BENNETT RESOURCES

Valhalla Gas Exploration and Appraisal Program

Valhalla Monitoring Plan

BNR_HSE_MP_016

VERSION HISTORY				
Ver. No.	**Ver. Date**	**Author**	**Reviewer**	**Revision**
1	10 Jan 2022	AdV, AF	SR	For EPA submission
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Acronym / abbreviation

Terms / acronym	Definition / expansion
AER	Annual Environmental Report
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BNR	Bennett Resources Pty Ltd
BTEXN	Compounds found in crude oil, including Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene
DDG	Dust deposition gauge
DEMIRS	(WA) Department of Energy, Mining, Industrial Relations and Safety (formerly DMIRS)
e.g.	For example
EP 371	Exploration Permit 371
EP Act	(WA) Environmental Protection Act 1986
EPA	(WA) Environmental Protection Authority
ERD	Environmental Review Document
HFS	Hydraulic Fracture Stimulation
i.e.	That is
km	Kilometres
km^2	Square kilometres
LOR	Limit of reporting
m	Metres
NEPC	National Environment Protection Council
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
Proposal	Valhalla Gas Exploration and Appraisal Program
QA/QC	Quality Assurance / Quality Control
VMP	Valhalla Monitoring Plan
WA	Western Australia
WHO	World Health Organization
~	Approximately

1 Summary

This Valhalla Monitoring Plan (VMP) has been prepared by Bennett Resources (BNR) to support the assessment, approval, and implementation of the Valhalla Gas Exploration and Appraisal Program (the Proposal) under Part IV of the *Environmental Protection Act 1986* (EP Act). With the exception of groundwater quality, this VMP presents information for all monitoring scopes proposed for the Proposal, specifically soil quality, air quality, methane emissions and Naturally Occurring Radioactive Material (NORM). The groundwater quality monitoring scope, criteria, indicators and relevant management measures have been presented in the BNR Groundwater Management Plan (BNR_HSE_MP_015) included in the Proposal's Environmental Review Document (ERD) (BNR_HSE_MP_013).

Bennett Resources referred the Proposal to the Environmental Protection Authority (EPA) under Part IV of the EP Act on 24 December 2020 (EPA Assessment Number 2281). The EPA set the level of assessment for the Proposal as Public Environmental Review. The ERD is to include environmental impact assessment and management information, including this VMP which will be subject to an 8-week public review period.

A summary of the VMP is provided in Table 1-1.

Table 1-1: Summary of the Proposal and associated Valhalla Monitoring Plan

Proposal title	Valhalla Gas Exploration and Appraisal Program (EPA Assessment Number 2281)
Proponent name	Bennett Resources Pty Ltd
Ministerial Statement number	The Proposal is currently being assessed by the EPA (Assessment 2281) and a Ministerial Statement and associated proposal implementation conditions are yet to be issued.
Purpose of the VMP	The purpose of this VMP is to detail the monitoring requirements along with response actions for trigger and threshold criteria that are required to be implemented for the duration of the Proposal.
EPA key environmental factors and objectives, and VMP outcomes	**Soil quality monitoring program** Terrestrial Environmental Quality – EPA Objective: *To maintain the quality of land and soils so that environmental values are protected.* VMP outcomes: No short or long-term adverse impacts to soil quality. **Air quality monitoring program** Air Quality – EPA Objective: *To maintain air quality and minimise emissions so that environmental values are protected.* VMP outcomes: No short or long-term adverse impacts to air quality. **Methane emissions monitoring program:** Methane Emissions – EPA Objective: *To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change.* VMP outcomes: No short or long-term adverse impacts to air quality. **NORM monitoring program** Human Health – EPA Objective: *To protect human health from significant harm.* VMP outcomes: No short or long-term adverse impacts to human health.
Key components in the VMP	The key provisions of this VMP are, where relevant: • localised baseline monitoring • activity monitoring • surveillance monitoring • trigger and threshold criteria and subsequent response actions • annual reporting (including results of monitoring).

Proposed commencement date	TBC
VMP required pre-construction ?	Yes ☐ No ☒

2 Context, scope and rational

2.1 Proposal

The Proposal is to complete an unconventional exploration and appraisal drilling and Hydraulic Fracture Stimulation (HFS) program within Petroleum Exploration Permit EP 371 (EP 371) in the Canning Basin, within the Shire of Derby / West Kimberley in Western Australia (WA). The intent of the Proposal is to evaluate the large tight gas resource in the region which has the potential to offer long-term energy security to Australia. The onshore Canning Basin is an early Ordovician to early Cretaceous aged geological basin that covers approximately 430,000 km^2 in the West Kimberley region. The Proposal is targeting hydrocarbons present from the Laurel through to the Devonian Formations, 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. Table 2-1 provides a summary of the proposal.

Table 2-1: 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 involves 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 total area of the physical disturbance footprint for the Proposal is ~112 ha, including some previously disturbed areas and proposed clearing. The estimated maximum amount of clearing for the Proposal is ~110 ha and comprises: • well sites ~40.1 ha • access Tracks ~59.1 ha • camps ~2.8 ha. The exploration and appraisal program are expected to commence in 2024.

2.2 Key environmental factors

Several activities have been identified as having the potential to affect key environmental factors. There have been summarised in the tables below for each relevant EPA factor.

Table 2-2: Summary of key environmental factor – Terrestrial Environmental Quality

EPA objective	To maintain the quality of land and soils so that environmental values are protected.
Policy and guidance	• Environmental Key Factor Guideline – Terrestrial Environmental Quality (EPA 2016a) • National Environment Protection Council (NEPC) (1999). Assessment of Site Contamination Measure (NEPM), Schedule B (1) – Guideline on the Investigation Levels for Soil and Groundwater (NEPC 1999)
Project activities	• site preparations, including ground disturbance • drilling • gas exploration method (unconventional)
Environmental values / receptors	• pastoral station (existing land-use)
Potential impacts – direct impacts	N/A
Potential impacts – indirect impacts	• erosion or scouring from a reduction in soil stability during civil works • inadequate rehabilitation arising from compaction.

	• contamination of land and soils from surface spills.

Table 2-3: Summary of key environmental factor – Air Quality

EPA objective	To maintain air quality and minimise emissions so that environmental values are protected.
Policy and guidance	• Environmental Key Factor Guideline – Air Quality (EPA 2021) • Environmental Protection Act 1986 (WA) • NEPC National Environment Protection (Ambient Air Quality) Measure (NEPM) (NEPC 2016) • National Environment Protection (Air Toxics) Measure (NEPC 2004)
Project activities	• site preparation and site reinstatement • well drilling • well testing
Environmental values / receptors	• local airshed • local Aboriginal communities – Yungngora and Jimbalakudunj Communities.
Potential impacts – direct impacts	N/A
Potential impacts – indirect impacts	• reduction in air quality causing impacts to sensitive social receptors • increased dust generation resulting in deposition impacts to flora and vegetation.

Table 2-4: Summary of key environmental factor – GHG Emissions

EPA objective	To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change.
Policy and guidance	• Environmental Key Factor Guideline – Greenhouse Gas Emissions (EPA 2020) • Environmental Protection Act 1986 (WA) (EP Act) • National Greenhouse and Energy Reporting Act 2007 (NGER Act) (Commonwealth).
Project activities	• land clearing • fuel usage during all activities • flaring during well testing • fugitive emissions.
Environmental values / receptors	• local airshed
Potential impacts – direct impacts	• contribution to GHG emissions.
Potential impacts – indirect impacts	N/A

Table 2-5: Summary of key environmental factor – Human Health

EPA objective	To protect human health from significant harm.
Policy and guidance	• Environmental Key Factor Guideline – Human Health (EPA 2016b).
Project activities	• well drilling • well testing
Environmental values / receptors	• local soil quality • local airshed • human receptors in the surrounds of the well sites

Potential impacts – direct impacts	• industrial processes that result in the build-up and release of radioactive substances or emissions.
Potential impacts – indirect impacts	N/A

2.3 Condition requirements

The Proposal is currently being assessed by the EPA (Assessment 2281) and a Ministerial Statement and associated proposal implementation conditions are yet to be issued.

2.4 Rationale and approach

2.4.1 Environmental outcomes

The overall purpose of this VMP is to quantify the potential environmental impacts and risks associated with the Proposal activities. In meeting this objective, BNR will be able to verify the outcomes of the ERD which state that the impacts and risks are not significant given the manner in which the Proposal is planned to be implemented.

Based upon the monitoring programs selected for the Proposal, an outcome-based approach has been selected given the ability to collect quantitative data that enables unbiased scientific analysis to be completed. Further to this, quantitative environmental and health indicators exist for the environmental factors detailed in this plan, enabling outcomes to be selected for the Proposal.

Consequently, the following outcomes have been defined for this VMP:

- no short or long-term adverse impacts to soil quality
- no short or long-term adverse impacts to air quality
- no short or long-term adverse impacts to human health.

2.4.2 Key assumptions and uncertainty

A number of assumptions have been made and uncertainties observed in the development of this VMP. These are detailed in Table 2-6.

Table 2-6: Assumptions and uncertainties

Regulatory uncertainty	Since the lifting of the moratorium into HFS, the Proposal is the first project that is subject to assessment under the EP Act under the new provisions. Given the project is the first of its kind post moratorium, there is uncertainty regarding EPA and WA government expectations for the project. This has been managed as best as possible through engagement with various government departments and through implementing a conservative monitoring approach (detailed in this VMP).
Code of Practice for HFS activities has not yet been completed	BNR understands that the Code of Practice, which is not currently publicly available, will contain more detail around the monitoring requirements for unconventional oil and gas projects. However, in the absence of the Code of Practice, BNR has tried to manage the uncertainty and assumptions in the development of this VMP following various engagements with different decision-making authorities (DMAs) and subject matter experts. These are detailed in Section 5.

2.4.3 Rational for choice of indicators

Following engagement with various DMAs and as required by the ESD, ecological and social environmental values have been identified for protection within the Development Envelope. To support these values three environmental outcomes have been defined for this VMP (Section 2.4.1).

For each relevant environmental outcome, a set of indicators have been established to provide the environmental quality benchmarks against which environmental quality and the performance of environmental management can be measured. These indicators are quantitative and are described numerically. The key to

successful environmental management is to maintain environmental quality within the bounds described by the indicators, thereby achieving the environmental quality outcomes and ensuring the environmental values continue to be supported.

Indicators have been selected through reviewing a range of industry standards, guidelines and scientific papers. Although these are detailed in the relevant programs, a summary of the documentation that BNR used to identify indicators for the various programs is detailed in Table 2-7.

Table 2-7: Indicator rationale

Program	Reference	Summary
Soil Quality	NEPC (1999). Assessment of Site Contamination Measure (NEPM), Schedule B (1) – Guideline on the Investigation Levels for Soil and Groundwater (NEPC 1999)	Provides: • a comprehensive list of analytes that BNR plans to sample at each well site • ecological screening levels and ecological investigation levels are presented for some of the constituents.
	Botta, C (2015). Understanding your soil test - Step by Step. Yea River Catchment Landcare Group (Botta 2015)	Provides: • information to assist land managers in understanding and interpreting soil test data • chloride critical levels for different types of soil where plant damage can occur.
	DEC (2010). Assessment levels for Soil, Sediment and Water. Contaminated Sites Management Series. Department of Environment and Conservation (DEC 2010)	Provides: • a comprehensive list of analytes that BNR plans to sample at each well site • ecological screening levels and ecological investigation levels are presented for some of the constituents • the source of these screening and investigation levels.
Air Quality	NEPC (2016). National Environment Protection (Ambient Air Quality) Measure. National Environment Protection Council (NEPC 2016)	Provides: • a list of air pollutants that BNR plans to sample for the Proposal • maximum concentration standards are presented for some of the air pollutants BNR plans to sample.
	NEPC (2004). National Environment Protection (Air Toxics) Measure. National Environment Protection Council (NEPC 2004)	Provides: • a list of air pollutants that BNR plans to sample for the Proposal • monitoring investigation levels are presented for some of the air pollutants BNR plans to sample.
	DWER (2019). Air emissions - draft guideline. Department of Water and Environmental Regulation (DWER 2019)	Provides: • a comprehensive list of substances and associated air quality guideline values (maximum ambient concentrations) • the maximum ambient concentrations for an air pollutant planned to be sampled by BNR.
	EPA NSW (2016). Approved methods for the modelling and assessment of air pollutants in New South Wales. Sydney: Department of Environment and Conservation (EPA NSW 2016)	Provides: • a comprehensive list of individual toxic air pollutants • the pollutants' impact assessment criteria, used as guideline values in other referenced sources in the VMP.
	WHO (2010). WHO guidelines for indoor air quality: selected pollutants. World Health Organization (WHO 2010)	Provides: • indoor air quality guideline values for selected pollutants, which have been used by BNR where health or environmental values were available.

Methane Emissions	Monitoring program laboratory reports	Provide: • laboratory limits of reporting, which have been used by BNR as indicators for trigger and threshold monitoring criteria, where no guideline values were available.
NORM	NCRP (1999). Report No. 129: Recommended screening limits for contaminated surface soil and review of factors relevant to site-specific studies. National Council on Radiation Protection and Measurements (NCRP 1999)	Provides: • a list of radionuclides which can be encountered in contaminated surface soils • screening limits (screening reference levels) for contaminated surface soils.
	APPEA. 2002. Guidelines for Naturally Occurring Radioactive Materials. Australian Petroleum Production & Exploration Association Limited (APPEA 2002)	Provides: • monitoring and management guidance of occupational radiation exposures • A radium trigger level for material.

3 VMP components

3.1 Soil quality

The EPA objective for Terrestrial Quality is:

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

BNR does not believe that the Proposal activities will result in any significant impacts to soil quality. Subsequently, the soil quality monitoring program has been developed to meet the following objective:

- no short or long-term adverse impacts to soil quality.

To understand if the Proposal and associated emissions have had any short or long-term adverse impacts to soil quality, BNR collected initial soil samples prior to submitting the draft ERD and followed up with the collection of localized samples in August 2023.

In addition, BNR will collect soil samples and analyse local soil quality at all well sites associated with the Proposal located within the Development Envelope and compare these to the earlier soil collections to finalise a pre-impact baseline. Pre-impact and post activity sampling can then be used to demonstrate upon completion of the activities that no contamination events occurred, or that contamination events occurred, and the area was appropriately rehabilitated. In completing this monitoring program, BNR can verify if the Proposal was undertaken in a manner that maintained the quality of land and soils such that that environmental and social values were protected.

3.1.1 Sample location and frequency

The proposed soil quality monitoring program (including the location and frequency) is detailed in Table 3-1.

Table 3-1: Soil quality monitoring location and frequency

Monitoring type	Location	Phase	Frequency	Number of samples
Pre-impact (profile)	At each well site	Post vegetation clearing and prior to well site sheeting.	Once only. BNR considers that the program will provide sufficient data to complement existing data sets and detail soil profile across the Development Envelope.	One profile will be taken at each well site.
Pre-impact (quality)	At each well site	Post vegetation clearing and prior to well site sheeting.	Once only. BNR considers that the program will provide sufficient data to complement existing data sets and confirm existing soil quality. Soil quality is not affected by seasonal conditions.	At least three samples will be taken at each well site.
Activity (quality)	Flare pit Mud Sump	Prior site reinstatement.	Once only. BNR considers that one sample at these locations will provide sufficient data to confirm if soil quality is suitable to undertake site reinstatement activities.	• Three soil samples to be collected from beneath the flare pit sump tank (0 m deep). • Four samples from the surrounding internal flare pit base (<0.5 m deep). • Two samples of native soils from the flare pit base beneath the gravel ballast material (as appropriate > 0.5m deep). • Three soil samples to be collected from beneath the mud sump (0 m deep). The number of samples were based upon the size of

				infrastructure being investigated and the risk profile of the infrastructure. Where samples indicate contamination has occurred, additional sampling will be undertaken at different locations (and depths) to understand the extent of potential contamination and remediation required.
	Spill Location	Post recovery of contaminated soils	In the event of a Level 2 or 3 spill event in accordance with the OSCP (i.e. a large spill event).	Soil samples will be taken beneath the recovered contaminated soil. Where soil samples provide evidence of contamination, additional soil is to be removed/ recovered, and additional samples collected. This will be repeated until the soil samples indicate a lack of contamination

3.1.2 Sampling methodology

Soil profiles will be manually collected by auger or shovels (or equivalent) such that soil horizons can be identified. Soil samples will be manually collected by auger or shovels (or equivalent) and analysed by a laboratory using NATA accredited methods.

3.1.3 Soil quality indicators

The NEPC Assessment of Site Contamination Measure (NEPM), Schedule B (1) – Guideline on the Investigation Levels for Soil and Groundwater (1999) (NEPC 1999) presents a comprehensive list of analytes that has been used and that BNR will use in the future to sample at each well site. As detailed in the ERD, BNR has identified the following fluids as having the potential to impact soil quality:

- hydrocarbons (diesel spill event)
- drilling fluids / cement (surface spill event)
- HFS fluids (surface spill event)
- produced formation water (PFW) (spill event).

On this basis, the following analytes have been identified for the Proposal to be used as indicators of spill events:

- barium
- cadmium
- chloride
- chromium III
- Total Petroleum Hydrocarbons (TPH).

These will serve as indicators to identify if a release has occurred and trigger a more detailed analysis of all CoPCs.

The Assessment of Site Contamination Measure (NEPC 1999) provides a guideline in which ecological screening levels and ecological investigation levels are presented for some of these analytes. The ecological screening levels and ecological investigation levels will be used as the indicators for this soil monitoring program and are detailed in Table 3-2.

Table 3-2: Soil quality analytes and indicators

Analyte	Indicators
Barium	300 mg/kg (NEPC 1999)
Cadmium	3 mg/kg – Environmental (NEPC 1999)
Chloride	No environmental or health guidelines have been defined for chloride, as such the indicator has been set to the chloride critical level for sands to sandy loam where plant damage can occur: 120 mg/kg (Botta 2015)
Chromium III	400 mg/kg (NEPC 1999)
TPH (C10-C14)	500 mg/kg (DEC 2010)
TPH (C15-C18)	1000 mg/kg (DEC 2010)
TPH (C6-C9)	100 mg/kg (DEC 2010)

Table 3-3: VMP components – soil quality

EPA factor/s and objective/s	To maintain environmental quality and to minimise the risk of environmental harm, so that environmental values are protected			
Outcome/s	No short or long-term changes to soil quality			
Key environmental values	Pastoral station (existing land-use)			
Key impacts and risks	Contamination of land and soils from surface spills			
Indicators	**Response actions**	**Monitoring**	**Frequency**	**Reporting**
Trigger criteria Impact vs control analysis [1] indicates no significant deviation from baseline soil quality samples	**Trigger level actions** Within 60 days of exceedance: • identify the reason for the exceedance and determine direct correlation to construction / ongoing activities or natural variation and review management measures with an adaptive management response • re-examine monitoring results (QA/QC) to validate data • conduct additional sampling/monitoring if required.	Refer to Table 3-1	Refer to Table 3-1	Routine reporting - annual reporting through the DEMIRS Annual Environmental Report (AER) Exceedance reporting to EPA compliance branch – exceedance of the threshold criteria and contingency actions that have been implemented – within 5 days.

Threshold criteria
Exceedance of soil indicators
(Table 3-2)
	Threshold contingency actions
	Within 30 days of exceedance initiate implementation of contingency measures including:
	• re-examine monitoring results (QA / QC) to validate data. Re-monitor if required
	• ground truth the monitoring results to validate findings of the assessment and/or determine/identify what may be causing the exceedance. Where cause is identified during ground truthing and can be rectified, undertake action immediately. For actions which require alternate resources, schedule works to be undertaken as soon as possible
	• where the threshold exceedance was not caused by construction or project activities, resume standard monitoring frequency
	• where the threshold exceedance can be attributed to project activities:
	  ○ implement adaptive management response that may then require:
	  ▪ remediation of soil to commence as required
	  ▪ soil to be disposed offsite
	  ▪ conduct additional sampling / monitoring if required, until a trend back to baseline levels has been demonstrated **and** at least two consecutive results reflect no significant deviation from ambient (baseline) samples.
		Refer to Table 3-1	Refer to Table 3-1	

[1] Given the limited data that is planned to be collected, BNR propose an Impact versus Control approach to assess impacts. BNR plans to collect control samples at each well site prior to construction activities commencing which will enable natural variation at each site to be understood.

3.2 Air quality

The EPA objective for Air Quality is:

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

BNR does not believe that the Proposal activities will result in any significant impacts to air quality. Subsequently, the air quality monitoring program has been developed to meet the following objective:

- no short or long-term adverse impacts to air quality.

To understand if the Proposal and associated emissions have had any short or long-term adverse impacts to air quality, BNR plans to collect air quality samples and analyse for presence of dust and volatile organic carbon (VOC). Pre-impact (baseline) and post activity sampling can then be used to demonstrate upon completion of the activities that no short or long-term impacts to air quality have occurred. In completing this monitoring program, BNR can verify if the Proposal was undertaken in a manner that maintained the quality of air such that that environmental and social values were protected.

3.2.1 Sampling location and frequency

The proposed air quality monitoring program (including the location and frequency) is detailed in Table 3-4.

Table 3-4: Air quality monitoring location and frequency

Monitoring type	Location	Phase	Frequency	Number of samples
Project activities	Downwind on the edge of the well site (or as near to the well site as is safe) At the Nidavellir and Jotunheim well sites (well sites closest to sensitive receptors)	During drilling and HFS	Continuous monitoring station instrument for particulate matter (PM) during drilling and HFS (March-November)	One monitoring station continuously recording hourly PM samples.
	On the edge of the well site (or as near to the well site as is safe) downwind from the proppant storage area, well head, and flare pit. At the Nidavellir and Jotunheim well sites (well sites closest to sensitive receptors)		24-hour VOC canister / location (monthly)	Three VOC canisters positioned in an impact gradient position to understand concentration dispersion over time.
	On the edge of the well site (or as near to the well site as is safe) downwind from the flare At the Nidavellir and Jotunheim well sites (well sites closest to sensitive receptors)		30-day dust deposition gauges (DDGs) / location (monthly)	Three DDGs.
	At existing baseline locations (named AQ_CN and AQ_CS) with a line-of-sight to two closest communities (sensitive receptors)	During drilling and HFS	• continuous monitoring station instrument for PM / location (March-November) • 24-hour VOC canister / location (monthly) • 30-day DDG / location (monthly)	• one monitoring station continuously recording hourly PM samples near each community • one DDG located at each monitoring station • one VOC canister at each monitoring location.

3.2.2 Sampling methodology

3.2.2.1 Dust

BNR plans to continue collecting dust samples using DDGs over an exposure time of 30 days, with the samples analysed by a NATA-accredited laboratory. This method measures dust deposition rate and involves the passive deposition and capture of dust within a funnel and bottle arrangement, thus determining the relative 'dustiness' of the sampling sites.

BNR will continue collecting and analysing PM_{10} and $PM_{2.5}$ using continuous light scattering instruments within air quality monitoring stations. By drawing a constant flow rate of ambient air through a filter, this method determines average dust concentrations over a 24-hour period. Coupled with wind records or collected wind data, this method enables determination of dust levels from a particular event or source. It also provides an indication of the potential health effects of the dust given it measures fine and very fine particles present in the atmosphere.

3.2.2.2 Volatile organic compounds

BNR plans to continue collecting VOCs using 24-hour canisters, in accordance with the *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), with the samples analysed by a NATA-accredited laboratory. Ambient air is admitted into the canister (under vacuum) using a calibrated passive air flow sampler, at a controlled rate over the set period of 24-hours, to obtain a time integrated, whole-air sample. Selected air toxics will then specifically be measured from the collected air in the laboratory. This method provides ambient concentrations of known pollutants present in air, thus enabling the assessment of the potential for risks to human and ecological health.

The location of VOC sampling will include the same sensitive receptor locations as the previously taken baseline samples, to provide directly comparable samples for the trigger and threshold criteria presented in Table 3-6. VOC samples will also be taken on site, with the canisters located in proximity and downwind of the project activities in a manner to understand concentration dispersion over time.

3.2.3 Air quality indicators

Consistent with advice provided throughout the ESD and ERD process, BNR has identified the following analytes to be used in the air quality monitoring program:

- PM_{10}
- $PM_{2.5}$
- total insoluble matter (ash content + combustible matter)
- benzene
- toluene
- ethylbenzene
- total xylenes (as a total of meta-, para- and ortho-xylene)
- naphthalene.

The National Environment Protection Council (NEPC)'s National Environment Protection (Ambient Air Quality) Measure (NEPM) (NEPC 2016), and the National Environment Protection (Air Toxics) Measure (NEPC 2004), provide standards (criteria) for PM_{10} and $PM_{2.5,}$ and monitoring investigation levels for VOCs, respectively. It should be noted that the monitoring investigation level values for VOCs are levels of air pollution below which lifetime exposure, or exposure for a given averaging time, does not constitute a significant health risk. If these limits are exceeded in the short-term it does not mean that adverse health effects automatically occur (NEPC 2004). The indicators for air analytes from other sources are also provided in Table 3-5.

Table 3-5: Air quality analytes and indicators

Analyte	Indicators (health / amenity)
PM_{10}	50 µg/m^3 (24-hour average) – Health (NEPC 2016)
$PM_{2.5}$	25 µg/m^3 (24-hour average) – Health (NEPC 2016)
Total insoluble matter (= ash content + combustible matter)	4 g/m^2/30 days (maximum) – Amenity (EPA NSW 2016) 2 g/m^2/30 days (above background) – Amenity (EPA NSW 2016)
Benzene	0.003 ppm (annual average) – Health (NEPC 2004)
Toluene	1 ppm (24-hour average) – Health (NEPC 2004)
Ethylbenzene	1.8 ppm (1-hour average) – Health (DWER 2019, EPA NSW 2016)
Total Xylenes (as a total of meta-, para- and ortho-Xylene)	0.25 ppm (24-hour average) – Health (NEPC 2004)
Naphthalene	Currently there is no available health guideline for naphthalene in ambient air. As such, the World Health Organization (WHO) indoor air guideline was selected as the indicator for the air quality monitoring program. 0.01 mg/m^3 (annual average) – Health (WHO 2010)

Table 3-6: VMP components – air quality

EPA factor/s and objective/s	To maintain air quality and minimise emissions so that environmental values are protected			
Outcome/s	No short or long-term changes to air quality			
Key environmental values	Aboriginal communities			
Key impacts and risks	Reduction in air quality causing impacts to sensitive social receptors			
Indicators	**Response actions**	**Monitoring**	**Frequency**	**Reporting**
Trigger criteria Impact vs control analysis [2] indicates significant deviation from ambient air quality samples.	**Trigger level actions** Within 60 days of exceedance: • identify the reason for the exceedance and determine direct correlation to drilling/HFS or natural variation and review management measures with an adaptive management response • re-examine monitoring results (QA/QC) to validate data • conduct additional sampling / monitoring if required until a trend back to baseline levels has been demonstrated and at least two consecutive results reflect no significant deviation from ambient (baseline) samples.	Refer to Table 3-4	Refer to Table 3-4	Routine reporting - annual reporting (AER)
Threshold criteria Exceedance of air quality indicators (Table 3-5)	**Threshold contingency actions** Within 30 days of exceedance initiate implementation of contingency measures including: • re-examine monitoring results (QA/QC) to validate data. Re-monitor if required until a trend has been demonstrated • ground truth the monitoring results to validate findings of the assessment and/or determine/identify what may be causing the exceedance. Where cause is identified during ground truthing and can be rectified, undertake action immediately. For actions which require alternate resources, schedule works to be undertaken as soon as possible • where the threshold exceedance was not caused by drilling/HFS, resume standard monitoring frequency • where the threshold exceedance can be attributed to the Proposal activities: o implement adaptive management response that may then require: ▪ for dust and particulate matter: ➢ augment dust suppression through use of water cart ➢ review and adapt the storage and transportation method of proppant sand on site ▪ for VOCs:	Refer to Table 3-4	Refer to Table 3-4	Exceedance reporting to EPA compliance branch – exceedance of the threshold criteria and contingency actions that have been implemented – within 5 days.

[2] BNR proposes an Impact versus Control approach to assess impacts. BNR plans to utilise existing baseline data from across the Development Envelope on the assumption that natural variation locally is likely to be limited, this approach is considered suitable.

	➢ increase the distance between the sampling locations and re-characterise the extent of exposure from the activities ➢ consider communicating exclusion zones around the well site to prevent exposure ▪ conduct additional sampling/monitoring if required until a trend back to baseline levels has been demonstrated and at least two consecutive results reflect no significant deviation from ambient (baseline) samples .			

3.3 Methane emissions

The EPA objective for GHG Emissions is:

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

BNR does not believe that the Proposal activities will result in a significant contribution to GHG emissions that will lead to environmental harm. Subsequently, the methane emissions monitoring program has been developed to meet the following objective:

- Verity that the Proposal and associated emissions have not had any short or long-term adverse impacts to air quality.

To understand if the Proposal and associated emissions have had any short of long-term adverse impacts to air quality, BNR plans to collect air quality samples and analyse for presence of methane. Pre-impact and post activity sampling can then be used to demonstrate upon completion of the activities that no short or long-term impacts to air quality have occurred. In completing this monitoring program, BNR can verify if the Proposal was undertaken in such a manner that reduced methane emissions in order to minimise the risk of environmental harm associated with climate change.

3.3.1 Sampling location and frequency

The proposed methane emissions monitoring program (including the location and frequency) is detailed in Table 3-7.

Table 3-7: Methane emissions monitoring location and frequency

Monitoring type	Location	Phase	Frequency	Number of samples
Surveillance	At each well site	Post HFS	Biennial sampling using 24-hour air canisters. BNR considers that the program will provide sufficient data to determine if any fugitive emissions from the well occur over the life of the well	One canister positioned around the well head

3.3.2 Sampling methodology

BNR plans to continue sampling for methane using 24-hour canisters, using the EP104 light hydrocarbon (calculated concentration) method, with the samples analysed by a NATA-accredited laboratory. Ambient air is admitted into the canister (under vacuum) using a calibrated passive air flow sampler, at a controlled rate over the set period of 24-hours, to obtain a time integrated, whole-air sample. Methane will then specifically be measured from the collected air in the laboratory. This method provides ambient concentrations of known pollutants present in air, thus enabling the assessment of the contribution to air pollution.

The location of methane emission monitoring will be based upon the location of the potential fugitive methane emissions arising post-activity from the Proposal.

3.3.3 Methane indicator

Given baseline samples within the Development Envelope determined that methane levels are below the detection limit (i.e. the laboratory LOR) of 3.3 mg/m^3, and given there is no environmental or health guideline value associated with methane levels, BNR has chosen to set the indicator as 3.3 mg/m^3 (Table 3-8).

Table 3-8: Methane analyte and indicator

Analyte	Indicator
Methane	3.3 mg/m^3 (laboratory LOR)

Table 3-9: VMP components – methane emissions

EPA factor/s and objective/s	To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change			
Outcome/s	No short or long-term changes to air quality			
Key environmental values	Various			
Key impacts and risks	Contribution to GHG emissions.			
Indicators	**Response actions**	**Monitoring**	**Frequency**	**Reporting**
Trigger criteria A single exceedance of the indicator (Table 3-8)	**Trigger level actions** Within 60 days of exceedance: • identify the reason for the exceedance and determine direct correlation to project activities or natural variation, and review management measures with an adaptive management response • re-examine monitoring results (QA/QC) to validate data • conduct additional sampling within 6 months if required and until a trend back to baseline levels has been demonstrated and at least two consecutive results reflect no significant deviation from ambient (baseline) samples.	Table 3-7	Table 3-7	Routine reporting - annual reporting (AER) Exceedance of the threshold criteria and contingency actions that have been implemented due to the exceedance of threshold criteria – within 5 days.

Threshold criteria
Consecutive exceedance of the indicator (Table 3-8)
	Threshold contingency actions
	Within 30 days of exceedance initiate implementation of contingency measures including:
	• identify the reason for the exceedance and determine direct correlation to well site fugitive gas emissions, existing land use, or natural variation and review management measures with an adaptive management response
	• re-examine monitoring results (QA/QC) to validate data.
	• where the exceedance was not caused by the assets, resume standard monitoring frequency
	• where the threshold exceedance can be attributed to the assets:
	  ○ implement adaptive management response that may then require:
	  ▪ conduct additional sampling monitoring if required, increasing the monitoring frequency if required, to determine if emissions reduce and continue monitoring until a trend back to baseline levels has been demonstrated and at least two consecutive results reflect no significant deviation from ambient (baseline) samples.
	  ▪ investigate assets to confirm if gas leakage is occurring and determine how leakage can be remediated on the asset
	  ▪ remediate assets to prevent further gas leakage and fugitive emissions
	  ▪ continue sampling/monitoring post remediation.
		Table 3-7	Table 3-7	

3.4 NORM

The EPA objective for Human Health is:

- to protect human health from significant harm.

BNR does not believe that the Proposal activities will result in any impacts to human health. Subsequently, the NORM monitoring program has been developed to meet the following objective:

- no short or long-term adverse impacts to human health.

To understand if the Proposal and associated NORM emissions have had any short or long-term adverse impacts to human health, BNR plans to collect drill cuttings and PFW samples and analyse for the presence of NORM. Based upon NORM presence and levels, post activity sampling can be used to demonstrate upon completion of the activities that no short or long-term impacts to human health (limited to public health) have occurred. In completing this monitoring program, BNR can verify that the Proposal was undertaken in such a manner that protected human health from significant harm.

3.4.1 Sampling location and frequency

The proposed NORM monitoring program (including the location and frequency) is detailed in Table 3-10.

Table 3-10: NORM monitoring location and frequency

Monitoring type	Location	Phase	Frequency	Number of samples
Project activities	Mud sump	Following well drilling	Once only. BNR considers that one sample will provide sufficient data to characterise the composition of drill cuttings and confirm if NORM is present	One sample of drill cuttings within the mud sump at each well site
Project activities	Produced water retention pond	During well testing	Once only. BNR considers that one sample will provide sufficient data to characterise the composition of the formation water produced during HFS and confirm if NORM is present	One sample of PFW at each well site

3.4.2 Sampling methodology

Drill cutting samples will be manually collected using lab-supplied jars, and PFW samples collected using lab-supplied bottles, and analysed by a laboratory using NATA accredited methods.

3.4.3 NORM indicators

NORM indicators were based on the screening reference levels from the NCRP Report No. 129 Recommended screening limits for contaminated surface soil and review of factors relevant to site-specific studies (NCRP 1999). For each radionuclide, the screening reference level is the most conservative value from the range of land-use scenarios presented in the NCRP report. The screening levels are designed to restrict the total annual dose to any exposed person from a single contaminated site to no more than 250 µSv. The indicators for drill cutting NORM are provided in Table 3-11.

Table 3-11: NORM and indicator for drill cuttings

Analyte	Indicators (soil)
Uranium-238	620 Bq/kg (NCRP 1999)
Radium-226	3.7 Bq/kg (NCRP 1999)
Radium-228	In the absence of a specific guideline value for Radium-228 in soil, BNR have used the general radium guideline limit for solid NORM specified in the APPEA NORM guidelines (APPEA 2002):

	2,400 Bq/kg – should the specific radium activity exceed this value, the material should be regarded as NORM (APPEA 2002)
Lead-210	14 Bq/kg (NCRP 1999)
Thorium-232	2.3 Bq/kg (NCRP 1999)

Produced formation water NORM indicators were based on the Australian Drinking Water Guidelines (NHMRC and NRMMC 2011 (updated March 2021)), which provide a guideline value for annual exposure to radioactivity in drinking water. Produced formation water NORM indicators are presented in Table 3-12 below.

Table 3-12: NORM Indicators for PFW

Analyte	Indicators
Uranium isotopes (Uranium-238)	0.17 mg/L – Non-potable groundwater use (DOH 2014) The Australian water quality guidance level in drinking water is 0.5 Bq/L for gross alpha (α) and 0.5 Bq/L for gross beta (β). 0.5 Bq/L (NHMRC and NRMMC 2011)
Radium isotopes (Radium-226, Radium-228) Lead isotopes (Lead-210) Thorium isotopes (Thorium-232)	The Australian water quality guidance level in drinking water is 0.5 Bq/L for gross alpha (α) and 0.5 Bq/L for gross beta (β). 0.5 Bq/L (NHMRC and NRMMC 2011)

Table 3-13: VMP components – human health

EPA factor/s and objective/s	To protect human health from significant harm			
Outcome/s	No short or long-term adverse impacts to human health			
Key environmental values	Human Health			
Key impacts and risks	Build-up and release of radioactive substances or emissions that may impact on human health			
Indicators	**Response actions**	**Monitoring**	**Frequency**	**Reporting**
Trigger criteria Exceedance of NORM indicators (Table 3-11 and Table 3-12).	**Trigger level actions** • Within 60 days of exceedance: ○ re-examine monitoring results (QA/QC) to validate data ○ conduct additional sampling/monitoring if required to determine if NORM levels have changed ○ adapt the waste management strategy (including storage and disposal of wastes) for drill cuttings and PFW.	Table 3-10	Table 3-10	Annual reporting (AER) Exceedance reporting to EPA compliance branch – exceedance of the threshold criteria and contingency actions that have been implemented – within 5 days.

4 Adaptive management and review of the VMP

4.1 Adaptive management

This VMP is intended to be dynamic and may be updated to reflect changes in management practices and the natural environment over time. Consequently, BNR will implement an adaptive management framework that allows BNR to adapt and implement improvements as a result of monitoring against trigger and threshold criteria detailed in this document. This will ensure that impacts and risks are reduced to as low as reasonably practicable as well as ensuring the environmental outcomes of this VMP are achieved.

The following approaches will apply:

- monitoring data will be systematically evaluated
- the effectiveness and relevance of trigger level and threshold contingency actions will be evaluated to determine if any changes to response actions are required.

Adaptive management practices that will be assessed as part of this approach may include:

- evaluation of each monitoring program, data and comparison to baseline data and reference sites on an annual basis to verify whether responses to Proposal activities are the same or similar to predictions
- evaluation of assumptions and uncertainties of the management and monitoring program
- re-evaluation of the risk assessment and revision of risk-based priorities as a result of monitoring outcomes
- review of data and information gathered over the review period that has increased understanding of site environment in the context of the regional ecosystem
- assessment of changes which are outside the control of the project and the response actions identified.

4.2 Monitoring plan review

In the event this plan is reviewed over the duration of the Proposal, BNR will treat it the same as other Part IV Environmental Management Plans. Specifically, a table summarising the changes following the template provided as Table 4-1 will be developed. This table will clearly indicate location and reason/s for changes. A tracked change version of the revised VMP will be provided for all minor, non-structural changes to the document.

Table 4-1: VMP review template

Complexity of changes	Minor revisions ☐	Moderate revisions ☐	Major revisions ☐	
Number of key environmental factors	One ☐	2-3 ☐	> 3 ☐	
Date revision submitted to EPA	DD/MM/YYYY			
Proponent's operational requirement timeframe for approval of revision	< One Month ☐	< Six Months ☐	> Six Months ☐	None ☐
Reason for Timeframe				

Item number	VMP section number	VMP page number	Summary of change	Reason for change
1.				
2.				
3.				

5 Stakeholder consultation

BNR consulted with stakeholders during the development of the EPA referral. Engagements that are deemed relevant are included in Table 5-1.

Table 5-1:Stakeholder engagement relevant to this VMP

Stakeholder	Method of engagement	Date of engagement	Summary of engagement
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.
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.
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.
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.
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.
EPA	Email	15 Feb 2021	Discussed monitoring frameworks for dust, VOCs, and 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.

For a full summary of stakeholder engagement records refer to the BNR Environmental Review Document (BNR_HSE_MP_013).

Any additional consultation specifically regarding this VMP will be captured in subsequent revisions.

6 References

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