Laurel Formation Tight Gas Pilot Exploration Program (TGS14)

Attachment 2: Supplement to EPA Referral

Document produced to support the referral of this proposal to the Environmental Protection Authority (EPA) under Section 38(1) of the Environmental Protection Act 1986

Document number	Revision	Date of revision
HSE-PLN-012	0	19 November 2013

Approval details

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Revision history

Date	Revision	Reason for revision	Reviewer
01.11.2013	A	Initial Draft	DO
26.11.2013	0	Issued for Use	DO

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Overview

Buru Energy Limited is an Australian ASX listed company engaged in oil and gas exploration and production in the northwest of Western Australia in an area known in geological terms as the Canning Superbasin. Buru Energy is committed to ensuring proper environmental standards will not be compromised and the Company will have a transparent process for the work undertaken, offering full disclosure of management of its exploration and production activities in its Environment Plans.

Buru Energy is at an early exploratory stage of evaluation of a large tight gas resource in the Canning Basin that potentially offers long term energy security to Western Australia, significant contribution to Australia's GDP and socio-economic opportunity and employment for people and businesses in the local and regional community. Tight gas is found in the pore space of rock comprised largely of silt and sand and bound in carbonate cement. Shale gas on the other hand is found in shale rock which is comprised largely of clay. The permeability of tight gas formations is much lower than conventional gas resources but substantially higher than gas containing shale formations.

In order to extract tight gas from the reservoir, a process called hydraulic fracturing (HF), also known as "*fraccing*", is used. A number of notable international reviews have concluded that the potential risks to human and environmental health associated with tight gas are low if the operations are properly run and regulated. This method of gas extraction has been routinely implemented for several decades on a large scale elsewhere in Australia and internationally in the petroleum and geothermal industries and has enabled significant economic prosperity and provided livelihoods to large numbers of local and regional communities in the areas where tight and shale gas resources are now extracted.

The particular area of interest for petroleum exploration to Buru Energy is a potential tight gas resource located in a geological formation known as the Laurel Formation where it occurs at depths below approximately 2,000 m to a foreseeable maximum of 5,000 m or more. This stratigraphic unit is over 350 million years old and was laid down in the late Devonian and early Carboniferous period. The sediments in the Laurel Formation are predominantly sandstone, carbonate and shale of shallow water marine, deltaic and fluvial origin. Within the Laurel Formation the permeability and porosity decreases with depth providing the constraining mechanism for gas accumulation.

The Company proposes to undertake testing for tight gas flows in the Laurel Formation using hydraulic fracturing (HF) at four existing exploration wells located in the Yulleroo and Valhalla & Asgard tight gas provinces. The testing operations proposed in the dry season of 2014 comprise of Tight Gas Stimulation (TGS 14) in the Laurel Formation using HF to determine if prospective gas flows may be achieved and to characterise the quality and quantity of the resultant hydrocarbon flows.

TGS14 Objectives

TGS14 is a pilot exploration program (the Activity) designed to determine the quality and rate of gas flow from the Laurel Formation at four sites where Company exploration wells are currently located in the Canning Basin. The wells were drilled and constructed in 2012-13 and their integrity subsequently assessed by an independent well examiner. No vegetation clearing will be required for the program at any of the four well sites or access tracks. The tests will be undertaken using the technique of hydraulic fracturing (HF) conducted in different zones in the Laurel Formation more than 2km below the surface. The Activities for TGS14 consist of HF which will be used to stimulate the tight gas reservoir, the well flowed back and the resultant flow of gas and liquid hydrocarbons from the well will then be measured and analysed over a period of time. A total of 34 HF treatments are proposed for TGS14. The HF equipment spread will be at each of the well sites for between 15 to 31 days depending on the number of HF treatments to be conducted at each well. A single HF treatment takes approximately two to three hours to complete. Flowback of fluid from the well in a cleanup phase is then undertaken for a period of time determined by the formation. This is then followed by flow of gas

and liquid hydrocarbons from the well which will then be measured and analysed over a period of time. The results of these tests will inform the decision process for further investigation and appraisal of the potential petroleum resource in the Laurel Formation. Other objectives of TGS14 are focused on demonstrating no or minimal risk to humans and the environment. In this regard, objectives of TGS14 include demonstrating that the flowback water from the HF can be 100% recycled, using it safely in HF treatments while minimising the amount of water required to be taken from the aquifer (a maximum total of 31 ML in TGS14) and demonstrating that there are no solid, fluid or air emissions from the activity that pose any risk to humans or the environment. Additional objectives relate to optimising the HF design for the Laurel formation in order to minimise land footprint and maximise resource recovery from the formation in a commercially viable manner.

Environment Plan

As part of the lead agency framework that has been implemented by the Western Australia Government (Department of Premier and Cabinet, 2011), the Department of Mines and Petroleum (DMP) has been designated lead agency for the regulation of mining, petroleum, geothermal and carbon capture and storage in Western Australia. The lead agency framework applies to all applications and proposals received by DMP. This lead agency approach means that the DMP is responsible for overseeing the project application approval process and liaising with other agencies as required.

Buru has prepared and submitted an Environment Plan for TGS14 to the DMP for assessment which sets out the means by which the environmental aspect of the Company's proposed testing operations (Activities – defined previously) will be managed. The well testing operations are part of the ongoing exploration of the potential tight gas petroleum resource identified by the Company. The Environment Plan will be assessed by the DMP as part of their overall assessment of the proposed TGS14 activity. The regulatory framework developed by the DMP for the regulation of petroleum activities is well established, having regulated onshore petroleum activities since the establishment of the Act in 1967. The framework is premised on a single Principal Act, the Petroleum and Geothermal Energy Resources Act 1967 (WA) (PGERA), and subordinate legislation in the three primary areas of regulation: Safety, Environment and Resource Management and Administration.

The *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (PGER(E)R) implemented by the DMP in August 2012 mirror the Commonwealth environment regulations under the Offshore Petroleum and Greenhouse gas Storage Act, developed for the regulation of conventional petroleum operations in Commonwealth Waters. Like the Commonwealth environmental regulation regime, the Environment Regulations establish an objective-based system, where the operator of a petroleum activity is required to have an approved Environmental Plan (EP) in place prior to a petroleum activity being undertaken.

The object of the PGER(E)R is to ensure that any petroleum activity carried out in Western Australia occurs in a manner consistent with the principles of ecologically sustainable development, and carried out in accordance with an EP that demonstrates that environmental impacts and risks associated with the activity will be reduced to As Low As Reasonably Practicable (ALARP)

The Environment Plan for TGS14 has been prepared in accordance with the PGER(E)R and the *Guidelines for the Preparation and Submission of an Environment Plan* published by the Western Australian Department of Mines and Petroleum (DMP) in 2012. The Environment Plan is intended to:

- Identify the potential environmental impacts of the Activities.
- Demonstrate that the environmental impacts and environmental risks of the Activities will be of an acceptable level and reduced to ALARP.
- Define relevant and measurable environmental performance objectives (including social and heritage considerations) with associated environmental performance standards and measurement criteria where appropriate.
- Undertake a risk assessment of the Activities in achieving the environmental performance objectives.

- Describe the risk mitigation, management and monitoring measures that will be implemented to ensure that the environmental performance objectives are achieved.
- Document the implementation strategy that will be employed to ensure that mitigation measures are in place, risks associated with the activities are effectively managed and monitoring of environmental values is undertaken, where required.
- Document the consultation process undertaken with stakeholders.
- Provide the information required by, and comply with, the *Petroleum and Geothermal Energy Resources Act 1967* (WA) and Regulations in a manner that is appropriate for the nature and scale of the Activities.

Environmental Risk Assessment

In accordance with the PGER(E)R and the *Guidelines for the Preparation and Submission of an Environment Plan,* Buru Energy and its specialist advisors have undertaken an Environmental Risk Assessment (ERA) of the proposed Activity for TGS14 at each of the four well sites proposed for HF activities in the 2014 dry season. The ERA process included:

- a detailed international review of the most recent environmental literature on tight gas developments and their management;
- detailed characterisation of water resources and the geological environment at each of Buru Energy gas well sites;
- the implementation and review of long-term and comprehensive baseline monitoring for groundwater water and seismicity in the Yulleroo and Valhalla and Asgard areas;
- incorporating the use of local knowledge of the landscapes as well as specialist expertise;
- independent specialist expertise that includes internationally acknowledged academic authorities in water resources in Western Australia and geological environmental risk management associated with tight gas development;
- world leading specialist operational expertise with individual experience spanning two decades in areas of tight gas field development, hydraulic fracturing in tight gas, well integrity in tight gas operations, and surface water management in tight gas fields; and international expertise and advice on best available techniques in monitoring to demonstrate Buru Energy is managing risks to ALARP.

Environmental Impact Assessment and Proposed Management

In accordance with Section 38(1) of the Environmental Protection Act 1986 (EP Act) and EPA's General Guide on Referral of Proposals, Buru Energy has prepared this supporting documentation on environmental impact assessment (EIA) and proposed management for the referral. A summary of Environmental Factors and proposed Activities (Aspects) is provided in Section 3 and Section 4 respectively. Section 6 provides an EIA framework conceptual model to present the hypothesised relationships between the source (S) of a hazard/risk, the pathways (P) by which exposure might occur, and the receptors (R) – those features of the environment that we value and that could be harmed (S-P-R). This approach to environmental risk assessment states that for an impact to occur, there must be a source of contamination, a receptor that may be impacted and a pathway connecting them. If either of the source, pathway or receptor is absent, there is no likelihood of environmental impact. The key sources of potential or perceived environmental risk in this proposed TGS14 Activity that are different to "traditional" petroleum activities historically and routinely assessed by the DMP have been identified by the Company as Hydraulic Fracturing Fluid, Hydraulic Fracturing Flowback and Air Emissions.

This structured approach to scoping EIA informs the assessment of Potential Environmental Impacts on Environmental Factors (Receptors) and the associated proposed management and mitigation measures which are summarised in Section 7.

The importance of safeguarding the Kimberley's water quality cannot be underestimated and for that reason Buru Energy will not compromise its commitment to environmental excellence. The TGS14 program will use a maximum total of 31 ML of water pumped from existing Company metered water bores at the well pads for the HF process. 31 ML equates to less than 2 days water use in Broome or 12 Olympic sized swimming pools.

The chemicals selected for the HF fluid system are an environmentally friendly suite derived from the food industry. A detailed Chemical Risk Assessment has determined that none of the chemicals to be used are classified as carcinogens or teratogens; are not persistent in the environment and do not bioaccumulate. The downhole HF fluid system and its breakdown products were tested using bioassays in a nationally accredited laboratory testing program. The bioassays used rainbow fish, a local species in the Fitzroy River, as the test fish and concluded that there was no effect on fish even at twice the concentration classified as "very slightly toxic", the lowest toxicity rating in Australia. In other words, the results indicate the fluid is non-toxic.

All flowback water from the wells, which is hyper-saline, will be stored on surface in a triple lined earthen reservoir at each well site until well testing is complete. Storing water in these reservoirs poses no risk to wildlife as the water is non-toxic based on flowback results from the Company operations in 2010. It is estimated that more than 95% of the flowback water will be returned down the wells to the Laurel formation following completion of the testing program at each well site later in the dry season of 2014.

Assessment of all three aspects (Hydraulic Fracturing Fluid, Hydraulic Fracturing Flowback and Air Emissions) as a source of potential hazard or risk is considered low, based on the technical characterisation of the fluids and emissions. This is outlined in more detail in Section 6. The pathway to receptors in all three cases is also shown to be either implausible or else of very low likelihood with the appropriate management measures in place.

An identification of potential environmental impacts on environmental factors including cumulative factors, the proposed management and mitigation measures and an assessment of significance is presented in Section 7. All are assessed to be Not Significant.

Community Engagement

Section 5 of this document supporting the referral sets out the consultation and engagement strategy with relevant stakeholders and the stakeholder consultation register maintained by Buru Energy since November 2011 for the Tight Gas Development Project. The consultation strategy is geographically broad based and has a diversity of recognised stakeholders including pastoralists, schools, community groups and businesses. A range of consultation methodologies have been employed. The consultation and engagement is strategic in nature by virtue of the establishment of "gas roadmaps" with Traditional Owners on whose Native Title lands the wells are situated. These "roadmaps" recognise that TGS14 is at an early exploratory stage of evaluation of a large tight gas resource in the Canning Basin that potentially offers long term energy security to Western Australia, significant contribution to Australia's GDP and socio-economic opportunity and employment for people and businesses in the local and regional community.

The "roadmap" establishes a participatory process that encompasses Traditional Owner values and heritage and ongoing community engagement in Company planning and development of this potential resource. This includes the establishment of a Company accredited training and employment program

for Environmental Science Cadets with candidates from Traditional Owner groups to assist in the ongoing environmental monitoring program for the gas development; the active identification of training and employment opportunities in Buru Energy and through its specialist service providers as well as active identification of business opportunities for local Aboriginal companies and enterprises.

The consultation and engagement strategy also includes a joint review process of Buru Energy environmental risk assessment (ERA) contained within the Environment Plan with relevant government agencies and the Traditional Owners and their independent specialist advisors during the assessment phase of the Environment Plan. The engagement program is focused on the broader Kimberley community and includes holding a series of information sessions at various locations in the Kimberley region, as well as separate presentations to community and business organizations. People are able to register their interest through a registration process, via email, a 1800 number or a designated email. The Company is also engaging with schools in Broome, Derby and remote areas throughout the Kimberley, providing presentations and supporting school initiatives, as well as offering scholarships.

Given the pilot nature of TGS14 in the Project area and community interest in this potential significant and strategic new industry in the region, a participatory review of Buru Energy risk assessment and management and monitoring methodologies, conducted during the assessment process, has been adopted using an iterative and interactive workshop and review approach that includes:

- Traditional Owners and their specialist advisors in relation to their land on which the wells are located
- An inter-agency working group including Department of Mines and Petroleum, Department of State Development, Office of Environment Protection Agency, Department of Agriculture and Food, Department of Environment Regulation, Department of Parks and Wildlife, Department of Water, Department Main Roads and Department of Lands
- Independent senior peer review of matters pertaining to water resources, the geological environment and operational procedures

Self-Referral to Office of Environment Protection Agency

Buru Energy considers that scope, spatial scale, and extent and duration of potential environmental impacts are adequately characterised and defined for the proposed Activities and that TGS14 is a small scale pilot project that is the early stage of a ‘proof of concept’ process in exploration of the Laurel Formation. With the appropriate risk mitigation/management measures outlined in the Environment Plan the uncertainty (risk) in not achieving the stated environmental performance objectives is low. This is further supported by the Impact Assessment contained within this referral and outlined above. It is Buru Energy’s view that the Environment Plan has adequately considered the:

- Character of the surrounding environment;
- Magnitude, extent and duration of anticipated change;
- Resilience of the environment and its ability to cope with change;
- Confidence of prediction of change; and
- Existence of environmental values, policies, guidelines and standards against which a proposal can be assessed.

The Potential Impact on Environmental Factors as a result of the proposed Activities has been assessed in the EP document and based on the assessment is considered Not Significant for the proposal.

Matters of National Environmental Significance

Buru Energy has considered whether the Activities proposed in TGS14 are likely to have a significant impact on Matters of National Environmental Significance (MNES) and concluded that there are no impacts on MNES matters that require referral under the EPBC Act. Bilbies, listed as Vulnerable under the *EPBC Act* occur in the Yulleroo area. Given that no clearing is required for this Activity, the short duration of the Activity, as well as management measures to be implemented to minimise disturbance of Bilbies, Buru Energy considers that the Activities will not have any significant impact on Bilbies at a species level nor at a local level.

All well sites are outside of environmentally sensitive areas (ESA). The West Kimberley National Heritage Place (WKNHP) is located approximately 25 km to the west of Valhalla North 1 well site and the RAMSAR listed Roebuck Bay wetlands are 65 km to the west of the Yulleroo 4 well site. Buru Energy considers that it neither of these areas will be impacted by the Activities and will not require a referral under the EPBC Act.

1. INTRODUCTION

Buru Energy is at an early exploratory stage of evaluation of a large tight gas resource in the Canning Basin that potentially offers long term energy security to Western Australia, significant contribution to Australia's GDP and socio-economic opportunity and employment for people and businesses in the local and regional community.

The particular area of interest for petroleum exploration to Buru Energy is a potential tight gas resource located in a geological formation known as the Laurel Formation where it occurs at depths below approximately 2,000 m to a foreseeable maximum of 5,000 m or more. This stratigraphic unit is over 350 million years old and was laid down in the early Carboniferous period. The sediments in the Laurel Formation are predominantly sandstone, carbonate and shale of shallow water marine, deltaic and fluvial origin. Within the Laurel Formation the permeability and porosity decreases with depth providing the constraining mechanism for gas accumulation.

TGS14 is a pilot exploration program (the Activity) designed to determine the quality and rate of gas flow from the Laurel Formation at four sites where Company exploration wells are currently located in the Canning Basin. The wells were drilled and constructed in 2012-13 and their integrity subsequently assessed by an independent well examiner.

1.1. Scope And Purpose

The purpose of this document is to support the referral of a proposal under Section 38 of the EP Act. It provides additional information on the Proposal, the existing environment in the area of the activities and potential impacts that could arise as a consequence of implementing the Proposal.

The Company proposes to undertake testing for tight gas flows in the Laurel Formation using hydraulic fracturing (HF) at four existing exploration wells located in the Yulleroo and Valhalla & Asgard tight gas provinces. The testing operations proposed in the dry season of 2014 comprise of Tight Gas Stimulation (TGS 14) in the Laurel Formation using HF to determine if prospective gas flows may be achieved and to characterise the quality and quantity of the resultant hydrocarbon flows. Other objectives of TGS14 are focused on demonstrating no or minimal risk to humans and the environment. In this regard, objectives of TGS14 include demonstrating that the flowback water from the HF can be 100% recycled, using it safely in HF treatments while minimising the small amount of water required to be taken from the aquifer and demonstrating that there are no solid, fluid or air emissions from the activity that pose any risk to humans or the environment. Additional objectives relate to optimising the HF design for the Laurel formation in order to minimise land footprint and maximise resource recovery from the formation in a commercially viable manner.

This Referral Document and the Environment Plan submitted under the PGER Act sets out the means by which the environmental aspect of the Company's proposed testing operations (Activities) will be managed.

2. BACKGROUND INFORMATION

2.1. Proponent Details

Buru Energy Limited (Company) is an Australian ASX listed company engaged in oil and gas exploration and production in the northwest of Western Australia in an area known in geological terms as the Canning Superbasin. Buru Energy is committed to ensuring proper environmental standards will not be compromised and the Company will have a transparent process for the work undertaken, offering full disclosure of management of its exploration and production activities in its Environment Plans.

The Company is committed to minimising the environmental impact of its operations and plans all of its operations to ensure that they are undertaken in an environmentally acceptable manner. The Company is continually looking for opportunities to improve its operating practices.

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2.2. Overview of Proposed Activities

2.2.1. Location

The Activities will be undertaken in the Yulleroo and Valhalla & Asgard tight gas provinces at existing petroleum wells; namely Yulleroo 3 and Yulleroo 4 in the west and Valhalla North 1 and Asgard 1 as detailed in Table 1 and shown in Figure 1.

Table 1: Details of existing wells and well sites.

Well Site	Exploration Permit Area	Easting	Northing	Existing Well Total Depth (m)	Month Drilling Completed
Yulleroo Area					
Yulleroo 3	EP 391 R2	488510	8026425	3,712	June 2012
Yulleroo 4	EP 436 R1	487081	8028803	3,846	March 2013
Valhalla & Asgard Area					
Valhalla North 1	EP371 R1	683112	8006105	3,344	Feb. 2012
Asgard 1	EP 371	714726	7981294	3,524	Oct. 2012

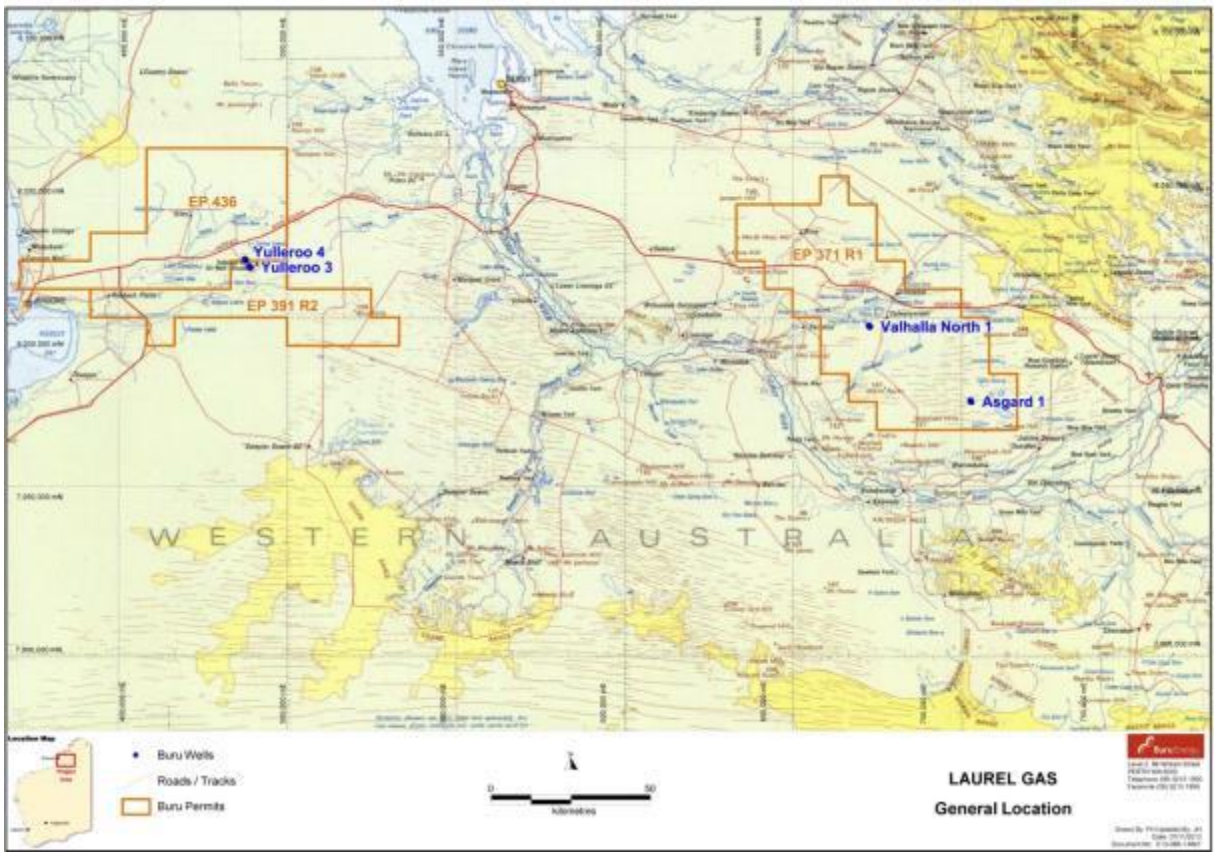

Figure 1: Location of the Company tight gas exploration wells.

The existing petroleum wells are currently “suspended” under an approved Program in accordance with regulatory requirements under the *Schedule of Onshore Petroleum Exploration and Production Requirements WA* (1991). Well suspension refers to sealing of the wellhead for a particular period of time in order to save the wellbore after the end of drilling. The usual context is an uncompleted well in which operations ceased following drilling but which has not been plugged and abandoned permanently. The last steps of well construction are the installation of a wellhead which is designed and pressure-rated for the HF operation. The system is then pressure tested and managed under care and maintenance until further activities at the well are undertaken.

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3. EXISTING ENVIRONMENT

3.1. Physical Environment

3.1.1. Geology

Geological Environment Risk Assessment

A detailed geological environment risk assessment was conducted for each of the well sites using information derived from seismic surveys and geophysical assessment as well as interpreted drilling logs and data derived from the drilling program. The ERA concluded that there are no geomechanical hazards (e.g. faults that are not closed) evident in the stratigraphy of the exploration wells that have any potential for upward propagation of HF fluids or hydrocarbons into the recognised aquifers or likely to cause significant induced seismicity. There is at least 600m of impermeable hard rock that separates the highest likely HF zone from any potential potable very deep aquifer. An ongoing baseline seismicity study has been conducted at each of the areas for more than one year. An independent peer review by a leading international expert has also been conducted to review and confirm the findings of the geological environment risk assessment.

The Canning Superbasin, covering ~430,000 km² (106 million acres) in the north of Western Australia, is one of Australia's largest onshore sedimentary basins situated between 17°S and 21°S. It was established in the early Paleozoic era as a broad northwest-southeast trending cratonic sag that is now divided by the Broome and Crossland Platforms into the Fitzroy-Gregory graben system ("Fitzroy Trough") in the north and the Willara and Kidson Sub-basins in the south (Figure 2). The Fitzroy Trough contains the thickest (locally up to approximately 15 km) and probably most complete stratigraphic section in the basin of Ordovician, Devonian and Permo-Carboniferous sediments. Deep exploration wells such as Yulleroo 1, drilled in 1967 have penetrated the Devonian to Lower Carboniferous (Fairfield Group) thick marine strata, overlain by shallow marine to deltaic mid to Upper Carboniferous Anderson Formation. Regional unconformities separate this package from the mostly non-marine Reeves Formation and Grant Group of Late Carboniferous - Early Permian age, the latter being partly glacigenic in origin. Further phases of marine and fluvial sedimentation took place in the latter part of the Permian to Early Triassic and during the Jurassic–Cretaceous. The deeper parts of the Fitzroy Trough are poorly known, being beyond penetration by exploration wells, but it is assumed that equivalents of the Ordovician to Silurian shallow marine and overlying salt-bearing succession, widespread elsewhere in the Canning Basin, are present below the Devonian section.

The Yulleroo and Valhalla provinces both lie within the Fitzroy Trough a major subdivision of the Canning Basin. The trough (Reeves, 1951) is a northwest trending graben (also called a rift valley) bounded on its north-eastern side by the Beagle Bay Fault and on its south-western side by the Fenton Fault system. It is generally about 110 km wide and has been in-filled over several hundred million years by 10,000 m or more of Ordovician to Cretaceous sediments (mostly Devonian to Permian), with common folding and faulting of the Triassic and older rocks sub-parallel to the alignment of the trough. The stratigraphic unit targeted for petroleum exploration using HF is the late Devonian to early Carboniferous Laurel Formation, where it occurs at depths below approximately 2,000 m to a foreseeable maximum of 5,000 m or more. The sediments in the Laurel Formation are predominantly sandstone, carbonate and shale of shallow water marine, deltaic and fluvial origin. Within the Laurel Formation the permeability and porosity decreases with depth providing the constraining mechanism for gas accumulation. The depositional material overlaying the Laurel Formation within the basin is also comprised of fluvial deposits including siltstone, sandstone, carbonates, gravels and sands.

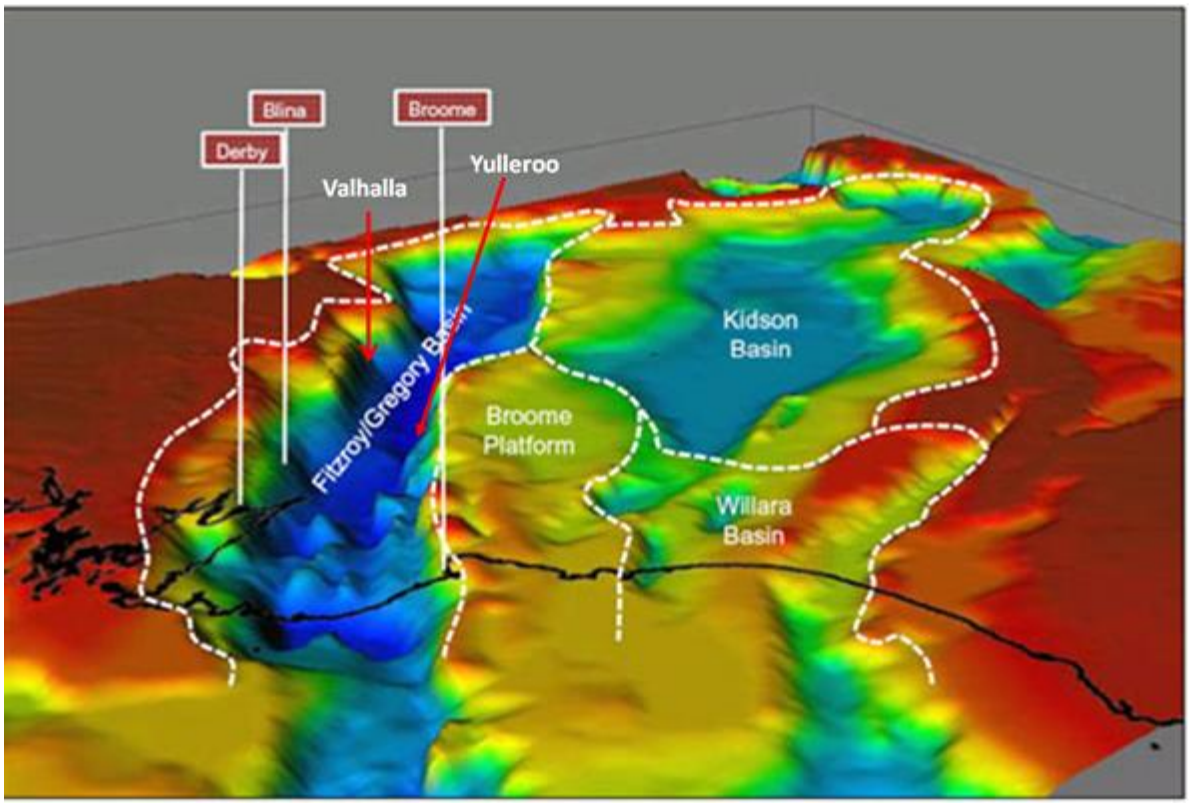

Figure 2: Geomorphology of Canning Basin showing the coastline, towns and Yulleroo and Valhalla field locations.

Yulleroo Area

A Geological Environment Risk Assessment study conducted for the Yulleroo area has characterised the geology in geological and well log cross sections coupled with seismic survey interpretation for each of the Yulleroo wells. The study identified that:

- Top of the Laurel Formation zones of interest for HF treatment is more than 2 km deep.
- There is more than 2,000 m of impermeable hard rock between the Broome sandstone aquifer which is the source of drinking water in the Yulleroo area and the highest proposed HF zone meaning it is implausible for HF fluid to reach the aquifer.
- There is more than 1,500 m of impermeable hard rock between the deepest recognised aquifer (Grant Aquifer – Betty Unit **which is not potable** in the Yulleroo area) and the highest proposed HF zone (Figure 3).
- The Anderson formation comprised of shale which is directly above the Laurel formation acts as a confining layer (seal) for hydrocarbon migration and would act as an immediate thick containment barrier of impermeable hard rock to unplanned vertical growth of HF (Figure 3).
- Zones for HF treatment are located in a thick sequence in the Laurel Formation of up to 1,500 m.
- There has been some low level natural hydrocarbon seepage upwards from the source rock in the Laurel Formation to overlying formations and their respective groundwater systems, occurring during the last 200 million years, as demonstrated by the logs taken during well drilling which show the presence of hydrocarbons in the overlying formations.
- The very low/lack of hydrocarbon saturations in the Upper Anderson, Reeves, Lower Grant and Mesozoic formations above the Laurel Basin-Centred Gas System demonstrate that hydrocarbons migrate vertically through these rocks at geological (millions of years) time scale and are therefore impermeable (Figure 3).
- One seismic scale normal fault lies within the section of interest for HF at each of the Yulleroo 3 and Yulleroo 4 wells. It is concluded by Company geologists and technical advisors that the fault

at each well may compromise fracture propagation but is not considered to be a geomechanical hazard.

- Analysis of seismic survey data at each of the Yulleroo wells within the section of interest for HF treatment indicates that no geomechanical hazards (e.g. faults that are not closed) intersect the well bore area at either of the Yulleroo wells and that neither have any potential for upward propagation of HF fluids or hydrocarbons into the recognised aquifers nor likely to cause significant induced seismicity.

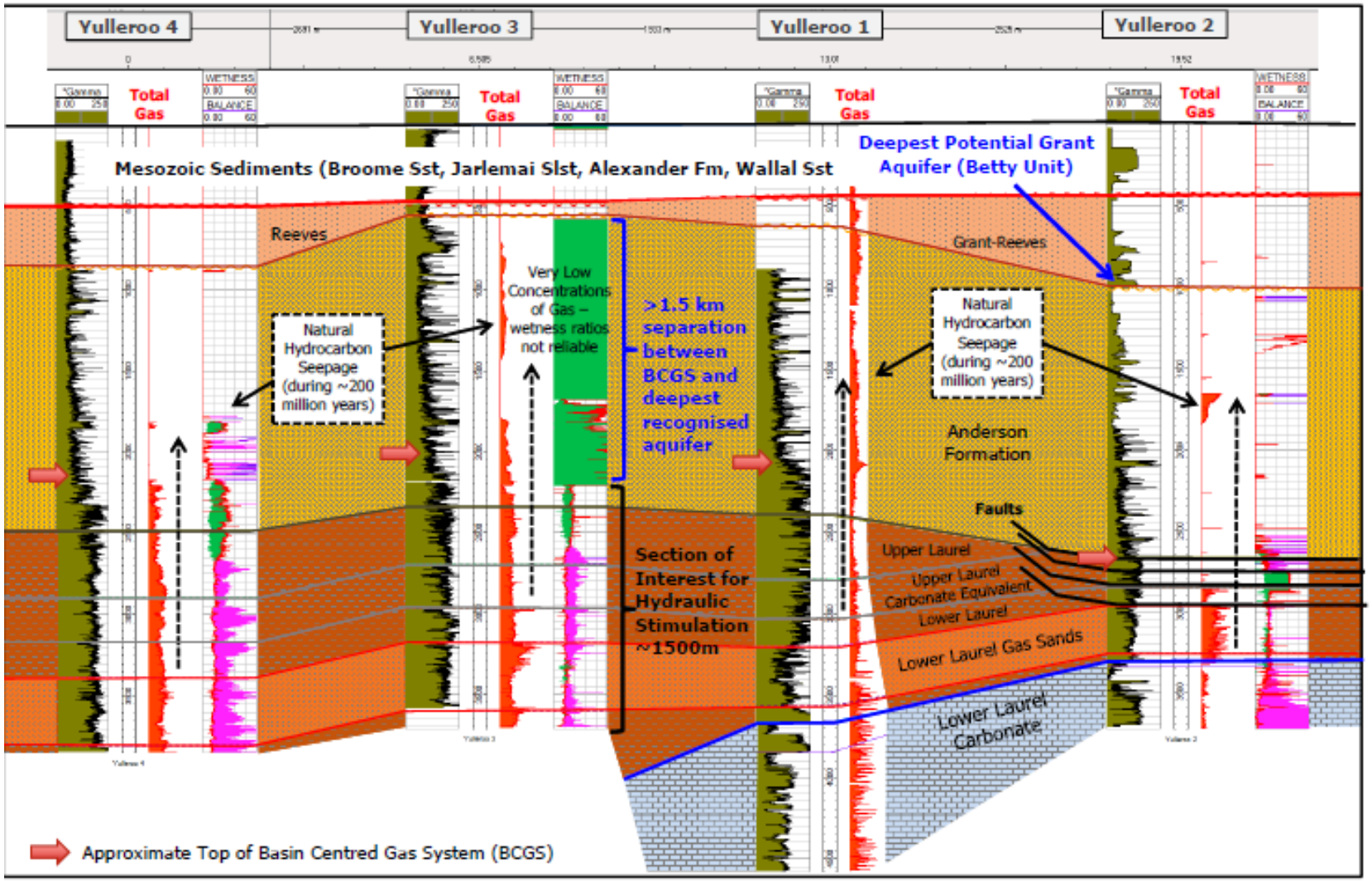

Figure 3: Geological and Log cross section at Yulleroo 3 and Yulleroo 4 wells.

Valhalla & Asgard Area

A Geological Environment Risk Assessment study conducted for the Valhalla and Asgard areas has characterised the geology in geological and well log cross sections for each of the wells (Figure 4). The study identified that:

- Top of the Laurel Formation zones of interest for HF treatment is more than 2 km deep
- There is more than 2,000 m of impermeable hard rock between the Liveringa sandstone aquifer which is the source of drinking water in the Asgard and Valhalla area and the highest proposed HF zone meaning it is implausible for HF to reach the aquifer.
- There is more than 600 m of impermeable hard rock between the deepest recognised aquifer (Grant Aquifer – Betty Unit) and the shallowest proposed HF zones.
- The Anderson formation comprised of shale which is directly above the Laurel formation acts as a confining layer (seal) for hydrocarbon migration and would act as an immediate thick containment barrier of impermeable hard rock to unplanned vertical growth of HF (Figure 4).
- Zones for HF treatment are located in a thick sequence in the Laurel Formation of up to 1,500 m.
- There has been some low level natural hydrocarbon seepage upwards from the source rock in the Laurel Formation to overlying formations and their respective groundwater systems, occurring during the last 200 million years, is demonstrated by the logs taken during well drilling which show the presence of hydrocarbons in the overlying formations (Figure 4).
- The very low/lack of hydrocarbon saturations in the Upper Anderson, Reeves, Lower Grant and Mesozoic formations above the Laurel Basin-Centred Gas System demonstrate that hydrocarbons migrate vertically through these rocks at geological (millions of years) time scale and are therefore largely impermeable (Figure 4).
- One seismic scale normal fault lies within the section of interest for HF at each of the Valhalla North 1 and Asgard wells. It is concluded that the fault at each well may compromise fracture propagation but is not considered to be a geomechanical hazard.
- Analysis of seismic survey data at each of the Valhalla and Asgard wells within the section of interest for HF treatment indicates that no geomechanical hazards (e.g. faults that are not closed) intersect the well bore area at any of the Valhalla and Asgard wells that have any potential for upward propagation of HF fluids or hydrocarbons into the recognised aquifers nor likely to cause significant induced seismicity.

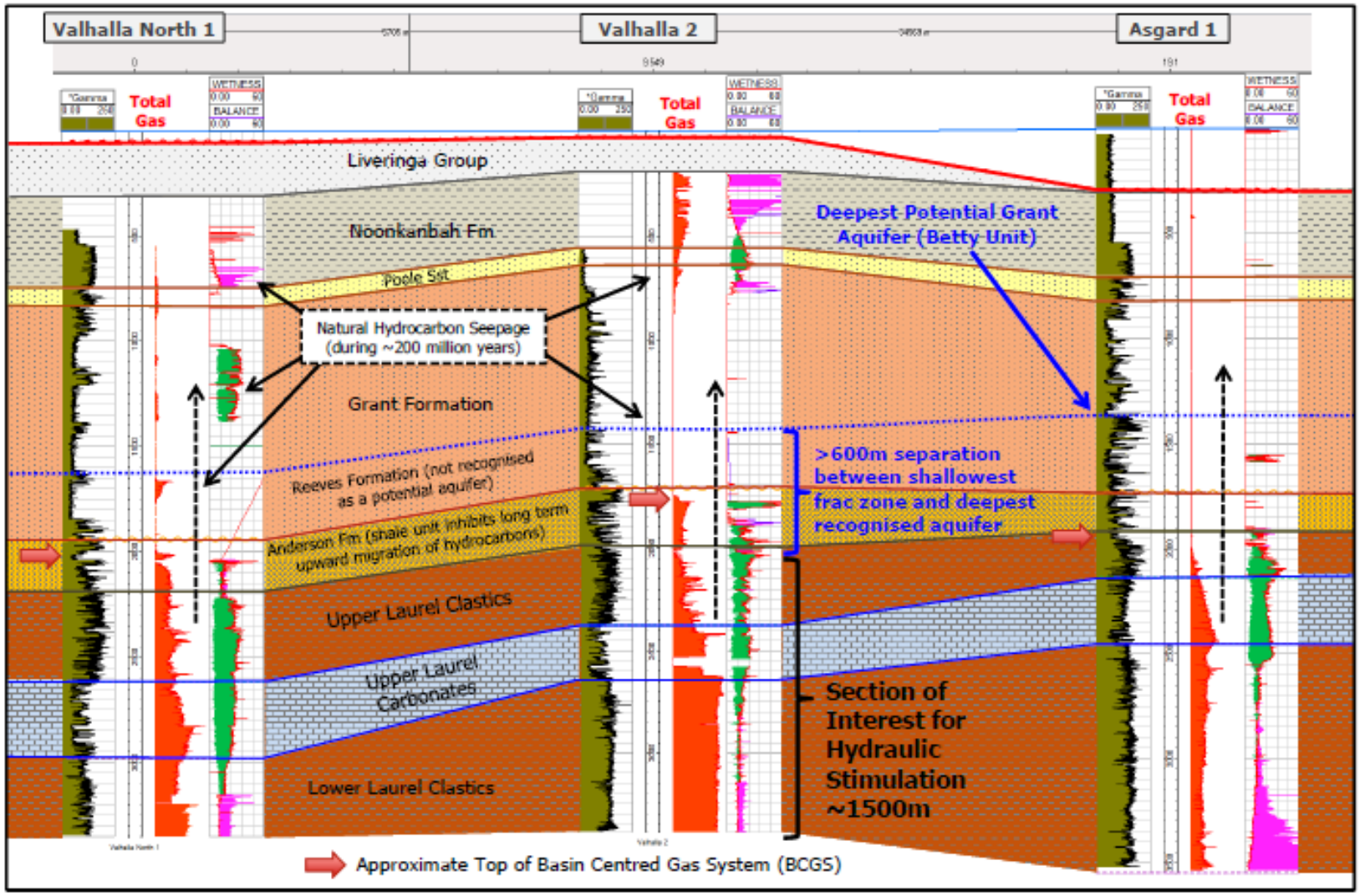

Figure 4: Geological and Log cross section at Valhalla North 1and Asgard 1 wells.

3.2. Climate and Weather

The climate of the areas in the Canning Basin where the Activities will be undertaken varies from semi-arid to dry tropical with distinct wet and dry periods (Figure 5) and an average annual total rainfall of 600-900 mm and annual evaporation of approximately 2,400 mm. Average annual total rainfall increases with decreasing latitude.

The north-west of Australia has seen a significant increase in annual rainfall since the 1950s and this trend is expected to continue. There are two main broad-scale influences on climate in the Kimberley; the band of high pressure known as the Sub-Tropical Ridge to the south, and the Monsoon which delivers moist air from the warm tropical waters to the north. Over 75% of the average annual rainfall falls from January to March associated with thunderstorms and tropical lows or cyclones.

From March to November a pronounced dry season occurs with on average, a total of 20 mm of rain. Aridity increases further inland, east of TGS14 activity area, into the Great Sandy Desert, which lies in the east of the Canning Basin where annual rainfall ranges from 25-300 mm. This arid zone is characterised by the historical recording of nil rainfall in any month. It is not uncommon for very little rain to occur for months on end. The median rainfall for the months of July to October is actually zero. Longer dry periods of over 12 months are associated with no wet season.

A graph of the mean monthly rainfall at Broome compared with evaporation shows that evaporation greatly exceeds rainfall in all months with a net moisture deficit of about 1.75 m/yr. Evaporation is highest during the last quarter of the calendar year (Figure 5). Evaporation data derived for dams in the Canning Basin indicate that monthly evaporation varies increases from approximately 150 mm in June to almost 300 mm in November (Luke et al., 1987).

In the Karajarri and Yawuru seasonal calendar there are four major seasons which are interspersed by two short transitional seasons; Marrul in April-May and Wirlburu in September when seasonal coastal current and wind reversals commence.

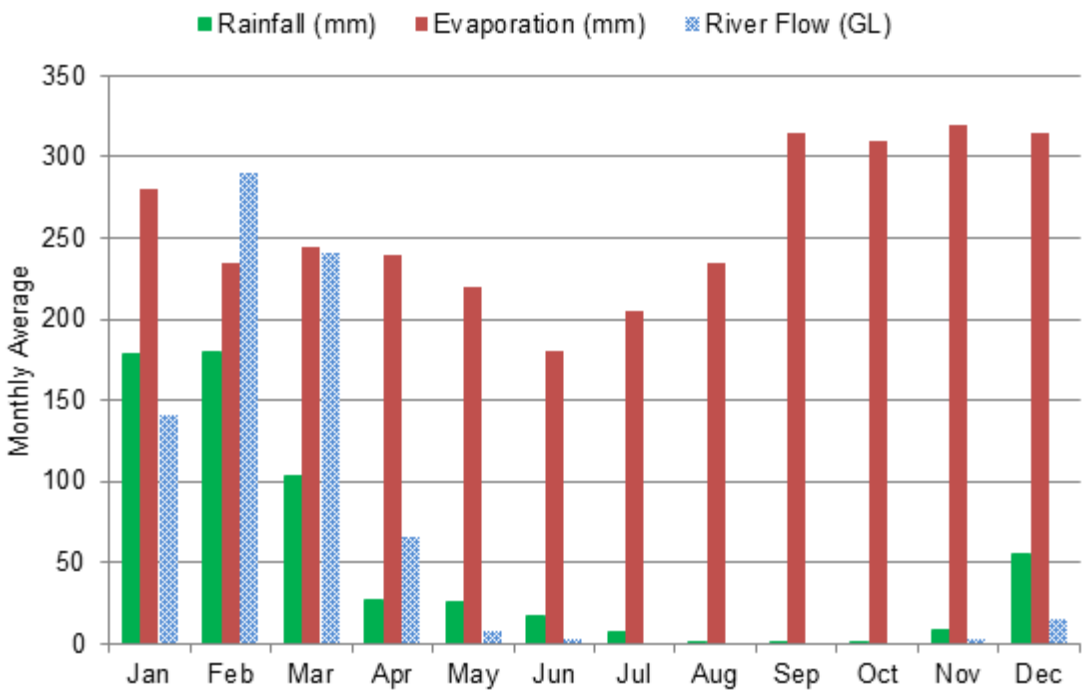

Figure 5: Monthly average rainfall and evaporation for Broome and river flow at Fitzroy Crossing (DoW, 2006).

3.3. Landform

The Activity areas are part of the “Sandland Province” (Figure 6). The Sandland Province is aptly named as red pindan sand dominates the landscape. In the last glacial (Quaternary Period), Australia suffered a number of extremely arid periods. There was a period of major water deficit from 25,000 to 14,000 years BP, and during this time (about 17,000 BP) there was intense movement of wind-blown material across Australia (Bowler 1982). The extreme aridity would have catastrophically reduced the vegetation cover, allowing wind to move vast volumes of dust and sand.

In the Sandland Province, this resulted in the already relatively flat landscapes being covered (drowned) by dust and sand deposits to produce today’s generally very flat “pindan” plains and parallel sand dunes. The term “pindan” is used in northern Australia for the red silty soils that dominate the landscapes from Port Hedland to Cape Leveque and eastwards into the Northern Territory. The pindan is characterised by baseline elevated levels of iron and chromium and has variable levels of clay content that may exceed 40% in some of the Company permit areas such as Sundown (L8).

The landscape is therefore mostly covered in pindan except for the rocky outcrops, breakaway and associated local drainages. Some drainage sumps are in pindan, especially swales between sand dunes whilst some appear to be remnants of the old landscape before the area was drowned in sand. There is generally little or no through-drainage. However, after exceptional weather events large bodies of water form little inland seas.

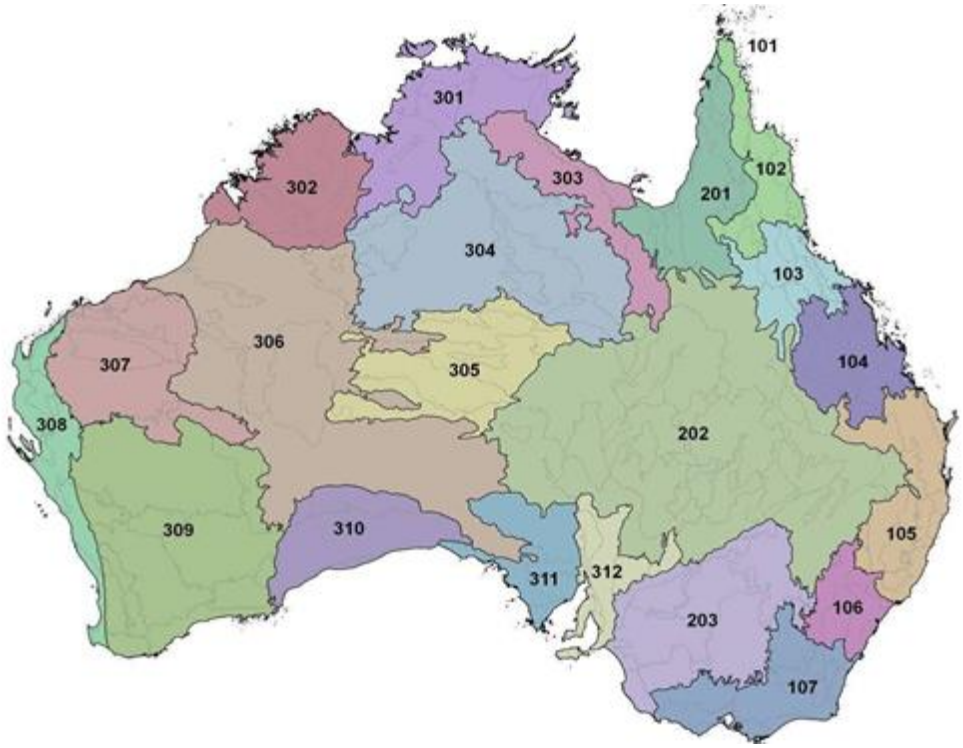

Figure 6: Sandland Province (306) from geomorphological classification of Australia (Jennings and Mabbutt, 1977).

3.4. Surface Waters

Protecting Values of Surface Water during the Activities

Major spills of fuel, potential condensate and certain chemicals present a small risk to surface water bodies as well as soil in the Activity area. The risks to surface water bodies is considered very low as the Yulleroo well sites are located over 4 km from the nearest surface water body and the Valhalla field well sites are located over 3 km from the nearest surface water body. The activities will be undertaken during the dry season so it is highly unlikely that there will be any surface water present near the well site or track that may be impacted by the activities. The volume of maximum potential spill is unlikely to spread more than 100 sq. m and can be readily scraped up and removed to an approved facility should any spills occur.

Yulleroo Area

The Yulleroo area lies at approximately 45 m (AHD) above sea level in the Cape Leveque catchment. Surface water in this catchment flows westerly towards the headwaters of Roebuck Bay, which is an ancient former mouth of the Fitzroy River. The Yulleroo 3 and Yulleroo 4 wells are located on Roebuck pastoral station and are approximately 57 km east from the highest astronomical tide line of Roebuck Bay. While there are no permanent flowing freshwater creeks and few permanent and semi-permanent lakes, for long periods wet season rain lies on the low-lying hinterland over the low gradient Roebuck Plain in the catchment west of Yulleroo. These lakes have important cultural and heritage significance to the Yawuru people (Yawuru RNTBC, 2011). The wet season's torrential rains inundate this hinterland every year and carry the detritus of the dry season: insects and larvae and organic carbon in the form of vegetation, into Roebuck Bay. These nutrients fuel a system that generates phytoplankton that is consumed by zooplankton that provides food for juvenile fish, and so forth. The result is that the Bay generates "bait balls" of small fish and other fauna (Wright and Pyke, 2009).

The Yulleroo area, defined as the area encompassed by the 3D seismic survey grid acquired in 2011 (Figure 7), is described in physiographic terms as comprised of sand plains and dune fields, with little organised drainage: stable dune field with swales opening locally into sand plain; restricted marginal plains with thin sand cover occurring adjacent to dissected tracts and there are minor, isolated hills rising up to almost 90 m (AHD) above sea level at the boundary of the Fitzroy and Cape Leveque catchment (Figure 8). The Yulleroo area has limited surface drainage with any surface drainage occurring mainly as sheet-flow tracts downslope from uplands and extending for short distances into dune field. Relief of dunes in the dune field is up to 12 m (Payne and Schoknecht, 2011).

The pindan dunes also provide surface alluvial water storage, possibly as discontinuous perched alluvial aquifers and mound springs. These alluvial aquifers are likely to feed the soaks and seepage areas at the base of the dune systems during the onset of the dry season. In this way, the inland and coastal soak waters are linked to permanent water sources (i.e. 'living waters') such as springs and waterholes (jila) that are spread throughout the country (Yu, 1999).

For much of the year, fresh water may be found in springs and soaks located on the edge of Roebuck Plain where the Broome sandstone aquifer is close to the surface (Figure 9). These wetlands include Yidarr (Lake Eda), Lake Campion and Gunbanyari (Ungani Lakes). These habitats provide resting and feeding areas for international migratory bird populations that begin to arrive from as far away as Siberia in October and return to the north in April/May. If these wetlands dry following the wet season, a rich annual herb/grassland develops.

The Yulleroo area is located within Roebuck pastoral station. Many of these surface water accumulations are also accessed by cattle and other fauna during the dry season.

The well pad at each of the Yulleroo sites is approximately 3 ha in size. The wells pads have been levelled and surfaced with gravel. Storm water runoff from the well pad is generally directed down the access track drain.

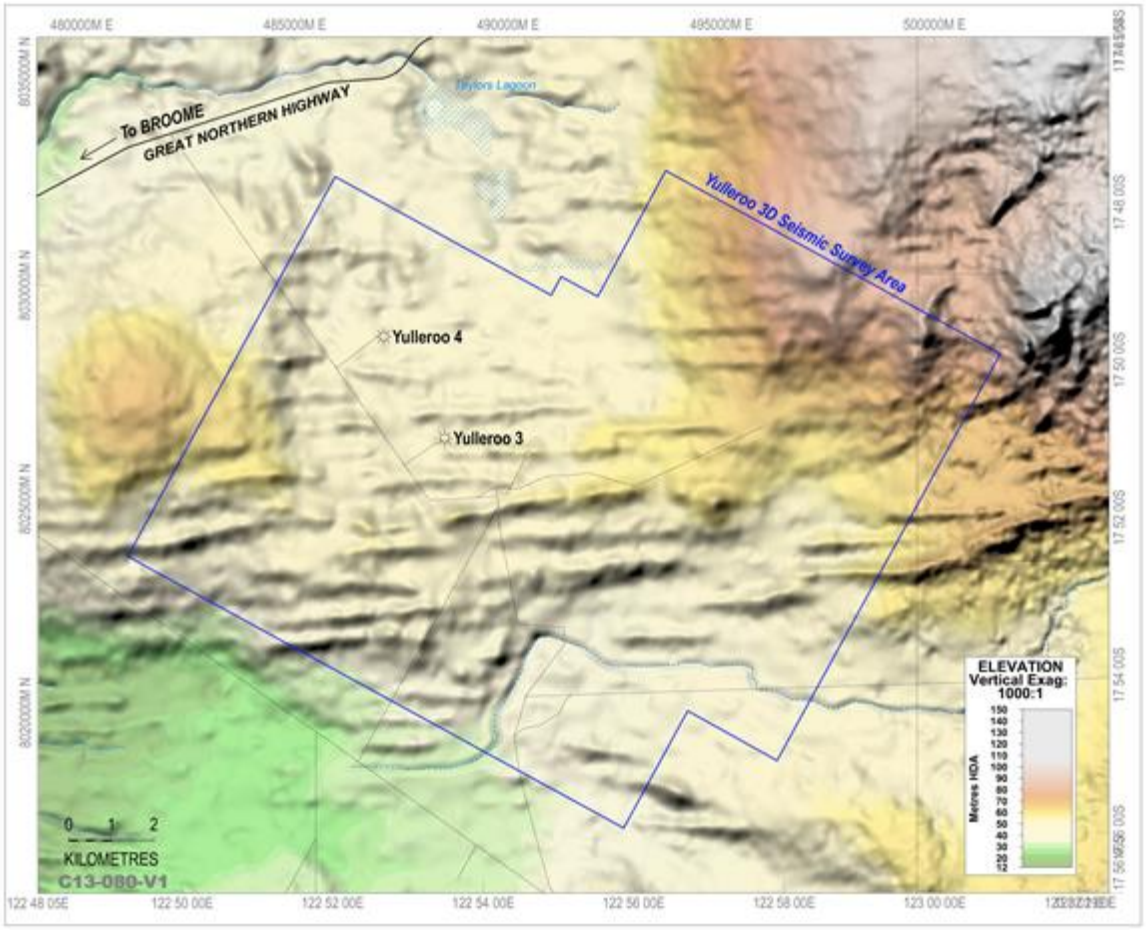

Figure 7: Yulleroo project area is defined as the 3D seismic survey area acquired in 2011.

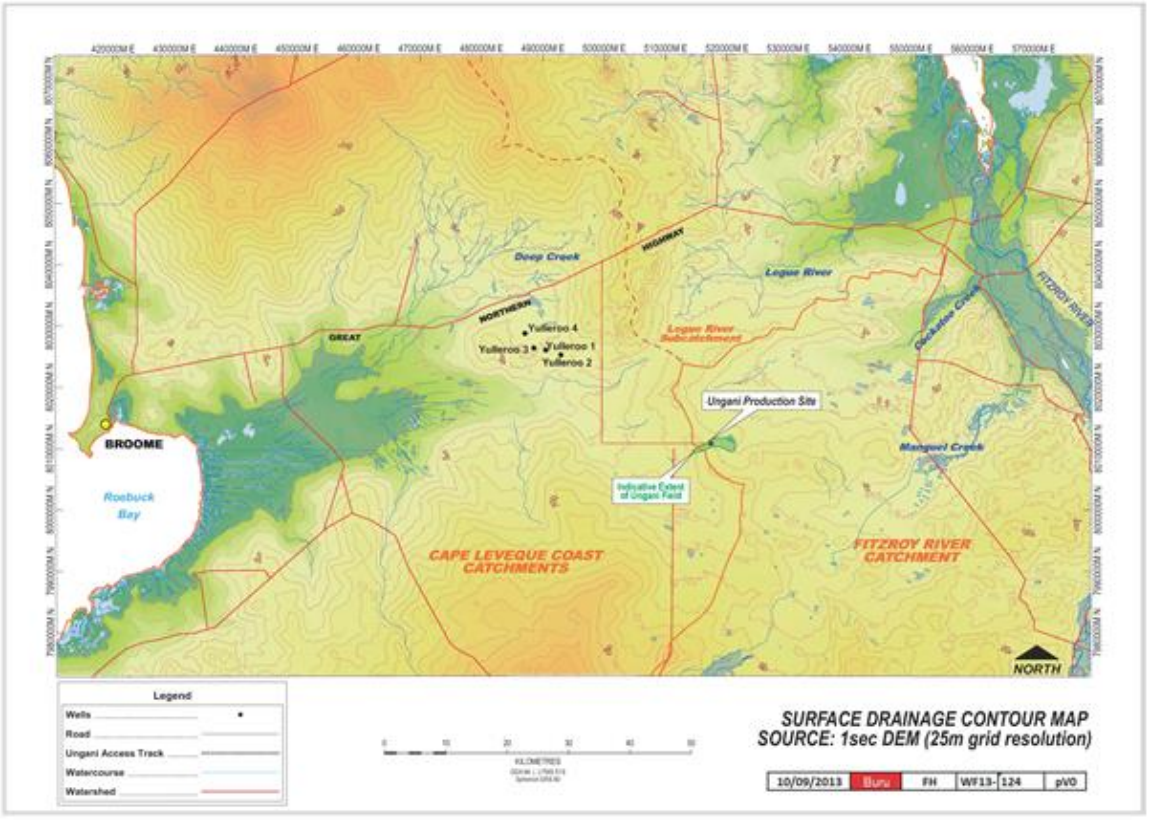

Figure 8: Catchment drainage in Yulleroo area and cross section transect to Roebuck Bay.

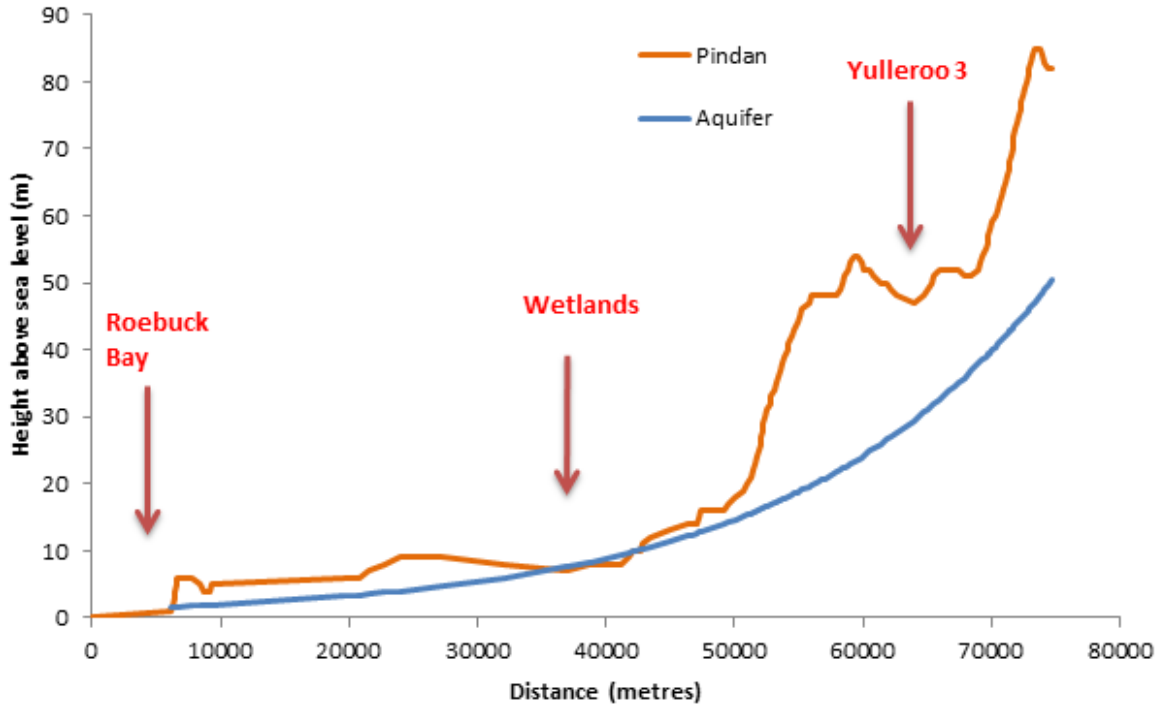

Figure 9: Transect plot across Roebuck Bay catchment showing elevation of ground level and indicative water level of Broome sandstone aquifer.

Valhalla Area

The Valhalla area lies at approximately 110 m (AHD) above sea level in the Fitzroy River catchment, approximately 30 km north of the Fitzroy River. Surface water in this catchment flows south westerly along tributaries of the Fitzroy River. Valhalla North 1 is located on Calwynyardah paddock on Blina Pastoral Station. The Noonkanbah pastoral station, in which the Asgard 1 well site is located, is situated on the Fitzroy River between Camballin and Fitzroy Crossing. The Mt Hardman Creek catchment dissects the pindan dune and swale system between Asgard and Valhalla. Mt Hardman Creek, an ephemeral tributary into Fitzroy River and crosses the access track (Calwynyardah Noonkanbah Road) to Asgard 1 (Figure 10). A 90 km transect of elevations was derived across the Valhalla & Asgard well sites to the Cunninghame River tributary of the Fitzroy River (Figure 11 and Figure 12).

Figure 10: Mt Hardman Creek crossing on Calwynyardah Noonkanbah station road.

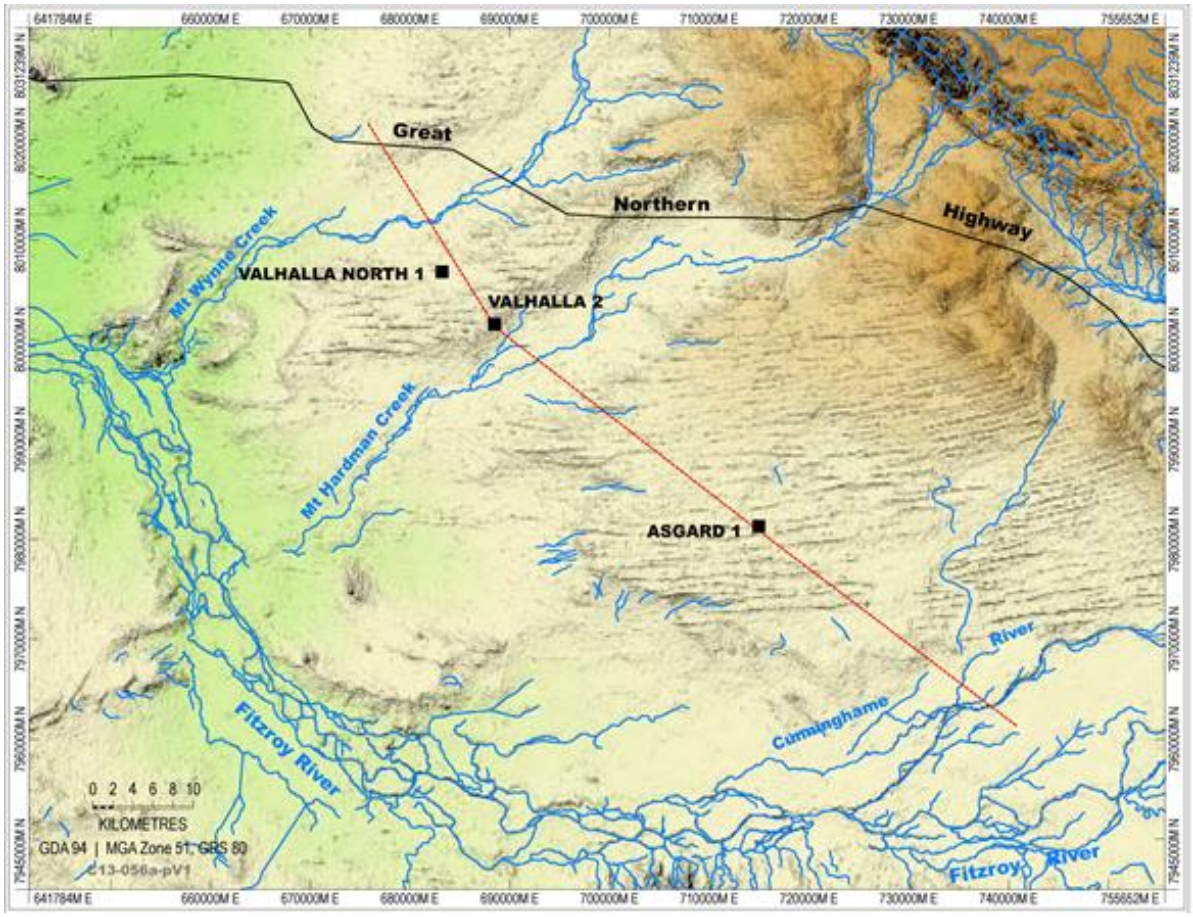

Figure 11: Transect used to derive elevation transect across the Valhalla-Asgard well sites.

The Mt Wynne Creek system dissects Valhalla North and the Great Northern Highway (Figure 11). The braided sheet flow erosion patterns that characterise the pindan is evident with broad ephemeral stream systems creating broad (5~10 km wide) “valley” areas interspersed by broad dune “hills” in the relatively flat savannah landscape.

The well pad at the Valhalla North 1 and Asgard 1 sites is approximately 3 ha in size. The wells pads have been levelled and surfaced with gravel. Storm water runoff from the well pad is generally directed down the access track drain.

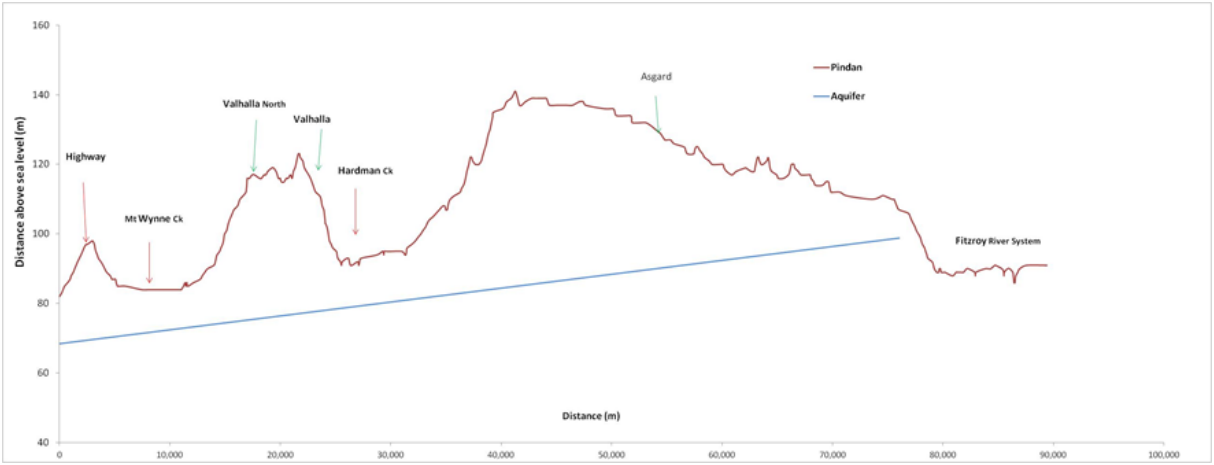

Figure 12: Ground level elevations and indicative water level of Liveringa aquifer (shown as blue line) based on hydrological model relative to sea level in Valhalla & Asgard well sites.

The Fitzroy River forms the primary catchment in the Valhalla & Asgard area. The river flows west for 733 km from the King Leopold and Mueller Ranges into King Sound south of Derby. The Fitzroy River has large but short duration floods (less than two months in a wet year); flood inundation is more confined to the areas adjacent to the main channel and the flood events occur as ‘pulse’ such that most water bodies on the floodplain are inundated for approximately the same period regardless of catchment position. River flows generally occur between November and May following seasonal rainfall (Figure 5). The geomorphology of the Valhalla and Asgard area is characterised by dune and swale systems which include rain-fed claypans in swales that are truncated drainage lines between dunes and intersected by creek lines and tributaries of the Fitzroy system. The swale system appears to operate as sheet flow to a drainage line connecting to the Cunninghame River which is a tributary of the Fitzroy River. Due to the long dry season present in the Activity area, many of the tributaries of the surface fluvial system draining into the Fitzroy River are ephemeral streams or swale washes draining the dune landscape prominent in the area. These ephemeral water bodies may occur in clay pans. The river contracts to pools with very low flows from about June to October (DoW, 2006). Ecologically, permanent pools are important refuges for aquatic species enabling them to survive the harsh dry season. The Traditional Owners suggest that infilling overtime has made some pools unsuitable for fishing and that floods are critical to flush these pools and ‘cleanse the country’ (DoW, 2006). Overall, there is a clear linkage between ecological and cultural values of specific freshwater habitats, particularly the permanent pools. Dams for livestock also occur on grazing lands. Salinity levels in the Fitzroy River have not been routinely measured; however, some records are available from five stations from 1996 to 2005. Wet season salinity levels of less than 250 mg/L compared with dry season levels which range up to 900 mg/L. The river is fresh (< 500 mg/L) between Fitzroy Crossing and Noonkanbah, it is marginal (500–1000 mg/L TDS) between Noonkanbah and Myroodah, and fresh from Myroodah to Willare (DoW, 2006). Dry season salinity of the river water can be interpreted to reflect the salinity of the groundwater, as contribution from surface runoff is negligible and river flows are supported by baseflow. The brackish stretch of river at Noonkanbah may reflect the baseflow contribution both from the alluvial aquifer, and possibly from the Noonkanbah and Liveringa Formation, over which the river flows along that section. There may also be an influence of the Blina Shale upstream from Noonkanbah. The salinity of river water often exceeds the desirable potable

water limit of 500 mg/L during the dry season, which, if a true reflection of the groundwater in the alluvial aquifer, may provide some constraints as a potable water supply source (DoW, 2006).

Sundown Evaporation Pond Area

In the event that reinjection of all flowback water into the Laurel formation at each well site in TGS14 is not possible the Company may seek approval to take residual flowback to an existing Company oilfield evaporation pond. The Sundown evaporation pond is located within the Sundown oilfield. The facility has been in operation for 32 years but is currently not producing oil. The area is managed under the Company *Blina Care and Maintenance Environment Plan* (HSE-PLN-008) which focuses on rehabilitating the legacy facilities and remediating the pond areas. The Sundown evaporation pond area has never been subject to flooding during its life. Naturally occurring salt pans are evident in the region. There is no surface connectivity with the surrounding landscape as evidenced in the terrain model (Figure 13). There are no permanent watercourses in the Sundown oilfield area. The closest ephemeral watercourse is Norman Creek, located over 3 km away from the evaporation pond. The evaporation pond will be capped with native clay soil and contoured to surrounding elevations once activities at the site are complete and during the remediation program outlined in the *Blina Care and Maintenance Environment Plan*.

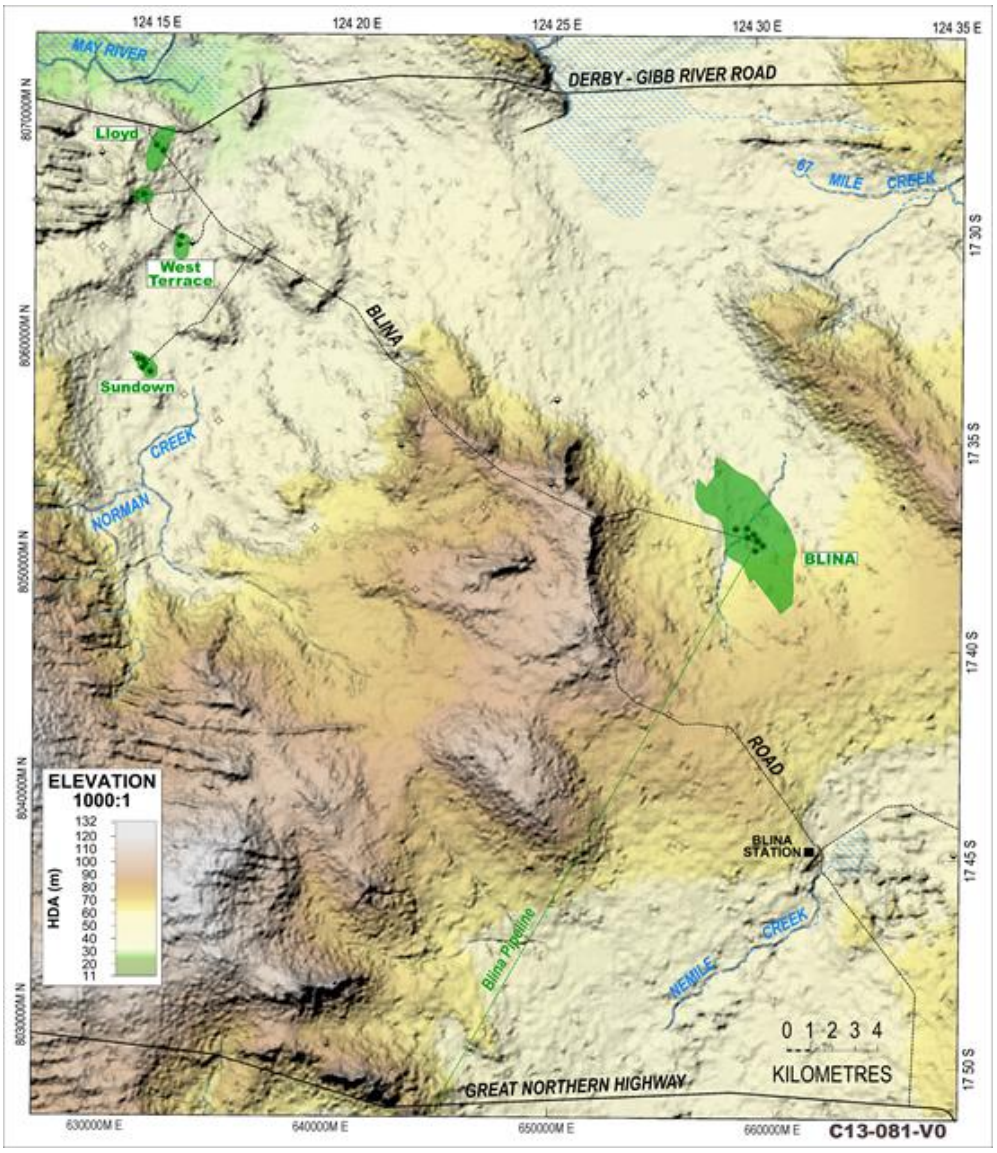

Figure 13: Sundown evaporation pond location in the Blina oilfield area.

3.5. Groundwater

Protecting Values of Groundwater Aquifers during the Activities

Effective protection of Groundwater aquifers requires an integrated approach that considers the well design and planning process, the composition of selected HF fluid, the isolation of HF and Flowback fluids from groundwater aquifers and the effective prevention and management of surface spills. The importance of safeguarding the Kimberley's water quality cannot be underestimated and for that reason Buru Energy will not compromise its commitment to environmental excellence. The Company's approach for protecting groundwater aquifers is outlined in the risk assessment section and employs methods consistent with leading practice across all of these aspects.

A comprehensive and detailed baseline groundwater characterisation study has been implemented at all well sites and the local region for over one year including detailed ongoing chemistry analysis of the aquifers using best available techniques. A comprehensive network of monitoring bores has been installed at the well pads including continuous loggers for detecting the presence of methane and other VOCs in the aquifer.

The quantity of water to be used in HF for TGS14 is a maximum of 31 ML which is less than 2 days water consumption for the town of Broome. TGS14 will aim to inform full recycling of HF fluid in any subsequent program. Returned fluid will subsequently be returned to the Laurel formation at the completion of testing at the respective well sites.

The ERA has concluded that source of risk to ground water is low. This is because the downhole HF fluid system and its breakdown products were tested using bioassays in a nationally accredited laboratory testing program. The bioassays used rainbow fish, a local species in the Fitzroy River, as the test fish and concluded that there was no effect on fish even at twice the concentration classified as "very slightly toxic", the lowest toxicity rating in Australia. In other words, the results indicate the fluid is non-toxic. All flowback water from the wells, which is hyper-saline, will be stored on surface in an impervious triple lined earthen reservoir at each well site until well testing is complete. Storing water in these reservoirs poses no risk to wildlife as the salty water is non-toxic based on flowback results from the Company operations in 2010. It is estimated that more than 95% of the flowback water will be returned down the wells to the Laurel formation following completion of the testing program at each well site later in the dry season of 2014.

Robust criteria for well design, construction, cementing and integrity testing are a key aspect of the Company procedures which follow Best Practice Guidelines of the WA Onshore Code of Practice for Hydraulic Fracturing (APPEA) and the Golden Rules (IEA) and to meet all regulatory requirements.

Furthermore and importantly, the extraction of fluid (e.g. gas and oil) at formation level via flowback up the well will create negative pressure gradients which will oppose any upward hydraulic gradient. This means that as a well produces over time, the pressure is actually lower inside the well than outside. Under these conditions, any potentially occurring leak path is into the well and pollution potential is absent. The likelihood of any potential for upward migration of fluids becomes impossible.

In addition, all assessment of the geological environment, well integrity and water resources made by the Company have been independently peer-reviewed by international experts in their field to ensure conclusions drawn by the Company are robust and meet or exceed best-practice.

A detailed hydrogeological assessment of the Yulleroo and Valhalla & Asgard areas has been undertaken for TGS14. 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 km^2 (DoW, 2012). The surface (<200 m BGL) groundwater aquifers which comprise the defined resource and from which all groundwater is presently sourced in the region, varies spatially across the basin (Figure 14). Sustainable groundwater yield from all the surficial potable aquifers in the basin combined has been estimated at between 615,000 ML/yr (WRC, 2001) and 827,000 ML/yr (ANRA, 2010). Current consumption of groundwater in the Canning basin, primarily by the township of Broome and Derby, is estimated to be 33,134 ML/yr which is less than 4% of the annual sustainable yield.

The major regional aquifer systems in the Canning Superbasin are (in order of decreasing age) the Grant Formation, Liveringa Formation, Wallal Sandstone and Broome Sandstone. These sandstone aquifers have very large stores of fresh to saline groundwater with variable total dissolved solids (TDS) content. TDS in drinking water is generally recommended to be less than 1,000 mg/L. Higher

TDS values may cause the water to have an unpleasant mineral or brackish taste. TDS values as high as 4,000 mg/L are suitable for stock watering. Good recharge conditions from monsoonal rains result in low salinities in many of the surface aquifers in the Canning Basin. Depending on the overlaying geological material, an aquifer may be either “unconfined” which means recharges from the surface can occur following rainfall or “confined” by overlying cap rock which is relatively impermeable to surface water recharge.

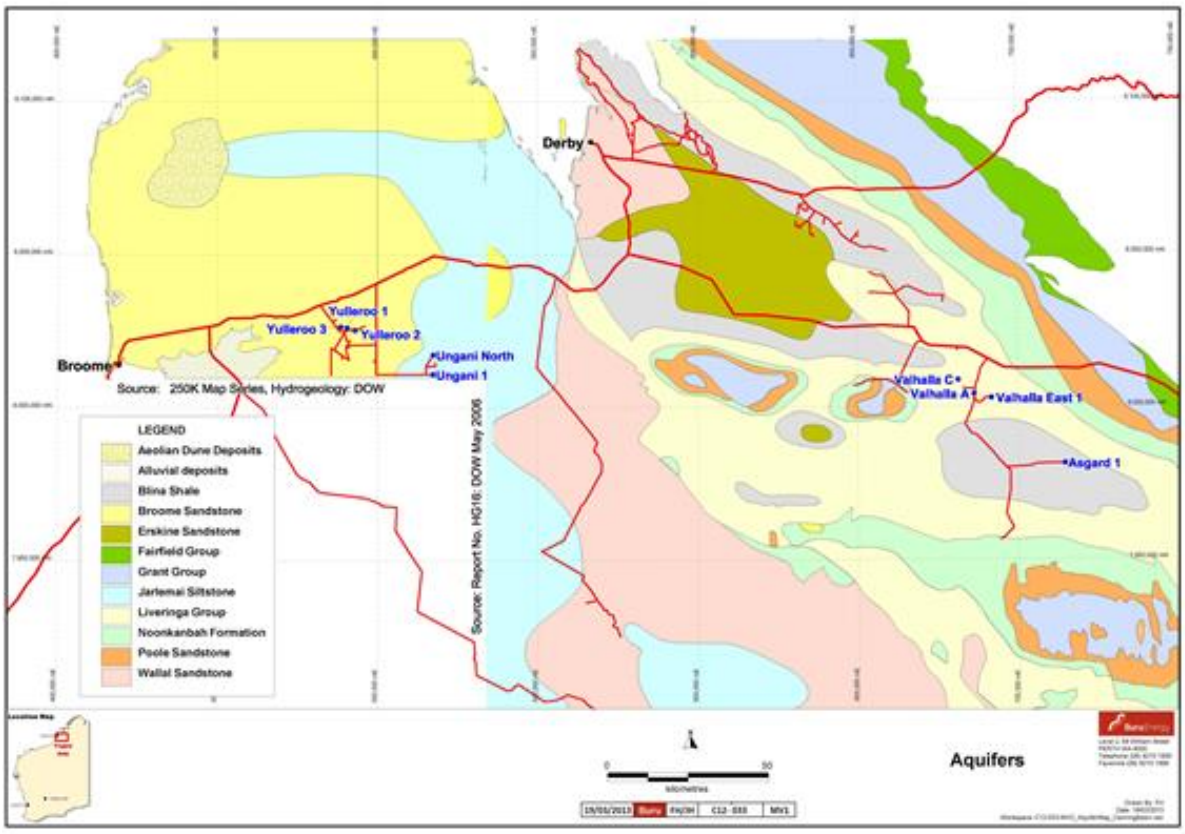

Figure 14: Indicative location of surficial aquifers that comprise the surface groundwater resource in the Canning Basin.

Yulleroo Area

Formation characteristics and respective elevations down to the Laurel formation at the Yulleroo well sites are summarised in Table 2 and Figure 15. The only potable aquifer in the Yulleroo area is the Broome Sandstone which is approximately 73 m thick in this area; the water table is 10 m to 20 m deep depending on ground level (Figure 15). Groundwater salinity of the Broome aquifer ranges from around 320-380 mg/L total dissolved solids (TDS) in the Yulleroo area. Recharge of the Broome Sandstone is mainly by direct percolation of rainfall. Water is expected to take at least 10 to 20 days to travel from ground surface to the water table through the overlying pindan soil in the Yulleroo area. Groundwater discharge is to the Indian Ocean in the west and by evapotranspiration in low lying coastal areas. Estimated groundwater travel times from Yulleroo 3 are 640 years to Lake Eda and 1,400 years to Roebuck Bay.

The Jarlemai Siltstone is approximately 200 m thick and sits under the Broome Sandstone. This forms an aquiclude which acts as a barrier to the flow of water between the Wallal Sandstone and the overlying Broome Sandstone in the Yulleroo area.

Below the Jarlemai Siltstone is the Alexander/Wallal Sandstone which is approximately 175 m thick in the Yulleroo area. Groundwater salinity of the Alexander/Wallal aquifer in the Yulleroo area is approximately 3,700 mg/L TDS (Table 2) which is not considered suitable for human consumption.

Below the Wallal Sandstone is the Grant Group sandstone. However, the salinity of the groundwater in this formation is approximately 14,000 mg/L TDS which is not potable. The underlying Anderson Units which are closest to the Laurel formation are also saline (Figure 15).

The Yulleroo area is located within Roebuck pastoral station. Consequently, water is extracted from the Broome Sandstone aquifer at numerous station bores via windmills and solar pumps to stock watering troughs or station homesteads. Bohemia Bore in the immediate Yulleroo area is an important stock watering bore. It is also used as one of the key baseline groundwater monitoring bores by the Company. Groundwater baseline chemistry has been measured at repeated intervals to date in bores the Yulleroo area. The town of Broome also uses the Broome Sandstone aquifer as its main source of water. The bore field to extract this town water is located east of Broome at Twelve Mile which is not in the groundwater flow path from Yulleroo area. Each year, over 5,000 ML are pumped from the Broome aquifer for the township of Broome.

Table 2: Formation characteristics and elevations at Yulleroo area down to the Laurel Formation.

Formation	**Dominant Lithology**	**Classification**	**Base Elevation (m AHD)**	**TDS (mg/L)**
Broome Sandstone	Sandstone	Aquifer	-16	200 to 1,500
Jarlemai Siltstone	Siltstone	Aquiclude	-216	
Alexander	Sandstone	Aquifer	-237	
Wallal Sandstone	Sandstone	Aquifer	-393	3700^{+}
Grant Group	Sandstone	Aquifer	-571	14000^{+}
Reeves	Sandstone	Aquifer	NA	
Anderson Unit A	Shale and Sandstone	Minor aquifer	-1010	11,600*
Anderson Unit B	Shale and Sandstone	Minor aquifer	-1821	
Anderson Unit C	Shale and Sandstone	Minor aquifer	ND	122,000**

* Based on DST in Cow Bore1

** Sample from 3,342-3357 m depth

$^{+}$ Estimated from resistivity logs

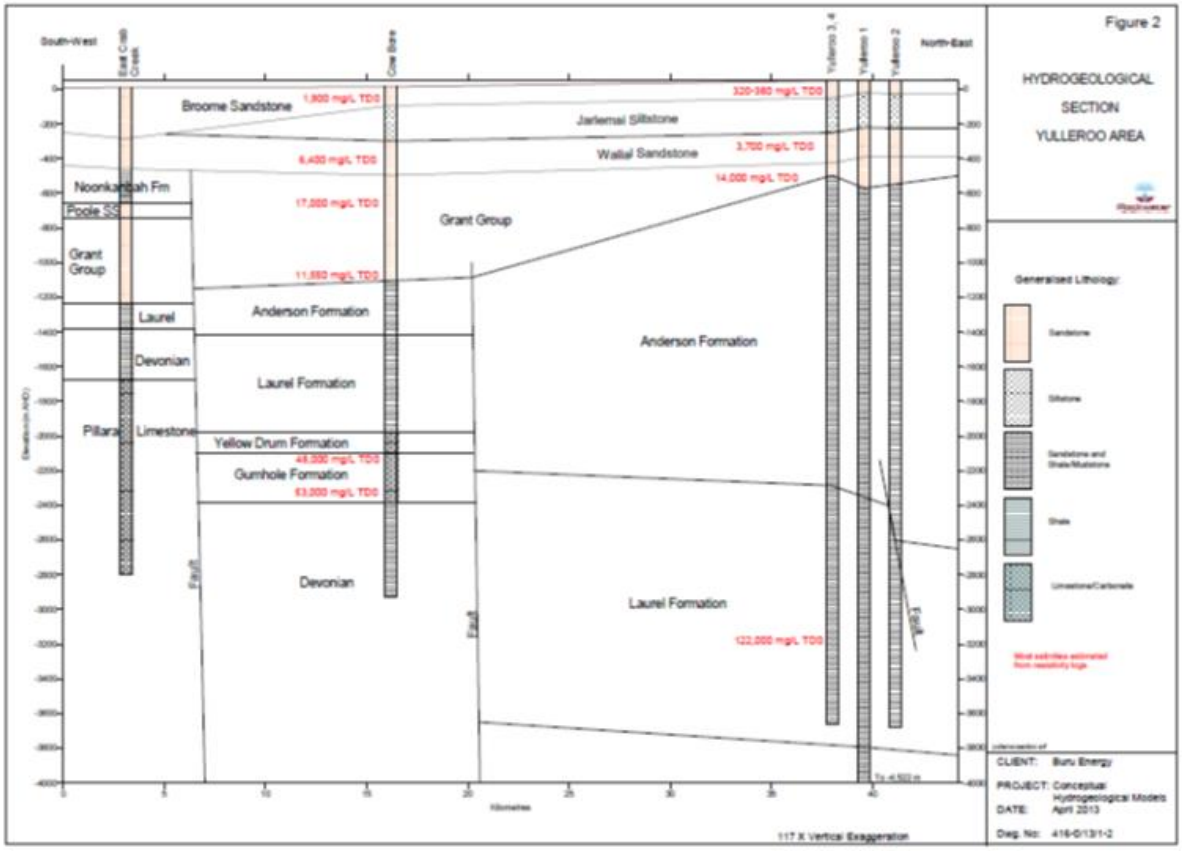

Figure 15: Hydrogeological model of the aquifers in the Yulleroo area.

Valhalla/Asgard Area

Formation characteristics and respective elevations down to the Laurel formation at the Valhalla & Asgard well sites are summarised in Table 3 and Figure 16. The Liveringa aquifer is the surficial aquifer in the Valhalla/Asgard area and consists of interbedded sandstones, siltstones and shales. In the Valhalla well area situated on Calwynyardah paddock on Blina Pastoral Station, the Liveringa Formation extends to to 250 m depth (Valhalla North 1). Reported salinities generally range from 550 to 925 mg/L TDS in the Liveringa Formation in this area. The infiltration will be retarded by clay, shale and siltstone layers, both above and below the water table. The water table depth ranges from 25 m at Asgard 1 water bore to 30 m at Valhalla North water bore. Water is likely to take between 70 and 300 days to travel from the ground surface to the water table. Groundwater in the Liveringa and Noonkanbah Formations generally flows westwards and would take about 16,000 years to move from Valhalla North 1 to the Fitzroy River.

In the Asgard well area situated on Noonkanbah Pastoral Station, the Liveringa Formation extends down to about 290 m depth. There are generally few sandstone beds which are typically thin. Reported salinities generally range from 250 to 1,000 mg/L TDS in the Liveringa Formation in this area, but could be up to 3,500 mg/L TDS, particularly at greater depth. Groundwater chemistry baseline results have been measured at repeated intervals to date in the Valhalla and Asgard area. A number of large pastoral stations in the region depend on the Liveringa aquifer for source water for homestead and cattle including Noonkanbah, Calwynyardah, Blina and Liveringa Stations.

The Liveringa aquifer overlies the Noonkanbah Formation which continues to about 720 m depth to the top of the Poole Sandstone. The latter formations comprise mainly fine-grained sediments (shale and siltstone) that are low-yielding. Groundwater is approximately 800 mg/L TDS in the Noonkanbah Formation. The Poole Sandstone is generally an aquifer, but the geophysical logs for Paradise 1, Valhalla North 1, and Asgard 1 Petroleum wells indicate there is interbedded shale and sandstone in the Poole Sandstone when intersected by those wells.

Table 3: Formation characteristics and elevations at Valhalla and Asgard area down to the Laurel Formation.

Formation	Dominant Lithology	Classification	Elevation – Base of Formation (AHD)			TDS (mg/L)
			Valhalla 2	Valhalla N	Asgard 1	
Liveringa	Carbonate/shale	Minor aquifer, Aquitard	-84	-196	-171	500 to 12,400
Noonkanbah	Shale	Aquiclude	-441	-635	-579	550 to 800
Poole Sandstone	Sandstone and Shale	Aquifer or Aquitard	-524	-715	-695	300
Grant Group	Sandstone	Aquifer	-1332	-1499	-1240	800-1000*
Reeves	Sandstone	Aquifer	-1588	-1826	-1606	
Anderson	Sandstone, siltstone, shale	Minor aquifer, Aquitard	-1858	-2105	-1790	70,000 to 100,000?
Laurel	Limestone, shale, siltstone and sandstone	Minor aquifer, Aquitard	<-3350	<-3241	<-3,400	70,000 to 100,000?

* Estimate from Resistivity Logs

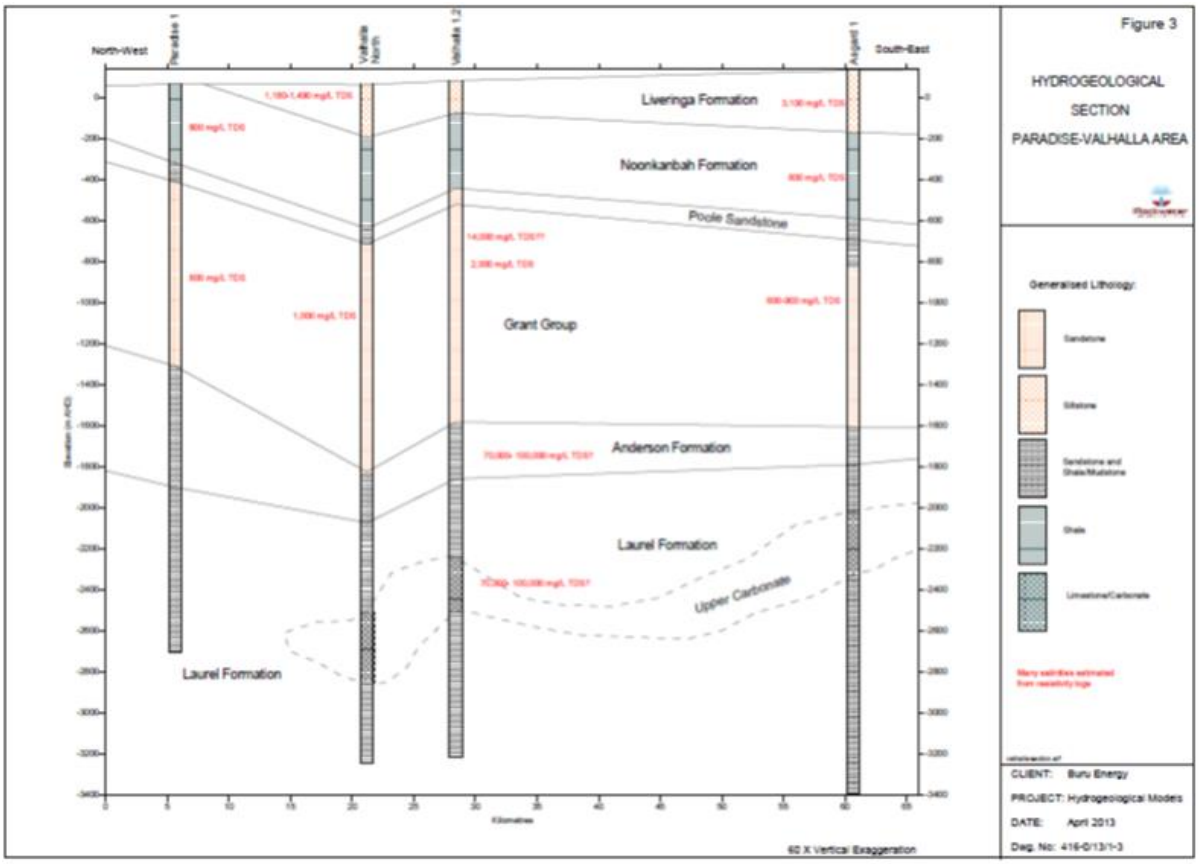

Figure 16: Hydrogeological model of aquifers in the Valhalla area.

Sundown Evaporation Pond Area

The Sundown petroleum well logs indicates alluvium between 12 and 30 m depth, overlying shale with minor sandstone of the Blina Shale to 230 m depth and then sandstone of the Liveringa Group. The

Sundown water bore is recorded in the WIN database in June 1982 to have been screened in the Liveringa Group and yielded water with a salinity of 14,030 mg/L TDS which is not potable, even to stock. This was before the first petroleum well was drilled at Sundown indicating the groundwater in this area is naturally saline. A further groundwater monitoring bore was installed in the area in June 2013. The water level in the bore was 14.0 m below ground level (about 25 m AHD); similar to a level of 27 m AHD in the shallow (31m deep) Clan A Bore, 5 km to the north-north-east. The evaporation pond area has been built on natural clay deposit and has very low permeability. A sample of the clay in the base of the Evaporation Pond was submitted to SGS Australia to measure permeability – a value of 2E-8 m/sec was determined. Consolidated clays and shale at depth would have even lower permeability. Given this low permeability, surface infiltration to the closest potable aquifer would conservatively take approximately 250,000 years. The formation characteristics with depth are shown in Table 4. The closest potable aquifer in the Sundown region is the Poole Sandstone with a top elevation of - 705 m (AHD).

Table 4: Formation characteristics at Sundown area through the Laurel Formation.

Formation	Dominant Lithology	Classification	Base Elevation (m AHD)	TDS (mg/L)
Alluvium	Clay	Aquiclude	13	25,000
Blina	Shale	Aquiclude	-191	
Liveringa	Carbonate/shale	Minor aquifer, Aquitard	-402	14,000
Noonkanbah	Shale	Aquiclude	-705	
Poole Sandstone	Sandstone and Shale	Aquifer or Aquitard	-820	500*
Grant Group	Sandstone	Aquifer	-1413	500-4,000*
Anderson	sandstone, siltstone, shale	Minor aquifer, Aquitard	-1757	<7,000*
Laurel	Limestone, shale, siltstone & sandstone	Minor aquifer, Aquitard	-1943	9,000-51,000*

* values determined by resistivity logs

3.6. Hydraulic Fracture Height

Distance between hydraulic fracture zones and aquifers

Research from Durham University published in 2012 analysed several thousand shale gas HF operations and reported the likelihood of HF extending more than 350 m is less than 1% and the maximum reported height for any fracture propagation is 588 m (Davies et al. 2012). HF fluid volume imposes a bulk limit on fracture height and unbounded fracture growth to shallow depths is not physically plausible. Based on this evidence, and following a Parliamentary inquiry into hydraulic fracturing, the UK Government has implemented a minimum separation of 600 m between the HF zone and overlying aquifers. The "respect" zone between the HF zone and overlying aquifers used for potable water exceeds 1,500 metres of hard impermeable rock. This distance between HF zone and aquifers during TGS14 exceeds recognised international leading practice approaches.

Concerns have been raised about HF and the possibility of gas seepage from the petroleum target play to overlying aquifers via various pathways (e.g. King, 2012; Rutter and Boult, 2012; ACOLA, 2013; Royal Society, 2012). Recent international reviews have found that HF in shale and tight gas formations affects a very limited portion of the entire thickness of the overlying bedrock and therefore, are unable to create direct hydraulic communication between target zones and shallow aquifers via induced fractures (Fisher and Warpinski, 2012; Davies et al., 2012).

Detailed analysis of data acquired from several thousand shale gas HF operations in the USA reported a maximum vertical fracture length of 588 m (Davies et al, 2012). Nearly four thousand micro-seismic fracture top comparisons to maximum ground water depths across four major US shale plays

showed that not one incident of maximum top fracture even closely approached (> 800 m separation) the local aquifers (Fisher and Warpinski, 2012) and that the height of only 1% of these fractures was greater than 350 m (Davies et al, 2012). The data indicated that in general for deeper formations the created hydraulic fractures remain well confined to the target interval, even in the presence of faults (Green et al., 2012). The proposed fracture envelopes for HF treatments during TGS14 are predicted to have a vertical height of approximately 100 m targeting specific zones and will occur at depths greater than 2 km below ground level.

Upward migration of HF fluid and brine is controlled by pre-existing hydraulic gradients and bedrock permeability. A recent study (Flewelling and Sharma, 2013) found where there is an upward gradient, permeability is low, upward flow rates are low, and mean travel times are long (often >1 million years). The study concluded unrealistically high estimates of upward flow are the result of invalid assumptions about HF and the hydrogeology of sedimentary basins (Flewelling and Sharma, 2013). Consequently, the recently proposed rapid upward migration of brine and HF fluid, suggested to occur as a result of increased HF activity, does not appear to be physically plausible. Furthermore and importantly, the extraction of fluid (e.g. gas and oil) at formation level via flowback up the well will create negative pressure gradients which will oppose any upward hydraulic gradient. This means that as a well produces over time the direction of subsurface pressure differentia is actually lower inside the well than outside. Under these conditions any potentially occurring leak path is into the well and pollution potential is absent (Flewelling and Sharma, 2013).

More recent work that models the relationship to predict maximum fracture height as a function of HF fluid volume has been undertaken (Flewelling et al., 2013). These predictions generally bound the vertical extent of microseismicity from over 12,000 HF stimulations across North America. These findings suggest that fracture heights are limited by HF fluid volume regardless of whether the fluid interacts with faults. These findings demonstrate that HF fluid volume imposes a bulk limit on fracture height and that unbounded fracture growth to shallow depths is not physically plausible. Direct hydraulic communication between tight formations and shallow groundwater via induced fractures and faults is not a realistic expectation based on the limitations on fracture height growth and potential fault slip (Flewelling et al., 2013).

A recent detailed study on methane sources in groundwater in an active shale gas area (Marcellus shale) in north eastern Pennsylvania (Molofsky et al., 2013) including the controversial Dimock Township (Gaslands, 2010) concluded that methane is ubiquitous in the region and that on a regional scale, methane concentrations are best correlated to topographic and hydrogeological features, rather than shale-gas extraction. The authors demonstrated that the source of gas in the county water wells was not from the Marcellus shale as had previously been suggested by Osborn et al (2011).

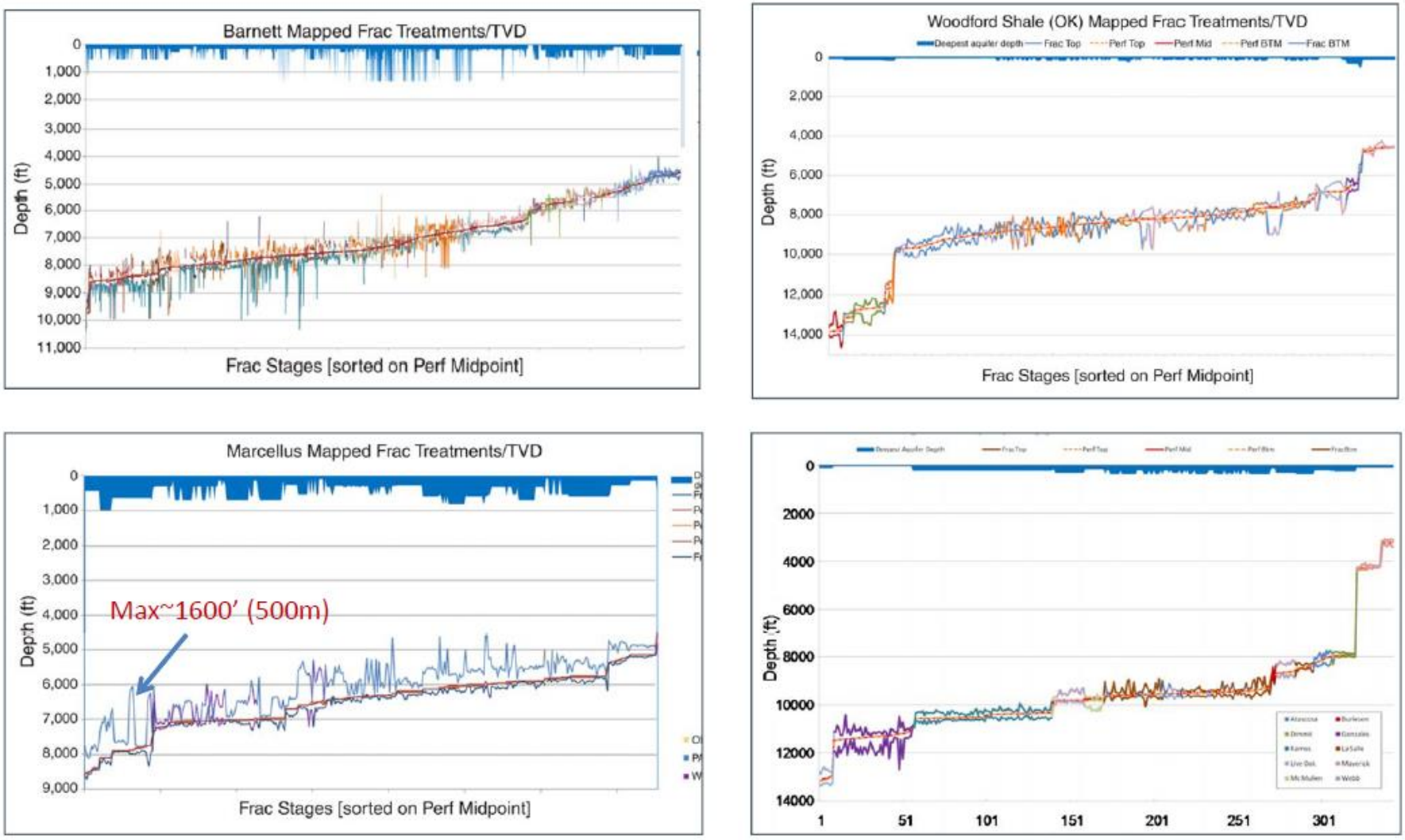

Figure 17: Graph of stimulated hydraulic fractures (n>4,000) in the Eagle Ford, Woodford Barnett, Marcellus and Niobrara shales (after Fisher and Warpinski, 2012; Davies et al, 2012).

3.7. Risk to Aquifers from Hydraulic Fracturing

The risk to aquifers from HF at Yulleroo and Valhalla & Asgard area is considered Low because:

- The Laurel Formation and the overlying surface aquifers are separated by at least 1,800 m at Yulleroo (Figure 18) and Valhalla/Asgard (Figure 19). This greatly exceeds the recommended "respect" zone of 600 m between the top of a hydraulic fracture zone and an overlying aquifer (Royal Academy, 2012), Given this significant vertical distance, it is implausible that the injection of HF fluid will lead to the migration of contaminants upwards into the surface aquifer.
- The thickness of the overlying confining rock layers to the Laurel Formation such as the Anderson shale unit and the strongly cemented nature of these rock layers has created an effective impermeable seal of hydraulic isolation that has prevented upward migration and escape of hydrocarbons in the Laurel Formation over tens of millions of years. This provides clear evidence the proposed HF zones are isolated and will adsorb fluid additives and produced formation water within the bedrock far below drinking water/ecosystem aquifers.
- Petroleum wells proposed for use in HF treatment of tight gas reservoirs are constructed using high grade steel casing with the surrounding annulus sealed with cement and tested for well integrity in accordance with PGER Regulations and examined independently in an independent Well Operations & Integrity Review. Escape of HF fluid or produced formation fluids due to failure of the well structure is considered unlikely.
- It is also important to note that potential for downhole leaks to the environment may diminish rapidly as the reservoir pressure is drawn down over the life of producing well. Low bottom hole pressure wells do not have the driving force to oppose constant hydrostatic pressure of fluids outside the wellbore; hence, if a leak path is formed through the sequence of barriers, the highest potential is for exterior fluids (usually salt water) to leak into a wellbore (King & King, 2013).

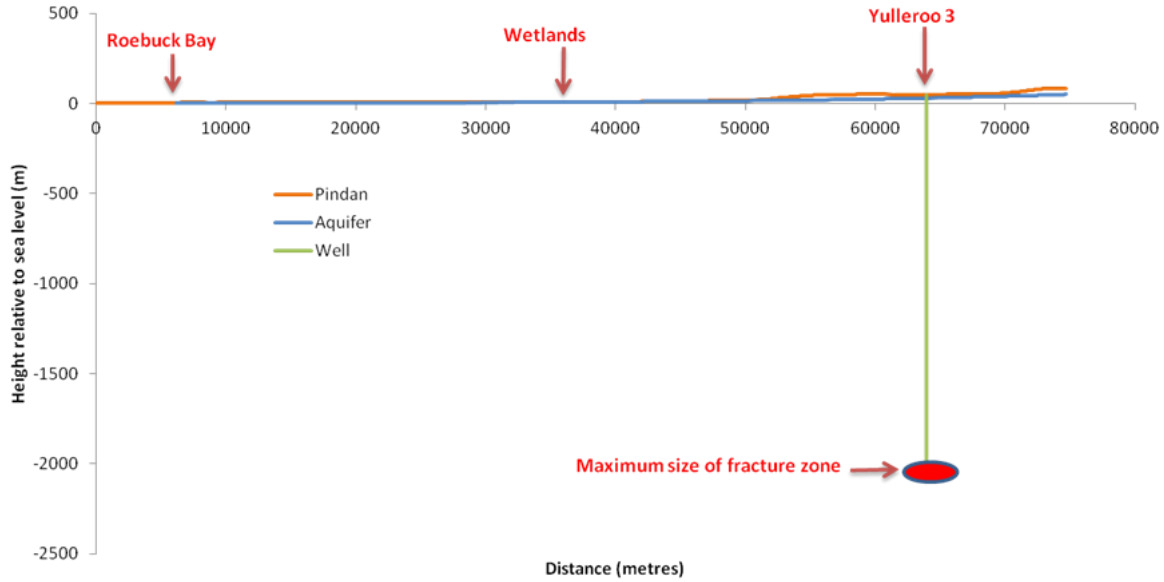

Figure 18: Distance between top of fracture zone and overlying aquifer at Yulleroo wells.

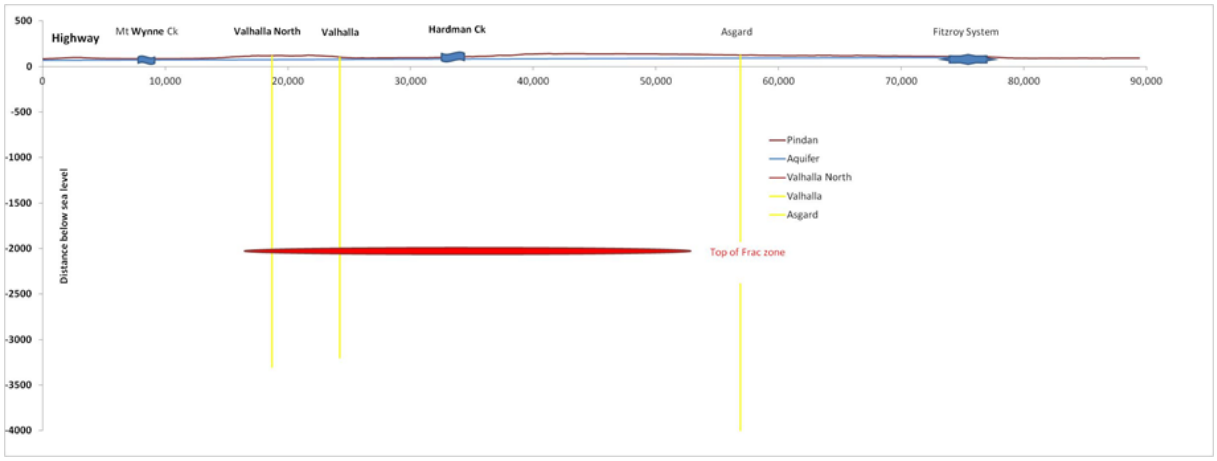

Figure 19: Distance between top of fracture zone and overlying aquifer at Valhalla wells.

3.8. Air Quality

Protecting Values of Air Quality during the Activities

Recent detailed international reviews of fugitive emissions from shale gas wells have shown emissions and human health risks are low provided operations are properly run and regulated. Management of flowback using "Green completion", where methane and other VOC emissions are minimised, has been adopted for the HF activities in TGS14. However, undertaking the TGS14 activities presents an opportunity to collect robust data regarding the fugitive emissions associated with HF activities. Previously, emissions from Petroleum Activities have been approximated from emissions factors and engineering estimates. These factor-based approaches provide only a rough estimate of actual emissions. To characterise emissions associated with the activities and confirm low risk, the Company will use the latest, spectral-based monitoring approaches to assess key compounds emitted from one of the well sites during activities. This approach will be implemented in real time and will compare reference (upwind) sites with impact (downwind) sites to determine project-attributable emissions and plume extent. Results will benchmark a range of emissions of interest associated with the TGS14 activities.

Ambient air quality in the region is profoundly influenced by season. During the winter period between June and August south-easterly winds predominate and dust storms blowing in from the Great Sandy Desert region are common. Grass and scrub fires are also a regular feature of the landscape during the later part of the dry season when activities are proposed to occur.

A recent international study on emissions from shale gas wells found that if adequately managed, local GHG emissions from shale gas operations should represent only a small proportion of the total carbon footprint of shale gas, which is likely to be dominated by CO_2 emissions associated with its combustion (MacKay and Stone, 2013). Another recent large study at 190 onshore natural gas sites in the United States found that the combined emissions of production sites, flow-backs and work-overs completion including pneumatics, and equipment leaks amounted to 0.42% of gross gas production (Allen et al., 2013).

A recent review of the potential public health impacts of exposures to chemical and radioactive pollutants in shale gas extraction concluded that risks are low if the operations are properly run and regulated. (Kibble et al, 2013). Typical levels of radon in natural gas have been reviewed and the estimated annual dose from use of natural gas has been found to be extremely small (Dixon 2001). Myers et al (2012) and Kibble et al. (2013) examined the issue of radon from shale gas and concluded that, based on the depth of target plays and decay rates, the impact of any radon released into groundwater would be minimal. There has been no evidence of elevated radiation levels in flowback from Yulleroo 2 in 2010 or from drill cuttings in the recently completed Company wells. However, elevated radiation levels above the drinking water guidelines have been found in some station bores during Company baseline studies in the Yulleroo area. These are presumably leached from naturally occurring mineral sand deposits above the groundwater system that are known in the area.

There are a number of gas emissions during gas extraction and related activities including those associated with drilling, completion, gas capturing and flaring, and those associated with infrastructure such as diesel engines, storage facilities, vehicles etc. These include the classical air pollutants such as PM, NOx, SO2, O3 and its precursors including VOCs comprised largely of ethane, propane, butane and pentanes (Zelinska et al, 2010; Lyon et al., 2011). Neither of these studies reported exposure levels that pose a risk to human health under properly managed operations and that there was no apparent serious ambient air quality issues. However, a recent study has suggested that an occupational health hazard was identified for HF workplace exposures to crystalline silica (from handling of sand proppant) and that appropriate protection measures for workers at risk similar to those employed in building, agriculture, foundry and sandblasting industries at risk of exposure to respirable crystalline silica should be considered (Esswein et al., 2013).

In this regard, management of flowback using "Green completion", where methane and other VOC emissions are minimised, has been adopted for the HF activities in TGS14. Flaring at the Company well pads will be a carefully controlled process. Venting of gas to the atmosphere is to be avoided and when this is not possible for operational or safety reasons, it is to be kept to a minimum.

To confirm the low level emissions and low human health risks of fugitive emissions during operations it is proposed to undertake air quality testing at one selected well pad in an intensive short term study to measure compound mass flux emissions from fugitive and area sources during Activities using path integrated Optical Remote Sensing (ORS) technology to provide a path integrated concentration of the analytes of interest. The monitoring program will be based on the USEPA Guidance Document 52 (USEPA, 2011) which outlines the requirements and techniques in evaluating flux emissions from fugitive and area sources. Based on the available methodology the field work will be performed via Vertical Radial Plume Mapping (VRPM). The VRPM methodology utilizes multiple non intersecting beam paths in a vertical plane downwind from the emission source to obtain a mass-equivalent plume map. This map, in conjunction with wind speed and direction, is used to obtain the flux of pollutants through the vertical plane. The measured flux is then used to estimate the emission rate of the upwind source being characterised. The typical compounds and detection limits for air quality using ORS methods are shown in Table 5. The focus would be based around methane and other light weight hydrocarbons based on a risk assessment of the activities.

Table 5: Typical Compounds and Detection Limits for air quality measurements using optical remote sensing.

Compound	OP-FTIR Est. Detect. Limit*	Compound	OP-FTIR Est. Detect. Limit*
Butane	0.0060	Methyl isobutyl ketone	0.040
Chloromethane	0.012	Methylene chloride	0.014
Dichlorodifluoromethane	0.0040	Propylene dichloride	0.014
Ethane	0.010	Tetrachloroethene	0.0040
Ethyl chloride	0.0040	Trichloroethylene	0.0040
Fluorotrichloromethane	0.0040	Vinyl chloride	0.010
Methane	0.024	Vinylidene chloride	0.014
Pentane	0.0080	Ethanol	0.0060
Propane	0.0080	Methyl ethyl ketone	0.030
Acetone	0.024	2-Propanol	0.0060
Acrylonitrile	0.010	1,4-Dichlorobenzene	0.012
Chlorobenzene	0.040	Ethyl benzene	0.060
Chloroform	0.012	Xylenes	0.030
Dimethyl sulfide	0.018	Hydrogen sulfide	6.0
Ethylene dibromide	0.0060	Methyl mercaptan	0.060
Ethylene dichloride	0.030	Methanol	0.0015
Hexane	0.0060	Octane	0.0025

* Detection limits are based on: Path Length = 100m, 1 min Ave. (ppmv).

3.9. Biological Environment

Protecting Biodiversity Values during the Activities

Activities will occur on existing well sites so no clearing will occur during the Activities. Each of these well sites is 3 Ha in size and was cleared previously following the completion of flora and fauna surveys. The lack of vegetation clearing associated with the Activities mitigates any potential impacts on biodiversity.

To further mitigate impacts on biodiversity, Buru Energy is one of the few resource Companies that has implemented a "no night time driving" policy. This policy was implemented to protect the health and safety of our people and other road users. However, it also serves to protect biodiversity through minimising road kill. Many species occurring in the Kimberley are nocturnal in nature, including the Greater Bilby (*Macrotis lagotis*). By implementing a no night time driving policy, the chance of our vehicles leading to road kill and impacting biodiversity values is greatly reduced.

The Interim Biogeographic Regionalisation of Australia (IBRA) divides Australia into 85 bioregions, which are further refined into 403 subregions (DSEWPaC, 2012). The Canning Basin is located within both the Dampierland and Great Sandy Desert bioregions. These bioregions are further divided into sub-regions: the Pindanland (DL2) and Fitzroy Trough (DL1) of Dampierland in the west and McLarty (GSD1) and Mackay (GSD2) sub-regions of the Great Sandy Desert in the east (see Figure 20).

The Yulleroo and Valhalla & Asgard areas are both located in Dampierland bioregion. The Yulleroo area is located in the more coastal sub-region of Pindanland (DL2) and is a fine-textured sand-sheet with subdued dunes and includes the paleodelta (delta formed in past geological time) of the Fitzroy River which today exits at King Sound near Derby. This is the coastal, semi-arid, north-western margin of the Canning Basin. The Valhalla & Asgard areas are located in the sub-region of Fitzroy Trough (DL1) and is the semi-arid northern periphery of Canning Basin containing the middle and lower catchments of the Fitzroy River. It includes the alluvial plains associated with the river and also areas of sandplain and eroded dune surfaces derived from the Canning Basin. The Valhalla & Asgard areas are located within the dune areas outside the floodplain.

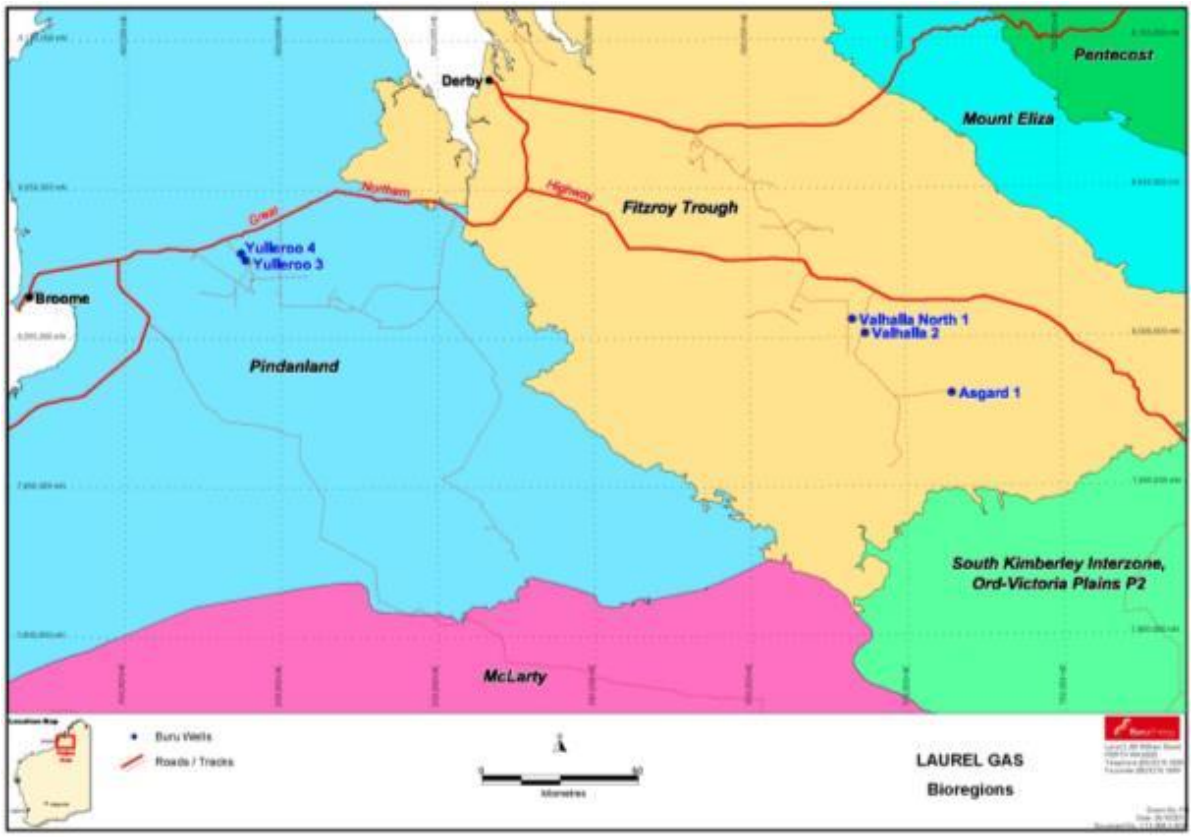

Figure 20: Biogeographical subregions of Activity area according to IBRA (DSEWPaC, 2011).

3.9.1. Vegetation

No vegetation clearing is proposed under this EP. However for completeness, the following information is included. Within Dampierland, the vegetation is characterised by the pindan assemblage that occurs on the sand plains. Vegetation on pindan plains is relatively uniform with the same species occurring in very predictable patterns (Andrew Mitchell Consulting, pers. comm. 2013). However, occasionally some common vegetation communities can be located in unusual situations.

Pindan is described by Beard (1979) as a "grassland wooded by a sparse upper layer of trees and a dense, thicket-forming middle layer of unarmed, phyllodal Acacia". It consists of shrublands and grasslands characterised by the low tree savanna mapped as ribbon grass with baobabs, bauhinia and beefwood. The trees are small reaching only 3-6 m except for baobabs. Other species include the bloodwoods *Eucalyptus dichromophloi* and *E. perfoliatia*, *Atalaya hemiglauca* (Whitewood), *Hakea arborescens* (Boomerang tree) and *H. lorea* (Corkwood). The tall perennial grass layer is 90-150 cm tall and distinguished by *Chrysopogon* (Ribbongrass), *Dichanthium* (Bluegrass) and annual *Sorghum* and other tall to medium height perennial grasses such as *Aristida latifolius* and clumps of spinifex (*Triodia pungens*) are present in places. Scattered *Eucalyptus microtheca* (Coolibah) and *Lysiphyllum cunninghammii* (Bauhinia) occur on the river plains. In lateritic areas on sandplain margins the vegetation comprises of shrub steppe dominated by *Triodia intermedia*, with *Acacia impressa*, *Eucalyptus perfoliata* and *Grevillea wickhami* (Beard, 1979).

Threatened Ecological Communities (TEC) and Priority Ecological Communities (PEC) databases have been interrogated for the area in which the existing well sites are located. No known TEC or PEC occurs at the well sites or in the near vicinity (Low Ecological Services 2011, Low Ecological Services 2012, Woodman Environmental Consulting 2007, Low Ecological Services 2011a, Buru Energy 2012).

3.9.2. Flora

As stated above, no vegetation clearing is proposed under this EP. However for completeness, the following information is included.

Flora species that have been formally recognised as threatened with extinction or as having special conservation value are protected under International, Commonwealth and State legislation. At the national level, flora are protected under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) and within Western Australia, rare flora are listed under the *Wildlife Conservation Act 1950* (WA) and *Wildlife Conservation (Rare Flora) Notice 2012*.

Desktop and on-ground flora surveys of the well sites and access tracks have been undertaken prior to drilling the wells (Low Ecological Services 2011, Low Ecological Services 2012, Woodman Environmental Consulting 2007, Low Ecological Services 2011a, Buru Energy 2012).

3.9.3. Weeds

Management of weed species in Western Australia is principally controlled by the *Agriculture and Related Resources Protection Act 1976* (ARRP Act), which is administered by the Agriculture Protection Board (APB), part of the Department of Agriculture and Food (DAF). Other legislation relevant to the management of weeds in Western Australia includes:

- *Plant Disease Act 1914 (WA)*
- *Plant Diseases Regulations 1989 (WA)*
- *Biosecurity and Agricultural Management Act 2007 (WA)*
- *Biosecurity and Agriculture Management Regulations 2013 (WA)*

During the on-ground flora surveys of the Activity areas prior to drilling of the wells, no introduced flora species were identified at the well sites. Three introduced species were identified along the access route to the Valhalla North 1 well site. *Calotropis procera* (Rubber Bush) was identified along the main Calwynyardah Nookanbah Road and *Sida cordifolia* (Flannel Weed) and *Cenchrus ciliaris* (Buffel Grass) at a disused bore along the access track to the well site.

Rubber Bush and Flannel Weed are both easily identifiable weed species (Figure 21). Rubber Bush grows as a small spreading shrub or a tree up to 4 m tall. This weed can be identified by its large, elliptical, rubbery grey-green leaves, and waxy purple, pink and white flowers (DEC, 2013). Flannel Weed grows up to 1.5 m high and is characterised by yellow-orange flowers and leaves covered with soft white hairs (DEC, 2013).

Buffel Grass is a low to tall growing (0.3 to 1.5 m), summer-growing, perennial tussocky grass. Buffel Grass is used as a drought tolerant permanent pasture grass (Cook, 2007).

Calotropis procera (Rubber Bush) (Image from DEC, 2013).

Sida cordifolia (Flannel Weed) (Image from Queensland Government 2011)

Figure 21: Weeds previously identified in the Valhalla area.

3.9.4. Fauna

The fauna assemblage of the Dampierland and Great Sandy Desert bioregions is unique as it represents a blending of Western Australia's desert and tropical coastal zones.

Fauna species that have been formally recognised as threatened with extinction or as having special conservation value are protected by International, Commonwealth and State legislation. At the national level, fauna are protected under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) and within Western Australia, rare fauna are listed under the *Wildlife Conservation Act 1950* (WA) and *Wildlife Conservation (Specially Protected Fauna) Notice 2008.*

Desktop and on-ground fauna surveys of the well sites and access tracks have been undertaken prior to drilling the wells (Low Ecological Services 2011, Low Ecological Services 2012, Woodman Environmental Consulting 2007, Low Ecological Services 2011a, Buru Energy 2012). During the on-

ground surveys one species of conservation significance, the Rainbow Bee-eater (*Merops lagotis*) was identified in both the Yulleroo and Valhalla & Asgard areas. This migratory species is listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) and has a widespread distribution across Australia. The Company considers that it is highly unlikely that this species will be impacted by the Activities and will not require a referral under the EPBC Act.

Bilbies (*Macrotis lagotis*), a conservation significant fauna species, were not observed during the on-ground surveys of the Activity areas however there have been positive identifications of Bilbies in the wider Yulleroo area (Outback Ecology, 2012).

The Company has considered whether the Activities are likely to have a significant impact on Bilbies in the Yulleroo area. Given that no clearing is required, the short duration of the Activity, management measures to be implemented to minimise disturbance of Bilbies such as no driving at night, and that the Company drilled Yulleroo 3 and Yulleroo 4 wells in 2012-2013 without any impact on Bilby populations, the Company considers that the Activities will not have a significant impact on Bilbies or any other matter of NES that requires referral under the EPBC Act.

3.10. Environmentally Sensitive Areas

Environmentally sensitive areas (ESA) are areas of high conservation value (e.g. Threatened Ecological Communities, Red Book Areas, National Heritage areas) or areas that are sensitive to disturbance with significant environmental risk (e.g. drinking water aquifers, riparian vegetation). Schedule one areas and environmentally sensitive areas located in the vicinity of the Company's petroleum exploration permits are shown in Figure 22.

The nearest ESA to the Yulleroo region is Taylors Lagoon, located approximately 4 km to the northeast of Yulleroo 4. Taylors Lagoon is one of a series of permanent lagoons (along with Lake Campion and Lake Eda) which occur along the northern margin of Roebuck Plains station. These areas are fed by drainage runoff from Acacia sandplains and are considered nationally important wetlands (DAF 2010). There has been a recorded presence of more than 45 EPBC listed migratory bird species, with a subset of these (20 species) occurring regularly (Watkins and Jaensch, 2007).

A recent report which assessed the environmental values of Taylors Lagoon in regards to bird populations made a number of recommendations for management (Watkins and Jaensch, 2007). These were primarily around maintaining good ground cover to provide suitable habitat for bird species and to prevent further alteration to the drainage pattern of the Acacia sandplains associated with the ESA (DAF 2010). The proposed Activities are not considered to impact on this ESA as they do not occur on this sandplain habitat nor in the catchment and will not alter the drainage pattern of the region.

The nearest ESA or Schedule 1 area to the Valhalla region is Camballin Floodplain, a Schedule 1 area. Valhalla North is located 24 km to the east of Camballin Floodplain. The Camballin Floodplain is a wetland area with importance as a major breeding area for waterbirds as well as a migration stop-over area for shorebirds. The floodplain is contiguous with the Fitzroy River floodplain. Part of this area is known as the Camballin Controlled Area because of its importance as a water supply area.

The West Kimberley National Heritage Place (WKNHP) is located approximately 25 km to the west of Valhalla North. The WKNHP is important due to its great biological richness and contains important geological and fossil evidence of Australia' evolutionary history. The Activity area is outside the WKNHP and the Company considers that it is highly unlikely that this area will be impacted by the Activities and will not require a referral under the EPBC Act.

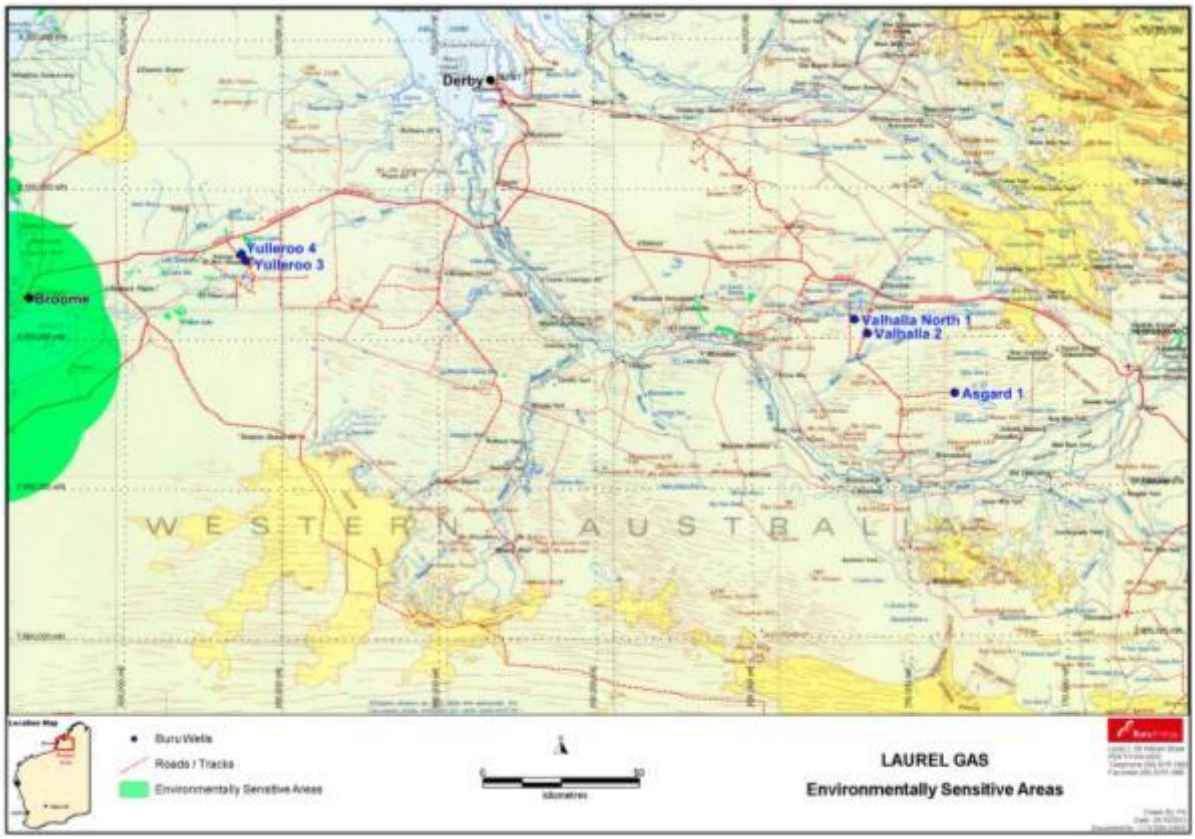

Figure 22: Environmentally sensitive areas identified in legislation in the Activity areas and surrounds.

3.11. Socio Economic Environment

Protecting Amenity during the Activities

The Company's activities occur in remote areas, being situated at least 20 km from the nearest homestead, 30 km from the nearest community and 56 km from the nearest town. While the remoteness of the areas presents logistical and operational challenges, it does mean that impacts to amenity are mitigated through the absence of nearby receptors. Disruption to traffic in the area presents a possible impact on amenity. However, all equipment will be mobilised to site over a short period and so the impact on amenity is expected to be low. Traditional Owners will be fully engaged in Activity updates and invited to site to view the program activities when operational under Company specified safety arrangements. Access to their lands will be unrestricted by the Activity except at the well site, or by prior permission, because of safety requirements.

The Kimberley region is relatively undeveloped, comprising of small coastal settlements that are economically dependent on fishing, agriculture, tourism, mining with oil and natural gas production. The three main population centres are Broome, Derby and Fitzroy Crossing although over 1,200 Aboriginal people live in communities and outstations.

The wells at which Activities will be undertaken are located within sparsely populated areas with limited settlement, transport or communications infrastructure. Land use is generally open range pasture grazing. The proposed Activities will be undertaken using self-contained portable camps located near the well sites to provide accommodation to the crew of service providers. The crew will operate on a roster basis and will predominantly consist of specialised personnel operating on a FIFO basis. The Company does not expect its Activities to have any adverse impact on the socio economic environment in the vicinity of the well sites but will consult with local Aboriginal groups, pastoralists and other stakeholders before undertaking Activities.

3.12. Cultural Environment

Respect for Traditional Owner Values

A comprehensive engagement program with Traditional Owners by virtue of a strategic "gas roadmap" process establishes a participatory process that encompasses Traditional Owner values and heritage and ongoing community engagement in Company planning and development of this potential resource. This includes the establishment of a Company accredited training and employment program for Environmental Science Cadets with candidates from Traditional owner groups to undertake the ongoing environmental monitoring program for the gas development; the active identification of training and employment in the Company and through its specialist service providers and active identification of business opportunities for local Aboriginal companies and enterprises.

The Company recognises the Traditional Owners, and all Aboriginal peoples and groups, of the Activity area and their affinity with the land. The Company has a strong and valued working relationship with Aboriginal Peoples and groups, demonstrated through:

- Heritage Protection Agreements in place for exploration activities to ensure Aboriginal heritage is protected.
- Conducting heritage surveys before commencing work on Traditional Owners' land.
- Keeping the relevant communities and groups informed of Company exploration activities.
- Engaging appropriate Traditional Owners as cultural monitors during ground disturbing exploration activities in the field.

Heritage approval has been obtained for all well sites where HF activities are proposed. No clearing will occur as part of the proposed Activities. However for completeness, the following information has been included. Heritage surveys have been conducted in the field with the relevant native title groups and searches of the Department of Aboriginal Affairs' Register of Aboriginal sites conducted before ground disturbance is undertaken by the Company to ensure that its exploration activities do not adversely impact the Aboriginal heritage values of an area or interfere with Aboriginal heritage sites.

In the event that any archaeological material/heritage sites are reportedly identified during operations, works will stop in that area and an investigation made to determine the appropriate response and course of action in that area.

4. DESCRIPTION OF PROPOSED ACTIVITIES

4.1. Activity Planning and Design

To ensure that potential environmental impacts and risks are reduced to ALARP, the Activities has been designed and planned as detailed below.

4.1.1. Well Design and Barrier Planning

The petroleum well at each site is the physical structure which enables the reservoir to be accessed. The integrity of this structure is of paramount importance in managing the subsurface risks associated with the Activities. Well integrity, is the application of technical, operational and organizational solutions and barriers to reduce the risk of uncontrolled release of formation fluids throughout the entire life cycle of the well. A well barrier is an envelope of one or several dependent barrier elements preventing fluids or gases from flowing unintentionally from the formation, into another formation or to surface. Barriers may be active, passive, or in some cases, reactive. Active barriers such as valves can enable or prevent flow, while passive barriers are fixed structures such as casing and cement. Reactive barriers deploy a containment response when a pressure, flow rate or other behaviour limit is exceeded such as a human or mechanical response to an activating or triggering event. Most production well barriers are static, available continuously over an extended period of time, usually without requiring human observation or action, whereas most drilling and completion (including HF) activity barriers are dynamic (King & King, 2013). Production barriers require less continuous monitoring compared to drilling and completion (e.g. HF) barriers that are dependent on correct human activity. The design principles of barrier planning is such that one or more barriers in a properly designed and constructed oil or gas well may fail without creating a pollution pathway or significantly increasing the risk of groundwater pollution.

4.1.2. Well Construction

The design and selection of the well casing is of utmost importance to the well integrity. The well casings are designed to withstand forces associated with drilling, formation loads, and the pressures applied during HF. The design of each of the Company petroleum wells includes four protective casing strings to provide a strong vertical structure and ensure well integrity Figure 23. The casing grade is selected in accordance with API Grades and design criteria. The construction details of each of the TGS14 wells are described in the well site specific Drilling Plans which were approved by the DMP for the construction and subsequent suspension of each of the wells. In accordance with *the Schedule of Onshore Petroleum Exploration and Production Requirements 1991* (WA) the Conductor and Surface Casing Strings are cemented to surface; all other casing strings are cemented to a minimum of 150 m above the casing shoe (the bottom of the casing string, including the cement around it), or to a height of at least 100 m above any zone not previously cased containing fluid hydrocarbons or mobile formation water. Each of the Company wells was constructed using the following generic process.

Conductor Casing (508 mm diameter): This outermost casing, which is installed to a depth of approximately 26 m, serves to hold back overburden deposits, isolate shallow groundwater, and prevent corrosion of the inner casings, and may be used to structurally support some of the wellhead load (API, 2009). The casing is secured and isolated from surrounding unconsolidated deposits by placement of a cement bond, which extends to ground surface.

Surface Casing - 340 mm (13&3/8”) diameter: After the conductor casing has been drilled and cemented, the surface casing is installed to protect potable aquifers. The *Schedule of Onshore Petroleum Exploration and Petroleum Requirements - 1991* require that all reasonable steps are taken during an operation on a well *to prevent communication between, leakage from, or the pollution of, aquifers that serve, or could serve, any useful purpose*. To meet this objective the casing is set to a suitable depth below the deepest potable aquifer. The surface casings of the Company gas wells

extend more than 500 m below ground level (BGL) into the confined Grant/Anderson Group or the Noonkanbah Formation as shown in Figure 24 and Figure 25 respectively. This casing section is thus isolated from the overlying fresh water aquifer by a formation seal (aquiclude) and cementing job which prevents upward migration of fluids and gas from the lower formations. Similar to the conductor casing, the surface casing is also cemented in-place to the ground surface. In accordance with good practice API Standards, two pressure integrity tests are conducted at this stage:

- Casing pressure test: to test whether the casing integrity is adequate (i.e. no leaks or zones of weakness) for meeting the well's design objectives; and
- Formation pressure integrity test (FIT): after drilling beyond the bottom of the surface casing shoe, a test is performed to ensure the cement job has provided a complete seal. The FIT test also provides assessment of the strength of the rock formation in that zone.
- A cement bond log (CBL) is also conducted at this stage in the well construction process, using a sonic scanner lowered in to the well, to confirm the presence and the quality of the cement bond between the casing and the formation along the entire well bore where the cementing has been completed. CBLs can also be undertaken during the life of the well to confirm integrity.

These tests help assess the adequacy of the surface casing/seal integrity and determine the need for remedial measures, if any, prior to proceeding to the next step.

Intermediate Casing - 244 mm (9&5/8”) diameter: The purpose of the intermediate casing is "to isolate subsurface formations that may cause borehole instability and to provide protection from abnormally pressured subsurface formations" (API, 2009). The intermediate casing is cemented either to the ground surface or at a minimum to above any drinking water aquifer or hydrocarbon bearing zone. Similar to the surface casing, casing pressure and formation pressure integrity tests are performed to ensure the adequacy of the casing and seal integrity.

Production Casing -178 mm (7”) diameter: The final step in the well installation process consists of advancing the production casing into the natural gas producing zone. The production casing isolates the natural gas producing zone from all other subsurface formations and allows pumping the HF fluids into the target zone without affecting other hydrogeologic units; the production casing also provides the conduit for natural gas and flowback fluid recovery once fracturing is completed. Finally, the production casing is pressure tested to ensure well integrity prior to perforating the casing within the hydrocarbon bearing zone and performing the HF stage.

Company petroleum wells therefore consist of a series of concentric steel casings and cement layers schematically depicted in Figure 23. This practice ensures that robust cement integrity exists across casing shoes providing complete zonal isolation in the wellbore. Casings are similarly tested and can also be repaired during the life of the well.

The depth location of the surface, intermediate and production casings and associated potable aquifers for each of the petroleum wells are shown in Yulleroo (Figure 24) and Valhalla & Asgard (Figure 25).

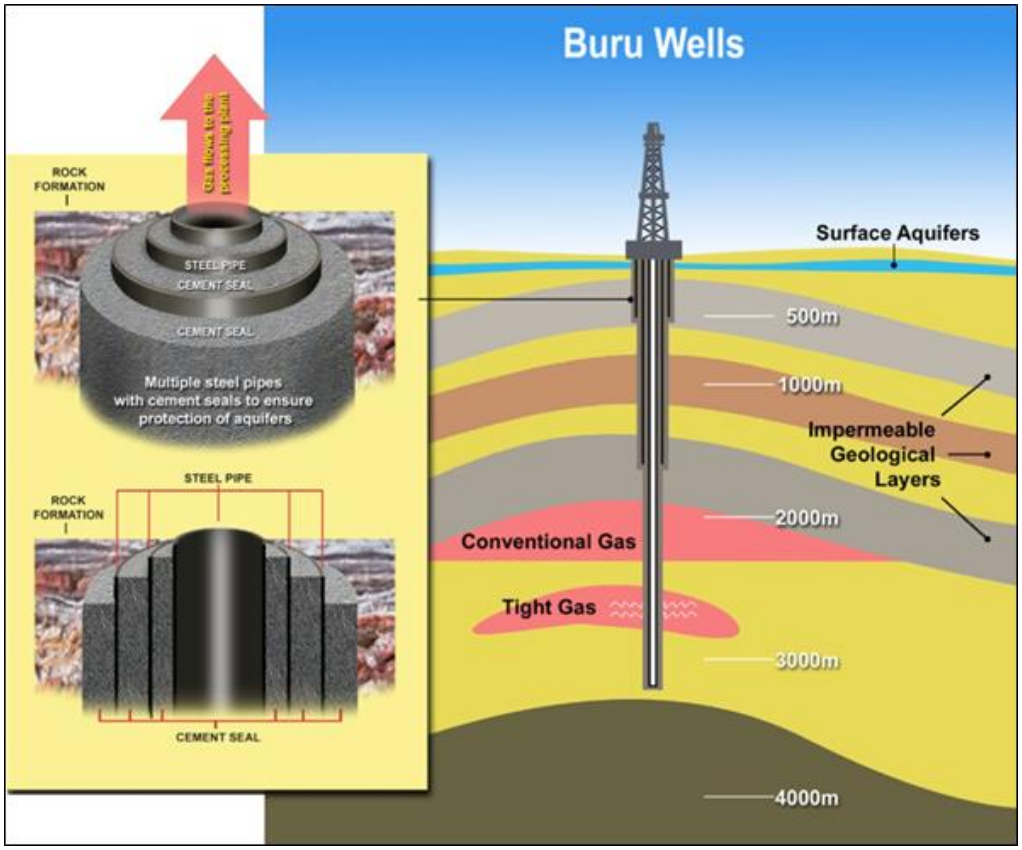

Figure 23: Typical Company well construction and casing design (not to scale).

4.1.3. Well Stratigraphy

Stratigraphic (rock layering) analysis of seismic and well data helps determine what rocks were deposited/eroded where and when in the basin fill process that occurs over many millions of years. The stratigraphy of the earth in the areas in which the petroleum wells in Yulleroo (Figure 24) and Valhalla & Asgard (Figure 25) are constructed has been developed in detail to help inform the quality and characteristics of the petroleum reservoir and the selection process for target zones in the Laurel Formation to be subsequently tested for hydrocarbon flows using HF. Understanding the stratigraphy of an area prior to drilling also informs the barrier planning in the wells to prevent fluids or gases from flowing unintentionally from the formation, into another formation or to surface. From an environmental perspective, the stratigraphic cross sections, or maps, inform the design depth of each of the casing shoes; most importantly for the depth of the surface casing *to prevent communication between, leakage from, or the pollution of, aquifers that serve, or could serve, any useful purpose*.

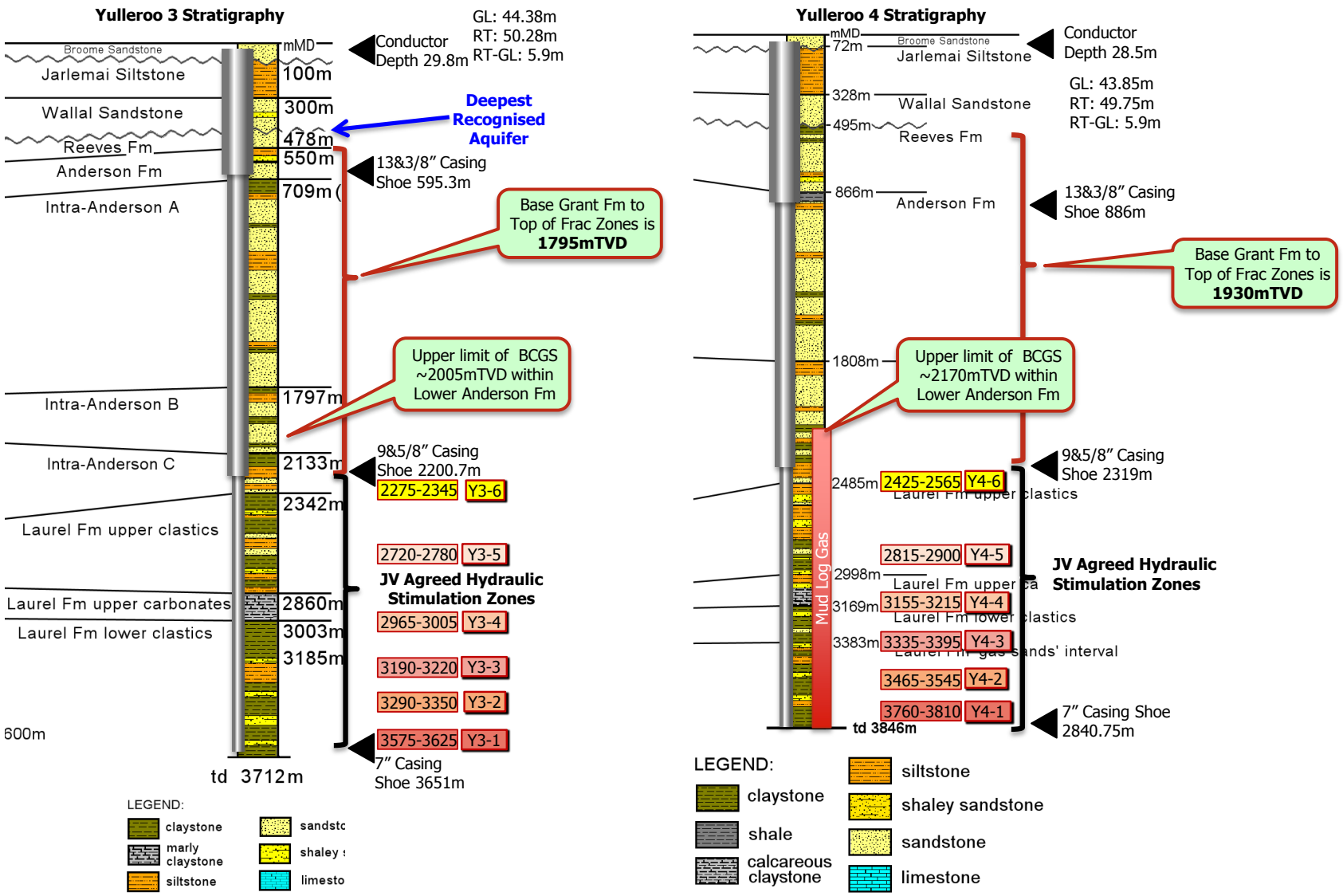

Figure 24: Yulleroo well design and stratigraphy

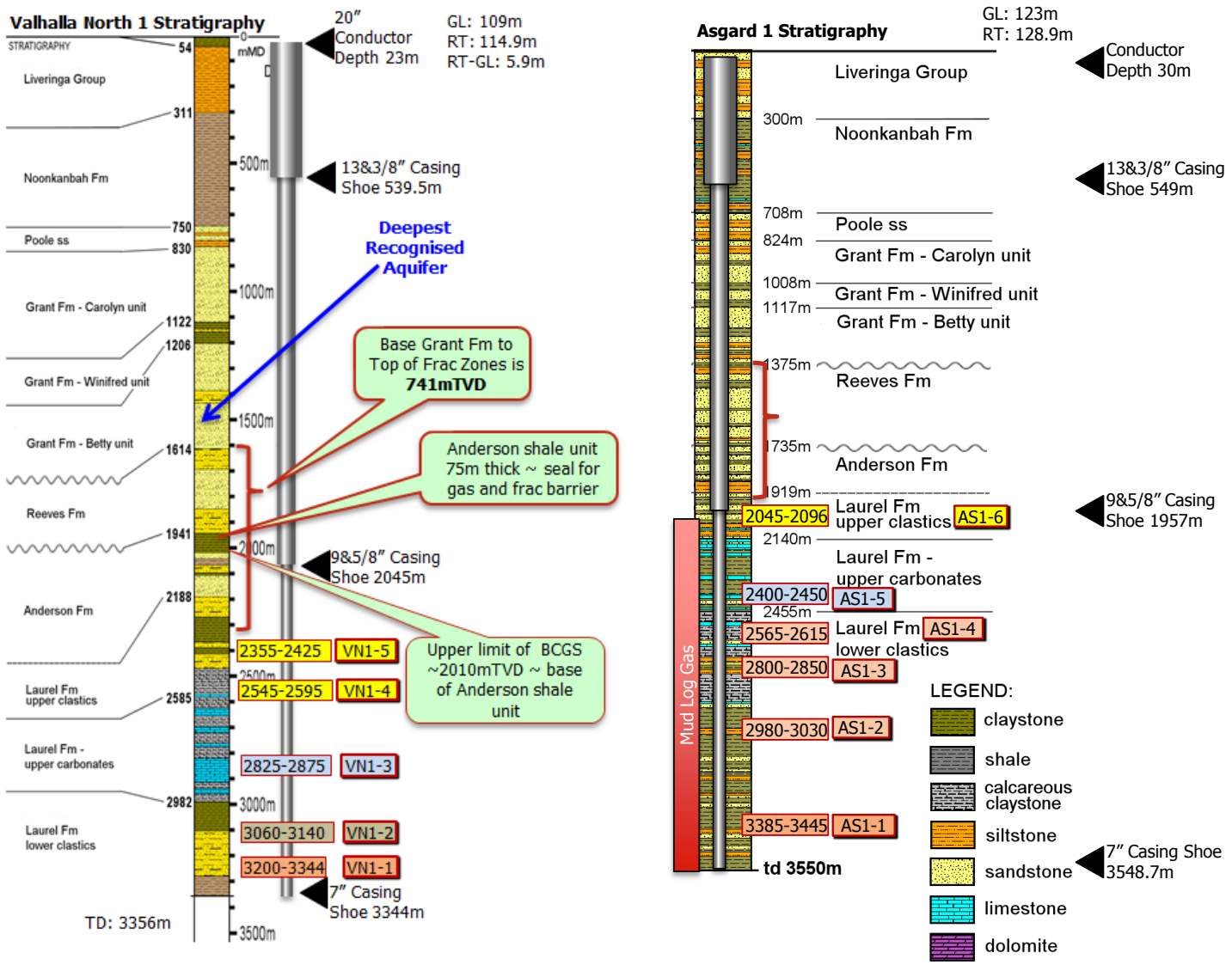

Figure 25: Valhalla & Asgard well design and stratigraphy

4.1.4. Well Integrity Assessment and Assurance

Best Practice Approach for Ensuring Well Integrity

Ensuring well integrity prior to HF operations is an important component of undertaking safe HF activities. Robust criteria for site assessment (geophysical and geomechanical), well design, construction, cementing and integrity testing are a key aspect of Best Practice Guidelines including the WA Onshore Code of Practice for Hydraulic Fracturing (APPEA) and the Golden Rules (IEA).

To ensure the Company meets and exceeds best practice during the proposed activities, cement bond-logs (CBLs) will be re-run prior to TGS14 Operations. The interpretation of these CBLs and related well documentation will be undertaken by an independent external reviewer. The reviewer's assessment will then form part of the peer review by Prof. Peter Styles Geological Environment Peer Review. This is consistent with the conservative approach adopted by the Company that exceeds the level required under the regulatory assessment process.

As noted, well integrity is of paramount importance in managing the subsurface risks associated with the Activities. This is a highly developed field of engineering in the petroleum industry from both a safety and environmental perspective (API, 2009; King, 2012). A review of over 600,000 wells worldwide indicated actual well integrity failures are very rare. Well integrity failure is where all barriers fail and a leak is possible. True well integrity failure rates are two to three orders of magnitude lower than single barrier failure rates (King & King 2013). A number of international reviews have noted instances of groundwater pollution attributed to poorly constructed and maintained wells, usually more than 70 years old before major advances in cementing technology (e.g. cement design software, data on flow at temperature, dynamic cementing, swelling cement, flexible, gas-tight and self-healing cements) and well engineering were implemented (e.g. Ravi et al., 2002; King & King 2013). A recent regulatory review of state oil and gas agency groundwater investigations in Texas found not a single groundwater contamination incident resulting from site preparation, drilling, well construction, completion, hydraulic fracturing stimulation, or production operations at over 16,000 horizontal shale gas wells that were drilled during the 16 year study period from 1993 to 2008 (Kell, 2011).

These reviews also indicated that demonstration of ongoing integrity of a well is a key regulatory concern (ACOLA, 2013; Royal Society, 2012). However, it is also important to note that potential for downhole leaks to the environment may diminish rapidly as the reservoir pressure is drawn down over the life of producing well. Low bottom hole pressure wells do not have the driving force to oppose constant hydrostatic pressure of fluids outside the wellbore; hence, if a leak path is formed through the sequence of barriers, the highest potential is for exterior fluids (usually salt water) to leak into a wellbore (King & King, 2013).

As part of the well integrity assessment and assurance program for TGS14, additional tests (CBLs, pressure tests) on each of the TGS14 gas wells was conducted. The specialist service provider assessments together with the specific Drilling Plans for each of the TGS14 wells have been provided to an independent well examiner for a final assessment and recommendations report on each of the TGS14 wells and confirm the integrity of the wells. This will be provided to the DMP during the assessment of the Environment Plan to confirm the integrity of each of the wells meets the relevant PGER regulations.

In addition, ongoing routine testing of the annulus pressure using a pressure gauge at surface between the Intermediate casing (9 & 5/8" diameter) and Production casing (7" diameter) can identify any anomalous pressure readings in this key annulus to ensure ongoing safety and integrity of the cement bond and confirm continued isolation of subsurface pressured formations.

4.1.5. Stimulation Zones

HF treatments will be performed in each of the wells at selected target zone(s) at defined depths below ground level in the Laurel formation. Zones will be accessed by perforating the production

casing and surrounding cement of the well with small holes approximately 3 mm in diameter, typically along four sides facing the target formation using a specially designed well perforating gun designed to make tiny holes through the casing, cementing, and any other barrier between the formation and the well. The perforations allow for injection of the HF treatment into the rock reservoir from the well and the subsequent flow back of spent HF fluid, produced water from the formation and hydrocarbons into the well and up to surface.

Selection of the zones has been undertaken by specialists using a range of criteria and characteristics from relevant data sets for each well and the Laurel formation generally. The provisional stimulation zones proposed for each well are summarised in

. Within each zone interval a series of up to 6-7 clusters of small holes will be perforated through the production casing and cement to allow access to the formation. There are 6-7 perforations in each cluster. Prior to HF, the well is plugged below the zone using standard cement plug bridging techniques to isolate the wellbore below the target zone. The HF process is designed and conducted in a series of sequenced pumping stages, typically over a period of 2-5 hours in order to achieve stimulation of the formation to release gas and other hydrocarbons into the well.

4.2. Stages of Works and Timing

Minimising Operational Risks during the Activities

The Company recognises that TGS14 is operationally a pilot program in the Canning Basin. The program will provide important logistical and operational lessons for future Activities. It is important that the logistical and safety risk components for both the Company and the Service provider are managed to ALARP. The Company has therefore made the decision to execute the TGS14 Activity as a single HF program conducted at each well site consecutively rather than two phases at each site. The exception to this will be Valhalla North 1 where there will be two phases to enable lower and upper zones to be flowed back separately. This will be done without significantly compromising the overall technical objectives of the TGS14 program.

The stages of works and associated job steps are set out in Table 6 below.

Table 6: Stages of Work.

STAGES of WORK	Job steps
Site Setup	Fill Water Reservoirs
	Establish bunded storage areas for fuel storage and refuelling, and storage of hazardous chemicals.
	Establish a bulk materials handling area for sand proppant storage and blending.
	Establish a site office and camp site with amenities.
	Mobilise equipment, personnel and supplies.
HF Operations	Rig-up and conduct pressure testing of the set-up and well.
	Conduct wireline and slickline operations and perforate the steel casing at selected intervals in the well.
	Set up, connect and test well stimulation equipment.
	Conduct HF operations at each of the well sites, monitor and report.

	Rig down and demobilise equipment and HF personnel.
Well Cleanup	Mill out plugs using coil tubing unit
	Recover sand and debris and HF fluid
	Clean-up of the well allowing flowback
Flowback testing	Conduct well flow-back for a 30-90 day period subsequent to HF at each of the wells.
	Depending on results an extended production test at each of the wells for a further period specified under the regulation may be sought from the regulator to determine decline curves in the reservoir.
	Conduct hydrocarbon flow testing and characterisation including intermittent and continuous periods of flaring; intensity-duration-frequency to be monitored and reported.
	Conduct produced water testing, including chemistry analysis, and characterisation including treatment optimisation for reuse or disposal.
Monitoring, Care & Maintenance	Reinject the flowback to formation; haul residual fluid to approved facility for disposal
	Conduct environmental monitoring of groundwater bores upstream and downstream of the well head prior to, during and post HF treatments at each well site.
	Conduct air quality monitoring prior to and during HF operations at one selected well site
	Conduct microseismic monitoring of each of the well areas prior to, during and post HF treatments at each well site.
	Care and Maintenance of the well sites following completion of operations.

The HF rigs and equipment, personnel and supplies will be mobilised on semi-trailers to each of the well sites and associated camp site. Access to each of the well sites will utilise existing roads and tracks. No clearing will be required for access to the well sites. Only maintenance grading of the existing access tracks to repair washouts and rough and corrugated track surface will be undertaken, where required.

The Activities will be timed such that they will not commence during the northern wet season (which lasts indicatively from December to March inclusive) to ensure minimum risk of track access issues for the HF rig fleet. Monitoring and well testing may be conducted during the subsequent wet season.

4.3. Preparation and Mobilisation

4.3.1. Access Track

Access tracks are already present at all well sites. Some grading and rolling maintenance work of the access track may be required at each location prior to mobilisation of equipment to the site.

4.3.2. Well Sites

The Activities will be contained within the existing fenced and cleared areas of the well sites. No additional vegetation clearing will be required at the well sites for the Activities. The existing facilities at the well sites are shown below.

Yulleroo 3 well site

Yulleroo 4 northwest fenceline

Yulleroo 4 well site looking north towards the well head

Vahalla North 1 well site

Vahalla North 1 well head

Asgard 1 well head

Figure 26: Existing well sites (May 2013).

The preparatory works that will be undertaken at each of the well sites for the Activities will include the establishment of the following:

- Filling of water reservoir by pumping from well site water bore
- Impermeable, bunded storage area for hazardous substances.
- Impermeable, bunded dangerous goods (fuel) storage area and refuelling area.
- Bulk materials handling area for sand proppant storage and blending.
- Firebreak maintenance and preparation of Flaring area within the well site.

Water and proppant sand requirements based on the proposed number of HF treatments conducted at the well in each phase has been calculated in

.

Table 7: Water and Proppant sand requirements with 30% contingency at each well site.

Well Site	# HF Treatments	Water (ML)	Proppant (m^3)
Yulleroo 3	5	5.5	435
Yulleroo 4	13	14.3	1130
Valhalla North 1	5	5.5	435
Asgard 1	11	12.1	955
TOTAL	**34**	**30.9**	**2950**

4.3.3. Water Use

Minimising Water Use during Activities

An estimated 31 ML of water will be used during the TGS14 Activities. This represents less than 0.005% of the annual sustainable yield of the Canning Basin. This is equivalent to two days water use in the town of Broome. Opportunities will be sought to re-use water during subsequent HF treatments at each site in TGS14 which will further reduce total water use. The Company has set itself a mandatory objective of achieving full reuse of HF Flowback water by 2015.

The Canning Basin is recognised as the second largest aquifer in Australia after the Great Artesian Basin. Estimates of sustainable yield from the basin are between 615,000 ML/yr and 827,000 ML/yr). Of the annual sustainable yield, only 33,134 ML/yr is being consumed. Water use for the proposed program is 31 ML which is less than 2 days of water use for Broome. This represents less than 0.005% of the annual sustainable yield of the Canning Basin. All water used for the activities will be extracted from water bores on site.

The taking of water will be licenced in accordance with the *Rights in Water and Irrigation Act 1914* (WA) as administered by the Department of Water. Volumes of water taken will be monitored and recorded in accordance with the Company *Health, Safety and Environment Reporting Procedure* (HSE-PR-014). These will be reported as part of the Company's Annual Environment Report.

4.3.4. Water Storage

Best Practice Approach for Managing Flowback Water

The Company will use "Turkey nests" for retention of source water and HF flowback water during the activities. Turkey nests are so-named because they resemble the nests made by turkeys in the landscape and are highly effective as water retention reservoirs. Each Turkeys nest will be triple-lined during construction with two x 400 HDPE impervious liners interleaved with Geotextile fabric (A34). This approach to water management exceeds the APPEA and IEA Guidelines and is consistent with the conservative approach adopted by the Company that exceeds the levels required under the regulatory assessment process.

Upon flowback, water will be fully characterised using laboratory analysis. This characterisation of HF flowback water will provide the information required as the Company moves towards the goal of full reuse of HF flowback water by 2015. Turkey nests can also be readily remediated to baseline landscape conditions at the end of the project.

Turkey nests are raised earthen embankments that will be triple-lined. The liners consist of 2 layers of 400 micron HDPE impervious liners interleaved with Geotextile fabric (A34). The design has proven to be robust and fit for purpose in the Company operations in the Canning Basin operations over many years. They are easily constructed and removed and the sites readily and rapidly returned to a state that is consistent with the surrounding landform. They are safe and secure containment systems for water including during the monsoonal wet season. Tanks were also considered but require major

trucking movements due the sheer number of tanks required and are susceptible to damage during transport and on site. Turkey nests therefore represent the most practicable and environmentally sound approach to managing water on site and mitigate potential risks to ALARP during the Activities. On average, approximately 1.1 ML of water will be required for each HF treatment at each of the wells. Each site facility will comprise the following infrastructure:

- Two Turkey nest water reservoirs approximately 50 m x 50 m x 4.5 m deep (+1.5 m embankments) for bore water and produced water containment (Figure 27);
- Three 77 m³ (500 bbl) tanks and two 54 m³ (350 bbl) steel tanks.

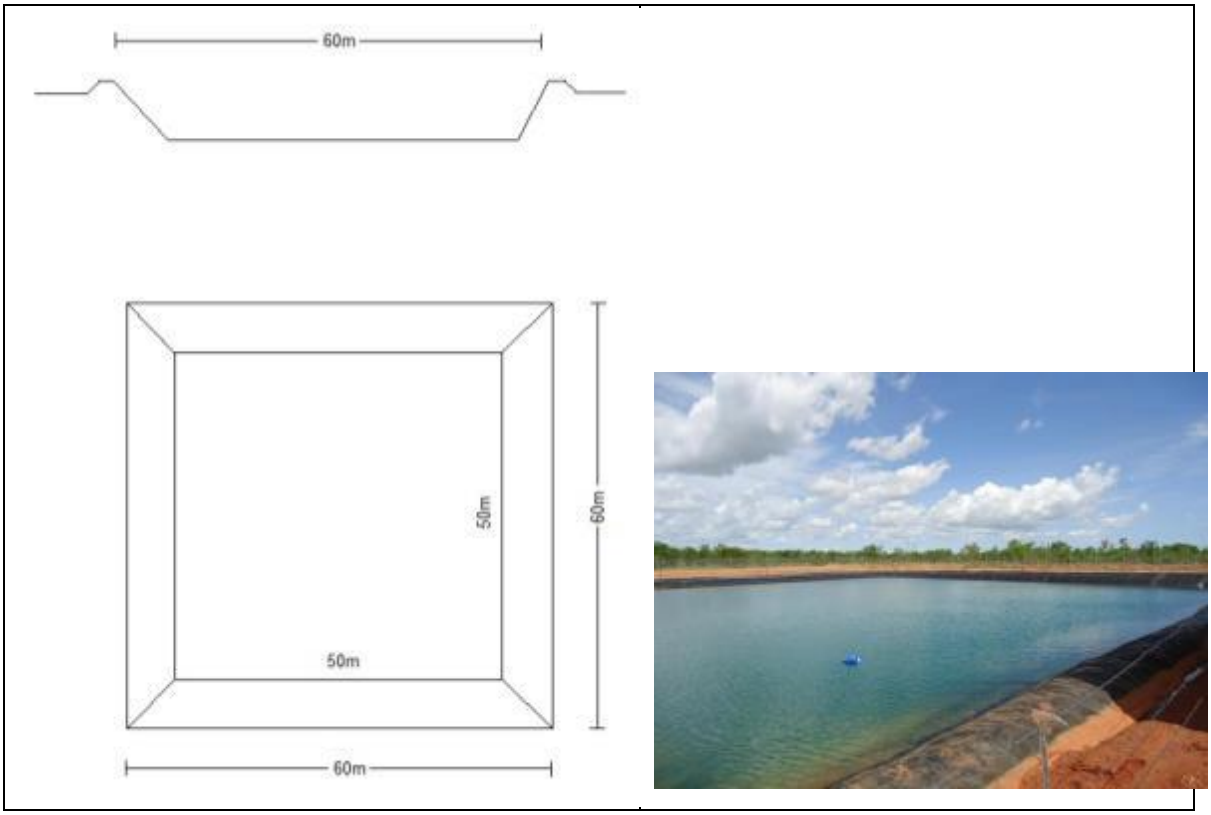

Figure 27: Turkey nest water reservoir design.

The Water Reservoir will be filled with water during preparatory works. Potable water used at the well site and camp site will be obtained from the existing water bores. The potable water requirement is estimated to be approximately 18 KL/day based on a 50 person work force at 350 L per person per day. Potable water will be stored in tanks at the camp sites.

4.3.5. Personnel and Camp Sites

Approximately 50 personnel are expected to be located at each well site during the HF Operations stage. These will principally be the Contractor personnel with a small number of Company operational and supervisory personnel.

A contractor (Contractor) will be appointed to conduct the Activities. The Contractor will be required to demonstrate to the Company that it has a proven track record of successfully completing HF operations to a high standard and that it has the appropriate and necessary health and environment safety management systems and policies in place. The Contractor will be contractually required to comply with the Environment Plan submitted to the DMP under the PGER Act and the Company's Environmental Policy as well as all applicable legislation and regulatory requirements including the APPEA Code.

A mobile camp will be established within an existing cleared area established as the camp site for the HF Operation Stage. The prefabricated accommodation facilities will be complete with kitchen, ablution and laundry. No additional vegetation clearing will be required for these camp sites.

A small mobile camp with accommodation for up to 4 personnel will be used during the Flowback Testing Stage.

4.3.6. Well Preparation

Prior to mobilising the HF spread to site, the following Activities will be undertaken to prepare each well for the HF treatment:

1. Cement Bond Logs (CBL) will be run at each of the wells and an independent assessment made that the cement bond is acceptable.
2. Each well will cleaned out using a wireline unit in preparation for the HF treatment. This will be done by flushing the wellbore with fresh water pumped from the turkey nest down the wellbore and returned to the Water Reservoir.
3. Following cleanout of the well, a brine solution (2% KCL) will be pumped down the wellbore so the well is partially full.
4. A specialist wellhead will be installed and pressure tested.
5. The wellbore has been pressure tested for integrity and determined to be free of any obstructions to allow access to the perforations.
6. Stage 1 perforations will be completed.

4.3.7. Mobilisation

Once the well sites and camp sites have been prepared, the equipment, personnel and supplies will be mobilised. The key equipment that will be utilised for the Activities includes:

- 50 tonne crane;
- Several high pressure truck mounted pumps;
- Proppant storage and conveyance units;
- Chemical additive unit (used to accurately monitor additives);
- Mixing unit (“Blender”) for blending water, proppant and required chemical additives;
- Command Centre or “Frac Van” with computer hardware and software to effectively monitor the pumping treatment;
- High pressure piping;
- Monitoring and control systems for flow rates, fluid density and treating pressure;
- Annulus pumps;
- Coil Tubing Unit (CTU) (used to mill out cement plugs in well);
- Flare tanks.

The trucks, pumps, and other equipment required for the HF activity will mobilise to site over a 48 hour period. The typical surface infrastructure that may be required for the HF treatment is shown in Figure 28.

Figure 28: Typical surface infrastructure for HF operation.

4.4. HF Operations

A Design of Service (DoS) has been prepared by the Contractor and the Company for the implementation of the HF Activity. This DoS contains the operational details and job steps for the proposed HF treatments at each of the well sites including HSE management during the HF activity.

The indicative duration of each of the steps in the HF treatment process at each well site are outlined in Table 8.

Table 8: Indicative duration of HF operations at each well.

Major stage	Yulleroo 3	Yulleroo 4	Valhalla North 1	Asgard 1
Transportation between wells	2 days	2 days	2 days	2 days
Mobilise/rig-up	2 days	2 days	2 days	2 days
HF operations	10 days	26 days	10 days	22 days
Demobilisation	1 day	1 day	1 day	1 days
Total	**15 days**	**31 days**	**15 days**	**27 days**

4.4.1. HF Rig-up

Once mobilised to site, HF equipment rig-up (Figure 29) is completed over approximately 2 days. Proppant sand required for the operation will be trucked from the quarry in roadtrains and pre-loaded into the sand conveyor (Mountain mover) at site. Water from the water reservoir will be pumped into three 77 m³ tanks (Figure 30) prior to the commencement of the Activities. Two transfer pumps will be

utilised, each with the capability of pumping up to 10 m³/minute from the water reservoir to ensure the tanks remain full of water for the duration of the HF treatment.

The water reservoir, transfer pumps, tanks and blender are all connected together with ruggedized heavy duty flexible hoses using standard 3" and 4" industrial Camlock connectors. All flexible hoses have 1,350 Kpa pressure rating but will typically be used at pressures around 330 Kpa. At the well sites, the hoses will be subject to visual inspection during mobilisation to ensure that no damage has occurred during transport. All high pressure surface lines and equipment used in the HF treatment will be tested to 70 MPa (10,000 psi) during rig-up to ensure pressure integrity before the Activities commence.

4.4.2. HF Treatment

Each of the four wells in TGS14 will be subject to a number of HF treatments based on the analysis of the formation at each well site and other specialist advice.

Well Site	# HF Treatments
Yulleroo 3	5
Yulleroo 4	13
Valhalla North 1	5
Asgard 1	11
TOTAL	**34**

Initially a DFIT (Diagnostic Fracture Injection Test) will be performed on Stage 1. This is a short duration, small volume diagnostic fracturing operation to validate the modelled HF design performance in the formation. The DFIT uses a small amount (<20,000 L) of brine water which is pumped into the formation until fracture initiation. At that point the frac valve is closed and the well's pressure decline is monitored over time and the results used to confirm the calibration of the modelled HF design.

Figure 29: Typical wellhead rig-up preparation for HF treatment.

The HF treatment is expected to have pumping rates down the well bore of up to 10 m³/minute. Water from the tanks will be pumped into the blenders where sand and chemical additives are mixed prior to being fed into the high pressure positive displacement pumps for pumping down the well hole. A single HF treatment takes approximately two to three hours to complete.

During the HF treatment process all pressures are carefully monitored by the Contractor engineers in the Command Centre or “Frac Van” which has high pressure alarms to warn of any imminent issues. The Company engineers can immediately shut down one or more pumps if any irregularities in pressure are observed. Each pumping unit has pre-set Pressure Relief Valves (PRVs) which are set just above the maximum expected HF treatment pressure ensuring that this cannot be exceeded. In addition another PRV is connected at surface to the annulus of the Intermediate and Production casings to ensure that anomalous pressures don’t occur in this area during the HF treatment.

At Valhalla North 1, there will be two phases of HF. HF Operations will first be undertaken on the lower section and the well will then be flowed back to clean up the lower stages. A plug will then be set between the lower and upper stages and HF Operations will then be undertaken on the upper stages. The upper stages will then be cleaned up and flowed back. Flowback of the upper and lower stages may occur sequentially or the plug may be milled out and the flowback comingled.

4.4.3. HF Fluid Composition

Choice of HF Fluid Composition

The types and use of HF fluids has evolved greatly over the last 60 years and continues to evolve due to the investment of significant research effort by service companies. This has led to the development of “green” HF fluids that optimise operational objectives and environmental outcomes. The Company has chosen Halliburton’s CleanStim® HF fluid for the TGS14 program. This fluid system is made with ingredients sourced from the food industry. An ecotoxicity assessment of the main components of the CleanStim® fluid was undertaken at a nationally accredited laboratory using local rainbow fish species. The results show the HF Fluid is classified as non-toxic under national guidelines. An independent chemical risk assessment found risks were low. Chemicals rapidly biodegrade or are consumed downhole (acids and bases). The biocide to be used in the HF fluid is readily biodegradable and its breakdown products have been tested to show they are also non-toxic.

HF fluid composition varies widely and a large number of ingredients have been used in fluid systems internationally. There have been major advances in the design and chemistry of these fluid systems in the last few years with a concerted move to more environmentally friendly fluid systems. The Company has selected one of the most environmentally friendly fluid systems presently available for HF in tight gas reservoirs. This is known by the trade name of CleanStim® fluid system and will be used for all TGS14 HF activities. This fluid system is made with ingredients sourced from the food industry.

Generally, the process of pumping the HF fluids down the well to create fractures in the formation involves the following three phases:

1. Pre-stimulation acid flush stage prior to fracturing consisting of water and hydrochloric acid to acidize the formation in the gas-bearing zone to be stimulated.
2. Fracturing stage, during which the fractures are induced in the target formation using water based fluid (“slick water”) and sand proppant that is pumped into the fracture network to "prop" the hairline fractures so that they remain open and enable the hydrocarbons in the formation to flow to the well.
3. Flush stage to clean out the well after fracturing, including removing excess proppant materials.

Water makes up the majority (~94%) of the HF fluid system, followed by proppants as the second largest component (~5%), and the remaining constituents (<1.0%) being made up of chemical additives – mostly salt. Total chemicals not including salt used in each HF treatment is approximately

3,908 L. The products to be used in the fluid system for the proposed HF and their purpose are provided in Table 9.

Table 9: HF fluid system to be used for the TGS14 Activities.

Trade Name	Supplier	Purpose	Volume (L)	Vol % of Total
Buru Energy PreJob Single Frac: 1154 kL gel FR Water, 189 kL gel CleanStimAUS, 3.8 kL LT Acid Blend, 20 T 100 Mesh Sand, 93 T 40/70 Sand, 63 T 20/40 Sand				
Water	Customer		1,347,460	94.1448%
Acetic Acid- 60%	Halliburton	Buffer	68	0.0048%
BE-9	Halliburton	Biocide	121	0.0085%
CLBXTAU121	Halliburton	High Temperature Breaker	189	0.0132%
CLLAU301	Halliburton	Crosslinker	1,893	0.1323%
CLWGAU421	Halliburton	Gelling Agent	567	0.0396%
FDP-S1085-13	Halliburton	Scale Inhibitor	672	0.0470%
FR-50D	Halliburton	Friction Reducer	188	0.0131%
FE-2	Halliburton	Buffer	14	0.0010%
HAI-150E	Halliburton	Corrosion Inhibitor	6.2	0.0004%
Hydrochloric Acid – 32%	Halliburton	Acid	867	0.0606%
Sodium Chloride	Halliburton	Clay Stabiliser	12,428	0.8683%
100 Mesh sand	Customer	Proppant	7,535	0.5265%
40/70 Sand	Customer	Proppant	35,279	2.4649%
20/40 Sand	Customer	Proppant	23,976	1.6752%
Total Fluid			**1,431,263**	**100.0%**

All chemicals and other substances to be used in HF treatment or otherwise introduced into the wells are fully disclosed in the accordance with Regulation 15(9) of the PGER(E)R regulations and *Chemical Disclosure Guideline – Version 2 (August 2013)* published by the DMP. All chemicals and other substances that will be used down the wells for the Activities are fully disclosed in the Environment Plan.

Laboratory assessment of the CleanStim® fluid system (minus the biocide, HCl and salt) was conducted at Ecotox Services Australia using the 96-hr fish imbalance toxicity test and a bioassay of the eastern rainbowfish *Melanotaenia splendida splendida* using the test protocol ESA SOP 117 (ESA 2011), based on USEPA (2002). The fish were unaffected at a concentration up to 200mg of CleanStim/L in water which indicates that it is nontoxic. According to Appendix 3 of the NICNAS guidance document (Commonwealth of Australia, 2013), any material with an EC50 >100mg/L is classified as very slightly toxic, which is the lowest toxicity rating in Australia (Table 10).

Laboratory assessment of the biocide (BE-6) indicates it is readily biodegradable. The biocide is hydrolysed by HCl and sulphuric acid. The degradation product has a 96-hour LC50 of approximately 700 ppm versus goldfish and zebrafish which indicates that it is essentially nontoxic. The active ingredient is used widely in household and industrial cleaners, detergents, dish detergents, disinfectants, hand sanitizers and personal care products.

Table 10: Ecotoxicity assessment guidelines (Commonwealth of Australia, 2013).

Classification	Acute (mg/L)	Chronic (mg/L)
Highly toxic	LC50/EC50 < 1	NOEC < 0.01
Moderately toxic	1 < LC50/EC50 < 10	0.01 < NOEC < 0.1
Slightly toxic	10 < LC50/EC50 < 100	0.1 < NOEC < 1
Very slightly toxic	LC50/EC50 > 100	NOEC > 1

A chemical risk assessment has been conducted for the HF fluid system by an independent specialist in accordance with the DMP Guidelines. This detailed Chemical Risk Assessment has determined that none of the chemicals to be used are classified as carcinogens or teratogens; are not persistent in the environment and do not bioaccumulate. The risk assessment concluded that the chemical constituents were readily biodegradable or consumed downhole (acids and bases).

Based on the HF fluid system constituents described in Table 9 and the number of zones to be tested using HF treatment described in

, the total quantities of water, proppant sand and chemicals (minus salt) to be used at each well site is listed in Table 11. A 30% allowance for constituents has been included to provide an upper bound for fluid volumes. A conservative estimated total of ~31 ML of water for TGS14 may be required to be abstracted from the surficial aquifers.

Table 11: Indicative HF ingredient requirements at each well site and TGS14 total.

Well Site	Number of HF	Water requirement (ML)	Proppant requirement (m^3)	Chemicals (kL)
Yulleroo 3	5	5.5	435	24.05
Yulleroo 4	13	14.3	1130	62.53
Valhalla North 1	5	5.5	435	24.05
Asgard 1	11	12.1	955	52.91
Total	**34**	**30.9**	**2950**	163.54

4.4.4. Management of Flowback and Produced Fluids

Green Completion

Ongoing monitoring of flowback will be conducted during the testing phase at each well. Water levels in Water Reservoirs will be actively monitored and managed. Methane is a potent greenhouse gas and all steps to mitigate its emission to the atmosphere will be undertaken during flowback at each well site in TGS14. In addition, emissions of VOCs will be mitigated by installation of equipment to capture condensate that comes up with hydraulic fracturing flowback, preventing their release into the air and making the valuable hydrocarbons available for sale.

The primary goal of the flowback operation is to determine the production rates of gas and liquid hydrocarbons. The volume and type of fluid coming back to surface will be accurately monitored and recorded according to the Company *HF Flowback Environmental Monitoring Procedure* (OP-PR-036). These volumes and rates are key to determining the quality of the reservoir. The Company has considered alternative approaches to managing the liquid hydrocarbons (condensate). Low rates and volumes of liquid will be flared with the gas. In order to conserve the resource, larger volumes of liquid hydrocarbon may necessitate storing in (60-100 m^3) tanks contained within impermeable HDPE membrane bunded areas at site and then trucked to a refinery rather than being wasted by direct flaring.

Flowback operations are a 24 hour a day operation, but at any time during the operation the well can be closed in to service equipment or change operations. The entire flowback manifold from the well to the Water Reservoir and flare are a closed piping system. All equipment used will be fully certified, tested, and have current inspection records available. The flowback and produced fluids coming from the well will be flowed through a flanged fixed steel line from the wellhead. All pressure piping and fittings will be fully certified with full traceability and have current inspection records available. The separator unit will be contained in an impermeable HDPE lined and bunded containment area.

Once the HF treatment has been completed, the well will be closed in until flowback operations are started as set out in the DoS. Switching from pumping the HF treatment to flowback may be immediate or take several days. The conceptual process flow diagram for water management at the well pad is shown in Figure 30.

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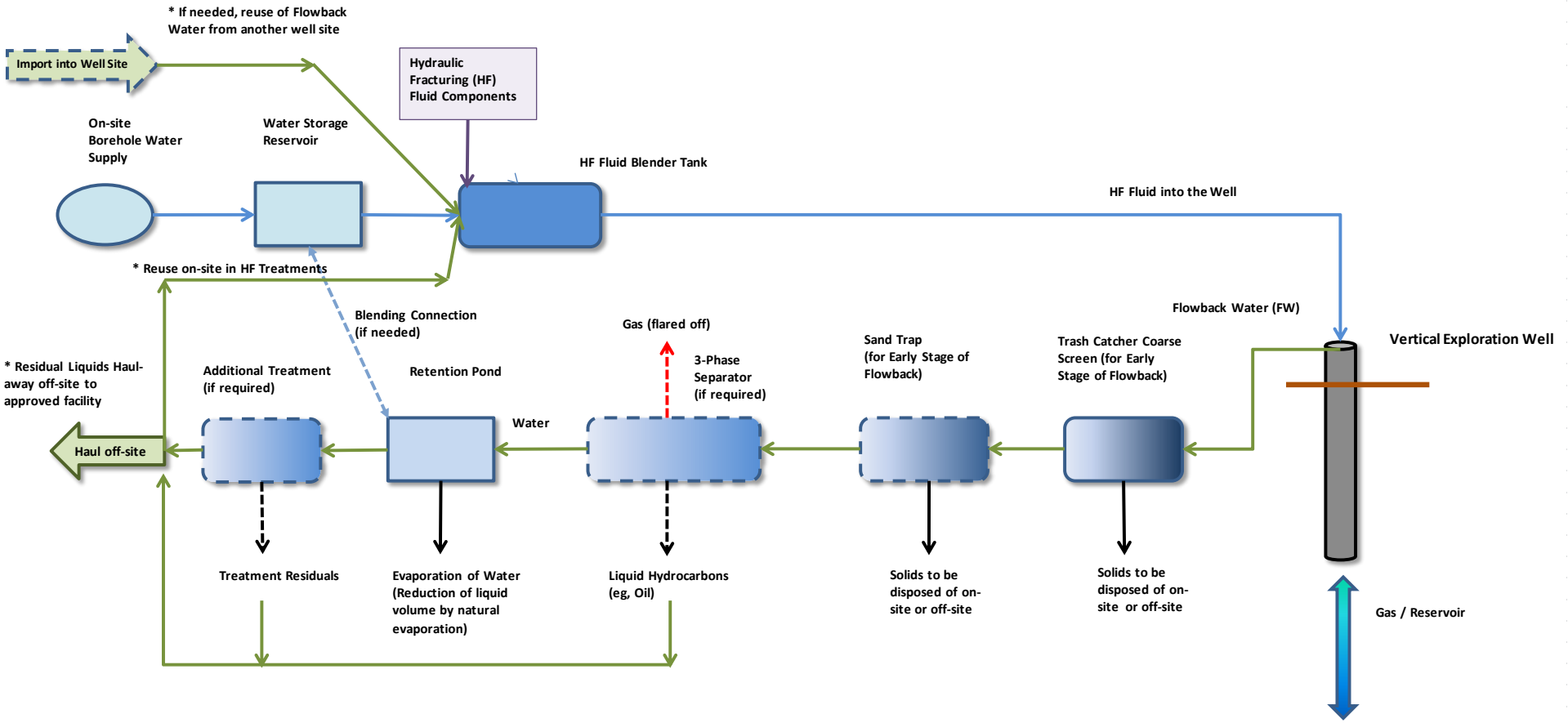


Figure 30: Process flow diagram for water management at the well pad.

Figure 31 and Figure 32 depicts a typical flowback setup with pictures of a trash catcher, sand trap, choke manifold, and Coiled Tubing Unit.

- The trash catcher catches pieces of rubber and composite from the plugs that were used to isolate the zones. During the flowback operations the plugs are drilled out by the Coiled Tubing Unit and may come to surface in 1-5 cm sized pieces. The total amount of these plugs will be less than a cubic meter.
- Sand traps are optional and are used to catch the sand before the fluid passes through the choke manifold. The sand trapped in the containers is flowed to the water reservoir via the valving.
- Choke Manifold holds an orifice or restriction that controls the amount of flow that can come out of the well, hence controlling the well pressure.
- Two 54 m³ water storage tanks are used to catch the initial flowback fluid. During the drilling of the plugs the flowback fluid is typically reused through these tanks until all plugs are drilled up.
- Coiled tubing unit is used to run a motor and mill in the well to remove the plastic composite plugs that were placed in between zones during the HF treatment.
- The water reservoir will be used for larger storage of fluid and returned sand upon flowback.

Mobile 77m³ water storage tank

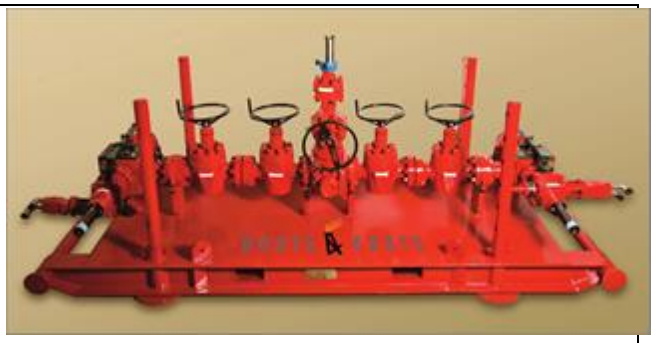
Skid mounted 54 m³ water storage tank

Figure 31: Tanks for water management during HF operations.

Coiled tubing unit rigged up on the well head

Trash catcher

Sand trap with two filter pods



Flowback manifold

Figure 32: Examples of the equipment for water storage, management, use and treatment.

Following completion of HF operations, flowback commences. During the flowback phase, the steps are basically:

1. HF pumping equipment is rigged down and removed from location.
2. Coiled Tubing and flowback equipment is rigged up and pressure tested.
3. Coiled Tubing is run in hole with a motor and mill to drill up the plugs. The motor is turned by pumping fluid through the coiled tubing and the mill will then grind/cut out the composite plugs.
4. The well flow is fully controlled by adjusting the choke size. Typical flowback rates from the well during milling of the plugs is 200-300 L/min.
5. Once all the plugs are drilled up, the coiled tubing unit is rigged down.
6. The well is then allowed to cleanup for a variable period of time depending on the nature of the formation. All liquids, except hydrocarbons are passed to the Water Reservoir under controlled flow.
7. During the early stages of flowback (Well Cleanup), there will be plug debris and sand and water only. The gas will not have made it to the well bore. At this time the flow will go directly to the Water Reservoir.
8. Once the initial flowback is completed and the HF fluids are mostly recovered the fluid will be diverted to pass through a separator. The separator is based on differences in the density of substances. As the gas is lighter, it will expand under pressure and is diverted through the top outlet of the separator via a pipeline to the flare. The denser liquid will build up in the bottom of the separator and then will flow into the Water Reservoir through an outlet.
9. The well is then flowed back at a faster rate for 30-90 days to test the hydrocarbon flow rates.
10. All significant hydrocarbons are either flared or caught. For these wells the primary fluid is expected to be gas and will therefore be flared during this test phase. Flow rates are not expected to exceed 5,000 m^3 (2 MMSCF)/day for each well.
11. There are two types of Gas Liquid separators (Figure 33). One is at atmospheric pressure and the other is pressurized. Typically, atmospheric pressure separators will be used during HF flowback operations:

    a) *Atmospheric Pressure Separator*: The tank of an atmospheric pressure separator is maintained at a certain water level using a pump. The bottom of the “gas buster” is open to the tank and hence below the water line. Gas rises through the atmospheric pressure separated to the vent stack at the top of the separator. A pilot light is kept burning at the top of the flare to burn the gas as it passes out of the separator. Water is then passed to the Water Reservoir.

b) *Pressurized Separator*: The pressurized separator is a contained vessel. The separator is split into water and oil compartments. The levels on both sides are controlled by valves. If the well is not producing oil then this side basically ends up dry. The little bit of back pressure (5-60 psi depending on style and rate) in the tank separator will push the fluid to the Water Reservoir so a pump is not required.

12. Should significant liquid hydrocarbon flow from the well, the Site PIC will have the option of bringing in a mobile 3-phase separator to separate the water, liquid hydrocarbon, and gas. A mobile 3-phase separator will be available on site in the Canning Basin during TGS14 operations. If liquid hydrocarbon flows back then the fluid is pumped into settling tanks and the natural density difference results in separation (the water on the bottom and the liquid hydrocarbon above). The water is then pumped off the bottom of the tanks, and the liquid hydrocarbon off the upper outlet tank inlet.
13. Throughout flowback operations, the flowback fluid will be monitored according to the Company's *HF Flowback Environmental Monitoring Procedure* (OP-PR-036). This will characterise flowback water to inform management and subsequent use/disposal of the material in a manner that demonstrates ALARP in managing potential environmental risks.

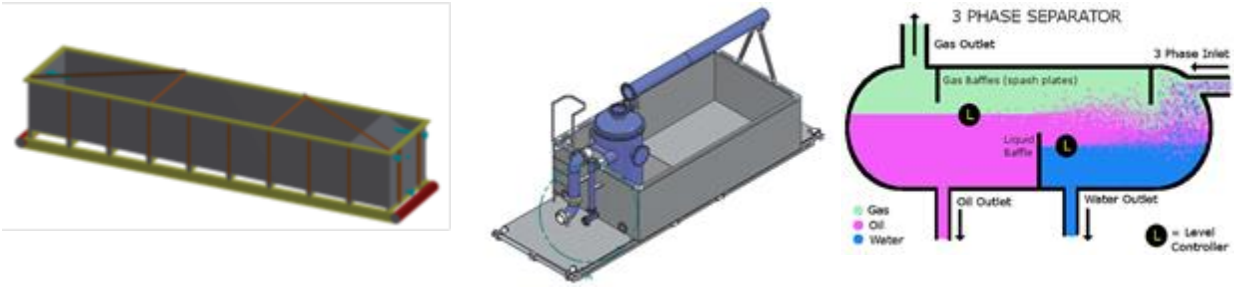


Figure 33: Open and closed Gas Liquid separator systems.

4.4.5. Flaring

Gas flow rates are not expected to exceed 5,000 m³ (2 MMSCF)/day for each well. The alternative to flaring is cold venting of gas to the atmosphere. Flaring converts methane (CH4) to carbon dioxide (CO2) and water (H2O). Emission of CH4 during cold venting (no flaring) to the atmosphere is 21 times worse in terms of greenhouse gases emission compared to emission of CO2 following flaring. The gas will be flared in TGS14. The flaring area will be located within the cleared, gravel sheeted and fenced well site area which has a minimum of 5 m wide firebreak maintained around the well site fence. An example vertical flare system to dispose of any produced gas is shown in Figure 34. The flare stack includes a 150 mm main flow pipe for reduced noise emissions, ignition system and trailer mounting for zero ground disturbances. The relevant authorities will be notified, including the DMP and Department of Fire and Emergency Services (DFES), when test flaring is required and operational. The volume and duration of gas flared will be recorded and reported to the DMP at each well site.

Flaring will be conducted for a period of up to 3 months following well cleanup and in accordance with the PGER Regulations.

Figure 34: Example flare system.

4.4.6. Fire Control Systems

Fire control systems at the well site and camp site will be in accordance with *Australian Standards (AS 1940 - Storage and Handling of Workplace Dangerous Goods)* and the Company's *Fire Prevention and Management Procedure* (OP-PR-015). A minimum of 5 m wide firebreaks will be maintained around the fence of the cleared and gravelled well site and also at the camp site. The Company has recently engaged with the Department of Fire and Emergency Services (DFES) in the Kimberley. Prior to commencing HF operations, the Company will coordinate a DFES visit to sites where HF operations are proposed to undertake site specific assessments of fire risk and ensure existing firebreaks around the well sites are appropriate for mitigating fire risk. Maintenance work on firebreaks where required, based on the review, will be undertaken following the wet season and prior to mobilisation to site.

During operations, ignition sources, apart from flaring, will be eliminated or, where this is not practicable, the risk arising from the ignition source will be controlled. The most substantial risk of ignition in the Activity area is posed by grass fires. Such grass fires are a regular occurrence in the Canning Basin during the dry season. Fire frequency varies but typically occurs every 2-4 years depending on environmental conditions and ignition sources. Weather conditions, fire history and vegetation fuel load all contribute to grass fire patterns and intensity.

The well site and camp site will be provided with adequate fire break, fire protection and fire fighting equipment. In accordance with AS 1940, installed fire protection and fire fighting equipment will be regularly tested and maintained. The fire fighting equipment consists of a trailer with a 1000 L skid mounted tank and a diesel powered fire fighting pump with provision of a foam branch for foam injection. Hand held DCP extinguishers will also be placed at various locations in the well site and campsite. Emergency firewater will be available from the Water Reservoir at each well site.

4.4.7. Waste Management

Disposal of Flowback

Following completion of the flowback testing phase, more than 80% of flowback water will be re-injected into the Laurel formation at each of the respective wells. Residual flowback will be characterised and trucked offsite to an approved facility. This may be the Sundown oilfield evaporation pond or another licensed facility depending on results of testing.

The treatment, storage and disposal of waste will be undertaken in accordance with the Company *Waste Management and Monitoring Procedure* (HSE-PR-005).

Putrescible Waste

Putrescible waste will be stored at the camp site and well site in securely covered skips/bins to prevent fauna access, including feral fauna, and litter generation. All putrescible waste will be regularly removed from the Activity area for disposal at a licensed waste disposal facility.

General and Industrial Waste

General and industrial waste will be suitably stored onsite in segregated areas including, but not limited to,

- Excess proppant sand stored within dry materials storage area;
- Produced liquid hydrocarbons stored in a fit for purpose storage tank within a bunded area;
- Residual flowback within the Water Reservoir; and
- Empty chemical containers returned to Service provider facilities offsite.

Where possible, industrial waste will be reused or recycled such as use of the returned proppant or sand as fill or bunding material. If the industrial waste cannot be reused or recycled, it will be removed from the Activity area for disposal at a licensed waste disposal facility in accordance with landfill operator requirements and the *Environmental Protection (Controlled Waste) Regulations 2004*, where applicable.

Sewage and Grey Water

Sewage and grey water at the well site and camp site will be treated by an Aerated Wastewater Treatment System (AWTS) which is a small scale onsite sewage treatment plant. An AWTS uses the processes of aeration and clarification to treat wastewater. The AWTS will be designed to treat all wastewater from the kitchen, bathroom, toilet and laundry and comply with AS/NZS 1546.3. The effluence will then either be discharged into a specifically designed leachate drain. The leachate drain consists of a deep trench laid with slotted agricultural drainage pipe, filled with ballast rocks and covered with soil. This results in a sealed unit that cannot be accessed by fauna during or after operations.

Residual Flow Back Management

Characterisation of flowback fluid quality, rates and quantity are key objectives of TGS14 at each of the well sites to enable the achievement of the goal set by the Company for 100% recycling of flowback fluid maximising reuse. The characterisation of flowback fluid is critical to inform future design and operation parameters for efficient tight gas extraction while minimising both the use of ground water resources and also surface water management.

Analysis of flowback from a previous HF operation conducted at Yulleroo 2 in 2010 found that:

- Salinity was high with TDS exceeding 100,000 mg/L.
- Radiation levels were low and did not exceed natural background levels found at the nearby Bohemia Bore.
- Flowback volumes were approximately 70% of the water volume used in the Yulleroo 2 HF treatment.

Results of the 2010 stimulation program have been used to develop flow back scenarios and management options. Anticipated flowback at each well site, based on the proposed number of HF treatments conducted at the well in each Phase has been calculated in Table 12.

The produced water from the HF treatment will be stored in the Water Reservoir at each well site. It will be sampled and analysed to characterise the composition of the water in accordance with the *Produced Water Monitoring Procedure* (OP-PR-024). This characterisation will also inform the treatment required for potential reuse and/or disposal of the flowback. **It is intended that more than 80% of flowback water will be re-injected into the formation at each of the respective wells following the completion of the testing phase for TGS14.** The wells will then be suspended.

At this early stage of testing of the Laurel Formation, disposal of all the flowback water by re-injection to the formation at the well may not be possible. Consequently, residual flowback water at each of the well sites will subsequently be allowed to evaporate in the Water Reservoir during the dry season while the characterisation of the flowback is completed. The estimated volume for disposal offsite from each of the well sites is shown in Table 12. The volume amounts to 2~7 truckloads to be hauled from each well site.

Table 12: Indicative flowback and disposal offsite at each well site and TGS14 total

	TOTAL			
Well Site	**# HF**	**Water requirement (ML)**	**Flowback (ML)**	**Disposal offsite (ML)**
Yulleroo 3	5	5.5	3.85	0.15
Yulleroo 4	13	14.3	10.01	0.40
Valhalla North 1	5	5.5	3.85	0.15
Asgard 1	11	12.1	8.47	0.34
TOTAL	34	30.9	21.63	0.65

If the results indicate the material meets Class 1 classification under Landfill Waste Classification and Waste Definitions (DEC, 2009) then it is proposed for TGS14, on approval of the DMP, to take the residual material to an existing oilfield brine evaporation pond (Figure 35) located at Sundown in the Blina oilfield area (Figure 36) operated by the Company. The Sundown evaporation pond is approximately 200 m x 80 m x 0.75 m = 12 ML capacity. Texture triangle classification suggests the soil is silty clay based on particle size distribution analysis. If the residual material is not suitable for disposal at the Sundown evaporation pond it will be disposed at a licensed waste disposal facility.

Figure 35: Sundown oilfield Evaporation Pond.

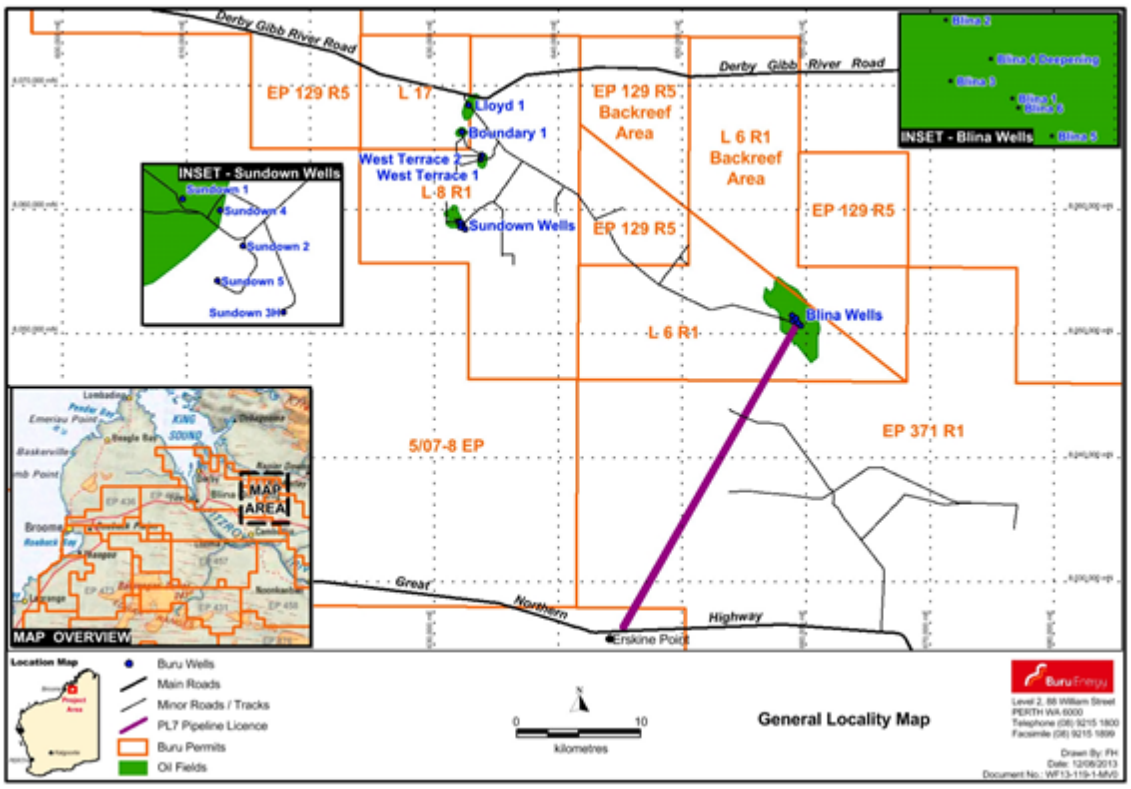


Figure 36: Sundown Oilfield Evaporation Pond location map.

4.4.8. Dangerous Goods and Refuelling

The Company defines dangerous goods according to the DMP's *Dangerous Goods Safety Information Sheet* (DMP, 2009) as substances or articles that because of their physical, chemical or acute toxicity properties present an immediate hazard to people, property or the environment. Dangerous goods will be stored, including segregation if applicable, in accordance with *Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2004* (WA) and relevant material safety data sheets (MSDS). A bunded or double skinned bulk diesel fuel storage tank will be established within the well site. Each dangerous good stored and handled will have a MSDS available onsite.

Vehicle and mobile equipment refuelling will be undertaken at designated refuelling areas at the well site and camp site in accordance with the Company *Refuelling Procedure* (HSE-PR-011). At the well site, the refuelling area will be located within an impermeable lined and bunded area. This Procedure provides specific requirements regarding refuelling operations including, but not limited to, the requirement for refuelling and fuel transfer operations to be manned at all times and spill kits located at the designated refuelling areas. All spills will be contained, cleaned-up and reported in accordance with the Company *Canning Basin Oil Spill Contingency Plan* (HSE-OP-010).

Refuelling of stationary equipment such as generators will typically be undertaken using a small tank (approximately 1,200 L) on the back of a service vehicle or dedicated refuelling trailer. All refuelling will be undertaken within the cleared area of the well site and camp site in accordance with the Company *Refuelling Procedure* (HSE-PR-011). This Procedure includes, but is not limited to, the requirements for a drip tray under refuelling points during mobile refuelling.

Spill kits will be available onsite for immediate containment and clean-up of spills of dangerous goods. Large spills (> 80 L) of dangerous goods will be contained, cleaned-up and remediated in accordance with the *Canning Basin Oil Spill Contingency Plan* (HSE-OP-010).

4.4.9. Hazardous Substances

Hazardous substances are those substances that following long term exposure can have an adverse effect on human health or the environment. Hazardous substances will be stored, including segregation if applicable, in accordance with relevant MSDS. All hazardous substances will be stored within impermeable bunds such as bunded pallets, inside bunded containers etc. All hazardous substances stored and handled onsite will have a MSDS available onsite.

Spill kits will be available onsite for immediate containment and clean-up of spills of hazardous substances. Large spills (> 80 L) will be contained, cleaned-up and remediated in accordance with the *Canning Basin Oil Spill Contingency Plan* (HSE-OP-010).

4.4.10. Power Source

Portable diesel generators onsite will provide power at the well site and camp site. All electrical equipment, instrumentation, lighting and cabling will be installed in accordance with statutory requirements.

4.5. Demobilisation

Upon completion of HF activities, all equipment, personnel and supplies will be demobilised from the Activity area in accordance with the *Demobilisation Procedure* (HSE-PR-021). This Procedure outlines the process and timing of demobilisation to be implemented by the Company at the conclusion of an Activity or Activity phase to ensure the area is left in a condition that minimises risk to the environment or people. This includes, but is not limited to, the requirement to complete a Demobilisation Handover Checklist in accordance with the *Operations Management Procedure* (OP-PR-025). Further information on demobilisation is stated in the Environment Plan submitted to the DMP under the PGER Act for this activity.

4.5.1. Suspension (Care and Maintenance)

Following the completion of the Activities, the well sites will be suspended and placed in a care and maintenance phase pending the potential implementation of a second stage of testing of the Laurel Formation exploration program. Specifically, the well sites will be fenced and locked to prevent personnel and macro-fauna access. Also any rain water collected during the wet season will be stored in the Water Reservoir ensuring there is sufficient freeboard of 800 mm to cope with the wet season (1:10 year ARI).

4.6. Rehabilitation

Depending on the results of the Activities, the respective exploration wells may be "plugged and abandoned". Should the well be plugged and abandoned, these works will be undertaken in accordance with clause 637 of the Schedule and the PGER Act. All facilities will be demobilised from site in accordance with the *Demobilisation Procedure* (HSE-PR-021). Cement plugs will then be set in the open hole and at surface before covering the site with soil. The collar will be removed from the wellhead cellar and the cellar backfilled to a grade consistent with the adjacent area. An abandonment plaque will be posted in accordance with the Schedule.

If a decision is made to discontinue subsequent testing at the well area, the DMP will be notified in writing and rehabilitation will commence within three months, depending on weather conditions and contractor/equipment availability. Rehabilitation will be in accordance with the commitments outlined in the exploration well drilling Environment Plans and the Company's *Rehabilitation Procedure* (OP-PR-022). This includes the ripping of compacted areas, the site re-contoured to match the surrounding environment and the re-spreading of topsoil and vegetation over the site. Post-rehabilitation monitoring and inspections will be carried out to determine if there is any need for active rehabilitation. Active rehabilitation includes spreading native local seeds, planting seedlings and additional erosion control measures.

Flora and vegetation monitoring during the Activity and rehabilitation of the Activity area will be conducted in accordance with the *Flora and Vegetation Monitoring Procedure* (HSE-PR-006).

5. COMMUNITY ENGAGEMENT

5.1. Buru's Commitment

5.1.1. Key Stakeholder Groups

The Company commenced a stakeholder consultation register database for the Tight Gas Development Project in November 2011. The Company maintains and updates the stakeholder database on a regular basis. Key stakeholders relevant to the proposed TGS14 activities are included below.

5.1.2. Government Departments

- Commonwealth Department of Environment (formerly Sustainability, Environment, Water, Population and Communities DSEWPaC)
- WA Department of Mines and Petroleum (DMP)
- WA Environmental Protection Authority (EPA)
- WA Department of State Development (DSD)
- WA Department of Water (DOW)
- Department of Environment Regulation (DER) – Formerly Department of Environment and Conservation (DEC)
- Department of Parks and Wildlife (DPAW) – Formerly Department of Environment and Conservation (DEC)
- WA Department of Agriculture and Food (DAF)

5.1.3. Traditional Owner Groups

- Yawuru PBC (Yulleroo Region)
- Valhalla Region (unclaimed area)
- Noonkanbah (Asgard)
- Warrawa Claim Group (Sundown Oilfield Area)

5.1.4. Local Community and Industry Associations

- Pastoralists and Graziers Association (PGA)
- Kimberley Rangelands Biosecurity Association (KBRA)
- Kimberley Development Commission (KDC)
- Broome Shire Council
- Derby Shire Council

5.2. Ongoing Consultation and Engagement

Buru Energy has embarked on an extensive community engagement program, with the overarching aim of developing long term and sustainable relationships with all stakeholders, particularly the Kimberley community, current and future.

The community engagement program involves proactively engaging with the regional Kimberley community and the overall State through a two-way communication process that ensures Buru Energy openly shares information about its activities and is proactive and genuinely responsive to community interest and feedback.

This engagement is being undertaken through direct community engagement as well as engagement with the community through media.

5.2.1. Dedicated engagement with Traditional Owners and the indigenous community

Buru Energy is very active with its direct engagement with indigenous communities in the Canning Basin and has good working relations with Traditional Owners.

By partnering with Traditional Owners throughout its operations, Buru Energy is forming strong relationships and mutual respect of traditions, culture and heritage.

Buru Energy is creating jobs and helping to build skills among communities. Buru Energy is also motivated to building capacity of local indigenous businesses as a way of investing in the future sustainability and viability of local communities.

Since earlier this year, Buru Energy has stepped up its direct engagement with Traditional Owners and their community groups to establish new employment and training programs and initiatives.

Increased levels of engagement have also been focused on ensuring an open and transparent two-way dialogue about Buru Energy's current and intended activities in the Canning Basin.

In addition to holding various meetings with Traditional Owners, Buru Energy has also engaged with local indigenous communities, many of which are regarded as remote communities.

Specific initiatives undertaken by Buru Energy in recent months include:

- Establishing a dedicated Traditional Owner liaison team to ensure continuous and ongoing engagement
- Development of cultural awareness training for all Buru staff and contracts, covering multiple Traditional Owner language groups
- Commencement of recruitment for environment monitoring personnel, offering Environmental Science Cadetships, in partnership with Broome TAFE
- Facilitating independent specialist advisor support on the gas project to Traditional Owner groups
- Establishing a strategic formal joint Traditional Owner engagement "gas development plan" process for Yawuru and other West Kimberley language groups
- Initiating joint venture companies with traditional owners to build capacity and to support services for exploration and development activity in the Kimberley

Buru Energy has also established a program for extensive engagement with 36 remote communities. This level of engagement will provide the opportunity for an open and transparent two-way dialogue about Buru Energy's current and intended activities, the opportunities these activities create for remote communities, and how to assist communities to identify real opportunities.

Specialist Review Process

To ensure traditional owner groups are well informed regarding the environmental impacts associated with the proposed activities, the Company is supporting a specialist review panel. This specialist review panel, chosen independently by the relevant TO groups, has been offered to each of the Traditional Owner groups. This panel will be independent of the regulatory review process and will involve review by independent international experts with expertise relating to environmental impacts associated with shale gas developments. The specialist review panel process will run concurrently with the regulatory approvals process from October 2013.

Key concerns raised by Traditional Owner groups will be incorporated into the risk assessment process for the proposed activities.

The specialist review panel will include a series of risk review workshops and information sessions undertaken in collaboration with the Yawuru people. This "Yulleroo Gas roadmap to approval" for activities in the Yulleroo region will ensure the concerns of the Yawuru and their constituents are addressed during the planning and assessment process. A similar process will be conducted with the Noonkanbah Community.

5.2.2. Engagement with pastoralists

Buru Energy is engaging with pastoralists through the Pastoralists and Graziers Association (PGA), attending various PGA zone meetings to ensure an open and ongoing dialogue. Buru Energy is also engaging with pastoralists on a one-on-one basis, visiting individual stations to discuss intended activities and respond to matters relating to the proposed process.

5.2.3. School community engagement

Buru Energy is engaging with 24 schools in Broome, Derby and remote areas throughout the Kimberley to make presentations to staff, students and the general community (for communities based in remote areas). These presentations, taking place between November and early next year, are being targeted to suit primary, high school students and/or the overall community.

Kimberley schools are a pivotal part of the regional community, providing various programs and initiatives to engage and motivate student attendance. Buru Energy recognises how important these initiatives are for students' education and future endeavours, as well as the strength of individual communities.

Buru Energy is engaging with the group of 24 schools to support their initiatives which provide further educational opportunities and help grow school community well-being. This support is being offered through:

- Donating prizes for students to encourage school participation
- Providing financial support for various school initiatives
- Offering scholarships for high school students for either the most improved attendance or showing an interest in their future studies and/or cultural incentives (the scholarships are being offered to one or two students at each high school, to assist with students' transition from primary to high school)
- Ongoing engagement with schools to explore additional opportunities to further the strength of school communities

5.2.4. General community engagement

In the past year, Buru Energy has been engaging with the broader Kimberley community about its program of activities through portions of the community, including the Shire of Broome, regional Government agency representatives and sections of the business community such as the local Chambers of Commerce in Broome, Wyndham and Derby.

Since early November this year, Buru Energy has launched a more intense engagement with the broader Kimberley community. This is being carried out through various initiatives and activities:

- Commencement of a community awareness campaign, promoted through the Kimberley media, to highlight Buru Energy's intended activities and encourage the community to have an open discussion with Buru Energy about these activities and what they mean for the local community
- Cross promotion of the community awareness campaign, through advertising, general media coverage and Buru Energy's website
- A dedicated 1800 information phone line and Community@buruenergy.com email to encourage a two-way dialogue between Buru Energy and the community
- A Community Register to log and respond to inquiries made through the dedicated phone line and email
- Provision of information kits and details on the schedule of presentations and information sessions, through a registration process via the internet, and dedicated phone line and email

- Providing presentations to community and business organisations, being held between November and early 2014
- Opportunity for community and business groups to request a specific presentation
- Providing community information sessions in the main regional centres including Broome and Derby, being held between November and early next year
- Providing attendees at presentations and information sessions a formal process for submitting feedback and making further inquiries

Community feedback through the community awareness campaign, information sessions and presentations will be thoroughly reviewed by Buru Energy to ensure matters of interest are properly targeted and taken into consideration as part of the process of moving forward with any activities.

Buru Energy engages with the Kimberley community through supporting various community events throughout the region including the Kimberley Art Prize, Derby Boab Festival and Broome's Shinju Matsuri Festival of the Pearl. Buru Energy also supports community organisations and sporting groups in various ways such as funding sporting teams to attend regional and State Carnivals. These are just some examples of the many organisations and activities Buru Energy has supported in recent years.

In regards to engagement with the broader Western Australian community, Buru Energy has been actively engaged with WA Government representatives, as well as industry and community peak organisations based in Perth such as PGA, Conservation Council of WA, Australian Petroleum Production & Exploration Association (APPEA) and Chamber of Minerals and Energy (CME). Buru Energy also sponsors and attends a wide range of technical workshops, seminars and conferences in WA and inter-state and presents papers on various disciplines including geology, environment, economics and Traditional Owner engagement.

Buru Energy will continue engaging with Perth based organisations to ensure ongoing engagement.

Throughout its current and future activities in the Kimberley, Buru Energy will maintain an active engagement program with the Kimberley community and the broader Western Australian community through an open and transparent dialogue.

5.2.5. Government Departments

Department of Mines and Petroleum

DMP is the lead agency for the regulation of mining, petroleum, geothermal and carbon capture and storage in Western Australia. Buru has prepared and submitted an Environment Plan for TGS14 to the DMP for assessment which sets out the means by which the environmental aspect of the Company's proposed testing operations (Activities) will be managed.

Office of the EPA

It is the Company's intention to refer the proposed TGS14 activities to the OEPA via this Referral document to confirm that it does not need to be assessed under the *Environmental Protection Act 1986* as the Activities are small scale "proof of concept" exploration.

Other State Government Departments

It is the Company's intention to undertake a risk assessment review workshop involving personnel from all relevant government departments. This would be facilitated by the Department of State Development. The intention of this workshop would be to review the Environmental Values (Factors) proposed for the activity area, review the potential impacting processes and ensure the management, mitigation and monitoring proposed for the activities are appropriate. Outcomes from this risk workshop will be incorporated into a revised Environment Plan for the proposed activities.

The Company will undertake this risk workshop during December 2013.

Commonwealth Department of Environment

A further briefing with DoE staff is planned in early 2014. This briefing will update the Department on the planned TGS14 program, environmental values for the area, potential impacting processes, management and mitigation measures and the monitoring program for the proposed activities.

5.3. Communication

During the conduct of the Activities, a weekly operations report is provided to relevant stakeholders in electronic format. This will include a progress report, summary of operations undertaken during the previous week and a summary of any operations proposed during the following week. All stakeholders will be advised of unforeseen changes, such as delays to the intended commencement or completion of the Activities.

Communications will be available onsite at all times by way of satellite phones, two-way radios and internet connections. All personnel in Perth hold mobile phones to facilitate after hours communication if required.

A summary of the Environment Plan submitted under the PGER Act will be available on the DMP and Company website including full chemical disclosure details.

Any third parties with concerns, queries or feedback in relation to the Activities, including stakeholders and members of the community, can contact the Company's head office in Perth between 08.30 and 18.00 Monday to Friday by phone, fax or email as set out below:

Telephone: 08 9215 1800

Facsimile: 08 9215 1899

Email: info@buruenergy.com

6. SOURCE-PATHWAY-RECEPTOR ASSESSMENT

In accordance with Section 38(1) of the *Environmental Protection Act 1986* (EP Act) and EPA's General Guide on Referral of Proposals, Buru Energy has prepared this supporting documentation on environmental impact assessment (EIA) and proposed management for the referral.

In EIA frameworks conceptual models can usefully present the hypothesised relationships between the source (S) of a hazard/risk, the pathways (P) by which exposure might occur, and the receptors (R) – those features of the environment that we value and that could be harmed (S-P-R). Existing or potential linkages between these components of a risk can be set out in tabular form. The intention is to represent the scope of the problem, clarify the environmental components at risk and set the boundaries of the risk assessment. This Section provides a risk scoping analysis using the Source-Pathway- Receptor framework. This structured approach to scoping EIA informs the assessment of Potential Environmental Impacts on Environmental Factors (Receptors) and the associated proposed management and mitigation measures which are summarised in Section 7.

The activities were evaluated based on the Source-Pathway-Receptor principle of risk assessment. This approach to environmental risk assessment states that for an impact to occur, there must be a source of contamination, a receptor that may be impacted and a pathway connecting them. If either of the source, pathway or receptor is absent, there is no likelihood of environmental impact.

The key sources of potential environmental risk in this proposed TGS14 Activity that are different to "traditional" petroleum activities historically and routinely assessed by the DMP have been identified by the Company as Hydraulic Fracturing Fluid, Hydraulic Fracturing Flowback and Air Emissions. It is these three aspects that have been evaluated in the S-P-R framework set out in Table **13**.

Table 13: Source-Pathway-Receptor assessment for TGS14

Hydraulic Fracturing Fluid		
Source = Low Risk	**Pathway = Implausible**	**Receptor**

Chemical Risk Assessment
• An ecotoxicity assessment of HF fluid to be used for the Activities has been undertaken at an accredited Ecotox laboratory using local rainbow fish species **(**Melanotaeniidae). The results show the HF Fluid is classified as non-toxic under national guidelines
• Independent chemical risk assessment indicates the constituent chemicals in the HF fluid have low persistence in the environment and readily biodegrade.
• There are no chemicals in the HF fluid that will plausibly cause exceedances of Class I (Inert) Landfill Classification
• Laboratory assessment of the biocide (BE-6) indicates it is readily biodegradable. The biocide is hydrolysed by HCl and sulphuric acid. The degradation product has a 96-hour LC_{50} of approximately 700 ppm which indicates that it is essentially nontoxic. At comingled concentrations of 0.2 ppm of biocide, the risk of environmental impact is considered minimal. The active ingredient is used widely in household and industrial cleaners, detergents, dish detergents, disinfectants, hand sanitizers and personal care products
• There are no chemicals in the HF fluid that will plausibly cause exceedances of Class 1 (Inert) Landfill Classification
 	
Induced seismicity
• Hayes (2012). No evidence to suggest that hydraulic fracturing itself is the cause of the increased rate of earthquakes
• Vermylen and Zoback (2012). The pressurisation during
	Operations Management
	• The largest feasible spill that may occur will be readily contained and absorbed on the gravel hardstand area within the perimeter fence of the well site
	• Spills can be readily scraped up, placed on a HDPE lined for storage and disposed of at an approved waste disposal facility under Company spill response plan There is no double handling during HF operations. All concentrated chemicals directly transferred from Industrial Bulk Containers (IBC) containers to blender via metred closed loop flowlines.
	• Given the large distance to the closest surface water body to the well sites and those operations will be conducted during the dry season it is implausible that minor spills will impact on surface water.
	
	Infiltration
	• Infiltration rates to groundwater enables cleanup of surface spills prior to impacting shallow aquifers:
	  ○ Infiltration rate at least 10 to 20 days to travel to shallow aquifer at Yulleroo.
	  ○ Infiltration rate of fluid is between 70 and 300 days to travel to shallow aquifer at Valhalla region.
	  ○ Feasible volume of spills is too low to reach groundwater system.
	• Independent groundwater study has determined that the groundwater transmission within the aquifer zones occurs over many hundreds of years to nearest sensitive receptors/biological interfaces.
	• Given the large distance to the closest surface water body to the well sites and that operations will be
		• Nearest permanent surface water body to Yulleroo is Taylors Lagoon located ~ 4 km northeast of Yulleroo 4.
		• Nearest surface water bodies to Valhalla & Asgard are Mt Wynne and Mt Hardman creeks. Mt Wynne Creek is located ~4 km northwest of Valhalla North and Mt Hardman Creek is located ~2 km southeast of Valhalla North 1.
		• Nearest aquifer in Yulleroo region is Broome Sandstone Aquifer (50m deep); nearest bore is a pastoral bore located 5km away: There are no drinking water bores that could plausibly be affected.
		• Nearest aquifer in Valhalla-Asgard area is Liveringa Aquifer (80m deep); nearest bore is a pastoral bore 5km away: There are no drinking water bores that could plausibly be affected.

HF affects only limited volumes of rock (typically several hundred meters in extent) and pressurisation typically lasts only a few hours. The source volume defined by the migration distance of the fluid in the HF process is too small to generate a large damaging event • Magnitudes of induced earthquakes during HF treatment in hydrocarbon fields such as the Barnett Shale are typically less than 1 M_L which means that these events are not detected by humans (Green et al. 2012). • There are 300,000 fracs per year in the US and no reports of significant microseismic events: ○ US NAS, 2012 ○ ACOLA, 2013	conducted during the dry season, it is implausible that spills will impact on surface water. • Spills can be readily scraped up, placed on a HDPE lined for storage and disposed of at an approved waste disposal facility under Company spill response plan • Baseline seismic monitoring in well site areas conducted • "Traffic light" system to monitor seismicity during HF treatment	
Hydraulic Fracturing Flowback		
Source = Low Risk	**Pathway = Unlikely**	**Receptor**
International Studies • Characterisation of HF flowback in numerous international studies indicate the constituents are not highly toxic or persistent: ○ API, 2009. ○ Bryant, J.E., Haggstrom, J. 2012. An environmental solution to help reduce freshwater demands and minimize chemical use. SPE 153867. ○ Gupta, D.V., B.T. Hildek. 2010. Frac-fluid recycling and water conservation: A case history. SPE119478. ○ Horner, P., Halldorson, B., Slutz, J. 2011. Shale gas water treatment value chain – A review of technologies including case studies. SPE 147264. ○ Paktinat, J., O'Neil, B., Aften, C. Hurd, M. 2011. High brine tolerant polymer improves the performance of slickwater frac in shale reservoirs. SPE 144210. ○ Platt, F.M., Burnett, D.B., Eboagwu, U.M., Vavra,	*International Studies* • There have been 300,000 fracs per year in the US and no reports of single instance of shallow potable groundwater contamination (US EPA, 2012). ○ Royal Society, 2012 classified the risk to the environment posed by HF flowback fluid as "Low Risk" ○ ACOLA, 2013 classified the risk to the environment posed by HF flowback fluid as "Low Risk" ○ Kell, 2011. A recent regulatory review of state oil and gas agency groundwater investigations in Texas found not a single groundwater contamination incident resulting from site preparation, drilling, well construction, completion, hydraulic fracturing stimulation, or production operations at over 16,000 horizontal shale gas wells that were drilled during the 16 year study period ○ King, 2013. Despite there being over 2 million petroleum wells (some over 100 years old) drilled in the USA, contamination from Petroleum Activities does not register in the top 20 pollution sources for groundwater	• Nearest permanent surface water body to Yulleroo is Taylors Lagoon located ~ 4 km northeast of Yulleroo 4. • Nearest surface water bodies to Valhalla & Asgard are Mt Wynne and Mt Hardman creeks. Mt Wynne Creek is located ~4 km northwest of Valhalla North and Mt Hardman Creek is located ~2 km southeast of Valhalla North 1. • Nearest aquifer in Yulleroo region is Broome Sandstone Aquifer (50m deep); nearest bore is a pastoral bore located 5km away: There are no drinking water bores that could plausibly be affected. • Nearest aquifer in Valhalla-Asgard area is Liveringa Aquifer (80m deep); nearest bore is a pastoral bore 5km away: There are no drinking water bores that could plausibly be affected.

T.J. 2011. Pre-treatment options for frac flow back brines: Laboratory and pilot plant testing of oil removal materials. SPE147417. ○ Shen, D. Scholnik, D. Perkins, R., Taylor, G. and Brown, M. 2012. Evaluation of Scale Inhibitors in Marcellus High-Iron Waters. SPE 141145. *Constituents of Potential Concern (COPC)* • Analysis of Yulleroo 2 flowback water indicates constituents of potential concern (COPC) in flowback water are likely to be low. • Analysis of Yulleroo 2 flowback water and the Laurel formation suggest flowback will have a very high salt (NaCl) content above 100,000 TDS. • Analysis of produced water from nearby Ungani wells indicates constituents of potential concern (COPC) in flowback water are likely to be low. • Analysis of drill cuttings from wells has been confirmed by DER to meet Class 1 (Inert) Landfill Classification *Naturally Occurring Radioactive Material (NORM) in Formation* • Analysis of cuttings from drilling Company wells indicates radiation levels are below guideline values. • Analysis of Yulleroo 2 flowback water indicates NORM in flowback water is 10% of guideline thresholds for drinking water. • Analysis of produced water from Ungani wells indicates NORM in flowback water is 10% of guideline thresholds for drinking water. • NORM from surface geology sources have been found above guideline values at some station bores in the region during baseline studies.	in that country. Producing wells represent a limited pollution source after the initial production because the well is below Normal Pressures. Therefore, there is not a pressure gradient capable of pushing the hydrocarbon into other zones. • Pressure relief valves provide a safety for overpressure during HF operations. The occurrence of HF pressure relief valve activation is less than 0.0022% from vendor supplied statistics based on 86,000 HF/year. *Well Operations & Integrity Review - Environmental Risk Assessment* • All water retention reservoirs will be triple-lined with two layers of 400 micron HDPE liners interleaved with Geotextile fabric (A34). • Multiple sets of casing and cement forming barriers are in place between stimulation fluid and aquifers. The integrity of these barriers is demonstrated by cement bond logs (CBL) providing confirmation that zonal isolation is achieved by cement cover over shoe between surface and intermediate casing. • Review of each well including construction report, CBL and pressure testing is undertaken prior to HF activities. • Independent review of well construction will be undertaken prior to HF activities. *Well Operations Manual* • Each of the wells have been drilled and constructed in accordance with the Company's approved *Drilling and Formation Evaluation Program* or "Drilling Program" with detailed engineering design and structural integrity assessments, monitoring and reporting procedures. • Following operations, the well will be suspended with two downhole barriers in accordance with the *Schedule of Onshore Petroleum Exploration and Production Requirements* 1991.	

	HF Design and Operational Review
	• HF designed to conform with well design specifications (e.g. casing design limits).
	• Independent review of each well HF design and sensitivity analysis undertaken around predicted heights for the HF in each zone.
	• Independent review of relevant operational elements of HF Activity prior to Activity.
	
	Geological and Hydrological Environment Risk Assessment
	• Likelihood of this pathway is implausible.
	• Review of geological features in the Activity area from seismic survey maps have identified the following natural features that will prevent surface aquifer contamination:
	  ○ More than 1,800 m of rock separating the stimulation zone and base of nearest surface aquifer which is three times “respect zone” recommended by the UK Parliamentary enquiry into HF activities.
	  ○ Natural stress barriers will highly constrain (<300 m) the vertical propagation of hydraulic fractures based on geomechanic principles of the geological profile.
	  ○ Isolation of surface aquifers from deeper zone by impermeable rock layers (aquicludes).
	• Independent groundwater study has determined that the groundwater transmission within the aquifer zones occurs over many hundreds of years to nearest sensitive receptors/biological interfaces.
	• Hydrogeological characterisation of groundwater systems at Activity areas demonstrates separation distance between top of HF zone and nearest potable groundwater system exceeds international recommendations.
	• Baseline seismic monitoring in well site areas conducted
	• Peer review of Company’s hydrological environmental	

	risk assessment by Professor Neil Coles.
	
	HF Design and Operational Review
	Subsurface modelling and design engineering of HF treatment is undertaken to manage fracture height/length growth within the planned stimulated rock volume (SRV).
	
	Separation and Storage of Condensate
	• Condensate will be stored in accordance with *Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2004* (WA), including segregation if applicable, into self bunded (double skinned) tanks.
	• Given the large distance from the well sites to the closest surface water bodies and that operations will be conducted during the dry season, it is implausible that spills will impact on surface water.
	• The largest feasible spill that may occur will be readily contained and absorbed on the gravel hardstand area within the perimeter fence of the well site
	• Spills can be readily scraped up, placed on a HDPE lined for storage and disposed of at an approved waste disposal facility under Company spill response plan.
	
	Infiltration
	• Infiltration rates to groundwater provides sufficient time for cleanup of surface spills prior to impacting shallow aquifers:
	  ○ Infiltration rate is expected to take at least 10 to 20 days to travel to shallow aquifer at Yulleroo.
	  ○ Infiltration rate of fluid is expected to take between 70 and 300 days to travel to shallow aquifer at Valhalla region.
	  ○ Feasible volume of spills is too low to reach groundwater system.
	• Independent groundwater study has determined that the groundwater transmission within the aquifer zones occurs over many hundreds of years to nearest sensitive receptors/biological interfaces.	

Air Emissions

Source = Low Risk	Pathway = Low Risk	Receptor
International Studies • Zelinska et al. 2010; Lyon et al., 2011. Neither of these studies reported exposure levels that pose a risk to human health under properly managed operations and that there was no apparent serious ambient air quality issues. • McKenzie et al. 2012. Identified that the well completion stage was highest risk to air emissions. However, emissions were restricted to immediate vicinity of well environment over a 20 month exposure period and so risk associated with air emissions was low. • Kibble et al 2013. Undertook a major review of shale gas in the UK and concluded that human health risks are low if the operations are properly run and regulated. • Allen et al. 2013. Collected direct measurements of methane emissions at 190 onshore natural gas sites in the United States and determined that fugitive emissions were equivalent to 0.42% of gross gas production. • Mackay & Stone 2013. Determined that any local GHG emissions associated with shale gas operations would fall within the nontraded sector of the UK's carbon budgets. When shale gas is used for electricity generation, its carbon footprint is likely to be less than half that of coal. • Esswein et al., 2013. Identified occupational health hazard for workplace exposures to crystalline silica (from handling of sand proppant) and that appropriate protection measures for workers at risk similar to those employed in building, agriculture, foundry and sandblasting industries at risk of exposure to respirable crystalline silica should be considered.	*Operational Management* • "Green completion" (where methane and other VOC emissions are minimised) will be adopted as standard operating practice during HF Operations. • There is no double handling during HF operations. All concentrated chemicals directly transferred (*on the fly*) from Industrial Bulk Containers (IBC) containers to blender via metred closed loop flowlines. • Couplings and flow lines on the flowback reticulation system will be pressure tested for leaks prior to the commencement of operations. • The Gas reticulation system on the flowback system will be pressure tested prior to the commencement of operations and will be monitored for gas leaks. • Regular monitoring of water retention reservoir for build-up of hydrocarbons will be undertaken. • Radiation monitoring of flowback water will be undertaken on a regular basis to monitor for naturally occurring radioactive materials (NORMs). • All chemicals and other substances to be used down hole during the Activities will be fully disclosed in accordance with regulation 15(9) of the *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) and *Chemical Disclosure Guideline*. • Contractor equipment is purpose designed for the HF Activities. Contractor will be required to provide evidence that all equipment is well calibrated and in good working order prior to mobilisation to site. • Regular maintenance to ensure integrity of equipment including pressure testing, maintenance assessment and fail-safe automation systems. • The Contractor will be required to provide full HSE documentation for site specific operations that will bridge to the Environment Plan for HF Operations submitted to the DMP under the PGER Act.	• Open bushland/savannah • Nearest sensitive receptor more than 20 km away • Air quality monitoring will be conducted during Activity at selected well site using Optical Remote Sensing for Measurement and Monitoring of Emission Flux.

	• All site personnel to have appropriate PPE equipment including respiratory protection where appropriate	

7. POTENTIAL ENVIRONMENTAL IMPACTS AND MANAGEMENT

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
Land				

Vegetation and Flora	To maintain representation, diversity, viability and ecological function at the species, population and community level.	• Invasive weed species competing with native flora
		• Loss of a local population of a conservation significant flora species due to fire, spills or spread of weeds
			Operational Management – General
			• In accordance with the Company *Operations Management Procedure* (HSE-PR-025)*, a* weekly operational checklist will be completed.
			• Vehicles and personnel are restricted to Operational areas (well site, camp site and access track) during Operations.
			• Environment induction and training provided to operational personnel.
			
			Operational Management - Weeds
			• In accordance with the Company *Quarantine Procedure* (HSE-PR-024), the following management measures will be implemented:
			  ○ Vehicles and machinery will be inspected, and cleaned if required, prior to mobilisation to the Activity and between the Yulleroo and Valhalla & Asgard regions in accordance with the *Biosecurity Checklist* (HSE-FM-007).
			  ○ Personnel will check clothing and shoes for weeds or weed material when entering from a high risk source area prior to going onsite in accordance with the *Quarantine Logbook* (HSE-FM-011).
			• The proppant used for HF Operations must be completely clean and screened for use in HF. Consequently it will be sterile of contamination with weed materials:
			  ○ Bulk proppant will be stored offsite within a covered area, such as a large warehouse.
			• Proppant will be transported to the Activity areas as required and will be blended into the HF treatment
				• No clearing will be required for the proposed activities.
				• Potential impacts from this proposal will be able to be managed to prevent significant impacts to vegetation and flora.
				
				The impact on vegetation and flora as a result of the activities is considered **Not Significant.**

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance

			system from the sand handling unit.
			
			Operational Management - Fire
			• In accordance with the Company *Fire Prevention and Management Procedure* (*HSE-PR-015*), the following fire prevention measures will be implemented:
			  ○ Maintenance of a firebreak on the outside of the well site and camp site fence line.
			  ○ Fire fighting equipment will be located at the well site and camp site and personnel will be trained in its use.
			• Flaring of gas will be keep to a minimum in accordance with APPEA Code of Practice for Hydraulic Fracturing (2011) Guideline 6.
			• A permit to flare will be obtained from DFES (if required).
			• Flaring will be undertaken in a closed loop flare system with design of flare (sizing) and location appropriate for expected volumes of gas.
			• Flaring can be controlled readily by shutting in the well if anomalous conditions occur during flaring.
			• Only diesel vehicles will be used during operations.
			• Restriction of vehicle and personnel access to operational areas will eliminate the chance of fire ignition sources.
			• Designated smoking areas will be in place.
			
			Spills
			• Refer to Terrestrial Environmental Quality Environmental Factor below for Operational Management and Mitigation.	

Terrestrial Fauna	To maintain representation, diversity,	• Death or injury of native fauna, including conservation significant	*Operational Management - General* • In accordance with the Company *Travel Management to or within Buru Operations*	• No clearing of fauna habitat will be required for the proposed activities • Potential impacts from the proposed activities will

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
	viability and ecological function at the species, population and community level.	fauna • Attraction of feral fauna impacting native fauna • Loss of fauna habitat due to spread of weeds, fire or spills	*Procedure* (HSE-PR-002): ○ Vehicles driving on station roads will be limited to 80 km/h ○ Vehicles driving on access tracks to well sites will be limited to 60km/h ○ No driving at night will be permitted except in an emergency. • Vehicles and personnel are restricted to Operational areas (well site, camp site and access track) to prevent disturbance outside of Activity area. • Boundary of the well sites and Sundown evaporation pond area fenced and gated, restricting fauna access. • Water retention reservoirs will be fenced with ringlock fence with birdwire at the base and egress paths, such as geo-fabric matting, installed to allow small fauna to climb out. • In accordance with the Company *Operations Management Procedure* (OP-PR-025), a weekly operational checklist will be completed including: ○ No disturbance outside of the Activity areas. ○ Inspection of fencing and egress paths on water retention reservoirs. • Broome Veterinary Hospital (9192 1319 - 24 hour emergency service) or DEC Wildcare Helpline (9474 9055 - 24 hour telephone service) will be contacted for advice if any fauna become injured. • Environment induction and training provided to operational personnel will include conservation significant species occurring in the region. *Operational Management - Light & Noise* • Mobilisation of HF treatment equipment to and from each Activity area will be undertaken once only over a short period (2-3 days).	be able to be managed to prevent significant impacts to fauna. The impact on terrestrial fauna as a result of the Activities is considered **Not significant**

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			• HF Treatment operations will be confined to daytime operations and will be short duration (~ one week). Loud (90 dB close to source) operations (ie. pumping) will be approximately one day. • Flowback operations (ie. separator and gas flare) will have low noise levels which will be barely audible beyond well site. • Well maintained and muffled trucks, equipment and machinery. • Security and safety lighting will be situated at the centre of the well site and light levels at the perimeter of the well site are expected to be very low (ambient levels). • No lighting is required around the perimeter of the well site. • Lighting intensity from flare will attenuate over a short distance at ground level and may only be visible over 1 km distance as horizon sky glow. • Only low light sources are used at the camp site (ie. no floodlights). Camp site will be arranged with internally lit walkways so that no artificial light sources illuminate the vegetation near the camp site. *Spills* Refer to Terrestrial Environmental Quality Environmental Factor below for Operational Management and Mitigation. *Operational Management - Waste* • Treated sewage and grey water will be discharged into a leach drain that is filled with ballast rock and covered with soil. • Putrescible waste will be stored in lidded bins/skips which are kept closed.	

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			Operational Management - Demobilisation • Demobilisation to be undertaken during the day. • The fence surrounding the well site, including the water retention reservoirs, will be left in place and the gate kept closed at the completion of activities to prevent feral fauna accessing the water source. • All waste will be removed from the Activity areas at the completion of activities.	
Landforms	To maintain the variety, integrity, ecological functions and environmental values of landforms	• Potential soil erosion and sedimentation.	• Well site landforms stabilised and no signs of erosion were detectable during last wet season indicating landforms are stable.	• All activities will occur on well sites previously established for exploration drilling and so there will be no impacts on landforms as a result of the proposed HF activities. • There have been no reported instances of soil erosion at any of the well sites. The impact on landforms as a result of the activities is considered **Not significant.**
Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environmental values, both ecological and social, are protected.	• Potential contamination of soil with: ○ dangerous goods or hazardous substances, ○ HF fluid ○ flowback water ○ liquid hydrocarbons ○ naturally occurring radioactive material ○ sewage. ○ liquids in industrial wastes.	*Operational Management - General* • All vehicle travel will be in accordance with the Company *Travel Management to or within Buru Operations Procedure* (HSE-PR-002). • Vehicles and personnel are restricted to Operational areas (well site, camp site and access track). • Dangerous goods will be stored in accordance with *Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2004* (WA), including segregation if applicable. Bulk diesel fuel storage will be within bunded or double skinned tanks. • Hazardous substances will be stored, including segregation if applicable, in accordance with relevant MSDSs. All hazardous substances will be stored within impermeable bunds such as bunded pallets, inside PVC lined bunded areas etc. • Handling of hazardous substances will be	• Section 6 assessment of source and pathway indicates low scope for risk • Potential impacts to land and soils can be managed through operational management, monitoring and spill response procedures Therefore, the impact on terrestrial environment quality as a result of the activities is considered **Not significant**

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance

			undertaken by suitably trained personnel in accordance with operating procedures or JHA.
			• Refuelling and fuel transfer will be undertaken in accordance with the Company *Refuelling Procedure* (HSE-PR-011) including:
			  ○ Vehicles and mobile equipment refuelling will be undertaken in designated refuelling area at the well sites comprising an impermeable lined and bunded area.
			  ○ Refuelling of stationary machinery and equipment will be undertaken using a mobile tanker and a drip tray placed under refuelling points.
			  ○ Refuelling operations to be manned at all times and spill kits will be available near refuelling points for immediate containment and clean-up of spills.
			• All concentrated chemicals will be directly transferred from Industrial Bulk Containers (IBC) containers to the blender via metred closed loop flowlines during HF operation – there will be no double handling on site.
			• A maximum of 15,800 L of dilute HF fluid will be stored at the well site prior to pumping.
			• Waste will be managed and monitored in accordance with the Company *Waste Monitoring and Management Procedure* (HSE-PR-005). Records will be kept of waste type and volume.
			• In accordance with the *Operations Management Procedure* (OP-PR-025) a weekly operational checklist will be completed and will include:
			  ○ Ensuring appropriate storage of dangerous goods and hazardous substances.
			  ○ Ensuring the integrity of bunded areas.	

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			Chemical Risk Assessment • All chemicals and other substances to be used down hole during the Activities will be fully disclosed in accordance with regulation 15(9) of the *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) and *Chemical Disclosure Guideline*. • An ecotoxicity assessment of HF fluid to be used for the Activities has been undertaken at an accredited Ecotox laboratory using local rainbow fish species (Melanotaeniidae). The results of the assessment show the HF Fluid is classified as non-toxic under national guidelines. • An independent chemical risk assessment indicates the constituent chemicals in the HF fluid have low persistence and readily biodegrade. • There are no chemicals in the HF fluid that will plausibly cause exceedances of Inert classification for landfill guidelines. *Contractor Design of Service Document and Implementation for HF Activity* • Well specific operational details will be provided by a suitably qualified Contractor with HF treatment experience including: o Ensuring all flowback equipment is certified and best available techniques for flowback followed. o All fluid will be contained in the designated retention reservoirs and tanks. o All equipment pressure tested after rig-up and prior to conducting the Activities. o Clean water will be circulated through reticulation system to clean system prior to demobilisation of equipment. o Pressure kickouts to prevent exceedances in	

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			design pressures in HF reticulation system. ○ Double isolation barriers provided on all fracture stimulation equipment. ○ Immediate shutdown monitoring system installed for both high and low pressure systems. ○ Implementation of an exclusion zone around high pressure pumping area during operations. • Contractor will be required to provide site specific HSE documentation that will bridge to the Environment Plan, and associated procedures, for the Activity submitted to the DMP. • Contractor equipment will be purpose designed. Contractor will be required to provide evidence that it is well calibrated and in good working order prior to mobilisation. • Regular maintenance will be undertaken by the Contractor to ensure integrity of equipment. This will include pressure testing, maintenance assessment and fail-safe automation systems. *Flowback Monitoring and Management* • All recovered fracturing fluids will be isolated in lined water retention reservoir designed to prevent leakage, as required by *APPEA Code of Practice for Hydraulic Fracturing (2011) Guideline 5*. • If significant liquid hydrocarbons occur in flowback then a mobile separator will be brought in and the liquids automatically separated and transferred by secure flowline to storage in a secure, lined and bunded storage tank for subsequent transport offsite to refinery. • Construction of water retention reservoirs with adequate storage capacity and two layers of 400 micron HDPE liners interleaved with Geotextile	

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			fabric (A34). • In accordance with the Company *Environmental Monitoring Procedure* (OP-PR-013), baseline, operational and post operational groundwater monitoring (quality, chemistry and water level) will be implemented through water bores and environmental monitoring bores on site. • In accordance with Company *Produced Water Monitoring Procedure* (OP-PR-024) the following will be monitored during flowback: o Characterisation of flowback water to confirm low toxicity o pH levels to ensure that acid concentrations are neutralised to required levels. o Analysis of flowback water with a radiation metre to detect anomalous readings above background bore water values/guideline levels due to NORMs in formation. • If elevated radiation levels are detected, then treatment of flowback water will be undertaken and the solids containing the NORMs taken to approved facility for disposal. *Environmental Monitoring* • Baseline and post-operations soil sampling for COPC will be undertaken at all well sites. • If anomalous conditions arise, such as a leak, then equipment will be taken off line and shut-in. This will include shutting down all pumping or flowback and closing in at the master valve of the well if necessary. *Spill Response* • The Activities will be a manned operation and therefore visual monitoring for anomalous conditions, including spills or leaks, will be	

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			undertaken at all times. • Hardstand area will be gravel surfaced and contain small (<20 L) volumes of fluid that may spill from the dilute HF fluid and flowback. • In the unlikely event of a spill outside of the well site, a monitoring program will be designed and implemented in consultation with the DMP. • Containment, clean-up and remediation of a spill will be undertaken in accordance with Company *Canning Basin Oil Spill Contingency Plan* (HSE-OP-010) (OSCP) and *Canning Basin Emergency Response Plan* (HSE-ER-001) (ERP). • Personnel will be trained in the implementation of the OSCP and ERP. This includes undertaking emergency response drills and/or emergency muster drills regularly. • Reporting, investigating and implementing corrective actions for all spills in accordance with Company *Incident Reporting Procedure* (HSE-PR-009).	
Water				
Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected	• Groundwater drawdown due to abstraction of groundwater for use in the activities • Alteration of surface water flow	*Operational Management - General* • Water use associated with the activities will be minimal (31 ML total). • Water extraction for operational requirements will be minimised by recycling of flowback fluids, where practicable. • All proposed activities will be undertaken during 2014 dry season so it is highly unlikely that there will be surface water or surface water flow in the vicinity of the well sites. *Environmental Monitoring* • In accordance with the Company *Environmental*	• Relatively small volumes of water (<31 ML Total) will be extracted during TGS14 resulting in minimal drawdown of aquifers. • Nearest permanent surface water body to Yulleroo is Taylors Lagoon located ~ 4 km northeast of Yulleroo 4. • Nearest surface water bodies to Valhalla & Asgard are Mt Wynne and Mt Hardman creeks. Mt Wynne Creek is located ~4 km northwest of Valhalla North and Mt Hardman Creek is located ~2 km southeast of Valhalla North 1. • All tracks and well sites have been previously cleared as for exploration drilling activities and are

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			Monitoring Procedure (OP-PR-032), baseline groundwater monitoring has been undertaken at the well sites since August 2012. ○ Baseline groundwater monitoring has included water quality, chemistry and water level. ○ Further baseline, operational and post-operational groundwater monitoring will occur from site water bores and dedicated environmental monitoring bores. • Near field and far afield measures of water depth has occurred to determine a regional baseline of groundwater depth. • Taking of water will be undertaken in accordance with DoW licencing requirements. • All production water bores will be metered and water use reported in the Company's Annual Environmental Report. • Any localised soil erosion or sedimentation on the access track, well site and camp site will be repaired where required	situated away from nearby surface water features. The impact on hydrological processes as a result of the Activities is considered **Not significant**
Inland Water Environmental Quality	To maintain the quality of groundwater and surface water, sediment and biota so that environmental values, both ecological and social, are protected	• Contamination of surface water or ground water with: ○ HF fluid ○ HF chemicals or produced formation water/liquid hydrocarbons. ○ Flowback water ○ Sewage ○ Dangerous goods or hazardous substances	Management measures as for Terrestrial Environmental Quality environmental factor above, and: • Well design and integrity ensures multiple sets of casing and cement forming barriers are in place between the stimulation fluid in the well bore and aquifers. The integrity of these barriers is checked by cement bond logs (CBL) prior to HF activities occurring. • Pre-fracture subsurface modeling and design engineering of HF treatment will occur to manage fracture height/length growth within the planned stimulated rock volume (SRV).	• Section 6 assessment of source and pathway indicates low scope for risk • Upward migration of fractures has been deemed implausible by a number of international studies. • Infiltration rates to shallow groundwater aquifers provides time for cleanup of surface spills prior to impacting shallow groundwater aquifers: ○ Infiltration rate of fluid to groundwater is expected to take at least 10 to 20 days to travel to water table at Yulleroo. ○ Infiltration rate of fluid to take between 70 and 300 days to travel from ground surface to water table at Valhalla region. • Unlikely minor spill will reach a shallow groundwater

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
		• Indirect impact on groundwater users of the aquifer.	*Environmental Monitoring* • Nested environmental monitoring bores installed in alluvium and groundwater up-gradient and down-gradient of well pads to detect leaks in accordance with the Company *Groundwater Characterisation & Assessment Program* (HSE-PGM-001). • Baseline groundwater monitoring has been undertaken at well sites since August 2012 in accordance with the Company *Environmental Monitoring Procedure (OP-PR-032)* and includes water quality and level. • Baseline groundwater quality will continue until the commencement of HF activities. Groundwater quality will then be monitored during (operational monitoring) and after (post operational monitoring) HF Activities from water bores on site and dedicated environmental monitoring bores. • Real time monitoring of anomalous pressure changes will occur during HF activity. The Company *Micro Seismic Monitoring Procedure* (OP-PR-044) outlines thresholds for the rapid shutdown of pumping and ceasing operations should anomalous pressure results be detected.	aquifer. The impact on Inland Environmental Water Quality as a result of the Activities is considered **Not Significant**
Air				
Air Quality		• Emissions to the atmosphere/localised reduction in air quality • Reduced air quality due to emissions of hydrocarbon gas/ sour gas/methane & other VOCs to atmosphere	*Nearby Receptors* • Proposed HF Activities will occur in remote areas, situated at least 20 km from the nearest homestead, 30 km from the nearest community and 56 km from the nearest town. *Fire* Management measures as for Vegetation and Flora environmental factor above.	• Section 6 assessment of source and pathway indicates low scope for risk As the proposed Activities are small scale “proof of concept”, and because best practice approaches are being followed to ensure fugitive emissions are minimised, it is the Company’s view that the impact on air quality as a result of the Activities is considered **Not Significant**.

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			Air Emissions • Green completion, where methane and other VOC emissions are minimised, has been adopted for the HF activities. *Monitoring* • Couplings and flowlines for flowback reticulation system will be pressure tested for leaks prior to activities commencing. • Gas reticulation system from flowback will be monitored for gas leaks during flowback operations. • Water retention reservoir will be regularly monitored for the buildup of hydrocarbons. • Air quality monitoring will be conducted during the HF Activity at one selected well site using Optical Remote Sensing for Measurement and Monitoring of Emission Flux. This will benchmark a range of emissions associated with proposed TGS14 activities and demonstrate low risk. • The Contractor will be required to provide independent verification of well-maintained and operating machinery, vehicles and equipment. • In accordance with the Company *Operations Management Procedure* (OP-PR-025) a weekly operational checklist will be required to be completed to ensure correct and specified operating practices are being followed. • The weather will be monitored at all times via Bureau of Meteorology updates. *Emergency Response* • Company *Emergency Response Plan* (ERP) in place during the Activities. • Personnel trained, including Buru employees and contractors, in the implementation of the ERP. This	

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			includes emergency response drills and/or emergency muster drills conducted regularly. • Caretakers will be onsite throughout flowback and flaring operations with emergency communications facilities.	
People				
Amenity	To ensure the impacts to amenity are reduced to as low as reasonably practicable	• Minor ground movements due to microseismic event damaging property or impacting on public safety. • Inconvenience to local landholders and other stakeholders. • Disturbance of stock • Damage to well site facilities. • Disturbance to local residents • Disturbance of local landholders.	*Nearby Receptors* The proposed HF Activities will occur in remote location, being situated at least 20 km from the nearest homestead, 30 km from the nearest community and 56 km from the nearest town. *Microseismic Monitoring* • Company *Micro Seismic Monitoring Procedure (OP-PR-044)* identifies monitoring and management measures for microseismic activity to be implemented including, but not limited to, thresholds for ceasing operations in the event anomalous pressure readings are detected during operations. In accordance with the Procedure, the following monitoring will be implemented: ○ Baseline monitoring of naturally occurring microseismic events will be in place for at least one year prior to commencing Activities. ○ Real time surface monitoring for anomalous pressure changes during HF activity and traffic light monitoring system for feedback control system to mitigate induced seismicity. ○ Ongoing monitoring of microseismic events in the region following the Activities and prior to any subsequent phases of appraisal. *Community Engagement* • The Company has implemented a comprehensive	• The remoteness of the Activity areas reduces the likelihood of detectable effects or impacts on built infrastructure to negligible. Based on international studies that indicate no reports of a single microseismic event during 300,000 fracs per year in the United States, the lack of nearby receptors, the short term and small scale pilot Activity, impacts on amenity as a result of the Activities is expected to be **Not Significant**

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			community engagement strategy available at www.buruenergy.com • The Company stakeholder communications register documents meetings and engagement that has occurred to date in relation to proposed HF Activities. • An Independent Peer Review process has been implemented in the areas of the Geological Environment (Professor Peter Styles) and Water Resources (Professor Neil Coles). • Support has been provided to Traditional Owners (Yawuru, Noonkanbah) for access to Independent Specialist advice regarding proposed HF Activities and a previous HF Operation conducted at Yulleroo 2 in 2010. • A joint Yulleroo Gas Roadmap for assessment has been developed with the Yawuru PBC and Community. • A joint Noonkanbah Gas Roadmap for assessment has been developed with the Yungngora PBC and Community. *Operations Management - General* • Communication with stake holders/landholders will occur prior to commencement of Activities. Communication with regional agencies, stakeholder groups will be ongoing. • Mobilisation of HF spread to and from site will occur during day light hours over a short period and only once at each site so impacts on traffic are expected to be low. • HF Activities will be confined to daytime and be short duration (~ 1 week). • Lighting for security and safety purposes will be situated at the centre of the well pad. Light levels at the perimeter of the well site are expected to be	

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			very low (ambient levels). Only low light sources are used at the camp site (no floodlights or similar). • Loud (90 dB in well site) HF Activities (pumping) will be of short duration ~ 1 day and will occur during daylight hours. Flowback operations will have low level noise associated with separator and gas flare and will be barely audible outside fence line. • During flowback, sites will be manned by caretakers on well sites. • Trucks, equipment and machinery will be well maintained and muffled. • Security guards will be assigned to patrol and supervise entry to site during HF Operations. *Operations Management - Demobilisation* • All equipment, personnel and supplies will be demobilised from the well site and camp site following the completion of HF Activities. • The fence surrounding the well site, including the water retention reservoirs, will be left in place and the gate kept closed to prevent unauthorised personnel access and stock entering the well sites. • Signage will be placed at the well site gate.	
Heritage	To ensure that historical and cultural associations are not adversely affected	• Damage to cultural heritage site/s or object/s	• On-going communication with Traditional Owners through the Buru Community Liaison team based in Broome. • Vehicles and personnel access to be limited to the well pad, camp site and access track to prevent disturbance outside of Activity area. • Heritage/Cultural Awareness Inductions with local Traditional Owner representatives for operational personnel, including the requirement to stay within Activity area. • Traditional Owner representatives invited to well sites to observe operations under Company specified safety arrangements.	• There are no cultural heritage sites or objects within the existing proposed area of Activities

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			• In accordance with the *Best Practice Operations Management Procedure* (HSE-PR-025), completion of the weekly operational checklist including disturbance outside of the Activity area.	
Human Health	To ensure that human health is not adversely affected	• Exposure to harmful substances	Management and Mitigation Measures as per Terrestrial Environmental Quality environmental factor above. In addition: *Operations Management* • Contractor will use trained personnel for undertaking the Activity in accordance with their standard operating procedures as applied elsewhere in Australia and overseas. • Appropriate PPE equipment including for sand dust exposure as required. • Flowback water will be contained within lined water retention reservoirs to prevent release of radioactive material. • In accordance with *Produced Water Monitoring Procedure* (OP-PR-024) analysis of flowback water conducted during and immediately after flowback ceases with radiation meter to detect anomalous readings above background bore water values/guideline levels. • If elevated radiation levels detected then treatment of flowback water to remove solids (which contain the NORMs) will be undertaken and the solids containing the NORMs taken to approved facility for disposal. • Green completion, where methane and other VOC emissions are minimised, adopted as standard operating practice. • Couplings and flow lines for flow-back reticulation system pressure tested for leaks. • Gas reticulation system from flow-back monitored	• Section 6 assessment of source and pathway indicates low scope for risk. Result of the Activities is expected to be **Not Significant**

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			for gas leaks. • Regular monitoring of the Retention Pond for build-up of hydrocarbons. • Air quality monitoring will be conducted during Activity at one selected well site using Optical Remote Sensing for Measurement and Monitoring of Emission Flux.	
Integrating Factors				
Rehabilitation and Closure	To ensure the return of biodiversity in rehabilitated areas by the reestablishment of self-sustaining and functional ecosystems comprised of local provenance species.		• Upon completion of all activities, all equipment, personnel and supplies will be demobilised from the Activity area in accordance with the Company *Demobilisation Procedure* (HSE-PR-021). • If the tests prove unsuccessful, the wells may be plugged and abandoned. The wells be plugged and abandoned in accordance with Clause 637 of the *Schedule of Onshore Petroleum Exploration and Production Requirements* 1991. • Sites will then be rehabilitated in accordance with the Company *Rehabilitation Procedure* (HSE-PR-022) which includes: ○ Recontouring Activity area to match the surrounding landscape. ○ Respreading topsoil and vegetation over the site. ○ Monitoring and inspection of rehabilitation success in accordance with the Company *Flora and Vegetation Monitoring Procedure* (HSE-PR-006). ○ Active rehabilitation of well sites through the spreading of native local seeds and planting of seedlings as required.	Rehabilitation, if required will be undertaken in accordance with the measures outlined in the Environment Plan submitted to the DMP under the PGER Act. Based on the rehabilitation measures in place, the environmental impact associated with ineffective rehabilitation is considered **Not Significant**
Cumulative Factors	Sum of all EPA objectives listed above	Combined risks to health or environment	• TGS14 is focused on demonstrating no or minimal risk to humans and the environment and designed to facilitate predicting scaling effects of potential future operations.	• TGS14 is a pilot program taken over a short term (weeks) duration and small scale on existing sites that are readily rehabilitated to baseline conditions. Therefore, cumulative impacts are extremely

Environmental Factor	EPA Objectives	Potential Environmental Impacts	Proposed Management and Mitigation	Assessment of Significance
			• Anticipated cumulative impact design objectives derived from TGS14 Activity include: ○ Demonstrating that the flowback water from the HF can be 100% recycled, using it safely in HF treatments while minimising the small amount of water required to be taken from the aquifer. ○ Demonstrating that there are no solid, fluid or air emissions from the activity that pose any risk to humans or the environment. ○ Optimising the HF design for the Laurel formation in order to minimise land footprint and maximise resource recovery from the formation in a commercially viable manner. ○ Informing concept design for future development if successful.	unlikely. Proposed activities are small scale "proof of concept" activities and so Cumulative Impacts as a result of the activities are considered **Not Significant**.

References:

- Environmental Assessment Guidelines for Environmental Factors and Objectives (EAG 8), Environmental Protection Authority, Western Australia, June 2013.
- Guidance for the Assessment of Environmental Factors: Rehabilitation or Terrestrial Ecosystems (EAG 6) , Environmental Protection Authority, Western Australia, June 2006.

8. PRINCIPLES OF ENVIRONMENTAL PROTECTION

Table 14: Principles of Environmental Protection. From Section 4A. The Object and Principles of the Environmental Protection Act 1986.

Principle	Relevant (Yes/No)	If Yes, How Addressed
1. The precautionary principle Where there are threats of serious or irreversible damage, lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by: a) Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and b) An assessment of the risk-weighted consequences of various options.	Yes	A range of technical studies have been undertaken to support the environmental risk assessment for the proposed activities. These include: • Flora and fauna studies for the well sites associated with the drilling of the exploration wells, • Targeted Bilby survey in the Yulleroo region, • Hydrogeological assessment of the activity areas, • Chemical risk assessment, • Geological environment risk assessment, • Well operations and integrity review. Predictions made in the preparation of this document and the Environment Plan prepared under the PGER Act are supported by expert peer reviews in the field of Water Resources and the Geological Environment to ensure the approaches adopted by Buru are aligned to best international practice in the field. Predicted impacts on the environment can be made with a high degree of certainty based on a range of international studies. These international studies cover areas including: • Microseismic effects, • Characteristics of flowback water, • Contamination from HF activities, • Well integrity, • Propagation of hydraulic fractures, and • Emissions associated with unconventional gas activities. Key international studies related to each Environmental Factor are cited in Section 7 of this document. From the approximately 300,000 hydraulic fractures are undertaken every year in the United States, there has been not a single instance of a significant microseismic event or instance of shallow groundwater contamination. The Company has extensive experience operating in the Canning Basin. The Service provider for HF Activities is chosen based on their experience in undertaking HF operations. Further, all activities will be undertaken in accordance with the best practice measures outlined in the *IEA Golden Rules* and *APPEA Code of Practice for Hydraulic Fracturing*.

		Where any lack of scientific certainty exists, a precautionary approach has been adopted by the Company.
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	Yes	The proposed activities are small scale proof of concept activities occurring on at existing exploration well sites. • The emissions associated with the Activities are restricted to vehicle movements and flaring. Green completions will be utilised by the Company to minimise greenhouse gas emissions. Monitoring at one well site using Optical Remote Sensing for Measurement and Monitoring of Emission Flux will be implemented to confirm this and collect quantitative data for emissions associated with shale gas activities. • There is no clearing associated with the activities as HF activities will occur on existing exploration well sites. • Measures are in place to ensure effective rehabilitation under the PGER Act, as required. • The risks to vulnerable species in the activity area have been mitigated as there will be no clearing associated with the activities, HF activities are restricted to well sites and no night driving is permitted during the program (except in emergencies).
3. The principle of conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Yes	There will be no clearing of native vegetation associated with the proposed HF Activities. A range of flora, fauna and hydrogeological studies have been undertaken in the areas where HF activities are proposed to ensure the biological diversity of the areas is identified and measures are in place to ensure the conservation of biological diversity and ecological integrity.
4. Principles relating to improved valuation, pricing and incentive mechanisms 1. Environmental factors should be included in the valuation of assets and services. 2. The polluter pays principle — those who generate pollution and waste should bear the cost of containment, avoidance or abatement. 3. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes. 4. Environmental goals, having been established, should be pursued in the most cost effective way, by	Yes	A risk based approach has been implemented to ensure the protection of Environmental Values of the Activity area during HF Activities. A range of technical studies have been undertaken and peer reviewed to ensure the impacts on these environmental values are reduced to ALARP. No areas or species of conservation significance will be impacted by the proposed Activities. Costs associated with mitigating impacts on the environment during the activities will be borne by Buru Energy. This includes costs associated with waste management, demobilisation, decommissioning and rehabilitation of the site, as required. Buru Energy's commitment to continual improvement is encapsulated in its Environment Policy (HSE-POL-005) and Management Plans. This includes the setting of objectives and monitoring performance against these objectives. Where deficiencies are identified through the Company's *Operations Management* (OP-PR-025) or *Internal Environmental Audit* (OP-PR-023) Procedures, the Company works to identify cost effective solutions to minimise the environmental impacts to ALARP. These are developed and implemented in accordance with on ground personnel to ensure the effectiveness of controls.

establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.		

5. The principle of waste minimisation
 	
All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.
	Yes	The treatment, storage and disposal of waste will be undertaken in accordance with the Company's *Waste Management and Monitoring Procedure* (HSE-PR-005). This includes the separation of waste into putrescible waste, general and industrial waste streams.
		
		• Putrescible waste will be stored at the camp site and well site in securely covered skips/bins to prevent fauna access, including feral fauna, and litter generation. All putrescible waste will be regularly removed from the Activity area for disposal at a licensed waste disposal facility.
		• General and Industrial waste will be suitably stored onsite in segregated areas including, but not limited to:
		  ○ Excess proppant sand will be stored within dry materials storage area;
		  ○ Produced liquid hydrocarbons stored in a fit for purpose storage tank within a bunded area;
		  ○ Residual flowback within the Water Reservoir; and
		  ○ Empty chemical containers returned to Service provider facilities offsite.
		• Where possible, industrial waste will be reused or recycled such as use of the returned proppant or sand as fill or bunding material. If the industrial waste cannot be reused or recycled, it will be removed from the Activity area for disposal at a licensed waste disposal facility in accordance with landfill operator requirements and the *Environmental Protection (Controlled Waste) Regulations* 2004, where applicable.
		• Sewage and grey water at the well site and camp site will be treated by an Aerated Wastewater Treatment System (AWTS) which is a small scale onsite sewage treatment plant. An AWTS uses the processes of aeration and clarification to treat wastewater. The AWTS will be designed to treat all wastewater from the kitchen, bathroom, toilet and laundry and comply with AS/NZS 1546.3.

9. CONCLUSIONS

Buru Energy and its specialist advisors has undertaken an environmental risk assessment (ERA) of the proposed Activity for TGS14 at each of the four well sites proposed for HF activities in the 2014 dry season. A description of the receiving environment, defined in terms of environmental factors is provided in Section 3 at each Project area.

Section 4 provides a detailed overview of proposed Activities including location, staging and timing, site layout, well integrity assessment, hydraulic fracturing process, associated water requirements and chemical disclosure, surface water management processes, demobilisation and rehabilitation.

Section 5 sets out the process for achieving Social Licence including consultation and engagement strategy with relevant stakeholders and the stakeholder consultation register maintained by Buru Energy since November 2011 for the Tight Gas Development Project. The consultation strategy is geographically broad based and has a diversity of recognised stakeholders including pastoralists, schools, community groups and businesses. A range of consultation methodologies have been employed. The consultation and engagement is strategic in nature by virtue of the establishment of "gas roadmaps" with Traditional Owners on whose Native Title lands the wells are situated. These "roadmaps" recognise that TGS14 is at an early exploratory stage of evaluation of a large tight gas resource in the Canning Basin that potentially offers long term energy security to Western Australia, significant contribution to Australia's GDP and socio-economic opportunity and employment for people and businesses in the local and regional community.

The "roadmap" establishes a participatory process that encompasses Traditional Owner values and heritage and ongoing community engagement in Company planning and development of this potential resource. This includes the establishment of a Company accredited training and employment program for Environmental Science Cadets with candidates from Traditional Owner groups to undertake the ongoing environmental monitoring program for the gas development; the active identification of training and employment in Buru Energy and through its specialist service providers as well as active identification of business opportunities for local Aboriginal companies and enterprises.

The engagement program is focused on the broader Kimberley community and includes holding a series of information sessions at various locations in the Kimberley region, as well as separate presentations to community and business organizations. People are able to register their interest through a registration process, via email, a 1800 number or a designated email. The Company is also engaging with schools in Broome, Derby and remote areas throughout the Kimberley, providing presentations and supporting school initiatives, as well as offering scholarships.

Given the pilot nature of TGS14 in the Project area and community interest in this potential significant and strategic new industry in the region, a participatory review of Buru Energy risk assessment and management and monitoring methodologies, conducted during the assessment process, has been adopted using an iterative and interactive workshop and review approach that includes:

- Traditional Owners and their specialist advisors in relation to their land on which the wells are located
- An inter-agency team including Department of Mines and Petroleum, Department of State Development, Office of Environment Protection Agency, Department of Agriculture and Food, Department of Environment Regulation, Department of Parks and Wildlife, Department of Water, Department Main Roads and Department of Lands
- Independent senior peer review of matters pertaining to water resources, the geological environment and operational procedures

Section 6 provides a risk scoping analysis using Source-Pathway- Receptor framework. This informs the assessment of Potential Environmental Impacts on Environmental Factors and the associated proposed management and mitigation measures which are summarised in Section 7.

The chemicals to be used in the hydraulic fracturing process are sourced from the food industry, All products biodegrade quickly and are not persistent in the environment. Laboratory assessment of the HF fluid and its breakdown products demonstrates it is essentially non-toxic under the national NICNAS guidelines.

The assessment of the Potential Impact on Environmental Factors as a result of the proposed Activities is considered Not Significant

Matters of National Environmental Significance

The Company has considered whether the Activities are likely to have a significant impact on Matters of National Environmental Significance (MNES) and concluded that there are no MNES matters that require referral under the EPBC Act. Bilbies, listed as Vulnerable under the *EPBC Act* occur in the Yulleroo area. Given that no clearing is required for this Activity, the short duration of the Activity, management measures to be implemented to minimise disturbance of Bilbies, the Company considers that the Activities will not have any impact on Bilbies at either a population or species level.

All well sites are outside of environmentally sensitive areas (ESA), World Heritage Areas, National Heritage Places and away from wetlands. The West Kimberley National Heritage Place (WKNHP) is located approximately 25 km to the west of Valhalla North 1 well site and the RAMSAR listed Roebuck Bay wetlands are 65 km to the west of the Yulleroo 4 well site. The Company considers that none of these areas will be impacted by the Activities and will not require a referral under the EPBC Act.

Company Self-Referral to EPA

Buru Energy considers that scope, spatial scale, and extent and duration of potential environmental impacts are adequately characterised and defined for the proposed Activities and that TGS14 is a small scale pilot project that is the early stage of a ‘proof of concept’ process in exploration of the Laurel Formation. With the appropriate risk mitigation/management measures outlined in this Environment Plan the uncertainty (risk) in not achieving the stated environmental performance objectives is low. It is Buru Energy’s view that this Environment Plan has adequately considered the:

- Character of the surrounding environment;
- Magnitude, extent and duration of anticipated change;
- Resilience of the environment and its ability to cope with change;
- Confidence of prediction of change; and
- Existence of environmental values, policies, guidelines and standards against which a proposal can be assessed.

As outlined earlier, the participatory review of Buru Energy risk assessment, management and mitigation measures and implementation strategy including monitoring and reporting and consultation process undertaken with relevant stakeholders in finalising this Environment Plan including regulators and in particular the relevant Traditional Owners and community groups in the proposed Activity areas, are extensive and comprehensive. Buru Energy believes this conservative approach to risk assessment and the associated consultation process has adequately considered, addressed and mitigated this element of “environmental significance”. Based on these criteria, Buru Energy does not consider that the Activities are not likely to have any significant effect on the environment.

10. REFERENCES

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