Atalaya hemiglauca* tall sparse shrubland over *Sorghum plumosum*, *Sorghum stipoides* tall open tussock grassland and *Aristida latifolia* mid sparse tussock grassland.	11.33 (10.07)
AgBc	*Adansonia gregorii* mid isolated trees and *Bauhinia cunninghamii* low open woodland over *Grevillea pyramidalis*, *Hakea arborescens*, *Hakea macrocarpa* tall sparse shrubland over *Indigofera colutea* low sparse shrubland, *Sorghum plumosum* tall open tussock grassland and *Eriachne obtusa* low sparse grassland.	12.35 (10.98)
BcCg	*Bauhinia cunninghamii*, *Corymbia greeniana* low open woodland over *Hakea macrocarpa*, *Grevillea pyramidalis*, *Acacia colei* tall sparse shrubland over *Triodia intermedia* low sparse hummock grassland, *Sorghum plumosum* tall open tussock grassland and *Eragrostis eriopoda* low sparse tussock grassland.	3.3 (2.94)
BcTc	*Bauhinia cunninghamii*, *Terminalia canescens* low open woodland over *Grevillea pyramidalis*, *Acacia ancistrocarpa*, *Acacia colei* tall sparse shrubland over *Triodia intermedia*, *Triodia bitextura* low sparse hummock grassland and *Sorghum plumosum* tall open tussock grassland.	7.25 (6.45)
Ag	*Adansonia gregorii* mid open woodland over *Grevillea pyramidalis*, *Hakea chordophylla*, *Dolichandrone occidentalis* tall sparse shrubland over *Triodia intermedia* low sparse hummock grassland, *Sorghum plumosum* tall sparse tussock grassland and *Aristida holathera* low sparse grassland.	9.16 (8.14)
AtAcDo	*Atalaya hemiglauca*, *Acacia synchronicia*, *Dolichandrone occidentalis* tall sparse shrubland over *Carissa lanceolata*, *Gossypium australe*, *Chamaecrista symonii* low sparse shrubland over *Triodia intermedia*, *Triodia wiseana* low hummock grassland and *Eriachne obtusa* low sparse grassland.	12.38 (11.01)

Vegetation code	Description	Extent (ha) within the disturbance footprint (% total)
BcGaCg	*Bauhinia cunninghamii, Gyrocarpus americanus, Corymbia greeniana* low open woodland over *Acacia platycarpa*, *Acacia tumida* tall open shrubland and *Carissa lanceolata* mid sparse shrubland over *Triodia bitextura* low sparse hummock grassland and *Aristida hygrometrica*, *Eriachne obtusa* low sparse grassland.	11.45 (10.18)
EcCg	*Erythrophleum chlorostachys, Corymbia greeniana* low open woodland over *Acacia tumida*, *Acacia ancistrocarpa* tall sparse shrubland and *Carissa lanceolata* mid sparse shrubland over *Bonamia pannosa*, *Bonamia linearis* low sparse shrubland and *Aristida hygrometrica* low open grassland.	4.68 (4.16)
CzEcCg	*Corymbia zygophylla*, *Erythrophleum chlorostachys*, *Corymbia greeniana* low open woodland over *Acacia tumida*, *Acacia platycarpa* tall sparse shrubland and *Waltheria indica* low sparse shrubland over *Triodia bitextura*, *Triodia wiseana* low open hummock grassland and *Eriachne obtusa* low sparse grassland.	11.95 (10.63)

None of the vegetation associations present within the Development Envelope were inferred to represent any known or potential conservation significant vegetation communities listed under the EPBC Act, the BC Act, or by the WA Department of Biodiversity, Conservation and Attractions (DBCA) . Eco Logical confirmed that vegetation communities Ag, AgBc, AgCgEc, AtAcDo, BcCg, BcGaCg, BcTc, CgAgBc, CgCzBc, EcCg and EmEcAg broadly comprise aspects of Beard's North Fitzroy Plains 64 and 710 vegetation associations with the presence of mixed hummock (*Triodia* spp.) and tussock grasslands, *Adansonia gregorii, Bauhinia cunninghamii* and ribbon grass (*Chrysopogon fallax)*; (Government of Western Australia 2019).

Eco Logical confirmed that vegetation communities AgCgEc, CbEc, BcTc, BcGaCg, EcCg, CzEcCg broadly comprise aspects of Beard's North Fitzroy Plains 699 and 700 vegetation communities with the presence of shrublands over curly spinifex (*Triodia bitextura*) on sandplain or between dunes (Government of Western Australia 2019).

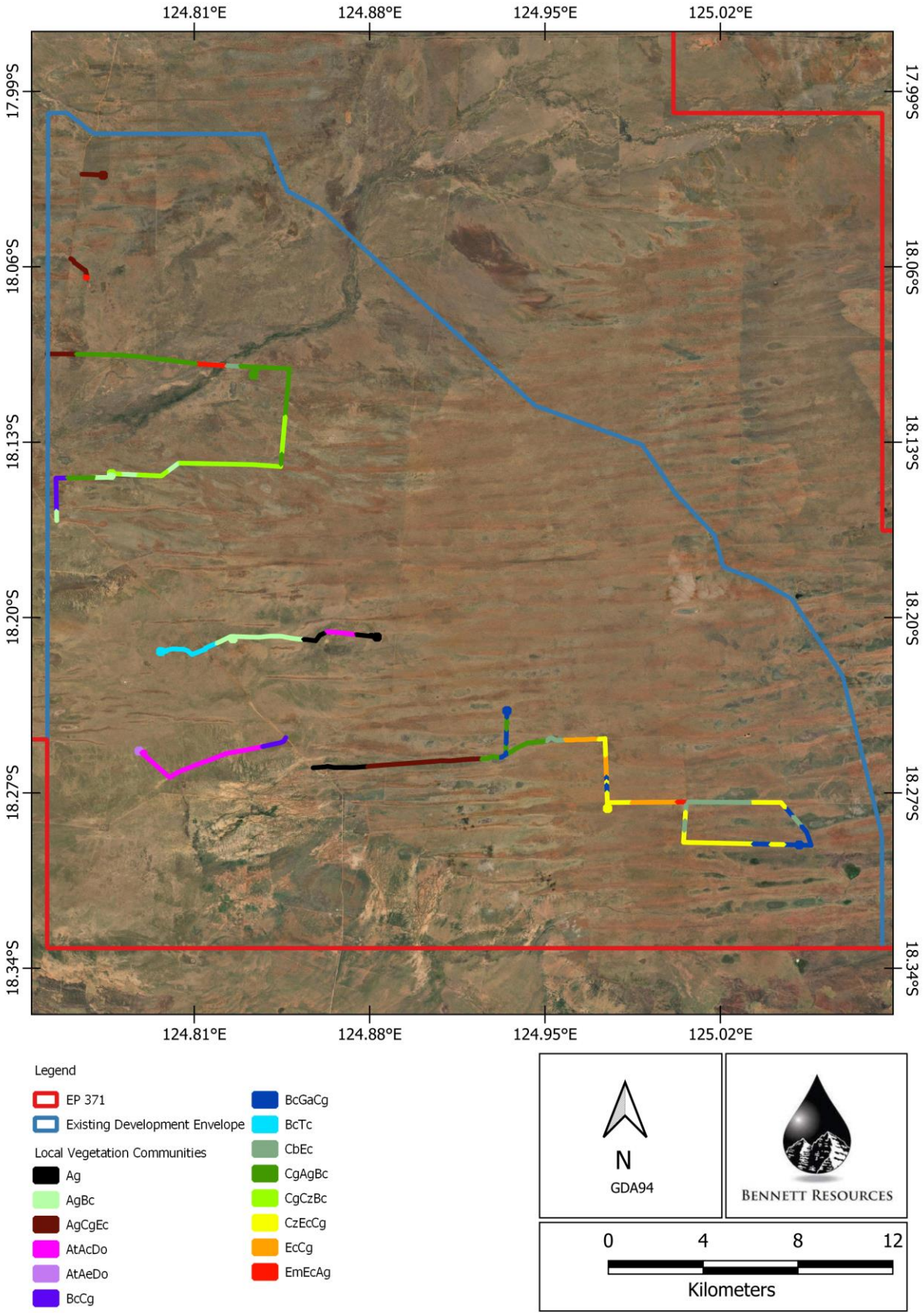


Figure 5-4: Local vegetation communities Eco Logical

To ensure that a sufficient understanding of all vegetation associations present throughout the entire Development Envelope (not just the disturbance footprint) is available, BNR reviewed all known flora surveys conducted within the Development Envelope (Table 5-2). To complete this task, all reports were reviewed and for each survey, the following information was documented:

- spatial survey location
- survey date
- vegetation codes and botanist description.

Where a specific vegetation associated was not provided, the descriptions of vegetation in detailed field notes were used to inform BNR's understanding of the vegetation association. Survey points were then plotted and reviewed against broadscale desktop vegetation communities, along with the 2021 field vegetation survey.

BNR determined that the vast majority of communities could be mapped back to broadscale desktop vegetation community descriptors with only a few exceptions consistent with the findings from Eco Logical . For the exceptions, vegetation communities were either matched to the nearest adjacent broadscale vegetation community (previously identified in the Development Envelope) or considered as part of a broadscale vegetation community adjacent to the Development Envelope (Figure 5-5). A summary of vegetation communities and their presence is included in Table 5-4 and the data is included as Appendix D.

Table 5-4: Extent of the vegetation associations in the Fitzroy Trough IBRA subregion (Government of Western Australia, 2018; Government of Western Australia, 2021a)

Vegetation Association	Flora Description	Pre-European extent (ha) within the subregion	Current extent (ha) within the subregion	Pre-European extent remaining
North Fitzroy Plains_64	Mainly ribbon grass with low woodland or scattered trees e.g. *Eucalyptus terminalis* over *Chrysopogon* spp., *Dichanthium* spp.	410,085.60	409,862.82	99.95%
North Fitzroy Plains_699	Acacia thicket with scattered low trees over spinifex *Acacia eriopoda, Corymbia dichromophloia, Triodia pungens, T. bitextura*	180,118.58	179,963.89	99.91%
North Fitzroy Plains_700	Acacia thicket with scattered low trees over spinifex *Acacia eriopoda, Corymbia dichromophloia, Triodia pungens, T. bitextura*	212,971.66	212,971.66	100.00%
North Fitzroy Plains_710	Curly spinifex or short grass low tree savanna / Grass-steppe	25,596.64	25,596.64	100.00%
North Fitzroy Plains_712	Curly spinifex or short grass low tree savanna / Grass-steppe	232,040.19	232,040.19	100.00%
North Fitzroy Plains_721	Hummock grassland with sparse Eucalypts e.g. bloodwoods and snappy gum *Triodia* spp., *Corymbia dichromophloia, C. opaca, Eucalyptus leucophoia*	51,884.13	51,884.13	100.00%
North Fitzroy Plains_93	Hummock grassland with scattered shrubs or mallee *Triodia* spp. *Acacia* spp., *Grevillea* spp. *Eucalyptus* spp	975.61	975.61	100.00%

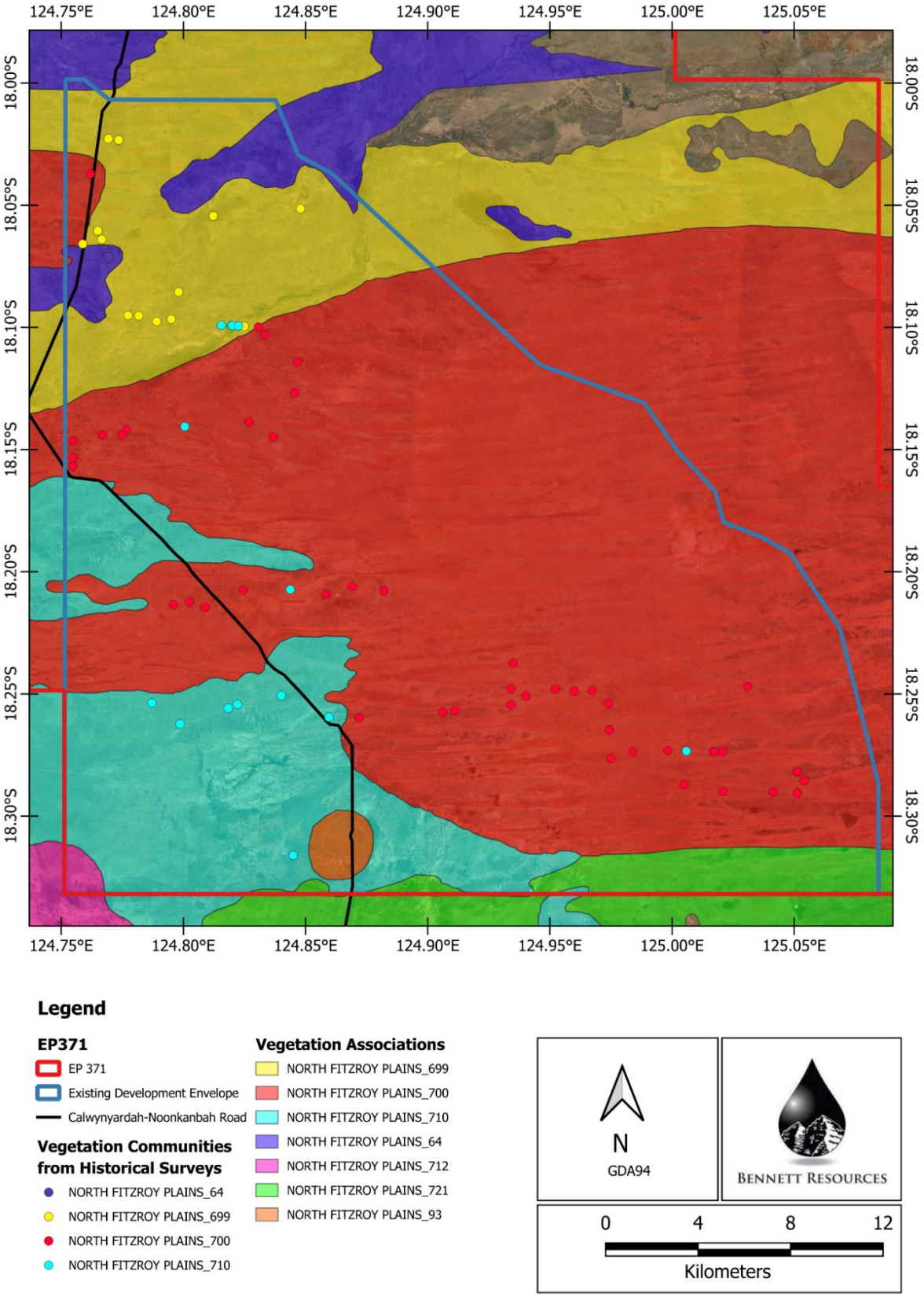


Figure 5-5 Desktop analysis of historical surveys and analysis of all vegetation associations within the Development Envelope

5.1.3.5 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, and under Commonwealth legislation under the EPBC Act. A desktop search of DBCA's NatureMap and of DAWE's Protected Matters Search Tool (PMST) database identified no Threatened or DRF species to be present within a five km buffer around the Development Envelope. This has been validated by earlier and recent flora and vegetation surveys conducted within the Development Envelope, revealing that no Threatened or DRF species have been identified in the surrounding region.

5.1.3.6 Priority flora

A desktop search of NatureMap identified only *Goodenia byrnesii* (P3) within a five km buffer around the Development Envelope. Flora and vegetation surveys conducted within the Development Envelope identified six Priority flora species known to occur within the Development Envelope:

- *Goodenia byrnesii* (P3)
- *Goodenia sepalosa* var. *glandulosa* (P3)
- *Goodenia virgata* (P2)
- *Nymphoides beaglensis* (P3)
- *Trianthema kimberleyi* (P1)
- *Triodia acutispicula* (P3).

Of the 35 conservation significant flora species identified from the pre-survey likelihood of occurrence assessment completed by Eco Logical , and the six species previously recorded within the Development Envelope, a single Priority listed species was recorded within the Disturbance Footprint; *Nymphoides beaglensis* (P3). A summary of the locations and number of individuals is provided in Table 5-5. Based on the post-survey likelihood of occurrence assessment, *Goodenia byrnesii* (P3) and *Goodenia sepalosa var. glandulosa* (P3) were identified as being likely to occur within the Project Area given historical records. However, as no individuals were recorded during the survey, and as no historic records were located within the Disturbance footprint the potential impact to this species is considered limited.

Species identification utilised taxonomic literature and keys and where required specimens were confirmed using the WAH reference collection.

Table 5-5: Location of *Nymphoides beaglensis*

EPBC Act	BC Act	Species Name	Date	Quadrat	Easting	Northing	# plants	Pop area (m)
-	P3	*Nymphoides beaglensis*	07/3/2021	ELA57	713276	7978347	50	2500
-	P3	*Nymphoides beaglensis*	07/3/2021	ELA58	713620	7978355	1	2500
-	P3	*Nymphoides beaglensis*	04/3/2021	ELA64	716838	7977401	20	2500
-	P3	*Nymphoides beaglensis*	-	Oppo	716841	7977397	5	-
-	P3	*Nymphoides beaglensis*	-	Oppo	716855	7977389	10	-
-	P3	*Nymphoides beaglensis*	-	Oppo	716869	7977387	14	-
-	P3	*Nymphoides beaglensis*	-	Oppo	716855	7977367	11	-
-	P3	*Nymphoides beaglensis*	-	Oppo	716872	7977362	1	-

5.1.3.7 Range Extension

Eco Logical identified four species within the project area as representing range extensions (RE), namely *Cajanus latisepalus*, *Lindernia chrysoplectra*, *Lindernia clausa* and *Tephrosia remotiflora*.

Cajanus latisepalus is currently known from 60 records in WA, over a range of approximately 500 km from Meda in the west across to the Northern Territory (NT) border in the east (DBCA 2007-2021). Within the project area, this species was recorded from one quadrat location; ELA29, within the AgBc vegetation

community on moist light brown clay loam flats. This record represents a minor range extension of approximately 60 km to the southwest of the known range of this species.

Lindernia chrysoplectra is currently known from 12 records in WA, over a range of approximately 465 km from the Dampier Peninsula in the northwest to 180 km west of Sturt Creek in the southeast (DBCA 2007-2021). Within the project area, this species was recorded from one quadrat location; ELA64, within the CbEc vegetation community on waterlogged dark brown sandy clay on open depression. This record represents a range infill, joining the eastern and western populations of this species, with the closest records of this species approximately 170 km to the west and 150 km to the east-southeast of the project area.

Lindernia clausa is currently known from 22 records in WA, over a range of approximately 675 km from the Dampier Peninsula in the southwest to near Kununurra in the east (DBCA 2007-2021). Within the project area, this species was recorded from three quadrat locations; ELA26, ELA27 and ELA31, within the BcTc and Ag vegetation communities on moist brown clay on open depression. This record represents a range extension of approximately 112 km to the south of the known range of this species.

Tephrosia remotiflora is currently known from 53 records in WA, over a range of approximately 1,795 km from near Onslow in the south Kununurra and into the NT in the north (DBCA 2007-2021). Within the project area, this species was recorded from one quadrat location; ELA01, within the AgCgEc vegetation community on red brown sandy loam on a gentle slope. This record represents a minor range extension of approximately 65 km to the south of the known range of this species.

As all species with range extensions were classified as grasses, individuals were not counted. However, percentage cover was recorded. The locations of the percentage cover of these species for the recorded quadrat is provided in Table 5-5.

Table 5-6: Location of species with identified range extension

EPBC Act	BC Act	Species Name	Quadrat	Easting	Northing	% cover
-	-	*Cajanus latisepalus*,	ELA29	692961	7985886	2
-	-	*Lindernia chrysoplectra*,	ELA64	716838	7977401	.01
-	-	*Lindernia clausa*	ELA26	689918	7985266	.01
-	-	*Lindernia clausa*	ELA 27	690616	7985383	.01
-	-	*Lindernia clausa*	ELA 31	696524	7985668	.05
-	-	*Tephrosia remotiflora*	ELA01	687296	8006395	0.2

5.1.3.8 Introduced and invasive species

The DAWE PMST desktop search identified that three weed species potentially occur within a five km buffer around the Development Envelope; these are:

- *Cenchrus ciliaris* (Buffel grass)
- *Jatropha gossypifolia* (Cotton-leaved Physic-nut, Bellyache bush)
- *Parkinsonia aculeata* (Parkinsonia, Jerusalem Thorn) – Declared Pest.

Historical and recent on-ground flora surveys undertaken in the Valhalla province (Table 5-2) identified these species as being present within the Development Envelope:

- *Calotropis procera* (Rubber Bush, Calotrope) – Declared Pest
- *Cenchrus ciliaris* (Buffel grass)
- *Cenchrus setiger* (Birdwood grass)
- *Cucumis* spp. (*C. argenteus* and *C. melo*)
- *Malvastrum americanum* (Spiked Malvastrum)

- *Melochia pyramidata* (Pyramid flower)
- *Portulaca oleracea* (Common Purslane)
- *Portulaca Pilosa* (Pink Purslane)
- *Parkinsonia aculeata* – Declared Pest
- *Sida cordifolia* (Flannel weed)
- Stylosanthes spp. (*S. hamata* and *S. scabra*)
- *Trianthema pilosum*
- *Vachellia farnesiana* (Mimosa bush).

Of all the weeds recorded, *Parkinsonia aculeata* has been declared as a Weed of National Significance (WoNS). Both *Parkinsonia aculeata* and *Calotropis procera* are listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (WA).

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 this direct impact to vegetation and flora:

- loss and fragmentation of native vegetation from clearing.

5.1.4.2 Indirect impacts

The Proposal may cause these indirect impacts to vegetation and flora:

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

5.1.5 Assessment of Impacts

5.1.5.1 Loss and fragmentation of native vegetation from clearing

The Proposal will result in a direct loss of native vegetation and flora as a consequence of clearing to construct well sites, required access tracks and some worker camps. Table 5-5 summarises the proposed clearing areas and their vegetation associations.

Table 5-7: Proposed clearing areas and vegetation associations

Vegetation association	Current extent (ha) within the subregion	Clearing (ha)	Impact of clearing at a regional scale
North Fitzroy Plains_699	179,963.89	~5	~0.0028%
North Fitzroy Plains_700	212,971.66	~86	~0.04%
North Fitzroy Plains_710	25,596.64	~14	~0.054%
TOTAL	**418,532.19**	**~105**	

5.1.5.1.1 Regional significance

The direct impact of clearing is limited to no more than 0.054 per cent of a single broadscale vegetation association. Having regard to the extent and distribution of these systems regionally, the loss of 0.054 per cent of a vegetation association is not considered to be significant at a regional scale.

The vegetation associations within the Development Envelope are well represented locally. Figure 5-1 shows the extent of the pre-European vegetation associations present within and surrounding the Development Envelope. The seven vegetation associations identified within the Development Envelope are present in and adjacent to EP 371. Mapping of other vegetation systems outside EP 371 show similarities in the types of vegetation present (Beard, Beeston, Harvey, Hopkins, & Shepherd, 2013). This reflects the domination of Pindan vegetation, which is found throughout the West Kimberley region, and also reflects previous surveys undertaken at various locations within EP 371 (Table 5-2 and Figure 5-1) and confirmed with the recent desktop analysis. With the small scale and low impact of the Proposal, the loss of vegetation within the well site locations, the access tracks and worker camps are not considered to result in significant local or regional impacts.

Additionally, the loss of vegetation associated with the Proposal is not expected to result in fragmentation effects. As detailed in Section 5.1.3.4, vegetation associations within the region are widespread and well represented. As the well sites are geographically separated, habitat fragmentation is not expected on a regional scale. Fragmentation impacts (if any) would only be highly localised to each well site. Fragmentation in relation to cumulative impacts from the Proposal is further detailed in Section 6.

5.1.5.1.2 Local Significance

Vegetation associations that are rare, but not currently threatened or have insufficient information available to be listed as a Threatened Ecological Community (TEC) are designated as a Priority Ecological Community (PEC). Having regard to the vegetation survey completed by Eco Logical , 13 vegetation associations were identified as being present. None of the vegetation associations present within the Development Envelope were inferred to represent any known or potential conservation significant vegetation communities listed under the EPBC Act, the BC Act, or by the WA Department of Biodiversity, Conservation and Attractions (DBCA) .

Vegetation communities mapped within the Project Area align with Beard's vegetation association mapping, as presented in Section 5.1.5.1.1. Vegetation communities Ag, AgBc, AgCgEc, AtAcDo, BcCg, BcGaCg, BcTc, CgAgBc, CgCzBc, EcCg and EmEcAg broadly comprise aspects of Beard's North Fitzroy Plains 64 and 710 vegetation associations with the presence of mixed hummock (Triodia spp.) and tussock grasslands, Adansonia gregorii, Bauhinia cunninghamii and ribbon grass (Chrysopogon fallax; Government of Western Australia 2019). Vegetation communities AgCgEc, CbEc, BcTc, BcGaCg, EcCg, CzEcCg broadly comprise aspects of Beard's North Fitzroy Plains 699 and 700 vegetation communities with the presence of shrublands over curly spinifex (Triodia bitextura) on sandplain or between dunes (Government of Western Australia 2019).

The association with the highest quantity of impact was CgAgBc, comprising 12 per cent of the disturbance footprint or 14 hectares, which is described by Eco Logical to broadly comprise aspects of Beard's North Fitzroy Plains 64 and 710 vegetation associations . Having regard to the extent and distribution of these systems locally, the loss of 0.056 per cent of a local vegetation association is not considered to be significant when compared to availability across the area.

Given that none of the vegetation associations mapped by Eco Logical are considered to be rare, nor do they match communities that have insufficient information available on them, BNR does not believe that the direct impact to each of the local vegetation communities, as detailed by Eco Logical , will result in a significant localised impact.

Vegetation communities recorded within the Project Area are similar to those recorded from previous studies within the region; Low Ecological Services (2012b) recorded a mix of Bauhinia cunninghamii, Adansonia gregorii, Corymbia spp. and Acacia spp. over hummock (Triodia spp.) and tussock grasslands (Aristida, Sorghum) within the Asgard 2D seismic survey area, located adjacent to and within the current Project Area. Low Ecological Services (2020) also recorded similar plant community structure and composition, including low open woodlands (Adansonia gregorii, Bauhinia cunninghamii, Corymbia spp.) and grasslands, riparian communities and low woodland on sand dunes within the Odin 2D and 3D seismic survey area, located adjacent to and within the current Project Area. Woodman Environmental (2007) also recorded a plant community of similar composition (open woodland of Eucalyptus and Corymbia over Aristida and Eriachne tussock grasses) within their Valhalla Well Site survey area.

Table 5-8: Proposed clearing areas and local vegetation associations

Vegetation association	Regional vegetation association	Current extent (ha) within the subregion (regional vegetation association)	Surveyed area (indicative clearing area [ha])	Impact of clearing at a local scale (%)
Ag	North Fitzroy Plains 710 and 64	25,596.64	9.16	0.036
AgBc	North Fitzroy Plains 710 and 64	25,596.64	12.35	0.048
AgCgEc	North Fitzroy Plains 699 and 700	392,935.55	11.44	0.003
AtAcDo	North Fitzroy Plains 710 and 64	25,596.64	12.38	0.048
BcCg	North Fitzroy Plains 710 and 64	25,596.64	3.3	0.013
BcGaCg	North Fitzroy Plains 710 and 64	25,596.64	11.45	0.045
BcTc	North Fitzroy Plains 710 and 64	25,596.64	7.25	0.028
CbEc	North Fitzroy Plains 699 and 700	392,935.55	1.77	0.000
CgAgBc	North Fitzroy Plains 710 and 64	25,596.64	14.24	0.056
CgCzBc	North Fitzroy Plains 710 and 64	25,596.64	11.33	0.044
CzEcCg	North Fitzroy Plains 699 and 700	392,935.55	11.95	0.003
EcCg	North Fitzroy Plains 710 and 64	25,596.64	4.68	0.018
EmEcAg	North Fitzroy Plains 710 and 64	25,596.64	1.15	0.004

5.1.5.1.3 Conservation Significant flora

As described in Table 5-2, many flora and vegetation surveys have been undertaken in and near the Development Envelope. These surveys indicate that Threatened or DRF species are not expected to occur within the Development Envelope. No TEC or PEC, as listed under the BC Act or EPBC Act, are reported to occur within the Development Envelope. Because 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 5.1.3.6 in the desktop assessment, six Priority species were recorded in the Development Envelope during these surveys:

- *Goodenia byrnesii* (P3)
- *Goodenia sepalosa* var. *glandulosa* (P3)
- *Goodenia virgata* (P2)
- *Nymphoides beaglensis* (P3)
- *Trianthema kimberleyi* (P1)
- *Triodia acutispicula* (P3).

Nymphoides beaglensis (P3) was the only Priority species recorded during the 2021 flora and vegetation survey undertaken for the Proposal (Table 5-5). *Nymphoides beaglensis* (P3) is an annual aquatic herb with white to pink and purple flowers from March to June (DBCA and WAH 2021). It is known from 20 records over a range of approximately 475 km from Roebuck in the southwest to the Mitchell Plateau in the northeast, with the nearest known record located approximately 38 km northwest of the Project Area (DBCA 2007-2021). Surveys in 2021 indicate that the species is prolific in the local area, having been recorded at eight point locations with over 100 records. However, as the Disturbance footprint was realigned to avoid the aquatic and marshy habitat, no direct impacts to any of the recorded species will occur.

Although this species was identified in the original disturbance footprint, BNR modified the disturbance footprint to avoid impacts to this species and its preferred vegetation community—this species is associated

with damp lands, which the Proposal will avoid. The "realignment" was completed whilst botanists were in the field and as such the entire area (including the realignment) was surveyed.

As detailed in Table 5-2 and depicted in Figure 5-2, a summary of all conservation significant flora identified within the Development Envelope, having regard to the disturbance footprint, verifies that no Priority species are expected to be impacted by the Proposal.

As detailed in Section 5.1.3.7, Eco Logical identified four recorded species within the project area as representing range extensions (RE), namely *Cajanus latisepalus*, *Lindernia chrysoplectra*, *Lindernia clausa* and *Tephrosia remotiflora*.

Cajanus latisepalus is an erect, spindly shrub with yellow pea flowers from March to August (DBCA and WAH 2021). It is known to grow in sandy or gravelly soils, sandstone and basalt on sandplains and rocky slopes (DBCA and WAH 2021). Cajanus latisepalus is currently known from 281 records in Australia, over a range of approximately 500 km from Meda in the west across to the Northern Territory (NT) border in the east (ALA, -2023). The species has been recorded across multiple IBRA regions including Central Kimberley, Northern Kimberley, Ord Victoria Plain and Victoria Bonaparte (DBCA, 2021).

This species was only recorded in a single quadrat within the disturbance footprint: ELA29, within the AgBc vegetation community on moist light brown clay loam flats. This record represents a minor range extension of approximately 60 km to the southwest of the known range of this species.

Given its broad distribution, clearing individuals of *Cajanus latisepalus* within a single location within the disturbance footprint is not considered to result in a significant impact to the species as:

- direct impacts to species are limited to a single vegetation community within disturbance footprint (AgBc) which comprises only 12.35 per cent of the disturbance footprint (Table 5-4)
- the taxon has been recorded across a broader number of IBRA regions suggesting any local impacts would not result in population level impacts
- vegetation communities were considered to broadly comprise aspects of broadscale desktop mapping, which themselves are not considered locally restricted. being widespread throughout the region demonstrating that these species will not be restricted to just to the disturbance footprint. Therefore, the Proposal will not affect the broader population.

Lindernia chrysoplectra is currently known from 13 records in WA and NT, over a range of approximately 465 km from the Dampier Peninsula in the northwest to 180 km west of Sturt Creek in the southeast (ALA, -2023a). The species has been recorded across multiple IBRA regions including Dampierland and Ord Victoria Plain (DBCA, 2021). This species was only recorded in a single quadrat within the disturbance footprint; ELA64, within the CbEc vegetation community on waterlogged dark brown sandy clay on an open depression. This record represents a range infill, joining the eastern and western populations of this species, with the closest records of this species approximately 170 km to the west and 150 km to the east-southeast of the project area. Given its broad distribution across multiple IBRA regions, clearing individuals of *Lindernia chrysoplectra* within a single location within the disturbance footprint is not considered to result in a significant impact to the species as:

- direct impacts to species are limited to a single vegetation community within disturbance footprint (CbEc) which comprises only 1.5 per cent of the disturbance footprint (Table 5-3)
- the taxon has been recorded across a broader number of IBRA regions suggesting any local impacts would not result in population level impacts
- vegetation communities were considered to broadly comprise aspects of broadscale desktop mapping, which themselves are not considered locally restricted, being widespread throughout the region. This demonstrates that these species will not be restricted to just to the disturbance footprint. Therefore, the Proposal will not affect the broader population.

Lindernia clausa is currently known from 230 records throughout WA, NT and Queensland over a range of approximately 1500 km (ALA, -2023b). The species has been recorded across multiple IBRA regions including Central Kimberley, Dampierland, Northern Kimberley and Victoria Bonaparte (DBCA, 2021). This species was recorded from three quadrat locations; ELA26, ELA27 and ELA31, within the BcTc and Ag vegetation communities on moist brown clay on open depression. This record represents a range

extension of approximately 112 km to the south of the known range of this species. Clearing individuals of *Lindernia chrysoplectra* within the disturbance footprint is not considered to result in a significant impact to the species as:

- direct impacts to species are limited to two vegetation communities within disturbance footprint (BcTc and Ag) which comprises 14.5 per cent of the disturbance footprint (Table 5-3)
- the taxon has been recorded across a broader number of IBRA regions suggesting any local impacts would not result in population level impacts
- vegetation communities were considered to broadly comprise aspects of broadscale desktop mapping, which themselves are not considered locally restricted, being widespread throughout the region demonstrating that these species will not be restricted to just to the disturbance footprint. Therefore, the Proposal will not affect the broader population.

Tephrosia remotiflora is currently known from 870 records across WA, NT and QLD, over a range of approximately 2,000 km from near Onslow in the south Kununurra to the Queensland coast (ALA, -2023c). The species has been recorded across multiple IBRA regions including Central Kimberley, Dampierland, Northern Kimberley, Ord Victoria Plain, Pilbara and Victoria Bonaparte (DBCA, 2021) This species was recorded from one quadrat location; ELA01, within the AgCgEc vegetation community on red brown sandy loam on a gentle slope. This record represents a minor range extension of approximately 65 km to the south of the known range of this species. Clearing individuals of *Tephrosia remotiflora* within the disturbance footprint is not considered to result in a significant impact to the species as:

- direct impacts to species are limited to two vegetation communities within disturbance footprint (AgCgEc) which comprises 10.8 per cent of the disturbance footprint (Table 5-3)
- the taxon has been recorded across a broader number of IBRA regions suggesting any local impacts would not result in population level impacts
- vegetation communities were considered to broadly comprise aspects of broadscale desktop mapping, which themselves are not considered locally restricted, being widespread throughout the region demonstrating that these species will not be restricted to just to the disturbance footprint. Therefore, the Proposal will not affect the broader population.

Noting that (EPA, 2016c) list other mechanisms in which flora species may be significant, BNR has reviewed this list and on the basis that:

- no threatened or priority species will be impacted
- no locally endemic species or species associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems) will be impacted
- no new species or anomalous features that indicate a potential new species were identified by Eco Logical
- although four species that are representative of range extensions were identified by Eco Logical, on review these species are not spatially restricted with distribution across multiple IBRA regions, states and identified within vegetation communities that are likely present and widespread throughout the Kimberley region
- no unusual species, including restricted subspecies, varieties or naturally occurring hybrids were identified by Eco Logical
- no species of relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape, were identified by Eco Logical.

BNR does not believe that the Proposal poses a risk to significant flora or vegetation values planned to be impacted within the disturbance footprint.

5.1.5.2 Degradation or loss 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 longer term impacts, where the new species out-compete native species, causing local vegetation associations and ecosystems to be significantly altered.

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

5.1.5.3 Habitat loss or degradation as a result of an unplanned fire event

Site activities, including site preparation, may have the potential to cause a fire that results in habitat loss and vegetation degradation. As described in Table 5-2 and Section 5.1.5.1, the general habitat and vegetation system surrounding the Development Envelope has a very large extent and distribution within the West Kimberley.

Grass fires are the most substantial ignition risk in the Development Envelope. Grass fires in the Canning Basin occur regularly during the dry season. Fire frequency varies, but typically occurs every two to four years (NAFI, 2021). Figure 5-6 and Figure 5-7 show the 2020 and 2021 fire scars resulting from natural fires, prescribed burning activities from the pastoral stations, or accidentally lit fires. 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. If the proposed activities cause a fire, impacts to vegetation associations and species diversity in the surrounding region is unlikely to be significant given the frequency with which fires pass through the landscape. Studies into the recovery of Pindan vegetation systems following fire events conclude that Pindan vegetation structural recovery took four to five years, but that recovery could be expected over a shorter period time (Radford & Fairman, 2015).

The incidences of fire can be suitably managed through standard mitigation measures that are enacted under the *Bush Fires Act 1954* (WA) 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 does not expect these indirect impacts to cause a significant environmental impact.

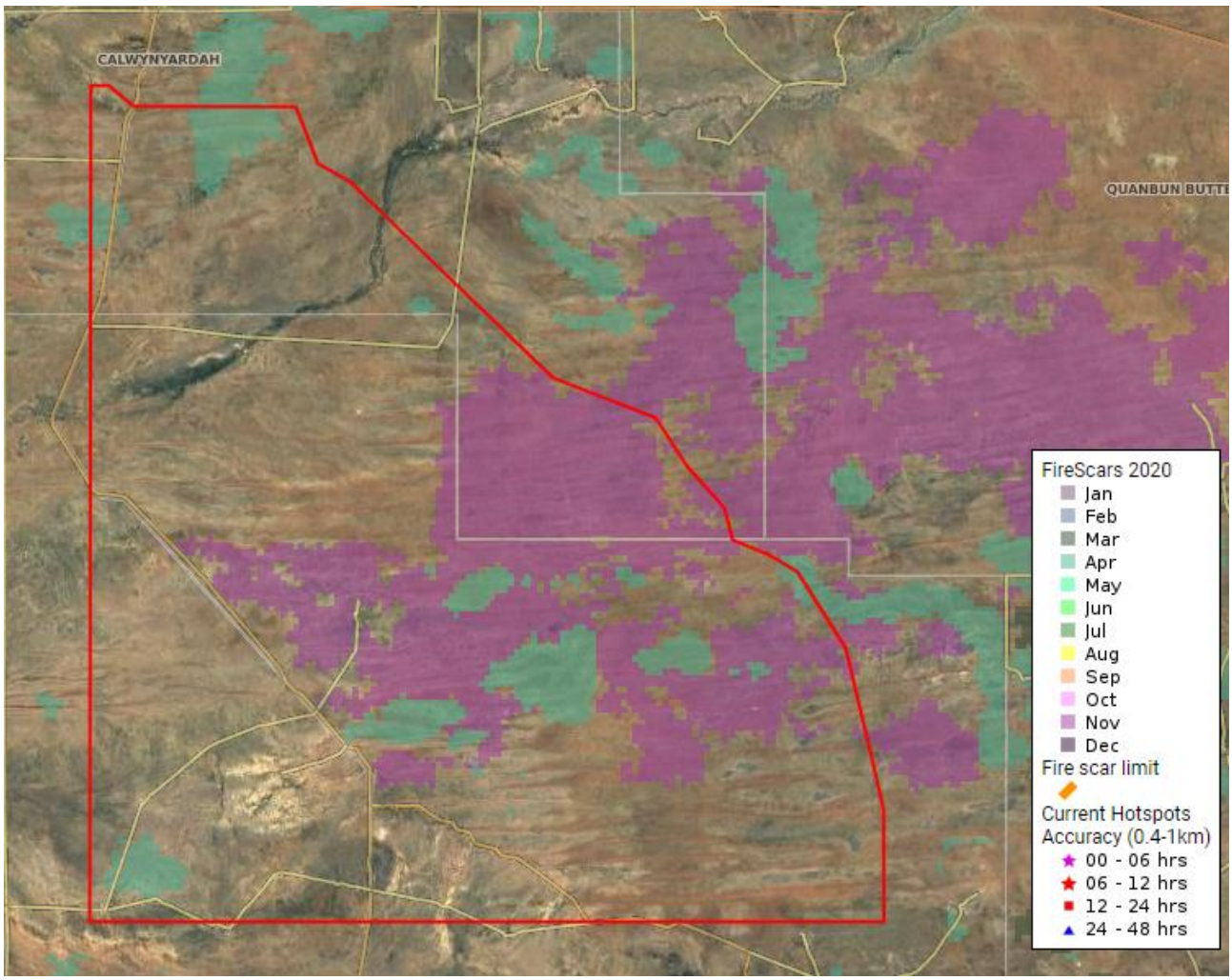


Figure 5-6: 2020 fire scars within EP 371 (NAFI, 2021)

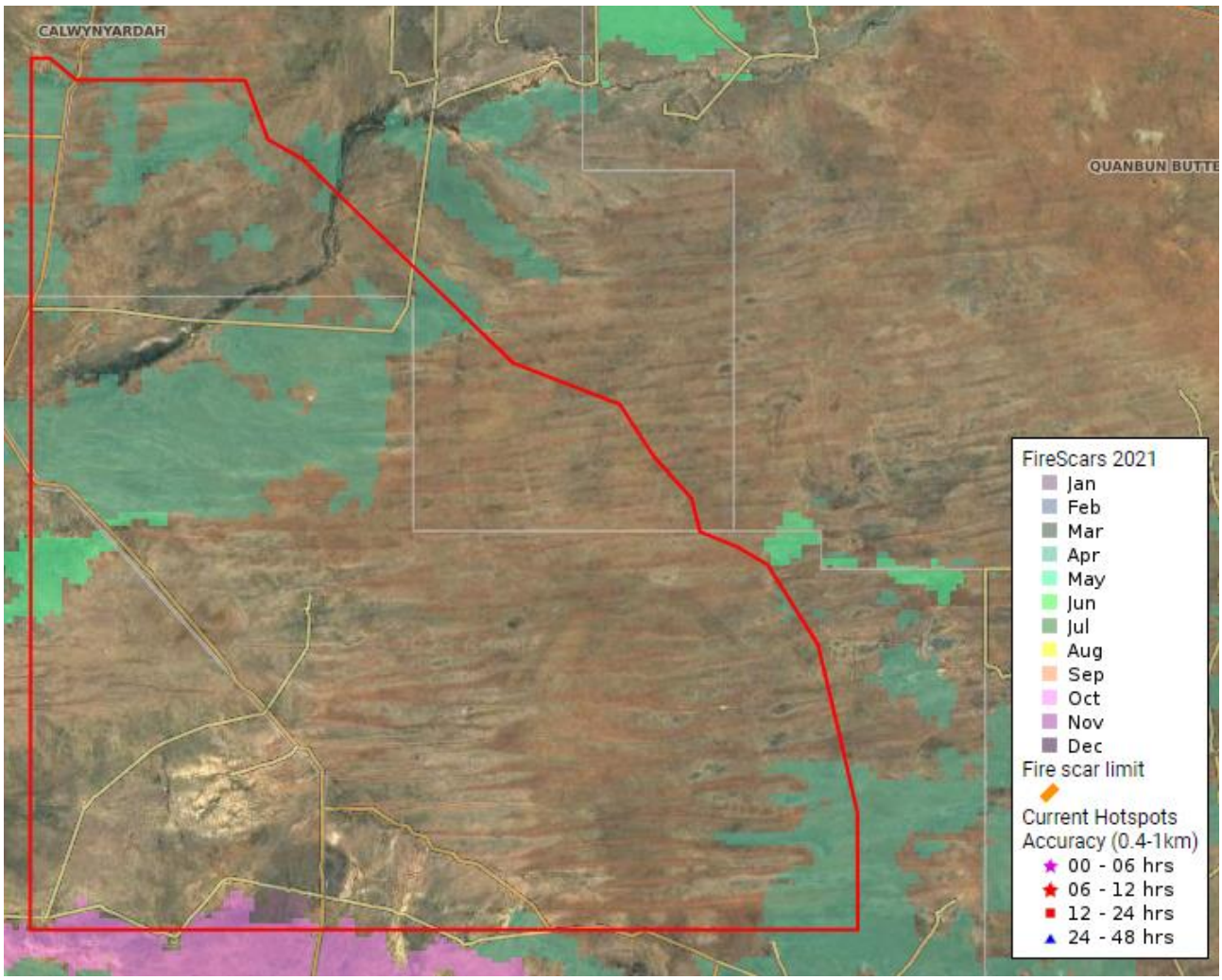


Figure 5-7: 2021 fire scars within EP 371 (NAFI, 2021)

5.1.5.4 Degradation or loss of vegetation ecology and biodiversity as a result of dust

Dust generated from vegetation clearing and driving on unsealed roads is anticipated to be produced during the proposed activities. Dust has the potential to extend outside the disturbance footprint, potentially impacting local vegetation. However, dust is not expected to extend outside the Development Envelope and impact vegetation on a regional level.

As identified in Sections 5.1.3.4, 5.1.3.5 and 5.1.3.6, no conservation significant vegetation communities and no Threatened, DRF or Priority flora species are expected to be present within the disturbance footprint; however, historically, Priority flora have been observed in the wider Development Envelope.

Dust is expected to settle on nearby native vegetation and pasture but is unlikely to create anything more than a temporary reduction in photosynthetic capacity because rainfall events tend to remove the dust from foliage. The impact is no different from other light and heavy vehicle traffic travelling over similar surfaces, such as pastoral station vehicles along pastoral tracks and vehicles travelling to the Yungngora Community along the gravel Calwynyardah–Noonkanbah Road.

A long-term monitoring program that investigated impacts of dust on vegetation for a significant development in the Pilbara over a five-year period, where high volumes of heavy and light vehicles and earthworks were present, determined that no adverse impacts occurred to plant health or vegetation communities as a result of dust loads associated with construction (Chevron Australia, 2015). Consequently, BNR does not believe that dust generation from the Proposal will result in a credible impact to vegetation.

Dust impacts to human health are evaluated in Section 5.5.5.1.

5.1.6 Mitigation

Table 5-7 summarises the mitigation measures and their hierarchy. These will be included in an EP for assessment and acceptance by DEMIRS under the PGER(E)R before activities commence.

Table 5-9: Proposed mitigation measures – flora and vegetation

Mitigation hierarchy	Mitigation measure	Further information
Avoid	Demarcation of clearing area	Demarcation of the proposed clearing area by a surveyor reduces, to the smallest possible extent, the chance of unplanned clearing outside the proposed footprint.
Avoid	Fire breaks	As required by local shire regulations, BNR is required to ensure clearances between vegetation and industrial activities are created and maintained to reduce the risk of causing a fire outside the site.
Avoid	Bush Fires Regulations 1954 and exemptions	Site preparation, construction and activities (e.g. hot work, off-road activities) (e.g. gas flaring) are prescribed activities in the Bush Fires Regulations 1954. As such, a range of management measures under the Regulations must and will be implemented.
Minimise	Topsoil windrows <2 m	With seeds and roots mainly conserved within the topsoil, topsoil will be removed and stockpiled into windrows following clearing, with subsoil left in place. It is a generally accepted industry standard that windrows should be no higher than two metres. The reason for this is that temperature in the centre of a windrow will get higher where the height/quantity of material increases. Because seed viability is reduced if temperatures increase, the quality / outcomes of revegetation using the topsoil and associated seedbank also reduces.
Minimise	Fill verified as having low weed risk	In accordance with DAWE's Arrive Clean, Leave Clean guidance (Commonwealth of Australia, 2015), it is considered good industry practice to prevent the spread of weeds by ensuring that any fill used on site (e.g. gravel, limestone marl, soil, sand) has been verified to have a low weed risk. BNR will follow this industry practice.
Minimise	Hygiene management requirements	It is considered good industry practice to prevent the spread of weeds by ensuring that civil earthmoving machinery is subject to an inspection and if required a clean-down before arriving on site and before starting ground-disturbing activities, and BNR will require its operators follow this practice.
Rehabilitate	Progressive rehabilitation	As required under the PGER(E)R, 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 environmental liability at the end of asset life. Topsoil is to be respread and rehabilitation sites actively monitored to ensure they meet the required completion criteria. Specifically, completion criteria will be developed to ensure that rehabilitation is conducted to enable long-term land use to continue. These completion criteria will be documented in the EP for acceptance by DEMIRS.

5.1.7 Environmental outcomes

The outcomes of the Proposal are predicted to be:

- no impacts to DRF, ESA, TEC, or PEC
- no impacts to Priority flora species
- no significant reduction in pre-European vegetation association extent
- no detrimental impacts to flora and vegetation values
- no impact to the overall biological diversity and ecological integrity of flora and vegetation within the Development Envelope.

Based on the predicted outcomes for the Proposal, BNR does 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 has considered the WA Environmental Offsets Policy (Government of Western Australian, 2011) and Guidelines (Government of Western Australia, 2014), and has used the Residual Impact Significance Model (Figure 3 in WA Environmental Offsets Guidelines) to determine if any residual impacts are significant and if these may require an offset. Using the model's process, it was determined that all residual impacts to flora and vegetation are not significant, and therefore BNR does not believe actions are required to offset the predicted outcomes of the Proposal. The assessment outcomes are presented in Section 5.11.1.

A self-assessment of impacts on matters of NES in relation to flora and vegetation was also undertaken against the Commonwealth's significant impact guidelines for matters of NES (Department of the Environment, 2013). The Proposal's activities were determined not to have a significant impact on any flora or ecological community MNES. Consultation with DAWE in June 2020 and October 2021 and the provision of BNR's self-assessment's outcomes to DAWE further confirmed that no significant impacts to any matters of NES were expected. Initial advice from the Commonwealth had been that this project was not required to be referred. BNR has continued to engage with DCCEEW to reiterate that the environmental impacts associated with the Proposal do not result in any direct or indirect mechanisms that would cause a significant impact to these matters of NES protected under the EPBC Act.

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 Note (WQPN) 26 (liners for containing pollutants, using synthetic membranes) (DoW, 2013).

5.2.2.1 Application of the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing and procedure of the environmental review, as required by Section 40(3) of the EP Act. Table 5-8 lists the ESD requirements specific to terrestrial environmental quality.

Table 5-10: ESD checklist – terrestrial environmental quality

Terrestrial environmental quality		
Required work		**BNR response**
65	Present a desktop soil quality assessment within the vicinity of the well pads.	Section 5.2.3
66	Include in the ERD, figures of the mapped soil units and soil profile.	Figure 5-8 Figure 5-9 Appendix E Appendix G
67	Describe the proposed management, monitoring and mitigation methods to be implemented to address direct and indirect impact on soils/lands/receiving environment. This description is to include soil handling methods to mitigate erosion, compaction, and contamination and soil quality monitoring following site reinstatement activities.	Table 5-10 Appendix E
68	Develop a suitable soil quality monitoring program for each well, documented within the ERD that includes: • A comprehensive list of analytes proposed to be collected • A scientifically justified baseline monitoring program (including extent and duration of the program) • Trigger and threshold contingency actions.	Appendix E
69	Predict residual impacts after considering the mitigation hierarchy.	Section 5.2.5 Section 5.2.7

Terrestrial environmental quality		
Required work		**BNR response**
70	Provide a waste management strategy, including methods for segregating wastes and appropriate disposal arrangements with licensed facilities. Wastes associated with hydraulic fracture stimulation requiring evaluation and management include drilling fluid, rock cuttings, flowback fluid, and produced formation water.	Section 2.6 Table 2-8

5.2.3 Receiving environment

5.2.3.1 Soil landscape systems

The Development Envelope is within the North Fitzroy Plain Zone, which covers an area of 17,925 km^2 (Tille, 2006). The North Fitzroy Plain Zone comprises floodplains and sandplains (with alluvial 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. Rangeland land system maps, prepared by DPIRD, describe the biophysical characteristics of each region and separates these into land systems, which are defined as repeating patterns of topography, soil and vegetation. The Development Envelope covers four soil landscape systems (Figure 5-8), which are described as (Government of Western Australia, 2021b; Payne & Schoknecht, 2011):

- 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 floodplains 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.

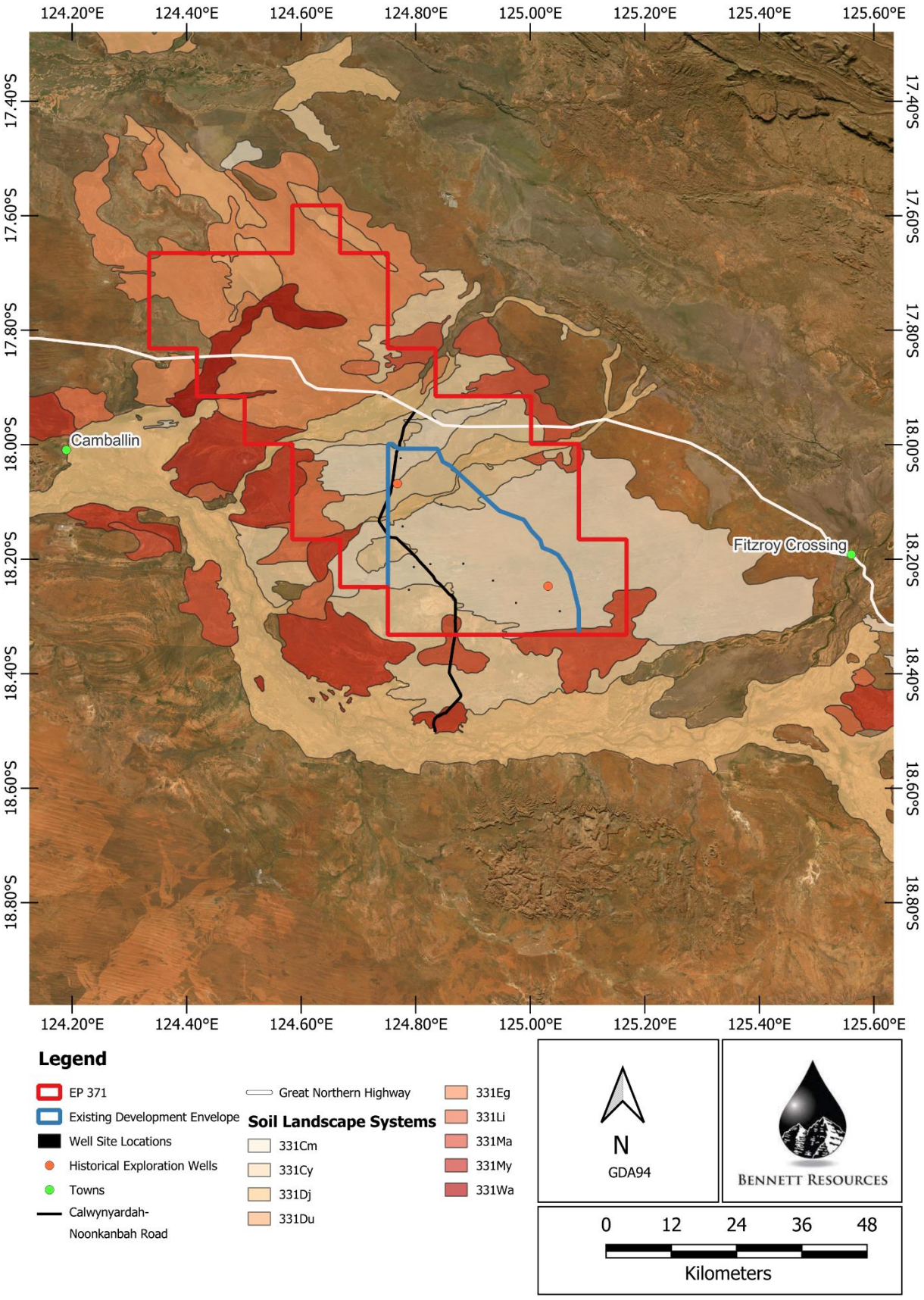


Figure 5-8: Regional extent of the soil landscape systems within the Development Envelope

5.2.3.2 Soil quality characteristics

To understand local and regional soil quality, a soil monitoring program was developed and implemented by BNR (Appendix E). The first stage of the program comprised regional baseline soil sampling undertaken within all relevant soil landscape systems near the proposed well sites in order to better understand soil quality and variability across the Development Envelope.

In August 2021, six sites were sampled within varying distances of the proposed well site locations. Soil sampling sites, shown in Figure 5-9, were selected based upon accessibility to the proposed well site locations and the relevant soil landscape system present in the area. Further information regarding the location and monitoring rationale is included as Appendix F.

At each site, a representative sample of up to 0.4 m depth within a 10 m × 10 m quadrat was taken. Sample chemistry was analysed at a National Association of Testing Authorities (NATA) accredited laboratory for a comprehensive list of analytes. Where possible, particle size distribution (PSD) by sieving and hydrometer was also undertaken. Field observations (including weather conditions, presence of pastoral activities [evidence of cattle], and fire regime) were recorded on the day of sampling. Table 5-8 lists the results of the regional baseline soil samples. The results were compared to ecological and health investigation and screening levels[7,8] as presented in the table of results; these levels are detailed in the (former) Department of Environment and Conservation's (DEC) Assessment levels for Soils, Sediment and Water document (DEC, 2010).

Further localised baseline soil sampling was undertaken in July 2023 that validated previous sampling programs the earlier sampling regime. Results from the 2023 sampling is summarised below and included as Appendix G.

5.2.3.2.1 Soil chemical analysis

Results from the baseline soil quality sampling show that, for all soil samples, all analytes were below any of the ecological and health investigation and screening levels (Appendix F). This result was expected because the land use is limited to pastoral use with no industrial activities occurring across the Development Envelope. Although some discrepancies were noted between the types of soil landscape systems within the Development Envelope, they are characteristic of the different types of soils found in this area. BNR plans to sample a standard suite of analytes, including specific analytes defined as CoPCs, which have been identified as triggers from the Proposal's activities. Table 5-9 summarises the results for several analytes and CoPCs that are relevant to the Proposal, including:

- barium
- cadmium
- chloride.

[7] "Ecological investigation levels have been developed for selected metals and organic substances and are applicable for assessing risk to terrestrial ecosystems. [These] depend on specific soil physicochemical properties and land use scenarios and generally apply to the top 2 m of soil." (NEPC, 1999).

"Ecological screening levels have been developed for selected petroleum hydrocarbon compounds and total petroleum hydrocarbon (TPH) fractions and are applicable for assessing risk to terrestrial ecosystems. [These] broadly apply to coarse- and fine-grained soils and various land uses. They are generally applicable to the top 2 m of soil. (NEPC, 1999).

"Health investigation levels have been developed for a broad range of metals and organic substances. [These] are applicable for assessing human health risk via all relevant pathways of exposure. [These] are generic to all soil types and apply generally to a depth of 3 m below the surface for residential use. (NEPC, 1999).

"Health screening levels have been developed for selected petroleum compounds and fractions and are applicable to assessing human health risk via the inhalation and direct contact pathways. [These] depend on specific soil physicochemical properties, land use scenarios, and the characteristics of building structures. They apply to different soil types, and depths below surface to >4 m. (NEPC, 1999).

[8] Analyte screening levels may be subject to change depending on various legislation and best scientific information at the time of the sampling.

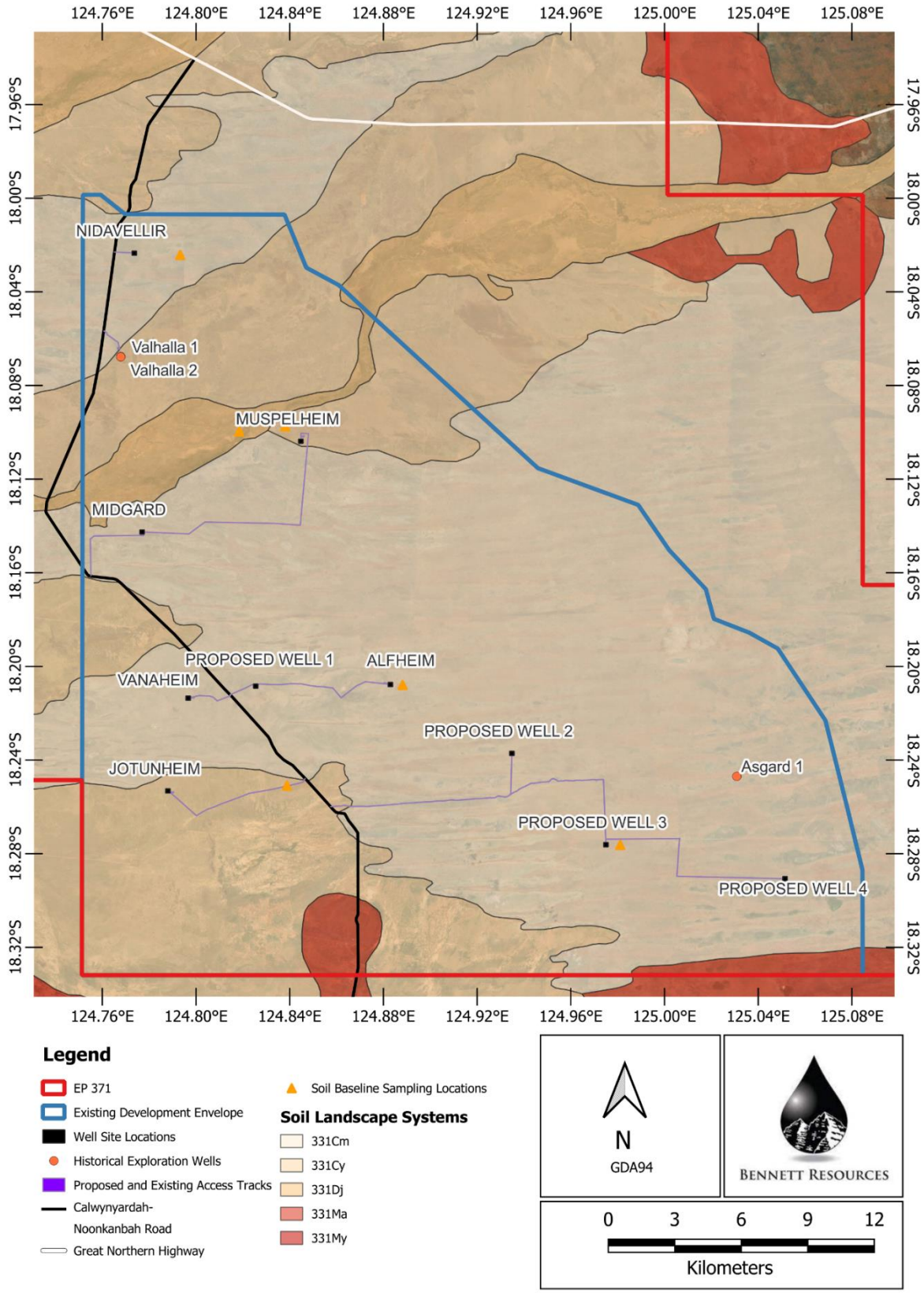


Figure 5-9: Baseline soil sampling locations

In summary, the project's baseline soil quality sampling program determined that:

- pH values ranged between circumneutral (pH 6.6–7.3) for red deep sands (331Cm) and yellow sandy earths (331Cy), and slightly alkaline (pH 7.4–7.8) for self-mulching cracking clays (331Dj)
- soils sampled within the Development Envelope recorded low electrical conductivity (EC) values that ranged from 4 µS/cm to 29 µS/cm; therefore, all samples were classed as non-saline
- deep red sands (331Cm) were found to be less saline than yellow sandy earths (331Cy), with the self-mulching cracking clays having the highest non-saline rating of 29 µS/cm
- all soils (mixtures of surface and subsoil) sampled within the Development Envelope recorded low levels of organic matter (OM) and total organic carbon (TOC), with TOC ranging between 0.38%w/w and 0.62%w/w, and OM ranging between 0.22%w/w and 0.36%w/w. In general, deep red sands recorded less OM and TOC
- metals (particularly chromium, manganese, iron) and minerals/nutrients (calcium, magnesium, potassium) were generally lower in samples from 331Cm than in 331Cy
- metals and silica in the comparative sample (located in a different soil landscape system) from the 331Dj self-mulching cracking clay (creek line soil sample) were in most cases significantly higher
- all benzene, toluene, ethylbenzene, and xylene (BTEX) and hydrocarbon results were below the laboratory's limit of reporting (LoR).

Table 5-11: Soil quality results for contaminants of potential concern

Analyte[9]	Units	Lab. Reporting Limit	Ecological Investigation and Screening Levels for Soils (mg/kg) (DEC, 2010)	Health Investigation and Screening Levels for Soils (mg/kg) (DEC, 2010)	Soil Sample					
					SM_1	SM_2	SM_3	SM_4	SM_5	SM_6
pH	pH units	0	-	-	6.7	7.8	7.1	6.8	6.6	6.7
Conductivity of extract (1:5 as received)	µS/cm	1	-	-	4	29	6	5	20	3
Total dissolved solids (TDS; by calculation)	mg/kg	5	-	-	12	87	18	15	62	10
% moisture	%w/w	0.5	-	-	<0.5	1.6	1.0	0.9	0.9	0.9
Aluminium, Al	mg/kg	50	-	-	990	5500	2200	1300	2000	1400
Barium, Ba	mg/kg	0.5	300	15,000	12	52	44	21	19	13
Boron, B	mg/kg	5	-	5,000	<5	<5	<5	<5	<5	<5
Cadmium, Cd	mg/kg	0.3	3	20	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chromium, Cr	mg/kg	0.5	Cr III: 400	Cr III: 120,000	8.4	18	26	13	20	14
Iron, Fe	mg/kg	50	-	-	3900	13000	10000	4300	14000	6000
Chloride (water extractable 1:5)	mg/kg	5	-	-	38	11	51	26	51	64
Sulfate (1:5 water extractable), SO_4	mg/kg	5	2000	-	59	52	66	93	87	57
Benzene (VOC)	mg/kg	0.1	1	1.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Toluene (VOC)	mg/kg	0.1	3	520	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

[9] Soil samples analysed at a NATA-accredited laboratory.

Analyte[9]	Units	Lab. Reporting Limit	Ecological Investigation and Screening Levels for Soils (mg/kg) (DEC, 2010)	Health Investigation and Screening Levels for Soils (mg/kg) (DEC, 2010)	Soil Sample					
					SM_1	SM_2	SM_3	SM_4	SM_5	SM_6
Ethylbenzene (VOC)	mg/kg	0.1	5	230	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
m/p-xylene (VOC)	mg/kg	0.2	-	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
o-xylene (VOC)	mg/kg	0.1	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total xylenes (VOC)	mg/kg	0.3	5	600	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Total BTEX (VOC)	mg/kg	0.6	-	-	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
TRH C6-C9	mg/kg	20	-	-	<20	<20	<20	<20	<20	<20
TRH C6-C10	mg/kg	25	-	-	<25	<25	<25	<25	<25	<25
TRH C6-C10 minus BTEX (F1)	mg/kg	25	-	-	<25	<25	<25	<25	<25	<25
TRH C10-C14	mg/kg	20	-	-	<20	<20	<20	<20	<20	<20
TRH C15-C28	mg/kg	45	-	-	<45	<45	<45	<45	<45	<45
TRH C29-C36	mg/kg	45	-	-	<45	<45	<45	<45	<45	<45
TRH C37-C40	mg/kg	100	-	-	<100	<100	<100	<100	<100	<100
TRH >C10-C16	mg/kg	25	-	-	<25	<25	<25	<25	<25	<25
Source of assessment levels		NEPM (NEPC, 1999)	Dutch B (Assink & van den Brink, 1986)	DoH (DoH, 2009)		US EPA Regional Screening Levels (US EPA, 2021)			ANZECC B (ANZECC & NHMRC, 1992)	

5.2.3.2.2 Soil physical analysis

Soil particles vary from fine clay to rocks, conventionally classed between coarse fragments (>2 mm) and fine earth (<2 mm). Sand and clay particles dominate in most WA soils and particularly within the Development Envelope. Limited PSD data (Appendix F) were available for these samples as particle sizing of soils <75 µm by hydrometer was not conducted where insufficient samples passed the 75 µm fraction. Only the comparative creek line sample SM_2, corresponding to self-mulching cracking clay soil, could be sized through hydrometry <75 µm, confirming that the other samples comprise larger particles characteristic of sandy soils.

Given that BNR plans to operate outside swamplands / damp lands where soil with high clay content is expected, the disturbance footprint is expected to consist mostly of coarse grainy sands.

5.2.3.3 Soil mapping profiles

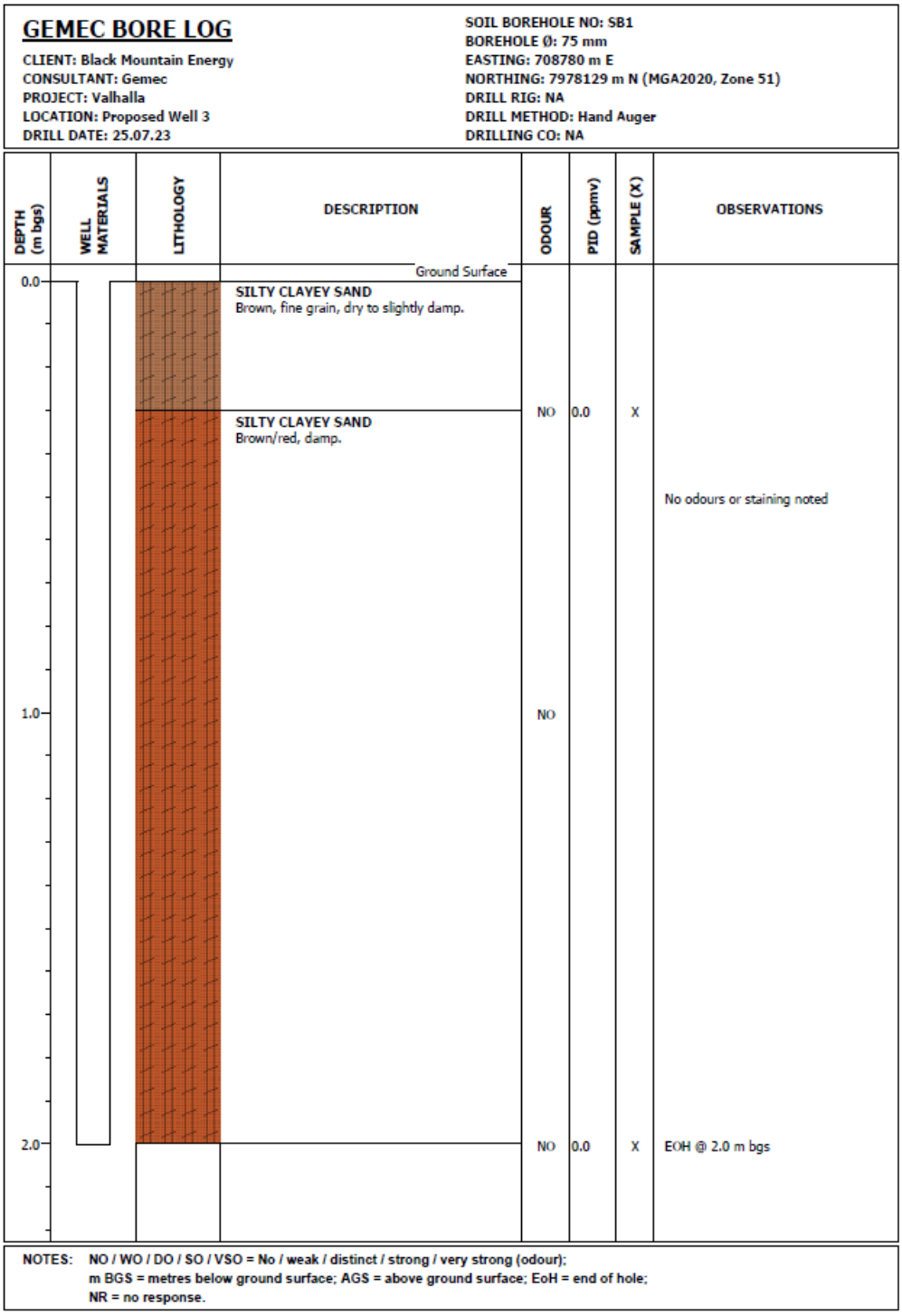
Soil profile relates to soil structure, which comprises topsoil and different subsoil layers, from the ground surface down to where the soil meets the underlying rock. Profiles at the location and time of sampling will vary depending on the soil unit and how rocks have weathered over time. Natural variation in profiles will also depend on the type of vegetation present, the vegetation cover, and other environmental factors such as influence from surface water and groundwater.

BNR conducted a desktop review of online databases to inform sampling design. However, within the DPIRD WA soil profile database (Government of Western Australia, 2021c), no soil profiles were available for the specific soil landscape systems present within the Development Envelope.

Additional localised soil sampling was undertaken in August 2023 (GEMEC, 2023), the results of which are included as Appendix G. In summary, the soil comprises:

- 0-0.3 m: Silty clayey sand, fine-medium grain, brown, dry-damp
- 1.7-2.0 m: Silty clayey sand, fine-medium grain, brownish red, damp (from 0.7 m bgs)

- no volatile organic compound concentrations were detected in the soil via photo ionisation detector.



GEMEC BORE LOG

CLIENT: Black Mountain Energy
CONSULTANT: Gemec
PROJECT: Valhalla
LOCATION: Proposed Well 3
DRILL DATE: 25.07.23

SOIL BOREHOLE NO: SB1
BOREHOLE Ø: 75 mm
EASTING: 708780 m E
NORTHING: 7978129 m N (MGA2020, Zone 51)
DRILL RIG: NA
DRILL METHOD: Hand Auger
DRILLING CO: NA

DEPTH (m bgs)	WELL MATERIALS	LITHOLOGY	DESCRIPTION	ODOUR	PID (ppmv)	SAMPLE (X)	OBSERVATIONS
0.0			Ground Surface				
			SILTY CLAYEY SAND Brown, fine grain, dry to slightly damp.				
			SILTY CLAYEY SAND Brown/red, damp.	NO	0.0	X	
							No odours or staining noted
1.0				NO			
2.0				NO	0.0	X	EOH @ 2.0 m bgs

NOTES: NO / WO / DO / SO / VSO = No / weak / distinct / strong / very strong (odour);
m BGS = metres below ground surface; AGS = above ground surface; EoH = end of hole;
NR = no response.

Figure 5-10: Soil profile analysed by GEMEC (Appendix G)

5.2.4 Potential impacts

5.2.4.1 Direct impacts

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

5.2.4.2 Indirect impacts

Activities from the Proposal may indirectly result in:

- erosion or scouring as a result of reduction in soil stability during civil works
- contamination of land and soils from surface spills
- inadequate rehabilitation arising from compaction.

5.2.5 Assessment of impacts

5.2.5.1 Erosion or scouring from a reduction in soil stability during civil works

Compaction can be very difficult in soils that contain significant organic matter. For this Proposal, a well site needs to have a suitable stable foundation for heavy equipment and machinery. When the site is cleared, organic material is removed (through removal of topsoil) and placed to one side. Once clearing is complete, the well site is either stabilised by importing construction fill material (e.g. 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 BNR will apply to reduce the likelihood that such impacts will occur. If soil materials on the site are well compacted after topsoil organics are removed 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 Contamination of land and soils from surface spills

Contamination of soils and the immediate surrounding land may occur from an unplanned surface spill event. To determine the spill risk and potential impacts arising from a spill, a spill risk characterisation for the Proposal is presented in Table 5-10.

Table 5-12: 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 <100 L being released to the ground.
Loss of diesel from onsite diesel storage tank	X	X	X		Based on the volumes of hydrocarbon and hazardous material types anticipated for use during the Proposal, the impact evaluation is based on a full release of a 75 m^3 diesel tank.
Loss of minor volumes of hydrocarbon or chemicals during storage and handling around the well site		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 on the loss of an entire container during transport or handling, this type of spill event is anticipated to result in a volume of <1000 L being released to ground.
Loss of drilling fluids due to circulation issues or well integrity failure		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) or via in the event of failed well integrity. 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 HFS fluid at the surface during HFS operations			X		During HFS, some small amounts of HFS fluid may leak from the lines when the fluid is pumped to the well head. Surface line leaks may occur given the fluid's pressure contained in the lines. Based upon a worst-case scenario, this type of spill event is anticipated to result in a volume of <500 L being released to ground.

Spill event	Activity				Event summary
	Site preparation operations	Drilling operations	HFS operations	Site reinstatement	
Loss of well control		X			During drilling activities, there is the potential for an underbalanced well or equipment failure to result in a loss of well control (i.e. failure of multiple barriers). Given the target formation is "tight" rock, the likelihood of a loss of well control scenario is low with situation required to release reservoir fluids. It is reasonable to estimate that a well could be controlled within 4 weeks based upon onsite access to well control expertise and equipment. With the anticipated negligible volume of condensate produced (well under <4 m^3/day from past well testing) with the gas, and as the most likely direction of gas flow is vertical, the liquid hydrocarbon component, if present, is expected to volatise or disperse via a mist and vaporise into the atmosphere.
Loss of formation water produced during well testing			X		Produced formation water from the Laurel Formation has been characterised by the previous operator of EP 371 through the analysis of multiple water samples at a NATA-accredited laboratory. The results of the sampling program are included in Table 5-30 and Table 5-54. In summary, the produced formation water in the water retention ponds is very high in salt (3–5 times the salt concentration of sea water), 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 produced formation water, BNR has evaluated the produced formation water system and identified that piping or connection points were the most likely source for a release of this fluid. Based on guidance for understanding the magnitude of other similar events, and given the HFS activities are continuously supervised, a maximum credible spill volume was based on the transfer rate × 15 minutes. When including pumping rates, this equates to an instantaneous spill volume 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. Upon release it will start spreading over and soaking into porous soils surrounding the hardstand area, which, as detailed in Section 5.2.3.1, comprise deep sands and sandy earths. Based upon Grimaz et al. (Grimaz, Allen, Stewart, & Dolcetti, 2008), it is anticipated that a large diesel release of 75 m^3 could result in an area of approximately 18,900 m^2 being contaminated if site containment and recovery is not in place. Based on the viscosity of diesel and assuming this large area is contaminated, there is the potential that hydrocarbons may seep through to a depth of around 0.50 m (calculated using equations from Grimaz et al. (Grimaz, Allen, Stewart, & Dolcetti, 2008)).

Although a spill event such as this has the potential to affect an area of approximately 18,900 m^2, the calculation also assumes that no management or mitigation barriers are in place. However, standard construction, petroleum storage, and petroleum use mitigation measures (Table 5-11) will be applied to this activity; therefore, the likelihood of such a spill event occurring is extremely low, and containment and recovery measures will ensure that any soil contamination would be minimised and remediated quickly.

Spill events from formation water produced during well testing, or spill events from chemicals during handling and transport, are expected to behave similarly to diesel upon release. However, any spill volume is expected to be much smaller. These materials will be stored within bunded areas, therefore the likelihood of an event that results in a large volume that reaches the environment is very low. Similarly, condensate from a loss of well control event is expected to volatise or disperse via a mist and vaporise into the atmosphere on release given its high volatility, suggesting soil and water contamination would be unlikely (or minimal). As a result, the extent of soil contamination associated with a 75 m^3 spill of diesel is considered to provide a conservative assessment of any spill event arising from the Proposal.

Loss of well integrity or circulation issues resulting in loss of drilling fluids to formation also have the potential to cause soil and groundwater contamination. Given these events are only credible during drilling activities (due to installation of tubing to flow hydrocarbons) the risk is limited to drilling fluids and associated chemicals. All drilling fluids selected for use are required to be assessed by DEMIRS (and publicly disclosed) under the PGER (E) Regulations. As top-hole sections are drilled with no/low toxicity drilling fluids specifically selected for use in useable aquifers, a release is considered likely to have little if any impact to other groundwater users.

Inappropriate management of waste can also result in a contamination event. However, a single waste contamination event is expected to be much smaller than a credible but unlikely worst-case hydrocarbon spill event.

Spill management measures, 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 will also implement a surveillance soil monitoring program (Appendix E) to ensure that any localised impacts to soil quality arising from minor contamination events can be compared to baseline levels. This will support any remediation activities to ensure residual impacts are kept ALARP.

5.2.5.3 Inadequate rehabilitation arising from compaction

The risk of inadequate site reinstatement comprises a mixture of social and environmental risks. Specifically, they include a risk that the land is returned to the landowner in a state that affects their functions, interests or activities, in addition to a long-term reduction in native vegetation association extent.

Based on the vegetation associations impacted, the small quantity of vegetation affected under the Proposal is not regionally or locally significant. As described in Section 2.4.5, once the well sites are no longer required, they will be ripped to mitigate any compaction impacts. Further, rehabilitation completion criteria will be included in the EP for submission and acceptance by DEMIRS to ensure any residual impacts are appropriately addressed.

5.2.6 Mitigation

Table 5-11 summarises the mitigation measures and their hierarchy. Additionally, BNR will implement a soil quality monitoring program (Appendix E). The program includes additional baseline and surveillance data collection and details the list of analytes to be collected, as well as trigger and threshold contingency actions to be implemented during surveillance monitoring at each well site.

Table 5-13: Proposed mitigation measures – terrestrial environmental quality

Mitigation hierarchy	Mitigation measure	Further information
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 their integrity before the HFS commences.
Minimise	Produced water retention pond design	As per WQPN 26 (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 90th percentile wet season, after allowance for any evaporative water loss and the effects of any water re-use recovery system.
Minimise	Pond design	As per WQPN 26 (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: • all fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s • a minimum thickness of 0.75 mm • dual liners • leak detection.
Minimise	Spill protection during refuelling	It is standard industry practice, which BNR will meet, 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 a refuelling process, drip trays will be used for this activity.

Mitigation hierarchy	Mitigation measure	Further information
Minimise	Chemical and hazardous liquid material storage	As per Australian Standard AS 1940:2004 recommendations, BNR will ensure that: • secondary containment for hazardous materials, chemicals, and hydrocarbons comprise a volume that equals 110% of the largest container within the contained area or 25% of the combined tank volumes • tanks are double-skinned.
Minimise	Chemical disclosure	In accordance with ESD Items 5, 6, and 8, a summary of all chemicals that may be used as ingredients in drilling and hydraulic fracture is included in Appendix A. As per the requirements of Regulation 9 of PGER(E)R 2012, chemicals or substances must be disclosed for acceptance by DEMIRS before commencing activities where they are: • in, or added to, any treatment fluids to be used for drilling or hydraulic fracturing undertaken in the course of the activity • otherwise introduced into a well, reservoir, or subsurface formation in the course of the activity. In addition, all chemicals to be used downhole under the Proposal must be 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.
Minimise	Oil Spill Contingency Plan (OSCP)	Regulation 15 of PGER(E)R 2012 requires that an OSCP be developed for the Proposal and accepted by DEMIRS before conducting any petroleum activities.
Minimise	Spill kits	As directed by the OSCP, spill kits will be made available onsite to support the first strike / immediate response actions in the event of a spill.
Minimise	Appropriately licensed waste contractor	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. Employing an appropriately licensed waste contractor reduces the risk of other accidental release events given the contractor will be experienced in transfer and transport of waste.
Minimise	Appropriate management of waste	Waste will be managed in accordance with Table 2-8 to ensure suitable disposal.
Minimise	Monitoring program	As detailed in Appendix E, BNR will implement a soil sampling and monitoring program. Specifically, additional local baseline samples, as required, will be collected from the well sites once they are established (i.e. post vegetation clearing and prior to well site sheeting) and will be used to verify the baseline sampling that has already taken place. Surveillance samples will also be undertaken prior to site reinstatement in accordance with Appendix E, and the trigger and threshold actions implemented as detailed. Appropriate site reinstatement activities and soil handling methods will also be undertaken, in accordance with the soil monitoring program, to ensure any potential soil erosion, compaction and contamination are mitigated.
Minimise	Waste management strategy	BNR will manage waste in accordance with Table 2-8.

5.2.7 Environmental outcomes

The outcomes of the Proposal are predicted to have:

- no significant or permanent impacts arising from contamination events
- no long-term impacts to the terrestrial environment or detrimental impacts from erosion, scouring, or drainage.

Based on the predicted outcomes for the Proposal, BNR does not believe that the Proposal will result in a significant impact to terrestrial environmental 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:

'*maintain the quality of land and soils so that environmental values are protected*'

can be met.

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

5.3.2.1 Application of the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing, and procedure of the environmental review, required by Section 40(3) of the EP Act. Table 5-14 lists the ESD requirements specific to terrestrial fauna.

Table 5-14: ESD checklist – terrestrial fauna

Terrestrial fauna		
Required work		**BNR response**
19	In accordance with the requirements of EPA Guidance, conduct a desktop study to identify and characterise the fauna and fauna habitats to inform local and regional context; and based on the results of the desktop study: • conduct a Basic survey and fauna habitat assessment • conduct a Detailed survey • conduct targeted surveys for significant fauna that may be directly or indirectly impacted. Note: The desktop study, surveys and ERD should consider vertebrates and short-range endemic, and/or other significant, invertebrates. Survey design should ensure that adequate local and regional contextual data are collected and should consider cumulative impacts. Surveys should include sites in both impact and non-impact (reference) areas.	Section 5.3.3 Appendix C
20	Demonstrate how surveys are relevant, representative, and consistent with current EPA policy and guidance and this Environmental Scoping Document.	Appendix C
21	Provide a map of the survey effort applied in relation to the fauna habitats, the study area, Development Envelope, identifying the direct and indirect impact areas.	Figure 5-1
22	Identify and describe the fauna assemblages present and likely to be present within the Development Envelope that may be impacted by the Proposal.	Section 5.3.3
23	Identify and describe the characteristics of the fauna habitats identified by the desktop study and surveys, including a map their extents in relation to the study area, the project area, and direct and indirect impact areas. Describe significant habitats, including but not limited to: refugia, breeding areas, key foraging habitat, movement corridors, and linkages.	Section 5.3.3.1 Appendix C
24	Identify significant fauna and describe in detail their known ecology, likelihood of occurrence, habitats, and known threats. Map the locations of significant fauna records in relation to the fauna habitats, the study area, the Development Envelope, and direct and indirect impact areas.	Section 5.3.3.1 Section 5.3.3.2 Section 5.3.3.3 Figure 5-9

Terrestrial fauna		
Required work		**BNR response**
25	Identify, describe, and quantify the potential residual impacts (direct, indirect, and cumulative) to fauna assemblages, habitats, and significant species that may occur following implementation of the Proposal, after considering and applying avoidance and minimisation measures, in a local and regional context. Provide a table of the proportional extents of each habitat within the study area and Development Envelope, and the predicted amount to be directly and indirectly impacted	Section 5.3.5 Table 5-16 Figure 5-11 Figure 5-12 Section 7.2
26	Outline and justify the proposed avoidance and mitigation measures to reduce the potential impacts of the Proposal. If any significant species are expected to be impacted, include proposed management and/or monitoring plans that will be implemented pre- and post- construction to demonstrate and ensure residual impacts are not greater than predicted. Management and/or monitoring plans may be required and if so, are to be presented in accordance with the EPA's Instructions.	Section 5.1.6
27	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (p. 11) and Western Australian Environmental Offsets Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014) and include reference to the Commonwealth Assessment Guide for any Matters of National Environmental Significance (MNES).	Section 5.3.7 Section 5.11.2
28	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and WA Environmental Offsets Guidelines and, where impacts relate to EPBC Act-listed taxa, the *Environment Protection and Biodiversity Conservation Act 1999* Environmental Offsets Policy. Spatial data defining the area of significant residual impacts should be provided.	Section 5.3.7 Section 5.11.2
29	Demonstrate and document in the ERD how the EPA's objective for these factors can be met.	Section 5.3.7

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. The fauna studies relevant to the Proposal are listed in Table 5-15, with survey efforts undertaken as part of the flora and vegetation studies 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 fauna survey conducted specifically for the proposed well sites, access tracks and workers' camp locations within the Development Envelope is attached in Appendix C. Following the EPA guidance, these surveys have provided a strong understanding of the local and regional context, with the most recent 2021 survey outcomes validating those of past surveys. Importantly, this survey covered the entirety of the proposed disturbance footprint.

In accordance with the Technical Guidance for Terrestrial Fauna Surveys (EPA, 2016g), further fauna and habitat reconnaissance surveys are scheduled to be undertaken before starting the proposed activities in order to ensure no adverse impact to flora or fauna. The disturbance footprint is also fixed at the proposed locations (Figure 1-2) and BNR does not seek flexibility in the proposed disturbance footprint under this Proposal.

Table 5-15: Baseline studies – terrestrial fauna

Author	Report	Distance to Development Envelope	Significant ecological communities	Significant fauna
Eco Logical Australia (2021)	Valhalla Flora and Fauna Survey	Within the Development Envelope – survey specifically undertaken for the Valhalla Gas Exploration and Appraisal Program and covered the proposed disturbance footprint	Nil	Secondary signs (i.e. diggings) of the Greater Bilby (*Macrotis lagotis*), were recorded at 4 locations in the southeast of the Development Envelope
(Low Ecological Services, 2020)	Flora and Fauna Assessment – Odin 2D and 3D seismic survey,	Within and immediately surrounding the	Nil	Unconfirmed signs of the Northern Quoll (*Dasyurus hallucatus*) and unconfirmed

Author	Report	Distance to Development Envelope	Significant ecological communities	Significant fauna
	Fitzroy Basin, Western Australia	Development Envelope		signs of the Greater Bilby (*Macrotis lagotis*) were observed
(Eco Logical Australia, 2018)	Valhalla Central 4 Flora and Fauna Survey	Within Development Envelope along creek line	Nil	Nil
(Eco Logical Australia, 2016)	Level 1 Vegetation, Flora and Fauna Survey of Kurrajong, Yakka Munga and Valhalla Central Well Sites	Valhalla Central A is the only relevant site located within Development Envelope	Nil at Valhalla Central A	Rainbow Bee-eater (*Merops ornatus*) (previously listed species)
(Murdoch University, 2016)	Targeted bilby survey of proposed well site 'Valhalla Central', and immediate area	Within Development Envelope, central	Nil	Nil
(Buru Energy and Outback Ecology, 2014)	Ophir, Paradise, Valhalla, Eden and Ellendale Flora, Vegetation and Fauna Survey Report	Adjacent to the west	Nil	Species identified up to <11 km to the west to the Development Envelope included Australian Bustard (*Ardeotis australis*) (previously listed species) and *Merops ornatus* (previously listed species)
(Low Ecological Services, 2012a)	Asgard-1 Exploration Well: Flora, Vegetation and Fauna Survey	Within Development Envelope	Nil	Nil
(Low Ecological Services, 2012b)	Asgard 2D Seismic Survey: Flora, Vegetation and Fauna Survey	Similar if not overlapping	Nil	A*rdeotis australis* (previously listed species) and *Merops ornatus* (previously listed species) – locations of the sightings not recorded in the report. Unconfirmed Greater Bilby burrow.
(Low Ecological Services, 2011a)	Flora and Vegetation Survey: Valhalla North	Adjacent to the northwest, ~2 km away from the Development Envelope	Nil	*Merops ornatus* (previously listed species)
(Low Ecological Services, 2011b)	Valhalla East-1 Exploration Well: Flora and Fauna Survey	Within Development Envelope, centre north, about 5 km south from northern extent.	Nil	*Ardeotis australis* (previously listed species)
(Woodman Environmental Consulting, 2007)	Valhalla – 01 Well Site Flora and Vegetation Survey	Within Development Envelope to northwest.	Nil	Nil

5.3.3.1 Fauna habitat

Fauna habitat has been distinguished by flora and fauna surveys conducted within the Development Envelope. The Proposal's disturbance footprint contains three broad fauna habitat types:

- fauna habitat 1: mixed open woodland over grassland on sandy clay flats and slopes
- fauna habitat 2: mixed open woodland over tussock grasses on dune slopes and crests
- fauna habitat 3: eucalypt open woodland and mixed shrubland on closed depressions and creek lines.

The fauna habitats align with the vegetation communities described in Valhalla Flora and Fauna Report . Fauna habitat 1 was the most common within the disturbance footprint, occurring across 74.80 ha (66.52 per cent) of the surveyed area. Table 5-16 lists the fauna habitats; Figure 5-11 and Figure 5-12 show their extent and location.

Table 5-16: Fauna habitat of the disturbance footprint

Fauna habitat description	Associated vegetation community [as per]	Extent (ha) within the disturbance footprint (% total)
Fauna habitat 1: Mixed open woodland over grassland on sandy clay flats and slopes	Ag, AgBc, AgCgEc, AtAcDo, BcCg, BcTc, CgAgBc	74.80 (66.52)
Fauna habitat 2: Mixed open woodland over tussock grasses on dune slopes and crests	BcGaCg, CgCzBc, CzEcCg, EcCg	34.73 (30.88)
Fauna habitat 3: Eucalypt open woodland and mixed shrubland on closed depressions and creek lines	CbEc, EmEcAg	2.92 (2.6)
	TOTAL	**112.46 ha (100%) as recorded in the survey report**

These fauna habitats are broadly representative of the three main soil landscape systems present within the Development Envelope—the Calwynyardah, Camelgooda and Djada land systems—as described in Section 5.2.3.1. These habitats are similar to those recorded in previous surveys within the area (Buru Energy and Outback Ecology, 2014; Eco Logical Australia, 2016) and the landscape systems are represented in the broader landscape; therefore, the fauna habitats identified are not considered locally restricted .

Evidence of Greater Bilbies was recorded in the form of diggings at four locations in the southeast of the Development Envelope within Fauna habitat 2 (Section 5.3.3.2). Fauna habitat 2—mixed open woodland over tussock grasses on dune slopes and crests—is considered to provide suitable habitat for this threatened species. However, with no significant ecological communities present and no locally restricted habitats, these fauna habitats are not deemed to be significant habitats (e.g. refugia, breeding areas, key foraging habitat, movement corridors, linkages) for any species.

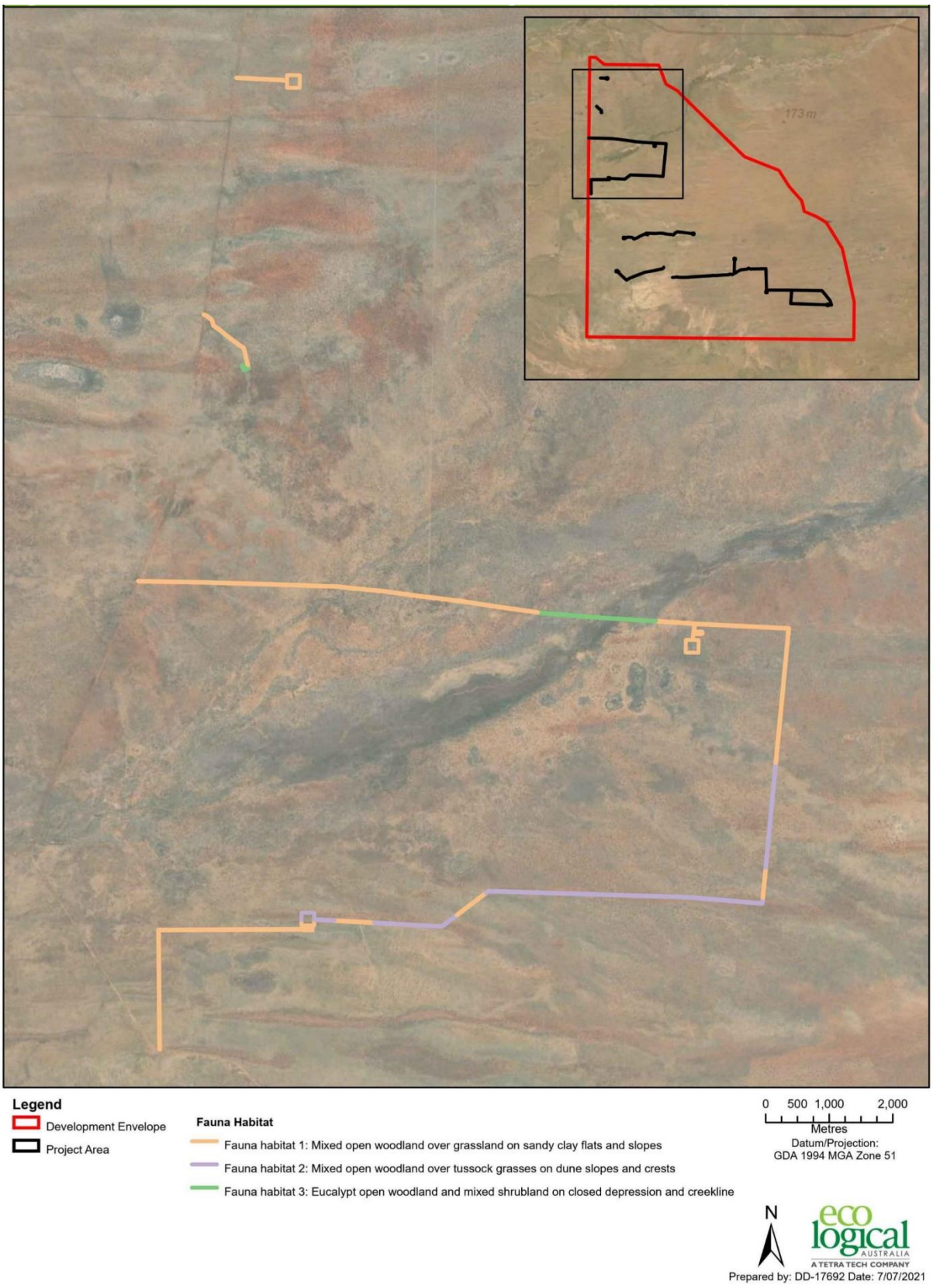


Figure 5-11: Fauna habitat within disturbance footprint (Map 1, Figure 12 from Eco Logical 2021)

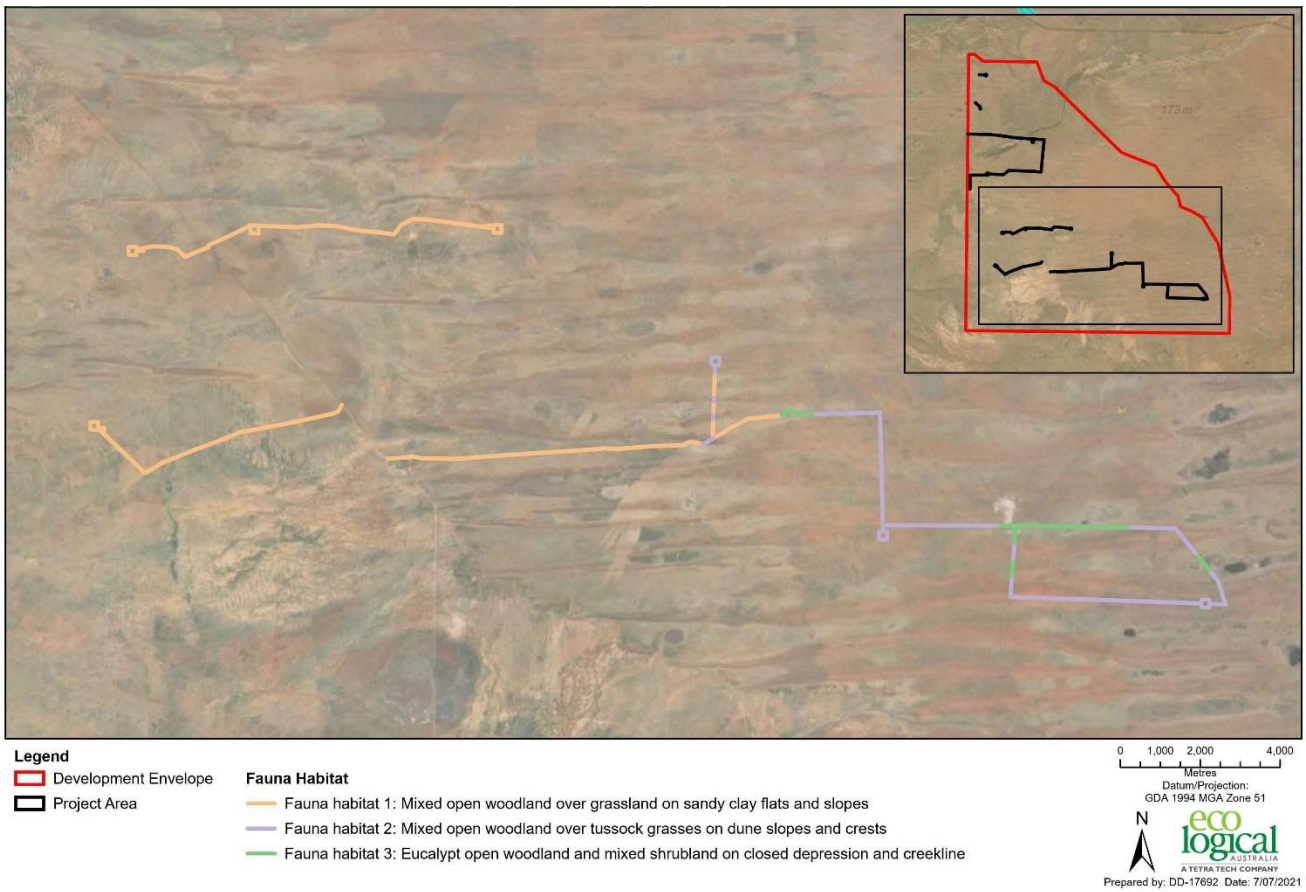


Figure 5-12: Fauna habitat within disturbance footprint, continued (Map 2, Figure 12 from Eco Logical 2021)

5.3.3.2 Protected fauna

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

A desktop search of DBCA's NatureMap database identified no Threatened and Priority fauna species within a five km buffer around the Development Envelope. A search of DAWE's PMST identified that nine conservation listed species had the potential to occur within a 5 km buffer around the Development Envelope.

In total, 54 conservation listed fauna species were identified via desktop sources; however, at the completion of the fauna survey only nine of these species were considered as having the potential to occur. Their likelihood of occurrence was based on their presence in previous records in and surrounding the Development Envelope and based on the availability of suitable habitat. Based on known species ecology, known presence records and mapped habitats from the recent survey, the species with the potential to be present are summarised in Table 5-17, along with their known threats.

Note also, that some species that are no longer listed were sighted, such as the Australian bustard (*Ardeotis australis*) and the Rainbow bee-eater (*Merops ornatus*).

Although no conservation listed species were directly sighted during the on-ground basic fauna survey in 2021, secondary signs (i.e. diggings) of the Greater Bilby were recorded within the disturbance footprint at four locations in the southeast of the Development Envelope (Figure 5-14).

BNR acknowledges that due to survey limitations, a targeted level fauna survey was unable to be adequately met within all sections of the Disturbance Footprint. However, given the presence of the species in the

region, it is likely that habitat is available for the Greater Bilby (Macrotis lagotis) throughout the entire Development Envelope. Specifically, it was identified that fauna habitat 2 provides preferred habitat for this species. BNR has assessed the impact to this species conservatively on the basis that all of Fauna Habitat 2 is habitat to this species. However, BNR does not believe that additional surveys are required given the mitigations presented in Section 5.3.6, which ensure that no impacts to active burrows can arise from this activity. However, BNR plans to complete a targeted survey at an appropriate time being (at least) six-months prior to commencing the activity to ensure no active burrows are present within the Disturbance Footprint. BNR believes that given the ability to eliminate direct impacts (to habitat considered critical to the species survival (i.e. active burrows) BNR believes a completed targeted survey is not required at this stage of the assessment.

Table 5-17: Conservation listed fauna species with the potential to occur within the disturbance footprint and Development Envelope (post-survey)

Common and scientific names	Conservation status		Preferred habitat based upon habitat mapping within the disturbance footprint	Known threats from the DAWE Species Profile and Threats Database (DAWE, 2021b) and associated species recovery plans
	Commonwealth (EPBC Act)	WA (BC Act)		
Greater Bilby (*Macrotis lagotis*)	Vulnerable	Vulnerable	**Fauna habitat 2**: Mixed open woodland over tussock grasses on dune slopes and crests is considered to provide suitable habitat for this species.	Habitat destruction Predation by feral cats and foxes
Northern Short-tailed Mouse (*Leggadina lakedownensis*)		Priority 4	Suitability of available habitat (spinifex and tussock grasslands, Acacia woodlands)	N/A
Spotted Ctenotus (northeast) (*Ctenotus uber johnstonii*)		Priority 2	Presence of potentially suitable habitat: **Fauna habitat 1** – hard reddish soils.	N/A
Gouldian Finch (*Erythrura gouldiae*)	Endangered	Priority 4	**Fauna habitat 1**: Mixed open woodland over grassland on sandy clay flats and slopes **Fauna habitat 2**: Mixed open woodland over tussock grasses on dune slopes and crests are considered to provide potentially suitable habitat for this species.	Inappropriate fire regimes Grazing impacts
Grey Falcon (*Falco hypoleucos*)	Vulnerable	Vulnerable	These species have wide ranges; thus their habitat requirements are broad and varied, some of which are met by all fauna habitats within the disturbance footprint in the form of plains, grasslands, and shrublands.	N/A
Peregrine Falcon (*Falco peregrinus*)		Other specially protected fauna		N/A
Common Sandpiper (*Actitis hypoleucos*)	Marine, Migratory	Migratory	Migratory bird species (of vagrant and mobile nature) may use habitat within the disturbance footprint only when conditions are favourable (e.g. after periods of heavy rainfall).	N/A
Fork-tailed Swift (*Apus pacificus*)	Marine, Migratory	Migratory		N/A
Sharp-tailed Sandpiper (*Calidris acuminata*)	Marine, Migratory	Migratory		Habitat loss Habitat degradation Direct mortality
Glossy Ibis (*Plegadis falcinellus*)	Migratory	Migratory		Wetland destruction or degradation Clearing, grazing burning, increased salinity, groundwater extraction, and invasion by exotic plants and fish species

Common and scientific names	Conservation status		Preferred habitat based upon habitat mapping within the disturbance footprint	Known threats from the DAWE Species Profile and Threats Database (DAWE, 2021b) and associated species recovery plans
	Commonwealth (EPBC Act)	WA (BC Act)		
				Hunting and pesticides

5.3.3.3 Short-range endemics

Short-range endemic (SRE) species are terrestrial or freshwater invertebrate species that have naturally small geographical distributions of <10,000 km^2 (Harvey, 2002). Assessments of SRE occurrences are often based on eight or fewer groups of invertebrates, such as land snails, earthworms, scorpions, pseudoscorpions, mygalomorph spiders, millipedes, centipedes, and isopods (crustaceans). Little information is available about SRE species in the Kimberley other than that they occur in the West Kimberley in restricted habitats or geographic features of smaller size that may be more likely to support unique species. These types of habitats with the potential to support SREs can occur in all WA bioregions, and may include vine thickets, boulder piles, isolated hills and rock outcrops, vegetated gullies, drainage features, and seasonally inundated swamps (Harvey, 2002). In the Kimberley, rocky ridges and outcrops (such as limestone), and seasonally inundated swamps are the habitat types with the potential to support SREs.

A desktop assessment of SRE fauna (Bennelongia, 2011) was undertaken across the Noonkanbah and Blina pastoral stations, with the defined search area of WA Museum (WAM) records covering most of the Development Envelope (Figure 5-12). The physical study area defined for the SRE survey was 33 km southeast of Camballin and as close as ~10 km west of the Development Envelope.

A further assessment was undertaken by Bennelongia for this Proposal (Bennelongia 2023, Appendix S) of the likelihood of habitats supporting SREs within this region. Bennelongia found no TECs or PECs in the vicinity of the project area.

The WAM search for arachnids and related species within the 10,000 km^2 search area encompassing most of the Development Envelope yielded two records of mygalomorph spiders in Camballin. However, these species are known to be widespread in WA and are not considered SREs. Because these arachnids tend to favour and inhabit vine thickets and microhabitats with soil accumulation and moisture-holding capacity (Main, 1991), it is unlikely for mygalomorph spiders to be encountered during the Proposal given the absence of such environments.

In accordance with the environmental impact assessment context in WA, the term SRE is used in this Proposal document to refer only to surface-dwelling invertebrates (EPA, 2016h). The likelihood of SRE fauna occurring within the Development Envelope can be inferred from the occurrence of geographic boundaries, landform changes, or those specialised and isolated habitats suitable for SREs. The habitats described above and considered within the Bennelongia desktop assessment (2011) and a follow-up assessment commissioned specifically for this project (2023 – Appendix S) (vine thickets, rocky limestone outcrops etc.) do not occur within the Proposal's disturbance footprint and are not expected to occur within the Development Envelope. Additionally, any perennial marshland areas (low probability of supporting SREs in this region) were avoided when defining the Proposal's disturbance footprint.

Consequently, BNR does not believe that the Proposal's activities, specifically ground disturbance, will result in a significant impact to surface-dwelling SRE invertebrate species; therefore, potential impacts to SREs from the Proposal are not considered further.

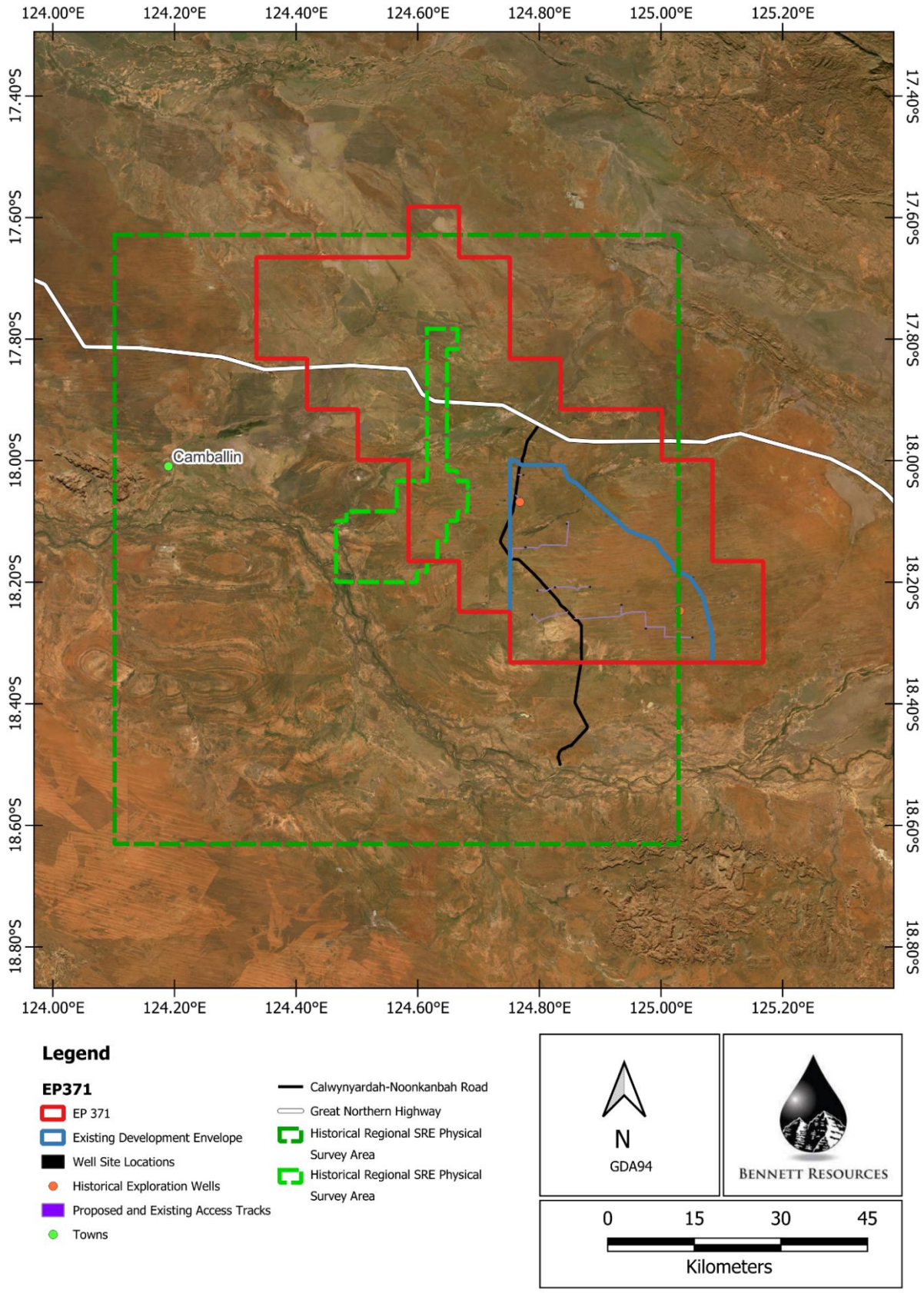


Figure 5-13: Location of regional SRE desktop assessment (adapted from Figure 1 in (Bennelongia, 2011))

5.3.3.4 Introduced species

The *Biosecurity and Agriculture Management Act 2007* (WA) allows animal species that have a negative impact on agricultural production and the environment to be Declared as pests. Declared species are listed with a corresponding category that determines the level of management required to control each species.

The DAWE PMST report lists seven pest species that are likely to occur within a five km radius of the well locations:

- *Canis lupus familiaris* (domestic dog)
- *Equus asinus* (donkey, ass)
- *Equus caballus* (horse)
- *Felis catus* (domestic cat)
- *Rhinella marina* (cane toad)
- *Sus scrofa* (pig)
- *Vulpes vulpes* (Red fox, fox).

All these species have been Declared under state legislation.

The Development Envelope is located within pastoral stations and these lands are used for cattle grazing; therefore, *Bos taurus* (Cattle) are also 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
- habitat fragmentation.

5.3.4.2 Indirect impacts

In addition to potential direct impacts to fauna and fauna habitat arising from the Proposal, these 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. Although mobile fauna may be encountered, the limited extent of disturbance and duration of the Proposal means that interactions with fauna (if any) are expected to be low in number.

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 two 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 activities, including mobilisation and demobilisation of people and equipment. Therefore, it is expected that fauna would avoid the area during these times. The death or displacement of native fauna species as a result of the Proposal remains possible;

however, the Development Envelope has 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.

Because the pathways for fauna interactions are well understood, the mitigation measures for preventing or 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 potential interaction and the significance of the Proposal's interaction with fauna of conservation significance recorded during the 2021 fauna survey is provided in the paragraph below. Given the combined results of the on-ground 2021 fauna and habitat survey and the desktop assessment detailed in Section 5.3.3.2, the impact assessment specifically focused on impacts to bilbies.

The lack of information regarding bilby habitat preference in northwestern 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, Pindan woodlands, and hummock and tussock grasslands (Cramer, et al., 2016). This species has 3,303 documented occurrences (Figure 5-14) 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 project area, secondary signs (i.e. diggings) were identified, as seen in Figure 5-15, indicating that the species is present . According to Eco Logical Australia , the vegetation around the southeast of the project area could be considered as appropriate bilby habitat (Fauna habitat 2 in Table 5-16, Section 5.3.3.1); however, suitable habitat is also widely available throughout the broader region. Although this species is likely present in/near the Development Envelope, any impacts would be as a result of unplanned interactions that would likely impact the species at an individual level rather than a population level. Consequently, as no direct impacts are planned, and as unplanned impacts would likely only be limited to individuals, this species is not expected to be significantly impacted due to the magnitude and duration of the Proposal and the species' widespread distribution throughout WA.

BNR understands that given the time lapse between completing the survey and getting the Proposal approved, an additional pre-construction survey is important to ensure that the Proposal will not impact on any bilbies or other priority flora or fauna.

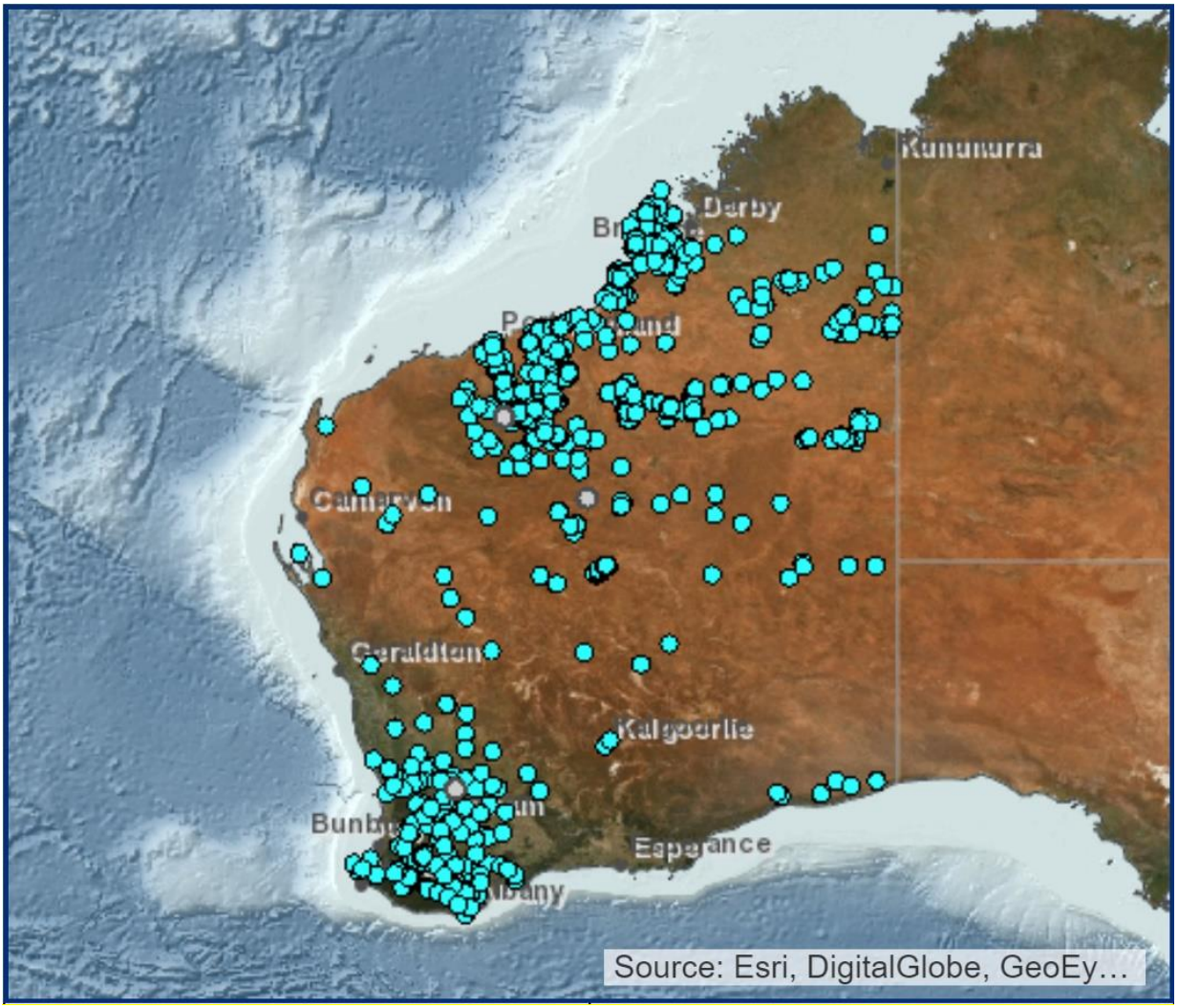


Figure 5-14: NatureMap records for *Macrotis lagotis* (Greater Bilby) (DBCA, 2021)

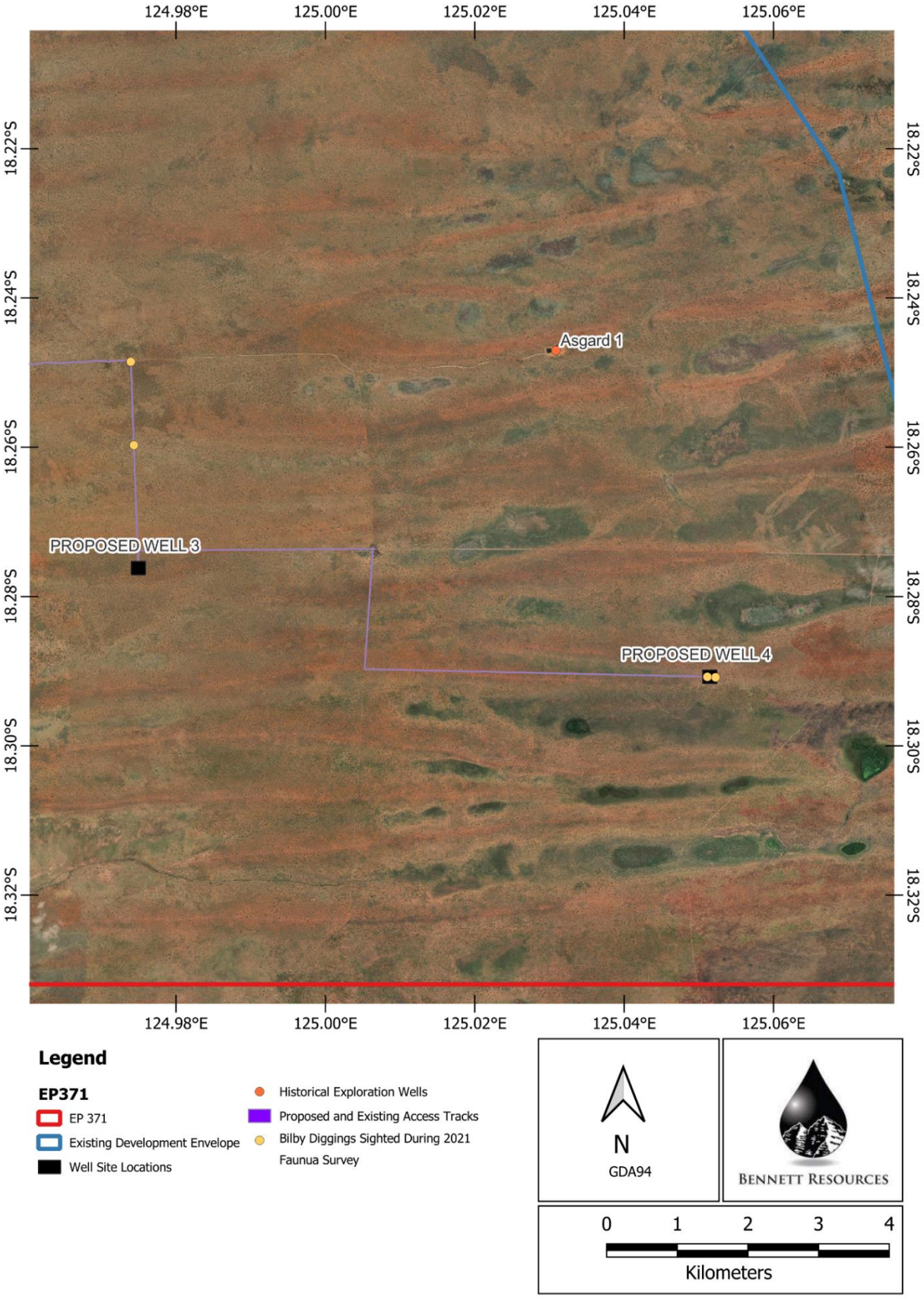


Figure 5-15: Location of recent Greater Bilby diggings (no direct species sighted on the permit)

5.3.5.2 Habitat destruction

Habitat destruction is listed as a specific threat (Table 5-17) under the National Recovery Plan for the Greater Bilby (*Macrotis lagotis*) (Pavey C. , 2006). The species is known to have a wide distribution, occupying a broad range of vegetation and localised impacts from the Proposal are limited to clearing approximately 110 ha of vegetation. As described in Section 5.1.3.4, vegetation associations identified within the project area 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 wider region.

Although ~30 per cent of the disturbance footprint comprises suitable bilby habitat (Table 5-16), the vegetation communities associated with this habitat type are contiguous and well represented in the wider area. Bilby habitat was associated with the broadscale vegetation association North Fitzroy Plains_700, therefore the extent of direct impact to bilby habitat within the project area is estimated to be <0.017 per cent. Because similar habitat is present outside the project area, the actual impact to bilby habitat is expected to be much smaller. In addition, no habitat critical for the survival of the species has been identified within the project area. 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 include 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 Greater Bilby (Pavey C. , 2006).

Mature bilbies have a large home range with individuals recorded on consecutive days as occupying burrows >2 km apart (Southgate & Possingham, 1995). Estimates of short-term home range sizes vary from 1.1 km^2 to 3 km^2 (Southgate & Paltridge, 1998). Consequently, localised fragmentation from the Proposal would not be expected to impact the movement of individuals. Although there is the potential for indirect impacts arising from opening up habitat to predators, there is no evidence to indicate any overall increase in predation because there is limited temporal overlap between the Greater Bilby and its predators (Dawson, 2017).

Consequently, the Proposal is unlikely to hinder these species moving through the landscape nor cause significant impacts due to habitat fragmentation.

5.3.5.4 Habitat degradation as a result of the introduction and/or spread of non-indigenous species (weeds)

Although the presence and introduction of weeds is not listed as a specific threat under the National Recovery Plan for the Greater Bilby (Pavey C. , 2006), monitoring of weed invasion impacts is noted as a research action. An increased presence of weeds may inhibit ground movements and hunting by fauna species including bilbies, or foster fire regimes that are more intense and that are more likely to cause direct mortality, reduce availability of shelter and reduce habitat heterogeneity.

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

5.3.5.5 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 Greater Bilby (Pavey C. , 2006). Fire events have the potential to cause various impacts, including direct mortality and injury, or indirect mortality by altering habitat, reducing food abundance, restricting breeding and increasing predation due to a reduction in ground cover. Fires may also impede dispersal and colonisation of unoccupied areas by the species (Pavey C. , 2006).

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, 2021). Weather conditions, fire history and vegetation fuel

load all contribute to grass fire patterns and intensity. Fire scar data shows that the areas in and around the project area has been subject to burning events (natural fires, or prescribed burns from pastoral activities), as seen in Figure 5-7.

Because the sources of fire events are well understood, the mitigation measures for preventing or 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.

5.3.6 Mitigation

Table 5-18 summarises the mitigation measures and their hierarchy. These will be included in an EP for assessment and acceptance by DEMIRS under the PGER(E)R before activities commence.

Table 5-18: Proposed mitigation measures – terrestrial fauna

Mitigation hierarchy	Mitigation measure	Further information
Avoid	Fauna exclusion and egress	In accordance with the Fauna Egress Matting and Ramps guidance (DMP, 2012), BNR will implement fauna exclusion and egress management measures where lined ponds / fauna traps are present to reduce likelihood of entrapment and allow egress if the initial exclusionary barriers fail. Water retention ponds will be fenced with 1 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	Targeted Bilby Survey	At least 6 months prior to clearing activities commencing, a targeted survey will be undertaken to identify any active and non-active bilby burrows throughout the Disturbance Footprint. Where evidence of species presence exists, specific bilby management measures (detailed below) will be implemented.
Minimise	Specific bilby management measures	To mitigate potential impacts to bilbies during site preparation, these steps will be implemented if a bilby burrow is identified within the disturbance footprint: • the disturbance footprint will be scouted for new burrows (within a range of ~75 m) • no clearing will be undertaken within 50 m of any identified burrows • no clearing will be undertaken within 75 m of identified active burrows • vehicle speed limits will be reduced from dusk to dawn to: ◦ 20 km/h in areas where bilbies have been recorded ◦ 40km in areas where bilbies have not been recorded.
Minimise	Speed limits	Vehicle speed limit signage will be installed along access tracks and at 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 local shire regulations, firebreaks will be installed and maintained to ensure clearances between vegetation and the petroleum activities reduce the risk of causing a fire.
Avoid	Bush Fires Regulations 1954	Under the Bush Fires Regulations 1954, site preparation, construction and activities (hot work and off-road activities) (i.e. gas flaring) are considered prescribed activities. As such, a range of management measures under the Regulations will be implemented, including the clearing of flammable material from around buildings, creating firebreaks and ensuring firefighting equipment is kept and well maintained at each well site.
Minimise	Site inspections of fauna traps	BNR will conduct routine inspections of areas considered to be potential fauna traps. These include open excavations or well cellars, if they need to be left open. Egress paths from ponds will also be regularly inspected to ensure their useability.
Minimise	Weed management measures	BNR will comply with the Arrive Clean, Leave Clean guidance (Commonwealth of Australia, 2015), to prevent spread of weeds by ensuring that fill for civil works (e.g. gravel, limestone marl, soil, or sand) has been verified to have a low weed risk. Good hygiene measures will also be implemented, as prior to entering the well sites, earthmoving machinery and equipment being checked for weeds or weed-contaminated materials and cleaned if necessary.

Mitigation hierarchy	Mitigation measure	Further information
Minimise	Introduced predator management	BNR will provide all records of introduced predatory species opportunistically observed over the course of the activity to DBCA. Where consistently high numbers are observed, and in consultation with DBCA, BNR will identify and implement measures that are considered suitable and commensurate to the nature of the activity.
Rehabilitate	Progressive rehabilitation	In accordance with the PGER(E)R requirements, 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 environmental liability at the end of asset life. Topsoil and vegetation will be respread, and rehabilitation sites actively monitored to ensure they meet required completion criteria. Completion criteria will be documented in the EP and approved by DEMIRS.

5.3.7 Environmental outcomes

The outcomes of the Proposal are predicted to be:

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

Based on the predicted outcomes for the Proposal as shown above, BNR does 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:

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

can be met.

BNR has considered the WA Environmental Offsets Policy (Government of Western Australian, 2011) and Guidelines (Government of Western Australia, 2014), and has used the Residual Impact Significance Model (Figure 3 in WA Environmental Offsets Guidelines) to determine if any residual impacts are significant and if these may require an offset. Using the model's process, it was determined that all residual impacts to terrestrial fauna are not significant, and therefore BNR does not believe actions are required to offset the predicted outcomes of the Proposal. The assessment outcomes are presented in Section 5.11.2.

A self-assessment of impacts on matters of NES in relation to terrestrial fauna was also undertaken against the Commonwealth's significant impact guidelines for MNES (Department of the Environment, 2013). Although the presence of the matter of NES—the Greater Bilby—within the Development Envelope was identified from diggings, the Proposal's activities were determined not to have a significant impact on this matter of NES. Consultation with DAWE in June 2020 and October 2021 and the provision of BNR's self-assessment's outcomes to DAWE confirmed that no significant impacts to any matters of NES were expected. Initial advice from the Commonwealth had been that this project was not required to be referred. BNR has continued to engage with DCCEEW to reiterate that the environmental impacts associated with the Proposal do not result in any direct or indirect mechanisms that would cause a significant impact to matters of NES protected under the EPBC Act.

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

- *Rights in Water and Irrigation Act 1914* (WA)
- Environmental Key Factor Guideline – Inland Waters (EPA, 2018)
- Australian and New Zealand Environment and Conservation Council (ANZECC and ARMCANZ, 2018)

- Department of Water – Water Quality Protection Note (WQPN) 26 (liners for containing pollutants, using synthetic membranes) (DoW, 2013)
- Department of Mines and Petroleum and Department of Water – Guideline for groundwater monitoring in the onshore petroleum and geothermal industry (DMP & DoW, 2016).

5.4.2.1 Application of the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing and procedure of the environmental review, required by Section 40(3) of the EP Act. Table 5-19 lists the ESD requirements specific to inland waters.

Table 5-19: ESD checklist – inland waters

Inland waters		
Required work		**BNR response**
1	Characterise the surface water and groundwater systems in a local and regional context and describe recharge and discharge mechanisms, aquifer connectivity, surface water/groundwater interaction and water chemistry. This should include identification and mapping of groundwater and surface water dependent ecosystems, and detail of the location of wells in relation to surface water features (e.g. Le Lievre Swamp, permanent/semi-permanent pools etc.).	Section 5.4.3
2	Undertake baseline groundwater level and water quality monitoring at representative sites that reflect the expected conditions of each well, including a comprehensive list of analytes including geogenic chemicals, radon and methane concentrations, for a minimum of 24 months prior to commencing the Proposal that is at least consistent with the Guideline for groundwater monitoring in the onshore petroleum and geothermal industry (DMP & DoW, 2016).	Section 5.4.3.3 Appendix M
3	Analyse, describe, and assess surface water and groundwater impacts, including direct, indirect and cumulative impacts, from the project. This should include, but not be limited to: a. changes to groundwater levels and surface water flows associated with the Proposal b. changes to water quality c. the nature, extent, and duration of impacts d. impacts on environmental values of ground and surface water dependent ecosystems.	Section 5.4.5 Section 7.1
4	Discuss the proposed management, monitoring and mitigation to ensure impacts on inland water quality and environmental values are not greater than predicted as a result of implementing the Proposal. This should include but not be limited to: a. ecotoxicology testing on produced or flowback water to better assess the potential impacts b. groundwater level and groundwater quality monitoring plan for the duration of the petroleum development activity and post closure, including concentrations of methane and of chemical constituents that are indicative of brine incursions c. surveillance monitoring of groundwater level and groundwater quality for the duration of petroleum development activity d. testing for, and assessment of the risk from a comprehensive list of analytes in groundwater, likely in produced and flowback water, including geogenic chemicals, technologically enhanced naturally occurring radioactive materials and radon e. a site water balance, accounting for water produced, evaporated, and disposed of, to enable detection of significant leakage of fluids and determine whether remedial action to track any contaminants is warranted f. proposed management of flowback water, including volumes of water that can be expected to be produced. If open air pits are proposed, risks to groundwater and surface water resources arising from leaky pit membranes or other pond failures should be addressed, and the monitoring required to identify and remediate leakages. If re-injection is proposed, the depth of re-injection and detailed construction details of injection wells should be provided.	Section 5.4.6 Appendix E Appendix M
5	Identify all chemicals intended to be used as ingredients in drilling and hydraulic fracture fluids.	Appendix A
6	Provide the Chemical Abstracts Service (CAS) number for the chemicals, and evidence that the chemicals are approved for their intended use in Australia and listed on the: a. Australian Inventory of Chemical Substances (AICS) b. Australian Pesticides and Veterinary Medicines Authority (APVMA) c. Therapeutic Goods Administration (TGA) d. Food Standards Australia and New Zealand (FSANZ) inventories.	Appendix A

Inland waters		
Required work		**BNR response**
7	Provide material safety data sheets (SDS) for the chemicals identified.	Appendix A
8	Confirm whether any chemicals intended to be used contain Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) or Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS).	Appendix A
9	Identify if chemicals proposed to be used are known or suspected carcinogens, mutagens, developmental toxicants, and endocrine disruptors. Use of chemicals with these properties should be minimised or avoided in all operations.	Appendix A
10	Identify the cumulative, short- and long-term public health and environmental risks from chemicals used in drilling and fracturing fluids and chemicals expected to be present in produced and flow-back water.	Section 3.4
11	The Western Australian Department of Health (DoH) should review and provide advice on the information and risk assessments provided for chemicals proposed to be used in hydraulic fracture stimulation or expected to be present in produced or flowback water.	Section 5.8
12	**Geotechnical risks** Undertake and provide a comprehensive geotechnical risk analysis, including: a. definition of subsurface state of stress b. definition of the structural context c. identification of any hydrogeologically active faults or fracture zones d. assessment of well-seal effectiveness e. appropriate expertise f. delineation of potential high-risk zones	Section 5.4.5 Appendix B Appendix T
13	Provide details of an appropriate early warning system mechanism to prevent adverse geo-mechanical events reaching a size of any consequence to land or hydrogeology.	Section 5.4.6 Appendix B
14	**Well Integrity** Well design, construction, stimulation, operation, and decommissioning are all addressed by International Standards Organisation (2017; ISO 165301), which encompasses each phase of the life of any oil and gas well. The Proposal must meet or exceed ISO 165301. The following should be provided: a. details of the well integrity management system over the entire Proposal lifecycle b. a risk assessment process for well barrier integrity, identifying appropriate remedial action should a well barrier be compromised c. details of a well integrity testing and validation program.	Section 1.4.3.2 Section 2.5 Section 5.4.6
15	Provide confirmation that well design, construction, and testing will be assessed by an independent, certified well examiner, reporting to the regulator as a required part of commissioning, licensing, and decommissioning.	Section 5.4.6
16	Demonstrate how the mitigation hierarchy of avoid, minimise, mitigate has been applied during the planning and design stages of the Project.	Section 5.4.6
17	Demonstrate and document in the ERD how the EPAs objective for this factor can be met.	Section 5.4.7
18	**Decommissioning** Include details of the entire life cycle of oil and gas wells, from establishment to decommissioning, including all supporting activities related to hydraulic fracture stimulation. Rehabilitation, decommissioning and well-monitoring post-decommissioning should include evaluating factors such as: a. life cycle of well from establishment to decommissioning b. land use post-decommissioning, developed in consultation with relevant stakeholders c. disposal of contaminated wastes, including the management of potentially radioactive drill cuttings and wastewater in a manner that is consistent with the requirements of the Radiological Council d. storage pond and site rehabilitation e. well-monitoring and groundwater monitoring post-decommissioning to ensure that leakage, fugitive emissions or contamination has not occurred. f. monitoring trigger-levels for intervention and commitment to immediate remediation if contamination is detected.	Section 2.4.5 Section 2.5 Section 2.6 Monitoring Program (Appendix E)

5.4.3 Receiving environment

5.4.3.1 Groundwater systems – regional context

The project area is situated in the Canning Basin region within the Fitzroy River Catchment. 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 >450,000 km^2 (DoW, 2012). The major regional aquifer systems in the Canning Basin are (in order of decreasing age):

- Grant Group
- Liveringa Formation
- Wallal Sandstone
- Broome Sandstone.

The two aquifers considered "useable" for other purposes within the project area include the Liveringa and Grant Group.

5.4.3.1.1 Grant Group

The Grant Group aquifer comprises several subsurface geological structures, including the Reeves Formation (formerly described as the Lower Grant Formation) and the Poole Sandstone, which is directly above the Grant Group.

The Poole Sandstone and Grant Group are considered to be hydrogeologically similar and are both regarded as good aquifers because of their combined thickness and widespread distribution (Lindsay & Commander, 2005). The Poole Sandstone is mainly fine-grained with some medium to coarse sandstone towards the base. The Grant Group is much thicker than the Poole Sandstone. Available salinity records from DWER's Water Information Reporting (WIR) database (DWER, 2021) for the Poole Sandstone range from 200 to 325 mg/L TDS, with 860 mg/L TDS for the Grant Group. In other areas of the Grant Group, oil accumulations are known to occur (hydrocarbons have previously been produced from the Grant Group from the Sundown, Boundary, and West Terrace wells at Blina Oilfield, which is north of the Development Envelope) (Jonasson, 2001).

5.4.3.1.2 Liveringa Formation

The Liveringa Formation comprises interbedded sandstones, siltstones with lenses, and minor beds of claystone and shale, varying in thickness from 320 m–900 m (Harrington & Harrington, 2015). Salinities, where recorded in the WIR database and by the previous operator, are generally <1,000 mg/L TDS in the Liveringa Aquifer but may range from 500–12,400 mg/L TDS (Appendix I (Rockwater, 2016)).

5.4.3.1.3 Wallal Sandstone

The Wallal Sandstone is present in the west and northwest of the Fitzroy River Catchment but has limited outcrop at the land surface due to overlying formations and a veneer of surficial sediments. This sandstone aquifer is likely to host intermediate-scale flow systems, though very little information currently exists other than from drilling around Derby and Mount Anderson (Gallardo, 2018; Smith, 1992). Bore yields can be high in places, with recent investigations reporting bore yields of up to 50 L/second (Stocker, 2015). Groundwater salinity is also fresh in most locations (i.e. TDS of 500–1,000 mg/L). Aquifer pumping tests on the Wallal Sandstone at Mowanjum Station (~95 km northwest of the Development Envelope) estimated a transmissivity of 273 m^2/day and a hydraulic conductivity of 4.8 m/day. Buru Energy (2012) reports a hydraulic conductivity for the Wallal Sandstone of 44 m/day.

5.4.3.1.4 Broome Sandstone

The Broome Sandstone aquifer is the principal groundwater resource in the West Kimberley (specifically for the Dampier, Broome, and La Grange areas) used for irrigation, stock and domestic supply. Within the Canning Basin, the Broome Sandstone is an extensive, flat-lying aquifer, coarsening with depth, with some siltstone layers and a saturated thickness of up to 200 m near the coast. Generally, the sandstone has high porosity, and bores screened within it are capable of producing up to 60 L/s of low salinity (Paul, George, & Gardiner, 2013). Salinity values for bores located within the Broome Sandstone indicate that TDS values decrease the further inland they are located. Of the 115 bores analysed from the WIR database, 43 bores

had a TDS below 500 mg/L, 33 bores had a TDS between 500 and 1,000 mg/L, and the remaining 39 bores had a TDS above 1,000 mg/L (Paul, George, & Gardiner, 2013).

5.4.3.2 Groundwater systems – localised context

Data from three petroleum wells drilled on EP 371 by the previous operator (Table 5-20) provides a two-dimensional cross-section of the aquifers located within the permit, as shown in Figure 5-16.

A detailed summary of these aquifers with reference to local data is provided in the following sections, and Appendix T outlines additional information regarding key geological intervals through the various aquifers.

Table 5-20: Local aquifer data

Formation	Dominant lithology	Classification	Elevation – base of formation (m AHD)			Thickness (m)	TDS (mg/L)
			Valhalla 2	Valhalla North 1	Asgard 1		
Liveringa	Carbonate and shale	Minor aquifer, aquitard	−84	−196	−171	84–196 m	500–12,400
Noonkanbah	Shale	Aquiclude	−441	−635	−579	357–439 m	550–800
Poole Sandstone	Sandstone and shale	Aquifer or aquitard	−524	−715	−695	80–116	300
Grant Group	Sandstone	Aquifer	−1,332	−1,499	−1,240	545–808	800–1,000
Reeves	Sandstone	Aquifer	−1,588	−1,826	−1,606	270–366	No data
Anderson	Sandstone, siltstone, shale	Minor aquifer, aquitard	−1,858	−2,105	−1,790	184–279	70,000–100,000
Laurel	Limestone, shale, siltstone, and sandstone	Minor aquifer, aquitard	<−3,350	<−3,241	<−3,400	1,136–1,610	70,000–100,000

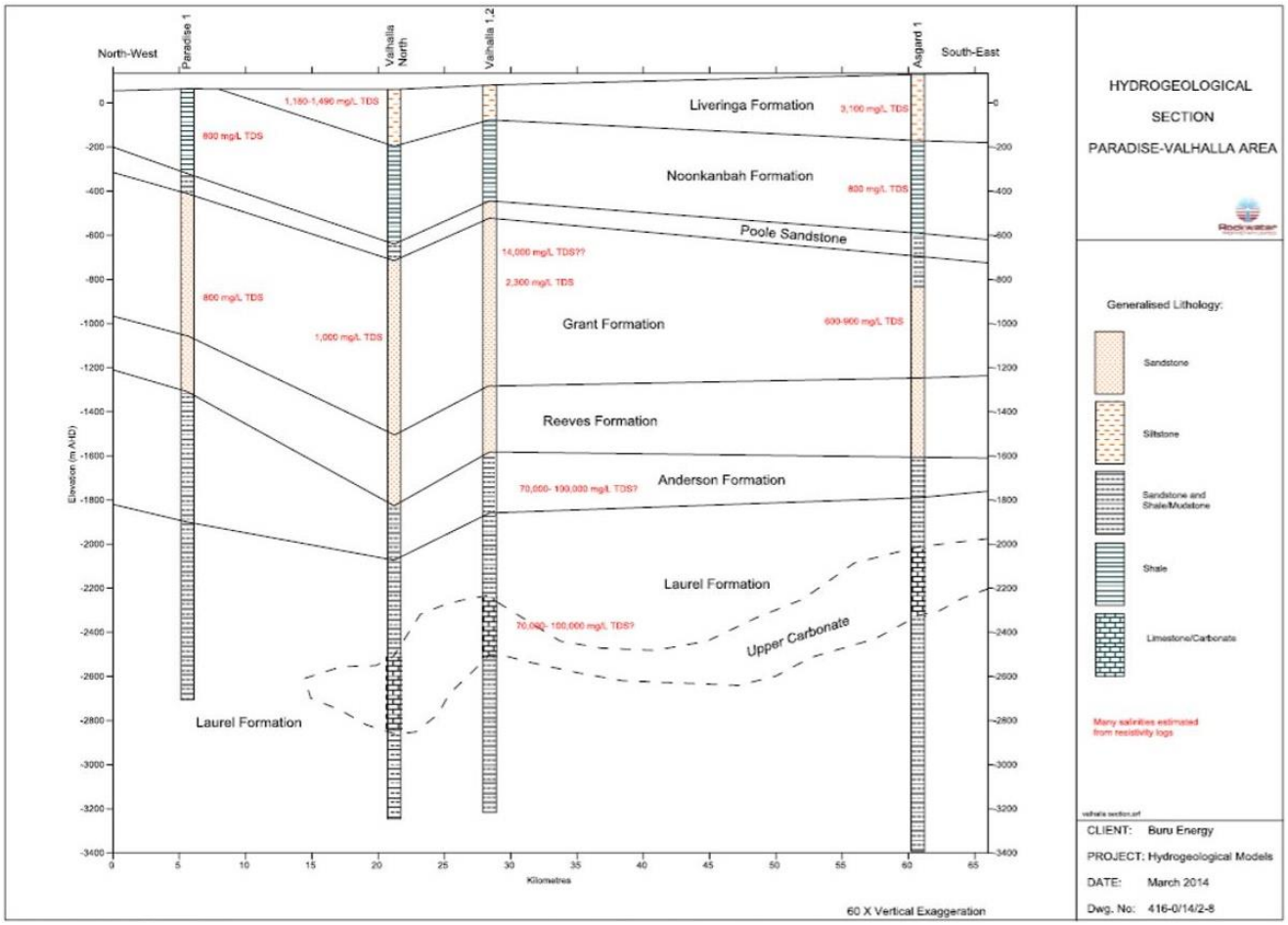


Figure 5-16: Hydrogeological cross-section

Although Figure 5-16 is a simplified cross section of the Development Envelope however, presentation of subsurface data this way is appropriate given the availability of three key wells with modern logs – Valhalla-1, Valhalla-N-1, and Asgard -1. BNR acknowledges presentation of this data is limited given the absence of regional sand/shale ratios other than in principally in two dimensions. A more detailed cross section of the subsurface geology is presented in Appendix T (Figure 2).

In addition to cross sections, semi-regional isochore (based on seismic data tied to wells) maps of key geological intervals along with the proposed locations have also been included in Appendix T (Figures 1a-Figure1e). The figures presented therein show the intervals that represent the isochores and associated stratigraphy highlighted. These figures are focused on the Poole aquifer unit (a deltaic sandstone) as well as the non-aquifers of the Grant Group and Anderson formations. For the Grant group Formation, the overall thickness within the development area is between 545m-808m. The deepest interval (Anderson) does thin updip but over most of the Development Envelope it is over 150m thick.

The shallowest interval that likely contains potentially economic hydrocarbons is located at 2600m to the top of the Grant Formation. Semi regional isochore figures (Appendix T) indicate there is 900m - 1800m of section between the shallowest potential HFS zone (2600m) and the Grant/Winfred Formation top (Base of the Poole).

5.4.3.3 Liveringa Aquifer

5.4.3.3.1 Recharge and discharge mechanisms

Groundwater recharge to the Liveringa Aquifer is believed to be mainly from rainfall on outcrop areas (Lindsay & Commander, 2005). During the Fitzroy River integrated ground and surface water hydrology assessment conducted between 2008 and 2011, monitoring of the Liveringa 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 then WA Department of Water (DoW) with funding provided by National Water Commission under the Raising National Water Standards (RNWS) program. The multilevel piezometers that were installed at three sites on Noonkanbah Station as part of the DoW and RNWS project showed a groundwater response to high river flow events (Lindsay & 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 Formation (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 70–300 days to travel from the ground surface to the water table within the Development Envelope (Appendix I (Rockwater, 2016)).

5.4.3.3.2 Aquifer connectivity (surface water/groundwater interaction)

As detailed in Table 5-20 and shown in Figure 5-16, the Liveringa Aquifer and Poole Sandstone (associated with the Grant Group) are separated by the Noonkanbah (shale) Formation. The Noonkanbah Formation is considered an aquitard, comprising siltstone, limestone and minor sandstone (Lindsay & Commander, 2005), and it is a geological barrier (at least 357 m thick) between the Liveringa and Poole Sandstone aquifers. Consequently, within the Development Envelope the surface aquifer (Liveringa) is geologically separated from the Poole Sandstone (and subsequently, the targeted Laurel Formation).

5.4.3.3.3 Water chemistry

BNR has developed a series of groundwater studies to inform and support both the environmental impact assessment within the PER and the ongoing monitoring and management of groundwater during the Proposal. Table 5-21 summarises each study.

Table 5-21: Groundwater field studies

Field study	Timing	Project Phase	Relevant Document – Sampling Design
GW1 – Local groundwater characterisation	Before 2021	Environmental approvals	PER
GW2 – Baseline monitoring - Upgradient control site monitoring	Before the project commences, and continuing until project completion	Pre-development, appraisal, post-development	Part IV EMP
GW3 – Surveillance monitoring	At least 6 months before well activity commences, and continuing until site-specific termination criteria are met	appraisal, post-development	Part IV EMP

The purpose of the PER local groundwater characterisation field study was to review the quality of the Liveringa Aquifer within the Development Envelope using historical groundwater data. The local groundwater characterisation study focused on several bores near the project area, namely:

- AB1D
- AB1S
- VNB4S
- VNB4D.

These bores were considered suitable for providing appropriate historical baseline data because:

- AB1D, AB1S, VNB4S and VNB4D are located up-gradient of previous historical petroleum activities conducted in EP 371 (Figure 5-28)
- these four are screened within the Liveringa Aquifer and although the bore logs are not available for the monitoring bores schematics are available for these bores (Figure 5-29)
- BNR validated bore schematics placing a camera down hole in July 2023. All four were shown to be intact and suitable for the purposes of collecting baseline groundwater samples. Details of this assessment, as well as photos from the down hole camera, form part of Appendix G. A summary of these recordings is:

- AB1S
  - stick-up: 0.5 m
  - standing water level: 23.070 metres below top of casing (m btoc)
  - screened interval: 30.8-36.3 m btoc
  - bottom of casing: 36.3 m btoc
  - some white build-up on lower ~5 m of casing walls
- AB1D
  - stick-up: 0.7 m
  - standing water level: 21.780 m btoc
  - screened interval: 67.0-76.6 m btoc
  - bottom of casing: 76.6 m btoc
  - ant ingress and some ant material build-up on walls from 20 m btoc
- VNB4S
  - stick-up: 0.5 m
  - standing water level: 30.686 m btoc
  - screened interval: 36.6 m btoc
  - bottom of casing: 42.3 m btoc
  - no or minor build-up on casing walls
- VNB4D
  - stick-up: 0.7 m
  - standing water level: 30.956 m btoc
  - screened interval: 66.9-78.3 m btoc
  - bottom of casing: 78.4 m btoc
  - minor build-up on casing walls

- VNB4S / VNB4D and AB1D / AB1S are located on the northwest and southeast of the proposed disturbance footprint respectively (Figure 5-30), thus providing geographical coverage across the project area
- groundwater flow is westerly (Figure 5-30), thus providing water quality at different hydrogeological gradients.

The local groundwater characterisation study on the four bores into the Liveringa was undertaken over five years (two of the four bores continued to be monitored for a further two years). The number of sampling events undertaken at each bore location and the data results are detailed in Appendix J. BNR has mapped specific CoPC over the sampling period in Figure 5-17 to Figure 5-27. The CoPC selected to be presented here are relevant because they are the indicator constituents used to determine if any release from petroleum activities (including drilling or HFS fluids) has occurred. These are consistent with those identified by the 'Groundwater Monitoring in the onshore petroleum and geothermal industry – Guideline' (DMP & DoW, 2016).

Except for the April 2016 sampling event, long-term data analysis indicates that groundwater chemistry influenced by the geology is stable.

Table 5-22: Summary of groundwater monitoring bores sampled

Location	Bore name	Number of sampling events	Total sampling duration
Asgard 1 well site	AB1D	23	>5 years
	AB1S	23	>5 years
Valhalla North 1 well site	VNB4D	21	>5 years
	VNB4S	21	>5 years

Figure 5-17 to Figure 5-27 show data from ongoing monitoring of bores in the Liveringa Aquifer in accordance with Buru Energy's and BNR's *Groundwater Baseline and Surveillance Monitoring Program*. One anomalous reading can be seen across all tested elements from VNB4S from samples taken on 19 April 2016. The causes of the anomalous results were immediately examined. BNR determined that that:

i) The VNB4S water bore was the reference bore located upstream of the wellsite, so the cause of the result was highly unlikely to be attributable to historical subsurface activities; and

ii) The VNB4S water bore was the first bore sampled on that day and it was possible that the bore pump and hose had not been adequately purged prior to sampling commencing.

A resampling of the bore was subsequently undertaken on 10 May 2016. When tested by SGS Australia, it showed that the range of values for BTEX, chloride and other constituents were within the range of values previously observed. During the development of this document, BNR engaged with DWER to discuss these outcomes and BNR came to the decision that the anomalous reading would not impact baseline groundwater data.

Baseline methane levels within the Liveringa indicate some natural variation, however it is otherwise considered stable. As detailed in Figure 5-27, increased methane concentrations were recorded in 2018 and 2019 before sampling in 2021 indicated levels had returned to baseline levels. On further investigation, all bores sampled in this area between 2018 and 2019 experienced an increase in methane levels, including those bores located hydraulically upgradient (in consultation with DWER (AB1D/S and VNB4D/S)) in a location that would enable the previous operator to differentiate between activity-related and natural occurring events. This area experienced, flood events followed by heatwaves in 2018, resulting in mass cattle death across the Noonkanbah Station. As the Liveringa is believed to be mainly recharged from rainfall on outcrop areas (Lindsay & Commander, 2005) it is likely that these events caused increased organics through surface recharge which produced the increased dissolved methane readings. Additional constituent analysis has determined this is not associated with the previous operator's activities.

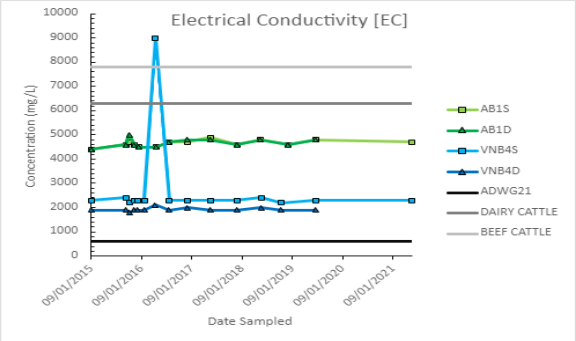


Figure 5-17: Electrical conductivity [Liveringa]

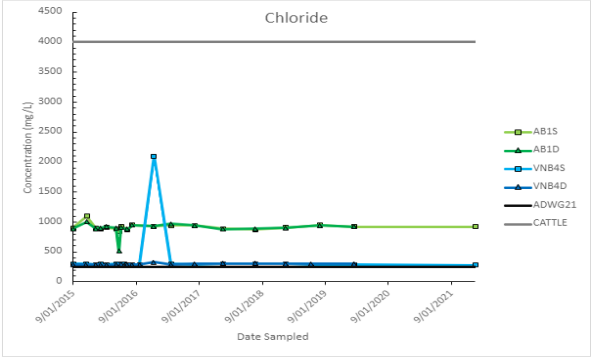


Figure 5-18: Chloride [Liveringa]

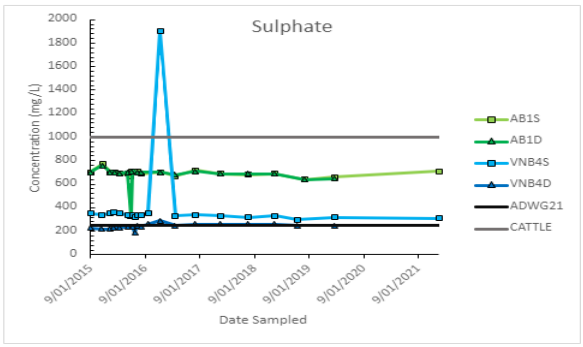


Figure 5-19: Sulfate [Liveringa]

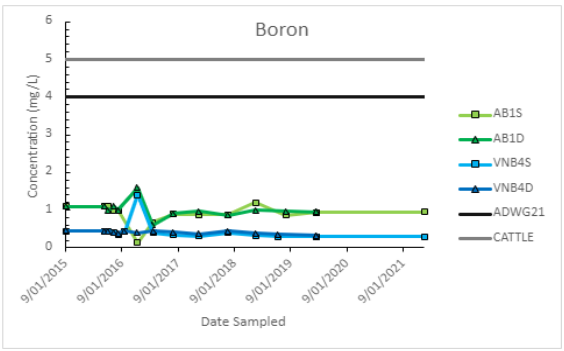


Figure 5-20: Boron [Liveringa]

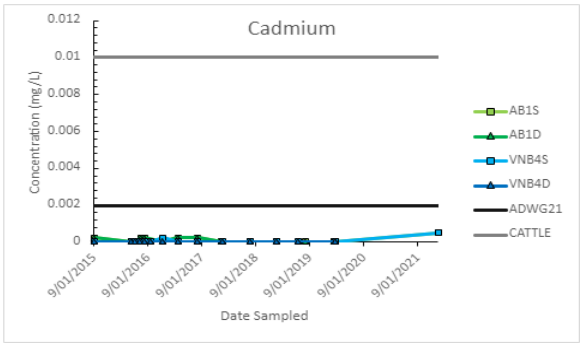


Figure 5-21: Cadmium [Liveringa]

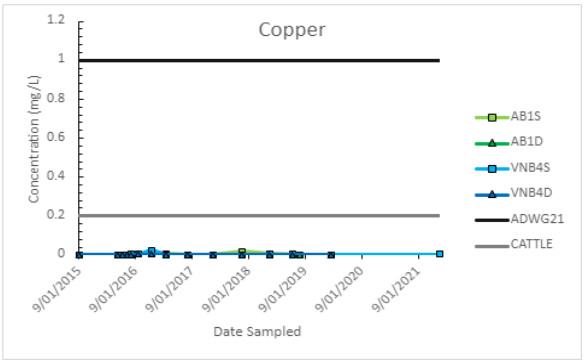


Figure 5-22: Copper [Liveringa]

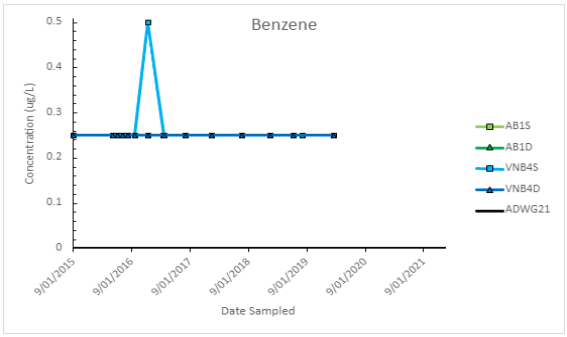


Figure 5-23: Benzene [Liveringa]

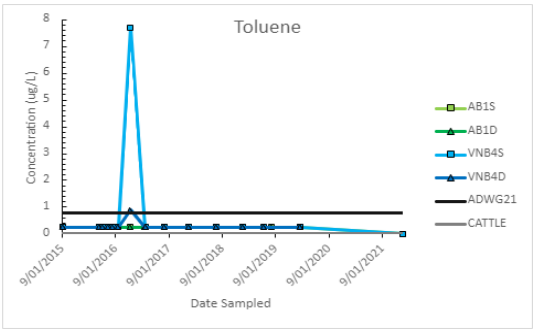


Figure 5-24: Toluene [Liveringa]

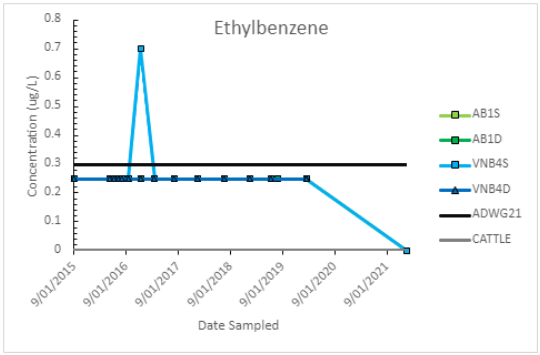


Figure 5-25: Ethylbenzene [Liveringa]

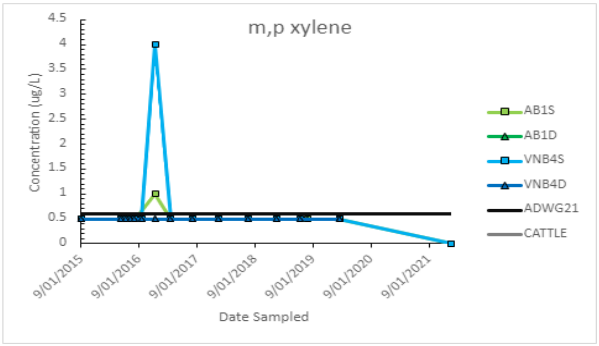


Figure 5-26: Xylene [Liveringa]

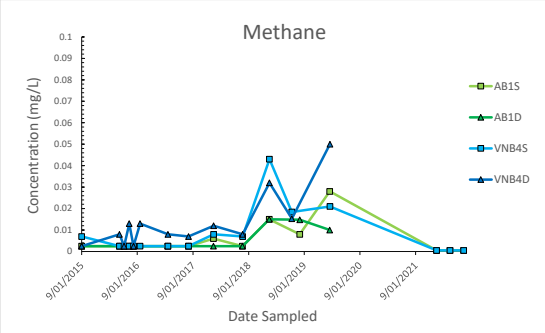


Figure 5-27: Methane [Liveringa]

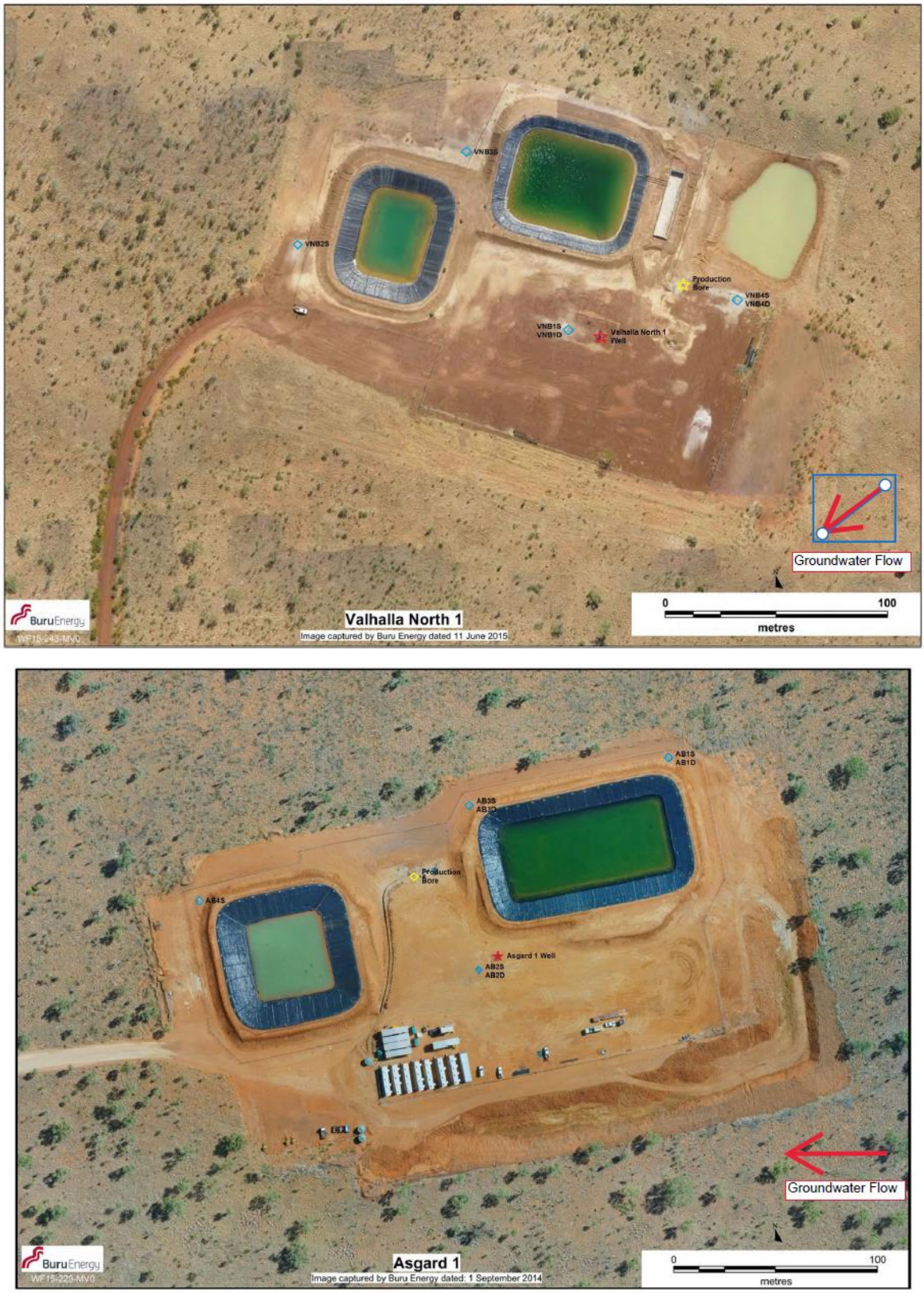


Figure 5-28: Location of VNB4S / VNB4D and AB1D / AB1S and proximity to existing infrastructure

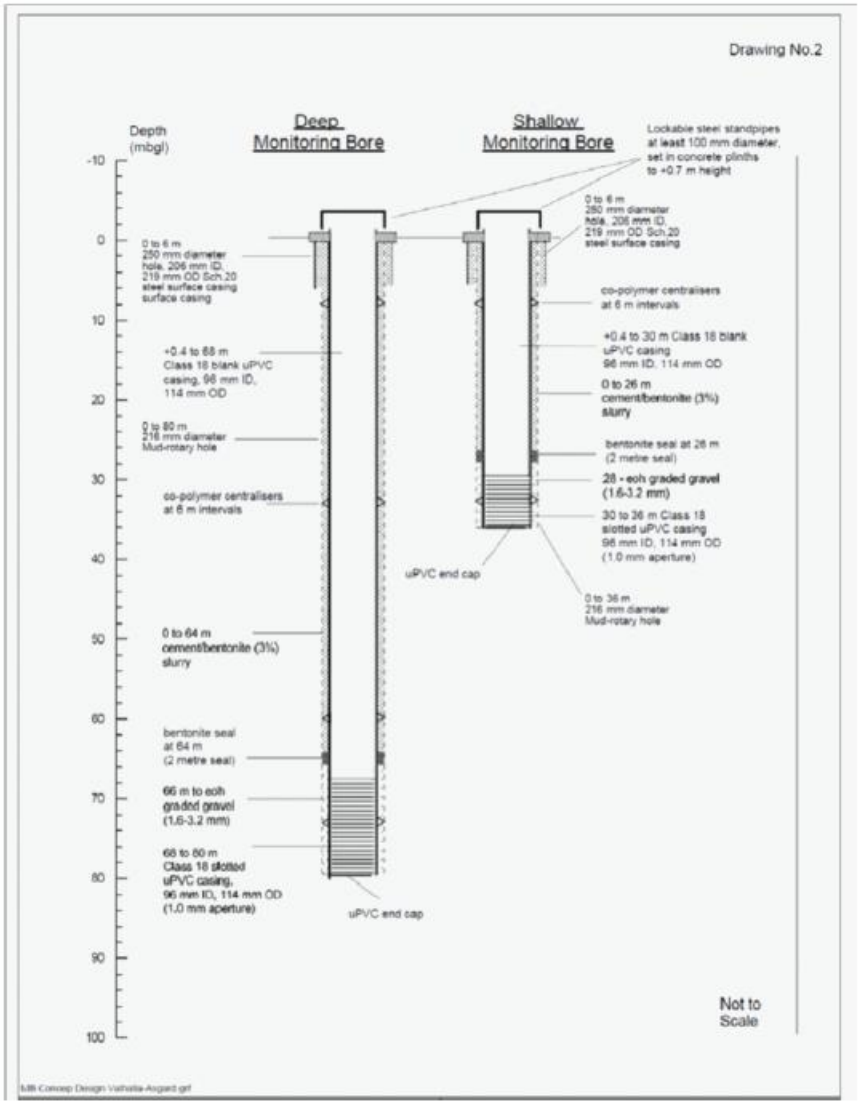


Figure 5-29: Schematic of the Asgard and Valhalla North groundwater monitoring bores

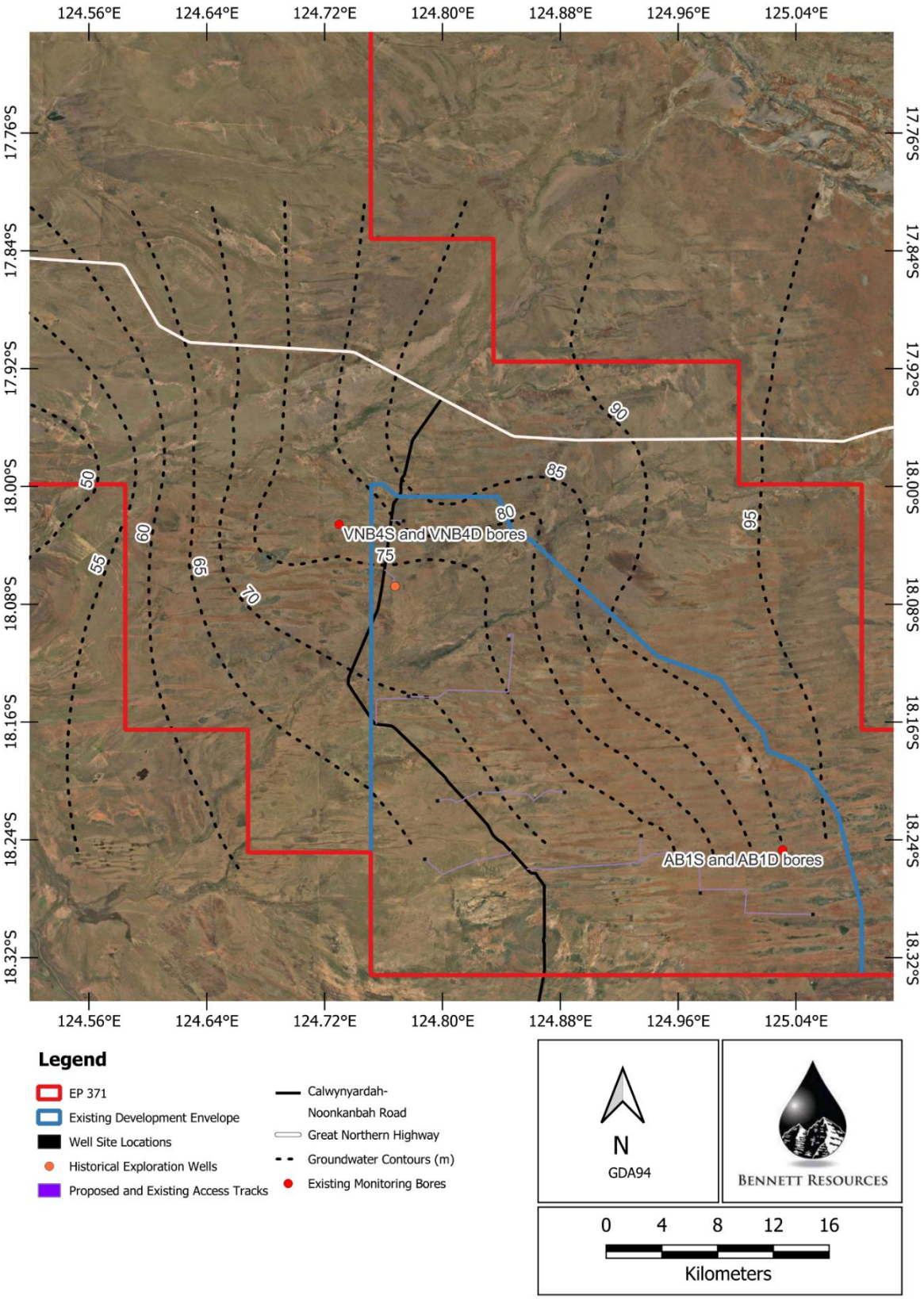


Figure 5-30: Location of Liveringa groundwater sampling bores for local groundwater characterisation and groundwater contours

5.4.3.3.4 Local and regional use

Groundwater is used for licensed and unlicensed water extraction in the region. Unlicensed extraction is likely to include domestic and stock watering, both of which extract relatively minor volumes of groundwater. In accordance with the RIWI Act 1914, DWER allocates water use via groundwater licences within the sustainable volume available for a groundwater resource. DWER has determined that the Canning–Kimberley groundwater area has an allocated limit of >300,000 ML/year (DoW, 2014), of which only 0.9 GL (4.3%) is licensed within the Liveringa Aquifer (Harrington & Harrington, 2015).

A search of DWER's Water Register licensing database (DWER, 2021) for licensed users within the Development Envelope identified only one other water licence targeting the Liveringa, as detailed in Table 5-2320. BNR currently has three groundwater licences but has extracted little to no water during the yearly care and maintenance program for its assets on EP 371. Although most of the water extraction within the broader region is licensed, unlicensed water use of the Liveringa Aquifer does occur, including for livestock bores (pastoral activities) (Harrington & Harrington, 2015). The nearest groundwater user outside the project area is the Yungngora Community, ~18 km south. However, unlicensed groundwater extracted for community bores is typically from deeper aquifers.

A review of existing pastoral bores was undertaken to understand the distance from the Proposal's disturbance footprint. Based upon publicly available information, currently operating pastoral bores are at least 1.5 km from the disturbance footprint. These bores are only used for stock watering purposes with no irrigation, human consumption or other purposes identified.

Table 5-23: Summary of groundwater extraction licences within the Development Envelope that target the Liveringa Aquifer

Licence number	Issue date	Expiry date	Allocation (ML)	Owner
174685	05 Oct 2020	04 Oct 2030	309	Main Roads Department
167493	07 Jan 2021	10 Sep 2023	30	Bennett Resources Pty Ltd
179134	07 Jan 2021	10 Sep 2023	33.4	Bennett Resources Pty Ltd
179166	07 Jan 2021	10 Sep 2023	39.4	Bennett Resources Pty Ltd

5.4.3.4 Poole Sandstone (Grant Group)

The Poole Sandstone is considered part of the Grant Group—therefore, BNR has focused on the Poole Sandstone as the key aquifer of importance from the Grant Group.

5.4.3.4.1 Recharge and discharge mechanisms

Recharge to the Poole Sandstone occurs at the aquifer outcrops and shallow sub crops in the centre of the catchment following intense wet season rainfall. Recharge rates are estimated between ~13 and 70 mm/year (Taylor, et al., 2018). Interpretation of environmental tracers in groundwater, particularly carbon-14 and Terri genic helium-4, indicate long residence times for the Poole Sandstone aquifer. Mean residence times of >30,000 years were estimated for several groundwater samples collected from very deep parts of the aquifer (>500 m) at distances as short as 10 km from their outcrop or sub crop. Elsewhere, the aquifers are confined by the Noonkanbah Formation (Harrington & Harrington, 2015).

Infiltration to the Poole Sandstone within the Development Envelope is not expected because the Noonkanbah Formation (a shale aquitard) overlies this formation. No outcrops or shallow sub crops are known to occur within the Development Envelope. This is consistent with Figure 5-31, which indicates that the Poole Sandstone is shallower both east and west of the Development Envelope.

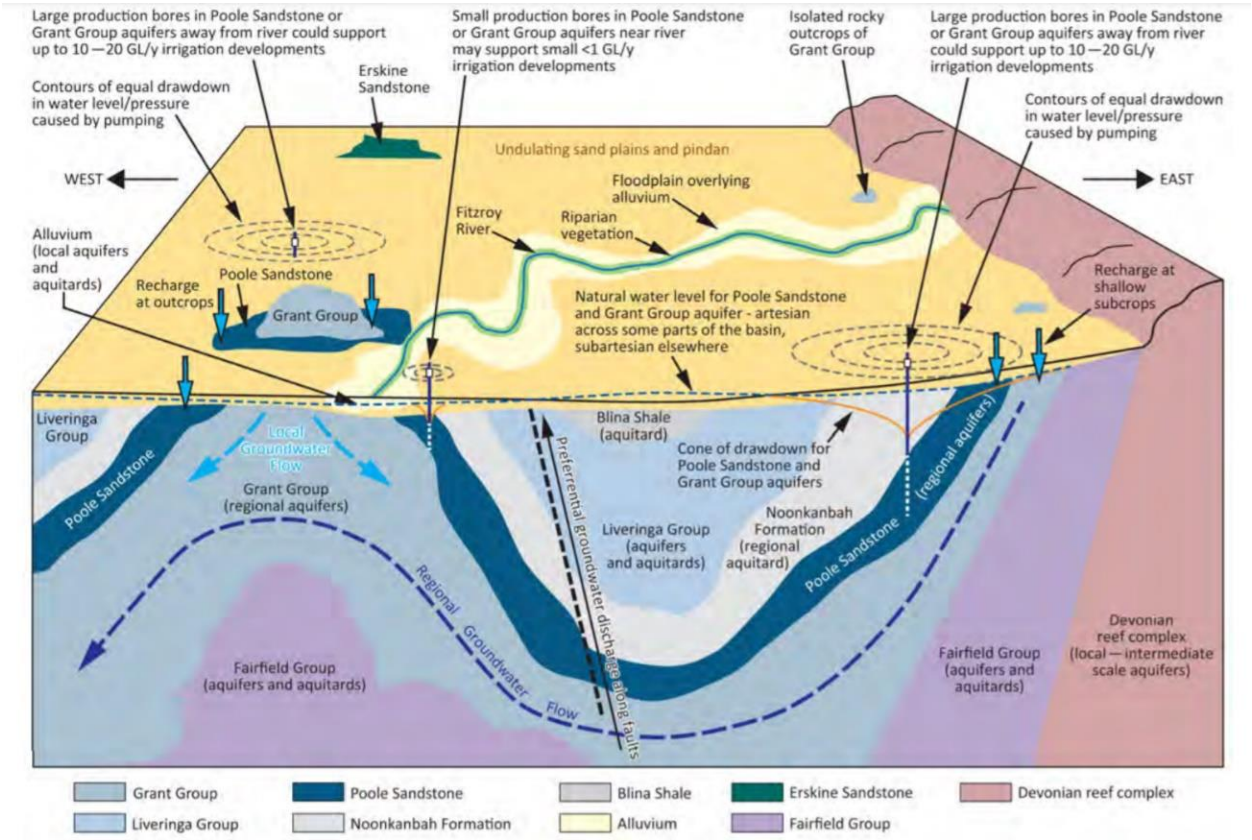


Figure 5-31: Conceptual schematic diagram of the regional groundwater flow process and positioning of the Poole Sandstone (taken from Figure 5-3 in (Taylor, et al., 2018))

5.4.3.4.2 Aquifer connectivity (surface water/groundwater interaction)

As detailed in Table 5-20, the Liveringa and Poole Sandstone aquifers are separated by the Noonkanbah shale Formation. The Noonkanbah Formation is considered an aquitard, comprising siltstone, limestone and minor sandstone (Lindsay & Commander, 2005), and is a geological barrier (at least 357 m thick) between the Liveringa and Poole Sandstone aquifers. Beneath the Grant Group, the Anderson Formation comprises a shale layer that acts as a confining seal between the Grant and lower formations (such as the targeted Laurel Formation). The Anderson Formation provides a geological barrier that is between 184 m and 279 m thick.

5.4.3.4.3 Water chemistry

BNR has developed a series of groundwater studies to inform and support both the environmental impact assessment within the PER and the ongoing monitoring and management of groundwater during the Proposal. Given the depth to the Poole Sandstone (-571 m) and the confinement of the Poole Sandstone within the Development Envelope, BNR used water quality data from groundwater users that are both licensed and unlicensed to extract groundwater from the Poole Sandstone, including the Yungngora Community and the town of Fitzroy Crossing.

BNR has been provided with data from the Yungngora Community's YG2/18 bore, which was constructed in 2018. The bore completion log for the Yungngora Community indicates that the total depth of the bore is 497 m and screens were installed between 398 and 497 m below ground level (Figure 5-32) (Australian Bore Consultants, 2019).

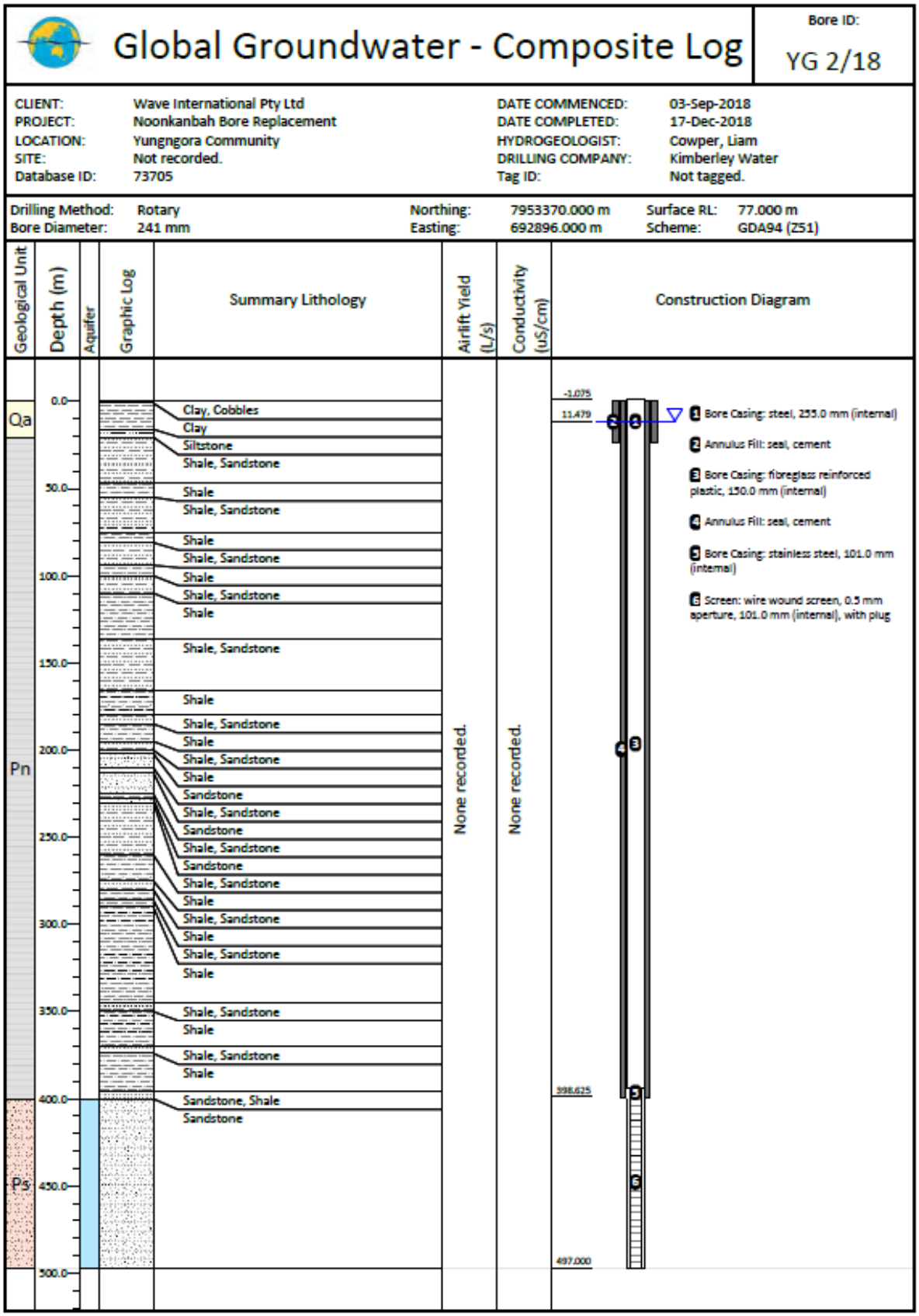


Figure 5-32: Drilling log of the YG2/18 bore

Data is collected from this bore as part of a larger monitoring program with all data tested and reported separately. Water quality data available for YG2/18 between April 2018 and April 2023 was reviewed to better understand the water chemistry of the Grant Group within the Development Envelope. All of the components tested from YG2/18 (for example, fluoride, chloride, nitrate, sulfate, sulfur, etc) are lower than acceptable levels (from an aesthetic perspective), with two exceptions. In April 2023, total dissolved solids were 820 mg/L (aesthetic acceptable level is 600), and sodium levels are higher than the aesthetic acceptable level of 180 mg/L on several occasions. For example, in April 2023 sodium levels were 250 mg/L, in November 2022 they were 220 mg/L and in April 2021 they were 190 mg/L. Water quality data for YG2/18 bore is included as Appendix K .

Table 5-24: Yungngora Community Bore (Grant Group) groundwater quality (Appendix K)

Parameter	Bore YG2/18	
	Minimum–Maximum	Median
Conductivity at 25 °C (mS/m)	890-990	*930*
Turbidity (Nephelometric turbidity unit)	0.1-0.2	*0.1*
pH (pH units)	7.6-8.6	*8.3*
Aluminium	0.04-0.22	*0.2*
Barium	0.03-0.04	0.03
Boron	0.001-0.27	0.01
Fluoride	0.5-0.9	*0.6*
Iron	0.02-0.15	*0.03*
Manganese	0.030-0.042	*0.040*
Nitrate as nitrogen	0.0-0.1	*0.0*
Nitrite as nitrogen	0.05	*0.05*
Uranium	0.001	

A summary of data for key CoPC for the Poole Sandstone monitored at Fitzroy Crossing is provided below in Table 5-25. Comparing the Yungngora Community and Fitzroy Crossing data, the data indicates that the Poole Sandstone overall produces fresher water than the Liveringa Aquifer, as demonstrated by lower chloride concentrations and lower EC/TDS. Sulfate concentrations within the Poole Sandstone were also substantially less that those observed in the Liveringa, but cadmium and copper concentrations were comparable. Long-term data analysis indicates that groundwater chemistry influenced by the geology is stable within the Poole Sandstone.

The town of Fitzroy Crossing sources water from the Fitzroy Crossing Water Reserve PDWSA. These production bores are located in hard cemented sandstone on joints or faults within the Poole Sandstone. The production bores range from ~30–60 m deep (DoW, 2008). Table 5-25 lists the water quality of this groundwater source (range and median values, all in mg/L unless stated otherwise). Figure 5-32 shows the location of the Grant Group bores discussed in this ERD.

Table 5-25: Fitzroy Crossing groundwater quality (DoW, 2008)

Parameter	Bore 3	
	Minimum–Maximum	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*

Parameter	**Bore 3**	
	Minimum–Maximum	**Median**
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*
Uranium	0.001	

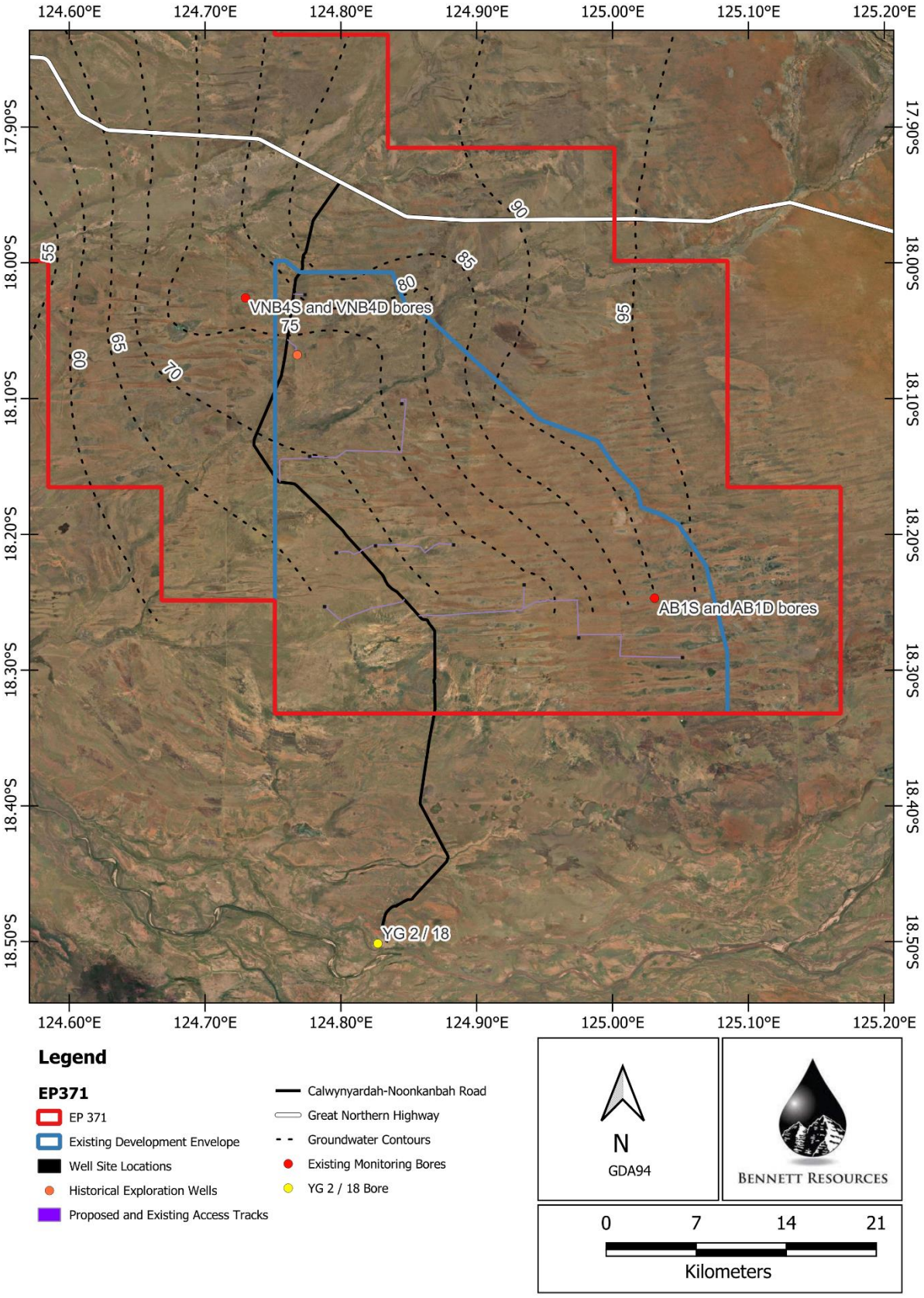


Figure 5-33: Location of Grant Group sampling bore for local groundwater characterisation

5.4.3.4.4 Local and regional use

Within the broader Canning–Kimberley area, the Grant Group comprises ~13.6 GL (67.4%) of the total water allocation within the proclaimed groundwater area (>300,000 ML/year (DoW, 2014)). Although there are multiple licences to take water from within the Grant Group (including from the Poole Sandstone), these are associated with other oil and gas operators, mining operators, Main Roads, communities, and the local shire. Some water extraction within the broader region is unlicensed for uses such as livestock and domestic bores (pastoral activities), tourist activities and Aboriginal community bores (Harrington & Harrington, 2015).

Table 5-26 summarises the groundwater extraction licences within the Grant Group, near the Development Envelope. Locally, there are three known users of groundwater from the Poole Sandstone, near the Development Envelope—the Yungngora Community, and the towns of Camballin and Fitzroy Crossing.

The known locations of pastoral bores within the Development Envelope are plotted on Figure 5-34. The nearest pastoral bore is located at least 1.5 kilometres away from any proposed groundwater abstraction points (well sites).

Table 5-26: Summary of groundwater extraction licences within the Grant Group, near the Development Envelope

Licence number	Issue date	Expiry date	Allocation (ML)	Owner	Targeted aquifer	Proximity to the Development Envelope
181107	04 Jun 2021	15 Jan 2027	10	Buru Energy Pty Ltd Origin Energy West Pty Ltd	Grant	Covers the Development Envelope and EP 371 entirely. No known extraction bores operating within the Development Envelope
165723	14 Sep 2020	13 Sep 2030	99	Main Roads	Grant	~9.5 km east of Proposed Well Site 4; ~9.5 km north of Nidavellir
65339	18 Oct 2018	12 Nov 2024	50	Water Corporation	Grant	~65 km west of Nidavellir
65334	23 Jul 2019	23 Jan 2027	300	Water Corporation	Grant	~58 km east of Proposed Well Site 4
111188	06 Apr 2017	05 Apr 2027	30	Jarlmadangah Burru Aboriginal Corporation	Grant	~85 km west of Nidavellir
175441	03 May 2017	28 Feb 2022	25	New Standard Onshore Pty Ltd	Grant	~72 km south of Proposed Well Site 3
175572	03 May 2017	28 Feb 2022	0.15	New Standard Onshore Pty Ltd	Grant	~72 km south of Proposed Well Site 3
177201	20 Jun 2013	30 Jun 2022	4.5	Kunawarritji Aboriginal Corporation	Grant	~72 km south of Proposed Well Site 3
179509	14 May 2021	13 May 2031	15.5	WA Department of Education	Grant	~58 km east of Proposed Well Site 4
179757	12 Jan 2015	11 Jan 2025	5.475	SDWK	Grant	~58 km east of Proposed Well Site 4
179796	18 Sep 2014	17 Sep 2024	0.35	New Standard Onshore Pty Ltd	Grant	~72 km south of Proposed Well Site 3
200028	28 Jun 2017	27 Jun 2027	2	India Bore Diamond Holdings Pty Ltd	Grant	~25 km north of Nidavellir
200952	19 May 2019	20 Feb 2028	10	Gibb River Diamonds Limited	Grant	~52 km north of Nidavellir
201114	19 May 2019	27 Mar 2028	350	Gibb River Diamonds Limited	Grant	~52 km north of Nidavellir
205296	22 Dec 2020	19 Sep 2024	1.5	West Kimberley Diamonds Pty Ltd	Grant	~65 km north-northwest of Nidavellir

Licence number	Issue date	Expiry date	Allocation (ML)	Owner	Targeted aquifer	Proximity to the Development Envelope
206454	12 Oct 2021	11 Oct 2032	50	Burgundy Diamond Mines Limited	Grant	~43 km north-northeast of Nidavellir

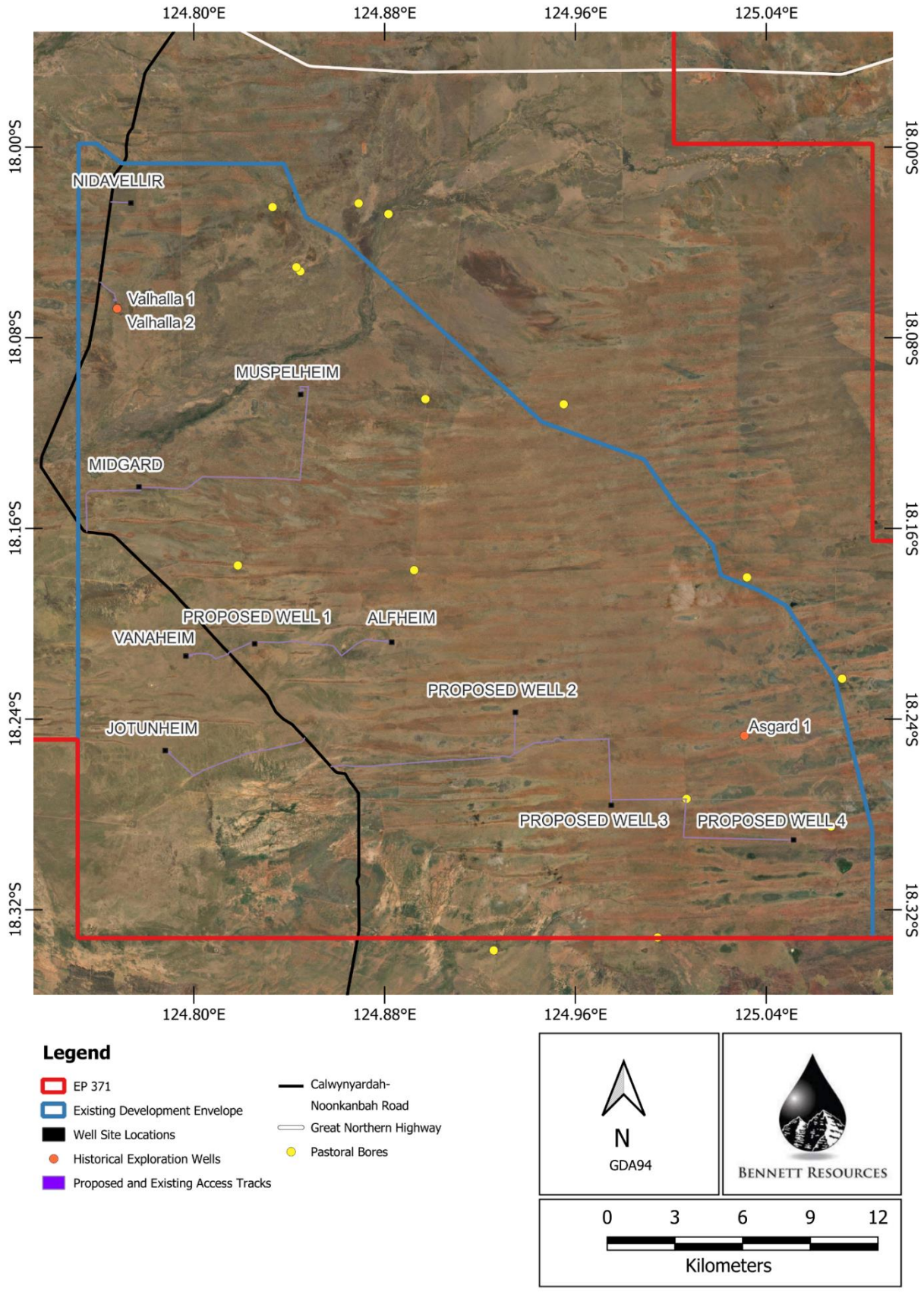


Figure 5-34: Location of known pastoral bores within the Development Envelope

5.4.3.5 GDEs

Knowledge of groundwater dependent ecosystems (GDE) within the Fitzroy River Catchment is limited and a search of the Groundwater Dependent Ecosystems Atlas (BoM, 2021) for GDEs within the Development Envelope indicates that, with the exception of Mount Hardman Creek, no other aquatic or terrestrial GDEs are present near the project area (Figure 5-36).

Mount Hardman Creek comprises limestone tableland and intricately dissected bevelled ridges; separated by plains and rocky karst surfaces with box valleys (BoM, 2021). The creek is non-perennial and only flows following large rainfall events. This indicates that, conceptually, groundwater influence is limited to maintaining areas of isolated surface water expressions until rainfall events result in the connection of surface waters and the creek flows.

FitzCAM—a community group comprising representatives from the key Traditional Owner groups of the Fitzroy River Catchment, pastoralists, irrigators, recreational fishers and catchment residents—developed a draft table of assets known to be water-dependent features (Harrington & Harrington, 2015). These assets included:

- Lake Gladstone, the largest permanent freshwater wetland in the Central Kimberley bioregion, providing a refuge for vulnerable species
- freshwater springs such as Udialla Springs and Honeymoon Springs
- Mallallah Swamp and Sandhill Swamp, which are potentially important waterbird habitats.

In addition, a review of Wetlands of National Significance (DAWE, 2001) was conducted under the Northern Australia Sustainable Yields Project in 2008, which identified that the Camballin Floodplain (Le Lievre Swamp System) and Geikie Gorge were ecologically important where changes in flow regimes occurred (Harrington & Harrington, 2015).

Table 5-27 lists the Development Envelope's distances to these ecological sensitivities, bearing in mind that the distance to the actual proposed disturbance footprint will be greater than these distances.

Table 5-27: Distance of the Development Envelope to water-dependent features

Feature	Distance and direction from the Development Envelope
Mallallah Swamp	~9 km south
Sandhill Swamp	~30 km southwest
Camballin Floodplain (Le Lievre Swamp System)	~38 km west/northwest
Geikie Gorge	~70 km east
Honeymoon Springs (fresh water)	~78 km west
Udialla Springs (fresh water)	~114 km west
Lake Gladstone	~177 km northeast

As detailed in Section 5.4.5.1, the Proposal will not interact with wetlands detailed in Table 5-27, nor are they located within the Development Envelope. As such a conceptual hydrogeology for wetlands detailed in Table 5-27 is not presented.

5.4.3.6 Surface waters

The Development Envelope does not intersect any Ramsar wetlands or Wetlands of National Significance within the DoIW. The Camballin Floodplain (Le Lievre Swamp System) is the closest DoIW system to the Development Envelope (~37 km from the western boundary of the Development Envelope). Three recognised surface waterbodies are present within or surrounding the Development Envelope:

- Fitzroy River, ~16 km south of the Development Envelope
- Mount Hardman Creek, crossing the Development Envelope (but the proposed disturbance footprint has been designed to avoid this creek)
- Mount Wynne Creek, north of the Development Envelope.

Figure 5-36 shows all the surface water features (in white) of the project area, Development Envelope and areas surrounding them.

Although not complex, the data provided in the subsections above (Section 5.3.1 – Section 5.4.3.5) have been used to inform the understanding of the hydrogeology of wetlands and waterways within the Development Envelope. Given the separation of Liveringa aquifer from the Grant/Poole due to the Noonkanbah shale, it is impacts to the Liveringa aquifer that is most likely to influence and affect surface water features. Groundwater in the Liveringa is recharged from local infiltration of rainfall where they outcrop, however infiltration is retarded by clay, shale and siltstone layers, both above and below the water table depending on the local stratigraphy.

The Mount Hardman Creek and ephemeral feeders are located within the physiographic region known as North Fitzroy plains (Lindsay & Commander, 2005). The North Fitzroy Plains consist principally of eolian sand and gravel, underlain by lateritised sandstone and mudstone of the Noonkanbah Formation and Liveringa Group (Lindsay & Commander, 2005). The ephemeral creeks are associated with small, internal drainage depressions consistent with others in the region (Lindsay & Commander, 2005). Eco Logical described these ephemeral waterways as occurring in sandy loams, clay or clay loams. The underlying formations are recharged mainly from rainfall on areas of outcrop, and locally from surface runoff and leakage through alluvium.

Mount Hardman Creek comprises limestone tableland and intricately dissected bevelled ridges; separated by plains and rocky karst surfaces with box valleys (BoM, 2021). The creek is non-perennial and only flows following large rainfall events. This indicates that, conceptually, groundwater influence is limited to maintaining areas of isolated surface water expressions until rainfall events result in the connection of these surface water expressions causing the creek to flow.

Claypans are likely prevalent throughout the Development Envelope. However, with the exception of Mount Hardman Creek, no known claypans or wetlands are located in or within close proximity of the Disturbance Footprint, which has been fixed to remove the uncertainty of impacts to surface sensitivities. As detailed in Section 5.4.5.1, modelling indicates the potential groundwater drawdown impacts are limited to 1 mm drawdown at 700 m from the abstraction point. As abstraction points will be located on the well sites themselves, the analysis considers impacts to surface waters within 700m of the well site disturbance footprint. The only identified surface water feature, or system with the potential to comprise a GDE, is Mount Hardman creek located ~1km away. Given the drawdown modelling provided in Appendix L has shown no impacts to Mount Hardman arising from the activity, no additional conceptual hydrogeological model has been completed.

Table 5-28 lists the distance of these features to the proposed well locations; they are shown in Figure 5-36.

Table 5-28: Surface waterbodies within the Fitzroy River Catchment

Well site name	Closest surface waterbody
Alfheim	~13.5 km southeast of Mount Hardman Creek
Jotunheim	~15 km south of Mount Hardman Creek ~26 km north of Fitzroy River
Midgard	~2.5 km southeast of Mount Hardman Creek
Muspelheim	~1 km southeast of Mount Hardman Creek
Nidavellir	~7 km southeast of Mount Wynne Creek ~10 km north of Mount Hardman Creek
Proposed well site 1	~10.7 km south-southeast of Mount Hardman Creek
Proposed well site 2	~18.7 km southeast of Mount Hardman Creek
Proposed well site 3	~25 km southeast of Mount Hardman Creek ~27 km north of Fitzroy River
Proposed well site 4	~24 km north of Fitzroy River
Vanaheim	~10 km south of Mount Hardman Creek

The Fitzroy River Catchment spans ~94,000 km^2, which is >20 per cent of the Kimberley region. The Fitzroy River generally flows between November and May following seasonal rainfall and has large but short duration floods (<two months in a wet year). Due to the long dry season, many of the tributaries of the surface fluvial system draining into the Fitzroy River are ephemeral streams or swale washes. The Fitzroy 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 of <250 mg/L TDS compared to dry season levels, which range up to 900 mg/L TDS (Vogwill, 2015). The river is fresh (<500 mg/L TDS) between Fitzroy Crossing and Noonkanbah, it is marginal (500–1,000 mg/L TDS) between Noonkanbah and Myroodah Station (~51 km west of the Development Envelope), and fresh from Myroodah to Willare (20 km south of Derby). Dry season river water salinity can be interpreted to reflect the salinity of the groundwater, because the contribution from surface run-off is negligible and the river flows are supported by baseflow. The brackish stretch of river at around the Yungngora Community 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 & Commander, 2005). The results from five historical sampling stations show that the salinity of river water often exceeds the desirable potable water limit of 500 mg/L during the dry season.

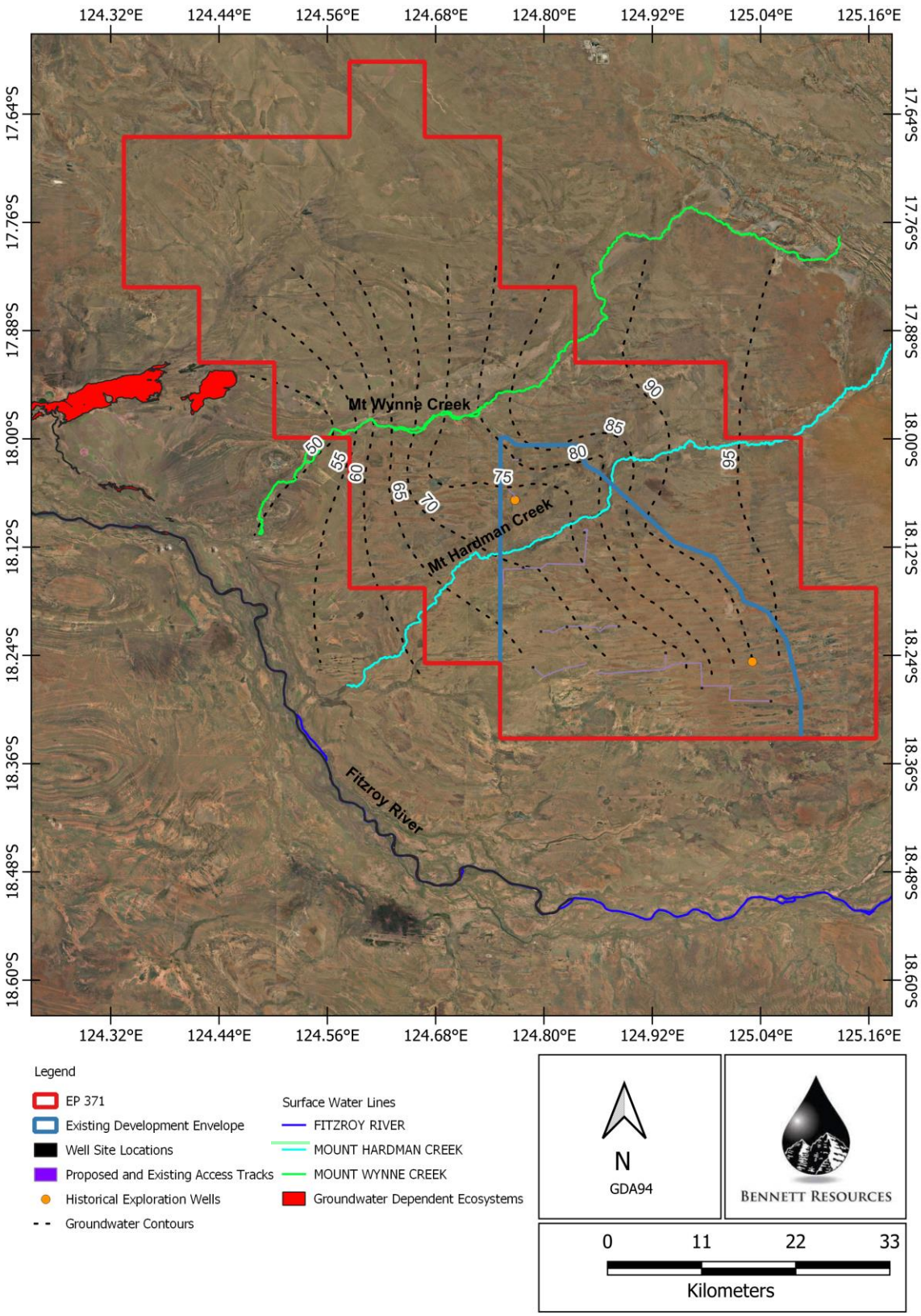


Figure 5-35: Water Bodies, Groundwater Contours, and Groundwater Dependent Ecosystems within the Development Envelope

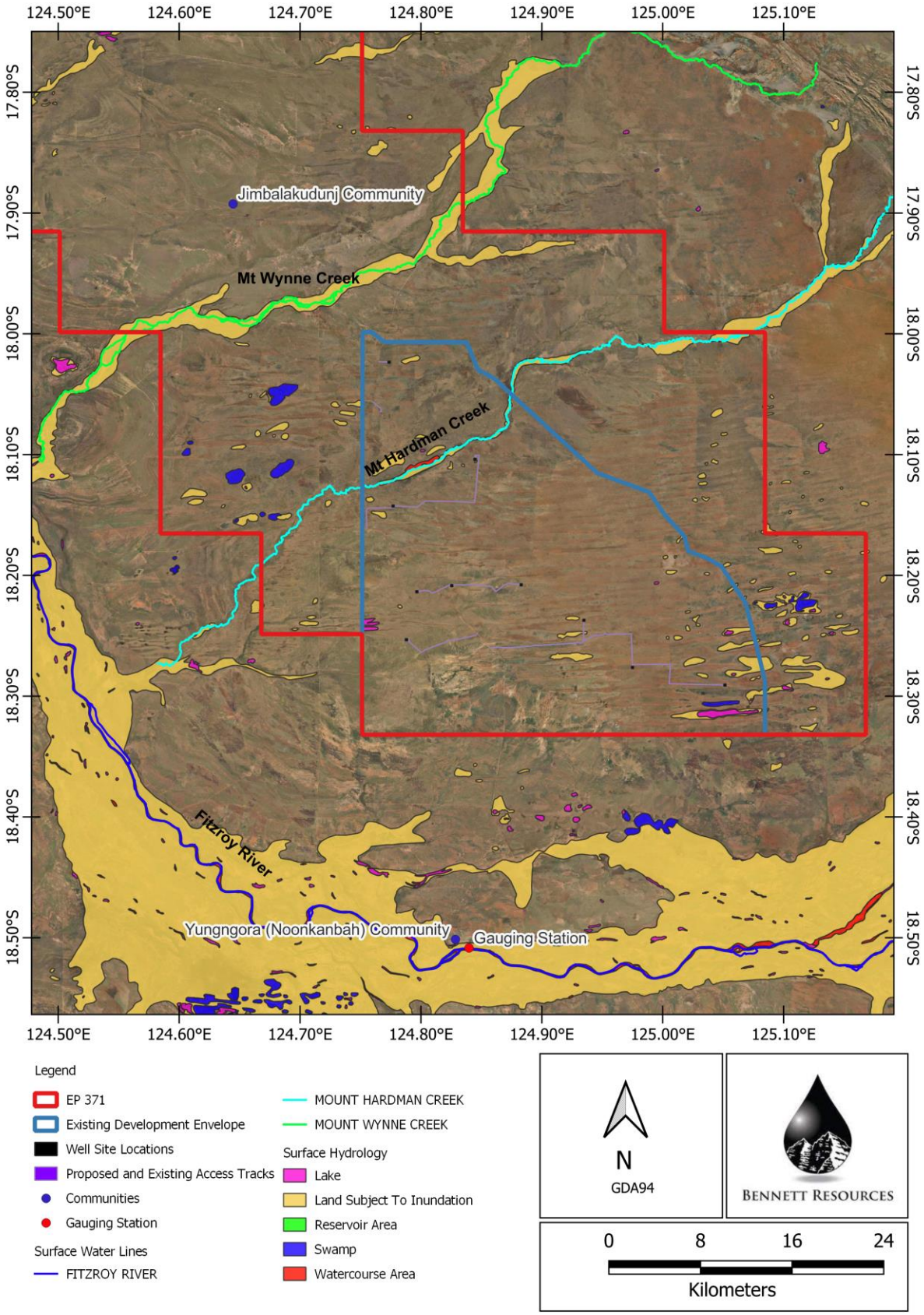


Figure 5-36: Surface waters within and surrounding the Development Envelope

5.4.3.7 Public drinking water source areas

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

- Camballin Water Reserve (~60 km west)
- Fitzroy Crossing Water Reserve (~51 km east of the Development Envelope).

The PDWSA for Camballin is supplied from groundwater within the Poole Sandstone (DoW, 2006). Table 5-29 lists the water quality (range and median values, all in mg/L unless otherwise stated) for these groundwater sources.

See Section 5.4.3.4.3 for the Fitzroy Crossing Water Reserve water quality information.

Table 5-29: 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*	NT
Hardness ($CaCO_3$)	35–75.4	45	40–65.3	*42.5*	45[10]
Turbidity	ND–160	*0.8*	ND–60	*0.8*	0.4[10]
pH	6.43–8.4	*6.6*	6.42–8.4	*6.6*	6.5[10]
Aluminium (unfiltered)	ND–0.03	*ND*	ND–0.02	*ND*	ND[10]
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[10]
Manganese (unfiltered)	ND–0.16	*0.032*	ND–0.103	*0.03*	0.026[10]
Nitrate + Nitrite (as N)	ND–1.13	*ND*	ND–0.28	*ND*	0.011[10]

ND = Not detected; NT = Not tested

5.4.4 Potential impacts

5.4.4.1 Direct impacts

Direct impacts to inland waters from the Proposal's activities, while unlikely, may include:

- changes to groundwater levels (groundwater drawdown) associated with water extraction
- contamination of surficial aquifers due to lost circulation.

5.4.4.2 Indirect impacts

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

- changes to surface water flow due to the construction of well sites and access tracks
- contamination of useable aquifers through unplanned fracture heights or well integrity failure (including casing failure)

[10] One test result only.

- contamination of surficial aquifers from an accidental release at the surface of drilling fluids, HFS chemicals, liquid hydrocarbons, or produced formation water
- potential risk to site activities and infrastructure due to extreme rainfall events
- impacts to subterranean fauna associated with groundwater drawdown or contamination.

5.4.5 Assessment of impacts

5.4.5.1 Changes to groundwater levels (groundwater drawdown) associated with water extraction

Groundwater is to be extracted 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 maximum estimate of <100 ML to be used per Phase II well. BNR's water use for the Proposal per well represents a negligible portion (<0.034%) of the Canning Basin allocation limit and is far less than water extracted for other uses in the region such as by communities and pastoralists.

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 depends on 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 5-37) was experienced at the two environmental monitoring bores (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 I (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.

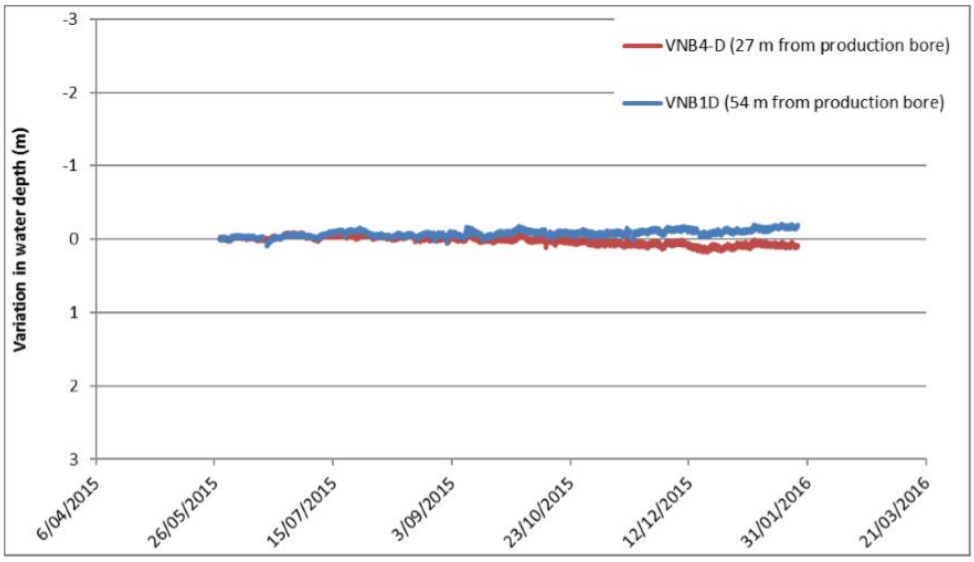


Figure 5-37: Variation in groundwater levels recorded at the Valhalla North 1 well site during the 2015 program

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 to understand drawdown impacts for considerably larger volumes of water extraction. Using an extraction volume of 100,000 kL (100 ML) (which is the conservative maximum extraction for a Phase II well), the model predicted that a short-term drawdown of 1 m or more could extend up to 780 m from the extraction water bore at the (deep) level of the screens in the extraction bore (Appendix IRockwater, 2016)).

The model predicted that even with pumping for the maximum volume of 100 ML, groundwater levels would be expected to recover rapidly to within 0.2 m of baseline levels within hours of stopping extraction and to fully recover within weeks. Consequently, extracting larger volumes than those required for the Proposal is expected to result in temporary drawdown that is within natural variability.

Discussions with DWER identified the need for additional modelling, therefore, additional modelling was commissioned from Intera Geosciences Pty Ltd. MODFLOW 2005 was selected as the appropriate software as it simulates steady and nonsteady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of confined and unconfined. Two primary models were developed, one simulating the unconfined Liveringa aquifer (Mod 1) and one simulating the confined Grant/Poole Group system (Mod 2). A full explanation of the modelling approach is contained in Appendix L.

Model results are presented as mapped drawdown contours with a minimum contour of 0.2 metres and a 0.2 metre contour interval. This contour interval was selected as normal seasonal fluctuations are known to range between 0.2 metres and one metre, so values less than 0.2 metres are not likely to constitute significant impacts relative to natural variations (Intera Geosciences Pty Ltd, 2023). To ensure a conservative approach to modelling was undertaken, BNR utilised a pumping duration of six months which is much longer than would be anticipated for any abstraction bore and assumed that each wellsite was producing water for the same 6-month period, which is not realistic as only one or two abstraction bores are expected to be producing at any one point in time. The modelled drawdown at the end of the six-month pumping period for Mod 1 (the Liveringa Aquifer) showed potential for a 0.2 m drawdown within 400 metres of each pumping bore assuming that all 10 well sites were abstracting water at the same time (Intera Geosciences Pty Ltd, 2023). However, given this model provides an unrealistic representation of groundwater drawdown as all well sites will not be pumping at the same time, and given the proximity of the Muspelheim wellsite to Mount Hardman Creek (1 km), additional predictive modelling for Mod 1 was performed with pumping only applied to the Muspelheim wellsite to provide an informed and realistic indication of potential drawdown exposure to the GDE. Modelling indicates that for a single wellsite a 10cm drawdown is expected 400 m from the pumping bore reducing to 2 cm at 500 m and 1 mm drawdown at 700 m (Intera Geosciences Pty Ltd, 2023).

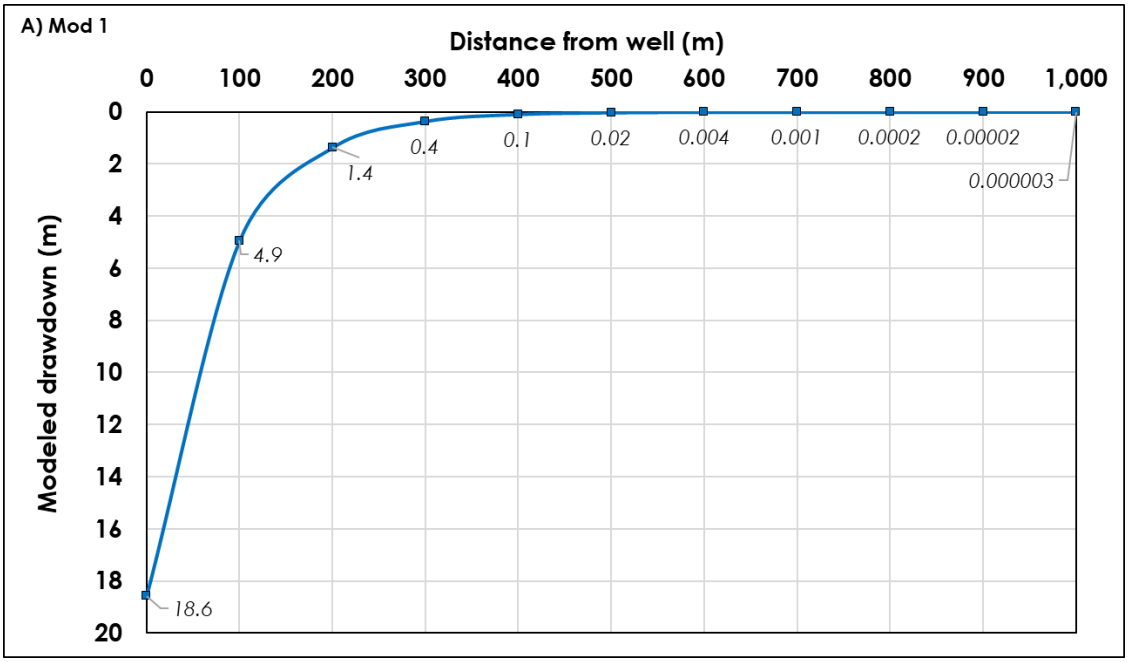


Figure 5-38: Liveringa Drawdown from Muspelheim (Intera Geosciences Pty Ltd, 2023)

Based upon modelling predictions from Intera Geosciences (2023), BNR does not believe that the potential drawdown associated with the Proposal pose a significant impact to the Mount Hardman Creek GDE or existing pastoral bores.

5.4.5.2 Potential contamination of surficial formations due to lost circulation or well integrity issues, including casing failure

During all drilling activities, the most sensitive well sections are the surface hole sections because they penetrate through surficial aquifers that generally have low salinities and thus are most suited for other uses (such as potable water or agricultural uses). Therefore, the loss of drilling fluid circulation (i.e. drilling fluids are released to subsurface formation) is the largest risk to surficial formation drilling activities. The risk of soil and groundwater contamination from these activities is well understood because onshore exploration and appraisal drilling is undertaken regularly throughout WA and the world. Consequently, there is a standard suite of management measures that will be implemented, including:

- drilling fluid systems for the surface hole sections comprise low-toxicity mud systems
- install and cement a surface casing across the useable aquifers to isolate them from deeper formations and aquifers (DMPR, 2002).

As detailed in Figure 2-1, the surface hole sections are likely to be installed to 550 m, well below the Liveringa Formation. This will ensure that sufficient isolation exists before drilling the next hole section.

BNR will also ensure that there are always two barriers between the well and any useable aquifers, which is standard (and required) practice.

Rockwater (2016) was engaged to predict duration of groundwater migration to key sensitivities based on hydraulic conductivity, hydraulic gradients and specific yields. The study (Appendix I) concluded that groundwater would take ~16,000 years to move ~32 km. Based on the unlikely event that a lost circulation occurs when drilling the top-hole sections, resulting in drilling fluids being released to groundwater, 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, noting that the closest groundwater user is at least 18 km from the project area.

5.4.5.3 Changes to surface water flow due to the construction of well sites and access tracks

Given the location of the disturbance footprint, significant surface water flows will not need to be diverted. In fact, since referring the Proposal, BNR has amended the disturbance footprint to ensure it is located away from the non-perennial Mount Hardman Creek, and away from any low-lying marshlands and areas that are subject to flooding.

However, seasonal rainfall that causes short-duration flooding events occur regularly in the Kimberley between November and May. Therefore, all hardstands (roads and well sites) need to be constructed with sufficient elevation to mitigate flooding impacts. At a regional scale, the total disturbance footprint for the Proposal is 112 ha. The Fitzroy River Catchment spans ~94,000 km^2—assuming that the disturbance footprint would result in 100 per cent run-off loss, disturbance associated with this Proposal is ~0.001% of the total natural catchment. Consequently, changes to surface water flow will not result in impacts to the regional catchment.

Locally, there may be minor changes to surface water flow, limited to flow of rainwater during the wet season. However, each well site is only ~200 m × 200 m, so the extent to which changes to surface rainwater flows will occur is limited. Each well site is subject to appropriate drainage design, with run-off diverted to sediment basins (or similar) to minimise erosion. Access roads will be constructed with a camber, table drains, culverts (as required) and regular turnouts to discharge the water into the natural surrounds.

With the proposed mitigations in place, changes to surface water flow is not expected to result in regional impacts, and any localised impacts are not expected to be significant.

5.4.5.4 Potential contamination of 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 & Warpinski, 2012; Davies, Mathias, Moss, Hustoft, & Newport, 2012). The review by Davies et al. (2012) was based on analysing the data acquired from several thousand shale gas HFS in the United States (US). This data reported a maximum vertical fracture length of 588 m (Davies, Mathias, Moss, Hustoft, & Newport, 2012).

The comparison of nearly 4,000 tops of micro seismic fractures to the maximum groundwater depths across four major US shale formations showed that in no cases did the fracture zones reach overlying aquifers. A separation of over 800 m remained between the local aquifers (Fisher & Warpinski, 2012), with only one per cent of these fractures being >350 m high (Davies, Mathias, Moss, Hustoft, & Newport, 2012). A further study by Davies et al. (2012) in the United Kingdom found that hydraulic fractures remain well confined to the target interval, even in the presence of faults.

As it relates to faults and fault seal for this Proposal, all significant faults in the development area are downthrown to the west and formation juxtaposition would place the proposed Laurel and Anderson unconventional reservoirs against Laurel or older units updip. Given the current data, there is unlikely to be any significant juxtaposition against younger (Grant or Poole) units updip. In addition, conventional hydraulic fracture stimulations are not considered long-term deformations. Once pumping stops, within minutes fractures close. Further, after a stimulation, the well is flowed back, and the local stimulated rock volume is depressurized as the load water is produced. There is no expectation of high pressures to remain above the local geopressured gradient beyond the time during which the wells are undergoing their stimulation.

With regard to stress Orientation, all faults are closed and pose no geomechanical hazard for upward propagation of fracturing fluids or hydrocarbons into the recognized aquifers as the activation energy required to dilate faults or fractures in tension is higher than overburden, which means the fracture growth would rotate to horizontal before opening such faults in tension (Appendix B).

The unconventional resources within the Laurel have permeabilities between 10nd to .17md and are predominately self-sealing without HFS. Historical HFS activities for the Asgard and Valhalla wells exhibited total stress heights of between 400-600m but exhibited more downward growth development than upward. While there are faults in the section, geomechanical data supports that the faults will not open from HFS. The shallowest aquifers that are currently used for drinking are less than 1,000m in depth and any stimulation zones here will be initiated at over 2,600m and more likely over 3,200m in depth providing a rock thickness of 1,600m – 2,200m between an injection point and any potential drinking water aquifer.

In summary, 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 HFS treatment is >2,400 m deep
- there is ~1,800 m separation between the targeted Laurel Formation and the surface Liveringa Aquifer, of which ~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 therefore would 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 ~150 m. It is deemed not plausible, physically, for induced fractures to create a hydraulic connection between the deep back shales and other tight formations and overlying potable aquifers such as the Grant and Poole Sandstone aquifers. This is determined based upon limitations to fracture height growth and potential fault slip, as discussed in the HFS Scientific Inquiry (Independent Scientific Panel Inquiry, 2018). Because there is ~1,800 m separation between the targeted Laurel Formation and the surface Liveringa Aquifer, at least 600 m separation between the Laurel Formation and the Grant/Poole Sandstone aquifers, and the predicted vertical extent of fractures for the activities is 150 m, the risk to aquifers is extremely low.

Based on available seismic data and previous reviews of the area, the potential for geomechanical hazards in the Development Envelope is considered low. This will be verified with the most up to date seismic information, followed by ongoing assessment as wells are constructed. 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 useable aquifers through unplanned fracture heights is a credible risk for the Proposal.

5.4.5.5 Potential contamination of surficial aquifers from an accidental release at the surface of drilling fluids, HFS chemicals, liquid hydrocarbons, or produced formation water

A spill from one of the water retention ponds used to store formation water produced during well testing, drilling fluids, or a spill from a chemical or chemical additive (unmixed) to the ground will result in a varying level of exposure, depending on the volume of release. BNR plans to install multiple liners for the produced water pond and mud sump, thus the most credible scenario is a small leak from a pond versus a catastrophic

failure of both liners. Consequently, the volume of any accidental release from these ponds would be small. In addition, these ponds will have a leak detection system that will monitor the integrity of the top liner.

As described in Table 5-28, water from the Laurel Formation that was produced during well testing ('produced formation water') was characterised by the previous operator of EP 371. The previous operator took multiple water samples and had them analysed at a NATA-accredited laboratory (Buru Energy, 2018); Table 5-30 lists these results. In summary, produced formation water from the water retention ponds is very high in salt at three to five times the salt concentration of sea water, not toxic to fauna or humans and has very low levels of heavy metals. In addition, although naturally occurring radioactive material (NORM) was detected, the concentrations were well below the exposure concentrations identified by the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ, 2018) and the Australian Drinking Water Guidelines (NHMRC and NRMMC, 2011 (updated March 2021)). Given the characterisation of the produced 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. Section 5.8.3 contains further information about NORMs.

Table 5-30: Produced formation water – Laurel Formation characterisation

Analyte	Unit	Date	October 2015	October 2015
		Onsite management levels	Asgard 1 pond post-well test	Valhalla North 1 pond post-well test
Arsenic	mg/L	0.5 [11]	<0.02	<0.02
Barium	mg/L	2 [12]	20	12
Boron	mg/L	4 [12]	9.4	14
Cadmium	mg/L	0.002 [12]	<0.002	<0.002
Chloride	mg/L	30,000	16,000	17,000
Chromium VI	mg/L	0.05 [12]	<0.02	<0.02
Copper	mg/L	1 [11]	<0.02	<0.02
Lead	mg/L	0.1 [11]	<0.02	<0.02
Manganese	mg/L	0.5 [12]	0.15	0.51
Mercury	mg/L	0.002 [11]	<0.0001	<0.0001
Nickel	mg/L	1 [11]	<0.02	<0.02
Selenium	mg/L	0.01 [12]	<0.02	<0.02
Zinc	mg/L	20 [11]	<0.1	<0.1

Because surface spill events are well understood, a standard suite of preventive and management measures (including spill response and recovery arrangements) will ensure that, should a spill occur, impacts to groundwater quality (if any) would be negligible.

If standard management measures are implemented, BNR does not expect these events to occur, but if they do, any indirect impacts are not expected to cause a significant environmental impact.

5.4.5.6 Potential risk to site activities and infrastructure due to extreme rainfall events

To understand potential risk to site activities and infrastructure arising from extreme rainfall events, BNR completed a desktop flood risk assessment. Data were obtained through the Department of Water and Environmental Regulation's Water Information Reporting (WIR) website to understand streamflow variation and flood height. Site 802006, located on the Fitzroy River at Noonkanbah (Lat -18.50842693, Long 124.8397398), was the closest gauging station to the Development Envelope (Figure 5-36) and subsequently was considered the most appropriate data source for completing this assessment. This station has been collecting stream gauging data since 26 October 1997 and is located 51.07m AHD.

[11] Stock water: Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ, 2018).
[12] Health values: Australian Drinking Water Guidelines 6, Version 3.5 (NHMRC and NRMMC, 2011 (updated March 2021)).

In January 2023, the Kimberley experienced a one in 100-year flood event. According to news reports, the Fitzroy River reached a “record” height of 15.8 metres on 4 January 2023. Reviewing the data gathered by DWER from Site 802006, a max gauged state of 18.223 was recorded which subsequently is the figure that will be used for further analysis.

Floods in the Fitzroy tend to disperse either side into the floodplains. Although not exact, for the purpose of this assessment, it is assumed that flooding is regular across the landscape, so that any area less than 69.29 AHD (51.07 + 18.22) would be subject to flooding. The 10 proposed well sites are shown in Figure 5-36 and Table 5-31 including the approximate elevation of each site.

Table 5-31: Well site locations and their approximate elevation

Well	Latitude	Longitude	Approximate elevation
Alfheim	−18.207772	124.882912	112m
Jotunheim	−18.253224	124.787923	73m
Midgard	−18.14258	124.776958	128m
Muspelheim	−18.103833	124.844723	137m
Nidavellir	−18.023477	124.773575	125m
Proposed Well 1	−18.208448	124.825451	110m
Proposed Well 2	−18.237182	124.934808	77m
Proposed Well 3	−18.276184	124.974959	73m
Proposed Well 4	−18.290737	125.051452	73m
Vanaheim	−18.213578	124.796585	87m

As can be seen from Table 5-31, all of the sites are situated at a higher elevation than the assumed flood level of 70 metres. Noting that Noonkanbah Community is located at 70 metre elevation and given that anecdotal evidence indicates that the community, while cut off due to road closures, was not significantly affected by floodwaters in January, the assessment above is considered suitable for informing the level of risk for the Proposal.

In addition to flood events, BNR considered the risk of an extreme rainfall event causing onsite ponds to overflow. To inform the assessment BNR reviewed rainfall statistics from Fitzroy crossing which has been collected for the period between 1997 and 2023. The annual average rainfall rates for Fitzroy Crossing over this period is 682 mm (BoM, 2023). Using the BoM Rainfall IFD data system (BoM, 2023a), a rainfall intensity chart has been created for Fitzroy Crossing (Figure 5-37). BoM (2023a) indicates that the average number of days during the wet season where rainfall of >= to 100 mm is recorded is three days. Thus, using IFD data for a one in 100-year event (with a duration of three days) the volume of rain was estimated to be 345 mm (based upon rainfall intensity of 4.80 mm/hr).

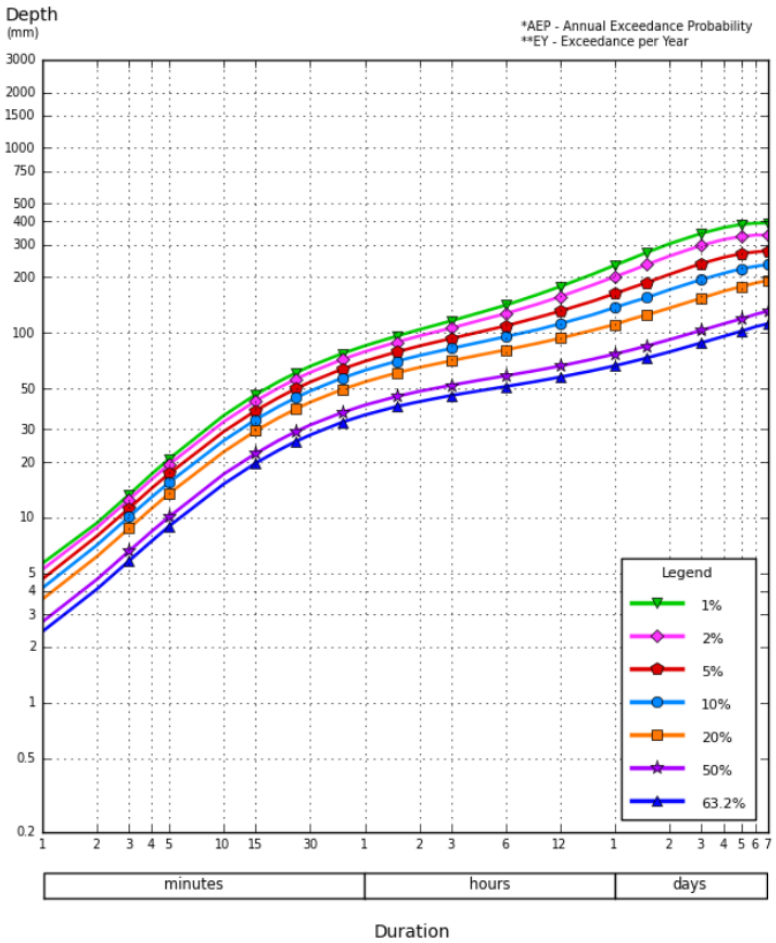


Figure 5-39: Rainfall Intensity Chart – Fitzroy Crossing

While the size of the mud sump and water retention pond have not yet been designed, they are anticipated to have volumes in the order of 5000 m^3 and 114,400 m^3 respectively. Based upon the calculations detailed in Table 5-32, BNR has demonstrated that the volume of ponds sufficiently caters for one in 100-year rainfall events and a 90th percentile wet season.

Table 5-32 Sump and pond calculations

Type	Sump
Drilling fluid[13]	1,750 m^3
Drill cuttings (well site)[14]	900 m^3
Freeboard (500mm)	600 m^3
Rainfall contingency (not considering evaporation offset)	
90 percentile wet season (682 mm)	819 m^3
1in 100-year storm event (345 mm in 3 days)	414 m^3
Total	4483 m^3
Volume (20m x 60 m x 4m)	5000 m^3

Type	Water retention pond
HFS water	78,242 m^3
Freeboard (500 mm)	10,400 m^3
Rainfall contingency (not considering evaporation offset)	
90 percentile wet season (682 mm)	14,186 m^3
1in 100-year storm event (345 mm in 3 days)	7176 m^3
Total	110,004 m^3
Volume (L-shaped pit: 200m x 96m x 5.5m +80m x 20m x 5.5m	114,400 m^3
Maximum produced water:	(Water pond)
Produced water (90 day well test, max[15])	54,769m^3
Freeboard (500mm)	10,400m^3
Rainfall contingency (not considering evaporation offset)	
90 percentile wet season (682mm)	14,186m^3
1 in 100-year storm event (345mm in 3 days)	7,176m^3
Total	**86,531m^3**
Volume (L-shaped pit: 200m x 96m x 5.5m +80m x 20m x 5.5m)	114,400m^3

5.4.6 Mitigation

Table 5-33 summarises the mitigation measures and their hierarchy These will be included in an EP for assessment and acceptance by DEMIRS under the PGER(E)R before activities commence.

In addition, a Part IV Groundwater Management Plan (GWMP) (Appendix M) has been prepared to support this ERD. The GWMP describes the proposed groundwater monitoring program as well as trigger and threshold criteria that will be implemented to minimise impacts associated with the Proposal. The GWMP will be implemented to demonstrate that residual impacts are not greater than predicted.

[13] This assumes no evaporation occurs between the first and second well on the wellsite and two wells worth of drilling fluid are stored in the pit after drilling is finished on the second well.

[14] This assumes the deepest/longest wellbore is drilled and covers two wells worth of cuttings.

[15] This assumes 70% of the HFS load is recovered during the 90-day well test. This is considered highly unlikely and 10-35% load recovery is expected.

Table 5-33: Proposed mitigation measures – inland waters

Mitigation hierarchy	Mitigation measure	Further information
Avoid	Geomechanical risks assessment	In accordance with ESD Item 12, a comprehensive geotechnical risk analysis has been conducted and is attached in Appendix B. Further geotechnical risk assessment will be completed after each well has been constructed and prior to any HFS taking place. The site-specific geotechnical risk assessment will also utilise information gathered during the installation of the groundwater monitoring bores.
Avoid	Early warning system for detecting geomechanical events	In accordance with ESD Item 13, an early warning system for detecting geomechanical events has been developed and will be implemented for the Proposal. The detection system is described in Appendix B. and includes monitoring for one-month pre and post any HFS activities.
Avoid	HFS not located within 2,000 m of a PDWSA	The wells are not located within 2,000 m of a PDWSA (Section 5.4.3.7).
Avoid	HFS treatment will have more than 600 m vertical separation to the nearest useable aquifer.	As is good industry practice (in the absence of a state Code of Practice), BNR will ensure that HFS will not occur in formations that have <600 m vertical separation to the nearest useable aquifer. This will be checked and confirmed once each well has been constructed, along with a geotechnical risk analysis.
Avoid	Surface casing cemented across all useable freshwater aquifers	In accordance with the Guidelines for the protection of surface and groundwater resources during exploration and appraisal drilling (DMPR, 2002), the potential for contaminating groundwater resources will be managed by installing casing that is secured and sealed by a sealing material such as cement.
Avoid	Well Management Plan	In accordance with ESD Item 14 and Regulation 10 of the PGER (Resource Management and Administration) Regulations 2015, every 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 DEMIRS before HFS commences. Therefore, well management plans will be developed and approved prior to each well being constructed. A summary of well integrity management is provided in Section 1.4.3.2.
Avoid	Well integrity assessment	In accordance with ESD Item 14, 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 approved by DEMIRS. A summary of assessment is provided in Section 1.4.3.2.
Avoid/Minimise	Part IV Groundwater Management Plan	As required by the ESD Item 4, BNR has developed a GWMP (Appendix M) that documents the groundwater monitoring requirements along with management actions associated with trigger and threshold criteria that must be implemented. BNR believes that with the triggers detailed in the GWMP, groundwater sensitivities (such as subterranean fauna) will be protected. BNR will ensure the location of all monitoring bores is completed in consultation with DWER and DEMIRS. BNR will complete all groundwater monitoring (including local baseline sampling) in accordance with the Part IV Groundwater Management Plan.
Minimise	Produced formation water storage pond design	As per WQPN 26 (DoW, 2013), all lined storage compounds will 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 90th percentile wet season, after allowing for any evaporative water loss and the effects of any water re-use recovery system. All water storage ponds will be designed to meet these requirements.
Minimise	Groundwater monitoring bore installation	Installation and drilling of all water bores (including abstraction bores) will be hydro stratigraphically logged in detail and geophysical interpretation of

Mitigation hierarchy	Mitigation measure	Further information
		groundwater quality collected, for the interval where fresh aquifers are known to be present (including through the Grant formation). Annulus seals and gravel packs will be used, where necessary, to isolate the zone being monitored and prevent potential cross contamination via the bore casing as required by the Minimum Requirements for Water Bores in Australia (National Uniform Drillers Licensing Committee, 2011) required to be followed as detailed in the Groundwater monitoring in the onshore petroleum and geothermal industry guideline (DMP & DoW, 2016). BNR will conduct validation water samples (along with QA/QC samples of any fluids or water used for the bore installation process) at a point of discharge from the circulation system to understand if cross contamination may be occurring as evidenced by fluid constituent presence associated with bore installation. This may involve the use of tracer dyes, but these specifics are subject to local conditions, aquifer depths and will be directed by a hydrogeologist during bore installation.
Minimise	Petroleum well installation	BNR will hydrostratigraphically log the petroleum well during drilling activities and collect a geophysical interpretation of groundwater aquifers.
Minimise	Pond design	In accordance with WQPN 26 (DoW, 2013), surface ponds used for short-term containment of wastewater or solids that may leach contaminants, require synthetic membranes and need to meet specific requirements, including: • all fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s • a minimum thickness of 0.75 mm • dual liners • leak detection All surface ponds will be constructed to meet these requirements.
Minimise	Chemical inventory	In accordance with ESD Items 5, 6, 7, 8, and 9, a chemical inventory has been developed for the Proposal (Appendix A).
Minimise	Low-toxicity mud system	BNR plans 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 volumes of fluids not recovered during circulation.
Minimise	Groundwater licences for extraction bores	In accordance with the RIWI Act, all water extraction must be licensed prior to take because the Development Envelope is located within a proclaimed groundwater area (DoW, 2010). BNR will ensure all groundwater licences are in place and kept up to date.
Minimise	Meter calibration and monitoring for extraction bores	As described in the Measuring the taking of water guidelines (DoW, 2016), Clause 46 of Schedule 1 of the RIWI Act state that licensees may be subject to metering, which is recognised as an accurate and reliable measuring technique. This is further expressed in the RIWI Regulations 2020, which now require water licences with annual water entitlements of between 10 – 50ML per year to install meters. Meters will be installed as required.
Monitor	Site water audit	As required by ESD Item 4, all water wastes and emissions, including formation water produced during well testing, resulting from the Proposal will be recorded and monitored. A site water audit on completion of HFS 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.
Monitor	Ecotoxicology testing on produced formation water	As required by ESD Item 4, Ecotoxicology testing of produced formation waters at each wellsite will be conducted by an independent NATA endorsed laboratory, either through the sea urchin fertilization test using Heliocidaris tuberculate or other appropriate methodology. Reporting will be done in accordance with annual compliance reporting to DMAs.

5.4.7 Environmental outcomes

Throughout the planning phase, BNR has reviewed studies undertaken by the previous operator of EP 371 and analysed geological records to understand the potential impacts associated with the Proposal. Based on 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 that is considered outside seasonal fluctuations
  - no change to groundwater quality attributable to the Proposal.

Based on these predicted outcomes and the evidence shown throughout this ERD, BNR does not believe that the Proposal will result in a significant impact to inland waters. The environmental mitigation measures intended to manage and minimise impacts to inland waters are considered effective. Consequently, BNR believes that the EPA's objective to:

> *'maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected'*

can be met.

BNR has considered the WA Environmental Offsets Policy (Government of Western Australian, 2011) and Guidelines (Government of Western Australia, 2014), and has used the Residual Impact Significance Model (Figure 3 in WA Environmental Offsets Guidelines) to determine if any residual impacts are significant and if these may require an offset. Using this process, BNR determined that all residual impacts to inland waters are not significant, and therefore BNR does not believe actions are required to offset the predicted outcomes of the Proposal. The assessment outcomes are presented in Section 5.11.

A self-assessment of impacts on matters of NES in relation to inland waters and regional wetlands was also undertaken against the Commonwealth's significant impact guidelines for matters of NES (Department of the Environment, 2013). The Proposal's activities were determined not to have any impacts on any wetlands of international importance. Consultation with DAWE in June 2020 and October 2021 and the provision of BNR's self-assessment's outcomes to DAWE further confirmed that no significant impacts to any matters of NES were expected. Initial advice from the Commonwealth had been that this project was not required to be referred. BNR has continued to engage with DCCEEW to reiterate that the environmental impacts associated with the Proposal do not result in any direct or indirect mechanisms that would cause a significant impact to matters of NES protected under the EPBC Act.

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, 2016j)
- Technical Guidance: Environmental impact assessment of Social Surroundings – Aboriginal cultural heritage (EPA, 2023)
- Environmental Protection (Noise) Regulations 1997 (Noise Regulations)
- Petroleum and Geothermal Energy Resources (Environment) Regulations 2012
- *Native Title Act 1993* (Commonwealth)
- *Aboriginal Heritage Act 1972* (WA).

While the bulk of the ERD was prepared in 2021, BNR has noted developments with the Aboriginal Heritage Act (including the enactment and subsequent repeal of the *Aboriginal Cultural Heritage Act* 2021) to ensure consistency with the Proposal and this environmental factor. On 15 November 2023 the Aboriginal Cultural

Heritage Act 2021 (WA) was repealed, meaning that the previous Aboriginal Heritage Act 1972 (WA) was restored, with amendments.

5.5.2.1 Application of the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing and procedure of the environmental review, required by Section 40(3) of the EP Act. Table 5-34 lists the ESD requirements specific to social surroundings.

Table 5-34: ESD checklist – social surroundings

Social surroundings		
Required work		**BNR response**
42	Characterise the surrounding land use and amenity values in, and adjacent to the Proposal Area with a focus on the sensitive receptors and important areas for human use that could be affected by noise and dust emissions, traffic, and amenity issues. Include relevant maps to show the locations of the sensitive receptors likely to be affected by the Proposal.	Section 5.5.3
43	Provide a collation of baseline information and processes to ensure the documentation and systematic monitoring of matters relating to amenity and aesthetics.	Section 5.5.3.3 Section 5.5.6
44	Undertake a site-specific noise assessment in accordance with EPA and contemporary guidance. Demonstrate that noise can be managed such that it complies the Environmental Protection (Noise) Regulations 1997 at sensitive receptor locations.	Section 5.5.5.2 Appendix P
45	Undertake and provide baseline site-specific noise level data.	Section 5.5.3.8 Appendix O
46	Provide predictive modelling of noise emissions and impacts.	Section 5.5.5.2 Appendix P
47	Provide ongoing monitoring and management covering the entire lifecycle of the Proposal.	Section 5.5.6
48	Include an assessment of the cumulative impact of noise from hydraulic fracture stimulation and associated activities, on places within proximity to people and domestic animals and provide management options to minimise noise.	Section 5.5.5.2 Section 7.4
49	Identify the types and sizes of trucks, the road upgrades required to accommodate operations and ensure the safety of other road users. Describe how BNR will engage with local government to ensure public roads are maintained to provide for the ongoing safety of road users.	Section 5.5.5.4 Section 5.5.6
50	Provide baseline road-use statistics measuring volumes of vehicle movement and type and provide details of monitoring of road use, throughout the lifecycle of the Proposal.	Section 5.5.3.9
51	Reduce emissions from traffic by ensuring the regular maintenance of all vehicles.	Section 5.5.6
52	Provide a peer-reviewed, site-specific human health risk assessment, addressing potential short and long-term health impacts of the Proposal that addresses health risks from: • airborne chemicals • chemicals proposed to be used in drilling and hydraulic fracture stimulation • fluids and those expected to be present in produced or flowback water • storage and handling of drilling and hydraulic fracture fluids • storage and disposal of drilling and hydraulic fracturing flowback fluids (including wastewater). Note: peer-reviewed, site-specific human health risk assessments will be provided to the Department of Health for comment.	N/A refer to Section 3.4
53	Undertake a comprehensive local social impact analysis prior to commencement of activities, to understand and measure the social dimensions of change and its links to mental health and wellbeing, due to impacts from changes to the physical or biological surroundings.	Section 5.5.5.8
54	Determine impacts to human health in relation to worker accommodation (particularly dust, water supply, wastewater disposal etc.) by using the Department of Health scoping tool.	N/A refer to Section 5.5.5 introduction
55	Undertake and provide baseline dust monitoring [minimum 12 months] prior to regulated activities.	Section 5.5.3.7
56	Identify cumulative impacts from dust on local and regional ecosystems and public health.	Section 5.1.5.4 Section 5.5.5.1

Social surroundings		
Required work		**BNR response**
57	Propose measures to minimise the generation of dust throughout all operations when compared to baseline monitoring.	Section 5.5.6
58	Characterise and describe the social, cultural and heritage values within the Proposal area and any sensitive receptors that may be directly or indirectly impacted as a result of this Proposal. Identify sites of social significance within a regional context, in consultation with the Traditional Owners.	Section 5.5.3.1 Section 5.5.3.2 Section 5.5.3.5 Section 5.5.3.6
59	Conduct investigations, including ethnographic, ethnobotanic, and archaeological surveys in consultation with the Traditional Owners, to determine the significance of potential impacts (direct, indirect and cumulative) to social surroundings as a result of this Proposal.	Section 5.5.3.5.2
60	Proposals likely to impact on Aboriginal heritage or significant sites must include an Aboriginal Heritage Management Plan developed in consultation with the Traditional Owners and the Department of Planning, Lands and Heritage. The Aboriginal Heritage Management Plan must: • include input from Traditional Owners whose land is under consideration for petroleum development • detail the role of the Traditional Owners in monitoring the condition and protection of their cultural heritage and significant sites • be reviewed and deemed acceptable by the Department of Planning, Lands and Heritage.	N/A no management plan required, refer to Section 5.5.3.5.2
61	Detail how cultural orientations will be made available to the Proposal employees and contractors to raise cultural awareness, including issues specific to Aboriginal heritage, and be undertaken by local Traditional Owner groups or their approved cultural awareness providers.	Section 5.5.6
62	Describe and assess the potential impacts (direct, indirect and cumulative) to social surroundings as a result of changes to the environment from the Proposal giving consideration to Traditional Owners and Pastoral Stations and their activities on the land.	Section 5.5.5
63	Apply the mitigation hierarchy and discuss proposed objectives/outcomes, monitoring, management and mitigation measures including decommissioning and rehabilitation outcomes to be implemented to appropriately avoid and minimise impacts to social surroundings.	Section 5.6.6
64	Demonstrate and document how the EPA's objective for this factor can be met.	Section 5.5.7

5.5.3 Receiving environment

5.5.3.1 Social context

The Kimberley region has a sparsely distributed population of ~40,000 people across a region twice the size of the state of Victoria. The regions has six towns, ~160 Aboriginal communities, and numerous pastoral homesteads—Broome is the largest town (population ~16,000 (ABS, 2016)), followed by Kununurra (population ~5,300 (ABS, 2016)).

There are two main towns in the Fitzroy River Catchment: Derby (population ~3,500) and Fitzroy Crossing (population ~1,300), and 57 smaller Aboriginal communities. Combined, the catchment has a population of about 7,500 (Merrin, Addison, & Austin, 2018). Much of the catchment is subject to native title (Figure 1-3). Overall, the population has a very high level of socioeconomic disadvantage, with high unemployment. There is a lack of settlement, communications and transport infrastructure in the Fitzroy River Catchment, with no rail network and a sparse road network—most of the catchment is 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. Table 5-35 lists the proposed well sites and their distance from the nearest communities and towns.

Most of the Yungngora people live in the Yungngora Community. The community is ~28 km from the nearest well site (Jotunheim) and ~88 km west southwest (~170 km by road) from Fitzroy Crossing, with limited road access and communications (Figure 1-3). Most Warlangurru 1 Claimants also live in Yungngora Community with other members living in Jimbalakudunj Community, which is ~20 km northwest of the proposed Nidavellir well site. As outlined in Section 2.7, close consultation and engagement has occurred with the Yungngora and Warlangurru Peoples regarding petroleum activities on their native title areas. This has occurred over many years and includes the proposed activities. The Aboriginal communities support the Proposal.

5.5.3.2 Surrounding land use

As further detailed in Section 3.2.1 and Section 2.7, the Canning Basin is covered by rangeland ecosystems, with the project area overlaying two pastoral stations (leased Crown Land)—Blina Station and Noonkanbah Station—that are leased for pastoral grazing purposes.

The well locations are remote from residential developments, local tourist attractions and main roads. The closest receptors to the project area include a small number of station homesteads and Aboriginal communities (Figure 1-3), which are tens of kilometres away. Table 5-35 details well site locations relative to their nearest town or community.

Table 5-35: Pastoral station, native title area, and closest community to the project area

Pastoral station	Well site name	Native title area	Closest town or community
Noonkanbah Station	Jotunheim	Noonkanbah	Yungngora Community, ~28 km south Fitzroy Crossing, ~82 km east
	Midgard	Noonkanbah	Jimbalakudunj Community, ~31 km northwest
	Alfheim	Noonkanbah	Yungngora Community, ~33 km south-southeast
	Muspelheim	Noonkanbah	Jimbalakudunj Community, ~31 km northwest
	Vanaheim	Noonkanbah	Yungngora Community, ~32 km south
	Proposed Well Site 1	Noonkanbah	Yungngora Community, ~32 km south
	Proposed Well Site 2	Noonkanbah	Yungngora Community, ~32 km south-southwest Fitzroy Crossing, ~66 km east
	Proposed Well Site 3	Noonkanbah	Yungngora Community, ~30 km southwest Fitzroy Crossing, ~66 km east-northeast
	Proposed Well Site 4	Noonkanbah	Yungngora Community, ~33 km southwest Fitzroy Crossing, ~55 km east-northeast
Blina Station	Nidavellir	Warlangurru	Jimbalakudunj Community, ~20 km northwest Camballin Town, ~62 km west

5.5.3.3 Amenity and aesthetics

It is difficult to describe in words the amenity and aesthetics of a place. Instead, BNR has used photographs taken during the 2021 monitoring program to attempt to capture the amenity and aesthetics of the project area and the essence of a region that comprises a rugged outback environment of rolling plains.

As detailed in Section 5.5.3.2, the project area overlies two pastoral stations. The natural environment is intersected by pastoral station land use. The landscape is ever changing throughout the year due to changing seasons and the presence of grassfires.

Most well sites associated with the Proposal are located off the Calwynyardah–Noonkanbah Road, thus the amenity and aesthetics along this access way has been considered in the baseline assessment.

Figure 5-40: Calwynyardah–Noonkanbah Road at the northern end of the project area

Figure 5-41: Pindan vegetation and trees along Calwynyardah–Noonkanbah Road at the northern end of the project area

Figure 5-42: Sand dunes and associated hill tops add to the landscape along the Calwynyardah–Noonkanbah Road

Figure 5-43: Cattle grids, fences, and pastoral tracks are present all along the Calwynyardah–Noonkanbah Road

Figure 5-44: Pastoral fence line track during the wet season leading off from the Calwynyardah–Noonkanbah Road

Figure 5-45: Pastoral fence line track during the dry season leading off from the Calwynyardah–Noonkanbah Road

Figure 5-46: Grassy pastoral track during the wet season

Figure 5-47: Grassy pastoral track during the dry season

Figure 5-48: Cattle roaming free along an existing petroleum access track off Calwynyardah–Noonkanbah Road

Figure 5-49: Areas cleared by cattle gathering around water sources, located away from Calwynyardah–Noonkanbah Road

Figure 5-50: Legacy pastoral station buildings with radio tower (can be seen from Calwynyardah–Noonkanbah Road ~700 m away)

Figure 5-51: Historical anthropogenic material is scattered throughout active pastoral land; includes petroleum infrastructure reclaimed by the stations

Figure 5-52: Dry grassy plains around the southern end of the project area

Figure 5-53: Dry grassy plains are particularly subject to fires in the dry season

5.5.3.4 Culturally significant flora species

As part of the flora and vegetation survey undertaken for the Proposal, an ethnobotanical analysis was also completed to identify and record the location of any culturally significant bush foods for Traditional Owners. Two flora species considered as significant bush foods for Traditional Owners were recorded within the proposed disturbance footprint and wider Development Envelope—Boabs (*Adansonia gregorii*) and Conkerberries (*Carissa lanceolata*) .

Boab trees (Traditional Owner name: jumuluny) were recorded as a dominant or associated species within five of the 14 vegetation communities described, at <5% cover. One particularly large Boab tree was found growing across a portion of the access track leading to the Midgard well site—BNR intends to deviate the access track around this tree so that it is not adversely impacted.

Boabs are a Kimberley icon, occurring throughout the Kimberley and into the Northern Territory. Typically, they are 10–15 m tall and 9–12 m wide (DBCA, 2021). The tree produces a hard pod containing a white, powdery fruit (pith), which contain 10–20 (or more) seeds. The pith is commonly crushed and mixed with water and bee honey (sugarbag) droplets and then eaten. The seeds can be dried and eaten like peanuts. The Boab also has other uses—in Traditional Owner cultures, the bark is used to make strong, thick twine; the trunk produces water; and the fruit is used for medicinal or artistic purposes (Low, 1991; Martin, 2014).

Conkerberry (Traditional Owner name: piriyalji) was recorded as a dominant or associated species within 10 of the 14 vegetation communities described, at <5% cover. While the Conkerberry is native mainly to the Northern Territory and central Australia, it is also found in the Kimberley region. In a hot, dry climate this species grows on a wide range of terrains and soil types. The Conkerberry is a multi-stemmed shrub, 1–3 m high. The small berries, also known as bush currants, are 1–2 cm long and appear in February to March; they turn dark purple or black when ripe. Traditional Owners frequently eat Conkerberries, as they have a sweet, refreshing taste. The Conkerberry has other traditional uses, including burning the wood to create smoke to treat colds and coughs, burning the orange roots to keep bad spirits away, or as an insect deterrent (Low, 1991; Martin, 2014).

Because Boabs and Conkerberries occur extensively throughout the area, and because ground-disturbing activities will avoid any significant Boabs, BNR does not believe that the Proposal's activities will result in a significant impact to culturally significant flora species. As such, potential impacts to significant flora species to Traditional Owners from the Proposal are not considered further.

5.5.3.5 Indigenous and non-indigenous cultural heritage

5.5.3.5.1 Native title

The project area 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).

Because 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 consults and engages with these stakeholders and will continue to do so throughout the development of the Proposal (Section 2.7). An ILUA and LAUA are in place respectively with the Yungngora (Yungngora Aboriginal Corporation RNTBC) and Warlangurru Peoples.

Under these agreements, the Yungngora 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.

5.5.3.5.2 Heritage sites

Several relevant heritage and due diligence surveys have been conducted within EP 371 that inform the baseline receiving environment described in this section. Table 5-36 lists previous and recent studies relevant to the Proposal, and the locations of recent heritage surveys for the Proposal are shown in Figure 5-54.

Table 5-36: Previous heritage surveys

Date	Survey name	Location	Heritage status
September and October 2021	Heritage survey for the Valhalla Gas Exploration and Appraisal Program	Blina and Noonkanbah stations	Cleared with conditions
May 2012	Heritage survey for Asgard 2D seismic survey	Blina and Noonkanbah stations	Cleared with conditions
May 2012	Heritage survey for Eden 2D, Asgard 2D, Valhalla 2D seismic, and Asgard 1 well site seismic survey	Blina, Liveringa, and Noonkanbah stations	Cleared
February 2012	Heritage survey for the Valhalla North A, Valhalla East 1 well sites	Noonkanbah Station	Cleared
October 2011	Heritage survey for the Valhalla North A, B, and C, Valhalla East well sites	Blina and Liveringa stations	Cleared
July 2009	Heritage survey for the Paradise 2D seismic survey	Blina and Liveringa stations	Cleared with conditions
August 2007	Heritage survey for the Paradise / Noonkanbah 2D seismic survey	Blina, Liveringa, and Noonkanbah stations	Cleared

A search of the WA Government's Aboriginal Heritage Inquiry System identified that two registered Aboriginal heritage sites are within the Development Envelope (Figure 5-54):

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

Two sites listed as other heritage places are also within the Development Envelope (DPLH, 2021a):

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

Various heritage surveys have been undertaken by previous oil and gas operators of EP 371 (Table 5-36), including surveys specifically for the Valhalla Gas Exploration and Appraisal Program (as shown in Figure 5-54). Although no Proposal wells are located within any known heritage sites, the proposed access track to the Alfheim well site crosses the No. 19 bore (other heritage place [not registered]). During heritage clearance surveys completed by BNR in 2021, it became clear that access for stock to existing dams and bores is of high concern and importance. As such, on request from the Traditional Owners, the access track was diverted around the existing dam (and outside of the area of importance [No. 19 bore]) so that no disturbance or unplanned impact (direct or indirect associated with traffic) would occur (Deep Woods Surveys, 2021). It should be noted that the heritage survey report has been provided on a confidential basis to the EPA and not attached to the ERD given cultural sensitivities and confidentiality associated with this piece of work.

In consultation with the Yungngora and Warlangurru Traditional Owners, a pre-disturbance ethnographic and archaeological heritage survey of the Proposal's disturbance footprint was undertaken in September and October 2021. Access tracks, camps and well sites were surveyed. No Aboriginal sites with an archaeological component were found in any parts of the proposed disturbance footprint (Deep Woods Surveys, 2021). Outcomes of the heritage surveys are further discussed in Section 5.5.5.6.

Disturbance of Aboriginal heritage sites is managed through Department of Planning, Lands and Heritage (DPLH) licencing in accordance with:

- s 16 authorisation to enter, excavate, examine or remove anything on an Aboriginal site.
- s 18 consent for impact on an Aboriginal site.

Although the Disturbance Footprint crosses the No. 19 heritage site – engagement with the Traditional Owners verified that no impacts to the site will occur (based upon realignment of the track). It should be noted that although BNR aligned the access track, the Disturbance Footprint still intersects the No. 19 heritage site due the geospatial buffer applied to the site. As such BNR will still be required to apply for s 16 approval (to enter the defined heritage site) even though Traditional Owners have validated that no impacts to the site will occur.

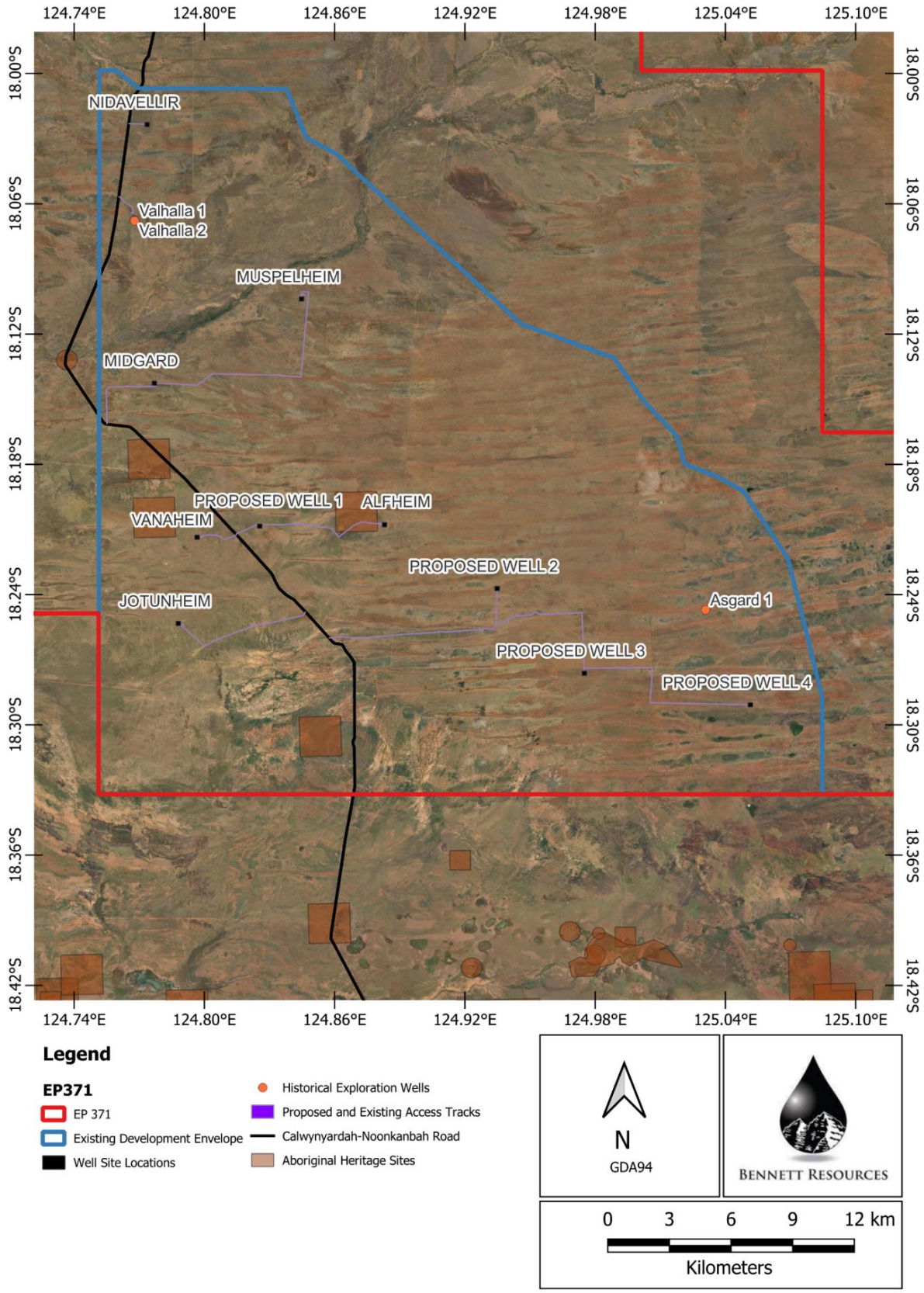


Figure 5-54: Location of heritage places with most recent heritage survey undertaken within the Proposal's disturbance footprint

5.5.3.6 Natural heritage

A search of the WA Government's InHerit database did not identify any registered natural heritage sites (statutory heritage listings) within or adjacent to the Development Envelope (Heritage Council, 2021). No sites listed on the National Heritage List occur within EP 371 (DAWE, 2021c). The nearest National Heritage List site is the West Kimberley (Listed Place – Heritage Place No. 18769), ~7.5 km south of the project area (Figure 5-55). 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 proposed activities from this listed heritage place, it is not considered further.

A search of the Australian Heritage Database (DAWE, 2021c) identified one site within the Development Envelope classed as a 'natural, indicative place' under the Register of the National Estate (non-statutory archive)—the Walgidee Hills Lamproite Site (Place ID: 101095). The Walgidee Hills Lamproite Site is on Noonkanbah Station, ~11 km south of the Alfheim well site. Although it does not have statutory heritage listing, it has been classified as a 'Landscape' by the National Trust since 1991 (Heritage Council, 2021).

5.5.3.6.1 Iconic natural heritage places

As part of the response to the recommendations and findings of the Report by the Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia (2018), the WA Government has undertaken an assessment and public consultation process to identify 'Places of Iconic Natural Heritage', using guiding identification principles (Government of Western Australia, 2019). After the public consultation period and consideration of submissions, the two proposed iconic natural heritage places—the Fitzroy River and the Camballin Floodplain—were extended to include additional parts of the Kimberley National Heritage Listed Area (Government of Western Australia, 2021d). Hydraulic fracturing will not be permitted where iconic natural heritage places intersect with existing petroleum titles.

The Proposal is not located within any of the iconic natural heritage places (Figure 5-55). The nearest iconic natural heritage place is the intersection of Mount Hardman Creek with the Calwynyardah–Noonkanbah Road, 4 km west of the proposed Midgard well site and outside the Development Envelope boundary. This iconic natural heritage place has the same coordinates as the registered Aboriginal heritage site Mt Hardman Creek (Mythological – site 14229).

5.5.3.6.2 World and Commonwealth heritage

No world heritage sites or Commonwealth heritage sites occur within EP 371 (DAWE, 2021c).

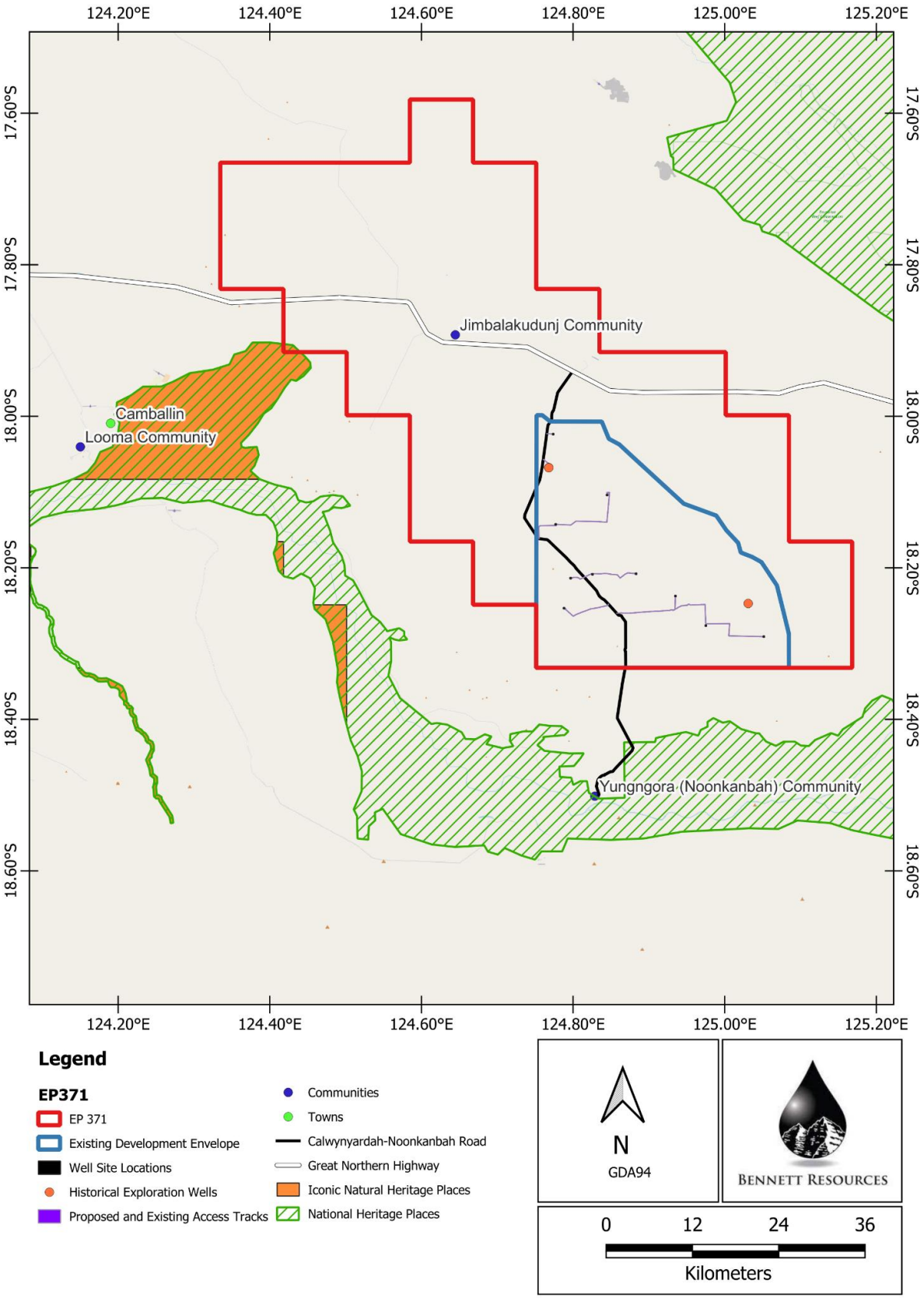


Figure 5-55: Natural and iconic natural heritage areas near EP 371

5.5.3.7 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). Vehicle and heavy machinery movements on unsealed surfaces, along with material stockpiles, contribute to the generation of dust and dispersal of particulate matter (PM).

Ambient air quality in the region is strongly influenced by season. During the winter dry season (June–August), southeasterly winds predominate. While dust storms blowing in from the Great Sandy Desert region may occur, these are rare. Between 1992 and 2010, the Dampierland bioregion had a mean dust storm index of 0.5 (McTainsh, O'Loingsigh, & Strong, 2011), which is considered very low compared with all other rangeland bioregions (Bastin & ACRIS Management Committee, 2008) (for comparison, the Great Sandy Desert bioregion's dust storm index is 1.7).

As part of the Air Quality Monitoring Program (Appendix E), baseline dust was monitored continuously for six months during the 2021 dry season (Appendix H). Five air quality monitoring stations were installed, including two near the two local Aboriginal communities. These recorded PM and depositional dust (comprising ash content, combustible matter, and total insoluble matter). A map showing the locations of the monitoring stations and baseline data are presented and further discussed in the Air Quality environmental factor in Section 5.6.3.1.

5.5.3.8 Noise

Given the remoteness of the region, baseline (background) noise within the Development Envelope and surrounds before commencing the Proposal is expected to be very low. The closest main road is Great Northern Highway, which is ~4.5 km north of the Development Envelope. Some smaller roads such as the gravel Calwynyardah–Noonkanbah Road and pastoral tracks are present within the wider region around the proposed well sites, but traffic is rare. Constant road traffic noise is not expected to be heard in such a region, which is distant and isolated from the main towns. No airstrips are near the proposed well site locations. Therefore, no aircraft noise is expected. Some occasional helicopter noise may be heard near the well sites during mustering activities.

Baseline noise was recorded continuously for one week in August 2021, then post-processed to generate 15-minute logging periods. Three field-calibrated noise loggers were installed near the air quality monitoring stations within and outside the Development Envelope. These noise loggers were positioned ~20–30 m away from the air quality stations to avoid recording the constant low-level noise generated by the stations' operating pump fans.

Table 5-37 summarises the outcomes of the baseline noise monitoring survey. A further breakdown of noise levels is presented in Appendix O. Results show that the baseline noise levels are consistent with remote locations not heavily influenced by human activity. Diurnal fluctuations in noise levels were influenced by bird song and insects that are active at dawn and evening / early night (Marshall Day Acoustics 2021 [Appendix O]). An extract of the time history plot for the noise logger placed ~5 km away from the Yungngora Community (logger 3) is presented in Figure 5-56. Brief periods of elevated noise levels (spikes in L_{Amax} levels) are likely due to vehicles passing or when birds or insects were near or on the microphone. This was confirmed through audio sampling on the loggers. As expected in remote locations, the average minimum background sound level was below L_{A90} 20 dB during night at all locations, with the lower night-time assigned noise level (average maximum noise level) around L_{A10} 35 dB.

Table 5-37: Day, evening, and night ambient noise levels within EP 371

Logger	Location (coordinates)	Comments
Logger 1	−17.898625 124.669033	Equipment: 01dB Cube® Wind shield Positioned on an infrequently used pastoral access track (~670 m from Great Northern Highway)
Logger 2	−18.262381 124.862839	Equipment: 01dB Cube® Wind shield Positioned near the Calwynyardah–Noonkanbah Road (~85 m away)
Logger 3	−18.463469	Equipment: 01dB DUO®

Logger	Location (coordinates)	Comments
	124.857686	Wind shield Positioned near the Calwynyardah–Noonkanbah Road (~115 m away), ~5 km north of the Yungngora Community

Day (07:00–19:00)	L_{A90} (dB)	L_{A10} (dB)	L_{Amax} (dB)
Logger 1	34	42	56
Logger 2	43	52	44
Logger 3	32	44	55
Evening (19:00–22:00)			
Logger 1	31	42	50
Logger 2	46	51	57
Logger 3	43	48	52
Night (22:00–07:00)			
Logger 1	25	36	63
Logger 2	34	39	51
Logger 3	26	28	43

L_{A10} – The noise level exceeded for 10% of the sample period. This is commonly referred to as the average maximum noise level.

L_{A90} – 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.

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

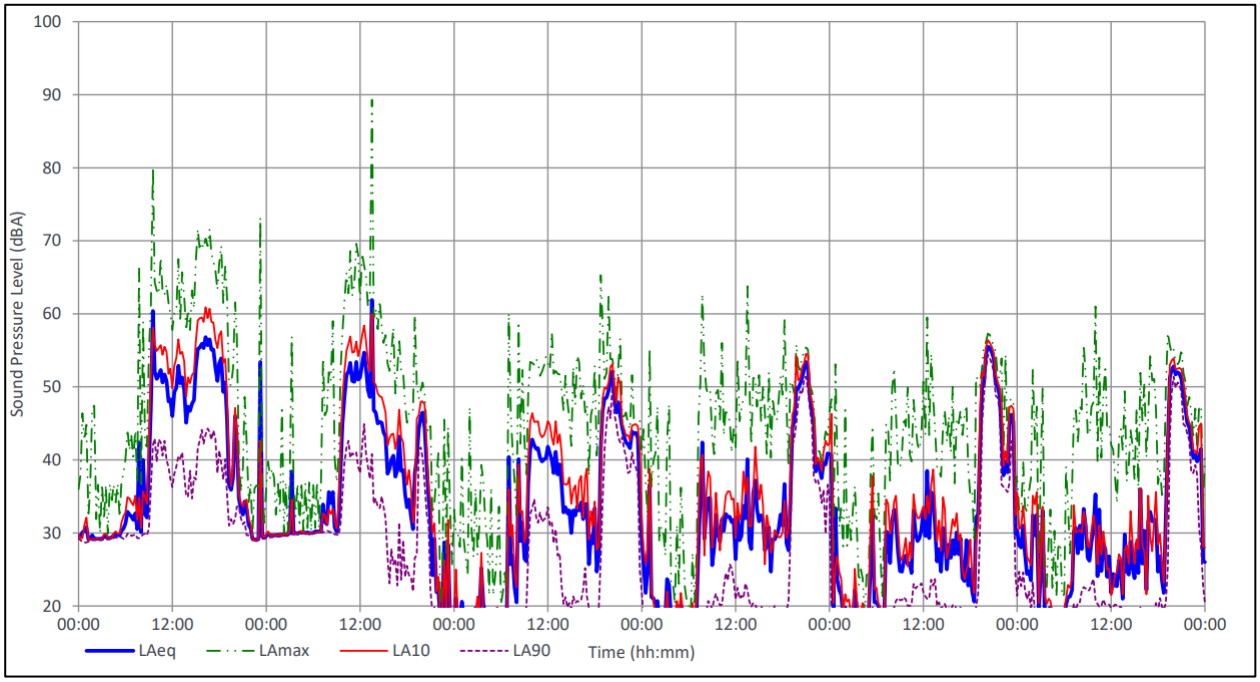


Figure 5-56: Noise logger 3 – time history plot of noise levels recorded between 17 – 22 August 2021 (Figure 3 in Marshall Day Acoustics 2021 [Appendix O])

5.5.3.9 Traffic

Main Roads (2020) records the average number of vehicles and heavy vehicles travelling at and between WA locations. Statistics about traffic volumes and percentage of heavy vehicles using key roads in the Kimberley region are available for the most recent six years.

The Development Envelope is ~4.5 km south of the closest main sealed road—Great Northern Highway. It is expected that equipment and machinery would be mobilised along the Great Northern Highway and then onto the rural track that is the main access road to the well sites. The ~72.5 km long Calwynyardah–Noonkanbah Road runs between Great Northern Highway and the Yungngora Community. This public unsealed access road is listed in the SDWK's road assessment and maintenance management database and is well maintained by the shire (SDWK, 2020) and Yungngora Association Incorporated (YAI) (the leaseholder of Noonkanbah Station), who use local contractors to grade the road one to two times a year. Although classed as a public road, the Calwynyardah–Noonkanbah Road is restricted to those accessing the Yungngora Community, pastoral station workers and those associated with industry assets or tenements on the land. Traffic volumes on this road are known to be low. Local publicly available traffic data from the SDWK show that the annual average daily traffic is between 20 and 100 vehicles (SDWK, 2020).

Baseline traffic was monitored continuously over five weeks in July–August 2021 (Appendix Q). The traffic monitoring equipment (one traffic logger with a pair of tubes) was installed along the Calwynyardah–Noonkanbah Road within the Development Envelope and recorded the classes (Austroads vehicle classification system), speed, and number of vehicles travelling. The results of this baseline survey were shared with the SDWK with the aim of updating local traffic records.

BNR divided the data into two vehicle classifications—Light (Class 1–2) and Heavy (Class 3–12). Light vehicles include sedans, wagons, 4WDs, and motorcycles. Heavy vehicles comprise two-axle trucks, buses, triple road trains, and heavy trucks with 3 trailers.

Over the five-week monitoring period, daily average usage ranged from ~20 vehicles (on Tuesdays) to ~49 vehicles on Thursdays (Figure 5-57). Most road users were predominantly light vehicles, with heavy vehicles comprising ~6% of the total vehicle use (per day). Because the road is used predominantly for commnuity access and pastoral activities, the traffic volumes and breakdown are consistent with pre-monitoring expectations.

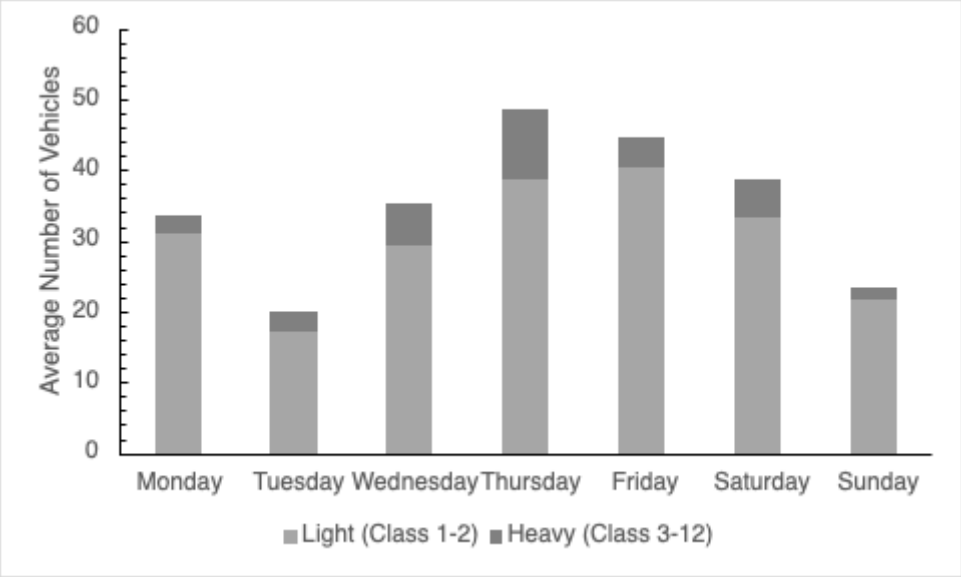


Figure 5-57: Average daily vehicle usage numbers for the Calwynyardah–Noonkanbah Road

To better understand potential traffic impacts at a regional level, Table 5-38 lists publicly available regional statistics for Great Northern Highway. Note: Great Northern Highway, east of Derby Highway, provides the most accurate traffic information for access into EP 371. Statistics recorded by Main Roads (2021) showed a record increase of traffic travelling in the West Kimberley (due to influx of Australian tourism), as seen as the significance increase in the average number of vehicles per day in Table 5-38.

Table 5-38: Road-use statistics for the Great Northern Highway in the Kimberley (Main Roads, 2020; Main Roads, 2021)

Location along the Great Northern Highway	Continuous monitoring	Average number of vehicles at each location for a typical day *(% of heavy vehicles)*							
		2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020	2020–2021	2021–2022
South of Broome Road	Yes	340 *(31.1)*	440 *(29.4)*	-	-	490 *(27.2)*	430 *(29.9)*	440 *(26.6)*	740 *(23.3)*
East of Derby Highway	Yes	-	-	-	-	470 *(32.8)*	-	-	-
West of Derby Highway	Yes	540 *(20.6)*	570 *(18.7)*	570 *(18.1)*	590 *(19.5)*	570 *(20.2)*	570 *(20.6)*	580 *(18.9)*	870 *(20.1)*
East of Derby Highway		-	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)*	360 *(39.3)*	-
East of Halls Creek	Yes	-	-	-	-	430 *(24.7)*	340 *(24.1)*	340 *(24.1)*	480 *(22.2)*
South of Victoria Highway	Yes	340 *(30.7)*	350 *(23.6)*	330 *(21.3)*	330 *(23.0)*	340 *(24.6)*	360 *(30.4)*	360 *(39.4)*	530 *(31.5)*

5.5.4 Potential impacts

5.5.4.1 Direct impacts

No sensitive receptors were identified for the Proposal; therefore, 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
- disruption to existing land users
- social and economic benefits
- impacts to workers' health.

5.5.4.2 Indirect impacts

Unplanned events may lead to indirect impacts including:

- potential impacts to heritage sites
- amenity and aesthetics
- local social impact arising from mental health and wellbeing, due to impacts from changes to the physical or biological environment.

5.5.5 Assessment of impacts

5.5.5.1 Increased dust emissions

5.5.5.1.1 Impacts to ecosystem health

Dust emissions generated by the Proposal's activities have the potential to extend outside the disturbance footprint, potentially impacting local vegetation. Dust impacts on vegetation are discussed for the flora and

vegetation environmental factor in Section 5.1.5.4 and noted in the air quality environmental factor in Section 5.6.5.2, and thus are not repeated here.

5.5.5.1.2 Impacts to public health

Dust emissions resulting from the Proposal can affect human health and decrease amenity in surrounding areas (dust reduces visibility and settles on surfaces, causing soiling and staining) (DEC, 2011). Typically, during early stages of site preparation and construction, dust is generated from vegetation clearing and activities on unsealed surfaces. Dust can be present as a $PM_{2.5}$ (fine particulate matter with a diameter of 2.5 micrometres or less) or PM_{10} pollutant (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, chemical composition, and concentration (DEC, 2011). The total suspended solid fraction of dust is typically responsible for nuisance or loss of amenity, whereas the smaller PM_{10} and $PM_{2.5}$ fractions are more commonly associated with the potential for health impacts because they have the ability to penetrate lungs (DEC, 2011).

A dust risk assessment and site classification for well site activities covered under the Proposal was completed in accordance with the DEC (2011), and is summarised in Table 5-39.

Table 5-39: Dust risk assessment for a proposed well site based upon DEC (2011)

Item	Score options				Allocated score for the Proposal
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	<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	>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 or sensitive land uses highly affected by prevailing winds (12)	1
				TOTAL score for Part B	**2**
				SITE CLASSIFICATION SCORE (A x B)	**58**

Based on the assessment criteria, the Proposal is considered to be classified under Site Classification 1; i.e. considered a negligible risk with no specific provisions or contingency arrangements required (DEC, 2011). This is consistent with the remote nature of the proposed project and the proximity to receptors. Consequently, the Proposal is not expected to cause a significant environmental and health impact associated with dust generation. This is consistent with the Human Risk (Scoping) assessment provided in Appendix N. Further detail on impacts to public health and receptors are discussed in the air quality environmental factor in Section 5.6.5.1.

5.5.5.2 Increased noise and vibrations

Noise monitoring studies have indicated that, for an average well construction site, noise emissions are ~65 dB(A) at 150 m from the location of any drilling Radtke, Autenrieth, Lipsey, & Brazi, 2017).

The previous operator of EP 371 conducted a noise monitoring program during HFS activities. Noise loggers were installed ~1 m from the noise source and ~800 m from the well site where HFS was being undertaken. Monitoring was done over two days during start-up, warm-up and shutdown of equipment and engines. Noise loggers located ~1 m from the source recorded noise levels from 89–106 dB(A) during engine warm-up / idling and 95–108 dB(A) during pumping (Buru Energy, 2014). Noise levels recorded during this monitoring program identified that HFS activities typically produce noise levels <65 dB(A) 800 m away from the source.

To further understand the extent of potential impact associated with the Proposal, BNR completed a baseline noise monitoring program (Section 5.5.3.8), and used this information to complete a quantitative model, as required by ESD Item 46. Modelling results (Appendix P) predict that for a noise of ~110 dB (e.g. originating from operating HFS pumps), noise levels are expected to reach below the maximum allowable external noise level (35 dB L_{A10}) at ~2,500 m away from the noise source, as shown in the noise contour plot in Figure 5-58. The closest sound sensitive receptor is >18 km from the project area. Modelling was based on known and assumed noise levels from equipment proposed to be used during the Proposal. An overall, worst-case operating scenario was developed—all equipment operating at the same time at each proposed well site. Note: Activities are likely to be only conducted at one well site at a time. Calculated noise levels associated with this worst-case operating scenario were <10 dB(A) at both the Jimbalakudunj and Yungngora Communties.

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 nearby that can be exposed to the Proposal's increased noise levels, noise emissions from the Proposal are not expected to result in a significant impact to social surroundings.

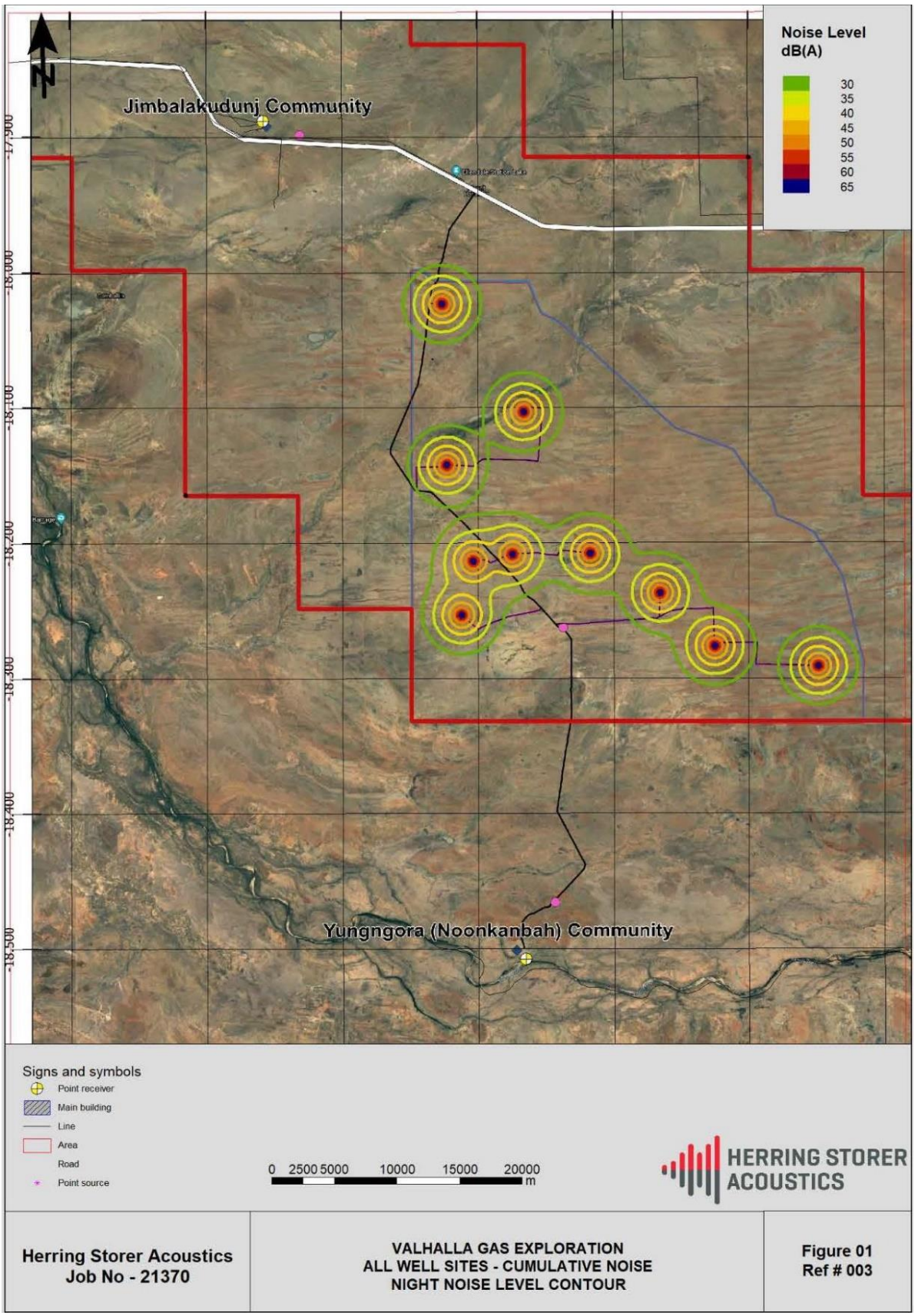


Figure 5-58: Worst-case noise level contour plot (Appendix P)

5.5.5.3 Disruption to existing land users

The Proposal is located on the Blina and Noonkanbah stations, which are on the Warlangurru and Noonkanbah native title areas, respectively. As further detailed in Sections 2.7, 3.2, and 5.5.3.2, these are active pastoral stations that have free-roaming cattle. Yungngora people from the Yungngora Community are employed by Noonkanbah Station and regularly travel on the station to verify cattle presence, check feedstock, fence lines, groundwater pastoral bores and associated watering troughs. Blina Station workers occasionally travel to the southern border of Blina Station, which intersects the northern section of the Development Envelope, to verify their cattle and check station equipment.

Blina and Noonkanbah stations have total areas of 254,600 ha and 172,400 ha, respectively. The clearing footprint of this Proposal is limited to 110 ha, thus the potential direct impact is limited to <0.026% of the total pastoral stations' area, and is considered negligible to existing pastoral activities. Further, the Proposal will not significantly disturb cattle (who already gather around current petroleum activities in the permit), and the additional access tracks created for the Proposal's activities will likely be used by pastoralists for their activities. Therefore, the Proposal is not expected to result in a significant disruption to pastoral activities.

In addition to pastoral activities, the Traditional Owners of the land and members of the Yungngora Community and Jimbalakudunj Community use the land within and surrounding the Development Envelope for cultural and recreational reasons, such as education, hunting, gathering, fishing and swimming. Over the past 10 years, BNR and the previous operator have proved that oil and gas activities can exist with cultural activities. BNR has a strong relationship with the Traditional Owners, who actively support BNR to complete routine inspections of existing BNR infrastructure and assets. The Traditional Owners are made aware of all BNR presence and activities on site, and discussions are ongoing regarding the participation and employment of community members in the Proposal's activities. The community supports current and future work opportunities on EP 371.

5.5.5.4 Increased traffic movement

Although the remoteness of the areas may present logistical challenges, it does mean that impacts to amenity are mitigated by 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 and the surrounding area is used for pastoral activities. Additionally, vehicle movements on the roads in the region are infrequent (Appendix Q), even on Great Northern Highway, the nearest major road (Table 5-38).

To understand the potential impacts associated with traffic for the Proposal, Table 5-40 summarises the traffic movements expected to be required for each activity covered in the Proposal.

Based on the expectation that the average number of moves per day related to the Proposal could be as high as 20 loads (during the HFS stage), the increase to regional road traffic along Great Northern Highway is calculated to be <6% of the total number of vehicles that would be expected to be encountered on an average day. This is based on traffic data collected east of Fitzroy Crossing (Table 5-38). Consequently, the increased traffic on major transport routes is not expected to result in significant impacts to regionally important roads.

Locally, monitoring completed by BNR in July and August 2021 identified that the average daily traffic movements along the Calwynyardah–Noonkanbah Road is ~35 vehicles, which is consistent with data from the shire that indicates the annual average daily traffic along the Calwynyardah–Noonkanbah Road is 20–100 vehicles (SDWK, 2020).

Using the highest average number of moves per day, BNR has estimated that the Proposal could result in a 60 per cent increase to road traffic along the Calwynyardah–Noonkanbah Road. As mobilisation periods are expected to be minimal (~2 weeks), any increased traffic attributable to the Proposal is not likely to significantly impact local road users as the road is of suitable quality to allow two directions of travel.

As mentioned in Section 5.5.3.9, the Calwynyardah–Noonkanbah Road is a public unsealed road maintained partly by SDWK (northern section) and partly by YAI (down to the Yungngora Community). Currently, grading of the road occurs after the wet season and maintenance of the road is organised where and when necessary throughout the dry season. The road has relatively low traffic volumes, and the traffic volumes resulting from the Proposal are not expected to have a significant influence on the safety of other road users. No specific upgrades to the Calwynyardah–Noonkanbah Road are required for the activities. However, BNR will liaise directly with SDWK and YAI regarding the frequency of road maintenance.

Access (dirt) tracks leading off from the Calwynyardah–Noonkanbah Road are only occasionally used by the Traditional Owners and pastoral stations (perhaps a couple of times a week for certain tracks), and less regularly by BNR (up to a couple of times a month). Vehicle movements associated with the Proposal are unlikely to result in impacts to traffic on local dirt tracks within the Development Envelope given that these (with the exception of one currently existing access track) are planned to be constructed specifically for the Proposal and only to access the proposed well sites.

Table 5-40: Indicative traffic requirements per well for the Proposal

Activity	Vehicle	Number	Mobilisation period (days)	Average number of moves per day
Site preparation	Flatbed truck (heavy machinery)	6	2	3
	Dump trucks (materials for hardstand construction)	40	14	~3
Drilling	Flatbed trucks (for drilling rig, mobile camp, bulk material, and related equipment)	50	7	7
	Service vehicles (heavy vehicles)	50	40	~2
HFS	HFS equipment, mobile camp etc.	40	4	10
	Triple road train – proppant sand	130	30	10
	Service vehicles (heavy vehicles)	50	25	~3
Site reinstatement	Flatbed truck (heavy machinery)	6	2	3

5.5.5.5 Social and economic benefits

During the HFS Scientific Inquiry (Independent Scientific Panel Inquiry, 2018), the Yungngora and Warlangurru people voiced their support for HFS activities on their native title areas located within EP 371. Table 5-41 lists the links to specific letters of support from these stakeholders.

Table 5-41: 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 YAI)	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/ewart_neil_52_redacted.pdf
Germaine Muller (Chairperson YAI)	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/muller_germaine_142.pdf
Warlangurru People	
Michael Costaine	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
Anthony Mulligan	https://frackinginquiry.wa.gov.au/sites/default/files/webform/submissions/mulligan_anthony_308.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

Stakeholder	Link to letters of support
Audrey Mulligan (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. BNR has continued to provide information through independent specialist subject matter experts, during multiple engagements with the Community in 2021, 2022 and 2023.

The outcomes of the independent specialist review are included with the Yungngora Aboriginal Corporation's submission to the HFS Scientific Inquiry (Independent Scientific Panel Inquiry, 2018) (see Table 5-41). The community 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 the 2015 HFS program, 33 workers from the community worked more than 14,000 hours on the program, in these areas:

- security and access control – Yungngora 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 areas of activity
- HFS spread – Yungngora Community 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 – Yungngora Community members were responsible for maintaining the access tracks and well sites during the program. This included watering to supress dust
- camp services – Yungngora Community members worked in the temporary camp during the program.

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

Approximately 400 people (median age 22) live in Yungngora Community (ABS, 2016). Of the ~240 people who are of working age, >80 per cent are either unemployed or are supported through the Commonwealth-funded Community Development Program. The Proposal will provide an important source of employment and socioeconomic opportunities to the Yungngora Community, as well as SDWK and the West Kimberley region generally.

BNR has an ILUA and LAUA in place with the Yungngora and Warlangurru people, respectively (Section 5.5.3.5.1). These agreements include a focus on employment and training opportunities and programs, particularly for young people. BNR will continue to work closely with the Yungngora and Warlangurru people to maximise the opportunities the Proposal brings to their communities.

5.5.5.6 Impacts to workers' health

As per ESD Item 54:

Determine impacts to human health in relation to worker accommodation (particularly dust, water supply, wastewater disposal etc.) by using the Department of Health scoping tool

BNR engaged with the EPA to understand the extent to which the EP Act provides for the assessment and protection of worker health. EPA Services confirmed that worker health is not covered under the Act (Table 3-1).

BNR can confirm that worker health is to be assessed and regulated under the new *Work Health and Safety Act 2020* (WA), which will replace the *Occupational Safety and Health Act 1984* (WA) and elements of the PGER Act that relate to work health and safety. The PGER (Occupational Safety and Health) Regulations 2010 and the PGER (Management of Safety) Regulations 2010 currently regulate petroleum safety matters (e.g. through the approval of BNR's Safety Management System for its petroleum activities). Impacts to worker accommodation will be managed through different approvals, such as those listed, but not limited to, in Table 1-3 in Section 1.4.

Although the EPA assesses human (public) health through the Part IV human health environmental factor consideration, the EPA does not assess human worker health. As such, BNR has not conducted a detailed assessment of impacts to worker health as this will be managed under the *Work Health and Safety Act 2020* (WA).

5.5.5.7 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 near the project area. No wells are located within any known heritage sites.

A heritage archaeological and ethnographical survey was conducted with native title representatives in September and October 2021 to identify if any heritage sites or material are present within the proposed disturbance footprint. After completing the survey and evaluating its outcomes, BNR reviewed the currently proposed well site, access track, and camp locations to ensure that, in line with the heritage survey results and advice, no damage to identified heritage sites or Traditional Owner heritage values would occur from the Proposal. It was determined that the proposed access track to the Alfheim well site should be deviated around the Aboriginal site No. 19 bore and a cattle yard. As detailed during the engagement with Traditional Owners during the heritage clearance survey, vehicle movement (along with associated dust, noise and air emissions) were of most concern given the potential to scare cattle away and prevent them from drinking at this location. As such, on request from the Traditional Owners, the access track was diverted around the existing dam (and outside of the area of importance [No. 19 bore]) so that no disturbance or unplanned impact (direct or indirect associated with traffic) would occur (Deep Woods Surveys, 2021). It should be noted that the heritage survey report has not been attached to the ERD given cultural sensitivities and confidentiality associated with this piece of work.

This deviation to the track has been reflected in all maps presented in the ERD and in the shapefiles provided to the EPA in the Index of Biodiversity Surveys for Assessments package.

Additionally, new locations for the proposed Muspelheim camp and for the proposed Muspelheim well site were also surveyed to relocate these areas further away from Mount Hardman Creek. These deviations and the new proposed locations were also surveyed for the presence of Traditional Owner archaeological sites—none were identified.

Apart from the diversions for the track, camp, and well site mentioned above, all other proposed disturbance footprint areas do not contain any significant cultural material, places, or sites, and BNR has the permission of the Yungngora Aboriginal Corporation and Warlangurru Aboriginal Corporation to proceed with the Proposal (Deep Woods Surveys, 2021). No heritage management plan was deemed necessary following the outcomes of the 2021 ethnographic and archaeological heritage survey.

Following close communication and engagement with the Noonkanbah and Warlangurru Traditional Owners, and following the survey's outcomes, no damage to the sites identified during the survey is expected to occur during the Proposal's activities. The proposed well site locations are deemed finalised, and the Noonkanbah and Warlangurru Traditional Owners will be invited to the well sites to monitor ground-disturbing activities when the Proposal commences. Participation of Traditional Owners and community members (Section 5.5.5.5) will be encouraged and supported.

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

Investigations were also conducted to understand the wider social surroundings of Traditional Owners' land, including personal sense of place. The Yungngora Aboriginal Corporation and Warlangurru Aboriginal Corporation representatives felt that the proposed tracks, camps and well sites were located well away from the Yungngora Community and the Calwynyardah–Noonkanbah Road connecting the Yungngora Community to Great Northern Highway. Apart from additional vehicles and dust in remote places, it was felt by the Yungngora Aboriginal Corporation and Warlangurru Aboriginal Corporation representatives that the impacts on their aesthetic, cultural, economic and social surroundings would be minimal.

5.5.5.8 Amenity and aesthetics

The potential impacts to amenity and aesthetics directly correlate with the ability to view the Proposal's activities from the public Calwynyardah–Noonkanbah Road that crosses the permit EP 371 in a north–south direction, from Great Northern Highway to the Yungngora Community. Given the landform profiles from the public road and the vegetation types in these areas (Section 5.5.3.3), the extent to which the activities are expected to be visible is limited. Specifically, BNR believes that visual amenity impacts will be limited to a few months during the drilling activity. Once the well is drilled, activities should only be visible from the access tracks leading off from the Calwynyardah–Noonkanbah Road.

EP 371 is flat in areas, yet is characterised by undulating plains, with some mature stable dunes of moderate height and limited sand exposure. Along with the Pindan vegetation present throughout area, the landscape should limit any visual amenity impacts from the public road and pastoral tracks.

The three closest proposed well sites are at least 800 m from the Calwynyardah–Noonkanbah Road (Figure 5-59, Figure 5-60, and Figure 5-61), with most other well sites well away from the road. The drilling rig mast is expected to be around <25 m high, so it may be seen from the road or any nearby pastoral tracks for short periods of time only, and only temporarily because of the temporary duration of the drilling activity on each well site. If using a flare pit on site, no other Proposal infrastructure is expected to be seen. Based upon availability of equipment at the time of undertaking the project, a flare stack may be used. Should a flare stack be used on site, the stack and the flare itself may be seen from the road or nearby pastoral tracks. The vegetation in direct line of sight to the proposed well sites is shown in Figure 5-59, Figure 5-60, and Figure 5-61.

The visual impact of the proposed access tracks to the well sites on amenity and aesthetics are expected to be no different to the other existing pastoral and petroleum access tracks that lead off from the Calwynyardah–Noonkanbah Road. With only occasional traffic on that road (~35 vehicles per day), the remote location of any nearby receptors (at least 20 km from the nearest well site), the short duration of the Proposal activities and the nature of the landscape, impacts to amenity (if any) are expected to be limited with no long-term impacts expected. Because road usage is limited to travelling community members, pastoralists and other occasional workers from the region, and as no tourism is currently present along this area nor within the project area, tourism activities should not be affected.

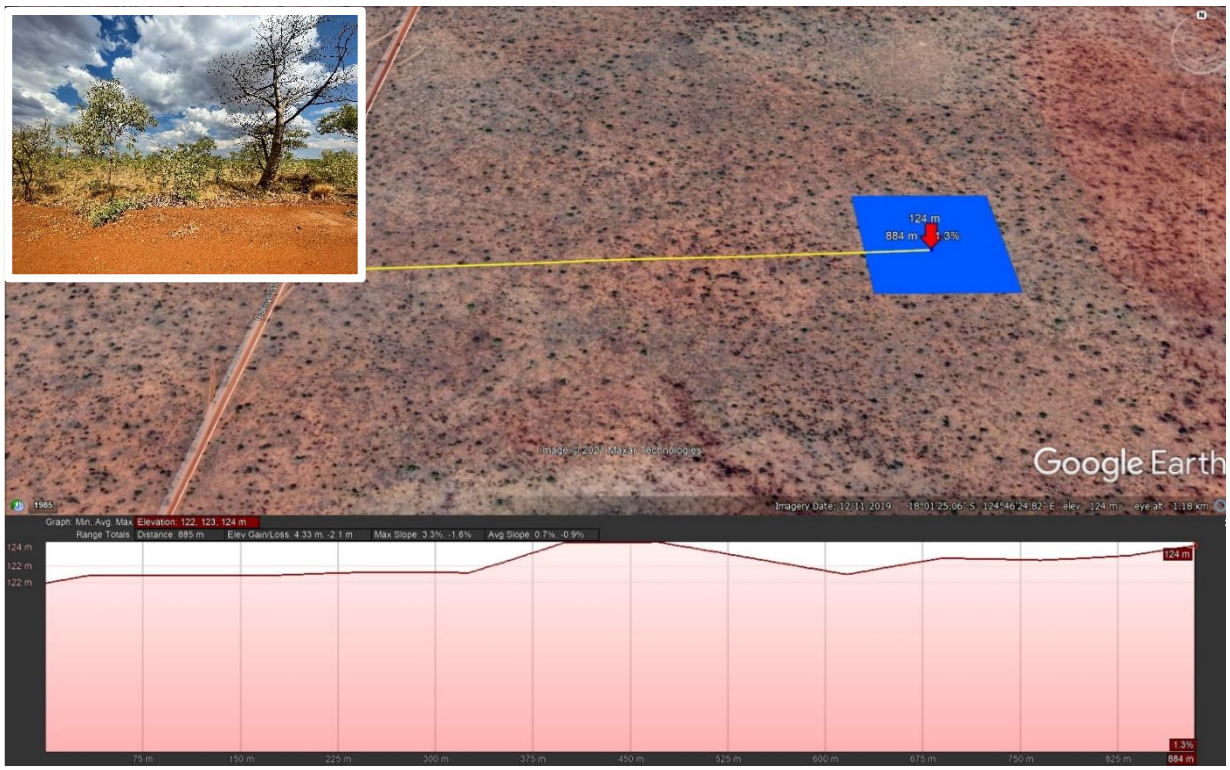


Figure 5-59: Profile – Nidavellir well site. Vegetation type – Pindan with low trees, Acacia thicket, spinifex

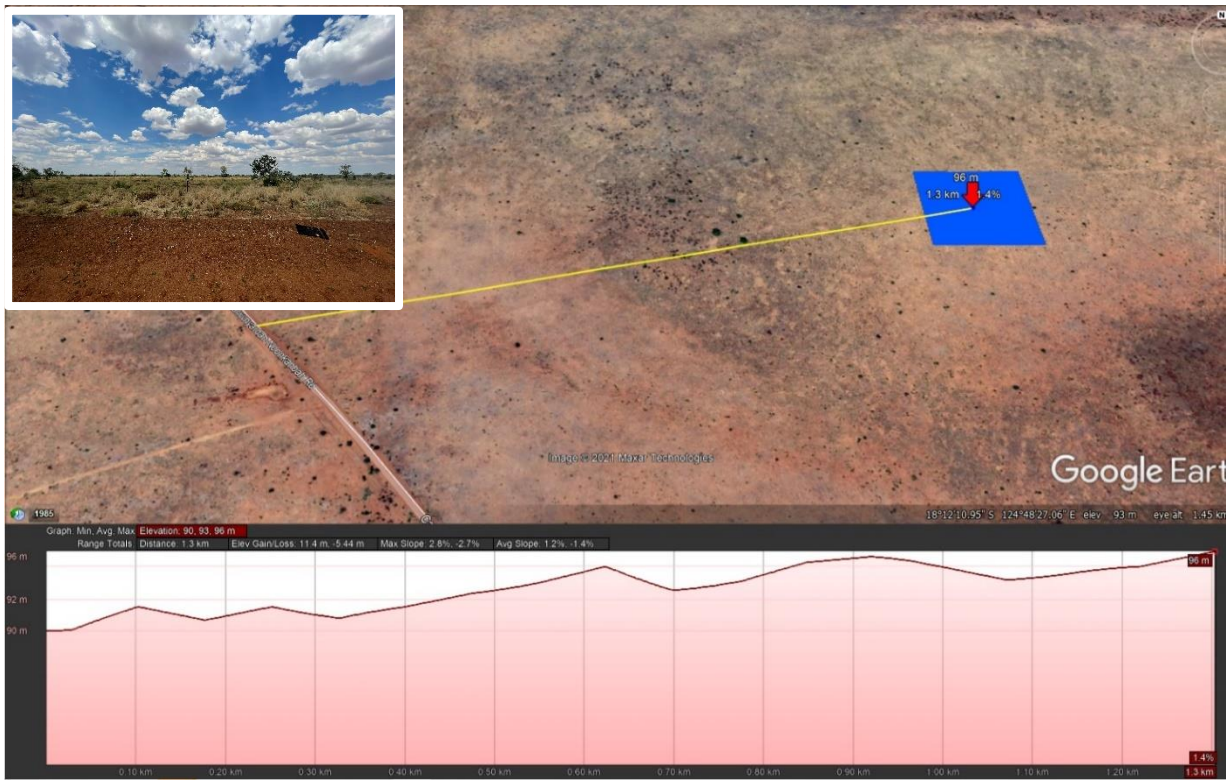


Figure 5-60: Profile – Proposed Well Site 1. Vegetation type – Pindan with low trees, Acacia thicket, spinifex

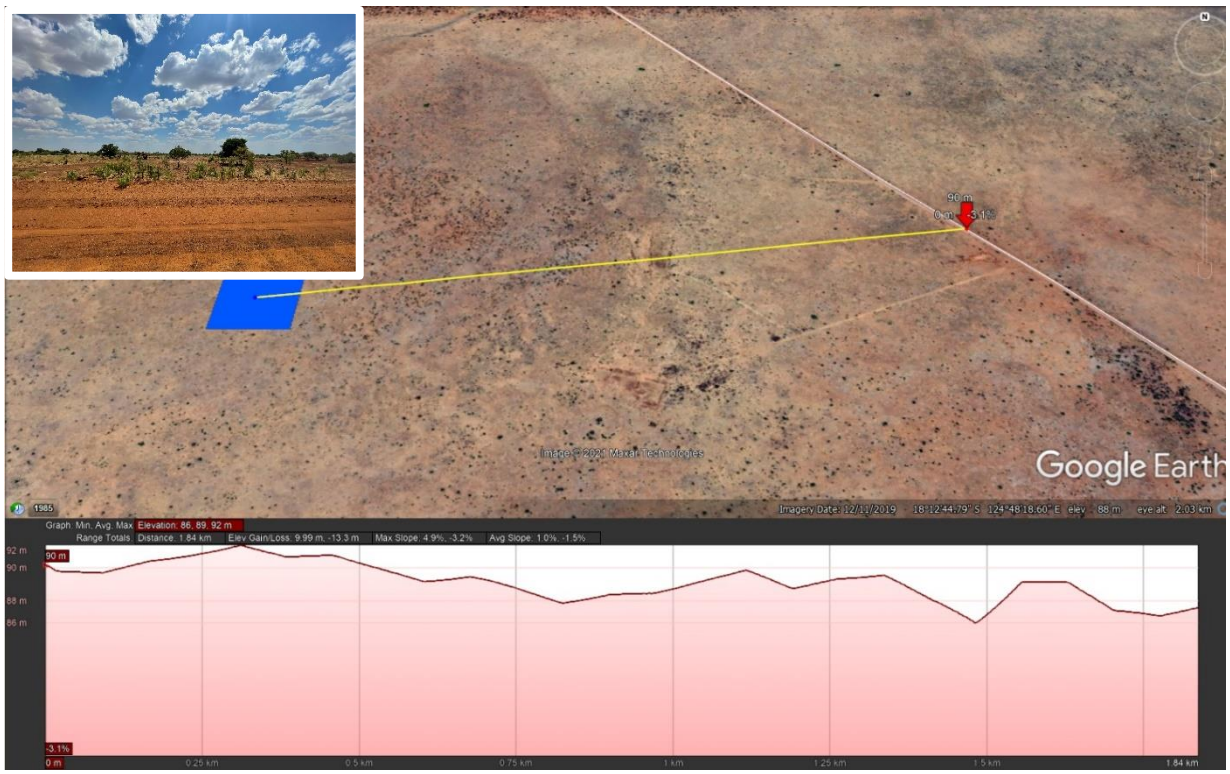


Figure 5-61: Profile – Vanaheim well site. Vegetation type – Pindan with low trees, Acacia thicket, spinifex

5.5.5.9 Local social impact arising from mental health and wellbeing

To understand the requirement from ESD Item 53, BNR reviewed the EP Act to understand how to best complete this assessment. Under the EP Act, a link to social impacts and mental health is made through emissions, specifically unreasonable emissions. An unreasonable emission is:

> *An emission or transmission of noise, odour or electromagnetic radiation which unreasonably interferes with the health, welfare, convenience, comfort or amenity of any person. (Part V, section 49)*

As the Proposal is related to an exploration activity that is short in duration, any emissions associated with the Proposal should be temporary. Specific assessments were undertaken for noise (Section 5.5.5.2), dust (Section 5.5.5.1), air emissions (Section 5.6.5.1), amenity and aesthetics (Section 5.5.5.8), and GHG emissions (Section 5.7.5). As a result of these assessments, BNR does not expect there will be any exposure from unreasonable emissions to local community members (the closest inhabited community is at least ~20 km from the proposed well sites). On this basis, exposure to any emission and credible mental health and wellbeing impacts are not expected.

5.5.6 Mitigation

Table 5-42 summarises the mitigation measures and their hierarchy relevant for the Proposal. It should be noted in particular that measures are in place to ensure there is no impact to Aboriginal heritage, as provided for under the *Aboriginal Heritage Act 1972*. As stated elsewhere, the Traditional Owners support the proposal and have engaged with BNR to identify sites of potential cultural significance. BNR has already revised the proposed disturbance footprint in response to requests from the TOs and, as shown below, TOs will be involved as heritage monitors in pre-construction surveys to ensure there will be no impact to any site of cultural significance.

An outcome of the Stakeholder engagement with TOs was acknowedgement of continued involvement once the project commences. Statements have been received from the TOs stating that “once the project commences, we will be involved with pre-construction surveys and will monitor all the ground-disturbing

activities to ensure there will be no impact to any cultural heritage sites or areas that we deem to be important for us." These statements have been provided in confidence to the EPA.

Table 5-42: Proposed mitigation measures – social surroundings

Mitigation hierarchy	Mitigation measure	Further information
Avoid	Demarcation of clearing area	Demarcation of the proposed clearing area by a surveyor reduces—to the smallest possible extent—the chance of unplanned clearing and potential damage to heritage sites outside the proposed footprint. Note, a pre-construction survey is planned to be undertaken to ensure no adverse impact to any priority flora or fauna.
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. This includes any complaints provided by the public regarding impacts to amenity and aesthetics.
Minimise	Visual amenity assessment during site activities	BNR will conduct an amenity and aesthetics assessment during site activities. This will comprise a visual assessment of the activity within the landscape to confirm that visual impacts, noise emissions and any other emissions do not reduce amenity at key points along the Calwynyardah–Noonkanbah Road.
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 Traditional Owner 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	Traditional Owners will be invited to partake in the Proposal as heritage monitors during ground-disturbing activities. Heritage monitors will be onsite during disturbance of the topsoil to ensure that activities cease if heritage material is uncovered, and discovery of the material is immediately reported to the Noonkanbah and Warlangurru Traditional Owners to verify if it is a heritage artefact subject to protection under the *Aboriginal Heritage Act 1972* (WA).
Minimise	Inductions and cultural orientations	BNR has a comprehensive induction process that considers environmental impacts and risks. As required by ESD Item 61, BNR will provide cultural awareness and orientation to staff involved in ground-disturbance activities. BNR will conduct these in accordance with the Yungngora ILUA that specifically requires induction material to be developed in consultation with the Traditional Owners. Under the agreement, Yungngora has the right to select community members to deliver the induction package in accordance with the terms of the agreement.
Avoid	Road maintenance	No specific upgrades to the Calwynyardah–Noonkanbah Road are required for the activities. However, for the safety of other road users, BNR will monitor the condition of the gravel road throughout the Proposal's activities. BNR will liaise directly with SDWK and YAI regarding the frequency of road maintenance.
Minimise	Vehicle maintenance	To reduce emissions from traffic, BNR will monitor vehicles and maintain these, as required, throughout the Proposal.
Minimise	Decommissioning	After completing the Proposal activities, and as required under the PGER Act, BNR will submit and implement a decommissioning EP.
Rehabilitate	Progressive rehabilitation	In accordance with the PGER(E)R requirements, 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 will be respread, and rehabilitation sites actively monitored to ensure they meet required completion criteria. Completion criteria will be documented in the EP.

5.5.7 Environmental outcomes

The outcomes of the Proposal are predicted to be:

- no impacts to the nearest receptors
- no impacts to heritage sites or artefacts
- no significant disruption to existing land users
- direct and indirect economic benefits to the local communities of the SDWK.

Based upon the predicted outcomes for the Proposal as shown in the information shown above, BNR does 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 believes that the EPA's objective to:

'protect social surroundings from significant harm'

can be met.

BNR has considered the WA Environmental Offsets Policy and does not believe actions to offset the predicted outcomes of the Proposal are required because the Proposal is not expected to have a significant impact on social surroundings.

5.6 Air quality

5.6.1 EPA objective

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

5.6.2 Legislation, policy, and guidance

- Environmental Factor Guideline: Air Quality (EPA, 2020)
- *Environmental Protection Act 1986* (WA)
- National Environment Protection (Ambient Air Quality) Measure (NEPC, 2016)
- National Environment Protection (Air Toxics) Measure (NEPC, 2004)

5.6.2.1 Application of the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing, and procedure of the environmental review, required by Section 40(3) of the EP Act. Table 5-43 lists the ESD requirements specific to air quality.

Table 5-43: ESD checklist – air quality

Air quality		
Required work		**BNR response**
71	Undertake and provide baseline air quality monitoring for volatile organic compounds and dust for a minimum of 12 months prior to commencing the Proposal.	Section 5.6.3 Appendix H Appendix H
72	Provide a site-specific air quality risk assessment.	Section 5.6.5
73	Describe the proposed management, monitoring and mitigation methods to be implemented to address direct and indirect impact on air quality, including undertaking ongoing monitoring of dust and volatile organic compounds.	Section 5.6.6 Appendix E

5.6.3 Receiving environment

As detailed in Section 5.5.3.2, the Development Envelope is at least 18 km from any public residential area. The Nidavellir well site is ~20 km from the Jimbalakudunj Community, the Jotunheim well site is ~28 km from the Yungngora Community, and the Proposed Well Site 4 is ~55 km from Fitzroy Crossing, the nearest town.

To understand local and regional air quality within and outside the Development Envelope, a baseline air quality monitoring program was developed in consultation with DWER. Three monitoring stations were

installed (two near communities). In addition to this, an additional two sites were used to sample VOCs. To support the sampling program, two monitoring frameworks were developed and implemented being:

- baseline dust monitoring (ash content, combustible matter, total insoluble matter, and particulate matter [PM_{10}, $PM_{2.5}$])
- baseline volatile organic compounds (VOCs – BTEX) monitoring.

The three air quality sampling sites comprising dust and VOC collection points were set up at AQ_CN, AQ_S2 and AQ_CS with a meteorological station set up at AQ_S2 as shown in Figure 5-62. The meteorological station comprised a Dust Master Pro 7000 integrated with WS200-UMB Smart Weather Sensors to gather real-time meteorological data.

These sampling locations were designed to provide coverage over the Development Envelope, but also to provide baseline data in proximity to the closest sensitive receptors (the communities). This provided an understanding of existing baseline conditions, against which potential project impacts can be assessed and managed. Given the existing use of the Development Envelope (Pastoral Station) fencing was installed around the stations to prevent impacts from cattle.

The number and locations of collection points are considered representative of the Development Envelope given the remote nature of the Development Envelope, distance to industry and distance to sensitive receptors. This is consistent with the (DEC, 2011)guideline which states: *"The number and location of monitors should adequately represent community exposure and should be selected as part of a risk-based approach".* Given the remote nature of the sites, pollutant sources in the vicinity of the sites were limited to pastoral activities, periodic road activity (cars), dust and bushfire events. Siting of the stations conforms to the requirements of AS3580.1.1 as provided in Figure 5-63.

The meteorological station was set up and calibrated in accordance with manufacturer's guidelines. It was calibrated during the initial set-up and deployment in 2021, and again during its deployment in 2022. The initial set-up was completed in accordance with its manual and in consultation with ERM and Thompsons. Thompsons confirmed that set-up was appropriately calibrated via the telemetry uplink during both deployments.

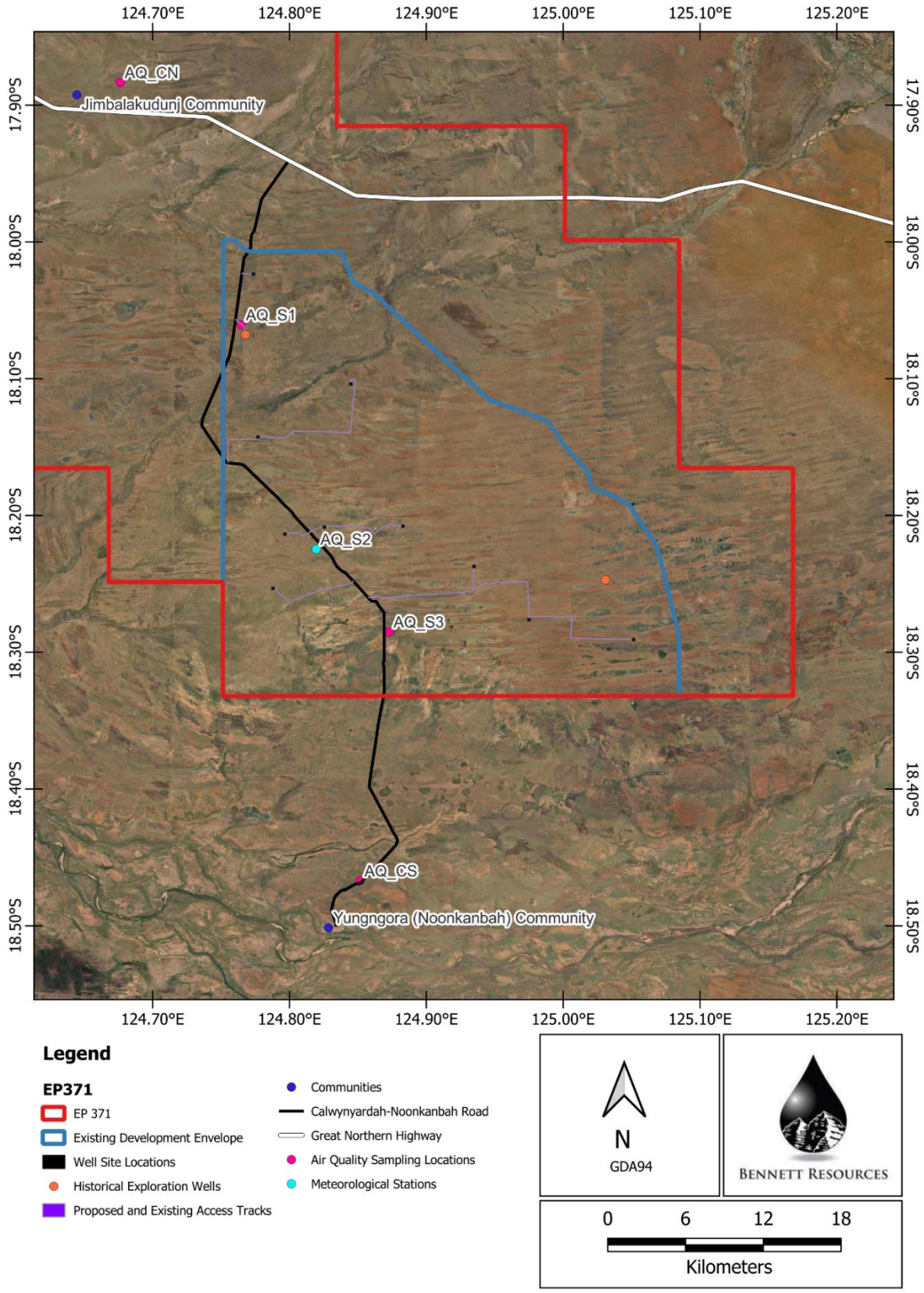


Figure 5-62: Baseline Dust and VOC Sampling Locations

Station Name	Photo of station	AS3580.1.1 – site assessment	
Station Name AQ_CN **Parameters Sampled** VOC Methane $PM_{2.5}$ PM_{10}		**GPS coordinate**	-17.8986, 124.6690
		Clear Sky angle 120º	✓
		Unrestricted air flow	✓
		>10m from road	✓
		>50m from road	✓
		10m from any object exceeding 2m	✓
		No extraneous sources nearby	✓
Station Name AQ_CS **Parameters Sampled** VOC Methane $PM_{2.5}$ PM_{10}		**GPS coordinate**	-18.4636, 124.8580
		Clear Sky angle 120º	✓
		Unrestricted air flow	✓
		>10m from road	✓
		>50m from road	✓
		10m from any object exceeding 2m	✓
		No extraneous sources nearby	✓
Station Name AQ_S2 **Parameters Sampled** VOC Methane Meteorological conditions $PM_{2.5}$ PM_{10}		**GPS coordinate**	-18.2159, 124.8056
		Clear Sky angle 120º	✓
		Unrestricted air flow	✓
		>10m from road	✓
		>50m from road	X due to the remote location, stations were set up within 50 m of roads, however these roads are not used frequently.
		10m from any object exceeding 2m	✓
		No extraneous sources nearby	✓

Figure 5-63: Overview of air quality monitoring stations

5.6.3.1 Particulate matter and dust

BNR monitored dust—comprising ash content, combustible matter, and total insoluble matter—using dust deposition gauges that have an exposure time of 30 days. BNR also used continuous light scattering instruments as part of the air quality monitoring stations that enabled particulate matter (PM_{10} and $PM_{2.5}$) data to be collected continuously throughout the monitoring period.

Given the simplicity of the dust deposition gauges, there was no requirement for calibration of the gauges. All quality assurance of laboratory samples were completed by the contractor (ALS). A sample of this data for June 2021 has been included in Appendix H.

The risk and impact of dust generation is significantly reduced during the wet season when the soil and roads are wet. Therefore, the dust monitoring period focused on the dry season months for multiple years being:

- 24 June to 21 November 2021
- 03 May 2022 to 08 November 2022.

Monitoring was primarily undertaken during the dry season, which typically lasts from May to October. For the purposes of contextualising the results of this monitoring, annual criteria were adopted as proxy criteria for comparison against the six-month averages. It must be noted that particulate matter from both wind erosion and vehicle transit on unsealed roads, and VOCs from bushfire activity are less prevalent with increased moisture in the environment. Therefore, the approach of evaluating six months of dry season data against annual averages is considered conservative.

Information from the most recent sampling year is provided below, however all available air quality data for 2021 and 2022 is included in Appendix H.

Figure 5-64, Figure 5-65, and Figure 5-66 summarise PM fluctuations over the air quality monitoring between 03 May and 08 November 2022 for the three monitoring stations. Key statistics are included for these stations in Table 5-44 and all data (presented as biannual reports) is included in Appendix H.

Table 5-44: Summary of 2022 air quality data

Period	AQ_CS	AQ_CN	AQ_S2
Start and end dates	03 May 2022 – 08 Nov 2022	02 May 2022 – 08 Nov 2022	03 May 2022 – 08 Nov 2022
Max $PM_{2.5}$	34.9	25.7	22.5
Max PM_{10}	353.2	39.5	251.1
Average $PM_{2.5}$	6.607027027	8.337234043	6.313368984
Average PM_{10}	57.49675676	15.01542553	68.87219251
Exceedance $PM_{2.5}$	6	1	0
Exceedance PM_{10}	71	0	103
Data Availability [16](%)	97%	98%	98%

For indicative purposes the period average from May to November was compared to annual average criteria of 25 µg/m^3 and 8 µg/m^3 for PM_{10} and $PM_{2.5}$, respectively. There were exceedances of the annual average PM_{10} criteria at location 397 (AQ_CS) and location 399 (AQ_S2). There were exceedances of the annual average $PM_{2.5}$ criteria at location 397 (AQ_CS). Given that particulate matter concentrations are anticipated to be lower during the wet season, this result is not necessarily indicative of an exceedance of the annual average criterion.

[16] *Based upon number of days where no reading was provided [NA in the data].*

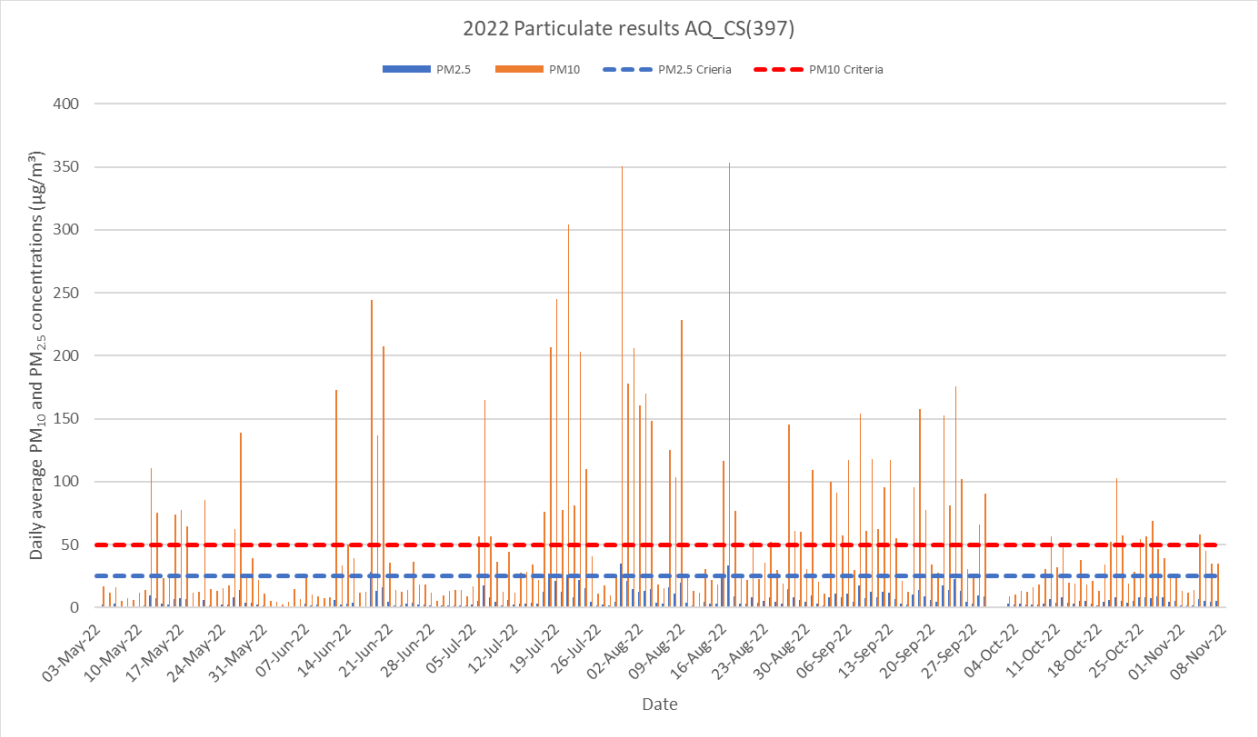


Figure 5-64: Daily average PM_{10} and $PM_{2.5}$ concentrations at location 397 (AQ_CS) from May 2022 to November 2022

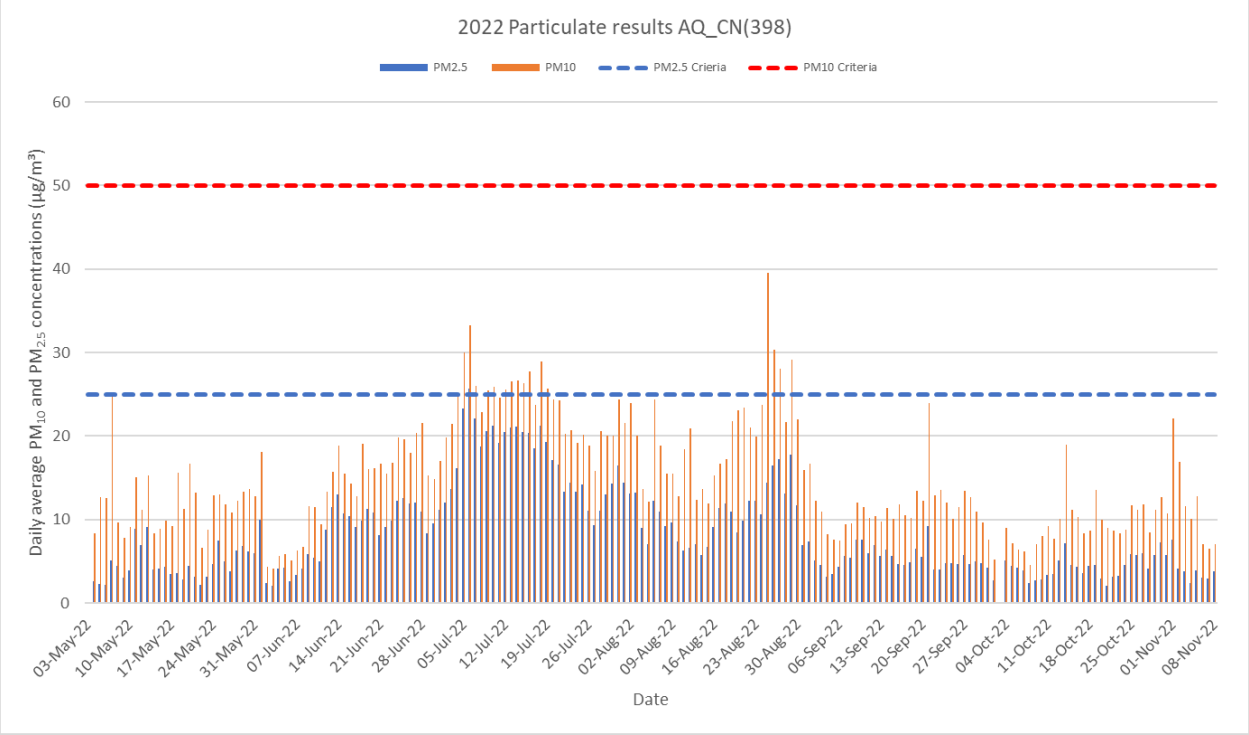


Figure 5-65: Daily average PM_{10} and $PM_{2.5}$ concentrations at location 398 (AQ_CN) from May 2022 to November 2022

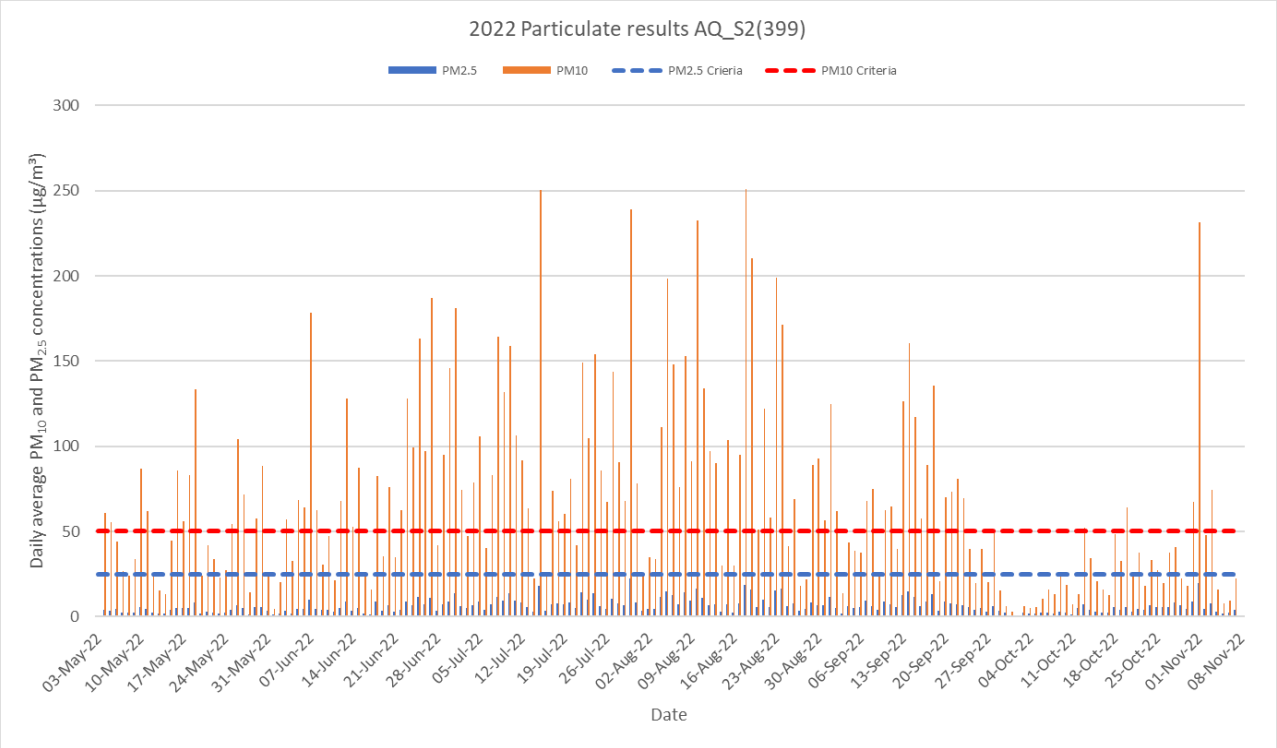


Figure 5-66: Daily average PM_{10} and $PM_{2.5}$ concentrations at location 399 (AQ_S2) from May 2022 to November 2022.

5.6.3.2 Volatile organic compounds

BNR monitored ambient VOCs using an evacuated canister method. Evacuated canisters are typically configured to provide measurements from a maximum 24-hour exposure, but the analysis suite can be broad and down to parts per billion resolution. The sampling method involves the collection of samples into passivated evacuated canisters, with canister preparation and post-sampling analysis undertaken by a third party laboratory that is NATA accredited for the USEPA TO-15 methodology, as specified within Compendium Method TO-15 - Determination of volatile organic compounds in air collected in specially-prepared canisters and analysed by gas chromatography / mass spectrometry US EPA, 1999).

Due to the batch nature of the method, for this baseline program canisters were deployed on a monthly basis to provide robust context on ambient VOC levels given the absence of identified sources of VOCs.

Although other methods were considered (such as radiello tubes for a 2-4 week period at a time), given the likelihood of them being impacted by heat and humidity this sampling method was not considered further. The gas cannisters were set up in the same location each month. Given the time limits associated with their deployment, journey management plans for the monitoring program were implemented to ensure that they were left in the field for precisely 24 hours. Once secured in place at the location, the cannisters were opened, allowing the inert gas to be displaced with the air sample collected. The canisters were then closed, collected, transported back to Perth and transported to the laboratory consistent with the requirement USEPA TO-15 methodology.

Given the nature of this sampling methodology limited QA/QC is required given the cannisters are swapped over at a laboratory. Prior to receiving the canisters, the laboratory cleans and certifies them. This ensure that the canisters are free of residual contamination prior to sample collection. The flow regulator is also calibrated at the laboratory before release. All laboratory calibration is available by the contractor (ALS). A sample of this data for June 2021 has been included into Appendix H.

The sampling program verified that VOCs across the sampling locations were low, with all samples returning results that were below the laboratory LoR thresholds. Because industrial activities are very limited in the area, the results correspond with what was expected before implementing the baseline monitoring program.

The results of the VOC monitoring were screened against Australian and US criteria that are nominated for use in the evaluation of ambient monitoring data, for identification of whether additional investigation is required. There were no positive detections present for any VOCs, and all results were significantly lower than respective screening criteria.

Table 5-43 lists VOC/BTEX baseline sampling data, aggregated for all locations, for the period June-November 2021 at the three monitoring locations, with the baseline monthly report provided in Appendix H. There were no positive detections above the laboratory's LoR. A comparison of the data against the health and amenity criteria (DWER, 2019; EPA NSW, 2016; WHO, 2010) presented in the Valhalla Monitoring Plan (Appendix E) confirmed that the monitored concentrations were all under the criteria values.

Table 5-45: Summary of reported VOC concentrations – June to November 2021

	Reported concentration (all locations) µg/m³ – June–July 2021			
Month	**Benene**	**Toluene**	**Ethylbenzene**	**Xylenes**
June	<1.6	<1.9	<2.2	<6.5
July	<1.6	<1.9	<2.2	<6.5
August	<1.6	<1.9	<2.2	<6.5
September	<1.6	<1.9	<2.2	<6.5
October	<1.6	<1.9	<2.2	<6.5
November	<1.6	<1.9	<2.2	<6.5

Note: "<" less than Limit of Reporting (LOR).

5.6.4 Potential impacts

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

- reduction in air quality causing impacts to sensitive social receptors
- increased dust generation resulting in deposition impacts to flora and vegetation.

5.6.5 Assessment of impacts

5.6.5.1 Reduction in air quality causing impacts to sensitive social receptors

Operating diesel-powered vehicles and heavy equipment and generating power during all phases of the Proposal will generate combustion emissions, including nitrogen oxides (NO_X), SO_2, PM_{10}, and VOCs. However, these emissions are expected to disperse rapidly upon release. This is due to the fact that the Proposal footprint is small, drilling will be undertaken for a short duration only and the amount of equipment on site will be very small.

Emissions associated with well testing (or flaring) are likely to also occur from Proposal activities. However, flaring emissions are known to disperse rapidly as they rise through the atmosphere, therefore exposure to sensitive receptors is not expected. Similar activities occur around the state, and flaring dispersion modelling conducted for much larger projects show ground-level concentrations in isolation and cumulatively are well below the corresponding ambient air quality and workplace exposure standard criteria (Ramboll, 2019).

The storage and onsite use of proppant along with general traffic on dirt roads will generate dust emissions. Dust emissions associated with the types of vehicles, machinery and equipment operating on unsealed surfaces are not expected to be significantly different from other sources in the region. Proppant storage and handling will only occur on the well sites. Dust can cause reduced air quality, acute and chronic health effects and amenity impacts (it reduces visibility and settles on surfaces, causing soiling and staining) (DEC, 2011). Using a dust risk assessment tool (DEC, 2011), which considered the soil type, wind speeds and location context, the risks associated with dust caused by the activities associated with the Proposal were classed as negligible (Table 5-39), with no provisions or contingency arrangements required.

To further understand the potential exposure pathways to the public, BNR completed a Public Health Risk Assessment (Appendix N). The nearest fixed receptors (Section 5.5.3.2) are at least 20 km from the well sites. Non-fixed receptors such as travelling Traditional Owners and station workers may also be

encountered near the well sites. Based on these distances and the surrounding rural land use, air emissions arising from using vehicles, heavy equipment and generators are not considered to represent a significant or long-lasting impact to air quality, human health, or aesthetics during site activities.

5.6.5.2 Increased dust generation resulting in deposition impacts to flora and vegetation

A five-year monitoring program that investigated impacts of dust on vegetation from a significant development in the Pilbara, 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 (Chevron Australia, 2015).

Because the dominant vegetation type within the Development Envelope is the same as that associated with the long-term monitoring program conducted in the Pilbara, BNR does not believe that dust deposition poses a significant impact to flora or vegetation. Impacts from dust on vegetation is also discussed in the flora and vegetation environmental factor in Section 5.1.5.4.

5.6.6 Mitigation

Table 5-46 summarises the mitigation measures and their hierarchy. Additionally, BNR will implement an air quality monitoring program (Appendix E). The program includes additional baseline and surveillance data collection, details the list of analytes to be collected, and the trigger and threshold contingency actions to be implemented during surveillance monitoring at each well site.

Table 5-46: Proposed mitigation measures – air quality

Mitigation hierarchy	Mitigation measure	Further information
Avoid	Green completions	BNR is considering using green completions, which allow gas produced during well completions to be separated for offtake to a sales gas pipeline. Given the distance of the well sites to existing gas markets, the emissions associated with transport offsite will also need to be considered. Because of the complexities of negotiating an offtake agreement with a gas supplier, the green completions option will be considered closer to the time of the activity.
Minimise	Monitoring program	Throughout the planning phase, BNR has conducted baseline air quality monitoring in accordance with EPA guidance and in consultation with DWER. Although the initial program formed the basis of this assessment, BNR plans to continue with a range of both baseline and surveillance monitoring programs to verify the Proposal activities can be undertaken in a way that has no significant impacts to the environment. A summary of the proposed air quality monitoring program to be undertaken for the Proposal is included in Appendix E. Specifically, the air quality monitoring planned for the Proposal includes: • continuing ambient air quality monitoring • verifying that ambient air quality levels near the communities (~2.5 to 5 km away) remain unaffected by the activity.
Minimise	Use of pilot flame during flaring, thereby minimising cold venting of methane	BNR will reduce cold venting during well test flaring to ALARP, which will significantly reduce methane emissions associated with this activity. Cold venting results in the release of methane, carbon dioxide, VOCs, sulphur compounds and gas impurities to the atmosphere, whereas flaring causes these gases to oxidise and form carbon dioxide, which has a global warming potential 25 times lower than methane.
Minimise	Dust management techniques	BNR will implement dust management techniques, such as dust suppression, to ensure that dust generation is minimised.
Minimise	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.

5.6.7 Environmental outcomes

The outcome of the Proposal is predicted to be no reduction in air quality that results in impacts to sensitive social receptors.

Based on the predicted outcomes for the Proposal as shown in the information above, BNR does 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:

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

can be met.

BNR has considered the WA Environmental Offsets Policy and does not believe actions to offset the predicted outcomes of the Proposal are required because the Proposal is not expected to have a significant impact on air quality.

5.7 Greenhouse gas emissions

5.7.1 EPA objective

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

5.7.2 Legislation, policy, and guidance

- Environmental Factor Guideline Greenhouse Gas Emissions (EPA, 2020)
- Environmental Factor Guideline – Greenhouse Gas Emissions (EPA, 2023)
- 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) (Commonwealth).

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 >100,000 tCO_2-e in a financial year, as defined in Section 22XJ of the NGER Act.

The Proposal is for a temporary exploration activity at several well locations; no well site meets the threshold of a 'designated large facility'. 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.

5.7.2.1 Application of the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing and procedure of the environmental review, required by Section 40(3) of the EP Act. Table 5-47 lists the ESD requirements specific to GHG emissions.

Table 5-47: ESD checklist – greenhouse gas emissions

Greenhouse gas emissions		
Required work		**BNR response**
74	Provide credible estimates of scope 1, scope 2 and scope 3 greenhouse gas emissions (annual and total) in tonnes of carbon dioxide equivalent (CO_2-e) over the life of the Proposal. Detail methods used to estimate emissions.	Section 5.7.5.1 Appendix R
75	Provide a breakdown of estimated scope 1 and scope 2 greenhouse gas emissions in tonnes of CO_2-e by all sources. Consider all proposed activities in determining the sources of emissions (e.g. clearing of land, site preparations, drilling operations, hydraulic fracture stimulation operations including flaring, potential leakage etc.).	Section 5.7.5.1
76	Provide calculations and calculation methodology for determining estimated emissions of CO_2-e for all sources.	Section 5.7.5.1 Appendix R
77	Benchmark the Proposal's emissions against other hydraulic fracture stimulation exploration projects. Information which supports that the identified projects are comparable to the Proposal should be included.	Section 5.7.5.1

Greenhouse gas emissions		
Required work		**BNR response**
78	Provide a greenhouse gas management plan, in accordance with EPA guidance, which demonstrates the Proposal's trajectory towards net zero emissions by 2050. The plan should include at a minimum: a. information required by 74 to 77 above b. a graph and table showing regular targets reflecting an incremental reduction in emissions towards net zero emissions by 2050. Where the proposed emissions reduction targets do not demonstrate a trajectory towards net zero by 2050, articulate clearly a compelling reason why it is not possible to achieve this c. mitigation (avoidance, reduction, offset) measures to be implemented with associated timeframes and evidence to demonstrate that the interim and long-term targets will be met. Where it is proposed that, following implementation of the avoidance and reduction measures, authorised offsets will be applied to meet the targets, evidence which supports that the mitigation measures are capable of achieving the stated targets is still required d. analysis of other potential abatement measures (e.g. renewables) relevant to the Proposal that are not proposed to be implemented which provides the rationale to support that these measures are unable to be implemented e. reporting requirements for publicly and periodically reporting against the stated targets.	Appendix R
79	Undertake and provide baseline measurements and monitoring for greenhouse gases, for a minimum of 12 months prior to any regulated activities.	Section 5.7.3
80	Provide a monitoring and reporting program measuring atmospheric concentrations and process leakage of methane over every well's entire life cycle, with recognition that any detected leaks must be fixed by the operator.	Appendix E Appendix R

5.7.3 Receiving environment

Six categories of 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 (CO_2), methane (CH_4), nitrous oxide (N_2O), and the synthetic GHGs—sulphur hexafluoride (SF_6), hydrofluorocarbons (HFC), and perfluorocarbons (PFC). In discussions with DWER, BNR identified that targeted monitoring of CH_4 would provide an indication of ambient GHG emissions within the Development Envelope.

Consequently, a methane monitoring program was developed to understand ambient methane levels in the project area. BNR conducted monthly samples at three separate locations using an evacuated canister method. The canisters provide measurements from a maximum 24-hour exposure. Passivated evacuated canisters were used to collect the samples and analysis was undertaken by a NATA-accredited laboratory using the EP104 light hydrocarbon (calculated concentration) method.

Table 5-48 and Appendix H summarises the ambient methane emissions recorded at three monitoring locations between June–November 2021.

Table 5-48: Summary of methane monitoring results

	Sampling location			
Date	**Laboratory LoR**	**AQ_S1 (mg/m³)**	**AQ_S2 (mg/m³)**	**AQ_S3 (mg/m³)**
24 June 2021	3.3 mg/m³	<6.60	<6.60	<6.60
22 July 2021		<6.60	<6.60	<6.60
18 August 2021		<6.60	<6.60	<6.60
21 September 2021		<6.60	<6.60	<6.60
21 October 2021		<6.60	<6.60	<6.60
16 November 2021		<6.60	<6.60	<6.60

5.7.4 Potential impacts

Due to the nature of the Proposal, emissions mainly occur at the onset of activities; exploration emissions are likely very small when distributed over the general producing life of an asset.

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

- contribution to GHG emissions.

5.7.5 Assessment of impacts

- Greenhouse gas emissions estimations

Table 5-49 lists the inventory of direct scope 1[17] GHG emissions. The methods used to calculate this inventory are detailed in Appendix R. As detailed in Appendix R, the sources of scope 1 GHG emissions (per well) are:

- gas flaring, comprising ~85.2% of scope 1 GHG emissions
- condensate flaring, comprising ~7.9% of scope 1 GHG emissions
- diesel fuel usage, comprising ~6.3% of scope 1 GHG emissions
- land clearing and fugitive emissions, comprising ~0.6% of scope 1 GHG emissions.

Table 5-49: Scope 1 GHG inventory

CO_2 emissions per exploration and appraisal well	Input parameter	Phase I – 6 wells (tCO_2-e)		Phase II – 14 wells (tCO_2-e)		Calculation reference
		~60 days flaring	~90[18] days flaring	~60 days flaring	~90 days flaring	
Land clearing (per well)						
Land clearing emissions	5.1 ha per well 56.3 tCO_2-e/ha	287	287	287	287	FullCAM Model (Australian Government, 2020)
Diesel emissions (per well)						
Site preparation	20	54	54	54	54	NGER Guidelines (Government of Australia, 2008) Section 2.41 with Table in Schedule 1 Part 3.
Drilling activities	316	857	857	857	857	
HFS activities	510	1,382	1,382	1,382	1,382	
Site reinstatement	20	54	54	54	54	
Transport (vehicles/rigs)	344	931	931	931	931	
Site power	8	15	22	15	22	
Flare (per well)						
Gas	Phase I: 5.9 mmscf/d Phase II: 10.7 mmscf/d	29,747	44,620	53,948	80,921	NGER Guidelines (Government of Australia, 2008) Section 3.44
Condensate	Phase I: 118 bbl/d Phase II: 214 bbl/d	2,760	4,140	5,005	7,507	NGER Guidelines (Government of Australia, 2008) Section 3.52

[17] Scope 1 GHG emissions: emissions released to the atmosphere as a direct result of an activity (direct emissions), or series of activities at a facility level.

Scope 2 GHG emissions: emissions released to the atmosphere from the indirect consumption of an energy commodity (indirect emissions).

Scope 3 GHG emissions: indirect GHG emissions other than scope 2 emissions that are generated in the wider economy.

[18] BNR has estimated that to collect the required data, the well must be flowed during the period of maximum gas concentration for up to 90 days.

CO_2 emissions per exploration and appraisal well	Input parameter	Phase I – 6 wells (tCO_2-e)		Phase II – 14 wells (tCO_2-e)		Calculation reference
		~60 days flaring	~90[18] days flaring	~60 days flaring	~90 days flaring	
Fugitive emissions (per well)						
Drill cuttings	Gas 0.12 tonnes	30	30	30	30	Based on volumes of drill cuttings and Valhalla gas saturation
Wastewater	2 ML produced formation water	20	20	20	20	API GHG Emissions Methodologies for Oil and Gas (API, 2009)
Total GHG emissions per well (tCO_2-e)		**36,136**	**52,936**	**62,582**	**92,065**	**Scope 1 (direct emissions)**
Total emissions exploration and appraisal program (tCO_2-e)	Phase I–6 wells Phase II–14 wells	216,814	314,378	876,144	1,288,915	Scope 1 (direct emissions)

As the Proposal does not intend to import power from third parties, no Scope 2 emissions are expected.

Although no Scope 3 emissions are expected, BNR may sell condensate collected during the well test program to third parties (if feasible) as a recommended GHG mitigation measure. By implementing this mitigation, BNR would avoid emissions associated with condensate flaring. The quantity of Scope 3 emissions associated with transporting and using condensate as a fuel was calculated on the basis that all condensate produced from a 90-day flaring period was captured and transported via Wyndham to Singapore where it was assumed to be processed and consumed. Table 5-50 lists the Scope 3 GHG emissions inventory.

Table 5-50: Scope 3 GHG emissions inventory

Scope 3 Emissions per well	~60 days flaring	~90 days flaring
Condensate volume (bbl)	222,240	333,360
Condensate transport emissions (tCO_2-e)	13,952	20,928
Condensate consumption emissions (tCO_2-e)	91,571	137,356
Total Scope 3 emissions (tCO_2-e)	**105,523**	**158,284**

5.7.5.1 Greenhouse gas emissions benchmarking

As required under ESD Item 77, BNR completed an emissions benchmarking assessment to understand how the Proposal compares to other HFS projects. Specifically, BNR benchmarked the Proposal emissions against these projects (company name – location – project name):

- Buru – Canning Basin – TGS14 Project
- Origin – Beetaloo Basin – Velkerri Project
- Origin – Beetaloo Basin – Kyalla Project
- Santos – McArthur Basin – EP161 Project
- Imperial – McArthur Basin – Carpenteria 1.

To benchmark projects for their GHG emissions, GHG emissions intensity values are typically calculated on a 'tCO_2-e per tonne of product' basis (for manufacturing projects) or 'tCO_2-e per kWh' basis (for power generation projects) so that project emissions can be compared. GHG emission intensities from gas exploration projects cannot be compared using either basis. Therefore, other methods were used to benchmark the Proposal.

GHG emissions intensities on a 'per Well per Test Day' basis for the Proposal are shown in Figure 5-67. The results indicate more emissions from the Valhalla per day rate are expected due to its higher flow rates per day. Note: The Origin and Santos test programs are planned for a significantly longer period (up to 3–12 months) compared to two to three months for the Proposal. Therefore, another comparison was made

based on flaring duration to understand total emissions per well from these exploration and appraisal programs. Figure 5-68 shows planned total emissions per well. The results indicate that wells associated with Phase I of the Proposal are comparable with the permitted/planned total emissions of other projects in the Beetaloo Basin in the Northern Territory. Phase II wells from this Proposal are higher than the other projects due to their potentially higher flow test rates.

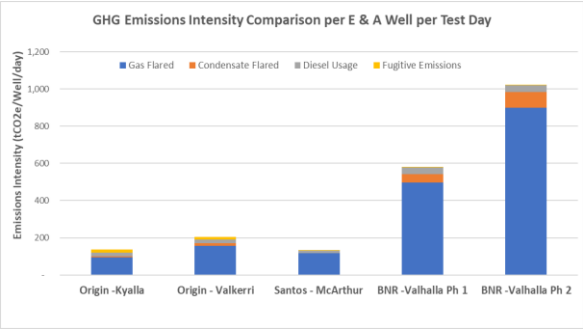


Figure 5-67: Benchmarking GHG emissions of the Valhalla program per well per test day

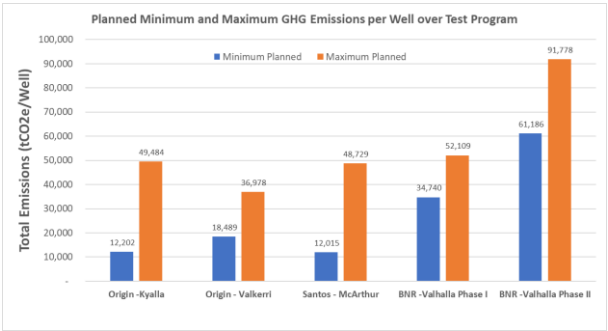


Figure 5-68: Benchmarking GHG emissions of the Valhalla program for planned total emissions per well

5.7.6 Mitigation

The Proposal is an exploration stage activity; therefore, BNR intends to flare (not vent) produced gas during well testing because flaring converts methane to CO_2 and water, thus significantly reducing methane emissions. Carbon dioxide has a global warming potential 25 times lower than methane over a 100-year span—removing 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 (Independent Scientific Panel Inquiry, 2018).

The nature of the Proposal (i.e. an exploration and appraisal program only) and the lack of available infrastructure, means that options for capturing and reinjecting CO_2 are not feasible. 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. A Part IV Greenhouse Gas Environmental Management Plan (GHG EMP) (Appendix R) has been prepared for submission with this ERD. The purpose of the GHG EMP is to develop management measures that minimise impacts associated with implementing this Proposal. The GHG EMP will be implemented to demonstrate that residual GHG impacts from the Proposal are not greater than predicted.

Table 5-51: Proposed mitigation measures – greenhouse gas emissions

Mitigation hierarchy	Mitigation measure	Further information
Reduce	Monitoring program	Throughout the planning phase, BNR has conducted baseline GHG emissions monitoring (limited to methane) in accordance with EPA guidance and in consultation with DWER. Although the initial program formed the basis of this assessment, BNR plan to continue its methane monitoring program with baseline and surveillance monitoring to verify the impacts of the Proposal's activities. Monitoring will continue until a trend *back to baseline levels has been demonstrated **and** at least two consecutive results reflect no significant deviation from ambient (baseline) samples* (Appendix E).
Avoid/Reduce	Valhalla GHGEMP	As required by the ESD Item 78, BNR has developed a GHGEMP that documents the mitigation and management measures associated with the Proposal. A summary of the proposed GHG monitoring to be undertaken in accordance with the GHGEMP is provided in Appendix R.
Minimise	NGER reporting	BNR will maintain emissions records to enable GHG emissions reporting as required under the NGER Act.

5.7.7 Environmental outcome

The outcome of the Proposal is predicted to be:

- GHG emissions minimised to ALARP to mitigate the risk of environmental harm associated with climate change.

Based on the predicted outcome for the Proposal, BNR does 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. Gas and thus associated emissions from the Proposal will enable BNR to gain a better understanding of the existing geology, and better identify mitigation measures that may be implemented during future field development. It should be noted that this program is an exploration and appraisal activity, thus assessment of GHG emissions from future development is outside the scope of the proposal.

5.8 Human health

5.8.1 EPA objective

To protect human health from significant harm.

5.8.2 Policy and guidance

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

5.8.2.1 Application of the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing, and procedure of the environmental review, required by Section 40(3) of the EP Act. Table 5-52 lists the ESD requirements specific to human health.

Table 5-52: ESD checklist – human health

Human health		
Required work		**BNR response**
81	Conduct a desktop assessment of the radionuclides and metals likely to be present in the geology of the Proposal area based on an interpretation of the site geology, exploration drilling data previously collected, and publicly available geophysical mapping. The assessment should explain if naturally occurring radionuclides and metals are likely to be of environmental significance or detrimental to human health during the development of the project and throughout operations.	Section 5.8.3
82	Conduct an assessment of potential impacts to human health.	Section 5.8.5.1
83	Outline the outcomes/objectives, management, monitoring, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Appendix E
84	Provide information on wastewater management on site.	Section 5.8.6 Section 2.6
85	Discuss the proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on human health.	Section 5.8.6 Appendix E
86	Provide a statement of how the proponent considers the EPA's objective for this factor has been addressed.	Section 5.8.7

5.8.3 Receiving environment

Generally, geological formations that contain oil and gas deposits also contain naturally occurring radionuclides (referred to as NORMs). These include uranium, thorium, and potassium, which can produce a range of other elements known as decay products such as radon and radium. NORMs are found everywhere in the environment including soil, rocks, water, air, and vegetation. They are also present in the human body and all living tissues, typically in very low concentrations (South Australian EPA, 2017). Table 5-53 lists the properties of radionuclides.

Table 5-53: Properties of radionuclide members of the ^{238}U and ^{232}Th decay chains (ARPANSA, 2008)

Radionuclide	Half-life (Chu & Ekström, 1999)	Principal radiation (α, β or γ)
^{238}U decay chain		
Uranium-238	4.468×10^9 years	α
Radium-226	1.6×10^3 years	α
Lead-210	22.3 years	β, γ
^{232}Th decay chain		
Thorium-232	1.41×10^{10} years	α, β, γ
Radium-228	5.75 years	β
Thorium-228	1.91 years	α

Although the ESD requests that BNR conduct a desktop assessment of the radionuclides and metals likely to be present in the geology of the Proposal area based on an interpretation of the site geology, BNR already has field data from the previous operator, which removes the uncertainty of relying on a simple desktop assessment and associated data. In 2015, the previous operator analysed formation water produced during well testing from the previous HFS program. Individual samples were taken before they were stored in the water retention ponds as well as samples from within water retention ponds to characterise the entire produced formation water volume. Table 5-54 and Table 5-55 list the results of this program. The Australian drinking water quality guidance level is 0.5 Bq/L for gross alpha (α) and 0.5 Bq/L for gross beta (β) (excluding potassium-40 activity) (NHMRC and NRMMC, 2011 (updated March 2021)). Additionally, the drinking water guidelines present a health guideline of 0.017 mg/L for uranium in water (NHMRC and NRMMC, 2011 (updated March 2021)).

These samples indicate that although water produced from the Laurel Formation did contain NORMs, the concentrations were well below the exposure concentrations as identified by the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ, 2018) for stock and irrigation land uses.

Table 5-54: Produced Laurel Formation water characterisation (metals and chloride)

Analyte	Onsite management levels (mg/L)	Asgard 1 pond post-well test	Valhalla North 1 pond post-well test
		Sep 2015–Oct 2015	Sep 2015–Oct 2015
Arsenic	0.5*	<0.02	<0.02
Barium	2#	20	12
Boron	4#	9.4	14
Cadmium	0.002#	<0.002	<0.002
Chloride	30,000	16,000	17,000
Chromium VI	0.05#	<0.02	<0.02
Copper	1*	<0.02	<0.02
Lead	0.1*	<0.02	<0.02
Manganese	0.5#	0.15	0.51
Mercury	0.002*	<0.0001	<0.0001
Nickel	1*	<0.02	<0.02
Selenium	0.01#	<0.02	<0.02
Zinc	20*	<0.1	<0.1

Notes –

** – Stock water: Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC and ARMCANZ, 2018)

 # – Health values: Australian Drinking Water Guidelines 6, Version 3.5 (NHMRC and NRMMC, 2011 (updated March 2021))

Table 5-55: Produced Laurel Formation water characterisation (radioisotopes)

Sample Number	Date	Unit	Radionuclides					
			Uranium Series			Thorium Series		
			Uranium-238	Radium-226	Lead-210	Thorium-232	Radium-228	Thorium-228
Asgard 1 produced formation water retention pond	25 Feb 2016	Bq/L	0.01 ±0.01	1.113 ±0.093	<0.22	<0.005	1.35 ±0.12	<0.034
Valhalla North 1 produced formation water retention pond	28 Jan 2016	Bq/L	<0.02	1.046 ±0.085	<0.14	<0.005	1.32 ±0.11	<0.025

5.8.4 Potential impacts

The potential impact associated with this environmental factor is limited to:

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

5.8.5 Assessment of impacts

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

During gas extraction processes, NORMs may be brought to the surface, resulting in the potential for human exposure. As the Proposal is a short-term exploration and appraisal program, occupational exposure to radiation is very limited. The potential for human exposure to NORMs will be limited to produced formation water storage within the water retention pond (Figure 2-4) and drill cuttings and fluids within the drilling sump. Public exposure to produced formation water or drill cuttings is considerent non-existent under normal operating conditions, and human exposure (workers) to the drill cuttings and water retention pond is also limited because they are closed-loop systems (Figure 2-4).

Monitoring of Laurel Formation water produced during well testing indicates that, on average, NORM levels for samples 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, 2018) and the Australian drinking water guideline levels (NHMRC and NRMMC, 2011 (updated March 2021)) (Table 5-55).

With the low levels of NORMs expected within the Laurel Formation and the mitigation measures in place (Table 5-56), BNR does not expect any NORM-contaminated material to be released to the environment that causes exposure to humans and risks human health. If an accidental release from the water retention pond or drilling sump did occur, impacts to human health are not expected because the NORM concentrations from the Laurel Formation have proven to be low and below the levels set out by industry guidelines.

5.8.6 Mitigation

Table 5-56 summarises the mitigation measures and their hierarchy that will be included in the EP for assessment and acceptance by DEMIRS.

Table 5-56: Proposed mitigation measures – human health

Mitigation hierarchy	Mitigation measure	Further information
Minimise	Produced formation water storage pond design	As per WQPN 26 (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 90th percentile wet season, after allowing for any evaporative water loss and the effects of any water re-use recovery system.
Minimise	Pond design	In accordance with WQPN 26 (DoW, 2013), surface ponds used for short-term containment of wastewater or solids that may leach contaminants, require synthetic membranes and need to meet specific requirements, which include: • all fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s

Mitigation hierarchy	Mitigation measure	Further information
		• a minimum thickness of 0.75 mm • dual liners • leak detection
Minimise	Waste management	All produced formation water will be managed in accordance with the principles detailed in Table 2-8.
Minimise	Monitoring/testing	As detailed in Appendix E, BNR will sample produced formation water (from within water retention ponds) and drill cuttings (from the mud sumps) for CoPC, including NORMs.

5.8.7 Environmental outcomes

The outcome of the Proposal is 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 on the predicted outcome for the Proposal, BNR does 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 believes that the EPA's objective to:

'protect human health from significant harm'

can be met.

BNR has considered the WA Environmental Offsets Policy and does not believe actions to offset the predicted outcomes of the Proposal are required because the Proposal is not expected to have a significant impact on human health.

5.9 Subterranean fauna

5.9.1 EPA objective

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

5.9.2 Policy and guidance

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

5.9.2.1 Application of the Environmental Scoping Document

The ESD was published on 8 November 2021 to define the form, content, timing, and procedure of the environmental review, required by Section 40(3) of the EP Act. Table 5-57 lists the ESD requirements specific to subterranean fauna.

Table 5-57: ESD checklist – subterranean fauna

Subterranean fauna		
Required work		**BNR response**
87	Conduct a desktop assessment of the subterranean fauna and their habitat to inform local and regional context.	Section 5.9.3
88	Undertake an assessment of potential impacts to Subterranean Fauna in accordance with EPA guidance.	Section 5.9.5
89	Conduct an assessment of potential impacts from HFS activities to subterranean fauna. The assessment should explain if drill fluids or other chemicals of environmental significance are detrimental to subterranean fauna or their habitat.	Section 5.9.5

Subterranean fauna		
Required work		**BNR response**
90	Discuss the proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on subterranean fauna.	Section 5.9.6
91	Outline the outcomes/objectives, management, monitoring, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Appendix E Appendix L Linked to Inland Waters factor and impacts
92	Provide a statement of how the proponent considers the EPA's objective for this factor has been addressed.	Section 5.9.7

5.9.3 Receiving environment

WA's subterranean fauna is recognised as being globally significant because of its extraordinarily high species richness and high levels of endemism. Significant subterranean fauna assemblages have been recognised through their listing in some TECs and PECs. These fauna may have important ecosystem service functions, such as maintaining water quality in groundwater aquifers.

The presence of subterranean fauna is strongly linked to the geology and hydrology of the area as well as the availability of suitable microhabitats, such as non-hypersaline aquifers for stygofauna (Innovative Groundwater Solutions, 2015) and air-filled voids or caves for troglofaunal.

The Liveringa Formation is the uppermost aquifer in the Development Envelope (Figure 5-16) and comprises mainly fine-grained sediments (siltstone and shale), with more-permeable sandstone beds being less common. The shallow shale and siltstone sediments of the formation provide a potential habitat for stygofauna; however, bore yields in the Development Envelope suggest that permeability is low, and thus it is less likely that stygofauna would be present. Groundwater salinity in the Liveringa Aquifer is within a range that stygofauna are known to occur, with salinities of local bores ranging from 450 to 1,600 mg/L TDS (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 troglofaunal (Bennelongia, 2023, attached as Appendix S). Further analysis of subterranean fauna presence, including a review of previous records and sampling undertaken near the Development Envelope, is provided by Rockwater (2016) in Appendix I.

Based on the 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 (Rockwater, 2016). The range of groundwater salinities are within the tolerance levels recorded for stygofauna, and the shale and siltstone of the Liveringa Aquifer 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 (Rockwater, 2016). The regional extent of aquifers in the Development Envelope, and absence of any geological barriers that may prevent dispersal, suggest that any stygofauna community likely has an unrestricted distribution.

Bennelongia undertook a desktop assessment in October 2023 (Appendix S) and found 21 species of stygofauna records in an area covering 100 x 100 km^2 around the project area, but no TECs or PECs.

5.9.4 Potential impacts

5.9.4.1 Direct impacts

The Proposal may cause this local change to habitat, which has the potential to result in impacts to subterranean fauna:

- groundwater drawdown of surficial aquifers associated with water extraction.

5.9.4.2 Indirect impacts

This indirect impact may occur:

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

5.9.5 Assessment of impacts

5.9.5.1 Groundwater drawdown of surficial aquifers associated with water extraction

Section 5.4.5.1 details the impact evaluation for groundwater drawdown. In summary, the modelled drawdown at the end of the six-month pumping period for Mod 1 (the Liveringa Aquifer) showed potential for a 0.2 m drawdown within 400 metres of each pumping bore assuming that all 10 well sites were abstracting water at the same time (Intera Geosciences Pty Ltd, 2023). However, given this model provides an unrealistic representation of groundwater drawdown as all well sites will not be pumping at the same time, and given the proximity of the Muspelheim wellsite to Mount Hardman Creek (1 km), additional predictive modelling for Mod 1 was performed with pumping only applied to the Muspelheim wellsite to provide an informed and realistic indication of potential drawdown exposure to the GDE. Modelling indicates that for a single wellsite a 10cm drawdown is expected 400 m from the pumping bore reducing to 2 cm at 500 m and 1 mm drawdown at 700 m (Intera Geosciences Pty Ltd, 2023).

These figures indicate the Proposal will result in only small-scale drawdown impacts, that will not impact or expose water resources (such as Mt Hardman creek) where GDEs may be present.

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

5.9.5.2 Potential contamination of surficial aquifers from an accidental release (of drilling fluids, HFS chemicals, liquid hydrocarbons, or produced formation water) at the surface

The highest potential for impact to subterranean fauna occurs during the drilling of the top-hole section. However, as detailed in Section 5.4, BNR will use a low-toxicity mud system that poses very low risk to the environment, and consequently, very low risk to any subterranean fauna populations. The composition of this fluid system is provided in Appendix A.

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 varying levels of exposure depending on the volume of release. However, as described in Section 5.4.3, based on the depth to groundwater, any surface release is expected to take 70–300 days to travel from the ground surface to the water table (Rockwater, 2016).

As detailed in Section 5.2.5.2, a large spill event (e.g. 75 m^3 of diesel) would only be expected to seep through soils to a depth of ~0.5 m. Consequently, it is extremely unlikely that any release would cause the groundwater to be contaminated. Because surface spill events are well understood, a standard suite of preventive and management measures (including spill response and recovery arrangements) would ensure that, should a spill occur, impacts to groundwater quality (if any) would be negligible.

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

5.9.6 Mitigation

Table 5-58 summarises the mitigation measures and their hierarchy These will be included in an EP for assessment and acceptance by DEMIRS under the PGER(E)R before activities commence. As detailed in the risk assessment, the source receptor pathways that would cause impacts to subterranean fauna are associated with groundwater drawdown and spill events. As such mitigations documented in Table 5-58 are duplicated from Section 5.4.6 and Section 5.2.

Table 5-58: Proposed mitigation measures – subterranean fauna

Mitigation hierarchy	Mitigation measure	Further information
Avoid	Surface casing cemented across all useable freshwater aquifers	In accordance with the Guidelines for the protection of surface and groundwater resources during exploration and appraisal drilling (DMPR, 2002), the potential for contaminating groundwater resources will be managed by installing casing that is secured / sealed by a sealing material such as cement.
Avoid/Minimise	Part IV Groundwater Management Plan	As required by the ESD Item 4, BNR has developed a GWMP (Appendix M) that documents the groundwater monitoring requirements along with management actions associated with trigger and threshold criteria that must be implemented. BNR believes that with the triggers detailed in the GWMP, groundwater sensitivities (such as subterranean fauna) will be protected.
Minimise	Chemical and hazardous liquid material storage	As per Australian Standard AS 1940:2004 recommendations, BNR will ensure that: • secondary containment for hazardous materials, chemicals, and hydrocarbons comprises a volume that equals 110% of the largest container within the contained area or 25% of the combined tank volumes tanks are double-skinned.
Minimise	Produced formation water storage pond design	As per WQPN 26 (DoW, 2013), all lined storage compounds will 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 90th percentile wet season, after allowing for any evaporative water loss and the effects of any water re-use recovery system. All water storage ponds will be designed to meet these requirements.
Minimise	Groundwater monitoring bore installation	Installation and drilling of all water bores (including abstraction bores) will be hydro stratigraphically logged in detail and geophysical interpretation of groundwater quality collected, for the interval where fresh aquifers are known to be present (including through the Grant formation). Annulus seals and gravel packs will be used, where necessary, to isolate the zone being monitored and prevent potential cross contamination via the bore casing as required by the Minimum Requirements for Water Bores in Australia (National Uniform Drillers Licensing Committee, 2011) required to be followed as detailed in the Groundwater monitoring in the onshore petroleum and geothermal industry guideline (DMP & DoW, 2016). BNR will conduct validation water samples (along with QA/QC samples of any fluids / water used for the bore installation process) at a point of discharge from the circulation system to understand if cross contamination may be occurring as evidenced by fluid constituent presence associated with bore installation. This may involve the use of tracer dyes, but these specifics are subject to local conditions, aquifer depths and will be directed by a hydrogeologist during bore installation.
Minimise	Pond design	In accordance with WQPN 26 (DoW, 2013), surface ponds used for short-term containment of wastewater or solids that may leach contaminants, require synthetic membranes and need to meet specific requirements, including: • all fluid containment liners should have a coefficient of permeability of less than 2×10^{10} m/s • a minimum thickness of 0.75 mm • dual liners • leak detection. All surface ponds will be constructed to meet these requirements.
Minimise	Low-toxicity mud system	BNR plans 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	Chemical disclosure	In accordance with ESD Items 5, 6, and 8, a summary of all chemicals that may be used as ingredients in drilling and hydraulic fracture is included in Appendix A.

Mitigation hierarchy	Mitigation measure	Further information
		As per the requirements of Regulation 9 of PGER(E)R 2012, chemicals or substances must be disclosed for acceptance by DEMIRS before commencing activities where they are: • in, or added to, any treatment fluids to be used for drilling or hydraulic fracturing undertaken in the course of the activity • otherwise introduced into a well, reservoir, or subsurface formation in the course of the activity. In addition, all chemicals to be used downhole under the Proposal must be 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.
Minimise	Groundwater licences for extraction bores	In accordance with the RIWI Act, all water extraction must be licensed prior to take because the Development Envelope is located within a proclaimed groundwater area (DoW, 2010). BNR will ensure all groundwater licences are in place and kept up to date.
Minimise	Meter calibration and monitoring for extraction bores	As described in the Measuring the taking of water guidelines (DoW, 2016), Clause 46 of Schedule 1 of the RIWI Act state that licensees may be subject to metering, which is recognised as an accurate and reliable measuring technique. This is further expressed in the RIWI Regulations 2020, which now require water licences with annual water entitlements of between 10 – 50ML per year to install meters. Meters will be installed as required.
Minimise	Oil Spill Contingency Plan (OSCP)	Regulation 15 of PGER(E)R 2012 requires that an OSCP be developed for the Proposal and accepted by DEMIRS before conducting any petroleum activities.
Minimise	Spill kits	As directed by the OSCP, spill kits will be made available onsite to support the first strike / immediate response actions in the event of a spill.

5.9.7 Environmental outcomes

The outcomes of the Proposal are predicted to be:

- no impacts to subterranean fauna demonstrated by:
  - no short-term significant drawdown of the aquifer
  - no change to groundwater quality.

Based on the predicted outcomes for the Proposal as shown throughout this document and, in particular, the groundwater abstraction modelling and the 2023 Bennelongia GDE survey undertaken for this project (Appendix S), BNR does 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:

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

can be met.

BNR has considered the WA Environmental Offsets Policy and does not believe actions to offset the predicted outcomes of the Proposal are required because the Proposal is not expected to have a significant impact on subterranean fauna.

5.10 Other environmental factors or matters

BNR have done a comprehensive review and believe that the preliminary key factors cover all factors and matters relevant to the proposal. As such no other factors or matters have been identified.

5.11 Residual impact significance model – assessment

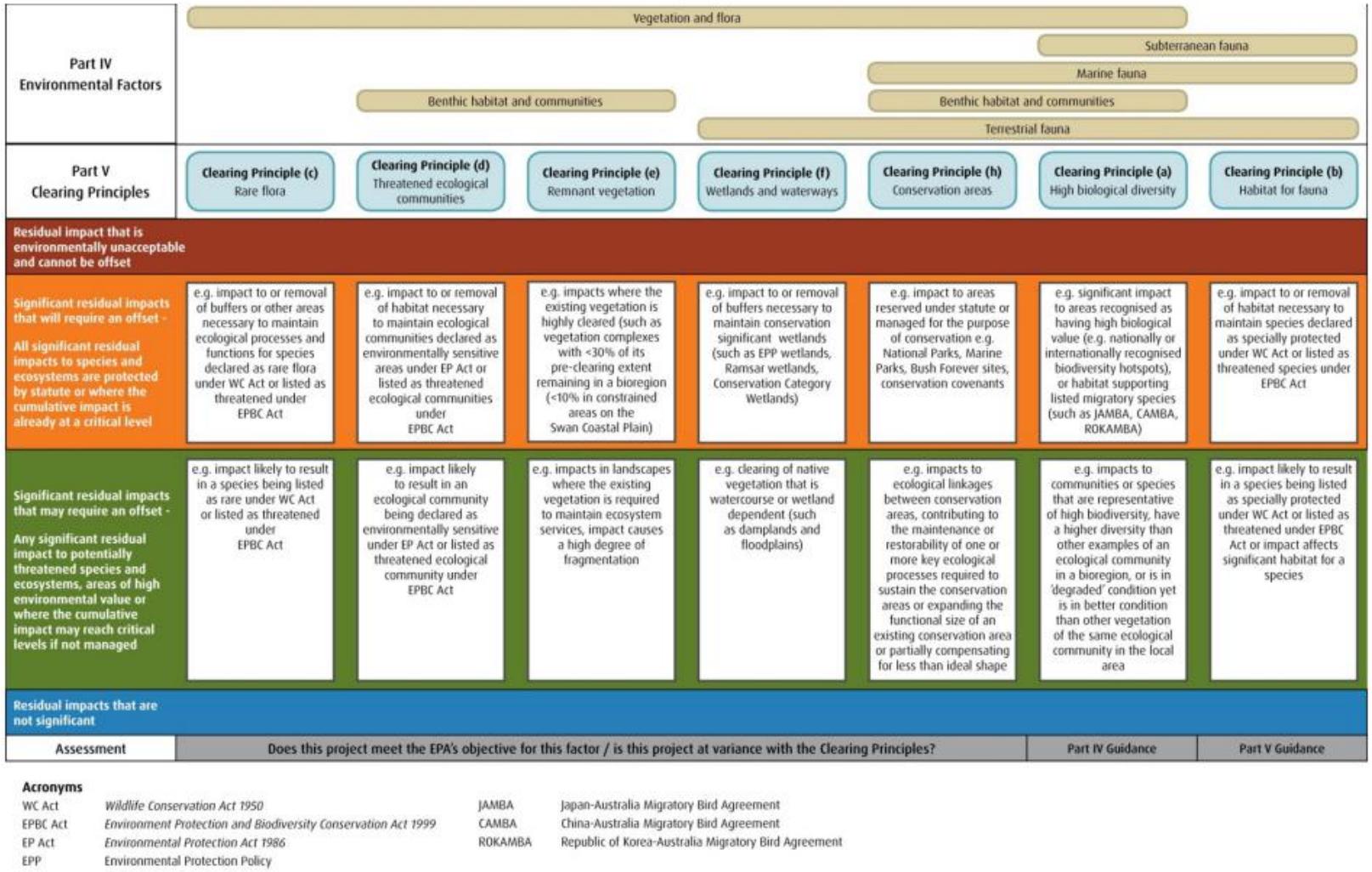
As detailed in the WA Environmental Offsets Guidelines (Government of Western Australia, 2014), the residual impact significance model (Figure 5-69) outlines how significance will be determined and when an offset is likely to be required, or may be required, in relation to relevant EPA environmental factors. The model identifies 4 levels of significance for residual impacts:

- unacceptable impacts – those impacts that are environmentally unacceptable or where no offset can be applied to reduce the impact. Offsets are not appropriate in all circumstances, as some environmental values cannot be offset
- significant impacts requiring an offset – any significant residual impact of this nature will require an offset. These generally relate to any impacts to species, ecosystems, or reserve areas protected by statute or where the cumulative impact is already determined to be at a critical level
- potentially significant impacts that may require an offset – the residual impact may be significant depending on the context and extent of the impact. These relate to impacts that are likely to result in a species or ecosystem requiring protection under statute or increasing the cumulative impact to a critical level. Whether these impacts require an offset will be determined by the decision-maker based on information provided by the proponent or applicant and expert judgement
- impacts that are not significant – impacts that do not trigger the above categories are not expected to have a significant impact on the environment and therefore do not require an offset. Application of the residual impact significance model is expected to ensure that the determination of significance of residual impacts is consistent, regardless of the regulatory process.

BNR has applied this model to the relevant Part IV environmental factors to determine if the residual impacts associated with the Proposal are significant and thus require offsetting (Table 5-59 and further detail in Section 5.11.1 - 5.11.3). Using the offsets guidelines (Government of Western Australia, 2014), this model was directly applied to these factors:

- flora and vegetation
- terrestrial fauna
- subterranean fauna

For all other factors, BNR reviewed the impact assessments, as detailed in the relevant sections of this ERD.



Acronyms

WC Act	*Wildlife Conservation Act 1950*	JAMBA	Japan-Australia Migratory Bird Agreement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*	CAMBA	China-Australia Migratory Bird Agreement
EP Act	*Environmental Protection Act 1986*	ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
EPP	Environmental Protection Policy		

Figure 5-69: Residual impact significance model (Government of Western Australia, 2014)

Table 5-59: Residual Impact Significance table

Part IV Environmental Factors	Vegetation and Flora					Subterranean Fauna	Terrestrial Fauna	All factors
	Rare flora	Threatened ecological communities	Remnant vegetation	Wetlands & waterways	Conservation areas	High biological diversity	Habitat for fauna	Other
Residual impact that is environmentally unacceptable or cannot be offset	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified
Significant residual impacts that will require an offset – All significant residual impacts to species and ecosystems protected by statute or where the cumulative impact is already at a critical level	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified
Significant residual impacts that may require an offset – Any significant residual impact to potentially threatened species and ecosystems,	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified

areas of high environmental value or where the cumulative impact may reach critical levels if not managed								
Residual impacts that are not significant – Flora and Vegetation	The Proposal's impacts are not expected to result in any direct or indirect impacts to conservation significant species (Threatened and Priority flora species), therefore the residual impacts are not considered significant	Flora and vegetation surveys within the Development Envelope did not identify the presence of any TECs or PECs, as listed under the BC Act or EPBC Act	The vegetation associations are not considered remnant patches, or poorly represented vegetation associations (<30%) and are not expected to result in impacts that would affect ecosystem function. The residual impacts are not considered significant	The Proposal will not result in clearing of vegetation within a wetland, creek or river, the residual impacts are not expected to be significant	The Development Envelope does not intersect any conservation areas. Consequently, the residual impacts are not expected to be significant	The Proposal will not impact any vegetation communities that are known to comprise high biodiversity, thus the residual impacts are not expected to be significant	The Proposal is not expected to result in any impacts to fauna species or impacts to significant fauna habitat and is not expected to result in any impact to species listed under the BC Act or EPBC Act. The residual impacts are not expected to be significant	N/A
Residual impacts that are not significant – Terrestrial Fauna				BNR identified fauna habitat as being suitable for three migratory species being the: • Common sandpiper (*Actitis hypoleucos*) • Fork-tailed swift (*Apus pacificus*)	The Development Envelope does not intersect any conservation areas. Consequently, the residual impacts are not expected to be significant	The Proposal will not impact any fauna species or habitat that is known to have high biodiversity values, the residual impacts are not expected to be significant	The Proposal is not expected to result in any impacts to fauna species, impacts to significant fauna habitat, or to result in any impact to species listed under the BC Act or EPBC Act, and the residual	N/A

				• Sharp-tailed sandpiper (*Calidris acuminata*). As the Proposal will not result in clearing of vegetation within a wetland, creek or river, the residual impacts are not expected to be significant			impacts are not expected to be significant	
Residual impacts that are not significant – Subterranean Fauna						Given the impacts from these activities are limited, any indirect impacts to subterranean fauna would not be expected. Consequently, the residual impacts from this Proposal are not expected to be significant	Given the impacts from these activities are limited, any indirect impacts to subterranean fauna would not be expected. Consequently, the residual impacts from this Proposal are not expected to be significant	N/A

5.11.1 Flora and vegetation

The principles that are deemed relevant for this factor are:

- Declared rare flora
- threatened ecological communities
- remnant wetlands
- wetlands and waterways
- conservation areas
- high biological diversity.

An assessment of the Proposal against these principles is detailed in the subsections below.

5.11.1.1 Declared Rare Flora

BNR has modified the disturbance footprint to avoid impacts to conservation significant species. Specifically, BNR has rerouted access tracks (and the general siting of well sites) to avoid damp lands and creek lines thus avoiding conservation significant species known to be associated with these areas. Figure 5-2 summarises all conservation significant flora identified within the disturbance footprint of the Development Envelope. No DRF or Priority species are planned to be impacted by the Proposal.

The Proposal's impacts are not expected to result in any direct or indirect impacts to conservation significant species (DRF and Priority flora species), therefore the residual impacts are not considered significant.

5.11.1.2 Threatened Ecological Communities

Flora and vegetation surveys within the Development Envelope did not identify the presence of any TECs or PECs, as listed under the BC Act or EPBC Act. The areas surveyed are considered representative of the expected flora and vegetation composition throughout the entire Development Envelope; therefore, BNR does not expect any TEC or PEC to be impacted by the Proposal.

Because the Proposal's impacts are not expected to result in any direct or indirect impacts to TECs or PECs, the residual impacts are not considered significant.

5.11.1.3 Remnant vegetation

Flora and vegetation surveys within the Development Envelope confirmed the presence of four predominant vegetation associations. The vegetation associations within the Development Envelope are well represented locally (see Table 5-5 for the Proposal's impact). The direct impact of clearing is limited to no more than 0.054% of a single vegetation association, which is insignificant at a regional scale. Consequently, the Proposal is not expected to result in any landscape scale impacts, and any fragmentation would be limited to localised impacts that are not expected to affect ecosystem functioning or restrict movement of local species.

Because the vegetation associations are not considered remnant patches, or poorly represented vegetation associations (<30%) and are not expected to result in impacts that would affect ecosystem function, the residual impacts are not considered significant.

5.11.1.4 Wetlands and waterways

Many tributaries of the surface fluvial system draining into the Fitzroy River are ephemeral streams or swale washes during the long dry season. The surface water lines within the Development Envelope (Figure 5-36) all have such ephemeral waterbodies. The only recognised surface waterbody within the Development Envelope is Mount Hardman Creek, which is also defined as a GDE.

BNR does not plan to clear vegetation associated with the GDE or vegetation associated with other perennial waterways. Because the Proposal will not result in clearing of vegetation within a wetland, creek or river, the residual impacts are not expected to be significant.

5.11.1.5 Conservation areas

As detailed in Section 5.1.3.2 and seen in Figure 5-3, the Development Envelope does not intersect any conservation areas. Consequently, the residual impacts are not expected to be significant.

5.11.1.6 High biological diversity

CSIRO (Pavey & Vanderduys, 2021) identified that 2,838 plant species were recorded within the Canning Basin, of which 220 species were classified as conservation significant. CSIRO (Pavey & Vanderduys, 2021) also identified that 43 threatened ecological communities (TECs) are known to be present in the Canning Basin. In the absence of suitable data at a sub-regional perspective, BNR reviewed species richness of the Fitzroy Trough by interrogating the Atlas of Living Australia database. The Atlas of Living Australia database identified that 1306 flora species have been recorded within the Fitzroy Trough (Atlas of Living Australia, 2023). In addition to this, four flora species classified as conservation significant and one threatened Ecological Community are known to be present (Graham, 2001).

The flora and vegetation survey commissioned by BNR recorded 235 flora species representing 54 families and 130 genera from 64 quadrats. The average diversity per quadrat was 27 species, ranging from a low of seven species to a high of 53 species. A species accumulation curve determined that the number of flora species recorded represents ~91.7% of the species potentially present within the Development Envelope.

Noting that 2,838 species are known to be present within the Canning Basin, the species identified within Development Envelope comprise only eight per cent of the species recorded.

For a more localised comparison, noting that 1,306 species are known to be present within the Fitzroy Trough IBRA sub-region, the species identified within Development Envelope comprise 18 per cent of the species recorded.

This indicates that within the Canning Basin (regional) and Fitzroy Trough (sub-regional), the level of species diversity within the Development Envelope is limited. As the Proposal will not impact any vegetation communities that are known to comprise high biodiversity, the residual impacts are not expected to be significant.

5.11.1.7 Habitat for fauna

As detailed in Section 5.3.3.1, the Development Envelope contains three broad fauna habitat types. An assessment against conservation significant fauna species that may be present within the Development Envelope indicates that this habitat may provide habitat for the:

- Gouldian Finch (*Erythrura gouldiae*)
- Greater Bilby (*Macrotis lagotis*)
- Northern Short-tailed Mouse (*Leggadina lakedownensis*)
- Spotted Ctenotus (northeast) (*Ctenotus uber johnstonii*).

The habitat throughout the Development Envelope and beyond as widely ubiquitous. During the most recent surveys, no bilbies (or recent burrows) were recorded or identified; however, the Greater Bilby is known to be present within the region based upon diggings identified by Eco Logical Australia . Eco Logical Australia indicate that although vegetation within the southeast of the Development Envelope could be considered as appropriate bilby habitat, suitable habitat is also widely available throughout the wider region. All fauna habitat identified is not considered as significant habitat (or habitat critical to the survival of the species).

As the Proposal is not expected to result in any impacts to fauna species or impacts to significant fauna habitat and is not expected to result in any species being listed under the BC Act or EPBC Act, the residual impacts are not expected to be significant.

5.11.2 Terrestrial fauna

5.11.2.1 Wetlands and waterways

As detailed in Section 5.3.3.1, BNR identified fauna habitat as being suitable for three migratory species being the:

- Common sandpiper (*Actitis hypoleucos*)
- Fork-tailed swift (*Apus pacificus*)
- Sharp-tailed sandpiper (*Calidris acuminata*).

These species are vagrant and mobile but were identified as having the potential to use habitat within the disturbance footprint when conditions are favourable (e.g. after periods of heavy rainfall).

However, given the extent of similar habitat within and surrounding the Development Envelope, removing a small amount of vegetation in this area is not expected to result in any impacts to migratory species given the disturbance will not restrict them accessing nearby habitat if required. BNR has amended the disturbance footprint to prevent impacts to damp land communities. As the Proposal will not result in clearing of vegetation within a wetland, creek or river, the residual impacts are not expected to be significant.

5.11.2.2 Conservation areas

As detailed in Section 5.1.3.2, the Development Envelope does not intersect any conservation areas. Consequently, the residual impacts are not expected to be significant.

5.11.2.3 High biological diversity

CSIRO (Pavey & Vanderduys, 2021) identified that 857 vertebrate species were recorded within the Canning Basin, with 155 of these species classified as conservation significant.

Although no conservation listed species were directly sighted during the 2021 on-ground basic fauna survey , of the 54 conservation listed fauna species identified in the 2021 fauna report's desktop assessment (pre-likelihood of occurrence), nine are considered as having the potential to occur post-survey, based on the location of previous records (sightings) to the Development Envelope and availability of suitable habitat within the Development Envelope.

Although 155 fauna species of conservation significance are known to be present within the Canning Basin, the fauna species likely present within Development Envelope only comprise six per cent of the species recorded across in the Canning Basin—the level of species diversity in the Development Envelope is low.

Because the Proposal will not impact any fauna species or habitat that is known to have high biodiversity values, the residual impacts are not expected to be significant.

5.11.2.4 Habitat for fauna

As detailed in Section 5.3.3.1, the Development Envelope contains three broad fauna habitat types. An assessment against conservation significant fauna species that may be present within the Development Envelope indicates that this area may provide habitat for the:

- Gouldian finch (*Erythrura gouldiae*)
- Spotted Ctenotus (northeast) (*Ctenotus uber johnstonii*)
- Northern short-tailed mouse (*Leggadina lakedownensis*)
- Greater Bilby (*Macrotis lagotis*).

The habitat throughout the Development Envelope and beyond is widespread. During the most recent surveys, no bilbies (or recent burrows) were recorded or identified; however, the Greater Bilby is known to be present within the region based on diggings identified by Eco Logical Australia . Eco Logical Australia indicate that although vegetation within the southeast of the Development Envelope could be considered as appropriate bilby habitat, suitable habitat is also widely available throughout the region. All fauna habitat identified is not considered as significant habitat (or habitat critical to the survival of the species) for the conservation significant species.

Therefore, the Proposal is not expected to result in any impacts to fauna species, impacts to significant fauna habitat, or to result in any species being listed under the BC Act or EPBC Act, and the residual impacts are not expected to be significant.

5.11.3 Subterranean fauna

The principles that are deemed relevant for this factor are:

- high biological diversity
- Habitat for fauna

An assessment of the Proposal against these principles is detailed in the subsections below.

5.11.3.1 High biological diversity / habitat for fauna

Based on results of previous sampling, the 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 Aquifer 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.

Although subterranean fauna have been identified within the region previously, there are no known hotspots or habitat that would signify high abundance of these communities within the Development Envelope.

Given impacts to subsurface are limited (limited to the excavation of the well cellar and drill pipe), direct impacts are not expected. Indirect impacts associated with changes to hydrological regime and accidental releases have been discussed in Section 5.4.4. Given the impacts from these activities are limited, any indirect impacts to subterranean fauna would not be expected. Consequently, the residual impacts from this Proposal are not expected to be significant.

6 Holistic impact assessment

A holistic impact assessment considers the environmental effect of two or more environmental factors or values that have the potential to expose the same receptors (EPA, 2024). To understand the connections between factors and receptors, BNR has developed a conceptual model, as presented in Table 6-1. This model identifies the connections between factors and receptors in this Proposal. If more than one factor had the potential to expose a single receptor, this value was assessed.

Table 6-1: Holistic impact assessment conceptual model

	Vegetation communities	Flora	Groundwater (GDE)	Soil	Fauna	Groundwater users	Aboriginal communities	Air quality
Flora and vegetation	✓	✓						
Terrestrial environmental quality				✓				
Terrestrial fauna	✓				✓			
Inland waters			✓			✓		
Social surrounds	✓					✓	✓	✓
Air quality								
GHG emissions								
Human health								
Subterranean fauna								

6.1.1 Vegetation communities

Vegetation communities provide multiple values across multiple factors. After the environmental impact assessment was completed, BNR reviewed the impacts associated with clearing vegetation communities. In summary, these impacts included:

- reducing the extent of the community (Section 5.1.5)
- reducing available fauna habitat (Section 5.3.5)
- reducing the amenity and aesthetics of a place (Section 5.5.5).

When considering these impacts together is there any potential for combined environmental effects?

BNR considered if there was any connection between these impacts that would increase the outcomes of the individual environmental impact assessment.

As the vegetation communities are well represented and widespread throughout the Development Envelope (and the Kimberley region), clearing should not result in any amenity or aesthetic impacts, with the siting of the well site and access tracks responsible for any incidental aesthetic impacts. The vegetation communities do not provide any critical habitat for conservation significant fauna species, thus clearing should not result in a significant impact to fauna. Consequently, the combined environmental effect is not expected to result in a significant environmental impact and therefore no additional mitigation measures are required to mitigate combined environmental effects.

6.1.2 Groundwater users

After the environmental impact assessment was completed, BNR reviewed the impacts to groundwater users. In summary, these impacts included:

- reducing availability of groundwater for other users (Section 5.3.5)
- contamination of useable aquifers (Section 5.5.5).

When considering these impacts together is there any potential for combined environmental effects?

BNR considered if there was any connection between these impacts that would increase the outcomes of the individual environmental impact assessment.

On review, BNR considers these impacts to be mutually exclusive–the impact of groundwater drawdown may prevent access to groundwater, and the exposure to contaminated aquifers requires access to groundwater.

Consequently, no further assessment was completed because there is no connection between these impacts that would result in a combined impact greater than that assessed in the environmental impact assessment.

7 Cumulative impact assessment

The ESD was published on 8 November 2021 to define the form, content, timing, and procedure of the environmental review, required by Section 40(3) of the EP Act. The ESD included specific requirements to complete accumulative impact assessment for specific factors. This Section assesses the cumulative impacts for various environmental factors, as required by the ESD. Specifically, the ESD requested a cumulative impact assessment be considered with a focus on these factors:

- inland waters
- terrestrial fauna
- flora and vegetation
- social surroundings.

To inform the cumulative assessment of the Proposal, BNR considered the context of other known developments near the Development Envelope. As detailed in Sections 5.5.3.1 and 5.5.3.2, the Development Envelope overlays two pastoral stations (leased Crown land)—Blina Station and Noonkanbah Station—who lease the land for pastoral grazing.

A search of the Plan WA website (DPLH, 2021b) did not identify any other planned developments near the Development Envelope. Consequently, the cumulative impact assessment of the Proposal is limited to those direct impacts associated with the Proposal, other EP 371 petroleum activities, and pastoral grazing activities.

7.1 Inland waters

As detailed in Section 5.4.3, a search for licensed water users within the Development Envelope identified only one other water licence targeting the Liveringa Aquifer, as detailed in Table 5-23. BNR currently has three groundwater licences but has extracted little to no water during the annual care and maintenance program of its assets on EP 371.

Currently, there are ~25 groundwater licences in the wider catchment, with an approximate allocation of <2 GL per year (Harrington & Harrington, 2015). Most groundwater licences are for Aboriginal community bores, some pastoral bores (for diversified activities other than livestock and domestic use), and limited horticultural activities. Unlicensed water use includes livestock and domestic bores (pastoral industry) and Aboriginal community bores.

The nearest licensed groundwater user outside the Development Envelope is the Yungngora Community, ~18 km south of the Development Envelope. BNR understands that other pastoral bores are prevalent throughout the Development Envelope; however, their use and volume of water extracted is not currently known. A review of known pastoral bore locations determined that no pastoral bore is located within 1.5 km of the well sites and modelling of groundwater abstraction (Intera Geosciences 2023) has demonstrated no impact to these wells.

Table 7-1: Summary of groundwater extraction licences targeting the Liveringa Aquifer

Licence Number	Issue date	Expiry date	Allocation (ML)	Owner
174685	05 Oct 2020	04 Oct 2030	309	Main Roads
167493	07 Jan 2021	10 Sep 2023	30	BNR
179134	07 Jan 2021	10 Sep 2023	33.4	BNR
179166	07 Jan 2021	10 Sep 2023	39.4	BNR

The Proposal requires water on a per well basis, and continual water extraction during the activities is not required. Quantitative drawdown modelling (verified by in-field monitoring from previous extraction activities) indicates that only a short-term drawdown would be experienced near the extraction bore (<55 m). Given the distance between well sites, and on the unrealistic assumption that water is extracted from all well sites at the same time, there would be no overlap in groundwater depressions.

No pastoral bores are known to be within 1.5 km of the well sites; therefore, there should be no overlap in groundwater depressions associated with pastoral and Proposal use. Even if there was overlap, any

cumulative impacts would be limited in duration and cease once water extraction was complete. Consequently, cumulative impacts across the Proposal are not expected.

7.2 Terrestrial fauna

As detailed in Section 5.3.3, BNR completed a fauna survey for the disturbance footprint within the Development Envelope , attached as Appendix B. The Development Envelope was characterised into three broad fauna habitat types. An assessment against conservation significant fauna species that may be present within the Development Envelope indicates that this area may provide habitat for the:

- Gouldian Finch (*Erythrura gouldiae*)
- Spotted Ctenotus (northeast) (*Ctenotus uber johnstonii*)
- Northern Short-tailed Mouse (*Leggadina lakedownensis*)
- Greater Bilby (*Macrotis lagotis*).

Other activities within the Development Envelope are limited to pastoral activities, therefore the cumulative impacts to these species are associated with direct disturbance to vegetation and damage to habitat. Cumulative impacts associated with clearing are detailed in Section 7.3.

7.3 Flora and vegetation

A search of the Plan WA website (DPLH, 2021b), DEMIRS EARS website and DWER Clearing Permit System did not identify any other planned developments within or near the Development Envelope. At the time of writing this ERD, the only other petroleum Proposal BNR was aware of near the Development Envelope was the Odin 2D Seismic Survey, located within the Development Envelope itself (Fig.7-1). Consequently, the cumulative impact assessment of the Proposal is limited to those direct impacts associated with:

- existing EP 371 assets (in care and maintenance)
- this Proposal
- Odin 2D Seismic Survey[19]
- pastoral grazing activities.

The Odin 2D Seismic Survey proposes to collect a high-quality 2D dataset that can be used to map geological formations to assist in the identification of gas reserves and detailed reservoir development. The seismic program comprises six lines of temporary clearing (with lines rehabilitated post clearing) totalling 55ha of clearing (Table 7-2). A summary of the activity can be found here: https://ace.dmp.wa.gov.au/ACE/Public/PetroleumProposals/ViewPlanSummary?registrationId=101018 .

Table 7-2 summarises the total clearing impacts associated with these activities, while Table 7-3 breaks down the clearing impacts to specific vegetation associations. The data indicate that the cumulative clearing impacts may result in impacts to <0.058% of a single vegetation association. Compared to the extent and distribution of these associations in the vicinity of the surveys and regionally, removing 0.058% of a vegetation association is not considered significant.

Consequently, the cumulative impact associated with the clearing associated with this Proposal is not considered significant when considered in combination with other known activities near the Development Envelope.

Table 7-2: Clearing impacts associated with various activities

Activity	Vegetation associations	Total proposed clearing or existing disturbance footprint (ha)
Existing EP 371 assets (already cleared and disturbed	North Fitzroy Plain_64 North Fitzroy Plain_699	~8.1 ~8.8

[19] The location of the Odin 2D Seismic Survey is provided in Figure 7-1

Activity	Vegetation associations	Total proposed clearing or existing disturbance footprint (ha)
areas, with some maintained areas)	North Fitzroy Plain_700	~7.6
This Proposal	North Fitzroy Plain_699 North Fitzroy Plain_700 North Fitzroy Plain_710	~5 ~86 ~14
Odin 2D Seismic Survey	North Fitzroy Plain_700 North Fitzroy Plain_710 North Fitzroy Plain_712	~30.9 ~23.5 ~0.6
Pastoral grazing activities	Unknown (not publicly available)	Unknown (not publicly available)

Table 7-3: Cumulative impact and associated vegetation communities

Vegetation association	Cumulative clearing impact (ha)	Current extent (ha) present within the subregion	Cumulative impact % clearing
699	~13.8	179,963.89	0.0076 %
700	~124.5	212,971.66	0.058 %
710	~14.6	25,596.64	0.057 %

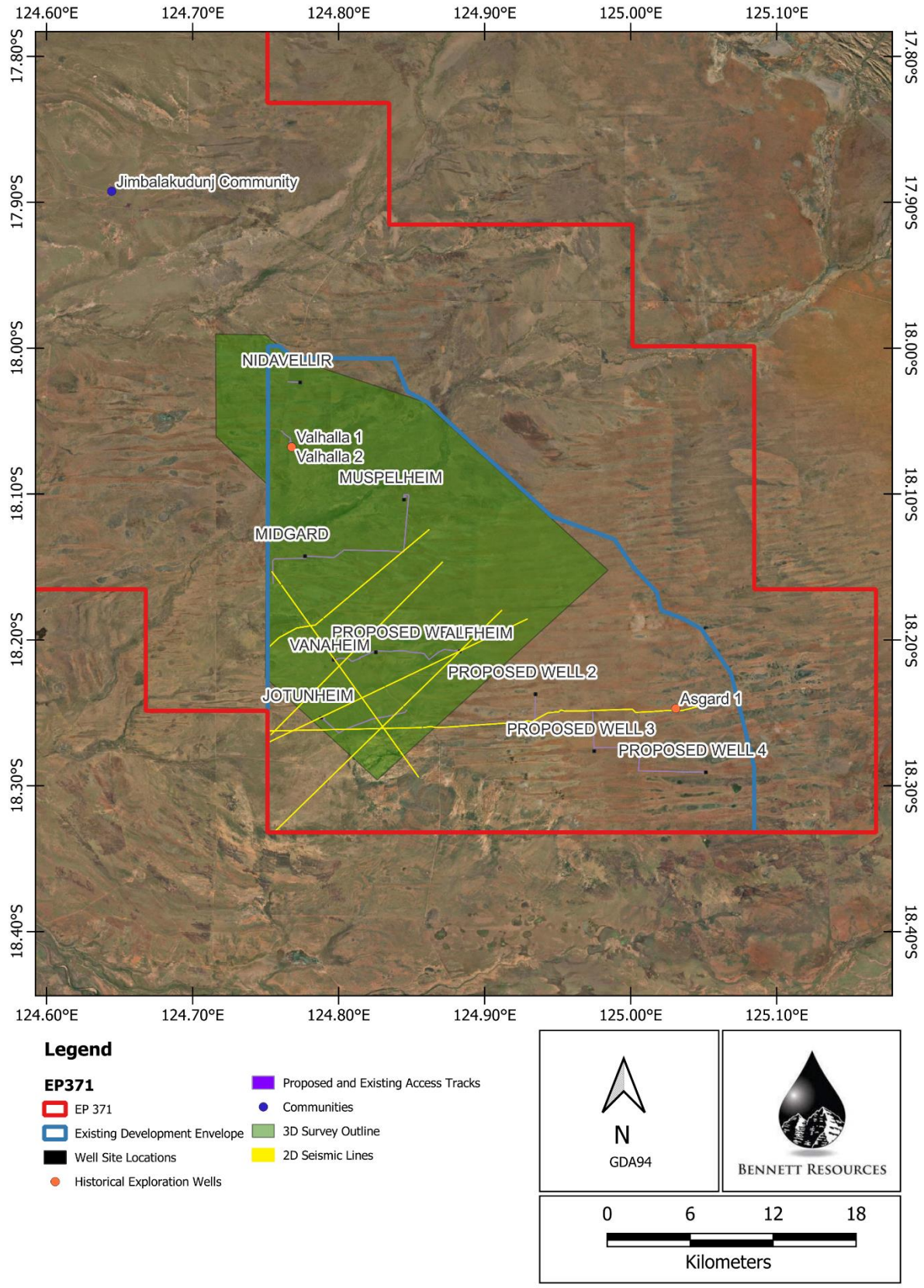


Figure 7-1 Odin seismic survey and location within the Development Envelope

7.4 Social surroundings

A search of the Plan WA website (DPLH, 2021b) did not identify any other planned developments within the Development Envelope. Therefore, the potential for cumulative noise impacts arising from this Proposal and other activities within the Development Envelope are non-existent. As detailed in Section 2, the Proposal plans a staged development for each well site, including:

- site preparation (well site construction)
- drilling activities
- HFS activities
- well testing.

The noise profile is likely to be different at each stage; however, the sound levels associated with HFS activities are expected to be the loudest so these were modelled to understand the extent to which environmental impacts may occur (see Section 5.5.5.2). Even if more than one well site was to operate simultaneously (which is not planned), they are significant enough distances away from each other that sound exposure extents would not overlap. Because the extent of impact does not overlap any sound-sensitive receptors and because sound attenuates rapidly to air, accumulative noise impacts are not expected; ambient noise levels are expected to return to normal almost immediately after each phase of the activity stops.

Consequently, the cumulative impacts arising from noise emissions are not expected to be significant.

Dust generation is significantly reduced during the wet season because the soil and roads are wet. Even if dust is generated at multiple sites, access tracks, and existing roads throughout the year, this will be negated by annual wet season rainfall that is likely to remove dust from vegetation within the Development Envelope. Consequently, the cumulative impact of dust to vegetation is not considered credible.

On the expectation that dust generated from the Proposal will be much less than that produced by bulk material loading/unloading, the EPA provides guidance that at least 1–2 km separation should be maintained between industrial and sensitive land uses (EPA, 2005). The separation from the general Development Envelope is >18 km from the nearest sensitive receptor; therefore, BNR does not believe that any cumulative impacts will arise from dust generation when combined with existing land uses and other activities known to occur within and near the Development Envelope.

No heritage sites have been impacted from historical petroleum activities within EP 371. The Proposal's heritage archaeological and ethnographic survey, which resulted in minor modifications to proposed access tracks, a camp and a proposed well site location, confirmed that the Proposal will not result in any impacts to heritage values. Consequently, no cumulative impacts are expected to heritage values.

The Yungngora and Warlangurru people are supportive of the Proposal and understand the potential benefits that a project such as this would have. They have seen the benefits that previous programs bring—such as training and employment opportunities—and have voiced their support for the Proposal. Although the Proposal may result in a change to the environment (associated with vegetation clearing), this can be mitigated over time because the Kimberley region has high rehabilitation success. Consequently, the cumulative impacts of the Proposal are not deemed significant by themselves, nor when considered in conjunction with the benefits that this Proposal should provide local people.

Blina Station and Noonkanbah Station cover areas of 254,600 ha and 172,400 ha, respectively. The clearing footprint of this Proposal is limited to 110 ha; therefore, the potential direct impact, and thus cumulative impact, is limited to <0.026% of the total area of these pastoral stations. Consequently, the Proposal is not expected to significantly impact pastoral station activities.

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Appendix A. Chemical Inventory

Appendix B. Geotechnical Risk Assessment

Appendix C. Valhalla Flora and Fauna Survey Report 2021

Appendix D. Desktop Vegetation Assessment

Appendix E. Valhalla Environmental Monitoring Program

Appendix F. Regional Baseline Soil Sampling Report

Appendix G. 2023 Soil Samping and Profile (Gemec 2023)

Appendix H. Air Quality and GHG Monitoring Report

Appendix H.1 2021 Data

Appendix H.2 2022 Data

Appendix I. Rockwater 2016 Hydrogeological Assessment

Appendix J. Local Groundwater Characterisation Results

Appendix K. Yungngora Groundwater Quality

Appendix L. Groundwater Modelling

Appendix M. Groundwater Management Plan

Appendix N. Public Health Risk Assessment

Appendix O. Valhalla Baseline Noise Monitoring Report

Appendix P. Valhalla Noise Modelling Assessment

Appendix Q. Baseline Traffic Monitoring Data

Appendix R. GHG Management Plan

Appendix S. Subterranean Fauna Desktop Study

Appendix T. Canning Basin Technical Discussion