Attachment 11- Impacts to key aspects when assessing changes in hydrological characteristics.

Changes in the water quantity

Groundwater is to be extracted from new extraction bores on each well site from the Liveringa Aquifer (Separate to the Laurel formation which is the target of the HFS Program). Water extraction will be licensed, and the volume extracted will be within the allocated licence volumes, with a conservative maximum estimate of <100ML to be used per well. Bennet Resources Pty Ltd's water use for the Proposal represents a negligible portion (<1 %) of the Canning Basin allocation limit and is far less than water extracted for other uses in the region such as by communities and pastoralists.

Results from site-based monitoring during the previous HFS program were used to develop a numerical model to determine the impact of groundwater extraction on the surrounding environment. This numerical model used the MODFLOW groundwater modelling software to understand drawdown impacts for considerably larger volumes of water extraction (Att 3 - Valhalla Gas Exploration S38 Assessment - Environmental Review Document – Appendix I, Section 3.3.4, Page 13). Using an extraction volume of 100,000 kL (100ML), the model predicted that a short-term drawdown of 1m or more could extend up to 780m from the extraction water bore at the (deep) level of the screens in the extraction bore and that 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 (Att 3 - Valhalla Gas Exploration S38 Assessment - Environmental Review Document – Appendix I, Section3.3.3, pp 15).

To further inform the potential impact, additional modelling was commissioned from Intera Geosciences Pty Ltd. MODFLOW 2005 was selected as the appropriate software as it simulates steady and nonsteady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of confined and unconfined. Two primary models were developed, one simulating the unconfined Liveringa aquifer (Mod 1) and one simulating the confined Grant/Poole Group system (Mod 2). A full explanation of the modelling approach is contained in Att 10 – Valhalla Project Groundwater Modelling, Section 2).

To ensure a conservative approach to modelling was undertaken, BNR utilised a pumping duration of six months which is much longer than would be anticipated for any abstraction bore and assumed that each wellsite was producing water for the same 6-month period, which is not realistic as only one or two abstraction bores are expected to be producing at any one point in time. The modelled drawdown at the end of the six-month pumping period for Mod 1 (the Liveringa Aquifer) showed potential for a 0.2 m

drawdown within 400 m of each pumping bore assuming that all 10 well sites were abstracting water at the same time.

The modelled drawdown at the end of the six-month pumping period showed potential for only a 0.2 m drawdown in proximity to four existing pastoral bores (Att 3 - Valhalla Gas Exploration S38 Assessment - Environmental Review Document – Appendix L, Figure 5-2).

However, given this model provides an unrealistic representation of groundwater drawdown as all well sites will not be pumping at the same time, and given the proximity of the Muspelheim wellsite to Mount Hardman Creek (1km), additional predictive modelling for Mod 1 was performed. Modelling indicates that for a single wellsite a 10cm drawdown is expected 400m from the pumping bore reducing to 2 cm at 500 m and 1 mm drawdown at 700 m.

Consequently, the proposed groundwater extraction is not expected to significantly impact water quantities to the extent that the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes is affected.

Further information is provided in Att 3 - Valhalla Gas Exploration and Appraisal Program: Section 38 Assessment – Environmental Review Document, Section 5.4.5.1 (pp. 161-162)

Changes in the integrity of hydrological or hydrogeological connections, including structural damage (for example, large scale subsidence)

BNR plan to abstract 1ML of water per well from the Liveringa formation. It is anticipated that water abstraction will occur over a period of weeks.

The Liveringa Formation comprises interbedded consolidated sandstones, siltstones with lenses, and minor beds of claystone and shale, varying in thickness from 320m–900 m (Harrington & Harrington, 2015).

As the formation comprises interbedded consolidated substrate, the abstraction of water is not expected to result in any change to hydrological or hydrogeological connections nor structural damage. Abstraction water bores are utilized throughout the pastoral station (and on existing unconventional gas wells), with water abstraction well practiced in this area. No previous occurrences of hydrogeological impacts have been observed or experienced in this region from identical activities.

Changes in the area or extent of a water resource

The Project Area is situated in the Canning Basin region within the Fitzroy River Catchment. The Canning Basin is considered the second largest groundwater resource in Australia after the Great Artesian Basin. It is a large sedimentary basin covering an

onshore area >450,000 km^2 (DoW, 2012). Taking <1% of the Canning Basin allocation limit for water purposes is not likely to affect the extent of the Canning Basin. Further to this, The water resource is licensed under the States Rights in Water and Irrigation Act 1914 thus sufficient mechanism exist at the State level to ensure the water resources is not over-allocated.

The water quality of a water resource

The two aquifers considered "useable" for other purposes within the project area include the Liveringa and Grant Group (including the Poole Sandstone) which do not extend below 1,000 m bgl, (Att 3 - Valhalla Gas Exploration S38 Assessment - Environmental Review Document – Appendix I, Section 2, Table 3). The impact mechanisms identified as potentially resulting in water quality impacts are:

Indirect impacts to water arising potential contamination of surficial formations due to lost circulation or well integrity issues

The surface hole section will penetrate the Liveringa aquifer which is utilised throughout the region for agricultural uses. To minimise risk of contamination, the drilling fluid for the surface hole sections comprise low-toxicity mud systems. The surface hole section is installed to well below the Liveringa Formation, ensuring sufficient isolation exists before drilling the next hole section. If loss of the drilling fluids were to occur within the project area, these would comprise low toxicity fluids and migration from the project area would take ~500 years for water to reach the closest surface water feature and (potential) groundwater dependent ecosystem. As low/nontoxic fluids are used during the installation of the surface hole, even if contamination was to occur, and then even if migration to other water users was to occur (outside of the project area) BNR does not believe that the event would result in any significant impact to water quality. Drilling fluids are required to be disclosed and are assessed under both the Environmental Protection Act 1986 and the Petroleum and Geothermal Energy Resources Act 1967 ensuring that sufficient regulation is in place to regulate drilling fluid systems. Surface drilling systems usually comprise of water (80%), Bentonite (2%), Salt (5%), Calcium Carbonate (5%) and other fluids at much smaller percentages. For a summary of all chemicals that may be used in the Project, refer to Att 3 – Valhalla Gas Exploration and Appraisal Program Section 38 Assessment – Environmental Review Document, Appendix A). For a detailed assessment please refer to Att 3 – Valhalla Gas Exploration and Appraisal Program Section 38 Assessment – Environmental Review Document, Section 5.4.5.2, pg. 163).

Indirect impacts to habitat arising potential contamination of aquifers through unplanned fracture heights

A detailed geotechnical risk assessment is included as Att 12 to support this section. Well analysis of the stratigraphy (rock layering) indicates that within the Project area, the

top of the Laurel Formation zones of interest for HFS treatment is >2,400 m deep, there is ~1,800 m separation between the targeted Laurel Formation and the surface Liveringa Aquifer, of which ~1,100 m is impermeable hard rock and located directly above the Laurel Formation, the Anderson Formation has a shale layer that acts as a confining geological seal for hydrocarbon migration and therefore would act as an immediate thick containment barrier of impermeable hard rock to unplanned vertical growth of fractures. The proposed vertical extent of the fracture envelope is expected to be ~150 m. It is deemed not plausible, physically, for induced fractures to create a hydraulic connection between the deep back shales and other tight formations and overlying potable aquifers such as the Grant and Poole Sandstone aquifers. This is determined based upon limitations to fracture height growth and potential fault slip. As there is ~1,800 m separation between the targeted Laurel Formation and the surface Liveringa Aquifer, at least 600m separation between the Laurel Formation and the Grant/Poole Sandstone aquifers, and the predicted vertical extent of fractures for the activities is 150 m. Consequently, the risk to aquifers is extremely low. Given the geological separation between the Laurel Formation and the Liveringa Aquifer (that supports the recharge of Mount Hardman Creek), BNR does not believe it is plausible that fracture heights will extend such that it connects with the Liveringa resulting in a reduction in water quality. For a detailed assessment please refer to Att 3 – Valhalla Gas Exploration and Appraisal Program Section 38 Assessment – Environmental Review Document, Section 5.4.5.4, pg. 163-164). BNR will implement our Groundwater Management Plan for the project that will include collecting local baseline data at each wellsite prior to drilling activities commencing and implement a longer-term surveillance monitoring program to demonstrate no impacts have arisen from the activity. For an overview of the proposed monitoring program, please refer to Att 3 – Valhalla Gas Exploration and Appraisal Program Section 38 Assessment – Environmental Review Document, Appendix M – Groundwater Monitoring Plan).

Indirect impacts to habitat arising potential contamination of surficial aquifers from an accidental release at the surface of drilling fluids, HFS chemicals, liquid hydrocarbons, or produced formation water

A spill from one of the water retention ponds used to store formation water produced during well testing, drilling fluids, or a spill from a chemical or chemical additive (unmixed) to the ground will result in a varying level of exposure, depending on the volume of release. Standard mitigations will be applied, as BNR plans to install multiple liners for the produced water pond and mud sump, ensuring that the most credible scenario is a small leak from a pond versus a catastrophic failure of both liners. As such the volumes of any accidental surface release would be small. Disclosure of all chemicals is required under both the Environmental Protection Act 1986 and Petroleum and Geothermal Energy Resources Act 1967 and all chemicals have been disclosed under the State EIA process (Att 3–Valhalla Gas Exploration and Appraisal Program

Section 38 Assessment – Environmental Review Document, Appendix A). In addition to all chemicals used, previous characterisation of Produced Formation water has been completed indicating, produced formation water is very high in salt at three to five times the salt concentration of sea water, however it is not considered toxic to fauna or humans and has very low levels of heavy metals. although naturally occurring radioactive material (NORM) was detected, the concentrations were well below the exposure concentrations identified by the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ, 2018). Consequently, if a surface release was to occur, it would be small in volume. If this did seep through the ground far enough to reach the groundwater, and then even if migration to surface water features or (potential) Groundwater Dependent ecosystems outside of the project area was to occur BNR does not believe that the event would result in any impact to vegetation and associated fauna habitat. This indicates no indirect impacts to threatened species habitat outside of the Project Area will arise from potential contamination arising from a surface release. For a detailed assessment please refer to Att 3 – Valhalla Gas Exploration and Appraisal Program Section 38 Assessment – Environmental Review Document, Section 5.4.5.5pg. 164-165).