



BENNETT RESOURCES

Valhalla Gas Exploration and Appraisal Program

Groundwater Management Plan

BNR_HSE_MP_015

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Contents

| | | |
|-------|---|----|
| 1 | Executive summary | 5 |
| 2 | Context, scope and rational | 6 |
| 2.1 | PROPOSAL | 6 |
| 2.2 | KEY ENVIRONMENTAL FACTORS | 6 |
| 2.3 | CONDITION REQUIREMENTS | 7 |
| 2.4 | RATIONALE AND APPROACH | 7 |
| 2.4.1 | <i>Receiving environment</i> | 7 |
| 2.4.2 | <i>Environmental outcomes</i> | 8 |
| 2.4.3 | <i>Groundwater Drawdown</i> | 9 |
| 2.4.4 | <i>Groundwater Contamination</i> | 13 |
| 2.4.5 | <i>Management approach</i> | 21 |
| 2.4.6 | <i>Rationale for choice of indicators and/or response actions</i> | 21 |
| 3 | GWMP components | 24 |
| 3.1 | GROUNDWATER MONITORING PROGRAM | 28 |
| 3.1.1 | <i>Groundwater Sampling Location</i> | 30 |
| 3.1.2 | <i>Groundwater Sampling Duration</i> | 31 |
| 3.2 | REPORTING | 31 |
| 4 | Adaptive management and review of the GWMP | 32 |
| 4.1 | MONITORING AND ADAPTIVE MANAGEMENT | 32 |
| 4.2 | MANAGEMENT PLAN REVIEW | 32 |
| 5 | Stakeholder consultation | 34 |
| 6 | References | 35 |

Figure

| | | |
|--------------|--|----|
| Figure 2-1 | Drawdown contours associated with the extraction of 33,306 kL (Rockwater model) | 10 |
| Figure 2-2: | Mod 1 model results presented as drawdown contours after six months of pumping, with contour interval = 0.2 m (Intera model) | 11 |
| Figure 2-3: | Electrical conductivity [Liveringa] | 15 |
| Figure 2-4: | Chloride [Liveringa] | 15 |
| Figure 2-5: | Sulfate [Liveringa] | 15 |
| Figure 2-6: | Boron [Liveringa] | 15 |
| Figure 2-7: | Cadmium [Liveringa] | 16 |
| Figure 2-8: | Copper [Liveringa] | 16 |
| Figure 2-9: | Benzene [Liveringa] | 16 |
| Figure 2-10: | Toluene [Liveringa] | 16 |
| Figure 2-11: | Ethylbenzene [Liveringa] | 16 |
| Figure 2-12: | Xylene [Liveringa] | 16 |
| Figure 2-13: | Methane [Liveringa] | 16 |
| Figure 2-14: | Location of VNB4S / VNB4D and AB1D / AB1S and proximity to existing infrastructure | 17 |

| | | |
|---|---------------------|----------------|
|  BENNETT RESOURCES | Document No: | BNR_HSE_MP_015 |
| | Revision: | 5 |
| | Issue Date: | 27 May 2025 |

Figure 2-15: Schematic of the Asgard and Valhalla North groundwater monitoring bores 18

Figure 2-16: Location of Liveringa groundwater sampling bores for local groundwater characterisation and groundwater contours 19

Table

| | |
|--|----|
| Table 1-1: Executive summary of the GWMP | 5 |
| Table 2-1: Summary of the Proposal | 6 |
| Table 2-2: Summary of key environmental factor – Inland Waters | 6 |
| Table 2-3: Summary of Liveringa Aquifer values | 8 |
| Table 2-4: Summary of Poole Sandstone Aquifer values | 8 |
| Table 2-5 Key assumptions and uncertainties | 13 |
| Table 2-6: Summary of groundwater monitoring bores sampled | 14 |
| Table 2-5 Key assumptions and uncertainties | 20 |
| Table 2-6: Groundwater Health Screening Levels | 22 |
| Table 3-1: GWMP components | 25 |
| Table 3-2: Groundwater monitoring program | 28 |
| Table 4-1: GWMP review template | 33 |
| Table 5-1: Stakeholder engagement relevant to this GWMP | 34 |

**Acronym / abbreviation / definition**

| 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 |
| Baseline groundwater monitoring | Refers to the measurement of groundwater levels and collection of groundwater samples to determine water quality prior to the commencement of proposed activities |
| BNR | Bennett Resources Pty Ltd |
| DEMIRS | (WA) Department of Energy, Mines, Industry Regulation and Safety (from 1 Dec 2023) |
| DMIRS | Former (WA) Department of Mines, Industry Regulation and Safety, now DEMIRS |
| DMP | Former (WA) Department of Mines and Petroleum; now DEMIRS |
| DoW | Former (WA) Department of Water; now DWER |
| DWER | (WA) Department of Water and Environmental Regulation |
| EIA | Environmental Impact Assessment |
| EMP | Environmental Management Plan |
| 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 |
| GDE | Groundwater Dependent Ecosystems |
| GWMP | Groundwater Management Plan |
| ha | Hectare |
| HFS | Hydraulic Fracture Stimulation |
| i.e. | That is |
| kL | Kilolitres |
| km | Kilometres |
| km ² | Square kilometres |
| m | Metres |
| ML | Megalitres |
| Proposal | Valhalla Gas Exploration and Appraisal Program |
| QA/QC | Quality Assurance / Quality Control |
| SD | Standard Deviation |
| Surveillance groundwater monitoring | Refers to monitoring that occurs after commencement of an activity and is not considered to be representative of 'baseline 'conditions. Any data collected after commencement of a petroleum activity should be directly compared to baseline data and relevant standards to determine whether changes have occurred |
| WA | Western Australia |



BENNETT RESOURCES

| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

| Terms / acronym | Definition / expansion |
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| ~ | Approximately |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

1 Executive summary

This Groundwater Management Plan (GWMP) 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).

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 has decided to assess the Proposal as Public Environmental Review. The Environmental Review Document (ERD) is to include environmental impact assessment (EIA) and management information, including this environmental management plan (EMP), which will be subject to an eight-week public review period.

This GWMP has been written in accordance with the guideline “Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans” (EPA 2021). An executive summary of this GWMP is provided in Table 1-1.

Table 1-1: Executive summary of the GWMP

| | |
|--|--|
| 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 GWMP | The purpose of this GWMP is to detail the monitoring requirements along with response actions for trigger and threshold criteria that are required for the Proposal. |
| EPA key environmental factor and objective, and GWMP outcomes | <p>Inland Waters – EPA objective: <i>To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.</i></p> <p>GWMP outcomes:</p> <ul style="list-style-type: none"> no long-term changes to groundwater levels no short or long-term changes to groundwater quality. |
| Condition clauses | No Ministerial Statement at the time of preparing the GWMP. |
| Key components in the GWMP | <p>The key components of this GWMP are:</p> <ul style="list-style-type: none"> baseline groundwater monitoring: which refers to the measurement of groundwater levels and collection of groundwater samples to determine water quality prior to the commencement of proposed activities. surveillance groundwater monitoring: which refers to monitoring that occurs after commencement of an activity and is not considered to be representative of 'baseline' conditions. Any data collected after commencement of a petroleum activity should be directly compared to baseline data and relevant standards to determine whether changes have occurred. trigger and threshold criteria and subsequent response actions annual reporting (including results of monitoring). |
| Proposed construction / commencement date | TBC – within Calendar Year 2026. |
| EMP required pre-construction / commencement? | Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |



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|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

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 km² 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 (EPA Assessment Number 2281) |
| Proponent name | Bennett Resources Pty Ltd (BNR) |
| Short description | <p>The Proposal is to undertake an unconventional exploration and appraisal drilling program within EP 371, located in the Canning Basin, West Kimberley of Western Australia. The Proposal involves constructing up to 20 exploration wells within 10 well sites.</p> <p>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.</p> <p>The exploration and appraisal program are expected to commence in 2026.</p> |

2.2 Key environmental factors

Two key elements have been identified as having the potential to affect the Key Environmental Factor – Inland Waters. These are:

- water abstraction for process water and camp supply
- gas exploration method (unconventional).

A summary of the Inland Waters environmental factor with a specific focus on these elements and subsequent impacts relating to this activity is included below in Table 2-2.

Table 2-2: Summary of key environmental factor – Inland Waters

| | |
|---|---|
| EPA objective | To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected. |
| Policy and guidance | <ul style="list-style-type: none"> • Environmental Key Factor Guideline – Inland Waters (EPA 2018) • Australian and New Zealand Environment and Conservation Council (ANZECC) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2018) • Department of Water – Water Quality Protection Notice 26 (liners for containing pollutants, using synthetic membranes) (DoW 2013) • Department of Mines and Petroleum (DMP) / Department of Water (DoW). Guideline for groundwater monitoring in the onshore petroleum and geothermal industry (DMP & DoW 2016). |
| Project activities | <ul style="list-style-type: none"> • water abstraction for process water and camp supply • gas exploration method (unconventional). |
| Environmental values / receptors | <ul style="list-style-type: none"> • Liveringa and Grant Group (including Poole Sandstone and Reeves) Aquifers • the Groundwater Dependent Ecosystem (GDE) Mount Hardman (associated with the Liveringa Aquifer) • other groundwater users (>18 km away from the Development Envelope). |
| Potential impacts – direct impacts | <ul style="list-style-type: none"> • changes to groundwater levels (groundwater drawdown) associated with water extraction • contamination of surficial aquifers due to lost circulation. |

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| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

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| Potential impacts – indirect impacts | <ul style="list-style-type: none"> contamination of aquifers through unplanned fracture heights contamination of surficial aquifers from an accidental release at the surface of drilling fluids, HFS chemicals, liquid hydrocarbons or produced formation water. |
|--|---|

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. Should this Proposal be approved for implementation, any conditions relating to this GWMP will be included in this section.

2.4 Rationale and approach

This section provides a concise description of the rationale and approach for this Plan. Specifically, the following sub-sections summarise:

- the site-specific environmental values, existing and/or potential uses, ecosystem health condition or sensitive component of the key environmental factor which will be affected (Section 2.4.1)
- study findings (Section 2.4.3)
- key assumptions and uncertainties (Section 2.4.4)
- management approach (Section 2.4.5)
- rational for choice of indicators (Section 2.4.6).

2.4.1 Receiving environment

The Development Envelope 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 of more than 450,000 km² (DoW 2012). The major regional aquifer systems in the Canning Basin are (in order of decreasing age):

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

Data from three petroleum wells drilled within the Development Envelope by the previous operator of EP 371 provides a detailed two-dimensional cross section of the aquifers located within the Development Envelope. Specifically, the major aquifers that are present within the Development Envelope include the:

- Liveringa aquifer
- Grant Group (including the Poole Sandstone aquifer).

A detailed summary of these aquifers with reference to local data has been provided in the Environmental Review Document for the Proposal (BNR_HSE_MP_013) and has not been duplicated here. However, a summary of the values of these aquifers is provided in Table 2-3 and Table 2-4.

Water quality of the Liveringa aquifer within the Development Envelope is well understood given the sampling programs that have been conducted for previous petroleum activities within EP 371.

Data provided from the Yungngora Community (over the past 4 years) and Fitzroy Crossing public drinking water source area reserve have been used to inform the water quality of the Poole Sandstone aquifer. These were selected as they are the closest groundwater users that extract water for potable drinking purposes. The Poole Sandstone aquifer is hydrogeologically similar to and considered to be part of the Grant Group.

Information regarding the aquifer quality of the Liveringa and Poole Sandstone aquifers is provided in the ERD and has not been duplicated here.

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| Author / Reviewer: | AES / SR | Approver: | ML | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 7 of 35 |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

Table 2-3: Summary of Liveringa Aquifer values

| | |
|---|--|
| Aquifer | Liveringa |
| Recharge mechanism | Rainfall on outcrop areas |
| Connectivity with other aquifers | Limited – underlain by the Noonkanbah (shale) Formation that is considered an aquitard, and is ~357 m thick |
| Number of baseline samples and duration of program | At least 21 samples (per bore) over 5 years |
| Number of groundwater licences within the Development Envelope | 4 |
| Regional use | <ul style="list-style-type: none"> • unlicensed livestock bores • main roads • oil and gas. |

Table 2-4: Summary of Poole Sandstone Aquifer values

| | |
|---|--|
| Aquifer | Grant Group (including Poole Sandstone) |
| Recharge mechanism | Rainfall on outcrop and shallow outcrops (none present within the Development Envelope) |
| Connectivity with other aquifers | Marginal – underlain by the Grant formation with similar rocks to the Poole Sandstone. The Grant group is underlain by the Anderson (shale) Formation that is considered an aquitard and is ~184–279 m thick |
| Number of baseline samples and duration of program | At least 5 samples (per bore) over 3 years |
| Number of groundwater licences within the Development Envelope | One, however, there are no known extraction bores. |
| Regional use | <ul style="list-style-type: none"> • oil and gas operators • mining operators • main roads • unlicensed for uses such as livestock and domestic bores • potential tourist operations • Indigenous community bores. |

2.4.2 Environmental outcomes

The overall purpose of this GWMP is to quantify the potential environmental impacts and risks associated with the Proposal activities on inland waters. 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.

It should be noted that source-receptor pathways are clearly described in Section 5.4 of the ERD and will not be repeated here. However, in short, all impact pathways fall into two key categories:

- Groundwater contamination event
 - surface release (Section 5.4.5.5 and Section 5.4.5.6 of the ERD)
 - subsurface release (Section 5.4.5.2 and Section 5.4.5.4 of the ERD)
- Groundwater drawdown event
 - Groundwater abstraction (Section 5.4.5.1 of the ERD)

Based upon the groundwater monitoring program selected for the Proposal (Section 3.1), an outcome-based approach has been selected given the ability to collect quantitative data that enables unbiased scientific analysis



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

to be completed. Further to this, the quantitative groundwater indicators for this GWMP have been based on baseline regional and local data, enabling outcomes to be selected for the Proposal.

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

- No long-term changes to groundwater levels
- No short or long-term changes to water quality.

2.4.3 Groundwater Drawdown

2.4.3.1 Study findings

To inform the impact assessment associated with groundwater drawdown to other groundwater users and the Mount Hardman Creek GDE, BNR utilised a study by Rockwater (2016) that considered groundwater drawdown associated with HFS water abstraction within the Development Envelope. To complete the drawdown modelling, Rockwater utilised Modflow Pro version 8.0.45, which incorporates MODFLOW, a groundwater modelling software designed by the US Geological Survey (McDonald and Harbaugh 1988). The model was set up with a rectangular grid of 57 rows, 57 columns and two layers covering an area of 5 km by 5 km centred on a single production bore. Layer 1 extends to 50 m depth, and Layer 2 to 170 m depth. Model cell sizes range from 25 m by 25 m near the production bore, to 100 m by 100 m in peripheral areas.

The model was set up initially with parameters that are typical of a minor aquifer such as the Liveringa but was calibrated with drawdown data observed during field monitoring. The model was run to predict groundwater level drawdowns arising from pumping a bore over a six-month period at the average rate required to produce 33,400 kL. The calculated drawdowns after six months of extraction are shown for each model layer in Figure Table 2-1. Modelling predicted that drawdowns of 1 m or more could extend up to 410 m from a production bore at the (deep) level of the screens in the production bore, but that there would be smaller drawdowns in the top 50 m of the Liveringa formation: 1.2 m close to the bore decreasing to 1 m at a distance of about 56 m from the bore, and 0.1 m at 690 m distance. Although the modelling is based on assumed parameters and the results are not unique, the calculated drawdowns are consistent with monitoring on the bores at the Valhalla North 1 and Asgard 1 well sites, where drawdowns at shallow depths (albeit with lower pumping rates) have been very small, and difficult to distinguish from normal seasonal fluctuations of about 0.2 to 1 m (depending on the frequency and magnitude of recharge events). For an overview of groundwater depth over the course of historic groundwater monitoring, refer to Appendix H of the Environmental Review Document (BNR_HSE_MP_013).

Using an extraction volume of 100,000 kL (100 ML) (which is the conservative maximum extraction for a Phase II well for the Proposal), 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 (Rockwater 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.

This model was not considered to be sophisticated enough and the potential for a drawdown of up to one metre raised concern through discussions with DWER. Therefore, additional modelling work was commissioned from Intera Geosciences Pty Ltd. MODFLOW 2005 was used to complete a detailed quantitative model to better understand groundwater drawdown. The Groundwater Vistas (ESI) modelling software was used to develop the input files, run the model executables and process model output. Two primary models were developed, one simulating the unconfined Liveringa Group (Mod 1) and one simulating the Poole aquifer system (Mod 2). A full explanation of the modelling approach is contained in annex to this management plan.

Model results are presented as mapped drawdown contours with a minimum contour of 0.2 m and a 0.2 m contour interval, which was chosen as normal seasonal fluctuations can range between 0.2 m and one metre, so any values less than 0.2 m are likely not significant relative to natural variations.

The modelled drawdown at the end of the six-month pumping period for Mod 1 showed the radius of the 0.2 m drawdown contour was within 400 metres of each pumping bore, so would have no impact on any existing bores or groundwater systems.

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| Author / Reviewer: | AES / SR | Approver: | ML | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 9 of 35 |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

The results from Mod 2 were similar, with predicted drawdowns of up to 0.4 m, which is expected to be difficult to distinguish from normal seasonal variations in water levels of 0.2 – 1 M (Rockwater 2016).

Note, this means that the short-term drawdown will have less effect on the environment than seasonal fluctuations, given a maximum drawdown of between 0.2 and 0.4 m and a recovery to 0.1 m within one year of the cessation of pumping.

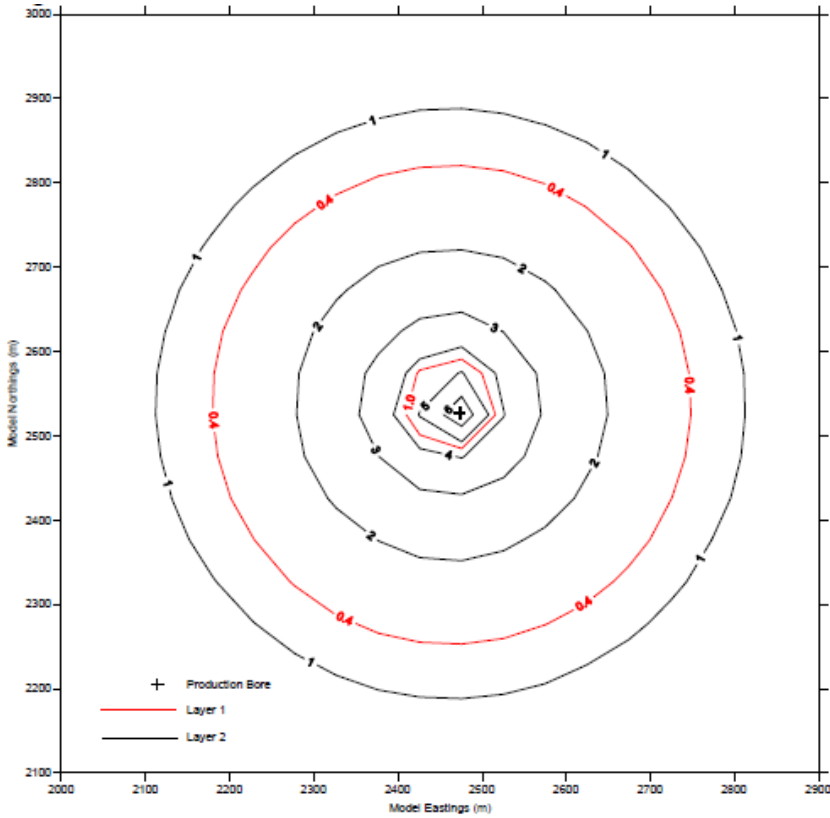


Figure 2-1 Drawdown contours associated with the extraction of 33,306 kL (Rockwater model)



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|--------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

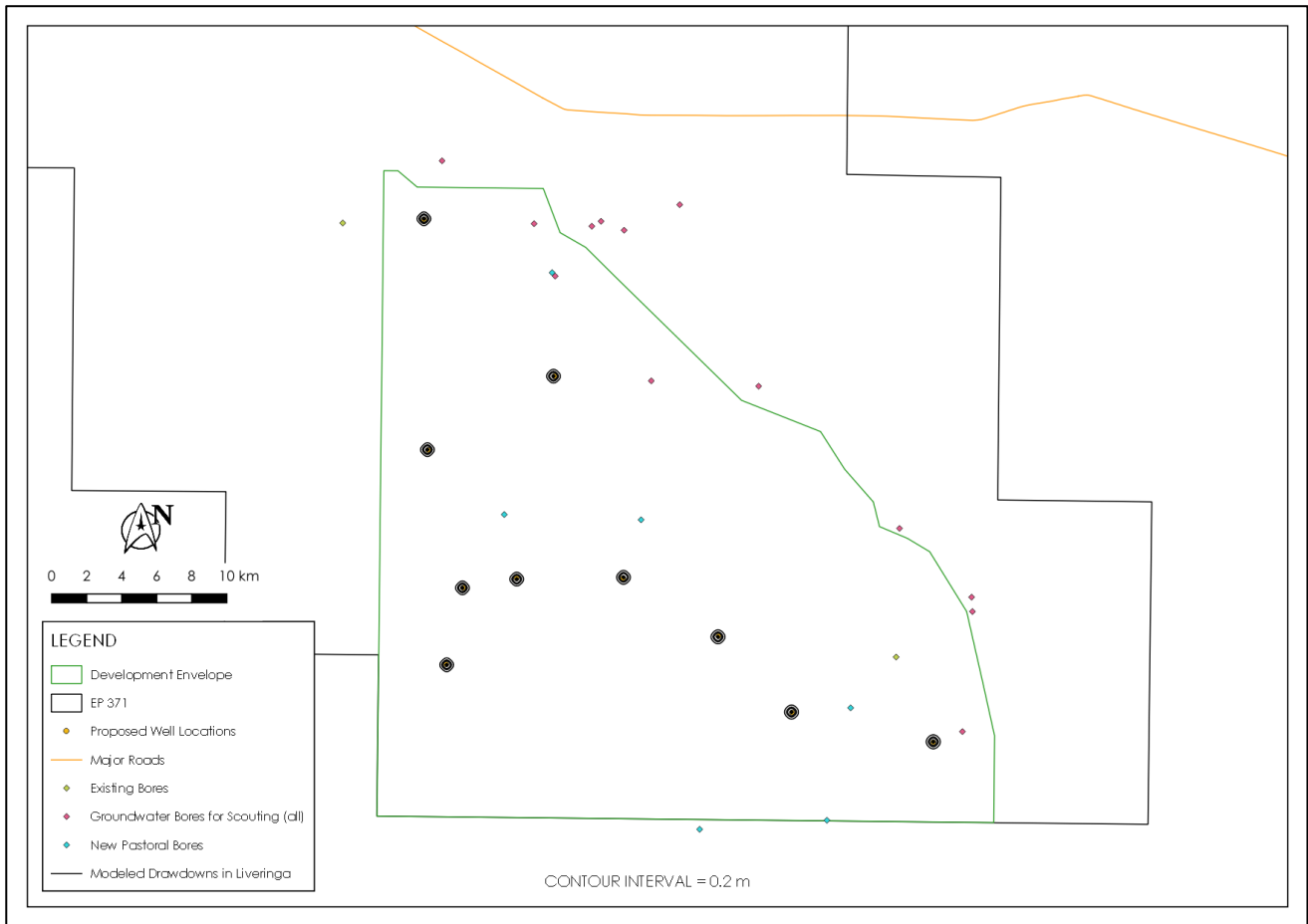


Figure 2-2: Mod 1 model results presented as drawdown contours after six months of pumping, with contour interval = 0.2 m (Intera model)



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |



Figure: Mod 2 model results presented as drawdown contours after six months of pumping with contour interval = 0.2 m (Intera model)

The results from Mod 1 indicate that abstraction of the required water volumes will not result in any noticeable impact to existing bores, and that the nearest GDE (Mount Hardman Creek or the Fitzroy River) are too far to experience any significant impacts.

The results from Mod 2 indicate that abstraction of the required water volumes from the Poole aquifer system would potentially induce temporary drawdowns of between 0.2 and 0.4 metres, and that these would likely recover within a year after the end of the pumping period. The impacts represent a very small percentage of the available water column in each well and would likely not induce any economic impact on existing wells.

Note, this model was considered conservative, as it assumed all rig supply bores to pump concurrently, which was unlikely to happen. In addition, recharge was not included in any of the model simulation.

2.4.3.2 Key assumptions and uncertainties

In accordance with EPA (2021), key assumptions or parameters that are used to support any numerical modelling are to be described in the GWMP. Specifically, key assumptions and uncertainties used in numerical groundwater modelling to understand the potential for water level drawdown associated with the Proposal are detailed in Table 2-5.

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|---|----------|---------------------------|----|----------------------------|----------|
| *Uncontrolled in Hardcopy Format* | | Printed: 28-May-25 | | Use Latest Revision | |
| Author / Reviewer: | AES / SR | Approver: | ML | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 12 of 35 |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

Table 2-5 Key assumptions and uncertainties

| Number | Assumptions and Uncertainties | Comment |
|--------|---|---|
| 1 | Number and location of extraction bores | BNR plans to install two extraction bores at each well site. Although modelling is based upon a single bore, abstraction bores are anticipated to either alternate or draw with reduced rates such that modelling from a single bore provides a conservative worst-case scenario. |
| 2 | Volume of water required to be extracted for the Proposal | The conservation maximum volume of water per well site is estimated to be 100 ML. Modelling volume was less (33 ML) but on review of a much larger number provided in Rockwater (2016) (100 ML), the modelling outcomes are expected to be sufficient to inform the EIA. |

2.4.4 Groundwater Contamination

2.4.4.1 Study Findings

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. The purpose of the 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
- 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
- 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. A summary of these recordings is:
 - AB1S
 - i. stick-up: 0.5 m
 - ii. standing water level: 23.070 m below top of casing (m btoc)
 - iii. screened interval: 30.8-36.3 m btoc
 - iv. bottom of casing: 36.3 m btoc
 - v. some white build-up on lower ~5 m of casing walls
 - AB1D
 - vi. stick-up: 0.7 m
 - vii. standing water level: 21.780 m btoc
 - viii. screened interval: 67.0-76.6 m btoc
 - ix. bottom of casing: 76.6 m btoc
 - x. ant ingress and some ant material build-up on walls from 20 m btoc



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

- VNB4S
 - xi. stick-up: 0.5 m
 - xii. standing water level: 30.686 m btoc
 - xiii. screened interval: 36.6 m btoc
 - xiv. bottom of casing: 42.3 m btoc
 - xv. no or minor build-up on casing walls
- VNB4D
 - xvi. stick-up: 0.7 m
 - xvii. standing water level: 30.956 m btoc
 - xviii. screened interval: 66.9-78.3 m btoc
 - xix. bottom of casing: 78.4 m btoc
 - xx. 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 2-16), thus providing geographical coverage across the project area
- groundwater flow is westerly (Figure 2-16), 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). BNR has mapped specific CoPC over the sampling period in Figure 2-3 to Figure 2-13. 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 2-6: 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 2-3 to Figure 2-13 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 well site, 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



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| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

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 2-13, 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 that were 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.

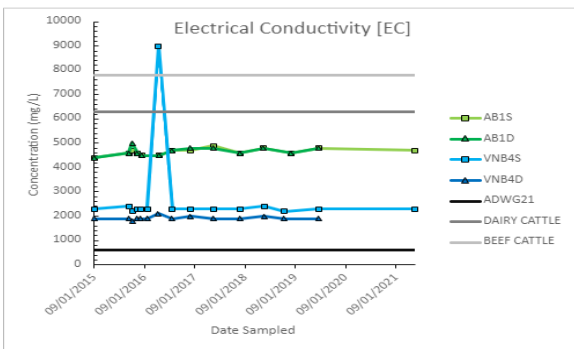


Figure 2-3: Electrical conductivity [Liveringa]

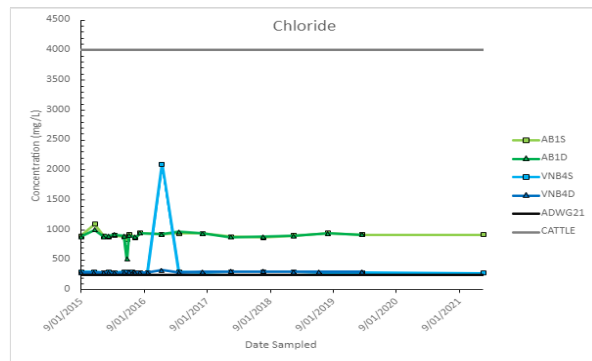


Figure 2-4: Chloride [Liveringa]

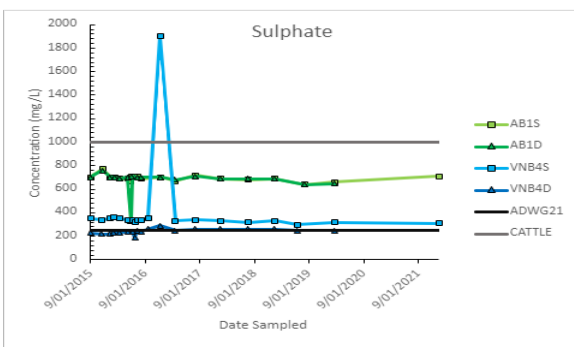


Figure 2-5: Sulfate [Liveringa]

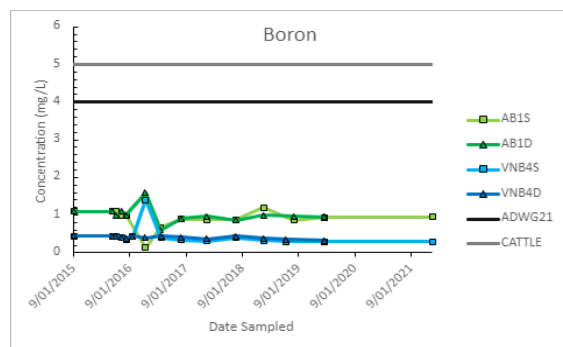


Figure 2-6: Boron [Liveringa]

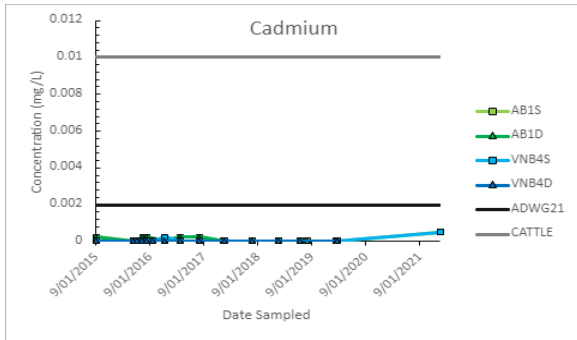


Figure 2-7: Cadmium [Liveringa]

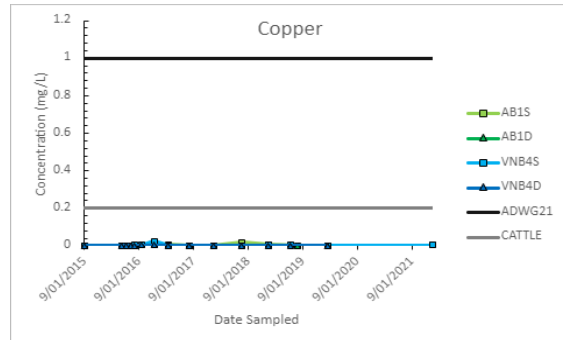


Figure 2-8: Copper [Liveringa]

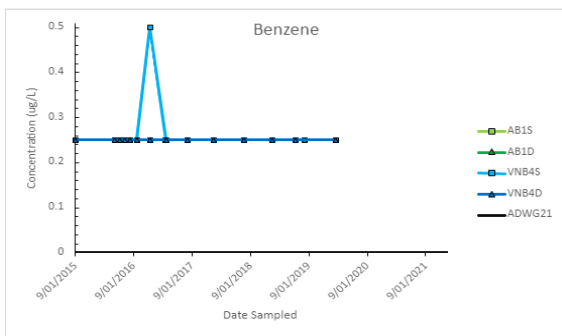


Figure 2-9: Benzene [Liveringa]

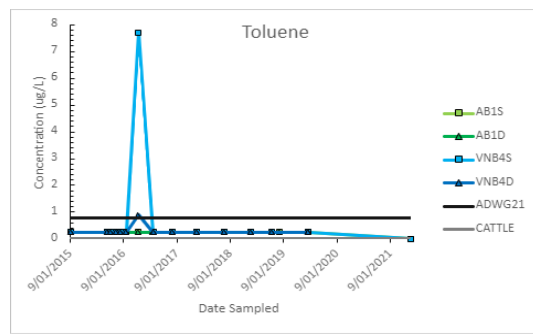


Figure 2-10: Toluene [Liveringa]

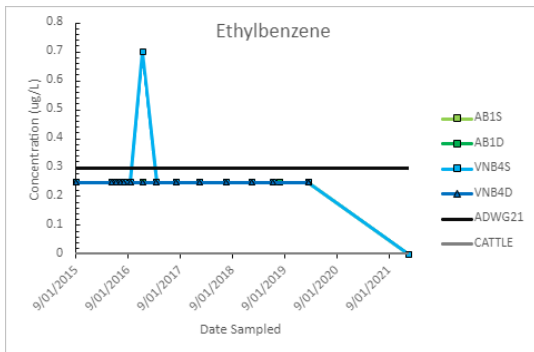


Figure 2-11: Ethylbenzene [Liveringa]

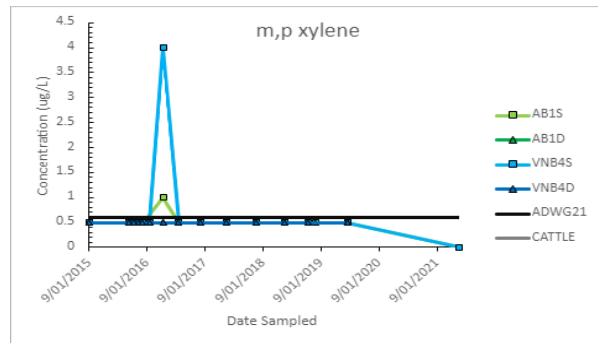


Figure 2-12: Xylene [Liveringa]

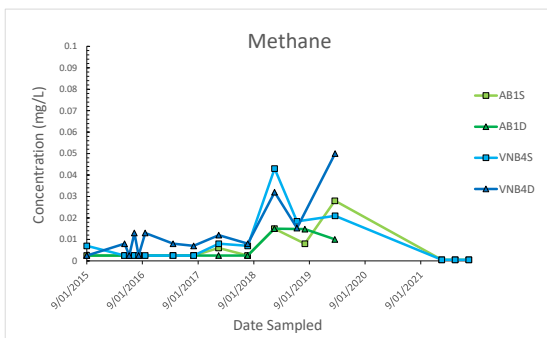


Figure 2-13: Methane [Liveringa]



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| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

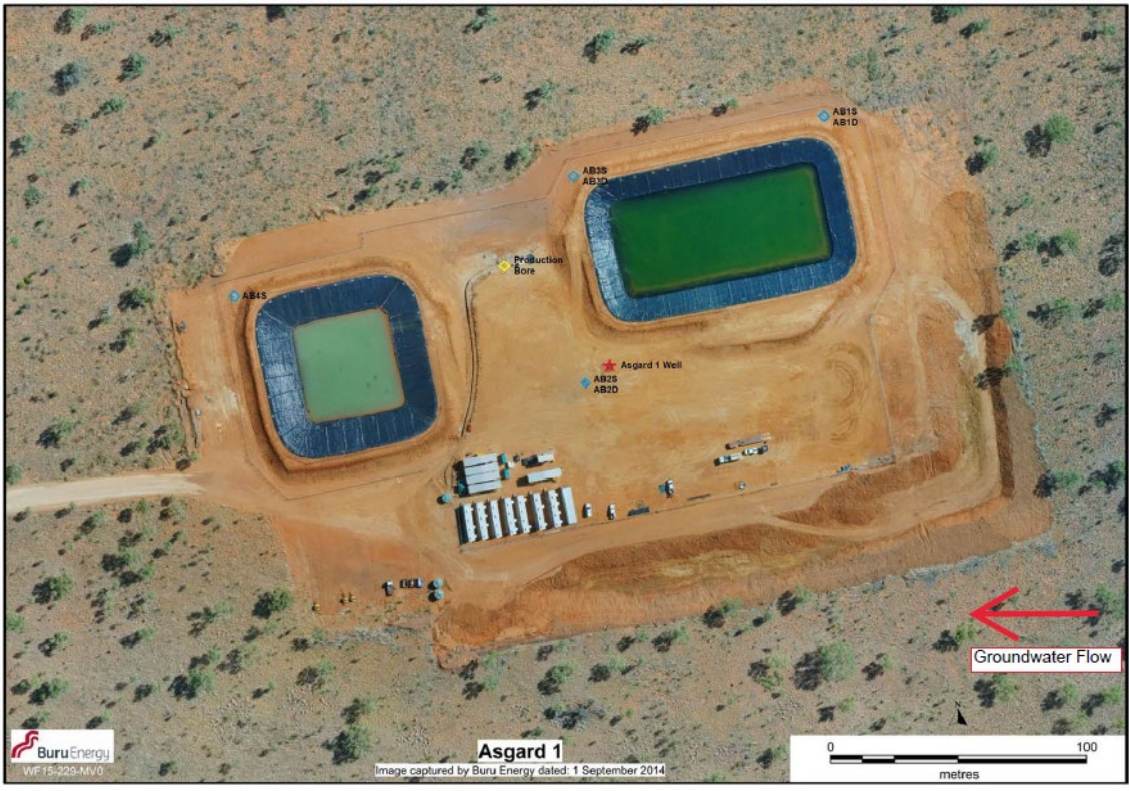
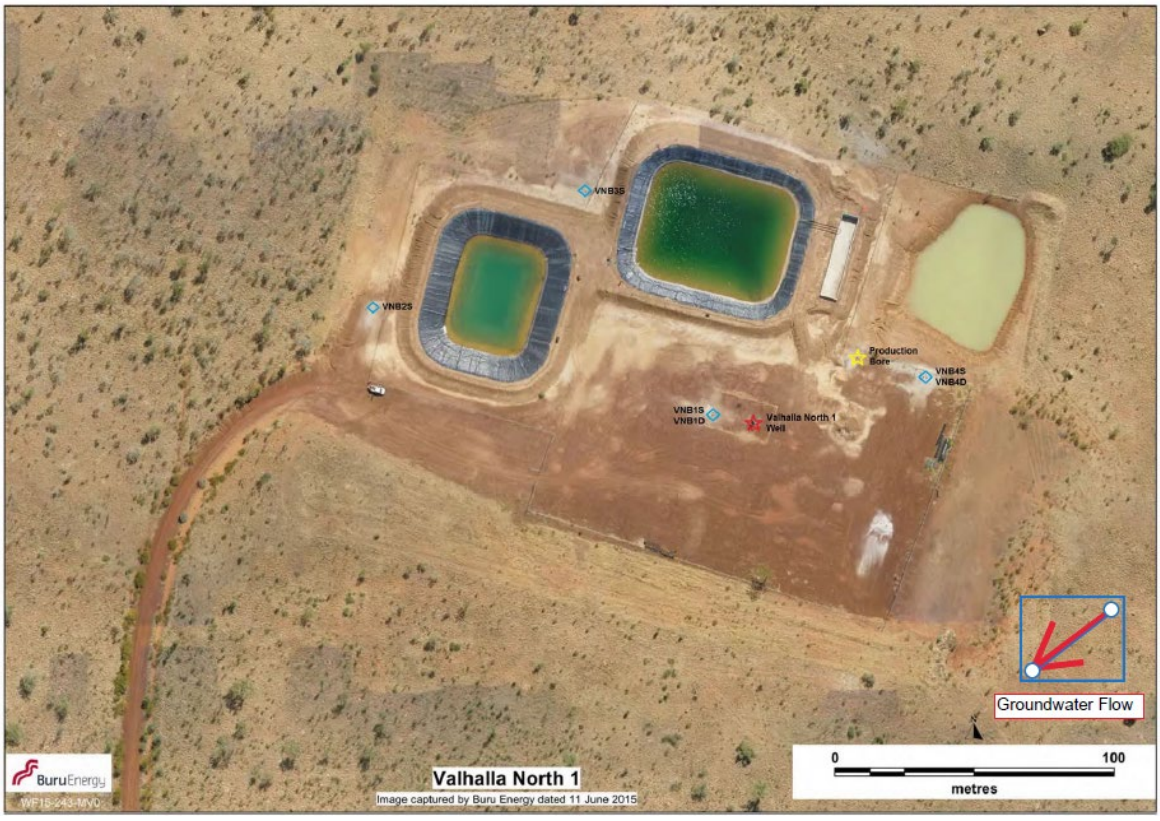


Figure 2-14: Location of VNB4S / VNB4D and AB1D / AB1S and proximity to existing infrastructure

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| | |
|--------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

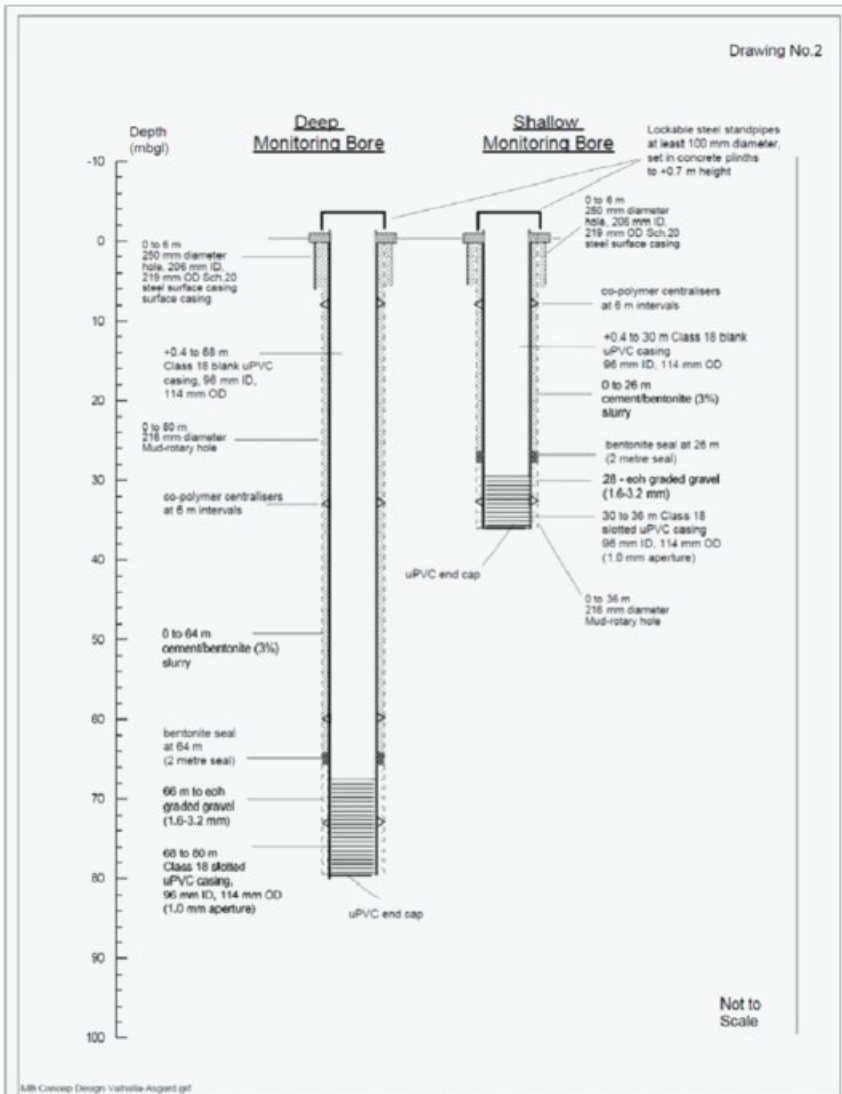


Figure 2-15: Schematic of the Asgard and Valhalla North groundwater monitoring bores

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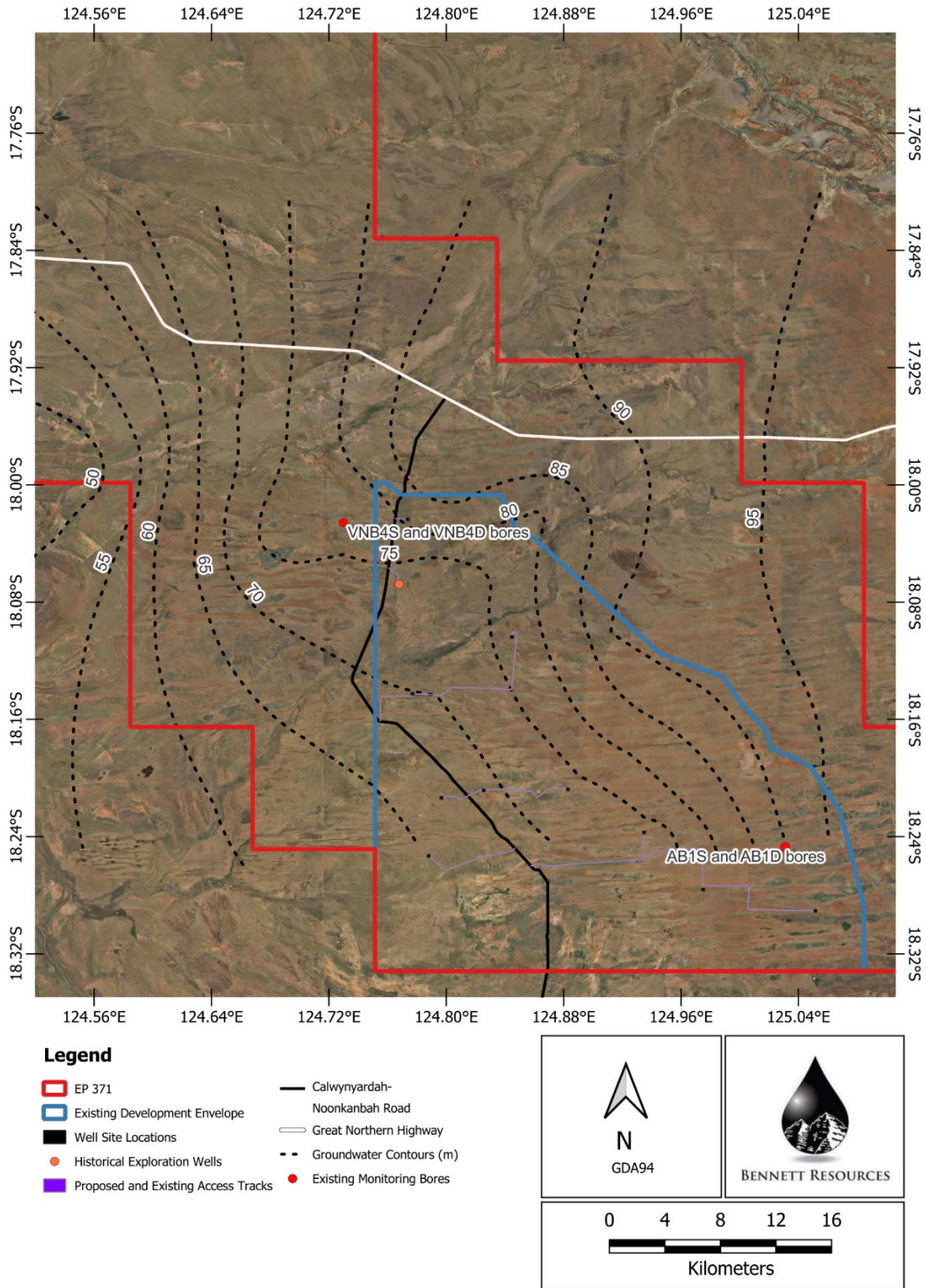


Figure 2-16: Location of Livinginga groundwater sampling bores for local groundwater characterisation and groundwater contours

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| Author / Reviewer: | AES / SR | Approver: | ML | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 19 of 35 |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

2.4.4.2 Key assumptions and uncertainties

Key assumptions and uncertainties associated with regional baseline information are detailed in Table 2-5.

Table 2-7 Key assumptions and uncertainties

| Number | Assumptions and Uncertainties | Comment |
|--------|---|--|
| 1 | Proximity of bores to proposed well site's | BNR plans to install additional monitoring bores on the well sites to collect local data as part of a baseline data collection process once the well sites are cleared. BNR will gather enough baseline ground water collection data to ensure seasonal variation is captured corresponding to a single a year. |
| 2 | Fluctuation of constituents of Potential Concern in 2018-2019 | <p>Baseline samples were collected from AB1S and VNB1S for 18 months starting in 2014 and completing in August 2015. Over this time a number of methane readings above the LOR (being 0.005) were recorded across Valhalla and Asgard aquifers indicating that methane may naturally fluctuate in the Liveringa aquifer. These readings were between 0.005 (LOR) and 0.015.</p> <p>HFS commenced in August 2015. During this period and the years that followed (2018) methane readings were stable hovering at or below 0.02 which was determined to be not inconsistent with the baseline readings.</p> <p>Between 2018 and 2019 all bores sampled onsite experienced an increase in methane levels. The operator at the time reviewed their field notes (reviewed by BNR) which suggested no additional outside activities could have contaminated the source, the samples were collected by the same people from 2017 and the only "petroleum activities to occur over this period" were relatively non-invasive down hole activities for Asgard completed in 2019 (not in 2018 when the increases were first identified). All other activities on site were limited to maintenance of existing hardstands ruling out potential contamination sources attributable to petroleum activities.</p> <p>BNR sampled VNB4S and AB1S in 2021 for methane with both bores returning methane levels that were below the methane LoR (0.001 mg/L). the methodology involved low-flow sampling to reduce purging volumes completed by the previous operator and to minimize disruption of the samples as much as possible.</p> <p>Given that that VNB4S and AB1S are up the hydraulic gradient from the well and the fracking activities, if methane would have been released from the wellbore, it is extremely unlikely that it would have been recorded upgradient (and thus in these bores). These bores were specifically located in consultation with DWER to ensure they were upgradient of the wellbore in a location that would enable the operator to differentiate between activity related and natural occurring events.</p> <p>Given all bores spiked over this period of time (not just the baseline / environmental bore), this indicates there may have been a broader change to groundwater across the canning basin (not restricted to Valhalla and Asgard locations).</p> <p>Given that the data doesn't indicate an increase in Total Dissolved Solids (TDS), Barium, Boron, or other highly concentrated Trace Metals (which would be expected in correlate with an increase in methane if it was attributed to the petroleum activity) BME expects that these results may be attributable to other naturally occurring events experienced in the Canning Basin at this time.</p> <p>In 2018, the region experienced a large drought, with significant heatwaves and then subsequent flooding events resulting in mass reported cattle death across the Noonkanbah Station. It is possible that these events could explain an increase in methane over this period of time (i.e. decomposition of organic material) and infiltrating the surficial aquifer.</p> <p>The only other explanation available to BNR is operator error which seems unlikely given the person responsible for sampling during 2017 was responsible for sampling in 2018 and 2019.</p> |



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| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

| Number | Assumptions and Uncertainties | Comment |
|--------|-------------------------------|--|
| 3 | Hydrogeological uncertainty | <p>BNR has access to a large amount of information within the West Kimberley from the previous operator including over 450 sampling events across 42 locations to support regional baseline characterisation</p> <p>Monitoring bores installed on Asgard and Valhalla well sites (located upgradient of the petroleum well) comprise over 45 sampling events over eight years</p> <p>BNR is aware of the significant amount of data collated by DWER in and around the Fitzroy River associated with the Fitzroy Surface Water and Ground Water Interaction Project 2010 detailing 133 pastoral bores and 95 indigenous community bores.</p> <p>A large amount of data exists to provide sufficient certainty regarding geochemistry of the Liveringa Aquifer in the region.</p> <p>Regardless BNR plan to utilise a 6 month baseline program to collect data on the well site then continue with an 18 month sampling program from a monitoring bore located up-gradient to ensure that each well site has 24 month's worth of geochemical and physical groundwater data to clearly detail local seasonal variance.</p> |

2.4.5 Management approach

BNR plans to implement outcome-based indicators under this GWMP. This approach has been determined to be the most appropriate as the outcome can be readily measured with clear thresholds set to enable a level of protection to be achieved.

2.4.6 Rationale for choice of indicators and/or response actions

The indicators proposed are based on the following rationale:

- groundwater modelling indicates that the Liveringa aquifer is in a state of dynamic equilibrium
- groundwater modelling indicates that a drawdown of groundwater is not expected to result in a significant impact to sensitive receptors or other users within proximity of the Proposal
- establishment of outcome-based indicators is achievable, and monitoring of groundwater parameters provide a direct insight into any potential environmental impact arising from the Proposal
- the adaptive management framework enables for clear decisions regarding water extraction to be made where any impacts may be observed. Where additional mitigation is implemented, the timeframe for mitigation to take effect is expected to be relatively short given the dynamic nature and throughflow of groundwater in the region.

A summary of the specific indicators and their justification is provided below.

2.4.6.1 Groundwater Quality

The DMP and DoW guideline (2016), details a comprehensive list of analytes that is standard for onshore oil and gas projects in WA. Specifically, the guideline recommends that the following criteria be sampled:

- in-field parameters, including water level and dissolved oxygen
- physico-chemical parameters
- ions, including chloride and sulphate
- total metals, including arsenic and chromium
- dissolved gases
- benzene, toluene, ethylbenzene, xylene, naphthalene
- other hydrocarbons.

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| Author / Reviewer: | AES / SR | Approver: | ML | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 21 of 35 |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

As the Scientific Inquiry states: An enforceable Code of Practice should include the requirement to test for, and assess the risk from, a comprehensive list of analytes in groundwater, produced and flowback water, including geogenic chemicals and radon, BNR has taken to include the following analytes to be included in the sampling plan:

- radon
- uranium
- geogenic chemicals.

To understand the specific Indicators or Constituents of Potential Concern (CoPC), BNR reviewed the potential environmental impacts and risks as detailed in the Valhalla Gas Exploration and Appraisal Program, Section 38 Assessment – Environmental Review Document (BNR_HSE_MP_013). The Proposal indicates the following fluids having the potential to impact water quality:

- surface release of drilling fluids and HFS fluids
- subsurface release of drilling fluids
- subsurface release of HFS fluids.

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
- sulfate
- Total Petroleum Hydrocarbons (TPH)

BNR reviewed the Assessment and Management of Contaminated Sites: Contaminated Sites Guidelines (DER 2014), to identify various health screening levels (Table 2-6). However, given the absence of health screening levels for most constituents, BNR has opted to utilize a before and after impact analysis for the data of these indicators. This ensures that should local geology impact water quality, the collection of baseline samples will enable historic averages to be collected, and simple average / standard deviation analysis be utilized to understand water quality variance.

Table 2-8: Groundwater Health Screening Levels

| Analyte | Indicators |
|---------------|----------------------|
| barium | - |
| cadmium | - |
| chloride | - |
| chromium III | - |
| sulfate | 500 mg/kg (DER 2014) |
| TPH (C10-C14) | - |
| TPH (C15-C18) | - |
| TPH (C6-C9) | - |



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| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

2.4.6.2 Groundwater Levels

As detailed in Section 2.4.3, groundwater levels fluctuate naturally between 0.2 to 1 m (depending on the frequency and magnitude of recharge events). For an overview of groundwater depth over the course of historic groundwater monitoring, refer to Appendix I Rockwater 2016 Hydrological Assessment of the Environmental Review Document (BNR_HSE_MP_013).

Consequently, BNR has adopted a trigger / threshold indicator of 1 m for groundwater level as historical data indicates natural variation of up to 1 m is present within the Development Envelope.



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|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 27 May 2025 |

3 GWMP components

This section of the GWMP identifies the legal provisions (components) in Table 3-1 that BNR will implement to ensure that the environmental outcomes are met during the implementation of the Proposal.

In accordance with the guideline “Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans” (EPA 2021), this section identifies the indicators that will be used to measure performance and the monitoring that will be undertaken in relation to these indicators. It defines the response actions (trigger level and contingency actions) that will be undertaken if the indicators are exceeded. Table 3-1 details the components of this plan, including monitoring and reporting commitments. Further information regarding monitoring has been described in Section 3.1.

BNR will update Table 3-1 in consultation with both the Department of Water and Environmental Regulations (DWER) and the Department for Energy, Mining, Industry Regulation and Safety (DEMIRS) prior to implementation of any drilling activity. This will include the review of trigger and threshold criteria following the completion of well site-specific baseline sampling.



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| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

Table 3-1: GWMP components

| | | | | | |
|--|---|---|----------------------|----------------------|---|
| EPA factor/s and objective/s | | Inland Waters – To maintain environmental quality and to minimise the risk of environmental harm, so that environmental values are protected | | | |
| GWMP outcome/s | | <ul style="list-style-type: none"> no long-term changes to groundwater levels no short or long-term changes to groundwater quality | | | |
| Key environmental values | | <ul style="list-style-type: none"> Liveringa and Poole Aquifers the Groundwater Dependent Ecosystem (GDE) Mount Hardman (associated with the Liveringa Aquifer) other groundwater users (pastoral stations and fixed receptors >18 km away from the Development Envelope). | | | |
| Key impacts and risks | | <ul style="list-style-type: none"> changes to groundwater levels contamination of groundwater from surface and subsurface spills | | | |
| Indicators | | Response actions | Monitoring | Frequency | Reporting (Section 3.2) |
| Groundwater Level | | | | | |
| GWMP outcome – No long-term changes to groundwater levels | <p>Trigger criteria</p> <p>Groundwater level measured at the upgradient control bore exceed historical average groundwater level values of 0.7 m.</p> | <p>Trigger level actions</p> <ul style="list-style-type: none"> identify the reason for the change in groundwater levels and determine direct correlation to the Proposal activities or natural variation and review management measures with an adaptive management response. This may include cessation of groundwater pumping until levels return to their historical average levels and an increase in data collection and monitoring re-examine groundwater level monitoring results (QA / QC) to validate data where the threshold exceedance was not caused by the Proposal, resume standard groundwater level monitoring frequency where the groundwater level threshold exceedance was caused by the Proposal, take steps to remedy the impact (for example cessation of pumping) re-monitor and increase monitoring frequency (to monthly [where quarterly sampling is being undertaken] or fortnightly [where monthly sampling is being undertaken]). <p>Threshold contingency actions</p> <p>Initiate implementation of contingency measures including:</p> <ul style="list-style-type: none"> where the groundwater level threshold exceedance was not caused by the Proposal, resume standard monitoring frequency where the threshold exceedance can be attributed to the Proposal activities: <ul style="list-style-type: none"> implement adaptive management response (modified abstraction) management guidance within Section 4. This may include | Refer to section 3.1 | Refer to section 3.1 | <p>Routine reporting – Annual Compliance Assessment Report to the DWER Compliance Branch</p> <p>Exceedance reporting to DWER Compliance Branch – exceedance of the threshold criteria and contingency actions that have been implemented – within 5 days.</p> |
| | <p>Threshold criteria</p> <p>When the groundwater level, measured at the upgradient control bore, exceed historical average groundwater levels of 0.7 m over two consecutive monitoring events which are attributable to the Proposal.</p> | | | | |



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|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

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| | | <ul style="list-style-type: none"> • ceasing abstraction, and sourcing water from other sources or reducing abstraction volumes ○ once response actions have been completed, extend the monitoring program and increase frequency (to monthly [where quarterly sampling is being undertaken] or fortnightly [where monthly sampling is being undertaken]) until level values recover ○ continue to implement actions to remediate the exceedance until approval to cease has been given by the relevant regulator. | | | |
|--|--|---|--|--|--|

Groundwater Quality

| | | | | | |
|--|--|---|-----------------------------|---|--|
| GWMP outcome – No short or long-term changes to groundwater quality | Trigger criteria | Trigger level actions | | | |
| | <p>Changes to groundwater quality at defined monitoring locations (Table 3-2) attributable to the project where they meet the following conditions:</p> <ul style="list-style-type: none"> • 2 out of 3 successive samples fall outside the mean ± 1 Sigma (SD) limit • 4 out of 5 successive samples fall outside the mean ± 1 Sigma (SD) limit • 8 consecutive points on the same side of the mean. | <ul style="list-style-type: none"> • identify the reason for the change in water quality and determine direct correlation to the Proposal activities or natural variation and review management measures with an adaptive management response. • re-examine water quality or groundwater level monitoring results (QA / QC) to validate data • where the threshold exceedance was not caused by the Proposal, resume standard water quality monitoring frequency • where the water quality threshold exceedance was caused by the Proposal, take steps to remedy the impact (for example stop stimulation activities) re-monitor and increase monitoring frequency (to monthly [where quarterly sampling is being undertaken] or fortnightly [where monthly sampling is being undertaken]). <p>Threshold contingency actions</p> <p>Initiate implementation of contingency measures including:</p> <ul style="list-style-type: none"> • ground truth the water quality 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 water quality threshold exceedance was not caused by the Proposal, resume standard monitoring frequency • where the threshold exceedance can be attributed to the Proposal activities: <ul style="list-style-type: none"> ○ implement adaptive management response management guidance within Section 4. This may include: <ul style="list-style-type: none"> • ceasing the petroleum activity to enable source of release to be investigated and mitigated • installing additional monitoring bores up-gradient of the wellbore in consultation with DWER# | | | |
| Threshold criteria | <p>Changes to groundwater and surface water quality at defined monitoring locations (Table 3-2) attributable to the project where they meet the following condition: 1 sample falls outside the mean ± 2Sigma (SD) limit.</p> | <p>Refer to section 3.1</p> | <p>Refer to section 3.1</p> | <p>Routine reporting – Annual Compliance Assessment Report to the DWER Compliance Branch</p> <p>Exceedance reporting to DWER Compliance Branch – exceedance of the threshold criteria and contingency actions that have been implemented – within 5 days.</p> | |



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|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

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| | | <ul style="list-style-type: none">• increasing monitoring frequency (to monthly [where quarterly sampling is being undertaken] or fortnightly [where monthly sampling is being undertaken])○ once response actions have been completed, extend the monitoring program and increase to monthly until groundwater quality values recover○ continue to implement actions to remediate the exceedance until approval to cease has been given by the relevant regulator. | | | |
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|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

3.1 Groundwater monitoring program

To clearly understand if the indicators (trigger and threshold criteria) have been met or exceeded, BNR has developed a groundwater monitoring program (Table 3-2) to be implemented over the life of the Proposal and following decommissioning/site reinstatement. This includes groundwater monitoring. Specifically, the monitoring program will be used to:

- establish local Liveringa aquifer site conditions by sampling for sufficient time to collect seasonal variation corresponding to a single year prior to commencing the petroleum activity.
- establish duration and frequency of baseline and surveillance monitoring for the duration of the Proposal and following decommissioning; and
- inform termination criteria for groundwater sampling.

Table 3-2: Groundwater monitoring program

| | |
|----------------------------|---|
| Overview | BNR has developed this monitoring program to collect and analyse local groundwater quality at all well sites associated with the Proposal located within the Development Envelope. |
| Relevant guidelines | <ul style="list-style-type: none"> • Guidelines for groundwater quality protection in Australia: National Water Quality Management Strategy, Department of Agriculture and Water Resources (Australian Government 2013) • National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council / Agricultural and Resource Management Council of Australia and New Zealand (ANZECC / ARMCANZ) (Australian Government 2018) • Health screening levels for petroleum hydrocarbons in soil and groundwater. Technical report No. 10. Australian Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (Friebel and Nadebaum 2011) • Guideline for groundwater monitoring in the onshore petroleum and geothermal industry (DMP & DoW 2016) • Environmental Factor Guideline – Inland Waters (EPA 2018) • National Environment Protection (Assessment of Site Contamination) Measure 1999. Schedule B1, as amended 16 May 2013 (National Environment Protection Council 2013) • National Water Quality Management Strategy Australian Drinking Water Guidelines (NHMRC and NRMCC 2011 (updated March 2021)) • Contaminated Sites Groundwater and Surface Water Chemical Screening Guideline. Western Australian Department of Health (DoH 2014) • <i>Water Quality Protection Note 30 (WQPN 30)</i>, Department of Water (Western Australian Government 2006, updated August 2023) • Minimum Requirements for Water Bores in Australia (National Uniform Drillers Licensing Committee 2011). |
| Purpose | To determine if the Proposal has had any adverse impacts to groundwater quality and groundwater levels during its implementation. |
| Monitoring approach | <p>Sampling location: <u>Liveringa aquifer:</u></p> <ul style="list-style-type: none"> • each well site will have three Liveringa monitoring bores installed¹ for each well pad that is: <ul style="list-style-type: none"> ○ one control bore upgradient from the well and produced formation water evaporation pond, located as far as possible from the contamination sources (noting the EPA's preference for a separation distance approximately 100m which we be considered during wellsite design). <i>BNR Notes that provisions can be made to allow disturbance required for installation and access of the control bore outside of the 'locked' disturbance footprint. These provisions will be managed by DEMIRS.</i> |

¹ Installation and drilling of all water bores will be hydrostratigraphically logged in detail and geophysical interpretation of groundwater quality collected, for the interval where fresh aquifers are known to be present. 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 direct by a hydrogeologist during bore installation.



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

- one impact monitoring bore within approximately 20 m down-gradient of the produced formation water evaporation pond.
- one impact monitoring bore down gradient and within approximately 20 m of the production well/s.
- monitoring bores will be constructed with similar screened intervals targeting the top, middle and bottom of the vertical extent of the Liveringa aquifer in consultation with DWER.
- the location of the bores has been selected to coincide with different perceived risks (i.e., a surface release from the evaporation pond or loss of well containment) or a migration of fluids through a fault to the Liveringa Aquifer and to inform natural variation or contamination events that may occur upgradient not related to the petroleum activity.
- the location of the monitoring bores will be identified in consultation with DWER and DEMIRS prior to installation.

Poole aquifer

- only two monitoring bores will be installed at the base of the Poole Aquifer for this Proposal within the Development Envelope:
 - one up-gradient from the production well, located as far as possible from potential contamination sources as possible (noting the EPA's preference for a separation distance of at least 100m which we be considered during wellsite design). *BNR Notes that provisions can be made to allow disturbance required for installation and access of the control bore outside of the 'locked' disturbance footprint. These provisions will be managed by DEMIRS*
 - one located down-gradient from either the first or second exploration well, as close as possible to the well and no further than the edge of the lease.
- both Poole bores will be screened at the base of the Poole aquifer in consultation with DWER. and appropriately constructed to mitigate risks of a hydraulic short circuit
- the location of all monitoring bores will be identified in consultation with DWER and DEMIRS prior to installation

Sampling frequency – Baseline:

Liveringa aquifer

- baseline samples from the Liveringa will be collected quarterly from at least the upgradient control bore prior to conducting drilling activities from the up-hydraulic gradient control monitoring bore (on each wellsite) to gather seasonal variation over a single a year (i.e. captures seasonal groundwater high post wet season, and seasonal groundwater low post dry season).
- where impact / surveillance bores are installed prior to drilling activities commencing², they will join the baseline sampling program to gather as much data as possible prior to drilling activities commencing.

Poole aquifer

- baseline samples from the only two Poole bores installed for the Proposal will be collected at least 6 months prior to drilling either the first or second exploration well.

Sampling frequency – Surveillance:

- during proposal implementation samples of all Liveringa monitoring bores will be collected quarterly.
- during proposal implementation (of either the first or second exploration well), samples of all Poole monitoring bores will be collected quarterly.
- if telemeters are installed in the Liveringa monitoring bores, BNR will implement:
 - continuous telemetered monitoring of all monitoring bores for PH, EC, TDS and ground water depth
 - annual in field sampling event of all monitoring bores telemetry is no longer utilised in the field, and
 - following completion of HFS where no significant variation from baseline is identified (and where telemetry is no longer utilised), the sampling frequency will drop to a single down gradient Liveringa bore twice a year and continue until the termination criteria is achieved (noting provisions to increase monitoring frequency should trigger or threshold criteria be met.
- if telemeters are not installed in the Liveringa monitoring bores, BNR will implement:

² There are a number of reasons that down gradient impact (surveillance) bores cannot be installed pre activity and meet the 12-month baseline requirements with, the major reason being operational constraints. The location of the wells and the ponds on the wellsite are subject to detailed wellsite design and engineering. To inform the wellsite design and engineering, the drilling rig that will be utilized needs to be contracted, given the rig will determine the layout of infrastructure to ensure that everything is positioned to enable the rig to operate safely. The Rig will not be contracted until all approvals are in place (resulting in multiple dependencies that result in significant time delay). If the impact bores are installed too early, there is the potential for them to be:

1. damaged given well cellar and pond construction requires heavy civil / earthmoving machinery, and
2. mispositioned resulting in them not being optimally placed for identifying contamination events arising from the activity.

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|---|----------|---------------------------|----|----------------------------|----------|
| *Uncontrolled in Hardcopy Format* | | Printed: 28-May-25 | | Use Latest Revision | |
| Author / Reviewer: | AES / SR | Approver: | SR | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 29 of 35 |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

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| Termination criteria | <ul style="list-style-type: none"> o monthly in field sampling during HFS activities (noting provisions to increase monitoring frequency (per updated trigger and threshold criteria), and o daily sampling of adequate screening parameters (i.e. PH, EC, TDS and groundwater depth). Of all wells. o following completion of HFS activities, samples will revert to quarterly and where no significant variation from baseline is identified, the sampling frequency will drop to a single down gradient Liveringa bore twice a year and continue until the termination criteria is achieved (noting provisions to increase monitoring frequency should trigger or threshold criteria be met). • where changes are identified during or after HFS activities, the frequency of sampling may be increased, and additional groundwater sampling bores installed (as required) to gain a clear understanding of any potential impact consistent with identified threshold and trigger criteria actions (Table 3-1). • this monitoring program (including bore location, frequency and methodology) can be reviewed by BNR and DWER post implementation and in accordance with Section 4.2 of this GWMP. <p>Analysis:</p> <ul style="list-style-type: none"> • as per the DMP and DoW guideline (2016), a comprehensive list of analytes will be sampled including: <ul style="list-style-type: none"> o in-field parameters, including water level and dissolved oxygen o physico-chemical parameters o ions, including chloride and sulphate o total metals, including arsenic and chromium o dissolved gases o benzene, toluene, ethylbenzene, xylene, naphthalene o other hydrocarbons. o radon o uranium o geogenic chemicals • surveillance samples will be compared to local baseline samples and upgradient monitoring bores to determine if there are changes to the groundwater that could be attributed to the Proposal. |
| Termination criteria | <p>Surveillance monitoring at each individual well site will be terminated following data collection of at least four consecutive sampling events following decommissioning where:</p> <ul style="list-style-type: none"> • chemical/hydrocarbon constituents are below relevant benchmarks or guideline values or have returned to within the expected natural dynamics of baseline state and/or control sites. |

3.1.1 Groundwater Sampling Location

The layout of the well site sampling bores has been specifically chosen to support both baseline and surveillance monitoring (Figure 3-1). The upgradient bore will enable BNR to compare ambient groundwater quality against the downgradient sampling bores in real time over the course of the activity and clearly show:

1. if a spike in a Constituent of Potential Concern is experienced in the downgradient bore but not the upgradient bore, then the spike is most likely associated with the petroleum activity, and is then unlikely to be associated with natural variation,
2. if a spike in a Constituent of Potential Concern is experienced in all bores during implementation of the proposal, that the spike is unlikely to be associated with the petroleum activity.

By installing an upgradient bore, BNR is able to achieve a more scientifically robust approach for groundwater sampling with sufficient data to inform natural variation, identification of scenarios that may cause groundwater contamination that are not associated with the petroleum activity whilst enabling the activity to commence in a timely manner. This is not inconsistent with the previously unconventional gas activities in the Kimberley with the groundwater monitoring program designed with DWER previously. Installation of additional downgradient bores can be considered following triggering events such as:

1. positive leak detection events (indicating the integrity of the top layer of the pond has been compromised), or
2. well pressure monitoring indicates well integrity may be compromised.

BNR will ensure that the location of all monitoring bores are discussed and agreed with DWER.

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|---|----------|---------------------------|----|----------------------------|----------|
| *Uncontrolled in Hardcopy Format* | | Printed: 28-May-25 | | Use Latest Revision | |
| Author / Reviewer: | AES / SR | Approver: | SR | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 30 of 35 |





| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

3.1.2 Groundwater Sampling Duration

BNR believes the hydrogeology of the Liveringa is sufficiently understood to support a baseline sampling program to ensure seasonal variation is captured corresponding to a single a year (i.e. captures seasonal groundwater high post wet season, and seasonal groundwater low post dry season) as:

1. BNR has access to a large amount of information within the West Kimberley from the previous operator including over 450 sampling events across 42 locations to support regional baseline characterisation
2. Monitoring bores installed on Asgard and Valhalla well sites (located upgradient of the petroleum well) comprise over 45 sampling events over eight years
3. With the exception of data in 2018-2019, which is most likely influenced from natural events, existing data from Asgard and Valhalla well sites show variation of constituents within the Liveringa are stable with sufficient information to understand local seasonal variability
4. BNR is aware of the significant amount of data collated by DWER in and around the Fitzroy River associated with the *Fitzroy Surface Water and Ground Water Interaction Project 2010* detailing 133 pastoral bores and 95 indigenous community bores.
5. BNR has included threshold criteria contingency measures for installation of additional bores outside of the wellsite and upgradient should any further doubt be shed on natural variability / or should an event occur.

3.2 Reporting

The environmental outcomes will be routinely reported in the Part IV Compliance Assessment Report. This report will include:

- an overall statement of compliance with this GWMP
- analysis against the trigger and threshold criteria (Table 3-1) for each year
- declaration of compliance status against each of the requirements detailed in the Groundwater Monitoring Program
- a description regarding the effectiveness of any adaptive response actions that have been implemented.

In the event that threshold criteria are exceeded during the annual reporting period, exceedances will be reported to the DWER compliance branch within five days.



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

4 Adaptive management and review of the GWMP

4.1 Monitoring and adaptive management

A monitoring program (as defined in Section 3.1) is required to measure the effectiveness of the response actions as defined in this GWMP. The outcomes of the monitoring program will contribute to ongoing improvements in response actions to ensure an adaptive management approach is adopted.

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.

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
- increased understanding of the hydrogeological regimes based on additional internal and external studies will be incorporated into the monitoring and management approach when newer relevant information becomes available where applicable.

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

- evaluation of the groundwater monitoring program, data and comparison to baseline data and reference sites on an annual basis to verify whether responses to project 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 Management plan review

This GWMP is intended to be dynamic and may be updated to reflect changes in management practices and the natural environment over time. Specifically, this GWMP will be reviewed and updated (as required):

- following completion of baseline monitoring and prior to commencing surveillance monitoring to ensure that the trigger and threshold criteria are updated in consultation with DWER
- annually
- and each time a new Environment Plan (under the *Petroleum and Geothermal Energy Resources Act 1967*) is approved.

This approach will allow flexibility to adopt new approaches / management measures. The effectiveness and relevance of trigger level and threshold contingency actions will be evaluated on an annual basis, and any amendments to response actions will be completed on an as-needed basis. This will include:

- amendment of response actions that are not achieving the desired outcomes
- monitoring that identifies additional impacts requiring additional response actions or changes to existing response actions
- changes to relevant legislation that may affect the implementation of response actions
- improvements to management practices to achieve a greater environmental outcome

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|---|----------|---------------------------|----|----------------------------|----------|
| *Uncontrolled in Hardcopy Format* | | Printed: 28-May-25 | | Use Latest Revision | |
| Author / Reviewer: | AES / SR | Approver: | SR | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 32 of 35 |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

- updates to trigger and threshold criteria following the completion of baseline sample collection prior to commencing any groundwater extraction.

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 GWMP will be provided for all minor, non-structural changes to the document.

Table 4-1: GWMP review template

| | | | | |
|---|--|---|---|--------------------------|
| Complexity of changes | Minor revisions <input type="checkbox"/> | Moderate revisions <input type="checkbox"/> | Major revisions <input type="checkbox"/> | |
| Number of key environmental factors | One <input type="checkbox"/> | 2-3 <input type="checkbox"/> | > 3 <input type="checkbox"/> | |
| Date revision submitted to EPA | DD/MM/YYYY | | | |
| Proponent's operational requirement timeframe for approval of revision | < One Month <input type="checkbox"/> | < Six Months <input type="checkbox"/> | > Six Months <input type="checkbox"/> None <input type="checkbox"/> | |
| Reason for Timeframe | | | | |
| Item number | GWMP section number | GWMP page number | Summary of change | Reason for change |
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

5 Stakeholder consultation

Consistent with the EPA’s expectations for this GWMP to align with the principles of EIA, BNR consulted with stakeholders, including the Department of Water and Environmental Regulation (DWER), during the development of the EPA referral. Engagements relevant to this GWMP are presented below in Table 5-1.

Table 5-1: Stakeholder engagement relevant to this GWMP

| Stakeholder | Method of engagement | Date of engagement | Summary of engagement |
|----------------------------|--------------------------------|--------------------|--|
| 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. |
| 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. |
| 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. |
| 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. |
| 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. |
| 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. |
| EPA | Response to Submission process | Q1 2025 | EPA Services provided comments on the GWMP throughout the public comments process. BNR has worked through the Response to comment process to update the GWMP to reflect those inputs. |

For a full summary of stakeholder engagement records refer to the BNR Environmental Review Document (BNR_HSE_MP_013). Any additional consultation regarding this GWMP will be captured in subsequent revisions.

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|---|----------|---------------------------|----|----------------------------|----------|
| *Uncontrolled in Hardcopy Format* | | Printed: 28-May-25 | | Use Latest Revision | |
| Author / Reviewer: | AES / SR | Approver: | SR | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 34 of 35 |



| | |
|---------------------|----------------|
| Document No: | BNR_HSE_MP_015 |
| Revision: | 5 |
| Issue Date: | 20 May 2025 |

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|---|----------|---------------------------|----|----------------------------|----------|
| *Uncontrolled in Hardcopy Format* | | Printed: 28-May-25 | | Use Latest Revision | |
| Author / Reviewer: | AES / SR | Approver: | SR | | |
| Review Frequency: Extreme/High=1yr; Medium=2yr; Low=3yr | 2 | Date Review Due: | | Page: | 35 of 35 |